GENERAL SESSION (CONTINUED) . . . . . Moderator: R. Fuester, USDA-ARS

Entomophaga maimaiga
Presenters: R. Webb, USDA-ARS; L. Bauer, USDA-FS; A. Hajek, Cornell University

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A CASE STUDY OF MANAGING THE GYPSY MOTH USING SILVICULTURE:

GYPSY MOTH POPULATION DYNAMICS

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ABSTRACT

Within the northeastern United States there is considerable variation in the susceptibility (defoliation potential) and vulnerability (tree mortality) of forests to gypsy moth (*Lymantria dispar* (L.)). Silvicultural thinnings have been suggested to reduce susceptibility and/or vulnerability. We evaluated how these practices affected the dynamics of gypsy moth populations by experimentally thinning half of each of 8 oak-mixed hardwood stands in the Central Appalachians of West Virginia. The population dynamics of gypsy moth were monitored using yearly counts of egg masses, numbers of larvae hatching per mass, estimates of larval density, and weekly collections of larvae and pupae which were reared to quantify mortality due to parasitoids and disease. During the 8-year study, 3 stands were heavily defoliated by outbreak populations of gypsy moth, 3 were sprayed accidentally with pesticides, and 2 were undisturbed. Egg-mass populations appeared slightly lower in the thinned portions of the undisturbed stands, but thinning seemed to have little or no effect on densities in the defoliated and sprayed stands. Variation in mortality of gypsy moth due to parasitoids and disease was related to variation in egg-mass densities in the current and/or preceding years. After adjusting for these effects of gypsy moth density, thinning had no significant effect on mortality caused by any parasitoid or pathogen. Our results indicate that these types of silvicultural manipulations do not directly influence the effectiveness of the natural enemies of gypsy moth. We conclude that it is more likely that the effect of thinnings on gypsy moth dynamics are related primarily to a reduction in foliar biomass.

SPATIAL AND TEMPORAL PATTERNS IN POLLUTANT DOSE THAT EXPLAIN FOREST HEALTH ENDPOINTS

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ABSTRACT

Many different forest health measures, or expressions of "forest decline," can be understood as important ecological or regulatory end points, but the mortality data reported by the USDA FS Forest Inventory and Analysis (FIA) remeasurements since the 1950's have many long-term advantages (see Powel *et al.* 1992). Measures of growth often are used to express forest health, but the growth rates of surviving trees are stimulated by the loss of competing trees (by decline or death), leading to an overstatement of health with growth data. On the other hand, tree death is readily defined in the plot remeasurements from years ago, and can inform us reliably about long-term trends. But, in addition, we want to look at tree mortality and its potential causes to see whether it could be evaluated hierarchically, i.e., long-term and at a large scale, as well as short-term and locally, to determine whether potentially significant influences on forest health exist at these large scales, in addition to the local tree and stand influences.

Using data from all the states with four consecutive measurements (a 10-state area of the montane east), we find a significant upward trend in tree mortality over the period 1960-1990, ranging from a doubling (for oak) to nearly a tripling (for hickory) in annual death rate of trees. We asked what are the processes that, over multiple decades, and at this large scale, would produce a trend toward higher mortality. We considered many possible explanations, including aging, stand dynamics, drought, defoliations, the invasion by gypsy moth, and air pollutant loads. All fail to explain the data except for the regional air pollutant loads. Indeed, the correlations between the average state-wide pollutant loads and mortality rate in all the sub-regions examined (25 states in all), for each of three wide-ranging tree species groups (red oaks, white oaks, and hickories), are highly significant ($p < .01$). For data from a recent survey of oak decline (Bechtold *et al.* 1991), the geographic pattern of pollutant loads (for ozone, wet sulfate, and wet nitrate) accounts for 92% of the variation in decline. There is abundant literature on mechanisms by which these pollutant loads alter tree metabolism, particularly the effects of pollutants on the trees' insect and disease defense mechanisms. For the tree and stand level, we conclude that pollutants increase the susceptibility of many trees species to insects and disease during modest droughts, defoliation events, and major changes in stand structure. Despite the death of individual trees having multiple causes, we find the 30-year, large-scale **change in tree mortality rate** has only one underlying cause, the air pollutant load in the rural eastern U.S. In this context, the U.S. Forest Service would serve its state and local clients well, and facilitate gypsy moth control, by publicly supporting the late-1996 proposals by the U.S. EPA to lower the standard for ground-level ozone.

DEVELOPMENT AND DYNAMICS OF MIXED MESOPHYTIC FORESTS OF THE SOUTHERN APPALACHIANS

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ABSTRACT

The Mixed Mesophytic Forest Region occupies the unglaciated portion of the Appalachian Plateau physiographic province as defined by E. Lucy Braun and A.W. Küchler. The region does not follow the prevailing trend in declining forest cover and early successional development as experienced in other deciduous forest regions. In spite of intensive and extensive use in the last 200 years, it remains the most forested area in the eastern United States and one of the most forested in the temperate world. Mixed mesophytic forests (also known as cove hardwood and Appalachian mixed forests) are found throughout the southern Appalachians in cool, moist environments of well-drained, dissected uplands.

Major characteristics of the regional forests include (1) forests of high species diversity in all strata; (2) shared dominance by at least 10 commercially important deciduous species; (3) an all-deciduous character; and (4) indicator species of yellow buckeye (*Aesculus flava*) and white basswood (*Tilia heterophylla*). Although Lucy Braun and others considered these forests to be millions of years old and the seed source for other modern forests, we now know that the region has developed with changing climates, retreating glaciers, and in conjunction with human culture. Human influence has dramatically increased from the millennia of use by Paleo-Indians and historic Native Americans into the few decades of intensive use in the 20th century.

The most significant changes have occurred in mixed mesophytic forests since 1870: extensive and intensive logging of the region from 1890 to World War II; death of American chestnut prior to World War II; suppression of fire, elimination of livestock grazing, and land abandonment since World War II; and subsequent forest development following these changes in forest composition and varying land uses. Predicting future change is complicated by a number of extrinsic factors such as invasion of exotic pest and disease species including gypsy moth, impacts of air and other pollutants, climate change and other shifts in the physical environment, and demands for a number of forest products ranging from timber and medicinal plants to selected animal species. Intrinsic factors that affect the future forest include continued composition changes in response to death of American chestnut; responses in growth and composition with changes in age structure and human use; and compositional responses to acute and chronic natural disturbances and disasters such as flooding, drought, and storms.

The economic, ecological, and recreational values of this large block of continuous forest cannot be overestimated. Maintaining ecological health of the Mixed Mesophytic Forest Region is essential to sustaining regional posterity and the numerous goods and services provided by these renewable resources.

SPECIES OF *DENDROLIMUS* (LEPIDOPTERA: LASIOCAMPIDAE) IN CHINA

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ABSTRACT

There are 25 known species in the genus *Dendrolimus* and all but two occur in the People's Republic of China. The most destructive species in China are *D. punctatus*, *D. spectabilis*, *D. tabulaeformis*, and *D. superans*. The latter species also is an important pest in Asian Russia. The only species in this genus not found in China, *D. pini* and *D. benderi*, are important pests in Europe and Pakistan, respectively.

The biology of species in the genus varies greatly. Most species are univoltine, but at least one is multivoltine and one is biennial. Depending on the species, overwintering occurs as eggs, young larvae, or mature larvae. Eggs are laid, without a hair covering, on needles in chains or loose masses. Newly hatched larvae congregate on the shoot tips and suspend themselves on silken threads for dispersal by wind. All species feed on conifers, with most preferring species in the pine family. Pupation takes place at the base of needle clusters. Adults of both sexes can fly.

The most serious defoliator of forests in China is *D. punctatus*. It is distributed widely, occurring in 17 provinces. It is multivoltine, with 2-3 generations per year in the Yangtze River drainage area, 3-4 in South China, and 5 on Hainan Island at the southern tip of China. The preferred host of *D. punctatus* is horse-tail pine (*Pinus massoniana*), though subspecies have developed that specialize on other native pines. Recently, its host range has expanded to the introduced wetland and torch pines, on which it often is a severe pest. It prefers to feed on older foliage but will feed on young needles after all of the old needles have been consumed. Infestations occur most frequently below 200 meters along railroads, highways, and rivers, and in monoculture pine plantations.

Egg parasites, primarily *Trichogramma dendrolimi*, *Telenomus dendrolimusi*, and *Anastatus* spp., are the most important natural control agents. *Exorista* spp. are the most effective of the larval parasites. Birds, especially cuckoos and even a falcon, are reported to feed frequently on the larvae. The most important disease is cytoplasmic polyhedrosis virus (CPV). The chemical pesticides used most often are deltametrin and diflurobenzuron. These often are applied from beneath the canopy using foggers. Biological pesticides include eggs of *T. dendrolimi*, spores of the fungi *Beauvaria bassiana* and *Pacilomycetes* spp., and CPV. *Bacillus thuringiensis* is not used widely because of its cost.

A CASE STUDY OF MANAGING THE GYPSY MOTH USING SILVICULTURE:

SECONDARY MORTALITY AGENTS: *AGRILUS BILINEATUS*

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ABSTRACT

Population densities of twolined chestnut borer, *Agrilus bilineatus* (Weber), adults were sampled over a 6-year period in a mixed hardwood forest in West Virginia. We were interested in understanding populations dynamics of *A. bilineatus*, for little is known about this species, despite its obvious importance as a mortality agent to stressed *Quercus* spp. Sixteen stands (average size 10.5 ha) were used in the study; eight of these were silviculturally thinned in 1989, the remainder were uncut. During 1990 and 1991, populations of gypsy moth, *Lymantria dispar* L., reached outbreak levels. Densities of *A. bilineatus* adults peaked in 1992, the year following the second defoliation year (1991), and were always greater in thinned stands than unthinned; however, overstory mortality was greater in unthinned stands. Correlations between twolined chestnut borer and tree mortality were not strong, nor were the relationships between defoliation and twolined chestnut borer.

A CASE STUDY OF MANAGING THE GYPSY MOTH USING SILVICULTURE:

UNDERSTORY: EFFECTS ON GROUND-DWELLING INVERTEBRATES

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ABSTRACT

The ground-dwelling arthropod communities of a mixed hardwood forest dominated by oak (*Quercus* spp.) in West Virginia, USA were sampled for four years in a study designed to examine the efficacy of silviculture for reducing *Lymantria dispar* L. populations. Spiders, carabid beetles, opilionids, and ants were collected from pitfall traps and identified to species. These groups were of interest because each has members which are known predators on some life stage of gypsy moth. During the sampling period, portions of the forest were defoliated by gypsy moth and some areas were selectively logged using silvicultural treatments designed to reduce forest susceptibility to and/or to reduce the vulnerability of the stands. The effect of canopy-opening disturbance was noticeable for both carabids and ants: total abundance decreased, but diversity increased. The dominant ant species, *Aphaenogaster picea*, decreased nearly 50% over the four-year period, particularly in defoliated areas. For spiders, the effect of either defoliation or logging was dampened by natural variation in the populations in terms of overall abundance and diversity. Individual family and species level variation, however, was detected. For example, the Linyphiidae, a family of web-spinning spiders, was positively related to abundance of fern understory, and fern coverage increased significantly in areas that were both logged and defoliated. Two spider families were significantly inversely related to fern abundance. The overall abundance of opilionids increased immediately after the disturbances, but decreased in subsequent years. Composition and abundance of ground-dwelling arthropod assemblages may be modified by and are sensitive to both 'natural' biotic disturbance and to forest management practices.

A CASE STUDY OF MANAGING THE GYPSY MOTH USING SILVICULTURE:

UNDERSTORY VEGETATION DYNAMICS

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ABSTRACT

Ground flora, both regenerating woody species and herbaceous vegetation, are significant components to consider when attempting to understand resilience and recovery of a forested ecosystem. With this study we were able to examine the influence of both disturbance (gypsy moth defoliation) and management practices (silvicultural thinnings) on vegetation in the lowest structural layers. Regenerating species were identified, measured, and counted in 1989, (pre-defoliation and pre-thinning), 1990, 1991, 1992, 1994, and 1996. Herbaceous vegetation was identified and coverage was estimated in 1992, 1993, and 1995. In four of the six defoliated stands, woody species regeneration was clearly dominated by *Acer rubrum* (red maple). This species dominated the larger size classes and also dominated in actual number of seedlings. Two of the defoliated stands, however, were dominated by *Prunus serotina* (black cherry). Although these stands were dominated by *Quercus* (oak) overstories, there was little evidence of adequate oak regeneration.

No pre-disturbance herbaceous vegetation data were collected, so it's not possible to examine changes due directly to defoliation and thinnings, but the data does provide the opportunity to look at temporal changes and contrast the stands that had been defoliated or thinned with those that had not. Using ordination techniques, it appears that disturbance plays a significant role in distinguishing the stands in multi-dimensional space. The species turnover is great, i.e., there are some stands that have few if any species in common, therefore variation among stands at the WVU Forest is great. Within a given stand, species richness did not change from 1992 to 1995.

A significant management and ecological implication of thinning in stands that have been or will be defoliated is the increase in competing vegetation with canopy opening. In stands that were either thinned or defoliated there were significant increases over time in ferns, *Rubus* spp., and grasses, any of which can interfere with woody species regeneration. In stands that were both thinned and defoliated the increases in these types of competing vegetation were even greater.

FAMILY STRUCTURE AND HABITAT RELATIONSHIPS OF SPIDERS IN AN APPALACHIAN FOREST

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ABSTRACT

Spiders of 24 families were collected by pitfall traps in an oak-mixed hardwood forest in north central West Virginia during an 11-week period in early summer of 1989--1992. All trapped individuals were identified at least to the family level. Quantitative vegetation data allowed assessment of spider habitat associations on a finer spatial scale than previously reported. The Lycosidae dominated each year despite great annual variation in abundance for each family. Percentage of fern coverage on a plot basis was related inversely to abundance of Thomisidae and Gnaphosidae, but related positively to abundance of Linyphiidae, a reflection of the strategies of the families. There was a strong positive correspondence between abundance of the Thomisidae and percentage of oak basal area in the overstory. Pitfall-trap catches were biased slightly toward capture of male spiders; the average sex ratio (male:female) for hunting-spider families over the 4 years was 8.1:1, and for web-spinners was 2.5:1. Abundance of juvenile spiders (over all families) varied temporally and was related inversely to total abundance.

DENDROCHRONOLOGY OF INTENSIVE PLOT SYSTEM (IPS) DATA

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ABSTRACT

Outbreaks of the gypsy moth, *Lymantria dispar* L., are sporadic and typically result in extensive defoliation of the preferred host species, *Quercus, Populus*, etc. Historical increments of host and non-host species from 1952-1976 were measured from samples collected in 6 sites located in Massachusetts, New Jersey, and New York. During that period, the gypsy moth expanded its range through these areas and several outbreaks occurred. Defoliation levels were recorded at sample locations from 1972-1976; outbreaks occurred at each location during this period. Standardized chronologies for each species were averaged by year at each location. All host tree species exhibited a decrease in increment associated with defoliation levels recorded from 1972-1976. While some non-host species exhibited increased growth during outbreaks, others did not. These differences may reflect the extent to which growth of different species is limited by light and nutrients. A difference series, i.e., subtraction of the non-host standardized chronology from the host standardized chronology, performed well as a measure of gypsy moth outbreak intensity. Examination of difference chronologies prior to 1972 indicated the occurrence of historical outbreaks in certain areas and these episodes appeared to coincide with historical outbreaks in the region. The use of difference chronologies appears to be a useful method for quantifying historical gypsy moth outbreaks when no other records exist.

PATTERNS OF TREE GROWTH IN FORESTS DEFOLIATED BY GYPSY MOTH

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ABSTRACT

Extensive mortality occurred at the WV University Forest in 1990, 1991, and 1992 following two years of severe gypsy moth defoliation. Dead trees were cored and ring-widths were measured to evaluate the occurrence of a 'signal' indicating suppressed growth and eventual mortality following the stress of defoliation. We also looked at increments of live trees for comparison and eventually to determine growth loss through defoliation. Most standardized chronologies extended to at least 1930. We found no evidence of a signal sufficient to differentiate trees that survived defoliation from those that did not. Live and dead standardized chronologies were similar for all oaks. Chronologies of non gypsy moth host species, such as red maple, reflected a distinct growth, i.e., increasing in growth as a result of mortality of oaks.

INFLUENCE OF PARASITIZATION BY THE SOLITARY PARASITOID *GLYPTAPANTELES PORTHETRIAE* (HYMENOPTERA: BRACONIDAE) ON THE DEVELOPMENT AND JUVENILE HORMONE DEGRADATION OF ITS HOST *LYMANTRIA DISPAR*

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ABSTRACT

Under natural conditions *G. porthetriae* attacks mainly first and second instar gypsy moth larvae. Depending on the time of parasitization the parasitoid emerges from 3rd or 4th instar hosts. In both groups the endophagous developmental time takes 14 days but it takes significantly longer if gypsy moth larvae are parasitized in the 3rd instar. The older the host larva is at the time of oviposition the lower is the percentage of truly parasitized larvae; pseudoparasitism also occurs more often.

Larval development and molting are dependent on the juvenile hormone titer in the hemolymph of the host. JH in the blood of gypsy moth is degraded by juvenile hormone esterase (JHE). JHE activity in control larvae, especially at the beginning of the instar, is significantly higher than in parasitized larvae where hardly any JHE activity was detected. This blocking of JHE activity by the parasitoid might be the reason for a high JH titer in the host's hemolymph which subsequently causes disruption of development.

JHE was purified with affinity chromatography and partial aminoacid sequence was obtained. The sequenced peptides showed high homology with JHE from H. virescens but no similarity with previously published peptides from JHE of *L. dispar* could be found.

GYPCHEK: A SURVEY TO DEFINE CUSTOMER NEEDS AND PRODUCT MARKET

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ABSTRACT

Representatives of both the gypsy moth management community and environmental and extension organizations were surveyed to determine the near-term product market for the Forest Service-produced microbial pesticide Gypchek and to ascertain how the product might be improved to meet user needs. Questionnaires mailed to administrators, mid-level managers (e.g., state pest control specialists), local-level managers (e.g., county coordinators, district rangers), industry representatives, and researchers with either an immediate or a potential interest in gypsy moth management resulted in 355 responses. Also, 33 representatives of environmental interest and extension organizations responded to a telephone survey.

Gypsy moth managers indicated that the number of environmentally sensitive acres infested with gypsy moth would likely increase to at least 375,000 acres in the near future. However, unless the cost of Gypchek could be reduced to between $5 and $10 per acre (excluding application costs), probably less than 20 percent of those acres would be treated with the product. Even though many recognized that the product's formulation could be improved and that the need for two applications was undesirable, cost and availability seemed to be the primary reasons for non-use. As expected, Gypchek was viewed in a more favorable light by environmental and extension organizations than by managers, presumably because of its positive environmental attributes. In the absence of a similar commercial product, managers (67%) and environmentalists (75%) favored continued Forest Service production and distribution of Gypchek at a reduced cost through cooperative suppression programs.

FURTHER NOTES ON THE DISTRIBUTION, HOST PLANTS, AND PARASITOIDS OF *LYMANTRIA OBFUSCATA* WALKER (LEPIDOPTERA: LYMANTRIIDAE)

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ABSTRACT

Lymantria obfuscata Walker (Lepidoptera: Lymantriidae) is known to cause considerable damage, often denuding alder, false acacia, oaks, poplars, willows, and several temperate fruit trees (apple, apricot, cherry, pear, peach, plum, and walnut) in India. Its confines in Himachal Pradesh, Kashmir, and Uttar Pradesh are widely separated from one another by the barriers of unsuitable hosts, climate, and topography. Since the 1960's, partly with the sustained interest of the USDA to obtain natural enemies of allied species to contain the related pest, *Lymantria dispar* (L.), an exhaustive study on the parasitoids of *L. obfuscata* was made in these regions. The research was biocontrol-oriented, seeking information on their identity, bioecology, life history, and host range. Further search for more suitable natural biocontrol agents of *L. obfuscata* elsewhere culminated in the author's recent exploratory survey in Nepal. In Nepal, several species of *Alnus, Populus, Quercus,* and *Salix* occur, but plantations of the preferred hosts of *L. obfuscata* viz., *Alnus nitida* and *Quercus incana,* are rare due to unfavorable conditions there. The site characteristics also are not favorable, lacking protected niches for concealment of large larvae, pupation, and oviposition by adults. Previous studies on the head capsule of *L. obfuscata* in Nepal were based on specimens misidentified as such. The author could neither locate specimens of *L. obfuscata* at the original collection site (Indrayani Village) nor elsewhere on any of the possible hosts available in Nepal. The record of it from Nepal is indicated as apparently erroneous.

Seasonal parasitism, based on pooling larval collections across dates at each site, by the parasitoids of *L. obfuscata* encountered in the Kullu Valley (Himachal Pradesh) was low in 1995, ranging from 0 to 5.5% and averaging 2.96%, but much higher in 1996, ranging from 4.0 to 55.2% and averaging 16.95%. Activity of the braconid parasitoids *Glyptapanteles flavicoxis* Marsh (23.3% at Khokhan Rd in 1996) and *Rogas indiscretus* (43.5% parasitism at Banogi in 1996) was more pronounced in the low density areas associated with apricot in the Kullu Valley. Live material of *Glyptapanteles indiensis, G. flavicoxis, Rogas indiscretus,* and tachinids was sent to the USDA quarantine facility at Newark, DE, for further study. Further exploration for any suitable parasitoids of other allied lymantriids occurring in Nepal, Sikkim, and Bhutan is suggested for their possible use against *L. dispar* in the United States or elsewhere.

ELECTROPHORETIC PATTERNS IN PROTEINS OF GYPSY MOTH DIFFERING FOR FLIGHT CAPABILITY

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ABSTRACT

Increased shipments of materials to the United States and Canada from Western and Central Europe and the Far East have resulted in new introductions of Eurasian strains of gypsy moth, *Lymantria dispar* (L.) into North America. These strains are considered more destructive than the strain already established in North America because larvae have broader host ranges and adult females are capable of flight. Analyses of variability in protein loci of gypsy moth indicate greater genetic diversity in populations from western to eastern Eurasia (Harrison *et al.* 1983, Arduino *et al.* 1994), but no genetic linkages with flight have been shown. In this study, allozymic markers were surveyed in the gypsy moth to investigate relationships with flight capability and to provide information for constructing a linkage map.

Populations of *L. dispar* that originated in Germany, Romania, Siberia, and a laboratory culture (NJSS), and for which flight capability data were available, were surveyed electrophoretically. Thoraxes were homogenized in tris buffer, analyzed using standard horizontal starch gel electrophoresis, and stained at 8 enzymatic loci. Measures of genetic diversity were compared with (1) flight behavioral data from free-flight estimates of sustained flight (W. Wallner and P. Grinberg, personal communication), and (2) data from a flip test relating a female moth's ability to upright itself as an indicator of flight capability (M. Keena, personal communication).

Among field populations, genetic diversity was highest in gypsy moth from Siberia, though overall diversity was highest in the NJSS sample. If NJSS is considered an outlier, an unpaired group mean weighted analysis with Nei distance measures affirmed greater genetic diversity in gypsy moth populations approaching the eastern Palearctic. Genetic heterozygosity in field populations of gypsy moth might indicate flight capability; however, whether genetic markers correlate with behavioral characters for flight remains to be determined. Ongoing research seeks to increase the number of loci available for scoring population diversity and to develop a linkage map for gypsy moth.

LITERATURE CITED

Arduino, P.; Bullini, L.; Prota, R.; Verdinelli, M. 1994. Differenziamento genetico del complesso *Lymantria dispar* (Lepidotera:Lymantriidae). In: Atti XVII Congresso nazionale italiano Entomologia Udine 13-18 giugno 1994:121-124.

Harrison, R.G.; Wintermeyer, S.F.; ODell, T.M. 1983. Patterns of genetic variation within and among gypsy moth, *Lymantria dispar* (Lepidoptera: Lymantriidae), populations. Ann. Ent. Soc. Amer. 76:652-656.

THE PINE MOTH, *DENDROLIMUS PINI*

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ABSTRACT

Data about the biology, diapause behavior, and the population dynamics of the important pest on pine in Europe, the pine moth *Dendrolimus pini*, are presented. The pine moth is distributed throughout the whole Euroasian continent from the Atlantic coast up to the Altai-mountains in the west of Mongolia. It prefers extensive pine stands on dry soils of low quality. Scots pine is the most favored host tree, but you can also find the caterpillars on *Pinus nigra* and other pine species as well as sometimes on spruce and fir. During the last 290 years, 80 outbreaks of the moth were recorded in the area of northern Germany and Poland, of which the heaviest one was from 1869 to 1872, when more than 1.7 million ha of pine stands were infested by the moth. Most of the heavily defoliated trees died.

During its univoltine cycle, which is common for most parts of middle and southern Europe, the pine moth larvae hibernate in the 3rd or 4th instar. The overwintering of the larvae, which is induced by short-day photoperiods, shows all physiological characteristics of a real facultative diapause, although there is no fixed manifestation stage of the diapause. The high phenotypic variability in its diapause behavior may be an advantage for the pine moth to disperse the risks during periods of low population density. Furthermore, it enables the moth to develop both in a univoltine or a two-year cycle which might be important for its existence in areas of more northern latitude. However, this phenotypical plasticity also reduces the synchronizing effect within a population which might have an influence on the population dynamics of the moth during outbreak periods. Factors regulating the extreme non-cyclic fluctuations with long periods of very low abundance and the sudden increase of its population are discussed.

BIOECONOMICS OF MANAGING THE SPREAD OF PEST POPULATIONS WITH A BARRIER ZONE

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ABSTRACT

Area-wide pest-management projects often require long-term economic planning. In this paper, we apply bioeconomical concepts initially developed for managing fish populations to the management of spread rates of invading exotic pest species via barrier zones. Exotic pests are serious threats to North American ecosystems, and thus, economic analysis of their management is important for making decisions about eradication, or stopping or slowing their spread. The rate of population expansion (which may be positive or negative) is considered a control function. The present value of net benefits from managing population spread is maximized using the calculus of variations. As the area already occupied by the population increases and/or the negative impact of the pest species per unit area decreases, the optimal strategy changes from eradication (by forcing the population front to retreat back) to slowing the spread and finally to doing nothing. The model shows that slowing population spread may be a viable strategy of pest control even when a relatively small area remains uninfested. Stopping population spread is not an optimal strategy unless natural barriers to population spread exist. The model was applied to the spread of gypsy moth (*Lymantria dispar* L.) in North America. Expected costs of the barrier zone were derived from the optimization model of slowing gypsy moth spread (Sharov and Liebhold 1997). Damage caused by the gypsy moth, $380 per 1 km^2 per year, was estimated from Leuschner *et al.* (1996) assuming that residential impacts occurred only in defoliated areas (i.e., ca. 5 times less often than it was assumed by Leuschner *et al.*). The model indicates that the optimal strategy of managing the expansion of large gypsy moth populations is slowing the rate of spread to 3.4-4.1 km/yr. Eradication of isolated small gypsy moth populations located far from the generally infested area is economically justified if their radius is >45-195 km.

MODEL OF SLOWING GYPSY MOTH SPREAD WITH A BARRIER ZONE

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ABSTRACT

The USDA Forest Service is currently conducting a Slow-the-Spread (STS) pilot project to evaluate the feasibility of slowing the spread of the gypsy moth (*Lymantria dispar* L.) in several areas along the population front. To predict the effect of the STS on the rate of gypsy moth spread, we developed a model that assumes establishment of isolated colonies beyond the expanding population front. These colonies grow, coalesce, and thereby contribute to the movement of the population front. The model estimates the rate of spread from 2 functions: (1) colonization rate as a function of the distance from the population front, and (2) population numbers in a colony as a function of colony age. Eradication of isolated colonies was simulated by truncating the colonization rate function beyond a specific distance from the population front. Model parameters were estimated using data on moth capture in pheromone-baited traps in the Appalachian Mountains in Virginia, West Virginia, and North Carolina. The rate of establishment of isolated populations declined with increasing distance from the population front and reached almost zero at a distance of 250 km from the boundary of defoliated areas. The intrinsic rate of population increase was estimated as $r = 1.706$ per year. The model predicts that the STS project will result in a 54% reduction in spread rate. The actual rate of gypsy moth spread in the Appalachian Mountains decreased from 20.1-26.5 km/yr before 1990 to 8.6 km/yr after 1990, which is a 59-68% reduction. The decrease in the rate of spread may have resulted from eradication of isolated colonies just beyond the expanding population front that started in 1990. Thus, model predictions were close to the observed reduction in the rate of population spread.

COMPARISON OF THORACIC MUSCULATURE OF ASIAN AND NORTH AMERICAN GYPSY MOTHS

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ABSTRACT

Female gypsy moths, *Lymantria dispar*, of the Asian race are capable of sustained flight, but females of the gypsy moth population established in North America are not. To gain insight into factors that might limit flight capability, we compared the anatomy, histology, and ultrastructure of the flight muscles of North American (NAGM) and Asian gypsy moths (AGM) and their F_1 and F_2 hybrids. We also compared the anatomy of flight muscles of F_2 hybrids that exhibited various degrees of flight capability.

The thoracic muscle mass of female AGM was greater than that of female NAGM. We found no significant differences in dry weight of either intact bodies or thoracic exoskeletons of AGM and NAGM. However, the thoraxes of female AGM weighed significantly more than those of female NAGM, and the thorax represented a greater proportion of the total body weight for female AGM than female NAGM. The thoracic weights of female F_1 hybrids were in the intermediate range between the parents, as were the ratios of thorax weight to total body weight. The body weight, thorax weight, and ratio of thorax weight to total body weight of female F_2 hybrids were highly variable, but covered the entire range between AGM and NAGM. The fibers that comprise the dorsolongitudinal flight muscles were larger in diameter in AGM than in NAGM, but there was no consistent difference in diameter of myofibrils within the fibers, or in diameter and configuration of actin and myosin filaments.

Female moths that are able to right themselves from an inverted position with one quick wing beat are generally able to glide or sustain flight. We found that female F_2 hybrids that can right themselves easily have flight muscle fibers that are similar in diameter to those of AGM; female hybrids that right themselves with difficulty have flight muscle fibers of intermediate diameter compared with AGM and NAGM; female hybrids that cannot right themselves have flight muscle fibers that are similar in diameter to those of NAGM. These findings suggest that flight capability in female gypsy moth is related to thoracic muscle mass and specifically to diameter of flight muscle fibers.

ALUMINUM MOBILIZATION, CALCIUM DEPLETION, AND VITALITY OF RED SPRUCE IN NORTHEASTERN FORESTS

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ABSTRACT

Dendrochemical and biochemical markers link stress in apparently healthy red spruce trees to acidic deposition. Dendrochemistry of spruce stemwood indicated a period of Ca, Mg enrichment consistent with cation mobilization in the root zone during the 1960's when acidic deposition to spruce forests in the northeastern U.S. increased sharply. As high levels of deposition continued, Al mobilized in mineral soil became available for interaction with Ca, Mg on cation exchange sites in soil and absorbing roots. At some locations, the interaction of Al with Ca, Mg induced strain and contributed to the death of mature trees. At most locations, increased Al has only induced stress as indicated by elevated concentrations of the biochemical stress marker, putrescine. Trees under high stress are at greater risk of declining health than those at low stress levels.

OAKS AND GYPSY MOTHS: AMELIORATION OF THE EFFECTS OF DEFOLIATION THROUGH ORGANIC BIOSTIMULANTS

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ABSTRACT

The effect of organic biostimulants on the growth and physiology of non-defoliated and chronically defoliated seedlings was monitored for three years. Organic biostimulants are vitamin-humic-algal mixtures which promote plant growth and vigor. Treatments of organic biostimulant, organic biostimulant with added casein hydrolysate, and a control were compared to assess ameliorative effects. The following parameters were measured: height increment, diameter increment, chlorophyll content, photosynthetic rate, chlorophyll fluorescence, and total leaf phenolics. Seedlings that were not defoliated or that were minimally defoliated had significantly greater height and diameter growth, photosynthetic rates, chlorophyll content, and chlorophyll fluorescence than heavily defoliated plants. Total leaf area and total plant photosynthesis were highest in plants treated with organic biostimulants with added casein hydrolysate, while photosynthetic rate per unit leaf area was highest in plants treated with organic biostimulants alone. Total phenolics was significantly higher in heavily defoliated plants than in plants that experienced little or no defoliation. Plants treated with the organic biostimulant Roots• with added casein hydrolysate showed greatest increments in diameter and height, and had the highest amounts of chlorophyll. Organic biostimulants caused a relatively greater increase in diameter as than in height of seedlings tested.

DEVELOPMENT OF IMPROVED STRAINS OF THE *LYMANTRIA DISPAR* NUCLEOPOLYHEDROVIRUS

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ABSTRACT

During propagation of baculoviruses in cell culture a class of viruses with an altered plaque phenotype, termed few polyhedra (FP) mutants, arise at high frequency. FP mutants exhibit the characteristics of formation of few polyhedra, the occlusion of few or no virions in polyhedra, and the synthesis of greater amounts of budded virus compared to wild type (many polyhedra, MP) virus. The enhanced production of budded virus is thought to be the basis for FP mutants becoming the predominant virus type during serial passage in cell culture. The rapid formation of FP mutants during propagation in cell culture is an impediment to the production of baculoviruses in this system on a commercial scale.

The *Lymantria dispar* nucleopolyhedrovirus (LdMNPV) rapidly mutates to FP mutants during serial propagation in *L. dispar* Ld652Y cells. After only three serial passages of LdMNPV in 652Y cells greater than 90% of the virus present exhibited the FP phenotype (Slavicek *et al.* 1995, Biological Control 5:251-261). Development of LdMNPV viral strains refractory to mutation to the FP phenotype would facilitate production of virus in cell culture systems. Several LdMNPV strains were developed, and the stability of polyhedra production by these isolates was assessed through serial passage in the *L. dispar* 652Y cell line.

One of the new viral strains exhibited stable polyhedra production levels through 14 serial passages in the Ld652Y cell line. In contrast, FP mutants were formed and become the predominate virus type after only 3 to 5 serial passages of wild type virus. The stability of the new LdMNPV isolate suggests that FP mutant formation would not occur or pose a problem during production of this viral strain in cell culture bioreactors.

In addition to development of viral strains for production in cell culture bioreactors, we are trying to develop viral strains with increased potency. We have identified a LdMNPV gene homolog to the enhancin gene present in granuolviruses. The enhancin protein is able to increase the potency of AcMNPV polyhedra. A genetically engineered strain of the LdMNPV is being constructed that overexpresses the LdMNPV enhancin gene. The potency of this engineered virus will be assessed.

ATTEMPTS TO ESTABLISH A GYPSY MOTH LIFE TABLE IN A SUBURBAN SETTING

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ABSTRACT

In 1996, an attempt was made to construct life tables for the gypsy moth at two residential sites, one with a high population and the other, a low population. Each site had a conventional yard and an adjoining woodlot. Calibrated frass collections and burlap counts were used to obtain weekly estimates of gypsy moth density following hatch, and samples of larvae and pupae were monitored in a screened, unheated outdoor insectary to identify causal agents and to obtain mortality estimates between census intervals. Survivorship trends differed between the two sites, collapsing at the low density site before late instars were present, and diminishing less dramatically at the high density site. Trends in the yard and woodlot were similar at each site. Sampling error most likely contributed to a case of apparent recruitment at the low density site. On several sampling dates, mortality in samples collected for analysis exceeded that reflected in differences between density estimates on successive sampling dates. These anomalies were expressed as unexplained negative mortality for the purpose of balancing the life table, so mortality estimates for those weekly intervals were considered approximate.

Nuclear polyhedrosis virus was the most important mortality factor at the high density site, whereas the fungal pathogen, *Entomophaga maimaiga*, was most important at the low density site. The larval parasite, *Cotesia melanoscela*, was recovered at both study sites, but parasitism was variable. The imported carabid, *Calosoma sycophanta*, was fairly abundant at the high density site, and destroyed many gypsy moth pupae there. Because of the high incidence of disease at both sites, none of the parasites that habitually attack large larvae (e.g., *Parasetigena silvestris*) was recovered. It remains to be seen whether *E. maimaiga*, which causes spectacular epizootics resulting in the sudden collapse of gypsy moth populations, will have long-term adverse effects on the complex of imported larval parasites.

COSTS ASSOCIATED WITH URBAN GYPSY MOTH CONTROL BY ARBORISTS

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ABSTRACT

The European gypsy moth, *Lymantria dispar* (L.), is an introduced forest pest that has significantly impacted hardwood forests and urban environments in the northeastern United States. In urban settings, high density gypsy moth populations generate enormous public concern. This is primarily due to the loss of aesthetic value after defoliation, the nuisance created by the presence of large numbers of insect larvae, and the fear of losing highly valued shade trees. The objective of this study was to provide a cost analysis of residential gypsy moth management programs.

Time, or number of man-hours required to spray the property, is a major cost factor. Due to the extreme variations in the size and foliar surface of urban trees, no specific guidelines exist for calculating the man-hour estimate. The time estimate is simply based on the salesperson's past experience with similar situations. The factors which influence this estimate include: (1) number and size of trees, (2) size of property, (3) physical layout of the property, and (4) proximity of the property to sensitive areas. Travel time to and from each job site is another factor that may influence the required number of man-hours.

Cost data were obtained from two large commercial tree care companies in the Northeast. On average, pest suppression services in the eastern region cost the residential property owner $104.70 per hour (does not include materials). This cost per hour was broken down into six major components: (1) labor, (2) administrative overhead, (3) equipment, (4) materials, (5) mobilization, and (6) profit.

Total actual cost for pest management (without profit) was $65.90. Labor accounted for approximately 30% of this cost, equipment for 11%, administrative overhead for 36%, and mobilization (travel and job set-up time) for 23%. Materials cost varied depending upon the treatment alternative chosen. Total costs for one treatment cycle of carbaryl, B.t.-low rate, B.t.-high rate, and diflubenzuron were $114.58, $256.20, $271.80, and $115.69, respectively. Material cost for one complete treatment cycle ranged from 12% to 62% of the total cost. An average profit figure was calculated for the two companies.

IDENTIFICATION AND CHARACTERIZATION OF THE GYPSY MOTH MIDGUT MEMBRANE RECEPTORS FOR THE LEPIDOPTERAN-SPECIFIC *BACILLUS THURINGIENSIS* DELTA ENDOTOXINS

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ABSTRACT

Bacillus thuringiensis (*Bt*) has become the most effective biopesticide used for the control of the gypsy moth and a large number of other insect pests. Although *Bt* is relatively specific and is very attractive from environmental and health standpoints, its effect on non-target insect species remains a serious concern. To facilitate the design and development of new *Bt*-based insecticidal proteins that are more toxic against target insects and that affect fewer non-target insect species, an understanding of the molecular mechanism of the insecticidal action of *Bt* and of the biochemical basis of the insect host specificity exhibited by different *Bt* toxins is needed.

Bt is a group of spore-forming soil bacteria that produce insecticidal proteins known as the Cry delta-endotoxins which are selectively toxic to insect midgut epithelia. The insecticidal activity of different *Bt* strains is dependent on the type of *Bt* toxins that are produced by the different *Bt* strains. The lepidopteran-specific *Bt* toxins are designated as the CryI proteins. They are produced as large protoxins which are activated by midgut proteases to yield active toxins that penetrate the peritrophic membrane, and then bind to specific receptors on the gut membranes. The binding of *Bt* to specific receptors in the gut membrane catalyzes the insertion of the insecticidal protein into the membrane, leading to ion channel formation and insect larval death. Isolation and elucidation of the functional role of the *Bt* receptors in insect larvae has become an area of intense interest because the binding of the activated *Bt* toxin to specific receptor sites on the brush border membrane of midgut cells in insects is considered to be the key step in the pathogenic process of the insecticidal activity of *Bt*.

In the gypsy moth two distinct receptors for the CryIA delta-endotoxins of *Bt* have been identified: a 120 kDa aminopeptidase (APN) which is a specific receptor for CryIA(c), and a 210 kDa epithelial membrane molecule which recognizes CryIA(a) and CryIA(b). Protein sequence obtained from the purified APN is currently being used to isolate and clone the receptor of the gypsy moth. Isolation, cloning, and characterization of the gypsy moth receptors will lead to genetic mapping of the *Bt* toxin recognition and binding sites, and should facilitate the structure-based design of new and improved *Bt*-based biopesticides.

RESPONSE OF ASIAN AND NORTH AMERICAN GYPSY MOTH POPULATIONS TO A FOOD SHORTAGE

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ABSTRACT

Gypsy moth larvae from North America (Massachusetts, United States) and Asia (Bellyk, South Siberia, Russia) were reared on different amounts of leaves of birch (*Betula pendula*) in a laboratory in Krasnoyarsk, Russia. Starting at the molt to fourth instar, larvae were kept individually in petri dishes, weighed, and fed fresh leaf disks daily. There were four groups of larvae in each population and 50 to 70 larvae per group. The control group was fed disks ad libitum, and the average consumption rate (number of 1-cm dia. disks per mg body weight) was estimated for particular weight of larvae. The other groups received an amount of food to provide 70%, 50%, and 30% of the control consumption rate. The number and duration of instars, daily weight of larvae, weight of pupae and emerging moths, and span of forewings were recorded for each insect. Female moths were dissected within 24-36 hours of eclosion and the number of fully formed eggs with vivid chorion sculpture was determined. The data are based on 454 larvae, 343 pupae, and 215 male and 126 female moths from the two populations.

As the food shortage increased, Asian larvae of both sexes produced one additional instar. Starvation of larvae from N. America gave an inconsistent reaction, from a decrease of one instar to an increase of two instars. Food shortage caused mortality in both populations, mainly at the molt to the pupal stage. The level of mortality was: 0, 2, 12, and 49% for Asian and 2, 33, 46, and 62% for N. American populations under full, 70, 50, and 30% of the food supply, respectively. Although the starting weight of fourth instar N. American larvae was less than the Asian, N. American female moths that survived the treatments were heavier than their Asian counterparts. American females had a shorter forewing span, higher relative fecundity, and a higher moth/pupae live weight ratio. The rate at which the wing span, pupal and higher moth weight, and fecundity declined with the increasing food shortage was not different between the Asian and American populations.

The Asian population was more resistant to food shortage only in higher survival rates. Food shortage affected the adult weight and female fecundity of both populations equally. Regardless of the amount of food available, N. American female moths were heavier and invested more of the gains in biomass into fecundity instead of muscles and fuel for migration.

PEST RISK ASSESSMENT AND INTERNATIONAL FOREST RESOURCES

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ABSTRACT

A risk assessment procedure for evaluating pest introductions on unprocessed logs into the United States from Russia, New Zealand, Chile, and Mexico is described. This generic process has been used to identify potential serious pest risks and provide estimates of economic and ecological impacts.

To meet demands for fiber, U.S. timber companies have increased their intention to import unprocessed wood from offshore. Such importation presents the risk of introducing plant pests that are regulated by the USDA's Animal and Plant Health Inspection Service (APHIS). The complexity of the biological analysis of risks associated with this activity prompted APHIS to ask the USDA Forest Service to provide technical assistance. This has resulted in risk assessments for the importation of logs from Russia (1991), New Zealand (1992), Chile (1993), and, more recently, from Mexico. To provide permanent technical assistance to APHIS, the Chief of the Forest Service and administrator of APHIS chartered the Wood Import Pest Risk Assessment and Mitigation Evaluation Team (WIPRAMET).

It is difficult to determine whether an organism will become a pest if introduced inadvertently. Certainly, if the host plant genera in the native country are comparable to those of a potential receiving country, the pest should be considered a serious threat. However, even benign organisms in their native habitat can become pests when introduced into a new environment. To address this uncertainty, a generic risk assessment process was used that analyzes potential pest introductions based on a specific commodity or pathway (Orr *et al.* 1993). The process begins with literature surveys and the opinion of international entomologists and pathologists to select an initial list of potential pests. From this list, individual pest risk assessments are conducted for exemplars for those found in the pathways of, on or under bark, or in wood.

Each risk assessment is divided into two components: probability of establishment (composed of four elements), and consequences of establishment (three elements). Information used by the assessor(s) is organized under each element and succinctly describes the raw material and how it led the assessor(s) to make a risk judgment. This judgment may be qualitative, quantitative, or a combination of both. By using a rating system for each element of high, medium, or low, the assessor must justify each conclusion with analytical biological statements. Detailed biological statements for each element are crucial to peer reviewers because of their transparency.

These seven elements and their characteristics are as follows:

ASSESS PROBABILITY OF PEST ESTABLISHMENT

Pest With Host At Origin: Probability of temporal and spatial association with the pathway.

Entry Potential: Ability of the organism to be transported and survive transit.

Colonizing Potential: Ability of the organism to contact adequate hosts and reproduce in the new environment.

Spread Potential: Propensity of the organism to spread beyond the initial colonized area.

In all evaluations, the first element carries greater weight than the remaining three.

ASSESS CONSEQUENCES OF ESTABLISHMENT

Economic Damage Potential: Impact on forests, subsidiary industries, and control costs.

Environmental Damage Potential: Impact on biodiversity, ecosystem description, and effects of control measures.

Perceived Damage: Political and social impacts, including consumer and aesthetic influences.

Estimating overall risk entails assigning a value to each of the seven elements and then combining them into a final pest risk potential. Such evaluations serve as recommendations for APHIS to consider when making decisions on mitigation. In general, APHIS considers mitigatable those organisms with moderate to high risk potential.

Estimates of long-term economic impacts of forest pest introductions easily exceed $100 billion. Ecological impacts also are recognized but difficult to assess due to complex interactions. However, major shifts in global wood production and transport portend an escalation of pest risk assessment internationally. Researchers are encouraged to acknowledge the biological requisites of risk analyses and the crucial role they can play in view of expanding global trade.

LITERATURE CITED

Orr, L.; Cohen, S.D.; Griffen, R.L. 1993. Generic non-indigenous pest risk assessment process. USDA Animal and Plant Health Inspection Service, Planning and Risk Analysis, Systems Policy and Program Development, Washington, DC. 40 p.

A CASE STUDY OF MANAGING THE GYPSY MOTH USING SILVICULTURE:

SECONDARY MORTALITY AGENTS: *ARMILLARIA*

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ABSTRACT

Colonization of defoliation-weakened trees by *Armillaria* spp. (predominantly *A. gallica*) is a dominant cause of mortality in mixed-oak forests defoliated by the gypsy moth. The incidence of *Armillaria*-induced mortality may be related to the inoculum-potential (abundance and aggressiveness of rhizomorphs) of the fungus in the soil. Abundance of *Armillaria* rhizomorphs in the soil in cut and uncut stands was measured in 1989 at the time of initial cutting. It was remeasured in 1995, six growing seasons after the initial cut.

Three of the eight stands in each cutting regime were defoliated by the gypsy moth in 1990 and 1991. Abundance of rhizomorphs in the uncut stands in 1995 compared to 1989 decreased in all but one stand (a defoliated stand). Abundance of rhizomorphs in the thinned stands increased in four of the five undefoliated stands and one of the defoliated stands. In general, abundance in 1995 was proportional to abundance in 1989 regardless of whether there was an increase or decrease in 1995. Rhizomorph abundance in defoliated stands was generally reduced. In 1995 the abundance of rhizomorphs of a competitive decay fungus, *Megacollybia platyphylla*, was measured on all stands. In general, there was an negative relationship of the two fungi. When *Armillaria* abundance was high, *Megacollybia* was low and vice versa. No causal relationships can be inferred yet from this data.

FUNGAL-INDUCED COLLAPSE OF A LEADING EDGE GYPSY MOTH POPULATION IN SOUTHWESTERN VIRGINIA

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ABSTRACT

In 1995 and again in 1996, we monitored 10 woodlots near Lexington, VA, for the presence of gypsy moth nuclear polyhedrosis virus (NPV) and the fungus *Entomophaga maimaiga* Humber, Shimazu, & Soper (fungus). Gypsy moth (*Lymantria dispar* (L.)) populations in the woodlots varied from very sparse to high (potentially defoliating levels). NPV was strongly density dependent, being confirmed only from the woodlots with higher gypsy moth populations. In contrast, presence of the fungus was confirmed from gypsy moth cadavers found in woodlots containing very sparse (less than 1 life stage found per burlap band larval trap) gypsy moth populations. Monitoring was most intense in the 5 blocks with the highest gypsy moth populations, where, beginning in the early season, larvae were collected weekly, with those dying within 7 days of collection examined by light microscopy to identify cause of death. Beginning in mid-season, weekly counts were also made from burlap band larval traps. In 1995, perhaps due to (1) fewer inoculative resting spores from 1994, (2) weather events, and/or (3) earlier gypsy moth population development, the fungal epizootic developed late in the season, with most larvae succumbing during instars 5-6, producing primarily resting spores (azygospores). Estimated mortality due to fungus averaged 81% in high-density plots, and 84% in low-density plots. Due to the lateness of the fungal attack, NPV occurred in a normal two-wave epizootic, although second-wave NPV mortality was undoubtedly reduced because of loss of late-season caterpillars due to fungus. Estimated mortality due to NPV averaged 6% in high-density plots and <1% in low-density plots. In 1996, perhaps due to (1) the large number of overwintering resting spores produced in 1995, (2) weather events, and/or (3) somewhat later gypsy moth population development, high levels of fungal-induced mortality occurred earlier in the gypsy moth season than in the previous year. Most gypsy moth larvae died in a mid-season wave of fungal-induced mortality, with necropsied cadavers containing only conidia. This resulted in relatively few larvae surviving to late instars. At this time, a second, late-season, wave of fungus-induced mortality occurred, with over half of the necropsied cadavers now containing resting spores. The depletion of the gypsy moth population by the early appearance of the fungus apparently suppressed the second wave of NPV, which virtually disappeared from late-season larval collections from all plots.

RANGE SHIFTS IN GYPSY MOTH OUTBREAKS AND OAK FOREST DISTRIBUTIONS IN THE NORTHEASTERN UNITED STATES UNDER CLIMATE CHANGE

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ABSTRACT

Rising global temperatures over the next century resulting from the greenhouse effect may profoundly affect the distribution and abundance of insect populations. One general hypothesis is the poleward shift of species distributions. We investigated potential range shifts for *Lymantria dispar* in the northeastern United States under several climate change scenarios. We analyzed maps of historical outbreaks, climatic variables, and the distribution of oak-hickory and oak-pine forests in a geographic information system. We developed linear discriminant function models of the occurrence of defoliation as a function of climatic and forest type variables and of the distribution of oak forests as a function of climatic variables. Using the models, we extrapolated range changes in gypsy moth defoliation and oak forests under three temperature increases, 2°, 4°, and 6° C, and the projections of three general circulation models (GCMs).

The basic responses of both forest and defoliation distributions to rising temperature were increases in the areas projected as forested by oak and defoliated by gypsy moth. Oak forest was projected to occupy nearly 29% of the study area under ambient conditions and increased rapidly with higher temperatures, reaching 100% at +6° C. The pattern for defoliation was nearly identical. The oak forest and defoliation projections exhibited a northward shift with increasing temperature. Projections for the GCM scenarios were generally more extreme than those for simple temperature increases, reflecting their more extreme temperature changes. Projections of oak forest distribution varied among the GCM scenarios, ranging from 79-100%. Those for defoliation were uniform and extreme, with the entire study area predicted to be defoliated in all cases. To understand the patterns of change in the distribution of defoliation, one must consider that defoliation requires both a defoliator population and a forest population to be defoliated. It seems likely that the projected changes in defoliation reflect primarily the redistribution of oak forests under rising temperatures and that these changes are on a time scale of centuries.

GLOBAL CHANGE AND GYPSY MOTH-TREE INTERACTIONS: ARE CHANGES AHEAD?

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ABSTRACT

There is considerable interest in how the predicted rise in global atmospheric CO_2 concentration and temperature may affect terrestrial ecosystems. Research shows that coniferous and deciduous tree species respond to elevated CO_2 atmospheres with increases in biomass production and alterations in leaf phytochemical constituents. Observed reductions in leaf nitrogen content in tree leaves, along with increases in non-structural carbohydrates and carbon:nitrogen ratios, have the potential to affect folivorous insects which feed on trees. For example, because nitrogen is essential for insect growth and reproduction, we might expect elevated CO_2-induced reductions in leaf nitrogen to alter insect growth, consumption, and development. Because leaf feeding insects, especially forest pests, have substantial impacts on forest productivity, tree survival, and forest management practices, the role of both increasing global atmospheric CO_2 and temperature has important ramifications for future forest health. We present here a brief overview of research addressing how global change scenarios may alter various tree-forest pest interactions, giving particular attention to research with the gypsy moth.

Reductions in leaf nutritional quality have been documented for several tree species grown under CO_2 enrichment, including loblolly pine (*Pinus taeda* (L.)), white oak (*Quercus alba* (L.)), quaking aspen (*Populus tremuloides* (Mich.)), paper birch (*Betula papyrifera* (Marsh.)), and sugar maple (*Acer saccharum* (Marsh)). When insects are presented elevated CO_2-grown foliage of these species several responses have been observed. These include increased consumption of needle biomass to compensate for reduced nutritional quality of foliage (*Neodiprion lecontei* (Fitch) - *P. taeda*) and reductions of larval growth and prolonging of instar development (*Malacosoma disstria* (Hübner) - *P. tremuloides*). Studies investigating responses of the gypsy moth, *Lymantria dispar* (L.), to elevated CO_2-grown tree saplings have produced mixed results. While larvae fed quaking aspen leaves grown under CO_2 enrichment consume more foliage than those fed ambient CO_2-grown leaves, insects consuming either paper birch or sugar maple do not. Similarly, the growth of larvae declines on some host trees and increases or remains unchanged on others. Although one of the preferred host trees of the gypsy moth, white oak, does have CO_2-induced reductions in leaf quality, this does not adversely affect the growth or development of F_1 sterile larvae. Current research efforts suggest that larvae feeding at an elevated temperature consume more sugar maple foliage than those feeding at ambient temperature and that this response is independent of plant CO_2 growth concentration. More long-term experiments using natural insect populations over several generations are necessary to understand how potential changes in global CO_2 concentration and temperature may alter important host tree-gypsy moth interactions.

LITHUANIAN GYPSY MOTH POPULATION: FEMALE FLIGHT POTENTIAL

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ABSTRACT

The gypsy moth population in Lithuania was assumed to belong to the European race of *Lymantria dispar*, in which female moths do not fly. However, no one had ever questioned this assumption or checked for evidence of flight by females. In 1995, gypsy moth females were noticed on the beach along the seacoast, cast ashore by waves. The nearest birch trees could be found located within pine stands 200 m away from the coastline. The nearest forest edge was 60-80 m from the sea. We believe that the females must have been elevated above the canopy (15-20 m) to have been driven by wind.

We observed eclosion and subsequent behavior of female moths and found that if mating was not allowed for 1-3 days after emergence, 45.5 ± 5% of females were flying, 15.2 ± 6.2% were walking, and 39.4 ± 8.5% were waiting. After mating, 53.8 ± 9.8% of the females were flying before egg laying, 23.1 ± 8.3% were walking, and 23.1 ± 8.3% started laying eggs immediately. If normal mating (within 24 hrs) was allowed, only 14.3 ± 6.6% of the females were flying prior to mating, 46.4 ± 9.4% were walking, and 39.3 ± 9.2% were waiting. When mated within 24 hrs, 50.0 ± 11.2% of females started laying eggs immediately after mating, while 35.0 ± 10.7% were walking and only 15.0 ± 8.0% were flying.

INSECT PARASITES OF GYPSY MOTH IN LITHUANIA

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ABSTRACT

To determine the natural enemies (insect parasites) regulating gypsy moth populations in Lithuania in 1995 and 1996, we collected gypsy moth life stages during the periods of gypsy moth development. Twenty larvae or pupae were collected each week from each of eight plots (5 ha) within damaged areas. Larvae were reared separately on artificial diet under laboratory conditions until death or eclosion. The gypsy moth population at the sampling sites was declining (in a naturally ceasing outbreak) with a density of 831 ± 281 egg masses/ha in 1995 and 3 ± 1 egg masses/ha in 1996. Defoliation reported at these sites was <20% in 1995 and none in 1996. Host tree species were birch (*Betula* spp.) and alder (*Alnus* spp.).

Insect parasites killed 37.1 ± 0.9% of reared larvae. Mortality at different life stages was: L1 = 4.1 ± 1.0%, L2 = 20.1 ± 1.7%, L3 = 40.1 ± 1.7%, L4 = 40.2 ± 2.1%, L5 = 55.1 ± 2.4%, L6 = 74.9 ± 2.9%, pupae = 54.8 ± 7.7%.

The dominant species of gypsy moth parasites and their occurrence have been determined to be:

Parasetigena silvestris R.D. - 58.8%
Phobocampe disparis Vier - 25.4%
Meteorus pulchricornus Wes. - 5.4%
Blepharipa spp. - 2.8%
Apanteles melanoscelus Ratz. - 1.8%
Glyptapanteles liparidis Bon. - 1.1%
Rogas spp. - 0.5%
Sarcophagidae - 0.3%
Chaldidoidea (Hym.) - 0.3%
Palexorista spp. - 0.1%

STATUS OF GYPSY MOTH IN LITHUANIA

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ABSTRACT

Lithuania is reported to be the northern boundary of gypsy moth occurrence. The insect was found in southern and western parts of the country and cold temperatures causing egg death in winter are assumed to be the main limiting factor in northern spread.

The first historical record of a major gypsy moth outbreak in southern and western Lithuania was in 1854-56 (which was part of a 1852-58 outbreak extending from Germany and Poland to western Latvia). Outbreaks later took place in 1898-99 and 1908-09 and a small local outbreak was recorded in 1914. Historical records indicate that only spruce stands were damaged. Insufficient data exist for the period of 1930-45. After World War II, gypsy moth was recorded only in the birch stands of Kursiu Nerija – a relatively small area of narrow sand spit along the coast of the Baltic Sea. A severe outbreak occurred there in 1971-75 and 1992-95 (with heavy defoliation in some smaller areas in 1982-83). Control measures have been very limited because of the protected status of this particular territory. Surprisingly, a new outbreak was recorded in 1996 in the southwestern part of Lithuania, and 2,500 ha of mixed spruce-birch forest is predicted to be totally defoliated in 1997. Also, there are indications of a gypsy moth outbreak in the southwestern part of Latvia. Causes of these new outbreaks are unknown and no research is currently underway in these areas.

Gypsy moth populations have been encountered regularly since 1968, but they have been limited to sites of previous outbreaks. No country-wide monitoring of gypsy moth presence and/or abundance has ever been performed. No special research on gypsy moth in Lithuania had been carried out until 1994 when a two-year cooperative research project was launched with the USDA Forest Service. This project was targeted toward research on gypsy moth natural enemies – insect parasites and pathogens in a naturally declining outbreak area.

USDA Interagency Gypsy Moth Research Forum
January 14-17, 1997
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