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Condition Classes of America's Lands: Appropriate Applications at the National Scale
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SUMMARY

Recent estimates of the number of acres at risk of catastrophic fire are from 80 to nearly 300 times the amount that federal agencies have been able to treat within a year. Thus, policy-makers, federal agencies and the public have recognized the need to set priorities for fuel reduction projects. In an effort to use a consistent science-based framework to set priorities, many, including legislators, are turning to a USDA Forest Service research publication, Development of Coarse-Scale Spatial Data for Wildland Fire and Fuel Management (Schmidt et al. 2002). The paper presents a map that assigns condition classes and indicates the degree of departure from historic fire regimes and associated risks of losing key ecosystem components to all of the land within the 48 conterminous United States. A review of the publication reveals that the condition class map is useful at the national level and that the methodology used to develop the map holds great potential if replicated at a finer scale with higher resolution data. Use of the condition class map at the project scale, however, is inappropriate for several reasons:

- The authors of the condition class map explicitly state that the information presented by the paper is not intended for use at any scale finer than the national level.
- The condition class map is unreliable when cross-checked against actual ground conditions.
- No specific information about forest structure, tree density or the amount and nature of combustible fuels, which are primary factors in determining fire risk, was used to develop the condition class map.
- The method used to develop the coarse, national scale map from fine scale data can significantly overestimate a forest's vulnerability to catastrophic fire.

Using condition class to set priorities for on-the-ground fuel reduction treatments will likely lead to expending federal resources on areas at low risk of catastrophic fire while areas at high risk go untreated.

INTRODUCTION

Several years of drought have exacerbated the cumulative and synergistic effects of logging, livestock grazing, fire exclusion, exotic plant species introduction, and attack by insects and disease. Many forests are vulnerable to extensive and intense wildfires, and the unprecedented fire seasons of 2000 and 2002 captured the nation's attention.

In response to the threats posed by wildfire, Congress and the federal land management agencies developed a cohesive strategy known as the National Fire Plan. After its first year, the federal land management agencies were able to treat 2.25 million acres (US Department of Agriculture and US Department of Interior 2002). Given current estimates from 89 million (Council of Environmental Quality 2000) to 182 million acres (Schmidt et al. 2002) at risk of catastrophic fire, however, the need to set priorities for hazardous fuel treatment projects has secured itself in the minds of the public and legislators.

As attempts are made to develop a consistent method for setting fuel reduction treatment priorities, the results of a USDA Forest Service Rocky Mountain Research Station study have been thrust into the spotlight. The publication, Development of Coarse-Scale Spatial Data for Wildland Fire and Fuel Management (Schmidt et al. 2002), introduces a national level system for classifying an ecosystem's degree of departure from historic fire regimes and the risk to those systems of losing key ecosystem components. The classification system also indicates the degree of change in fire size, intensity, severity or landscape patterns that would result should a fire burn today. Fire regime current condition class, or condition class, is that measure and it has turned up everywhere from newspaper articles to public addresses. Condition class has even been worked into proposed legislation.

During the 107th Congress of 2002, two bills were introduced that would have required condition class to be used as a tool for land management decisions. H.R. 5319 sought to establish expedited procedures that would supersede environmental analysis otherwise required under the National Environmental Policy Act of 1969 for any project that sought to raise the status of the land from a condition class 2 or 3 toward a condition class 1. Another bill, H.R. 5376, proposed to exempt projects that reduced fuels on condition class 3 lands from the Department of the Interior's or the USDA Forest Service's administrative review appeals processes. While neither of these bills were passed into law, the potential for legislation to be predicated upon condition class still exists.

Despite the frequent use of the term and concept of condition class, the source from whence condition class came is little discussed. This paper explains how condition class was developed and its strengths and weaknesses as a tool for setting priorities.

REVIEW OF METHODOLOGY

Among the several products coming out of the work by Schmidt et al. (2002) was a map "depicting the degree of departure from historical fire regimes, possibly resulting in alterations of key ecosystem components." Generally, a fire regime is "'the nature of fires occurring over an extended period of time'" (Brown 1995, from Morgan et al. 2001). More specifically, fire regimes are described by the frequency, severity, intensity, predictability, size, seasonality and spatial patterns of fire in a given area (Morgan et al. 2001). Often, however, descriptions are limited to the frequency and severity of wildfire.

This condition class map assigned one of three rankings to all of the land comprising the 48 conterminous states. The condition classes are:

1. *Condition Class 1*: Lands where fire regimes are within an historical range, and the risk of losing key ecosystem components is low.
2. *Condition Class 2*: Lands where fire regimes have been moderately altered from their historical range. The risk of losing key ecosystem components is moderate. Fire frequencies have departed from historical frequencies by one or more fire return intervals. The altered fire regime results in moderate changes to one or more of the following: fire size, intensity, severity, and landscape patterns.
3. *Condition Class 3*: Lands where fire regimes have been significantly altered from their historical range. The risk of losing key ecosystem components is high. Fire frequencies have departed from historical frequencies by multiple return intervals. The altered fire regime results in dramatic changes to one or more of the following: fire size, intensity, severity, and landscape patterns. Vegetation attributes have been significantly altered from their historical range.

Development of the condition class map can be broken down into two steps. These steps involved: (1) synthesizing existing information, and (2) measuring departure from historical land cover and forest density, and assigning condition class.

Synthesizing Existing Information

The first step in developing the condition class map was to identify and synthesize existing, spatially explicit data. In all, five intermediate spatial data sets were created from ten pre-existing data sets.

- *Ecoregions*, derived from three data sets, divides the U.S. into broad ecological regions;
- *Potential Natural Vegetation,* compiled from two maps, partitions the contiguous U.S. into 63 different vegetation types;
- *Fire Regime*, created from expert opinion and by referencing two pre-existing fire regime maps, is a map of historical fire regimes;
- *Current Cover*, derived from two spatial data sets; and
- *Forest Density*, developed by revising one data layer, approximates the current conditions of forests of the contiguous 48 states.

What follows is a brief description of how the data sets were used.

Ecoregions

Bailey and others (1994) developed a map at a scale of 1:7,500,000, or 1 inch to 118 miles, that divided the U.S. into 165 relatively homogenous ecological areas. Because the ecological areas did not conform to landscape features that could be mapped, Bailey's map was synthesized with a map that delineated watersheds across the U.S. These two data layers were then combined with a map of Forest Service region administrative boundaries such that expert panels could be organized and conducted according to the USDA jurisdictions.

Potential Natural Vegetation

The vegetation that would be present on the landscape in the absence of human interference was estimated using Küchler's Potential Natural Vegetation (PNV) map (1975). Because of the coarse-scale of the vegetation map (1 inch to 50 miles), PNV designations were adjusted to match topographic features using an elevation map. The PNV map was also tailored to correspond to watershed boundaries by using the same watershed map from the Ecoregion layer.

Fire Regime

The ideal information source for mapping fire regimes is a detailed account of the frequency and severity of wildfires across a landscape over time. An alternative source lies in the fire scars of trees. By counting the growth rings of a tree and noting where there are scars from past fires, scientists can establish a fire history for that tree. Replicating the process across many or all of the trees in a given area can help to estimate an historical fire regime for the area. Unfortunately, this fine-scale, detailed information is available in only a few locations. For this reason, limited site-specific data is extrapolated to broader scales to hypothesize about historical fire regimes.

One method of extrapolation is the rule-based approach. The rule-based approach uses expert opinion to assign fire regimes to different landscapes and then assumes uniform fire behavior and frequency for each hypothesized regime. This method typically incorporates, but does not depend upon, specific fire history data (Morgan et al. 2001).

The fire regime map layer developed by Schmidt et al. integrated two pre-existing fire regime maps. The first map version used expert opinion to assign fire regimes across the lower 48 states according to general land cover types. The second version incorporated expert knowledge, remotely sensed data, and biophysical data to map fire regimes of eleven western states (from Washington south to California, east to New Mexico and north to Montana). The resulting layer used by Schmidt et al. to develop their condition class map assigns one of five regimes to all land within the lower 48 states. The fire regimes are:

- I 0-35 year frequency, low severity
- II 0-35 year frequency, stand-replacement severity
- III 35-100+ year frequency, mixed severity
- IV 35-100+ year frequency, stand-replacement severity
- V 200+ year frequency, stand-replacement severity

Current Cover

The current land cover for the contiguous U.S. was derived from two separate maps. Forest cover type was taken from the Resource Planning Act's (RPA) map of US Forest Type Groups (Powell et al. 1992; Zhu and Evans 1992, 1994). The RPA map is at a resolution of 1-km^2 and is based on intensive field data. Schmidt et al. cross-referenced the forest cover type map with the Society of American Foresters' Forest Cover Types of the United States and Canada (Eyre 1980). Non-forest cover types were taken from a separate land cover database (Loveland et al. 1991).

Forest Density

Forest density is a measure of forest cover developed for the RPA assessment. The forest cover measure, originally broken down into four percentage density categories (0-25%, 26-50%, 51-75%, 76-100%) were restructured into non-forest, 0-32%, 33-66%, and 67-100% classifications.

The forest density map is at a 1-km^2 resolution and was used as a surrogate for forest structure because no spatial data for forest structure for the entire conterminous U.S. was available.

Assigning Condition Classes

Regional experts, during the course of a series of workshops, used three of the synthesized spatial data layers--the ecoregion, the potential natural vegetation, and the fire regime maps--to construct a hypothetical model of how a forest would grow in the absence of major human impacts. These growth models, or succession diagrams, were very simplified in terms of mimicking actual, natural forest growth processes and were used to establish what a 'natural' forest should look like with the inclusion of periodic fire.

Regional experts then estimated present forest conditions using the following four synthesized data sets:

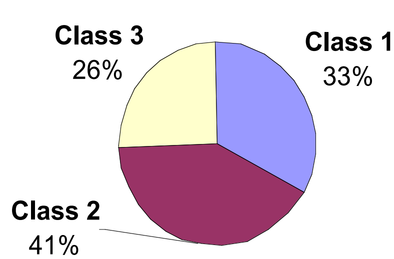
- ecoregion,
- potential natural vegetation,
- current cover, and
- forest density information.

Estimated present conditions were then compared to the hypothesized 'natural' conditions and relative departure indices (RDI) were assigned. The RDI represents the difference between the present conditions and the hypothesized 'natural' conditions as quantified by the number of times that a fire return interval had been skipped, where an interval is the average amount of time between fire events in the historical fire regime. An RDI of 2, for instance, means that two fires that would have historically burned on the land must not have occurred in order to explain the present land cover. The estimated number of fires missed was subsequently used to assign condition class rankings of 1, 2 or 3, with 3 denoting the most significant degree of departure from historical fire regimes.

Condition Class Acreage

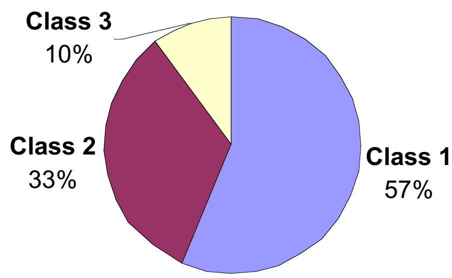
Schmidt et al. found that 51,125,000 acres (or 26%) of all lands managed by the USDA Forest Service were in condition class 3. This is an area roughly the size of the state of Utah. Forest Service lands in condition class 2 exceed the size of the state of New Mexico at 80,446,000 acres. This is 41% of the entire National Forest system.

Figure 1. **USDA Forest Service Lands by Condition Class**



For lands managed by the Department of the Interior, 23,473,000 acres are assigned a condition class of 3 (10% of all DOI land) while 75,829,000 acres (33%) of the land managed by the DOI, or an area larger than Arizona, is mapped as condition class 2.

Figure 2. **US Department of the Interior Lands by Condition Class**



EVALUATION OF FOREST DENSITY

Forest density is the sole measure of current forest condition used by Schmidt et al. (2002). In considering forest density, it is important to note the authors' caveat regarding the map layer. "We used this forest density data as a surrogate for forest structure because no spatial layer of forest structure for the conterminous United States existed and it was beyond the scope of this project to develop such a product" (Schmidt et al. 2002). Second, forest density should not be confused with tree density. Whereas tree density is a measure of the number of trees on a landscape, the forest density map "represents the percent of forested area" (Zhu and Evans 1994). Forest density is an approximation of tree canopy cover more than of any other forest attribute.

How the Forest Density Layer Was Developed

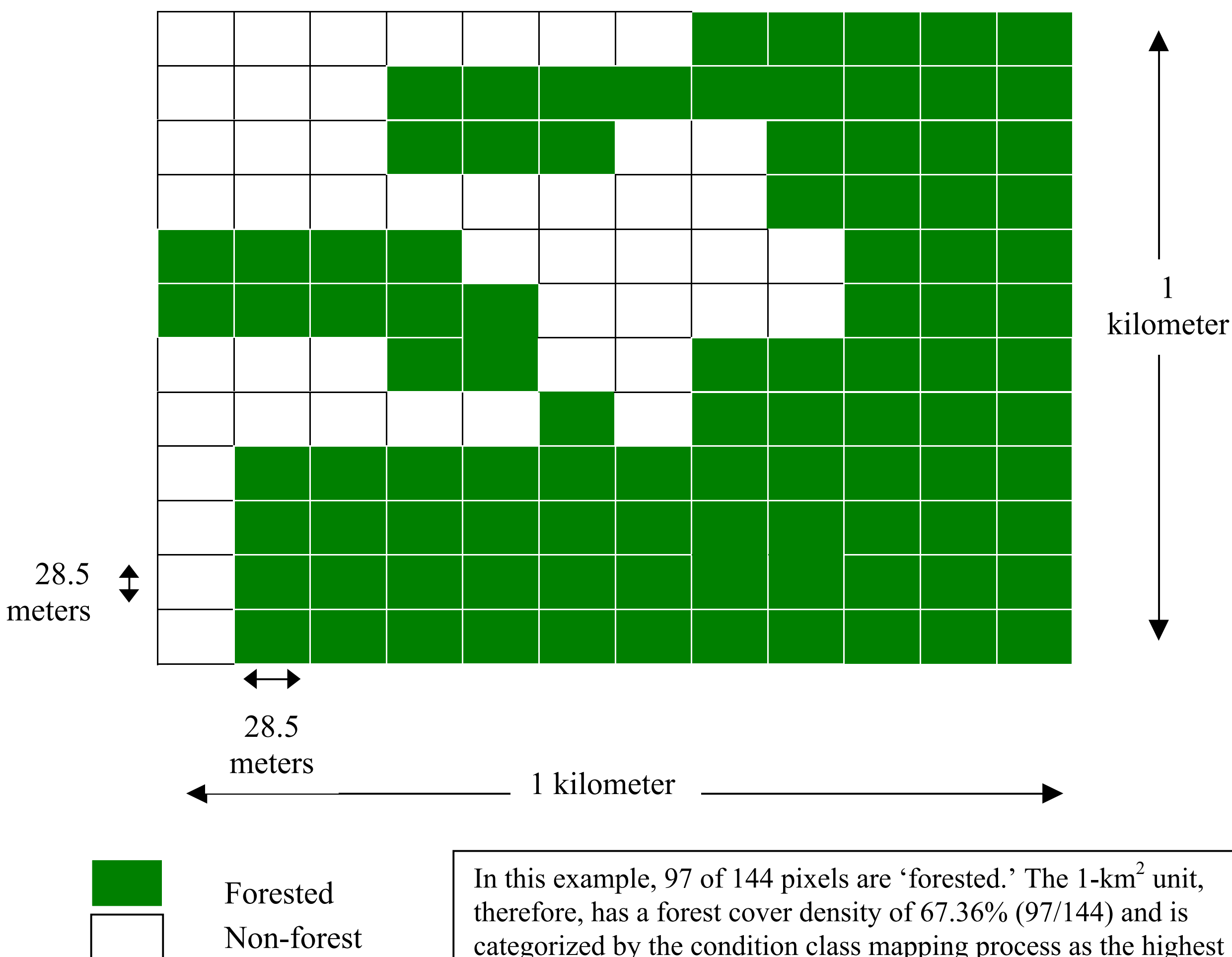
Understanding the process by which fine-scale data were aggregated to develop the coarse-scale forest density map is important if one is to recognize its strengths and limitations. First, the contiguous United States was divided into 15 physiographic regions. Then, for each region, at least one focus area was remotely sensed in 28.5 m^2 pixels. These pixels were then classified using satellite imagery as either 'forested' or 'non-forest' depending upon the percentage of tree cover. A pixel was categorized as 'forested' if at least 20% of the land was covered by forest vegetation.

The 28.5-m^2 pixel data was then aggregated to a scale of 1-km^2 and extrapolated across the entire physiographic region. Aggregation of the 28.5-m^2 pixels up to the 1-km^2 scale involved 3 steps (Figure 1).

1. The number of forested 28.5-m^2 pixels within each 1-km^2 unit were counted.

2. A forest density percentage was calculated based upon the number of forested pixels in the 1-km^2 unit. For example, there are 1,225 pixels in each 1-km^2 unit. If 900 of the 28.5-m^2 pixels are forested, then the 1-km^2 unit was assigned a forest density of 73.45%.
3. Finally, the forest density percentages were lumped into four broad categories. For the condition class map, the categories are non-forest, 0-32%, 33-66%, and 67-100% forest cover densities.

Figure 1 **Example of the Aggregation of forest cover density information from a resolution of 28.5-m^2 to the 1-km^2 unit size.**



In this example, 97 of 144 pixels are 'forested.' The 1-km^2 unit, therefore, has a forest cover density of 67.36% (97/144) and is categorized by the condition class mapping process as the highest forest cover density rating of 67-100%.

[Note: This is not to scale. There are approximately 1,225 28.5-m^2 pixels in a 1-km^2 block.]

LIMITATIONS OF CONDITION CLASS

One of the first efforts to provide a national database of the current conditions of vegetation, Schmidt et al.'s work is both innovative and impressive. The study, however, does have its limitations and weaknesses.

At its current resolution, condition class is useful only at the national-level, and not the project-level scale. Schmidt et al. are very clear about the intended use and the limitations of the condition class map. **"**The objectives of this mapping project were to provide national-level data on the current condition of fuel and vegetation. Therefore, the data are most useful at that scale. The end products were not intended to be used at scales other than a coarse scale… The large cell size (1-km^2) combined with the coarse map scale (approximately 1:2,000,000) of these data products provide appropriate detail when viewed in their entirety or at a regional scale, but details expected at finer scales will be lacking" (Schmidt et al. 2002). The authors add, "end products are not intended to be absolute or precise in terms of accuracy in minute detail. It is the regional perspective and analysis that are most important in using the maps" (Schmidt et al. 2002 from Zhu and Evans 1992).

The condition class map layers that can be found on the Forest Service website carry the same warnings. "These coarse-scale data were developed for national-level planning. Summaries of the data were restricted to state or Forest Service regional scales. The data were not intended to be used at finer spatial scales" (USDA Forest Service 2004).

The condition class map can be inaccurate when checked in the field. Condition class data are frequently inaccurate when the condition class map is checked against conditions found on the ground. The map is at such a coarse-scale that testing its accuracy by using field data is infeasible (Schmidt et al. 2002). Some individual efforts to crosscheck the information presented in the condition class paper illustrate this problem of resolution.

In New Mexico, areas that were clearcut in the 1960s and 1970s, and have required three re-plantings before any successful tree regeneration could be noticed, are mapped as condition class 3. These areas have very low fuel loads and do are not pose a fire risk. Also, areas that have burned within the last 20 years are mapped as though they have missed multiple fire return intervals and are at high risk of a catastrophic fire. Some spruce-fir forests that should have 200+ natural fire return intervals are mapped as though they should experience a fire every 0-35 years and therefore need to be treated to avoid catastrophic fire. In the Pacific Northwest, while attempting to verify forest density information, researchers found that areas that are mapped as the highest forest density classification of 67-100% are actually clearcut patches (Wilmer, personal communication).

No fuel load data was used in calculating and assigning condition classes. Developing a data set that reflected forest structure and fuel loading was, as the authors state, "beyond the scope" of the project. Using forest cover density as the sole measure of the current condition of forests is a significant weakness of the condition class mapping process.

> "Another weakness of our methodology was using forest density as a surrogate for structural stage. Because forest density data were mapped as the amount of forest per unit area, not as actual forest structure, the data were sometimes inadequate to reliably determine what condition class to assign to the combination of potential natural vegetation group, cover type, forest density, and fire regime. Mapping detailed and accurate forest structure over large areas is complex, data intensive, and usually requires high-resolution data (in other words, small cell size) (Cohen and Spies 1992). It was beyond the scope of this project to develop a National Forest structure map. Therefore, we used one of the few available spatial datasets covering the conterminous United States as a proxy for structure" (Schmidt et al. 2002).

Fuel loading in forests can be difficult and labor intensive to measure. The forest cover density data used by Schmidt et al. does not incorporate any fuel measurements. The spatial data layer does not address crown fire issues such as the presence of overlapping crowns or the bulk density of the crowns. It also fails to employ any estimate of the available combustible material on the ground, which is a prerequisite for an active crown fire (DeBano et al. 1998). The condition class map makes assumptions about fuels given the vegetation type and the canopy cover, which is scientifically defensible if used to make broad generalizations about the landscape across a large scale. It is not defensible if the information is used to guide, prioritize and direct project-scale planning.

The aggregation process can lead to significantly overestimating forest density. Because the threshold for a 'forested' pixel is set at 20% forest cover, the way the forest density map was aggregated onto the 1-km^2 scale has the potential to significantly overestimate forest cover on the landscape.

Consider a 1-km^2 unit that is mapped at the highest forest density value of 67-100%. Revisiting the explanation of the aggregation process, an assignment of 67-100% forest density rating means that at least 67%, or 821, of the 1,225 pixels are forested. Given that a 'forested' pixel can have as little as 20% tree cover, the 1-km^2 unit could have as little as 13.4% (20% x 67%) tree cover and yet still qualify as the highest density rating.

To compare these percentages to what might be physically found on the landscape, the percent cover qualification for 'forested' can be equated to a basal area threshold for 'forested.' According to the USDA Forest Service Forest Inventory Analysis (FIA), 20% tree cover is a little more than, but roughly corresponds to, 10% stocking. For ponderosa pine, 10% stocking means that each acre of forest supports at least 19 trees measuring between 11 inches and 12.9 inches diameter at breast height (dbh) (USDA Forest Service 2003). Using a Forest Service conversion chart, 19 twelve-inch dbh trees correspond to a basal area for that forested tract of just under 15 ft^2 per acre. Restated, a 1-km^2 unit could be classified in the highest forest density category with a forest that maintains a 15 ft^2 per acre basal area. For comparison, the most aggressive prescriptions for fuel reduction projects in New Mexico ponderosa pine forests seek to thin forests down to a basal area of 30 ft^2 per acre after the treatment.

The forest density map was created through the use of regression equations. While much resolution is lost during its aggregation up to the 1-km^2 scale, the error for the forest density map is acceptable at the national scale. That is, where forest density is underestimated at one point on the landscape, it may be overestimated at another, and the result is a map that is acceptable when viewed across the nation as a whole. When the forest density map is reduced down to the project level, however, inaccuracies will result. At times, these inaccuracies can be as extreme as prioritizing a forest for treatment because it is mapped as a high density forest at risk of catastrophic fire but that has a basal area of only 15 ft^2 per acre.

USES OF CONDITION CLASS

Because of the strong public and political will to prioritize hazardous fuel reduction treatments, use of the condition class map in its present form is a recurring topic of discussion. As noted, condition class entered into the language of two proposed bills in 2002, and allocating resources to federal agencies based upon condition classes of the lands they manage is a prospect.

While Schmidt et al.'s condition class is attractive in that it is a system that already exists and that would require neither time nor resources to develop, the information is not suited for either of the bills introduced in the 107th Congress. Both bills suggested some form of expedited environmental review process based upon condition class, but the condition class map is not appropriate in this capacity. Environmental assessments are required to evaluate the potential impacts of activities at the project level. The condition class map cannot provide reliable information at that scale. Attempts to use condition class to prioritize project level decisions will lead to poorly placed projects and considerable waste of public investment. Exempting reviews for these projects will likely result in some detrimental, environmental impacts. The potential for resources to be spent on areas that are not in fact at risk of catastrophic fires, while areas that are at risk and that may pose a threat to human life and property go untreated, is high. The map is not at a fine enough scale to set project level priorities with accuracy.

Predicating resource allocation upon condition class is also problematic. Some federal agency personnel in the Southern U.S., for instance, are concerned about the potential for Congress to hinge funding on condition class (Menakis, personal communication). At present, the condition class map does not depict high percentages of at-risk acres in the southern United States. Thus, future funding based upon condition class would be minimal in the South. The high growth rates of the South, however, mean that it would not take long for fuels to accumulate and for low risk forest to become high risk. Without the resources to treat lands in the South to maintain low fuel loads, the risk of losing key ecosystem components would increase, and by the time the funding mechanism caught up with the true state of the land, a catastrophic fire could already have burned.

Instead, decision-makers should focus on the strengths of the condition class work. The authors highlight their succession diagram methodology, described above (Assigning Condition Classes), as a process that has the potential to yield useful results when replicated. There also exists the opportunity to take the overall methodology of synthesizing information about different ecosystem attributes in a spatial format to evaluate fire risk at a finer scale. Nationally, federal agencies and partners are developing such a tool, called Landfire, that is expected to be ready for use in 2008. Locally, at least one Forest Service Ranger District in New Mexico has developed its own fine-scale methodology based upon the Schmidt et al. model for estimating the condition class of its lands.

CONCLUSION

The purpose of the condition class project was to provide managers with spatial data "to describe regional trends in current conditions and to *support* (emphasis added) fire and fuel management program development and resource allocation" (Schmidt et al. 2002). The data was not meant to *drive* fire and fuel management and resource allocation. The key to the Schmidt et al. project is the methodology and the potential to replicate it on a smaller scale that could then be useful in making management decisions. Use of the national condition class map for public policy that sets project-level direction, however, is not appropriate and could misapply resources to areas that are not actually at high risk.

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