Annotated Bibliography of Climate and Forest Diseases of Western North America


Abstract: Measurements of cores or disc samples representing slightly more than 76,000 annual rings from 336 western white pine tree were compiled to obtain a set of deviations from normal growth of healthy trees that would express the response of these trees to variation in the environment during the last 280 years. Their growth was demonstrated to be a function of temperature and available moisture for the period of climatic record from 1912 to 1958. Extrapolating the relation of growth to weather to the long tree ring record of western white pine, we find that the period 1916—40 represents the most adverse growth conditions with regard to intensity and duration in the last 280 years. This drought, superimposed on sites having severe moisture-stress characteristics, triggered the chain of events which ultimately resulted in pole blight. If the unfavorable conditions for growth during 1916—40 do not represent a shift to a new climatic mean and if western white pine is regenerated only on sites with low moisture-stress characteristics, the probability is high that pole blight will not reoccur for many centuries in stands regenerated from this date on.


Abstract: Root density and mortality were determined in 30 healthy western white pine (Pinus monticola Doug.) stands ranging from 20 to 160 years old. Similar determinations were made in 16 stands of the 60- to 80-year age class affected by pole blight, a disease of unknown cause. Various physical soil characteristics were measured in 26 healthy and diseased stands of the 60- to 80-year age class in conjunction with the root study. Both rootlet mortality and density in the upper 1 foot of soil in the 60- to 80-year age class are significantly correlated with the available water storage capacity in the soil depth occupied by a major portion of the root system. The available water storage capacity is dependent upon effective soil depth. As the severity of pole blight increases, rootlet mortality increases and available water storage capacity and effective soil depth become less. These results indicate an edaphic relationship to the pole blight disease.


Abstract: Two organisms, an endemic cerambycid beetle Plagithmysus bilineatus and a widespread root fungus Phytophthora cinnamomi, have been associated with the decline of `ohi`a trees on the island of Hawaii. While neither organism appeared to trigger epidemic ohia decline, each was an integral part of the complex decline syndrome. The two organisms we studied acted independently, but attack by the cerambycid was apparently encouraged by rootlet mortality or crown loss brought on by unknown stress factors. Data and observations support Houston's (1973) concept of decline diseases, in which tree mortality is thought to result from a sequence of events that starts with stress, predisposing trees to invasion by organisms that eventually attack and kill them.

http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/


Abstract: Carbon dioxide, the major plant food, is on the rise, but forests on both sides of the Atlantic are known to be declining, and industrial pollution is widely suspected to be the principal cause. However, significant contemporary forest declines also are occurring in several Pacific forests, in areas completely unaffected by industrial pollution. This paper focuses on researched forest declines in the Pacific area (New Zealand, Japan, and the Hawaiian and Galapagos islands), where canopy dieback was found to be a natural aspect of forest dynamics. It then summarizes characteristics of forest decline in central Europe (Czechoslovakia and Germany), where decline relates mostly to anthropogenic causes. Commonalities among the natural causes in the Pacific and anthropogenic causes in the European forests are emphasized through recognition of a third factor complex, the demographic component, which so far has been largely neglected in the European forest decline research. The natural cause complexes identified as demographic, disturbance, and biotic components are placed into a causal hierarchy theory based on cohort senescence. It is suggested that this may serve as a framework for comparative ecosystem research of forest declines at the global level, which includes a consideration of ongoing biotic impoverishment and climate change.


Abstract: Portions of the ohia (Metrosideros polymorpha) forests on the windward slopes of Mauna Loa and Mauna Kea on the island of Hawaii began dying in 1952. Little mortality has occurred since 1972. About 50,000 ha are affected by the decline. Individual trees exhibit several symptoms, from slow progressive dieback to rapid death. Seven types of decline have been identified on the basis of differential response of the associated rainforest vegetation. Two of the types, Bog Formation Dieback and Wetland Dieback, make up more than 80 percent of the decline area. The decline has affected bird populations and plant species in some areas, but has had no major effect on runoff or water quality. Ohia decline appears to be a typical decline disease caused by a sequence of events. Poor drainage is probably the major cause of stress and is followed by attack of the ohia borer (Plagithmysus bilineatus) and two fungi (Phytophthora cinnamomii and Armillaria mellea), which kill the trees. Except for controlling introduced plants and feral animals that spread them, little can be done to ameliorate the effects of the decline.


Abstract: A soil and foliar nutrient analysis was carried out in the Hawaiian Metrosideros rain forest for the purposes of elucidating a previously published physical habitat classification and for finding an explanation for the widespread canopy dieback, which is not caused by a biotic agent in this ecosystem. Soil elements analyzed were C, N, P, Ca, Al, Mn, Fe, and other parameters such as pH. Foliar analysis was restricted to N, P, Ca, Mn, and Fe and assessed only for the canopy M. polymorpha and its major associate, the tree ferns, in the undergrowth. It was found that the earlier recognized two-way breakdown into oligotrophic and eutrophic nutrient regimes had to be enlarged for the habitat classification to a mesotrophic category. Young, deep-ash soils were recognized as mesotrophic on account of their extreme acidity and associated higher and potentially toxic levels of soluble AI, Mn, and Fe. Except for the mesotrophic ‘a’a lava site, other shallow rock outcrop habitats on pahohoe...
were recognized as oligotrophic, because of very low available N and high acidity and, in the poorly drained sites, also high levels of potentially toxic metals. The bog habitats had the highest levels of potentially toxic metals, but surprisingly moderate levels of available N and P. The canopy dieback phenomenon cannot be entirely explained from the nutrient imbalances found in most of the substrate types, but these imbalances are considered contributory in the sense that they become increasingly stressful with stand development, thereby decreasing tree vigor and predisposing stands to dieback.


Abstract: Pythium vexans caused rootlet necrosis of ohia in greenhouse and field tests. No correlation between ohia tree decline and occurrence of P. vexans in ohia tree roots or ohia forest soil was evident. Phytophthora cinnamomi was recovered from ohia forests of healthy appearance, and from some but not all decline forests. When P. vexans was present in declining forests, Phytophthora cinnamomi was also present. In greenhouse tests, P. cinnamomi was a more virulent root pathogen than P. vexans.


Abstract: Stands of native ohia trees in Hawaii are in serious decline and many trees have died. Declining trees treated with a complete fertilizer (NPK plus micronutrients) responded by producing numerous new leaf buds on branches and trunks. The trees also responded to a mixture of NPK without micronutrients. Application of N, P, and K individually or a mixture of micronutrients were not effective. Decling trees responded to a combination of NP, but not to combinations of NK, and PK. Results indicated that ohia trees are declining because of nutrient deficiency. Inability of roots to obtain sufficient nutrients to maintain the crown could result from various factors, including infection of roots by a pathogen(s), low soil fertility, or a combination of both.


Abstract: Ohia transplanted to soils collected from declining forests became infected with Phytophthora cinnamomi; inoculation of healthy ohia trees in the field with soils and roots from declining forests resulted in root necrosis and P. cinnamomi was isolated. Phytophthora cinnamomi was recovered from 96% of the decline areas and from 24% of the apparently healthy areas sampled throughout the island of Hawaii. Lupine baiting and the use of soil dilution plates indicated little difference between population of the fungus in soil of declining and healthy forests. Addition of nutrients to ohia trees in the greenhouse had little effect on subsequent root infection by P. cinnamomi, and the fungus was recovered from soil in areas where declining ohia trees produced new growth following application of complete fertilizer. Fungicides reduced infection of ohia trees and lupine by P. cinnamomi in greenhouse and laboratory experiments. Broadcast applications of fungicides plus complete fertilizer to declining ohia trees resulted in a greater growth response than application of complete fertilizer only.


Abstract: Phytophthora cinnamomi caused root rot and death of ohia in greenhouse tests. The isolation of this from ohia in the field was correlated with high rainfall and poor drainage, but not with ohia decline.


Abstract: Alaska-cedar, Chamaecyparis nootkatensis (D. Don) Spach, has been dying in undisturbed forests throughout southeast Alaska for the last 100 years. To determine if decline spreads, boundaries of mortality at seven sites with decline were mapped using aerial photographs taken in 1927, 1948, 1965, and 1976. Mortality was present at all seven sites in 1927. The boundaries of mortality have since expanded, but not by more than 100 m beyond the 1927 limit. In ground surveys, dead Alaska-cedar trees, classified according to their degree of deterioration, were recorded in 427 plots along 39 transects. Fifty five taxa of understory vegetation were also recorded from 280 plots along these 21 transects; an ordination was produced from their distribution that represented a gradient from bogs to sites with better drainage. Most mortality was associated with bog and semibog sites. Alaska-cedar has a disproportionate level of mortality (65% of basal area dead) relative to other conifers. Although decline is relatively species specific and has patterns of local spread, the spread of mortality is along a specific, preexisting ecological gradient. These results, and the apparent lack of any site to site spread in the last 100 years, suggest that Alaska-cedar decline is not caused by some biotic agent.


Abstract: In order to test the hypothesis that the deterioration of trembling aspen (Populus tremuloides Michx.) is related to variations in climate, soil properties, and genotype, 59 trembling aspen clones were sampled in Michigan, Wisconsin,
Minnesota, and Ontario. A longevity index (LI) was calculated by taking the difference between predicted basal area from normal yield tables and measured basal area for each clone. Correlations of environmental variables with LI indicate that aspen longevity decreases with increasing mean annual temperature. Under similar temperature regimes, aspen growing on xeric sites and on sites low in exchangeable Ca are most susceptible to early breakup. Since there were negligible differences in soil properties between nine parts of adjacent deteriorating and relatively well stocked clones, the authors hypothesize that, under similar environmental conditions, variation in the timing of deterioration may be due to genotypic differences between clones.


Levine and Associates and the National Institute of Justice, Houston, Texas and Washington, DC.


Abstract: Elk browsing and conifer species mixing with aspen (Populus tremuloides Michx.) present current challenges to aspen forest management in the western United States. We evaluated the effects of conifers and elk browsing on quaking aspen stands in and near Rocky Mountain National Park using tree rings to reconstruct patterns of aspen establishment, growth, and mortality over the past 120 years. High conifer encroachment and elk browse were both associated with decreased aspen recruitment, with mean recruitment dropping over 30% from pure aspen to mixed stands and over 50% from low-browse to high-browse stands. Maximum aspen recruitment was lower in mixed stands than in pure stands with the same tree basal area. High levels of elk browsing were also associated with a 30% decrease in stand-level growth of aspen. Neither high conifer abundance nor elk browse affected the growth of individual trees or aspen mortality. Aspen establishment was negatively influenced by conifers and elk browsing; however, aspen growth and mortality appeared to be resilient to these two external influences. Overall, these results suggest that long-term preservation of aspen forests could be achieved by enhancing aspen recruitment.


Abstract: This paper presents data on early postfire tree regeneration. The data were obtained from repeated observations of recently burned forest stands along the Yukon – British Columbia border and in interior Alaska. Postfire measurements of tree density were made periodically for 20–30 years, providing direct observations of early establishment patterns in boreal forest. Recruitment rates of the dominant tree species in both study areas were highest in the first 5 years after fire, and additional net establishment was not observed after 10 years. The postfire population of spruce (Picea mariana (Mill.) BSP and Picea glauca (Moench) Voss s.l.) remained constant after the first decade in the two study areas. Populations of aspen (Populus tremuloides Michx.) and lodgepole pine (Pinus contorta Doug. ex Loud. var. latifolia Engelm.) both declined after 10 years in mixed-species stands along the Yukon – British Columbia border. Mortality rates of aspen and pine were positively correlated with their initial densities, indicating that thinning occurred as a density-dependent process. At all sites, measurements of stand density and composition made early were highly correlated with those made late in the monitoring period, indicating that patterns of stand structure initiated within a few years after fire are maintained through subsequent decades of stand development.


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Abstract: The branch bag method was used to monitor photosynthesis and transpiration of trembling aspen (Populus tremuloides Michx.) and hazelnut (Corylus cornuta Marsh.) over a 42-day midsummer period in 1996, as part of the Boreal Ecosystem–Atmosphere Study (BOREAS). During the same period, daytime measurements of stomatal conductance (gs) and leaf water potential (Ψleaf) were made on these species, and sap flow was monitored in aspen stems by the heat pulse method. Weather conditions during the study period were similar to the long-term average. Despite moist soils, both species showed an inverse relationship between daytime gs and vapor pressure deficit (D) when D was > 0.5 kPa. Daytime Ψleaf was below –2 MPa in aspen and near –1.5 MPa in hazelnut, except on rainy days. These results are consistent with the hypothesis that stomatal responses are constrained by hydraulic resistance from root to leaf, and by the need to maintain Ψleaf above a minimum threshold value. Reductions in gs on sunny afternoons with elevated ambient D (maximum 2.3 kPa) were associated with a significant decrease in photosynthetic rates. However, day-to-day variation in mean carbon assimilation rate was small in both species, and appeared to be governed more by solar radiation than D. These results may...
be generally applicable to healthy aspen stands under normal midsummer conditions in the southern boreal forest. However, strong reductions in carbon uptake may be expected at the more extreme values of D (> 4 kPa) that occur during periods of regional drought, even if soil water is not locally limiting.


Abstract: Greenhouse, field, and laboratory studies examined the role of selected environmental stresses on the development of Cytospora chrysosperma after exposure to drought, flooding, or defoliation. Drought-stressed trees had larger cankers than control trees, whereas flooded trees did not. Water potential of trees was a significant covariant that explained variation in canker size. Severely defoliated trees (75 to 100%) had larger cankers than nondefoliated control trees or trees with 50% defoliation. Carbohydrate content of roots of defoliated trees was significantly less in 100% defoliated trees than in 75 and 50% defoliated trees. Canker size on field-inoculated aspen and cottonwood (cv. Siouxland) was related inversely to tree water potential. Peak susceptibility to canker expansion occurred when water potential dropped below -1.6 MPa. Relative turgidity was not associated with canker size. In vitro growth of C. chrysosperma was affected positively by decreasing osmotic- and matrix-based water potential until water potentials were lowered to -1.0 MPa. Below -1.0 MPa, fungal growth was affected negatively.


Abstract: Adaptation in forestry is sustainable forest management that includes a climate change focus. Climate change over the next 100 years is expected to have significant impacts on forest ecosystems. The forestry community needs to evaluate the long-term effects of climate change on forests and determine what the community might do now and in the future to respond to this threat. Management can influence the timing and direction of forest adaptation at selected locations, but in many situations society will have to adjust to however forests adapt. Adapting to climate change in the face of the uncertain timing of impacts means we must have a suite of readily available options. A high priority will be coping with and adapting to forest disturbance while maintaining the genetic diversity and resilience of forest ecosystems. A framework for facilitating adaptation in forestry is discussed and a review of adaptive actions presented. KEYWORDS: climate change, sustainable forest management, adaptation.
Kim, Mee-Sook; Richardson, B.A.; Klopfenstein, N.B. null. Western forest diseases and climate relations: root diseases and climate change. null.

Abstract: Climate change could alter patterns of disturbances from pathogens through (1) direct effects on the development, survival, reproduction, dispersal, and distribution of pathogens; (2) physiological changes in tree defenses; (3) indirect effects from changes in the abundance of mutualists and competitors. In general, any climate change could increase the incidence and spread of root disease if host trees become maladapted and undergo stress due to climate change. In addition, climate change could alter fitness of various mycorrhizal fungi and other beneficial microbes that currently suppress root disease. Some reports suggested that hot and dry conditions (e.g., prolonged drought) are expected to increase incidence and spread of root diseases in forests. However, it is difficult to specifically predict how this climate change will affect diverse root diseases under various projected climate scenarios. Currently, the distribution of pathogens that cause root disease in the western USA is not well documented. Current disease surveys often overlook non-symptomatic trees that are infected by pathogens. Furthermore, precise diagnostic tests are seldom performed to accurately identify pathogens, and precise GPS-recorded data about pathogen distribution is frequently lacking. Without reliable and accurate information of pathogen distribution under present climate conditions, it is difficult to assess the relationships among root-disease pathogens and climate variables. Determining the precise distribution of currently existing pathogens and disease is the first step toward understanding impacts of climate change on root pathogens. An example of predicting *Armillaria ostoyae* based on climate variables will be discussed at the workshop. A short description of this pilot project follows: To develop a climatic envelope for *A. ostoyae*, latitude, longitude, and elevation were compiled from 102 confirmed locations where this species was found. These location data were used to develop climate-variable estimates from a spline-climate model at 1 km² resolution followed by Random Forests multiple-regression tree analyses. Currently available climate models that predict suitable climate space for forest tree/shrub/forb species based on various climate change scenarios will also provide a basis to determine climate effects on host vigor and pathogen distribution in the western USA. These approaches will be discussed at the Workshop.


Abstract: After nearly 100 years of fire exclusion, introduced pests, and selective harvesting, a change in forest composition has occurred in many Inland West forests of North America. This change in forest structure has frequently been accompanied by increases in root diseases and/or an unprecedented buildup of fuels. Consequently, many forest managers are implementing plans for fuels treatments to lower the risk of severe wildfires. Impacts on root disease should be considered before selecting appropriate fuels treatments. Complex interactions exist among conifer root diseases, fuels treatments, forest structure, species composition, stand history, and other environmental factors. As forest managers prescribe fuels treatments, their success in lowering the risk of severe wildfire will depend in part on the impacts of these treatments on root disease. Root diseases are one of many factors to be considered when developing plans for fuels treatments. Choices must be made on a site-by-site basis, with knowledge of the diseases that are present. This paper provides examples of how fuels treatments may increase or reduce specific diseases and demonstrates their importance as considerations in the fuels management planning process. Several root diseases prevalent within Inland West of North America are addressed: *Armillaria* root disease, *annosus* root disease, laminated root rot, black stain root disease, *Schweinitzii* root and butt rot, *Tomentosus* root disease, *Rhizina* root rot, and *stringy* butt rot. For each disease, general information is provided on disease identification, management options, and potential effects of fuels treatments. However, many long-term studies are needed to assess effects of specific interactions among fuels treatments, root diseases, and host trees. Key words: wildfire, forest planning, forest structure, mechanical treatments, prescribed fire, coniferous hosts, pathogens, disease management.


Abstract: To better understand evolution we have studied aggressiveness of the anthracnose pathogen, *Colletotrichum gloeosporioides*, collected from *Stylosanthes scabra* pastures between 1978 and 2000 and by inoculating two isolates onto two cultivars over 25 sequential infection cycles at ambient (350 ppm) and twice-ambient atmospheric CO₂ in controlled environments. • Regression analysis of the field population showed that aggressiveness increased towards a resistant cultivar, but not towards a susceptible cultivar, that is no longer grown commercially. • Here we report for the first time that aggressiveness increased on both cultivars after a few initial infection cycles at twice-ambient CO₂ as isolates adapted to combat enhanced host resistance, while at ambient CO₂ this increased steadily for most cycles as both cultivars selected for increased aggressiveness. Genetic fingerprint and karyotype of isolates changed for some CO₂-cultivar combinations, but these were not related to changed aggressiveness. • At 700 ppm fecundity increased for both isolates, and this increased population size, in combination with a conducive microclimate for anthracnose from an enlarged plant canopy under elevated CO₂, could accelerate pathogen evolution.


Abstract: This paper reviews the potential consequences of temperature changes on infectious plant, wildlife and marine diseases, and considers the hypothesis that climate warming will affect host-pathogen interactions by (i) increasing pathogen development rates, transmission, and number of generations per year; (ii) relaxing overwintering restrictions on pathogen
life cycles; and (iii) modifying host susceptibility to infection. For example, several plant diseases are more severe after mild winters or during warmer temperatures, which suggests that directional climate warming alters plant disease severity.


Abstract: Patterns of both above- and belowground biomass and production were evaluated using published information from 200 individual data-sets. Data sets were comprised of the following types of information: organic matter storage in living and dead biomass (e.g. surface organic horizons and soil organic matter accumulations), above and belowground net primary production (NPP) and biomass, litter transfers, climatic data (i.e. precipitation and temperature), and nutrient storage (N, P, Ca, K) in above- and belowground biomass, soil organic matter and litter transfers. Forests were grouped by climate, foliage life-span, species and soil order. Several climatic and nutrient variables were regressed against fine root biomass or net primary production to determine what variables were most useful in predicting their dynamics. There were no significant or consistent patterns for above- and belowground biomass accumulation or NPP change across the different climatic forest types and by soil order. Similarly, there were no consistent patterns of soil organic matter (SOM) accumulation by climatic forest type but SOM varied significantly by soil order-the chemistry of the soil was more important in determining the amount of organic matter accumulation than climate. Soils orders which were high in aluminum, iron, and clay (e.g. Ultisols, Oxisols) had high total living and dead organic matter accumulations - especially in the cold temperate zone and in the tropics. Climatic variables and nutrient storage pools (i.e. in the forest floor) successfully predicted fine root NPP but not fine root biomass which was better predicted by nutrients in litterfall. The importance of grouping information by species based on their adaptive strategies for water and nutrient-use is suggested by the data. Some species groups did not appear to be sensitive to large changes in either climatic or nutrient variables while for others these variables explained a large proportion of the variation in fine root biomass and/or NPP.


Abstract: The ecological and economic impacts of individual forest pathogens on forest stands are often difficult to measure because of indirect impacts arising from their interactions with other agents. Root diseases, especially interact with many elements of the forest. This study uses a method called path analysis to estimate direct and indirect effects of Armillaria root disease and other small-scale disturbances on a pristine Pinus ponderosa stand in the Black Hills of South Dakota. Indirect effect was defined as an outcome where one small-scale disturbance alters the effect that another has on canopy gap size. Results indicate that key factors affecting gap size include Armillaria root disease, bark beetles, weak pathogens, ice/snow damage, lightning, and wildfires, presented in order of relative importance. Interactions occur between Armillaria and lightning, beetles, wind, and fire; between bark beetles and wind, fire, and weak pathogens; and between wind and fire. Armillaria and beetles both tend to occur where damage by wind is absent. Armillaria root disease was predicted to have the largest overall effect on gap size, which is mostly due to its direct effects, and not resulting from its interactions with other disturbances. Path analysis generates a predictive model based on covariance among disturbances and offers a way of quantifying the effects of these associations.


Abstract: Diversification of cereal cropping systems with alternative crops, such as oilseed, pulse, and forage crops, furnishes producers with a range of agronomic and economic options. Crop diversification also improves management of plant diseases through manipulation of host factors such as crop and cultivar selection; interruption of disease cycles through crop rotation, fungicide application, and removal of weeds and volunteer crop plants; and modification of the microenvironment within the crop canopy using tillage practices and stand density. Management practices, such as seed treatment, date and rate of seeding, balanced fertility, control of weeds, field scouting, harvest management, and record keeping, can also be utilized to manage plant diseases. This review evaluates the risks to diversified crop production systems associated with the major plant diseases in the northern Great Plains and the influence of host, pathogen, and environmental factors on disease control. Principles to help producers reduce and manage the risk from plant diseases are presented, and discussion includes strategies for countering fusarium head blight (Fusarium spp.), commonly called scab; and leaf spot.
Abstract: Armillaria ostoyae, a cause of armillaria root disease, is a normal component of many forest ecosystems in western Canada. The equilibrium between the fungus and its hosts which usually exists in undisturbed forest stands is upset in favour of the fungus by forest management practices that create stumps. Damage caused by the fungus following these management practices is described. Strategies for reducing damage are discussed.

Abstract: The relationship between aboveground symptoms and belowground incidence of Armillaria ostoyae (Romagn.) Herink on conifers in 13- to 24-year-old stands was investigated at five sites in each of the dry, moist, and wet climatic regions in the Nelson forest region, British Columbia. All trees >1.3 m in height in 0.01-ha circular plots centred on a tree killed fewer than two or more than five years previously or located where there were no symptomatic trees were removed from the soil by an excavator. The location and host response at each A. ostoyae lesion on root systems were recorded. Significant differences in belowground incidence were seen among climatic regions and plot types, with distance from the centre of plots, and between planted and naturally regenerated trees. Belowground incidence was related to the percentage of putatively colonized stumps within and adjacent to plots. There were significant differences among climatic regions in the intensity of infection, host reaction to infection, and percentage of diseased trees showing aboveground symptoms. These results have implications for interpreting results of surveys for Armillaria root disease in juvenile stands and for tending of such stands.


Abstract: Whitebark pine (Pinus albicaulis), an important treeline conifer in northern Montana, is considered both a keystone and foundation species in high-elevation ecosystems. The introduced fungal pathogen Cronartium ribicola, which causes white pine blister rust, has resulted in severe declines in white pine in subalpine forest communities throughout the northern Rockies during past decades. However, the prevalence of blister rust in white pine within the alpine treeline community and its impact remain to be determined. We gathered field data on blister rust infection incidence in the treeline ecotone at two locations east of the Continental Divide in the northern Rocky Mountains, Montana, U.S.A. Our objectives were (1) to examine the potential importance of whitebark pine in tree island formation, (2) to determine if blister rust is present in whitebark pine within the alpine treeline community, and (3) to characterize the incidence and intensity of blister rust in krummholz tree islands. We found that whitebark pine is the primary initial colonizer in tree island formation, indicating that the species is important in generating vegetation pattern in these communities. Thirty-five percent of all sampled whitebark pine were infected with blister rust. Although more cankers were found in solitary whitebark pine trees, highest infection incidence per tree occurred in trees that were part of multtree islands. Finally, we found a significant correlation between tree island length and infection incidence. These results have important implications with respect to alpine treeline dynamics on a landscape scale, especially in the context of climate change.

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Abstract: White pine blister rust (Cronartium ribicola) entered northern California in 1929 and advanced southward on sugar pine (Pinus lambertiana) to the central Sierra Nevada by 1944. Surveys in 1971–1972 found that the rust had spread south in the 1960s to isolated centers 150 miles further south. Incidence and impact surveys on the Sierra and Sequoia National Forests in 1982–83 found rust at 22 unreported locations and at the southern extent of sugar pine in the Sierra Nevada. Rust was adversely impacting the resource in local situations where significant spread and intensification had occurred since 1972. Canker incidence generally decreased from stream bottom to upper slope, but the disease was also found on ridge tops. Cankers in lower branches of smaller trees were most common. The southern Sierra Nevada climate is favorable for infection most years and local spread and intensification will continue


Abstract: A sequence of 47 potato late-blight (Phytophthora infestans) epidemics in the Netherlands, from 1950 to 1996, was analysed using agronomic and meteorological variables. The intensity of annual epidemics was characterized by an index of disease intensity (DI, 0—absence of late blight; 4—severe epidemic). Three periods were identified, with average DIs of 2.9, 0 and 2, respectively. Period I (1950–68) had relatively regular epidemics; period II (1969–78) was virtually blight free; and period III (1979–96) showed large variations in disease intensity. Disease-enhancing factors were number of days with precipitation, and number of hours with temperatures between 10 and 27°C and relative humidity >90% during the growing season. Limiting factors were number of hours with temperatures >27°C, and amount of global radiation. Linear discriminant analysis of DI using the blight status of the previous year and meteorological variables correctly classified up to 40 years out of 47 (87·0%), with five out of the six incorrectly classified years falling in period III. Blight status of the previous year and number of days with precipitation were important discriminating variables.


Abstract: The currently known distribution in Europe of Phytophthora species of threat to forest trees is summarized. Although many species of Phytophthora have been identified in European forests to date, including the potentially highly destructive P. cinnamomi and P. ramorum, with increased investigation of the soil microbial communities in forests, further hitherto unrecognised species have been found. Several species are known to cause severe disease syndromes; other species appear to be involved in pathogen complexes and may be partly responsible for forest decline syndromes. This presentation discusses the known range of Phytophthora species in Europe from the maritime climates of the west, into the continental climate of Russia and considers the potential changes in impact of different Phytophthora in the context of climate change.


Abstract: Outbreaks of leaf fall caused by Phytophthora botryosa, which occurred for the first time in Malaysia in 1966, were for the first 4 years dependent upon high rainfall intensities experienced only in very limited localities. In 1970, however, the disease occurred in a region of lower rainfall. The severity of defoliation is closely correlated with the duration of periods of surface wetness and 100 % RH 7 days previously. Rainfall, temperature and solar radiation do not appear to influence defoliation directly once it has begun, but they are important in determining its onset.

Abstract: The Phytophthora complex associated with Castanea sativa Mill. was investigated in five European countries in 35 regions and with respect to various domestication levels. Annual precipitation and length of drought season were the main parameters that regulated the presence of Phytophthora species in the chestnut stands. Seven species of Phytophthora were detected; three of these, P. megaspora, P. cryptogea and P. syringae had not been previously reported on sweet chestnut. P. cinnamomi, P. cambivora and P. citricola were most frequently isolated. P. cinnamomi and P. cambivora were the species significantly associated with declining trees with symptoms of Ink Disease. P. cinnamomi required distinct ecological conditions compared to the other species. P. cinnamomi was never detected in sites characterized by minimum temperatures below 1.4 °C, maximum temperature above 28°C, or soil pH below 5.4. The results obtained provide useful information for modeling the probability of Ink Disease, crown decline and associated Phytophthora species in chestnut groves in global climatic change scenarios.


Abstract: Soil-borne species of Phytophthora were isolated from 19 of 30 examined oak forest areas in Italy. The frequency of isolated Phytophthora spp. (35.2%) was significantly correlated with soil pH and longitude of the sites. Eleven Phytophthora species were detected. Phytophthora cambivora, P. cinnamomi and P. cactorum were recovered from sites in central and southern Italy whereas P. quercina was isolated in the northern and central part of the country. Phytophthora citricola occurred all over Italy. Phytophthora quercina was the only species significantly associated with declining oak trees.


Abstract: Phytophthora ramorum has caused extensive mortality to tanoak (Lithocarpus densiflorus) and several oak species (Quercus agrifolia, Q. kelloggii and Q. parvula var. shrevei) in coastal California, USA. This pathogen has infected at least 72 plant species under natural conditions and 32 additional species in the laboratory. Many infected hosts have been distributed across the USA by the horticultural industry. We developed a simulation model using CLIMEX software to evaluate the suitability of the climate in the USA for establishment of P. ramorum. CLIMEX was driven by monthly climate normal data for the period 1971-2000 collected from >5300 weather stations in the contiguous USA. CLIMEX growthrequirement and stress-response parameters were derived from literature data. Values for the ecoclimatic index (EI), a measure of overall climatic suitability based on temperature and soil moisture, were between 0 and 53. Much of the Intermountain West and the Great Plains was climatically unsuitable for establishment of P. ramorum (EI=0). Many states bordering the Great Lakes were marginal (0 < EI < 11). Areas considered climatically highly favourable (EI=25) for establishment of P. ramorum were common in the Gulf States, and areas considered favourable (10 < EI < 26) extended into southern Illinois, southern Indiana, and northwards into southern Maine. Predictions derived from CLIMEX matched known occurrences of P. ramorum in California and Oregon. Finds of the pathogen were 3.4-times more likely in areas classified as favourable or very favourable than in areas classified as marginal or unsuitable. Model results were only modestly sensitive to changes in values assigned to temperature parameters for growth but were more sensitive to changes in values assigned to moisture parameters for growth. Additional research is needed to determine the effects of low moisture on population growth of the pathogen. Nevertheless, our model distinguishes some areas within the contiguous USA that do not have a suitable climate for the pathogen. Such information could be used to refine survey and detection programmes.


Abstract: Incidences of oak decline have occurred repeatedly during the past three centuries as well as in the most recent decades. On the basis of historical records and dendrochronological measurements, oak decline in Central Europe has been attributed to the single or combined effects of climatic extremes (winter frost, summer drought), defoliating insects, and pathogenic fungi. Starting from a literature review, we discuss the possible roles of various abiotic (air pollution, nitrogen eutrophication, soil chemical stress, climatic extremes, site conditions) and biotic factors (insect defoliation, borer attack, infection by pathogenic fungi, microorganisms) that have been related to oak decline. On the basis of investigations on Quercus petraea and Quercus robur at three different levels (from experiments with young trees to monitoring on a supragenreal scale), we suggest a conceptual model of the interaction of abiotic and biotic factors responsible for the onset of oak decline. This model should be valid for Central European oak stands at more acidic sites (soil pH (H2O)≤4.2; on soils with higher pH, pathogenic Phytophthora species may contribute to oak decline). The combination of severe insect defoliation in at least two consecutive years with climatic extremes is the most significant complex of factors in the incidence of oak decline. Combined with defoliation, summer drought or winter/spring frost or both have to occur within the same year or in consecutive years to trigger major outbreaks of decline. Important additional stress factors are the following: (1) hydromorphic site conditions which, particularly in the case of Q. robur, render the trees more susceptible to drought stress as a result of an impairment of root growth in the subsoil; and (2), possibly, excess nitrogen which, in combination with drought stress, results in distinct decreases in the foliar concentrations of allelochemicals in Q. robur, thereby probably making the trees more susceptible to insect defoliation. Air pollution, soil chemical stress (including excess manganese), and nitrogen-induced nutritional imbalance do not seem to be important causal factors in the complex of oak decline. On the basis of the model, the appearance of the most recent oak decline in North-western Germany can be adequately explained.

Sanchez-Hernandez, M.E.; Sanchez-Solana, J.E.; Navarro-Cerrillo, R.M.; Fernandez-Rebollo, P.; Trapero-Casas, A.
Boletín-de-Sanidad-Vegetal,-Plagas. 29(1): 87–108.

Abstract: The root rot caused by P. cinnamomi is one of the biotic factors frequently associated with Mediterranean oak decline. The aim of this experiment was to study the incidence of P. cinnamomi in declining Quercus forests in southern Spain. It was carried out in eight forests located in the provinces most affected by oak decline. The fungus P. cinnamomi was the main pathogen associated with decline symptoms, but other diseases and insect pests were also detected. Morphological differences were observed between the isolates of P. cinnamomi from Quercus ilex and those from Quercus suber. In contrast, optimal growth temperatures were similar for all the isolates. In addition, the presence of P. cinnamomi in infected trees was correlated with some climatic variables. Fungal isolation did not correlate with rain, soil humidity and temperature registered before sampling. However, isolation appeared to be favoured by high minimum and average temperatures.


Abstract: Oak decline that was affecting three holm oak sites in the province of Huelva (south-western Spain) was studied during 1998-1999. The syndromes of dieback and sudden death have been observed and, in both cases, foliar symptoms were associated with root rot. Characterization of the fungal isolates from necrotic roots led us to identify Phytophthora cinnamomi A2 as consistently associated with the disease. The optimum growth temperatures of these isolates were very high (30°C). Inoculation tests under controlled conditions demonstrated the pathogenicity of the isolates on holm and cork oak seedlings. None of the other biotic factors of Mediterranean oak decline that have been previously described were found in the present study and so, in this case, the forest decline model does not seem to be necessary in order to explain the disease observed. The defoliation and mortality of the oaks was primarily caused by P. cinnamomi, although some abiotic factors such as alternating periods of drought and wet weather in the region may play an important role.


Abstract: Commentary


Abstract: Population dynamics of Phytophthora capsici were monitored in artificially infested plots in fields planted with bell peppers (Capsicum annuum). Plots were drip-irrigated on either a more frequent (three times per week) or a less frequent (one or two times after infestation) schedule and were infested with one of three levels of inoculum or left uninfested. Pathogen population densities increased and then decreased over time in each field. In a field with moderate rainfall, plots had population densities of 0, 5, 18, and 41 cfu/g of dry soil at the time of infestation.


Abstract: During 1984-86 in Kerala, India, correlation studies on P. palmivora infection of black pepper (Piper nigrum) in an arecanut-black pepper mixed cropping system were carried out. Correlations were drawn between disease incidence and meteorological factors at weekly intervals. There was a positive correlation between rainfall, number of rainy days and RH but a negative correlation between temp. and sunshine hours. Av. climatic factors during increasing and decreasing phases of the disease showed that low temp., shorter sunshine duration and high RH contributed to increased disease.


Abstract: The effects of temp., RH, sunlight and wind on diseases of rubber caused by Colletotrichum gloeosporioides (Glomerella cingulata), Oidium heveae and Phytophthora meadii in Sri Lanka are examined and the importance of weather in relation to the economics of control and to disease forecasting is discussed.


Abstract: Many epidemics of root diseases involving soil fungi depend on the interplay between fungal growth and the spatial and temporal heterogeneity of the soil environment. Colonization or infection of a root occurs at fine scales with growth and movement of fungal mycelia through soil. However, epidemics are observed at coarser scales, and depend on a cascading spread through populations of roots. We briefly review conventional analyses of soil-borne epidemics and argue that these treat soil physical conditions at scales too coarse to be meaningful for interactions between soil, plants and fungi,
and fail to consider the effect of soil physical conditions on the underlying epidemiological processes. Instead, we propose a conceptual epidemiological framework that integrates spatial scales and use this to review the effect of soil structure on the dynamics of soil-borne pathogenic fungi. Using the soil-borne fungal plant pathogen *Rhizoctonia solani* as an example, we demonstrate that invasion of fungi into host populations is critically affected by environmental conditions operating at each of two scales: (i) at the microscopic scale (mm - cm) the fungus preferentially explores certain pathways in soil, and small changes in soil physical conditions make the fungus switch from small, dense colonies to large, sparse and rapidly expanding ones; (ii) at the larger scale (cm - dm) a critical density of susceptible hosts is required, in excess of which fungi switch from non-invasive to invasive spread. Finally, we suggest that the approach will increase the applicability of research dealing with microscopic soil-plant-microbe interactions towards the solution of large-scale epidemiological problems.


**Abstract:** Although decline of cork (*Quercus suber*) and holm oak trees (*Quercus rotundifolia*) has been described in Portugal in the late years of the 19th century, its development has become a motive of high concern during the last two decades. The presence of *Phytophthora cinnamomi* in cork and holm oak stands was surveyed in four different regions of the country (Trás-os-Montes, Alentejo, Ribatejo and Algarve) during 1995–98. Tree decline severity, sudden death and site characteristics were assessed in 56 sites representing varied conditions. The pathogen was isolated from oak roots and rhizosphere samples in 27 of those places. Other plant species from natural vegetation were sampled in three active disease centres. This survey showed that 56% of the surveyed species of shrub flora were infected with *P. cinnamomi*, which was detected mainly on species belonging to the families *Ericaceae, Cistaceae* and *Leguminosae*. Recovery of *P. cinnamomi* was more frequent in shallow soils (Leptosols and complex Leptosols and Luvisols). These soils are more common in the south (Algarve), where decline has a high impact. Soils with low fertility and low mineral nutrient levels, particularly phosphorus, seemed to favour infection. Site aspect and topographic tree situation were also evaluated. Sites facing south showed higher occurrence of *P. cinnamomi*, which was also more frequent in slopes and valleys than on hilltops. In Algarve, a relationship could be established between the crown status and the presence of *P. cinnamomi* in roots and rhizosphere. Different morphotypes of *P. cinnamomi* could be distinguished in vitro, and their occurrence in the field was correlated with particular site characteristics. Further research needs and management strategies to limit the extension of the disease are discussed.


**Abstract:** Sudden oak death, caused by the recently described pathogen *Phytophthora ramorum*, is an emerging forest disease that has reached epidemic levels in coastal forests of central California. We present a rule-based model of *P. ramorum* establishment and spread risk in California plant communities. The model, which is being used as a management tool to target threatened forests for early-detection monitoring and protection, incorporates the effects of spatial and temporal variability of multiple variables on pathogen persistence. Model predictions are based on current knowledge of host susceptibility, pathogen reproduction, and pathogen transmission with particular regard to host species distribution and climate suitability. Maps of host species distributions and monthly weather conditions were spatially analyzed in a GIS and parameterized to encode the magnitude and direction of each variable's effect on disease establishment and spread. Spread risk predictions were computed for each month of the pathogen's general reproductive season and averaged to generate a cumulative risk map (Fig. 6a and b). The model identifies an alarming number of uninfected forest ecosystems in California at considerable risk of infection by *Phytophthora ramorum*. This includes, in particular, a broad band of high risk north of Sonoma County to the Oregon border, a narrow band of high risk south of central Monterey County south to central San Luis Obispo County, and scattered areas of moderate and high risk in the Sierra Nevada foothills in Butte and Yuba counties. Model performance was evaluated by comparing spread risk predictions to field observations of disease presence and absence. Model predictions of spread risk were consistent with disease severity observed in the field, with modeled risk significantly higher at currently infested locations than at uninfested locations (*P* < 0.01, *n* = 323). Based on what is known about the ecology and epidemiology of sudden oak death, this model provides a simple and effective management tool for identifying emergent infections before they become established.


**Abstract:** Chestnut ink disease, induced by *Phytophthora cinnamomi*, is the most important tree disease currently affecting north eastern Portugal. However, variations in disease severity have been recognised in soils with different directional exposure. During 1996-98, quarterly assessments were made of air temperature, air humidity, wind speed, solar radiation, soil water content and soil temperature (at 25 cm depth) in two stands of chestnut trees located in PODENCE, Macedo de Cavaleiros, north eastern Portugal. Soil and climatic parameters were shown to be more stressful in south-facing stands, i.e. soil temperature was higher and the soil drier, while air temperature and wind speed were higher and air humidity lower. Thus, the severity of the disease was greater on south-facing stands.


**Abstract:** *Phytophthora cinnamomi* is the causal agent of a perennial canker that develops on the lower bole on northern red oak and pedunculate oak. The disease has a limited range in Europe, being reported only in southwest France. This limited
distribution is probably linked to the susceptibility of *P. cinnamomi* to frost. A model was developed in previous work to estimate the impact of temperatures of <0 degrees C on the winter survival of *P. cinnamomi* in trunk cortical tissues and on the subsequent development of cankers. In this article, we report the use of this model to simulate canker development in 503 locations across France during a 30-year period. The predicted canker extension decreased sharply when the median *P. cinnamomi* winter survival index decreased from 0.95 to 0.65, with cankers that poorly developed when the median survival index was lower than 0.5 to 0.6. The actual incidence of the disease in 192 stands located across southwest France was compared with that of the model outputs. Both presence of disease in stands and frequency of cankered trees in infected stands, but not canker size on infected trees, were strongly related to the median *P. cinnamomi* survival index. No disease was present in stands with median survival index lower than 0.65, and the frequency of cankered trees in infected stands remained very low in stands with a median survival index between 0.65 and 0.70. Aspect was an additional factor explaining disease incidence, while the effect of elevation was likely due to its effect on winter temperatures. Maps of winter suitability to *P. cinnamomi*-induced cankers on oaks in France are presented.


**Abstract:** Influence of water status of oak trees (*Quercus rubra*) on the development of *Phytophthora cinnamomi* lesions was studied. On agar media or excised inner bark, growth of *P. cinnamomi* was reduced by low water potentials. In contrast, on young saplings or mature oak trees the development of *P. cinnamomi* lesions was not affected during a period of water stress. But after the end of the water stress treatment, susceptibility of the young saplings to *P. cinnamomi* increased.


**Abstract:** Several atypical *Phytophthora* strains, isolated from a range of horticultural hosts, were tentatively identified as *P. cactorum*. Numerous abortive oospores were observed in these strains and isozyme analysis showed all were heterozygous for the dimeric malic enzyme (MDHP). More detailed comparisons indicated that their MDHP alleles matched those of both *P. cactorum* and *P. hedraiandra*. Cloning and sequencing of the nuclear ribosomal internal transcribed spacer (ITS) regions of the atypical *P. cactorum* strains demonstrated the presence of sequences characteristic for both *P. cactorum* and *P. hedraiandra*. It was concluded that the atypical strains represented hybrids between the resident *P. cactorum* and the apparently recently introduced *P. hedraiandra*. Most strains had the mitochondrially inherited cytochrome oxidase I (Cox I) gene typical of one putative parent *P. hedraiandra*, while one single strain had that of the other putative parent, consistent with the hybrid hypothesis. Our data also suggest that the hybrids are evolving. The hybrids have proliferated on multiple new hosts in the Netherlands.


**Abstract:** In this study, a simple generic infection model was developed for predicting infection periods by fungal foliar pathogens. The model is designed primarily for use in forecasting pathogens that do not have extensive epidemiological data. Most existing infection models require a background epidemiological data set, usually including laboratory estimates of infection at multiple temperature and wetness combinations. The model developed in this study can use inputs based on subjective estimates of the cardinal temperatures and the wetness duration requirement. These inputs are available for many pathogens or may be estimated from related pathogens. The model uses a temperature response function which is scaled to the minimum and optimum values of the surface wetness duration requirement. The minimum wetness duration requirement (*Wmin*) is the number of hours required to produce 20% disease incidence or 5% disease severity on inoculated plant parts at a given temperature. The model was validated with published data from 53 controlled laboratory studies, each with at least four combinations of temperature and wetness. Validation yielded an average correlation coefficient of 0.83 and a root mean square error of 4.9 h, but there was uncertainty about the value of the input parameters for some pathogens. The value of *Wmin* varied from 1 to 48 h and was relatively uniform for species in the genera *Cercospora*, *Alternaria*, and *Puccinia* but less so for species of *Phytophthora*, *Venturia*, and *Colletotrichum*. Operationally, infection models may use hourly or daily weather inputs. In the case of the former, information also is required to estimate the critical dry-period interruption value, defined as the duration of a dry period at relative humidities <95% that will result in a 50% reduction in disease compared with a continuous wetness period. Pathogens were classified into three groups based on their critical dry-period interruption value. The infection model is being used to create risk maps of exotic pests for the U.S. Department of Agriculture’s Animal Plant Health and Inspection Service.


**Abstract:** Ecological niche modelling techniques were applied to address the questions of the origins and potential geographic extent of sudden oak death, caused by the pathogen *Phytophthora ramorum*. Based on an ecological niche model derived from the phytopathogen's California distribution and distributions of potential host species, it was determined that the disease has high potential to colonize the southeastern United States, and that its likely source area is eastern Asia.


**Abstract:** Soils from three ohia forest sites in Hawaii with trees showing varying degrees of decline, and from adjacent
healthy and declining sites, were sampled bi-weekly for population levels of *Phytophthora cinnamomi* over an 8- to 13-month period. Population levels varied considerably among sites and within the same site throughout the course of the study. At all sites population levels were lowest in the winter months when minimum soil temperatures were near 10°C, increasing as soil temperatures rose. Population levels decreased after extended periods of heavy rain. Measurements at six of the eight monthly sampling times were significantly higher at the decline site than at the adjacent healthy site. Significant correlations between *P. cinnamomi* population levels and maximum soil temperature, minimum soil temperature, and rainfall were found at some sites but not at others. Soil matric potentials at all sites ranged from 0 to -30 mb and were seldom less than -25 mb. High water holding capacity of the soils combined with rainfall averages ranging 2,984-3,489 mm/yr were apparently favorable for sporangium formation. Zoospores were prevalent at certain times of the year.


**Abstract:** Efforts to model the potential habitat and risk for spread of invasive diseases such as Sudden Oak Death (SOD) are important for disease regulation and management. However, spatially referenced risk models using identical data can have differing results, making decision-making based on the mapped results problematic. We examined the results from five spatial risk models generated from common input parameters, and investigated model agreement for mapping risk for the causal pathogen for SOD, *Phytophthora ramorum* across the conterminous United States. We examined five models: Expert-driven Rule-based, Logistic Regression, Classification and Regression Trees, Genetic Algorithms, and Support Vector Machines. All models were consistent in their prediction of some SOD risk in coastal California, Oregon and Washington states, and in the northern foothills of the Sierra Nevada Mountains in California, and in an east–west oriented band including eastern Oklahoma, central Arkansas, Tennessee, Kentucky, northern Mississippi, Alabama, Georgia and South Carolina, parts of central North Carolina, and eastern Virginia, Delaware and Maryland states. The SVM model was the most accurate model, and had several advantages over the other models. Although theoretical in nature, this paper presents results that have practical, applied value.


**Abstract:** The effect of *Phytophthora* species, soil chemistry, precipitation and temperature on the vitality of oak was evaluated in 32 oak stands in southern Sweden. In addition, the relationship between the occurrence of *Phytophthora* species and soil conditions was determined. The results showed that there was a weak association between the presence of *P. quercina*, the most frequently recovered *Phytophthora* species in southern Sweden, and the vitality of the oak stands (determined from estimates of crown defoliation of individual trees). The pathogens occurred more frequently in clayey and


**Abstract:** Efforts to model the potential habitat and risk for spread of invasive diseases such as Sudden Oak Death (SOD) are important for disease regulation and management. However, spatially referenced risk models using identical data can have differing results, making decision-making based on the mapped results problematic. We examined the results from five spatial risk models generated from common input parameters, and investigated model agreement for mapping risk for the causal pathogen for SOD, *Phytophthora ramorum* across the conterminous United States. We examined five models: Expert-driven Rule-based, Logistic Regression, Classification and Regression Trees, Genetic Algorithms, and Support Vector Machines. All models were consistent in their prediction of some SOD risk in coastal California, Oregon and Washington states, and in the northern foothills of the Sierra Nevada Mountains in California, and in an east–west oriented band including eastern Oklahoma, central Arkansas, Tennessee, Kentucky, northern Mississippi, Alabama, Georgia and South Carolina, parts of central North Carolina, and eastern Virginia, Delaware and Maryland states. The SVM model was the most accurate model, and had several advantages over the other models. Although theoretical in nature, this paper presents results that have practical, applied value.


**Abstract:** Within the scope of a research project on the condition of roots of declining oaks (*Quercus robur, Quercus petraea*), samples of fine roots and surrounding soil, specimens of stripe cankers on the stem base, and samples of stream water were examined for the presence of *Phytophthora* species using both baiting methods and selective agar media. At 27 sites in Germany (Bavaria, Rheinland-Pfalz, Schleswig-Holstein), Switzerland, Hungary, Italy and Slovenia the following species were isolated (mainly from soil): *Phytophthora citricola, Phytophthora cactorum, Phytophthora cambivora, Phytophthora gonapodyides, Phytophthora undulata, a species with affinity to Phytophthora drechsleri*, and two additional species with close affinity to the *Phytophthora cactorum* group. Moreover, *Pythium* group P, *Pythium ananurum, Pythium chamaeaphypon*, and many other *Pythium* species that have not yet been identified could be recovered. In a soil infestation test most isolates induced dieback of long root tips and necrotic lesions in the root cortex and at the root collar of *Quercus robur* seedlings. All *Pythium* species tested and *Pythium* group P caused cortical necrosis after stem inoculation of young *Quercus robur* trees. It could be seen in vitro that *Phytophthora gonapodyides* and *Pythium* group P were able to produce a wilting toxin. Nitrogen input and climatic changes are discussed as predisposing factors for root damage observed in the field.


**Abstract:** A survey was made on the occurrence of soilborne *Phytophthora* species in 35 oak stands on a range of geologically different sites in Bavaria. The most widespread species were *P. quercina, P. cambivora* and *P. citricola*. Seven other *Phytophthora* species were isolated infrequently. The fine root systems of 106 healthy and 111 declining mature trees of *Quercus robur* and *Q. petraea* were intensively investigated. The results indicate that, depending on the site conditions, at least two different complex diseases are referred to under the name `oak decline`. On sites with a mean soil pH (CaCl2) > 3.5 and sandy-loamy to clayey soil texture *Phytophthora* spp. were commonly isolated from rhizosphere soil, and highly significant correlations existed between crown transparency and various root parameters. Oaks with *P. quercina* or other *Phytophthora* spp. in their rhizosphere had markedly higher levels of fine root damage than oaks without *Phytophthora* spp., and were subject to a relative risk of severe crown symptoms of 2’1 and 2’8, respectively. In contrast, in stands with sandy to sandy-loamy soils and a mean soil pH < 3.9, *Phytophthora* spp. were not found. In these stands, correlations between crown transparency and various root parameters were either less significant or not significant. It is concluded that *Phytophthora* species are strongly involved in oak decline on sandy-loamy to clayey sites with a mean soil-pH (CaCl2) > 3.5.
loamy soils that were less acidic and which had higher base saturation. However, they were found in all but the most acidic soils (pH<3.5). In stands where Phytophthora species were not present, positive correlations between the average crown defoliation and proportion of damaged trees with average summer precipitation and average annual precipitation were found. There were no significant differences in soil chemistry between healthy and declining stands included in this study, and no significant correlations were found between any soil parameter and crown vitality. Based on the results from these 32 oak stands, it is likely that the decline of oaks in southern Sweden can be attributed to several different site-specific factors, such as infection by P. quercina or unusual weather events, which interact with a number of biotic and abiotic factors, leading to oak decline.


**Abstract:** Here, a conceptual model is presented for the development of Phytophthora disease in pedunculate oak. The model is presented using the causal loop diagram tool and gives an overview of how various abiotic and biotic factors, such as soil moisture, nutrient availability and mycorrhizal colonization, may affect the reproduction and the infective capacity of soil-borne Phytophthora species, the susceptibility of the host and subsequent disease development. It is suggested that the link between the root damage caused by Phytophthora species and overall tree vitality is in the assimilation and allocation of carbon within the plants. The potential impact of environmental factors on these processes is discussed. The model is presented with reference to scenarios related to variation in soil moisture and nutrient availability. The need for species-specific validation of the model and the implications of the model are discussed.


**Abstract:** Global severity of potato late blight was estimated by linking two disease forecast models, Blitecast and Simcast, to a climate data base in a geographic information system (GIS). The disease forecast models indirectly estimate late blight severity by determining how many sprays are needed during a growing season as a function of the weather. Global zonation of estimated late blight severity was similar for both forecast models, but Blitecast generally predicted a lower number of sprays. With both forecast models, there were strong differences between potato production zones. Zones of high late blight severity include the tropical highlands, western Europe, the east coast of Canada and northern USA, south-eastern Brazil and central-southern China. Major production zones with a low late blight severity include the western plains in India, where irrigated potato is produced in the cool dry season, north-central China, and the north-western USA. Using a global GIS data base of potato production, the average number of sprays was calculated by country. These averages were compared with estimates of current fungicide use. The results using Blitecast and Simcast were correlated but only Blitecast estimates correlated with observed data for developed countries. The estimated number of sprays, whether from Blitecast or Simcast, did not correlate with the observed number of sprays in developing countries, and in a number of developing countries the predicted optimal number of sprays was much higher than the actual number observed. In these countries, increased access to host resistance and fungicides could have a strong economic impact.


**Abstract:** Changes in the incidence and onset of potato late-blight epidemics in Finland were investigated and compared with possible changes in climate, presence of soil-borne inoculum, and aggressiveness of Phytophthora infestans populations. Datasets were constructed from leaf blight assessments in cultivar trials or fungicide tests carried out at eight experimental sites during the periods 1933-1962 and 1983-2002. Additional data were obtained from late-blight monitoring projects carried out from 1991 to 2002. From 1998 to 2002, the risk of blight outbreak was 17-fold higher compared with the periods 1933-62 and 1983-1997. Simultaneously, the outbreaks of the epidemics began 2-4 weeks earlier. The changes observed were associated with a climate more conducive to blight in the late 1990s. Lack of rotation also advanced blight epidemics by an average of 9 days in 1998-2002, but it did not have this effect in 1992-1997, suggesting that soil borne inoculum may not have been a significant threat to potato until the late 1990s. The aggressiveness of the P. infestans isolates seemed to have only minor effect on the onset of the epidemics after 1991, as the apparent infection rate remained unchanged despite weather conditions more favourable to late blight in the late 1990s. As a consequence of the more frequent and earlier epidemics, the sales of fungicides used against late blight in Finland increased 4-fold from the 1980s to 2002.


**Abstract:** Phytophthora root rot is described for the first time killing sugar pine (Pinus lambertiana) in a seed orchard and four species of true fir (Abies spp.) in a forest nursery. P. cactorum was recovered from true firs and P. megasperma was recovered from sugar pine. P. cryptogea was recovered from sugar pine and true fir but isolates from the two locations differed from each other in pathogenicity and colony appearance. Isolates recovered from these hosts and isolates of 6 Phytophthora species previously recovered from Douglas-fir (Pseudotsuga menziesii) were then tested for pathogenicity on seedlings of 9 Northwest conifers. P. megasperma Group 1, P. cryptogea, and P. cinnamomi were pathogenic to all tree species except western redcedar (Thuja plicata). Western hemlock (Tsuga heterophylla) and true firs were susceptible to most species tested; ponderosa (P. ponderosa) and sugar pines were damaged only by P. cryptogea and P. cinnamomi; western redcedar was resistant to all isolates.

Abstract: In the central California coastal forests, a newly discovered virulent pathogen (Phytophthora ramorum) has killed hundreds of thousands of native oak trees. Predicting the potential distribution of the disease in California remains an urgent demand of regulators and scientists. Most methods used to map potential ranges of species (e.g. multivariate or logistic regression) require both presence and absence data, the latter of which are not always feasibly collected, and thus the methods often require the generation of ‘pseudo’ absence data. Other methods (e.g. BIOCLIM and DOMAIN) seek to model the presence-only data directly. In this study, we present alternative methods to conventional approaches to modeling by developing support vector machines (SVMs), which are the new generation of machine learning algorithms used to find optimal separability between classes within datasets, to predict the potential distribution of Sudden Oak Death in California. We compared the performances of two types of SVMs models: two-class SVMs with ‘pseudo’ absence data and one-class SVMs. Both models performed well. The one-class SVMs have a slightly better true-positive rate (0.9272 ± 0.0460 S.D.) than the two-class SVMs (0.9105 ± 0.0712 S.D.). However, the area predicted to be at risk for the disease using the one-class SVMs (18,441 km2) is much larger than that of the two-class SVMs (13,828 km2). Both models show that the majority of disease risk will occur in coastal areas. Compared with the results of two-class SVMs, the one-class SVMs predict a potential risk in the foothills of the Sierra Nevada mountain ranges; much greater risks are also found in Los Angeles and Humboldt Counties. We believe the support vector machines when coupled with geographic information system (GIS) will be a useful method to deal with presence-only data in ecological analysis over a range of scales.


Abstract: Epidodes of dying back of pedunculate oak have occurred in Europe. In this paper, which follows an earlier one by Day, W. R. (The oak mildew Microsphaera quercina and Armillaria mellea in relation to dying back of oak) published in the inaugural issue of this journal in 1927, the 1920s episode, as described by contemporary research workers, is evaluated. The second part of the paper is concerned with an account of the 1989-94 episode in Great Britain and comparisons are made with occurrences elsewhere in Europe. In Britain, one feature not previously recorded was attack on declining trees by the buprestid beetle, Agrilus pannonicus. The causative factors recognized by Day are still considered to be involved (the oak roller moth Tortrix viridana which initiates the problem by defoliation, infection by Microsphaera quercina (M. alphitoides), drought and secondary infection by Armillaria mellea) but other factors now recognized (apart from A. pannonicus) are the increasing importance of drought, air pollution, and fine root death from infection by Phytophthora.


Abstract: This volume integrates guides to literature, background information, physiology and genetics, the effect of environmental factors on disease, control by biological and cultural means, resistant cultivars, fungicides, and techniques for recognizing, identifying, and isolating Phytophthora pathogens. Featured are detailed descriptions of 59 species, including photomicrographs and drawings, and discussion of related diseases, their development and control, and distribution.

Dirac-M.F.; Menge, J.A. 2002. High temperatures are not responsible for lack of infection of citrus roots by Phytophthora citrophthora during the summer, but suppressive soil microorganisms may inhibit infection by P. citrophthora. Plant and Soil. 241(2): 243–249.

Abstract: In regions with a mediterranean climate such as southern California, P. citrophthora infection of citrus does not normally occur during the summer. However, in this study, P. citrophthora was isolated abundantly from alternative hosts planted in an infested citrus grove, in the middle of the summer. Citrus root infection from P. citrophthora did occur in this study but it was extremely low. Citrus seedlings grown in autoclaved soil from Pauma Valley, artificially infested with P. citrophthora, contained significantly higher levels of infection than seedlings grown in infested, non-autoclaved, soil or in part autoclaved, part non-autoclaved, infested soil. This suggests that the Pauma Valley soil contains microorganisms naturally suppressive to P. citrophthora. The low occurrence of P. citrophthora infection of citrus roots during the summer may be partially due to soil microorganisms associated with the citrus host and not the inability of P. citrophthora to grow well at the soil temperatures found during the summer in southern California.


Abstract: Sudden oak death is an emerging forest disease caused by the pathogen Phytophthora ramorum that is invading the west coast of the United States and semi-natural areas in Europe. This disease causes lethal stem infections in oaks (Quercus spp.) and tanoak (Lithocarpus densiflorus), as well as non-lethal foliar infections in a range of other species. We investigated two questions to evaluate the effect of landscape structure on the spread of P. ramorum: (i) does the spatial pattern of forested habitat predict P. ramorum disease severity, and is this relationship scale-dependent; and (ii) what influence does spatial pattern have on the optimal microclimate conditions for P. ramorum reproduction? We mapped the spatial distribution of suitable forest habitat for P. ramorum and established 86 randomly located field plots within a 20-km<sup>2</sup> region of northern California. For each plot, we quantified P. ramorum disease severity and measured the abundance of woody species. Disease severity in each plot was examined in relation to the surrounding landscape structure measured for nested landscapes of increasing scale. P. ramorum disease severity was greatest in plots surrounded by a high proportion of contiguous forest, after accounting for plot-level variables of host abundance, elevation, canopy cover and microclimate. The explanatory power of the model increased with increasing scale up to 200 m, but was not significant at scales less than 50 m. High disease severity was associated with lower temperatures in the field than the laboratory-
determined optimal range for pathogen reproduction. Variation in microclimate conditions was explained by elevation, not the pattern of host vegetation, indicating that spatially varying disease severity was not a function of microclimate-related edge effects on pathogen growth and survival. Both landscape-scale configuration and local composition of host habitat are related to the severity of this destructive forest disease. Increased disease severity within contiguous woodlands may have a considerable impact on the composition of such woodlands, with cascading effects on the population dynamics of both host and pathogen.


Abstract: Seventeen isolates of P. cinnamomi (9 from New Zealand, the rest foreign) were compared for growth and sporulation under various temperature and pH conditions, and their pathogenicity tested on 7 species of conifers. Although variation existed, it did not warrant recognition of distinct strains. There is no evidence of adaptation to cooler climatic conditions in New Zealand, and sporulation does not occur at temperatures that prevail in the soil during the normally wet winter months in New Zealand. This agrees with earlier observations that epidemic losses due to P. cinnamomi tend to be restricted to years when rainfall is abnormally high in autumn and late spring when soil temperatures are sufficient to support sporulation.


Abstract: The effects were examined of reduced stand density on (i) water status of jarrah (Eucalyptus marginata) and (ii) growth rate of artificially induced lesions of Phytophthora cinnamomi in phloem of E. marginata. Plots in the high (>1100 mm/year), intermediate (900-1100 mm/year), and low (<900 mm/year) rainfall zones of the jarrah forest were thinned to controlled fractions of original stand density. Phytophthora cinnamomi lesions in the phloem of stems and roots were established by wound inoculation. Lesions of P. cinnamomi were longer in stems of trees with small water deficits than in trees with larger water deficits. For example, in 1991 at the intermediate rainfall site, water potentials and lesion lengths of trees on unthinned and thinned plots were -1.1 and -0.9 MPa and 23 and 45 cm, respectively. Lesions grew more slowly in roots than in stems (average 10.0 and 26.2 cm, respectively, after 55 days at unthinned high rainfall site in 1991); however, the relative difference between lesions in trees with the highest and lowest water potentials was greater in roots (up to 2.7 times) than in stems. Lesion extension was also affected by summer rainfall, with longer lesions occurring in summers of highest rainfall. Viability of P. cinnamomi in 10-week-old and 1-year-old lesions decreased as tree water deficits increased. Differences in lesion extension between jarrah in different amounts of summer rainfall were largely explained by differences in dawn water potential.


Abstract: Causes of current severe declines of the deciduous oaks Quercus robur and Q. petraea in northern and central Europe and of the evergreen Q. ilex, Q. suber and other Quercus spp. in the Mediterranean area are reviewed. Factors implicated include drought, pollution, winter cold, flooding, and stress-related attacks by insects and fungi. Additional factors in Mediterranean oak declines include changing land-use patterns and root disease caused by the aggressive, exotic oomycete root pathogen P. cinnamomi. Under conditions of global warming the survival and degree of root disease caused by this fungus seems likely to be enhanced, while the host range of the organism might also be increased. Application of the CLIMEX climate-matching program suggests that with a mean increase in temp. of 1.5-3 degrees C the fungus might considerably increase its disease activity in its existing locations, and to some extent spread northwards and eastwards. However, it seems unlikely to become significantly active in areas of Europe with colder winters such as parts of Scandinavia, Russia and the central Danube. It is suggested that the predictive value of research on major environmental problems such as oak declines could be enhanced by more highly coordinated European forestry research programmes.


Abstract: The potential impact of climate change on disease development was evaluated using mathematical modelling. Disease forecasting systems for late blight of potato (Phytophthora infestans), apple scab (Venturia inaequalis), and cercospora blight of carrot (Cercospora carotae) were selected to evaluate their relevance in predicting future events related to climate change. In general, if these models are to be valid for such predictions, they must predict adequately actual field observations. Many of the forecasting systems developed a few years ago are in need of updating. Disease forecasting systems using nonlinear responses to temperature and leaf wetness offer more potential to represent the impact of climate change and variability on disease epidemiology.


Abstract: From 1999 to 2001, a survey on the occurrence of Phytophthora spp. in the rhizosphere soil of healthy and declining oak trees was conducted in 51 oak stands in Turkey. Seven Phytophthora spp. were recovered from six out of the nine oak species sampled: P. cinnamomi, P. citricola, P. cypriotica, P. gonapodyides, P. quercina, Phytophthora sp. 1 and Phytophthora sp. 2. The most frequently isolated species, P. quercina, was very common on slopes susceptible to drought. It
occurred in four different climatic zones and on six Quercus spp., suggesting that it is native to oaks. The second most common species, *P. citricola*, was separated into three subgroups: type C was recovered only in Anatolia, whereas A and B occurred only in the European part of Turkey. *Phytophthora cinnamomi* was recovered at one site only, and may not be involved in oak decline in Turkey. The other four species were recovered sporadically. On affected sites there was a significant association between deteriorating crown status and the presence of *Phytophthora* spp., particularly *P. quercina*. The occurrence of *Phytophthora* species was significantly influenced by soil pH. Stem inoculation tests on oak seedlings revealed that *Q. petrea* was the most susceptible species.

**Abstract:** A survey on the occurrence of *Phytophthora* species in oak ecosystems in Austria was conducted from April to May 1999 and in June 2000. The investigations were carried out at 35 study sites distributed throughout the zone of oak forests in eastern Austria. Four oak species, including *Quercus robur*, *Q. petrea*, *Q. cerris* and *Q. pubescent* were considered in the survey. Rhizosphere soil samples were taken from sample trees, which consisted of healthy and declining trees as indicated by their crown transparency. Young oak leaflets were used as baits to recover species. The assemblage of *Phytophthora* spp. detected in Austrian oak forests consisted of five species, including *Phytophthora quercina*, *P. citicola*, *P. gonapodyides*, *P. euroea* and *P. syringae*. *P. quercina* and *P. citicola* were isolated from 11 and seven sites, respectively, and were thus the most common and most widely distributed species. The three other species were recovered only sporadically. *P. citicola* could be separated into two morphologically and genetically well-characterized types (A and B). species, in particular the common *P. quercina* and *P. citicola* occurred on sites showing a wide variety of soil types, soil textures and moisture classes. There was mild evidence for connection between deteriorating crown status and the presence of *Phytophthora* spp. Furthermore, significant differences in contents of magnesium, as well as calcium, aluminium, nitrogen and carbon at different soil depths (0–10, 10–20 and 20–40 cm) were detected between *Phytophthora*-free sites. The results of the present study provide circumstantial evidence that *Phytophthora* species are involved in oak decline at certain sites in Austria.


**Abstract:** Concern in the agricultural community over observed and projected climate change has prompted numerous studies on the possible implications for crop yields. However, relatively little work has focused on disease management. In the upper Great Lakes region of the United States, late blight (*Phytophthora infestans*) of potato (*Solanum tuberosum*) is a temporal sporadically occurring disease, occurring only when microclimate conditions within the canopy are favorable and inoculum is present. This and other studies indicate that historical climatological trends in the upper Great Lakes region have resulted in warmer and wetter growing season conditions, as well as local increases in precipitation totals and in the frequency of days with precipitation. Consequently, the risk of potato late blight is increasing. Historical trends in hourly weather variables and potato late blight risk as expressed by a modified Wallin disease severity value index were analyzed at seven regional weather stations from 1948–99. All sites showed significant trends in at least one of the risk estimates. While late blight risk was greatest at all locations in August, periods of increasing risk occurred across the region particularly during July. The increases in disease risk appeared to be associated with upward trends in dry bulb and dew point temperature at nearly all of the stations, especially during July and August. Increased risk of potato late blight has implications for extension agents and commercial horticulturists that include increased emphasis on grower education and application of integrated disease management techniques.


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**Abstract:** We provide a first detailed analysis of long-term, annual-resolution demographic trends in a temperate forest. After tracking the fates of 21338 trees in a network of old-growth forest plots in the Sierra Nevada of California, we found that mortality rate, but not the recruitment rate, increased significantly over the 22 years of measurement (1983–2004). Mortality rates increased in both of two dominant taxonomic groups (Abies and Pinus) and in different forest types (different elevational zones). The increase in overall mortality rate resulted from an increase in tree deaths attributed to stress and biotic causes, and coincided with a temperature-driven increase in an index of drought. Our findings suggest that these forests (and by implication, other water-limited forests) may be sensitive to temperature-driven drought stress, and may be poised for die-back if future climates continue to feature rising temperatures without compensating increases in precipitation.


**Abstract:** The identification of past climatic extremes and norms is important for a better understanding of the climate systems and the way they change. Here we present an almost continuous tree-ring and climate record from Vancouver Island, Canada for the last four millennia from Douglas-fir trees (*Pseudotsuga menziesii* (Mirb.) Franco var. *menziesii*) that are sensitive to precipitation variation. Spring droughts more severe than that of the mid-1920s occurred in the late 1840s, mid-1460s AD, and similar to mid-1860s BC. A remarkable climatic anomaly occurred in similar to the 19th century BC during which strong pentadecadal oscillation prevailed and radial growth decreased by 71% in four years. This event could
have been the final stage in the process of climatic and environmental transition beginning 2–3 centuries earlier that led to major cultural transformation in regions sensitive to climate change.


Abstract: Notes are given on the effects of high temperature (30-45 degrees C), low light intensity (0, 7, 15, and 30 micro mol m-2 s-1) and drought (withholding water for up to 16 days) on the subsequent development of Botrytis cinerea on Picea mariana seedlings in paperpot containers. The three treatments, both separately and in combination, predisposed the seedlings to B. cinerea. Seedlings kept in normal (nonextreme) environments did not develop symptoms. Improving management of the mould by avoidance of certain environmental conditions is discussed.


Annotation: Notes: Although (or because) it was written over 50 years ago, this is a fascinating article addressing the "strong evidence of very recent changes in climatic conditions over the United States." The best quote: "Past and present epidemics, caused by insects and fungi, have shown that such a policy [the concept of single species management over large areas] may be no less foolhardy than sitting on a powder keg with a lighted fuse."

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Abstract: Forest management in the Interior Cedar-Hemlock (ICH) zone of the Kispiox TSA in northwest British Columbia has focused on two tree species. Interior spruce (Picea engelmannii Parry ex Engelm. x Picea glauca (Moench) Voss) and lodgepole pine (Pinus contorta var. latifolia Doug. ex Loud.) have dominated plantations, while historically, western hemlock (Tsuga heterophylla (Raf.) Sarg.), true firs (Abies lasiocarpa (Hook.) Nutt. and (Abies amabilis (Dougl. ex Loud.) Doug. ex Forbes) and western redcedar (Thuja plicata Donn ex D. Don), have dominated the landscape. Tomentosus root disease (Inonotus tomentosus (Fr.) Teng) and Dothistroma needle blight (Mycosphaerella pini Rostr. in Munk) are the principal diseases affecting interior spruce and lodgepole pine plantations, respectively. Tomentosus root disease was found in 92% of spruce-dominated plantations 100 years and older in the study area. The annual recruitment of dead interior spruce and lodgepole pine tree volume due to the disease in those stands is 4.29 m(3)/ha or 51990 m(3). The incidence of Tomentosus root disease in ten randomly selected spruce leading plantations aged 25-30 years ranged from 0.6% to 10.4% and averaged 5.9% of the host trees. Dothistroma needle blight was the most prevalent pest in a survey of 100 randomly selected lodgepole pine plantations and has caused considerable crop tree mortality. The disease has even caused mortality in 55-year-old lodgepole pine trees. Maintaining species diversity is essential to long-term forest health. Intensive planting of interior spruce and lodgepole pine in this study area appears to have exacerbated disease problems.


Abstract: Dothistroma needle blight, caused by the fungus Dothistroma septosorum, is a major past of pine plantations in the Southern Hemisphere, where both the host and the pathogen have been introduced. In northern temperate forests where the pest and host trees are native, damage levels have historically been low; however, Dothistroma is currently causing extensive defoliation and mortality in plantations of lodgepole pine in northwestern British Columbia, Canada. The severity of the disease is such that mature lodgepole pine trees in the area are succumbing, which is an unprecedented occurrence. This raises the question of whether climate change might enable the spread of the disease by surpassing an environmental threshold that has previously restricted the pathogen's development in northern temperate regions. Establishing a causal relationship between climate change and local biological trends is usually difficult, but we found a clear mechanistic relationship between an observed climate trend and the host-pathogen interaction. A local increase in summer precipitation, not climate warming, appears to be responsible. We examine whether the recently observed climate change trend exceeds natural fluctuations in the local climate.


Abstract: "Of climatic factors, CO₂ concentration was found to be the most influential factor at all locations." "Our model estimated that loblolly growth will likely decrease slightly throughout its 12-state range. However, due to large uncertainties in both climate factors and the influence of these factors on forest growth, there is a substantial chance of either a large decrease or a large increase in loblolly pine basal area growth rate under future climate conditions."


Abstract: Human-induced changes in climate are likely to affect U.S. domestic forests and the economic systems which rely on them. This paper reviews current knowledge of how changes in temperature and precipitation could affect tree species, forest ecosystems, and the forest products sector of the economy. The various types of models used to predict change and the results they calculate are examined. Models currently project both increases and decreases in the range of various species and ecosystems, and similar results for changes in the productivity, biomass and growth of forests in response to changes in climate. Results vary with the models used, the species or ecosystem studied, and the specific condition of the forest in question. The science of forests and global change is reviewed with regard to plant responses to enhanced CO2 environments and forests' response to other bioclimatic and indirect factors, such as insect predation, fire, climatic variation and ozone. Three studies of the economic effects of climate change on forests, which project a range of losses and benefits to the economy, are compared. Economic results vary directly with the results of the forest growth and productivity models which were employed as inputs. No one model can provide a complete answer, and current knowledge and models are limited in various ways which point to areas where further research could provide benefits.


Abstract: The northern treeline is generally limited by available warmth. However, in recent years, more and more studies have identified drought stress as an additional limiting factor for tree growth in northern boreal forests and at treelines. Three growth responses to warming have been identified: increase in growth, decrease in growth, and nonsignificant correlation of tree growth with climate. Here we investigate the effect of drought stress on radial growth of white spruce at northern treelines along a longitudinal gradient spanning the entire Brooks Range in Alaska. We systematically sampled 687 white spruce at seven treeline sites. Where possible, we sampled three site types at a given site: high-density forest, low-density forest, and floodplain forest. We investigated the relationship of site and site type to tree growth responses. In the western part of our study area, we found very high numbers of trees responding with increase in growth to recent warming; while in the eastern part, trees responding with decrease in growth to recent warming are predominant. Within a given site, more trees reacting positively to warming grow on site types characterized by low tree density. These patterns coincide with precipitation decreases from west to east and local water availability gradients, therefore pointing to drought stress as the controlling factor for the distribution of trees responding with increase or decrease in growth to recent warming. Compared to 20th century climate, we project a 25-50% basal area (BA) increase in the western region for the 21st century due to climate warming as projected by five general circulation models, 4-11% in the central region and decreases (+1 to -11%) in the eastern region. The overall net change in projected 21st century BA increase at each site seems to be controlled by the relative proportion of responder groups. If these are similar, differences in the magnitude of increase versus decrease in growth control BA projections for that site. This study highlights the importance of regional-scale investigations of biosphere-climate interactions, since our results indicate a substantial gain in aboveground biomass as a result of future warming only in the western regions; while in the eastern regions, climate warming will decrease overall wood production and therefore carbon uptake potential.


Abstract: Forestry investments are long term. Failure to incorporate climate change influences in predictions of future yields and forest land values can result in incorrect current forest management choices. However, there is significant uncertainty regarding the magnitude and direction of future effects of climate change on yields for particular species at stand levels. A best case and worst case scenario based on climate scenarios and growing conditions for northern Saskatchewan will be presented as a way of a) identifying factors that will influence yield responses and sources of uncertainty, and b) illustrating the relative range of potential impacts on stands yields and timber supply. The combined effects of climate change on expected yields and changes in the relative uncertainty in expected yields has important implications for forest management decisions such as rotation age choice.


Abstract: There is now ample evidence of the ecological impacts of recent climate change, from polar terrestrial to tropical marine environments. The responses of both flora and fauna span an array of ecosystems and organizational hierarchies, from the species to the community levels. Despite continued uncertainty as to community and ecosystem trajectories under global change, our review exposes a coherent pattern of ecological change across systems. Although we are only at an early stage in the projected trends of global warming, ecological responses to recent climate change are already clearly visible.


Abstract: Climate is a major determinant for the phenology, physiology, distribution and interactions of plants. The world's recent climate has shown a substantial increase in average temperature, which is changing these processes in a perceivable
The following review compiles and discusses studies reporting recently observed changes in the behaviour, ranges and interactions of species which are thought to be associated with climate change. The multitude of recently published studies providing evidence for the ecological impacts of climate change on many different continents strongly suggests that the last 30 years of warmer temperatures have had a substantial influence on both seasonal patterns, and altitudinal and poleward shifts in vegetation. Common features of change, but also some discrepancies in the response of plants to climate change, are discussed, as well as implications for biodiversity, higher level impacts on community structure and trophic interactions, and some ecosystem consequences.


Abstract: The forest sector in Canada makes a significant contribution to the wealth of the nation. Many of our forest ecosystems, like the phoenix, need fire for rebirth and renewal. In contrast, other forests rely on a cool, wet disintegration driven by insects and their commensal fungi feeding on trees to effect this renewal. This disparity has a manifest difference in the character of these forests and how they have developed and evolved over thousands of years. While there are characteristic natural temporal and spatial patterns to these disturbances, recent work has shown that they are being perturbed by global change. Compounding these perturbations is the emergence of extensive anthropogenic disturbances in these forests. If humans continue trying to manage complex natural systems as though they were machines, problems with unknown consequences will compound. For example, we have only recently begun to understand that changes in disturbance regimes can generate positive feedbacks leading to what could amount to sudden and drastic change for certain forest communities. Systems-based techniques aimed at adapting to these consequences are emerging and will need to be implemented in a timely fashion to minimize the risks and maximize the opportunities associated with sustainable forest management under a changing climate.


Abstract: Similarities and differences of tree- and stand-related decline in 2 different ecosystems (forests and tree-fruit orchards) are analysed with special reference to conditions in Hungary. In orchards, economic restructuring and changes in land ownership strongly influence health conditions. In forests, decline is a consequence of self-thinning, short-term climatic fluctuations, climate change and anthropogenic disturbance. It is suggested that decline may play the role of regulation of forest tree population (a process of selection, a force of negative succession of forest ecosystems). A basic similarity in species of pathogenic fungi that contribute to decline is reported in both the forest and orchard ecosystems. The Manion's decline disease spiral as a general model is proposed for fruit tree decline diseases. Control strategies in respect of the two ecosystems are discussed.


Abstract: This "Research Work Unit Description" includes an outline of one of the major forest management issues: the deterioration of forest health and sustainability caused by natural and human-induced disturbances.


Abstract: The subhumid boreal forest of western Canada is different today from what it was 25 years ago. Before the 1950s, the main human impacts on this forest were agricultural expansion, escaped settlement fires, and high-grade logging. The latter half of the 20th century saw increased human stresses placed on the ecosystems, against a background of insect outbreaks and high forest fire activity. In the Prairie provinces, current annual area burned is greater and more variable than it was in the 1970s. Over the past 25 years, the area disturbed by insects (primarily forest tent caterpillar) and disease has declined, but both the area and timber volume logged have risen. The boreal forest (particularly its southern half) is being converted to a fragmented landscape dominated by young aspen, shrub, grass, plantations, exotic species, industrial infrastructure, and agricultural fields. The current disturbance level has increased to the point that forest land and volume losses now exceed forest accruals in some regions; average forest age and biomass have been declining since about 1970. Relative to past decades, the present subhumid boreal forest region of Canada is warmer, and more fragmented and dissected; it supports less old growth, less old white spruce, and more young aspen and recently disturbed areas; it has simplified and truncated age-class structures; and it has a greater prevalence of non-native plants. Future stresses may include in situ tar sands development, groundwater depletion or degradation, and water diversions. Should present trends continue, declining forest productivity and predictability, and spread of exotic species are likely, as is replacement of coniferous forest by deciduous forest in some regions. Stressed aquatic systems may undergo major changes in biotic composition, productivity, and physical characteristics. Without a rapid decrease in the rate of disturbances, the establishment of a more complete protected areas network, and the adoption of ecosystem-centred management, the subhumid boreal ecosystem will continue to be degraded.


Abstract: Decay and root rot caused by Heterobasidion annosum (Fr.) Bref. s. lato is the most serious disease of Norway spruce [Picea abies (L.) Karst.]. Mathematical models of disease development have recently been developed for forestry planning purposes. Functions for predicting the probability of decay were developed from two data sets, one comprising trees and another comprising stumps. From the years 1983 to 2001, 45,587 Norway spruce trees from the Swedish National Forest Inventory (NFI) were analysed for decay incidence at 1.3 m height and correlation with environmental conditions. The decay frequency increased in all studied regions from the first to the second half of the period for trees with comparable tree and environmental attributes. In a stepwise logistic regression, sets of functions were developed showing significance regarding stand age, site index class, temperature sum, height above sea level, diameter at 1.3 m, soil moisture and texture, proportion of spruce and eastern coordinates. The functions were calibrated and validated with a data set from the Swedish NFI from the years 1993-2002 comprising 7,893 stumps. The calibration of decay incidence at breast height to stump height doubled the decay incidence (R-2 =0.85). The developed functions could be used to establish initial conditions for dynamic modelling of disease and in strategic planning.


Abstract: Three bioclimate variables (growing degree days after budburst, temperature of the coldest month and a moisture index) are used in a model (STASH) to predict potential range limits of north European tree species. CO2-induced climate warming scenarios cause major changes in these limits. The dominant conifers of the mixed conifer/northern hardwoods zone, \{Picea abies\} and \{Pinus sylvestris\}, retreat from the south and west while \{Fagus sylvatica\} and other temperate hardwoods spread to the north. A gap model (FORSKA 2) is used to simulate the associated transient responses of a forest reserve within this zone. In both dry Pinus- and moist Picea-dominated forest communities, Picea continues to increase while Pinus sooner or later declines. These changes are continuing successional (non-climatic) responses to the cessation of disturbance 150 years ago. Climate warming speeds up the succession, and allows Fagus to establish and increase. The eventual decline of Picea however is delayed due to the persistence of old-growth stands. Picea forests subject to continuing disturbance show a more rapid shift to dominance by Fagus and other temperate hardwoods. Delayed immigration of new species, including Fagus would favour early-successional species such as Betula pendula and Quercus spp. in a forest with reduced biomass and diversity. The results emphasize the complex and sometimes counter-intuitive nature of transient responses, and the importance of considering disturbance history and potential migration rates when predicting the impacts of rapid climate change on forests.


Svenning, J.C.; Skov, F. 2005. The relative roles of environment and history as controls of tree species composition and

**Abstract**

This study investigates the determinants of European-scale patterns in tree species composition and richness, addressing the following questions: (1) What is the relative importance of environment and history? History refers to past large-scale events and time-dependent cumulative effects of ongoing processes, notably dispersal limited range dynamics. (2) Among the environmental determinants, what is the relative importance of climate, soils, and forest cover? (3) Do the answers to questions 1 and 2 differ between conifers and Fagales, the two major monophyletic groups of European trees? **Location**

The study area comprises most of Europe (34 degrees N-72 degrees N and 11 degrees W-32 degrees E). Methods

Atlas data on native distributions of 54 large tree species at 50 x 50 km resolution were linked with climatic, edaphic and forest cover maps in a geographical information system. Unconstrained (principal components analysis using Hellinger distance transformation and detrended correspondence analysis) and constrained ordinations (redundancy analysis using Hellinger distance transformation and canonical correspondence analysis) and multiple linear regressions were used to investigate the determinants of species composition and species richness, respectively. History is expected to leave its mark as broad spatial patterns and was represented by the nine spatial terms of a cubic trend surface polynomial. **Results**

The main floristic pattern identified by all ordinations was a latitude-temperature gradient, while the lower axes corresponded mostly to spatial variables. Partitioning the floristic variation using constrained ordinations showed the mixed spatial-environmental and pure spatial fractions to be much greater than the pure environmental fraction. Biplots, forward variable selection, and partial analyses all suggested climatic variables as more important floristic determinants than forest cover or soil variables. Tree species richness peaked in the mountainous regions of East-Central and Southern Europe, except the Far West. Variation partitioning of species richness found the mixed spatial-environmental and pure spatial fractions to be much greater than the pure environmental fraction for all species combined and Fagales, but not for conifers. The scaled regression coefficients indicated climate as a stronger determinant of richness than soils or forest cover. While the dominant patterns were similar for conifers and Fagales, conifers exhibited less predictable patterns overall, a smaller pure spatial variation fraction relative to pure environmental fraction, and a greater relative importance of climate; all differences being more pronounced for species richness than for species composition. **Main conclusions**

The analyses suggest that history is at least as important as current environment in controlling species composition and richness of European trees, with the exception of conifer species richness. Strong support for interpreting the spatial patterns as outcomes of historical processes, notably dispersal limitation, came from the observation that many European tree species naturalize extensively outside their native ranges. Furthermore, it was confirmed that climate predominates among environmental determinants of distribution and diversity patterns at large spatial scales. Finally, the particular patterns exhibited by conifers probably reflect greater environmental specialization and greater human impact. These findings warn against expecting the European tree flora to be able track fast future climate changes on its own.


**Abstract**

Designing policies for long-term forest management is difficult, in part because ecological processes that drive forest structure and composition interact strongly, both spatially and temporally, with the many values we want to obtain from the forest. Using the Robson Valley in east-central British Columbia as a study area, we developed a spatio-temporal landscape model to assess the effects of uncertainties about stand-replacing natural disturbance regimes on indicators related to the sustainability of forest harvesting and biodiversity. Results show that key timber policy indicators were relatively less sensitive to natural disturbance regime parameters than were the biodiversity indicators of seral stage distribution and tree species composition. The other biodiversity indicator we examined, structural connectivity among old-forest patches, was among those indicators least sensitive to any of the parameters we varied. Other timber supply indicators including non-recoverable losses, and volumes and areas disturbed were the most sensitive to both the particular natural disturbance agent chosen and to the parameters describing its behaviour. Projections of a range of scenarios for present and alternative natural disturbance and management regimes for the study area show that most indicators varied from less than 1% up to 93% from the value of the present management/disturbance regime. Generally, three alternative management policies had weak-to-moderate capabilities of reducing effects of natural disturbances. Despite the range of uncertainties explored, the results provided little indication that, at the scale of the whole study area, current timber-harvesting targets are not sustainable over the long term. However, our findings highlight the lack of knowledge about the future, particularly about changes in climate, resulting in significant uncertainty about the future condition of the forest and about future forest-management opportunities.


**Abstract**

The findings of the recent IPCC Second Assessment Report conclude that the boreal forest is more sensitive and will be more affected by climate change than either temperate or tropical forests. Results suggest that over the next century in response to projected changes in temperature and moisture patterns the boreal ecosystem will undergo major changes in ecosystem boundaries, growth and natural disturbances related to fire and insects. This paper outlines the key highlights of the IPCC and more recent literature in terms of the effects of climate change for the boreal forest over the next 100 years. As well, the boreal forest appears to be responding to environmental changes that have occurred over the last century and more particularly over the last 30 years. Changes in boreal ecosystems related to the permafrost zone, vegetation productivity, disturbances related to fire and the carbon cycle have been noted. This paper reviews some of the major highlights of the changes that have been noted. Many of the changes projected for the boreal forest that forest managers will have to respond to in relation to climate change are not new. Subsequently, forest managers have many tools at their disposal that will enable
them to assist the forest to both mitigate and adapt to climate change. The challenge for forest managers will be dealing with the rate and intensity of change that occurs. This paper outlines broadly some of the things forest managers can and are doing to respond to climate change. As well, additional actions forest managers need to take to better prepare for and respond to climate change are briefly discussed.


Abstract: Adaptation in forestry is sustainable forest management that includes a climate change focus. Climate change over the next 100 years is expected to have significant impacts on forest ecosystems. The forestry community needs to evaluate the long-term effects of climate change on forests and determine what the community might do now and in the future to respond to this threat. Management can influence the timing and direction of forest adaptation at selected locations, but in many situations society will have to adjust to however forests adapt. Adapting to climate change in the face of the uncertain timing of impacts means we must have a suite of readily available options. A high priority will be coping with and adapting to forest disturbance while maintaining the genetic diversity and resilience of forest ecosystems. A framework for facilitating adaptation in forestry is discussed and a review of adaptive actions presented.


Abstract: Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) is an important species for timber production in the Georgia Basin with growth dependent on moisture availability during the summer. The potential effect of climate change on water availability and the productivity of coastal Douglas-fir was evaluated using relationships between available water and Douglas-fir yield developed from field measurements and the Ministry of Forests' timber production and recovery analysis system. Summer water availability (May to July rainfall plus 60% of the water storage capacity of the root zone) ranged from 175 to 295 mm for the sites investigated. The May to July potential evaporation for 1951 to 2002 calculated using the Penman-Monteith equation and a field derived canopy resistance function varied from 153 to 279 mm. The sites had a sensitivity of 6.1 m$^3$/ha of available water. Summer potential evaporation for a range of climate change scenarios was calculated. Change in water availability through a 10% reduction in rainfall or a 6% increase in potential evaporation over the life of the stand could result in a reduction in stand volume by up to 80 m$^3$/ha at harvest, 10 to 30% of current merchantable volume.


Annotation: Notes: Considering the foregoing uncertainties, the conclusion remains that little measurable tree migration and forest development will take place under the climate changes expected during the next 70-80 years, but that a significant "climatic obsolescence" and mortality of forest trees will take place. If the values of biome-level carbon density used in the foregoing analysis are approximately correct, the result would be a terrestrial biosphere which provides a source rather than a sink for atmospheric carbon at this time.

Key Words: Notes: Considering the foregoing uncertainties, the conclusion remains that little measurable tree migration and forest development will take place under the climate changes expected during the next 70-80 years, but that a significant "climatic obsolescence" and mortality of forest trees will take place. If the values of biome-level carbon density used in the foregoing analysis are approximately correct, the result would be a terrestrial biosphere which provides a source rather than a sink for atmospheric carbon at this time.


Abstract: Mortality patterns in an old-growth, mixed-conifer forest, in the absence of wildfire, were investigated at the Teakettle Experimental Forest from 2000 to 2002. We tested the hypothesis that after a century of fire suppression, pathogen- and insect-associated mortality (between episodic droughts) would be significantly greater on ingrowth trees (i.e., smaller-diameter, shade-tolerant species in high-density clusters). Using a survey of over 30,000 mapped trees, overall mortality, as measured by standing dead trees, was 8.7% of all stems 5 cm dbh. Mortality levels were proportional to the population size of the five dominant conifer species, white fir (Abies concolor), red fir (A. magnifica), incense cedar (Calocedrus decurrens), Jeffrey pine (Pinus jeffreyi), and sugar pine (Pinus lambertiana). There was also no significant difference in mortality between shade-tolerant and shade-intolerant species. All dead trees were clustered within plots. Mortality was significantly higher than expected for large-diameter trees (100 cm dbh) with all conifer species combined and for each individual species, except Jeffrey pine. Small-diameter dead trees were grouped in high-density clusters. Mortality was less than expected among small-diameter trees (5-20 cm dbh) for all species combined, red and white fir, and
sugar pine. Mortality for all conifers was higher than expected in areas of high stand density and lower in areas of low stand density. Mortality of small-diameter trees was clustered and particularly high in areas of high stand density. Our data suggest pathogen- and insect-associated mortality is significantly greater in areas of high stand density but it is not higher for shade-tolerant species. Furthermore, mortality is higher than expected for large-diameter trees, suggesting an acceleration of old-tree mortality under current fire suppression conditions.


Abstract: Introduced species already cause billions of dollars of damage annually in United States forests, plus massive ecological damage whose economic value has often not been estimated. The variety of impacts is staggering and includes herbivory, predation, disease, parasitism, competition, habitat destruction, hybridization, and changed disturbance regimes and nutrient cycles. How global climate change will affect these impacts has scarcely been assessed. Range changes of existing introduced species will be prominent, as many species’ biogeographic ranges are set primarily by climate. Similarly, some species that might otherwise not have survived will be able to establish populations in a changed climate. It is more difficult to predict what the impacts of the introduced species will be. What is most needed are studies of the combined impacts of changing climate, CO2, and nutrients. Certain aspects of the biology of introduced species, such as evolution and autonomous dispersal, greatly complicate the prediction of spread and impact of introduced species.


Abstract: Sediments from lakes in the northeastern United States ("New England") document climatic changes over the past 15,000 years that may, in turn, explain the long-term history of regional forest development. A rise in New England temperatures similar to 14,600 yr BP (calendar years before present) coincided with the initial increase in spruce (Picea spp.) populations after deglaciation. Later temperature fluctuations correlated with changes in spruce forest composition until 11,600 yr BP, when evidence for a shift to warm, dry conditions agrees with the replacement of spruce by pine (Pinus spp.) populations. Raised lake levels indicate increased moisture availability by 8200 yr BP when mesic hemlock (Tsuga canadensis) and beech (Fagus grandifolia) populations replaced the dry-tolerant pines. Cooler-than-modern temperatures, however, persisted until 6000 yr BP and appear to have limited the expansion of hickory (Carya spp.) populations. Similarly, moisture-dependent chestnut (Castanea dentata) populations did not increase until similar to 3000 yr BP, when moisture availability rose to modern levels. Pathogens played a key role in a dramatic decline in hemlock populations around 5400 yr BP, but the decline also corresponds with low lake levels indicating that moisture availability may have been a factor in the decline and recovery. Our analysis, therefore, demonstrates that changes in both the abundance of existing taxa and the arrival of new taxa closely correlate with independently documented changes in climate. Temperature trends do not explain all aspects of the vegetation history, but when both temperature and moisture balance are considered, we see that forest composition consistently changed within centuries or less of climatic changes.


Abstract: Increases in atmospheric greenhouse gases are driving significant changes in global climate. To project potential vegetation response to future climate change, this study uses response surfaces to describe the relationship between bioclimatic variables and the distribution of tree and shrub taxa in western North America. The response surfaces illustrate the probability of the occurrence of a taxon at particular points in climate space. Climate space was defined using three bioclimatic variables: mean temperature of the coldest month, growing degree days, and a moisture index. Species distributions were simulated under present climate using observed data (1951-80, 30-year mean) and under future climate (2000-09, 10-year mean) using scenarios generated by three general circulation models—HADCM2, CGCM1, andCSIRO. The scenarios assume a 1% per year compound increase in greenhouse gases and changes in sulfate (SO4) aerosols based on the Intergovernmental Panel on Climate Change (IPCC) IS92a scenario. The results indicate that under future climate conditions, potential range changes could be large for many tree and shrub taxa. Shifts in the potential ranges of species are simulated to occur not only northward but in all directions, including southward of the existing ranges of certain species. The simulated potential distributions of some species become increasingly fragmented under the future climate scenarios, while the simulated potential distributions of other species expand. The magnitudes of the simulated range changes imply significant impacts to ecosystems and shifts in patterns of species diversity in western North America.

at 0.5° latitude-longitude resolution and the boundaries of 39 national parks superimposed in a geographic information system (GIS). Park management plans and other planning documents were also reviewed as part of the analysis. **Results:** The proportional distribution of biomes in Canada's national park system was very similar (within 3% of area for each biome) using BIOME3 and MAPSS under the current climate. Regardless of the GVM and climate change scenario used, the modelling results suggest the potential for substantial change in the biome representation in Canada's national park system. In five of six vegetation scenarios, a novel biome type appeared in more than half of the national parks and greater than 50% of all vegetation grid boxes changed biome type. The proportional representation of tundra and taiga/tundra in the national park system declined in each of the vegetation scenarios, while more southerly biomes (temperate forests and savanna/woodland) increased (in some scenarios doubling to quadrupling). Results for boreal forest varied among the climate change scenarios. A range of potential vulnerabilities in existing policy and planning frameworks were identified, including the national park system plan, individual park objectives, and fire and exotic species management plans. **Conclusions:** Climate change represents an unprecedented challenge to Parks Canada and its ability to achieve its conservation mandate as presently legislated. Research is needed not only on ecosystem responses to climate change, but also on the capacity of conservation systems and agencies to adapt to climate change.


**Abstract:** Global change encompasses changes in atmospheric composition, climate and climate variability, and land cover and land use. The occurrence of these changes and their interactive effects on biological systems are worldwide; thus, an effective global change research and impact assessment program must be based on international and interdisciplinary research and communication. With this in mind, several collaborative research networks with focus on global change have been established in the biological sciences. They include the Global Change and Terrestrial Ecosystems (GCTE) Core Project of the International Geosphere-Biosphere Programme (IGBP) which aims to predict the effects of global change on terrestrial ecosystems, including agriculture and production forestry. Because of the importance of plant pests (arthropods, microbial pathogens, weeds) as yield-reducing factors in agriculture and as early indicators of global change, GCTE initiated a network Activity on "Global Change Impacts on Pests, Diseases and Weeds" with the overall goal of developing a predictive capability for impact assessment and adaptation. The network's specific objectives, contributing research projects, initial results and future challenges are discussed.


**Abstract:** The science of climate change has matured considerably during the past decade, both relative to the strength of the evidence documenting the ongoing anthropogenic climate change and in terms of the quality of climate models projecting future changes in climate. Concomitantly, modeling studies to project the likely impacts of climate change on agricultural production also have become more sophisticated. Nonetheless, agricultural impact assessments still do not account for all important factors; for example, potential changes in yield losses due to altered dynamics and intensity of pests (insects, plant pathogens, and weeds) under climate change are generally ignored - an important omission, given the significant role of plant pests in constraining the production of food and fiber worldwide. This paper highlights selected challenges that must be overcome before we can hope to quantify the impacts of a changing climate on plant disease intensity and yield loss. They pertain both to retrospective analyses seeking to identify fingerprints related to climate change in long-term plant-disease records, as well as to the use of mathematical models to predict likely impacts on plant pathosystems in the future. The use of climate-change fingerprints has been limited because time series containing disease variables collected in a standardized manner are unavailable for most plant pathogens; in cases where such long-term records do exist, trends are often confounded by changes in biological or management factors over time. As for the use of models for impact assessment, key challenges pertain to uncertainty in input variables, the difficulty in predicting biological responses in the presence of nonlinearities and thresholds, and the high likelihood of genetic adaptation to climate change.


**Abstract:** In the coming century, forecast climate changes caused by increasing greenhouse gases may produce dramatic shifts in tree species distributions and the rates at which individual tree species sequester carbon or release carbon back to the atmosphere. The species composition and carbon storage capacity of northern Wisconsin (USA) forests are expected to change significantly as a result. Projected temperature changes are relatively large (up to a 5.8°C increase in mean annual temperature) and these forests encompass a broad ecotone that may be particularly sensitive to climate change. Our objective was to estimate the combined effects of climate change, common disturbances, and species migrations on regional forests using spatially interactive simulations. Multiple scenarios were simulated for 200 years to estimate aboveground live biomass and tree species composition. We used a spatially interactive forest landscape model (LANDIS-II) that includes individual tree species, biomass accumulation and decomposition, windthrow, harvesting, and seed dispersal. We used data from two global circulation models, the Hadley Climate Centre (version 2) and the Canadian Climate Center (version 1) to generate transient growth and decomposition parameters for 23 species. The two climate change scenarios were compared with a control scenario of continuing current climate conditions. The results demonstrate how important spatially interactive
processes will affect the aboveground live biomass and species composition of northern Wisconsin forests. Forest composition, including species richness, is strongly affected by harvesting, windthrow, and climate change, although five northern species (Abies balsamea, Betula papyrifera, Picea glauca, Pinus banksiana, Pinus resinosa) are lost in both climate scenarios regardless of disturbance scenario. Changes in aboveground live biomass over time are nonlinear and vary among ecoregions. Aboveground live biomass will be significantly reduced because of species dispersal and migration limitations. The expected shift towards southern oaks and hickory is delayed because of seed dispersal limitations.


Abstract: Forests exchange large amounts of CO₂ with the atmosphere and can influence and be influenced by atmospheric CO₂. There has been a recent proliferation of literature on the effects of atmospheric CO₂ on forest trees. More than 300 studies of trees on five different continents have been published in the last five years. These include an increasing number of field studies with a long-term focus and involving CO₂×stress or environment interactions. The recent data on long-term effects of elevated atmospheric CO₂ on trees indicate a potential for a persistent enhancement of tree growth for several years, although the only relevant long-term datasets currently available are for juvenile trees. The current literature indicates a significantly larger average long-term biomass increment under elevated CO₂ for conifers (130%) than for deciduous trees (40%) in studies not involving stress components. However, stimulation of photosynthesis by elevated CO₂ in long-term studies was similar for conifers (62%) and deciduous trees (53%). Recent studies indicate that elevated CO₂ causes a more persistent stimulation of biomass increment and photosynthesis than previously expected. Results of seedling studies, however, might not be applicable to other stages of tree development because of complications of age-dependent and size-dependent shifts in physiology and carbon allocation, which are accelerated by elevated CO₂. In addition, there are many possible avenues to down-regulation, making the predicted canopy CO₂ exchange and growth of mature trees and forests in a CO₂-rich atmosphere uncertain. Although, physiological down-regulation of photosynthetic rates has been documented in field situations, it is rarely large enough to offset entirely photosynthetic gains in elevated CO₂. A persistent growth stimulation of individual mature trees has been demonstrated although this effect is more uncertain in trees in natural stands. Resource interactions can both constrain tree responses to elevated CO₂ and be altered by them. Although drought can reduce gas-exchange rates and offset the benefits of elevated CO₂, even in well watered trees, stomatal conductance is remarkably less responsive to elevated CO₂ than in herbaceous species. Stomata of a number of tree species have been demonstrated to be unresponsive to elevated CO₂. We conclude that positive effects of CO₂ on leaf area can be at least as important in determining canopy transpiration as negative, direct effects of CO₂ on stomatal aperture. With respect to nutrition, elevated CO₂ has the potential to alter tree-soil interactions that might influence future changes in ecosystem productivity. There is continued evidence that in most cases nutrient limitations diminish growth and photosynthetic responses to elevated CO₂ at least to some degree, and that elevated CO₂ can accelerate the appearance of nutrient limitations with increasing time of treatment. In many studies, tree biomass responses to CO₂ are artefacts in the sense that they are merely responses to CO₂-induced changes in internal nutritional status of the tree. There are numerous interactions between CO₂ and factors of the biotic and abiotic environment. The importance of increasing atmospheric CO₂ concentrations for productivity is likely to be overestimated if these are not taken into account. Many interactions, however, are simply additive rather than synergistic or antagonistic. This appears to hold true for many parameters under elevated CO₂ in combination with temperature, elevated O₃, and other atmospheric pollutants. However, there is currently little evidence that elevated CO₂ will counteract O₃ damage. When the foliage content of C, mineral nutrients and secondary metabolites is altered by elevated CO₂, tree-insect interactions are modified. In most trees, mycorrhizal interactions might be less important for direct effects of CO₂ than for alleviating general nutrient deficiencies. Since many responses to elevated CO₂ and their interactions with stress show considerable variability among species/genotypes, one principal research need is for comparative studies of a large variety of woody species and ecosystems under realistic conditions. We still need more long-term experimental data on mature trees and stands to address critical scaling issues likely to advance our understanding of responses to elevated CO₂ at different stages of forest development and their interactions with climate and environment. The only tools available at present for coping with the consequences of rising CO₂ are management of resources and selection of genotypes suitable for the future climate and environment.


Abstract: Although trees have responded to global warming in the past - to temperatures higher than they are now - the rate of change predicted in the 21st century is likely to be unprecedented. Greenhouse gas emissions could cause a 3-6°C increase in mean land surface temperature at high and temperate latitudes. Despite this, few experiments have isolated the effects of temperature for this scenario on trees and forests. This review focuses on tree and forest responses at boreal and temperate latitudes, ranging from the cellular to the ecosystem level. Adaptation to varying temperatures revolves around the trade-off between using the full growing season and minimizing frost damage through proper timing of hardening in autumn and dehardening in spring. But the evolutionary change in these traits must be sufficiently rapid to compensate for the temperature changes. Many species have a positive response to increased temperature - but how close are we to the optima? Management is critical for a positive response of forest growth to a warmer climate, and selection of the best species for the new conditions will be of vital importance.


Abstract: The International Workshop on Reducing Vulnerability of Agriculture and Forestry to Climate Variability and
Climate Change held in Ljubljana, Slovenia, from 7 to 9 October 2002 addressed a range of important issues relating to climate variability, climate change, agriculture, and forestry including the state of agriculture and forestry and agrometeorological information, and potential adaptation strategies for agriculture and forestry to changing climate conditions and other pressures. There is evidence that global warming over the last millennium has already resulted in increased global average annual temperature and changes in rainfall, with the 1990s being likely the warmest decade in the Northern Hemisphere at least. During the past century, changes in temperature patterns have, for example, had a direct impact on the number of frost days and the length of growing seasons with significant implications for agriculture and forestry. Land cover changes, changes in global ocean circulation and sea surface temperature patterns, and changes in the composition of the global atmosphere are leading to changes in rainfall. These changes may be more pronounced in the tropics. For example, crop varieties grown in the Sahel may not be able to withstand the projected warming trends and will certainly be at risk due to projected lower amounts of rainfall as well. Seasonal to interannual climate forecasts will definitely improve in the future with a better understanding of dynamic relationships. However, the main issue at present is how to make better use of the existing information and dispersion of knowledge to the farm level. Direct participation by the farming communities in pilot projects on agrometeorological services will be essential to determine the actual value of forecasts and to better identify the specific user needs. Old (visits, extension radio) and new (internet) communication techniques, when adapted to local applications, may assist in the dissemination of useful information to the farmers and decision makers. Some farming systems with an inherent resilience may adapt more readily to climate pressures, making long-term adjustments to varying and changing conditions. Other systems will need interventions for adaptation that should be more strongly supported by agrometeorological services for agricultural producers. This applies, among others, to systems where pests and diseases play an important role. Scientists have to guide policy makers in fostering an environment in which adaptation strategies can be effected. There is a clear need for integrating preparedness for climate variability and climate change. In developed countries, a trend of higher yields, but with greater annual fluctuations and changes in cropping patterns and crop calendars can be expected with changing climate scenarios. Shifts in projected cropping patterns can be disruptive to rural societies in general. However, developed countries have the technology to adapt more readily to the projected climate changes. In many developing countries, the present conditions of agriculture and forestry are already marginal, due to degradation of natural resources, the use of inappropriate technologies and other stresses. For these reasons, the ability to adapt will be more difficult in the tropics and subtropics and in countries in transition. Food security will remain a problem in many developing countries. Nevertheless, there are many examples of traditional knowledge, indigenous technologies and local innovations that can be used effectively as a foundation for improved farming systems. Before developing adaptation strategies, it is essential to learn from the actual difficulties faced by farmers to cope with risk management at the farm level. Agrometeorologists must play an important role in assisting farmers with the development of feasible strategies to adapt to climate variability and climate change. Agrometeorologists should also advise national policy makers on the urgent need to cope with the vulnerabilities of agriculture and forestry to climate variability and climate change. The workshop recommendations were largely limited to adaptation. Adaptation to the adverse effects of climate variability and climate change is of high priority for nearly all countries, but developing countries are particularly vulnerable. Effective measures to cope with vulnerability and adaptation need to be developed at all levels. Capacity building must be integrated into adaptation measures for sustainable agricultural development strategies. Consequently, nations must develop strategies that effectively focus on specific regional issues to promote sustainable development.


Abstract: Pollen data from 55 sediment cores show complex patterns of change in the vegetation of the northeastern USA in recent centuries caused both directly and indirectly by human impact, as well as by climate change. In the few centuries before European colonization, the abundance of Picea increased and Tsuga canadensis and Fagus grandifolia decreased in the northern part of the region, possibly due to climate cooling. In the rest of the region the vegetation was fairly stable in the few centuries before European colonization. After European colonization, the abundance of Betula increased throughout the region in response to forest disturbance, while Tsuga canadensis and F. grandifolia decreased, at least in part because of greatly increased fire frequency. The decrease in T. canadensis was also caused by cutting for the tanning industry. In addition to Betula, successional species included Castanea dentata in the south and Abies balsamea in the north. Both of these have been severely affected in the last century by disease or insect infestation, probably exacerbated by their increased population densities. Sorting out the direct and indirect causes of fluctuations in these species provides valuable information for predicting the responses of vegetation to continuing human impact and possible future changes in climate.


Abstract: Longlife pine (Pinus palustris Mill.) seedlings were grown in 45-1 pots and exposed to ambient or elevated (365 or 730 mu mol CO2 mol(-1)) CO2 concentration in open-top chambers for 20 months. Two water-stress treatments (target values of -0.5 or -1.5 MPa xylem pressure potential) were imposed 19 weeks after initiation of the study. At harvest, tissues (needles, stems, taproots, coarse roots, and fine roots) were analyzed for carbon (C), nitrogen (N), nonpolar extractives (fats, waxes, and oils), nonstructural carbohydrates (sugars and starch), structural components (cellulose and lignin), and tannins. The greatest dry weights and lowest N concentrations occurred in tissues of plants grown at elevated CO2, with or without increased CO2. Although allocation of C fractions among tissues was generally unaffected by treatments, concentrations of the analyzed compounds were influenced by treatments in needles and taproots, but not in stems and lateral roots. Needles and taproots of plants exposed to elevated CO2 had increased concentrations of nonstructural carbohydrates. Among plant tissues, elevated CO2 caused reductions in structural C concentrations and foliar concentrations of fats, waxes and oils.
Abstract: Frequently asked questions about how climate change will affect trees in the UK.


Abstract: Pathogens and herbivores can severely reduce host fitness, potentially leading to altered succession rates and changes in plant community composition. Thus, to predict vegetation dynamics under climate change, it is necessary to understand how plant pathogens and herbivores will respond. Pathogens and herbivores are predicted to increase under climate warming because the amount of time available for growth and reproduction will increase. To test this prediction, we used a warming experiment in which heaters were suspended over a natural montane meadow for 12 years. In the summer of 2002, we quantified damage by all the observable (aboveground) pathogens and herbivores on six of the most common plant species (Artemisia tridentata, Helianthella quinquenervis, Erigeron speciosus, Potentilla gracilis, Potentilla hippiana, and Lathyrus leucanthus). We found that plants in the earlier melting plots generally had the most damage and were attacked by a larger number of species, which is consistent with predictions. However, although the overall trend was an increase in damage with warmer temperatures and earlier snowmelt, some pathogens and herbivores performed better in cooler or later melting plots. The idiosyncratic response of each species to environmental conditions suggests that there are likely to be changes in community composition as the planet warms.


Annotation: Notes: Full Source Title: Sustaining Aspen in Western Landscapes: Symposium Proceedings. Aspen exhibits a variety of ecological roles. In southern Colorado, the 1880 landscape mosaic contained a range of stand ages, of which half were > 70 years old and half were younger. Pure Aspen stands in southern Colorado are widespread and may result from previous short fire intervals that eliminated local conifer seed sources. Aspen regeneration in northern Yellowstone Park is controlled by unregulated browsing pressure and fire, so it has been limited since 1920. However, an episode of aspen seedling establishment occurred after the 1988 fires. We urgently need additional detailed, local case studies of aspen ecology to inform management decisions.

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Abstract: Culture in vitro may result in anatomical abnormalities in the leaves, stems and roots of micropropagated plants. It may also affect major physiological processes, reducing the frequency of survival of micropropagated trees at the acclimatization stages. Two major strategies have emerged for the successful acclimatization of trees. The first involves encouraging micropropagated plantlets to become autotrophic and the second reducing water stress by changing culture environment. Both strategies may be applied in vitro at the preparatory stage, or ex vitro in the basic stage of acclimatization. The environmental factors involved in photosynthesis may be modified at the preparatory stage. Several modifications are possible, including decrease of the sugar concentration in the medium, increase in light intensity and modifications to gas exchange. Aerated vessels with bacteriological filters have been successfully used with several hardwood and conifer species. The beneficial effects of aeration have also been demonstrated from the initial stages of micropropagation onwards. However, the use of antitranspirants or surface-covering agents at the basic stage has not proved to be very efficient for woody plants. Water and mineral uptake, root system development and the prevention of infection by soil pathogens, are markedly improved by the addition of mycorrhizas. Trees that form ectomycorrhizae may be inoculated in vitro, at the preparatory stage. However, the in vitro technique is unsuitable for trees that form mycorrhizas with endomycorrhizal fungi. For such species, mycorrhizal development is generally stimulated ex vitro, by transferring the
plantlets to inoculated soil. Mycorrhizal development has been shown to increase the survival rate of almost all tree species tested, whether conifers, orchard or broadleaved forest trees. Several of these techniques, used in combination, may facilitate successful acclimatization of micropropagated trees. However, the techniques used must be chosen on a case-to-case basis.


Annotation: Notes: Are conifers a host?This article examines the discovery of six species of fungi never found before in Scotland, and the possible link of this finding to global climate change.
Key Words: Notes: Are conifers a host?This article examines the discovery of six species of fungi never found before in Scotland, and the possible link of this finding to global climate change.


Abstract: Effects of the timing of soil thawing in the spring on Scots pine (Pinus sylvestris L.) were studied under controlled laboratory conditions. Sixteen 6-year-old saplings were lifted from the field, replanted in containers and placed in four treatments in controlled environment (CE) chambers with four replicate saplings per chamber. The saplings were held in the CE chambers during one simulated winter and one simulated growing season. The soil was frozen to -2 degrees C during a second simulated winter in the CF chambers, and the soil thawing treatments began at the end Of the second simulated winter. Soil thawing began at various times before (no delay in thawing) and after (delay in thawing) chamber air conditions were changed from simulated winter to simulated summer. Delayed soil thawing subjected saplings to stress, with the severity of stress depending on the length of the delay in thawing. If there was no delay in soil thawing, stress was minor and reversible. A 2-week delay in soil thawing led to death of the saplings. Stress was apparent as decreases in the variable to maximal chlorophyll fluorescence ratio (F0/Fm), chlorophyll a/b ratio and needle water potential.

In needles of stressed saplings, apoplastic electrical resistance first decreased and then increased and there were anomalies in the electrical impedance spectra of the stems. Stress from the soil thawing treatments affected both root and shoot growth.


Abstract: Fundamental plant-environment relationships were revealed by analyses of 20-yr height and survival of 118 populations representing two subspecies of Pinus contorta growing in common gardens at 60 environmentally disparate test sites in British Columbia. The approach involved (1) preparing models that described the general climate of British Columbia, (2) developing population-specific response functions driven by predicted climate variables, (3) developing general transfer functions that predict performance from the climatic distances over which populations were transferred, and (4) interpreting the results in terms of niche breadth, effects of climate change on adaptedness of populations, and reforestation in a changing environment. Polynomial regression models used physiographic descriptors to predict seven climate variables from normalized records of 513 weather stations. Values of R2 ranged over 0.80-0.97 for thermal variables and 0.54-0.61 for precipitation variables. Validations with independent data from 45 stations were strong and suggested that the models were generally free of bias within the limits of the original data. Response functions describing the height or survival of each population were developed from quadratic regressions using predicted climate variables for each test site. Mean annual temperature and mean temperature in the coldest month were the most effective variables for predicting population height, while the ratio of summer temperature to summer moisture was the best predictor of survival. Validation of the response functions with independent data from two additional test sites produced values of R2 between actual and predicted values that were as high as 0.93 for height and 0.73 for survival. The results demonstrated that natural populations have different climatic optima but tend to occupy suboptimal environments. Nevertheless, the general transfer functions showed that optimal growth and survival of the species as a whole is associated with the null transfer distance. These seemingly anomalous results suggest that the same processes thought to determine the distribution of species control the distribution of genotypes within species: (1) environmental selection to produce a broad fundamental niche, and (2) density-dependent selection to produce a relatively narrow realized niche within which most populations are relegated to suboptimal environments. Consequently, the steep geographic clines typical of P. contorta seem to be driven more by density-dependent selection than by environmental selection. Asymmetric gene flow from the center of distribution toward the periphery is viewed as a primary regulator that provides the fuel for both environmental and density dependent selection and thereby indirectly perpetuates suboptimality. The response functions predict that small changes in climate will greatly affect growth and survival of forest tree populations and, therefore, that maintaining contemporary forest productivities during global warming will require a wholesale redistribution of genotypes across the landscape. The response functions also provide the climatic bases to current reforestation guidelines and quantify the adjustments necessary for maintaining adaptedness in planted trees during periods of small (18C) temporal temperature shifts.


Abstract: Five population-specific response functions were developed from quadratic models for 110 populations of Pinus sylvestris growing in 47 planting sites in Eurasia and North America. The functions predict 13 year height from climate: degree-days > 5 C; mean annual temperature; degree-days < 0 C; summer-winter temperature differential; and a moisture index, the ratio of degree-days > 5 oC to mean annual precipitation. Validation of the response functions with two sets of independent data produced for all functions statistically significant simple correlations with coefficients as high as 0.81 between actual and predicted heights. The response functions described the widely different growth potentials typical of natural populations and demonstrated that these growth potentials have different climatic optima. Populations nonetheless
tend to inhabit climates colder than their optima, with the disparity between the optimal and inhabited climates becoming greater as the climate becomes more severe. When driven by a global warming scenario of the Hadley Center, the functions described short-term physiologic and long-term evolutionary effects that were geographically complex. The short-term effects should be negative in the warmest climates but strongly positive in the coldest. Long-term effects eventually should ameliorate the negative short-term impacts, enhance the positive, and in time, substantially increase productivity throughout most of the contemporary pine forests of Eurasia. Realizing the long-term gains will require redistribution of genotypes across the landscape, a process that should take up to 13 generations and therefore many years.


Abstract: The availability of climate data and sophisticated software for high-speed computers has made it possible to assess the climate factors underlying geographic patterns of genetic variation in forest trees. Analyses have demonstrated anew that the clines in genetic variation that typify most tree species indeed have been molded by and are perpetuated by the climate. Yet, distribution of genotypes across the landscape is controlled by an interaction between adaptation to climate and competition, the same factors governing the distribution of competitively excluded form their climatic optima. Most populations, therefore, exist in climates that are colder than the optimal for their growth, productivity, and survival, with the discrepancy between the inhabited and the optimal climate increasing with the severity of the climate. Responses to climate change can be viewed (1) as short-term plastic responses that accrue in endemic populations as physiological systems adjust to climate, and (2) as long-term evolutionary processes that realign genetic variability with environmental diversity. Immediate short-term responses to a warming climate are dependent on the discrepancy between the inhabited and optional climates. Responses, therefore, should be highly negative in populations occupying the mildest climates but positive in the coldest. As a result, expected short-term responses in *Pinus sylvestris* and *Larix sibirica* of Siberia are strongly positive while those of *Picea engelmannii* of western United States are highly negative. Accommodating global warming in the long term will require a redistribution of genotypes within species to match the projected speed of global warming. Without the intervention of mankind in the evolutionary processes, accommodating the warming expected by 2100 may require many centuries.


Abstract: Weibull regression models were used to relate height and survival of Eurasian populations of Scots pine (*Pinus sylvestris* L.) at age 13 and three species of larch (*L. sukaczewii* Dylis, *L. sibirica* Ledeb., and *L. gmelinii* (Rupr.) Rupr.) at age 12 to the difference in climate between their provenance and a planting site. Univariate models using five climate variables as predictors all were statistically significant ($p < 0.01$), and all but the pine survival functions received strong verification with independent data. The models showed that the growth and survival of most populations of the pine and each species of larch are enhanced when populations are transferred from their provenance to warmer climates. The results are consistent with the view that most populations occur in climates that are suboptimal, the degree of which is directly related to the severity of the climate. Because of this, projected responses to a climate-change scenario of the Hadley Centre were highly variable geographically. Short-term plastic responses tended to be strongly negative for the least severe climates and strongly positive for the most severe. Long-term evolutionary responses primarily reflected extirpation and immigration for the species of larch but showed additionally for the pine that the accommodation of global warming will require a redistribution of genotypes throughout the species’ range.


Abstract: A series of common garden studies of 336 populations representing *Picea engelmannii*, *P. pungens*, *P. glauca*, *P. mexicana*, and *P. chihuahua* provided as many as 13 growth and morphologic characters pertinent to biosystematics and genecology. Canonical discriminant analyses discretely segregated populations of *P. pungens* and *P. chihuahua* while positioning *P. engelmannii* populations along a continuum anchored by Southwestern United States populations at one extreme and those classified as hybrids of *P. engelmannii* with *P. glauca* on the other. A population of *P. mexicana* was closely aligned with Southwest populations of *P. engelmannii*, while populations of *P. glauca* were intermixed with and peripheral to those identified as hybrid. While consistent with most taxonomic treatments of these taxa, the analyses nonetheless suggested that Southwestern United States populations should be considered as a variety of *P. engelmannii* that most likely should include *P. mexicana*. Geneecological analyses detected ample genetic variation among the 295 populations in the *P. engelmannii* complex. The analyses demonstrated that populations were distributed along clines driven primarily by the winter temperature regime of the provenance. For northern populations, summer temperatures also became a key factor in accounting for genetic differences among populations. Analyses also detected clines for the 19 *P. pungens* and 23 *P. glauca* populations. An assessment of the effects of global warming according to the IS92a scenario of two general circulation models demonstrated for the current century: (1) an increasingly favorable climate for *P. pungens* as its distribution moves upward in elevation throughout much of the Great Basin, Colorado Rockies, and mountain islands of the Southwest; (2) a widespread reduction in the areal extent of *P. engelmannii* in the inland Northwestern United States to the extent that *Picea* may become rare in the local flora; (3) extirpation of *P. glauca* from the Black Hills and Cypress Hills; and (4) a widespread redistribution of genotypes across the landscape as contemporary populations adjust genetically to change.

**Abstract:** Large numbers of Scots pine are dying in the dry inner-alpine valleys of the European Alps; in Switzerland, locally almost half the Scots pine (*Pinus sylvestris* L.) population has died since 1995. As Switzerland's temperature has increased at more than twice the global average in the 20th stop century and as most of this increase has occurred during the last 20 years, we investigated possible relationships between the dying Scots pine and climatic parameters. We centred our studies in the upper Rhone valley. Our results show that the strong climatic warming that has occurred in recent years may well be the indirect cause of the mortality observed in these forests. Tree mortality was highest following the dry and hot year 1998, and tree defoliation, an indicator of tree vitality, showed a strong correlation with the previous year's precipitation. While precipitation showed no clear significant trend over time, the number of warm days (mean >20 degrees C, maximum >25 degrees C) and potential evapotranspiration have significantly increased over the last 20 years. Higher temperatures favour pine wood nematodes and bark beetles, both of which are found at the study site, and increasing drought stress reduces tree resistance against pathogens. As these forests have in part protective functions, there is a need to better understand the mortality through interdisciplinary research and also to find means to change the species composition to establish tree species that are better able to withstand warmer temperatures.


**Abstract:** The development of fungal diseases within plant populations is simultaneously affected by spatially varying factors, which include environmental variables as well as characteristics of the host population itself. We studied the effects of such variation by investigating the relationships between several environmental factors and the occurrence and abundance of pathogenic fungi (*Phacidium infestans* L., *Gremmeniella abietina* (Lagerb.) Morelet, and *Lophodermella sulcigena* (Rostr.) Hohn) in a naturally regenerated, postfire population of Scots pine (*Pinus sylvestris* L.) saplings. The fieldwork was carried out in the pristine forest of Kostamuksha Strict Nature Reserve in the Karelian Republic, Russia. The microhabitat as well as the density and height of the saplings were factors that were related to the extent of damage caused by fungal diseases. However, the factors were correlated to the amounts of single pathogen species in different ways. Most obviously, microhabitat was related to the amount of *G. abietina*, while the amount of *P. infestans* was positively correlated with the increasing density of the stand. *Lophodermella sulcigena* was most abundant on tall saplings. *Gremmeniella abietina* occurred together with the other two fungi less frequently than would be expected from random occurrence, suggesting different ecological requirements or competitive exclusion. Fungal diseases caused considerable mortality and damage in the Scots pine population in question. We suggest that pathogenic fungi affecting shoots and foliage may affect the spatial distribution and regeneration dynamics of natural Scots pine populations.


**Abstract:** A study was carried out in southern Italy to determine the role of some factors in favouring *Heterobasidion annosum* s. l. spread and damage in eight silver fir (*Abies alba* Mill.) forests. All the studied stands were colonised by *H. abietinum*. The presence of the fungus (as carphophores on colonised wood) was detected by transects, and varied from 7.0 to 56.0% of trees. Stand history, precipitation and forest origin, analysed by the chi(2)-test, had a significant effect on rot severity. Damage was more severe in stands more xerophytic where the woods were planted on pasturelands.


**Annotation:** Notes: "...When assessed in terms of land area capable of supporting a general yield class greater than 18 cubic metres per year (a value likely to provide an internal rate of return of approximately 6%), this area was predicted to almost double within the next 20 years with a similar increase occurring during the subsequent 40 years."

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**Annotation:** Notes: Includes downloadable spatial database

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**Abstract:** Plant migration is a very real phenomenon with evidences from prehistoric and present observations. This migration may be in the form of habitat expansion through the outlier individuals or the success of hitchhiking. Humans have also contributed to plant migration through the introduction of economic and aesthetic species to new habitats. At the same time, humans are also contributing to the failure of plant migration through habitat fragmentation. The global implications of plant migrations are discussed.

**Peterson, D.W.; Peterson, D L.** 2001. Mountain hemlock growth responds to climatic variability at annual and decadal time...
Abstract: In the geologic past, natural climate changes have caused large-scale geographical shifts in species’ ranges, changes in the species composition of biological communities, and species extinctions. If the widely predicted greenhouse effect occurs, natural ecosystems will respond in similar ways as in the past, but the effects will be more severe because of the extremely rapid rate of the projected change. Moreover, population reduction and habitat destruction due to human activities will prevent many species from colonizing new habitat when their old becomes unsuitable. The synergy between climate change and habitat destruction would threaten many more species than either factor alone. These effects would be pronounced in temperate and arctic forests, where temperature increases are projected to be relatively large. Localized species might face extinction, while widespread forest trees are likely to survive in some parts of their range. New northward habitat will become suitable even as die-offs of tree species occur to the south. However, it may be difficult for many species to take advantage of this new habitat because dispersal rates for tree species are very slow relative to the rate of warming, and therefore ranges of even many widespread species are likely to show a net decrease during the next century. Range retractions will be proximally caused by temperature and precipitation changes, increases in fires, changes in the ranges and severity of pests and pathogens, changes in competitive interactions, and additional effects of non-climatic stress such as acid rain and low-level ozone. Changes in species composition will have large effects on local and regional economies and biological diversity.


Percy, K. 2004. Implications of rising CO2 and O3 for forest health. Proc. 36th Air Pollution Workshop, April 26–29, 2004; Rhinelander, WI.


Abstract: The adaptation of agriculture and forestry to the climate of the 21st century supposes that research projects will be conducted cooperatively between meteorologists, agronomists, soil scientists, hydrologists, and modellers. To prepare for it, it is appropriate first of all to study the variations in the climate of the past using extensive, homogenised series of meteorological or phenological data. General circulation models constitute the basic tool to predict future changes in climate. They will be improved, and the regionalisation techniques used for downscaling climate predictions will also be made more efficient. Crop simulation models using input data from the general circulation models applied at the regional level ought to be the favoured tools to allow the extrapolation of the major trends on yield, consumption of water, fertilisers, pesticides, the environment and rural development. For this, they have to be validated according to the available agronomical data, particularly the available phenological series on cultivated crops. In addition, climate change would have an impact on crop diseases and parasites, as well as on weeds. Very few studies have been carried out in this field. It is also necessary to quantify in a more accurate way the stocks and fluxes of carbon in large forest ecosystems, simulate their future, and assess the vulnerability of the various forest species to a change in climate. This is all the more important in that some propagate species choices must be made in the next ten years in plantations which will experience changed climate. More broadly speaking, we shall have not only to try hard to research new agricultural and forestry practices, which will reduce greenhouse gas emissions or promote the storage of carbon, but it will also be indispensable to prepare the adaptation of numerous rural communities for the climate change (with special reference to least developed countries in tropical areas, where malnutrition is a common threat). This can be accomplished with a series of new environmental management practices suited to the new climatic order.


Abstract: The geographic distribution, vigor, virulence, and agricultural impact of weeds, insects, and plant pathogens will be affected by climatic changes accompanying the global "greenhouse effect." Weed/crop competitive interactions, particularly among species differing in photosynthetic pathway (C3 vs. C4), may be altered, with the C3 species favored by increasing CO2. Physiological and biochemical changes induced in host crop plants by rising CO2 may affect feeding patterns of pest insects. Compilation of climatic thresholds for phenological development of pest insects reveals the potential for shifts in pest behavior induced by global warming and other climatic change. Generation times may be reduced, enabling more rapid population increases to occur. Poleward migration may be accelerated during the crop season. The epidemiology of plant diseases also will be altered. Prediction of disease outbreaks will be more difficult in periods of rapidly changing climate and unstable weather. Environmental instability and increased incidence of extreme weather may reduce the effectiveness of pesticides on targeted pests or result in more injury to non-target organisms. Biological control may be affected either negatively or positively. Overall, the challenge to agriculture from pests probably will increase.

Abstract: We examined the effects of several photoperiod and temperature regimes imposed during the winter--spring period on the timing of bud burst in rooted cuttings of Norway spruce (Picea abies (L.) Karst.) grown in a greenhouse in Finland. The treatments were initiated in November and December after the cuttings had been exposed to natural chilling and freezing events. Irrespective of the treatments applied, time to bud burst decreased with increased duration of previous exposure to natural chilling and freezing events. Fluctuating day/night temperatures and continuous lengthening of the photoperiod hastened bud burst. Shortening the photoperiod delayed bud burst, suggesting that little or no ontogenetic development toward bud burst takes place during mild periods before the winter solstice. In the case of climatic warming, this phenomenon may prevent the premature onset of growth that has been predicted by computer simulations with models that only consider temperature regulation of bud burst.


Abstract: "Substantial climate-related changes have also been conjectured for the coastal forest over several decades, including the appearance of new fungi..."


Abstract: Causal attribution of recent biological trends to climate change is complicated because non-climatic influences dominate local, short-term biological changes. Any underlying signal from climate change is likely to be revealed by analyses that seek systematic trends across diverse species and geographic regions; however, debates within the Intergovernmental Panel on Climate Change (IPCC) reveal several definitions of a "systematic trend." Here, we explore these differences, apply diverse analyses to more than 1,700 species, and show that recent biological trends match climate change predictions. Global meta-analyses documented significant range shifts averaging 6.1 km per decade towards the poles (or metres per decade upward), and significant mean advancement of spring events by 2.3 days per decade. We define a diagnostic fingerprint of temporal and spatial "sign-switching" responses uniquely predicted by twentieth century climate trends. Among appropriate long-term/long-scale/multi-species data sets, this diagnostic fingerprint was found for 279 species. This suite of analyses generates "very high confidence" (as laid down by the IPCC) that climate change is already affecting living systems.


Abstract: Climate change may profoundly influence Ontario's forest ecosystems and their management. Elevated atmospheric CO2 concentrations, increased temperature and altered precipitation regimes will affect forest vegetation through the influence on physiological (e.g., photosynthesis, respiration) and ecological processes (e.g., net primary production, decomposition), and may result in dramatic northward shifts in the natural range of forest types and species. More importantly, climate change is expected to increase the frequency of natural disturbances. Silvicultural intervention will increasingly be relied on to maintain forest health, managing declining stands, regenerate disturbed areas and cutovers with desired species and genotypes, maintain genetic diversity, and assist in species migration. Given the increasingly important role of Ontario's forests in national and provincial efforts to meet greenhouse gas emission reduction targets of the Kyoto Protocol, afforestation, conservation of existing forests, and increased forest management activities to accelerate the storage of carbon in Ontario's forests will be key aspects of forestry at the start of the third millennium.


Abstract: In recent decades, convincing scientific evidence has been accumulated that climate change, caused mainly by increasing atmospheric CO2 concentration, has already begun. Forests, which are major carbon pools, and cover large areas, were identified as potential major contributors to the mitigation of climate warming through their C sequestering capacity. Two are the most important characteristics of forecasted climate change: temperature increases of 3 ± 1.5 °C at the time of doubling CO2 concentration, with a more accentuated increase toward poles, and amplified climatic variability. This paper suggests a series of comprehensive silvicultural interventions likely to achieve a more active CO2 sequestration, and an ensuing temporary climate change mitigation. The importance of this measures of general interest has grown sharply recently. A new assessment made in an IPCC report contends that the expected rise of temperature until the end of the 21st
century will be in the range from 1.4 to 5.8 °C (IPCC 2001). In concert with efforts aiming at increased conservation of fossil fuels, the suggested measures are aimed to increase the carbon, C, storage term in the C balance of future forests and soils, thus significantly enhancing the C sink role of forested areas. In comparison with the past, when enormous C pools were locked underground, in the future, sequestered C will pass through a chain of transitional pools and ultimately end up in the atmosphere. Forests and soil can only provide temporary C storage, while true mitigation can only be achieved through very long-term C removal, e.g., in durable goods. All the recommended measures towards this aim fall in the «no regrets» category, enhancing the forest stewardship function that society expects from forest managers without affecting the status of forest industry.


Abstract: Increasing levels of greenhouse gases, GHGs, in atmosphere are at the root of increased global temperatures, also termed global climate change. Using sophisticated general circulation models, GCMs, until recently, predictions were consistent in documenting that a doubling of atmospheric CO₂ concentration will likely result in an increase of 3 ± 1.5 °C, globally, probably before the end of 21st century (Houghton 1997). However, a recent IPCC report (IPCC 2001) affirms that the warming will be in the range of 1.4 to 5.8 °C. Associated with climate warming are increased variability and more frequent extreme phenomena, droughts and floods. Ecosystems, in general, will have difficulties adapting to this fast pace of change. Due to their longevity, forests are likely to suffer severe hydric stress during extended dry episodes. The paper shows that already in the 20th century in central North America (Ontario and Michigan) sizable warming was clearly evident in standard weather records and was accompanied by a corresponding increase in precipitation. In search for practical means to adapt existing forests to the ecological challenges of warmer weather, especially to accrued potential evapotranspiration, ETp, this paper examines the effect of stand density reduction on soil water regime. Through continuous soil moisture measurements in a mature stand of red pine, accomplished with time-domain reflectometry equipment, TDR, in various treatments of a thinning experiment, the soil moisture regime was found to react strongly to stand density manipulation. It is inferred that, to avoid hydric stresses that might become acute, even deadly in dense stands, due to increased weather variability, forests will have to be thinned more often in the future. At the same time, the beneficial effect of density reduction on the growth of individual trees is demonstrated through diameter increment measurements. With stand density reduction, the diameter increment of thinned stands increases, revealing a potential for shortening the rotations.

Summary: Considering the large area of existing Canadian forest, the paper argues for the idea that a common and long known silvicultural practice, thinning, when periodically applied, shows a real possibility to achieve (1) increased ecological stability of stands, through lessened acuteness of anticipated summer water deficits, (2) shorter rotations, and (3) larger diameter stems. These consequences will accelerate the opportunity for renewal of existing stands with species better adapted to the shifting of ecological conditions.

Annotation: Notes: "Editorial" on Eco-Web page

Key Words: Notes: "Editorial" on Eco-Web page


Annotation: Notes: ORIGINAL TITLE: Lietuvos misku monitoringas: vizualiai identifikuojami medziu pazeidimai ir ju dinamika. Visible damage to forest trees in Lithuania is reported for 1991-1997. An average 20.5% of trees showed damage symptoms each year. Insects caused about 50% of the damage overall, and caused increasing amounts of damage after heavy storms in 1993 and droughts in 1992 and 1994. Crown defoliation was 20-22% on conifers without visual symptoms of damage. It is concluded that the main factors associated with forest decline in Lithuania are predisposing and of long duration, e.g. climate change, low concentrations of air pollutants and altered soil moisture regimes.

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Abstract: Global climatic change may impact forest productivity, but data are lacking on potential effects of elevated CO₂ and temperature on tree growth. We determined changes in shoot growth for Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) seedlings exposed to ambient or elevated CO₂ (+≈179 µmol·mol⁻¹), and ambient or elevated temperature (+≈3.5°C). Seedlings were grown for 4 years (three complete growing seasons) in outdoor, sunlit chambers. In each season, height growth was initiated earlier and, in two seasons, ceased earlier for elevated compared with ambient temperature treatments. Elevated temperature reduced intermediate and final plant heights. Stem diameter growth began earlier each season at the elevated compared with the ambient temperature, but temperature had no affect on final stem diameter. Elevated temperature tended to reduce leaf (p = 0.07) but not woody biomass. Elevated CO₂ had no significant effects on stem diameter, height, and leaf or woody biomass, and there were no significant CO₂ × temperature interactions. Thus, elevated
temperatures (but not elevated CO\textsubscript{2}) associated with climate change may decrease seedling canopy growth as indicated by reduced height and leaf biomass but have little or no effect on overall woody growth as indicated by stem diameter and woody biomass.


\textbf{Abstract:} Climate change presents a risk to the composition, health, and vitality of Canada's forests and forest sector. Effects may be either negative or positive, and will interact in complex ways over many spatial and temporal scales depending on such factors as physical geography, forest type, and forest management practices. Given the apparent vulnerability of forests and the forest sector to climate change, it is prudent that forest and forest-based community managers begin to develop adaptive strategies to minimize the risks and maximize the benefits of climate change. A flexible planning framework that incorporates key principles of structured decision-making and risk management is presented as a practical way to integrate climate change adaptation into forest management planning.


\textbf{Abstract:} The need to assess the role of forests in the global cycling of carbon and how that role will change as the atmospheric concentration of CO\textsubscript{2} increases has spawned many experiments over a range of scales. Experiments using open-top chambers have been established at many sites to test whether the short-term responses of tree seedlings described in controlled environments would be sustained over several growing seasons under field conditions. Here we review the results of those experiments, using the framework of the interacting cycles of carbon, water and nutrients, because that is the framework of the ecosystem models that are being used to address the decades-long response of forests. Our analysis suggests that most of what was learned in seedling studies was qualitatively correct. The evidence from field-grown trees suggests a continued and consistent stimulation of photosynthesis of about 60% for a 300 p.p.m. increase in [CO\textsubscript{2}], and there is little evidence of the long-term loss of sensitivity to CO\textsubscript{2} that was suggested by earlier experiments with tree seedlings in pots. Despite the importance of respiration to a tree's carbon budget, no strong scientific consensus has yet emerged concerning the potential direct or acclimation response of woody plant respiration to CO\textsubscript{2} enrichment. The relative effect of CO\textsubscript{2} on above-ground dry mass was highly variable and greater than that indicated by most syntheses of seedling studies. Effects of CO\textsubscript{2} concentration on static measures of response are confounded with the acceleration of ontogeny observed in elevated CO\textsubscript{2}. The trees in these open-top chamber experiments were in an exponential growth phase, and the large growth responses to elevated CO\textsubscript{2} resulted from the compound interest associated with an increasing leaf area. This effect cannot be expected to persist in a closed-canopy forest where growth potential is constrained by a steady-state leaf area index. A more robust and informative measure of tree growth in these experiments is the annual increment in wood mass per unit leaf area, which increased 27% in elevated CO\textsubscript{2}. There is no support for the conclusion from many studies of seedlings that root-to-shoot ratio is increased by elevated CO\textsubscript{2}; the production of fine roots may be enhanced, but it is not clear that this response would persist in a forest. Foliar nitrogen concentrations were lower in CO\textsubscript{2}-enriched trees, but to a lesser extent than was indicated in seedling studies and only when expressed on a leaf mass basis. The prediction that leaf litter C/N ratio would increase was not supported in field experiments. Also contrasting with seedling studies, there is little evidence from the field studies that stomatal conductance is consistently affected by CO\textsubscript{2}; however, this is a topic that demands more study. Experiments with trees in open-top chambers under field conditions have provided data on longer-term, larger-scale responses of trees to elevated CO\textsubscript{2} under field conditions, confirmed some of the conclusions from previous seedling studies, and challenged other conclusions. There remain important obstacles to using these experimental results to predict forest responses to rising CO\textsubscript{2}, but the studies are valuable nonetheless for guiding ecosystem model development and revealing the critical questions that must be addressed in new, larger-scale CO\textsubscript{2} experiments.


\textbf{Abstract:} Most entomologists think that environmental damage and insect damage in forests are two different things. However, recently a new type of forest decline has appeared in Europe and North America which seems to be the result of various stress factors, where no single factor is killing the trees, but the total effect of several stresses. The disease begins with pollution-related symptoms, which include growth anomalies and general weakening, but later it culminates to fatal injury caused by insects or plant pathogenic fungi.


\textbf{Abstract:} We investigated the influence of spatial aggregation on modeled forest responses to climate change by applying the professor-based Terrestrial Ecosystem Model (TEM) to a fine resolution spatial grid (100 km(2)) and to a coarse resolution spatial grid (2500 km(2)). Three climate scenarios were simulated: baseline (present) climate with ambient CO\textsubscript{2} and 2 future climates derived from the general circulation models OSU and GFDL-Q with elevated atmospheric CO\textsubscript{2}. For baseline
climate, the aggregation error of the national (U.S.) study area was very small, -0.4%. Forest-level aggregation error ranged from -1.6 to 11.8%, with the largest aggregation error occurring in boreal forest types. Coarse grid resolution inputs underestimated production for boreal and forested boreal wetland forests and overestimated net primary production (NPP) for temperate conifer, temperate deciduous, and temperate forested wetland forests. Aggregation error for coarse grid cells ranged between -25.6 and 27.3%. Aggregation errors were especially large in transition regions between temperate and boreal forest types. An analysis that homogenized inputs for the 10 km grid cells within a 50 km grid indicated that aggregation of forest types and air temperature from fine to coarse grid cells contributed most to the spatial aggregation error. The aggregation error for the OSU climate was similar to the GFDL-Q climate and both results were similar to the aggregation error of the baseline climate in magnitude, sign, and spatial pattern. While aggregation error was similar across the baseline, GFDL-Q and OSU scenarios, NPP response to the GFDL-Q and OSU climates increased 13 to 30% above the baseline NPP. Within each climate scenario, the estimated NPP response to climate change differed by less than 1% between the coarse and fine resolutions. Except for transition regions and regions with substantial variability in air temperature, our simulations indicate that the use of 0.5 degrees resolution provides an acceptable level of aggregation error at the 3 scales of analysis in this study. Improvements could be made by focusing computational intensity in heterogeneous regions and avoid computational intensity in regions that are relatively homogeneous with respect to vegetation and air temperature.


Abstract: The need to assess the role of forests in the global cycling of carbon and how that role will change as the atmospheric concentration of CO2 increases has spawned many experiments over a range of scales. Experiments using open-top chambers have been established at many sites to test whether the short-term responses of tree seedlings described in controlled environments would be sustained over several growing seasons under field conditions. Here we review the results of those experiments, using the framework of the interacting cycles of carbon, water and nutrients, that is the framework of the ecosystem models that are being used to address the decades-long response of forests. Our analysis suggests that most of what was learned in seedling studies was qualitatively correct. The evidence from field-grown trees suggests a continued and consistent stimulation of photosynthesis of about 60% for a 300 p.p.m. increase in [CO2], and there is little evidence of the long-term loss of sensitivity to CO2 that was suggested by earlier experiments with tree seedlings in pots. Despite the importance of respiration to a tree's carbon budget, no strong scientific consensus has yet emerged concerning the potential direct or acclimation response of woody plant respiration to CO2 enrichment. The relative effect of CO2 on above-ground dry mass was highly variable and greater than that indicated by most syntheses of seedling studies. Effects of CO2 concentration on static measures of response are confounded with the acceleration of ontogeny observed in elevated CO2. The trees in these open-top chamber experiments were in an exponential growth phase, and the large growth responses to elevated CO2 resulted from the compound interest associated with an increasing leaf area. This effect cannot be expected to persist in a closed-canopy forest where growth potential is constrained by a steady-state leaf area index. A more robust and informative measure of tree growth in these experiments is the annual increment in wood mass per unit leaf area, which increased 27% in elevated CO2. There is no support for the conclusion from many studies of seedlings that root-to-shoot ratio is increased by elevated CO2; the production of fine roots may be enhanced, but it is not clear that this response would persist in a forest. Foliar nitrogen concentrations were lower in CO2-enriched trees, but to a lesser extent than was indicated in seedling studies and only when expressed on a leaf mass basis. The prediction that leaf litter C/N ratio would increase was not supported in field experiments. Also contrasting with seedling studies, there is little evidence from the field studies that stomatal conductance is consistently affected by CO2; however, this is a topic that demands more study.


Annotation: Notes: Document Type: Article. Climate change predictions derived from coupled carbon-climate models are highly dependent on assumptions about feedbacks between the biosphere and atmosphere. One critical feedback occurs if C uptake by the biosphere increases in response to the fossil-fuel driven increase in atmospheric [CO2] ("CO2 fertilization"), thereby slowing the rate of increase in atmospheric [CO2]. Carbon exchanges between the terrestrial biosphere and atmosphere are often first represented in models as net primary productivity (NPP). However, the contribution of CO2 fertilization to the future global C cycle has been uncertain, especially in forest ecosystems that dominate global NPP, and models that include a feedback between terrestrial biosphere metabolism and atmospheric [CO2] are poorly constrained by experimental evidence. We analyzed the response of NPP to elevated CO2 (550 ppm) in four free-air CO2 enrichment experiments in forest stands. We show that the response of forest NPP to elevated [CO2] is highly conserved across a broad range of productivity, with a stimulation at the median of 23 +/- 2%. At low leaf area indices, a large portion of the response was attributable to increased light absorption, but as leaf area indices increased, the response to elevated [CO2] was wholly caused by increased light-use efficiency. The surprising consistency of response across diverse sites provides a benchmark to evaluate predictions of ecosystem and global models and allows us now to focus on unresolved questions about carbon partitioning and retention, and spatial variation in NPP response caused by availability of other growth limiting resources.

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http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/
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Abstract: Morphological and photosynthetic acclimation of current-year needles to canopy gradients in light availability (seasonal mean integrated quantum flux density, Q(int)) was studied in the temperate conifer, Pinus sylvestris L., at two sites of contrasting nutrient availability. The nutrient-rich site supported a monospecific P. sylvestris stand on an old-field. The trees were approximately 30 years old and 19-21 m tall. Mean foliar N and P contents (+/- SD) were 1.53 +/- 0.11% and 0.196 +/- 0.017%, respectively. The nutrient-poor site was located on a raised bog supporting a sparse stand of 50- to 100-year-old trees, with a height of 1-2 m, and mean needle N and P contents of 0.86 +/- 0.12% and 0.074 +/- 0.010%, respectively. At both sites, needle thickness (T) and width (W) increased with increasing Q(int), and leaf dry mass per unit leaf area (M-A) was also greater at higher irradiance. The light effects on M-A—the product of needle density (D) and leaf area (A)—was positively related to the foliar P/N ratio, indicating that J(max) was more strongly suppressed than V-cmax rate (J(max)) scaled positively with foliar N and P contents. The correlations were generally stronger with P than with N, suggesting that needle photosynthetic capacity was more heavily limited by the availability of P than of N. The J(max)/V-cmax ratio was positively related to the foliar P/N ratio, indicating that J(max) was more strongly suppressed than V-cmax under conditions of low P availability. Phosphorus and N deficiency also limited the plasticity of foliar photosynthetic characteristics. There was a moderate increase in needle photosynthetic capacity of up to 1.6-fold from the bottom to the top of the canopy at the nutrient-rich site, but net assimilation rates were essentially independent of canopy position at the nutrient-poor site. Stomatal constraints on photosynthesis were similar between the sites, indicating that photosynthetic acclimation was curtailed at the biochemical level. We conclude that the foliar capacity for morphological and physiological acclimation to high light significantly decreases with decreasing nutrient availability in P. sylvestris, and that both N and P availability are potentially important determinants of foliar carbon gain capacities.


Abstract: Lodgepole pine (Pinus contorta var. latifolia Engelm. ex. S. Wats.), interior spruce (including Picea glauca (Moench) Voss, P. engelmannii Parry ex. Engelm., P. glauca × engelmannii), and interior Douglas-fir (Pseudotsuga menziesii var. glauca (Beissn.) Franco) are the most important commercial species in the interior of British Columbia. We develop statistical models to predict site index (a measure of site productivity) from climate for these species. Using data from 193 climate stations, we first developed models that predict mean annual temperature, mean temperature of the warmest and coldest months, number of frost-free days, and frost-free period from latitude, longitude, and elevation. With these models and the Parameter-elevation Regressions on Independent Slopes Model (used to predict mean annual and mean summer precipitation), we predict 10 climate attributes for site index plots of lodgepole pine, interior spruce, and interior Douglas-fir. These attributes are then used in regression models to estimate site index. The models allow us to investigate
the current relationship between climate (particularly temperature and precipitation) and site productivity for these species. The productivity for all the species studied increased as temperature increased, with loblolly pine exhibiting the greatest response. The productivity of lodgepole pine and interior Douglas-fir also increased with increasing precipitation, with interior Douglas-fir having a greater response than lodgepole pine. We discuss the application of the models in relation to the impact of climate change on site productivity.


Abstract: The increase in the crimped gill fungus has been attributed to the warmer summers of the last twenty years. It cannot be explained by an increase in dead branches of deciduous trees: there were always plenty of these around. url: http://www.mnp.nl/mnc/i-en-1112.html


Abstract: To help manage the disease risks associated with white pine blister rust, researchers are pinpointing the locations where blister rust might cause damage, given the local topography, latitude, and altitude, and considering the effect of climate change on rust incidence. The maps produced will allow foresters to adapt local reforestation options in response to anticipated climate change.


Abstract: What is climate change? Human activity is changing our climate. We are warming the atmosphere by emitting increasing amounts of greenhouse gases into the atmosphere.


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Abstract: The study objectives were (a) to evaluate the degree of change in land cover (species composition) under forest harvesting and various climate change scenarios; (b) to analyze timber availability under different climate change scenarios, and harvesting; (c) to describe possible scenarios of land cover change as a result of climate change impact and harvesting to assist in policy-making related to land-use and landscape planning; and (d) to identify possible sources of both land-use conflicts and synergies as a result of changes in landscape composition caused by climate change. Located in northwestern Ontario, the study area corresponded to a boreal forest currently under harvest (about 800,000 ha). We used the fire landscape model BFOLDS to simulate landscape change under different climate change scenarios (CCSRNIES A21, CGCM2 A22), which were then compared to simulations under a baseline climate scenario (1961-1990). We also developed an algorithm based on a geographic information system to simulate harvesting and regeneration rules after logging. The period analysed covered 60 years to analyze impacts in the medium term. Results obtained indicated that species composition did not change importantly among the scenarios of climate change and the baseline. They also showed that the combined impact of climate change and harvesting could diminish timber availability up to 35% compared to the baseline by year 2040. On the other hand, shortages could occur in as short a period as 20 years for harvestable hardwood and 30 years for harvestable softwood. Because of its economic and ecological importance, as well as the dependence of local
communities within the study area on the forest, results found can have serious social, economic and ecological implications. Data obtained in this research constitute a valuable reference for planning the sustainable use of the boreal forest in northwestern Ontario.


Abstract: The potential impact of climate variability and climate change on agricultural production in the United States and Canada varies generally by latitude. Largest reductions are projected in southern crop areas due to increased temperatures and reduced water availability. A longer growing season and projected increases in CO₂ may enhance crop yields in northern growing areas. Major factors in these scenarios analyses are increased drought tendencies and more extreme weather events, both of which are detrimental to agriculture. Increasing competition for water between agriculture and non-agricultural users also focuses attention on water management issues. Agriculture also has impact on the greenhouse gas balance. Forests and soils are natural sinks for CO₂. Removal of forests and changes in land use, associated with the conversion from rural to urban domains, alters these natural sinks. Agricultural livestock and rice cultivation are leading contributors to methane emission into the atmosphere. The application of fertilizers is also a significant contributor to nitrous oxide emission into the atmosphere. Thus, efficient management strategies in agriculture can play an important role in managing the sources and sinks of greenhouse gases. Forest and land management can be effective tools in mitigating the greenhouse effect.


Abstract: The impacts of year-to-year and decade-to-decade climatic variations on some of the Pacific Northwest’s key natural resources can be quantitated to estimate sensitivity to regional climatic changes expected as part of anthropogenic global climatic change. Warmer, drier years, often associated with El Nino events and/or the warm phase of the Pacific Decadal Oscillation, tend to be associated with below-average snowpack, streamflow, and flood risk, below-average salmon survival, below-average forest growth, and above-average risk of forest fire. During the 20th century, the region experienced a warming of 0.8degreesC. Using output from eight climate models, we project a further warming of 0.5-2.5degreesC (central estimate 1.5degreesC) by the 2020s, 1.5-3.2degreesC (2.3degreesC) by the 2040s, and an increase in precipitation except in summer. The foremost impact of a warming climate will be the reduction of regional snowpack, which presently supplies water for ecosystems and human uses during the dry summers. Our understanding of past climate also illustrates the responses of human management systems to climatic stresses, and suggests that a warming of the rate projected would pose significant challenges to the management of natural resources. Resource managers and planners currently have few plans for adapting to or mitigating the ecological and economic effects of climatic change.


Abstract: Old-growth forests are assumed to be potential reservoirs of genetic diversity for the dominant tree species, yet there is little empirical evidence for this assumption. Our aim was to characterize the relationship of stand traits, such as age, height and stem diameter, with the genetic and reproductive status of old-growth and older second-growth stands of red spruce (Picea rubens Sarg.) in eastern Canada. We found strong relationships between height growth (a fitness trait) and measures of genetic diversity based on allozyme analyses in red spruce. The negative relationship between height and the proportion of rare alleles suggests that high proportions of these rare alleles may be deleterious to growth performance. Latent genetic potential, however, showed a significant and positive relationship with height. Stand age was not correlated to height, but was correlated to seedling progeny height. In late-successional species such as red spruce, age and size (e.g., height and stem diameter) relationships may be strongly influenced by local stand disturbance dynamics that determine availability of light, growing space, moisture and nutrients. In larger and older stands, age appeared to provide a good surrogate measure or indicator for genetic diversity and progeny height growth. However, in smaller and more isolated populations, these age and fitness relationships may be strongly influenced by the effects of inbreeding and genetic drift. Therefore, older populations or old-growth forests may represent superior seed sources, but only if they are also of sufficient size and structure (e.g., stem density and spatial family structure) to avoid the effects of inbreeding and genetic drift. Thus, larger and older forests appear to have an important evolutionary role as reservoirs of both genetic diversity and reproductive fitness. Given the rapid environmental changes anticipated (as a result of climate change, increasing population isolation through fragmentation, or following the introduction of exotic pests and diseases), these older populations of trees may have a valuable function in maintaining the adaptive potential of tree species.


Abstract: Carbon compound concentrations in plant tissues depend on the environment in which plants grow. However, little is known about how these concentrations vary across a range of forest environmental conditions. Our study examined root tissue (phloem, cambium, phellum, and phelloderm) collected from naturally regenerated mature Douglas-fir (Pseudotsuga menziesii var. glauca [Bess.] Franco) trees in eight stands on three habitat type series encompassing a range of temperature and moisture conditions. The objective was to determine root chemical composition (sugar, starch, phenol, and tannin) differences among the habitat types. Douglas-fir roots collected from dry, warm Douglas-fir habitat types had
sugar concentrations of 4% compared to 3% for roots from cool, moist habitat types. Root samples collected from Douglas-fir habitat types showed tannin concentrations about double those from grand fir or western redcedar habitat types. Phenol/tannin ratios for the cool, moist habitat types were about double those from warm, dry Douglas-fir habitat types. Roots sampled from western redcedar habitat types had phenol concentrations and phenol/sugar ratios more than 50% higher than those from Douglas-fir and grand fir habitat types. We speculate that root chemistry of Douglas-fir growing on Douglas-fir habitat types could make them more drought resistant but less disease resistant, while Douglas-fir growing on western redcedar types would be less drought resistant but more disease resistant. Douglas-fir growing on warm, dry sites allocated more carbon to tannin production and less to phenols.


Annotation: Notes: Several lines of evidence suggest that the severity of many plant diseases is likely to increase with climate warming and be affected by changes in moisture. First, while suitable long-term data sets are uncommon, interannual variation in the severity of several crop and forest diseases is positively correlated with temperature and moisture, suggesting that they will also track directional climate change. Second, controlled experiments have documented that the growth and reproduction of numerous pathogens requires highly humid conditions occurring primarily overnight, and that growth and reproduction are often maximized at temperatures greater than current overnight lows. Third, outside the tropics, overwintering survivorship of many pathogens is near zero, causing a drastic population bottleneck that climate warming may alleviate. Finally, the most severe and least predictable disease outbreaks may occur if shifts in species' geographic ranges under climate change allow pathogens to infect novel hosts from which they were previously geographically isolated and which lack resistance.

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url: http://aslo.org/phd/disccrs/200106-2.html


Abstract: Both native and exotic insects and diseases affect southern forest health and vitality and therefore have ecological and economic effects. In addition, abiotic factors, such as climate change and air pollution, may interact with and sometimes exacerbate the dynamics of insect and disease outbreaks. Managing for forest health in this changing environment remains a critical challenge for forest managers in the South. The Southern Forest Resource Assessment (SFRA) addressed questions regarding the health of forest ecosystems; this summary of the findings focuses on the implications for forest management in the region.


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Abstract: This paper briefly reviews the process of exotic pest risk assessments and presents some examples of emerging opportunities for spatial bioclimatic modeling of exotic species in Canada. This type of analysis can support risk assessments but does not replace the need for on-going high quality field-based observations to validate and update models.
Bioclimatic analysis of several exotic pests is provided to illustrate both opportunities and limits. A link is demonstrated to the National Forest Inventory to characterize timber volumes at risk for one exotic species. 'Challenges' are both scientific and administrative. More accessible and current field survey data are required to improve models. Our experience is that for many exotic species, historical, and even current, data are not always digital or quality controlled for taxonomic identity and accurate georeferencing. This inhibits their use for integrated spatial modeling applications. The purpose of this study was to quantify relationships between conifer species distributions and climatic and biophysical variables, to provide better insight into the potential for redistribution of species on the landscape in response to climatic change. Location Data are from 10,653 georeferenced sites in Washington State, USA, along a longitudinal gradient from west of the crest of the Cascade Range to the beginnings of the western slope of the Rocky Mountains, and across two physiographic provinces, the Northern Cascades, characterized by steep, rugged topography, and the Okanogan Highlands, presenting moderate slopes and broad rounded summits. Methods: Tree data were drawn from the USDA Forest Service Area Ecology Program database, collected in mature, undisturbed stands. We compared simple climatic variables (annual temperature, growing-degree days, annual and seasonal precipitation) to biophysical variables (soil, hydrologic, and solar radiation) derived from climatic variables. Climatic and biophysical variables were taken from the output of climatological and hydrological simulation models and estimated for each plot in the tree database. Generalized linear models were used, for each of fourteen tree species, at multiple spatial extents, to estimate the probability of occurrence of that species as a function of climatic and biophysical predictors. Models were validated by a combination of bootstrapping and estimating receiver operating characteristic (ROC) curves. Results: For the majority of species, we were able to fit variables representing both moisture and temperature gradients, and in all but a few cases these models identified a unimodal response of species occurrence to these gradients. In some cases the ecological/environmental niche of a species had been clearly captured by the model, whereas in others a longer gradient in the predictor variable(s) would be needed. Responses of most species were consistent across three spatial scales. Main conclusions: By identifying the ecological niches of multiple species, we can forecast their redistribution on the landscape in response to climatic change, evaluate the predictions of simulation models, and alert managers to particularly sensitive or vulnerable ecosystems and landscapes.


Abstract: A multi-period, regional, mathematical programming economic model is used to evaluate the potential economic impacts of global climatic change on the US forest sector. A wide range of scenarios for the biological response of forests to climate change are developed, ranging from small to large changes in forest growth rates. These scenarios are simulated in the economic forest sector model and results are summarized in response functions that may be used instead of rerunning the model as improved or altered biological response scenarios arise. The response functions are used to characterize broad impacts of climate change on the sector. We find that aggregate impacts (across all consumers and producers in the sector) are relatively small but that producers income and future welfare 30 to 40 yr in the future are most at risk. The forest sector is found to have adjustment mechanisms that mitigate climate change impacts, including interregional migration of production, substitution in consumption, and altered stand management.


Abstract: Agriculture and forestry will be particularly sensitive to changes in mean climate and climate variability in the northern and southern regions of Europe. Agriculture may be positively affected by climate change in the northern areas through the introduction of new crop species and varieties, higher crop production and expansion of suitable areas for crop cultivation. The disadvantages may be determined by an increase in need for plant protection, risk of nutrient leaching and accelerated breakdown of soil organic matter. In the southern areas the benefits of the projected climate change will be limited, while the disadvantages will be predominant. The increased water use efficiency caused by increasing CO\textsubscript{2} will compensate for some of the negative effects of increasing water limitation and extreme weather events, but lower harvestable yields, higher yield variability and reduction in suitable areas of traditional crops are expected for these areas. Forestry in the Mediterranean region may be mainly affected by increases in drought and forest fires. In northern Europe, the increased precipitation is expected to be large enough to compensate for the increased evapotranspiration. On the other hand, increased precipitation, cloudiness and rain days and the reduced duration of snow cover and soil frost may negatively affect forest work and timber logging determining lower profitability of forest production and a decrease in recreational possibilities. Adaptation management strategies should be introduced, as effective tools, to reduce the negative impacts of climate change on agricultural and forestry sectors.


Abstract: Since the early 1990s, Swiss needle cast disease caused by *Phaeocryptopus gaeumannii* has been increasing in Douglas-fir plantations in the Oregon Coast Range. Considerable variation in disease severity across the affected area often has been noted. We investigated the influence of site microclimate on fungal colonization as a basis for this variation with a combination of seedling inoculation and field studies. Development of *P. gaeumannii* ascocarps on inoculated seedlings subjected to mist, irrigation, and shading treatments was followed for 10 months. Contrary to expectations, numbers of ascocarps on foliage were negatively correlated with shade and mist and positively correlated with temperature. Numbers of
ascocarps on foliage, site temperature, and leaf wetness were monitored over 5 years at nine field sites in the Oregon Coast Range. Factors most highly correlated with ascocarp abundance were winter mean daily temperature and spring cumulative leaf wetness. Predictive models for disease severity on the basis of these correlations were tested against disease and climate data measured at field sites during 2003-2004. A temperature-based disease prediction model was developed in combination with geographical information systems (GIS)-linked climate databases to estimate disease levels across a portion of the Oregon Coast Range. This model can be used for hypothesis testing and as a decision support tool for forest managers.


Abstract: We determined the incidence of pathogens and insects across mixed-conifer stands in the Sierra San Pedro Martir (SSPM) of northern Baja, Mexico, to assess the role of pests in a pristine forest ecosystem. We also determined the spatial distribution of the two most common pests, mistletoe, Phoradendron pauciflorum Torrey, and the fir engraver, Scolytus ventralis LeConte, of white fir (Abies concolor (Gord. & Glend.) Lindl.), across a 25-ha grid to assess spread and what host and pest variables were related. In these open park like stands the mean tree density was 160 trees/ha, of which 58% were trees >20 cm diameter at breast height (DBH). In these low-density, mixed-aged stands we found that mixed-conifer species were well represented with no one species being completely dominant. Percent cumulative mortality for the SSPM was 12.7%, ranging from 2 to 24%, with the greatest amount of mortality occurring in the larger size classes, trees greater than or equal to 50 cm DBH. Multiple linear regression analysis showed that 78% of the mortality we observed was explained by pathogens and bark beetles (r² = 0.78, P = 0.0001, F = 84). Mean pest incidence for Jeffrey pine (Pinus jeffreyi Grev. & Balf. in A. Murray), white fir, and sugar pine (Pinus lambertiana Doug.) was 21, 88, and 2%, respectively. We found a number of relationships among host and pest variables, as well as a pathogen-insect interaction, and across the SSPM we found that nonhost species may be interfering in certain host-pest interactions. Spatial patterns from the 25-ha grid survey revealed that both P. pauciflorum and S. ventralis incidence were widespread. Phoradendron pauciflorum showed no spatial structure across the 25 ha but S. ventralis showed some degree of spatial structuring across the survey area. We also found that mistletoe severity was negatively correlated with regeneration of white fir. In pristine forests, pathogens and insects influence mortality and regeneration success, affecting stand structure and composition.


Abstract: Disturbance regimes strongly determine vegetation patterns and succession in the boreal landscape. One of the current challenges for boreal vegetation modellers is to represent disturbance agents as dynamic factors that can respond to climate change. Outbreak species of insects and plant pathogens can cause marked changes in vegetation patterns and should be incorporated into vegetation change models. This introduction to the ecology of boreal biotic disturbance agents is designed as a brief overview for global change researchers and modellers. We discuss the importance of biotic disturbance agents in the boreal forest, offer an overview of their ecology, and review modelling approaches. We illustrate these issues with examples from different systems, drawing largely from our experience with bark beetles.


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Abstract: The level of infection of symptomless green needles of Sitka spruce (Piceaitchensis) by Lophodermium piceae and Rhizosphaera kalkhoffii was compared in poor growth/polluted and good growth/unpolluted stands in Wales, UK, from 1989 to 1991. Generally, isolation of these two endophytes from green needles increased with needle age. This was supported by both culturing of the endophytes on media and the total ergosterol content of needles. Statistically significant correlations were obtained between the two techniques on some sampling occasions. Over the 3-year experimental period there was a markedly higher isolation frequency of R. kalkhoffii from the poor growth/polluted site than from the good
growth/unpolluted site. This was less apparent for *L. piceae*. Complimentary in vitro studies showed that *R. kalkhoffii* was more tolerant of elevated sulfur dioxide, low water availability, and had a lower temperature optimum than *L. piceae*. The use of such endophytic fungi as possible bioindicators of tree vitality is discussed.


**Abstract:** Today's forests are largely viewed as a natural asset, growing in a climate envelope, which favors natural regeneration of species that have adapted and survived the variability of past climates. However, human-induced climate change, variability and extremes are no longer a theoretical concept. It is a real issue affecting all biological systems. Atmospheric scientists, using global climate models, have developed scenarios of the future climate that far exceed the traditional climate envelope and their associated forest management practices. Not all forests are alike, nor do they share the same adaptive life cycles, feedbacks and threats. Much of tomorrow's forests will become farms forests, managed in a proactive, designed and adaptive envelope, to sustain multiple products, values and services. Given the life cycle of most forest species, forest management systems will need to radically adjust their limits of knowledge and adaptive strategies to initiate, enhance and plan forests in relative harmony with the future climate. Protected Areas (IUCN), Global Biosphere Reserves (UNESCO) and Smithsonian Institution sites provide an effective community-based platform to monitor changes in forest species, ecosystems and biodiversity under changing climatic conditions.


**Abstract:** We undertook a survey of the vegetational ecology of 94 peatlands at Duck Mountain, Manitoba, to discriminate differences among peatland types at the southeastern edge of the boreal plain, especially black spruce swamps, and to clarify boreal swamp terminology. The majority of peatlands surveyed were wooded, relatively small (mean = 1.8 ha), and in depressions on the landscape. A classification and indicator species analysis identified the dominant peatland types as moderate-rich fens, with bogs and extreme-rich fens as rare. Black spruce swamps were relatively common and found on gentle slopes. They were distinguished from wooded fens by larger trees (mean height = 9.7 m; diameter = 12.6 cm), denser understory (68%), shallower peat depth (90 cm), and small size (1.6 ha). Although most similar to wooded moderate-rich fens by vegetation, black spruce swamps have a denser bryophyte layer and more mesic plant species. Significant indicator species on hummocks and drier areas include *Pleurozium schreberi*, *Hylomocion splendens*, *Equisetum sylvaticum*, *Petasites frigidus* var. *palmatus*, *Comus canadensis*, *Linnaea borealis*, *Rosa acicularis*, *Moneses uniflora*, *Geocaulon lividum*, *Orthilia secunda*, *Equisetum arvense*, *Listera cordata*, and *Mertensia paniculata*. Species characteristic of black spruce swamp hollows include *Rhizomium pseudopunctatum*, *Rhizomnium gracile*, and *Plagiochila porelloides*. We discuss confier swamp terminology globally, and recommend that black spruce swamps be recognized as a peatland type distinct from eastern white cedar-dominated boreal swamps found in the eastern boreal region, wooded fens, and black spruce-dominated uplands. The environmental gradients most strongly associated with an ordination of the Duck Mountain peatland plant community data were forest mensuration variables, e.g., overstory density (range = 7-80%), peat depth (0.4-3.0 m), peat C:N (14-67), organic C (54-98%), bulk density (0.19-6.40 g/cm), surface-water temperature (3.0–19.5 degrees C), specific conductivity (0.989 μS/cm), and Ca2+ (1.8-111.4 mg/L). Wooded bogs were distinguished from the other peatland types based on mean pH (3.8), alkalinity (0.2 mg/L), Ca2+ (5.0 mg/L) and other cations, but there was much overlap among the fens and black spruce swamp. A number of isolated, topographically high, open peatlands were characterized by plant species with affinities to open moderate-rich fens, including *Drepanocladus aduncus*, *Helodium blandowii*, *Salix discolor*, *Equisetum flaviatile*, and *Calamagrostis canadensis*, but mean surface water pH (5.4), Ca2+ (13 mg/L), DOC (47 mg/L), and NH4+ (188 μg/g/L) were more similar to wooded bogs. This may be the consequence of fluctuating water levels. The potential impact of climate change, in addition to current impacts from logging, emphasizes the importance of understanding the vegetation and environmental variables in southern boreal peatlands.


**Abstract:** Borrowing from landscape ecology, atmospheric science, and integrated assessment, we aim to understand the complex interactions that determine productivity in montane forests and utilize such relationships to forecast montane forest vulnerability under global climate change. Specifically, we identify relationships for precipitation and temperature that govern the spatiotemporal variability in Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) growth by seeking similarities in patterns of growth/climate models across a significant portion of the climatological range of the species. In the 21st century and beyond, sustainable forestry will depend on successful adaptation to the impacts of climate change and climate variability on forest structure and function. The combination of these foci will allow improved prediction of the fate of montane forests over a wide range of biogeoclimatic conditions in western North America and thus allow improved management strategies for adapting to climate change. We describe a multi-disciplinary strategy for analyzing growth variability as a function of climate over a broad range of local-to-regional influences and demonstrate the efficacy of this sampling method in defining regional gradients of growth-limiting factors.


**Abstract:** Forests and the forest sector are sensitive to climate change at greatly varying scales. The complexity of the interactions among the physical environment, forest growth, the management and utilization of forest resources, and market responses has stimulated efforts to model the impact of global changes on the forest sector by linking impact models developed from different disciplines. This paper reviews existing experiences in integrated forest sector impact assessments.
Different ways of integrating cross-disciplinary impact assessments are classified as linking, coupling and integrated modelling. To date the most common method is a "one-way" linking, where results from one model are used as input to a different model. When different impact models are coupled, feedbacks can be analysed, e.g., between ecological and economic systems. Integrated modelling is described as a third step, where different sub-models are embedded into a common model framework. The concept of balance is introduced as a key to successful integration of different disciplines in integrated assessment (IA) studies. The review of existing experiences emphasizes the problem of complexity and the need to simplify disciplinary approaches. It also illustrates how methodologies applied to forest sector IA studies have evolved over the last few years. Several scaling issues that are particularly important for IA modelling in forestry are discussed, including the consequences of heterogeneity in site conditions, the variable influence of extreme events on ecosystems and on the economic sector, and the differences in temporal and spatial scales over which key forest growth and renewal processes operate. Climate impact assessments include uncertainties. Some common sources of uncertainty in forest IA modelling are outlined, and methods that have been used to address this uncertainty are reviewed. We discuss the policy relevance of integrated impact assessments and stress the importance of stakeholder involvement in IA projects. The paper concludes with some recommendations for future developments in this relatively new field of research.


Annotation: Notes: Numerous investigations have indicated that projected climate change will impact strongly on forest growth and composition. To adapt managed forests to changing environmental conditions it may be necessary to modify traditional forest management strategies. An extended version of a forest gap model was applied to a managed forest district in northeastern Germany. The model was initialized with forest inventory data and run using routines devised to simulate three management scenarios: (1) maximized timber production, (2) climatically well-adapted forest composition, and (3) maximized tree species diversity. The strategies were compared with a baseline scenario of traditional management without any response to climate change. The comparisons were based on simulated wood production and species composition after 110 years of development. The results underline the important influence that management strategies have on forest growth. Forest management may adopt a variety of strategies to respond to the expected changes in climate. Process-oriented forest gap models can aid in the assessment of these strategies.

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Abstract: Inonotus tomentosus causes tomentosus root disease of spruce in boreal and sub-boreal forests of south-central Alaska. The relationship between the incidence of I. tomentosus and spruce diameter, density and basal area was examined on two different sites on the Kenai Peninsula. Sites were systematically surveyed using 50 m2 plots and disease incidence was calculated as the percent of spruce trees infected with I. tomentosus. Transects from the top of slopes to the bottom were also established at the same sites and soil moisture probes were installed in the upper 15-20 cm at five equidistant points on each transect. The relationship between slope position, percent soil moisture content, soil pH and disease incidence was determined by ANOVA and regression analysis. The incidence of I. tomentosus in the plot survey ranged from 0 to 100% and spruce density (stems per hectare) and basal area had no relationship with disease incidence. Disease incidence was significantly and positively related to individual tree diameter and disease was most common on slopes compared to either bottom or top (flat) positions. Percent moisture content was greatest at bottom slope positions and at flat sites located beyond the crest of slopes. Disease incidence was negatively related to percent moisture content, but not related to pH. Slope position, or soil moisture content, may be used by forest managers to indicate areas more likely to have a higher incidence of I. tomentosus. The strategies were compared with a baseline scenario of traditional management without any response to climate change. The comparisons were based on simulated wood production and species composition after 110 years of development. The results underline the important influence that management strategies have on forest growth. Forest management may adopt a variety of strategies to respond to the expected changes in climate. Process-oriented forest gap models can aid in the assessment of these strategies.


Abstract: Thirty-eight trees from Alaska’s Kenai Peninsula and 39 from the interior near Fairbanks (Delta Junction) were sampled by detailed stem dissections to determine the impact of tomentosus root disease [Inonotus tomentosus (Fr.: Fr.) S. Teng] on growth and decay volume in spruce, with and without the influence of past spruce beetle activity in stands. Disease severity was assessed by the number of primary roots (out of four) infected and by the average proportion of root cross-section area colonized by stain and (or) decay. Butt rot volumes were positively related to disease severity at both locations, but only the Delta Junction trees showed a significant negative relationship between relative volume increment and disease severity. Substantial mortality of spruce, caused by the spruce beetle (Dendroctonus rufipennis (Kirby)), has occurred on the Kenai Peninsula since the late 1970s. Mortality of overstory spruce trees released surviving trees from competition, causing compensatory growth in healthy to moderately infected trees, which masked the effect of the root disease. We found that the
magnitude of growth release was negatively related to disease severity and that the mean proportion of root cross-section with decay or stain was a better estimator of disease impact on tree growth.


**Abstract:** This project investigated the interaction between tomentosus root disease of spruce, caused by *Inonotus tomentosus* (Fr. :Fr.) S. Teng, and spruce beetle (*Dendroctonus rufipennis* Kirby). Both organisms are important agents of mortality and volume loss in boreal and sub-boreal spruce forests of British Columbia. They also occur in similar stand types with respect to species composition and tree age. One study involved an intensive survey of 23 spruce stands, where trees were sampled for both beetle and root disease. Tree condition (dead standing, live, windthrown) was also recorded. Few stands showed a significant relationship between incidence of spruce beetle and incidence of root disease, regardless of tree condition. Observations indicated that beetles actually tended to avoid severely infected trees. A second study involved pheromone baiting of paired healthy and infected trees, and measurements of phloem thickness. Two sites were used, one with very high (epidemic) populations of beetles, and the second with low (endemic) levels. Spruce beetle attacks were more successful on infected trees compared with healthy trees only at the site with endemic levels of beetles. Collectively, the results indicate that tomentosus root disease helps to maintain endemic levels of spruce beetle, and disease incidence may be useful as a tool to identify areas that may have endemic populations of spruce beetle


**Annotation:** Notes: "Predicted changes in climate patterns over the next fifty years hold the potential to severely alter normal oak physiology and growth through increases drought and temperature stress in the southern United States. After a healthy tree has been stressed one or more times, its defense systems can become impaired making it vulnerable to attack by insects and diseases (Wargo and Haack, 1991), and the oak decline syndrome is fully expressed."

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**Abstract:** "Just like lichens, fungi can quickly expand their distribution range if conditions are favourable. *Plicatoderma crispa*, a small fungi that lives on dead branches and trunks of various deciduous trees, had a typical southern distribution in Europe and was until recently completely absent in the lowlands of western Europe. At the end of the 1980s the first observations were recorded (RVIM et al. 2003). Since then, the population expanded strongly and became abundant in many locations far to the north and west of the original range. This dramatic increase can only be explained by a lack of severe winters in recent decades."


**Abstract:** Changes in species composition of overstory trees (percent of basal area) and size class were monitored over 60 years on 441 cruise plots located on the Bartlett Experimental Forest, a 1052 ha experimental forest in the White Mountains of New Hampshire. The plots were analyzed by elevation class, landtype (deciduous and coniferous), and year (1931-1932, 1939-1940, and 1991-1992) within managed and unmanaged stands. The primary changes in species composition over the 60-year period were due to natural succession, which resulted in marked increases (doubling) of the eastern hemlock (*Tsuga canadensis* (L.) Carr.) component, and consistent decreases in paper birch (*Betula papyrifera* Marsh.), yellow birch (*B. alleghaniensis* Britton) (at medium or low elevations), and aspen (*Populus* spp.). Timber management resulted in small decreases in the beech (*Fagus grandifolia* Ehrh.) and red spruce (*Picea rubens* Sarg.) component and slight increases in sugar maple (*Acer saccharum* Marsh.). Natural disturbances (beech-bark disease and hurricane damage) had only minor effects on species occurrence. No consistent evidence of red spruce (*Picea rubens* Sarg.) decline was detected. Eastern hemlock, a climatically sensitive species in northern New England with a limited elevational range, increased dramatically at moderate to low elevations, but showed little tendency to invade the highest elevation class; apparently, the warming trend reported elsewhere in New Hampshire is not occurring, or the species are not responding in terms of changes in elevational distribution. The results emphasize the resilience of New England forests and their resistance to exogenous disturbance.


**Abstract:** Yellow-cedars (*Chamaecyparis nootkatensis* (D. Don) Spach) are the oldest known coniferous trees in Canada. This paper reports on the first dendrochronological investigation of yellow-cedar trees at montane sites on Vancouver Island.
Island. Mature yellow-cedar trees were selected for study at four sites along a 200-km northwest-southeast transect. Trees older than 500 years were common at three of the four sites, with numerous individuals older than 750 years identified. Carefully prepared cores proved well suited for ring-width measurement, with 220 cores from 156 trees included in our final four chronologies. The best replicated segment of the four chronologies (1800-1994 A.D.) show common intervals of reduced radial growth in the 1800s, 1840s, 1860s, 1920s, 1950s, and 1970s. While the relative strength of the between-site signals varies over this interval (r = 0.424-0.908), it is apparent that the chronologies share a common radial growth signal. Our efforts to identify the role climate played in this relationship were successful and the results appear to have a dendroecological basis within the annual yellow-cedar growth cycle. Six different temperature and precipitation variables explain 61% of the annual ring width variance. Our results suggest that further dendrochronological and dendroclimatological studies using this long-lived species are warranted.


Abstract: Tree-ring radial expansion estimator (TREE) is an integrated radial growth model that allows users to define short-term climate change scenarios to anticipate the impact upon mature trees found growing at high elevation on Vancouver Island, British Columbia. Five individualistic models were built to represent the radial growth behaviour of mountain hemlock (Tsuga mertensiana (Bong.) Carr), yellow-cedar (Chamaecyparis nootkatensis (D. Don) Spach), western redcedar (Thuja plicata Donn), Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco), and western hemlock (Tsuga heterophylla (Raf.) Sarg.) trees. The models were developed on climate-radial growth relationships incorporating Nanaimo climate station data, and were able to explain from 55 to 68 per cent of the variance in radial growth. The models can be run with modifications to yearly precipitation and temperature variables, giving the user the ability to investigate the radial-growth impacts of a wide range of possible climate change scenarios. Results from eight such scenarios show that species growing within their ecological limits illustrate a limited change in radial growth to forecasted climate, while species growing at an ecotonal boundary are usually very sensitive to a specific climate variable (e.g., July temperature). A forecasted alteration to this key variable will then radically alter the radial growth rate of the species.


Abstract: Afforestation can increase soil organic carbon (SOC) storage, but the selection of tree species may be critical. This study explored soil CO₂ production and effluxes in relation to SOC contents in temperate forests. Sites included even-aged (38 years) first generation stands of eight coniferous and two deciduous species planted at three sites along a gradient in soil fertility. SOC stocks (forest floor + mineral soil 0-50 cm) differed significantly between tree species, but soil type influenced SOC stocks the most. SOC stocks were significantly higher for stands on low-fertility sandy soils (141 ± 31 Mg C·ha-1) than stands on fertile loamy soils (62 ± 14 Mg C·ha-1). Soil CO₂ effluxes were measured on two occasions in 2002 and varied between 18.7 and 36.3 kg C·ha-1·day-1. Variability within temperature adjusted fluxes was not clearly related to tree species or soil type. Potential CO₂ production rates in a laboratory incubation experiment (reported as CO₂ produced per unit soil C) were mainly affected by site and were two times higher for soils from the nutrient-rich site compared with the most nutrient-poor site. Thus, the combined effect of contrasting CO₂ production rates and stocks of soil C may explain the similar CO₂ effluxes measured in the field. Results suggest that selection of soil type and tree species are important for SOC sequestration in future afforestation projects.


Abstract: Some ambrosia beetles are primary attackers of healthy, living trees, but in recent years normally secondary species have been increasingly observed attacking living trees, either as exotics or in their native geographic ranges. We identified five factors that could underlie an increasing prevalence of attack by secondary ambrosia beetles on living trees: (1) early flight before the host tree has recovered the ability to resist attack in the spring, possibly associated with climate change; (2) nutritional independence from the host that may enable ambrosia beetles to feed on ambrosia fungi that live on dead tissue in a living tree; (3) potentially pathogenic fungi that could become more pathogenic with climate change or through hybridization with exotic strains; (4) cryptic behavior that facilitates international transport and the establishment of exotic species and genotypes; and (5) a complex chemical ecology that enables secondary ambrosia beetles to locate stressed living trees that may temporarily appear to be suitable hosts for secondary beetles. We propose four avenues of research that will lead to an increased understanding of attack of living trees by ambrosia beetles, and may facilitate the implementation of effective pest management strategies and tactics: (1) intensive surveys, particularly for exotic beetle species and associated fungal strains; (2) molecular genetics studies that would facilitate the identification of known and new strains and genotypes, particularly of ambrosia fungi; (3) studies of the pathogenicity of ambrosia fungi as well as other fungi that could predispose trees to attack; and (4) investigations of the chemical ecology of tree-attacking species that could lead to new pest management tools and tactics.


Abstract: Review of literature indicates that many uncertainties and assumptions exist in predicting the impacts of a climate change on forest ecosystems. However, current knowledge is sufficient to encourage any measures that are combating...
climate change, that is, to reduce first and foremost the release of harmful substances to the atmosphere.


Abstract: Whitebark pine (Pinus albicaulis Engelm.) is threatened across its native range by an exotic fungal pathogen introduced within the last century. Mortality has been extensive, and projected potential range shifts based on impeding climate change have revealed further pressures to survival and adaptation for this long-lived, high-elevation conifer.

Quantifying genetic variation and the mating system of whitebark pine in its northern range provides a basis for effective conservation measures. Isozyme analysis of vegetative bud tissue revealed high expected heterozygosity (0.262), moderate population differentiation (FST = 0.061) and highly significant correlations between observed heterozygosity and geographic variables (R² = 0.36, latitude; R² = 0.30 longitude), supporting the hypothesis that this species recolonized its current northern range following glacial retreat from several refugia in the Washington and Oregon Cascades and in the northern Rockies. Mating system analysis based on simultaneous isozyme analyses of embryo and haploid megagametophyte tissues found relatively high levels of consanguineous mating and selfing for a conifer (tm = 0.73) within populations. Avian seed distribution by the Clark's nutcracker (Nucifraga columbiana Wilson) appears to be the overriding factor influencing genetic patterns: being a mutualistic seed disperser, caches comprised of related seeds develop into clumped stands with strong family substructure. While it is a critical wildlife habitat component, lack of commercial utilization has made in situ adaptation the primary conservation focus. Encouraging regeneration success and nutcracker caching by maintaining natural fire regimes will provide an ecosystem-based conservation solution; however, in the Rocky Mountains between 52 degree N and 47 degree N, disease-resistant individuals should be located and propagated to ensure long-term survival of the species in high pathogen hazard areas.


Abstract: "I have found that climate although not most favorable to the spread of blister rust in the GYE, is not limiting, and that it is likely blister rust will increasingly be a source of mortality to whitebark pine in the GYE. Under projected climate change conditions, blister rust is likely to be even more of a problem region-wide. I am still in the preliminary stages of my GIS analysis."


Abstract: Concentrations of atmospheric CO2 and tropospheric ozone (O-3) are rising concurrently in the atmosphere, with potentially antagonistic effects on forest net primary production (NPP) and implications for terrestrial carbon sequestration. Using free-air CO2 enrichment (FACE) technology, we exposed north-temperate forest communities to concentrations of CO2 and O-3 predicted for the year 2050 for the first 7 yr of stand development. Site-specific allometric equations were applied to annual nondestructive growth measurements to estimate above- and below-ground biomass and NPP for each year of the experiment. Relative to the control, elevated CO2 increased total biomass 25, 45, and 60% in the aspen, aspen-birch and aspen-maple communities, respectively. Tropospheric O-3 caused 23, 13, and 14% reductions in total biomass relative to the control in the respective communities. Combined fumigation resulted in total biomass response of -7.8, +8.4 and +24.3% relative to the control in the aspen, aspen-birch and aspen-sugar maple communities, respectively. These results indicate that exposure to even moderate levels of O-3 significantly reduce the capacity of NPP to respond to elevated CO2 in some forests.


Abstract: Until now, cold winters in the boreal region and in some temperate regions have protected forests from many insects and fungi that are common further south. Throughout Europe, major outbreaks of many damaging insects and fungi are closely related to the occurrence of dead and dying trees produced by abiotic damages. High summer temperatures and associated summer drought increase the growth of existing insect populations through enhancing physiological activity and the turnover of insect populations. Throughout Europe, the forests seem to be quite well buffered against damages induced by new species coming outside Europe, but the risk exists.

Abstract: Many uncertainties remain regarding how climate change will alter the structure and function of forest ecosystems. At the Aspen FACE experiment in northern Wisconsin, we are attempting to understand how an aspen/birch/maple forest ecosystem responds to long-term exposure to elevated carbon dioxide (CO2) and ozone (O3), alone and in combination, from establishment onward. We examine how O3 affects the flow of carbon through the ecosystem from the leaf level through to the roots and into the soil micro-organisms in present and future atmospheric CO2 conditions. We provide evidence of adverse effects of O3, with or without co-occurring elevated CO2, that cascade through the entire ecosystem impacting complex trophic interactions and food webs on all three species in the study: trembling aspen (Populus tremuloides Michx.), paper birch (Betula papyrifera Marsh), and sugar maple (Acer saccharum Marsh). Interestingly, the negative effect of O3 on the growth of sugar maple did not become evident until 3 years into the study. The negative effect of O3 effect was most noticeable on paper birch trees growing under elevated CO2. Our results demonstrate the importance of long-term studies to detect subtle effects of atmospheric change and of the need for studies of interacting stresses whose responses could not be predicted by studies of single factors. In biologically complex forest ecosystems, effects at one scale can be very different from those at another scale. For scaling purposes, then, linking process with canopy level models is essential if O3 impacts are to be accurately predicted. Finally, we describe how outputs from our long-term multispecies Aspen FACE experiment are being used to develop simple, coupled models to estimate productivity gain/loss from changing O3.


Abstract: Atmospheric CO2 is rising rapidly, and options for slowing the CO2 rise are politically charged as they largely require reductions in industrial CO2 emissions for most developed countries. As forests cover some 43% of the Earth’s surface, account for some 70% of terrestrial net primary production (NPP), and are being bartered for carbon mitigation, it is critically important that we continue to reduce the uncertainties about the impacts of elevated atmospheric CO2 on forest tree growth, productivity, and forest ecosystem function. In this paper, I review knowledge gaps and research needs on the effects of elevated atmospheric CO2 on forest above- and below-ground growth and productivity, carbon sequestration, nutrient cycling, water relations, wood quality, phenology, community dynamics and biodiversity, antioxidants and stress tolerance, interactions with air pollutants, heterotrophic interactions, and ecosystem functioning. Finally, I discuss research needs regarding modeling of the impacts of elevated atmospheric CO2 on forests. Even though there has been a tremendous amount of research done with elevated CO2 and forest trees, it remains difficult to predict future forest growth and productivity under elevated atmospheric CO2. Likewise, it is not easy to predict how forest ecosystem processes will respond to enriched CO2. The more we study the impacts of increasing CO2, the more we realize that tree and forest responses are yet largely uncertain due to differences in responsiveness by species, genotype, and functional group, and the complex interactions of elevated atmospheric CO2 with soil fertility, drought, pests, and co-occurring atmospheric pollutants such as nitrogen deposition and O3. Furthermore, it is impossible to predict ecosystem-level responses based on short-term studies of young trees grown without interacting stresses and in small spaces without the element of competition. Long-term studies using free-air CO2 enrichment (FACE) technologies or forest stands around natural CO2 vents are needed to increase the knowledge base on forest ecosystem responses to elevated atmospheric CO2. In addition, new experimental protocols need to continue to be developed that will allow for mature trees to be examined in natural ecosystems. These studies should be closely linked to modeling efforts so that the inference capacity from these expensive and long-term studies can be maximized.


Abstract: Armillaria root disease (ARD) occurrence on ponderosa pine (Pinus ponderosa) is not uniform in the Black Hills of South Dakota, USA. To help manage this ecosystem, a model was developed to predict the probability of observing diseased trees. A kernel density estimator was used to estimate the probability of observing ARD using presence data from two field studies. An eight-parameter regression equation using topographical data (UTM) coordinates, elevation and slope) derived from a Digital Elevation Model was fitted to the estimated probabilities and the residuals kriged to produce correction factors for the regression estimates. The final model, which had a relative mean squared error of 0.128, identified two peaks of high probability in the north-west portion of the Black Hills and several peaks of moderate probability throughout the Black Hills.


Abstract: Studies by light and scanning-electron microscopy in combination with specific isolation techniques revealed the presence of soil-borne Phytophthora species in declining oak, beech and other forest trees. The sequence of histopathological reactions in infected roots and distinct fungal structures found in necrotic tissues are documented. Specific laboratory procedures used for the detection and identification of Phytophthora are presented. Pathogenicity of the isolated Phytophthora species is shown by common tests of soil infestation and stem inoculation. The possible role of predisposing and contributing factors leading to this type of decline is discussed with emphasis on climate change and excess nitrogen.


Abstract: Climate change scenarios in central North America were projected for selected weather stations using a stochastic daily weather simulation model. The projections were conditioned on changes in seasonal temperature and precipitation as predicted by several global climate models. The impacts of these projected changes on temperate forest ecosystems were evaluated through projected changes in such variables as average annual temperature, average growing season temperature, and the ratio of potential evaporation to precipitation during July and August. Even the mildest climate change scenario examined indicated that ecologically significant changes could occur in the composition and productivity of these forests. The possibility also exists that climatically induced regional decline episodes for a number of important commercial species could occur in the northern temperate forests of central North America.


Abstract: Because species affect ecosystem functioning, understanding migration processes is a key component of predicting future ecosystem responses to climate change. This study provides evidence of range expansion under current climatic conditions of an indigenous species with strong ecosystem effects. Surveys of stands along the northern distribution limit of lodgepole pine (Pinus contorta var. latifolia) in central Yukon Territory, Canada showed consistent increases in pine dominance following fire. These patterns differed strongly from those observed at sites where pine has been present for several thousand years. Differences in species thinning rates are unlikely to account for the observed increases in pine dominance. Rates of pine regeneration at its range limits were equivalent to those of spruce, indicating a capacity for rapid local population expansion. The study also found no evidence of strong climatic limitation of pine population growth at the northern distribution limit. We interpret these data as evidence of current pine expansion at its range limits and conclude that the northern distribution of lodgepole pine is not in equilibrium with current climate. This study has implications for our ability to predict vegetation response to climate change when populations may lag in their response to climate.


Abstract: The temperature during maternal reproduction affects adaptive traits in progenies of Norway spruce (Picea abies (L.) Karst.). Seed production in a cold environment advances bud set and cold acclimation in the autumn and dehardening and flushing in spring, whereas a warm reproductive environment delays timing of these traits. We repeated crosses between the same parents and produced seeds under contrasting temperatures. Elevated temperatures were applied at different time points from female meiosis to embryogenesis, followed by full-sib progeny tests in common environments. We measured timing of terminal bud formation, cold acclimation in the autumn and transcription levels of conifer phytochromes PhyO, PhyN, PhyP, and the class IV chitinase PaChi4 in these tests. No progeny differences were found that could be related to temperature differences during prezygotic stages and fertilization. In contrast, progeny performance was strongly associated with the degree-days from proembryo to mature seeds. Progenies with a warm embryonic history formed terminal buds later, were less hardy and expressed lower transcription levels of the Phy and PaChi4 genes. We hypothesize that temperature during zygotic embryogenesis and seed maturation regulates an "epigenetic memory" in the progeny, involving differential expression of genes that may regulate bud phenology, cold acclimation and embryogenesis in Norway spruce.


Abstract: Adaptive traits in Picea abies (Norway spruce) progenies are influenced by the maternal temperatures during seed production. Here, we have extended these studies by testing the effects of maternal photoperiod and temperature on phenology and frost hardiness on progenies. Using eight phytotron rooms, seeds from three unrelated crosses were made in an environmental 2 x 2 factorial combination of long and short days and high and low temperatures. The progenies were then forced to cease growth rapidly at the end of the first growing season. An interactive memory effect was expressed the second growth season. Progenies from high temperature and short days, and from low temperatures and long days, started growth later in spring, ceased shoot growth later in summer, grew taller and were less frost hardy in the autumn than their full siblings from low temperatures and short days, and from high temperatures and long days. Norway spruce has developed a memory mechanism, regulating adaptive plasticity by photoperiod and temperature, which could counteract harmful effects of a rapidly changing climate.

Johansson, S.M.; Pratt, J.E.; Asiegbu, F.O. 2002. Treatment of Norway spruce and Scots pine stumps with urea against the

**Abstract:** The mode of action of urea in inhibiting infection of stumps of Norway spruce and Scots pine by *Heterobasidion annosum* was investigated. Stem discs from both species were treated with either urea, ammonium salt, ammonia or potassium hydroxide. Neither urea per se nor ammonium ions affected the growth of *H. annosum*, but the fungus was inactivated in wood at pH greater than or equal to 7. Urea treatment of pine stem discs or stumps caused a significant rise in both pH (to pH > 8) and ammonia content within 24 h in sapwood but not in heartwood. In spruce, rises in pH started in the outer sapwood and were followed by sequential increases progressively towards the heartwood. After urea application to freshly-cut pine and spruce stumps, ammonia formation and pH rise started immediately, and initially there was a correlation between pH rise and ammonia content in the wood. High pH and high ammonia content were maintained for at least 3-4 months in warm humid weather. Ammonia was released to a greater extent in spruce and pine bark than in the adjacent sapwood but without a corresponding P rise in pH. Studies on the urease activity suggested that the urea was initially decomposed by urease of host rather than microbial origin. The rate of ammonia decomposition and pH rise was found to be strongly dependent on temperature.

JISAO Climate Impact Group (University of Washington) null. Impacts of climate change and variability in the Pacific Northwest. JISAO Contribution #715.

**Annotation:** Notes: Some interesting references

**Key Words:** Notes: Some interesting references


**Abstract:** The aim of the study was to define the rate of stress load of existing Norway spruce stands of nutrient-rich sites of the Drahany Highlands (the Czech Republic) and to predict its further development with respect to risks of the activation of fungal pathogens and insect pests. In the past, stands under conditions of the 3(rd) and 4(th) forest vegetation zones of the Drahany Highlands were relatively slightly up to moderately loaded by synergistic effects of natural and anthropogenic stress factors on assimilatory organs. In the majority of stands, the inner tolerance of trees to the stressors has been already exceeded. However, the adaptation potential of stands to multiple stress impact has not been used up yet. Changed climatic conditions predicted by the climatic change scenarios will result in the destabilization of existing spruce stands. The stand disintegration will be accompanied with the acceleration of Armillaria sp. and cambioxylophagous insect as mortality stressors. It is possible to expect that growing spruce in the present 1(st) to 3(rd) forest vegetation zones will not be possible. Similarly, in the most distributed Management Group 45 nutrient-rich sites of medium altitudes, it is possible to expect destabilization and disintegration of existing stands.


**Abstract:** Human activities have altered the distribution and quality of terrestrial ecosystems. Future demands for goods and services from terrestrial ecosystems will occur in a world experiencing human-induced climate change. In this study, we characterize the range in response of unmanaged ecosystems in the conterminous U.S. to 12 climate change scenarios. We obtained this response by simulating the climatically induced shifts in net primary productivity and geographical distribution of major biomes in the conterminous U.S. with the BIOME 3 model. BIOME 3 captured well the potential distribution of major biomes across the U.S. under baseline (current) climate. BIOME 3 also reproduced the general trends of observed net primary production (NPP) acceptably. The NPP projections were reasonable for forests, but not for grasslands where the simulated values were always greater than those observed. Changes in NPP would be most severe under the BMRC climate change scenario in which severe changes in regional temperatures are projected. Under the UIUC and UIUC + Sulfate scenarios, NPP generally increases, especially in the West where increases in precipitation are projected to be greatest. A CO2-fertilization effect either amplified increases or alleviated losses in modeled NPP. Changes in NPP were also associated with changes in the geographic distribution of major biomes. Temperate/boreal mixed forests would cover less land in the U.S. under most of the climate change scenarios examined. Conversely, the temperate conifer and temperate deciduous forests would increase in areal extent under the UIUC and UIUC + Sulfate scenarios. The Arid Shrubland/Steppe would spread significantly across the southwest U.S. under the BMRC scenario. A map overlay of the simulated regions that would lose or gain capacity to produce corn and wheat on top of the projected distribution of natural ecosystems under the BMRC and UIUC scenarios (Global mean temperature increase of +2.5 degrees C, no CO2 effect) helped identify areas where natural and managed ecosystems could contract or expand. The methods and models employed here are useful in identifying: (a) the range in response of unmanaged ecosystem in the U.S. to climate change and (b) the areas of the country where, for a particular scenario of climate change, land cover changes would be most likely.

http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/ 9/12/2008

**Abstract:** Aim We describe and use a model, SHIFT, to estimate potential migration due to climate change over the next 100 years. Location Eastern United States. **Methods** Five species, currently confined to the eastern half of the United States and not extending into Canada, were used to assess migration potential: *Diospyros virginiana* (persimmon), *Liquidambar styraciflua* (sweetgum), *Oxydendrum arboreum* (sourwood), *Pinus taeda* (loblolly pine), and *Quercus falcata* var. falcata (southern red oak). SHIFT is a matrix simulation model using simple inverse power functions to provide a distance decay of seed dispersal and is driven primarily by the abundance of the species near the boundary, the forest density within and beyond the boundary, and the distance between cells. For each cell outside the current boundary, the model creates an estimate of the probability that each unoccupied cell will become colonized over a period of 100 years. SHIFT is a 'fat-tailed' migration model that allows rare very long distance dispersal events and colonization could occur up to 500 km beyond the current distribution boundary. Model outputs were analysed using transects through sections showing relatively low and high colonization probabilities as a result of low and high densities of target trees (high source strength) as well as high densities of forest (high sink strength). We also assess migration potential for species by concentric rings around the current boundary. **Results** Model outputs show the generally limited nature of migration for all five species over 100 years. There is a relatively high probability of colonization within a zone of 10-20 km (depending on habitat quality and species abundance) from the current boundary, but a small probability of colonization where the distance from the current boundary exceeds about 20 km. Whether biologically plausible or not, rare very long distance migration events are not sufficient to rescue migration. Species abundance (the source strength of migration) near the range boundary carried relatively more influence than percentage forest cover (sink strength) in determining migration rates. **Main conclusion** The transect evaluation revealed the importance of abundance of the species near the boundary, indicating that rare species may have much more difficulty in unassisted northward migration due to climate change. The concentric rings analysis of the model outputs showed that only the first 10-20 km of area would have a reasonably high probability of colonization. Rare, long-distance events permit colonization of remote outliers, but much more needs to be understood about the likelihood of these rare events to predict the frequency of outlier establishment.


**Abstract:** Potential changes in tree species richness and forest community types were evaluated for the eastern United States according to five scenarios of future climate change resulting from a doubling of atmospheric carbon dioxide (CO₂). DISTRIB, an empirical model that uses a regression tree analysis approach, was used to generate suitable habitat, or potential future distributions, of 80 common tree species for each scenario. The model assumes that the vegetation and climate are in equilibrium with no barriers to species migration. Combinations of the individual species model outcomes allowed estimates of species richness (from among the 80 species) and forest type (from simple rules) for each of 2100 counties in the eastern United States. Average species richness across all counties may increase slightly with climatic change. This increase tends to be larger as the average temperature of the climate change scenario increases. Dramatic changes in the distribution of potential forest types were modeled. All five scenarios project the extirpation of the spruce-fir forest types from New England. Outputs from only the two least severe scenarios retain aspen-birch, and they are largely reduced. Maple-beech-birch also shows a large reduction in area under all scenarios. By contrast, oak-hickory and oak-pine types were modeled to increase by 34% and 29%, respectively, averaged over the five scenarios. Although many assumptions are made, these modeled outcomes substantially agree with a limited number of predictions from researchers using paleoecological data or other models.


**Intergovernmental Panel on Climate Change** 2001. Working Group II: Impacts, adaptation and vulnerability [Web Page].

**Annotation:** Notes: "At present, cold winters in boreal and some temperate regions protect forests from many insects and fungi that are common further south (Straw 1995). High summer temperatures and associated drought increase the growth of existing insect populations through enhanced physiological activity and turnover of insect populations. Throughout Europe, forests seem to be quite well buffered against new species coming from outside Europe, but the risk exists."

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**Intergovernmental Panel on Climate Change** 1998. Chapter 8: North America [Web Page].

Annotation: Notes: Climate change is expected to increase the areal extent and productivity of forests over the next 50-100 years (medium confidence). Extreme and/or long-term climate change scenarios indicate the possibility of widespread decline (low confidence). Climate change is likely to cause changes in the nature and extent of several "disturbance factors" (e.g., fire, insect outbreaks) (medium confidence). Of particular interest in North America are changes in fire regimes, including an earlier start to the fire season, and significant increases in the area experiencing high to extreme fire danger. The long-term effects of fire will depend heavily on changes in human fire management activities, which are uncertain, especially in remote boreal forests. There is a strong need for a long-term comprehensive system to monitor forest "health" and disturbance regimes over regional scales that can function as an early warning system for climate change effects on forests.

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url: http://www.grida.no/climate/ipcc_tar/wg2/547.htm#4


Abstract: Increasing greenhouse gas concentrations are expected to have significant impacts on the world's climate on a timescale of decades to centuries. Evidence from long-term monitoring studies is now accumulating and suggests that the climate of the past few decades is anomalous compared with past climate variation, and that recent climatic and atmospheric trends are already affecting species physiology, distribution, and phenology.


Abstract: Sugar maple (Acer saccharum) is a keystone species in the forests of the northeastern and midwestern United States and eastern Canada. Its sustained health is an important issue in both managed and unmanaged forests. While sugar maple generally is healthy throughout its range, decline disease of sugar maple has occurred sporadically during the past four decades; thus, it is important to understand the abiotic and biotic factors contributing to sugar maple health. Soil moisture deficiency or excess, highway deicing salts, and extreme weather events including late spring frosts, midwinter thaw/freeze cycles, glaze damage, and atmospheric deposition are the most important abiotic agents. Defoliating insects, sugar maple borer (Glycyphagus species), Armillaria root disease, and injury from management activities represent important biotic factors. Studies of sugar maple declines over the past four decades reveal that nutrient deficiencies of magnesium, calcium, and potassium; insect defoliation; drought; and Armillaria were important predisposing, inciting, and contributing factors in sugar maple declines. Forestland managers can contribute to sustained health of sugar maple by choosing appropriate sites for its culture, monitoring stress events, and examining soil nutrition.


Abstract: Data from a study of 3001 dominant or codominant Picea rubens in Maine, New Hampshire, and Vermont and the Adirondack Mountains of New York showed that annual growth in basal area increased consistently from 1910 to 1920 to about 1960. It then fluctuated around a generally declining trend and by the early 1980s was 13 to 40% below its peak. Defoliation by the spruce budworm, climate change, maturation of the forest, and acid deposition are discussed as possible explanations.


Abstract: The activities of insects and diseases greatly influence the structure and function of Canada's forest ecosystems from regeneration through mortality. Currently insects and diseases cause about 100 million m3, in annual losses to Canada's productive forest. The relationship between climate and plant disease is well established, though there has been
little attention paid to the link between climate change and tree diseases. While global warming might influence the distribution and abundance of diseases, our ability to identify and predict these factors is limited. On this basis, working to understand and monitor diseases is an important part of Canada's work to manage for climate change impacts. Proposed climate change scenarios, which include warmer winter temperatures and more frequent droughts, will affect the occurrence of plant diseases in forestry in eastern Canada. Climatic change could influence the epidemiology of plant diseases through effects on survival of primary inoculum, rate of disease progress during the growing season, and duration of epidemics. These effects will positively or negatively influence individual pathogens. Environmental extremes are expected to increase, and interactions between diseases and other biotic and abiotic events, might represent the most important effects of climate change on plant diseases. Due to the long-lived nature of trees, the impact of climate change will have to be considered in forest management plans.


**Abstract:** This report discusses possible effects of climatic and hydrological changes on Norwegian terrestrial ecosystems. Norway is tentatively subdivided into four ecoclimatic sensitivity regions, based on Norwegian climatic and hydrological scenarios. The most sensitive region is suggested to be alpine ecosystems including mountain forests (region I). The ecologically most significant factor for the changes in region I is snow cover and hydrology. The flat river valley bottom region (region IV) is suggested to have the same sensitivity as region I. Melting of permafrost can lead to substantial changes in Svalbards, ecosystems. In the forest region (region II) Scots pine may be favored at the expense of Norway spruce. Dutch elm disease may reduce or even eradicate most elm populations in region II. Natural and anthropogenic migration barriers will delay the invasion of temperature and oceanic plant species. One may expect enhanced biodiversity in the hemiboreal and southern boreal zone in South Norway, whereas Central Norway may have lower biodiversity in the long run. From existing lists of rare and threatened plants, 12 species are suggested to be threatened (directly or indirectly) by climate change. A non-linear type of ecosystem changes is expected in most ecosystems, triggered by a higher frequency and intensity of extreme weather events. The assessment of critical rates and levels of climatic change and tolerance limits for species, will depend of the much better knowledge on ecosystem dynamics and processes, especially demographic processes. The ecotonal boundary method is recommended both for research and monitoring in terrestrial environments, the axis ICSU -IGBP-GCTE is recommended.


**Abstract:** Trembling aspen (Populus tremuloides Michx.) is the most important deciduous tree in the Canadian boreal forest, with >1000 Tg of carbon stored in the aboveground biomass of this species. Since the early 1990s, aspen dieback has been noted over parts of the southern boreal forest and aspen parkland in western Canada. In this study, tree-ring analysis and forest health assessments were conducted in 18 aspen stands near Grande Prairie, Alta., to examine causes of reduced growth and dieback. Defoliation histories were reconstructed based on light-coloured ("white") tree rings and records of past insect outbreaks. The results indicated that several factors contributed to the observed dieback. Defoliation by forest tent caterpillar (Malacosoma disstria Hbn.) and drought in the 1960s and 1980s led to reduced growth and predisposed some stands to secondary damage by wood-boring insects and fungal pathogens. Thaw-freeze events during a period (1984-1993) of unusually light snow cover in late winter may have also contributed to the observed dieback. Under global change, the severity of these stresses may increase, which would pose a serious concern for the future health, productivity, and carbon sequestration of aspen forests in the region.


**Abstract:** Increasing mean global temperatures due to rising levels of carbon dioxide and other "greenhouse" gases in the atmosphere could significantly affect the distribution of commercially important forests in North America. Warmer mean annual temperatures and changing precipitation patterns could cause the range of most temperate forests to shift northward. The temperature increases could outpace the ability of forests to adapt, causing considerable stress and mortality to trees in the southern part of their range without a commensurate increase in growth across the expanding range. If realized, these potential biological impacts on forest distribution and health would affect forest management decisions substantially and could adversely affect forest-based economies in the USA. Specific effects on forest management include changes in the methods and costs of fire, insect, and disease protection; greater demands on forest lands for conversion to food production; and uncertain changes in site quality. Such impacts could affect the economic feasibility of forest management substantially. Subsequent impacts of climate change on the forest products sector in the southern USA alone could total $300 million for declining timber volume and resulting pulp and paper yields, and more than $100 million for increased management costs.


**Annotation:** Notes: Summarizes the lessons from paleoecological records and how managers can apply them.

**Key Words:** Notes: Summarizes the lessons from paleoecological records and how managers can apply them.

Abstract: We developed a species- and location-specific database of published ecophysiological variables typically used as input parameters for biogeochemical models of coniferous and deciduous forested ecosystems in the Western United States. Parameters are based on the requirements of BIOME-BGC, a widely used biogeochemical model that was originally parameterized for the forests of the Pacific Northwest. Several other ecosystem models, including Century 5, Daycent, TEM, and PnET, also use some of the inputs described here. This database provides a compendium of ecophysiological data for the Pacific Northwest that will provide easily accessible information for particular tree species, parameters, and ecosystems for application to simulation modeling.

Annotation: Keywords: Ecological modeling, ecophysiology, Pacific Northwest forests

Key Words: Keywords: Ecological modeling, ecophysiology, Pacific Northwest forests


Abstract: *Abies lasiocarpa* is a major element of high elevation forests and parkland of British Columbia, Canada, and adjacent regions, yet its history, especially in the late-glacial, is poorly understood. We present four new pollen and macrofossil records, summarize modern surface spectra and review previous studies to understand the role of *A. lasiocarpa* during the marked climatic changes of the late-glacial and early-Holocene. Today, in southern British Columbia, *A. lasiocarpa* reaches between 5 and 20% cover in the vegetation at Crater Lake, Buckbean Bog, and Lake of the Woods, but the 1-5% *Abies* pollen values under-represent its occurrence in the vegetation. At Sicamous Creek Lake, *A. lasiocarpa* grows at 50% cover and Pinus is absent locally, but the modern pollen surface spectra under-represent subalpine fir at 10% of the pollen rain. Based on these observations, sediments from Sicamous Creek Lake, Crater Lake, Buckbean Bog, and Lake of the Woods reveal that *Abies* grew locally in the late-glacial period. On southern Vancouver Island, British Columbia, the occurrence of an *A. lasiocarpa* needle, dated to 11 900±400 14C yr BP in a lake core, along with only 1-2% *Abies* pollen, suggests that the tree grew at low elevations where it does not today. These results and a review of regional paleobotanical records suggest that the role of *A. lasiocarpa* in late-glacial and early-Holocene vegetation communities has been under-estimated. This species was likely a major element of the vegetation during this interval and among the first tree species to colonize deglaciated surfaces. Considering the magnitude of future climate change, a better understanding of the history of *A. lasiocarpa* during previous climate changes is necessary to project vegetation response and design effective resource management plans.


Annotation: Notes: Assuming that future climate will be significantly warmer and effectively drier on the northwest coast of North America, major changes in forest composition and structure must be expected (Hebda 1994, 1997a). Being species of relatively moist settings, both red- and yellow-cedars may be expected to decline in abundance. The fossil pollen record clearly reveals that cedars were not abundant during past warm and dry climatic episodes (Hebda and Mathewes 1984; Hebda 1995). However, the current abundance of western redcedar compared to the near absence of western hemlock in the Coastal Douglas-fir biogeoeclimatic zone suggests that redcedar's response to climate change may be complex. Clearly, western redcedar seems to have more drought tolerance than western hemlock. The factors limiting redcedar's abundance in the early Holocene may have involved disturbance regimes in addition to soil moisture. For example, fires may have been more frequent at that time than in the past few thousand years (Mathewes 1985). Soils may have generally been less mature, especially with respect to the development of A horizons and organic matter content. More research is needed on the factors affecting the distribution and growth of cedars. As far as climate change goes, western redcedar should not be written off as a poor choice for future forests. Areas that may experience limited drought and warming, such as the east side of the Queen Charlotte Islands (Haida Gwaii), might become highly favourable to the species. Once again, numerous giants may repopulate the Pacific northwest coast as they probably have done intermittently for hundreds of thousands of years.

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url: http://www.fore.gov.bc.ca/hfd/pubs/Docs/Mr/Mr094/Mr094-01.pdf


Abstract: Predicted changes in climate have raised concerns about potential impacts on terrestrial forest ecosystem productivity, biogeochemical cycling, and the availability of water resources. This review summarizes characteristics of drought typical to the major forest regions of the United States, future drought projections, and important features of plant and forest community response to drought. Research needs and strategies for coping with future drought are also discussed. Notwithstanding uncertainties surrounding the magnitude and direction of future climate change, and the net impact on soil water availability to forests, a number of conclusions can be made regarding the sensitivity of forests to future drought. The primary response will be a reduction in net primary production and stand water use, which are driven by reductions in stomatal conductance. Mortality of small stature plants (i.e., seedlings and saplings) is a likely consequence of severe drought. In comparison, deep rooting and substantial reserves of carbohydrates and nutrients make mature trees less susceptible to water limitations caused by severe or prolonged drought. However, severe or prolonged drought may render even mature trees more susceptible to insects or disease. Drought-induced reductions in decomposition rates may cause a buildup of organic material on the forest floor, with ramifications for fire regimes and nutrient cycling. Although early model predictions of climate change impacts suggested extensive forest dieback and species migration, more recent analyses suggest that catastrophic dieback will be a local phenomenon, and changes in forest composition will be a relatively gradual process. Better climate predictions at regional scales, with a higher temporal resolution (months to days), coupled with carefully designed, field-based experiments that incorporate multiple driving variables (e.g., temperature and CO2), will advance our ability to predict the response of different forest regions to climate change.


Abstract: Tree mortality is an important process causing forest structural and compositional change. In this study, we investigate the influence of drought and topography on recent patterns of tree mortality in old-growth mixed conifer forests in Yosemite National Park, located in the Sierra Nevada Mountains of northern California, USA. The surveyed stands have experienced a century of fire exclusion and are dominated by associations of *Pinus ponderosa*, *Calocedrus decurrens* and *Abies concolor*. The average age of trees in the stands was 88 years. We sought answers to the following questions: (1) Do periods of high tree mortality correspond with drought? (2) Do spatial and temporal patterns of high tree mortality vary by slope aspect? and (3) Do different tree species exhibit similar temporal and spatial patterns of tree mortality? We identified temporal patterns of tree mortality on three north- and south-facing slopes by determining the death date of trees using dendrochronology. Tree death date frequency was then compared by slope aspect and to Palmer Drought Severity Index (PDSI), and April snowpack depth as measures of growing season water availability. The frequency of tree death dates was negatively correlated with annual and seasonal PDSI and April snowpack depth, and more trees died in years with below normal PDSI and snowpack. Correlations between tree mortality and drought were evident only for multi-year periods (2-3 years). Temporal patterns of tree death were similar on north- and south-facing slopes and among species, but the density of dead trees was higher on north than south slopes. Dense stand conditions caused by fire suppression, and the coincident outbreak of bark beetles during drought, may have limited any buffering effect of topography on tree mortality. Drought induced tree mortality in mixed conifer forests in Yosemite National Park highlights the importance of both historical legacies such as fire suppression and exogenous controls such as climate as drivers of vegetation change.


Abstract: The inherent clinal responses of four quantitative traits thought to be adaptive for trees in cold-limited environments (i.e., height-growth cessation, growth rate, resource allocation to aboveground and belowground tissues, and resource allocation to photosynthetic and nonphotosynthetic tissues in the shoot) were characterized under nonlimiting conditions in a controlled glasshouse study for seedlings of three ecologically distinct and co-occurring northern tree species (*Pinus contorta* Dougl. var. latifolia Engelm. (lodgepole pine), *Picea glauca* (Moench) Voss x *Picea engelmannii* Parry ex Engelm. (interior spruce), and *Abies lasiocarpa* (Hook.) Nutt. (subalpine fir)). For each species, clinal trends were quantified among populations adapted to increasing cold-limited climates across an elevation gradient approaching the tree line. In subalpine fir seedlings, strong clinal variation for all the quantitative traits indicated an increasingly conservative response to climate moving toward harsher conditions. Variation in lodgepole pine and interior spruce seedlings suggested a more plastic strategy, favoring competitive traits across a wide range of climate conditions. Study findings suggest that ecologically distinct species may exhibit different strategies in adapting to local climates.

Abstract: Ecological diversity (the product of ecosystem, species, and genetic diversity) will change significantly in the 21st century in response to the combined influence of climate, human activities, the movement of indigenous and non-indigenous species, and natural disturbances like fire (also modified by climate). Many species will acclimate (phenotypic variation) and/or adapt (genotypic variation) to changing conditions. Many will not. Species with a high rate of reproduction that are able to move long distances, rapidly colonize new habitats, tolerate humans, and survive within a broad range of biophysical conditions will be most successful in finding new niches. Large changes in ecosystem composition, structure, and function are expected to occur at northern latitudes and higher altitudes. In some areas novel ecosystems likely will replace existing subalpine, alpine, boreal forest, and tundra ecosystems.


Abstract: This paper was originally presented at "Greenhouse '89 - Climatic change and its impacts," of the 1989 conference of the Meteorological Society New Zealand held at Wellington. It predicts that a change in New Zealand's climate because of the increase in "greenhouse" gases in the atmosphere may affect the productivity of Pinus radiata through increased wind damage, more severe infection by fungal pathogens, and areas becoming too dry or too wet for satisfactory growth. The current P. radiata improvement strategy is well suited to maintain genetic improvement in a changing environment. Future research should consider planting identical field trials at particular sites several years apart, and planting trials at and beyond the current extremes of climate. Research on alternative species in New Zealand (e.g., hybrids of P. caribaea and hybrids of P. pinaster) should be encouraged.


Annotation: Notes: This is the first-ever assessment of the social, biological, and economic impacts of climate change on the different regions of Canada.

Key Words: Notes: This is the first-ever assessment of the social, biological, and economic impacts of climate change on the different regions of Canada.

url: www.climatechange.gc.ca/english/publications/ccs


Abstract: Patterns of spore deposition by Heterobasidion species were studied between the spring of 1998 and December 2000 in four forests in the western Alps using woody traps. The maximum spore deposition rate (DR) ranged from 169 to 1,550 spores m(-2) h(-1). Although spores were captured from February to October at most sites, inoculum concentration consistently peaked in the late summer or early fall. In one of the four study sites, similar patterns of DR were recorded in 2 years of sampling. A significant correlation (r = 0.654, P = 0.001) was found between DR and the average minimum air temperature in the 4 weeks before sampling. Approximately 1,200 spores were isolated and identified at the species level by polymerase chain reaction-based methods. Single-spore isolates were consistently clampless, indicating the sampled airspora was almost exclusively composed of haploid basidiospores. No significant variations of basidiospore frequencies were detected for either H. abietinum or H. annosum among sampling periods. However, the frequency of H. parviporum spores was always significantly higher in the summer. These findings suggest different patterns of sporulation among Heterobasidion species.


Abstract: In this paper we review the ecology and physiology of mountain hemlock (Tsuga mertensiana (Bong.) Carrière) in the context of a dendroclimatological analysis. To better understand the relationship between mountain hemlock growth and climate variability throughout its range we have analyzed chronologies from 10 coastal sites, located along a transect extending from northern California to southern Alaska. The chronologies exhibit significant large-scale cross-correlations, with two distinct growth regions implied: chronologies from the northern Cascades in California, to the Queen Charlotte Islands, British Columbia, are correlated with each other but are distinct from Alaskan chronologies. While intervals of coherent reduced growth along the entire transect occur episodically throughout the record, intervals of coherent enhanced
growth are less common. Response function analyses indicate that summer temperature is the most influential factor limiting growth throughout the study region, while winter precipitation is an additional limiting factor south of Alaska. Warm summer temperatures are associated with enhanced growth in the current year but with reduced growth in the following year. This response is believed to be a reflection of the energy required to mature cones initiated in the preceding year. The association with winter precipitation may reflect the role of deep, persistent snowpacks in regulating the duration of the growing season.


Abstract: Thermostability of photosynthesis was studied in four Mediterranean conifer species growing in southern France, namely Cedrus atlantica and Pinus nigra growing usually on mid-elevation areas, and Cupressus sempervirens and Pinus halepensis from coastal areas. Chlorophyll a fluorescence was used and lead to two indices assessing the degree of thermostability of the photosynthetic apparatus: the critical temperature at ground fluorescence breakpoint (T-c) and the temperature threshold inducing a 15% decrease in photochemical efficiency (T-15). The two indices were correlated and yielded similar rankings among species, although mean values of T-15 were 6.5 degrees C lower than that of T-c. Values of T-c were in the range 44 to 52 degrees C and clear interspecific differences were detected. C. atlantica consistently displayed higher Tc than the other species (1-1.5 degrees C difference during a seasonal time course). Among the three other species (C. sempervirens, P. nigra and P. halepensis), the differences were smaller and not always significant. T-c also displayed a large intraspecific plasticity, with: (i) a seasonal time-course showing significant increases during summer and lower values during Spring and Autumn; and (ii) large responses to ambient temperatures, with 5-6 degrees C increases in response to a gradual rise of temperature from 10 to 35 degrees C. The amplitude of the rise was of the same magnitude in all species. Therefore records of thermostability of photosynthesis, whatever the parameter used (T-c or T-15) need to take into account the large plasticity in this parameter when comparing species or genotypes. The degree of plasticity in response to given changes in micro-environment could be an important functional trait for the tolerance to environmental stresses.

Friends of the Earth Cymru 1997. Climate change potential impacts on Wales. 19 p.

Annotation: Notes: "Milder winters bring increases humidity, which favours pathogenic fungi on pine...Sitka spruce, for example, is more likely to be susceptible to Elatobium surviving the winter...Milder winters will also cause problems with he hardening of seedlings."

Key Words: Notes: "Milder winters bring increases humidity, which favours pathogenic fungi on pine...Sitka spruce, for example, is more likely to be susceptible to Elatobium surviving the winter...Milder winters will also cause problems with he hardening of seedlings."


Abstract: Carbon (C) stocks were assessed for hybrid interior spruce (Picea glauca × Picea engelmannii)-dominated upland forests within the Aleza Lake Research Forest in central British Columbia, Canada. Four old-growth (141-250 years old) and four young second-growth (<20 years old) forest plots were established on the two dominant soil texture types, coarse and fine, for a total of 16 plots. Mean total C stocks for old-growth stands ranged from 423 (coarse) to 324 tonnes C ha-1 (fine), intermediate between Pacific Northwest temperate forests and upland boreal forests. Total C was lower in second-growth stands because of lower tree (mostly large tree stem), forest floor, and woody debris C stocks. In contrast, old-growth forest-floor C stocks ranged from 78 (coarse) to 35 tonnes C ha-1 (fine), 2.9- and 1.2-fold higher than in corresponding second-growth stands, respectively. Woody debris C stocks in old-growth stands totaled 35 (coarse) and 31 tonnes C ha-1 (fine), 2.7- and 3.4-fold higher than in second-growth stands, respectively. Mineral soil C to 1.07 m depth was similar across soil type and age-class, with totals ranging from 115 to 106 tonnes C ha-1. Harvesting of old-growth forests in sub-boreal British Columbia lowers total C stocks by 54-41%.


Annotation: Notes: What the future holds for our forests is difficult to know, partly because regional climate change scenarios are presently not well understood. Some scientists believe that species that thrive in warmer and drier environments, such as white pine, sugar maple, and beech, will have a natural advantage over species of cold, humid environments, such as spruce and balsam fir, which may move further north as the climate warms (Jacobson et al. 1987). Others see spruce and balsam fir gaining ground in the GFE area in the coming decades and centuries because expected temperature variability will cause further dieback in hardwoods which are more susceptible to this process. Insects and disease outbreaks will continue to affect the forest in ways that are difficult to predict. These factors interact with others, including atmospheric nutrient and acid input, which makes prediction of future trends of natural forest change very difficult and risky. In addition, human activity in the post-settlement period has resulted in a reduction in the number of tree species of moderate to high shade tolerance in the forest, and an increase in the dominance of shade-intolerant hardwood species,
and other species readily able to exploit clearcuts, such as balsam fir and red maple. Given the uncertainties associated with future climate change, a reasonable forest objective for the "working" landscape would be to conserve the genetic and species diversity of trees in the forest, or to re-introduce species and genetic diversity where its loss is suspected. The principal benefit is the building of forest stability and resilience for an uncertain future by building stand-level diversity of tolerant and moderately tolerant species. A second benefit of managing for diverse natural regeneration reflecting historical composition is the conservation of microsite variability throughout the forest, which would have positive effects on non-tree species that have limited area requirements, such as many plants, animals and fungi. This does not mean that every species should be propagated everywhere. Rather, species should be matched to the sites where they can be expected to thrive. Natural forest landscape patterns of recent prehistoric and historic time provide clues to how this can be done. Replacement of lost diversity can be attempted by various means, including seeding or planting. Where species and genetic diversity remains intact, harvesting should be conducted so as to maintain species and genetic diversity through natural regeneration. Increased use of tactics such as partial harvesting and limiting opening sizes will provide seed sources and a variety of microsite conditions that will promote diversity at the stand level.

Key Words: Notes: What the forest future holds for our forests is difficult to know, partly because regional climate change scenarios are presently not well understood. Some scientists believe that species that thrive in warmer and drier environments, such as white pine, sugar maple, and beech, will have a natural advantage over species of cold, humid environments, such as spruce and balsam fir, which may move further north as the climate warms (Jacobson et al. 1987). Others see spruce and balsam fir gaining ground in the GFE area in the coming decades and centuries because expected temperature variability will cause further dieback in hardwoods which are more susceptible to this process. Insects and disease outbreaks will continue to affect the forest in ways that are difficult to predict. These factors interact with others, including atmospheric nutrient and acid input, which makes prediction of future trends of natural forest change very difficult and risky. In addition, human activity in the post-settlement period has resulted in a reduction in the number of tree species of moderate to high shade tolerance in the forest, and an increase in the dominance of shade-intolerant hardwood species, and other species readily able to exploit clearcuts, such as balsam fir and red maple. Given the uncertainties associated with future climate change, a reasonable forest objective for the "working" landscape would be to conserve the genetic and species diversity of trees in the forest, or to re-introduce species and genetic diversity where its loss is suspected. The principal benefit is the building of forest stability and resilience for an uncertain future by building stand-level diversity of tolerant and moderately tolerant species. A second benefit of managing for diverse natural regeneration reflecting historical composition is the conservation of microsite variability throughout the forest, which would have positive effects on non-tree species that have limited area requirements, such as many plants, animals and fungi. This does not mean that every species should be propagated everywhere. Rather, species should be matched to the sites where they can be expected to thrive. Natural forest landscape patterns of recent prehistoric and historic time provide clues to how this can be done. Replacement of lost diversity can be attempted by various means, including seeding or planting. Where species and genetic diversity remains intact, harvesting should be conducted so as to maintain species and genetic diversity through natural regeneration. Increased use of tactics such as partial harvesting and limiting opening sizes will provide seed sources and a variety of microsite conditions that will promote diversity at the stand level.

url: www.unb.ca/web/forestry/centers/cwru/soe/chater3.htm


Abstract: Although the speed of growth and adaptability of the north-west American conifer Douglas-fir has been recognized in Portugal, it represents only about 0.1 per cent of the total forest cover. This small area is spread across the mountainous areas of the north and centre of the country. This study models Douglas-fir productivity based on site factors and estimates the potential area for Douglas-fir in Portugal. Soil, climate and topographic data were collected on 39 plots across the range of sites where Douglas-fir grows in Portugal. The analysis of the data followed three steps: (1) selection of site factors related to the variation in the site index; (2) choice of candidate models; and (3) consideration of the best model to explain and predict the site index from site factor variables. The best multiple linear regression model explained 90 per cent of site index variation but included variables not readily available in the field. A model using digitized site data explained 54 per cent of the variation in the site index and mapped the areas with potential for Douglas-fir growth in Portugal. It is estimated that a potential Douglas-fir planting area of 250 000 ha exists where trees will exceed 17 m dominant height at age 30 years. This would correspond to 8 per cent of the existing Portuguese forest area. The best sites and estimates the potential area for Douglas-fir in Portugal. Soil, climate and topographic data were collected on 39 plots across the range of sites where Douglas-fir grows in Portugal. The analysis of the data followed three steps: (1) selection of site factors related to the variation in the site index; (2) choice of candidate models; and (3) consideration of the best model to explain and predict the site index from site factor variables. The best multiple linear regression model explained 90 per cent of site index variation but included variables not readily available in the field. A model using digitized site data explained 54 per cent of the variation in the site index and mapped the areas with potential for Douglas-fir growth in Portugal. It is estimated that a potential Douglas-fir planting area of 250 000 ha exists where trees will exceed 17 m dominant height at age 30 years. This would correspond to 8 per cent of the existing Portuguese forest area. The best sites for Douglas-fir growth are located along north coastal to central regions at altitudes between 500 and 1000 m with moisture deficit (precipitation minus evapotranspiration) above 1000 mm. Areas with acceptable sites for Douglas-fir growth are located in the north and centre of Portugal at 700-1000 m elevation and have a moisture deficit above 400 mm.


Annotation: Notes: "Recent studies conducted in the Olympic Mountains show quite a different view of forest response to climate change than is found in existing literature on low-elevation systems. Tree growth response to winter precipitation is negatively correlated with growth, and is considerably more important than temperature."

Key Words: Notes: "Recent studies conducted in the Olympic Mountains show quite a different view of forest response to climate change than is found in existing literature on low-elevation systems. Tree growth response to winter precipitation is negatively correlated with growth, and is considerably more important than temperature."


Abstract: This study examines the genetic structure of subalpine fir along an elevation gradient in the Olympic Mountains, Washington. Starch gel electrophoresis was used to resolve 15 isozyme loci from 9 populations on 3 mountains. First, we describe the genetic variation of these 9 populations in the Olympic Mountains, and compare these results to those of other tree species. Then we compare genetic differentiation (G(ST)) among populations to test if selective pressures alter genotypic frequencies in response to steep environmental gradients over the elevation range of this species. Genetic variation is relatively uniform throughout most of the sites sampled (H-0 range = 0.103-0.139 in the eastern Olympic Mountains), with notably lower diversity observed at the western extent of subalpine fir's range (H-0 = 0.70 in the central Olympic Mountains). Lower diversity in the western Olympics may result from either founder effects as the species expanded its range from a glacial refugium, or from selection pressures on the loci considered. Genetic differentiation is greater among high elevation sites on different mountains, than among different elevation sites on the same mountain, or lower elevation sites on different mountains. Estimates of gene flow (N-m = 7.8) are high among all sites.


Abstract: At the Wind River Canopy Crane Facility in southeastern Washington State, USA, we examined phenotypic variation between upper- and lower-canopy branches of old-growth Thuja plicata J. Donn ex. D. Don (western redcedar). Lower-canopy branches were longer, sprouted fewer daughter branches per unit stem length and were more horizontal than upper-canopy branches. Thuja plicata holds its foliage in fronds, and these had less projected area per unit mass, measured by specific frond area, and less overlap, measured by silhouette to projected area ratio (SPAR(max)), in the lower canopy than in the upper canopy. The value of SPAR (max), used as an indicator of sun and shade foliage in needle-bearing species, did not differ greatly between upper- and lower-canopy branches. We suggest that branching patterns, as well as frond structure, are important components of morphological plasticity in T. plicata. Our results imply that branches of old-growth T. plicata trees have a guerilla growth pattern, responding to changes in solar irradiance in a localized manner.


Abstract: 1 Plant-plant interactions are increasingly considered as complex phenomena involving both negative and positive components. Within a community, the relative importance of these components is probably species-specific and may also vary among life-history stages and along environmental gradients. 2 We used the tree line of the north-eastern Calcareous Alps of Austria, composed of shrubby Pinus mugo and upright Picea abies and Larix decidua, as a simple system in which to investigate these interactions. We focused on the largely unknown effects of pines on spruce and larch, rather than on P. mugo, which is known to be competitively displaced by the two tree species. 3 We used regression models on observational data to analyse the responses of the trees to a gradient of pine cover in terms of recruitment, growth, fecundity and browsing damage, and to determine whether effects involved both competitive and facilitative components, if they depended on the life-history stage of the trees and if they were species-specific. 4 We detected a pronounced negative effect of pine cover on recruitment and growth of both spruce and larch, whereas seed production was unaffected. Larch turned out to be more sensitive to pine competition: its recruitment and growth are superior to that of spruce in open habitats but this advantage vanishes in dense pine thickets. 5 Contrary to expectations, the effects of pine cover on growth rates of spruce and larch did not depend on the life-history stage of the trees. 6 Pine cover is a major determinant of browsing damage for both spruce and larch, indicating that it does have a positive effect in providing shelter against herbivores. 7 The differential effects of pines on spruce and larch are likely to favour spruce at the expense of larch in realizing potential habitat expansion as a result of climate change. Disregarding the complex details of plant-plant interactions may thus result in unrealistic predictions of species responses to environmental changes.


Abstract: 1 Global warming will probably shift treelines upslope in alpine areas and towards the pole in arctic environments. However, responses of regional treelines to climatic trends over the last century do not show any clear trends. We hypothesize that these equivocal responses may partly be caused by limitation of dispersal and/or recruitment that is species-specific to particular trees with potentially expanding ranges. 2 To test this hypothesis, we established and parameterized a temporally and spatially explicit model of plant spread and analysed its sensitivity to: (a) variation in
predicted climatic trends; (b) the spatial distribution of recruits around a seed source; and (c) variation in the resistance of resident non-woody vegetation to invasion. We used data from a high mountain landscape of the Northern Calcareous Alps in Austria where the treeline is dominated by Pinus mugo Turra, a shrubby pine. 3 Low growth rates and long generation times, together with considerable dispersal and recruitment limitation, resulted in an overall slow range expansion under various climate-warming scenarios. 4 Running the model for 1000 years predicted that the area covered by pines will increase from 10% to between 24% and 59% of the study landscape. 5 The shape of the dispersal curve and spatial patterns of competitively controlled recruitment suppression affect range size dynamics at least as severely as does variation in assumed future mean annual temperature (between 0 and 2 °C above the current mean). Moreover, invasibility and shape of the dispersal curve interact with each other due to the spatial patterns of vegetation cover in the region. 6 Ambiguous transient responses of individual treeline systems may thus originate not only from variation in regional climatic trends but also from differences in species' dispersal and recruitment behaviour and in the intensity and pattern of resistance of resident alpine vegetation to invasion.


Abstract: Climate warming is believed to directly affect the growth of trees and, hence, the productivity of the boreal forest in Quebec. We present a recently started NSERC strategic project that aims to model the effects of future climate changes on growth of four dominant boreal (jack pine, black spruce, trembling aspen, and white birch) and two sub-boreal (sugar maple and yellow birch) species of western Quebec to ultimately quantify the impacts on the annual allowable cut for a forest management unit in bitibi-Témiscamingue. Ecophysiological modeling as well as dendroclimatic analysis of forest stands along a latitudinal gradient, from the mixedwood forest to the conifer-dominated forest, will allow identification of the major climatic factors determining the diameter growth of the six species at different latitudes. The resulting climate-growth relationships will drive a series of models to render climate sensitive growth and yield tables and, based on climate simulations of the Regional Canadian Climate Model, to estimate future changes in annual allowable cut due to climate change. The results will allow forest managers to adapt currently used growth and yield tables as well as annual allowable cut to improve forest planning and silviculture of mixed stands and, finally, to assure sustainable forestry.


Abstract: Widespread concern about the sustainability of clearcut regeneration systems has led to the increased use of partial retention systems in British Columbia. In particular, uncertainty surrounds the relative performance of tree species of different shade tolerance, prompting increasing interest in seedling response to a range of light environments. Even more uncertainty surrounds, our understanding of the development of trees in partially cut stands infected with the root diseases. Armillaria ostoyae (Romagnesi) and Inonotus tomentosus (Fr. Fr) S. Teng. We compared light retention (25% of the original basal area), heavy, retention (50% of the original basal area) and clearcut treatments at two sites. A root removal technique (pushover falling) was used for root disease mitigation. Light levels were measured using hemispherical photography. Growth rate increased as the level of canopy openness increased, but did not vary among species differing in shade tolerance. The root removal treatment, by contrast, had no effect on seedling survival after 5 years. Development and expression of the root diseases over the longer term may alter these results. Our findings demonstrate that a variety of partial retention systems can be used to regenerate mixed species forests in the Interior Cedar-Hemlock zone.

Danish Environmental Protection Agency 2004. The decline of Norway spruce [Web Page].

Abstract: To counterbalance the predicted negative impacts of climate change on Norway spruce growth, Danish forest managers are looking to planting it in a mix of mostly native tree species and on suitable sites.

Currie, D. J. 2001. Projected effects of climate change on Norway spruce growth, Danish forest managers are looking to planting it in a mix of mostly native tree species and on suitable sites.


Abstract: Climate change is likely to impact whitebark pine significantly over the next century. Long life span and late maturity of whitebark pine limit its ability to adjust rapidly to change. Three models showed that under current projections of a doubled CO₂ level, whitebark pine will be reduced to less than 10% of its current range in Yellowstone National Park, where it is a major component of alpine and subalpine ecosystems (Mattson and Reinhart 1994). The warmer climate will favor less-hardy species, which heretofore have been restricted to lower elevations by temperature, but will likely find more opportunities to compete with whitebark pine at higher, more rugged locations. Whitebark pine will be less successful at regeneration, and future stands are likely to be more mixed. Implications of this decline are severe, since bears in this area rely heavily on whitebark pine seeds for food year-round.


Abstract: Global change includes dynamics of both the changing physical and chemical climate in which our forests grow.
These stresses or agents of change can act singularly, together, or in tandem and their interactions need to be understood to accurately forecast impacts on productivity, functioning, and composition of our forests. Experiments dealing with global change agents and their interactions will be discussed in view of predisposition of northern hardwoods to climate extremes. Bioclimatic analyses of current and historical declines will also be reviewed and their role in identifying and verifying key agents affecting northern hardwood resources will be discussed. Determination of key agents and their effect thresholds is essential for the mining of climatic databases for biologically relevant events that can form the bases of temporal and spatial correlations with observed dieback and declines. An example of this approach with birch decline will be presented in the light that, defined winter thaw-freeze events known to be damaging to yellow birch (Betula alleghaniensis Britt.), had an increasing trend in annual frequency and intensity during the last 30 years. The geographic extent of the most severe thaw-freeze events when compared with the extent of previously observed yellow birch decline, showed a coincidence with 83% and was 55% of the geographic range.


Abstract: A needle blight common in Pinus strobus in the northeastern U.S.A. has been found to be a syndrome of acute and chronic O₃ damage in current-season needles of susceptible field and potted trees, and is related to ambient O₃ fluctuations, damage occurring at concentrations >3 parts per hundred million. Fumigation of sensitive trees in a polythene chamber at 32 to 38 degrees C produced more severe symptoms of damage with mist than under other environmental conditions. Acute and chronic symptoms are described. Phenotypic susceptibility of the trees varies, but susceptible trees are most sensitive to damage in the 6- to 8-week period of needle elongation in the summer.


Abstract: With improvements in mapping regional distributions of vegetation using satellite-derived information, there is an increasing interest in the assessment of current limitations on forest growth and in making projections of how productivity may be altered in response to changing climatic conditions and management policies. We utilised a simplified physiologically based process model (3-PG) across a 54000 km² mountainous region of southwestern Oregon, USA, to evaluate the degree to which maximum periodic mean annual increment (PAI) of forests could be predicted at a set of 448 forest inventory plots. The survey data were pooled into six broad forest types (coastal rain forest, interior coast range forest, mixed conifer, dry-site Douglas-fir, subalpine forest, and pine forest) and compared to the 3-PG predictions at a spatial resolution of 1 km². We found good agreement (r² = 0.84) between mean PAI values of forest productivity for the six forest types with those obtained from field surveys. With confidence at this broader level of integration, we then ran model simulations to evaluate the constraints imposed by (i) soil fertility under current climatic conditions, (ii) the effect of doubling monthly precipitation across the region, and (iii) a widely used climatic change scenario that involves modifications in monthly mean temperatures and precipitation, as well as a doubling in atmospheric CO₂ concentrations. These analyses showed that optimum soil fertility would more than double growth, with the greatest response in the subalpine type and the least increase in the coastal rain forests. Doubling the precipitation increased productivity in the pine type (> 50%) with reduced responses elsewhere. The climate change scenario with doubled atmospheric CO₂ increased growth by 50% on average across all forest types, primarily as a result of a projected 33% increase in photosynthetic capacity. This modelling exercise indicates that, at a regional scale, a general relationship exists between simulated maximum leaf area index and maximum aboveground growth, supporting the contention that satellite-derived estimates of leaf area index may be good measures of the potential productivity of temperate evergreen forests.


Abstract: Previous climatic response model results are reviewed and more detailed time-dependent modelling of tree growth-climate interactions are performed using the Kalman filter. These new results show that in the NE USA over the past 150 yr there is a clear temporal and altitudinal dependence in response of red spruce (Picea rubens) to climate. Influence of abnormally warm prior-August temperatures become increasingly time-dependent with decreasing altitude, which is contrary to the altitudinal gradient in severity of decline. Thus, this variable, which had been implicated in red spruce decline from previous studies, is unlikely to be a primary cause of current decline. However, it may be implicated in earlier decline at low altitude. Prior-December temperatures are influential at all altitudes, but time-dependent only at the highest altitudinal zone. The emergence of a strongly time-dependent prior-November temperature response is clearly associated with a time-trend in the temperature record. Thus, it is likely that red spruce is responding, in a transient sense, to changing climate. An additional transient response to current-July temperatures is not associated with any unusual behaviour in the data and is, as yet, unexplained. These results show that red spruce is not in equilibrium with its climatic environment, which may have made it more susceptible to damage caused by natural and anthropogenic factors.


Abstract: This report reviews literature concerning the effects of global climate change on forest plants and communities and discusses the potential impacts climate change may have on the forests of Ontario (Canada). There are 10 chapters by different authors, and introductory and concluding sections. There is growing evidence that environmental changes caused by increases in atmospheric CO₂ and its potential effects on global climate will alter forest ecosystems in Ontario. A doubling of CO₂ from pre-industrial levels is expected to occur within 80 yr. Increased CO₂ may increase average summer temperatures in Ontario between 3 and 6 degrees C, with the largest increases in NW and S. Ontario. Precipitation is predicted to increase in NE Ontario, but to decrease in S. and NW Ontario. An increase in summer temperatures with no or little increase in precipitation would increase the frequency and severity of drought by increasing evapotranspiration. Also, extreme weather events and variations in weather are expected to increase. The length of the forest fire season is expected to increase with longer growing seasons, and increased moisture loss from forests due to increased temperatures would increase forest fire frequency and severity. Increases in drought stress could also increase the frequency of major forest insect and disease outbreaks. Increases in forest fires, insect outbreaks and diseases would, in turn, alter the age structure and species in forest ecosystems, with the greatest impacts expected in NW and S. Ontario. Extreme weather events could further damage or stress plants. Increased CO₂, drought, and temperature will affect the growth and survival of plants by altering their physiological behaviour. The genetic structure of plant populations may be affected by altered selection pressures, and species with larger genetic variability are likely to be more adaptable to changed climatic conditions and may be more successful. Competitive abilities of plant species now present in Ontario's forests may change, with some species becoming more competitive and others less so. Productivity and timber supply in NW and S. Ontario may decline due to increases in drought, forest fires, insects and disease, although this may be partially offset by increases in growth rates accompanying higher CO₂ levels, warmer temperatures, and a longer growing season. Increases in precipitation in NE Ontario along with higher CO₂ levels, increased temperatures and longer growing season could significantly increase productivity and timber supply. Over hundreds of years, plant species may migrate northward. Differing migration rates and the species' reactions to new environmental conditions could result in new plant species mixes for which forest management experience is lacking. However, forest management through changed silvicultural and harvesting practices could reduce the impacts of climatic change to forests. Climatic adaptation could also be increased through tree breeding, and carbon sequestration could become a goal of forest management.


Climate Change Impacts and Adaptation Directorate 2002. Climate change impacts and adaptation: a Canadian perspective-Forestry. Ottawa, ON: Climate Change Impacts and Adaptation Directorate.


Abstract: An integrated stratigraphic, paleoecological, and geochronological study of lake and fen sediments just beyond the terminus of Berendon Glacier provides insights into late Holocene climate, vegetation, and glacier change in the northern Coast Mountains of British Columbia. Cores collected from two small lakes in the foreland of Berendon Glacier and pits dug in a nearby fen record Little Ice Age and older glacier advances. The first Little Ice Age advance in this area began more than 500 years ago and peaked in the early 17th century. An earlier Neoglacial advance began about 2800-3000 cal yr ago and may have lasted for hundreds of years. There is also evidence for an intervening advance of even smaller magnitude around 1200-1300 cal yr ago. The advances are broadly synchronous with those in other parts of western North America, indicating that they were caused by regional, possibly global, changes in climate. Plant communities within the study area did not change dramatically during the late Holocene. The ranges of some plants, however, likely retracted or

http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/ 9/12/2008
extended near treeline in response to changes in mean temperatures of perhaps 1-2[deg]C, as well as changes in summer
snow cover. The greatest changes in vegetation occurred within and just beyond the forefields of Berendon, Frank Mackie,
and other nearby glaciers. The largest climate shifts of the last 3000 years took place during the late Little Ice Age and the
last century. Climate warmed about 1-2[deg]C during the 20th century, accompanied by a rise in treeline, an increase in
coniferous tree cover in the subalpine zone, and an increase in the temperature and biological productivity of ponds. These
trends are likely to continue if climate, as expected, continues to warm.

D. (editor). Climate Change and Forest Genetics: 29th Meeting of the Canadian Tree Improvement Association; Kelowna,
6.

Cherry, M. 2005. Options for allocating afforestation stock in Ontario with anticipated climate change. Sault Ste. Marie,
ON: Ontario Forest Research Institute; Forest Research Information Paper No. 148. 36 p.

Chen, X.; Li, B.-L. 2003. Effect of global climate change and human disturbances on tree diversity of the forest regenerating

Abstract: Studies on the combined effects of global climate change and human disturbances are important for biodiversity
conservation and natural resources management. Here we use the modified forest dynamics model to simulate the tree
diversity change of a typical mixed broadleaved Korean pine forest regenerating from clearcuts in Northeast China in
response to global climate change, double concentration of CO2 and human disturbances during the next 50 years. We
consider the following climate change scenario: the annual temperature will increase 2 [deg]C, the annual precipitation will
increase 10% and CO2 concentration will increase to 700 [mu]l l-1 linearly in 50 years. Five kinds of human disturbances
under climate change are considered: logging, which removes all trees with diameter at the breast height of more than 50
cm; removing all individuals of any one species; and removing all individuals of shade tolerant, shade intolerant and
medium type tree species, respectively. We find that the index of proportional representation of species ([alpha] index) for
the forest growing from clearcuts increases significantly under climate change, but decreases under climate change plus
logging. The index of changing representation of species ([beta] index) increases significantly under climate change and
climate change plus logging. When any one species is removed [alpha] diversity of the forest growing from clearcuts
changes significantly under climate change, but [beta] index remains almost the same. When all individuals of shade
tolerant species, shade intolerant species, or medium type species are removed, respectively, [alpha] diversity decreases, but
[beta] diversity changes in more complicated ways. The implications of these results for preserving tree diversity in this
type of forest are also discussed.


Abstract: This bulletin article contains an inventory (including tables and figures) of human and animal (wild and
domesticated, and aquatic and terrestrial) infectious diseases in Ontario, Canada that could be affected by climate change.
Adaptation and mitigation strategies that will help the people of Ontario to prepare for the potential health impacts of
climate change are also discussed.

Chapin, F.S.; Mcguire, A.D.; Randerson, J.; Pielke, R.; Baldocchi, D.; Hobbie, S.E.; Roulet, N.; Eugster, W.;
Kasischke, E.; Rastetter, E. B.; Zimov, S.A.; Running, S.W. 2000. Arctic and boreal ecosystems of western North
America as components of the climate system. Global Change Biology. 6: 211–223.

Abstract: Synthesis of results from several Arctic and boreal research programmes provides evidence for the strong role of
high-latitude ecosystems in the climate system. Average surface air temperature has increased 0.3 degrees C per decade
during the twentieth century in the western North American Arctic and boreal forest zones. Precipitation has also increased,
but changes in soil moisture are uncertain. Disturbance rates have increased in the boreal forest; for example, there has
been a doubling of the area burned in North America in the past 20 years. The disturbance regime in tundra may not have
changed. Tundra has a 3- to 6-fold higher winter albedo than boreal forest, but summer albedo and energy partitioning differ
more strongly among ecosystems within either tundra or boreal forest than between these two biomes. This indicates a need
to improve our understanding of vegetation dynamics within, as well as between, biomes. If regional surface warming were
to continue, changes in albedo and energy absorption would likely act as a positive feedback to regional warming due to
earlier melting of snow and, over the long term, the northward movement of treeline. Surface drying and a change in
dominance from mosses to vascular plants would also enhance sensible heat flux and regional warming in tundra. In the
boreal forest of western North America, deciduous forests have twice the albedo of conifer forests in both winter and
summer, 50-80% higher evapotranspiration, and therefore only 30-50% of the sensible heat flux of conifers in summer.
Therefore, a warming-induced increase in fire frequency that increased the proportion of deciduous forests in the landscape,
would act as a negative feedback to regional warming. Changes in thermokarst and the aerial extent of wetlands, lakes, and
ponds would alter high-latitude methane flux. There is currently a wide discrepancy among estimates of the size and
direction of CO2 flux between high-latitude ecosystems and the atmosphere. These discrepancies relate more strongly to
the approach and assumptions for extrapolation than to inconsistencies in the underlying data. Inverse modelling from
atmospheric CO2 concentrations suggests that high latitudes are neutral or net sinks for atmospheric CO2, whereas field

http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/
measurements suggest that high latitudes are neutral or a net CO2 source. Both approaches rely on assumptions that are difficult to verify. The most parsimonious explanation of the available data is that drying in tundra and disturbance in boreal forest enhance CO2 efflux. Nevertheless, many areas of both tundra and boreal forests remain net sinks due to regional variation in climate and local variation in topographically determined soil moisture. Improved understanding of the role of high-latitude ecosystems in the climate system requires a concerted research effort that focuses on geographical variation in the processes controlling land-atmosphere exchange, species composition, and ecosystem structure. Future studies must be conducted over a long enough time period to detect and quantify ecosystem feedbacks.


Abstract: Global climate has changed since pre-industrial times. Atmospheric CO2, a major greenhouse gas, has increased by nearly 30% and temperature has risen by 0.3 to 0.6[°C]. The intergovernmental panel on climate change predicts that with the current emission scenario, global mean temperature would rise between 0.9 and 3.5[°C] by the year 2100. There are, however, many uncertainties that influence these predictions. Despite the significance of weather on plant diseases, comprehensive analysis of how climate change will influence plant diseases that impact primary production in agricultural systems is presently unavailable. Evaluation of the limited literature in this area suggests that the most likely impact of climate change will be felt in three areas: in losses from plant diseases, in the efficacy of disease management strategies, and in the geographical distribution of plant diseases. Climate change could have positive, negative, or no impact on individual plant diseases. More research is needed to obtain base-line information on different disease systems. Most plant disease models use different climatic variables and operate at a different spatial and temporal scale than do the global climate models. Improvements in methodology are necessary to realistically assess disease impacts at a global scale.


Abstract: Burning of fossil fuel, large scale clearing of forests, and other human activities have changed global climate. Atmospheric concentration of radiatively active CO2, methane, nitrous oxide, and chlorofluorocarbons has increased to cause global warming. In Australia temperature is projected to rise between 1 and 3 degrees C by 2100. This review is the result of a recent workshop on the potential impact of climate change on plant diseases of economic significance to Australia. It gives an overview of projected changes in Australian climate and the current state of knowledge on the effect of climate change on plant diseases. Based on an assessment of important diseases of wheat and other cereals, sugarcane, deciduous fruits, grapevine, vegetables and forestry species, climate change in Australia may reduce, increase or have no effect on some diseases. Impacts will be felt in altered geographical distribution and crop loss due to changes in the physiology of host-pathogen interaction. Changes will occur in the type, amount and relative importance of pathogens and diseases. Host resistance may be overcome more rapidly due to accelerated pathogen evolution from increased fecundity at high CO2, and/or enhanced UV-B radiation. However, uncertainties about climate change predictions and the paucity of knowledge limit our ability to predict potential impacts on plant diseases. Both experimental and modelling approaches are available for impact assessment research. As the development and implementation of mitigation strategies take a long time, more research is urgently needed and we hope this review will stimulate interest.


Abstract: ClimateBC v.2.2 is a standalone MS Windows® application written in Visual Basic 6.0. It extracts and downscales PRISM monthly data (2.5 x 2.5 arcmin), and calculates seasonal and annual climate variables for specific locations based on latitude, longitude and elevation (optional) and for producing climate maps based on digital elevation models (DEM) for British Columbia, Yukon Territories, the Alaska Panhandle, and part of Alberta and US (Figure 1). This program also downscales and integrates future climate datasets for 2020s (2010-2039), 2050s (2040-69) and 2080s (2070-2099) generated by various global circulation models, and observed changes for the years around 2000 (1998-2002), as described in Wang et al. (2005). The output of the program includes both directly calculated and derived climate variables. Downscaling of PRISM monthly data including bilinear interpolation and elevation adjustment, and calculation of climate variables and estimation of derived climate variables are also described in Wang et al. (2005).

Abstract: Italy has a wide range of plant pathological problems. Many are closely related to the tree species grown, to the country's history, ancient or recent, to the type of cultivation of the trees, and to climatic and environmental factors. In the last 50 years, infectious diseases, sometimes caused by pathogens introduced from abroad, have frequently spread through natural forests of chestnut \textit{[Castanea sativa]} and cypress \textit{[Cupressus]} as well as through ornamental plantations of elm \textit{[Ulmus]} and plane \textit{[Platanus]}. At other times, fungal diseases such as rusts have found very favourable environmental conditions for their spread, especially in conifer afforestations, and more particularly those of pine, causing epidemics that are very damaging also from an economic point of view. More often, however, these reforestations are attacked by infectious diseases caused by opportunistic fungi that find the most suitable conditions for their spread in peculiar climatic situations that from time to time arise to put the trees under stress. In many situations, the causes of fungal spread and ways to prevent them are related to particular cultural practices; in other cases it is necessary to counter the disease with biological control, legal measures, genetic improvement, or the improvement of biodiversity.

Annotation: ORIGINAL TITLE: Aspetti fitopatologici delle regioni dell'Italia centrale.

Key Words: ORIGINAL TITLE: Aspetti fitopatologici delle regioni dell'Italia centrale.


Abstract: Site studies have shown that conifer plantations in northern Britain have increased in General Yield Class (GYC) by 1 m3(3 ha-1 a-1) per decade or more (20-40 per cent) since the 1930s. Large increases in forest productivity have also occurred in many other regions of Europe. Are these increases due to improved silvicultural practices or to increases in N deposition, CO2 and temperature? Two process-based mathematical models of forest growth were used to simulate the responses of conifer forests growing in the Scottish southern uplands to increases in atmospheric N deposition, CO2 concentration and temperature, during this century and next century. The models differed substantially in the ways in which underlying processes were represented: one simulated a managed plantation, the other a natural forest. Nevertheless, both showed that: (1) increases in N deposition, CO2 and temperature together might account for up to half of the observed increase in GYC this century; (2) increased N deposition and CO2, considered separately, probably increased forest productivity by a modest amount (7-14 per cent), but their combined effect has been approximately additive; (3) increased temperature, even when combined with increasing CO2 concentrations, promoted growth less than expected from site studies relating GYC to temperature; and (4) substantial further increases in productivity, GYC, leaf area index and standing biomass are forecast during the next century as a result of increasing CO2 concentrations and continued N deposition, with or without climatic warming. The predicted increases in GYC could be large enough to have profound effects on the forest industry.


Abstract: The ability of species to disperse, migrate and adapt is a crucial determinant of their survival in a context of climate change. Trees' capacity to adapt to changing environmental conditions depends mainly on the genetic diversity that exists within their population, since they cannot "flee" when problems arise in their environment. In forest tree species, adaptation is a process that typically spans several generations.


Abstract: Climate change is an undeniable reality, and the boreal forest's response to accelerated global warming will surely have a major impact on forest ecosystems. The effect that higher concentrations of carbon dioxide (CO2) will have on the growth and productivity of forest tree species is one of the concerns at hand.

Canadian Forest Service 2001. Climate change and forests: Context for the Canadian Forest Service's.

Abstract: A major decline in the abundance of whitebark pine (Pinus albicaulis Engelm.) has recently occurred in the United States, primarily as a result of white pine blister rust (Cronartium ribicola J.C. Fisch. ex Raben.). However, no information on the status of whitebark pine in British Columbia, Canada, was available. We sampled 54 subalpine stands in British Columbia, examining all whitebark pine trees within plots for evidence of blister rust and mountain pine beetle (Dendroctonus ponderosae Hopk.) damage. About 21% of all whitebark pine stems were dead, and blister rust was the most important agent of mortality. Of all living trees sampled, 27% had obvious blister rust infection (cankers), but actual incidence was suspected of being as high as 44% (using all evidence of blister rust). Blist er rust incidence and whitebark pine mortality were significantly related to differences in stand structure and the presence of Rihe s spp., but relationships with local climate and site variables were absent or weak. The lack of strong relationships with climate suggests favourable conditions for the spread of the disease throughout most of British Columbia. Very little evidence of mountain pine beetle was found. Overall, the prospects for whitebark pine in British Columbia do not appear good; a large reduction in population levels seems imminent.


Abstract: Elevated solar UV-B radiation associated with stratospheric ozone reduction may exert effects on terrestrial ecosystems through actions on plants, microbes, and perhaps on some animals. At the ecosystem level, the effects are less well understood than at the molecular and organismal levels. Many of the most important, yet less predictable, consequences will be indirect effects of elevated UV-B acting through changes in the chemical composition and form of plants and through changes in the abiotic environment. These indirect effects include changes in the susceptibility of plants to attack by insects and pathogens in both agricultural and natural ecosystems; the direction of these changes can result in either a decrease or an increase in susceptibility. Other indirect effects of elevated UV-B include changes in competitive balance of plants and nutrient cycling. The direct UV-B action on plants that results in changes in form or function of plants appears to occur more often through altered gene activity rather than damage. The yield of some crop varieties can be decreased by elevated UV-B, but other varieties are not affected. Plant breeding and genetic engineering efforts should be able to cope with the potential threats to crop productivity due to elevated UV-B. For forest trees, this may be more difficult if effects of elevated UV-B accumulate over several years. All effects of elevated UV-B radiation must be considered in the context of other climate changes such as increased temperature and levels of carbon dioxide, which may alter the UV-B responses, especially for plants. The actions of elevated carbon dioxide and UV-B appear to be largely independent, but interactions occur between changes in UV-B and other factors. Other ecosystem-level consequences of elevated UV-B radiation are emerging and their magnitude and direction will not be easily predicted.


Abstract: Over the last decades much of the work on the impact of air pollution on forests in Europe has concentrated on central and northern countries. The southern part of Europe has received far less attention, although air pollutants—especially the photochemical ones—can reach concentrations likely to have adverse effects on forest vegetation. Although international forest condition surveys present serious problems where data consistency is concerned, they reveal considerable year-by-year species-specific fluctuations rather than a large-scale forest decline. Cases of obvious decline related to environmental factors are well circumscribed: (1) the deterioration of some coastal forests due to the action of polluted seaspray; (2) the deterioration of reforestation projects, especially conifers, mainly due to the poor ecological compatibility between species and site; and (3) the decline of deciduous oaks in southern Italy and of evergreen oaks in the Iberian peninsula apparently due to the interaction of climate stresses and pests and diseases. However, besides obvious deterioration, changes in environmental factors can provoke situations of more subtle stress. The most sensitive stands are Mediterranean conifer forests and mesophile forests of the Mediterranean-montane plane growing at the edges of the natural ecological distribution. Evergreen sclerophyllous forests appear less sensitive to variations in climatic parameters, since they can adapt quite well to both drought and the action of UV-B rays. Several experiments were carried out to test the sensitivity of Mediterranean forest species to air pollutants. Most of those experiments used seedlings of different species treated with pollutant concentrations too high to be realistic, so it is difficult to derive adequate information on the response of adult trees in field conditions. Ozone has been proved to cause foliar injury in a variety of native forest species in different Southern European countries, while the effects of other pollutants (e.g. nitrogen, sulphur, acidic deposition) are less obvious and likely to be very localized. In the case of ozone, visible symptoms were almost completely missed by large-scale surveys and—at the same time—non-visible symptoms are suspected to be even more widespread than the visible ones. Owing to this and to the complex relationships existing between species sensitivity, ozone exposure and doses, length of the vegetative periods, influence of climatic and edaphic condition on the tree's response, the impacted areas are yet to be identified. Therefore, the large-scale impact of air pollutants on the forests of Southern Europe remains largely unknown, until more specific investigations are carried out.


Abstract: The concept of biological diversity (biodiversity) is reviewed, with special attention to its measurement and natural trends. While generalizations regarding the necessity of biodiversity need to be interpreted with caution, it is argued...
that biodiversity should be protected in more ecosystem and landscape reserves, and that biodiversity is a reasonable management objective on timber lands as well. Maintaining biodiversity is important because we cannot always identify which individual species are critical to ecosystem sustainability, nor which species may be useful to mankind in future. Many wild species can provide useful natural products and genetic material, and can serve as ecological indicators. Diversity reduces pest and disease problems, and encourages recovery from disturbance. Uncertainty exists with regard to climate change and future socioeconomic values. It is therefore prudent to maximize flexibility by promoting a wide array of species and potential products. Suggestions are offered on how to promote biodiversity in multiple-use forests.


Abstract: Pollen and charcoal from East Sooke Fen, Pixie Lake, and Whyac Lake were used to reconstruct the post-glacial vegetation, climate, and fire-disturbance history across a precipitation gradient on southern Vancouver Island, British Columbia. An open Pinus woodland covered the landscape in the early late-glacial interval. Fires were absent under a cool and dry climate. Closed mixed-conifer forests of Pinus, Picea, Abies, Tsuga heterophylla (Raf.) Sarg., and Tsuga mertensiana (Bong.) Carriere replaced the Pinus biogeochron in the late late-glacial interval. Fires became more common although climate was cool and moist. Open Pseudotsuga menziesii (Mirb.) Franco forests expanded westward during the warm dry early Holocene, though closed Picea and Tsuga heterophylla forests grew in the wettest part of the area at Whyac Lake. Modern precipitation gradients likely originated at this time. Fires occurred in forested ecosystems, although East Sooke Fen at the driest end of the gradient experienced less fire. The middle and late Holocene was characterized by...
increasing precipitation and decreasing temperature, respectively. *Quercus garryana* Dougl. stands spread westward during the mid-Holocene. Extant closed *Tsuga heterophylla* and Cupressaceae (*Thuja plicata* Donn. ex D. Don) forests arose in the wetter part of the gradient, whereas *Pseudotsuga* forests occupied drier eastern areas. During this interval, fires were rare in wet western regions but apparently more common in dry eastern regions.

**Abstract:** The global climate is changing as a result of human activity, caused primarily by the increased concentration of carbon dioxide in the atmosphere. The most recent predictions for the UK suggest an increase in temperature and changes in rainfall patterns, wind speed, cloud cover and humidity. This Information Note explains how these environmental changes may affect the growth of trees, including the distribution of individual species. Implications for woodland management and practice are outlined, and guidance is given on climate change adaptation.


null 2004. Climate change in the south-west: implications for timber production. .

**UK Forestry Commission** 2000. Climate change - implications for forestry in Britain. .  
**Abstract:** Global climate is changing as a result of human activity, particularly because of the effects of increased amounts of carbon dioxide in the atmosphere. The most recent predictions from the UK Climate Impacts Programme (UKCIP) suggest an increase in temperature and changes in rainfall, wind speed, cloud cover and vapour pressure. This Information Note explains how the environmental changes that Britain is likely to experience may affect the growth of trees, and how research can improve our understanding of these effects.


**Abstract:** Tree-ring chronologies that represent annual changes in the density of wood formed during the late summer can provide a proxy for local summertime air temperature. Here we undertake an examination of large-regional-scale wood-density/air-temperature relationships using measurements from hundreds of sites at high latitudes in the Northern Hemisphere. When averaged over large areas of northern America and Eurasia, tree-ring density series display a strong coherence with summer temperature measurements averaged over the same areas, demonstrating the ability of this proxy to portray mean temperature changes over sub-continents and even the whole Northern Hemisphere. During the second half of the 20th century, the decadal-scale trends in wood density and summer temperatures have increasingly diverged as wood density has progressively fallen. The cause of this increasing insensitivity of wood density to temperature changes is not known, but if it is not taken into account in dendroclimatic reconstructions, past temperatures could be overestimated. Moreover, the recent reduction in the response of trees to air-temperature changes would mean that estimates of future atmospheric CO₂ concentrations, based on carbon-cycle models that are uniformly sensitive to high-latitude warming, could be too low.

**Abstract:** One of the most destructive of all tree root pathogens, the oomycete fungus *Phytophthora cinnamomi*, is associated with mortality and decline of cork oak (*Quercus suber*) and holm oak (*Q. ilex*) in the Mediterranean region. The symptoms and distribution of this forest decline are described. *P. cinnamomi* is a primary pathogen on a very wide range of tree species and woody ornamentals worldwide, but is probably a native of the Papua New Guinea region. It is soil borne and requires warm, wet soils to infect roots. Since 1900 it has caused major epidemics on native chestnuts (*Castanea* sp.) in the United States and Europe, and is also implicated in jarrah (*Eucalyptus marginata*) ecosystems in some parts of Australia. Together with drought, it may be a major predisposing factor in cork oak and holm oak dieback and decline in southern Spain and Portugal. The possible role of *P. cinnamomi* in this decline, including its interaction with drought, is discussed, and a generalised working hypothesis of forest decline is presented. The potential influence of climate warming on the activity of *P. cinnamomi* is also considered. A computer model based on the CLIMEX program suggests that warming would significantly enhance the activity of the pathogen at its existing disease locations (such as the western Mediterranean and coastal northwest Europe), but that it would not greatly extend its activity into areas with cold winters such as central and eastern Europe.

**Abstract:** The value of trembling aspen (*Populus tremuloides* Michx.) as a resource has increased in Canada in recent years,
but key information regarding the health of this species and its interrelationships with biotic and abiotic agents is lacking. A regional study was conducted to (i) assess the general health of trembling aspen trees in the three prairie provinces of Canada, (ii) determine the incidence of biotic and abiotic agents affecting these trees and (iii) determine what factors most influenced the health of trembling aspen trees between forest tent caterpillar (Malacosoma disstria Hübner) outbreaks. A total of 8296 trembling aspen trees in 85 plots were monitored during 1992-1994. Trembling aspen health was assessed and related to biotic and abiotic damage agents and symptoms. Trembling aspen in the study area were generally healthy: crowns were in good condition, trees had few pests, and mortality rates were low. Confidence intervals for proportion of trees dead less than 2 years are reported by age class. Large aspen tortrix (Choristoneura contigata [Wlk.]) and poplar peniophora (Peniophora polygonia [Pers.:Fr.] Boud. were the most common pests, occurring on 15 and 13% of live trees, respectively; incidences of other pests were <7%. Significant associations between incidences of pests and several stand characteristics were found. Regression analysis showed tree age, a climate moisture index, number of years of forest tent caterpillar defoliation, and incidence of Armillaria root disease (Armillaria spp.) accounted for a significant proportion of the variation in trembling aspen health and mortality. Our results highlight the need to consider pests, especially forest tent caterpillar and Armillaria root disease, in the management of trembling aspen or in landscape-level simulations of trembling aspen productivity.


Abstract: Intra-annual radial growth variations of two Norway spruce trees (Picea abies (L.) Karst.) were monitored over 4 years, at four heights up the stem, by means of point-dendrometers. The trees were then felled and radial wood samples were cut from the radii that had been monitored by the dendrometers and analyzed for density. From the radial growth measurements recorded by the dendrometers, we related positions within the rings to dates, thus making possible investigation of the relationships between changes within the rings in wood density and fluctuations in climate or growth rate. Radial growth started in early April and ended, with large intra-annual differences, in August or September. Short-term variations in growth rate were related to fluctuations in climate parameters and soil water reserves. The sensitivity of radial growth to climate decreased with stem height. Wood density responded strongly to drought events, and a dry period in June 1996 induced false-ring formation. Wood density was relatively independent of growth rate and climatic conditions during the variation in trembling aspen health and mortality. Our results highlight the need to consider pests, especially forest tent caterpillar and Armillaria root disease, in the management of trembling aspen or in landscape-level simulations of trembling aspen productivity.


Abstract: The effects of climatic change on the incidence of fungal, bacterial and viral diseases; nematodes; phytoplasmas; and abiotic diseases/disease complexes in Ontario, Canada are discussed. Tabulated data on the predicted effects of climatic change in the diseases of major agricultural and forestry species in Ontario are appended. Case studies on Sclerotinia sclerotiorum, angular leaf spot of bean (caused by Phaeosiporiopsis griseola), Stewart's wilt on maize (caused by Pantoea stewartii), bacterial spot (caused by Xanthomonas axonopodis pv. vesicatoria) and speck (caused by Pseudomonas syringae pv. tomato) of tomato, potato leafroll virus, soybean cyst nematode (Heterodera glycines), aster yellows, and maple (Acer saccharum) decline are included.


Annotation: Notes: Includes a summary of forestry options to reduce emissions or enhance sinks.

Key Words: Notes: Includes a summary of forestry options to reduce emissions or enhance sinks.


Abstract: This paper addresses processes that affect near-surface climate over the boreal forest, using data from the Boreal Ecosystem-Atmosphere Study (BOREAS) northern study area just west of Thompson, Manitoba. The boreal forest is marked by a very large seasonal cycle with below-freezing temperatures for half the year. The freezing and thawing of the soil plays an important role in the climate at high latitudes. It moderates winter temperatures (together with the insulating snow cover), because during the freeze process, the effective heat capacity of the soil is greatly increased, and it introduces a significant lag into the climate system. Perhaps the most important consequence is that water is unavailable for evaporation and photosynthesis until snow melts and the ground thaws, which occurs late in spring. As a result, in April and in early May, relative humidity (RH) is a minimum, the surface sensible heat flux is large, and the daytime boundary layer (BL) is very deep, because of this unavailability of water. The situation reverses in the fall, when the ground is warmer than the cooling atmosphere, and mean RH is high and BL depths low. This asymmetry between spring and fall can be seen in both seasonal and diurnal cycles. The forest is heterogeneous, and there is a marked difference in summer in daytime evaporative fraction between the conifers and the deciduous forest and fens. However, above the forest the daytime BL has a strong homogenizing effect, and it is the dominant coniferous forest that controls the mean BL depth. The impact of recent rainfall, stored on the canopy, in the surface moss layer, and in the top soil layer can be readily seen in summer. BL depths rise on succeeding days without rain. A comparison of the fen and young jack pine sites shows the important role of the stomatal
control by conifers on transpiration. Since evaporation goes down at high net radiation and low RH for conifer sites, it is clear that the low RH and high BL depth over the forest are a direct consequence of stomatal control. At night, however, temperature, relative humidity, and CO2 are quite heterogeneous under the stable BL. We show that uncoupling of the stable BL at night inside the forest canopy occurs at low wind speeds and high outgoing net radiation and can lead to a 5K cooling within the canopy.


Abstract: Winter survival is a complex trait that does not solely rely on the plant's ability to withstand the direct effects of extreme cold temperatures. During long overwintering periods, plants are exposed to multiple abiotic (ice encasement, frost heave, desiccation, anoxia) and biotic (snow mould and other psychrophilic pathogens) stresses. Tolerance to these various stresses is based in part on shared adaptive traits and, consequently, cross-adaptation to environmental stresses is a key aspect of plant adaptation to cold. Increasing evidence of multiple functions for stress-induced proteins in overwintering plants confirms the need for a global approach in the analysis of adaptive mechanisms. From that perspective, the valorization of rapidly increasing knowledge on the molecular and genetic basis of plant and microbe adaptations to cold will demand multidisciplinary collaborations. Climate change will also need to be taken into account to identify the adaptive traits that will be required for agricultural and forest plants to survive winter in the future. More studies at the global and regional scales will be needed to assess the potential impact of climate warming on plant adaptation to winter and their interactions with low-temperature pathogens.


Abstract: This study examines the effects of climate warming on one of the most widely distributed and destructive forest pathogens, *Phytophthora cinnamomi*. In Europe, the winter survival of the pathogen is the dominant cue for the development of the disease it causes to oaks, especially *Quercus robur* and *Q. rubra*. The potential pathogen and disease geographic ranges were compared in France between two reference periods, 1968-1998 and 2070-2099. Simulations were obtained by combining a physiologically based approach predicting the pathogen winter survival in relation to microhabitat temperature (in the phloem of infected trees) with a regionalized climatic scenario derived from a global circulation model. Positive anomalies in winter temperatures calculated with this scenario were in the range 0.5-5 degrees C between the periods 2070-2099 and the 1968-1998, according to sites and months. As a consequence, higher annual rates of *P. cinnamomi* survival were predicted, resulting in a potential range expansion of the disease of one to a few hundred kilometres eastward from the Atlantic coast within one century. Based on this example, the study emphasizes the need of a better understanding of the impacts of global change on the biotic constraint constituted by plant pathogens.


Abstract: The effects of clear-cutting and thinning as well as heartwood and sapwood moisture content on spore infection by *Heterobasidion annosum* (Fr.) Bref. were investigated in summer cuttings in southern and central Sweden. At five sites, 20-100 stumps in clear-cut, thinned, and precommercially thinned stands of Norway spruce (*Picea abies* (L.) Karat.) were created and left for natural spore infection. An additional 20 stumps per stump type and site were artificially inoculated with conidiospores of *H. annosum*. The probability of natural infection was 0.73 and 0.53 for stumps in thinned and clear-cut stands, respectively. Almost all (95%) of the artificially inoculated stumps in thinned and clear-cut stands became colonized, and no differences due to stump type were found. The probability of infection of stumps in precommercially thinned stands was lower than for the other stump types of both naturally and artificially inoculated stumps. The proportion of colonized sapwood was reduced with increasing moisture content. Stump colonization seemed unaffected by temperature, even though stump temperatures exceeded 40 degrees C for 2 h at one site.


Abstract: One feature of climate change is the trends to earlier spring onset in many north temperate areas of the world. The timing of spring flowering and leafing of perennial plants is largely controlled by temperature accumulation; both temperature and phenological records illustrate changes in recent decades. Phenology studies date back over a century, with extensive databases existing for western Canada. Earlier spring flowering has been noted for many woody plants, with larger trends seen for species that develop at spring's start. Implications for ecosystems of trends to earlier spring arrival include changes in plant species composition, changes in timing and distribution of pests and disease, and potentially disrupted ecological interactions. While Alberta has extensive phenology databases (for species, years, and geographic coverage) for recent decades, these data cannot provide continuous ground coverage. There is great potential for phenological data to provide ground validation for satellite imagery interpretation, especially as new remote sensors are becoming available. Phenological networks are experiencing a resurgence of interest in Canada (www.plantwatch.ca) and globally, and linking these ground-based observations with the view from space will greatly enhance our capacity to track the biotic response to climate change.
climate changes.


Abstract: Photosynthesis of temperate trees growing in a competitive environment was investigated here in a factorials design of community composition (deciduous, coniferous and mixed species), carbon dioxide and nitrogen treatments. This study included seedlings of three deciduous (Betula alleghaniensis, Quercus rubra, Acer rubrum) and three coniferous (Pinus strobus, Picea rubens, Tsuga canadensis) species. Nitrogen partitioning changed significantly in response to the treatments. Higher area-based nitrogen concentrations (N-a) in the conifer needles, however, did not induce higher growth rates. Analysis of biochemical limitations of photosynthesis revealed that deciduous trees invested more nitrogen into carboxylation (V-cmax), electron transport (J(max)) and P-i regeneration capacity, but at much lower absolute concentrations for Na than conifers; consequently conifers maintained much higher rates for all three parameters. Deciduous species showed a strong stomatal limitation, whereas conifers maintained higher stomatal conductance at increasing mesophyll internal carbon dioxide concentration, indicating a much stronger assimilatory response to elevated carbon dioxide. Differences between the biochemical and stomatal response to elevated carbon dioxide and nitrogen indicate that within mixed stands, individual plant responses do not fully, characterize community response.


Abstract: The extension of growing season at high northern latitudes seems increasingly clear from satellite observations of vegetation extent and duration1,2. This extension is also thought to explain the observed increase in amplitude of seasonal variations in atmospheric CO2 concentration. Increased plant respiration and photosynthesis both correlate well with increases in temperature this century and are therefore the most probable link between the vegetation and CO2 observations3. From these observations1,2, it has been suggested that increases in temperature have stimulated carbon uptake in high latitudes1,2 and for the boreal forest system as a whole4. Here we present multi-proxy tree-ring data (ring width, maximum late-wood density and carbon-isotope composition) from 20 productive stands of white spruce in the interior of Alaska. The tree-ring records show a strong and consistent relationship over the past 90 years and indicate that, in contrast with earlier predictions, radial growth has decreased with increasing temperature. Our data show that temperature-induced drought stress has disproportionately affected the most rapidly growing white spruce, suggesting that, under recent climate warming, drought may have been an important factor limiting carbon uptake in a large portion of the North American boreal forest. If this limitation in growth due to drought stress is sustained, the future capacity of northern latitudes to sequester carbon may be less than currently expected.


Abstract: Forests cover much of British Columbia's landscape and are the source of numerous important resources. The damage or loss of these resources due to climate change would have serious environmental and socio-economic consequences for the province. Forest managers will not be able to mitigate all the potential impacts over such an extensive landbase. However, some measures may be taken in regenerating harvested areas to reduce the risks, and to take advantage of some the benefits, of climate change in the province's managed forests. Using formative evaluation research methods, this study will identify suitable reforestation strategies for adapting BC's managed forests to anticipated climate change. Such strategies may include modifications to seed transfer, species selection, planting densities, and site treatments. Barriers and opportunities for implementing these strategies within the province's existing forest policy framework will subsequently be examined, with a view to recommending changes necessary to facilitate adaptation. Informing this research will be a review of policy decision-making in consideration of scientific uncertainty, ecosystem complexity and sustainability.


Abstract: Paper birch (Betula papyrifera Marsh.) is routinely chemically or mechanically weeded from Douglas-fir (Pseudotsuga menziesii var. glauca) (Beissn.) Franco plantations to increase conifer productivity, but these practices are controversial because of unknown effects on forest health and diversity. This study examined effects of paper birch density reduction treatments on productivity and disease incidence of Douglas-fir saplings in the southern interior of British Columbia. Five paper birch density treatments (0, 400, 1111, 4444 stems ha(-1) and an un-thinned control of > 7000 stems ha(-1)), where paper birch was manually cut at the root collar in 1999, were replicated on four sites in a randomized block design. After 2 years, Douglas-fir survival did not differ significantly among treatments, but where Armillaria ostoyae (Romagn.) Herink was present in untreated stands, mortality due to root disease increased significantly with increasing paper birch thinning increment. Mean diameter increment and height: diameter ratio of Douglas-fir improved where paper birch was completely removed or partially thinned compared with the control. Mean light transmittance and soil moisture content increased with decreasing paper birch density, but Douglas-fir foliar N status was unaffected. Our results suggest that Douglas-fir growth can be improved and root disease incidence minimized by thinning paper birch to 4444 stems ha(-1) in young mixed stands, but that subsequent release treatments may be necessary to maintain Douglas-fir growth rates.

Abstract: The extent to which parent trees within breeding zones of coastal Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) are locally adapted to their native environments was evaluated. Forty families from each of one Coastal and one Cascade breeding population in Oregon were assessed for cold hardiness and growth phenology, and family means for traits were summarized using principal components analysis (PCA). Composition of the first two principal components (PCs) was consistent between breeding zones, years, and test sites. PC-1, describing 39-46% of trait variation, represents a suite of traits related to spring phenology and spring cold hardiness. PC-2, describing 20-22% of trait variation, consists of cold-hardiness traits not associated with phenology. The first two PCs from each population, as well as univariate traits, were regressed on parent tree location variables and modeled climatic indices separately. In the Coastal zone, PC-1 was weakly but significantly related to temperature and moisture regimes (0.176 < r2 < 0.235), varying with elevation and distance from the ocean. PC-2 was related to temperature and moisture regimes in both populations (0.087 < r2 > 0.249). These relatively weak geographic patterns for adaptive traits within breeding zones suggest that current zone size is not excessive and could likely be increased north or south.


Key Words: Accessed 2005 Dec 13


Annotation: Notes: Forest management policies and practices have shifted the natural equilibrium of forests in the Kispiox TSA in favour of disease and potential instability. There is a wealth of tree species options in the ICH zone for forest managers to use. Opting to concentrate on only two species results in not only a loss in diversity but also a loss in overall forest resiliency and health. The fact that there is a high incidence of Tomentosus root disease throughout the ICH, and that interior spruce is still prescribed for many areas points to the need for thorough pre-harvest root disease assessments. The location of root disease infestations from the former mature stands must be known prior to regenerating new spruce stands. Lodgepole pine is now present in far greater concentration and abundance than the previous forests in the study area. I believe this result of past forest management, coupled with possible climate change, has lead to the very significant impacts associated with the current Dothistroma foliar disease epidemic. (Available at: http://www.for.gov.bc.ca/hfp/DFAM-Website/resources/Kispiox%20FH%20Strategy31.pdf)

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Abstract: Herbivores and pathogens impact the species composition, ecosystem function, and socioeconomic value of forests. Herbivores and pathogens are an integral part of forests, but sometimes produce undesirable effects and a degradation of forest resources. In the United States, a few species of forest pests routinely have significant impacts on up to 20 million ha of forest with economic costs that probably exceed $1 billion/year. Climatic change could alter patterns of disturbance from herbivores and pathogens through: (1) direct effects on the development and survival of herbivores and pathogens; (2) physiological changes in tree defenses; and (3) indirect effects from changes in the abundance of natural enemies (e.g., parasitoids of insect herbivores), mutualists (e.g., insect vectors of tree pathogens), and competitors. Because of their short life cycles, mobility, reproductive potential, and physiological sensitivity to temperature, even modest climate change will have rapid impacts on the distribution and abundance of many forest insects and pathogens. We identify 32 syndromes of biotic disturbance in North American forests that should be carefully evaluated for their responses to climate change: 15 insect herbivores, browsing mammals; 12 pathogens; 1 plant parasite; and 3 undiagnosed patterns of forest decline. It is probable that climatic effects on some herbivores and pathogens will impact on biodiversity, recreation, property value, forest industry, and even water quality. Some scenarios are beneficial (e.g., decreased snow cover may increase winter mortality of some insect pests), but many are detrimental (e.g., warming tends to accelerate insect development rate and facilitate range expansions of pests and climate change tends to produce a mismatch between mature trees and their environment, which can increase vulnerability to herbivores and pathogens). Changes in forest disturbance can produce feedback to climate through affects on water and carbon flux in forest ecosystems; one alarming scenario is that climate warming may increase insect outbreaks in boreal forests, which would tend to increase forest fires and exacerbate further climate warming by releasing carbon stores from boreal ecosystems. We suggest a list of research priorities that will allow us to refine these risk assessments and adopt forest management strategies that anticipate changes in biotic disturbance regimes and mitigate the ecological, social, and economic risks.


Abstract: A comparison of declining forests in Alaska, British Columbia, and the Pacific Northwest USA with forest declines in eastern North America suggested that strong similarities existed and justified the use of the western forest region as an acid rain control. The current level of acid rain deposition over the western region was a quarter that of eastern Canada and the USA. The onset of crown dieback on Chamaecyparis nootkatensis (1900) and Pinus monticola (1936) did not relate to the incidence of regional air pollution but to extreme climatic variation. The injury mechanism differentiating persistent decline on P. monticola from sporadic but transient dieback, which was observed on a larger number of conifer and deciduous tree species, was believed to be cavitation. This dysfunction of the xylem was induced by anomalous winter thaw-freeze conditions in 1936 followed by high summer temp. and evapotranspiration stress in that and subsequent years. Similar extreme climatic conditions were present at the onset of forest declines in eastern North America and central Europe, which suggests that the climate-cavitation-forest decline mechanism may be universal.


Abstract: The response of net ecosystem productivity (NEP) and evaporation in a boreal aspen (Populus tremuloides Michx.) forest and a black spruce (Picea mariana (Mill.) BSP) forest in Canada was compared using a newly developed realistic model of surface-atmosphere exchanges of carbon dioxide (CO2), water vapor, and energy as well as eddy covariance flux measurements made over a 6-year period (1994-1999). The model was developed by incorporating a process-based two-leaf (sunlit and shaded) canopy conductance and photosynthesis submodel in the Canadian Land Surface Scheme (CLASS). A simple submodel of autotrophic and heterotrophic respiration was combined with the photosynthesis model to simulate NEP. The model performed well in simulating half-hourly, daily, and monthly mean CO2 exchange and evaporation values in both deciduous and coniferous forests. Modeled and measured results showed a linear relationship between CO2 uptake and evaporation, and for each kilogram of water transpired, approximately 3 g of carbon (C) were photosynthesized by both ecosystems. The model results confirmed that the aspen forest was a weak to moderate C sink with considerable interannual variability in C uptake. In the growing season, the C uptake capacity of the aspen forest was over twice that of the black spruce forest. Warm springs enhanced NEP in both forests; however, high mid-summer temperatures appear to have significantly reduced NEP at the black spruce forest as a result of increased respiration. The model suggests that the black spruce forest is a weak C sink in cool years and a weak C source in warm years. These results show that the C balance of these two forests is sensitive to seasonal and interannual climatic variability and stresses the importance of continuous long-term flux measurement to confirm modeling results.


Abstract: Emerging infectious diseases (EIDs) pose threats to conservation and public health. Here, we apply the definition of EIDs used in the medical and veterinary fields to botany and highlight a series of emerging plant diseases. We include EIDs of cultivated and wild plants, some of which are of significant conservation concern. The underlying cause of most plant EIDs is the anthropogenic introduction of parasites, although severe weather events are also important drivers of disease emergence. Much is known about crop plant EIDs, but there is little information about wild-plant EIDs, suggesting...
that their impact on conservation is underestimated. We conclude with recommendations for improving strategies for the surveillance and control of plant EIDs.


Abstract: Seed orchard production of Chamaecyparis nootkatensis (D. Don) Spach seed faces several challenges including low seed production, pollen-cone abortion, self-pollination, and accelerated reproductive development. In a seed orchard study in 1988 and 1989, approximately eight seeds were produced per cone, but only one to three seeds per cone contained viable embryos. Pollen-cone abortion in 21 clones ranged from 6 to 87% in 1989-1990 and from 0 to 6% in 1990-1991. A bud mite, identified as Triestesca chamaecyparisi Smith, was consistently associated with pollen-cone abortion in two orchard locations. This mite may be the cause or simply a symptom of unhealthy pollen cones. In a pollination study involving wind, self, and cross pollinations on five clones, self-pollinated cones had significantly fewer seeds containing embryos (4%) compared with the other treatments (28-33%). Pollen-cone development at a seed orchard occurred in July and August 1990 and was comparable with natural stand phenology. However, embryo development was significantly accelerated, with embryos at a seed orchard substantially larger than embryos at the natural stand at comparable times.


Abstract: In the near future, forest tree species growing in eastern Canada are expected to be affected by climate change due to an increase of human-induced greenhouse gas emissions. In this study, models were developed to estimate the impact of climate change on growth in white spruce (Picea glauca (Moench) Voss). Data were collected in a genealogical test, replicated in three locations, and involving 45 distinct geographical seed sources, most of them represented by five open-pollinated families. Transfer models predicting the performance of seed sources were developed, based on temperature and precipitation differentials between the geographical origin of seed sources and the experimental site locations. These models were validated using data collected in a second genealogical test series. We found that white spruce populations located within the sampled area were optimally adapted to their local environment for thermal conditions but not for moisture conditions; populations that originated from sites receiving more precipitation generally showed higher tree growth than the local sources. We predict that the adaptive lag currently related to precipitation will increase under global warming conditions. Simulations of growth under various scenarios of climate change indicated that it would be diminished tangibly under more intense warming. However, for a given temperature increase, the relative loss in growth will be less if precipitation is reduced than if it increases. Consequently, predictions based solely on temperature change appear inaccurate, and more effort should be directed toward better anticipating the magnitude and the direction of changes in precipitation patterns at the regional scale. The necessity of human intervention to assist tree migration under climate change is examined.


Abstract: A model of product and land markets in U.S. forest and agricultural sectors is used to examine the private forest management, land use, and market implications of carbon sequestration policies implemented in a "least social cost" fashion. Results suggest: policy-induced land use changes may generate compensating land use shifts through markets; land use shifts to meet policy targets need not be permanent; implementation of land use and management changes in a smooth or regular fashion over time may not be optimal; and primary forms of adjustment to meet carbon policy targets involve shifting of land from agriculture to forest and more intensive forest management in combinations varying with the policy target.


Annotation: Notes: "One difficult aspect associated with modeling climate change impacts on forests is that climate change effects will likely differ between existing trees and trees regenerated in the future (naturally or planted)."

Key Words: Notes: "One difficult aspect associated with modeling climate change impacts on forests is that climate change effects will likely differ between existing trees and trees regenerated in the future (naturally or planted)."


Abstract: The aim here was to separately assess mycorrhizal fungal and plant responses under elevated atmospheric CO2, and to test a mycocentric model that assumes that increased carbon availability to the fungus will not automatically feed back to enhanced plant growth performance. Meta-analyses were applied across independent studies. Responses were compared in ectomycorrhizal (ECM) and arbuscular mycorrhizal (AM) fungi, and ECM and AM plants. Responses of both mycorrhizal fungi and mycorrhizal plants to elevated CO2 were significantly positive. The response ratio for ECM fungi was 1.34 (an increase of 34%) and for AM fungi 1.21 (21%), indicating a significantly different response. The response ratio for ECM plants was 1.26, similar to that of AM plants (1.25). Fractional colonization proved to be an unsuitable fungal parameter. Evidence was found for the mycocentric view in ECM, but not in AM systems. Fungal identity and plant identity were important parameters that affected response ratios. The need for better descriptors of fungal and plant responses is...
emphasized.


**Abstract:** Aim To understand how tree growth response to regional drought and temperature varies between tree species, elevations and forest types in a mountain landscape. **Location** Twenty-one sites on an elevation gradient of 1500 m on the San Francisco Peaks, northern Arizona, USA. Methods Tree-ring data for the years 1950-2000 for eight tree species (Abies lasiocarpa var. arizonica (Merriam) Lemm., Picea engelmannii Parry ex Engelm., Pinus aristata Engelm., Pinus edulis Engelm., Pinus flexilis James, Pinus ponderosa Dougl. ex Laws., Pseudotsuga menziesii var. glauca (Beissn.) Franco and Quercus gambeli Nutt.) were used to compare sensitivity of radial growth to regional drought and temperature among co-occurring species at the same site, and between sites that differed in elevation and species composition. **Results** For *Picea engelmannii*, *Pinus flexilis*, *Pinus ponderosa* and *Pseudotsuga menziesii*, trees in drier, low-elevation stands generally had greater sensitivity of radial growth to regional drought than trees of the same species in wetter, high-elevation stands. Species low in their elevational range had greater drought sensitivity than co-occurring species high in their elevational range at the pinyon-juniper/ponderosa pine forest ecotone, ponderosa pine/mixed conifer forest ecotone and high-elevation invaded meadows, but not at the mixed conifer/subalpine forest ecotone. Sensitivity of radial growth to regional drought was greater at drier, low-elevation compared with wetter, high-elevation forests. Yearly growth was positively correlated with measures of regional water availability at all sites, except high-elevation invaded meadows where growth was weakly correlated with all climatic factors. Yearly growth in high-elevation forests up to 3300 m a.s.l. was more strongly correlated with water availability than temperature. **Main conclusions** Severe regional drought reduced growth of all dominant tree species over a gradient of precipitation and temperature represented by a 1500-m change in elevation, but response to drought varied between species and stands. Growth was reduced the most in drier, low-elevation forests and in species growing low in their elevational range in ecotones, and the least for trees that had recently invaded high-elevation meadows. Constraints on tree growth from drought and high temperature are important for high-elevation subalpine forests located near the southern-most range of the dominant species.


**Abstract:** This article reviews recent developments in plant disease risk assessment. The role of risk assessment as an application area in macrophytopathology and its contribution to the development of macroscale disease study are discussed. This article also discusses the concepts and components of risk assessment for different end points and the assessment framework of different potential ranges of a new pathogen: establishment range, suitability range, damage range, and dispersal range. Different end points generate risk information suitable for decision makers at different levels. New insights gained from selected major diseases, especially from risk assessment due to the recent global movement of soybean rust, are presented. The role of pathologists in presenting risk information has extended beyond the professional research domain and has become critical in influencing decision-making, evident by soybean rust in both South and North America. The bias components of risk communication are defined, and different levels of receivers for risk information are identified based on their interpretation capability of risk information, bias potential, and utilization of risk information. Lack of predictability of dispersal potential contributes to uncertainty of risk assessment for airborne diseases. Potential research areas in disease risk assessment are discussed.

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**Annotation:** Diffusion. Plant temperatures. Integrating effect of varying temperature upon pathogen. Recognizes character of blister rust spread at night into not out of the ribes-swamp as distinct from the diffusion process

**Key Words:** Diffusion. Plant temperatures. Integrating effect of varying temperature upon pathogen. Recognizes character of blister rust spread at night into not out of the ribes-swamp as distinct from the diffusion process


**Abstract:** Weather, insects and plant diseases are the three major national hazards to crop production. For a plant disease to occur, a susceptible plant must be in a vulnerable stage, the pathogen must be in an infectious stage, and environmental conditions must be favorable for disease development. The primary environmental conditions that affect the plant–pathogen relationship are temperature, humidity, light, and wind. Descriptions of weather influences on diseases caused by fungi, bacteria, and viruses are given. The influence of weather on nematodes is also discussed. Details of plant disease forecasting for potato blight (*Phytophthora infestans*), apple scab (*Venturia inaequalis*), pecan scab (*Fusarium effusum*), tobacco blue mold (*Peronospora tobacina*) and downy mildew of Lima beans (*Phytophthora phaseoli*) are given, together with sample forecasts.

**Annotation:** a few forestry examples

**Key Words:** a few forestry examples


Abstract: Contributions from the field of population biology hold promise for understanding and managing invasiveness; invasive species also offer excellent opportunities to study basic processes in population biology. Life history studies and demographic models may be valuable for examining the introduction of invasive species and identifying life history stages where management will be most effective. Evolutionary processes may be key features in determining whether invasive species establish and spread. Studies of genetic diversity and evolutionary changes should be useful for understanding the potential for colonization and establishment, geographic patterns of invasion and range expansion, lag times, and the potential for evolutionary responses to novel environments, including management practices. The consequences of biological invasions permit study of basic evolutionary processes, as invaders often evolve rapidly in response to novel abiotic and biotic conditions, and native species evolve in response to the invasion.


Abstract: Although pairwise interactions have always had a key role in ecology and evolutionary biology, the recent increase in the amount and availability of biological data has placed a new focus on the complex networks embedded in biological systems. The increased availability of computational tools to store and retrieve biological data has facilitated wide access to these data, not just by biologists but also by specialists from the social sciences, computer science, physics and mathematicians. This fusion of interests has led to a burst of research on the properties and consequences of network structure in biological systems. Although traditional measures of network structure and function have started us off on the right foot, an important next step is to create biologically realistic models of network formation, evolution, and function. Here, we review recent applications of network thinking to the evolution of networks at the gene and protein level and to the dynamics and stability of communities. These studies have provided new insights into the organization and function of biological systems by applying existing techniques of network analysis. The current challenge is to recognize the commonalities in evolutionary and ecological applications of network thinking to create a predictive science of biological networks.


Abstract: Assessing impacts of global change is complicated by the problems associated with translating models and data across spatial and temporal scales. One of the major problems of ecological scaling is the dynamic, self-organized nature of ecosystems. Ecological organization emerges from the interaction of structures and processes operating at different scales. The resilience of ecological organization to changes in key cross-scale processes can be used to assess the contexts within which scaling methods function well, need adjustment, and break down.

Annotation: Four major difficulties arise due to non-linearity and heterogeneity, different processes dominating at different scales, cross-scale connections, and emergent properties.

Key Words: Four major difficulties arise due to non-linearity and heterogeneity, different processes dominating at different scales, cross-scale connections, and emergent properties.


Abstract: Classical criticality describes sudden changes in the state of a system when underlying processes change slightly. At this transition, patchiness develops which lacks a characteristic or dominant spatial scale. Thus, criticality lies at the interface of two important subjects in ecology, threshold behavior and patchiness. Most ecological examples of criticality involve processes of disturbance and recovery; the spatial and temporal scales of these processes enable three different types of critical system to be distinguished: classical phase transitions, self-organized criticality (SOC) and 'robust' criticality. Here, we review the properties defining these three types and their implications for threshold behavior and large intermittent temporal fluctuations, with examples taken from spatial stochastic models for predator–prey, infected–susceptible, and disturbance–recovery interactions. In critical systems, spatial properties of patchiness alone are insufficient indicators of impending sudden changes, unless complemented by the spatial and temporal scales of disturbance and recovery themselves.

Annotation: Near the critical value, organism distribution may be statistically correlated or scale invariant; but this pattern not always associated with sudden state shift or high sensitivity. Classical criticality refers to shorrangte interactions leading to long-range correlations characterized by power-law relationships (density dependent windthrow). SOC display no sudden shift in relation to environmental perturbations (sand pile). Robust criticality has similarities and differences to CC and SOC as scaling occurs over a broad range and even though there is a critical point for patch connectedness there is neither large temporal shifts or high sensitivity of environment perturbations.

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**Abstract:** Novel plant-pathogen combinations occur whenever pathogen or plant species are introduced to regions outside their native range. Whether a pathogen is able to acquire a new host depends on the genetic compatibility between the two, through either preadaptation of the pathogen or subsequent evolutionary change. The ecological outcome of the novel interaction—for example, a spreading disease epidemic or the extinction of an incipient plant invasion—depends on the life history of the pathogen, opportunities for rapid evolution of virulence or resistance, and the presence of a suitable environment. We review recent work on the biology of pathogen virulence and host resistance, their mechanisms, and their costs. We then explore factors influencing the ecological and evolutionary dynamics of novel plant–pathogen interactions, using that evolutionary ecology framework to provide insight into three important practical applications: emerging diseases, biological invasions, and biological control.

O’Neill, G.; Yanchuk, A. 2005. A primer on seed transfer for compliance and enforcement in B.C.

**Annotation:** Concern over potential maladaptation due mismatch of seed transfer zone with changing climate (serious issue in BC)

**Key Words:** Concern over potential maladaptation due mismatch of seed transfer zone with changing climate (serious issue in BC)


**Abstract:** Understanding the risks posed by anthropogenic climate change and the possible societal responses to those risks has generated a prototypical example of the challenge of “collectively seeing complex systems.” After briefly examining the ways in which problems like climate change reach the scientific and public agenda, we look at four different ways in which scientists collectively address the problem: general circulation models, integrated assessment models, formal assessments (e.g., the Intergovernmental Panel on Climate Change), and distributed learning networks. We examine the strengths and limitations of each of these methods, and suggest ways in which a greater self-consciousness of the need for plural approaches could improve the basis for learning and decision making.


**Abstract:** Assisted migration is a contentious issue that places different conservation objectives at odds with one another. This element of debate, together with the growing risk of biodiversity loss under climate change, means that now is the time for the conservation community to consider assisted migration. Our intent here is to highlight the problem caused by a lack of a scientifically based policy on assisted migration, suggest a spectrum of policy options, and outline a framework for moving toward a consensus on this emerging conservation dilemma.

**Annotation:** Research agenda: 1 estimation and monitoring of species distributions, 2 biogeographic modeling, 3 community interactions, 4 long-distance dispersal, and 5 genetic diversity.

**Key Words:** Research agenda: 1 estimation and monitoring of species distributions, 2 biogeographic modeling, 3 community interactions, 4 long-distance dispersal, and 5 genetic diversity.

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**Abstract:** This paper briefly reviews the process of exotic pest risk assessments and presents some examples of emerging opportunities for spatial bioclimatic modeling of exotic species in Canada. This type of analysis can support risk assessments but does not replace the need for on-going high quality field-based observations to validate and update models. Bioclimatic analysis of several exotic pests is provided to illustrate both opportunities and limits. A link is demonstrated to the National Forest Inventory to characterize timber volumes at risk for one exotic species. 'Challenges' are both scientific and administrative. More accessible and current field survey data are required to improve models. Our experience is that for many exotic species, historical, and even current, data are not always digital or quality controlled for taxonomic identity and accurate georeferencing. This inhibits their use for integrated spatial modeling applications.


**Abstract:** Foundation concepts in forest pathology are based on experiences evolving over time. Three examples will be addressed. (i) The primary concept behind education and research in forest pathology is the widely accepted attitude that disease-causing agents limit full utilization of forest resources. Therefore, we study diseases to find a weak link and then utilize this information to enhance our portion of the shared resource. The sustainable environmental issues of today have changed this concept, in my mind, to one of addressing what is the appropriate "healthy amount of disease" in a sustainable forest ecosystem. (ii) The initial concept that weakened understory trees and poorly managed forestry deteriorate and decline over time because of numerous insults from biotic and abiotic agents has evolved into a decline disease stabilizing selection concept whereby healthy dominant trees in the forest (the survivors) are selectively killed by a combination of specifically ordered factors. (iii) The concept that heart-rot decay is initiated by infection through wounds that expose heartwood has evolved into the concept of infection in the sapwood that is compartmentalized over time in the center of the tree.

Abstract: Humans have caused an unprecedented redistribution of the earth's living things. Both incidentally and deliberately, through migration, transport, and commerce, humans are continuing to disperse an ever-increasing array of species across previously insurmountable environmental barriers such as oceans, mountain ranges, rivers, and inhospitable climate zones. Among the most far-reaching consequences of this reshuffling of species that establish new ranges in which they proliferate, spread, and persist to the detriment of native species and ecosystems. In a world without borders, few if any areas remain sheltered from these immigrations, and for some areas, such as oceanic islands, are subject to high rates of invasion. Despite ubiquitous arrivals of new plants, animals and microorganisms, the fate of immigrants is decidedly mixed. Few survive and only a small fraction become naturalized. Most that do become naturalized exert no demonstrable impact in their new range. However, some naturalized species do become invasive, and these can cause severe environmental damage. There are several potential reasons why immigrants succeed: Some escape constraints such as predators or parasites, some find vacant niches to occupy, some are aided by human-caused disturbance that disrupts native communities. Whatever the cause, successful invaders can in many cases inflict enormous ecological damage. The scientific literature reviewed by the panel makes it clear that: Animal invaders can cause extinctions of vulnerable native species through predation, grazing, competition, and habitat alteration. Plant invaders can completely alter the fire regime, nutrient cycling, hydrology, and energy budgets in a native ecosystem, greatly diminish the abundance or survival of native species, and even block navigation or enhance flooding. Many non-native animals and plants can hybridize with native species. In agriculture, the principle pests of temperate crops are non-native, and the combined expenses of pest control and crop losses constitute a "tax" on food, fiber, and forage production. The global cost of virulent plant and animal diseases caused by organisms transported to new ranges and presented with susceptible new hosts is currently incalculable. Identifying future invaders and taking effective steps to prevent their dispersal and establishment is a major challenge to ecology, agriculture, aquaculture, horticulture and pet trades, conservation, and international commerce. The panel finds that: Identifying general attributes of future invaders has proven difficult. Predicting susceptible locales for future invasions seems even more problematic, given the enormous differences in commerce among various regions and thus in the rate of arrival of potential invaders. Eradication of an established invader is rare and control efforts vary enormously in their efficacy. Successful control depends more on commitment and continuing diligence than the efficacy of specific tools themselves (trapping or spraying insecticides, releasing biological control agents). Control of biotic invasions is most effective when it employs a long-term, ecosystem-wide strategy rather than a tactical approach focused on battling individual invaders. Prevention of invasions is much less costly than post-entry control. Changing national and international quarantine laws by adopting a "guilty until proven innocent" approach, instead of the current strategy of denying entry only to species already proven noxious or detrimental, would be a productive first step. The global consequences of failing to address the issue of invasions effectively would be severe, including wholesale loss of agricultural, forestry and fishery resources in some regions and disruption of the ecological processes that supply natural services on which the human enterprise depends. Given their current scale, biotic invasions have also taken their place alongside human-driven atmospheric and oceanic change as major agents of global change, and left unchecked, will influence these other forces in profound but still unpredictable ways.

url: http://www.esa.org/science/Issues/FileEnglish/issue5.pdf


Abstract: The forests of eastern North America have been subjected to repeated introductions of exotic insect pests and pathogens over the last century, and several new pests are currently invading, or threatening to invade, the region. These pests and pathogens can have major short- and long-term impacts on forest ecosystem processes such as productivity, nutrient cycling, and support of consumer food webs. We identify six key features of the biology of exotic animal pests and the ecology of their hosts that are critical to predicting the general nature and severity of those impacts. Using three examples of introduced pests and pathogens in eastern forest ecosystems, we provide a conceptual framework for assessing potential ecosystem-scale effects.

Annotation: Six key features are 1) model action 2) host specificity, 3) virulence, 4) importance of host, 5) uniqueness of host, 6) phytosociology of host.

Key Words: Six key features are 1) model action 2) host specificity, 3) virulence, 4) importance of host, 5) uniqueness of host, 6) phytosociology of host.


Abstract: Why common bias exists: tree growth is based on the realized rather than the fundamental niche, lifespans of trees in the models are too low, vegetative reproduction is not incorporated, tolerance of climatic fluctuations is given inadequate attention, the unique niche of fire-tolerant species is not considered, the protected position of species growing under unique edaphic conditions is not included.


Abstract: While current projections of future climate change associated with increases in atmospheric greenhouse gases have a high degree of uncertainty, the potential effects of climate change on forests are of increasing concern. A number of studies based on forest simulation models predict substantial alteration of forest composition, forest dieback, or even loss of...
forest cover in response to increased temperatures associated with increasing atmospheric carbon dioxide concentrations. However, the structure of these computer models may cause them to overemphasize the role of climate in controlling tree growth and mortality. Model functions that represent the influence of climate on tree growth are based on the geographic range limits of a species, predicting maximal growth in the center of the range and zero growth (100% mortality) at the range limits and beyond. This modeling approach ignores the fact that the geographic range of a species reflects the influence of both climate and other environmental factors, including competition with other tree species, soil characteristics, barriers to dispersal, and distributions of pests and pathogens. These climate-response functions in forest simulation models implicitly assume that tree species occur in all environments where it is possible for them to survive (their fundamental niche or potential habitat) and that these potential habitats are entirely defined by climate. Hence, any alteration of climate must result in a fairly rapid decline of species near their range limits and rapid alteration of forest composition and structure. The climate-response functions that lead to these unrealistic conclusions have no basis in plant physiology or actual measurements of tree responses to climate stressors. Rather, these functions were chosen as a necessary expedient for modeling the climatic responses of many tree species for which there were limited or no ecophysiological data. There is substantial evidence, however, that some tree species can survive, and even thrive, in climatic conditions outside their present range limits. This evidence suggests that nonclimatic factors exclude some species from natural forests beyond their present range limits and that climate may not be the only determinant of these limits. Hence, there is reason to suspect that published projections of forest responses to climate change based on forest simulation models may exaggerate the direct impact of climate on tree growth and mortality. We propose that forest simulation models be reformulated with more realistic representations of growth responses to temperature, moisture, mortality, and dispersal. We believe that only when these models more accurately reflect the physiological bases of the responses of tree species to climate variables can they be used to simulate responses of forests to rapid changes in climate. We argue that direct forest responses to climate change projected by such a reformulated model may be less traumatic and more gradual than those projected by current models. However, the indirect effects of climate change on forests, mediated by alterations of disturbance regimes or the actions of pests and pathogens, may accelerate climate-induced change in forests, and they deserve further study and inclusion within forest simulation models.


Abstract: Stress ecology represents the field of ecology that measures and evaluates impacts of perturbations on the structure and function of ecosystems. Many human ecologists and philosophers maintain that environmental ethics should be predicated upon holistic ecological principles. Specifically, this implies the successful application of stress ecology to environmental problems. However, few thoroughly discuss the extent to which stress ecology is capable of serving as a basis for environmental ethics, nor do they make substantial reference to the scientific literature which examines this question. A number of factors constrain the successful development and application of stress ecology, and its usefulness as a basis for a holistic environmental ethics. These factors include: 1) lack of consensus about the definitions of stress to organisms or ecosystems, 2) insufficient knowledge about causes of environmental perturbations (e.g., pollution), 3) inadequate ecosystem knowledge, and 4) lack of integration of ecosystem and socioeconomic systems into formal approaches of systems analysis. Accordingly, stress ecology will not fulfill the goals of a holistic and ecologically based environmental ethics.

Annotation: But consider: active adaptive management and governance of resilience

Key Words: But consider: active adaptive management and governance of resilience


Abstract: Projections in the Forest Service Assessment assume a future in which changes in timber production and land use are not abrupt discontinuities from the past. These assumptions may not be met if the earth's climate changes rapidly. This document summarizes the current research on the impacts of climate change on America's forests.


Abstract: The environmental and biotic history of the late Quaternary represents a critical junction between ecology, global change studies, and pre-Quaternary paleobiology. Late Quaternary records indicate the modes and mechanisms of environmental variation and biotic responses at timescales of 10^3 to 10^4 years. Climatic changes of the late Quaternary have occurred continuously across a wide range of temporal scales, with the magnitude of change generally increasing with time span. Responses of terrestrial plant populations have ranged from tolerance in situ to moderate shifts in habitat to migration and/or extinction, depending on magnitudes and rates of environmental change. Species assemblages have been disaggregated and recombined, forming a changing array of vegetation patterns on the landscape. These patterns of change are characteristic of terrestrial plants and animals but may not be representative of all other life-forms or habitats. Complexity of response, particularly extent of species recombination, depends in part on the nature of the underlying environmental gradients and how they change through time. Environmental gradients in certain habitats may change in relatively simple fashion, allowing long-term persistence of species associations and spatial patterns. Consideration of late Quaternary climatic changes indicates that both the rate and magnitude of climatic changes anticipated for the coming century are unprecedented, presenting unique challenges to the biota of the planet.

http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/ 9/12/2008

**Abstract:** Influence of climatic factors on pathogenic diseases. Influence of climatic factors on physiogenic diseases. Climate change and species recessions


**Abstract:** Exotic pest introductions are a global threat occurring at an unprecedented rate. Comprehensive research programs are required at the onset to prevent the spread of the invasive insects, pathogens or plants, and rehabilitate and restore native habitats and ecosystems. Unfortunately, much of the current research on invasives is piecemeal. Past experiences with exotic and native pests provide some valuable lessons about how we should approach research programs on invasive organisms. The infrastructure required for effectively administering comprehensive research programs is complex. An example is discussed.

**Annotation:** eastern forest bias

**Key Words:** eastern forest bias


**Abstract:** In 1973, C. S. Holling introduced the word resilience into the ecological literature as a way of helping to understand the non-linear dynamics observed in ecosystems. Ecological resilience was defined as the amount of disturbance that an ecosystem could withstand without changing self-organized processes and structures (defined as alternative stable states). Other authors consider resilience as a return time to a stable state following a perturbation. A new term, adaptive capacity, is introduced to describe the processes that modify ecological resilience. Two definitions recognize the presence of multiple stable states (or stability domains), and hence resilience is the property that mediates transition among these states.

Transitions among stable states have been described for many ecosystems, including semi-arid rangelands, lakes, coral reefs, and forests. In these systems, ecological resilience is maintained by keystone structuring processes across a number of scales, sources of renewal and reformation, and functional biodiversity. In practice, maintaining a capacity for renewal in a dynamic environment provides an ecological buffer that protects the system from the failure of management actions that are taken based upon incomplete understanding, and it allows managers to affordably learn and change.


**Abstract:** Invasive species pose a major, yet poorly addressed, threat to sustainable forestry. Here we set forth an interdisciplinary science strategy of research, development, and applications to reduce this threat. To spur action by public and private entities that too often are slow, reluctant, or unable to act, we recommend (a) better integrating invasive species into sustainable forestry frameworks such as the Montreal Process and forest certification programs; (b) developing improved cost estimates to inform choices about international trade and pest suppression efforts; and (c) building distributed information systems that deliver information on risks, identification, and response strategies. To enhance the success of prevention and management actions, we recommend (a) advancing technologies for molecular identification, expert systems, and remote sensing (b) evolving approaches for ecosystem and landscape management, and (c) better anticipating interactions between species invasions and other global change processes.

**Annotation:** Page 4 of 12

**Key Words:** Page 4 of 12


**Abstract:** Coniferous trees are often dominant species in both boreal and temperate forests, wherein they play critical roles in ecosystem function. In natural environments, ecosystem stability appears to be the norm, notwithstanding the co-occurrence of insect and microbial species inherently capable of killing their host trees. Adaptive plasticity of host trees involving inducible mechanisms of resistance against invading organisms is likely to play a crucial role in these interactions. We hypothesize that systemic-induced resistance represents a common and important phenomenon in coniferous trees.

Abstract: Climatic mapping, which predicts the potential distribution of organisms in new areas and under future climates based on their responses to climate in their home range, has recently been criticised for ignoring dispersal and interactions between species, such as competition, predation and parasitism. In order to determine whether these criticisms are justified, the different procedures employed in climatic mapping were reviewed, with examples taken from studies of the Mediterranean fruit fly (Ceratitis capitata), Karnal bunt of wheat (Tilletia indica) and the Colorado potato beetle (Leptinotarsa decemlineata). All these studies stressed the key role played by non-climatic factors in determining distribution but it was shown that these factors, e.g., the availability of food and synchrony with the host plant, together with the difficulties of downscaling and upsampling data, were different to those highlighted in the criticisms. The extent to which laboratory studies on Drosophila populations, on which the criticisms are based, can be extrapolated to general predictions of species distributions was also explored. The Drosophila experiments were found to illustrate the importance of climate but could not accurately determine potential species distributions because only adult and not breeding population densities were estimated. The experimental design overestimated species interactions and ignored other factors, such as the availability of food. It was concluded that while there are limitations, climatic mapping procedures continue to play a vital role in determining what G.E. Hutchinson defined as the “fundamental niche” in studies of potential distribution. This applies especially for pest species, where natural dispersal is generally less important than transport by man, and species interactions are limited by the impoverished species diversity in agroecosystems. Due to the lack of data, climatic mapping is often the only approach which can be adopted. Nevertheless, to ensure that non-climatic factors are not neglected in such studies, a standard framework should be employed. Such frameworks have already been developed for pest risk analyses and are suitable for general use in studies of potential distribution because, in order to justify the phytosanitary regulation of international trade, they must also consider the potential for pests to invade new areas and the impacts of such invasions.

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Abstract: The tree diseases of western Canada caused by rust fungi (Uredinales) are reviewed. Botanical keys and taxonomic descriptions are presented to distinguish between 70 tree rusts that are known to occur in western Canada. The life cycle of most of these rusts is outlined and illustrated by 21 spiral life cycle diagrams. Notes on damage caused, epidemiology and methods of control, as well as a complete list of native hosts and worldwide geographic distribution, are given for each rust. A glossary of 308 technical terms and 157 photographs and photomicrographs are included to facilitate preliminary identification the rusts; 272 literature references lead to more detailed information on specific aspects of uredinology.


Abstract: Genetic variation in North American (NA) Cronartium ribicola (CR) originates from 1) dispersal from a diverse Asian CR complex to Pinus strobus and Ribes in Europe; 2) introduction to NA locations on European nursery stock; and 3) ongoing dispersal and adaptation to NA habitats and hosts. Differences in RAPD and codominant DNA markers from eastern, midwestern, and western populations suggest that founder effects have not been overcome by inter-regional interbreeding. Virulence occurs to major gene resistance (MGR) in sugar pine (race V1), western white pine (V2), and both hosts (V1V2), but spread of V1 and V1V2 races has been minimal. CR variants having differential development and/or reduced urediniospore cycling on different clones of Ribes hudsonianum var. petiolaris or differences in teliospore germination at different temperatures have been tentatively identified, but factors affecting spread and persistence of CR variants and potential for life cycle variations need further investigation.

Annotation: presentation includes graph for Krebill's germination data of basidiospores derived from limber pine or whitebark pine at Yellowstone. Compared to spores from limber, more spores from whitebark germinate in the low range of temperature, but after a longer delay.

Key Words: presentation includes graph for Krebill's germination data of basidiospores derived from limber pine or whitebark pine at Yellowstone. Compared to spores from limber, more spores from whitebark germinate in the low range of temperature, but after a longer delay.

url: epidemiology, genetics


Abstract: Germination of urediniospores, aeciospores, and teliospores was assessed after pre-storage equilibration to 0, 30, 40, 50, 60, 80, or 100% relative humidity (RH) at 4 C; storage at 4, -20, or -80 C for 3-4 weeks; and 0 or 5 min post-storage heat shock (HS) at 40 C. Treatments were followed by rehydration to 100 RH and incubation at 20, 16 and 16 C for urediniospores, aeciospores, and teliospores, respectively. For urediniospores, germination was high (70-90%) whenever -20 or -80 C storage at 0-50 RH or 4 C storage at 0-80 RH was followed by HS, and after 4 C storage at 100 RH regardless of HS. Urediniospore germination was low (<5%) when -20 or -80 C storage at 0-100 RH or 4 C storage at 0 RH was not...
followed by HS. For aeciospores, germination was high (60-80%) regardless of HS, after 4, -20, or -80 C storage at 0-60 RH, 4 or -80 C storage at 80 RH, or 4 C storage at 100 RH. Teliospore germination was based on basidiospores produced per cm² telia-bearing leaf disks. Leaf disks were suspended over water agar containing Triton X-100 to suppress basidiospore germination, the basidiospores suspended in 5% Triton X-100, and numbers estimated using a hemocytometer. Basidiospore production was high (ca. 105/cm² leaf tissue) when -20 or -80 C storage at 30-60 RH was followed by heat shock, or after 4 C storage at 30-100 RH regardless of heat shock, but was low (<10² spores/cm²) when -20 or -80 C storage at 0-100 RH was not followed by HS. Yield of all teliospore treatments stored at 0 RH was <10⁴ spores/cm².

url: epidemiology


Abstract: Seedlings from 291 open-pollinated families of lodgepole pine (Pinus contorta Dougl. ex Loud. var. latifolia Engelm.) from three breeding regions (B1, B2, and C) in west-central Alberta were evaluated in the greenhouse during 1992–1994 for their response to infection by western gall rust (WGR) (Endocronartium harknessii (J.P. Moore) Y. Hiratsuka). Region C is a foothill outlier whereas the two western regions are under strong cordilleran influence in the Rocky Mountains. Significant variation in WGR resistance was found among and within regions. A general east-west trend was observed, with western and high-elevation families being more susceptible to WGR infection. Regression of WGR resistance on geographic origins of families accounted for up to 25% of the among-family variation. However, the among-family variation in region C could not be predicted by any geographic variables. Canonical discriminant analysis of WGR resistance and geographic variables could discern families in region C from those in regions B1 and B2. While the widespread introgression from jack pine (Pinus banksiana Lamb.) could contribute to WGR resistance in lodgepole pine, the observed geographic variation could also be a selection gradient induced by regional patterns of geoclimatic conditions for WGR development.

url: lodgepole pine, distribution.


Abstract: We developed two models to predict volume loss due to western gall rust (Endocronartium harknessii (J.P. Moore) Y. Hiratsuka) and comandra blister rust (Cronartium comandrae (Peck) on juvenile lodgepole pine (Pinus contorta Dougl. ex Loud.) dominated stands in central British Columbia. The models suggest that volume loss is significantly and positively correlated to the incidence of comandra blister rust. The relationship between volume loss and western gall rust incidence was weak. The addition of stand density data improved the statistical fit of the model. We used the growth and yield model Tree and stand simulator (TASS) to predict volume at culmination age (age at which the merchantable mean annual increment was maximized) in thirty 1-ha stem-mapped stands. The lodgepole pine trees we stem mapped were also assessed for hard pine stem rust incidence. We developed our volume loss functions assuming that trees with stem infections of both comandra blister rust and western gall rust were lethal, and that infected trees would die from ages 21 to 40. In areas where comandra blister rust is common, the losses due to the disease can be considerable. We predict that the volume losses due to hard pine stem rusts in lodgepole pine dominated stands are as high as 7.2% by culmination age.

url: pest model


Abstract: In 1997, 30 one-ha stem mapped plots were located in randomly selected juvenile lodgepole pine (Pinus contorta Dougl. ex Loud.) leading stands aged 15-20 years. The growth and yield model TASS was then used to predict volume losses at rotation. The average loss at rotation due to hard pine rusts in lodgepole pine dominated stands was estimated to be 7.2%. In order to model rust impacts over a rotation three basic modeling assumptions had to be made. This study reviews those three basic assumptions by re-assessing all trees within the 30 plots seven years later. The first assumption was that rust incidence would have stabilized in stands aged 15-20 years. I found that the incidence of both comandra blister rust (Cronartium comandrae (Peck) (CBR) and western gall rust (Endocronartium harknessii (J.P. Moore) Y. Hiratsuka) (WGR) continued to increase. The greatest increase in CBR incidence occurred in stands that already had a high incidence while increases in WGR incidence were universally distributed over all 30 plots. The second assumption was that the voids created by rust killed trees would not fill with merchantable sized non-host trees by the time the lodgepole pine crop is ready to harvest. I found that the mean height of interior spruce is just over 1/3 the height of the lodgepole pine crop trees. The mean stocking of interior spruce is 243.7 + 102.0 sp while that of lodgepole pine was 968.2 + 196.2 sp (95% CI). It is unlikely these spuce trees will be of merchantable size prior to harvest of the lodgepole pine crop. The third assumption was that CBR infected trees would die at an annual rate of 5% between the ages of 20 and 40 years. I found that after approximately 1/3 of that time period elapsing, 1/3 of the CBR infected trees were dead. Very few WGR infected trees have died. I also examined the relationship between the abundance of alternate host and the number of CBR infected trees. From this reassessment, I conclude that the three main modeling assumptions used to predict rust impact were valid and that the impact of hard pine rusts in juvenile lodgepole pine dominated stands in central British Columbia is approximately 7.2%.

url: lodgepole pine, damage


Annotation: Injuries of non-infectious origin. Sporadic diseases of infection origin: pinyon rust, comandra rust, western gall
rust... *C. occidentale* occurs from Carson River south in CA and NV on *Ribes velutinum*. In some locations infection is consistent and moderate; in other locations it is sporadically severe. Thousands of infections found south of Gardnerville, NV in mid-1920s; most cankers date to about 1920; few old cankers; no evidence of recent waves. Little change in pinyon-Ribes sox suspect wave due to a season of favorable weather. Also see interesting descriptions of outbreaks of gall rust and comandra rust

**Key Words:** Injuries of non-infectious origin. Sporadic diseases of infection origin: pinyon rust, comandra rust, western gall rust... *C. occidentale* occurs from Carson River south in CA and NV on *Ribes velutinum*. In some locations infection is consistent and moderate; in other locations it is sporadically severe. Thousands of infections found south of Gardnerville, NV in mid-1920s; most cankers date to about 1920; few old cankers; no evidence of recent waves. Little change in pinyon-Ribes sox suspect wave due to a season of favorable weather. Also see interesting descriptions of outbreaks of gall rust and comandra rust


**Abstract:** Cold winter of 1948–49 (-31 F) had a marked sanitary effect on comandra blister rust of ponderosa pine at Mink Creek, ID. Thirty yr prior to this article experimental plantations of ponderosa pine were made in the South Fork drainage of Mink Creek, Caribou NF, se of Pocatello, ID. *C. comandrae* has appeared in damaging numbers. After several cold spells this rust was very hard to find except on areas that occupy gentle easterly slopes above the South Fork of Mink Creek


**Abstract:** We conducted a population genetic study of the western gall rust fungus (*Peridermium harknessii*) using isozymes as genetic markers. Electrophoresis of 341 single-gall aeciospore isolates collected from several pine species revealed that western gall rust is comprised of two distinct zymodemes (multilocus electrophoretic types) in the western United States. Within zymodemes, all 15 loci studied were monomorphic (0.95 criterion), although variants were found at low frequencies (<0.03) at 3 loci. Zymodeme I was characterized by single bands, indicating homozygosity at all loci; it consisted of isolates from all pine species and environments studied, including the Pacific Coast and Cascade Ranges and the Sierra Nevada and Rocky Mountains. Zymodeme II, which was absent from coastal forests, was characterized by double or triple bands at 6 of 15 loci. The additional bands were interpreted as products of alternative alleles in heterozygous condition; isozyme phenotypes at the other nine loci were identical to those of zymodeme I. Presumed heterozygotes were fixed within zymodeme II, and homozygotes of alleles unique to this zymodeme were not found. Generally, all isolates sampled from a forest stand were in the same zymodeme, and when isolates from both zymodemes were found in the same location, recombinant genotypes between zymodemes were not observed. Such extreme disequilibrium is inconsistent with sexual reproduction, indicating that *P. harknessii* is asexual


**Abstract:** Species in *Cronartium* and its anamorphic genus *Peridermium* form a morphologically homogenous group of rust fungi that infect stems, branches, and cones of *Pinus* species in North and Central America, Asia, and Europe. Several species are important forest pathogens, causing severe economic and aesthetic damage to pines in forests and parks throughout the northern hemisphere. Morphological characters have been used to distinguish among these rust fungi, but have proven inadequate for assessing phylogenetic relationships within the group. In this study, we extracted fungal DNA from spores and infected host tissue representing collections of all major North American and Eurasian *Cronartium* and *Peridermium* species and of two related rust genera, *Chrysomyxa* and *Pucciniastrum*. Using the polymerase chain reaction, we amplified and sequenced the internal transcribed spacer region from the nuclear ribosomal RNA genes, aligned sequences for all taxa, and generated phylogenetic trees using parsimony and neighbor-joining techniques. Parsimony analysis yielded a strict consensus of 24 trees that is congruent with the single tree generated by neighbor-joining analysis. Neighbor-joining was also used to compare trees derived from nucleotide sequences and from isozyme phenotype data from an earlier study; in general, the same species groups were supported in both data sets. Our analyses indicate that the pine stem rust fungi form distinct clades that correlate with telial host families (e.g., *Fagaceae* and *Santalaceae*). Close phylogenetic relationships between autoecious, short-cycled *Peridermium* species and putative heteroecious relatives were confirmed (e.g., *P. harknessii* with *C. querquery* f. sp. *banksianae*, and *P. bethelii* with *C. comandrae*). Nucleotide sequences and isozyme phenotypes were used to identify four undescribed taxa, including: California oak rust, which may be a cone or gall rust that has become isolated from its aerial host; white-spored gall rust from the southwestern U.S., which was thought to be an albino form of orange-spored *P. harknessii*; a previously undescribed yellow-spored gall rust from California, and stalactiform limb rust of Jeffrey pine, which was thought to be a host-form of *C. coleosporioides*. In light of these results, a systematic reevaluation of *Cronartium* and *Peridermium* morphology and biology is needed

**url:** phylogeny


**Abstract:** *Endocronartium harknessii* (J.P. Moore) Hirat. populations never approach the level where all susceptible *Pinus contorta* Dougl. ex Loud. var. *latifolia* Engelm. tissue is infected, even in years when environmental conditions are favourable for infection. A simple simulation model was developed to determine whether a hyperparasite could regulate the rust population and maintain it at an equilibrium level far below host saturation. The model assumed that galls begin sporulating and first become susceptible to parasitism 2 years after formation and requires specification of infection rates for
the rust and the hyperparasite, mortality rates for normal and parasitized galls, and the degree to which aeciospore production is reduced following hyperparasite infection. Analysis of the model showed that the hyperparasite could regulate the rust population, producing a stable equilibrium, but only if the various rates were such that healthy galls, in their lifetime, produced enough aeciospores to give rise to more than one new gall, while galls that were parasitized during the first year of aeciospore production produced, in their lifetime, fewer than one new gall. The model of hyperparasite regulation provides one possible explanation of the dynamics of the gall rust pathosystem. It shows that control measures such as sanitation and breeding for resistance may reduce the effectiveness of the hyperparasite in regulating the system and, thus, may fail to achieve the anticipated goals.

doi: 10.1139/cjfr-26-7-1256


Abstract: The incidence of western gall rust, stalactiform blister rust, comandra blister rust and atropellis canker was measured in 16 permanent sample plots in young lodgepole pine stands in the Interior of B.C. in 1980, shortly following juvenile spacing, and again in 1985 and 1992. The incidence (as percent of living trees with live rust infections) of the three rusts increased substantially between 1980 and 1985 in both treated and control plots, but declined from 1985 to 1992, partially because of infected tree mortality, but mostly because of a low rate of new infections and the death of all branch infections on many surviving trees. More than 85% of all stalactiform and comandra blister rust infections and 60% of all gall rust stem infections occurred within 2 m of the ground. The low incidence of new infection in these plots since 1985 is probably attributable to the loss of live branches due to crown closure and branch suppression in that 2 m zone as well as altered climatic conditions and reduced inoculum levels. Atropellis canker infection increased at each remeasurement, and in 1992, was less in spaced plots than in unthinned controls (3.4 and 8.9% of trees infected). A set of recommendations concerning allowances for disease mortality at the time of regeneration and juvenile spacing is presented.


Abstract: Seven lodgepole pine (Pinus contorta Dougl.) provenances collected along an east-west transect from Cypress Hills, Saskatchewan, to Vancouver, British Columbia, were inoculated as 1-year-old seedlings with one coastal and three British Columbia interior western gall rust (Endocronartium harknessii (J.P. Moore) Y. Hiratsuka) spore sources in a factorial design. Infection levels ranges from 4 to 95% (average 56.4%, based on 1032 inoculated seedlings). ANOVA of arc sine transformed percent seedlings infected demonstrated a significant interaction between provenance and spore source (P = 0.029). Provenance, spore source, and their interaction accounted for 70, 14, and 6% of the variation, respectively.


Abstract: Variation in infection of lodgepole pine (Pinus contorta) by Endocronartium harknessii over time was determined by back dating in a 20-year-old natural stand in central British Columbia. The effect of height, branch order and aspect within the crown and the influence of stand density on the amount of gall rust infection is described. The year of greatest infection (1976) accounted for 26% and the year of least infection (1982) for 2% of all infections on 370 trees over an 11-year period. More than 80% of galls were alive 5 yr after infection, but less than 10% 3 yr later. Infection severity in 9 heavily galled trees decreased with height above ground from 1.4 galls/m of branch length at 1 and 2 m above the ground to less than 0.05 at 7 and 8 m. The number of stem infections decreased with height at a similar rate. Branch order and aspect had no significant influence on galls/m branch length. Infection did not vary significantly over the range of densities studied (640–2200 stems/ha). The probability of damaging stem infections decreases rapidly with stand age, and few new infections are likely to occur following precommercial thinning.


Abstract: Some of the information in this important study on the relation of environmental conditions to the spread of white pine blister rust in Wisconsin has already been noticed. On inoculated plants of black currant, Ribes cynosbati, R. americanaum, R. hirtellum, and R. missouriensies, urediospores developed at day temperatures ranging from 16 to 28 C and night from 28 to 20 C, but not when a temperature of 35 C prevailed during a five-to-seven day. In general 20 days at 35 C sufficed to prevent subsequent sporulation of the fungus, and sometimes the same result was achieved with 10 days. A 2-week period of suitable temperatures was requisite for fertile teleutospore production which was inhibited by 20 C at night and 35 C by day. Teleutospores formed on wild Ribes plants in the field during a three-week period of temperatures ranging from 15 to 25 C were practically sterile, whereas those that developed in a week of less than 20 C temperatures were fertile. In one location a three-day period with diurnal maxima of 28 to 32 C and a night range of 8 to 18 C was long enough to cause sterility. High temperatures also inhibited germination of previously formed teliospores the risk of infection being eliminated for a further 7 to 8 days, for temperatures at 5 days at 35 C for teleutospores formed at a constant temperature 16 C a period 42 to 48 hours was necessary for sporidial production and germination, but the substitution of a nocturnal temperature of 2 C expedited the processes so that 36 hours were enough. Production of fertile teleutospores in quantity needs 2 weeks with no three consecutive days over 28 C, and a subsequent 48 hours of saturated air below 20 C is sufficient for infection of pine. Lack of these conditions is the principal factor limiting blister rust spread in the state.

Abstract: It had been noted that in certain large areas of southern Wisconsin where the alternate hosts were common and rust had been omnipresent on *Ribes* bushes, the white pines were, nevertheless, generally free of infection. This study was undertaken to determine blister rust behavior on favorable and unfavorable sites and to provide a means for estimating the pine infection probability on a given site. Individual trees examined in an area In Rock County (southern Wisconsin) with abundant *Ribes* showed that the blister rust cankers occurred less than 5 feet above the ground. Cankers were limited to pine trees in openings in the forest canopy and in a kettle hole. In systematic samples of white pine associated with *Ribes* in southern and lowland western Wisconsin, blister rust was most often found in sheltered valleys. It occurred on 54 percent of the plots at the bases of slopes and 38 percent of those in small (D/H less than 1.0) forest openings. Larger openings and a closed forest had rust present less often. Only one-twentieth of the samples at the shoulders of slopes showed rust present. A site formula based on the above factors was prepared. This predicted rust canker locations with 89-percent accuracy in southern and western Wisconsin at elevations below about 1000 feet in that area with an average July temperature of more than 70 F. Studies of local variation in temperature and moisture distribution indicated that the bottoms of narrow valleys were under 68 F for a longer period than level ground was and that the shoulders of valleys were warm longer than either the valley or level ground. The bases of slopes were cool, somewhat like a valley, but the effect was less pronounced. A kettle hole averaged cooler than flat land sites. Openings in the forest with diameters less than the height of surrounding trees were under 68 F longer than sites in the open or under the forest canopy. High humidities were more common near the ground; the bottoms of narrow valleys had higher humidities, and kettle holes averaged more moist than flat land sites. Small openings in the forest were more humid and had saturated air more hours per day than did sites in the open field or in unbroken woods. Northern Wisconsin had general blister rust distribution on pine with rust present on almost all sites. The lowest rust presence (68 percent of plots) was under tree canopy overstories. There were indications that rust distribution was fairly well correlated with average July temperatures. As July temperature averages increased, rust became less common on the white pines. Rust was more general where July temperatures averaged less than 70 F; where the average was higher, rust was usually confined to locally cool moist places.

Annotation: Classic demonstration that different processes may be important in different ecosystems and how a understanding of the driving process can lead to slection of proper predictor variables.

Key Words: Classic demonstration that different processes may be important in different ecosystems and how a understanding of the driving process can lead to slection of proper predictor variables.


Abstract: Surveys of the pinyon pine blister rust were made on pine May 1992, 1993, and 1994, and on *Ribes* in August of 1993. There was a zone without *Ribes* at the lowest (driest level) than a zone with *Ribes* but no rust. Above this zone various percentages of the pines were infected. The percentage of infected trees was found to be highest in a belt from 6300 to 6700 feet elevation on three Great Basin mountain ranges. Above 6700 feet there was less rust, although there were abundant *Ribes* and numerous pines with good growth. The rust distribution seems to depend on spore transport as well as temperature and moisture distribution. The greatest concentration of infected trees seems to occur at the backflow recharge area of slope drainage winds where spores are carried in night breezes and the areas are cool and wet enough to favor rust infections.


Abstract: Pine trees can be free of blister rust infection either because they are growing in a climate unfavorable to rust or because they are genetically resistant to the rust. The climatic escape is hundreds of times more common than genetic resistance in the American white pines. The minimum time and temperature required for penetration by an isolate of the rice blast fungus (*Piricularia oriza*) differed significantly from one rice variety to another. This illustrates an interrelationship between environmental influences and genetic susceptibility. In the pine rusts, the minimum conditions for infection might, for example, be less limiting in sugar pine (*Pinus lambertiana*) than eastern white pine (*Pinus strobus*). As an example of local variation in blister rust incidence due to environmental differences, 29 Lake States plots with a median of 250 trees each were used. They were regularly examined for rust incidence for periods exceeding 10 years. In the 4 years prior to alternate host (*Ribes* spp.) eradication, the infection incidence on the 29 plots varied from 0 to 118 cankers/100 trees/yr. The mean was 67 cankers/100 trees. After eradication the variation was reduced and the infection incidence averaged 1.34 cankers/100 trees. In warmer zones, white pine blister rust is largely confined to locally cool, wet openings in the forest and at the bases of slopes. In cool zones the rust is more abundant when the pines are open to the sky in small openings. Trees escaping infection are usually under trees, in large openings, and where sea breezes carry the spores out over the water. Fusiform rust on slash pine was also favored in small openings and was rarer under overstories. It was rarest in large openings. Small openings are those that have diameters less than the height of the surrounding trees.


Abstract: In summary, these examples of snow molds, white pine blister rust, and rice blast show that local microclimates can be very important in determining whether plant disease epidemics develop or not. In the first example, local warming in a very cold climate allowed local epidemics. In the second example, locally cool wet spots favored infection. In the third example, local warming favored heavy infection. In all three examples, copious moisture was needed, and the knowledge of
the micrometeorological epidemiology has permitted climatic escape to be used as a control of the disease.  

**Annotation:** This discussion is confined to those microclimatic variations that result in important changes in disease incidence and that can be used to control the disease in certain conditions. Emphasis is on principles rather than details. Topics are: local temperature and/or moisture differences, radiation effects, air drainage, and night breezes applied to several diseases including white pine blister rust in the Lake States.

**Key Words:** This discussion is confined to those microclimatic variations that result in important changes in disease incidence and that can be used to control the disease in certain conditions. Emphasis is on principles rather than details. Topics are: local temperature and/or moisture differences, radiation effects, air drainage, and night breezes applied to several diseases including white pine blister rust in the Lake States.


**Abstract:** Information on the time of spore release in the diurnal cycle shows that spores released at night play an important role in the spread of some major plant diseases. Spores released at night encounter different environmental conditions than spores released during the day. Many spores released at night are smaller and lighter and thereby spread better in the nocturnal environment. Traditional statistical diffusion theories do not apply to night-released spores. On the assumption that the spores go where the winds blow, the theory is advanced that spore clouds exist in a structured atmosphere and that these structures are stable and found to a greater extent at night. The relation of traced airflow to the spread of white pine blister rust sporidia illustrates the usefulness of tracer methods, because blister rust infections can be seen on pine and dated for many years after the infection occurs. For example, the locations of the cankers in trees and tracer studies show that lake breezes from Lake Michigan and Lake Superior control the location of blister rust infections on white pines. The spores nearest the lakes are blown over the water at night so pines near the Great Lakes rarely have rust. A higher flow of air toward the land carries the spores 10–17 miles from the lake where downdrafts deposit the spores to make numerous infections high in the trees and far from the nearest pines.

**Annotation:** Good example of how distant *Ribes* and pine populations in the same landscape may be connected.

**Key Words:** Good example of how distant *Ribes* and pine populations in the same landscape may be connected.


**Abstract:** Transplants (2-1 stock) representing 73 seed sources of *Pinus ponderosa* were planted at two sites 74 km apart in 1968 in southwestern Michigan. Before being planted in Michigan, 0.5% or less of the stock became infected with *Endocronartium harknessii* at a Nebraska nursery. In 1982, disease severity (number of galls per tree) was recorded for each tree and mapped. *P. ponderosa* var. *scopulorum* was more severely diseased than *P. ponderosa* var. *ponderosa* (P=0.05). Within *P. ponderosa* var. *scopulorum*, two southern ecotypes, Colorado Plains and Southern Rockies, were more severely diseased than other (P=0.001). Resistant and susceptible seed sources occurred within ecotypes of both varieties.


**Abstract:** On March 26, 1919, two collections, of leaves of *Ribes nigrum*, heavily infected with the uredinial stage of *Cronartium ribicola*, were sent in from Newport, Rhode Island, by Dr. H. H. York. The leaves had been on the ground, well covered up with grass during the winter and were dead and dry. On March 28, inoculations were made on two healthy *Ribes* plants, one *Ribes* nigrum, the other an undetermined species, in the pathological greenhouse at Washington, D.C. The difficulty experienced in scraping uredinia from dried leaves made a new method necessary. Therefore the most heavily infected leaves were pulverized and the fine dry powder applied thickly to the under sides of the moistened *Ribes* leaves. The plants were then put into an iceless refrigerator, the type of inoculation chamber used by this office, for 48 hours; after which they were placed in the open greenhouse on a bench with healthy plants. These healthy plants served as controls. On April 9, a small group of uredinia were noted on each of three inoculated leaves of the *Ribes nigrum*; none were discovered on the other plant until April 22, when three uredinial spots appeared on two leaves. At the same time heavily infected *Ribes* leaves were sent in by Mr. G. B. Posey, from a collection he had made at Temple, New Hampshire, on March 23. Inoculations were made in the same way and at the same time and place as with the Newport material. On April 9 six small groups of uredinia were observed on four of the inoculated leaves. These tests agree with similar ones made in the spring of 1918 by York and Spaulding2 and seem to confirm their conclusion that *Cronartium ribicola* may occasionally overwinter on dead *Ribes* leaves.


**Abstract:** Some of the factors influencing the period of production of the telia of *Cronartium ribicola* are weather conditions, time of season when the *Ribes* drop their leaves, and the varying ability of the species of *Ribes* to produce a second crop of leaves after the first has been dropped. The germination of the teliospores is especially dependent upon moisture. Temperature per se does not seem to be so important; low temperatures merely inhibit or check the rate of germination. High temperatures have not been tested. Newly-matured teliospores germinate abundantly in about six hours at 75°F., while they require about twelve hours at 55–70°F. Increase in age increases the time needed for germination. Longevity in this paper means the length of time during which teliospores remained ungerminated and still viable. Some of the factors influencing longevity of teliospores are: the habitat of the *Ribes* hosts, and the structure of the *Ribes* leaves.
Both are closely associated with the access of moisture to the teliospores. The factors which are necessary for the infection of white pines by Cronartium ribicola are many, and some of them are not known. It is known that there must be a period of sufficient moisture to germinate the teliospores, and that this must be followed by a period of high humidity during which the infection can take place. An attempt has been made to illustrate some of these conditions graphically.


Abstract: First attempt at a physiological study of sporidia of Cronartium. The influence of alternate wetting and drying upon the sporidia of 8 species of Ribes was studied. The time necessary for the production of sporidia increased directly with the length of storage of the material. Temperature also affected this same time period. Water was determined necessary for germination. Viability was decreased merely by air-drying and rewetting the spores. Injury increased directly with increase in saturation deficit of the air in which they were dried. This injury was primarily evident in reduced germination percentages rather than in growth vigor. Some sporidia were able to survive over 9 hours of air-dried exposure. Viability decreased as exposure length increased. Precooling appeared to stimulate germination of sporidia. Sporidia from all tested host species produced secondary sporidia, those not having been dried doing so more readily.


Abstract: Cronartium ribicola, during the past season, has shown an aggressiveness which it hitherto has not shown in this country. This it is believed is due largely to favorable weather conditions. This year, for the first time, two-year wood of white pine was found bearing fruiting bodies. This year the American variety of gooseberry, Downing, has become infected quite liberally by the fungus in one instance. A general warning against stem inhabiting Peridermiums seems necessary. These two species at least are destructive to nursery trees and may become equally destructive to native reproduction. Dr. Hedgcock's work with some of the other species has shown that they are also destructive and may very easily become a menace to nurseries in localities where they are present. A general campaign on the part of nurserymen located in proximity to natural pine reproduction should be instituted for the eradication of the alternate hosts for a considerable distance about their nursery.


Abstract: Experiments have been carried out at Bethel, Vermont to determine how late in the season the teleutospores of Cronartium ribicola may remain viable under natural conditions. Vigorous leaves of five species of Ribes—nigrum, odoratum, americanum, rotundifolium, and cynosbati, bearing abundant teletiosori were enclosed in mosquito bags and hung out of doors on September 26, 1921. Germination tests were made at intervals until December 8, when the experiment ended. The results obtained showed that while teleutospores on R. cynosbati, rotundifolium, and odoratum had almost reached their limit of viability by December 8, those of R. americanum retained considerable vigor and those of R. nigrum were almost as vigorous as when first collected. It has long been recognized that R. nigrum is far the most dangerous species of Ribes known in relation to the blister rust of white pine. Further tests showed that leaves killed suddenly by frosts bore teleutospores of maximum germinating power, and attention is called to the fact that the danger of infection is increased by ability of teleutospores to germinate in winter, when the temperature rises a few degrees above freezing, although it is not known whether the pines are susceptible at this season. Telia on green leaves (or recently frost-killed) germinated well; telia on dead (dry) leaves did not germinate. Ribes nigrum is far the most dangerous species because: (1) The plant is nearly maximum in height. (2) Its is maximum in vigor of growth. (3) It produces new growth throughout the season. (4) It produces new shoots and leaves to a maximum lateness in the season. (5) It produces a maximum area of leaf surface. (6) It is more susceptible than other species. (7) A maximum number of telia per unit of leaf area are produced on this host. (8) These telia are of maximum vigor in germination and production of sporidia. (9) The telia are of maximum longevity in the season. Telia on Ribes will remain alive in the winter and will germinate readily when the temperature rises above freezing, but it remains to be determined whether the pines are in condition to become infected.

Annotation: Useful guide for identifying some of the factors involved in ranking the epidemiological importance of various Ribes species.

Key Words: Useful guide for identifying some of the factors involved in ranking the epidemiological importance of various Ribes species.


Abstract: A number of species of insects, chiefly beetles, were found in June, 1917, on or near blister rust lesions on white pine, bearing aciospores in varying quantities. One beetle (Setica sericea) was collected feeding upon a red currant bush and bore aciospores on its body. Slugs, spiders, and many species of insects are habitual frequenters of or casual visitors to lobs bushes, wild or cultivated. Many species of insects were found in 1918 to bear urediniospores from infected leaves, some in large quantities. Sporidia were found in a few cases on ants. One insect (Neodiprion pinetum) collected upon Ribes is known to feed upon Pinus strobus. Inoculations prove that insects may spread the urediniospore stage from bush to bush. Hence, while the spread of Cronartium ribicola by the agency of insects from pine to Ribes or vice versa may be infrequent and accidental, the spread of the urediniospore stage upon Ribes probably occurs with some regularity.

Abstract: We investigated whether white pine blister rust (Cronartium ribicola) (J.C Fischer in Rabenh.) severity, tree diameter at breast height (DBH), bark and phloem thickness, and sapwood moisture content influence the preference of the mountain pine beetle (Dendroctonus ponderosae Hopkins) for individual trees of whitebark (Pinus albicaulis Engelman) and lodgepole pine (P. contorta Loud.). We measured these variables at 5 sites in Montana and Idaho and found a significant relationship between blister rust severity and attack of trees by D. ponderosae, with trees exhibiting greater blister rust severity being more likely to be attacked by the beetle. Sapwood moisture content was negatively correlated with blister rust severity indicating that as severity increases there is an increasingly negative effect on water relations within the tree. Sapwood moisture content was significantly lower in P. albicaulis than in P. contorta at sites with beetle activity suggesting that there may be an interaction between blister rust severity and drought stress that, in turn may affect beetle preference. DBH and bark and phloem thickness did not appear to influence beetle preference for individual trees. As blister rust spreads in P. albicaulis stands across the western U.S. this may translate to increasing levels of beetle-caused mortality in these areas  

url: whitebark pine, lodgepole pine, physiology, bark beetle


Abstract: A survey in a lodgepole pine, Pinus contorta var. latifolia Engelm., provenance trial showed that the western pine moth, Dioryctria cambicola (Dyar) (Lepidoptera: Pyralidae), was the most prevalent pitch moth, and stalactiform blister rust, Cronartium coleosporioides Dharth., the most prevalent stem rust. Also present were the Douglas-fir pitch moth, Synanthedon novaroensis (Hy. Edwards) (Lepidoptera: Sesiidae), comandra blister rust, Cronartium comandreae Phk., and western gall rust, Endocronartium harknessii J.P. Moore, and the stem canker Atrophellis piniphila (Weir). Results from a likelihood ratio test indicated an association of western pine moth with stalactiform blister rust and of Douglas-fir pitch moth with both western gall rust and stalactiform blister rust. Western pine moth attacks are most commonly found along the active edge of stalactiform blister rust cankers, suggesting that the moth larvae derive some specific benefit from the fungus. The association of Douglas-fir pitch moth with the rusts appears to be a result of the physical wounds caused by the fungi, since attacks by this pitch moth are also frequently found at pruning wounds or other injuries  

url: lodgepole pine, associated insects


Abstract: The influence of environment on infection of Ribes by Cronartium ribicola has been studied both in the greenhouse and at the Wisconsin blister-rust nursery, where white pines are being selected or rust resistance. Readings were made at intervals on the percentage of Ribes leaf area covered by uredia, necrosis, telia, and total infection. Uredia developed on Ribes nigrum at constant temperatures of 16, 20, 24, and 28 C. With increasing temperatures, incubation time was shorter; area involved was larger; subsequent leaf necrosis was greater. However, telia developed as follows: abundant on R. cynosbati, R. missouriense, and R. nigrum in the nursery and on R. americanum, R. glandulosum, R. hertellum, and R. triste nearby was observed in detail during the seasons of 1942, 1943, 1944, and 1945. The development of rust in the nursery correlated closely with that at corresponding temperatures in the greenhouse. These results help to clarify the observations (1) that telia seldom develop well on most species during hot weather, and (2) that hot, weather improves the chances for white pine to escape infection  


Abstract: Aeciospores of two cauliculous rusts, Peridermium stalactiforme Arth. & Kern (orange- and white-spored) and P. harknessii J. P. Moore, belonging to the Cronartium coleosporioides Arth. complex, were germinated under different temperature and pH conditions. P. stalactiforme germinated from 10 to 25 C, and P. harknessii from 10 to 30 C, with optimum for both occurring between 15 and 20 C. Germination was best at pH 6, markedly reduced at pH 5 and 8, and inhibited outside pH 5 to 9 in P. stalactiforme and pH 4 to 9 in P. harknessii. Growth at the optimum temperature and pH for 24 hours resulted in average germ lengths of 870 u and 230 u for P. stalactiforme and P. harknessii, P. harknessii initiated germination more rapidly than P. stalactiforme. Germ tubes of P. stalactiforme were long with multiple irregular short distal end of the germ tube often produced an appressorium with peg. Germ tubes of P. harknessii were short, with one to three branches and no appressoria. Few differences were found between the two color variants of P. stalactiforme. A technique for dispersing spores evenly on media is described  


Abstract: One hundred and sixty species of arthropods, representing 137 insects, 19 mites, and 4 spiders, were collected or reared from the cankers of the Comandra blister rust, Cronartium comandreae Peck, on lodgepole pine, Pinus contorta Dougl. var. latifolia Engelm., in southwestern Alberta. The insects damaged 40 to 60% of the cankers observed in any one year and reduced aeciospore production by 10%. Eleven orders of insects were represented, of which Coleoptera (29 species), Lepidoptera (14), Diptera (21), and Hymenoptera (38) were the most important. Epuraea obliquus Hatch, Paracoxenos guttatus Hardy and Wheeler, and a Mycoidiosis species appeared to be true mycetobionts. Several others which damaged the cankers, such as Pissodes schwarz Hopk., Cylindrocupressatus deleoni Buchanan, Ernobius sp., Corticaria sp., Bradsyia sp., Dioryctria spp., Laspexresia sp., Grapholitha sp. prob. Caeruleana Weshm., Eucordylea sp.,

Abstract: Cronartium comandrae Pk. aeciospores germinated over the temperature range 1 to 30 degrees C, but germination outside the range 5 to 22 degrees C was poor. Optimum for germination was about 15 degrees C, although initial germination was better at 20 degrees C. Some aeciospores germinated after 1 h of incubation and most within 4 to 5 h. The rate of germ tube elongation was reduced after 8 h, and generally had ceased after 24 h. Each spore produced an average of 2.5 cm from the canker was 17,217 spores/m3, but on more than half the days fewer than 100 spores were collected. The highest hourly concentration observed from an individual canker was 128,208 spores/m3, which coincided with the onset of heavy rains. Atmospheric turbulence was associated with all peak aeciospore concentrations. Little release occurred when temperatures were below [?] when relative humidity levels were high, or when dew was present. Peak release occurred when temperatures were above 20 degrees C, and relative humidity levels were at their lowest. Heavy rains initially increased spore concentrations, but light rains did not have the same effect. Wind was important to initiation of spore release, but there was no close correlation between high wind velocities and high spore concentrations released from a canker.


Abstract: Limb rust attacks and kills several species of hard pines from California to South Dakota and southward to Central America. Rocky Mountain ponderosa pine and Jeffrey pine are most heavily attacked. In most managed stands, selective cutting coupled with a natural decline in rust abundance have reduced this disease to the status of a local and controllable hazard to timber crops. Limb rust is not so easily controlled where block cutting is practiced. In stands not managed for timber, limb rust continues to cause serious damage. A sample in Bryce Canyon National Park shows that of 12 dead trees in the sample that had been attacked by Dendroctonus bark beetles, 11 had been limb rusted: apparently a large part of the Park's endemic beetle population exists in trees weakened by limb rust.


Abstract: Comandra blister rust is widespread on lodgepole pine in the Rocky Mountain Region. Damage is concentrated; no abundant new infections are now known. Sometime after 1915, damaging concentrations of comandra blister rust on ponderosa pine were noted near Pagosa Springs, CO. The rust was also found on lodgepole pine at Berthoud Pass near Fraser, CO. Around 1958, C. comandrae was common in parts of Arapaho, Rout, and White River NF's on lodgepole pine. In the 1960s, few cankers were found at the Pagosa Springs site and none were found in the Berthoud Pass site. In 1961, the infected stands in WY were systematically sampled, these included: four of the ranger districts of the Bighorn NF and four districts of the Shoshone NF. No outbreaks were seen on trees less than 11 years. The outbreaks of two to several decades ago are affecting yield and delaying profitable harvest. Other outbreaks are reported in the Black Hills and Bear Lodge Mts. (WY–SD)


Abstract: Peridermium harknessii infection is concentrated in relatively few years: in nearly all stands studied, more than 50% of the infections originated in 1 or 2 yrs of a 10-yr sample period. Epidemics are often only a few miles in extent, but

Cinara spp., Diapterobates (Berlese) could be classed as mycetophiles. About half the species appeared to be mycetoxenes. New habitat for host information was obtained and several new species were collected. Several of the genera represented have been provide a suitable habitat for development.


Abstract: Release of Cronartium comandrae Pk. aeciospores from stem cankers on Pinus contorta Doug. var. latifolia Engelm. in southwestern Alberta occurred from mid-May to late August, the peak period being between late May and mid-June, after which there was a gradual decrease. Diurnal aeciospore periodicity showed spores to be usually released between 0800 and 1900 hours, with some evidence for a double peak. Maximum daily concentration of trapped spores at a distance of 2.5 cm from the canker was 17,217 spores/m3, but on more than half the days fewer than 100 spores were collected. The highest hourly concentration observed from an individual canker was 128,208 spores/m3, which coincided with the onset of heavy rains. Atmospheric turbulence was associated with all peak aeciospore concentrations. Little release occurred when temperatures were below [?] when relative humidity levels were high, or when dew was present. Peak release occurred when temperatures were above 20 degrees C, and relative humidity levels were at their lowest. Heavy rains initially increased spore concentrations, but light rains did not have the same effect. Wind was important to initiation of spore release, but there was no close correlation between high wind velocities and high spore concentrations released from a canker.


Abstract: Cronartium comandrae Pk. aeciospores were collected daily from individual cankers and pustules on Pinus contorta Doug. var. latifolia Engelm. Germination was high for the initial 2 to 4 weeks, but much lower during the second half of the sporulation period. Most individual cankers and pustules showed similar trends in their daily spore germination. Germination and weather conditions had no consistent relationship. However, wet spores rapidly lost color and germinated poorly. Contamination from the associated microflora, especially Penicillium spp., Cladosporium spp., and bacteria, increased as the season progressed, and contributed to the reduced spore viability.
occasional wave years may also be detected over a whole region such as Idaho and adjacent Montana.

Annotation: Provides locations and age distributions for wave years in Colorado, South Dakota, Wyoming, Idaho, and Montana.

Key Words: Provides locations and age distributions for wave years in Colorado, South Dakota, Wyoming, Idaho, and Montana.


Abstract: Western gall rust, caused by Peridermium harknessii, is prevalent in pine plantations on the Nebraska National Forest near Halsey, Nebr. As high as 4% of pine seedlings and transplants in the adjacent Bessey Nursery have been infected by this rust. Automatic volumetric spore traps and weather recording equipment were installed in and adjacent to the nursery to determine when and under what conditions aeciospores are dispersed. On rainless days, there was diurnal periodicity in the number of spores trapped. The number of spores increased sharply in the morning (0700 hr) as air temperature increased and relative humidity decreased. Numbers of spores reached a maximum about 1100 hr, and decreased sharply about 1300 hr. This periodicity was interrupted on days with rain. Aeciospores were dispersed as early as 8 May; dispersal was essentially completed by the end of June. During the 2 years of trapping, dispersal was over 80% completed by the end of May.


Abstract: The white-pine blister rust has been in British Columbia at least since 1910. It became widespread by 1913. It has spread upon the white pine practically to the north and east limits of the coast belt of white pine. It has spread a relatively short distance to the south. It has become established at four places in the eastern belt of white pine in British Columbia. An average of one season in every four years has been favorable for general spread of the disease along the coast of British Columbia. In the summer of 1922 there was infection of Ribes by aeciospores as far south as Ilwaco, Wash. In 1923 infection was not found south of the vicinity of Port Townsend, Wash. In 1923 infection was found on Ribes at Namu and Bella Coola, 80 and 110 miles, respectively, north of the limit of white pine upon the coast. Prevailing westerly winds favor aeciospore dispersal from the coast toward the east. Northerly winds, which favor aeciospore dispersal to the south, are most common in dry seasons, which are unfavorable for pine infection. West of the Cascades, northerly winds in the period of aeciospore production increase to the southward as far as northern California. The amount of summer precipitation diminishes southward. The rust is practically certain to spread southward at a much slower rate than to the north and east. The spread of the rust to the Inland Empire may be greatly retarded by the elimination of Ribes nigrum from that region.


Abstract: The aim of this study was to assess the effect and importance of the feeding of the pine top weevil on the germination of Endocronartium pini in Scots pine, and thus to establish the possibility of the E. pini infection via insect woundings. Germination tests were therefore carried out on current and previous year needle and phloem extracts. Elucidation of the importance of pathogen infection for insect feeding preference was also required; were carried out with healthy and infected pine branches using the pine top weevil as a test insect. Weevil feeding increased the germination E. pini aeciospores on pine extracts. Germination of previous year annual-shoot extracts was lower than that on current year annual extracts. The advance of the growing season increased this trend, but weevil feeding increased germination on extracts from older annual shoots to levels found on extracts from current annual shoots. Spores germinated equally well on needle extracts and on phloem extracts. The weevils ate more often on infected branches than on healthy branches. E. pini infections may occur via woundings on branches and weevil feeding may facilitate this.


Abstract: Infection caused by white pine blister rust varies sharply in intensity from year to year. Early intensification of the disease in the west occurred in 4-year cycles traceable to the length of the average blister rust life cycle. Subsequent intensification has followed no regular pattern except that it seemed to occur to a greater extent during wet seasons. The abundance of inoculum in the inland empire white pine region precluded dependence on the life cycle for periodic intensification on western white pine after 1934.


Abstract: Larvae of the phalacrid beetle, Phalacropsis dispar (LeConte) consumed aeciospores and the underlying sporogenous mycelium, thereby destroying the aecia of all native western pine stem rust fungi studied. Aecia of the introduced white pine blister rust fungus (Cronartium ribicola) were not found to be infected by the beetle. A close, if not obligate, biosis of the beetle apparently exists with the native rust fungi, and their geographic distributions closely coincide. Laboratory tests and field observations indicate that the beetle completes its life cycle in 30 to 40 days and apparently
overwinters as an adult. Quantitative data on aeciospore inoculum destruction were beyond the means of this study; however, observations over a 12-year period evidenced widespread and extensive destruction of aeciospores. The beetle may be an effective element in the natural control of native pine stem rust fungi. Natural control by secondary organisms could significantly reduce the selective pressure for high host resistance in a naturally evolving host-parasite population.

**Annotation:** Reports a large outbreak of C. occidentale on *Pinus monophylla* near Monitor Pass, Alpine Co., CA; aecial spore masses were virtually destroyed by the beetle in all trees for 3 seasons.

**Key Words:** Reports a large outbreak of C. occidentale on *Pinus monophylla* near Monitor Pass, Alpine Co., CA; aecial spore masses were virtually destroyed by the beetle in all trees for 3 seasons.


**Abstract:** The terpenoid and phenyl propanoid content of xylem resin as well as phloem nitrogen and carbohydrate levels of lodgepole pine trees infected with *Armillaria* root disease, *Comandra* blister rust, and dwarf mistletoe and check (asymptomatic) trees were determined. Comparisons were made to determine if differences existed that might influence their susceptibility to bark beetle attack. These variables were also contrasted with respect to aspect (north and south). Five volatiles (tricyclic, alpha-pinene, camphene, gamma-terpinene, and bornyl acetate) were significantly high in trees with one or more diseases than in check trees. Four volatiles (myrcene, camphor, 4-allylanisole, and gamma-terpinol) were significantly lower in diseased trees. Camphene was the only resin constituent found to differ with respect to aspect, with a higher concentration on the north aspect of check trees. There were no significant differences in carbohydrate or nitrogen content with respect to aspect. The check trees were found to have significantly higher starch, total nitrogen, and free amino-N contents than diseased trees. Trees infected with *Comandra* blister rust were found to contain lower levels of reducing and nonreducing sugars than the other diseased trees and the check trees. Changes in terpenoids and phenyl propanoids in trees susceptible to mountain pine beetle attack suggest a biochemical basis for host selection. Only trees with an infection rating of 6 were used in the DMT group. Classes 2–4 were used in the CBR group.


**url:** WWP, resistance


**Abstract:** Temporal changes in three factors (shoot susceptibility, spore availability, and spore germinability) were evaluated to estimate their effects on the infection of lodgepole pine (*Pinus contorta* var. *latifolia*) by *Endocronartium harknessii*. Germinability of rust spores from sori free of hyperparasites remained above 80% during the growing season and thus would not have significantly limited infection. In contrast, there was a slight, but statistically insignificant, increase in estimated susceptibility as infection increased from 94% of maximum at 45% shoot elongation to maximum susceptibility at 90% shoot elongation. This was followed by a precipitous decline in estimated susceptibility to 57% of maximum when shoots were 95% elongated. Spore availability was 24% of maximum when shoots were 45% elongated, and thus may have been limiting at the beginning of the growing season. At the end of the growing season, spore availability declined prior to, or simultaneous with, the decline in susceptibility. The combined effect of both factors drastically reduced the number of infections estimated to occur once shoots are more than 95% elongated. As shoots elongated, relatively more infections formed higher on the shoot, supporting the hypothesis that periderm is important in limiting infection.

**url:** epidemiology


**Abstract:** Western gall rust caused by *Endocronartium harknessii* (J. P. Moore) Y. Hiratsuka is common on *Pinus contorta* Dougl. ex Loud, in western Canada. A study was conducted to determine factors influencing rust infection and seasonal occurrence of the mycoparasite *Scytalidium uredinicola* Kuhlman et al. Spore viability remained above 90% in both field seasons indicating that pathogen viability does not limit infection. Field shoots elongated to 90%, 95% and 100% of their final length by the third and fourth week of June, and first week of July, respectively. Susceptibility at these stages was 100%, 60%, and less than 10%, respectively. The decline in spore production and decrease in susceptibility combined to reduce infection once shoots reached 90% of their final length. The likelihood of *Scytalidium uredinicola* presence increased by a factor of 1.3 for each year of growth and increased by a factor of 2.1 for each 1 cm increase in gall size. The incidence of *S. uredinicola* was only weakly associated with rust severity in the stand. *Scytalidium uredinicola* was isolated from the surface of galls and from tissues beneath the periderm throughout the year on galls six years of age or older. Histological study confirmed the presence of *S. uredinicola* in unruptured sori as early as 24 April 1994. *Scytalidium uredinicola* occurred in the same location over 3 successive sporulating seasons from 1992 to 1994. On parasitized galls, *S. uredinicola* reduced rust spor germination to 5.5%. Given that *S. uredinicola* is active at the beginning of the growing season when lodgepole pine is most likely to be infected by *E. harknessii*, and that it greatly reduces rust spore viability, its potential as a biological control agent would appear quite great. However, the weak association with rust severity in nature suggests that it may not be an important regulating factor in the pathosystem. Further, failure to establish on young galls may be a significant disadvantage for its use as a biological control agent.

**url:** epidemiology, phenology, associated fungi

Abstract: Stands of lodgepole pine diseased by comandra blister rust area common in the Intermountain Region: Shoshone, Teton, Bridger, Caribou, Cache, Targhee, Sawtooth National Forests and Teton and Yellowstone National Parks. According to older forest officers, there were no damaged lodgepole pine stands 20 or 25 years ago as there are now. Changed climate is not a likely explanation. Plausible that there has been an increase in toadflax, due to overgrazing. To develop a damage appraisal in this situation the following factors must be considered: commercial timber value, fire hazard, recreation, watershed, domestic livestock, big game, commercial recreation, disease incidence and severity, site hazard, rodent populations, bark beetle populations, lack of practical control


Abstract: Scan Ribes recent epidemic behavior of comandra blister rust in lodgepole pine in the Intermountain Region


Abstract: Origin of white pine blister rust. Introduction to North America. White pine of western North America. rust on pine. The rust on Ribes. Scouting for the rust. Early history of blister rust in the west. Spread of the rust by years (1910–1942). General aspect of spread. Disseminating agencies and spore stage involved. Possible limits of long-distance spread. Relation of weather to spread and intensification of the rust. Wavelike character of spread of the rust. Rate and direction of spread of the rust. Some relations of Ribes species in the spread of the rust. Pinyon rust: its complication in spread of blister rust. Some biological factors unfavorable to development of the rust. Strains of white pine blister rust. Map. In the course of field investigations in 1922-3, circumstantial evidence was obtained of the capacity of the rust to spread from pine to Ribes for distances upwards of 100 miles by means of wind-borne aeciospores, while data accumulated during the last 20 years indicated that, under favorable conditions spread may occur over distances of 300 to 400 miles and possibly further. In this connection, records of upper-air winds have proved much more valuable than those dealing with surface movements, the direction of which is largely dependent on local topography. With the aid of charts of the upper-air winds it has been possible to forecast with a high degree of accuracy the southward spread of infection to Ribes in California. Moisture is a very important contributing factor in the dissemination and intensification of C. ribicola, a wide extension of which may be anticipated in any season when wind and humidity combine to favor its development. The spread of rust has been wave-like in character, with the waves being irregularly timed owing to the weather and other conditions that are not favorable for heavy pine infection locally, with long-distance spread to Ribes and the subsequent establishment of the fungus in new localities. The years 1917, 1921, 1923, 1927, and 1937 were outstanding in this regard. While the rust has extended more to the south than to the east, the intensity of spread has been heaviest eastward. Black currants are stated to have played only a very minor part in the spread of the rust on pines except in the interior of British Columbia


Abstract: A simulation model of white pine blister rust is described in both word and mathematical models. The objective of this first generation simulation was to organize and analyze the available epidemiological knowledge to produce a foundation for integrated management of this destructive rust of 5-needle pines. Verification procedures and additional research needs are also discussed


Abstract: A major problem facing, those who wish to inoculate white pines, with Cronartium ribicola is the reliable production of teliospores. Also, a better understanding of the nature of the various spore stages will add to our ability to develop workable integrated rust management plans. The results reported in this paper will increase the reliability of teliospore production in both whole plant and detached-leaf-culture of Cronartium ribicola on Ribes plants, and add to our understanding of the interaction between genes and the environment in the functioning of epidemiological fitness traits.

Annotation: Cultures of C. ribicola obtained from aeciospores or urediospores differ in patterns of teliospores production. Temperatures near 55 F stimulate both infection success and teliospores production.

Key Words: Cultures of C. ribicola obtained from aeciospores or urediospores differ in patterns of teliospores production. Temperatures near 55 F stimulate both infection success and teliospores production.


Abstract: Comparison of weather records from the southern Sierra Nevada and northern Idaho and other evidence demonstrated that the southern Sierra Nevada climate was potentially unsuited for a northern ecotype of blister rust. A north Idaho ecotype, characterized by actual spore germination data, and several theoretical southern Sierra Nevada ecotypes were subjected to the two environments in a simulation model of rust epidemics. Output showed the Idaho ecotype incapable of basidiospore production in the southern Sierra Nevada, but indicated that a hypothesized southern Sierra Nevada ecotype
adapted or acclimated to cooler infection-period temperatures and shorter growing seasons could have infected local sugar pines by mid-June. Observed high levels of rust damage in the southern Sierra Nevada may be explained by the appearance of the new rust ecotype. Comparing spore germination response over temperature gradients for actual genotypes from the southern, central, and northern Sierra Nevada and north Idaho would constitute a powerful test of the hypothesis.


Abstract: A synthesis of several studies highlights above-average performing seed sources (n = 108) of whitebark pine (Pinus albicaulis), which practitioners can utilize for restoration, wildlife habitat improvement, and operational planting programs. It is the first report of this magnitude of blister rust resistance for this species. Whitebark pine does have genetic variation and demonstrated resistance to white pine blister rust, increasing from the southeast to the northwest in the Inland Northwest. Early outplanting reports have shown that some seedlings have frost damage or exhibit increased mortality in cold pockets or swales. Cold hardiness, measured in late winter on a smaller sample of sources (n = 55), also showed genetic variability increasing from the northwest to the southeast. Seed zones were delineated by Mahalovich and Hoff (2000) based on information on relative rust hazard and demarcation of mountain ranges. These geographic seed zones support conservation seed transfer with a special emphasis on blister rust infection levels. Sufficient variability exists to maintain these seed zone boundaries, because whitebark pine exhibits more of an intermediate adaptive strategy as compared to the generalist adaptive strategy of western white pine (P. monticola). Based on this composite information, it is feasible to outplant whitebark pine without the additional delay of waiting until blister rust resistant seedlings are developed from a breeding program. There are sources within each seed zone that have both rust resistance and greater cold hardiness, so those factors should not limit tree planting for restoration or critical wildlife habitat improvement objectives. Typical stock orders involve container-grown seedlings. A comparison between Economy and copper-lined Ray Leach Super Cell ContainersSTM (10 in 3 (164 CM3)) shows no advantage to using copper lining.

url: abiotic stress, biogeography, climate change


Abstract: Interspecific hybrids between eastern white pine (Pinus strobus L.) and Himalayan blue pine (P. wallichiana A. B. Jacks.) were developed in Ontario, Canada, to introduce blister rust (Cronartium ribicola Fisch.) resistance genes to P. strobus. There is concern that introducing blister rust resistance has resulted in reduced cold hardiness of the progeny compared with non-hybridized eastern white pine. To test the efficacy of backcrossing with P. strobus to improve cold hardiness, 1-year-old seedlings from hybrid crosses differing in P. strobus genome composition were artificially freeze-tested. In Experiment 1, unhardened seedlings were allowed to acclimate to progressively lower temperatures in a growth room, whereas in Experiment 2, seedlings were hardened outdoors under natural weather conditions in Sault Ste Marie, Ontario. Needle cold injury was determined by calculating relative electrical conductivity based on post-freezing electrolyte leakage. Results indicated that needle fascicles from unhardened seedlings of all genotypes in the greenhouse tolerated –5 °C for 3 hours with little or no injury. Cold hardiness increased in parallel with declining growth room minimum temperature over the 7-week period of hardening. Cold hardiness was improved for hybrid crosses with increased Pinus strobus genome composition in Experiment 2, but the results were less conclusive in Experiment 1.

url: EWP, physiology, abiotic stress


Abstract: Management has asked, what is the difference in microclimate between areas with low Ribes population and heavy infection and areas with high Ribes population and light infection? Answers to this question will make it possible to designate and delineate areas where conditions for the rust may be so favorable that even a few remaining Ribes could cause a rust buildup that could not be tolerated. Management also wants to know what air flow conditions prevail in areas where long-distance spread may be involved. If basic criteria for long-distance spread can be established and recognized when observed on working units, then they can be considered in planning eradication work. When these questions have been answered, standards for Ribes tolerance and for width of protective zones can be established on each blister rust working unit. Areas for protection and performing local Ribes eradication can be selected which will not require protective zones of proportions beyond which it is not economically feasible to eradicate Ribes. Areas where local intensification from a few remaining Ribes might be expected can be avoided.


Lloyd, M.G. 1957. Proposed research program of the Intermountain Station on the relationship of the spread and

http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/
intensification of blister rust disease to microclimate. In: Microclimate research in relation to white pine blister rust; Aug. 29–30; Berkeley, CA..


Abstract: The number of white pine trees with blister rust cankers caused by the fungus Cronartium ribicola and stem deformities caused by the weevil Pissodes strobi were fewer in the sample areas close to Sudbury. White pine blister rust was almost entirely absent in the sample areas near to the smelters. Since infected leaves were noted on some Ribes species in these areas, it is possible that (1) the sensitive rust spores were injured by contaminants in the atmosphere in passing from the Ribes host to the white pine host, or (2) as the incubation period of blister rust in white pine requires approximately three years from the time of needle infection to the first appearance of aecia, the premature shedding of any two-year-old foliage may have removed some of the infected needles from the trees.


Abstract: Under favorable storage spores can survive over a year, if they do so in nature is questionable.


Abstract: Considerable damage of comparatively recent origin has been observed in ponderosa pine in Montana along the Clark Fork River between Superior and Missoula. The rust is both scattered and concentrated in a few severe centers. Little rust is encountered in side drainages or slopes bordering the benchland of the main river bottom. Infections occur in even and uneven aged stands ranging from 50 to 175 years old; in uneven-aged stands only older trees are affected. Up to 60% of branches may be infected. Infection occurs on wood 1 to 3 years old.


Abstract: The results of ten years' field studies in western North America of the early stages of blister rust on the native western white pine showed that on trees over 3 ft in height and more than 8 years old the duration of the incubation period to the production of visible bark symptoms usually ranges from about 20 to 26 months, but is sometimes considerably longer, depending on the time of infection, seasonal conditions, and altitude. After infection the minimum time required for canker formation in such trees is generally not less than 16 months, although recent data from Idaho indicate that in certain cases the minimum might have been as low as 9-1/2 months. On younger trees, not over 5 years old, the incubation period is shorter and incipient cankers were observed to form after a minimum of 6 months. The time required for the production of pycnospores after the incubation period ranges from less than 1 month to 10 months. Aecidiospores are usually formed from 6 months to 2-1/2 years after the production of the pycnospores, but sometimes the intervening period extends over 3 or even 4 years, and under certain conditions occasionally ranges as high as 10 to 20 years. On the younger trees it rarely extends beyond 2-1/2 years.

Annotation: Incubation is through needles. Incubation, period from infection to appearance on bark, lasts 2 to 4 yr. After incubation, pycniospore production requires 1 to 10 months; then aeciospore production requires 0.5 to 2.5 yr and continues for about 1 to 5 yr.

Key Words: Incubation is through needles. Incubation, period from infection to appearance on bark, lasts 2 to 4 yr. After incubation, pycniospore production requires 1 to 10 months; then aeciospore production requires 0.5 to 2.5 yr and continues for about 1 to 5 yr.


Abstract: An account is given of the discovery of the rust disease caused by Cronartium Comptoniae in the Pacific Northwest. Its range includes the section west of the Cascade Mountains from Ilwaco, Washington, north to Prince Rupert, British Columbia. The disease is indigenous here, as in the East. The only known uredial host of the rust within this range is Myricia Gale. The aecial stage has been found only on Pinus Contorta. The uredial host is a plant of very scattered occurrence in 'bogs and along lake margins where it is of little or no value, inaccessible, and easily overlooked. The aecial stage of the fungus closely resembles another indigenous and much more widely distributed rust, C. Filamentosum which completely overlaps its range. These two factors contributed largely to the fact that the disease was not discovered earlier in the West. In the fall, a wide distribution of the disease has been noted on M. Gale, irrespective of the proximity of the aecial hosts. This distribution is attributed to long distance dissemination of the rust by wind-borne aeciospores. Both the aecial and the uredial hosts occur transcontinentally between the northern limits of the known ranges of rust in the East and the West. It is probable, therefore, that the disease also is transcontinental and that the eastern and western ranges of it are connected. The disease is destructive to young Pinus Contorta in the near vicinity of sweetgale. As high as 10 or more per cent of the seedlings may be killed in such situations. Studies indicate that nodes and internodes originating in the first four years of the life of the seedling only are sufficiently susceptible for the establishment of infection. Many of the trees have the faculty of largely recovering from the disease. Possible modes of infection and evidence on the development of resistance of the host are discussed. No associations of the alternate host with Pinus ponderosa which has shown itself to be highly susceptible in eastern nurseries, have been found. Such associations probably are rare, if they exist at all. Consequently, the rust can not be considered a serious threat within the native range of this pine. Observation on Myricia Californica at Ilwaco corroborated results of inoculation by others in the East, showing, this species of Myricia to be
immune. The fact that it ranges southward into the Oregon and California pitch- and hard-pine ranges may be concluded to be of no significance in connection with the possible distribution of the rust into these regions.


Abstract: During 1971 Berg deployed 6 hygrothermographs on Mt. Washburn. Some pine infection might have occurred if telia were present.

Annotation: from Appendix B part 3 of compilation of items on blister rust control program at Yellowstone Natinal Park.

Key Words: from Appendix B part 3 of compilation of items on blister rust control program at Yellowstone Natinal Park.


Abstract: The history of comandra rust infection in lodgepole pine in the Rocky Mountains was traced by dating cankers in infested stands from n UT to c MT. Analysis of infection of 730 cankers showed that throughout the region the rust had remained endemic for almost 100 yr, then increased to epidemic proportions between about 1910 and 1945. The rarity of cankers <10 yr old indicates that infection by the rust has subsided again to an endemic level. Older cankers are abundant and are likely to cause increasing damage for a few years, even without new infections.

Annotation: Extensive field studies were located in: Ashley, Beaverhead, Bridger, Sawtooth, Cache, Custer, Gallatin, Lewis and Clark, Caribou, Teton, Wasatch, and Targhee NF's. The northern part of the Targhee NF had few cankers. Twenty-nine plots were scattered throughout the study areas. Of the 29 plots studied 280 cankers were found. Ninety percent were found in the trunks and 1/4 of these caused spike tops. The Caribou NF and the Grand Teton NP showed recent outbreaks. The intensive field studies were located in: the Gros Ventre RD of the Teton NF and the White Sulphur RD of the Lewis and Clark NF. On the Gros Ventre RD, 393 cankers were found on 20 plots. Twenty-six percent of the live lodgepole was infected with the rust. In the past 5 yr 14% had died of comandra blister rust. Ninety percent of the cankers occurred in the trunks and of these 1/2 caused spike tops. Fewer old cankers were found than in the extensive studies. On the White Sulfur RD, 52 old cankers were found. Approximately 1/4 of these cankers were over 100 yr old. There was an absence of cankers in sapling stands. Cankers are present in less than 4% of the live lodgepole; another 2% died recently from girdling cankers. Seventy percent of the cankers have already caused spiked tops and 96% are found in the trunks.

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Abstract: In field tests from 1935–1950 by the Portland, Oregon, and San Francisco field stations, the forest pathologist, U.S.D.A., at 2 places in southern Oregon and 4 in northern California, special efforts to retain Cronartium ribicola on Ribes at plot centres, 34 tests (60 percent) yielded no infection on sugar pine (Pinus lambertiana), mostly due to lack of favorable moisture conditions or to premature shedding of infected leaves from Ribes roezli. Infection patterns from a single source of sporidia in the pine region were largely irregular, the commonest trend being downslope, probably form night time drift. The max. intensity of infection was 3,596 cankers/acre within 75 ft radius of the plot centre. Because of this irregularity, circular plots are not suitable for gauging rust damage on an area basis. From R. nevadense, which retains infected leaves and contracts uniform, moderate susceptibility, 9 of 11 tests were positive, of which 6 were usable for determining infection level. Rainfalls probably min. for pine infection (0.3 In./Days) were compared for 1927–1956 at 6 sites. In the pine region: the number of favourable periods decreased southwards from 84 to 18, while the number of years unfavourably dry for infection increased southwards from 0 to 18


Abstract: The observations herein described and tabulated on the development and defoliating action of white pine blister rust on Ribes roezli and R. nevadense, the principal associates of sugar pine in their native habitat in the northern Sierra Nevada, California, were made in 1938, 1941, and 1943. In general, the susceptibility of the two species to infection and the capacity of R. nevadense for teleutospore production agreed with results of earlier studies in British Columbia and the Pacific Northwest. R. roezli remained the more susceptible, its infected leaf area producing a higher percentage of teleutosorus-bearing surface and about twice the amount of teleutosorus columns per unit of such surface, but the premature shedding of its diseased leaves still rendered it less of a menace to pines than R. nevadense per unit of population. In unworked areas of the sugar pine region, on the other hand, the larger population of R. roezli (2,900 ft living branch stem per acre compared with 420 for R. nevadense) more than counterbalances its limited capacity for the retention of teleutosorus-bearing leaves, and here it is liable to prove a richer source of inoculum than R. nevadense. Factors contributing to the
premature shedding of infected leaves of *R. roezli* include severity of infection, relatively dry sites, youth and vigor of the leaves, exposure to direct sunlight, and early autumn frosts, of which only the first and last appreciably affected the process in *R. nevadense*. Infected *R. roezli* plants growing under shade and forming a profusion of new woody growth, especially on moist sites, are the most potentially dangerous in respect of the spread of blister rust, since the apical leaves of the current season's growth on such plants were the last to drop in the autumn and consequently bore uredospores and viable telia sori for a maximum period. The success or failure of *C. ribicola* to infect pines in any given year depends largely on the duration of rainfall before *Ribes* defoliation.


Abstract: A survey of limber pine (*Pinus flexilis* James) to determine the geographic distribution, incidence, and severity of white pine blister rust (WPBR) throughout 13 study areas in central and southeastern Wyoming and northern Colorado was conducted from 2002 to 2004. The majority (81.1%) of the 18,719 surveyed limber pines > 1.37 m tall were classified as healthy, 13.5% were declining or dying from various causes, and 5.4% were dead. WPBR was present on 278 (55%) of the 504 survey plots. Incidence of the disease ranged from 0% to 100% and averaged 15.5% over all the plots and 28.0% on the infested plots. Likelihood of infection by WPBR was significantly greater for limber pines in larger diameter classes. Incidence was negatively correlated with elevation and positively correlated with geographic position, with more northerly and easterly plots having higher incidences of WPBR. Incidence varied by slope position and did not vary by aspect, slope configuration, or degree of canopy closure. The current level of infestation in central and southeastern Wyoming and northern Colorado has been attained within the past two to four decades. With time, the pathogen may spread to currently uninfested white pine populations and intensify throughout its current distribution impacting valuable ecosystems.

Annotation: project funded in part by RMRS (Forest Pathology).

Key Words: project funded in part by RMRS (Forest Pathology).
doi: 10.1139/X06-231
url: distribution


Abstract: Incidence of cankers caused by comandra blister rust on lodgepole pine and distribution of the rust's alternate host, pale comandra were mapped in portions of two Wyoming forests. Rust incidence in 24 stands in the Shoshone National Forest varied from 14 to 64%, and rust incidence in 190 plots in the Medicine Bow National Forest ranged from 0 to 36%. Comandra populations occurred on open, upper slopes surrounded by lodgepole pine stands in the Shoshone study area and on dry ridge tops along the eastern and western slopes of the Medicine Bow study area. Simulations of wind speed and direction during periods favorable for basidiospore dispersal were used to identify comandra populations upwind of surveyed lodgepole pine stands. Rust incidence was highest in stands older that 40 yr along forest edges adjacent to comandra but also was high in some stands 1–10 km downstream of likely inoculum sources. Rust incidence was significantly negatively correlated with distance to comandra and with stand density was significantly positively correlated with average tree diameter, height, and age. Expected incidence of comandra blister rust across surveyed portions of the two forests can be predicted from average tree height or diameter and distance to comandra.


Abstract: Insects were trapped from caged stem sections taken from 35 lodgepole pine trees girdled at mid to bottom crown by Comandra blister rust cankers (*Cronartium comandrae*). The trees were cut in 1987 and 1988 in two national forests in Wyoming and one in Montana. Two or three stem sections were removed from above, and one section from below, individual rust cankers. Emerging insects were collected biweekly for 5–8 months. *Pityogenes knechteli* was the most abundant bark beetle associated with cankered lodgepole pine, with *Pityophthorus murrayanae* and Ips sp. slightly less common. Cylindrocopturus deleoni was found occasionally. Insects non-damaging to lodgepole pine also emerged including individuals in the families Anthocoridae, Cleridae, and Chrysomelidae. The mountain pine beetle (*Dendroctonus ponderosae*) was endemic in the collection areas but was not found on sampled trees.


Abstract: This report updates a study that was undertaken to identify causes of limber pine decline and mortality in central Montana (Taylor and Sturdevant 1998). Taylor and Sturdevant determined that 85% of the mortality along permanent transects in the Lewis and Clark National Forest from 1995 through 1998 was associated with defoliation from the needle pathogen *Dothistroma septospora* (Doroguine) Morelet. Although 41% of the study trees were reportedly infected with the white pine blister rust pathogen *Cronartium ribicola* Fisch, Taylor and Sturdevant believed rust-caused mortality was low, accounting for only 12% of the total mortality. The remaining mortality, approximately 3%, was attributed to suppression of needle disease, limber pine, tree mortality.

url: foliage disease, limber pine, tree mortality

http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/

Abstract: Cronartium comptoniae incidence was measured on 62 provenances of Pinus banksiana and 77 provenances of P. contorta. Infection incidence varied among provenances in both hosts, Pinus banksiana provenances beyond the geographic range of Comptonia peregrina, and P. contorta provenances beyond the range of Myrica gale, were more susceptible than some provenances within the range of these alternate hosts. It is hypothesized that selection pressure is important in maintaining resistance to C. comptoniae


Abstract: For the white pine blister rust disease (WPBR), reports conflict concerning the time of year the pathogen, Cronartium ribicola J.C. Fisch., infects western white pine (Pinus monticola D. Don) and what needle age increments are most susceptible. To determine timing of infection, western white pine seedling were placed under infected currants (Ribes nigrum L.) for 1-week periods from May to November. Needles became spotted and stems cankered after exposure to diseased currants from early summer until leaf drop in November. To determine what foliage age increment was most susceptible, 5-year-old seedlings were placed in a disease garden, and older trees were inoculated in situ. All age increments of pine foliage were susceptible to infection. For young seedlings, all age increments were about equally susceptible, but on some older seedlings and trees, the current year's foliage appeared more resistant than older foliage

title: epidemiology, WWP


Abstract: By isolating cankers and by bagging them during the appropriate seasons Cronartium ribicola Fisch. was found to be heterothallic. The flies Paracacoxenus guttatus Hardy & Wheeler and Megaselia (Aphiochaeta) spp. were particularly attracted to pycnia and were readily caught in sticky traps. It is postulated that these are the main insects responsible for cross-fertilization of Cronartium ribicola


Annotation: re-fit of Kearns's model.
Key Words: re-fit of Kearns's model.

url: distribution, meteorology, map, risk


Abstract: Aecidiospores of Cronartium ribicola from Pinus strobus in New York were experimentally shown to be capable of 31 percent germination at a maximum temperature of 28 C. The corresponding figure at the optimum of 11 to 12 being 83 percent. The capacity of the rust for germination at a relatively high temperature may be of importance in connection with Ribes infection in the newly invaded regions.

Annotation: infection may occur at temps as high as 28 C but more apt at lower temps.
Key Words: infection may occur at temps as high as 28 C but more apt at lower temps.


Abstract: A study was made of the relation of certain meteorological factors to the natural and artificial infection of eastern white pine by the blister-rust fungus in northern and central New York. The particular weather factors that received most attention were temperature, relative humidity, rain, fog, dew, and sunshine. These factors may vary markedly between localized areas not far removed from one another. Consequently, within forest and reforestation areas of large size, there may be localized sites that are more favorably disposed than others toward pine infection. This fact suggests that the same control measures applied over an area as large as New England or even New York may meet with very different results in different localities, and further suggests that control measures need to be more intensive in sections where localized weather conditions are especially favorable to rust spread


Abstract: The direct penetration of the epidermal cells by germ tubes from spordidia of the blister-rust fungus is reported for the first time. It seems probable that stomatal activity has very little significance in the infection of Pinus strobus by Cronartium ribicola. Stomata of Pinus strobus are arranged in rows on the ventral surface of the needles. The average distance between the pores in contiguous rows of stomata was found to range from 88 to 95 mu; between the pores of consecutive stomata within a row, the average distance was 32 mu; and the distance in a straight line from any point on the margin of a stoma-bearing surface of a mature needle to the nearest pore averaged between 161 and 165 mu. A stoma is opened and closed, in part, by the movement of the beak-like projections of the guard-cell walls. Considering the depth of the stomatal pit and pore, it is probable that a minimum of 10 hours of favorable weather must elapse, following inoculation
by primary sporidia of *Cronartium ribicola*, before a hypha can elongate sufficiently to come in contact with the mesophyll tissue by way of a stoma. In case of inoculation with secondary sporidia, the time may be shortened to 4 hours. The greater percentage of the stomata were open between 10 A.M. and 2 P.M. This periodic opening occurred similarly in potted pines and pines growing under natural conditions, during periods of precipitation as well as intervals of clear weather with low relative humidity.

**Annotation:** The direct penetration of the epidermal cells by germ tubes from sporidia of the blister-rust fungus is reported for the first time.

**Key Words:** The direct penetration of the epidermal cells by germ tubes from sporidia of the blister-rust fungus is reported for the first time.


**Abstract:** The elapsed time between inoculation of a *Ribes* leaf with urediniospores and the production of teliospores by *Cronartium ribicola* J. C. Fisch. ex Rabenh. was shortened by reducing post-infection incubation temperatures and by using host plants that had dormant buds. The effect of temperature was relatively small, but that of dormancy was large; this suggests that factors responsible for teliospore induction were related to changes in the physiological status of host tissues.

**Key Words:** dormancy, teliospore induction, *Cronartium ribicola*.


**Abstract:** Recent publications, surveys, and cooperative projects on white pine blister rust are reviewed with an emphasis on collaborative work in the Interior Mountain West. This broad region is important as the location where spread is occurring under circumstances different from those farther north and west. Observations in the Southwestern Mountains, Great Basin, and Rocky Mountain regions allow us to track development of individual outbreaks with a comparative, multi-scale approach. The objective is to provide information useful for sustained, long-term ecological management.

**url:** distribution


**Abstract:** Insects present in western white pine blister rust cankers in northern Idaho were: two weevils, *Cylindrocopturus* n. sp. and *Pissodes* sp. near Swartzi Hopk.; Two bark beetles, *Pityophthorus* sp. near Nitidulus (Mann.), and *Procryphalus* ? sp.; a drosophilid fly, *Paracoccusenxus guttatus* hardly and wheeler; and a phycid moth, *Dioryctria abietioborella* (Grote). Mites associated with insect infestation were: *Lasioseius* ? n. sp., *Ameroseius longirichius* Hirschmann, and *Histigaster arborsignis* Woodring.


**Annotation:** poster

**Key Words:** poster

**url:** dispersal, meteorology


**Abstract:** This study outlines the development of a methodology to temporally classify large scale, upper level atmospheric conditions over North America, the Upper Level Synoptic Index (ULSI). Four meteorological variables: geopotential height, specific humidity, and u- and v- wind components, at the 500 mb level over North America were obtained from the NCEP/NCAR Reanalysis Project data set. These data were subjected to principal components analysis to standardize and reduce the data set and then to an average linkage clustering algorithm to identify groups of observations with similar flow patterns. The ULSI calendar of synoptic conditions can be used to identify situations that lead to periods of extreme weather and to explore the transport of airborne particles across North America. In this study, the ULSI is applied to the problem of the spread of a forest pathogen in the western United States. White Pine Blister Rust (WPBR), *Cronartium ribicola*, is believed to have arrived in the Sacramento Mountains of south-central New Mexico around 1970. The rust in New Mexico is genetically identical to that present in the southern Sierra Nevada. The ULSI is employed to identify days with upper level flow patterns that were favorable for the transport of the rust spores from California to New Mexico. This likelihood was evaluated four times daily for the period 1965-1974 when the rust was most likely to have been transported from the Sierra to the Sacramentoos. The results of this upper level investigation are then coupled with a surface evaluation of periods of favorable temperature and humidity for germination f the rust at the target. The result is a calendar of infestation likelihood for the Sacramento Mountains. The period 1–15 June, 1969, was found to be the most likely for infestation in this case. This technique may now be applied to other white pine populations in western North America and to other problems of atmospheric transport of forest and agricultural pathogens.

**url:** http://www.udel.edu/SynClim/Frank2003_TOCandAbstract.pdf


http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/
Abstract: The pH optimum for germination of aeciospores of Arkansas collections of Cronartium comandrae Pk. was determined to be 6.9. The temperature optimum was determined to be 19-20°C, which is considerably higher than reported for most Rocky Mountain collections of this fungus.

Doran, W.L. 1919. The minimum, optimum, and maximum temperatures of spore germination in some Uredinales. Phytopathology. 9: 391–402.


Annotation: Van Arsdel descRibes the results as suspect.

Key Words: Van Arsdel descRibes the results as suspect.


Abstract: The comandra blister rust fungus, Cronartium comandrae, is a macrocyclic heteroecious rust fungus that is an obligate parasite of some hard pines (Pinus spp.) and the genus Comandra (Santalaceae). In Arkansas, rupture of aecial peridia of C. comandrae on pine was associated with the passage of a cold frontal system. Aecia cast spores for approximately 1 wk in mid-April. Uredia were first visible on comandra 8 days after the initial release of aeciospores. Early infections were restricted to lower portions of the comandra plants. As surrounding vegetation grew in height, new infections developed higher on the comandra. The passage of another cold frontal system in mid-May favored the uredial repeating stage and was followed by a notable increase of uredia in late May on upper portions of the plants. Telia first appeared on 11 May, with the increase in incidence parallel to that of uredia, but telia reached maximum development after a 7-day lag. Maximum germination of teliospores followed the passage of another cold front on 23–24 June. After 24 June telial production declined. July was hot and dry and the comandra population defoliated completely during this time. Pycnia were evident on the pine host by late August and actively continued to exude pycniospores through mid-November.


Abstract: Sugar pine seedlings were included in mixed-species plantations on Blodgett Research Forest (av. elevation 1130 m) beginning in 1976. In 1983, the disease was detected on planted saplings, and a study was initiated in 1984. A total of 1277 saplings in 11 plantations and 476 scattered naturally-occurring saplings was examined; 16 percent of the planted saplings (1–53% of seedlings per individual plantation) and 12 percent of the natural saplings were infected. The years of origination of the infected internodes were determined: 60% of the infections were on 1981 tissue; 15% on 1982; 10% on 1980; 6% on 1979; and less than 1% on tissue of other years. Local weather data indicate that 1981 (with 6 days) were the only years since 1977 with more than one day of conditions favorable to infection. There was a strong correlation between infection and distance to Ribes. Both mature pycnia and aecia were detected during Fall, 1984.


Abstract: Hourly measurements of spore release by E. harknessii on Pinus contorta var. latifolia were obtained for 2 yr. Two spore traps were placed beside 2 sporulating galls and electronic data loggers were used to record environmental data. On rainless days, most spores were trapped between 0900 and 2200, when vapor pressure deficit, temp., light intensity and wind velocity were high. A similar pattern of spore release occurred under simulated daytime and nighttime condition in a growth chamber. On rainy days, most spores were released, an average, over a longer time period than on dry days. Within 9 h of being placed in a dew chamber, the previously intact peridium on a single gall had ruptured, presumably from pressure caused by spore production. Further evidence that spore production is simulated by low vapor pressure deficit was obtained by moving 11 galls alternately between humid and dry conditions. Thus, it is proposed that the diurnal periodicity of spore release on dry days results from the production of spores during the night and the subsequent passive release of those spores during the next day.


Abstract: Two spore traps were placed beside each of the two sporulating galls near Hinton, Alberta during the summer of 1985. A CR-21 micrologger was placed nearby to record meteorological data. On rainless days, most spores were released after 10 a.m. with very few spores being trapped at night. This period corresponded to the time of maximum temperature, wind speed, and sunlight. Spores were deposited on microthreads wound on rectangular frames and were exposed to sunlight, at a height of 100 cm above ground. Germinability of the spores was reduced by 2, 24, 33, 37, and 48% after 2, 4, 6, 8, and 10 hr exposure, respectively. Spores were incubated on microthreads at 6, 15, and 24 degrees C and 40, and 98% relative humidity in a three by two factorial design. Initial results suggested that spore survival decreased with increasing relative humidity and temperature.


Abstract: The effects of temperature and relative humidity (RH) on the survival of Endocronartium harknessii teliospores and the longevity of these spores out of doors during daylight hours were studied. In one experiment, fresh and liquid
Abstract: Spatial structuring is important in understanding the ecological and evolutionary dynamics of natural populations since local demes are rarely, if ever, completely isolated from neighboring demes. Plant host-pathogen interactions provide good examples of coevolutionary systems where both numerical and genetic dynamics have been explicitly investigated in a spatial context and where genes under selection can be unambiguously identified. In this article, we focus on long-term studies of several natural host-pathogen interactions that span a range of life histories and taxa. We use these studies to evaluate some predictions for numerical and genetic patterns at local and regional scales. Specifically, we examine the degree of among-population asynchrony in disease presence/absence and abundance, and the extent to which this is a function of isolation. For one host-pathogen interaction (Linum-Melampsora), we focus on whether there is local correspondence between resistance and virulence genes (as would be predicted by single-population coevolutionary models) or whether such correspondence occurs at larger spatial scales. Finally, we discuss the implications of these studies with respect to the impact of host and pathogen life-history variation on the spatial scale of coevolutionary interactions.

Understanding coevolutionary interactions in nature requires a multidisciplinary approach, including long-term empirical studies of multiple populations and computer modeling

url: geneticecoecology.stanford.edu/coevolutionary_interactions.html


Abstract: To estimate the frequency of comandra blister rust (Cronartium comandrae Pk.) infection episodes during a typical 80–100 year lodgepole pine (Pinus contorta Dougl.) rotation, weather data were analyzed for three study areas in Wyoming and Montana. Weather episodes that may allow for the infection of pine occurred an average of 67% of the years examined. The relationship between infection episodes and canker ages was examined. A correlation existed between potential infection episodes and years of infection. Climatological and canker age data did not support the wave year theory often associated with rust outbreaks. A survey of the Laramie District, Medicine Bow National Forest, Wyoming recorded the severity and density of comandra plants (Comandra umbellata (L.) Nutt.) Disease incidence ranges from 0 to 42% and was greatly affected by the distance of the pines from the alternate host. A weak correlation existed between rust incidence and tree height and diameter. Risk rating of stands can be accomplished by a distance relationship between lodgepole and comandra plants. Pines in a high hazard area have a high probability of being infected during a rotation because favorable weather episodes commonly occur


Abstract: To determine whether spore dispersal gradients of Endocronartium harknessii (J.P. Moore) Y. Hiratsuka were present adjacent to heavily infected pine stands, spore samplers were placed 0.5 m above ground at five distances, 2-80 m from the edge of an 18-year-old stand and were operated for a total of 33 days over 2 years. Six weather parameters were recorded inside the stand, and multiple regression was used to determine the relationship between weather and parameters of spore dispersal. To determine whether gradients of lodgepole pine (Pinus contorta Doual. var. latifolia Engl.) seedlings infested by gall rust were present adjacent to heavily infected pine stands, seedling infection was determined in 75-m2 plots centered 2.5-120 m from the stand edge, in five such plots in the center of that stand, and in transects of two-tree plots through a second stand. Spore concentration decreased with increasing distance from the stand edge in accordance with the power law model. Spore concentrations and the slopes of spore dispersal gradients were significantly affected by wind velocities. Although there was considerable unexplained variation, there was little evidence for the existence of disease gradients


Abstract: A sample of 29 405 lodgepole pine (Pinus contorta Dougl. var. latifolia Engl.) trees was assessed from 1982 to 1985, and stem analysis data of 75 trees from five heavily infested second-growth stands in the foothills of the Rockies were analyzed to determine the incidence, development, and impact of western gall rust Endocronartium harknessii (J.P. Moore) Y. Hiratsuka, in relation to age of trees and stand and site factors. The incidence of western gall rust increased with stand age and time. In stands up to 12 years old, the incidence averaged about 5% and increased rapidly to about 20% at age 20. A rapid increase in incidence over time occurred in younger age-classes. In stands 20 years or older, the incidence of new infection was low. Mortality associated with western gall rust among crop trees was low. There was, however, 30% mortality in an unthinned 22-year-old stand over its life. Impact on growth was highly significant (p < 0.01). In the periods 11-15 years and 16-20 years after the wave of heavy infection, reductions in volume growth of infected crop trees were 15 and 25%, respectively. This loss amounts to 15% of the total volume over the 20-year period during which the stands are affected. Western gall rust incidence was higher (p < 0.01) in stands on east-facing slopes than on south- and north-facing slopes. Stands at elevations between 1200 and 1400 m had the highest incidence. Forest management strategies to reduce the
Abstract: In a sample of 121 young lodgepole pine (Pinus contorta Dougl. var. latifolia Engelm.) stands in naturally regenerated cut blocks near Hinton, Alta., strong positive correlations were observed in the incidence of gall rust (Endocronartium harknessii (J.P. Moore) Y. Hiratsuka) and leader damage from terminal weevil (Pissodes terminalis Hopp.) and from pitch twig month (Petrola spp.) with tree size in both thinned and unthinned stands. Although tests on a selected number of the largest trees from each plot showed no significant differences in incidence of the two pest categories between thinned and unthinned stands, thinning that retains the large trees may result in an increase in relative incidence of these pests unless special effort is made to cut damaged trees and retain undamaged ones.

Annotation: see also Bella. 1985. Forestry Chronicle 61:233-238

Key Words: see also Bella. 1985. Forestry Chronicle 61:233-238


Abstract: Sporidia of Cronartium ribicola were subjected to various environmental conditions to determine the effect of environment on germination. Type, time and vigor of germination were given primary emphasis because germination per se was found not to be an accurate measure of sporidial response to environment. Artificial light vs. dark was studied as to its effect on type and vigor of sporidial germination. No significant effect of light was noted. In laboratory studies, primary sporidia were capable of producing up to six successive generations of sporidia but the fourth to sixth generations appeared to be of minor importance in the disease spread. Secondary and tertiary sporidia, however, were produced in great enough abundance to warrant consideration. Indirect germination, therefore, is a means of vegetative perpetuation and can be an aid in dispersal and longevity of sporidia. A sporidium, with its ability to germinate either directly or indirectly, can act as an agent of infection or as an organ of sporulation. Germination of primary sporidia occurred over a range of pH from 3.0 to 1.0. The optimum pH was 3.0 for direct germination and 7.0–9.0 for indirect. It was inhibited at pH 2.0. The optimum pH for vigor of germination (length of germ tube) was at 4.0 and decreased with increase in pH. Secondary sporidia showed the same reactions. Germination occurred from 0.5–1 to 24 h at pH 6.8 and from 0.5–1 to 28 h at pH 4.0. Time was found to be an important factor in vigor of germination. At the higher temperatures sporidia exhibited greater vigor at pH 4.0 after 6 hours than at pH 6.8 after 24 hours. The influence of time–temperature–pH on direct vs. indirect germination was studied. Direct germination was favored at all temperatures studied at pH 4.0. Sporidia germinated on needles of Pinus lambertiana from 0.5–1 to 28 C. Vigor of germination was exemplified by the predominance of 2–3 germ tubes per spore and by branching of germ tubes. Germ tube length increased as the temperature increased to 16–20 C after which length decreased to 4.2 u at 28 C. Few secondary sporidia were formed on the needles at any of the temperatures studied. On needles of conifer species other than white pines indirect germination increased, and direct germination consisted predominantly of one germ tube per spore. No significant difference in vigor of germination was noted on needles of 6 species of white pine tested.

Annotation: Fig. 8 shows vigor of germination at different temperatures after 6 and 24 hours at pH 4.0 and 6.8. At both pH units optimum vigor was displayed at 16 C after 24 hours, but after only 6 hours the optimum at pH 4.0 was found to be 20 C. Figure 6 shows 100% germination at about 16 C after only 6 hours. The results presented here suggest that somewhat longer but warmer periods will ultimately give as much infection as a shorter, cooler period.

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Abstract: A quantitative method of measuring teliospore germination was based on the ability of a telial column of Cronartium ribicola to cast sporidia. The beginning, crest, and capacity of sporidium production were determined from the individual detached telial columns of known size and age formed both at constant temperatures and out-of-doors. Time intervals were determined by using the clocks of rotating drum-type hygrothermographs. A representative telial column 1,330 X 105 um, 10 days old, from Ribes aureum Pursh held at 16 C, cast 4,930 sporidia. Casting began 8.5 hours after subjection of the column to 100% humidity. The peak of production began after 14 hours and continued through the 45th hour. Complete exhaustion of the column took 70 hours from the time of subjection. A telial column 770 X 73.6 um, 7–9 days old, also from R. aureum but kept out-of-doors, cast 2,954 sporidia. Casting began during the 7th hour; peak of production occurred between the 11th and 30th hours. Forty-three hours after subjection to 100% humidity the column stopped casting sporidia. Artificial light had no effect on germination of teliospores and subsequent casting of sporidia.


Abstract: Stalactiform blister rust, caused by Cronartium coleosporioides, occurs on hard pines throughout the northern United States and Canada. Locations of lodgepole pine reported in disease surveys of Idaho forests, 1968-1980, showed stalactiform blister rust occurring at elevations between 1,500 and 2,477 m. Abies lasiocarpa-Xerophyllum tenax and A. lasiocarpa-Vaccinium scoparium were the most common habitat types supporting lodgepole pine and stalactiform blister rust.

Abstract: Surveys at 5 sites in Wyoming showed that within 2 yr of the fires in 1988, some 67% of Pseudotsuga menziesii had been infested by bark beetles (primarily Dendroctonus pseudotsugae) and wood borers, 44% of Pinus contorta were infested (primarily by Ips pini), 82% of Picea engelmannii were infested (mostly by D. rufipennis) and 71% of Abies lasiocarpa were infested (mainly by wood borers). Bark beetle infestation occurred mainly in trees having <more or =>50% basal girdling by fire, although many uninjured Pseudotsuga menziesii were infested by D. pseudotsugae.


Abstract: Phaeocryptopus gaeumannii, the causal agent of Swiss needle cast disease, is widely distributed throughout New Zealand, where the disease may cause significant growth losses in Douglas-fir (Pseudotsuga menziesii) plantations. In western Oregon, where the pathogen is native, pathogen abundance and disease severity are correlated with mean daily winter temperatures and spring moisture, enabling the development of climate-based disease prediction models. The distribution of P. gaeumannii and severity of Swiss needle cast was surveyed in 16 Douglas-fir plantations throughout New Zealand in 2005. Retention of foliage was assessed in the field and samples of 1- and 2-year-old needles were collected for assessment of P. gaeumannii abundance. Foliage retention and abundance of P. gaeumannii varied across sites. Less colonization by P. gaeumannii and greater needle retention was found in the South Island. Abundance of P. gaeumannii was found to be positively correlated with August minimum temperature and June average temperature, and showed a similar relationship to winter temperature as observed in western Oregon. These data will be used to derive a disease prediction model for Swiss needle cast in New Zealand that can be used to guide further research and provide short- and long-term disease risk predictions and cost/benefit analyses.


http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/ 9/12/2008
Abstract: Losses through reduced growth or mortality attributable to pests, diseases, and abiotic disturbances are generally less in intensively managed, planted forests than in natural forests. Among plantation forests, the most healthy forests are those of exotic species growing a long way from their native range (e.g., Pinus radiata D. Don in New Zealand) and the least healthy ones are those of indigenous species (e.g., Eucalyptus nitens (Deane & Maiden) Maiden in Tasmania). The better health of plantations is a reflection of the generally good growing conditions, the proper matching of site to species that is possible in artificial culture and in the case of exotic species, the freedom from the many pests and diseases present in the native habitat of exotics.


Abstract: This bulletin brings together all the work carried out on Cyclaneusma needle-cast in New Zealand, mainly by the Forest Health group. Part I deals with the biology of the fungus - knowledge of which is fundamental to planning control strategies. Part II comprises chapters on distribution and severity of the needle-cast in different regions of New Zealand, its effect on volume growth, and the economic implications of the disease. Part III is concerned with methods of controlling the disease, including silvicultural techniques. A Glossary and Index are provided.


Abstract: Global warming is a key threat to biodiversity, but few researchers have assessed the magnitude of this threat at the global scale. We used major vegetation types (biomes) as proxies for natural habitats and, based on projected future biome distributions under doubled-CO sub(2) climates, calculated changes in habitat areas and associated extinctions of
endemic plant and vertebrate species in biodiversity hotspots. Because of numerous uncertainties in this approach, we undertook a sensitivity analysis of multiple factors that included (1) two global vegetation models, (2) different numbers of biome classes in our biome classification schemes, (3) different assumptions about whether species distributions were biome specific or not, and (4) different migration capabilities. Extinctions were calculated using both species-area and endemic-area relationships. In addition, average required migration rates were calculated for each hotspot assuming a doubled-CO\textsubscript{2} climate in 100 years. Projected percent extinctions ranged from \textless 1 to 43\% of the endemic biota (average 11.6\%), with biome specificity having the greatest influence on the estimates, followed by the global vegetation model and then by migration and biome classification assumptions. Bootstrap comparisons indicated that effects on hotspots as a group were not significantly different from effects on random same-biome collections of grid cells with respect to biome change or migration rates; in some scenarios, however, hotspots exhibited relatively high biome change and low migration rates. Especially vulnerable hotspots were the Cape Floristic Region, Caribbean, Indo-Burma, Mediterranean Basin, Southwest Australia, and Tropical Andes, where plant extinctions per hotspot sometimes exceeded 2000 species. Under the assumption that projected habitat changes were attained in 100 years, estimated global-warming-induced rates of species extinctions in tropical hotspots in some cases exceeded those due to deforestation, supporting suggestions that global warming is one of the most serious threats to the planet's biodiversity.


Lonsdale, D.; Gibbs, J.N. 1994. Effects of climate change in fungal disease of trees. In: Frankland, J.C.; Magan, N.; Gadd, G.M. (eds.). Fungi and environment change: symposium of the British Mycological Society. Cambridge: Cambridge University Press: 1–19. The effects of possible climate change on fungal diseases of trees can, to some extent, be judged by analyzing the existing role of climate and of fluctuations in weather. For pathogens whose geographic ranges or pathogenic activity are clearly affected by temperature, the effects of climate warming are probably predictable. These pathogens include both those that are favored by relatively high summer temperatures and also those that require mild temperatures in the dormant season because it is only then that they can attack the host. The effects of any increase in the frequency of summer droughts is also reasonably predictable, since the role of host stress in allowing attack by many pathogens, especially root pathogens, is well known. In particular, it can be predicted that such a climate change would alter the stability of associations between tree species and various members of their endophytic mycofloras, some of which would be triggered more frequently into curtailing such associations through pathogenesis. Prediction is more difficult in the case of pathogens whose reproduction and dispersal is strongly affected by rainfall and atmospheric humidity. This is also true of pathogens that are strongly affected by interactions with other organisms, such as insect vectors or protective mycorrhizal fungi. 


Abstract: Forest insects and pathogens are the most pervasive and important agents of disturbance in North American forests, affecting an area almost 50 times larger than fire and with an economic impact nearly five times as great. The same attributes that result in an insect herbivore being termed a "pest" predispose it to disruption by climate change, particularly global warming. Although many pest species have co-evolved relationships with forest hosts that may or may not be harmful over the long term, the effects on these relationships may have disastrous consequences. We consider both the data and models necessary to evaluate the impacts of climate change, as well as the assessments that have been made to date. The results indicate that all aspects of insect outbreak behavior will intensify as the climate warms. This reinforces the need for more detailed monitoring and evaluations as climatic events unfold. Luckily, we are well placed to make rapid progress, using software tools, databases, and the models that are already available.


Intergovernmental Panel on Climate Change [IPCC] 2001. Chapter 5: Ecosystems and their goods and services/ 5.6.2.2.2. Pressures from diseases and insect herbivory [Web Page].


Abstract: Climate warming may provide more favorable conditions for P. cinnamomi in northern California than occur now. Garbelotto and others (2006) reported P. cinnamomi infecting coast live oaks (Q. agrifolia Nees.) in southern California (San Diego County). Inoculations in February (average temperature of 19°C) resulted in small lesions (26 ± 15 mm) while September (average temperature of 24°C) inoculations resulted in larger lesions (135 ± 68 mm), confirming previous research that colder temperatures are unfavorable to the pathogen.


Abstract: Red fir mortality was examined in the Sayles summer home tract. Cause of mortality is due to a combination of drought stress, fir engraver beetles, red fir dwarf mistletoe, and annosum root disease. Management alternatives to ameliorate stand conditions are presented. Dwarf mistletoe (Arceuthobium abietinum f. sp. magnificae) is infecting much of the red fir. A second species of dwarf mistletoe, A. americanum, is infecting lodgepole pine. Cytospora canker (Cytospora abietis) has infected red fir branches that are supporting dwarf mistletoe infections. This canker fungus was killing some branches, resulting in branch flagging. Nectria canker (Nectria fuckeliana) is also present on the boles of red fir. Levels of mortality are unusually high. Red fir are predisposed to fir engraver attack by severe drought conditions, overstocking, and dwarf mistletoe. Actual insect attacks and tree mortality occurred last fall, but needles remained green until spring warming caused needle desiccation. The existence of overstocked aggregations, dwarf mistletoe, continuing water shortage, and insects will result in increased tree mortality. Red firs will continue to fade through spring of 1989. If normal levels of precipitation do not return in 1988–89, then high levels of tree mortality are expected into at least 1990. The presence of large, dead firs will significantly increase the probability of property damage or personal injury from tree failure.


Abstract: Climate change can affect forests by altering the frequency, intensity, duration, and timing of fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, or landslides


Abstract: Climate change affects forests both directly and indirectly through disturbances. Disturbances are a natural and integral part of forest ecosystems, and climate change can alter these natural interactions. When disturbances exceed their natural range of variation, the change in forest structure and function may be extreme. Each disturbance affects forests differently. Some disturbances have tight interactions with the species and forest communities which can be disrupted by
climate change. Impacts of disturbances and thus of climate change are seen over a broad spectrum of spatial and temporal scales. Future observations, research, and tool development are needed to further understand the interactions between climate change and forest disturbances.


Abstract: Guidelines are provided to help forest managers and silviculturists develop even- and / or uneven-aged cutting methods and associated silvicultural practices needed to convert ponderosa pine forests in the Black Hills into managed stands, and maintain them, for a variety of resource needs. Guidelines consider stand conditions and insect susceptibility. Cutting practices are designed to maintain water quality, improve wildlife habitat, and enhance opportunities for recreation and scenic viewing, and provide wood products. P.7. Dwarf mistletoe. The Black Hills and Bearlodge mountains are unique because of the absence of dwarf mistletoe (*Arceuthobium* spp.). Although Black Hills ponderosa pine is susceptible to the disease, the climate will not support the pest. Absence of dwarf mistletoe greatly simplifies the use of cutting methods that depend on natural regeneration.


Abstract: The effects of several rapidly changing environmental drivers on ecosystem function, discuss interactions among them, and summarize predicted changes in productivity, carbon storage, and water balance are reviewed.


Abstract: A canker disease of young Douglas firs became epidemic in the northern Coast Ranges of California during 1930 because of a combination of climatic conditions unfavorable to the host and favorable to the disease. The epidemic had subsided by 1931. It will recur again when similar conditions arise. The disease resembles a canker disease of Douglas firs in Europe, but it is apparently indigenous, or at least behaving as an indigenous disease. The damage resulting was negligible, most of the dying of Douglas fir and other species resulting from the protracted drought of 1929.


Abstract: Pitch canker, caused by *Gibberella circinata* (anamorph = *Fusarium circinatum*), causes canopy dieback and
mortality in susceptible pine species in many parts of the world. Pitch canker is most problematic in areas with a relatively warm climate, suggesting a possible limitation imposed by low temperatures. To test this hypothesis, the effect of temperature on radial growth was examined in isolates of G. circumvulata of diverse geographic origin. All isolates grew most rapidly at 25°C and progressively more slowly at 20, 15 and 10°C. Spore germination occurred most rapidly at 20°C and was slowest at 10°C. To determine if the time required for germination might influence the likelihood of infection, branches of susceptible Monterey pines (Pinus radiata) were inoculated at intervals after wounding in each of six field trials. Two trials, conducted during winter, yielded very low infection rates. In trials conducted during spring and summer, wounds inoculated on day zero became infected at a significantly higher rate than those inoculated two days later. Thus, low temperatures could extend the time required for spore germination beyond the interval of wound susceptibility and thereby limit infection frequency. This limitation could help to explain the present distribution of pitch canker.

Abstract: Two-year-old seedlings of European mountain ash were differentially exposed to freezing temp. Plants were inoculated at three heights on the stem with a non-aggressive isolate of B. dothidea. Exposed portions of stem were predisposed to attack but unfrozen portions remained resistant. The pathogen colonized frozen tissue near the margins of insulation but did not colonized unfrozen portions.


Abstract: Disease symptoms associated with B. dothidea in South Africa may thus result from the manifestation of previous latent infections after the onset of stress.


Abstract: Benomyl, injected in June into the potting mix of containerized 1-yr-old C. stolonifera at 36 g/m2, provided complete protection against water stress predisposition to B. dothidea canker. Benomyl conc. in stems, estimated by a chloroform extract bioassay, remained high (14.9 µg/g) for 32 days after injection. The same treatment applied in Sept. gave good protection against freezing predisposition in 1-yr-old, but not in 3-yr-old, plants. The conc. of benomyl in dormant stems was low (8.6 µg/g) compared with that in stems of growing plants treated in spring. Because benomyl applied to soil accumulates in woody stems and remains at fungicidal or fungitoxic conc. over an extended period, this treatment may be of practical value in reducing losses caused by nonaggressive pathogens that attack plants predisposed by stress, particularly during the critical period following transplanting. Improved timing, or a higher rate of fungicide application, or both, may increase protection in older plants.


Abstract: Hyphae in unstressed stems of white birch seedlings were thin, contorted, highly vacuolated, and restricted to xylem vessels within 5 mm of inoculation wounds. Hyphae in drought stress stems were thick, branched, rectilinear, and spread extensively through vessels. SEM photographs revealed a 2-layered sheath on all hyphae appressed to vessel walls in stressed stems, but the sheath was seen only rarely in unstressed stems.


Abstract: A negative linear relationship was found between plant water content and canker length.


Abstract: Have abstract


Abstract: Drought stress and winter injury have been associated with increased infection and canker expansion of B.dothidea (several supporting citations given)


Abstract: Human-induced climate change has become increasingly important in our everyday lives and, inevitably, will continue to do so. This Bulletin describes current thinking on the most likely effects of climate change on UK forests and woodlands. Predicted changes in the main environmental drivers - temperature, water availability, wind and rising atmospheric carbon dioxide levels - are discussed, together with their potential impacts on forest growth and the incidence of pests and diseases. The Bulletin also explores the implications of environmental change for semi-natural woodland ecosystems and for species choice in managed forests.


Abstract: California’s changing climate, characterized primarily by warmer summers and drier winters, will influence forest pest dynamics in the future. However, many of these changes are unknown. Predictions regarding these changes rely upon accurate models of pest ecology and future climate scenarios. Even with the best models available, the complex dynamics involved with forest pests force uncertainty into model predictions and create a situation of ongoing research and modeling. Forest pests are likely to expand their geographic and potentially their host ranges under increasing temperatures. Furthermore, increasing summer drought conditions will leave host trees more susceptible to forest pests that tend to attack less vigorous trees. These include root diseases, such as Armillaria spp. and many bark beetles (such as Ips spp.). Pitch canker appears to be primarily limited to the coastal regions of California due to the warm and moist conditions favorable for pathogen survival and growth (Gordon 2005; Gordon et al. 2001). However, the pathogen has recently become established in the Sierra Nevada Mountains, where many of the conifer species are susceptible to pitch canker (Vogler et al. 2004; Gordon 2005; Gordon et al. 2001). Although the recent Sierra Nevada infection zone is limited in extent, climate warming, coupled with the right moisture conditions (which may be met at nighttime), could greatly expand the current pathogen range. While pitch canker relies to some extent on insect vectors, environmental conditions are believed to limit disease distribution more than do insect vector populations (Gordon and others 2001). Furthermore, any beneficial impacts of climate change on vector populations will presumably increase disease expansion and severity as well.


Abstract: Described as a new species. Since the early 1980s, a serious decline of oak trees has been recognized in the Iberian Peninsula and the Mediterranean basin. Several factors, including drought, severe summer flooding, changes in traditional agronomic practices, wood-boring insects, and fungal diseases – P. cinnamomi and several fungi that cause cankers and diebacks.


Abstract: Insect-caused tree mortality, fires, and pathogens are primary disturbance agents in forest ecosystems. The mountain pine beetle, Dendroctonus ponderosae Hopkins, is a bark beetle that can cause extensive mortality in ponderosa pine, Pinus ponderosa Lawson, along the Colorado Front Range. Despite the history of outbreaks of this insect in Colorado, no models have been developed to estimate the probability of infestation. Thirty-five clusters of one infested and three baseline plots were established from 1998 to 2000 in the Arapaho-Roosevelt National Forest in north-central Colorado to develop empirical models of probability of infestation based on forest conditions. Mountain pine beetle-infested plots exhibited higher basal area and stand density index (SDI) for ponderosa pine and for all tree species combined, and higher number of ponderosa pine trees per hectare. Within infested plots, infested trees were larger in diameter at breast height and in the dominant and co-dominant crown positions. A classification tree model indicated that the likelihood of infestation by mountain pine beetle is 0.71 when ponderosa pine basal area is $>17.1$ m$^2$/ha at the stand level. A second plot-level model indicated that the probability of infestation increased with increasing ponderosa pine SDI, ponderosa pine quadratic mean diameter, and total basal area. For individual trees within infested plots the likelihood of infestation was 0.77 for dominant or co-dominant trees $>18.2$ cm in diameter at breast height. Results are consistent with other studies that have documented increased likelihood of infestation or enhanced mortality levels or both as a result of higher host type stocking. The simple models developed should help to guide silvicultural treatments and restoration efforts by establishing stocking levels below which mountain pine beetle-caused mortality is less likely, particularly in the dry sites and poor growing conditions.

**Abstract:** Numerous wildfires in recent years have highlighted managers' needs for reliable tools to predict postfire mortality of ponderosa pine (*Pinus ponderosa*) trees. General applicability of existing mortality models is uncertain, as researchers have used different sets of variables. We quantified tree attributes, crown and bole fire damage, ground fire severity, and insect presence from a total of 5083 trees in four 2000 wildfires in four Intermountain states in the USA (i.e., Arizona, Colorado, South Dakota and Montana). Crown scorch (percentage) and consumption (percentage) volume collectively accounted for the majority of predictive capacity in all four individual models and in the pooled four-site model. The addition of tree diameter and presence of *Ips* beetles in the pooled model slightly improved predictive power. Four other statistically significant variables added little to the pooled model's predictive ability. The pooled model correctly classified 3-year postfire mortality of 89.9% of the trees and had a receiver operating characteristic (ROC) score of 0.96. In the external validation step, the model correctly classified 3-year postfire mortality of 96% of 1361 trees in a 2001 wildfire. Our results and a number of previous studies suggest that a two-variable model using percentage crown scorch volume and crown consumed volume will have applicability beyond the Intermountain West.


**Abstract:** Fire and insects are natural disturbance agents in many forest ecosystems, often interacting to affect succession, nutrient cycling, and forest species composition. The literature pertaining to effects of fire-insect interactions on ecological succession, use of prescribed fire for insect pest control, and effects of fire on insect diversity from northern and boreal forests in North America is reviewed. Fire suppression policies implemented in the early 1900s have resulted in profound changes in forest species composition and structure. Associated with these changes was an increased vulnerability of forest stands to damage during outbreaks of defoliating insects. Information about the roles that both fire and insects play in many northern forests is needed to increase understanding of the ecology of these systems and to develop sound management policies.


**Abstract:** An intensive survey of bark beetle activity was conducted annually during 1989-92 on 24 permanent plots in or near stands burned by surface fire in 1988 in the Greater Yellowstone area. Stands were located adjacent to areas of extensive crowning and torching. By August 1992, some 79% of the 125 Douglas firs (*Pseudotsuga menziesii*) had been infested by bark beetles (primarily *Dendroctonus pseudotsugae*) and wood borers; 62% of the 151 lodgepole pines (*Pinus contorta*) were infested, primarily by *Ips pini*; 94% of the 17 Engelmann spruce (*Picea engelmannii*) were infested, primarily by *D. rufipennis*; and 71% of the 17 subalpine firs (*Abies lasiocarpa*) were infested, primarily by wood borers. Fire injury combined with subsequent insect attack killed 77% of Douglas fir, 61% of lodgepole pine, 94% of Engelmann spruce and all the subalpine fir. An extensive survey in 1991-92 on 519 plots in unburned and surface-fire burned areas throughout the Park showed that insects killed 13% of 1012 Douglas fir, 18% of 4758 lodgepole pine, 7% of 439 Engelmann spruce, 8% of 134 subalpine fir and 3% of 144 whitebark pine (*Pinus albicaulis*). For all tree species, insect infestation increased with the percentage of basal girth killed by fire, except for Engelmann spruce where infestation was greatest with 40-80% of basal girth girdled. Infestation in Douglas fir, lodgepole pine and Engelmann spruce increased with time. The high level of infestation suggests that insect populations increased in fire-injured trees and then spread to uninjured trees. Delayed tree mortality attributed to fire injury accounted for more mortality than did insects. Both types of mortality greatly altered the original mosaics of live and dead trees that were apparent immediately after the 1988 fires.


**Abstract:** Estimation of post-fire conifer survival depends on many factors besides the extent of fire injury. The probability of initial survival is related to extent of damage to crown, cambium and roots. Bark beetles (*Scolytidae*) often increase mortality rates significantly. This discussion focuses on *Pinus ponderosa* and *Pseudotsuga menziesii*, 2 species that may survive fire in western US forests, but are then killed by beetles.


**Abstract:** Recent historical and current vegetation composition and structure were characterized for a representative sample of subwatersheds on all ownerships within the interior Columbia River basin and portions of the Klamath and Great Basins.
Abstract: An investigation into the effects of low intensity, late-season prescription fire on Jeffrey pine (Pinus jeffreyi) and associated short-term presence of various bark beetles of the family Scolytidae was completed on forests along the north edge of Lake Tahoe, Nevada, USA. A total of 38 permanent 0.040-ha plots were located among five different prescription burn sites treated during October 1997. An additional twenty-seven 0.040 ha plots were located in adjacent unburned forest stands. All trees within-study plots were visited thrice between June and October of 1998. Results showed a highly significant correlation between burning and bark beetle presence. Over 24% of trees in prescription burn plots were attacked by one or more species of bark beetle. Less than 1% of all non-burned trees were similarly attacked. Highly significant multiple logistic regression models were developed for each of the two occurring species of Dendroctonus and a composite model for all observed species of Ips. The indirect burn severity measurements of crown scorch, duff consumption, andbole scorch were highly significant; other tested variables were species specific or not significant.


Abstract: Population abundance of Ips spp. (Coleoptera: Scolytidae) and the resin flow of mature red pines (Pinus resinosa) were estimated before and after a prescribed burn, inside and outside the burn, in an old-growth forest at Itasca State Park, Minnesota, USA. Following a prescribed burn in April 1998, the local abundance of Ips pini increased by two-fold during May, decreased by a comparable amount during 6 weeks starting in mid-July, and was otherwise unchanged. The abundances of I. grandicollis and I. perroti were unaffected, while that of a specialist predator, Thanasimus dubius (Coleoptera: Cleridae) increased by 30-90% during May. Many mature trees that sustained no visible crown damage from the fire were attacked by Ips within the scorched region of the lower bole. Oleoresin flow increased substantially in trees with scorched boles, which may limit the probability that trees will be killed by bark beetles following a ground fire. It was tested whether fire increases the probability that a healthy tree will sustain bark beetle attacks by locating beetle-infested trees inside and outside the burned area, and comparing their growth history (from growth rings) with paired, unattacked trees. Surprisingly, there was no indication of recently declining growth, or chronically slow growth, in beetle-infested trees, either inside or outside the prescribed burn. Half of the trees attacked by Ips in 1998 were dead in 1999 and the remainder were partly girdled by the attacks, which increases their subsequent vulnerability to fires, insects, and pathogens. It is concluded that Ips bark beetles can exert meaningful effects on the survivorship of red pine populations, and their demographic impact is probably increased by ground fires.


Abstract: Bark beetles are well described in terms of life history and general ecology for the six beetle species of concern in eastern Oregon and Washington, USA: Douglas fir beetle, Dendroctonus pseudotsugae; mountain pine beetle, D. ponderosae; western pine beetle, D. brevicomis; spruce beetle, D. rufipennis; fir engraver, Scolytus ventralis; and pine engraver, Ips pini. Many interactions between bark beetles and other agents and resources have been described. Wildfire, windstorms, disease, other insects, and land management practices can weaken trees and attract bark beetles that become locally epidemic. At low population levels, beetles perform useful functions by creating habitat and forage for many organisms, but outbreaks can cause extensive tree mortality and increase risk of wildfire. Natural control agents such as birds, predatory beetles, parasitoids, and parasites, have been studied, but have not been employed operationally in management strategies. While semichemical-baited traps provide information about population fluctuations locally, large area monitoring relies primarily on aerial surveillance. Stand susceptibility, hazard, or risk-rating systems exist for most of

http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/
these species, and infestation growth or damage models are available for a few. In most cases, pesticide sprays, attractants and anti-aggregants, and trap-tree techniques have been useful in specific applications. Anti-aggregants have been proven useful in large-scale operations for Douglas fir beetle. Salvage or sanitation of infested, wind- or fire-damaged trees can prevent population build-ups if done promptly. Integration of these methods along with prescribed fire and tree thinning has been recommended. Decision-support tools are becoming more prevalent but each requires validation for different geographic variants.

**Annotation:** ADDITIONAL TITLE DATA: Special issue: Forest health and productivity in eastern Oregon and Washington

**Key Words:** ADDITIONAL TITLE DATA: Special issue: Forest health and productivity in eastern Oregon and Washington


**Abstract:** Wildfires burned over 200,000 ha of forest lands in Florida, USA, from April to July 1998. This unique disturbance event provided a valuable opportunity to study the interactions of summer wildfires with the activity of pine (Pinus) feeding insects and their associates in the southeastern USA. We compared tree mortality with abundance of bark and ambrosia beetles, reproduction weevils and wood borers relative to fire severity. Over 27% of residual live trees in stands that experienced high fire severity died between October 1998 and May 1999. An additional 2-3% of trees that initially survived the fire died during the second year compared to <1% mortality in unburned stands. One year after the fire, more than 75% of the trees surviving in high fire severity stands had roots infected with one or more species of Leptographium and/or Graphium spp. and nearly 60% of the sampled roots were infested. No such fungi were recovered from roots of trees in unburned stands. Significantly, more root weevils, Hylobius pales and Pachylalus pictivorus, were captured in unbaited pitfalls in the moderate and high fire severity stands than in the controls. Mean trap catches of Ips grandicollis, Dendroctonus terebrans and Hylastes salebrosus, three common bark beetles that feed on phloem tissue of pines, were lower in Lindgren traps in the fire-damaged areas than in the control stands. In contrast, catches of the ambrosia beetles, Xyleborus spp. and Monarthrum mali, were higher in burned stands than in control stands. The generalist predator, Temnochila virens [Temenoscheila virens] (Coleoptera: Trogositidae), showed a strong positive relationship between abundance and fire severity, while the flat bark beetle, Silvanus sp. (Coleoptera: Sylvanidae), exhibited the reverse trend.

Our results show that most tree mortality occurred within 1 year of the fire. Ips or Dendroctonus bark beetle populations did not build up in dead and weakened trees and attack healthy trees in nearby areas. The prevalence of Leptographium spp. in roots may be a symptom of, or result in, weakened trees that may affect the trees’ susceptibility to bark beetles in the future.

**Annotation:** Keywords: Wildfire; Scolytidae; Root disease; Leptographium; Piuns elliotti; Pinus palustris

**Key Words:** Keywords: Wildfire; Scolytidae; Root disease; Leptographium; Piuns elliotti; Pinus palustris

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**Abstract:** Ponderosa pine (Pinus ponderosa) forests in northern Arizona (USA) have degraded due to overgrazing, logging, and fire suppression that accompanied Euro-American settlement in the late 1800s. Overstocked stands of suppressed trees with low structural diversity dominate the landscape. These conditions create high risk of catastrophic fires and insect outbreaks. We investigated long-term effects (8-16 years post-treatment) of thinning and control-burned on ponderosa pine water stress, leaf carbon isotope discrimination and nitrogen concentration, oleoresin exudation flow, phloem thickness, radial growth, and bark beetle abundance relative to unmanaged control stands over 2 years of measurement in 12 stands replicated across the landscape. Predawn water potential in late June, phloem thickness, and basal area increment were lower in unmanaged than managed stands. Oleoresin exudation flow in July was greater in unmanaged and thinned + burned stands than thinned stands, and greater in a warm year than a cooler year. Leaf nitrogen concentration differed between years, but not among treatments. Tree competition and water stress were positively correlated, and tree competition was negatively correlated with radial growth and phloem thickness. Phenorneme-baited trap catches of Dendroctonus spp. (D. brevicomis pooled with D. frontalis) were higher in unmanaged than managed stands, whereas catches of Ips spp. did not differ among treatments. We conclude that thinning with and without controlled burning can have long-term effects on ponderosa pine water stress, growth, phloem thickness, resin flow, and bark beetle abundance. Low levels of tree mortality from bark beetles at our study sites suggest remarkable resistance of ponderosa pine in mid-elevation forests in northern Arizona, even at high tree densities.


**Abstract:** This study examined the effects of spring and autumn restoration burning in an old-growth mixed-conifer -ponderosa pine (Pinus ponderosa) forest in southern Oregon, USA. Variables measured included fuel loads, forest structure indices, mortality of large ponderosa pines, and pine resin defenses. One year after treatment, reductions in surface fuel loads and changes to forest structure parameters suggested that burning treatments could meet restoration objectives with autumn burns being somewhat more effective than spring burns. However, mortality of pre-settlement pines was significantly higher in autumn burns than in spring burns, and both were higher than in unburned controls. Bark beetles (Coleoptera: Scolytidae) were important mortality agents within 2 years after burning. Resin defenses (pressure and flow) were variable over the 2 years of postburn study but showed no evidence of decrease in burned trees; rather, resin defenses were significantly higher in burned trees than in controls at several measurement dates. While increased beetle attacks have

Abstract: Selective logging, fire suppression, forest succession and climatic changes have resulted in high fire hazards over large areas of the western USA. Federal and state hazardous fuel reduction programs have increased accordingly to reduce the risk, extent and severity of these events, particularly in the wildland-urban interface. In this study, we examined the effects of mechanical fuel reduction treatments on the activity of bark beetles in ponderosa pine (Pinus ponderosa) forests located in Arizona and California, USA. Treatments were applied in both late spring (April-May) and late summer (August-September) and included: (1) thinned biomass chipped and randomly dispersed within each 0.4 ha plot; (2) thinned biomass chipped, randomly dispersed within each plot and raked 2 m from the base of residual trees; (3) thinned biomass lopped-and-scattered (thinned trees cut into 1-2 m lengths) within each plot; and (4) an untreated control. The mean percentage of residual trees attacked by bark beetles ranged from 2.0% (untreated control) to 30.2% (plots thinned in spring with all biomass chipped). A three-fold increase in the percentage of trees attacked by bark beetles was observed in chipped versus lopped-and-scattered plots. Bark beetle colonization of residual trees was higher during spring treatments, which corresponded with peak adult beetle flight periods as measured by funnel trap captures. Raking chips away from the base of residual trees did not significantly affect attack rates. Several bark beetle species were present including the roundheaded pine engraver (Dendroctonus adjunctus, AZ), western pine beetle (D. brevicomis, AZ and CA), mountain pine beetle (D. ponderosae, CA), red turpentine beetle (D. valens, AZ and CA), Arizona fivespined Ips (Ips lecontei, AZ), California fivespined Ips (I. paracoccus, CA) and pine engraver (I. pini, AZ). Dendroctonus valens was the most common bark beetle infesting residual trees. A significant correlation was found between the number of trees chipped per plot and the percentage of residual trees with D. valens attacks. A significantly higher percentage of residual trees was attacked by D. brevicomis in plots that were chipped in spring compared to the untreated control. In lopped-and-scattered treatments, engraver beetles produced substantial broods in logging debris, but few attacks were observed on standing trees. At present, no significant difference in tree mortality exists among treatments. A few trees appeared to have died solely from D. valens attacks, as no other scolytids were observed in the upper bole. In a laboratory study conducted to provide an explanation for the bark beetle responses observed in this study, monoterpenes elution rates from chip piles declined sharply over time, but were relatively constant in lopped-and-piled treatments. The quantities of beta-pinene, 3-carene, alpha-pinene and myrcene eluting from chips exceeded those from lopped-and-piled slash during each of 15 sample periods. These laboratory results may, in part, explain the bark beetle response observed in chipping treatments. The implications of these results to sustainable forest management are discussed.


Abstract: Whitebark pine (Pinus albicaulis Engelm.), an important component of high elevation ecosystems in the western United States and Canada, is declining due to fire exclusion, white pine blister rust (Cronartium ribicola J.C. Fisch.), and mountain pine beetle (Dendroctonus ponderosae Hopkins). This study was conducted to evaluate the effects of whitebark pine restoration treatments on the distribution of bark beetle attacks. At a site in Idaho, silvicultural treatments were implemented in summer 1998 and 1999, with controlled burning implemented in Oct. 1999. Permanent plots (400 m2) were established during summer 1999 within each treatment and monitored for 4 years. Within plots, tree characteristics were measured and a bark beetle survey was conducted. Bark beetle attacks remained low throughout the study; however, there was an increase in bark beetle attacks in 2000 after the controlled burning. By years 3 and 4, there were virtually no successful attacks. Although bark beetles were not a serious concern at the site assessed in this study, our results indicate that managers should consider and monitor the bark beetle component of these ecosystems when implementing restoration treatments. If baseline bark beetle populations are high at the time of implementation, our results indicate that increases in beetle activity would be expected in some treatments, perhaps requiring mitigation.


Abstract: Over the last century, fire exclusion in the forests of the Sierra Nevada has allowed surface fuels to accumulate and has led to increased tree density. Stand composition has also been altered as shade tolerant tree species crowd out shade intolerant species. To restore forest structure and reduce the risk of large, intense fires, managers have increasingly used prescription burning. Most fires prior to EuroAmerican settlement occurred during the late summer and early fall and most controlled burning has taken place during the latter part of this period. Poor air quality and lack of suitable burn windows during the fall, however, have resulted in a need to conduct more prescription burning earlier in the season. Previous reports have suggested that burning during the time when trees are actively growing may increase mortality rates due to fine root damage and/or bark beetle activity. This study examines the effects of fire on tree mortality and bark beetle (Dendroctonus valens, D. ponderosae, D. jeffreyi and Scolytus ventralis) attacks under prescription burning during early and late season. Replicated early season burn, late season burn and unburned control plots were established in an old-growth mixed conifer (Abies-Pinus) forest within the Marble Fork watershed of the Kaweah River Sequoia National Park, California, USA, that had not experienced a fire in over 120 years. Although prescribed burns resulted in significant mortality of particularly the
smallest tree size classes, no difference between early and late season burns was detected. Direct mortality due to fire was associated with fire intensity. Secondary mortality due to bark beetles was not significantly correlated with fire intensity. The probability of bark beetle attack on pines did not differ between early and late season burns, while the probability of bark beetle attack on firs was greater following early season burns. Overall tree mortality appeared to be primarily the result of fire intensity rather than tree phenology at the time of the burns. Early season burns are generally conducted under higher fuel moisture conditions, leading to less fuel consumption and potentially less injury to trees. This reduction in fire severity may compensate for relatively modest increases in bark beetle attack probabilities on some tree species, ultimately resulting in a forest structure that differs little between early and late season controlled burning treatments.


Abstract: Tree mortality in western conifer forests is a complex process involving several related factors. Conifer mortality tends to be more common in high-elevation forests where stress from weather, insects, and disease result in higher rates of mortality and in the drier interior forests where mortality from fire, insects, and disease are common. Immediate mortality from fire damage may be obvious, but currently there is considerable controversy about labelling fire-injured green trees as dead that have a high probability of experiencing delayed mortality. Trees die when carbohydrates used in respiration exceed those produced in photosynthesis or water movement is impaired, the tree desiccates, and photosynthesis ceases. Immediate or delayed tree mortality may be directly due to biotic or abiotic causes and may be affected by previous damage, current condition vigour, and attack by secondary agents such as bark beetles. A particular pathogen or insect usually attacks, damages, or kills only one portion of a tree. Trees that are damaged or attacked by pests and expected to have a dead or nonfunctional root system or a nonfunctional stem within 5 years may be considered either dead or death is imminent. Numerous studies have produced logistic regression equations or other statistical models to help determine probability of tree survival. We define and propose that a “dead tree” designation is justified for most species when at least three of the four quadrants from around the base of the root collar has cambium, inner bark, or phloem that is discolored and dead. For large ponderosa pines, a dead tree has all four quadrants with dead cambium.


Abstract: The outbreak, active since 1950 but restricted to an area of 162 ha. on a south slope in stands aged ca. 60, with trees 10.2 to 50.8 cm. in d.b.h., has killed nearly all trees of d.b.h. >25.4 cm. between 1954 and 1967. Mortality, which fluctuated between 0 and 4.7 trees/acre during that period, was reduced by woodpeckers feeding heavily on the brood in 1957 and 1958, but increased again during drought years.

Annotation: Platypodidae, Scolytidae, bark beetles, Coleoptera, Dendroctonus ponderosae, insect pests, damage types, insect pests, outbreaks history, Pinus contorta ind. P. contorta var. latifolia, P. bolanderi, insect pests, Coleoptera, insect pests, predators, natural enemies, birds.

Key Words: Platypodidae, Scolytidae, bark beetles, Coleoptera, Dendroctonus ponderosae, insect pests, damage types, insect pests, outbreaks history, Pinus contorta ind. P. contorta var. latifolia, P. bolanderi, insect pests, Coleoptera, insect pests, predators, natural enemies, birds.

Lang, J; Heald, R.C; Stone, E.C; Dahlsten, D.L; Akers, R. 1978. Silvicultural treatments to reduce losses to bark beetle. California Agriculture. 32(7): 12–13.

Abstract: Following heavy losses of second-growth ponderosa pine [Pinus ponderosa] in California in 1977-78 through the attack of Dendroctonus brevicomis Lec. and D. ponderosae Hopk., combined with the effects of 2 years of drought and diseases, a study was begun at Blodgett Forest Research Station to test the hypothesis that susceptibility to bark-beetle attack is related to the vigour of the aggregation of trees as a collective unit rather than to the growth rate of individual trees. The aggregations consisted of P. ponderosa as the dominant species, with white fir [Abies amabilis], sugar pine [P. lambertiana] and Douglas fir [Pseudotsuga menziesii] also in the overstory, and incense cedar [Libocedrus decurrens] predominating in the understory. Measurements taken in the first part of the study showed that pine aggregations with a high risk of bark-beetle attack were characterized by a basal area greater than 350 ft²/acre and a mean basal-area growth rate of less than 0.26 ft² in 5 years. In the second part of the study, a silvicultural experiment was set up in order to evaluate the effectiveness of thinning in reducing the susceptibility of ponderosa pine aggregations to bark-beetles; this part of the investigation is still in progress.


Abstract: Panoramic aerial photographs were obtained with a KA-80A optical bar panoramic camera on a U-2C aircraft.
over 40 million acres of forest in northern California in 1978-79. These were used as an aid in planning timber salvage sales and to locate concentrations of trees (including ponderosa pines) killed by scolytids (especially Ips paraconfusus Lanier and Dendroctonus brevicomis Lec.) following a severe drought. Several new methods for using these photographs are described. The photographs were used in 223 salvage sales, resulting in a harvest of 532.2 million board feet of timber that had been killed by scolytids.


**Abstract:** The effects of induced translocation stress on heat pulse velocity, reactions to pathogenic fungi and attack dynamics by D. ponderosae were studied before, during and after severe cooling of the stem and after girdling of xylem and phloem in trees in Kootenai National Forest, Montana. Cooled trees showed a reduced heat pulse velocity and a lack of observable wound response when inoculated with Ceratocystis clavigera. Re inoculation without cooling of these trees a year later resulted in lesion production. Heat pulse velocity in girdled trees did not change. A tree naturally attacked and colonized by D. ponderosae also showed reduced heat pulse velocity within 2 wk of beetle attack. It is suggested that stress due to drought and/or bark beetle attack may be analogous to that induced by cooling and may reduce the ability of a tree to resist beetle attack and fungus invasion.


**Abstract:** The cedar-hemlock-white pine (Thuja plicata/Tsuga heterophylla/Pinus monticola) forests of northern Idaho have undergone significant changes in the past 150 years, in response to natural and human-caused changes. The changes include: a reduction in the amount of white pine and western larch (Larix occidentalis); increases in Douglas fir and grand fir (Pseudotsuga menziesii, Abies grandis); altered vegetation patterns on the landscape; altered successional patterns; declines in stem decays and mountain pine beetles (Dendroctonus ponderosae); an increase in root diseases and bark beetles (Scolytidae) in Douglas fir and grand fir; and reduction in timber productivity. The causes of the changes include fire suppression, timber harvesting, drought, and the introduction of the white pine blister fungus (Cronartium ribicola). The changes indicate that the health of these forests has been altered significantly. Strategies are suggested for restoring and enhancing their health.


**Abstract:** Wilderness areas comprise 65% of the 1.92 million acre Kenai National Wildlife Refuge, Alaska, USA. Fire history studies indicate that fire frequency increased substantially in both white (Picea glauca) and black spruce (P. mariana) forests after European settlement. Dendrochronology studies indicate that regional-scale spruce bark beetle (Dendroctonus rufipennis) outbreaks occurred in the 1820s, 1880s, and 1970s. None of these outbreaks was as intense as the 1990s outbreak, which has killed most of the large white and Sitka/Lutz spruce on the southern Kenai Peninsula. Strong climate warming appears to have accelerated the recent outbreak, probably through drought-stress of large trees. Logging of once-mature beetle-killed forests on private lands on the southwestern flank of the Refuge is shrinking available brown bear habitat and making protection of the wilderness areas more crucial.


**Key Words:** CONFERENCE INFORMATION: Wilderness science in a time of change conference. Volume 3: Wilderness as a place for scientific inquiry, Missoula, Montana, USA, 23-27 May 1999.


**Abstract:** Natural and recurring disturbances caused by fire, native forest insects and pathogens have interacted for millennia to create and maintain forests dominated by seral or pioneering species of conifers in the interior regions of the western United States and Canada. Changes in fire suppression and other factors in the last century have altered the species composition and increased the density of trees in many western forests, leading to concomitant changes in how these three disturbance agents interact. Two- and three-way interactions are reviewed that involve fire, insects and pathogens in these forests, including fire-induced pathogen infection and insect attack, the effects of tree mortality from insects and diseases on fuel accumulation, and efforts to model these interactions. The emerging concern is highlighted regarding how the amount and distribution of bark beetle-caused tree mortality will be affected by large-scale restoration of these fire-adapted forest ecosystems via prescribed fire. The effects of fire on soil insects and pathogens, and on biodiversity of ground-dwelling arthropods, are examined. The effects of fire suppression on forest susceptibility to insects and pathogens, are discussed, as is the use of prescribed fire to control forest pests.

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Abstract: We report measurements and analysis of a boreal forest fire, integrating the effects of greenhouse gases, aerosols, black carbon deposition on snow and sea ice, and postfire changes in surface albedo. The net effect of all agents was to increase radiative forcing during the first year (34 or 31 Watts per square meter of burned area), but to decrease radiative forcing when averaged over an 80-year fire cycle (-2.3 or -2.2 Watts per square meter) because multidecadal increases in surface albedo had a larger impact than fire-emitted greenhouse gases. This result implies that future increases in boreal fire may not accelerate climate warming.

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Abstract: Fire is an important disturbance agent in the southern California (USA) landscape and plays a large role in the function and structure of its pine and mixed conifer forests. However, humans have changed the forest fire regime across the western USA by excluding fire. Fire suppression has been blamed for increasing stand densities and a shift from fire-tolerant trees to shade-tolerant but fire sensitive trees. These changes had been observed in the Cuyamaca Rancho State Park (CRSP), Peninsular Ranges, San Diego County, California. We surveyed an area in CRSP during the first two post-fire growing seasons following the October 2003 Cedar Fire, a historically large and severe fire, to determine patterns of tree mortality and vegetation recovery. This area is a mosaic of mixed evergreen and mixed conifer forest, oak woodland, chaparral and grassland. Most conifers were killed by the fire, especially smaller trees, and very few pine seedlings have established. Oaks were top-killed but most were resprouting by the second year, although larger oaks were more likely to have died than smaller. A rich herbaceous community of native annuals was established in the first post-fire growing season. With a record rainy season during the winter of 2004-05, all plant functional groups increased in abundance in the second year, including exotic annual grasses. The spread of exotic grasses in CRSP is a plant community change that may be of concern to resource managers. As forest succession is a long-term process, it is important to continue monitoring vegetation recovery.


Abstract: There is little quantitative information on relationships between insect attacks and fire damage for ponderosa pine, Pinus ponderosa Douglas ex Lawson, in the southwestern United States. Tree mortality and insect attacks were measured on 1,367 trees for three years after a spring wildfire (4 May 1996), a summer wildfire (20 June 1996), and a fall prescribed fire (9 September 1995) in northern Arizona. Western pine beetle, Dendroctonus brevicomis LeConte, mountain pine beetle, D. ponderosae Hopkins, roundheaded pine beetle, D. adjunctus, Blandford, red turpentine beetle, D. valens LeConte, Ips species, and wood borers in the Buprestidae and Cerambycidae families were found in fire-damaged trees. The most frequently occurring insects, listed from most to least frequent, were wood borers, red turpentine beetle, Ips spp., western pine beetle, roundheaded pine beetle, and mountain pine beetle. Trees attacked by Dendroctonus and Ips spp. as a group had more crown damage from fire than unattacked trees. The percentage of trees attacked by Dendroctonus and Ips species was lowest during the fall fire (11%, 25 of 222 trees), intermediate during the summer fire (19%, 154 of 833 trees), and highest during the spring fire (41%, 127 of 312 trees). More than one-half of all wood borer colonization (58%) and attacks by western pine beetle (68%), roundheaded pine beetle (56%), and Ips spp. (66%) occurred in the first year after the fire. Measures of tree damage from fire and insect attacks were used to develop logistic regression models of tree mortality to quantitatively investigate factors that influenced tree mortality. Tree mortality 3 yr postfire was low until crown damage by fire exceeded 70-80% for unattacked trees, 40-50% for trees with partial attacks by Dendroctonus and Ips species, and 30-40% for trees with mass attacks. We concluded that several Dendroctonus and Ips species colonize fire-damaged ponderosa pines in northern Arizona and colonization is promoted by heavy crown damage from fire.


Abstract: Sphaeropsis sapinea can act as a latent pathogen; physiological alteration, through water stress, can affect release from the quiescent condition to result in rapid disease development.

Abstract: Disease symptoms associated with B. dothidea in South Africa may thus result from the manifestation of previous latent infections after the onset of stress.


Abstract: Die-back and canker of several Eucalyptus species and clones were observed during a survey of the most important forestry areas of South Africa. Disease was often associated with extreme environmental conditions such as drought, hot winds and frost. Botryosphaeria dothidea, which is well known as a cause of canker and die-back of Eucalyptus in other countries, was consistently isolated from symptomatic trees. Artificial inoculations of Eucalyptus nitens resulted in lesion development, confirming the pathogenicity of S. dothidea to Eucalyptus in South Africa. This is the first report of this disease in South Africa.


Abstract: This review, in which predisposition is regarded as an effect of stress, deals almost entirely with diseases of trees. The type of stress considered are those caused by deficiency, or sometimes excess, of water, temperature, nutrients, and light, and by defoliation and transplanting. Some previously unpublished work is included on the effects of freezing or defoliation of Botryosphaeria dothidea (B. ribis) canker in Liquidambar styraciflua and some other diseases of trees used for landscaping planting.


Abstract: Key findings:
1. The likelihood of injury to trees by winter cold may be slightly lower than at present.
2. It is likely that spring flushing will advance as a result of milder winters, but the risk of spring frost injury is unlikely to change; nevertheless, unseasonal frosts will still have the potential to cause damage. Autumn frosts may become more damaging in England because of later hardening and predicted increases in diurnal temperature range in the south.
3. The widespread planting of southern provenances of species such as Sitka spruce, in anticipation of climate change, should be avoided because of the potential for unseasonal frost damage.
4. No prediction is possible for the frequency of the type of winter injury known as ‘red belt’.
5. ‘Top-dying’ of Norway spruce is likely to increase in England and eastern Scotland; Norway spruce could cease to be a productive species over much of England.
6. Increasing heat and drought in the south and east can be expected to increase losses, particularly among newly established trees and mature trees in hedgerows and urban environments. Defects in coniferous timber due to drought crack are also likely to increase in England.
7. An increased incidence of summer drought would make trees more vulnerable to attack by weak pathogens.
8. Increased winter rainfall may raise water tables enough to kill roots, thereby reducing effective rooting depth and making trees more vulnerable to summer droughts.
9. Higher temperatures in summer may reduce the risk of Brunchorstia damage to Corsican pine, enabling it to be planted more widely in the uplands in the future.


Abstract: In order to assess the influence of water stress on the development of Sphaeropsis sapinea cankers in Pinus halepensis, the stems of 4- to 5-year-old potted seedlings were artificially inoculated with the fungus before and after being kept at controlled water regimes from April 1997 to March 1998. In the pre-water-stress inoculation experiment, the canker length, measured 5 months after inoculation (September 1997), was greater in seedlings predisposed to extreme water deficit (midday needle water potential between −4.5 and −5.5 MPa). In the post-water-stress inoculation experiment, the fungus was inoculated in April 1998, after irrigation had enabled the seedlings to resume normal needle water potential. In this case also, at 5 months after inoculation, longer cankers were visible in seedlings that had been subjected to extreme water deficit. These findings suggest that the occurrence of marked water stress, although apparently tolerated by Aleppo pine, can enhance the development of S. sapinea cankers in this species, regardless of whether the stress occurs before or after infection by the fungus.


Abstract: Septoria musiva causes leaf spot and canker diseases of trees in the genus Populus, and is one of the most damaging fungal pathogens of hybrid poplar in eastern North America. The effect of host water stress on Septoria canker development was studied in two separate greenhouse experiments. Hybrid poplar clones NM6, NC11396, and NE308 were stressed by withholding water until predawn water potential fell below −1.0 MPa. Stems were treated by removing a leaf and applying agar plugs that were either colonized by S. musiva (inoculated) or sterile (control) to the wound. Cankers on inoculated water-stressed trees were significantly larger than those on nonstressed trees. A leaf disk assay also was conducted three times with the NM6 and NE308 trees. We cut two disks from each of 120 stressed and 120 well-watered trees, placing them on water agar in 24-well tissue culture plates. A conidial suspension was applied to one disk in each pair...
and sterile water to the other. Inoculated disks from water-stressed trees developed less necrosis than those from well-watered trees. These results demonstrate that environmental influences on host condition must be considered in evaluating resistance of clones proposed for widespread culture of hybrid poplar.


Abstract: Although B. dothidea has been found on a wide range of host species, it can cause serious damage only to those host plants that are weakened or under environment stress (Schoeneweiss, D.F. 1986). The most common stresses associated with predisposition in woody plants are drought and freezing (Schoeneweiss, D.F. 1981a).


Abstract: Decline and dieback of eucalypts (Eucalyptus) have been attributed to an exotic pathogen, various native organisms, climatic factors and agricultural or urban pollution. Where particular biotic or abiotic factors could not be singled out, they have been regarded as predisposing, inciting or contributing factors in diseases of complex etiology. Ongoing monitoring of eucalypt decline during recent droughts in eastern Australia, together with extensive one-time observations across temperate Australia, provided opportunities to further examine some hypotheses of decline and dieback that were largely based on retrospective investigations. Episodes of dieback can be distinguished from the process of chronic decline. Dieback episodes were associated with natural climatic extremes whereas chronic decline was associated with human management. Decline of forests in nature reserves was associated with exclusion of fire and grazing, while decline of rural trees was mostly associated with pasture improvement. Trees growing low in the landscape on soils with poor drainage and aeration were especially predisposed to decline. It appears that chronic abiotic stress causes tree decline when the function of roots is impaired by changes in soils. Climatic extremes can accelerate chronic declines associated with human management. A variety of pests, 'pathogens' and parasites can take advantage of trees that are stressed by environmental changes, especially eutrophication. Similarities between diebacks and declines in the Atlantic and Pacific regions suggest a simple unifying concept of tree decline and dieback. The implications for management of forest health are discussed.


Abstract: The disease is a serious problem in cork oak and Turkey oak in the Mediterranean area, but had never been detected further north the southern Tuscany. The appearance of the disease in Slovenia, indicated that climate change could lead to outbreaks of this disease further north.


Abstract: The authors propose the following hypothesis to explain tree death (methods in parentheses): landscape features (digital elevation model via LiDAR) and soil properties (soil descriptions) produce poor drainage (wells and piezometers) which create open canopy forests (LiDAR and hemispherical photography) and shallow rooting; exposure allows soils to warm in early spring (air and soil temperature loggers) which triggers dehardening, the loss of cold tolerance, and eventual spring freezing injury (electrolyte leakage testing of tissues). The distribution of yellow cedar decline is associated with areas of low snowpack in winter and spring. Snow delays soil warming and presumably protects yellow-cedar roots through spring freezing injury. It appears that chronic abiotic stress causes tree decline when the function of roots is impaired by changes in soils. Limited to higher elevations throughout most of its natural range, perhaps yellow-cedar migrated to exposed, open canopy forests where forest decline is now severe.


Abstract: A classic; gives a good overview. Some statements regarding abiotic include:
1. Occasional low temperatures are regarded by Wagener as restricting two species of Phorodendron. To their present limits in California and account for their absence over large parts of their hosts range.
2. It is probable that weather changes over many years duration have had a role in sweetgum blight, pole blight of western white pine, pitch streak of turpentine pines, and littleleaf of shortleaf pines.
3. A continuation of the warming trend would accentuate the northward movement of tropical and subtropical organisms, such as Phytophthora cinnamomi.


Abstract: This review synthesizes the available knowledge on drought-disease interactions in forest trees with a focus on (1) evidence and patterns of drought-disease interactions, (2) current understanding of processes and mechanisms, and (3) three well documented cases studies. The first part is based on the analysis of a database of slightly more than one hundred studies, obtained by keyword searches combining drought, diseases or pathogens, and forest trees. A large majority of published studies referred to a positive association between drought and disease, i.e. disease favoured by drought or drought.
and disease acting synergistically on tree health status, with a predominance of canker/dieback diseases, caused by pathogens like *Botryosphaeria*. *Sphaeropsis*, *Cytospora* and *Biscogniauxia* (*Hypoxylon*). The type of disease-related variables (incidence vs. severity) and the intensity and timing of water stress were shown to be significant factors affecting the drought- infection interaction. Interactions with other abiotic stresses and species-specific and genetic effects, related to host or pathogen, have also been reported. Direct effects of drought on pathogens are generally negative, although most fungal pathogens exhibit an important plasticity and can grow at water potentials well below the minimum for growth of their host plants. Studies on indirect effects of drought on pathogens through other community interactions are still relatively scarce. Positive drought-infection effects can mostly be explained by indirect effects of drought on host physiology. The predisposition and the multiple stress hypotheses are presented, as well as recent developments in the study of the molecular basis of abiotic and biotic stress, and their interactions. *Sphaeropsis sapinea* on pines, *Biscogniauxia mediterranea* on oaks and root pathogens in declines associated with drought provide illustrative examples, treated as case studies, of pathogens of current significance associated with drought. The conclusion highlights some knowledge gaps, e.g. the role of latent parasites and the shift to a pathogenic stage, or the genetics of some fungal groups. The need for prevention of pathogen dispersal, especially crucial in the case of latent pathogens, is emphasized.

**Annotation:** This review synthesizes the available knowledge on drought-disease interactions in forest trees with a focus on 1) evidence and patterns of drought-disease interactions, 2) current understanding of processes and mechanisms, and 3) three well documented case studies. *S. sapinea* on pines is an example of canker pathogens with only positive interactions with drought reported. A case study for the canker is presented. A few reports, however, demonstrated a negative effect of drought on some canker diseases, such as Thyronectria canker of honeylocust and *Cryphonectria cubensis* on Eucalyptus.

**Key Words:** This review synthesizes the available knowledge on drought-disease interactions in forest trees with a focus on 1) evidence and patterns of drought-disease interactions, 2) current understanding of processes and mechanisms, and 3) three well documented case studies. *S. sapinea* on pines is an example of canker pathogens with only positive interactions with drought reported. A case study for the canker is presented. A few reports, however, demonstrated a negative effect of drought on some canker diseases, such as Thyronectria canker of honeylocust and *Cryphonectria cubensis* on Eucalyptus.


**Abstract:** An excellent paper. “Facultative pathogens, causing diseases such as Armillaria root rot, and wilt diseases, such as verticillium wilt and those caused by pine wood nematode as well as secondary canker-causing fungi would benefit from the heat and drought stress caused to forest and urban trees.


**Abstract:** Nonwatered trees with competing vegetation (nontreated condition) had significantly lower predawn needle water potentials (more water stress) and more severe disease development than trees that received the herbicide, water, or combined herbicide and water treatments. The most severe disease occurred in the driest year and the least in the wettest year. Competing vegetation indirectly affected disease development by inducing water stress, even in relatively moist years, on trees previously considered well established.


**Abstract:** Results indicate that water stress at levels observed typically in the field can result in increased disease development by isolates of *S. sapinea* morphotype A on red pine. The reduction of water stress of red pines in the field may reduce losses due to *Sphaeropsis* shoot blight.


**Abstract:** Three-year-old Austrian, Scots, and Japanese black pines growing in a loamy clay soil were inoculated with *Sphaeropsis sapinea*. Water was withheld for periods sufficient to create soil water potentials of -0.1, -0.6 to -0.8, and -1.2 to -1.5 MPa. Increasingly negative soil water potentials promoted greater linear fungal growth in stems. These findings support field observations of increased infection by *S. sapinea* on droughted or unhealthy trees.


**Abstract:** To date, very few studies have assessed the impact of summer droughts on forest biodiversity and ecosystem functioning. Decreased ecosystem productivity and increased mortality are general consequences of drought on biodiversity. Competitive species, species adapted to cold and wet conditions as well as species with low reproduction rates and/or limited mobility seem the more affected. However, species-specific effects are regulated by mechanisms allowing for resistance to drought. The short-term consequences of drought on biodiversity depend on species abilities to resist, and to recover after, drought, and on competitive interactions between species. Although the abundance of many species generally decreases during drought, some taxa may increase in number during drought or shortly after. The effects of recurrent droughts must be evaluated in the wider context of global climate and habitat change. Considering the predicted increase in
drought frequency and intensity, interdisciplinary research initiatives on this issue are needed urgently.


Abstract: P. 17. "Raz. robuata is a serious menace to Pinus ponderosa. In the Coconino and Tusayan National Forests there are large areas where over 60 percent of the timber has been attacked. On some situations, particularly on the Sitgreaves mountain, groups of blackjack with every tree infested are common. According to Dr. George G. Hedgcock, from 1 to 2 percent of all the western yellow pine is attacked. The mistletoe usually starts in the forks of lateral branches and spreads as the tree grows, or it may even infect seedlings. The seeds of the mistletoe, which are sticky, are formed in the summer and ripen in the fall. When the seed covering bursts then they may be shot from 5 to 20 feet, and often adhere to the bark of the tree grows, or it may even infect seedlings. Saplings attacked by mistletoe are deformed. Some of their branches are killed outright, their height and diameter growth is stunted, and the seed crop is lessened. In case of severe attack no seed is produced. A dry climate such as that of the southwest lessens the danger from attack. Sometimes when a host tree is weakened the mistletoe may die from lack of nourishment."


Abstract: During 1990 and 1991, pinyon pine, Pinus edulis Engelm., mortality was reported in many areas across the woodland type in northern Arizona. One of the largest areas detected was located between Heber and the Chevelon work station on the Apache-Sitgreaves National Forest, covering approximately 23,800 acres (Rogers and Conklin, 1991). The primary causal agent was a bark beetle (Coleoptera: Scolytidae), Ips confusus (Leconte), however severe drought combined with several other factors including dense stand conditions, and presence of pinyon dwarf mistletoe, Arceuthobium divaricatum Engelmann, were thought to have predisposed these areas to attack. This paper will review published information on the biology of the insect and the mistletoe, summarize findings of a survey completed during the summer of 1991, and discuss implications for management of pinyon-juniper woodlands. Pinyon dwarf mistletoe infection levels were relatively low in the survey area. The percentages of infected trees for areas high, medium, and low levels of pinyon mortality were 10.8, 3.2, and 8.9 respectively. However, levels in the survey area may have been higher than detected due the difficulty of finding evidence of mistletoe in dead trees except in previously heavily infected ones. Levels of mistletoe infection were highest in areas high and low where numbers of attacked trees were also highest. Presence of dwarf mistletoe has been implicated as an agent predisposing ponderosa pine trees to attack by Ips spp. (Parker 1991, Hawksworth and Geils 1990). On several of the plots examined during this study, many of the trees killed during this outbreak were heavily infected with pinyon dwarf mistletoe. In addition, the percentages of infected trees were somewhat greater on the two areas with the greatest mortality levels. However, since overall levels of mistletoe appeared to be fairly low in the study areas, it is not clear how much of a role this pathogen played in initiating this outbreak.


Abstract: Surveys of occurrence, possible slope preference, and severity of the dwarf mistletoe species Arceuthobium vaginatum, A. americana, and A. campylopopodum parasitizing Pinus ponderosa, P. contorta and P. flexilis, respectively, in Boulder County, CO., revealed distinct altitudinal zones of parasitism specific for each host-parasite interaction. Arceuthobium vaginatum is present to the upper range of its host (9200 ft.), but is absent below 6100 ft. Below 7000 ft, ponderosa pine is vigorous and may be resistant to mistletoe, with temperature possibly being important. Arceuthobium americana on lodgepole pine was observed to the lower, but not to upper elevational limits of host growth. A. americana is restricted to elevations of 8700 to 9600 ft. P. flexilis grows at altitudes of 8300 to 9400 ft., and its principal parasite, A. campylopopodum, is present between 8600 and 9200 ft. Pinus ponderosa was 38 percent infected, with 37 percent infection on ridge sites, 41 percent on north-facing slopes, and 38 percent on south-facing slopes. Pinus contorta was 22 percent infected with 19 percent diseased trees on ridges, 25 percent on north-facing slopes, and 21 percent on south-facing slopes, whereas P. flexilis showed 26 percent infection over-all with mistletoe most severe on ridges.


Abstract: Information on seed viability, germinability, dormancy, and longevity for several species of Arceuthobium is presented and methods for testing these qualities during storage are described. Data on the effects of temperature, relative humidity, and light on seed vitality are reported. Some mold fungi capable of reducing the vitality of dwarf mistletoe seed are identified.
California pine region as a whole the incubation period for the parasite averages about a year less than that reported for *Arceuthobium vaginatum* on *P. ponderosa* in the southwestern US.


**Abstract:** Three dwarf mistletoe species in British Columbia are limited to only a portion of the geographic range of their principal hosts. *Arceuthobium tsugense* is not present in the large population of western hemlock (*Tsuga heterophylla*) in the British Columbia interior; only two records exist of *A. americanum* on coastal lodgepole pine (*Pinus contorta var. contorta*), and *A. douglasii* is restricted to a small part of the range of Douglas-fir (*Pseudotsuga menziesii*) in the southern interior. Inoculations of these mistletoes beyond their known natural ranges indicate that northward movement of *A. douglasii* is limited by increasingly cold winters, that *A. americanum* can become established and thrive in a coastal (e.g., Vancouver Island) environment and that the development of *A. tsugense* would not be hampered by the more rigorous climate of the interior western hemlock zone. Explanations for the absence of *A. tsugense* from the interior western hemlock forests and the virtual lack of *A. americanum* on shore pine remain based on historical events rather than on present climate. Lodgepole pine dwarf mistletoe survived in areas of -32 C. Minimum temperatures and Douglas-fir mistletoe in areas as cold as -29 C. A fungus similar to *Coniophyllum* occurred on 47% of *Arceuthobium douglasii* seeds in the moist interior site. Tympanis occurred on 5 mistletoe cankers on lodgepole pine. These studies support the idea that two ecological races or pathotypes exist in *Arceuthobium tsugense*.


**Abstract:** P. 7. Growth rate. Any effect that cloud seeding would have on increasing tree growth would influence the incidence and severity of certain diseases. For instance, dwarf mistletoes (*Arceuthobium*) would become less severe in individual trees, and possibly in stands, which had greater height growth, since vigorous conifers on good sites suffer less damage and mortality from these parasites than do trees on poor sites or those suffering from moisture stress. Thus, the additional moisture derived from cloud seeding would be beneficial in helping trees with lower growth rates combat such diseases. P. 8. Foliage. Infection by such pathogens as *Cronartium* spp. (which attack all pine species within the study area) and dwarf mistletoes (which attack most members of the *Pinaceae* within the area) partly depend on the numbers of needles presenting a "target" for spore or seed deposition. Since any increase in vigor associated with augmentation would lead to more needles and an increased needle retention, some increase in the numbers of mistletoe populations or rust infections might occur. Such effects would change disease incidence very little because any increase would probably be balanced by reducing damage on trees of increased vigor. P. 9. Moisture. Observations in California also indicate that the incidence of *Cytospora* canker of fir increases during drought years. Fir infected with mistletoe (*Felix*, et al., 9) are also more susceptible to bark beetle attack. Root diseases increase moisture stress as does heavy mistletoe infection in fir (*Ferrell*, 11). P. 17–18. Stand structure, composition, and density. Classes should decrease serious outbreaks of disease and insects since susceptibility is restricted to one, or a few tree species. However, this generality does not hold true at all times. For example, greater diversity in age class within stands infected by dwarf mistletoe usually leads to increased infection of young trees from infected overstory trees (*Scharpf*, 18). Spread of dwarf mistletoe is limited among widely scattered trees in sparsely stocked stands and also among trees in dense overstocked stands. In the first instance, the trees are beyond range of seed dispersal. In the latter case, dense trees provide a barrier to effective dispersal, and, in addition, lower branches become "shaded out" and die, thus reducing dwarf mistletoe populations. P. 33. Since trees grow faster with a plentiful water supply, it is expected that less severe attacks and less mortality from pathogens such as dwarf mistletoe and *Cytospora* canker will occur under augmented conditions than under drought conditions.


**Abstract:** Hemispherical photography was used to quantify the relationship between canopy light and the distribution of hemlock dwarf mistletoe (*Arceuthobium tsugense* (Rosendahl) G.N. Jones subsp. *tsugense*) aerial shoots in an old-growth Douglas-fir/western hemlock forest to determine if aerial shoots only occur in higher light environments in the upper canopy. The Wind River Canopy Crane provided three-dimensional access by lowering a gondola into gaps between trees and stopping at 5 m intervals and sampling all trees around the gap at that height. A total of 89 dwarf mistletoe infections in live branches were sampled on 14 trees from 18 to 60 m. Forty-one infections had no aerial shoots whereas 48 had aerial shoots. All infections above 50 m had shoots, while all infections below 30 m (except one) had none. There were no aerial shoots at infections exposed to estimated insolation (yearly insolation = diffuse light * indirect site factor + direct light * direct site factor) of 1,000 MJ m-2yr-1, while all infections above 3,200 MJ m-2yr-1 had aerial shoots. Height and light were highly correlated but between 30 and 50 m the light environment became especially heterogeneous, with a 50% probability of aerial shoots occurring at 40 m, or at 2,200 MJ m-2yr-1. A complex of biotic and abiotic factors may account for the correlation of high light and aerial shoot occurrence in the field because laboratory studies have shown dwarf mistletoe produces the most aerial shoots in low light and high temperature. In this tall, multilayered canopy, the source of the seed rain from western hemlock dwarf mistletoe was above the bulk of the western hemlock foliage, perhaps another explanation for the fast spread and intensification of mistletoe in old-growth forests.


Abstract: The Grider Burn is located in the Grider Roadless Area. The area was proposed as non-wilderness, but is included in the state of California vs Bergland, et al., lawsuit. An existing temporary road to a 40 acre parcel of private land runs through the burn. Except for the removal of right-of-way timber along the temporary road, the area has not been harvested. The area is generally mixed conifer type, consisting of Douglas-fir, white fir, ponderosa pine, sugar pine, incense-cedar and madrone. Douglas-fir dwarf mistletoe, _Arceuthobium douglasii_, is quite prevalent throughout the area. The fire started on July 17, 1981, on or near the pacific crest trail which parallels Grider creek. The fire burned up a west-facing slope and became quite intense from about mid-slope to ridgeline. In an area of about 250 acres (units 2 through 6 on attached map) the fire consumed the crowns on most of the trees and "cooked" the cambium of all trees under about 12 inches dbh. Some of the larger diameter trees had substantial live cambium at the time they were examined and it is possible that there may be scattered individuals, particularly ponderosa pine, which will be alive in 1982. The combination of severe injuries and sudden exposure will lead to continued mortality in and around the burned area for a number of years if nothing is done. Douglas-fir dwarf mistletoe will spread to Douglas-fir in the new stand and lead to deflected and slow growing trees. Units 1, 7 and 8 will continue to be relatively decadenct stands with high mortality due to a combination of overmaturity, Douglas-fir dwarf mistletoe and bark beetles during periods of low precipitation. Management alternatives 2, 3, and 4, which follow, assume that there are plans to rehabilitate all or part of the burn.


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Abstract: _Cytospora abietis_ grew in culture at constant temperatures that ranged from 5 to 30 C. The rate of linear growth of the fungus was most rapid at constant 25 and 30 C. No growth was observed at 35 C. Infection occurred and cankers developed on inoculated, greenhouse-grown white firs (_Abies concolor_) at constant temperatures of 17.1, 22.1, and 28.5 C. At 32.7 C, early symptoms of infection appeared, but no cankers developed. One factor known to predispose firs to infection...
by *C. abietis* is dwarf mistletoe (*Arceuthobium abietinum* Engelm. ex. Munz.). Portions of fir branches invaded by dwarf mistletoe are preferred sites for infection and development of *C. abietis*. Another observation in this study was that cankers stopped developing about 3 mo. after inoculation. It is not known why actively growing cankers suddenly stopped enlarging. In the field, *C. abietis* often continues to grow and kill branches, particularly those infected by dwarf mistletoe. In this study, however, no trees were girdled and killed by *C. abietis*. Further studies are needed to explain why some cankers caused by *C. abietis* girdle and kill branches and tops and others cease to grow and develop, thereby allowing the infected portions to heal.


**Abstract:** The seeds of *Arceuthobium abietinum* and *A. occidentale* have a high initial viability, but are relatively short lived and do not survive from one season to the next in the field. Even under nearly optimum conditions for storage (dry at 2 °C) only about half were viable after a year. Initial viability did not vary significantly with regard to year of collection, area of collection, or plant from which collected. Temperature was the most important factor influencing viability of seeds in storage—2 °C was most nearly optimum. Other factors tested, such as light, relative humidity, and moisture content had no effect except that seeds stored moist or at high relative humidities either germinated or became overrun by mold fungi. Proper temperature and light favored germination of dwarf mistletoe seeds although light was not required. A temperature of 13 °C was most nearly optimum for both rate of germination and maximum percentage germination of seeds. Other treatments used to promote or increase percentage germination, such as varying pH, scarification, after-ripening, removal of germination inhibitors, and chemical stimulants.


**Abstract:** Temperature influenced penetration and infection of digger pine (*Pinus sabiniana* Doug.) and Monterey pine (*P. radiata* D. Don) by dwarf mistletoe (*Arceuthobium campylopadum* Engelm. *f. campylopadum*). No penetration or infection occurred at constant temperatures of 27 °C or above. Infection occurred at 16 °C and 21 °C constant temperatures, but greatest percentage of penetration and infection occurred under outdoor temperatures (mean = 13 °C).


**Abstract:** Under the short growing season of the Sierra Nevada, both flowering and seed dispersal of *Arceuthobium campylopadum* occurred earlier in the fall and dispersal extended for a shorter duration than at lower elevations and along the coast of California. Also in years of above normal summer temperatures, flowering seed dispersal occurred earlier in the season than in years of below normal temperature.


**Abstract:** Dwarf mistletoes induce abnormal growth patterns and extreme changes in the biomass allocation of their hosts as well as directly parasitizing them for resources. Because biomass allocation can affect the resource use and efficiency of conifers, we studied the influences of dwarf mistletoe infection on above-ground biomass allocation of Douglas fir and western larch, and the consequences of such changes on whole-tree water use and water relations. Sap flow, tree water potentials, leaf: sapwood area ratios (AL:AS), leaf carbon isotope ratios, and nitrogen content were measured on Douglas fir and western larch trees with various degrees of mistletoe infection during the summer of 1996 in western Montana. Heavy dwarf mistletoe infection on Douglas fir and western larch was related to significant increases in AL:AS. Correspondingly, water transport dynamics were altered in infected trees, but responses were different for the two species. Higher AL:AS ratios in heavily infected Douglas fir trees were offset by increases in sapwood area-based sap flux densities (QSW) such that leaf area-based sap flux densities (QL) and predawn leaf water potentials at the end of the summer did not change significantly with mistletoe infection. Small (but statistically insignificant) decreases of QL for heavily infected Douglas fir trees were enough to offset increases in leaf area such that whole-tree water use was similar for uninfected and heavily infected trees. Increased AL:AS ratios of heavily infected western larch were not offset by increases of QSW. Consequently, QL was reduced, which corresponded with significant decreases of water potential at the end of the summer. Furthermore, mistletoe-infection-related changes in AL:AS as a function of tree size resulted in greater whole-tree water use for large infected larches than for large uninfected trees. Such changes may result in further depletion of limited soil water resources in mature infected stands late in the growing season. Foliage from infected trees of both species had lower water use efficiencies than non-infected trees. Our results demonstrate substantial changes of whole-tree processes related to mistletoe infection, and stress the importance of integrating whole-tree physiological and structural processes to fully understand the mechanisms by which pathogens suppress forest productivity.


**Abstract:** Dwarf mistletoes are parasitic, destructive and economically damaging in the coniferous forests where they occur. Timber volumes of native forests infected with dwarf mistletoes are lower than are timber volumes in healthy forests of the...
same age. In the past, human activities in the forests—such as logging and fire control measures—actually encouraged the spread of the mistletoes. Positive steps toward control of dwarf mistletoe must now be taken or future stands will suffer even more acutely than those of the contemporary forests. Differences in climate and in distribution of hosts, site quality, and stand structure are known, natural limitations to spread of infection. Most dwarf mistletoe plants are visible so that boundaries of disease occurrence are easily observed, and development of the parasite in space and time is now well understood. After evaluating form and extent of damage, forest managers should plan appropriate strategies to contain dwarf mistletoe spread well within the critical threshold of infection. Because fire can influence shifting population balances in forest communities, it may become a tool for dwarf mistletoe control. In addition, resistance to dwarf mistletoe will be raised as a secondary benefit of silvicultural treatment through selection of better crop trees.


Abstract: Needles of ponderosa pine rather than stems are the primary interceptors of dwarf mistletoe seeds. An effective biological adaptation brings the seeds into contact with stem tissues of the most susceptible age and also positions the seeds on the stems, usually in the axil of the fascicle, or at the fascicle opening. Apparently both locations are highly favorable for penetration by the primary root of the parasite. This adaptation seems essential to survival of pine dwarf mistletoe. Naked stems in a position to be hit by flying seeds offer a relatively small target, they retain the seeds poorly and are too old to be readily infected. Foliated stems in themselves present even smaller targets and are so clothed with needles that direct stem hits seldom occur. On the other hand, the numerous and widely spreading needles offer a target of great area and because of their individual flexibility they are ideally suited to seed interception. As a result of their large numbers and distribution they literally screen the seeds from the air. At this point a means of transferring the seeds from the needles to the susceptible stem becomes necessary. This is provided by movement attending gelatinization of the viscin during rainy weather. On the tree studied for this report approximately 20 percent of the seeds had been transferred to the twigs by the end of the year. Twenty-five percent remained on the needles and 55 percent were washed off or otherwise removed.


Abstract: The epidemiology of dwarf mistletoe (Arceuthobium) is simulated for the reproduction, dispersal, and spatial patterns of these plant pathogens on conifer trees. A conceptual model for mistletoe spread and intensification is coded as sets of related subprograms that link to either of two individual-tree growth models (FVS and TASS) used by managers to develop silvicultural and land management plans. This dwarf mistletoe model is based on knowledge of mistletoe biology and forest practices acquired through a series of workshops, programming exercises, and continuing research and development. Key components of mistletoe epidemiology are identified as life history, ballistics, and contagion. An infestation is quantified at the tree-level by a standard measure of mistletoe intensity, the dwarf mistletoe rating (DMR). Life history describes the progression of mistletoe populations from new infections to seed-producing plants and includes bioclimatic and mortality of the mistletoe. The model tracks mistletoe populations as changes in DMR rather than individual plants. Life history is represented as changes in pools for various developmental stages; and rates of change are modified by time, light, and other environmental factors (including hyperparasites). Dwarf mistletoes disperse by explosive discharge of small seeds followed by ballistic flight that displaces seeds horizontally to a maximum distance of about 14 m. The model represents dispersal as probabilistic, spatially explicit, ballistic trajectories for each host tree in a simulated stand. The spacing of trees and mistletoe within infested stands exhibits a range of patterns as regular, random, or clumped; the rates of spread to new hosts and intensification within infested hosts are influenced by crown and canopy distributions derived from descriptors of stem clumping and mistletoe contagion. Spatial arrangements of trees in the model are determined from stand-level statistics that characterize groups of trees at the scale of a 14m radius neighborhood, the maximum distance for ballistic dispersal. The number of trees in a simulated neighborhood is a function of the variance to mean ratio for tree density in the stand. The autocorrelation of trees of more similar DMR is used to simulate aggregation of infected trees into infestation patches. Model behavior for sensitivity to key relationships and fit to observed stands is demonstrated using data for a dense western hemlock stand and two initially similar, open-canopy ponderosa pine stands either treated for mistletoe or left untreated. The model provides a practical tool for assessing the long-term, cumulative effects of disease and

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management in mistletoe-infested stands.
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Abstract: Surveys of five campgrounds, only one of which had mistletoe: Juinata lake, Goose Nest Ranger District, Siskiyou county, California (6 miles east of Maloe). P. 6–7. *Arceuthobium campylopodum* in ponderosa pine and *Phoradendron juniperinum* on incense-cedar. Western dwarf mistletoe on ponderosa pine is currently at rather low infection levels, but with time will intensify and spread. The progressive impact of dwarf mistletoe on a stand is not immediately obvious to the casual or one-time observer, but rather it is gradual and subtle. Any natural ponderosa pine regeneration that becomes established or pines that are planted within the area of infestation will eventually be infected from overstory or adjacent trees. As infection levels increase, trees become more susceptible to insect attacks and drought stress and will not live as long as healthy trees. As impacted areas continue to deteriorate they will be seriously under-stocked of pine. A suppression project done in the near future could significantly lower the impact of dwarf mistletoe for many decades. Usually, the longer control efforts are put off, the more drastic the treatment will have to be. Treatments in recreation areas normally include removing heavily infected trees, pruning to eliminate all infection, and pruning witches' brooms to prolong tree life. Almost all of the dwarf mistletoe at Juinata lake could be dealt with by branch pruning the lower crown.


Abstract: General discussion of dwarf mistletoe biology and control, and association with drought and bark beetles. Insects gradually asserted themselves as the primary destructive agent. During the first two years, insects alone accounted for 22% (by number) and 13% (sbf = standing board feet) of losses, while in the third year insects alone caused 39% (by number) and 28% (sbf) of losses. Insects alone or in combination with other stressors were involved in 97% (by number) and 80% (sbf) of mortality in 1977–1978 or expressing the situation in another way, beetles were an agent involved in the destruction of 4.4 thousand millions of board feet (20.77 million cubic metres) in a year on the surveyed national forests. Dwarf mistletoe as a contributory, weakening agent was down from 50% (by number) and 63% (sbf) implication in 1975-1977 to 38% (by number) and 39% (sbf) in 1977–1978 (Forest Insect and Disease Management, 1977, 1978). The relative destructiveness of the dwarf mistletoes might have been somewhat unexpected in view of the far greater identification of beetles with drought damage. Of species, western dwarf mistletoe (*Arceuthobium campylopodum*) infection was second in total sbf mortality only to the western pine beetle (*Dendroctonus brevicomis*) during the peak epidemic (table 3), both these organisms being hosted by the dominant *Pinus ponderosa*. Proportioning of destructive agents in hosts invaded by two or more afflictions was done either by mechanical partitioning of losses in combination or by determining the order and extent of each affliction (L. Freeman pers. comm. 1979). In general, dwarf mistletoes tended to claim larger specimens than beetles attacking the same host species. For instance, dwarf mistletoe (*A. abietinum*, 2 subspecies) on fir (*Abies* sp.) destroyed approximately five times as much sbf as the white-fir engraver beetle (*Scolytus ventralis*), yet the engraver killed approximately five times as many trees.


Abstract: Relationships between forest habitat types, topographical and stand factors (slope, aspect, elevation, topography, configuration, site index, and basal area), and the frequency and severity of ponderosa pine dwarf mistletoe (*Arceuthobium vaginatum* subsp. *cytopodum*) were assessed in Colorado. A total of 547 plots (171 infested with dwarf mistletoe) were established in eight habitat types. *A. vaginatum* occurred most frequently and was most severe on the driest ponderosa pine (*Pinus ponderosa*) sites, which are typically the *P. ponderosa*/Muhlenbergia montana* habitat type. Severity of dwarf mistletoe was least in the wetter *P. ponderosa*/Quercus gambelii* habitat types common in southwest Colorado.


Abstract: Pollen analyses from a core from Lost Trail Pass Bog, 2152 m, Bitterroot Mountains, Ravalli county, Montana. *Arceuthobium* pollen mentioned on p. 355 (pollen diagram), p. 356. Although never abundant, *Arceuthobium* is most common in zones 2 and 3; it first occurs in zone 2 with the rapid increase in pine pollen. P. 363. Ca. 11,500 years b.p. *Arceuthobium* pollen consistently present for the first time. Although the species is unknown, Baker (1976) concluded from studies in Yellowstone, that the species is probably *A. americanum*, as it occurred with the first *Pinus contorta* macrofossils and indicates temperatures about the same as today.


Abstract: Factors affecting outbreaks—Food supply. This is perhaps the key factor regulating populations of the mountain pine beetle. Through some survival mechanism, beetles frequently but not always select the larger trees, where food is likely to be most abundant. Adequate food, most likely found in large diameter trees during better than minimum moisture periods, remains a major requirement for infestation buildup. After larger trees are killed, beetles infest smaller and smaller trees, where phloem is thin. When this happens, beetle populations decline and epidemics subside. There is no clearcut evidence
that mountain pine beetle epidemics develop because of drought or in heavily mistletoe-infected stands. Sugar pine and white pine may be exceptions since drought or snow breakage are believed to trigger epidemics.


Abstract: Past studies of the relationship between habitat types and the incidence and distribution of dwarf mistletoes are reviewed. Recent productivity studies of several mixed conifer species in relation to habitat type and dwarf mistletoe infection are examined. In the South west, damage caused by Arceuthobium douglasii in Douglas-fir varied greatly by habitat types: stands moderately infested (mistletoe classes 3–4) ranged from no detectable effect on diameter increment in several habitat types to 31% in the Picea pungens–Picea engelmannii/Erigeron superbus habitat type. For heavily infested stands (mistletoe classes 5–6), diameter increment reduction ranged from 24% in the Abies concolor-Pseudotsuga menziesii/Quercus gambelii habitat type to 75% in the Abies concolor-Pseudotsuga menziesii, Barbers repens phase.


Abstract: This study examined the relationships between the frequency of occurrence and severity of Douglas-fir dwarf mistletoe (Arceuthobium douglasii Engelmann), environmental and stand conditions, and plant communities in Southern Oregon Cascade Mountain Province. Data for the study was collected from the same ecology plots that were previously used to define the plant associations in the province. This study suggested that plant associations and climax series were useful indicators of the relative frequency of occurrence of DFDM in the Southern Oregon Cascade, but not of its severity. However, if the current distribution of DFDM was influenced by past harvesting and fire regime, changes in these factors may change the disease' distribution in the future.


Abstract: Douglas fir dwarf mistletoe (Arceuthobium douglasii) is a parasitic plant widely distributed on Douglas fir (Pseudotsuga menziesii) in SW Oregon, USA. This study examined the relationship of frequency of occurrence and severity of Douglas-fir dwarf mistletoe with stand conditions and plant associations in the southern Cascade Mountains of Oregon. Data were collected from a subsample of existing permanent plots. Fifteen stand variables and the level of dwarf mistletoe infection in all live Douglas firs were measured at each plot. Douglas fir dwarf mistletoe occurred most frequently in the white fir (Abies concolor) series. It occurred least in the Douglas fir series. It occurred in plots at significantly higher elevations, with lower mean annual temperatures and lower mean annual and dry season precipitation than plots where it was absent. Occurrence of Douglas fir dwarf mistletoe was also significantly associated with steeper slopes, andesite and basalt soil parent materials, lower basal area, and a lower percentage of Douglas fir in the stand. The average plot Dwarf Mistletoe Rating did not differ significantly among climax series, but increased significantly as total basal area decreased and age of the oldest canopy layer increased. The results suggest that climax series could be used as indicators of the relative frequency of Douglas fir dwarf mistletoe in the southern Cascade Mountains.


Abstract: Dwarf mistletoe does not occur throughout the entire range of ponderosa pine. Distinct northern, upper altitude, and lower altitude limits exist. Temperature, precipitation and relative humidity data were collected from 93 ponderosa pine sites, 51 US Weather Bureau weather stations and 42 US Forest Service fire-weather stations in Arizona, Colorado, Nebraska, New Mexico, South Dakota, Texas, Utah, and Wyoming. The presence or absence of dwarf mistletoe can be predicted fairly accurately from thermal correlation diagrams which relate January and July mean temperatures. Stations with dwarf mistletoe present generally have a greater differential between these two means. Temperatures and relative humidities during certain periods of the year are also useful in delineating distribution. The northern and upper altitudinal limits appear to be cold-temperature related. No dwarf mistletoe was found in stations with a January mean temperature below 6 C.


Abstract: Dwarf mistletoes (Arceuthobium spp.) are serious parasites on ponderosa pine and other western conifers. Their patterns of attack are patchy. There is no evidence, yet, of genetic differences at the electrophoretic level between ponderosa that are infested and others that are not, though a genetic basis for resistance to Arceuthobium in this pine has been suggested (Roth 1978; Scharf 1984). In addition, the Arceuthobium parasite itself shows large amounts of genetic variability (Nickrent 1984; Linhart 1984). A. vaginatum, whose primary host is ponderosa pine, can also infect lodgepole pine. There are significant genetic differences between Arceuthobium colonies on the two hosts (Linhart 1984; Linhart et al., in prep.). Furthermore, Hawksworth (1961) reported that seeds of A. vaginatum from infected stands of ponderosa pine were
more successful at re-infecting trees from infected stands than they were at infecting trees from previously non-infected stands. This implies that the trees in the two types of stands differ phenotypically and that the Arceuthobium have become adapted to specific phenotypes. With respect to pest species interacting with ponderosa pine, there is evidence for genetic heterogeneity within populations of Nuculaspis, Arceuthobium, and Dendroctonus ponderosae. In Nuculaspis, colonies on individual trees are genetically differentiated from one another, and transplant experiments have shown that colonies show higher survival on their tree of origin than when they are moved onto ponderosa pines in other stands (Edmunds and Alstad, 1978). In both Arceuthobium americanum and A. vaginatum, groups of dwarf-mistletoe individuals parasitizing a given clump of trees are genetically significantly differentiated from other groups occupying nearby clumps (Linhart et al., in prep.). We still need to determine the extent to which Arceuthobium differentiation is the result of differential survival of specific Arceuthobium phenotypes on specific host phenotypes or the restricted dispersal known to occur in Arceuthobium (Scharpf and Parmeter, 1978).


Abstract: As with other aspects of mistletoe biology, the truths about seed dormancy and germination must first be separated from a large body of myth. It can be concluded, for example, that the viscid layer plays no role in maintaining dormancy, that digestion by birds is not a prerequisite for germination, and that the type of substrate to which the seed adheres is not relevant. Limited evidence indicates that gas exchange is restricted by the pericarp and that high CO2 levels around the seed control predispersal dormancy. Rupture of the fruit wall, which corresponds to the act of dispersal, signals the onset of germination when external conditions are mild, and sometimes moist as well (mesophytic species). The seed is short-lived, with a record life of four years at low temperatures. Many xerophytic mistletoes germinate in dry air, while embryo elongation is enhanced by light. Cool climate species have an optimum temperature of 15–20 C for germination; warm climate species may have an optimum 10 C higher. Apart from predation, the major cause of germination failure in over-wintering species is fungal decay. The emergent embryonic axis is essentially composed of the hypocotyl and is geotropically neutral and negatively phototropic. Establishment successes after lodgement of 5–69% attest to highly efficient germination and establishment processes in mistletoes at a critical and precarious stage in their life cycle.


Abstract: Seeds of Arceuthobium species account for 5–18% of mature fruit weight. Viscin accounts for 26–61% of mature seed weight. Repeated wet-dry cycles of mistletoe seeds reduce the water-holding capacity of viscin. Seed germination is improved with light and with time since harvest. Radicle elongation was 24–92 micrometers per day. Arceuthobium seeds are negatively phototropic, positively thigmotropic, and geotropically neutral. Greatest infection was at low temperature–high light regime, but growth of both infected and uninfected trees was best at a high temperature regime. Growth of aerial shoots of A. campylopodum was best at the high temperature regime.


Abstract: Height growth of 2-year-old ponderosa pine seedlings was compared in uninfected plots and plots with campylopodum. For a 2-year period, uninfected trees in infected plots have been significantly taller than either the infected trees or trees in uninfected control plots. Mean heights (from cotyledons to the shoot apex) in March 1972 were 75 mm for infected trees, 84 mm for trees in control plots, and 100 mm for uninfected trees in infected plots. Differential root competition is the probable reason infected trees have less-developed root systems, and are poor competitors for soil nutrients. Differences in growth of paired infected and uninfected trees were significant at high, but not at low, temperature regimes. In other studies with trees grown at two light intensities (750 and 1,500 ft-c), host vigor was a better predictor of dwarf mistletoe growth (aerial shoot elongation) than was the level of light reaching the dwarf mistletoe plants.


Abstract: Dwarf mistletoe (Arceuthobium campylopodum) seed survival was determined for seed stored at 16 temperature x relative humidity regimes (-18, 1, 4, 9 C more than 2-, 6-, 10-, 75-percent relative humidity). Concentrated salt solutions (NaOH, ZnCl2, and NaCl) and (anhydrous CaSO4) were used for the different relative humidities. Germination was tested after 5, 10, and 15 months. The best germination was at 1C and 75% relative humidity, 94% (5 months), 80% (10 months), and 58% (15 months). Inoculations can now be done throughout the year facilitating studies of the infection process and mass production of dwarf mistletoe-infected trees needed for out-planting studies.


Abstract: True fir mortality and associated pest condition on portions of South Fork Mountain were evaluated to develop pest management alternatives for consideration during preparation of the silvicultural prescriptions and environmental assessments for proposed timber sales on the mountain. The major insect and disease complex associated with the mortality
Dwarf mistletoes are obligate parasites which are completely dependent on their host for support, for water, and for most of their mineral and organic nutrients. Infection of trees by dwarf mistletoe results in reduction of growth, growth abnormalities, mortality, and predisposition to other pests. Dwarf mistletoe swellings on true fir provide openings in the host bark for invasion by the canker causing fungus. Open bole swellings resulting from dwarf mistletoe infections provide entrance courts for insects and decay fungi and weaken the tree at that point, making them prone to wind breakage. The fungus Cytospora abietis causes a canker and dieback disease of true firs throughout their range. In California, dwarf mistletoe predisposes branches to attack by the fungus by providing openings in the host bark through which the fungus can infect. Together with dwarf mistletoe, Cytospora is responsible for frequent and often severe branch flagging. Cytospora is generally a weak parasite, requiring a stressed or predisposed tree before it can attack. Other stressing factors that can predispose true firs to dwarf mistletoe infections are moisture stress and drought, wounds from fire or logging, weakening of trees from sudden exposure, and patch killing of cambium by twig or bark beetles. Avoiding situations which create these stress factors, and removal of dwarf mistletoe-infected trees, will reduce damage from this disease.


Abstract: Lake Alpine area, Alpine county California. Five campgrounds (Silver Valley, Pine Marten, Backpackers, Lake Alpine, and Silvertip) and two picnic areas (Marmot and Chickaree) were examined for forest pest conditions. Red fir dwarf mistletoe is important, lodgepole pine dwarf mistletoe is minor and found at Marmot picnic area. Red fir dwarf mistletoe occurred on overstory and understory trees at various intensities in the basin. It was present on most overstory trees at Pine Martin, Silvertip, and Chickaree, but limited to specific, identifiable, infection centers at Silver Valley (vicinity of unit 7), Lake Alpine (vicinity of unit 10), and Marmot (vicinity of restrooms). Dwarf mistletoe was not observed at backpackers campground. Infection in understory red firs was noted only at Pine Marten. Dwarf mistletoe in red fir may increase as the proportion of red fir in the stands increases due to loss of lodgepole pine from stress factors and bark beetle attack. Dwarf mistletoe will infect understory red fir and lodgepole pine from the overstory source of infection to perpetuate the disease. Decay will develop in red fir dwarf mistletoe bole cankers and create potentially hazardous trees. Red fir in dense aggregations or red fir infected with root disease may become severely infected with dwarf mistletoe because of slow growth. Although presently at low levels, pine bark beetles and the fir engraver may contribute to an increase in mortality, particularly in trees weakened by root disease, dwarf mistletoe, and excess soil moisture.


Abstract: The Coldbrook and Pineknot campgrounds and the Aspen Glen picnic area on the Big Bear Ranger District, San Bernardino National Forest, were evaluated for pest problems which may affect management objectives for the areas. The major problem noted at Coldbrook campground was western dwarf mistletoe. Management options for reducing the impact of this parasite, including 1) pruning of infected branches; 2) removing infected overstory trees to protect regeneration; and 3) thinning, are presented. Other pest problems noted were white fir true mistletoe and elytrodema disease at Coldbrook; annosus root disease and elytrodema disease at Pineknot; and western dwarf mistletoe at Aspen Glen. The major pest problem present in the campground is western dwarf mistletoe (Arceuthobium campylopodum), which occurs throughout the area except in the vicinity of sites 11, 12 and 13. Jeffrey pines in the understory and overstory were, in general, moderately to heavily infected, with Hawksworth 6-point dwarf mistletoe ratings of 5 and 6 common. Numerous witches' brooms were present. In some areas, densely stocked aggregations containing both infected and noninfected Jeffrey pines were present. Many of the older overstory white fir had dead tops and were heavily infected with white fir true mistletoe (Phoradendron bolleanum subsp. pauciflorum). Elytroderma disease, caused by Elytroderma deformans, was present at low levels on a few Jeffrey pines. Root diseases were not observed in the campground. A few pines were dead or dying in the vicinity of sites 36 and 25. Some of the trees contained larvae of the California flatheaded borer (Melanophila californica) as well as pine engravers (Ips spp.) In the tops. The trees were probably predisposed to successful attack by these insects by heavy dwarf mistletoe infections and below-normal precipitation.


Abstract: Water vapor conductance measurements with a null-balance diffusion porometer on potted trees in late summer and fall showed generally low conductance values for mistletoe relative to host. Mistletoe conductance exceeded that of the host on some occasions when afternoon air temperature approached 30 C and conductance decreased in a moderately water-stressed host but not in the mistletoe. Under these conditions, parasite transpiration accounted for about 10% of the day's total water loss from the infected tree, with mistletoe shoots representing 5% of the total transpiring surface area. Others have found transpiration rates in this mistletoe to be consistently much higher than in the host, particularly under moisture conditions.
stress conditions. The difference may be seasonal, as stomata were determined to be most abundant on flowers, fruits, and leaves immediately below flowers. In this study, mistletoe shoots were not in flower, though flower buds were abundant.


Abstract: Following an Ips bark beetle outbreak in 2002, mortality of ponderosa pine (Pinus ponderosa Douglas ex C. Lawson) was evaluated in 2 study areas infested with southwestern dwarf mistletoe (Arceuthobium vaginatum [Willd.] Presl subsp. cryptopodum [Engelm.] Hawksworth and Wiens) in the Coconino and Tonto National Forests, Arizona. A pair-wise comparison of dwarf mistletoe ratings for live and dead ponderosa pines was conducted to determine whether dead ponderosa pines had higher dwarf mistletoe ratings than pines that were not attacked. In both study areas, dead ponderosa pines had significantly higher dwarf mistletoe ratings, indicating an association between the severity of dwarf mistletoe infection and susceptibility to attack by Ips spp. We suggest that the probability of ponderosa pine mortality is greater in stands severely infested with southwestern dwarf mistletoe in northern Arizona.


Abstract: The worst disease of Jeffrey pine is caused by western dwarf mistletoe (Arceuthobium campylopodum). Heavy infections cause witches' brooms, severely reduce growth, and eventually kill the tree. Young trees are highly susceptible to infection forming numerous infected overstory trees. Dwarf mistletoe has predisposed many stands to insect attack and has induced 60 to 80 percent of all Jeffrey pine mortality in years of severe drought.


Abstract: Seed dispersal of eastern dwarf mistletoe (Arceuthobium pusillum) parasitizing black spruce (Picea mariana) in the Fond du Lac State Forest, Carlton co., Minnesota, USA., began in the 1st week of September and continued until the first frost. Most seeds were discharged during the first 3 hr after sunrise. Seed expulsion was a function of rising temperature during that time. The mean horizontal distance traveled by discharged seeds was 1.65 m. One seed traveled 13.7 m. Freezing temperatures on August 31, 1970, caused nearly complete fruit abortion in that year of the study and caused a substantial reduction in seed discharge in the other 2 years. Of 3200 seeds placed on the needles of healthy black spruce in September 1971, only 6.5 percent of the seeds had germinated by August 1972.


Abstract: The distribution and effects of the mistletoes Arceuthobium divaricatum Engelm. on Pinus edulis Engelm. and Phoradendron juniperinum Engelm. on Juniperus osteosperma (Torr.) Little on the pinyon-juniper vegetation type on the South Rim of Grand Canyon National Park were investigated. Fire was the most limiting factor in the distribution of the mistletoes. The incidence of infection increased as trunk diameter and height increased in both pinyon and juniper. Arceuthobium divaricatum had the more serious impact on its host in respect to both vigor and mortality. Both mistletoes appear to be in equilibrium with their hosts at this time.


Abstract: Factors affecting the germination of dwarf mistletoe seeds were studied. Three species—Arceuthobium americanum on lodgepole pine, A. campylopodum f. cyanocarpum on limber pine and A. vaginatum on ponderosa pine were used. Seeds of these mistletoes were collected in September, 1967, and seed germination was examined under different light and temperature conditions. Tests were replicated eight times. All the seeds were already naturally discharged at the time of collection except those of limber pine mistletoe, which were still in the fruit. When cold treatment was given by keeping seeds at -5 C for a week and then raising the temperature to 16 C., the seed germination of limber pine mistletoe was greatly stimulated. This treatment increased germination about four times. Seeds of other mistletoes, however, did not respond to the cold treatment. There was no difference in germination between the seeds kept under the continuous light and in total darkness.


Abstract: This paper examines, by climax conifer series, historical and current roles of many important pathogens and insects of interior Northwest coniferous forests, and their unique responses to changing successional conditions resulting from management. Insects and pathogens of the subalpine fir and mountain hemlock series historically reduced inter-tree competition for site resources, and generated most of the coarse woody debris between fires. Severity of growth and mortality effects was proportional to the abundance of susceptible seral species such as Douglas-fir, grand fir, and lodgepole pine within and adjacent to subalpine fir and mountain hemlock forests. Laminated root rot, a mortality factor, influenced successional status, fire intensity, and fire behavior. Insect and disease disturbances in present day western hemlock and western red cedar climax forests are much the same as those occurring historically, but increased scale of fire disturbance
resulting from fire exclusion, has increased the scale of insect and pathogen disturbances associated with changing successional conditions. Spectacular differences are apparent when comparing historical and current roles of pathogens and insects of the Douglas-fir and grand fir series. Before the advent of fire control on public lands, late successional and climax forest stands were relatively scarce in comparison with current distribution. A century of fire protection has produced a steady shift away from parklike ponderosa pine and western larch forests toward denser late-successional fir forests. Harvesting of high-value seral overstorys accelerated conversion to insect- and pathogen-susceptible late-successional forests. Douglas-fir and grand (white) fir are highly susceptible to root pathogens, bark beetles, defoliators, and dwarf mistletoe. Excluding fire from grand fir and Douglas-fir forests has perhaps been the single greatest detriment to diversity of eastside forests, and a primary factor in current susceptibility to major pathogens and insects. Low intensity fires, once common to historical ponderosa pine climax forests, maintained low fuel loads, minimized fuel ladders, and spaced trees struggling to survive under severe moisture-limited growing conditions. The western pine beetle and mountain beetle thinned densely stocked areas missed by fire, and killed trees in jured by wind and weather, or weakened by root disease, dwarf mistletoe, pandora moth, or advanced age. With fire control, overstocked conditions became widespread and bark beetles assumed the role of underburning to the elimination of trees in excess of site potential. Regeneration of historical lodgepole pine forests was predicated on mountain pine beetle outbreaks and subsequent stand replacing fire events. Today, with fire control, mountain pine beetle outbreaks affect larger areas, for longer periods, often with greater intensity than historical outbreaks. Specific solution to elevated insect and disease disturbance in current forests is complicated by great variety in environmental and vegetal conditions where rehabilitation might be needed, and change in biological and physical potentials as a direct result of management. Still, much can be done. Stocking can be reduced where long-term carrying capacity is exceeded. The shift toward late-successional, fire intolerant, pathogen- and insect-susceptible forests can be reversed by developing a seral-dominated forest matrix. Management activities can promote landscape structure, composition, and pattern, consistent with historical disturbance regimes and land potentials. Future research on forest pathogens and insects should address three primary subject areas: insect and pathogen population dynamics in managed and unmanaged forests; ecological roles and effects of native and introduced pathogens and insects; and, effects of natural disturbances and management practices on native insects, pathogens, and their natural enemies.


Abstract: Hemlock dwarf mistletoe, Arceuthobium tsugense (Rosendhal) G.N. Jones, infects western hemlock in old-growth forests throughout southeast Alaska. Although western hemlock is the principle host in the region, A. tsugense also infects, albeit rarely, Sitka spruce (Laurent 1966) and mountain hemlock (Shaw 1982). To date, however, it has not been found on either Pacific silver fir or shore pine, two known hosts in British Columbia (Hawksworth and Wiens 1972). True clear-cut logging could eliminate this disease as a management concern in young-growth stands. Infected, but non-merchantable hemlock trees are, however, frequently not cut during harvest of the old-growth. Spread of dwarf mistletoe from these infected residuals is the principle form of infestation in young hemlock stands. Recent research indicates, however, that in southeast Alaska the levels of infection by A. tsugense on young hemlocks near infected residuals are much lower than occur in Washington, Oregon, and British Columbia (Shaw 1982, Bloomberg, these proceedings). Also, most infected, young hemlocks have less than three infections per tree, and these are concentrated in the lower third of the crown—a location that limits their ability to spread the disease. These factors, together with the removal or killing of infected residuals during precommercial thinning, the height growth response of crop trees to thinning, and the common interspersion of resistant Sitka spruce, should prevent hemlock dwarf mistletoe from reaching damaging disease levels within the planned 90–120 year rotation. Reasons for the lower incidence of disease in young stands in southeast Alaska are unknown, but may relate to differences in stand composition, weather conditions, and mistletoe seed production. A demonstration area has been installed near Thorne Bay on Prince of Wales Island (fig.1) to provide foresters and the general public with information on the recognition, biology, impact, and silvicultural control of hemlock dwarf mistletoe in young-growth stands (Hennon and Shaw 1986).


Abstract: Most dwarf mistletoe-infected ponderosa pine stands near the South Rim of Grand Canyon, Arizona are within 2 miles of the rim, but the parasite extends southward at one point for about 7 miles from the rim along a broad ridge. The reason for this peculiar distribution is unknown, but it could be either a reflection of climatic factors associated with the canyon rim or a relatively recent colonization of this area by the parasite.


Abstract: Includes a general review on the biology of this dwarf mistletoe including nomenclature, hosts, geographic range, description of the plant, physiology, damage, biological interrelationships (fungi, insects, birds, mammals), ecology and control. Plus details on six studies. Arceuthobium vaginatum f. cryptopodum is the most important pathogen of ponderosa pine in the southwestern United States. About 36 percent of the commercial ponderosa pine acreage in Arizona and New Mexico is affected. 1. Life history. The seeds germinate within 1 month after they are expelled. Insects and other agents destroyed many of the seeds, and only about 5 percent of the seeds planted resulted in infection. The more recent internodes are the most susceptible but some infection occurred on growth as old as 9 years. Over 90 percent of the infections first produced shoots during the third, fourth, and fifth years. Flowers were first produced in 5 years and the first mature fruits in 6 years. A 1 to 1 sex ratio exists for this species. 2. Seed flight. The average horizontal distance traveled by the seeds was 17.4 feet, with a maximum of 42.0 feet. There was a linear relationship between the logarithm of the number of seeds falling

http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/
on a unit area and the distance from the seed source. The natural angle of discharge averages 30 deg. to 40 deg. above the horizontal. 3. Seed dispersal period. The dispersal period was measured during 3 successive years on the Fort Valley Experimental Forest, AZ. The bulk of the seeds were expelled during the 3-week period including the last week in July and the first 2 weeks in August. 4. Rate of spread. Measurements on spread of the parasite were made in 42 stands in Arizona and New Mexico. Infection in young stands progressed from an infected overstory at an average rate of 1.7 feet per year in stands where the crown canopy had not closed, and 1.2 feet annually in closed-canopied stands. The rate of lateral spread through even-aged stands averaged 0.9 foot per year. 5. Effects on growth rate of the host. Measurements of 1,600 trees of two age classes were made on the Mescalero-Apache Reservation, NM. There was a significant reduction in recent (last 5 years) radial increment only in trees in which at least two-thirds of the crown was infected. Recent radial increment in heavily infected trees was reduced 35 percent in 55-year-old stands and 52 percent in 140-year-old stands. There was a marked reduction in vigor of heavily infected trees of both age classes. The effect of dwarf mistletoe in heavily infected trees was most pronounced on recent radial increment and total volume, intermediate on height, and least on total diameter. 6. Witches'-broom formation. Three types of witches'-brooms associated with this parasite on ponderosa pine are described. The characteristics and relative abundance of the three types, are discussed. Systemic dwarf mistletoe infections are shown to arise from dormant pine buds that are stimulated by the parasite.


Abstract: The results of a survey of 215,000 acres of commercial forest on the Mescalero Apache Reservation, New Mexico, which are based on the frequency of ponderosa pine dwarf mistletoe (Arceuthobium vaginatum L. cryptopodium) on 2,464 ponderosa pine type plots and on Douglas-fir dwarf mistletoe (A. douglasii) on 979 plots of that type showed that, (1) the frequency of A. vaginatum is highest on ridges, less on slopes, and least in bottoms. A. douglasii showed no significant difference in the 3 slope positions. The following relationships pertain to the slope-type plots, which constituted about 88 percent of the area. (2) A. vaginatum is most common on southwesterly aspects, and A. douglasii occurs most commonly on north and northeastern exposures. (3) A. vaginatum decreases slightly with increases in steepness of slope, but the reverse is true for A. douglasii. (4) the frequency of A. vaginatum was highest at medial elevations in the ponderosa pine type, but there was no consistent relationship between A. douglasii and elevation of the sample plot.


Abstract: Upper limits of A. americanum are 200 to 600 feet below the upper limits of commercial lodgepole pine in Colorado and Wyoming.


Abstract: Study near Dillon Lake, Colorado. The stands averaged 236 trees per acre in lodgepole pine. The average diameter of the measured trees was 18 cm dbh. A total of 1,301 trees were examined, but only the 1,051 with complete information on diameter, mistletoe rating, and phloem thickness were used in these analyses. As has been shown for other studies, there is a direct relationship between dwarf mistletoe intensity and tree diameter, and crown class. Dwarf mistletoe infection increases with diameter, and dominant trees are most heavily infected. The results (table 1) do not show a direct relationship between phloem thickness and dwarf mistletoe intensity class. However, as a group, uninfected trees and those lightly infected (infection class 1) had slightly but significantly (p=0.05) thicker phloem than trees in higher infection classes (classes 2 through 6). However, the correlation between phloem thickness and diameter, when computed for 2.5-cm dbh classes (such as reported by Cole and Amman, 1980) was r = 0.85. When computed for individual trees, r=0.04 for uninfected and class 1 trees, and r=0.15 for infected trees in classes 2 through 6. This Colorado study indicates a much less significant relationship between phloem thickness and dwarf mistletoe intensity than that reported by Roe and Amman (1970) for Idaho. If, as has been shown for other areas, brood production of mountain pine beetles is correlated with phloem thickness in lodgepole pine (Amman 1972), little correlation would be expected between bark beetle activity and dwarf mistletoe intensity in Colorado. Our observations tend to confirm this, although quantitative data are not available.


Abstract: The release and dispersal of pollen of Arceuthobium americanum Nutt. ex Engelm. parasitizing Pinus banksiana Lamb were examined in relation to microclimate in southern Manitoba. Time-lapse photography revealed that once open, the long-lived staminate flowers remain open. The anthers, however, open in response to rising temperatures and falling relative humidities and close under the reverse conditions. Small diptera (Sciaridae) appeared on the photographs on 25 occasions during the wet spring of 1986. Nectar was scarce on pistillate flowers, but accumulated on the central cushions of stamineate flowers when relative humidities were high. In the dry spring of 1987, nectar was rarely seen on the stamineate flowers when relative humidities were high. In the dry spring of 1987, nectar was rarely seen on the stamineate flowers and one small dipiteran was photographed just once. Large beads of concentrated nectar (50–65% sugar), however, formed on the stigmas in 1987. Large diptera were rarely seen in 1986, but were numerous in 1987. Visits to stamineate flowers were more frequent than to pistillate (2.7:1.0), but individual insects spent more time on pistillate flowers than stamineate (9:6.1:0). Pollen grains, trapped on a continuously recording volumetric spore trap, increased in number during warm periods and fluctuated when weather alternated between rainy and dry. Pollination is effected by unspecialized insect visitors and wind. Like other dichinous species, A. americanum represents a compromise between entomophily and anemophily.

**Abstract:** Freezing avoidance by deep undercooling has also been found in winter-collected seeds of the dwarf mistletoes *Arceuthobium americanum* and *A. cyanocarpurn*. Becwar (1980) is the first to report undercooling of seeds collected from a natural setting. He found deep undercooling to be the mechanism of freezing resistance in seeds of the two dwarf mistletoe species noted above. Seeds were collected in winter in the Rocky Mountains of Colorado. The seeds of these mistletoe parasites overwinter on the leaves or stems of host trees, principally lodgepole pine (*Pinus contorta*) and limber pine (*P. flexilis*). The results of differential thermal analysis (DTA) studies showed that no freezing occurred in the seeds until just below -30°C when rapid crystallization of tissue water was observed. This freezing also correlated with the killing point of the seeds as determined in separate viability tests. Seeds were further tested by bringing them into contact with ice at -3°C and then cooling directly to below -40°C, or cooling to -17°C and holding for 48 hr before cooling to low temperature. Neither treatment appreciably affected the freezing behavior of the seeds. In the case of the mistletoe seeds it appears that freezing resistance by deep undercooling may be a factor limiting the alpine distribution of the species, but not its northern range. Becwar (1980) notes that the upper elevational limits of the mistletoe species in his study are near 3000 m. In this alpine region, temperatures below -30°C are probable. The northern distribution of *A. americanum*, however, extends to 58° north latitude in Canada where temperatures below -40°C are common. The author speculates that seeds from that region may lose their undercooling water in a manner identical to the primordial tissues previously discussed. This remains to be shown. The importance of deep undercooling in the other seeds is less clear.


**Abstract:** A review and synthesis of the literature on water relations on the mistletoes, with special emphasis on the author's research on *Arceuthobium americanum* and *A. vaginatum* in Colorado. Topics discussed: (1) mistletoe and host structure in the context of water relations (development of the xylem-to-xylem connection, and mistletoe foliar morphology), (2) water and solute movement through host and parasite (pathway of the transpiration stream, water movement and free energy, measurement of tissue water energy status, host-mistletoe water and pressure potential gradients, and factors controlling energy gradients) and (3) parasite-induced host water stress.


**Abstract:** Evaluation of the Tamarack Thin timber sale area, Goosenec Ranger District, Klamath National Forest, California. The area is in T44N, R2E, sections 29 and 32. The stand is about 70 percent white fir and contains moderate to heavy infection of *Arceuthobium abietinum* f. sp. *concoloris*. The stand is suffering heavy mortality due to a combination of dwarf mistletoe infection, fir engraver beetles, and prolonged drought. Gives suggestions for thinning to reduce dwarf mistletoe levels and to increase the proportion of ponderosa pine in the stand.


**Abstract:** The recent drought in California and related loss of forest trees provided a dramatic illustration of the need for the greater use of the applied ecology that is called "integrated pest management". Dr. R. W. Stark discussed this concept in the May 1977 Journal of Forestry (vol. 75, 251–254). He noted the need to look at the population of the host forest—to consider stand dynamics—as well as pest populations. Dr. Stark said "the pest and the host must be considered as a single interacting system, each with their own related systems." he added "optimization of resource values implies the management of organisms preventing optimization." he also noted the importance of pathogens, vertebrates, plants and other pests besides insects, but used the latter for illustration. He further said "outbreaks probably occur most commonly in relatively unproductive forest ecosystems already under stress by natural factors. Certainly, much of the national forests of California qualify as unproductive forest ecosystems. According to the Forest Service 1972 data, the commercial forest lands therein were producing 31% of their capacity in 1970. While the national forests in California include just under half of the commercial forest land in California they had 64% of the mortality and only 40.5% of the softwood timber growth. Recently the California regional office of the USFS estimated that 12.3 million trees with 8.6 million bd. ft. died during the 1976–1977 drought. All sites and forest types were affected. Forest insects and diseases were important contributors to 98% of the volume loss. Of this loss 65% was the result of both insect and disease attack; weakening by dwarf mistletoe and root diseases predisposing them to drought stress. The beetles and flat headed borers then killed the stressed trees. These signify an unhealthy forest. The health of the commercial timber stands in the national forests can be improved generally only through timber harvesting. The saw must replace fire and pests as the reducer of moisture stress. Commercial thinning can be used to increase drought and pest resistance. However, scheduled harvest levels are much too low to be fully effective. Of great importance in achieving IPM is the need for changing the stocking and age-class distribution of stands on the national forests.


**Abstract:** Monitoring plots containing a sample of 265 ponderosa pine were installed following a dwarf mistletoe sanitation-thinning treatment on the Carson National Forest in 1991. From 1992 to 2002, average dwarf mistletoe ratings (DMR) increased from 1.20 to 2.12 (0.92) in the treated area, and from 2.20 to 2.44 (0.24) in an adjacent untreated area. The
greater increase on the treated plot was a function of both a more rapid intensification of mistletoe on infected trees on that plot and the death of several heavily-infected trees on the untreated plot. Average diameter growth over the 10-year period was 2.2 inches on the treated plot and 1.0 inches on the untreated plot; growth was markedly reduced on both plots in the second five-year period because of drought. Tree mortality was four times higher on the untreated plot, and mortality was strongly correlated with dwarf mistletoe infection on this plot. Regeneration was healthier and more abundant on the treated plot. Management implications are discussed.


Abstract: Oregon and Washington. Summer of 1958 was unusually hot and that of 1959 was unusually dry in the Pacific Northwest. Branch killing was widespread, particularly in trees previously injured by fungi, dwarf mistletoe, insects and hail. Drought probably has some long-range benefits, such as killing branches infected by obligate parasites, such as dwarf mistletoes, may slightly hinder spread of the disease by diminishing the supply of inoculum.


Abstract: Needles and twigs of western hemlock, Tsuga heterophylla, were inoculated with seed of Arceuthobium tsugense in October 1972, 1973, 1974. One infection developing from the earlier inoculations produced mature seed within 4 years; however, most produced seed in the fifth year. Success of inoculation was affected by loss of seed to winter storms, fungus attack, and insect predation. Approximately two-thirds of the 4,584 seeds placed on host trees were retained over winter. Seed placed on twigs was more likely to overwinter on the host than seed placed on foliage. About 45% of these 3,069 overwintering seeds germinated and about 8% (243) caused infection of host tissues. No strong relationship existed between success of infection and branch height or aspect, nor exposure of tree crown to direct light.


Abstract: Lodgepole pine dwarf mistletoe (Arceuthobium americanum Nutt. ex Engelm.) is one of the most damaging pathogens of jack pine (Pinus banksiana Lamb.) in western Canada. Jack pine forests in the colder, more northerly areas, however, are free of dwarf mistletoe, suggesting that the pathogen is limited by low temperature. The effect of extreme cold temperatures on germination rates of over-wintering dwarf mistletoe seeds and survival of dwarf mistletoe germinants was evaluated. Germinative ability of over-wintering seeds increased with increasing temperatures between –39 and –35 °C, regardless of seed source. Exposure period also strongly influenced germination rates. Exposure to temperatures near –38, –46, or –53 °C for 96 h was almost always lethal. At –37 °C, germination was greater after 48 h than after 96 h, although it was still significantly lower than in the controls. Temperatures down to –6 °C in late spring did not reduce germinant survival. Overall, these results may explain the absence of dwarf mistletoe from northern areas commonly exposed to winters with minimum temperatures below about –40 °C. These areas are potentially at risk from the pathogen if the climate of Canada’s northern interior continues to warm as it has over the last several decades.

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Abstract: P. 2–3. Douglas dwarf mistletoe, Razoumofskyia douglasii (Engelm.) Kuntze, so destructive to Douglas-fir throughout much of its range, and particularly in Oregon and Washington on the east slope of the Cascade Mountains, is unknown west of the summit of the range except in southern Oregon. For example, in the Hood River valley, which lies east of the summit, the mistletoe is common. From this valley through the Columbia River Gorge has stretched an unbroken belt of Douglas-fir extending practically to the Pacific Ocean. Yet the mistletoe has not followed through with its host. Neither has it followed through from southern Oregon to north of the divide between the Umpqua and Rogue Rivers. Climatically, the region with its high rainfall and cloudy weather in contrast to the much drier, more sunshiny weather east of the summit, is not unfavorable to the dwarf mistletoes as a group, for hemlock dwarf mistletoe, R. tsugensis Rosend., is common on western hemlock, Tsuga heterophylla (Raf.) Sarg., and fir dwarf mistletoe, R. abietina (Engelm.) Abrams, is occasionally met with on lowland white fir, Abies grandis Lindl. The factors limiting the distribution of the mistletoe on Douglas-fir present an interesting and unsolved problem.


Abstract: P. 23. Dwarf mistletoe in hemlock is one of the major disease problems in the Puget Sound area, causing cull and reducing growth. It generally does not cause mortality except in very old stands where it weakens trees and makes them susceptible to insect attack or unable to survive periods of drought. Apparently the tips of old western hemlock trees (350 years or older) begin to die in periods of warm, dry weather possibly because the tips farthest from the roots lose moisture faster than can be replaced when humidity is low. A heart-rotting (coral fungus) then enters the dead branches in the top. In many cases, dwarf mistletoe also becomes a factor (dwarf mistletoe often develops prodigiously in hemlock stands that are opened up to light by selective logging, storm damage, or other causes). For several years the Mount Baker National Forest has been concentrating its timber sales in areas of heavy hemlock dieback.

Abstract: Published data on infestation rate, incidence, severity and impact of hemlock dwarf mistletoe were compared for Alaska, British Columbia Washington, and Oregon. Infestation was relatively high in Alaska and British Columbia and moderate in Washington and Oregon. Incidence and severity were low in Alaska, moderate in Washington and Oregon and ranged from moderate to high in British Columbia. Reduction in volume and volume increment ranged from moderate to severe in British Columbia. But was not significant in Washington and Oregon. Possible factors contributing to differences in epidemiology of the disease among geographic areas include effect of climate on seed production and spread, stand composition and growth rate, and dwarf mistletoe biotypes.


Abstract: Much research has focused on effects of plant parasites on host-plant physiology and growth, but little is known about effects of host physiological condition on parasite growth. Using the parasitic dwarf mistletoe Arceuthobium vaginatum subsp. cryptopodum (Viscaceae) and its host Pinus ponderosa, we investigated whether changes in host physiological condition influenced mistletoe shoot development in northern Arizona forests. We conducted two studies in two consecutive years and used forest thinning (i.e., competitive release) to manipulate host physiological condition. We removed dwarf mistletoe shoots in April, before the onset of the growing season, and measured the amount of regrowth in the first season after forest thinning (Study I: n=38 trees; Study II: n=35 trees). Thinning increased tree uptake of water and carbon in both studies, but had no effect on leaf N concentration or d13C. Mistletoe shoot growth was greater on trees with high uptake of water and carbon in thinned stands than trees with low uptake in unthinned stands. These findings show that increased resource uptake by host trees increases resources to these heterotrophic dwarf mistletoes, and links mistletoe performance to changes in host physiological condition.


Abstract: Seeds of dwarf mistletoe parasites, A. americanum and A. cyanocarpum, native to the Colorado Rocky Mountains, avoid freezing by deep under-cooling all freezable tissue water to near -35 C. Seeds nucleated with ice at -3 C and cooled to -40 C were killed. Seeds cooled to -30 C had germination levels equivalent to non-frozen seeds. Differential thermal analysis studies showed that the position and size of the exotherms of the seeds were not significantly changed by the following treatments: absence or presence of external ice-nucleation at -3 C, ice-nucleation at -3 C followed by holding at -17 C for 48 hr prior to subsequent cooling, and changes in cooling rate between 0.1 and 1.0 C/min. Thus, the deep undercooling mechanism is persistent and the imposed hardiness limit of the mistletoe seeds over-wintering on the host may be a factor in restricting the distribution of the mistletoe parasite relative to the distribution of the host tree.


Abstract: Initial seed viability of the western dwarf mistletoe, Arceuthobium campylopodum f. campylopodum, varied with seed source, but in all cases retention of viability was influenced by temperature. Seeds stored at 1.5 C retained high viability for 10 months and in some cases were viable after 48 months of storage. Western dwarf mistletoe seed germinated at temperatures of 1.5–31 C. The optimum constant temperature for germination was between 17 and 19 C, whereas most favorable alternating night-day temperature intervals were 12 hr at 5 and 15 C. Dormancy appears to be regulated by a chemical inhibitor associated with the persistent endocarp.


Abstract: Horsethief Basin Basin has a long history of southwestern dwarf mistletoe and lps bark beetle activity, and the summer home area is no exception. A majority of the lots have a mistletoe-infected pine overstory and understory with infection intensities ranging from moderate to heavy. On some lots, every tree is infected. The deleterious effects of dwarf mistletoe on the growth and vigor of ponderosa pine have been well documented. Infected trees are less healthy and vigorous than uninfected trees; dwarf mistletoe stresses the trees and makes them more susceptible to attack by bark beetles, environmental stresses such as drought, invasion by wood decay fungi that contributes to stem failure, and direct mortality. Another significant impact is due to the fact that dwarf mistletoe infections in the overstory result in infection and eventual destruction of most, if not all, of the understory component is especially valuable in a heavily used recreation area because of its value as (1) a source for overstory replacement, (2) screening between lots, (3) shading, and (4) aesthetics. Recommendations: initiate a control project to sanitize the area as much as possible using all or a combination of the control methods listed above (broom pruning, branch pruning, sanitation and thinning in the understory, overstory removal, and under-planting with resistant species.) The goal of the project would not be to eradicate dwarf mistletoe from the area; there are too many valuable infected trees with no replacements for eradication to be feasible. However, by selectively cutting some trees and pruning witches' brooms and infected limbs, the health and vigor of individual trees, as well as the stand as a whole, can be improved.


Abstract: Seed dispersal of Arceuthobium pusillum Peck on Picea mariana (Mill.) B. S. P. was studied at two locations in Minnesota from 1974–1980. Seed dispersal began as early as August 23 and was observed as late as September 27. Most seeds were dispersed in the mornings between 0400 and 0900. The mean annual distance of dispersal ranged from 1.0 to 2.3 m. The density of seeds trapped on the plots ranged from 4.2 to 16.7 seeds/m². At both locations, the number of seeds trapped outside the stand decreased logarithmically with distance from the source trees. Within stands, seeds were more frequently trapped 1–4 m from source trees than under them. Most seed dispersal occurred 1–3 days after rain. Seeds were dispersed normally on 23 of 30 days when minimum temperatures were less than 0 C. Fruit abortion was noted on four occasions. Insects were not found to carry dwarf mistletoe seeds.


Abstract: Compares recent mortality rates of mistletoe-infected and uninfected ponderosa pine and Douglas-fir, on 2,924 plots throughout the Southwest. Distribution. Dwarf mistletoe on 2.5 million acres (36 per cent) of ponderosa pine type and
dwarf mistletoe on 275,000 acres (47 per cent) of Douglas-fir type.


Abstract: Lodgepole pine stands were thinned in the Shoshone National Forest of northwestern Wyoming in 1979 and 1980 using different forms of partial cutting. Average losses of trees 5 inches diameter at breast height and larger to mountain pine beetles during the 5 years following thinning ranged from less than 1 percent in spaced thinnings to 7.4 percent in the 12-inch diameter limit cut, compared to 26.5 percent in check stands. Residual trees increased radial growth significantly, but change in growth efficiency is slow. Regeneration 5 years after thinning ranged between 1,160 and 3,560 seedlings per acre, with pine being favored in the more open stands. The Cole and McGregor (1983) model was developed for unmanaged lodgepole pine stands at lower elevations in Montana. Therefore, the difference between actual and predicted mortality values on the Shoshone National Forest probably is related to treatment effects and, in the case of check stands, the relatively high elevation of the stands for that latitude (7,600 to 8,800 ft). Hence, the stands are not as susceptible as lower elevation stands (Amman and others 1977). In addition, heavy dwarf mistletoe infection in the stands (Rasmussen 1987) may have reduced tree vigor and resulted in phloem too thin to attract and support higher beetle populations. McGregor (1978) observed less loss of lodgepole pine to MPB as dwarf mistletoe infection increased in the Gallatin National Forest in southwestern Montana.


Abstract: A literature review with 92 references. Wildfires play a multiple role in the distribution of dwarf mistletoes—they may either inhibit or encourage these parasites depending primarily on the size and intensity of the burn. Many reports suggest that fire exclusion policies of the past half century have resulted in increased dwarf mistletoe levels as well as increased fire behavior potential. Prescribed burning as a supplemental method of dwarf mistletoe control has been little used, but seems to be applicable in some forest types and stand conditions both to eliminate infected residuals in cutover areas and to eliminate heavily infested unmerchantable stands. Suggested areas of research relating to fire ecology and prescribed burning are given.


Abstract: Engelmann spruce (Picea engelmannii) was parasitized by dwarf mistletoe (Arceuthobium microcarpum) on 3.4 percent of 2,350 observation points taken over 18,360 acres on the Fort Apache Indian Reservation, Arizona. The dwarf mistletoe was most abundant in mixed conifer stands and at lower elevations. It was rare at elevations above 10,000 ft. Maximum elevation noted was 10,400 feet.

Annotation: western spruce dwarf mistletoe distribution limited in elevation below that of host.

Key Words: western spruce dwarf mistletoe distribution limited in elevation below that of host.


Abstract: There is no evidence that Pyrenophora semeniperda, the causal agent of leaf spotting in many annual and perennial grasses, currently occurs in Europe or Asia. However, there is potential phytosanitary concern that the importation of infected commodities could result in the introduction of this fungus into Eurasia, putting crops at risk and possibly resulting in economic losses. To assist in assessing the risk of geographic range extension of P. semeniperda, an analysis was undertaken to estimate the potential global distribution of this species, based on climatic suitability. Geographic distribution data for P. semeniperda in part of its current range were used to fit parameter values in a CLIMEX pest risk assessment model, and the remaining distribution data were used to validate the model. The CLIMEX model correctly predicts that virtually all locations where P. semeniperda has been found are climatically suitable. Only five locations worldwide where the fungus was recorded present are predicted as being unsuitable. These "outliers" may have been transient populations occurring during a favorable season and then dying out. Exploratory adjustments of the model to accommodate these records created unsatisfactory distortions in the projected climatic suitability surfaces, extending the suitable climatic zone beyond well-established traditional range boundaries. We are therefore confident that the model is credibly predicting the potential distribution of P. semeniperda worldwide. The CLIMEX model suggests that P. semeniperda could potentially extend its range throughout Europe and temperate regions of Asia, Africa, and South America. Our heavy reliance upon geographic data to build this CLIMEX model departs from most previous published examples in plant pathology, which have depended primarily upon experimentally derived physiological data to estimate model parameters. The use of geographic data to infer climate parameters is popular in CLIMEX models of weeds and arthropod pests and can provide decision-makers with early risk assessments of potential pathogen invasions, particularly where the pathogens have long, or difficult-to-study, life cycles.


Abstract: Although the effect of biodiversity on ecosystem functioning has become a major focus in ecology, its
significance in a fluctuating environment is still poorly understood. According to the insurance hypothesis, biodiversity insures ecosystems against declines in their functioning because many species provide greater guarantees that some will maintain functioning even if others fail. Here we examine this hypothesis theoretically. We develop a general stochastic dynamic model to assess the effects of species richness on the expected temporal mean and variance of ecosystem processes such as productivity, based on individual species’ productivity responses to environmental fluctuations. Our model shows two major insurance effects of species richness on ecosystem productivity: (i) a buffering effect, i.e., a reduction in the temporal variance of productivity, and (ii) a performance enhancing effect, i.e., an increase in the temporal mean of productivity. The strength of these insurance effects is determined by three factors: (i) the way ecosystem productivity is determined by individual species responses to environmental fluctuations, (ii) the degree of asynchronicity of these responses, and (iii) the detailed form of these responses. In particular, the greater the variance of the species responses, the lower the species richness at which the temporal mean of the ecosystem process saturates and the ecosystem becomes redundant. These results provide a strong theoretical foundation for the insurance hypothesis, which proves to be a fundamental principle for understanding the long-term effects of biodiversity on ecosystem processes.


Abstract: Can heritable traits in a single species affect an entire ecosystem? Recent studies show that such traits in a common tree have predictable effects on community structure and ecosystem processes. Because these 'community and ecosystem phenotypes' have a genetic basis and are heritable, we can begin to apply the principles of population and quantitative genetics to place the study of complex communities and ecosystems within an evolutionary framework. This framework could allow us to understand, for the first time, the genetic basis of ecosystem processes, and the effect of such phenomena as climate change and introduced transgenic organisms on entire communities.

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Abstract: During the twentieth century disease detectives progressed by jagged leaps in understanding patterns of plant disease. With ladders, airplanes, and automatic traps they observed airborne spores, and with meteorological theory they explained takeoff, flight, and landing. They analyzed the grand, logistic rise of epidemics and the roles of horizontal versus vertical resistance. From early experiments on the details of life cycles and weather, they simulated epidemics with new computers. Early in the century they revealed genetic diversity with differential varieties and late in the century with differential fungicides and DNA. They learned the interplay of pest, photosynthesis, and supply and demand to reckon loss. Integrating observations of pest losses, and weather, they placed winning short-term bets for farmer and environment on whether to spray. In the twenty-first century, their goal can be analysis so sound that the world can securely place winning long-term bets.


Abstract: Records of uredinia and telia production on the alternate hosts of CronartiumColeosporioides in British Columbia and inoculation of Castilleja miniata with aeciospores collected from various locations showed that rust isolates from dry areas of the interior of British Columbia do not produce uredinia and may have lost the ability to do so. Collections from somewhat wetter areas produced uredinia or mixtures of uredinia and telia immediately following aeciospore inoculations, and field collections from such areas in June commonly had mixtures of uredinia and telia. Loss of the uredinial stage may be a response to climates that are often unsuitable for the spread or survival of the rust on the alternate host.


Abstract: The ability to assess the potential for a severe infestation of white pine blister rust is an important management tool. Successful hazard rating requires a proper understanding of blister rust epidemiology, including environmental and genetic factors. For the blister rust caused by Cronartium ribicola, climate and meteorology, and the ecology, distribution, and pathology of ribes and other telial hosts affect spread and intensification of rust on white pine hosts (several sections in subgenus Strobus of genus Pinus). The importance of ribes (genus Ribes) for supporting effective inoculum production varies according to differences in susceptibility, diversity, distribution, and abundance by taxon and population. Temperature and humidity regimes and air circulation patterns at micro to synoptic scales influence the development and dispersal of the rust. Spatial and temporal variations in the dispersal processes are expressed as differences in rust severity
distributions. These differences can be mapped as hazard zones and used to choose among alternative management prescriptions. When C. ribicola was first introduced to North America, its epidemiological behavior displayed a limited range of hosts and environments. The diversity of related rusts, however, suggests that C. ribicola may have the capacity to adapt to previously unrecognized hosts and environments. Pine populations have also been shown some ability to respond with lower susceptibility to this introduced pathogen, indicating that the North American pathosystems are dynamic and evolving. Efforts to manage such high-elevation species as whitebark pine would be aided by continued research in the epidemiology of this pathosystem in diverse hosts and environments.

url: http://www.treesearch.fs.fed.us/pubs/25712


Abstract: The metapopulation concept is useful when considering ecological and evolutionary dynamics of spatially structured populations. Recent theory suggests that the dynamics (epidemic vs. endemic) and migration rates of host and pathogen will be important factors in the maintenance of genetic polymorphisms in resistance and virulence. We argue that the relative spatial scales at which hosts and pathogens interact are crucial to understanding the evolution of resistance/virulence structure. We predict that life-history features that influence encounter rates between specific host and pathogen genotypes will be important factors in determining the evolution of resistance/virulence structures. Understanding the co-evolution of plant-pathogen systems will require research programmes that integrate long-term descriptive and experimental studies of multiple populations, with analytical and computer simulation modeling and comparative/phylogenetic studies.


Abstract: The concept of gene-for-gene coevolution is a major model for research on the evolution of resistance against parasites in crop plants, reciprocal evolution between species in natural plant populations, and mathematical models of the dynamics of coevolution. Recent studies have begun to challenge the prevailing view that natural selection within local plant populations is the major evolutionary process driving this form of coevolution. The emerging pattern from these studies suggests that metapopulation structure, including the effects of gene flow and genetic drift, may be at least as important as local natural selection in determining the genetic dynamics and outcomes of these evolutionary arms races.

doi: 10.1038/360121a0


Abstract: Rapid evolution of interspecific interactions (during a time span of about 100 years) has the potential to be an important influence on the ecological dynamics of communities. However, despite the growing number of examples, rapid evolution is still not a standard working hypothesis for many ecological studies on the dynamics of population structure or the organization of communities. Analysis of rapid evolution as an ecological process has the potential to make evolutionary ecology one of the most central of applied biological...


Annotation: The framework of coevolutionary biology. Specific hypotheses on the classes of coevolutionary dynamics.

Key Words: The framework of coevolutionary biology. Specific hypotheses on the classes of coevolutionary dynamics.


Abstract: A recent test for the existence of suture zones in North America, based on hybrid zones studied since 1970, found support for only two of the 13 suture zones identified by Remington in 1968 (Swenson and Howard 2004). One limitation of that recent study was the relatively small number of hybrid zones available for mapping. In this study, we search for evidence of clustering of contact zones between closely related taxa using data not only from hybrid zones but from species range maps of trees, birds, and mammals and from the position of phylogeographic breaks within species. Digital geographic range maps and a geographic information system approach allowed for accurate and rapid mapping of distributional data. Areas of contact between closely related species and phylogeographic breaks within species clustered into areas characterized by common physiographic features or predicted by previously hypothesized glacial refugia. The results underscore the general importance of geographic barriers to dispersal (mountain chains) and climate change (periods of cooling alternating with periods of warming, which lead to the contraction and expansion of species ranges) in species evolution.


Abstract: This paper provides a summary of some of the principle potential effects of climate change on forest species and forest pathogens (figure 1), forest species-pathogen interactions, and the management of these proposed effects.

Annotation: good summary of many ideas in a bulleted format

Key Words: good summary of many ideas in a bulleted format

Abstract: Environmental problem solving needs science but also inevitably requires subjective judgment. Science can help in dealing with subjectivity, because scientists have long experience developing institutions and practices to address the subjective and value-laden choices that are essential to scientific progress. Democracy has also developed approaches to the problem. The underlying principles can be applied to environmental policymaking. This article explores these issues in the context of decisions about environmental risks, drawing on the work of the National Research Council and other sources. It suggests some guidelines for risk deliberation—including broad-based participation, commitment to scientific quality, explicit attention to values, transparency of deliberative processes, and rules for closure and reconsideration— and recommends that an experimental approach be employed to learn how best to use deliberative methods.


Abstract: General Circulation Models (GCMs) have been developed to assess the impacts of potential global climate change. However, these models do not provide specific weather information at the whole-plant level and thus provide only very gross estimates of conditions that affect plant and disease development. Also, climatic change may increase the frequency of extreme events that influence plant production more than changes in daily or monthly averages. One solution is a simulation approach that can scale weather information from the global down to the plant scale. Over the last 4 years, we have been developing methods to hierarchically define current and forecast weather conditions down to the whole-plant level based on nested high-resolution atmospheric (mesoscale) numerical models. Two hierarchical mesoscale model approaches were tested to downscale weather data in a vineyard. The first, known as the Localized Mesoscale Forecast System (LMFS) uses surface databases to localize' mesoscale output. The second, known as the Canopy- Mesoscale Forecast System (CMFS), uses a boundary layer model to downscale mesoscale output. To illustrate the utility of this approach we focused on surface wetness duration (SWD), a variable with high spatial and temporal variability. SWD is also a critical variable for prediction of plant disease. Simulations of SWD with on-site input data were compared to those derived from the mesoscale models and to on-site sensors. Forecasts of atmospheric variables by the two systems were compared to on-site observations. Success in this effort leads us to extend this method to GCMs where factors such as temperature, rainfall, relative humidity, and surface wetness can be estimated within plant and crop canopies. We explore the implications of this work on evaluating the assessment of climate change on the risk of plant disease development.


Abstract: The subtle changes in climate attributed to climate change can affect plant-disease development. These changes are not easily determined, and consequently, the ability to forecast how disease changes under altered growth conditions is not simple. One method is the use of forecast climate change derived from global-change models that are analogous to general-circulation models used for weather forecasts. However, these models predict conditions on such a gross scale that they are unacceptable for most disease forecasting. Downscaling provides a method whereby weather and climate conditions estimated at a very large scale can be transferred to a fine resolution (similar to200-m grid points). This process is explained, in particular, in the context of disease forecasting. An example is presented of how estimates of extreme low temperature at a local scale have been derived from a mesoscale (mid-range) weather forecast model, which in turn was derived from a general-circulation model. Similarly, the derivation of forecasts at local scale from mesoscale weather forecast models have been demonstrated for grapevine downy mildew. Important considerations of scale definition and information transfer across different scales are discussed.


Abstract: Scenarios of changes in biodiversity for the year 2100 can now be developed based on scenarios of changes in atmospheric carbon dioxide, climate, vegetation, and land use and the known sensitivity of biodiversity to these changes. This study identified a ranking of the importance of drivers of change, a ranking of the biomes with respect to expected changes, and the major sources of uncertainties. For terrestrial ecosystems, land-use change probably will have the largest effect, followed by climate change, nitrogen deposition, biotic exchange, and elevated carbon dioxide concentration. For freshwater ecosystems, biotic exchange is much more important. Mediterranean climate and grassland ecosystems likely will experience the greatest proportional change in biodiversity because of the substantial influence of all drivers of biodiversity change. Northern temperate ecosystems are estimated to experience the least biodiversity change because major land-use change has already occurred. Plausible changes in biodiversity in other biomes depend on interactions among the causes of biodiversity change. These interactions represent some of the largest uncertainties in projections of future biodiversity change.

Annotation: linear approach

Key Words: linear approach
doi: 10.1126/science.287.5459.1770


Abstract: Pinon-juniper vegetation covers some 100 million acres in the western U.S., where it provides economic
products, ecosystem services, biodiversity, and aesthetic beauty in some of the most scenic landscapes of North America. There are concerns, however, that the ecological dynamics of pi±on-juniper woodlands have changed since Euro-American settlement, that trees are growing unnaturally dense, and that woodlands are encroaching into former grasslands and shrublands. Yet surprisingly little research has been conducted on historical conditions and ecological processes in pi±on-juniper vegetation, and the research that does exist demonstrates that pi±on-juniper structure, composition, and disturbance regimes were very diverse historically as well as today. This report from more than a dozen scientists across the West highlights areas of broad agreement as well as those requiring more site-specific information.

url: http://www.cfri.colostate.edu/docs/P-J_disturbance_regimes_short%20synthesis_5-07.pdf


Abstract: Uniparentally inherited mitochondrial (mtDNA) and chloroplast (cp)DNA microsatellites (cpSSRs) were used to examine population genetic structure and biogeography patterns of bird-dispersed seed and wind-disseminated pollen of whitebark pine (Pinus albicaulis Engelm.). Sampling was conducted from 41 populations throughout the range of the species. Analyses provide evidence for an ancestral haplotype and two derived mtDNA haplotypes with distinct regional distributions. An abrupt contact zone between mtDNA haplotypes in the Cascade Range suggests postglacial biogeographic movements. Among three cpSSR loci, 42 haplotypes were detected within 28 cpSSR sample populations that were aggregated into six regions. Analysis of molecular variance (AMOVA) was used to determine the hierarchical genetic structure of cpSSRs. AMOVA and population pairwise comparisons (FST) of cpSSR, and geographical distribution of mtDNA haplotypes provide insights into historical changes in biogeography. The genetic data suggest that whitebark pine has been intimately tied to climatic change and associated glaciation, which has led to range movements facilitated by seed dispersal by Clark's nutcracker (Nucifraga Columbiana Wilson). The two hypotheses proposed to explain the genetic structure are: (i) a northward expansion into Canada and the northern Cascades in the early Holocene; and (ii) historical gene flow between Idaho and the Oregon Cascades when more continuous habitat existed in Central Oregon during the late Pleistocene. Genetic structure and insights gained from historical seed movements provide a basis on which to develop recovery plans for a species that is at risk from multiple threats.


Abstract: „A living system exhibits integrity if, when subjected to disturbance, it sustains an organizing, self- correcting capability to recover toward an end-state that is normal and "good" for that system. End-states other than the pristine or naturally whole may be taken to be 'normal and good.' I first sketch a characterization of ecosystems which reflects different perspectives adopted by ecological experts, and refer to the features which characterize the self-organization of ecosystems. I then note the particular set of human values associated with maintaining or enhancing these features of ecosystems, in part by contrasting them with other sets of cultural values that guide human activities vis-a-vis nature. Cultural integrity, as I define it, is human capability individually and through institutions to complement the integrity of a modified natural ecosystem in an overall context that is inevitably turbulent, socially and ecologically. At the conclusion of this paper, I have sketched, with the help of colleagues, a general image of an ecosystem in a state of integrity.


Abstract: As the Earth warms, many species are likely to disappear, often because of changing disease dynamics. Here we show that a recent mass extinction associated with pathogen outbreaks is tied to global warming. Seventeen years ago, in the mountains of Costa Rica, the Monteverde harlequin frog (Atelopus sp.) vanished along with the golden toad (Bufo periglenes). An estimated 67% of the 110 or so species of Atelopus, which are endemic to the American tropics, have met the same fate, and a pathogenic chytrid fungus (Batrachochytrium dendrobatidis) is implicated. Analyzing the timing of losses in relation to changes in sea surface and air temperatures, we conclude with 'very high confidence' (99%, following the Intergovernmental Panel on Climate Change, IPCC) that large-scale warming is a key factor in the disappearances. We propose that temperatures at many highland localities are shifting towards the growth optimum of Batrachochytrium, thus encouraging outbreaks. With climate change promoting infectious disease and eroding biodiversity, the urgency of reducing greenhouse-gas concentrations is now undeniable.


Abstract: Ecological changes in the phenology and distribution of plants and animals are occurring in all well- studied
Abstract: The study of natural plant populations has provided some of the strongest and most convincing cases of the operation of natural selection currently known, partly because of amenability to reciprocal transplant experiments, common garden work, and long-term in situ manipulation. Genetic differentiation among plant populations over small scales (a few cm to a few hundred cm) has been documented and is reviewed here, in herbaceous annuals and perennials, woody perennials, aquatics, terrestrialis, narrow endemics, and widely distributed species. Character differentiation has been documented for most important features of plant structure and function. Examples are known for seed characters, leaf traits, phenology, physiological and biochemical activities, heavy metal tolerance, herbicide resistance, parasite resistance, competitive ability, organellar characters, breeding systems, and life history. Among the forces that have shaped these patterns of differentiation are toxic soils, fertilizers, mowing and grazing, soil moisture, temperature, light intensity, pollinating vectors, parasitism, gene flow, and natural dynamics. The breadth and depth of the evidence reviewed here strongly support the idea that natural selection is the principal force shaping genetic architecture in natural plant populations; that view needs to be more widely appreciated than it is at present.


Abstract: It is argued that the problem of pattern and scale is the central problem in ecology, unifying population biology and ecosystems science, and marrying basic and applied ecology. Applied challenges, such as the prediction of the ecological causes and consequences of global climate change, require the interfacing of phenomena that occur on very different scales of space, time, and ecological organization. Furthermore, there is no single natural scale at which ecological phenomena should be studied; systems generally show characteristic variability on a range of spatial, temporal, and organizational scales. The observer imposes a perceptual bias, a filter through which the system is viewed. This has fundamental evolutionary significance, since every organism is an ‘observer’ of the environment, and life history adaptations such as dispersal and dormancy alter the perceptual scales of the species, and the observed variability. It likewise has fundamental significance for our own study of ecological systems, since the patterns that are unique to any range of scales will have unique causes and biological consequences. The key to prediction and understanding lies in the elucidation of mechanisms underlying observed patterns. Typically, these mechanisms operate at different scales than those on which the patterns are observed; in some cases, the patterns must be understood as emerging from the collective behaviors of large ensembles of smaller scale units. In other cases, the pattern is imposed by larger scale constraints. Examination of such

Abstract: What explains the remarkable regularities in distribution and abundance of species, in size distributions of organisms, or in patterns of nutrient use? How does the biosphere maintain exactly the right conditions necessary for life as we know it? Gaia theory postulates that the biota regulates conditions at levels it needs for survival, but evolutionary biologists reject this explanation because it lacks a mechanistic basis. Similarly, the notion of self-organized criticality fails to recognize the importance of the heterogeneity and modularity of ecological systems. Ecosystems and the biosphere are complex adaptive systems, in which pattern emerges from, and feeds back to affect, the actions of adaptive individual agents, and in which cooperation and multicellularity can develop and provide the regulation of local environments, and indeed impose regularity at higher levels. The history of the biosphere is a history of coevolution between organisms and their environments, across multiple scales of space, time, and complexity.


Abstract: We explore the practical difficulties of interdisciplinary research in the context of a regional- or local- scale project. We posit four barriers to interdisciplinarity that are common across many disciplines and draw on our own experience and on other sources to explore how these barriers are manifested. Values enter into scientific theories and data collection through scientists' hidden assumptions about disciplines other than their own, through the differences between quantitative and interpretive social sciences, and through roadblocks created by the organization of academia and the relationship between academics and the larger society. Participants in interdisciplinary projects need to be self-reflective about the value judgments embedded in their choice of variables and models. They should identify and use a core set of shared concerns to motivate the effort, be willing to respect and to learn more about the "other," be able to work with new models and alternative taxonomies, and allow for plurality and incompleteness.


Abstract: The evolutionary genetics of invasive species has been relatively unexplored, but could offer insights into mechanisms of invasions. Recent studies suggest that the invasion success of many species might depend more heavily on their ability to respond to natural selection than on broad physiological tolerance or plasticity. Thus, these studies stress the importance of genetic architecture, selection upon which could result in evolutionary adaptations and possibly speciation. For instance, epistatic interactions and the action of a few genes could facilitate invasion success. These findings emphasize the utility of genomic approaches for determining invasion mechanisms, through analysis of gene expression, gene interactions, and genomic rearrangements that are associated with invasion events.


Abstract: Six of nine five-needle white pine species native to the U.S. are found in California, and all of these are susceptible to the exotic pathogen, white pine blister rust (Cronartium ribicola). Since entering California, the rust has spread south over the geographic range of sugar pine, but until recently little was known about its impact on the higher elevation pines. From 1995 to 1999, a survey of five species in Sequoia and Kings Canyon National Parks revealed rust in plots of sugar and western white pine only. In 2004–2005 a survey of the high elevation species over their California ranges revealed rust in plots of western white pine, whitebark, and the northern foxtail populations, but not in limber, southern foxtail, or Great Basin bristlecone pines. Mean incidence of rust across all plots was relatively low (12 to 15%), but variation among plots was high (0 to 92%). Rust was observed in a plot at 3400 m elevation in the southern Sierra. Other stress factors such as mountain pine beetle, fire exclusion and climate change are discussed in relation to their impacts on these pines. Practical issues for future management of these high-elevation pines and their ecosystems are also presented.


Abstract: A survey of limber pine to determine the geographical distribution, incidence, and severity of white pine blister rust (WPBR), caused by the introduced forest pathogen Cronartium ribicola, was performed in central and southeastern Wyoming and northern Colorado in 2002-2004. WPBR was present in 55% of the 504 survey plots. Incidence, the proportion of infected trees, ranged from 0 to 100% and averaged 15.5% over all plots and 28.0% on infested plots. Diameter class and crown class were significantly related to likelihood of infection by WPBR. Incidence varied significantly by elevation and slope position and did not vary by aspect, slope configuration, limber pine density, or degree of canopy closure. In the summers of 2002-2004, 1258 survey plots were established to determine the distribution of Ribes species, the alternate host for the pathogen, growing within and in the vicinity of native white pine stands in Colorado and Wyoming. Species of Ribes were present in all study areas. The most commonly encountered species were R. cereum, R. inerme, R. lacustre, and R. montigenum. Densities and probabilities of occurrence were related to site variables and varied by Ribes.
species. An analysis of canker growth rates was performed on 134 WPBR cankers harvested from limber pine. Mean annual total longitudinal (both up and down the branch or stem) growth rate was 8.4 cm/yr. Annual proximal (toward the stem) canker growth rate averaged 4.9 cm/yr, and circumferential growth rate averaged 6.5 cm/yr. Longitudinal canker growth rate varied by branch diameter, branch height, and condition of the branch distal to the canker, but did not vary by study area. Data collected in the field surveys was used to develop a series of regression and categorical and regression tree analysis models to predict risk and hazard of WPBR in Colorado. Risk models predicting the presence of WPBR employed meteorological, Ribes, and tree size data and resulted in good agreement between predicted and actual presence. Models developed to predict disease pressure and hazard also employed meteorological, Ribes, and plot-level data. The complexity of modeling disease epidemics across vast landscapes will likely require calibration of models to specific conditions found in Colorado.


Abstract: Rapid increases in global temperature are likely to impose strong directional selection on many plant populations, which must therefore adapt if they are to survive. Within populations, microgeographic genetic differentiation of individuals with respect to climate suggests that some populations may adapt to changing temperatures in the short-term through rapid changes in gene frequency. We used a genome scan to identify temperature-related adaptive differentiation of individuals of the tree species Fagus sylvatica. By combining molecular marker and dendrochronological data we assessed spatial and temporal variation in gene frequency at the locus identified as being under selection. We show that gene frequency at this locus varies predictably with temperature. The probability of the presence of the dominant marker allele shows a declining trend over the latter half of the 20th century, in parallel with rising temperatures in the region. Our results show that F. sylvatica populations may show some capacity for an in situ adaptive response to climate change. However as reported ongoing distributional changes demonstrate, this response is not enough to allow all populations of this species to persist in all of their current locations.

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Abstract: Comandra blister rust is a damaging canker disease of lodgepole pine in the Central Rocky Mountains. Our knowledge of previous blister rust outbreaks and the effects of weather and climate on rust epidemiology has not been sufficient to explain the frequency and severity of disease outbreaks. Thus, we sought to describe the seasonal and annual frequency and duration of meteorological conditions favorable for infection of lodgepole pine, to relate infection episodes to various weather phenomena, to observe new canker appearances on young trees, and to age existing cankers on mature trees. We examined comandra blister rust outbreaks for three areas in the Central Rockies—Beaverhead in southwestern Montana, Shoshone in western Wyoming, and Medicine Bow in south-central Wyoming. We defined periods suitable for comandra blister rust infection of lodgepole pine (potential infection episodes), based on published criteria, and identified as continuous periods longer than 6 hours during the months of July, August, and September when temperature ranged between 10 and 20 C and the air was nearly saturated. Synoptic daily weather maps were examined to classify weather systems associated with potential infection episodes. We also observed canker establishment on young and mature lodgepole pine trees to determine canker age distributions. Meteorological records indicated that weather conditions considered suitable for infection of lodgepole pine occurred at least every few (~3) years. The frequency, but not the duration of potential infection episodes, were related to the prevailing summer weather patterns within various regions of the Central Rocky Mountains. The pattern of infection observed in one young stand for 8 years was like that which would result from several, sequential wave years. We found no evidence in the age distribution of bole cankers for only one comandra blister rust outbreak in the three study areas. A consistent pattern between meteorological and canker age data indicates that infection occurs frequently enough across the Central Rocky Mountains that comandra blister rust can be considered a continuing threat where populations of comandra and lodgepole coexist.


Abstract: Humans are altering the composition of biological communities through a variety of activities that increase rates of species invasions and species extinctions, at all scales, from local to global. These changes in components of the Earth's biodiversity cause concern for ethical and aesthetic reasons, but they also have a strong potential to alter ecosystem properties and the goods and services they provide to humanity. Ecological experiments, observations, and theoretical developments show that ecosystem properties depend greatly on biodiversity in terms of the functional characteristics of organisms present in the ecosystem and the distribution and abundance of those organisms over space and time. Species effects act in concert with the effects of climate, resource availability, and disturbance regimes in influencing ecosystem properties. Human activities can modify all of the above factors; here we focus on modification of these biotic controls. The scientific community has come to a broad consensus on many aspects of the relationship between biodiversity and ecosystem functioning, including many points relevant to management of ecosystems. Further progress will require integration of knowledge about biotic and abiotic controls on ecosystem properties, how ecological communities are structured, and the forces driving species extinctions and invasions. To strengthen links to policy and management, we also need to integrate our ecological knowledge with understanding of the social and economic constraints of potential
management practices. Understanding this complexity, while taking strong steps to minimize current losses of species, is necessary for responsible management of Earth's ecosystems and the diverse biota they contain. Based on our review of the scientific literature, we are certain of the following conclusions: 1) Species' functional characteristics strongly influence ecosystem properties. Functional characteristics operate in a variety of contexts, including effects of dominant species, keystone species, ecological engineers, and interactions among species (e.g., competition, facilitation, mutualism, disease, and predation). Relative abundance alone is not always a good predictor of the ecosystem-level importance of a species, as even relatively rare species (e.g., a keystone predator) can strongly influence pathways of energy and material flows. 2) Alteration of biota in ecosystems via species invasions and extinctions caused by human activities has altered ecosystem goods and services in many well-documented cases. Many of these changes are difficult, expensive, or impossible to reverse or fix with technological solutions. 3) The effects of species loss or changes in composition, and the mechanisms, by which the effects manifest themselves, can differ among ecosystem properties, ecosystem types, and pathways of potential community change. 4) Some ecosystem properties are initially insensitive to species loss because (a) ecosystems may have multiple species that carry out similar functional roles, (b) some species may contribute relatively little to ecosystem properties, or (c) properties may be primarily controlled by abiotic environmental conditions. 5) More species are needed to insure a stable supply of ecosystem goods and services as spatial and temporal variability increases, which typically occurs as longer time periods and larger areas are considered. We have high confidence in the following conclusions: 1) certain combinations of species are complementary in their patterns of resource use and can increase average rates of productivity and nutrient retention. At the same time, environmental conditions can influence the importance of complementarily in structuring communities. Identification of which and how many species act in a complementary way in complex communities is just beginning. 2) Susceptibility to invasion by exotic species is strongly influenced by species composition and, under similar environmental conditions, generally decreases with increasing species richness. However, several other factors, such as propagule pressure, disturbance regime, and resource availability also strongly influence invasion success and often override effects of species richness in comparisons across different sites or ecosystems. 3) Having a range of species that respond differently to different environmental perturbations can stabilize ecosystem process rates in response to disturbances and variation in abiotic conditions. Using practices that maintain a diversity of organisms of different functional effect and functional response types will help preserve a range of management options. Uncertainties remain and further research is necessary in the following areas: 1) Further resolution of the relationships among taxonomic diversity, functional diversity, and community structure is important for identifying mechanisms of biodiversity effects. 2) Multiple trophic levels are common to ecosystems but have been understudied in biodiversity/ecosystem functioning research. The response of ecosystem properties to varying composition and diversity of consumer organisms is much more complex than responses seen in experiments that vary only the diversity of primary producers. 3) Theoretical work on stability has outpaced experimental work, especially field research. We need long-term experiments to be able to assess temporal stability, as well as experimental perturbations to assess response to and recovery from a variety of disturbances. Design and analysis of such experiments must account for several factors that covary with species diversity. 4) Because biodiversity responds to and influences ecosystem properties, understanding the feedbacks involved is necessary to integrate results from experimental communities with patterns seen at broader scales. Likely patterns of extinction and invasion need to be linked to different drivers of global change, the forces that structure communities, and controls on ecosystem properties for the development of effective management and conservation strategies. 5) This paper focuses primarily on terrestrial systems, with some coverage of freshwater systems, because that is where most empirical and theoretical study has focused. While the fundamental principles described here should apply to marine systems, further study of that realm is necessary. Despite some uncertainties about the mechanisms and circumstances under which diversity influences ecosystem properties, incorporating diversity effects into policy and management is essential, especially in making decisions involving large temporal and spatial scales.


Annotation: Tectonic stressors: population, differences between rich and poor and spiraling growth of megacities in poor countries; energy, scarcity of conventional oil; environmental, damage to ecosystems; climate, rapid change; economic, instability and income gap between rich and poor. Multipliers: increasing speed and connectivity of global systems; escalating destructive power of a few individuals. Thresholds. Synchronous failure, when multiple, connected cycles are at vulnerable, cycle stage. Panarchy--potential, connectivity, resilience. Limits of growth, interests in status quo, and management. Catastrophe and breakdown. Uncertainty. Creative opportunity for adaptive renewal--an new Axial Age (need to be prepared).

Key Words: Tectonic stressors: population, differences between rich and poor and spiraling growth of megacities in poor countries; energy, scarcity of conventional oil; environmental, damage to ecosystems; climate, rapid change; economic, instability and income gap between rich and poor. Multipliers: increasing speed and connectivity of global systems; escalating destructive power of a few individuals. Thresholds. Synchronous failure, when multiple, connected cycles are at vulnerable, cycle stage. Panarchy--potential, connectivity, resilience. Limits of growth, interests in status quo, and management. Catastrophe and breakdown. Uncertainty. Creative opportunity for adaptive renewal--an new Axial Age (need to be prepared).


Abstract: This paper tests the proposition that a small set of plant, animal, and abiotic processes structure ecosystems across scales in time and space. Earlier studies have suggested that these key structuring processes establish a small number of dominant temporal frequencies that entrain other processes. These frequencies often differ from each other by at least an order of magnitude. If true, ecosystems therefore will have a few dominant frequencies that are endogenously driven and

http://www.fs.fed.us/psw/topics/climate_change/forest_disease/fdbib/ 9/12/2008
that are discontinuously distributed. This paper additionally tests the proposition that these structuring processes should also
generate a discontinuous distribution of spatial structures coupled with the discontinuous frequencies. If that is the case,
animals living in specific landscapes should demonstrate the existence of this lumpy architecture by showing gaps in the
distribution of their sizes. This proved to be the case for birds and mammals of the boreal region forest and the short-grass
prairie. Alternative hypotheses to explain the body mass clumps include architectural, developmental, historical, and trophic
causes. These were all tested by comparing body-mass clump distributions (1) in ecosystems having different spatial
structures (forest, grassland, and marine pelagic) and (2) in different animal groups having different body plans (birds and
mammals) or feeding habits (carnivore, omnivore, and herbivore). The only hypothesis that could not be rejected is that the
body-mass clumps are entrained by discontinuous hierarchical structures and textures of the landscape. There is evidence for
at least eight distinct habitat “quanta,” each defined by a distinct texture at a specific range of scales. These eight quanta
together cover tens of centimeters to hundreds of kilometers in space and at least months to millennia in time. The paper
provides a direction for the development of programs to evaluate, monitor, and predict ecosystem and community changes
across scales. The necessary research elements include (1) models that incorporate a few scale-dependent structuring
processes to allow cross-scale analysis; (2) comparative studies of different disturbed and undisturbed landscapes using the
animal body-mass bioassay technique to identify critical scales of ecosystem geometry; (3) analysis of remote imagery to
identify spatial discontinuities and regions of scale invariance; and (4) behavioral studies of the hierarchy of animal
decisions to identify species groups vulnerable to predicted (using models) or observed (using remote imagery) changes in
vegetation geometry.


Abstract: Forest pathology inherently involves a landscape perspective, because tree pathogens propagate according to
heterogeneous spatial patterns of flow and isolation. Landscape pathology is a field that is now emerging from the trans-
disciplinary cooperation of forest pathologists with landscape ecologists. Here, we review recent broad scale assessments of
tree disease risk, investigations of site and host preferences for several root rot pathogens, and regional historical analyses of
pathogen outbreak in plantations. Crucial topics include fragmentation effects on pathogen spread and geophysical features
that predispose forest patches to disease expression. Recent methodological developments facilitate the spatially explicit
analysis of reciprocal coarse-scale relationships among hosts and pathogens. Landscape pathology studies fill a significant
research gap in the context of our understanding of sustainable forest management, the introduction of exotic organisms and
how climate change might affect the spread of disease.
doi: 10.1016/j.tree.2004.06.003

Hiratsuka, Y.; Blenis, P.; Chang, K.-F. 1987. The role of biotic and climatic factors in the epidemiology of western gall

Abstract: Western gall rust is caused by the rust fungus Endocronartium harknessii (J.P. Moore) Y. Hiratsuka. To develop
proper management strategies for this disease it is important to understand the conditions and requirements for infection. It
is known that heavy years of infection in a given area occur once every 5 to 6 years; these are called "wave years" (Peterson,
1971; Powell and Hiratsuka, 1973). Suitable climatic conditions during the critical period of spore dissemination may be the
main reason for the occurrence of the "wave years". Biotic factors, such as fungi, bacteria, and insects, also may play
important roles in reducing the production and dissemination of viable spores. Since most infections happen during a
relatively short period in late spring and early summer, weather conditions at that time likely would have a profound effect
on the amount of infection occurring in any given year. Although most spores are released during the daylight hours, it
appears that more spore production occurs at night, when humidity is high, than during the day, when humidity is low.
Spore dispersal was studied. The occurrence of significant numbers of infections at considerable distances from the infected
stand suggests that sanitation might not be an effective control measure for this disease. Spore survival was studied. Survival
was found to be favored by cool temperatures and low relative humidity.

Hendrickson, W.H. 1970. Assessing the potential of white pine blister rust to limber pine and whitebark pine in Yellowstone

Abstract: The general nature of white pine blister rust and of the two Yellowstone white pine species that are vulnerable to
it are discussed. Some rationale pertinent to National Park Service management is included. The concept of climatic escape
is reviewed. The hypothesis that a too-cold and too-dry climate in Yellowstone is limiting to the disease is set forth. Data
from two years taken at six field stations is presented to sustain the hypothesis. High humidity, which is essential to the rust,
was present but for relatively short periods. The high humidity was accompanied by cooler temperatures which are known to
retard and thus limit sporidial formation. These doubtlessly also extend the time required for and thus similarly limit
sporidial germination. However, the limited infection present in Yellowstone National Park, 28 or 26 years after its first
detection, suggests that climate locally enables the rust to establish from ribes to pine. The retention of both humidity and
relative warmth in certain drainages could operate to favor the disease. Climographs from several United States locations
which have rust are presented to support the concept that Yellowstone's climate is drier and colder than that generally
associated with the disease. The future direction of the Yellowstone blister rust program is discussed. Recommendations
which evolved for a research-oriented meeting that was held in Yellowstone in December 1968 are concurred with.
Annotation: Document includes detailed meteorological records for temperature and humidity at 6 sites.
Key Words: Document includes detailed meteorological records for temperature and humidity at 6 sites.

Abstract: Here we consider how extreme events, particularly climatic and biotic, affect the physiology, development, ecology and evolution of organisms, focusing on plants. The marked effects on organisms are of increasing interest for ecological prediction, given the natural and anthropogenic changes in spectra of extreme events being induced by global change. Yet there is currently a paucity of knowledge or even a common world-view of how extreme events shape individuals, communities and ecosystems. We propose that extreme events need be defined in terms of organismal responses of acclimation and of de-acclimation or hysteresis. From this definition we proceed to develop a number of hypotheses, including that fitness effects of extreme events occur primarily during recovery. We review evidence that, on the evolutionary time scale, selection is virtually absent except during extreme events; these drive strong directional selection, even to trait fixation and speciation. We describe a number of new tools, both conceptual and technological, that are now at hand or that merit rapid development
doi: 10.1046/j.1469-8137.2003.00866.x


Abstract: Evidence from woodrat middens and tree rings at Dutch John Mountain (DJM) in northeastern Utah reveal spatiotemporal patterns of pinyon pine (Pinus edulis Engelm.) colonization and expansion in the past millennium. The DJM population, a northern outpost of pinyon, was established by long-distance dispersal (40 km). Growth of this isolate was markedly episodic and tracked multidecadal variability in precipitation. Initial colonization occurred by AD 1246, but expansion was forestalled by catastrophic drought (1250–1288), which we speculate produced extensive mortality of Utah juniper (Juniperus osteosperma (Torr.) Little), the dominant tree at DJM for the previous 8700 years. Pinyon then quickly replaced juniper across DJM during a few wet decades (1330–1339 and 1368–1377). Such alternating decadal-scale droughts and pluvial events play a key role in structuring plant communities at the landscape to regional level. These decadal-length precipitation anomalies tend to be regionally coherent and can synchronize physical and biological processes across large areas. Vegetation forecast models must incorporate these temporal and geographic aspects of climate variability to accurately predict the effects of future climate change.


Abstract: Plant pathogens cause mortality and reduce fecundity of individual plants, drive host population dynamics, and affect the structure and composition of natural plant communities. Pathogens are responsible for both numerical changes in host populations and evolutionary changes through selection for resistant genotypes. Linking such ecological and evolutionary dynamics has been the focus of a growing body of literature on the effects of plant diseases in natural ecosystems. A guiding principle is the importance of understanding the spatial and temporal scales at which plants and pathogens interact. This review summarizes the effects of diseases on populations of wild plants, focusing in particular on the mediation of plant competition and succession, the maintenance of plant species diversity, as well as the process of rapid evolutionary changes in host-pathogen symbioses.


Abstract: Research in the effects of climate change on plant disease continues to be limited, but some striking progress has been made. At the genomic level, advances in technologies for the high-throughput analysis of gene expression have made it possible to begin discriminating responses to different biotic and abiotic stressors and potential trade-offs in responses. At the scale of the individual plant, enough experiments have been performed to begin synthesizing the effects of climate variables on infection rates, though pathosystem specific characteristics make synthesis challenging. Models of plant disease have now been developed to incorporate more sophisticated climate predictions. At the population level, the adaptive potential of plant and pathogen populations may prove to be one of the most important predictors of the magnitude of climate change effects. Ecosystem ecologists are now addressing the role of plant disease in ecosystem processes and the challenge of scaling up from individual infection probabilities to epidemics and broader impacts.
doi: 10.1146/annurev.phyto.44.070505.143420


Abstract: Annual precipitation and August-to-October mean monthly temperature were analyzed for six climate divisions in Oregon and California where sugar pine has been infected by white pine blister rust. There was little or no overlap in the statistical distributions of the climate variables between the northern and southern divisions. Precipitation differences were greater than temperature differences between divisions, but a wave event was as likely to occur in a dry year as in a wet year. Results were inconclusive, because both climate and infection data lacked the spatial and temporal resolution to describe precisely the spread of the
Annotation: The focus is on wave years, spread, and intensification within province.
Key Words: The focus is on wave years, spread, and intensification within province.

Abstract: Phenotypic plasticity describes the capacity of a genotype to exhibit a range of phenotypes in response to variation in the environment. Environmental variation encompasses both abiotic and biotic components of the environment, including interactions among organisms. The strength and outcome of many ecological interactions, ranging from antagonism to mutualism, are mediated through the phenotypically plastic responses of one or more players in the interaction. Herein, three broadly defined, non-mutually exclusive, evolutionary consequences of ecological interactions mediated through phenotypic plasticity are discussed. (1) The predictable plastic response of one partner can favor behaviors, physiological responses, and life history traits of an interacting partner that manipulate, circumvent, or ameliorate the response of that partner. (2) Phenotypic plasticity can generate substantial spatial and temporal variation within and among populations. Such phenotypic variation can depend on the density and identity of interacting players in an ecological community, and can ultimately affect the evolutionary outcome of ecological interactions. (3) Phenotypic plasticity affects the strength and direction of natural selection. Ecological interactions mediated through phenotypic plasticity are ubiquitous in nature, and the potential evolutionary consequences of these interactions illustrate the complexity inherent in understanding evolution in a community context.

doi: 10.1242/jeb.02271


Abstract: Given the increasingly global stresses on forests, many ecologists argue that managers must maintain ecological resilience: the capacity of ecosystems to absorb disturbances without undergoing fundamental change. In this review we ask: Can the emerging paradigm of natural-disturbance-based management (NDBM) maintain ecological resilience in managed forests? Applying resilience theory requires careful articulation of the ecosystem state under consideration, the disturbances and stresses that affect the persistence of possible alternative states, and the spatial and temporal scales of management relevance. Implementing NDBM while maintaining resilience means recognizing that (i) biodiversity is important for long-term ecosystem persistence, (ii) natural disturbances play a critical role as a generator of structural and compositional heterogeneity at multiple scales, and (iii) traditional management tends to produce forests more homogeneous than those disturbed naturally and increases the likelihood of unexpected catastrophic change by constraining variation of key environmental processes. NDBM may maintain resilience if silvicultural strategies retain the structures and processes that perpetuate desired states while reducing those that enhance resilience of undesirable states. Such strategies require an understanding of harvesting impacts on slow ecosystem processes, such as seed-bank or nutrient dynamics, which in the long term can lead to ecological surprises by altering the forest's capacity to reorganize after disturbance.

doi: 10.1139/X06-132


Abstract: Different environmental forcing functions influence vegetational patterns and processes over a wide range of spatial and temporal scales. On the micro-scale (1 year to 5 x 10^5 years, m^2 to 10^8 m^2) natural and anthropogenic disturbances affect establishments and succession of species populations. At the macro-scale (5 x 10^3 years to 10^6 years and 10^6 to 10^12 m^2) climatic changes influence regional vegetational processes that include migrations of species as well as displacement of ecosystems. Mega-scale phenomena such as plate tectonics, evolution of the biota and development of global patterns of vegetation occur on the time scale of >10^6 years and over areas > 10^12 m^2. Our knowledge of past vegetational changes resulting from Quaternary climatic change can be used to predict biotic responses to future climatic changes such as global warming that may be induced by increased carbon dioxide (CO2) concentrations in the atmosphere. The time scale for future climatic warming may be much more rapid than that characterizing the early- to mid-Holocene, increasing the probability of rapid turnover in species composition, changes in local and regional dominance of important taxa, displacement of species ranges and local extinction of species. Integration of ecological and paleoecological perspectives on vegetational dynamics is fundamental to understanding and managing the biosphere.


Abstract: Research on impacts of climate change on plant diseases has been limited, with most work concentrating on the effects of a single atmospheric constituent or meteorological variable on the host, pathogen, or the interaction of the two under controlled conditions. Results indicate that climate change could alter stages and rates of development of the pathogen, modify host resistance, and result in changes in the physiology of host-pathogen interactions. The most likely consequences are shifts in the geographical distribution of host and pathogen and altered crop losses, caused in part by changes in the efficacy of control strategies. Recent developments in experimental and modeling techniques offer considerable promise for developing an improved capability for climate change impact assessment and mitigation. Compared with major technological, environmental, and socioeconomic changes affecting agricultural production during the next century, climate change may be less important; it will, however, add another layer of complexity and uncertainty onto a system that is already exceedingly difficult to manage on a sustainable basis. Intensified research on climate change–related issues could result in improved understanding and management of plant diseases in the face of current and future climate extremes.

Pathogens are powerful evolutionary forces shaping the structure and dynamics of both individual species and of the communities of which they are part, at a broad range of genetic, ecological, spatial, and temporal scales. At all these levels their impact varies from the subtle and little recognized through to the most obvious destruction. Today the direct role of pathogens in natural plant communities is better recognized than at previous times, although the nuances of their interactions and the cascade of ramifications that can flow through changing biotic and abiotic effects are only now gaining recognition. However, as human influence on pathogens increases--either directly through enhanced if accidental dispersal, or through anthropogenic impacts on climate--we may expect to see increasing evidence of pathogens affecting plant species, community structure, and ecosystem function.

Key Words: Climate and climatic variability. Climatic variability and prediction of plant disease. Suggestions for future research.


Abstract: This literature review begins with some basic terminology associated with forest diseases and an examination of the evolution of the concept of decline. Case histories are presented for decline events from various forest regions throughout the world. Conclusions are drawn from an analysis of these case histories to provide a better understanding of the causes of decline, its role in forest dynamics, effects on forest health, and to aid in development of management strategies to minimize impacts of sustained use of forest ecosystems.


Annotation: The earth's climate - a dynamic entity. The greenhouse effect. Predicted changes in the earth's climate and expected effects. The global carbon cycle. Trees and forests as sources and sinks of carbon. Possible effects of climate change on forests. Helping forests adapt to climate change. The role of forests in mitigating the effects of climate change. Reducing sources of greenhouse gases.

Key Words: The earth's climate - a dynamic entity. The greenhouse effect. Predicted changes in the earth's climate and expected effects. The global carbon cycle. Trees and forests as sources and sinks of carbon. Possible effects of climate change on forests. Helping forests adapt to climate change. The role of forests in mitigating the effects of climate change. Reducing sources of greenhouse gases.


Abstract: In understanding present-day ecosystems and deciding how they should be managed, it is important to understand how they came to be as they are today. Both natural and human forces have brought about changes in past ecosystems that may not be readily apparent in today's landscapes. Data gathered from archaeological sites, including faunal, floral and climatological data, can be used to reconstruct important aspects of past ecosystems and to determine how they changed through time. Human beings have been an integral part of pinon-juniper ecosystems in the Southwest for over 10,000 years. Archaeological evidence of past human use is abundant and has the potential to yield information crucial to our understanding of these ecosystems today. Current evidence indicates that pinon-juniper woodlands were not pristine and unmodified prior to the arrival of Europeans in the Southwest, but had a complex history of natural and human caused variability and change.


Abstract: Invasive organisms have become a focal interest in ecology, owing not only to the tremendous destruction that they can cause, but also because we do not yet understand fully how they change from being minor components of their native communities to dominant components of invaded communities. Here, we discuss our perceptions of how the study of exotic plant species has contributed to the changing face of ecology over the past 20 years. Research on invasive organisms has promoted synthetic efforts between fields that have historically operated in isolation. Most importantly, the study of invasions has resulted in significant intellectual shifts in the way that old paradigms are perceived by ecologists and have led us into

Annotation: Opinions on evolutionary ecology (speed and importance), communities (coevolution, interactions, species saturation, and ecosystems.

Key Words: Opinions on evolutionary ecology (speed and importance), communities (coevolution, interactions, species saturation, and ecosystems.

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url: http://www.erin.utoronto.ca/~w3bio205/exotic_plants.pdf


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Abstract: Pathogens are potent selective forces whose importance in shaping the size and structure of individual plant populations and whole communities has been underestimated. Even in situations where host and pathogen have been associated over long periods of time, pathogens regularly affect host fitness by reducing fecundity and increasing mortality either directly or indirectly through reductions in competitive ability. The genetic consequences of such disease-induced reductions in fitness are profound. On a broad geographic scale, race-specific resistance generally occurs more frequently in regions characterized by environments favorable for disease development. Within such areas, however, the distribution of resistant plant genotypes is often very patchy. This probably reflects the importance of extinction and colonization events in the continuing co-evolutionary dynamics of host-pathogen associations. At a demographic level, pathogen-induced reductions in host fitness may lead to changes in the size of populations. In turn, this may lead to changes in the relative diversity of whole communities. Documentation of this scale of interaction is poor, but the devastating consequences of the introductions of pathogens into alien environments provides a salutary reminder of the power to change plant communities radically.


Abstract: Future drought is projected to occur under warmer temperature conditions as climate change progresses, referred to here as global-change-type drought, yet quantitative assessments of the triggers and potential extent of drought-induced vegetation die-off remain pivotal uncertainties in assessing climate-change impacts. Of particular concern is regional-scale mortality of overstory trees, which rapidly alters ecosystem type, associated ecosystem properties, and land surface conditions for decades. Here, we quantify regional-scale vegetation die-off across southwestern North American woodlands in 2002-2003 in response to drought and associated bark beetle infestations. At an intensively studied site within the region, we quantified that after 15 months of depleted soil water content, ~90% of the dominant, overstory tree species (Pinus edulis, a pinyon) died. The die-off was reflected in changes in a remotely sensed index of vegetation greenness (Normalized Difference Vegetation Index), not only at the intensively studied site but also across the region, extending over 12,000 km2 or more; aerial and field surveys confirmed the general extent of the die-off. Notably, the recent drought was warmer than the previous subcontinental drought of the 1950s. The limited, available observations suggest that die-off from the recent drought was more extensive than that from the previous drought, extending into wetter sites within the tree species' distribution. Our results quantify a trigger leading to rapid, drought-induced die-off of overstory woody plants at subcontinental scale and highlight the potential for such die-off to be more severe and extensive for future global-change-type drought under warmer conditions.

doi: 10.1073/pnas.0505734102


Abstract: General conclusions: (1) Climate change is likely to be broadly detrimental to tree health and favour some highly damaging pathogens. (2) Host x pathogen systems involving non-native hosts and invasive pathogens are likely to be at highest risk, a further argument for more effective controls to prevent the arrival of invasive pathogens. (3) There is a case for planting native trees and encouraging native ecosystems, assuming these are better ecologically buffered and may have a wider gene pool for host adaptation.


Abstract: From existing evidence for short- and long-term evolutionary change in relation to climate, it must be concluded that such evolutionary change can take place. At the same time there is clear evidence that such evolutionary change does not necessarily take place, even if the environmental conditions, and therefore the conditions for selection, are appropriate. Where such evolution does occur there appear to be definite limits to what takes place. Similar evidence is forthcoming from situations where artificial selection has been applied. The explanation appears to be that all evolution depends on the occurrence of appropriate variability, and that for various reasons this is not always present in natural populations. This picture is confirmed by an examination of the historic evidence for changes in species distribution in relation to past climatic changes. Generally species have behaved, from an evolutionary point of view, in a conservative manner, and have responded to climatic change not by evolution, but by migration. Although some evolution in relation to climatic change may take place, we must not therefore presume that its power will be unlimited in relation to future climatic change. As a result, and because the natural migration of species is now very restricted, we should expect considerable numbers of extinctions, unless we take special steps to transfer artificially whole groups of species from one geographic region to another.


Abstract: The demand for accurate forecasting of the effects of global warming on biodiversity is growing, but current methods for forecasting have limitations. In this article, we compare and discuss the different uses of four forecasting methods: (1) models that consider species individually, (2) niche-theory models that group species by habitat (more
specifically, by environmental conditions under which a species can persist or does persist), (3) general circulation models and coupled ocean--atmosphere--biosphere models, and (4) species--area curve models that consider all species or large aggregates of species. After outlining the different uses and limitations of these methods, we make eight primary suggestions for improving forecasts. We find that greater use of the fossil record and of modern genetic studies would improve forecasting methods. We note a Quaternary conundrum: While current empirical and theoretical ecological results suggest that many species could be at risk from global warming, during the recent ice ages surprisingly few species became extinct. The potential resolution of this conundrum gives insights into the requirements for more accurate and reliable forecasting. Our eight suggestions also point to constructive synergies in the solution to the different problems.


Abstract: Recent models suggest that a trade-off in plants between tolerance of water limitations vs. tolerance of light limitation result in changes in dominant species over productivity gradients of increasing soil moisture and decreasing forest-floor light. With increasing elevation (1568-2296 m) in the Chiricahua Mountains in southeastern Arizona, soil moisture and plant cover increased and, as a result, mean forest-floor light levels decreased, in accordance with the models. The light-moisture trade-off hypothesis predicts that, over this gradient, (1) shade tolerance and drought resistance should be negatively correlated, (2) decreasing light and lack of shade tolerance (i.e., tolerance of light competition) should control upper elevational limits of species distributions, and (3) low soil moisture availability and lack of drought resistance should control lower elevational limits. With increasing elevation, however, fire frequency and litter depth also increased and soil temperature decreased. I tested the trade-off hypothesis and the role of these three additional factors in controlling upper elevational limits of three pine species distributed along this gradient. Consistent with the trade-off hypothesis, results suggested that water stress controlled lower elevational limits of all three species. Seeds of each species germinated with the summer rains in experimental plots below their respective lower elevational limits, but all seedlings died by the end of the following May-June drought, apparently from water stress. In contrast, seedlings were still alive in experimental plots within control over plant distribution and community composition, and should be incorporated into the proposed general models relating plant strategies to community structure.

These results suggest that fire, or other agents of selective mortality correlated with soil resource gradients, can exert strong influence distribution. Emergence and survival were actually higher at middle than upper elevations in the field experiment. Litter removal and canopy removal did not increase P. discolor emergence and survival, respectively, even at high elevation. In the highest elevation plots, P. discolor seedlings occurred in microsites slightly lower in light, higher in litter depth, and equivalent in soil temperature to random microsites, contrary to expectations it these variables were limiting. Finally, in greenhouse experiments, P. discolor was more shade tolerant than higher elevation species, including P. leiophylla. Two tests supported the hypothesis that the upper elevational limits of P. discolor were controlled by the high fire frequency found at higher elevation. First, P. discolor exhibited slow juvenile growth rates, thin bark, and other traits suggesting a lack of fire resistance compared with the two higher elevation pine species. Second, in two wild fires, survival of P. discolor stems was significantly lower than that for the other two species. This conclusion is corroborated by the observation that juvenile P. discolor occurred commonly at much higher elevations than did adults, into plots with very low light and soil temperature levels and very deep litter, a pattern likely resulting from fire suppression. Results for a third species, P. engelmannii, were equivocal, showing weak support for control of upper elevational limits by light. The lack of a light-soil moisture trade-off in these species may result from P. discolor's strategy of exploiting nurse tree sites at low elevation and the apparent fire-associated regeneration of the other two species. Nevertheless, control of P. discolor upper elevational limits by fire may, in part, be a result of constraints imposed by drought resistance on maximum growth rate and height. These results suggest that fire, or other agents of selective mortality correlated with soil resource gradients, can exert strong controls over plant distribution and community composition, and should be incorporated into the proposed general models relating plant strategies to community structure.


Abstract: Biotic responses to future changes in global climate are difficult to project for a particular region because the responses involve processes that operate at many spatial scales. This difficulty is exacerbated in mountainous regions, where future vegetation changes are often portrayed as simple upward displacements of vegetation zones in response to warming. We examine the scope of future responses that may occur in a mountainous area by illustrating the potential distributions of selected tree taxa In the region of Yellowstone National Park. The output of a coarse-resolution climate model that incorporates a doubling of carbon dioxide concentration in the atmosphere was interpolated onto a 5-minute grid of topographically adjusted climate data The output was also used as input into statistics relationships between the occurrence of individual taxa and climate. The simulated vegetation changes include a combination of elevational and directional range adjustments. The range of high-elevation species decreases, and some species became regionally extirpated. The new communities have no analogue in the present-day vegetation because they mix low-elevation, montane species currently in the region with extralocal species from the northern and central Rocky Mountains and Pacific Northwest. The projected
climate changes within the Yellowstone region and the individualism displayed by species in their potential range adjustments are equal or greater than the changes seen in the paleologic record during previous warming intervals. Although the results support conservation strategies that include habitat connectivity, the magnitude of the changes may exceed the ability of species to adjust their ranges. The predicted patterns call into question the adequacy of current management objectives to cope with the scope of future changes.


Abstract: Global warming may have many consequences for natural ecosystems, including a change in disturbance regimes. No current model of landscapes subject to disturbance incorporates the effect of climatic change on disturbance on decade to century time scales, or addresses quantitative changes in landscape structure as disturbances occur. A new computer simulation model, DISPATCH, which makes use of a geographic information system for managing spatial data, has been developed for these purposes. The concept and structure of the DISPATCH model are described here, and a hypothetical example of its use is illustrated, but the model requires refinement before it can be used to predict the effects of global warming on specific landscapes. The model includes provisions for (1) temporally varying weather conditions and their effect on disturbance sizes, and (2) the effect of spatial variation in vegetation condition and physical setting on the probability of disturbance initiation and spread. The potential use of the model is illustrated with a hypothetical example in which the age structure of disturbance patches is monitored for a 250-year period as weather fluctuates. The model run suggests that landscape structure fluctuates even if a disturbance regime remains constant.


Abstract: The fossil record of whitebark pine (Pinus albicaulis) is still sketchy. Only two fossil sites older than the last glacial advance contain whitebark pine pollen and macrofossils, but they show that it was present in the Yellowstone National Park region for over 100,000 years. The history of whitebark pine during the last 15,000 years in parts of the Rocky Mountains is fairly well understood. Pinus albicaulis apparently survived the last glaciation in protected areas throughout much of the Northern Rocky Mountains. It was well adapted to colonizing the treeless sites with mineral soils that prevailed during late-glacial times (about 15,000 to 10,000 years ago). Whitebark pine remained abundant, probably as a subalpine forest species, in many areas at the beginning of the early Holocene (about 10,000 to 8,000 years ago). During “Altithermal” warming in the middle Holocene of the Rocky Mountains (about 8,000 to 4,000 years ago), the species apparently was confined to high-altitude sites, and it has not substantially recovered during the slightly cooler climates of the late Holocene (the last 4,000 years).


Abstract: An ecoregion is a large area of similar climate where similar ecosystems occur on similar sites (Bailey 2002). The pattern of these local ecosystems within regions recurs predictably. Understanding these patterns and their origins can be used to design research networks and transfer knowledge. This paper explains, describes, and displays the ecosystem-based regions of the Rocky Mountain Research Station. Ecoregions are identified at three hierarchical levels of detail—domain, division, and province—based primarily on climatic conditions and on the prevailing plant formations determined by those conditions. The third level may include additional criteria, for instance altitude variation within climate types (i.e., lowland versus mountain regions). These regions are based on an explicit approach in which regions are differentiated on the basis of comparable likeness and differences. This approach has the advantage over intuitive "place name regions" that cannot be confirmed or reproduced. Because of this, these regions have been widely applied in conservation and management programs. For example, in 1993, as part of the National Hierarchical Framework of Ecological Units, the US Forest Service adopted these ecoregions for use in ecosystem management. It is important to link the ecosystem management hierarchy with the Forest Service research hierarchy. In do so, research structures and ecosystem hierarchies correlate such that research information, mapping levels, and research studies work well together.


Abstract: Yellow-cedar (Callitropsis nootkatensis (D. Don) Oerst.) is a valuable tree species that is experiencing a widespread decline and mortality in southeast Alaska. This study evaluated the relative importance of several potential risk factors associated with yellow-cedar decline: soil saturation, soil aluminum (Al) toxicity or calcium (Ca) deficiency, and air and soil temperature. Data were collected from permanent vegetation plots established in two low-elevation coastal forests exhibiting broad ranges of cedar mortality. Measurements of each risk factor were contrasted among classified forest zones to indicate if there were strong links with decline. Hydrology alone is weakly associated with yellow-cedar decline, but could have a predisposing role in the decline by creating exposed conditions because of reduced forest productivity. Yellow-cedar decline is not strongly associated with soil pH and extractable Al and Ca, but there appears to be Ca enrichment of surface soils by feedback from dead yellow-cedar foliage. Air and soil temperature factors are strongly associated with decline. Based on these results, an hypothesis is presented to explain the mechanism of tree injury where exposure-driven tree mortality is initiated in gaps created by soil saturation and then expands in gaps created by the tree-mortality itself. The exposure allows soils to warm in early spring causing premature dehardening in yellow-cedar trees and subsequent freezing injury during cold events. Yellow-cedars growing in the protection of shade or snow are not preconditioned by this...
warming, and thus not as susceptible to cold injury. Yellow-cedar decline appears to be associated with regional climate changes, but whether the cause of these changes is related to natural or human-induced climate shifts remains uncertain. Management implications, the possible role of climate, and recommended research are discussed.

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url: http://www.dartmouth.edu/~mpayres/pubs/gepidem.PDF


Abstract: Existing and emerging pathogens pose unusual challenges for conservation because of their potential to drive rapid changes in the numerical abundance and genetic composition of wild host populations. An increasing number of studies indicate that host genetic diversity plays an important role in buffering populations against widespread epidemics, and that parasites represent powerful selective agents in natural populations. The observation that infectious diseases might be both mitigated by and rapidly change the genetic composition of host populations gives new significance to the role of host genetic diversity in species conservation. Less clear is the role that pathogen evolutionary change plays in the emergence and spread of new diseases, but recent examples indicate that humans might be selecting unknowingly for rapid changes in pathogen biology through habitat fragmentation, climate shifts and environmental pollution. Although the risks they pose to endangered species are apparent, pathogens and other natural enemies can be a driving force behind species and genetic diversity in natural populations, and preserving interacting networks of coevolving populations should enable hosts to respond better to future disease threats.

Annotation: animal and plant examples, biased toward conservation

Key Words: animal and plant examples, biased toward conservation

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