
Analysis of 1988 Post-Fire Forest Conditions in Yellowstone National Park from the 2002 Forest Inventory and Analysis of Wyoming

Michael T. Thompson

*U.S. Forest Service, Rocky Mountain Research Station, Forest Inventory and Analysis, Ogden Forestry
Sciences Lab, 507 25th Street, Ogden, UT 84401 (801-625-5374, mtthompson@fs.fed.us)*

Jock Blackard

Same address (801-625-5394, jblackard@fs.fed.us)

Abstract

In the summer of 1988, during the driest period in Yellowstone National Park's history, large-scale fires burned more than one-third of the park's area. The 2002 inventory of Wyoming's forest conducted by the U.S. Forest Service's Forest Inventory and Analysis (FIA) program marked the first comprehensive forest inventory of Yellowstone National Park. Information was collected on each FIA sample that identified sample plots with evidence of burn in 1988. This information allows for summaries and statistical analysis of current forest conditions in Yellowstone that had evidence of fire in 1988. Forest area attributes such as forest type, stand size, stand age, stand density index, and basal area class are presented in this paper. Tree-level attributes such as species, numbers of trees, diameter class distribution, growth, and mortality are also presented. FIA's estimate of the amount of forest area that burned in 1988, based on the 2002 plot burn history, is 803,000 acres. The most dramatic effect is the heavily skewed age class distribution toward the youngest age class. Sixty-four percent of the burned area is currently classified as a lodgepole pine forest type, and another 19% is non-stocked. Spruce-fir types account for 7% of the burned area; the remaining 10% is comprised of aspen, Douglas-fir, Engelmann spruce, whitebark pine, and limber pine types. More than 58% of the burned area is classified as a sapling/seedling stand size class, 18% is sawtimber stands, and 5% is poletimber stands.

Introduction

In the summer of 1988, the driest recorded period in the history of Yellowstone National Park, large-scale fires burned more than one-third of the park's area. The fires created a unique forest ecosystem that has been extensively studied in subsequent years to evaluate how forests and wildlife recover from severe disturbance. Ecological succession, spatial heterogeneity, herbaceous production, and effect on mammal populations are some examples of studies conducted on the areas burned in 1988.

The U.S. Forest Service's Forest Inventory and Analysis (FIA) program recently completed a comprehensive forest inventory for the state of Wyoming that included Yellowstone National Park. The data from this inventory included information about those sample plots that had evidence of burn in 1988. The forest inventory estimates from sample plots that burned in 1988 provide an opportunity to examine forest area attributes, population estimates of live trees, and stand dynamics from a broad-scale

perspective about 11 years after the fires occurred.

Methods

FIA's extensive, sample-based inventory includes a systematic grid of permanently established field plots across all lands in the interior West. The FIA program uses a mapped, fixed-plot design as part of its national core sampling protocols (Hahn et al. 1995). Each ground plot contains a cluster of four points spaced 120 feet apart. Each point is surrounded by a 24-foot, fixed-radius subplot where trees 5.0 inches diameter at breast height (d.b.h.) and larger are measured. All four subplots total approximately 1/6 of an acre. Each subplot contains a 6.8-foot, fixed-radius microplot where saplings (1.0–4.9 inches d.b.h.) and seedlings are measured. All four microplots total approximately 1/75 of an acre.

To divide the forest into various domains of interest for analytical purposes, the tree data recorded on these plots is properly associated with the area classifications. To accomplish this, plots are mapped

by condition class. Field crews assign an arbitrary number (usually 1) to the first condition class encountered on a plot. This number is then defined by a series of predetermined discrete variables attached to it: land use, forest type, stand size, regeneration status, tree density, stand origin, ownership group, and disturbance history. Additional conditions are identified if a distinct change occurs in any of the condition-class variables on the plot.

Sometimes a plot straddles two or more distinct condition classes. Boundaries between condition classes can bisect the subplots, or they can be located between the subplots. Microplots are mapped in a similar fashion. Thus, for each ground plot, the microplot and subplot area in each condition class is known, as are the location and condition class of every tree tallied.

Fieldwork began in Wyoming in 1998, and was completed in 2003. Most of Yellowstone National Park was inventoried in 1999. The most recent inventory of Wyoming marks the first wall-to-wall coverage inventory of Yellowstone National Park. Previous forest inventories did not install sample plots on

reserved public land. For each inventory plot that sampled forest land, field crews recorded evidence of fire and the year in which it occurred. Figure 1 illustrates those inventory plots that sampled forest land with evidence of burn in 1988, overlaid with ancillary coverage of the 1988 burned area. Figure 2 illustrates those inventory plots that sampled forest land with no evidence of fire in 1988. A total of 132 inventory plots had evidence of burn in 1988, and a total of 131 inventory plots had no evidence of burn in 1988.

Forest area

Forest Inventory and Analysis estimated the total land area (excluding census water) in Yellowstone National Park to be 2.0 million acres. Eighty percent of the total land area was classified as forest land. About 803,000 acres were estimated to have evidence of fire in 1988; 795,000 acres were estimated to have no evidence of fire in 1988.

Forest type is a classification of forest area based on the predominant tree species in a stand. It affects wildlife habitat, timber supply, and other forest eco-

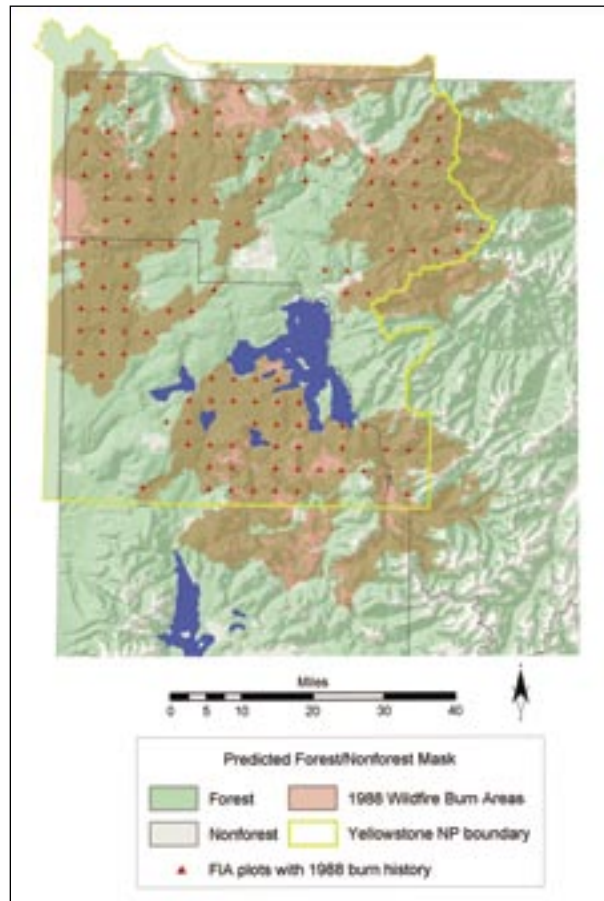


Figure 1. Forest inventory plots that sampled forest land with evidence of fire in 1988, Yellowstone National Park, in Wyoming, 2002.

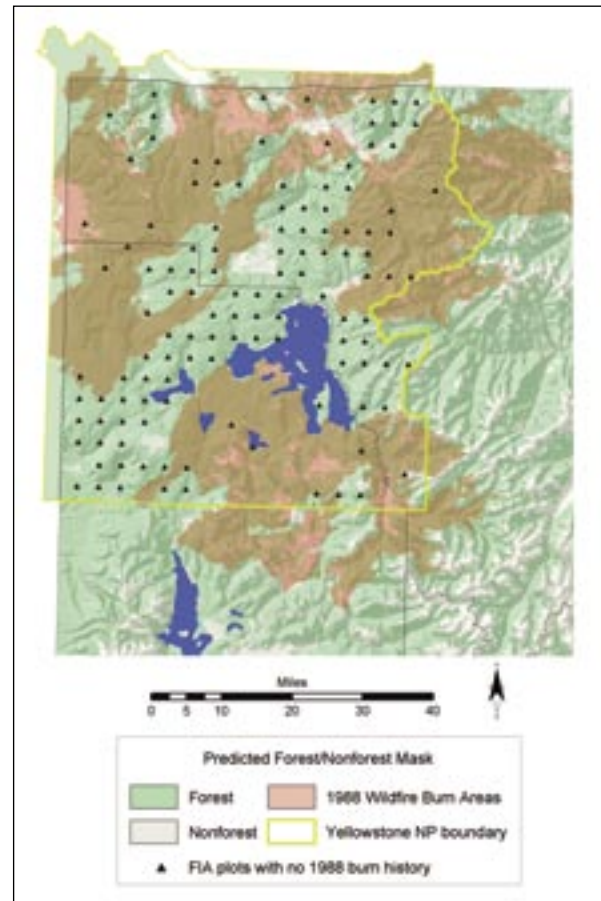


Figure 2. Forest inventory plots that sampled forest land with no evidence of fire in 1988, Yellowstone National Park, Wyoming, 2002.

system goods and services. Lodgepole pine occupies the largest amount of forest area burned in 1988, at 64% (513,000 acres) (Figure 3). Second in abundance is non-stocked timberland at 19% (149,000 acres). Non-stocked timberland refers to land that is less than 10% “stocked” (covered) with live trees but has the potential to support live tree cover at or above 10%. Third, the spruce-fir type accounts for 7% of the burned area, followed by aspen forest types at 3%.

Comparisons of forest inventory estimates on burned and unburned forest land illustrate some striking differences in forest cover type in Yellowstone National Park. Figure 4 compares the area burned in 1988 against the area with no evidence of burn in 1988 by major forest type. Lodgepole pine predominates on the unburned area at 55% (441,000 acres). There is significantly less non-stocked timberland on the unburned area compared to the burned area, where non-stocked timberland accounts for 20,000 acres, or 3%. Spruce-fir, Englemann spruce, and whitebark pine types on the unburned area are more than double that recorded on the burned area. Also noteworthy is the absence of aspen forest types recorded on the unburned area.

The most significant impact of the 1988 fires from a macro-forest land condition perspective is the effect on stand-age class. Stand age is a computed variable using only those ages of trees within a computed stand-size class and weighted by trees per acre. If a computed stand-size class is non-stocked/unclassified, the age class is defined as non-stocked/unclassified. Figure 5 shows 50-year stand age classes for the burned and unburned areas. Fifty-seven percent of the burned forest area is concentrated in stands less than 50 years of age, and nearly 77% of the burned stands classified as lodgepole pine forest type are less than 50 years of age. Most of these young stands, especially lodgepole pine, are newly regenerated stands that reestablished following the 1988 stand-replacing fires. In contrast, only 13% of the unburned forest area in Yellowstone National Park is in stands of 50 years and younger. The forest area in the unburned area is more normally distributed than the burned area, with the majority (50%) in stands 100–200 years old.

Several studies suggest that all forest types across all stand ages were affected by the 1988 fires (Christensen et al. 1989). Initially the public and some ecologists assumed that the 1988 fires would result in a uniform landscape of exclusively even-aged stands similar to what would be expected following a large,

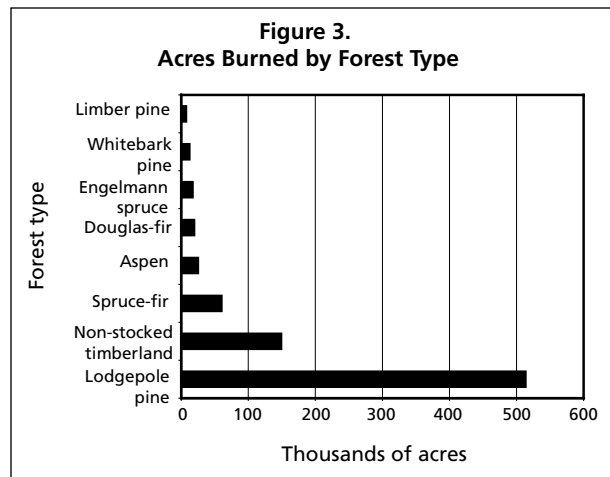


Figure 3. Area of forest land with evidence of burn in 1988 by forest type, Yellowstone National Park, Wyoming, 2002.

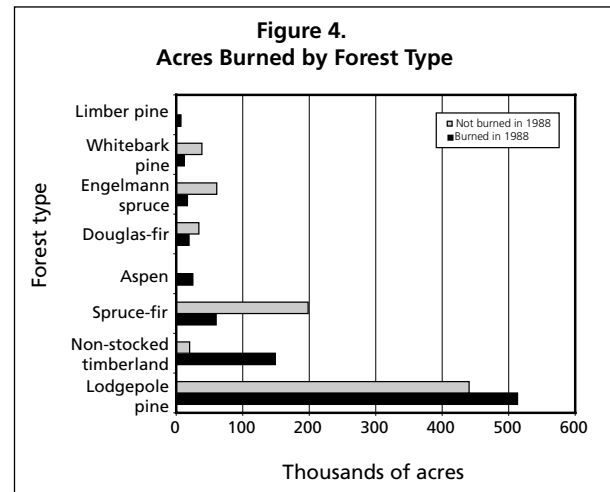


Figure 4. Area of forest land by forest type and 1988 burn status, Yellowstone National Park, Wyoming, 2002.

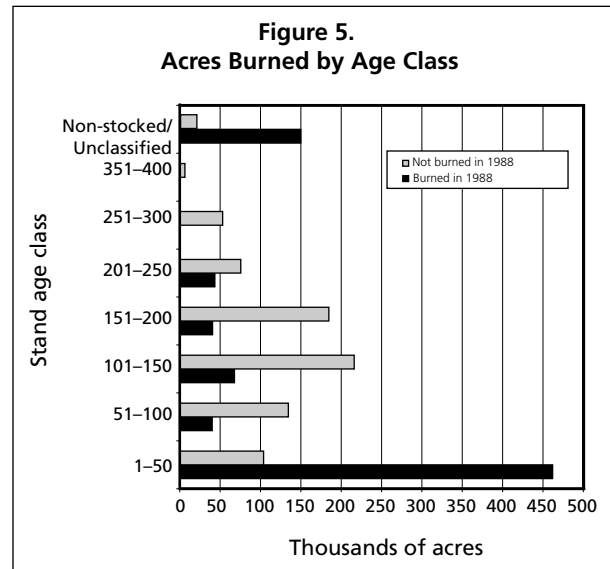


Figure 5. Area of forest land by stand-age class and 1988 burn status, Yellowstone National Park, Wyoming, 2002.

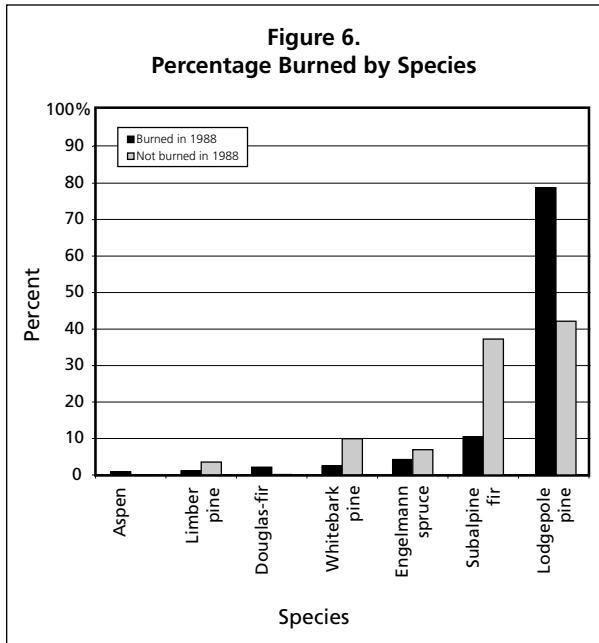


Figure 6. Distribution of all live trees by 1988 burn status, Yellowstone National Park, Wyoming, 2002.

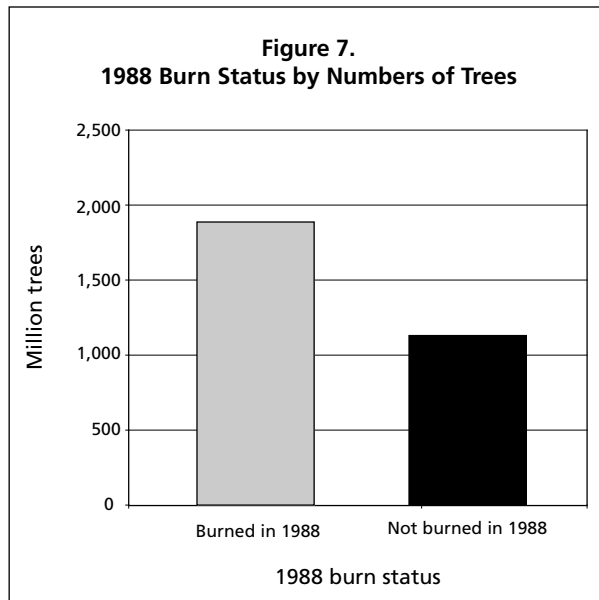


Figure 7. Number of live lodgepole pine seedlings on forest land classified as lodgepole pine forest type by 1988 burn status, Yellowstone National Park, Wyoming, 2002.

human-caused disturbance such as clear cutting followed by natural or artificial regeneration. However, the fires actually created a spatially complex mosaic of unburned and burned patches as the result of a wide range of burn severities (Turner et al. 2003). Within the burned area, the amount and spatial distribution of the forest area classified as non-stocked/unclassified suggest that the fires created patches of marginally stocked forest land. These non-stocked

forest conditions are widely distributed spatially in the burned areas and are not concentrated in any one geographic location. The large numbers of these forest areas with low live-tree density are probably the result of patch size, burn severity, and pre-fire cone serotiny. Small patches, low intensity of surface burns, and small percentages of pre-fire stand serotiny (measured by percentage of lodgepole pine trees bearing serotinous cones) are strongly correlated with post-fire lodgepole pine seedling density (Turner et al. 2003).

Numbers of live trees

Forest Inventory and Analysis generates population-level estimates of numbers of live and dead trees. These estimates are used for species diversity measurements, timber supply studies, old-growth analysis, and stand density assessments. On the forest area burned in 1988, the estimate of all live trees, including seedlings, is 2.6 billion trees. Lodgepole pine accounts for 79% of all live trees on the burned area, at 2.0 billion trees. Next in abundance is subalpine fir at 10%, followed by Englemann spruce at 4%, whitebark pine at 2%, Douglas-fir at 2%, and limber pine at 1%. Lodgepole pine also predominates on the unburned area, at 1.4 billion trees or 42% of the live tree total. Subalpine fir is second in abundance at 37%, followed by whitebark pine at 10%, Englemann spruce at 7%, and limber pine at 4%. Figure 6 illustrates the distribution of all live trees on the burned and unburned forest areas.

Lodgepole pine regenerated well in most forest areas following the 1988 fires. Figure 7 compares the estimate of live lodgepole pine seedlings on forest areas classified as lodgepole pine between the burned and unburned areas. Figure 8 compares the estimate of live lodgepole pine trees on lodgepole pine stands between the burned and unburned areas. These illustrations indicate the significant differences in number of lodgepole pine stems by diameter class and also underscore the slow-growing nature of lodgepole pines in the subalpine plateau. Most lodgepole pine stands that burned in 1988 still remain in the seedling/sapling stage despite 11 years between the date of the fires and date of inventory.

The 1988 post-fire dynamics of aspen were surprising to many ecologists who discovered seedling regeneration in areas where aspen did not previously exist. From a broad-scale perspective, aspen is a minor component in Yellowstone National Park, accounting for less than 1% of the live tree population. However, there is a striking difference in the

estimate of live aspen stems between the burned and unburned areas. The number of live aspen trees on the burned areas totals 22 million trees, all of which are in the seedling and sapling size class. This figure is more than 22 times the number of live aspen trees in the non-burned areas, where the estimate of live aspen trees is 965,000 trees (Figure 9). Turner et al. (2003) also found that aspen regenerated successfully throughout the burned forests and well beyond the pre-fire range of aspen.

Summary

The 1988 Yellowstone fires produced spatially complex patterns of succession in what a casual observer might consider a homogeneous landscape dominated by lodgepole pine. The large proportion of non-stocked forest conditions on the burned area are areas with low stand density where gradual recruitment may or may not continue. The heavily skewed stand age distribution on the burned areas is a classic macro-scale example of stand structure following a major stand-replacing disturbance. Aspen appears not only to have established itself successfully following the fires, but also to be appearing in areas where it previously did not exist.

Estimates from FIA inventories are broad-scale in nature. These estimates of forest area and numbers of trees in Yellowstone National Park are coarse compared to many of the site-specific studies conducted after the 1988 fires. However, FIA can be used to verify many of these studies conducted at a much finer scale. The difference between population estimates of live aspen stems on the burned and unburned areas is an example of how FIA inventories may be used to verify the findings of other studies.

The FIA program of the U.S. Forest Service is rapidly implementing an annual inventory system that features a nationally consistent plot configuration; a nationally consistent sample design; integration with the ground sampling component of the Forest Health Monitoring program; a complete, statewide, systematic, annual sample of each state; and new reporting requirements. These new systems will be implemented in future inventories of Wyoming, and will greatly enhance the timeliness, quality, and usefulness of estimates on unique ecosystems such as Yellowstone National Park.

References

Christensen, N. L., J. K. Agee, P. F. Brussard, J. Hughes, D. K. Knight, J. M. Minshall, J. M. Peek, S. J. Pyne, F. J. Swanson, S. Wells, J. W. Thomas, S. E. Williams, and H. A. Wright. 1989. Interpreting the Yellow-

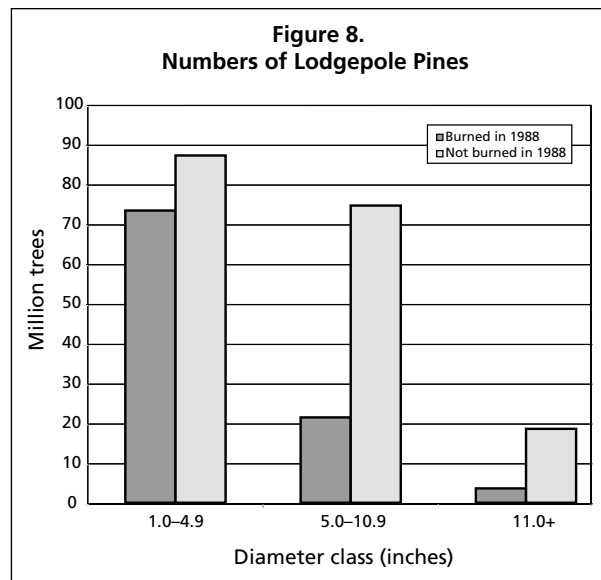


Figure 8. Number of live lodgepole pine trees 1.0 inches in diameter at breast height and larger on forest land classified as lodgepole pine forest type by 1988 burn status, Yellowstone National Park, Wyoming, 2002.

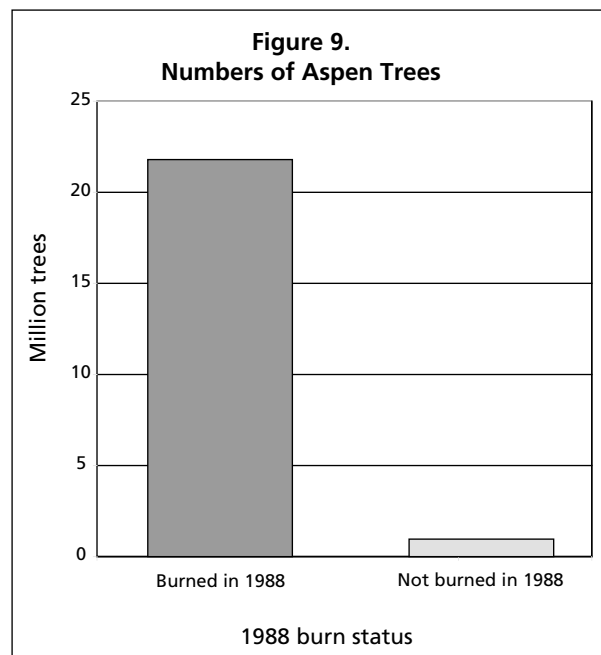


Figure 9. Number of live aspen trees on forest land by 1988 burn status, Yellowstone National Park, Wyoming, 2002.

stone fires of 1988. *BioScience* (39):678-685.

Hahn, J. T., C. D. MacLean, S. L. Arner, and W. A. Bechtold. 1995. Procedures to handle inventory cluster plots that straddle two or more conditions. *Forest Science Monograph* (31):12-25.

Turner, M. G., W. H. Romme, and D. B. Tinker. 2003. Surprises and lessons from the 1988 Yellowstone fires. *Frontiers in Ecology and the Environment* 1(7):351-358.