Fuel Mapping for the Future

C.W. Woodall, G.R. Holden, and J.S. Vissage

The large wildland fires that raged during the 2000 and 2002 fire seasons highlighted the need for a nationwide strategic assessment of forest fuels. The lack of a nationally consistent and comprehensive inventory of forest fuels has hindered large-scale assessments—essential for effective fuel hazard management and monitoring reduction treatments. Data from the USDA Forest Service's enhanced Forest Inventory and Analysis (FIA) Program is key to creating fuel maps to improve large-scale assessments.

The Program

The enhanced FIA Program has three phases that contribute to fuel map synthesis.

Phase 1. Remotely sensed images help determine whether field crews can access potentially permanent FIA field plots. Forest and nonforest stratification data layers from phase 1 might both constrain fuel loading predictions in forested areas and facilitate certain analyses, such as locating fuels adjacent to wildland/urban interfaces.

Phase 2. Permanent FIA field plots are established (fig. 1), and standing live and dead trees are inventoried. The data from this phase provide information about tree species, crown ratio, and height. They are useful for estimating fuels in each plot's live and dead standing tree stands.

Chris Woodall is a research forester, Geoff Holden is a GIS specialist, and John Vissage is a research forester for the USDA Forest Service, North Central Research Station, St. Paul, MN.

The lack of a nationally consistent and comprehensive inventory of forest fuels has hindered large-scale assessments.

Phase 3. Subsets of the permanent FIA field plots are sampled for indicators of forest health. Down woody material (DWM)—duff, litter, and fine and coarse woody debris—is one indicator. Both planar intercept methodologies and fixed-radius plots are used to measure DWM. In addition, inventory data from indicators, such as soils and vegetative diversity, when combined with DWM data, help refine estimations of nonwoody fuels. When using the enhanced FIA Program, all three phases should be sampled annually for a portion of all permanent plots to maintain current fuels data.

Seamless Dataset. When all phases of the FIA inventory program are integrated, the result is a seamless dataset connecting DWM inventories, traditional forest inventory data, and remotely sensed imagery. The resulting multidimensional fuel maps, developed using the most current data available, provide national fuel estimates from the duff layer to the top of the forest canopy (fig. 2).

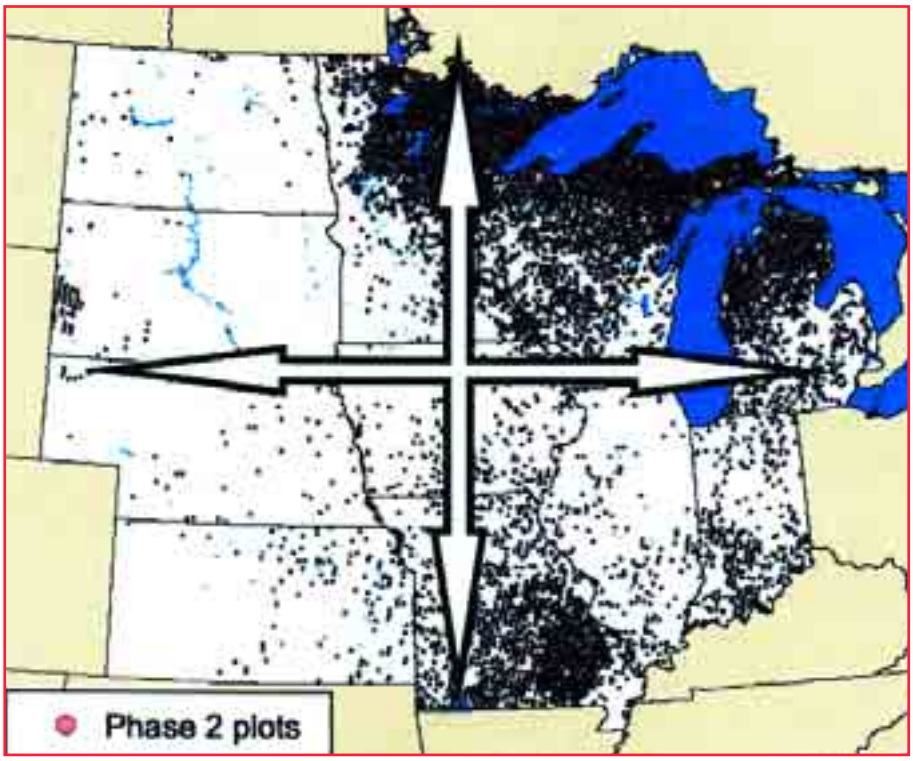

Figure 1—*Annual forest inventory analysis phase-2 plots (forested condition) for the North-Central United States from 1999 to 2001. The plots allow for timely fuel hazard assessments at strategic scales.*

Mapmaking

Modeling, interpolation, and ancillary stratification are methods for creating fuel maps using all phases of the enhanced FIA Program to satisfy a variety of needs. Selecting the appropriate fuel-mapping technique depends on the objectives, acceptable levels of error, regional DWM sampling intensity, and the proximity of the map region to international borders and large bodies of water.

A modeling approach is appropriate when fuel loads are predicted based on a DWM inventory from phase-2 plots. Another approach is to use spatial interpolations to estimate fuel loadings for forests not directly sampled by DWM inventory. When combined with phase-1 forest and nonforest data layers, the fuel loading estimates can produce fuel maps. A third way to create effective fuel maps is to use mean fuel loadings from an ancillary data layer, such as ecological units or forest type, combined with phase-1 forest and nonforest data layers.

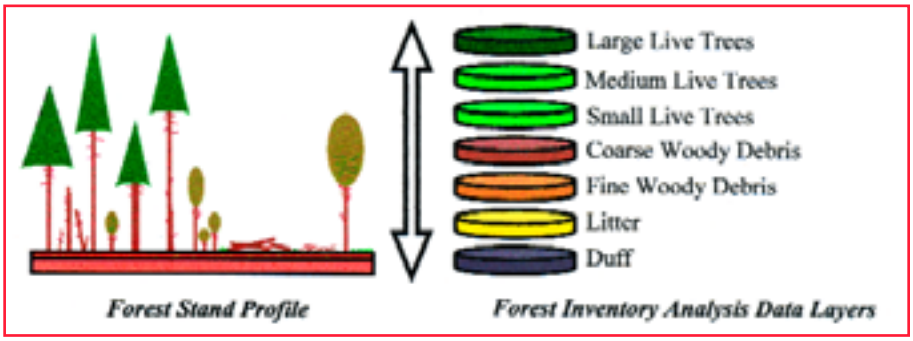

Figure 2—*Components of forest fuels. Individual components were sampled during a comprehensive, vertical fuel hazard assessment.*

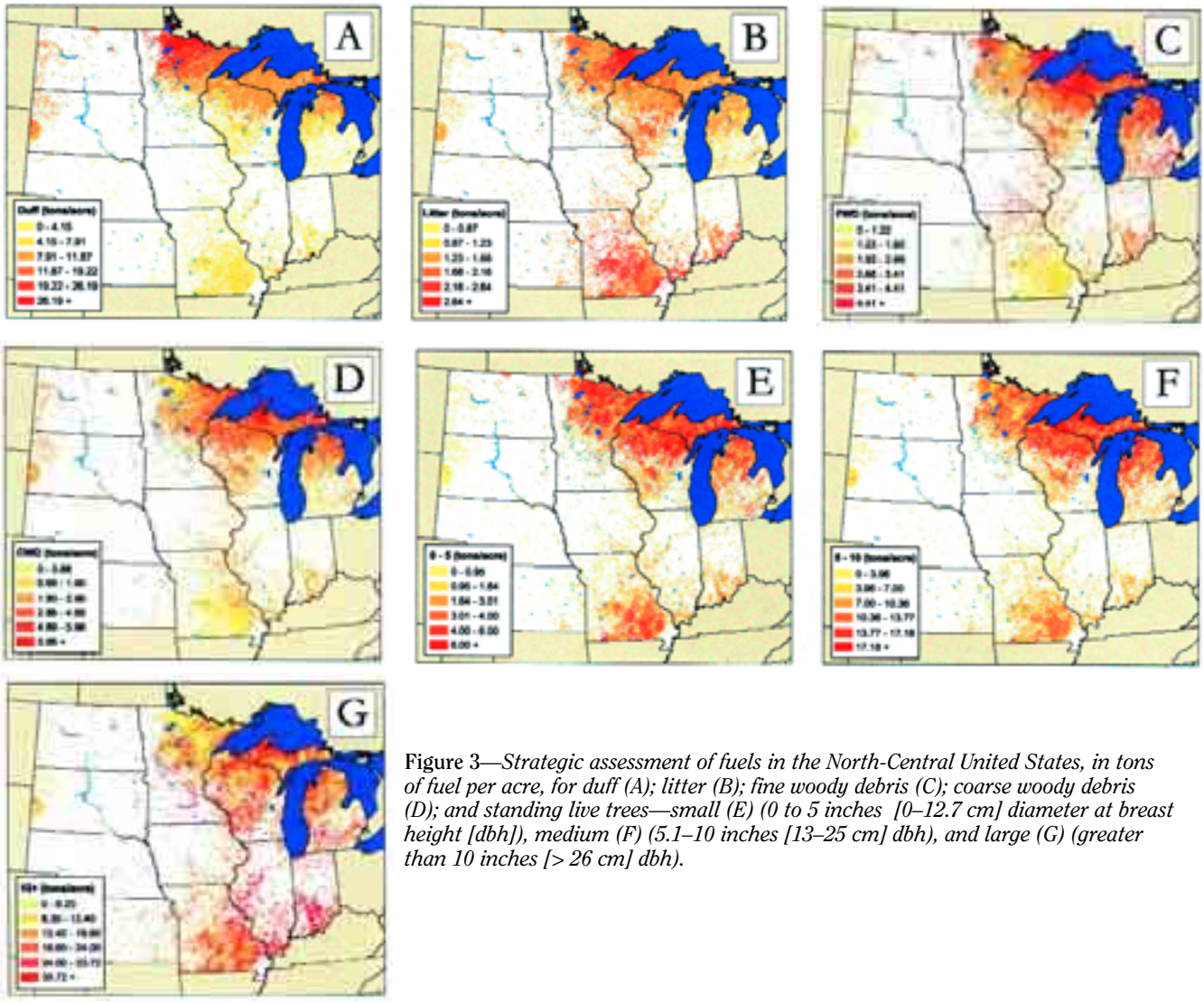

Figure 3—*Strategic assessment of fuels in the North-Central United States, in tons of fuel per acre, for duff (A); litter (B); fine woody debris (C); coarse woody debris (D); and standing live trees—small (E) (0 to 5 inches [0–12.7 cm] diameter at breast height [dbh]), medium (F) (5.1–10 inches [13–25 cm] dbh), and large (G) (greater than 10 inches [> 26 cm] dbh).*

When all phases of the inventory program are integrated, a seamless dataset connecting downed-wood material inventories, traditional forest inventory data, and remotely sensed imagery results.

For example, figure 3 shows seven regional maps for each of the seven fuel layers (duff, litter, two layers of woody debris, and three layers of standing live trees). We produced the maps by interpolating fuel loadings from DWM sample plot locations, combined with phase-1 forest and nonforest data layers. The maps were based on 8,569 phase-2 plots inventoried from 1999 to 2001 and 249 DWM plots inventoried in 2001.

Figure 4 shows a single map integrating all the data in figure 3. Fuel loadings for each individual map were scaled to a uniform data range (0 to 1), then combined and rescaled, yielding a comprehensive assessment of fuels on a strategic scale.

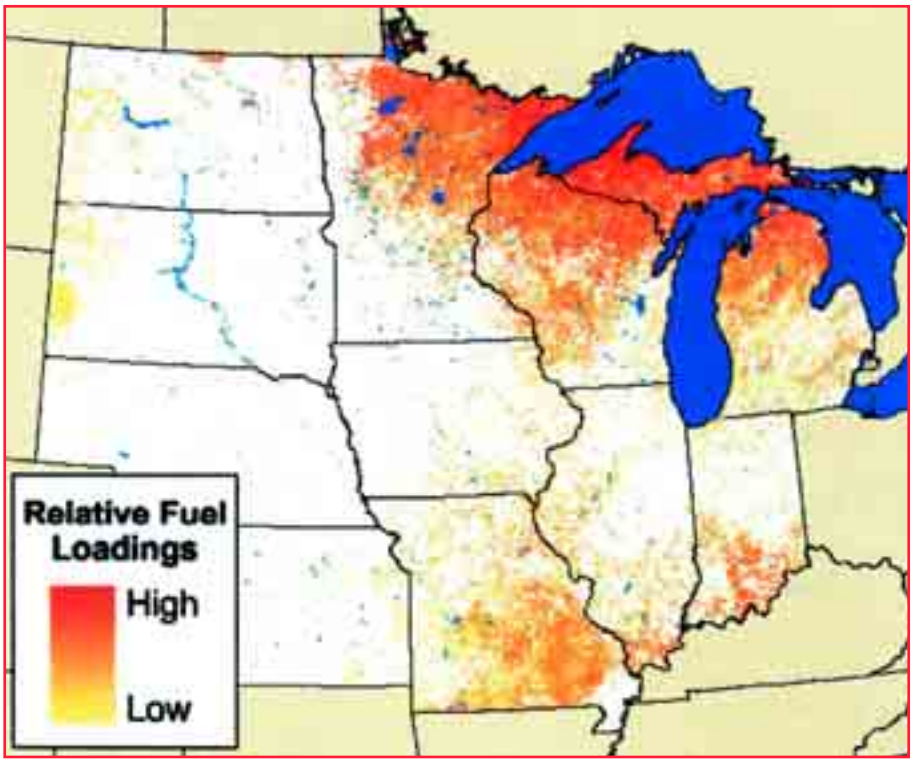

Figure 4—*Relative fuel loadings (duff layer to canopy top) for the North-Central United States, based on combining scaled inventory maps for duff, litter, two layers of woody debris, and three layers of standing live trees.*

Value of Fuel Mapping

Creating comprehensive and consistent national fuels maps is possible using the extensive forest inventory data available through the enhanced FIA program, coupled with new mapping and remote-sensing technologies. Based on the information provided in such maps, completing large-scale assessments, essential for managing and monitoring fuel hazards across forest ecosystems, might mitigate the potential for another devastating fire season.

For more information, contact Chris Woodall, USDA Forest Service, North Central Research Station, 1992 Folwell Ave., St. Paul, MN 55108, 651-649-5141 (tel.), cwoodall@fs.fed.us (e-mail).