RMA Science Accomplishments 2011-2015

Table of Contents

2015 RMA Science Accomplishments 2
Highlighted Findings and Accomplishments 2
Tools and Emerging Technologies 9
2014 RMA Science Accomplishments 13
Highlighted Findings and Accomplishments 13
Tools and Emerging Technologies 24
2013 RMA Science Accomplishments 26
Highlighted Findings and Accomplishments 26
Tools and Emerging Technologies 35
2012 RMA Science Accomplishments 37
Highlighted Findings and Accomplishments 37
Tools and Emerging Technologies 49
2011 RMA Science Accomplishments 50
Highlighted Findings and Accomplishments 50
Tools and Emerging Technologies 53
2010 RMA Science Accomplishments 55
Highlighted Findings and Accomplishments 55

Top of Document

2015 RMA Science Accomplishments

Highlighted Findings and Accomplishments

1. Seedlings of most tree species in California, Oregon and Washington have shifted towards areas colder than those occupied by mature trees.

Experimental forest

NA

Context and Reason

Global warming is predicted to cause systematic changes in the distribution of tree species. Those changes pose a major risk for conservation efforts, so determining whether they are currently occurring and estimating their magnitude is crucial for large-scale policy and management decisions. For trees, tracking the warming climate depends on seedling colonization of newly favorable areas. Thus, we compared the distribution of seedlings and mature trees for all but the rarest tree species in California, Oregon and Washington. Across all forestlands in the region, the mean annual temperature of the range of seedlings is 0.120°C colder than that of the range of mature trees. Individual species followed the same pattern, except for some species common in California mixed conifer forest. For most species, the estimated shift is less than the increase in temperature during the last decades, suggesting that tree migration may be lagging temperature increases.

Outcome

Examining changes in the geographic range can be misleading. Elevational and latitudinal range shifts run in opposite directions for the majority of the species, probably because those variables are not biologically meaningful. The broad scale, variety of disturbance regimes, exhaustive sampling of tree species, and direct relationship between temperature response and a warming climate, provide strong evidence to attribute the observed shifts to climate change.

Contact

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Partners

Oregon State University

Citations

Monleon, Vicente.J.; Lintz, Heather E. 2015. Evidence of tree species' range shifts in a complex landscape. Plos ONE 10(1): e0118069. http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0118069.

Top of Document

2. Proximity and amount of development affects forest structure, invasive plant abundance, and probability of management of remaining forested lands.

Experimental forest

NA

Context and Reason

Rural residential development in forests of Oregon and Washington continues to be a key driver of land use change. This type of development can have a variety of effects on the goods and services forests provide to the region. We used structure density from photo-interpreted points around forest inventory and analysis plots to examine differences in forest attributes with respect to varying development metrics. Our results demonstrate that forest ownership (public vs. private), structure density, and proximity of development are critical factors in explaining variation in forest attributes. Small-scale fragmentation, standing dead tree volume, coarse woody debris, and the propensity for introduced species are all affected by development close to the borders of public land. Differences in coarse woody debris, small scale fragmentation, and propensity for introduced species are also affected by the density and proximity of development on private ownership.

Outcome

There tended to be less standing and down dead wood, lower abundance of conifer trees, and fewer large trees with greater housing density and shorter distances to housing. Conversely, abundance of invasive plants and forest fragmentation increased with greater housing density and shorter distances to housing. Likelihood of forest management decreased with proximity to development on private lands, but the opposite was true on public lands.

Contact

Andrew Gray, agray01@fs.fed.us, Resource Monitoring & Assessment Program

Partners

Oregon State University

Citation

Azuma, David L.; Eskelson, Bianca N.I.; Thompson, Joel L.. 2014. Effects of rural residential development on forest communities in Oregon and Washington, USA. Forest Ecology and Management 330: 183-191.

3. A method to efficiently estimate and monitor species groups and carbon storage of moss and lichen layers in boreal and temperate forests was developed.

Top of Document

Context and Reason

Mat-forming ‘‘ground layers’’ of mosses and lichens often have functional impacts disproportionate to their biomass, and are responsible for sequestering one-third of the world’s terrestrial carbon as they regulate water tables, cool soils and inhibit microbial decomposition. Without reliable assessment tools, the potential effects of climate and land use changes on these functions remain unclear; therefore, we implemented a novel ‘‘Ground Layer Indicator’’ method as part of the Forest Inventory and Analysis (FIA) program. Non-destructive depth and cover measurements were used to estimate biomass, carbon and nitrogen content for nine moss and lichen functional groups among eight contrasted habitat types in the Pacific Northwest and boreal Alaska. Bootstrap resampling revealed that thirty-two microplots per site were adequate for meeting data quality objectives. Here we present a non-destructive, repeatable and efficient method (sampling time: ca. 60 min per site) for gauging ground layer functions and evaluating responses to ecosystem changes.

Outcome

Ground layer cover, volume, standing biomass, carbon content and functional group richness were greater in boreal forest and tundra habitats of Alaska compared to Oregon forest and steppe. Biomass of up to 22,769 kg/ha in upland black spruce forests was nearly double other reports, likely because our method included viable, non-photosynthetic tissues. Functional group richness was greatest in lowland black spruce forests. High biomass and functional distinctiveness in Alaskan ground layers highlight the need for increased attention to currently under-sampled boreal and arctic regions, which are projected to be among the most active responders to climate change.

Contact

Sarah Jovan, sjovan@fs.fed.us, Resource Monitoring & Assessment Program

Partners

Oregon State University

Citations

Smith, Robert; Benavides, Juan; Jovan, Sarah; Amacher, Michael; McCune, Bruce. 2015. A rapid method for landscape assessment of carbon storage and ecosystem function in moss and lichen ground layers. The Bryologist 118: 32-45.

4. Opportunities for improving the reliability and precision of equations used to estimate regional tree biomass and carbon were identified

Experimental forest

Top of Document

NA

Context and Reason

Accurate biomass measurements and analyses are critical components in quantifying carbon stocks and sequestration rates, assessing potential impacts due to climate change, locating bio-energy processing plants, and mapping and planning fuel treatments. To this end, biomass equations will remain a key component of future carbon measurements and estimation. As researchers in biomass and carbon estimation, we review the present scenario of aboveground biomass estimation, focusing particularly on estimation using tree-level models and identify some cautionary points that we believe will improve the accuracy of biomass and carbon estimates to meet societal needs. In addition, we discuss the critical challenges in developing or calibrating tree biomass models and opportunities for improved biomass. Some of the opportunities to improve biomass estimates include integration of taper and other attributes and combining different data sources. Biomass estimation is a complex process, and when possible, we should make use of already available resources such as wood density and forest inventory databases.

Outcome

Developing nationally-consistent methods for defining, measuring, and calculating biomass components, and for sampling trees across the full range of forest conditions will be improve the reliability and application of biomass and carbon estimation. A focus on collecting new data that merges tree taper and biomass sampling, and includes estimates of belowground (root) biomass, is recommended.

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Citation

Temesgen, Hailemariam; Affleck, David; Poudel, Krishna; Gray, Andrew N.; Sessions, John. 2015. A review of the challenges and opportunities in estimating above ground forest biomass using tree-level models. Scandinavian Journal of Forest Research. 30: 326-335.

5. Efficient indices to monitor changes in air pollution and climate using lichens developed for the northeastern USA.

Context and reason

Top of Document

Lichens have a long history as strong indicators of air quality and have also been used as indicators for forest response to other environmental factors such as climate. We developed indices for lichen response to climate and air quality in forests across the northeastern U.S., using 218–250 plot surveys with 145–161 macrolichen taxa from the Forest Inventory and Analysis (FIA) Program. Lichen indicator species for response to climate and air quality were selected using Indicator Species Analysis, correlations with environmental variables, and published literature. Ordinations were used to evaluate the strength and relationships of the final indices. The Pollution Index was correlated with modeled deposition of acidifying sulfur and oxidized nitrogen and with lichen community ordination pollution axes. The Climate Index was correlated with minimum January and annual maximum temperatures. The two indices are statistically independent.

Outcome

Repeat sample variability for each index was 7– 14.5%, supporting detection of consistent trends of 16–20% change over time or variation across space. The continuous gradient of Pollution Index values suggests that even the cleanest areas in the northeast may have air pollution that exceeds levels above the critical threshold to fully protect lichen communities.

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Sarah Jovan, sjovan@fs.fed.us, Resource Monitoring & Assessment Program

Partners

USDA Forest Service Northern Research Station, USDI National Park Service, University of Wisconsin, Pennsylvania State University

Citations

Will-Wolf, Susan; Jovan, Sarah; Neitlich, Peter; Peck, Jerilynn; and Rosentreter, Roger. 2015. Lichen-based indices to quantify responses to climate and air pollution across the northeastern USA. The Bryologist 118: 59-82.

6. Trends in California's wood utilization include an 18% decline in timber harvest since 2006; 83% of the 2012 harvest came from private lands; and over half of the wood fiber harvested was used to generate energy (heat for steam or electricity).

Context and reason

The Forest Inventory and Analysis program includes regular production of statewide assessments of timber products outputs. These studies trace the flow of a state's timber harvest through the primary wood products industry and provide a description of the structure, condition, and economic impacts of

Top of Document

the forest products sector. Historical trends in forest products industry, harvest, production, mill residue, and sales are discussed.

Outcome

Station staff collaborated with economists to produce an updated report of California's 2012 timber harvest. The report summarizes the most recent information on California's timber utilization and the conditions, structure, and operations of the state's primary forest products industry.

Used to inform policy?

This research can help land managers, policymakers, and the forest products industry to make informed decisions that have broad implications for the future. This report is the third such study of California's timber harvest and forest products industry since 2000, providing important historical context for future policy decisions.

Contact: Glenn Christensen, gchristensen@fs.fed.us

Partners: University of Montana's Bureau of Business and Economic Research

Citations: McIver, Chelsea P.; Meek, Joshua P.; Scudder, Micah G.; Sorenson, Colin B.; Morgan, Todd A.; Christensen, Glenn A. 2015. California's forest products industry and timber harvest, 2013. Gen. Tech. Rep. PNW-GTR-908. Portland, OR: US Department of Agriculture, Forest Service, Pacific Northwest Research Station. 49 p.

7. Key Finding: Landsat and airborne LiDAR data used to assess fire effects on forest spatial structure in Yosemite National Park.

Context and Reason

Mosaics of tree clumps and openings are characteristic of forests dominated by frequent, low- and moderate severity fires. When restoring these fire-suppressed forests, managers often try to reproduce these structures to increase ecosystem resilience. We examined unburned and burned forest structures for 1937 0.81 ha sample areas in Yosemite National Park, USA. We estimated severity for fires from 1984 to 2010 using the Landsat derived Relativized differenced Normalized Burn Ratio (RdNBR) and measured openings and canopy clumps in five height strata using airborne LiDAR data. We found three spatial structures, canopy-gap, clump-open, and open, that differed in spatial arrangement and proportion of canopy and openings. As fire severity increased, the total area in canopy decreased while the number of clumps increased, creating a patchwork of openings and multistory tree clumps. Low- to moderate-severity fires best replicated the historic clump-opening patterns that were common in forests with frequent fire regimes.

Outcome

Top of Document

Our results suggest that managers consider the following goals for their forest restoration: 1) reduce total canopy cover by breaking up large contiguous areas into clumps and large trees; 2) create a range of opening sizes and shapes, 3) create multistory clumps in addition to single story clumps; 4) retain historic densities of large trees; and 5) vary treatments to include canopy-gap, clump-open, and open mosaics across project areas to mimic the range of patterns found for each forest type in our study.

Used to inform policy?

This research can help to guide restoration activities designed to increase the resilience of forest ecosystems.

Contact: Robert J. McGaughey, rjmcgaughey@fs.fed.us, Resource Monitoring & Assessment Program

Partners: University of Washington

Citations

Kane, Van R, M. North, J. Lutz, D. Churchill; S. Roberts, D. Smith, R.J. McGaughey, J. Kane, M. Brooks. Assessing fire effects on forest spatial structure using a fusion of Landsat and airborne LiDAR data in Yosemite National Park. Remote Sensing of Environment. 151: 89-101.

8. A Landsat time series and change visualization tool (TimeSync) used to derive independent estimates of forest change and assess the quality of change maps derived from remote sensing.

Experimental forest: NA

Context and Reason

Forests are constantly changing, whether due to new disturbances, post-disturbance succession, or land use change. While inventory plot data can be used to characterize forest change, the field revisit time can vary from five to 10+ years and direct change observations using a consistent approach nationally is a recent inventory implementation. Although many forest changes (e.g., clear cuts, severe fires) have a lasting impact, detectable on the ground several years after they occur, many changes are subtle and gradual (forest decline) and difficult to detect at intervals in the field. Additionally, start and end dates for all changes are undetectable when evaluated at intervals. Landsat time series augmented with high-spatial resolution temporal snapshots from Google Earth, via TimeSync, enable highly accurate detections and characterizations of change agent (e.g., fire, harvest, etc.) at an annual or greater resolution at 30 m spatial resolution. The average cost per Landsat plot is well under ½-hour for one person.

Outcome

Top of Document

TimeSync was used to assess the quality (QA) of Landsat-based annual disturbance maps for the Northwest Forest Plan Effectiveness Monitoring Program (R6) for both the 15- and 20-year reports. It was also used to QA a national-level map of forest disturbance for a NASA-funded study (to University of Maryland) that was part of the North American Carbon Program.

Used to inform policy?

This research is being used by several land management agencies (USFS, USGS, EPA) to guide restoration and monitoring activities.

Contact: Warren Cohen, wcohen@fs.fed.us, Resource Monitoring & Assessment Program

Partners: Oregon State University, USFS Region 6, NASA, University of Maryland, USGS Earth Resources Observation and Science (EROS) Center, SilvaCarbon, EPA

Citations

Cohen, W.B., Z. Yang, and R.E. Kennedy. 2010. Detecting trends in forest disturbance and recovery using yearly Landsat time series: 2. TimeSync - Tools for calibration and validation, *Remote Sensing of Environment* 114:2911-2924.

Cohen, W.B., Z. Yang, S.V. Stehman, T.A. Schroeder, D.M. Bell, J.G. Masek, C. Huang, G.W. Meigs. In review. Forest disturbance in the conterminous US from 1985-2012: The emerging dominance of forest decline. *Forest Ecology and Management*.

Tools and Emerging Technologies

1. Update to FUSION/LDV LiDAR processing and visualization software (version 3.50)

Context and reason: The Vegetation Monitoring and Remote Sensing team (VMaRS) has been involved in the development of tools to assess the overall quality of LiDAR data, process LiDAR data to produce basic information, and use LiDAR data to model vegetation structure over large areas for nearly a decade. The team's FUSION/LDV software is used worldwide in research, academia, and industry. This release includes several maintenance items along with a new tool to compute topographic metrics using bare-earth surface models. The new tool computes basic metrics describing the terrain shape and orientation along with a topographic position index (TPI) that compares local and surrounding topography. When computed using large window sizes, this index informs analyses of landform shape and position and has proven useful when looking at factors influencing overall vegetation patterns across a landscape and assessing things such as moisture-related stress or solar input into riparian areas. When small windows sizes are considered, the index helps identify local topographic features that influence vegetation patterns or serve as resting sites for animals**.**

Top of Document

Outcome: The FUSION/LDA software continues to be used to analyze data from large LiDAR acquisitions. In addition, the software is used in several universities to teach the basics of LiDAR and to help students understand how LiDAR can be used in the forestry context.

How to get it: FUSION/LDA software is free and available online at http://forsys.cfr.washington.edu/fusion/fusionlatest.html.

Contact: Robert J. McGaughey, rjmcgaughey@fs.fed.us, Resource Monitoring & Assessment Program

2. LiDAR data products for the Rim and King fires in California

Context and reason: In the last five years, unusually large fires-- those fires that exceed the size and severity normal for a region --have become more frequent across the western United States. Because of their historically rare nature and different behavior from other, more typical, fires information regarding drivers and their relationship to forest management practices has been limited. One approach to characterize fire spread and fire severity uses satellite remote sensing, but this is limited in spatial and spectral resolution. In August 2013, the Rim fire burned over 104,000 hectares in Yosemite National Park and the Stanislaus National Forest and in September and October 2014 the King Fire burned over 39,000 hectares on the Eldorado National Forest.

Use: Scientific interest in these two fires is high and an organized data set is useful to ensure that any studies of pre- and post-fire conditions and their relationships to fire behavior and severity are comparable. The three data sets are: (1) hyperspectral Airborne Visible/Infrared Imaging Spectrometer (AVIRIS), (2) MODIS/ASTER Airborne Simulator (MASTER), and (3) high resolution (~1m) LiDAR. Coverage for the pre-fire conditions varies but post-fire data products cover the entire burned area for both fires.

How to get it: Pre- and post-fire data products from three airborne campaigns focused on the Rim and King fires were developed and are hosted on a web site managed by the Jet Propulsion Laboratory.

Data portal: http://wildfire.jpl.nasa.gov/

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Partners

University of Washington, Cal Tech/JPL, University of California-Irvine, Utah State Univ, PSW Research Station

3. Tablet-based field data collection system for carbon monitoring

Context and reason: To increase the efficiency of data collection and management, PNW-RMA scientists have developed an iPad-based field data collection system and are testing it on 300 plots

Top of Document

distributed throughout the United States. The data collected on field plots is uploaded (wirelessly) to a server and the main plot database is updated on a daily basis, allowing for data quality checking and feedback to crews on a near-real-time basis. Although this system is currently only used in a research setting, it may provide insights into how tablet devices and cloud storage can be used to increase the efficiency of both research and production inventory applications.

Use: The products developed from this study could help to inform and improve the efficiency of larger field data collection programs, such as FIA, in the future. Although there will be challenges to implementing this system on a large (FIA) scale, the benefits of managing data "in the cloud" (including near-real-time quality assessment) could increase the quality and timeliness of inventory database delivery in the future.

Contact: Hans-Erik Andersen

Partners: University of Washington, Cirrus North, Inc.

4. Updated PNW-FIA database user tools (PNW-FIADB)

Description: This updated set of user-friendly tools now includes data from California, Oregon, Washington, Alaska, and U.S.-affiliated Pacific Island groups. Additional features include remeasurement data from FIA plots sampled from 2001-2014, an expanded set of summary tables, and greater customization for specific users. This tool integrates a full public FIA database with documentation using a simple interface allowing users to begin working with complex FIA data to answer meaningful forest resource questions.

Use: The annually updated PNW-FIA database user tools (PNW-FIADB) are made publicly available for use by any public or private entity through the RMA website or on digital media by request. Workshops are available for those interested in learning more about the database and FIA data in general. An online tutorial based on the workshop is in development.

Distribution: Existing clients and known users are alerted via email; website updates are posted.

How to get it: Downloadable from RMA website; request a copy on CD or other digital media via RMA website, brochures, and outreach materials with FIA contact information.

Contact: Karen Waddell, Joel Thompson

5. Updated DecAID (Decayed Wood Advisor) tool

Description: DecAID is a publicly available online tool that can be used by land managers to help identify snag diameter and density (numbers of snags per hectare or acre), and down wood diameter and

Top of Document

percent cover, that pertain to wildlife usage. Users can incorporate this information into stand growth and harvest simulators, such as the Forest Vegetation Simulator (FVS), to predict snag and down wood numbers or to determine what numbers would be provided under management scenarios, and relate those outcomes to levels of wildlife use.

Use: RMA staff collaborated with Station scientists and Region 6 staff to update this widely-used advisory tool that helps managers evaluate the effects of forest conditions and proposed management activities on wildlife that use snags, down wood, or other wood decay elements. The tool was updated to include data through 2014 and additional functionality is being added. DecAID is a statistical summary of published research data on wildlife and forest inventory data, and of professional knowledge on fungi, insects, and pathogens. It is not a "model" in the sense of mathematically extrapolating or simulating wildlife use of wood decay elements. It uses actual field data, summarized by using conventional statistical methods.

Distribution: Existing clients and known users are alerted via email; website updates are posted; found through online search engines.

How to get it: Online interface through Region 6 website.

Contact: Karen Waddell

Top of Document

2014 RMA Science Accomplishments

Highlighted Findings and Accomplishments

1 Forest stress linked to climate change

Context

Climate change, including increased temperature and decreased precipitation, is expected to have profound effects on forest stress (loss of vigor and leaf area and increased mortality from drought, insects, and disease), a key indicator of forest health. Individual studies for specific geographical regions and key affected species have already demonstrated the link between changes in temperature and precipitation, but there has not been a study that systematically examines these linkages across regions and species using a single set of methods, until now. Landsat satellite annual time series data from 1984-2012 were used to characterize forest change by disturbance agent type, including forest stress. The data were visually interpreted using a newly developed tool, TimeSync, across 7,200 plots distributed throughout the conterminous U.S. A probability sample design permitted an unbiased statistical estimate (with sample error bounds) by disturbance agent, per year, to be plotted across time. Regional differences were evident, but nationally, forest stress dramatically increased between the late 1980s and the early 2000s, declining somewhat in the mid-late 2000s. Seeking a linkage to climate, we plotted annual average summer temperatures and precipitation amounts against estimated annual forest stress. Results indicate exceptionally high correlation between stress and both increased temperatures and decreasing precipitation.

Outcome

Results provide evidence to inform forest policy makers and managers about direct connections between forest health and climate change. There is now ample motivation of the need to monitor forest stress in near real time with Landsat-based remote sensing to (1) determine where and when remedial silvicultural prescriptions should be prioritized, and (2) to help set realistic expectations of climate change effects on forest health and to adapt forest policy accordingly. Modeling the effects of climate change on forest structure and function, in the context of national efforts such as the North American Carbon Program can now be more grounded in national level observations.

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Partners

NASA, Rocky Mountain Research Station, University of Maryland

Citations

Top of Document

Manuscript in preparation.

2 Small gains in forest carbon seen in PNW forests as effects of tree growth and afforestation were offset by fire, insects, cutting, and deforestation.

Experimental forest

NA

Context and Reason

A substantial portion of the carbon (C) emitted by human activity is apparently being stored in forest ecosystems in the Northern Hemisphere, but the magnitude and cause are not precisely understood. The goal of these studies was to directly track changes in forest C using repeated inventory measurements of nonfederal lands in Oregon, and of National Forests in Oregon and Washington. Although net area of forestland increased in Oregon, the net effect on C was a decrease because forest gains in low-C juniper forests were offset by losses in high-C Douglas-fir forests. On nonfederal lands, C decreased significantly in eastern Oregon due to the effect of western spruce budworm, but increased significantly in western Oregon due to growth on nonfederal public lands. On national forest lands, C increases were higher on the west side of the Cascades, and primarily stayed in the live tree pool, compared to lower increases on the east side, where most of the increase was seen in the down wood pool. C stores decreased somewhat in east-side Wilderness areas from the effect of fires.

Outcome

The small impact of recent fires on carbon storage in national forests suggests fires may not be a cause for concern, although investigation of longer term effects is warranted. Better understanding of the magnitude of effects of land-use change, management, and disturbance on carbon storage from repeated inventory measurements will improve our ability to predict the effects of future changes in those drivers.

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Partners

USDA Forest Service Forest Pacific Northwest Region (NFS Region 6), Oregon State University

Citations

Top of Document

Gray, Andrew N., Thomas R. Whittier, and David L. Azuma. 2014. Regional estimation of forest carbon flux: adding components of change to stock-difference assessments. Forest Science 60: 317-326. http://dx.doi.org/10.5849/forsci.12-139

Gray, Andrew N., and Thomas R. Whittier. 2014. Carbon stocks and changes on Pacific Northwest national forests and the role of disturbance, management, and growth. Forest Ecology and Management 328: 167-178. http://dx.doi.org/10.1016/j.foreco.2014.05.015

3. Increasing development near public forest lands in Washington and Oregon has implications for public land management and fire suppression

Experimental forest

NA

Context and Reason

Development owing to population increases over the last 30 years has greatly affected forested lands in the United States. To assess and compare increases in development, we counted changes in the number of structures on a systematic grid of photo-interpreted points around public forest land in Washington and Oregon. Areas bordering public forest land are showing substantial increases in development, with the number of structures on private lands near almost all types of public forest more than doubling between the 1970s and 2000s. Lands bordering Washington's Department of Natural Resources lands have more than twice as many new structures along their edges compared to other public owners. In Oregon, the greatest amount of development occurred along the edges of Bureau of Land Management forests. The greatest increases in structure density along the borders of public forests occurred in Pierce, King, Snohomish, and Clark Counties in Washington, and Deschutes County in Oregon.

Outcome

The continuing development pressure along the edges of public forests in Washington and Oregon has numerous consequences, including increased road density with more human-caused ignition of wildfire, higher probability for invasive species, greater demand for local recreation, higher fire suppression costs, and increased complexity for managers trying to reduce wildfire hazard through fuel treatments.

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Oregon Department of Forestry

Citation

Top of Document

Azuma, D., Thompson, J., Weyermann, D., 2013. Changes in development near public forest lands in Oregon and Washington 1974-2005: implications for management. Research Paper PNW-RP-596. USDA Forest Service Pacific Northwest Research Station, Portland, Oregon, 21 p. http://www.treesearch.fs.fed.us/pubs/45205

4. To estimate forest attributes in small areas, composite methods that incorporate information from both the area of interest and the entire population perform better than traditional estimators.

Context and Reason

One of the challenges often faced in forest inventory is the estimation of forest attributes for smaller areas of interest within a larger population. Small-area estimation is a set of techniques to estimate forest attributes for small areas in which the existing sample size is small and auxiliary information is available. They combine information from direct estimation, using the available plots, and indirect estimation, based on predictions from regional models. We compare the performance of two families of small area estimators with that of the direct estimator, multiple regression, and imputation, both for stand-level prediction and regional prediction. The predicted variables were total stem volume, basal area, quadratic mean diameter, tree density and height of the dominant trees.

Outcome

In general, the composite estimators performed better than the indirect estimators in terms of bias, and better than the direct estimators in terms of precision. However, there was not a clear best performer across all variables. The choice of estimator should be evaluated for each particular case, depending on the variable of interest and the available auxiliary information.

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Partners

Oregon State University

Citations

Goerndt, M.E., Monleon, V.J., Temesgen, H. 2011. Using small area estimation and LiDAR-derived auxiliary variables to estimate attributes for selected forests stands. Canadian Journal of Forest Research 41: 1189-1201.http://www.treesearch.fs.fed.us/pubs/46164

Goerndt, M.E., Monleon, V.J., and Temesgen, H. 2013. Small area estimation of county-level forest attributes using ground data and remote sensed auxiliary information. Forest Science 59: 536-548. http://www.ingentaconnect.com/content/saf/fs/2013/00000059/00000005/art00004

Top of Document

5. Nitrogen in lichen tissues closely correlates with measured nitrogen (N) deposition in forests near natural gas wells in the Bridger Wilderness, WY

Experimental forest

NA

Context and Reason

Using lichens to assess air quality on public lands is increasingly common, serving as a budget-friendly supplement to widely spaced monitoring networks like NADP and IMPROVE. Two common epiphytic lichen species, *Letharia vulpina* and *Usnea lapponica*, were collected from the Bridger Wilderness < 30 km from a concentration of active oil and gas wells in Sublette County, WY. Lichens accumulate nutrients, like N, in excess of metabolic needs, making tissue levels a reflection of atmospheric N levels. The main objectives were to calibrate N levels in lichen with co-located N measurements and determine the extent of N dispersal into the wilderness. Overall N levels were relatively low (0.9 Kg N ha^{-1} yr^{-1} to 4.1 Kg ha^{-1} yr^{-1}) although visual signs of damage to lichens were seen at the highest deposition sites. Nitrogen in lichens and in throughfall deposition were highly correlated (R^2 = 0.91 for *L. vulpina, 0.78* for *U. lapponica*), demonstrating that tissue indicators are a simple, accurate tool for N monitoring.

Outcome

The Clean Air Act mandates that federal land managers protect air quality related values for Federal Class I parks and wilderness; this involves assessing the impact of new pollution sources and reporting to local regulators. At present, all FS regions except R2 and R8 use lichen tissue-based indicators in some way to inform management decisions. This study was the first to validate use of lichen tissue indicators for dry interior forests and for detecting low level N inputs from oil and gas operations.

Contact

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Partners

Forest Inventory and Analysis -Interior West Region, Montana State University, USFS Pacific Southwest Research Station, FS region 6 Air Resource Management Program.

Citation

McMurray, J.A.; Roberts, D.W.; Fenn, M.E.; Geiser, L.H.; Jovan, S. 2013. Using Epiphytic Lichens to Monitor Nitrogen Deposition Near Natural Gas Drilling Operations in the Wind River Range, WY, USA. Water Air and Soil Pollution. 224: 1487. http://www.treesearch.fs.fed.us/pubs/44538

Top of Document

6. In Douglas-fir and true-fir dominated dry mixed-conifer forests of the northwest, implementing selective harvest and surface fuel treatments generates greater climate benefits than no treatment, when accounting for in- and out-of-forest effects on greenhouse gases.

Context and reason

Some recent studies have suggested that fuel treatments compromise the climate benefits of forests by reducing carbon sequestration and by generating greater net greenhouse gas emissions than would forgoing management. Were this conclusion accurate, then the forest restoration efforts beginning to take place on federal lands could be construed as counterproductive to mitigating climate change. We tested this premise empirically by applying, in the Forest Vegetation Simulator, the silvicultural prescriptions typically used by foresters seeking to restore forest health. Thirteen different prescriptions were applied to several hundred forest inventory and analysis plots that comprise a statistically representative sample of current conditions in Douglas-fir and true-fir forests in the northwestern U.S., and the resulting forest stands projected forward for 32 years under four scenarios: no wildfires, and one wildfire at one of three times since treatment: 1, 16 or 32 years.

Outcome

Over this short period, absent wildfire, treatments did not produce net climate benefits. However, with fire return intervals of 20 or 50 years, implementing the most effective treatments generated considerable climate benefits when considering carbon stored in the forest, carbon in forest products and landfills, and substitution benefits from the use of wood and woody biomass generated energy, refuting the premise that forest restoration increases greenhouse gas emissions. On about half of the forest area where treatment would be effective, sales of merchantable and energy wood could more than offset the costs of implementing treatments, provided prescriptions were not restricted by arbitrary limits on the size of trees that can be harvested in the course of implementing effective treatments.

Contact

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Partners

USDA Forest Service Rocky Mountain Research Station, University of Montana, Humboldt State University

Citations

Fried, J.S., Jain, T.B., Sandquist, J., 2013. Modeled forest inventory data suggest climate benefits from fuels management. Fire Management Today 73, 2: 11-14.
http://www.fs.fed.us/fire/fmt/volumes_authors.html

Top of Document

Jain, Theresa B.; Battaglia, Mike A.; Han, Han-Sup; Graham, Russell T.; Keyes, Christopher R.; Fried, Jeremy S.; Sandquist, Jonathan E. 2014. A comprehensive guide to fuel management practices for dry mixed conifer forests in the northwestern United States: Inventory and model-based economic analysis of mechanical fuel treatments. Res. Note RMRS-RN-64. Ft. Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. http://www.treesearch.fs.fed.us/pubs/45661.

7. Guidelines created for monitoring wildlife habitat using vegetation composition and structure attributes

Context

Information about the status and trend of wildlife habitat is important to the USDA Forest Service to accomplish its mission and meet legal requirements. Vegetation composition and structure are key components of wildlife habitat and are, therefore, essential components of all wildlife habitat monitoring. The objectives of this chapter are to describe common habitat attributes derived from vegetation composition and structure and to provide guidance for obtaining and using existing and new vegetation data to monitor wildlife habitat. We begin this chapter by addressing key concepts relevant to monitoring vegetation. Next, we describe each of the common habitat attributes associated with vegetation composition and structure and how they are measured or derived using field-sampled and remotely sensed data. We also describe sources of existing data, as well as methods for obtaining new data using established protocols. The chapter concludes with a call for standardization and consistency in habitat monitoring efforts.

Outcome

The target audience for this guide is professionals charged with forest planning, project impact analysis, and habitat monitoring at the ranger district, national forest or grassland, and regional levels. It represents the best available science from a broad base of published literature and from the expertise of co-authors.

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Partners

Rocky Mountain Research Station, Northern Research Station, National Forest System, Remote Sensing Applications Center, and State and Private Forestry

Citation

DeMeo, T.E.; Manning, M.M.; Rowland, M.M.; Vojta, C.D.; McKelvey, K.S.; Brewer, C.K.; Kennedy, R.S.H.; Maus, P.A.; Schulz, B.; Westfall, J.A.; Mersmann, T.J. 2013. Chapter 4. Monitoring Vegetation

Top of Document

Composition and Structure as Habitat Attributes. In: Rowland, M.M.; Vojta, C.D. (Eds.), A technical guide for monitoring wildlife habitat. General Technical Report WO-89. USDA Forest Service, Washington DC, p. 64. http://www.treesearch.fs.fed.us/pubs/45217

8. LiDAR-derived information products can be used to evaluate habitat characteristics for individual species over large land areas at high spatial resolutions.

Context and Reason

The red-cockaded woodpecker (RCW) is a federally endangered forest-dwelling species that occupies a narrow ecological niche in southern pine forests. The RCW recovery plan, developed by the U.S. Fish and Wildlife Service (USFWS), describes specific habitat requirements to sustain existing populations and facilitate population expansion. Habitat quality is evaluated using criteria that involve tree species, size, and stocking; groundcover and understory characteristics; and spatial considerations. Current efforts to characterize habitat involve the installation and measurement of field plots using a protocol specific to RCW management. LiDAR can be used to describe vegetation structure and spatial arrangement across large land areas while maintaining high spatial resolution. For the RCW habitat evaluation, LiDAR data were combined with data measured on forest inventory plots to develop layers describing specific attributes for softwood and hardwood vegetation. Unique to this study was the use of LiDAR to describe the attributes of specific size classes of trees. This allowed evaluation of habitat conditions using the guidelines specified in the RCW recovery plan.

Outcome

This work provides an example of how LiDAR data can be used to generate high-resolution information products to support the evaluation of habitat requirements for individual species. This work is being monitored by the USFWS as an alternative to the plot-based methods currently used to assess and report RCW habitat conditions.

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Savannah River Site (operated by the Department of Energy, forest land managed by USFS), North Carolina State University, Southern Research Station

Citation

Garabedian, James E.; McGaughey, Robert; Reutebuch, Stephen E.; Parresol, Bernard R.; Kilgo, John C.; Moorman, Christopher E.; and Peterson, M. Nils. 2014. Quantitative analysis of woodpecker habitat

Top of Document

using high-resolution airborne LiDAR estimates of forest structure and composition. Remote Sensing of Environment. 145:68-80.

9. Changing forestland definition will increase estimates of forestland area in marginal types on the west coast and require adjustments to individual plot status to assess change over time

Experimental forest

NA

Context and Reason

A key function of forest inventory is to detect changes in the area of forest land over time, yet different definitions of forest land are used in different regions of the world. Changes in the definition of forest intended to improve international consistency can affect the ability to quantify true changes over time. The objective of this study was to evaluate the effects of a definitional change from relative stocking to canopy cover on the area classified as forest land and its relationship to species and forest density in California, Oregon, and Washington. Both western juniper and ponderosa pine forest types will have higher estimates of forest land area using a canopy cover definition in comparison to a stocking-based definition, with the difference being most pronounced where land is marginally forested.

Outcome

The change in definition may result in an additional 146,000 ha of forest land identified on the West Coast. Measuring marginal forest lands with both metrics for the first cycle after implementation should make it possible to distinguish real change from definitional change, but will require reclassifying older plot measurements using the new definition.

Contact

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Partners

NA

Citation

Azuma, D.L., Gray, A.N., 2014. Effects of changing forest land definitions on forest inventory on the West Coast, USA. Environmental Monitoring and Assessment 186: 1001-1007. http://link.springer.com/article/10.1007/s10661-013-3434-6

10. LiDAR-based, accurate and precise assessment of sunlight illumination in forested landscapes

Top of Document

Experimental Forest:

NA

Context and reason

Sunlight controls major ecological processes, but its ephemeral nature due to diurnal and seasonal cycles, lack of spatial continuity, and challenges in describing terrain and vegetation with sufficient detail, inhibit its accurate assessment. Innovative analyses, specially developed software, and high-density, airborne, LiDAR data have overcome the aforementioned limitations allowing unbiased and precise assessment of sunlight illumination. The tools developed have various potential applications including contributions to forest growth and yield models, assessment of regeneration potential, and in support of management and tactical decision making. Of particular interest is the assessment of shading regimes in riparian areas known to influence stream temperature and fisheries habitat. Owing to this research we can now quantify the impact to shading conditions of future disturbances or future anthropogenic interventions. We can also identify the landscape elements responsible for providing shade to specific locations of interest and generate summaries over user-specified time periods.

Outcome

Mean growth season illumination indices have been computed for several stream reaches in Deschutes, Ochoco, and Malheur NFs. Assessment of correlation between riparian zone illumination and recorded stream temperatures is ongoing. Region 6 hydrologists and ecologists will be using developed tools to determine a variable width buffer around fish-bearing streams where forest thinning of pre-specified intensity will not reduce shading below an *apriori* set threshold.

Contact

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Partners

BLM of Oregon and Washington, Forest Service Region 6, Willamette, Ochoco, Malheur, and Siuslaw NFs.

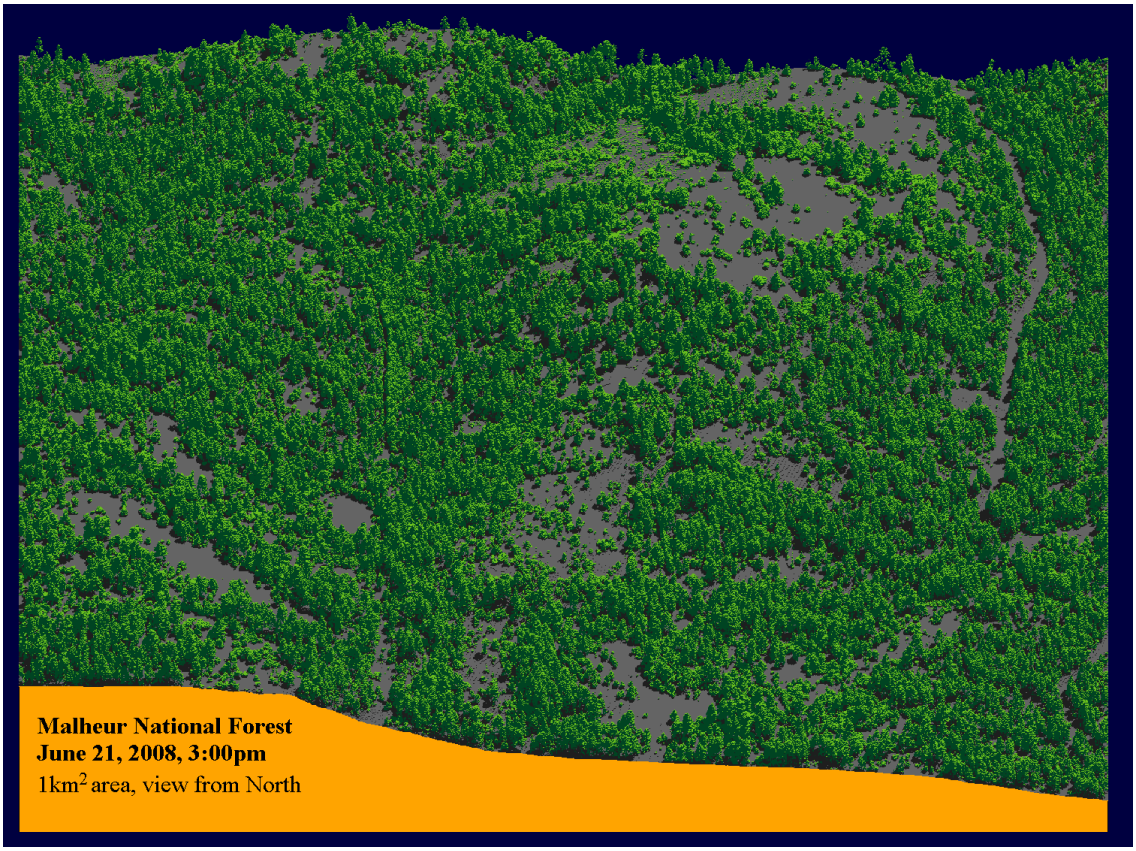
Citation

Dynamic, LiDAR-based assessment of lighting conditions in Pacific Northwest forests. In Proceedings of Silvilaser 2012 - The 12th International Conference 'First return', Coops, N., Wulder, M. (Eds.), 16-19 September ,Vancouver, Canada.

Attachments

PNG image

Top of Document



11. Assessed aspen mortality risk to climate change in the western U.S.

Context: Recent incidence of sudden aspen decline has increased interest in understanding and predicting aspen mortality in the western U.S. By studying remotely sensed or dendrochronological (i.e., tree rings) responses, previous work has highlighted drought as a major contributing factor to sudden aspen decline. However, these studies ignore the fact that individual- and population-level factors, such as tree density, competition, tree size, and disease, are likely to mediate responses to climate. In other words, aspen sensitivity to drought is likely to vary between forest stands and individual trees. A collaborative team of Forest Service, USGS, and University of Wyoming scientists examined patterns of aspen mortality on Forest Inventory and Analysis plots across the western U. S. and found that while mortality rates did increase with spatial variation in dry conditions, forest stand structure, productivity, and age, as well as individual size and incidence of disease, impacted mortality responses.

Outcome

The scientists are currently working to develop aspen mortality risk maps for the southwestern United States to be distributed to forest managers in the region. Results from this work have been presented at the 2014 Annual Meeting of the Ecological Society of America.

Top of Document

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University of Wyoming and U.S. Geological Survey

Citations

Bell, D. M., Bradford, J. B., Lauenroth, W. K. 2014. Forest stand structure, productivity, and age mediate climatic effects on aspen decline. *Ecology* 95 (8): 2040-2046.

Bell, D. M., Bradford, J. B., Lauenroth, W. K. *in Review*. Scale-dependence of disease impacts on quaking aspen (*Populus tremuloides*) mortality risk in the southwestern U.S.

Tools and Emerging Technologies

1. TimeSync Landsat time series visualization and data collection tool

Description

TimeSync allows for very highly accurate forest change characterizations at the plot level on an annual basis. When used in conjunction with a probability sampling design, unbiased change estimates with estimated variance are provided across a range of spatial extents from regional to continental.

Use

TimeSync has been used by a number of researchers across a variety of institutions to characterize change map accuracy and provide independent estimates of forest change by disturbance agent. Within the North American Carbon Program, TimeSync has been used to assess the quality of a national level disturbance map and to provide independent estimate of forest disturbance. These estimates have provided characterizations of regional differences in disturbance regimes and direct linkages of forest stress to climate change. TimeSync is also a central component of the nascent Landscape Change Monitoring System (LCMS) under development by the USFS and USGS.

Distribution

The TimeSync user community has grown slowly via word of mouth. However, currently in development and nearing completion are tutorials for use of the tool that will be presented via webinar (in November, 2014) and as standalone training modules accessible via the TimeSync webpage.

How to get it

Top of Document

A webpage exists (http://timesync.forestry.oregonstate.edu/) but is being redesigned for release later this year. The redesign will facilitate access to training and on demand use of the tool.

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Top of Document

2013 RMA Science Accomplishments

Highlighted Findings and Accomplishments

1. Resource-use land area declines in Washington state while rural housing density increases over 30 years.

Experimental forest

NA

Context and Reason

Changes in human land use patterns have wide-ranging social, economic and ecological implications. The purpose of this study was to apply a robust manual image classification method to assess changes in land use and housing density across Washington State between 1976-2006. Population in Washington increased by 2.5 million people, leading to the conversion of 1.16 million acres of forest and agricultural land to residential and urban land uses. Nonfederal forest lands declined 4.7 percent over 30 years (an annual rate of 0.2 percent—the equivalent of losing a football field-sized area every 42 minutes each year). Agricultural lands in western Washington declined at a rate of 0.7 percent per year, for a net loss of 22 percent over 30 years. Housing density on these resource lands also increased, particularly around agricultural areas. Low-density residential lands increased substantially, more than doubling over 30 years in eastern Washington.

Outcome

The loss of nonfederal forestland in Washington to development could represent a significant impact on resource availability, including timber production as well as wildlife habitat. Increased density of houses in and near resource lands can also affect their resource production, habitat quality, and difficulty in fighting wildfire. Providing comprehensive, consistent information on the type and location of land-use changes in Washington enables assessment of desirable and undesirable impacts and provides a foundation for future assessments and comparison to development in neighboring states.

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USDA Forest Service Forest Health Monitoring Program, Oregon Department of Forestry

Citation

Top of Document

Gray, A.N.; Azuma, D.L.; Lettman, G.J.; Thompson, J.L.; McKay, N. 2013. Changes in land use and housing on resource lands in Washington State, 1976-2006. Gen. Tech. Rep. PNW-GTR-881. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 51 p. http://www.treesearch.fs.fed.us/pubs/42975

2. Introduced plant species found on two-thirds of forest inventory plots in the Northeast and Midwest US

Context and reason:

Introduced plant species have significant negative impacts in many ecosystems and are found in many forests around the world. However, there are few data sources that enable the assessment of introduced species occupancy in native plant communities over broad regions. Vegetation data from 1,302 forest inventory plots across 24 states in northeastern and mid-western USA were used to examine and compare the distribution of introduced species in relation to forest fragmentation across ecological provinces and forest types, and to examine correlations between native and introduced species richness. There were 305 introduced species recorded, with multiflora rose (*Rosa multiflora*) being the most common species. Sixty-six percent of all forested plots had at least one introduced species, where they made up 7% of the plant flora in intact stands, but 14% of the flora on forest edges. Substantial variation in occupancy was found among ecological provinces.

Outcome:

The study is the first to document the abundance of nonnative plant species over a broad region – specifically, 24 states and 14 ecological provinces. Because it compares the distribution of introduced species to native species in relation to forest fragmentation across ecological provinces and forest types, the study can help managers to target forest stands where management actions will be most effective.

Identifying seemingly benign introduced species that are more prevalent than realized will also help focus attention on newly emerging invasives.

Contact:

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Partners:

USDA Forest Service Northern Research Station

Citation:

Schulz, B.K.; Gray, A.N. 2013. The new flora of northeastern USA: quantifying introduced plant species occupancy in forest ecosystems. Environmental Monitoring and Assessment 185, 3931-3957.

Top of Document

3. Populations of nitrogen (N) "loving" lichens increase in response to all types of N, leading to reassessment of lichen-based emissions limits in Europe focused on ammonia.

Context and reason:

Epiphytic lichens are among the most N-sensitive organisms in Mediterranean, temperate, and boreal forest ecosystems. Shifts in lichen indicator species are commonly used to develop critical loads (CLO) for N deposition and critical levels (CLE) for N gases, especially ammonia (NH_3). The point of CLO/CLE is to quantify how much N an ecosystem can tolerate before its sensitive components are affected. For instance, a threshold of 1µg NH_3 m^{-3} is the proposed critical level for NH_3 gas and effects on lichens in Europe. CLO/CLE serve as guidelines for setting pollutant emissions limits and are currently utilized by the United Nations Economic Commission for Europe (UNECE) and the Environmental Protection Agency.

To be most effective, CLO/CLE must establish a clear link between detrimental effects on bioindicator populations and pollutants causing the effects. However, this is difficult to accomplish in field studies because high costs limit the variety of N measurements taken. We studied lichen communities at forest monitoring sites that had an unprecedented diversity of N measurements: NH_3, nitric acid (HNO_3), nitrogen dioxide, ozone, N in throughfall, and modeled estimates of eight forms of N. We focused on the most widely utilized group of indicator species, the cosmopolitan "N loving" eutrophic lichens. This study was the first to directly compare effects of N gases and depositional pollutants. Our study area, the Transverse Ranges of the Los Angeles Basin, also provided a unique perspective because N emissions are dominated by oxidized N gases (NO_x) from motor vehicle emissions; most prior eutroph work focused on agricultural regions and thus, N emissions dominated by NH_3.

Outcome:

Our results challenge the widespread misconception that eutrophs respond specifically to NH_3, a core premise behind lichen-based CLEs for NH_3 used by the UNECE. The N gases, and NH_3 especially, had much poorer correlations to eutroph abundance than throughfall N, the amount of N measured under tree canopies. Throughfall is a highly integrative measure of N deposition that includes depositional products of NH_3 and any other reactive N compounds in the atmosphere. It appears that European CLO/CLE studies are biased for NH_3 because they focus on agricultural landscapes where NH_3 dominates N deposition and is the only pollutant measured. In contrast, the dominant reactive N gas in the L.A. Basin, HNO_3, had a much better correlation to eutrophs than NH_3, but was considerably weaker than throughfall.

Used to inform policy?

We conclude that eutrophs are accurate, sensitive bioindicators for CLOs and risk assessments of total N deposition. Eutrophs are not suitable for CLEs or NH_3 mapping unless NH_3 is the only N pollutant in the

Top of Document

vicinity. This would exclude forests receiving NOx emissions from fossil fuel combustion or other emissions from urban and industrial airsheds.

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USDA Forest Service Pacific Southwest Research Station, Arizona State University School of Life Sciences

Citation:

Jovan, S.; Riddell, J.; Padgett, P.E.; Nash III, T.H. 2012. Eutrophic lichens respond to multiple forms of N: implications for critical levels and critical loads research. Ecological Applications 22(7): 1910-1922.

4. Restoration of fire into forests of the Sierra Nevada at low and moderate severities recreates mosaics of tree clumps and openings reminiscent of pre-fire suppression patterns.

Context

Mosaics of tree clumps and openings are characteristic of forests dominated by frequent, low- 26 and moderate-severity fires. Following decades of fire suppression, many western forests have developed more homogenous canopies that lack the distinct tree-clump and opening structure. When restoring these fire-suppressed forests, managers often try to reproduce these structures to increase ecosystem resilience. We found three spatial structures, canopy-gap, clump-open, and open, that differed in spatial arrangement and proportion of canopy and openings. As fire severity increased, the total area in canopy decreased while the 35 number of clumps increased, creating a patchwork of openings and multistory tree clumps. The presence of openings >0.3 ha, an approximate minimum gap size needed to favor shade- intolerant pine regeneration, increased rapidly with loss of canopy area. The range and variation of structures for a given fire severity was specific to each forest type. Low- to moderate-severity fires best replicated the historic clump-opening patterns that were common in forests with frequent fire regimes.

Outcome

Our results suggest managers consider the following goals for their forest restoration: 1) reduce total canopy cover by breaking up large contiguous areas into variable-42 sized tree clumps and scattered large individual trees; 2) create a range of opening sizes and shapes, including ~50% of the open area in gaps >0.3ha; 3) create multistory clumps in addition to single story clumps; 4) retain historic densities of large trees; and 5) vary treatments to include canopy-gap, clump-open, and open mosaics across project areas to mimic the range of patterns found for each forest type in our study.

Top of Document

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Partners

University of Washington, School of Environmental and Forest Sciences; National Park Service, Yosemite National Park

Citation

Kane, V.R., North, M., Lutz, J.A., Churchill, D.C., Roberts, S.L., Smith, D.F., McGaughey, R.J., Kane, J.T., & Brooks, M.L. (In press). Assessing fire effects on forest spatial structure using a fusion of Landsat and airborne LiDAR data in Yosemite National Park. Remote Sensing of Environment

5. Taking stock of circumboreal forest carbon with ground measurements, airborne and spaceborne LiDAR.

Experimental forest

NA

Context and reason:

The boreal forest biome contains a large proportion of global forests, but is largely inaccessible from the ground. It contains large stores of carbon in its vegetation and soils, and it will likely be subject to increasingly severe climate-driven disturbance. In this study a combination of ground-, airborne- and space-based measurement techniques were used to derive the first satellite LiDAR-based estimates of aboveground carbon for the entire circumboreal forest biome.

Outcome:

An estimate of total aboveground carbon (and associated uncertainty) of 38 ± 3.1 Pg was obtained, and this boreal forest carbon is mostly concentrated from 50 to 55° N in eastern Canada and from 55 to 60° N in eastern Eurasia.

Use to inform policy?

The maps developed in this study establish a baseline for future quantification of circumboreal carbon and the described technique should provide a robust, repeatable method for future monitoring of changes in the aboveground carbon content. These regions are expected to warm significantly in the future, and monitoring the effects of warming on these stocks is important to understanding future global carbon balance and dynamics.

Top of Document

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Partners:

NASA Goddard Space Flight Center, Université Laval (Canada), Sigma Space Corporation, University of Maryland, Russian Academy of Sciences, Norwegian University of Life Sciences, Canadian Forest Service

Citation:

Christopher S.R. Neigh, Ross F. Nelson, K. Jon Ranson, Hank A. Margolis, Paul M. Montesano, Guoqing Sun, Viacheslav Kharuk, Erik Næsset, Michael A. Wulder, Hans-Erik Andersen, 2013. Taking stock of circumboreal forest carbon with ground measurements, airborne and spaceborne LiDAR, Remote Sensing of Environment 137:274-287

6. The relationship between fire severity and changes to forest structure varies depending on forest type.

Experimental forest

NA

Context

The details of how fire modifies forest structure are difficult to evaluate because of complex interactions between fire, forest type, and forest structure. Using a combination of airborne LiDAR data and Landsat-derived Relativized differenced Normalized Burn Ratio (RdNBR), researchers were able to measure the vertical and horizontal structure of canopy material and landscape patterning of canopy patches and gaps and relate these measurements to fire severity. Each of the three forest types studied (ponderosa pine, white fir-sugar pine, and red fir) showed an individual trajectory of structural change as fire severity increased. Compared to stands outside fire perimeters, increasing fire severity generally resulted first in loss of canopy cover in lower height strata and increased number and size of gaps, then in loss of canopy cover in higher height strata, and eventually the transition to open areas with few or no trees. However, the estimated fire severities at which these transitions occurred differed for each forest type.

Outcome

Managers have been using fire as a management tool to thin forests for decades. This work suggests that even the low severities associated with prescribed burns will thin forests and create new gaps. Knowledge of the relationship between fire severity and forest structural change can help answer

Top of Document

questions related to the level of fire severity that is likely needed to return forests to structural conditions similar to those prior to fire suppression.

Contact

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Partners

University of Washington, School of Environmental and Forest Sciences; National Park Service, Yosemite National Park

Citation

Kane, V. R., J. A. Lutz, S. L. Roberts, D. F. Smith, R. J. McGaughey, N. A. Povak, M. L. Brooks. 2013. Landscape-scale effects of fire severity on mixed-conifer and red fir forest structure in Yosemite National Park. Forest Ecology and Management: 287:17-31.

7. Assessment of sunlight availability in forest stands via lidar data.

Experimental forest: NA

Context and reason:

Lidar technologies employed over forested landscapes provide a detailed representation of tree crowns and ground surfaces. Our study in the Pacific Northwest forests showed that lidar data are conducive to assessing actual sunlight illumination regimes within forests. The approach used overcomes limitations known to limit the utility of satellite or airborne imagery for assessing light conditions. The methodology used explores the detailed, three-dimensional nature of the lidar and uses ray tracing to determine if a component of forested scene, such as ground or vegetation, receives direct sunlight from a given sun location. The process can be repeated for as many sun locations or time intervals to ultimately provide location-specific daily, seasonal, or periodic assessments of sunlight availability. The methodology was evaluated using precisely georeferenced and timed field observations of ground illumination conditions in eastern Oregon. Remarkable agreement between recorded and derived lighting conditions was observed.

Outcome:

The methodology introduced in this study enables assessment of sunlight regimes wherever high-density LiDAR data are available. It has various potential applications including contributions to forest growth and yield models, assessment of regeneration potential, stream shading, and in support of management and tactical decision.

Used to inform policy: -

Top of Document

Contact: Demetrios Gatziolis, dgatziolis@fs.fed.us

Partners: -

Citation: Gatziolis, D. 2012. Dynamic, LiDAR-based assessment of lighting conditions in Pacific Northwest forests. In Proceedings. of Silvilaser 2012 – The 12th International Conference 'First return', Coops, N., Wulder, M. (eds), 16-19 September ,Vancouver, Canada.

8. A comprehensive guide to fuel management practices for dry mixed conifer forests in the northwestern United States

Experimental forest

NA

Context and reason:

Managers need synthesized, scientifically sound knowledge on how to plan, implement and monitor a successful fuel treatment program, including an understanding of when treatment will be beneficial, the pros and cons of different treatment approaches in specific situations, how to integrate fuel treatments with other resource planning and management objectives and constraints, and the economic challenges and opportunities of committing to a fuel treatment program. This product is a 331 page synthesis to support fuels management in the ecologically complex dry mixed conifer forests of the Northern Rockies, Cascades, Klamath Mountains, Northern California, and Utah. Key topics include:

- How the ecology and historical disturbance patterns endemic in dry mixed conifer forests create fire management challenges that differ from those commonly addressed in ponderosa pine forests;
- Integrating fuels management with wildlife objectives;
- Mechanics of fuel treatments, including mechanical manipulation, prescribed fire, targeted grazing and application of chemicals;
- A decision analysis tool to select the best treatment method for any situation;
- How to apply prescribed fire to achieve diverse and specific resource objectives;
- Key principles for developing and maintaining an effective monitoring plan;
- Regionally relevant economic analysis of effective fuel treatments and principles of fuel treatment longevity;
- Appendix of internet-accessible, contemporary fuels management decision tools.

Outcome:

Top of Document

This guide was targeted to meet manager needs, determined via extensive interviews, and differs from other syntheses. For example, we emphasize fuel treatment design in light of the full range of potential fire weather and behaviors, address other factors (e.g., climate change, disease, insect, snow, wind) that modulate treatment effectiveness and/or longevity, recommend fuel treatment maintenance for these forests where regeneration and growth make for rapid ladder fuel development, and lay out a strong case for monitoring fuel treatment effectiveness over time. A unique component is the FIA based analysis of current fire hazard conditions and fuel treatment effectiveness and economics.

Contact:

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Partners:

USDA Forest Service Rocky Mountain Research Station, University of Montana, Humboldt State University

Citation:

Jain, Theresa B.; Battaglia, Mike A.; Han, Han-Sup; Graham, Russell T.; Keyes, Christopher R.; Fried, Jeremy S.; Sandquist, Jonathan E. 2012. A comprehensive guide to fuel management practices for dry mixed conifer forests in the northwestern United States. Gen. Tech. Rep. RMRS-GTR-292. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 331 p.

http://www.treesearch.fs.fed.us/pubs/42150

9. Assessing the effects of lidar pulse density and sample size on a model-assisted approach to estimation of forest inventory variables

Experimental forest

NA

Context and Reason

When used in a model-assisted statistical framework, airborne lidar has the potential to significantly increase estimation precision for some forest inventory variables. This study describes the bias and precision of a model-assisted approach to forest inventory with lidar-derived auxiliary variables and quantifies the effects of lidar pulse density and the number of sample plots. The study area was managed forests on Lewis-McChord Joint Base in western Washington state, and a regression estimator was evaluated with different combinations of pulse density (.05 - 3 pulses / m^2) and sample size (15 – 105 plots) in order to estimate five forest yield variables: basal area, volume, biomass, number of stems, and Lorey's height.

Top of Document

Outcome

The results of this study indicate that there is almost no decrease in precision in using a density as low as .05 pulses / m^2 relative to 3 pulses/ m^2. In contrast, precision for reduced sample sizes decreases quickly and even influences the validity of inference; simulations indicate that confidence intervals based on the central limit theorem were too small (on average) for sample sizes smaller than 45.

Used to inform policy?

The results from this study can aid in selecting an appropriate pulse density and sample size for large regional or state-wide lidar data acquisitions.

Contact

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Partners

Oregon State University

Citation

Strunk, J., H. Temesgen, H.-E. Andersen, J. Flewelling, and L. Madsen. 2012. Assessing the effects of lidar pulse density and sample size on a model-assisted approach to estimation of forest inventory variables. Canadian Journal of Remote Sensing 38(5):644-654.

Tools and Emerging Technologies

1. Updated PNW-FIA database user tools (PNW-FIADB)

Description: This updated version of our user-friendly database tools includes remeasurement data, expanded reporting features such as error estimates, and a large set of data summary tables that can be easily exported into spreadsheet or text editing software. This tool integrates a full public FIA database with documentation using a simple interface allowing users to begin working with complex FIA data to answer meaningful forest resource questions.

Use: The database and tools are used by resource managers and policy makers to inform questions for decision making. For example, data are used to model changes in carbon pools under various management scenarios and to assess trends in forest resource availability.

Distribution: PNW-FIADB is available on the web (http://www.fs.fed.us/pnw/rma/fia-topics/inventory-data/) or on CD by contacting us.

Top of Document

How to get it: Send email to the contact below.

Contact: Karen Waddell, kwaddell@fs.fed.us, Resource Monitoring & Assessment Program

Top of Document

2012 RMA Science Accomplishments

Highlighted Findings and Accomplishments

1. Large-scale forest conversion slowed in Oregon in the 2000s but housing density on forest- and farm-land continues to increase.

Experimental forest

NA

Context and Reason

Population growth has an effect on natural resources when land is converted from a resource use to more urban uses. In fact when more developed uses occur in close proximity to resource uses, the resource oriented uses tend to suffer. It is important to track changes in land use, identify where these changes are occurring, and evaluate the changes with respect to state land use planning goals. The objective of this study was to further document land use change on another point in time in a series that started from 1973.

Outcome

Land use change slowed in the 2005-2009 period as the economy entered recession in 2007. Urbanized conversion fell to the lowest level in the 35-year study period. However the number of housing units per square mile continued to increase on private land remaining in wildland forest, intensive agriculture, wildland range and other resource uses after 1984. This set of studies has been used by the Oregon legislature to inform land use policy over the past decade.

Contact

David Azuma, dazuma@fs.fed.us, Resource Monitoring & Assessment Program

Partners

Oregon Department of Forestry

Citation

Lettman, G.J.; Herstrom, A.A.; Heibenthal, D.R. , McKay, N., and Robinson, T.J.. 2011. Land use change on non-federal land in Oregon 1974-2009. Salem, OR: Oregon Department of Forestry. 69 pp.

2. Maps of forest vegetation and change and regional inventory plot data were used to assess the distribution and trends of late-successional old growth forest on federal and other lands in the Northwest Forest Plan area over the monitoring periods 1994 to 2007 in California and 1996 to 2006 in Washington and Oregon.

Top of Document

Context and reason:

Late-successional and old-growth (LSOG) monitoring characterizes the status and trends of older forests to answer such questions as: How much older forest is there? Where is it? How much has changed and from what causes? Is the Northwest Forest Plan (the Plan) maintaining or restoring older forest ecosystems to desired conditions on federal lands in the Plan area? In this study, statistical mapping techniques were used to develop maps of forest composition and structure at the two monitoring cycle endpoints ("bookend" maps), and yearly maps of forest disturbance. From the two bookend maps we assessed changes in the amount and distribution of LSOG over time. We used the disturbance maps to characterize the agents of change (harvest, wildfire, and insects/disease) associated with areas mapped as LSOG loss from the bookend maps.

Outcome:

The results support the assumption made in the Plan that the primary responsibility for maintaining or restoring LSOG in the Pacific Northwest would fall to public lands. Federal lands contained less than half of the total forest land, but the federal share of total LSOG increased from 65 to 67 percent over the monitoring period.

Use to inform policy?

This product represented the first Plan-wide estimates of LSOG on all ownerships from a regionally consistent inventory design. This document, the mid-cycle "15-year report," updates the assessment to 2006 in Washington and Oregon and to 2007 in California, and will serve a primary role in evaluating the efficacy of NWFP implementation throughout the region. The next major assessment will be the 20-year report.

Contact:

Janet Ohmann

PNW Research Station

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Figure: For the recent 15-Year Report for the Northwest Forest Plan, Effectiveness Monitoring employed both map-based and plot-based analyses. The LandTrendr algorithms applied to Landsat time-series data provided maps of forest disturbance, as well as normalized spectral data for use in GNN mapping of older forest at the beginning and end of the monitoring period ("bookend" maps). Regional forest inventory plots were used in the GNN mapping, and also provided independent, design-based estimates of older forest to complement the maps. Finally, the GNN maps of multiple forest attributes were used in modeling habitat for the northern spotted owl and marbled murrelet, as well as watershed condition

Top of Document

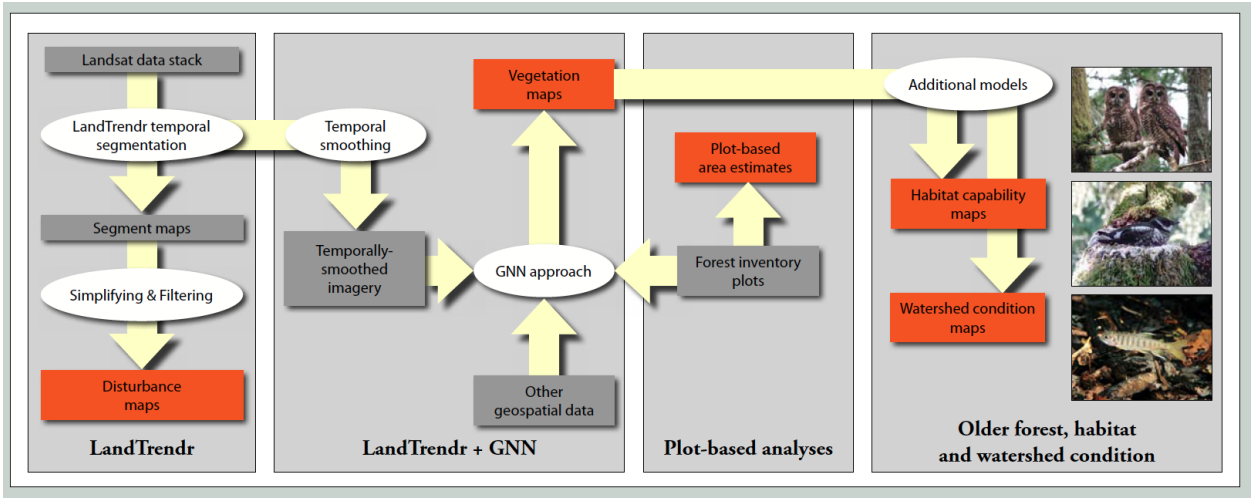
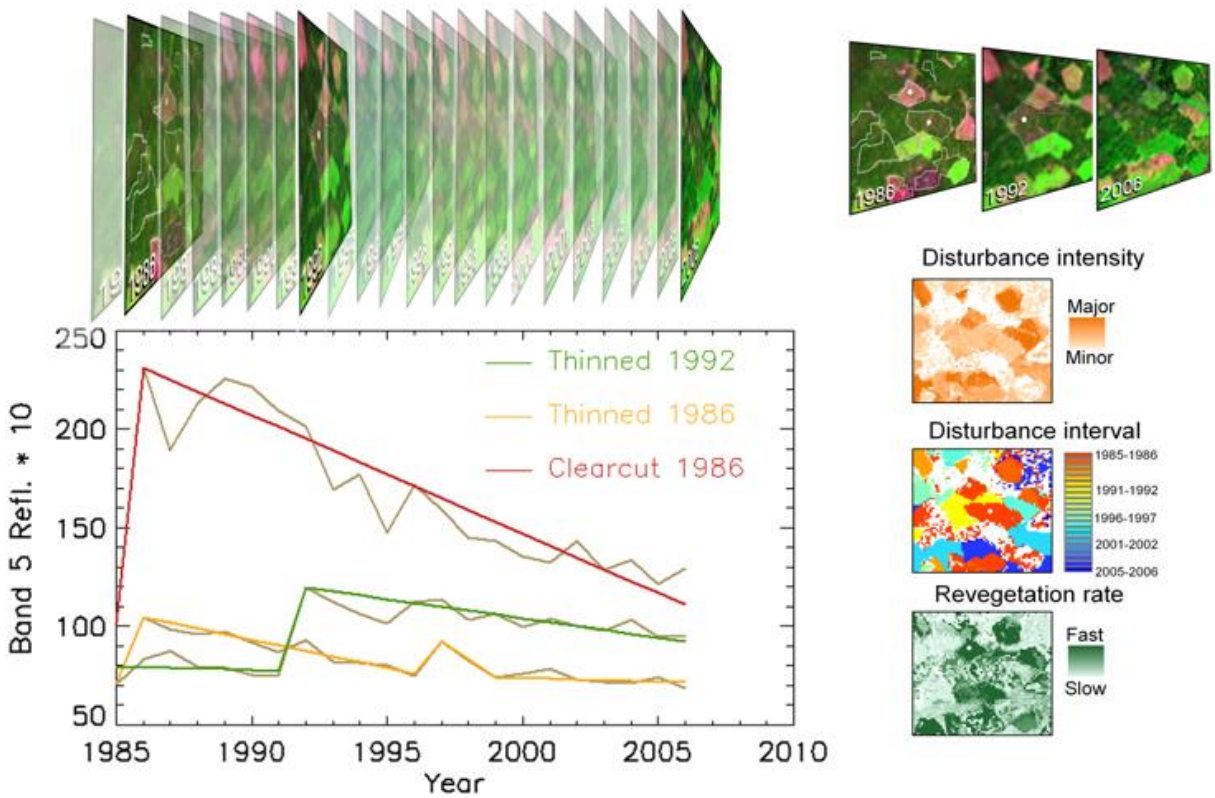


Figure: Analysis of forest disturbance and revegetation trajectories using Landsat TM time series and LandTrendr algorithm. The LandTrendR algorithm finds breakpoints in spectral trajectories and fits linear segments to the trends in between the breaks. Each break (vertex) represents a time when there is an observed change in spectral direction and indicates a new ecological shift (disturbance, succession, etc.).



Top of Document

Partners:

Oregon State University

Citation:

Moeur, M.M.; Ohmann, J.L.; Kennedy, R.E.; Cohen, W.B.; Yang, Z.; Gregory, M.J.; Roberts, H.M.; Fiorella, M. 2011. Northwest Forest Plan -- status and trends of late-successional and old-growth forests from 1994 to 2008. PNW-GTR-853. Pacific Northwest Research Station, USDA Forest Service, Portland, OR.

3. We combined airborne Light Detection and Ranging (LiDAR) characterizations of landforms, topography, and overstory vegetation with historical climate, field measurements of snow depth, tree abundance, and tree ages to reconstruct spatial and temporal patterns of tree invasion over five decades in a subalpine meadow complex in the Oregon Cascade Range, USA.

Context and reason:

Tree invasions have been documented throughout Northern Hemisphere high elevation meadows, as well as globally in many grass and forb-dominated ecosystems. Tree invasions are often associated with large-scale changes in climate or disturbance regimes, but are fundamentally driven by regeneration processes influenced by interactions

between climatic, topographic, and biotic factors at multiple spatial scales. The purpose of this research was to quantify spatiotemporal patterns of meadow invasion; and how climate, larger landforms, topography, and overstory trees have interactively influenced tree invasion.

We found that the proportion of meadow occupied by trees increased from 8 % in 1950 to 35 % in 2007. Larger landforms, topography, and tree canopies interactively mediated regional climatic controls of tree invasion by modifying depth and persistence of snow pack, while tree canopies also influenced seed source availability.

Outcome:

Our results indicated that that landscape context played an important role mediating snow depth and tree invasion; on glacial landforms tree invasion was negatively associated with spring snowfall, but on debris flows tree invasion was not associated with snow fall.

Used to inform policy?

Top of Document

This research – based upon an innovative, combined use of field measurements of snow depth and vegetation abundance, as well high-resolution topographic information from airborne lidar data – enabled scientists and managers to better understand the importance of snow, and uncertain climate change impacts on snow, and mediation of snow by interacting and context-dependent factors in complex mountain terrain poses, as well as how these ecotones may respond to future climate conditions.

Contact:

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Partners

United States Geological Survey

Citation:

Zald, H.S.J., Spies,T.A., Huso, M., and Gatziolis, D. 2012. Climatic, landform, microtopographic, and overstory canopy controls of tree invasion in a subalpine meadow landscape, Oregon Cascades, USA. *Landscape Ecology*, DOI: 10.1007/s10980-012-9774-8.

[Paper is published online on July 25th. In printed form later. No pages or issue number available yet]

4. Airborne laser scanning (LIDAR) can be used to accurately estimate leaf area index, above ground biomass, carbon, and growth rate in young radiata pine plantations in New Zealand.

Context and reason:

In New Zealand, LiDAR is being used in national inventories of carbon change in planted forests in a double sampling approach to reduce costs while improving precision of estimates. In this study, lidar canopy percentile heights and cover explained 81, 88, and 93% of the variation in directly measured crown, stem, and above ground live carbon and 75, 89 and 88% of the modeled carbon, respectively. In addition, lidar-derived forest structure metrics explained 80% of the variation in total LAI. Periodic mean annual increments in stem volume, above ground live carbon, and total carbon between ages 9 and 13 years were significantly related to lidar metrics, with regression models explaining 56, 58, and 55%, respectively, of the variation in growth rate per plot. Results also indicated that lidar models developed for pine plantations can be substantially improved by incorporating supplementary site and seedling genetics data.

Outcome:

Top of Document

In this study, methods for estimating radiata (*Pinus radiata* D. Don) pine leaf area index (LAI), stem volume, above ground carbon, and carbon sequestration in young plantations with discrete-return lidar were developed. Results indicate that LiDAR can be a useful tool in carbon monitoring programs in New Zealand and elsewhere.

Contac:

Steve Reutebuch

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Partners:

New Zealand Forest Research Institute

Citation:

Beets, Peter N.; Reutebuch, Stephen; Kimberley, Mark O.; Oliver, Graeme R.; Pearce, Stephen H.; McGaughey, Robert J. 2011. "Leaf Area Index, Biomass Carbon and Growth Rate of Radiata Pine Genetic Types and Relationships with LiDAR." *Forests* 2, no. 3: 637-659.

5. Canopy gaps affect tree growth and mortality in mature and old-growth forests in the Pacific Northwest. Mortality rates did not differ among gap sizes and controls, although mortality causes did differ for understory trees. Diameter growth rates of trees were greater next to gaps than in controls. Growth patterns with respect to sun exposure suggested that trees in mature stands responded uniformly to increased soil moisture in gaps, while trees in old-growth stands had positive and negative responses to increased solar radiation depending on crown class and position around gap. Results suggest canopy gaps can create heterogeneity of ecosystem function through spatial variation in effects on growth and mortality across mature and old-growth stands.

Experimental forest

Wind River and H.J. Andrews Experimental Forests

Context and Reason

Canopy gaps created by tree mortality are a natural part of the development of diverse structure and composition in mature forests. Gaps can affect species establishment and the speed and trajectory of vegetation growth. Most studies focus on plant development within gaps, yet gaps also affect mortality and growth of surrounding trees. The fate of surrounding trees determines whether gaps increase in size, how much shading and root encroachment occurs, and how quickly gaps becomes occupied by recovering vegetation. The objective of this study was to determine the effect of canopy gap size on

Top of Document

mortality and growth of surrounding trees over a 16-year period in mature and old-growth Douglas-fir dominated forests in the Cascade Mountains. Four sizes of experimental gaps were created in two mature stands (90 and 145-years old) and two old-growth stands (350–525-years old); mortality and diameter of surrounding trees were measured over 16 years.

Outcome

The results of this study can help us to predict how forest growth and mortality might change in response to future disturbances and climate change. It shows for example that growth of centuries-old trees can still increase in response to increased light and moisture. The results can also be used to validate computer models that simulate forest growth and succession.

Contact

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Thomas A. Spies, tspies@fs.fed.us, Ecological Processes and Function Program

Partners

Oregon State University

Citation

Gray, A.N., Spies, T.A., and Pabst, R.J. 2012. Canopy gaps affect long-term patterns of tree growth and mortality in mature and old-growth forests in the Pacific Northwest. Forest Ecology and Management 281: 111-120.

6. A comparison of lichen communities from 1976-77 to 2008 suggests a continued deterioration of air quality in the Los Angeles Basin despite policy and technological advances to control the primary emissions source, motor vehicles.

Experimental forest

NA

Context and Reason

The heavily urbanized Los Angeles Basin in Southern California has experienced poor air quality since the early 1940s. The structure of forests in the region has been shaped by severe smog incidents and chronic nitrogen (N) deposition. We looked at species composition of lichen communities growing on trees in 2008 to assess the current state of air quality. Lichens are highly responsive to N and monitoring

Top of Document

species changes is an inexpensive tool for evaluating local air quality impacts to forests. We re-surveyed sites where lichens were previously inventoried in 1976-77 when it was concluded that over 50% of species had been extirpated since the lichen flora was first documented in the early 1900s. Improvements to motor vehicle efficiency and changes to air quality policy, such as mandating the use of catalytic convertors, have since decreased the frequency of smog episodes and reduced emissions of certain N pollutants. We wanted to determine if these changed are reflected by a rebound in the lichen community.

Outcome

Lichen communities in all three forests included in the sample, the Cleveland NF (Palomar region), San Bernardino NF, and Angeles NF (Sawmill region), showed symptoms of worsening of air quality. No sensitive lichen species had recolonized trees and the abundance of N-loving species associated with polluted areas had increased, in some cases dramatically. Declines were most severe for the Palomar region, which was formerly determined to be “relatively clean” in 1976-77 based on its lichen communities. We recommend that the Palomar and Sawmill regions be given high priority in future air quality monitoring activities planned for southern California. The concentration of several pollutants is already measured in the pollution impacted forests of San Bernardino NF. However the degradation of lichen communities at Palomar and the Sawmills is about the only information we have about conditions at these sites.

Contact

Sarah Jovan sjovan@fs.fed.us, Resource Monitoring & Assessment Program

Partners

USDA Forest Service Pacific Southwest Research Station, Arizona State University School of Life Sciences

Citation

Riddell, J., Jovan, S., Padgett, P.E., and Sweat, K. 2011. Tracking lichen community composition changes due to declining air quality over the last century: the Nash legacy in Southern California; peer-reviewed journal article (Bibliotheca Lichenological 106: 263-277).

7. Models estimate canopy cover from Forest Inventory and Analysis (FIA) plots in western Oregon

Experimental forest

NA

Context and Reason

Top of Document

Reliable measures of tree canopy cover are important to forest management because management guidelines, habitat models, and even regulations are often based on maintaining specific levels of cover. However, direct sampling of canopy cover is labor-intensive and a variety of disparate methods are available. Equations for estimating canopy cover from more readily measured tree and stand attributes would improve efficiency and flexibility. This study developed new equations from line-intercept canopy transects and tree measurements on Forest Inventory and Analysis (FIA) plots, and compared results to estimates using equations of individual tree crown width and crown overlap used in the Forest Vegetation Simulator (FVS) and to aerial-photography-derived estimates.

Outcome

Models of predicted canopy cover were within 15% of measured cover for 82% of the plots. Unlike previous studies that used basal area, the best predictive models included species-specific stocking equations. FVS equations underestimated cover in the wetter forest types more than in drier forests. A follow-up study is measuring a greater variety of plots across Oregon to attempt to develop more robust modeling options for estimating tree cover.

Contact

Andrew N. Gray, agray01@fs.fed.us, Resource Monitoring & Assessment Program

Partners

Oregon State University

Citation

McIntosh, A.C.S., Gray, A.N., and Garman, S.L. 2012. Estimating canopy cover from standard forest inventory measurements in western Oregon. Forest Science 58(2):154-167.

8. High-density airborne laser scanning (LiDAR) data were used to successfully identify and map low-intensity selective logging areas in natural Amazonian rainforests in the Brazilian state of Acre.

Context and reason:

LiDAR remote sensing appears to provide an effective method for monitoring low-intensity harvest activities in tropical forests. In this study, LiDAR was also used to quantify differences in above ground biomass in logged and unlogged areas of a study site in the Brazilian Amazon. The study was jointly conducted by the USDA Forest Service's International and Research branches and Embrapa, the Brazilian agricultural research organization. It was the first study of LiDAR for monitoring harvesting conducted in Brazil.

Top of Document

Outcome:

A relative density model (RDM) that quantified the density of LiDAR returns in the understory was used to identify skidtrails, landings, and tree gaps, even in areas with high levels of residual overstory canopy. A LiDAR modeling approach provided a more precise estimate of above ground biomass than that computed using only a systematic sample of ground plots.

Used to inform policy?

The Brazilian State of Acre is further testing this LiDAR-based monitoring approach to determine if it can be used to account for above ground biomass and carbon changes associated with selective logging. The study area was reflown in 2011 after selective logging had been completed in most of the unit. Using the RDM approach, new skidtrails, landings, and tree gaps were readily identified and mapped.

Contact:

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Partners:

Embrapa - Brazil

Citation:

d'Oliveira, M. V.N., S.E. Reutebuch, R. J. McGaughey, H.-E. Andersen. Estimating forest biomass and identifying low-intensity logging areas using airborne scanning lidar in Antimary State Forest, Acre State, Western Brazilian Amazon. *Remote Sensing of Environment*, 124 (2012): 479-491.

9. Data from airborne laser scanners (LiDAR) collected in leaf-off conditions can be used to map hardwood and softwood vegetation types over large land areas.

Context and reason:

For many southeastern forest types, the presence or absence of hardwood species and their position in the canopy often dictate the application of management activities such as thinning or prescribed burning. In addition, the characteristics of the under- and mid-story layers, often dominated by hardwood species, are key factors when assessing habitat for threatened and endangered species such as the Red Cockaded Woodpecker (RCW) (Picoides borealis). In this study, statistical metrics describing the intensity and vertical structure of LiDAR returns were used as part of a supervised classification approach to identify hardwood and softwood vegetation for an 80,267 ha study site in the southeastern

Top of Document

United States. The classification was conducted at high-resolution (2-m cells) and then the results were summarized over larger areas more useful to land managers (80-m cells). LiDAR metrics describing the mean and variability of intensity, cover, and height of mid-story vegetation proved the most useful for the classification.

Outcome:

An innovative technique for characterizing species class was developed using a combination of LiDAR-derived reflection intensity and forest structure information.

Used to inform policy?

Managers at the Department of Energy's Savannah River Site, located in the southeastern coastal area of the United States in west central South Carolina, are using the summarized GIS data layers produced by this research to assess the availability of small-diameter hardwood material for bio-energy production and habitat suitability for the RCW.

Contact:

Robert J. McGaughey

PNW Research Station

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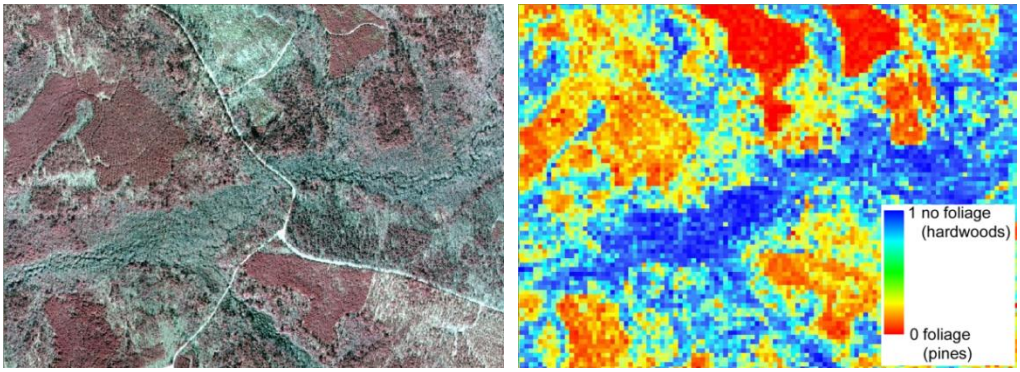
Figure: Color infrared aerial photograph taken in 2007 (left) and a GIS data layer computed from the 2009 LIDAR data that shows the proportion of canopy with/without foliage at 20m resolution (right). In the color infrared image, vegetation with foliage is generally red and vegetation without foliage is gray.



Citation:

McGaughey, Robert J.; Reutebuch, Stephen E. Vegetation classification in southern pine mixed hardwood forests using airborne scanning laser point data. Proceedings of Silvilaser 2012: First Return. September 16-19, 2012. Vancouver, British Columbia, Canada. CD-ROM. Not paginated.

Top of Document

10. An interdisciplinary, SAF task force science synthesis, assembled by a team of nine scientists and analysts with expertise on different aspects of forest carbon dynamics, carbon and climate change policy and biomass/bioenergy, that is presented in technical/scientific language appropriate for forestry and natural resource professionals: Managing Forests Because Carbon Matters: Integrating Energy, Products, and Land Management Policy

Experimental forest: NA

Context and reason:

Foresters participate in a variety of forest carbon offset projects, only some of which meet key requirements concerning additionality, baseline setting, permanence, and leakage. Will these live up to the promise of supplying significant quantities of new climate benefits as well as profits to those who create, market and manage them? What are the implications of widespread utilization of forest biomass for energy on greenhouse gases, ecosystems, and markets for materials used in the production of wood and paper? Over 200 publications and published FIA inventory statistics are summarized to synthesize what is known about U.S. forest carbon dynamics and prospects for forest based carbon mitigation. Integrated ecological, inventory, economic, engineering and policy analyses address climate and energy policy implications of choices in contemporary forest management. Barriers to carbon offsets are identified (e.g., insurmountable measurement challenges); relative magnitudes of storage, product substitution and energy substitution benefits are explained; and attention is called to the ultimate consequences of non-management for realizing climate benefits, some of which are shown to be already evident via inventory analysis.

Outcome:

Product was featured prominently on SAF's web site, in the Forestry Source, SAF Policy Update and the E-Forester. Report is used in briefings with Congressional staffs and as assigned reading in university courses. It has also been the subject of press releases at most of the authors' institutions, which have generated interest from reporters and articles and notices posted (e.g., in Biomass Magazine, Wood Bioenergy).

Used to inform policy?

The supplemental JoF issue was submitted by SAF to the EPA Science Advisory Board Biogenic Carbon Emissions Panel, where it is expected to factor into deliberations concerning how to develop policies for biogenic carbon.

Contact: Jeremy Fried, jsfried@fs.fed.us, Resource Monitoring and Assessment Program

Top of Document

Partners: Society of American Foresters, SUNY Syracuse, Dovetail Partners, USFS Washington Office, University of Georgia, Mississippi State University, University of California, University of Washington, NCASI.

Citation:

Malmshimer, R.W., J.L. Bowyer, J.S. Fried, E. Gee, R. L. Izlar, R.A. Reid, I.A. Munn, E. Oneil, and W.C. Stewart. 2011. Managing Forests because Carbon Matters: Integrating Energy, Products, and Land Management Policy. Journal of Forestry 109(7S):S7–S50
http://www.safnet.org/documents/JOFSupplement.pdf

Tools and Emerging Technologies

1. Updated PNW-FIA database user tools (PNW-FIADB)

Description: This updated set of user-friendly tools now includes additional reporting features such as calculation of all error estimates, a greatly expanded set of output tables, and increased user customization. This tool integrates a full public FIA database with documentation using a simple interface allowing users to begin working with complex FIA data to answer meaningful forest resource questions.

Use: The database and tools are used by resource managers and policy makers to inform questions for decision making. For example, data are used to model changes in carbon pools under various management scenarios.

Distribution: PNW-FIADB is available on CD by contacting us.

How to get it: Send email to the contact below.

Contact: Karen Waddell, kwaddell@fs.fed.us, Resource Monitoring & Assessment Program

Top of Document

2011 RMA Science Accomplishments

Highlighted Findings and Accomplishments

1. New field guide highlights nonnative invasive plants found in Pacific Coast forests

Nonnative plants affect the composition and function of natural and managed ecosystems. They can limit or degrade land use options and can be costly to eradicate. Despite their influence, very little comprehensive information on the abundance, distribution, and impact of nonnative invasive plants is available. To remedy this, researchers developed a prioritized list of nonnative invasive plants affecting forest lands in the Pacific coastal states of California, Oregon, and Washington. They produced a field guide featuring 56 invasive plants believed to be the most prevalent or problematic. The color photos of each plant in various stages of development and written descriptions in nontechnical language facilitat reliable identification in the field.

The PNW Forest Inventory and Analysis program (FIA) is considering adopting the list and guide for targeted sampling of nonnative plants. Future FIA analyses would be able to assess the distribution and impact of these key nonnative species more effectively than current protocols.

Contact: Andy Gray, agray01@fs.fed.us, Resource Monitoring and Assessment Program

Partners: Institute of Applied Ecology, University of Washington

For more info: Gray, A.N.; Barndt, K.; Reichard, S.H. 2011. Nonnative invasive plants of Pacific coast forests: a field guide for identification. Gen. Tech. Rep. PNW-GTR-817. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 91 p.
http://www.fs.fed.us/pnw/pubs/pnw_gtr817.pdf

2. LIDAR used to estimate biomass supply near interior Alaska communities

Remote rural communities in interior Alaska generally rely on fossil fuel to meet their power and heating needs. Diesel prices increased 83 percent from 2000 to 2005, however, and utility costs can amount to more than a third of a household's income. Wood-based energy may be a viable alternative, but estimates of available forest biomass are needed before comprehensive plans for bioenergy production can be developed. Interior Alaska has relatively few roads, making it difficult to measure biomass availability over a large area using conventional ground-based sampling methods. Therefore, researchers tested the precision of data collected by aircraft equipped with LIDAR (airborne laser scanners) and used it in conjunction with data from sparse field plots.

The LIDAR sampling approach estimated total biomass with an 8 percent level of precision, indicating that the 200,000-hectare study in the upper Tanana valley contained 8.1 million (± 0.7 million) metric

Top of Document

tons of biomass. They found that precision increased when plot locations were more accurately located, when larger plots were measured, and when additional smaller trees in the ground plots were measured.

This study indicates that airborne LIDAR sampling can be useful in planning bioenergy development in interior Alaska. In regions with very limited road access, an approach to field plot selection within accessible areas can be used to ensure that representative plots are measured to develop robust LIDAR biomass estimates.

Contact: Hans Andersen, handersen@fs.fed.us, Resource Monitoring and Assessment Program

Partner: Oregon State University

3. Scientists evaluate methods for estimating biomass of leaves and branches

Different sampling schemes have been used to estimate tree foliar biomass, but the effectiveness of these schemes has rarely been evaluated. To address this, researchers used extensive branch and tree foliage biomass data sets for Douglas-fir and ponderosa pine to evaluate the statistical and cost efficiency of various sampling schemes. They wanted to know how inclusion of auxiliary data (e.g., branch diameter or position) affected estimates of foliar biomass. Although auxiliary information may improve the precision of the estimators, it involves a cost: the information has to be collected and compiled and it may require processing larger samples. Researchers found that including auxiliary information after samples were drawn resulted in a more cost-efficient sampling scheme than when auxiliary information was used earlier in the design phase of the sampling scheme. For both species, a simple systematic sampling design with ratio estimation provided the most efficient method for estimating tree foliage biomass.

The results can be used to develop efficient and cost effective methods to estimate individual tree foliar and branch biomass. These methods will help improve estimates of forest and ecosystem biomass and carbon.

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Partners: Oklahoma State University, Oregon State University, University of Maine

4. New models help detect spread of sudden oak death

Sudden oak death (SOD) was discovered in Oregon forests in 2001. Despite considerable control efforts, the disease continued to spread. In response, scientists developed two models to map where SOD was likely to become established and its risk of spread. The scientists determined that 40 square miles of forested land were likely invaded by 2009, and that the disease threatens more than 1,300 square miles

Top of Document

of forests across western Oregon. The greatest risk is in southwest Oregon where susceptible host species, such as tanoak, are concentrated. The Oregon Department of Forestry and other agencies are using the models to prioritize early detection and eradication efforts in the state.

Contact: Janet Ohmann, johmann@fs.fed.us, Resource Monitoring and Assessment Program

Partners: Oregon Department of Forestry, Oregon State University, University of North Carolina at Charlotte

Use: Oregon Department of Forestry uses models in eradication efforts.

5. Choice of model influences live-tree carbon estimates

Estimates of the amount of carbon stored in a tree are influenced by numerous uncertainties. One of them is model-selection uncertainty: the user has to choose among multiple empirical equations and conversion factors that can be plausibly justified as locally applicable to calculate the carbon store from inventory measurements such as tree height and diameter at breast height (DBH). Researchers quantified model-selection uncertainty for the five most common tree species in northwest Oregon. They found that model-selection error may introduce 20 to 40 percent uncertainty into a live-tree carbon estimate, making this form of error the largest source of uncertainty when estimating live-tree carbon stores. Uncertainty from sampling error, represented as a 95-percent confidence interval, was only 6 percent. Predicted carbon content of individual trees can vary even more among model aggregating pathways, especially the predictions for large trees, which on the Pacific Coast comprise an unusually large share of carbon stores.

Model-selection uncertainty is not an easily remedied error and may call into question the premise of tracking forest carbon with the precision and accuracy required to support contemplated offset protocols. The greatest risk is the potential for choosing a particular calculation pathway to justify a preferred outcome.

Contact: Jeremy Fried, jsfried@fs.fed.us, Resource Monitoring and Assessment Program

Partner: Oregon State University

6. Forest Inventory and Analysis in the Pacific Islands

Researchers collected, analyzed, and summarized field data gathered on islands throughout the western Pacific. They summarized forest information for the Federated States of Micronesia and compared it to prior vegetation mapping work done there. Researchers found that the extreme diversity of vegetation across Micronesia can be attributed to differences in longitudinal climatic influences and human land use practices. Similar data collection and analysis of forest resources were done on the Commonwealth

Top of Document

of the Northern Mariana Islands; there researchers found that urban areas have grown, contributing to losses in forest land area. On the Marshall Islands, rising sea levels are threatening numerous native plant species.

Data and summaries from these inventories are used by island groups to develop their statewide assessments and resource strategies that enable them to compete for funding. The data also are used to guide resource management and policy decisions.

Contact: Joseph Donnegan, jdonnegan@fs.fed.us, Resource Monitoring and Assessment Program

Partners: American Samoa Forestry; Department of Land and Natural Resources, Commonwealth of the Northern Mariana Islands; Federated States of Micronesia Forestry; Kosrae Forestry; Marshall Islands Forestry; National Tropical Botanical Garden; University of Guam; USDA Forest Service Pacific Southwest Research Station Region, State and Private Forestry

Tools and Emerging Technologies

1. LandTrendr and TimeSync

Description: These tools are used in tandem to detect trends in forest disturbance and recovery. LandTrendr (Landsat-based detection of Trends in Disturbance and Recovery) is a mapping tool that automatically extracts information on land surface changes (e.g., fire, insect and disease damage, timber harvesting or regrowth) from Landsat satellite imagery. TimeSync is a companion image interpretation software tool for synchronizing algorithm and human interpretations of Landsat imagery. These tools capture both short-duration events such as harvest and fire, and long-term trends such as declines in forest health and regrowth. Researchers can use these new tools to comprehensively map change over every Landsat pixel (30 m) since 1972 in forested ecosystems and understand the accuracy of the maps.

Use: The National Park Service uses these tools for its inventory and monitoring program. The Forest Service Pacific Northwest Region uses them for the Effectiveness Monitoring Program of the Northwest Forest Plan. The PNW Research Station, Oregon State University, NASA Goddard Space Flight Center, and the University of Maryland are using these tools to help characterize the U.S. carbon budget.

How to get it: http://landtrendr.forestry.oregonstate.edu

http://www.fsl.orst.edu/larse/

Contact: Warren Cohen, wcohen@fs.fed.us, Resource Monitoring and Assessment Program

Partners: Oregon State University, NASA, University of Maryland, USDA Forest Service Rocky Mountain Research Station

Top of Document

2. PNW-FIADB

Description: This tool allows users to work with the database populated and maintained by the Pacific Northwest Research Station's Forest Inventory and Analysis team. Users can answer questions about the status and trends of forest resources by summarizing data on live and dead trees, down woody materials (fuels), and understory vegetation.

Use: Resource managers and policymakers can use this tool to help inform their decisionmaking process. The LANDFIRE project used the database to update its comprehensive fuels maps and spatial data layers for the Pacific Northwest. The California Climate Action Registry used the database to develop baseline levels of carbon stocks in private forests in the state. The database was used to quickly respond to congressional requests about biomass size distribution and the availability of wood supplies from national forests.

How to get it: Contact Karen Waddell, kwaddell@fs.fed.us, Resource Monitoring and Assessment Program

Top of Document

2010 RMA Science Accomplishments

Highlighted Findings and Accomplishments

1. Scientists identify amount of nitrogen pollution that triggers shift in lichen communities

A critical load for nitrogen is the maximum amount of nitrogen deposition that an ecosystem or ecosystem component can accommodate without being damaged. Certain species of lichen are exceptionally sensitive to airborne nitrogen pollution, thus air quality management that uses lichen critical loads is expected to protect the larger forest ecosystem. Researchers analyzed how lichen communities west of the Cascade Range respond to nitrogen inputs. They found that when nitrogen deposition reached 3 to 9 kilograms of nitrogen per hectare per year, there was a 20- to 40-percent decline in ecologically important lichen species that are used by wildlife and involved in nutrient cycling. Forests exceeding this critical load also characteristically see a three- to fourfold increase in "weedy" nitrogen-loving lichen species.

Critical loads for pollutants provide benchmarks of ecological harm that guide pollution permitting and regulation. Critical loads developed for the most sensitive indicator species, like lichens, should convey ecosystem-wide protection. This research is likely to be integral to all forthcoming integrated science assessments conducted by the Environmental Protection Agency for establishing secondary standards for nitrogen compounds. These critical loads may be used by managers to set and negotiate target pollutant loads for lands under their charge.

Contact: Sarah Jovan, sjovan@fs.fed.us, Resource Monitoring and Assessment Program

Partners: USDA Forest Service, Pacific Northwest Region; Washington State University

Use: EPA uses findings to assess secondary pollution standards for nitrogen compounds.

2. More fires likely to escape initial attacks as climate changes in California

Subtle shifts in fire behavior induced by anticipated climate changes over the next century are sufficient to increase the number of fires that escape initial attack, especially in shrub-covered wildlands in California. Comparison between high and reduced emissions scenarios shows that the lower emissions scenario is sufficient to produce modest reductions in the anticipated negative impacts on wildland fire

Top of Document

severity and outcomes. Relatively modest augmentations to existing firefighting resources appear to be sufficient to compensate for climate change-induced changes in wildland fire outcomes.

This information was submitted to the governor of California to serve as a basis for action on climate change in the state.

Contact: Jeremy Fried, jsfried@fs.fed.us, Resource Monitoring and Assessment Program

Partners: ATMOS Research and Consulting; U.S. Department of Energy, Lawrence Berkeley National Laboratory; Universidad Rey Juan Carlos; University of California, Berkeley

Use: California governor considers findings in climate change action.

3. Five-year report summarizes forest conditions in Washington

Scientists summarized and interpreted basic information about public and private forest land in Washington. Topics include land use change, ownership, timber volume, biomass and carbon stocks, biodiversity, insects and diseases, invasive plants, air pollution, and more. This report, based on data from 2002 through 2006, establishes a baseline against which future conditions can be compared and trends can be identified. This information is useful to state and federal agencies and private firms.

The authors identified several key findings in the report. They found that Washington's forests are presently a net sink for carbon, whereas most timber production is coming from private lands. Nonnative invasive plant species already are well established in Washington's forests, covering 4 percent of all forest land on average. They also found lichen communities indicative of nitrogen pollution in forests west of the Cascade Range, particularly in the Puget Trough ecoregion, which runs the length of the state along the Interstate-5 corridor.

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Partners: Washington Department of Natural Resources, USDA Forest Service Pacific Northwest Region

For more information: Campbell, S.; Waddell, K.; Gray, A., tech. eds. 2010. Washington's forest resources, 2002 to 2006: five-year Forest Inventory and Analysis report. Gen. Tech. Rep. PNW-GTR-800. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 189 p. http://www.treesearch.fs.fed.us/pubs/35068

4. Forest Inventory and Analysis begins work on Hawaiian Islands

Top of Document

Policymakers and natural resource managers need up-to-date, consistent, and credible information on the status and trends of forests in Hawaii and the Pacific Islands to guide decisions at state, national, and international levels. The Pacific Northwest Research Station is responsible for delivering the Forest Inventory and Analysis program in Hawaii and is partnering with the Hawaii Division of Forestry and Wildlife, the Institute of Pacific Islands Forestry, and numerous other agencies including state governments and foresters throughout the Pacific to implement this inventory.

In 2010, the station hired Hawaiian field crew who installed most of the potential plots on the islands of O'ahu and Lanai and began work on the island of Hawaii. The station also strengthened its partnerships with the Hawaii Division of Forestry and Wildlife and the Institute of Pacific Islands Forestry and established itself as an important future resource to understanding the status and trends of Hawaii's forest resources.

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Partners: Hawaii Division of Forestry and Wildlife, USDA Pacific Southwest Research Station Institute of Pacific Islands Forestry

5. Oregon coastal old-growth forests developed under different disturbance histories

Old-growth forests provide unique features compared to younger stands, thus many management plans in the Pacific Northwest aim to increase the area of late-successional forest. Researchers examined existing old-growth forests in the northern Oregon Coast Range that might serve as examples of desired future conditions and developmental pathways. Many old-growth attributes in all forests in the region also were assessed. Researchers found that most old-growth stands had experienced moderately severe disturbances during their development. Nevertheless, most of the stands had the full complement of old-growth attributes (large shade-intolerant trees, smaller shade-tolerant trees, snags, and down wood).

Results from this study suggest that although old-growth forests can develop along multiple disturbance pathways, stand composition and productivity constrain development. Expecting all late-successional stands to have the full complement of old-growth attributes may not be realistic. Managers could use the detailed stand descriptions and inferred disturbance histories as reference points for establishing

Top of Document

desired future conditions. Analyzing the frequency of old-growth attributes could be a more informative approach to regional monitoring than efforts based on stand diameter class.

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Partner: Northwest Forest Plan Adaptive Management Program

6. Maps of biomass dynamics support North American Carbon Program

Knowing where and at what rates biomass accumulates or is lost across broad scales is critical to understanding how forest disturbance and regrowth processes influence carbon dynamics. Station scientists modeled live, aboveground tree biomass by using Forest Inventory and Analysis field data and applied the models to more than 20 years of Landsat satellite imagery to derive trajectories of aboveground forest biomass for study locations across the continental United States. Maps of biomass dynamics were integrated with maps depicting the location and timing of forest disturbance and regrowth to assess the biomass consequences of these processes over large areas and long timeframes. These maps enable a first approximation of continental rates of biomass loss and accumulation as a result of forest disturbance and regrowth and can be used to support the North American Carbon Program. Scientists from a variety of universities and government agencies that model carbon dynamics are using this information. Policymakers and managers now have information to use in understanding how forest biomass has changed over the past 20 years to inform their decisions about how forest management affects biomass change today and in the future.

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Partners: Montana State University, NASA Goddard Space Flight Center; Oregon State University; University of Maryland; USDA Forest Service Northern Research Station and Rocky Mountain Research Station

7. New maps facilitate richer analysis of older forest and associated species

The 1994 Northwest Forest Plan (NWFP), covering federal lands within the range of the northern spotted owl in the Pacific Northwest, is one of the most significant forest conservation efforts in the world. As part of a 15-year report on the effectiveness of the plan, researchers used the gradient nearest neighbor (GNN) mapping technique to develop forest maps for two years: 1996 and 2006 in

Top of Document

Washington and Oregon, and 1994 and 2007 in California. The GNN maps integrate forest data collected on regional inventory plots with satellite imagery that is normalized through time using LandTrendr algorithms. This results in more stable multiyear estimates than is possible with traditional image-processing techniques.

The GNN maps provide detailed attributes of forest composition and structure spanning all land ownerships and allocations in the NWFP area. Mapped attributes of forest structure such as densities of large trees, snags, and down wood, and canopy layering are being used to identify older forest and model habitat for the northern spotted owl, marbled murrelet, and aquatic species.

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Partners: Oregon State University; USDA Forest Service Pacific Northwest Region; USDI Bureau of Land Management, Fish and Wildlife Service

8. Canopy structure may not develop linearly

Forest structure, as measured by the physical arrangement of trees and their crowns, is a fundamental attribute of forest ecosystems that changes as forests develop. Unfortunately it is difficult to characterize forest structure over large land areas by using field measurements. Looking for another option, researchers used information derived from airborne laser scanners (LIDAR data) to describe and classify conifer forest structure across a broad range of age classes.

They found that characteristics normally associated with older forests, such as variability in vertical structure, size, and distribution of various-sized gaps, and vertical canopy gaps, may be present in younger stands, and that some older stands may lack these same characteristics. These results suggest that canopy structure may not develop in a linear fashion and emphasize the importance of measuring structural conditions rather than relying on development models to estimate structural complexity across forested landscapes.

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Partners: Seattle Public Utilities, University of Washington

Top of Document