focus on…

Wildfire

The Right Tools: Managing for Fire Using FIA Inventory Data

The relative severity of recent fire seasons has led to numerous debates about the health, associated fire hazards, and effectiveness of fuel reduction treatments in forests across the United States. Scientific analyses of forest inventories offer policymakers and other interested parties objective information with which to make crucial forest management decisions.

The Forest Inventory and Analysis (FIA) program of the USDA Forest Service has been monitoring the nation's forest resources for more than 75 years. The program's systematic, georeferenced, and multiphase inventory represents the most comprehensive, consistent, and current assessment of US forests available. The FIA inventory is well-suited to provide answers to the multitude of fire and forest management questions. The four brief articles that follow provide just a few examples of how the program's inventory and analysis can be used to inform current forest fire debates.

—Dennis M. May
Program Manager, Forest Inventory and Analysis,
USDA Forest Service, North Central Research Station

The Right Tools: Managing for Fire Using FIA Inventory Data

The relative severity of recent fire seasons has led to numerous debates about the health, associated fire hazards, and effectiveness of fuel reduction treatments in forests across the United States. Scientific analyses of forest inventories offer policymakers and other interested parties objective information with which to make crucial forest management decisions.

The Forest Inventory and Analysis (FIA) program of the USDA Forest Service has been monitoring the nation's forest resources for more than 75 years. The program's systematic, georeferenced, and multiphase inventory represents the most comprehensive, consistent, and current assessment of US forests available. The FIA inventory is well-suited to provide answers to the multitude of fire and forest management questions. The four brief articles that follow provide just a few examples of how the program's inventory and analysis can be used to inform current forest fire debates.

—Dennis M. May
Program Manager, Forest Inventory and Analysis,
USDA Forest Service, North Central Research Station

Coming Soon: A National Assessment of Fuel Loadings

The Forest Inventory and Analysis Program (FIA) of the USDA Forest Service conducts a national inventory of downed forest fuels of the United States. The inventory—the Down Woody Materials (DWM) Indicator—is a subsample of FIA forest inventory plots where downed fuels are sampled for regional-scale estimation of fuel complexes. Forest fuel components estimated by the DWM inventory program match those common to many fire behavior modeling efforts: coarse woody debris (CWD; 1,000+-hr), fine woody debris (FWD; 1-hr, 10-hr, 100-hr), litter, herbs and shrubs, slash, duff, and fuelbed depth. This comprehensive and nationally consistent inventory of downed fuels, together with the entire forest inventory program, makes possible the first national assessment of fuel loadings.

How It Works

A subset of FIA permanent inventory plots is sampled every year for downed forest fuel components. For each FIA plot, DWM components are sampled on each FIA subplot using planar intercept methodologies, fixed-radius sampling, and point sampling. Only accessible forestland is sampled for DWM. If an FIA subplot contains nonforest conditions, the affected DWM transects are ended and mapped accordingly.

CWD is sampled on each of three transects (24-foot horizontal distance) radiating from each FIA subplot center at 30, 150, and 270 degrees. FWD is sampled using transects of varying length on the 150° transect on each subplot. FWD with a transect diameter of 0 to 0.99 inches (1-hr and 10-hr) is tallied using a 6-foot slope-distance transect, and FWD with a transect diameter of 1.00 to 2.99 inches (100-hr) is tallied using a 10-foot slope-distance transect. Duff and litter are sampled using a point estimate of their depth at a 24-foot slope distance location along each CWD transect (for a total of 12 sample points for a fully forested plot). The depth of the fuelbed (from the base of the litter layer to the highest point of fuel) is also measured at the duff/litter sample points. The shrub and herb fuel complex is sampled on each subplot using a microplot (6.8-foot radius) with estimates of cover (10 percent classes) and total height. Slash pile centers that intersect FIA subplots are classified into four slash pile shapes, and their dimensions and packing ratio are estimated.

What It Tells Us

The DWM inventory began in 2001 and has been implemented in 38 states. Field data, organized both by fuel and sampling design components, are available through regional FIA contacts and through a national website—www.ncrs.fs.fed.us/4801/dwm/. Processed data, expressed as estimates of tonnage per acre by fuel component, will be available on the website in the coming months. Preliminary mapping efforts indicate that national and regional assessments of forest fuel components may be produced by combining FIA forest and nonforest maps with fuel component interpolations between DWM inventory sam-
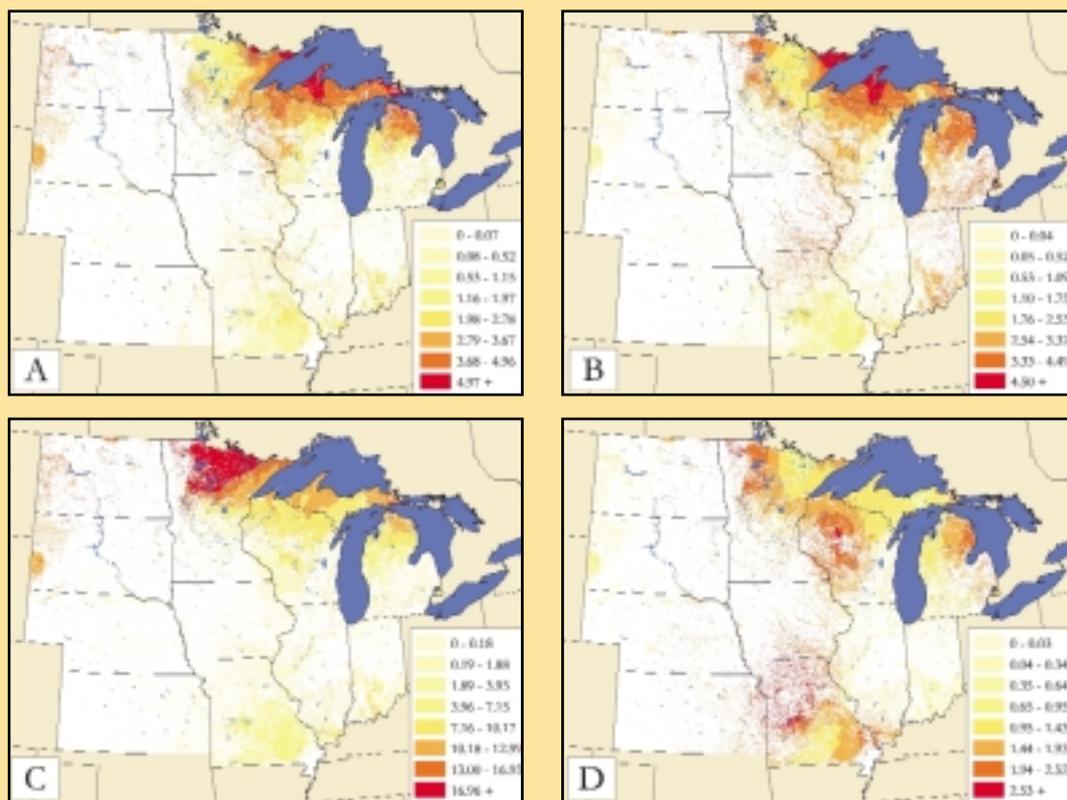
Figure 1. Preliminary fuel maps for North Central states based on FIA's 2001 Down Woody Materials (DWM) inventory: (a) coarse woody debris (tons per acre); (b) fine woody debris (tons per acre); (c) duff (tons per acre); (d) herb and shrub height (feet).

ple points *(fig. 1).*

Given the breadth of DWM inventory plots across the United States, their linkage with the entire FIA forest inventory, and our ability to seamlessly link them with fire and fuel models, FIA's DWM inventory promises to serve as a robust source of fuels data for national and regional fire science researchers and managers.

Contributed by Christopher W. Woodall (cwoodall@fs.fed.us), research forester, USDA Forest Service, North Central Research Station, 1992 Folwell Avenue, St. Paul, MN 55108.

Fuel-Reduction Treatment: A West-wide Assessment of Opportunities

Fuel reduction treatments may offer the potential to restore the health and reduce the fire hazards of western forests. To achieve effective landscape-scale treatments, stand treatments should be targeted in areas where increasing stand densities have altered the historic frequency and intensity of forest fires. This study analyzed the entire West-wide FIA database to identify areas where fuel-reduction treatments may be most effective.

Analysis

Target treatment areas were identified by determining the relative stand density–based yield of acreage and then cross-linking with assessments of current fire regimes. To determine how much of the western timberland (130 million acres, not reserved from timber harvests, and meets minimum productivity standards) was overstocked, a stand density index (SDI) approach was developed that compared the actual stocking of each plot to a desired stocking level. The target SDI was evenly divided among the inventory plots' diameter classes, with excess di-

ameter-class SDI identified as potential yield. This methodology identified trees in each diameter class that may be available for fuel-reduction removals, while ensuring sufficient "leave" trees to maintain site occupancy. Acreage with the greatest potential for fuel reduction treatments was identified by combining the SDI-based high-density plot locations with fire regime "condition class 3" areas, as defined by the Fire Sciences Lab of the Rocky Mountain Research Station (www.fs.fed.us/fire/fuelman/curcond.htm).

Findings

This study identified 29 million acres as high-priority treatment "hotspots," with a potential biomass yield of 576 million dry tons *(fig. 1)*. Nearly 6 billion trees were identified as potential yield from treatments in these hotspots. Most trees were in the smaller diameter classes *(fig. 2a)*, with the majority of biomass in the larger diameter classes *(fig. 2b)*. While the removal of small-diameter trees (ladder fuels) may decrease fire hazards, the removal of large-diameter trees may both reduce fire hazard and provide net economic benefits. More than 30 percent of the total potential biomass yield is in saplings, tops, and limbs that often are not used. From strictly a fuel-reduction standpoint, much of this material should be used or disposed of in some manner. The evaluation of regional-scale forest management hypotheses, based on FIA's national inventory, may not only address West-wide fuel-reduction treatment scenarios but also may be applicable to other fire-related issues throughout the United States.

Contributed by John S. Vissage (jvissage@fs.fed.us), research forester, and Patrick D. Miles, research forester, USDA Forest Service, North Central Research Station, 1992 Folwell Avenue, St. Paul, MN 55108.
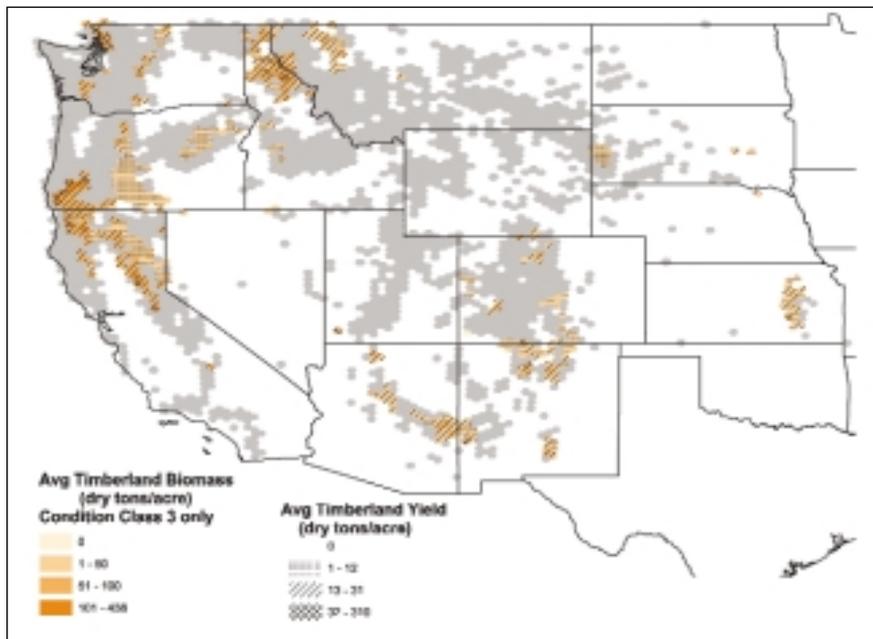

Figure 1. High-priority fuel reduction thinning opportunities on timberland in the western United States.
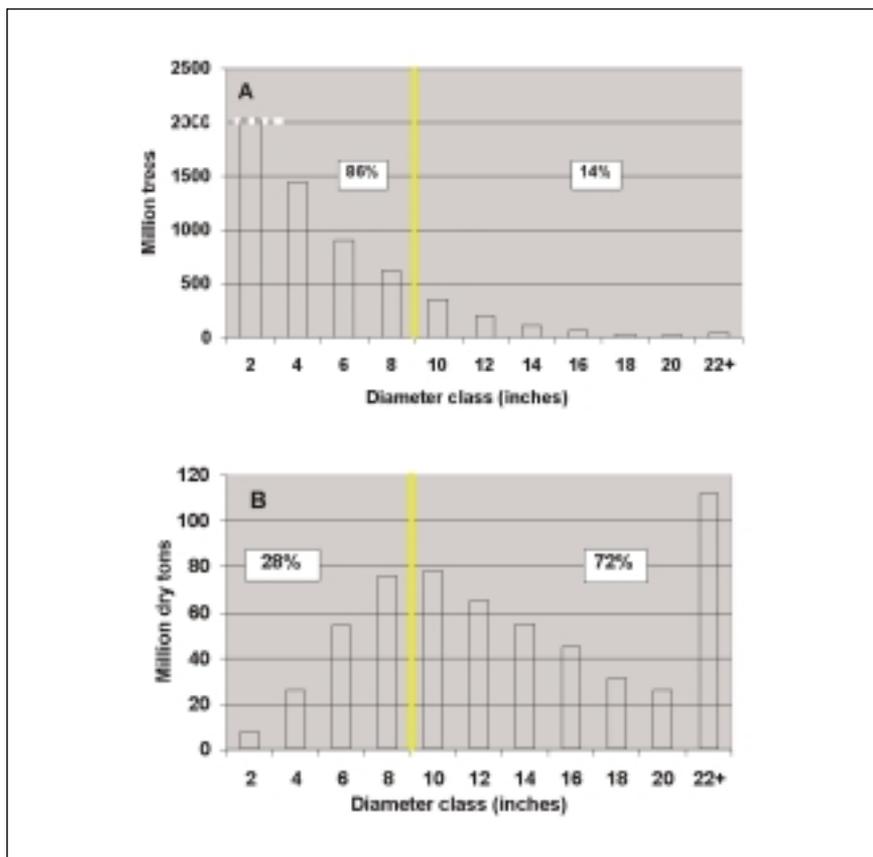

***Figure* 2.** Number of trees (a) and biomass (b) identified as potential yield in this analysis. While 86 percent of trees were below the 10-inch class, 72 percent of the biomass was above it.

Fire Hazard and Potential Treatment Effectiveness: A Statewide Assessment in Montana

Developing strategies to reduce the fire hazard in Montana's forests raises several critical questions: What conditions are most vulnerable to crown fire? What kinds of treatments are most effective in reducing hazard and how much do they cost? A uniform forest inventory was recently completed across all ownerships in Montana through the Forest Inventory and Analysis (FIA) program. This inventory made possible a statewide assessment to address these questions.

Analysis

Data collected from Montana's 3,700-plus FIA plots were summarized by forest type, density, and structure. Associated crown fire hazard was modeled using the Fire and Fuels Extension to the Forest Vegetation Simulator. Hazard was quantified in terms of crowning index—the wind speed necessary to sustain a crown fire. Crowning index values <25 mph were rated high hazard, 25–50 mph values were rated moderate hazard, and >50 mph were rated low hazard.

Our analysis focused on ponderosa pine/Douglas-fir/dry mixed-conifer forests that were historically adapted to low-intensity fire. These once open, large-tree-dominated forests have become dense, choked with ladder fuels, and highly vulnerable to crown fire. We evaluated two contrasting approaches for reducing fire hazard in these dramatically altered conditions:

1. Thin-from-below: *Cut* only trees up to 9 inches dbh (low thinning).

2. Comprehensive: Ecologically based treatment; *leave* mostly larger serals but some trees of all sizes (low thinning, improvement/selection cutting).

We developed algorithms to simulate application of the thin-from-below and comprehensive prescriptions to the tree list associated with each FIA plot. After the prescriptions were implemented, the resulting leave-tree lists were linked with the Fire and Fuels Extension to model post-treatment crowning indexes, while cut-tree lists were linked with cost models and databases to estimate net revenues (i.e., product values minus harvest, slash treatment, and haul costs).

Findings

Our analysis shows that pine/fir/dry mixed-conifer forests occupy about 9.3 million acres, 80 percent of which rate high or moderate for crown fire hazard. The primary purpose of hazard reduction treatments is to modify conditions sufficiently to allow a manageable residual stand to survive after fire. However, simply calling a treatment "hazard reduction" does not make it so. In this analysis, for example, the comprehensive treatment increased average crowning index from 27 to 82 mph—equating to a very low hazard condition—whereas the thin-from-below treatment had little effect on hazard, increasing average crowning index only from 27 to 34 mph. The comprehensive treatment also yielded positive net revenues of $624 per acre, compared to an average out-of-pocket expense of more than $600 per acre required to implement the thin-from-below treatment.

The comprehensive prescription moved 90 percent of treated acres into a low-hazard category, versus only 13 percent for the thin-from-below treatment (*fig. 1*). The more open conditions created by the comprehensive treatment also favor regeneration of shade-intolerant pine, increase tree vigor, and promote large-tree development. Whether the fire problem is viewed from a hazard reduction, eco-logical condition, or financial standpoint, the comprehensive approach is superior to approaches that focus only on removing small trees.

Future Work

The analytical methods developed for this project can be used to develop similar assessments in other states as
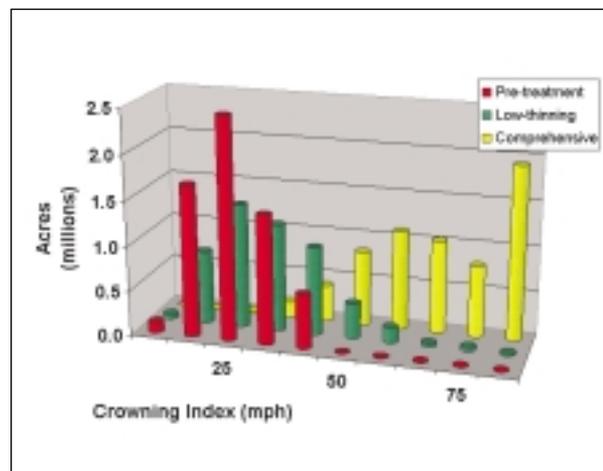

Figure 1. **Distribution of Montana's lower-elevation forestlands by crowning index for existing conditions and after thin-from-below and comprehensive treatments.**

FIA data become available. Results from statewide or regional analyses can also be used to estimate the potential contribution of a strategic-scale hazard reduction program to rural employment and the nation's wood supply.

FIA BioSum: Applying a Multiscale Evaluation Tool in Southwest Oregon

In California, small-diameter trees are being removed via landscape-scale, mechanical fuel treatments and then used for feedstock to generate electricity. This practice is under active consideration in other western states. Because little is known about the concentration and distribution of biomass available from such treatments, or about the financial feasibility of this approach to reducing wildfire hazard, it has been difficult to attract capital investment to biomass-based energy generation facilities. With support from

evaluated using the Fire and Fuels Extension to the Forest Vegetation Simulator. Treatments included thinning across all diameter classes between 3 and 21 inches to a residual basal area of 125 square feet and thin-from-below to a residual basal area of 80 square feet. Cut-tree lists from each plot were valued for merchantable (7–21 inch dbh) and submerchantable (3–7 inch dbh) trees, and treatment costs were evaluated via STHARVEST, a compendium of regression equations for logging cost components derived from

Tradeoffs among costs, merchantable and submerchantable size yield, area treated, and treatment effectiveness were evaluated using linear optimization in which the model was allowed to choose among multiple prescriptions, including the no-treatment option, for each forested acre.

Preliminary Findings

Results vary widely depending on the assumptions and objectives specified. Preliminary findings for the Klamath ecoregion reveal that if revenues generated during treatments were all reinvested to treat additional acres, 2.7 million tons of submerchantable woody biomass suitable as power-plant feedstock could be generated and 636,000 of the 1.6 million treatable acres could be treated at no net cost. At the other extreme, unconstrained biomass maximization would generate 9 million tons of submerchantable woody biomass and treat all 1.6 million treatable acres, but at a net revenue *loss* of $1.7 billion, largely due to the high cost of removing small-diameter wood from steep slopes.

Policymakers are excited about FIA BioSum because it lets them examine the interactions among financial return, fire hazard reduction, and wood utilization potential, facilitating their search for a reasonable balance between acceptable costs and desired outcomes. FIA BioSum analyses of a four-ecoregion area spanning Oregon and northern California, as well as Arizona and New Mexico, are nearing completion and will be available through published reports.
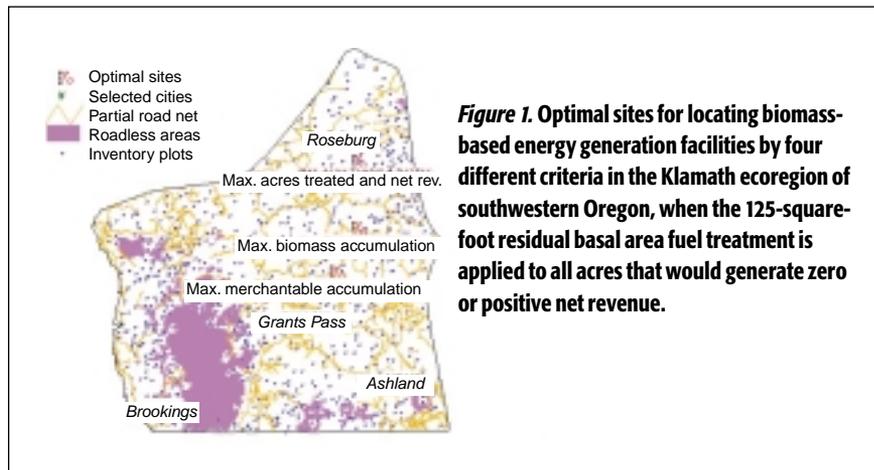

Figure 1. Optimal sites for locating biomass-based energy generation facilities by four different criteria in the Klamath ecoregion of southwestern Oregon, when the 125-square-foot residual basal area fuel treatment is applied to all acres that would generate zero or positive net revenue.

the National Fire Plan and building on work supported by the Joint Fire Science Program, the FIA BioSum modeling framework was developed to estimate biomass availability, financial returns, and fuel treatment efficacy associated with application of silvicultural prescriptions.

Analysis

In the model development and pilot testing phase of FIA BioSum, fire risk reduction–inspired silvicultural treatments were applied to nearly 1,000 FIA plots representing more than 3 million acres of federal and private forestland in southwestern Oregon's Klamath ecoregion. Pre- and post-treatment fire hazard (as represented by torching and crowning indices) were

engineering cost studies. Logging costs were high on steep slopes (>40 percent), where cable yarding was considered necessary; such steep slopes comprise about half of the forested terrain in the Klamath ecoregion.

Haul costs for moving harvested material from each plot to each potential processing site were calculated in a GIS through cost accumulation and added to onsite fuel treatment costs to assess total treatment costs. Biomass accumulation and economic and fire hazard implications associated with each potential processing site were assessed under a variety of assumptions (*fig. 1*). Detailed estimates of amounts of material removed by size class and species are easily generated in this analytic framework.

Contributed by Jeremy S. Fried (jsfried@ fs.fed.us), research forester, R. (Jamie) Barbour, program manager, and Roger Fight, research forester, USDA Forest Service, Pacific Northwest Research Station, 620 SW Main Street, Portland, OR 97205.