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Wyoming's Forest Resources, 2011–2015

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Abstract

This report summarizes the most recent inventory of Wyoming's forests based on field data collected between 2011 and 2015. The report includes descriptive highlights and tables of area, numbers of trees, biomass, carbon, volume, growth, mortality, and removals. Most sections and tables are organized by forest type or forest-type group, species group, diameter class, or owner group. The report also describes the inventory design, inventory terminology, and data reliability. Results show that Wyoming's forest land covers 10.5 million acres. Fifty-five percent (5.8 million acres) of this forest land is administered by the USDA Forest Service, and another 26 percent (2.8 million acres) is administered by other Federal agencies. There are approximately 1.5 million acres (14 percent) of privately owned forest land in Wyoming. Wyoming's most abundant forest-type group is Fir/spruce/mountain hemlock, which covers more than 2.9 million acres, but is followed closely by the Lodgepole pine forest-type group, which covers more than 2.5 million acres. Lodgepole pine is the most abundant species by number of trees but is second to the Fir/spruce/mountain hemlock forest-type group in volume (and biomass), 4.2 and 6.2 million cubic feet, respectively. In total, Wyoming's forests contain more than 14.6 million cubic feet of net volume in trees 5.0 inches in diameter and larger. Gross growth of all live trees 5.0 inches in diameter and larger averaged 270.4 million cubic feet per year. Average annual mortality amounts to 578.3 million cubic feet per year. Therefore, average annual net growth was -361.2 million cubic feet per year. The primary mortality causing disturbance agents were, in descending order, insects, fire, and disease, which affected 1,415.3, 446.3, and 382.8 thousand acres, respectively.

Keywords: biomass, estimates, forest inventory, field data, growth, mortality, volume, Wyoming

Cover photo: Salt River Range, Wyoming (photo: R.J. DeRose).

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Report Highlights

Forest Area

- Wyoming's forest land area totals 10.5 million acres.
- Unreserved forest land accounts for most of the forest land in Wyoming (68 percent) and totals approximately 7.2 million acres.
- Approximately 75 percent, or 5.4 million acres, of Wyoming's unreserved forest land is classified as timberland and the remaining 25 percent is classified as unproductive forest land.
- About 56 percent of Wyoming's total forest land area, or 5.8 million acres, is administered by the USDA Forest Service.
- About 15 percent of Wyoming's total forest land area, or 1.6 million acres, is administered by the National Park Service.
- Privately owned forest land totals 1.5 million acres, or about 14 percent of Wyoming's forest land area.
- The Fir/spruce/mountain hemlock forest-type group is the most extensive, covering 2.9 million acres, or 27.8 percent of Wyoming's forest land.
- The second most abundant forest-type group is Lodgepole pine, which encompasses over 2.5 million acres, or 24 percent of Wyoming's forest land.

Forest Growth, Mortality, and Removals

- Gross annual growth of all live trees 5.0 inches in diameter and larger on Wyoming forest land totaled 270.4 million cubic feet.
- Average annual mortality of trees 5.0 inches in diameter and larger totaled about 578.3 million cubic feet.
- Average annual net growth totaled -307.9 million cubic feet.
- The leading cause of mortality in Wyoming was insects, which resulted in approximately 16 million cubic feet of mortality in the Fir/spruce/mountain hemlock forest-type group, and another approximately 10 million cubic feet in the Lodgepole pine forest-type group.
- Mortality exceeded gross growth for six of the eight tree species with the greatest volume in Wyoming, including, lodgepole pine, Engelmann spruce, whitebark pine, Douglas-fir, limber pine, and aspen.
- Total removals in 2014 were nearly 25 million cubic feet, of which about 20.8 million cubic feet included timber products.

Numbers of Trees, Volume, and Biomass

- There are an estimated 4.6 billion live trees greater than 1.0 inch in diameter in Wyoming.
- Softwood species total 4.3 billion, or 94 percent of all live trees.
- The most abundant tree species is lodgepole pine with nearly 1.8 billion trees, accounting for 39 percent of live trees in Wyoming.
- Growing stock volume on timberland in Wyoming totals 8.7 billion cubic feet.
- The net volume of sawtimber trees on Wyoming forest land is 33.6 billion board feet.
- The aboveground weight for all live trees greater than 1.0 inch in diameter on Wyoming forest land is 256 million tons of oven-dry biomass.

Current Issues in Wyoming's Forests

- About 8 percent of Wyoming's forest land occurs in stands older than 200 years.
- Approximately 416,000 acres of forest land in Wyoming could be classified as potential Canada lynx habitat.
- There are over 2.4 million acres in Wyoming that include some component of whitebark pine, and they have experienced an average annual net volume loss of 57.5 million cubic feet per year.
- Snags suitable for a large number of cavity-nesting birds can be found across the range of forest types and age classes in Wyoming.
- Invasive weeds were found on 12.4 percent of forest land in Wyoming, and Canada thistle accounted for 60 percent of those occurrences.
- Average aspen volume (cubic feet per acre) has increased over the first 5 years of the annual inventory.
- From 1988 to 2015, nearly 2 million acres of Wyoming have burned, 41 percent on forest land and 59 percent on nonforest land.
- A large amount of National Forest System forest land area has been classified as unsuitable for timber production. While there are over a million acres suitable for timber production on NFS land in Wyoming, roughly one-fourth falls within the inventoried roadless designation.
- Juniper ages in the Rocky Mountain juniper and Pinyon/juniper forest types primarily occur in the 50-149 year age class, whereas a much higher proportion (over 45 percent) of younger-aged juniper occur in other forest-type groups.

Acknowledgments

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Contents

Introduction

Wyoming encompasses a wide variety of forest types and tree species that are valued for their scenic beauty, wood products, wildlife habitat, and ecological functions. This report contains highlights of the status of Wyoming's important forest resources, with a discussion of pertinent issues based on the first 5 years of inventory data. As a result, for the first time, forest scientists, managers, policy-makers, and users have access to the first half of inventory data for Wyoming collected under the new Forest Inventory and Analysis (FIA) annual system (Gillespie 1999).

Wyoming's Annual Forest Inventory

In 1998, the Agricultural Research Extension and Education Reform Act, also known as the Farm Bill, mandated that inventories would be conducted throughout the forests of the United States on an annual basis. The annual forest inventory of Wyoming's forests follows sampling procedures specified by this Federal legislation and the national FIA program. The annual system integrates FIA and Forest Health Monitoring (FHM) sampling designs into a mapped-plot design that includes: a systematic national sampling design consisting of one plot per approximately 6,000 acres; a nationally consistent plot configuration with four fixed-radius subplots; annual measurement of a constant proportion of permanent plots; data or data summaries within 6 months after completion of yearly sampling; and a State summary report following 5 years of sampling. The inventory sampling design for the Western United States involves the measurement of 10 systematic samples, or subpanels, where one subpanel is completed each year resulting in the measurement of all subpanels over a 10-year period. Each subpanel is pre-assigned to be surveyed during a specific calendar year, which is referred to as an inventory year (see Appendix A for standard FIA terminology). The year in which each plot was actually surveyed is recorded as its measurement year.

Interior West Forest Inventory and Analysis first implemented the annual inventory in Wyoming in 2011. This report is based on the aggregated data collected over 5 measurement years, 2011–2015, or 50 percent of the full cycle. The aggregated dataset includes a total of 5,271 plots, where: 858 (16.3 percent) plots contained at least one forested condition; 4,283 plots (81.3 percent) were entirely nonforest; and 130 plots (2.4 percent) were not sampled.

Previous Inventories of Wyoming's Forests

Prior to the implementation of the annual inventory, three plot-based periodic inventories were conducted in Wyoming. During the first two inventories, estimates of forest land area were based solely on photo-interpretation and mapping of forest attributes using aerial photography, and estimates of wood volume were based on measurements collected on ground plots. The first periodic inventory was conducted in the late 1950s (Choate 1963). This inventory used interpretation of aerial photographs to produce map-based estimates of forest land area across all ownership groups. Volume estimates were based on ground measurements from more than 1,100 plots on commercial forest lands (Choate 1963), although the data from these plots are not available in the FIA database. A second periodic inventory was conducted in 1983 on all ownership groups except for national forests, each of which conducted their own inventories at that time, and on reserved lands including National Parks (Green and Conner 1989). Like the first inventory, this report estimated forest land area using aerial photographic interpretation combined with a dot-grid. Volume estimates were also estimated from plot measurements. More than 7,000 plots were field-measured, although only about 500 were forested, and 20 percent of these occurred on timberland (Green and Conner 1989).

The third and final periodic inventory was conducted across all ownership groups between 1998 and 2002 (Thompson et al. 2005). This inventory differed from the two earlier periodic inventories in two important ways. First, it was based on the same probabilistic sample design that is used for the annual forest inventory, which was already being implemented in other States at that time. The shift from a sample design that targeted commercial timberland to a probabilistic sample of all forest lands, including woodlands and unproductive and/or reserved forest lands, produced apparent declines in tree volume; however, these apparent declines are largely due to the change in sample design (Goeking 2015). Second, the 1998–2002 periodic inventory also used the same fixed-radius subplot configuration that is currently used in the annual inventory; however, the location of the microplot changed. Regional forest assessments using the 1998–2002 periodic data within Wyoming have been conducted, including the Black Hills National Forest (DeBlander 2002), the Shoshone National Forest (Menlove 2008), the Medicine Bow National Forest (Steed 2008), and the Bighorn National Forest (Witt 2008).

Ground-based plot data from the periodic inventories of the 1980s and 1998–2002 are available in the national FIA database, FIADB (O'Connell et al. 2015). FIADB includes a data structure that designates specific groups of plots for producing estimates of forest attributes, such as forest land area and tree volume, associated with particular time periods. This data structure is known as an evaluation, and each plot's nominal inventory year generally links it to a particular evaluation (O'Connell et al. 2015). For example, this report is based on the 2015 evaluation, which includes plots scheduled for measurement from 2011 to 2015. Prior to the annual inventory, measurements were not collected every year, so the evaluations for individual periodic inventories use nominal inventory years that may be very different from the actual years when the plots were measured. For example, the 1983 inventory is assigned a 1984 inventory year although plots were measured in 1983, 1984, 1992 and 1994. The 1998–2002 periodic inventory is assigned a nominal inventory year of 2000 in FIADB; however, here it is referred to as the 2002 inventory to be consistent with the previous State report (Thompson et al. 2005).

Although the nominal inventory years and evaluations described above can be used to query periodic inventory data from FIADB, we strongly recommend against making broad-scale comparisons of periodic inventory data to annual inventory estimates. Goeking (2015) demonstrated that comparing broad-scale estimates of forest attributes between periodic and annual inventories may lead to erroneous conclusions, compared to changes detected from consistent samples over time. The *Periodic to Annual Inventory Comparisons* section describes a method for making appropriate use of periodic inventory data to assess temporal changes in forest attributes.

Overview of Standard and Supplemental Tables

Forest Inventory and Analysis produces a set of standard tables using both Phase 2 and Phase 3 data (see the *Three-Phase Inventory* section below). Annual forest inventory data collected in Wyoming between 2011 and 2015 are summarized in Appendix B (tables B1–B37) in terms of traditional FIA attributes. Statistical estimates for land area, numbers of trees, wood volume, biomass, growth, mortality, and sampling errors are presented in these tables. Only in table B1 are all land cover types included, which are summarized by the proportions of sample plots that were recorded as forest, nonforest, and nonsampled (e.g., due to inaccessibility). All other tables in Appendix B exclude nonforest land and therefore include only accessible forest land or timberland (see Appendix A for definitions). This report also contains supplemental tables within the text. To avoid confusion between supplemental tables and standard tables (Appendix B), we labeled tables in the body of the report consecutively as they appear. Standard FIA tables will be referred to beginning with the appendix letter followed by the table number (e.g., table B1).

Accessing Wyoming's Forest Inventory Data

FIA data are publicly available from the national FIA website at https://fia.fs.fed.us. This site includes data downloads; online tools that allow users to perform custom queries; and documentation of FIA's field inventory protocols, database structure, and publications. For assistance with finding information on this site or with performing custom analyses, data users are encouraged to contact one of the members of the Analysis Team of the Interior West FIA Program who are listed as authors at the beginning of this report.

The national FIA database contains data from the 1984 and 2000 periodic inventories as well as the annual forest inventory data, which is updated each year as additional measurements are collected. Data collected as part of the annual inventory is assigned an inventory year that corresponds to the year in which the plot was scheduled to be measured on a 10-year remeasurement cycle. The FIA database supports six possible evaluation periods for Wyoming (1984, 2000, 2011–2012, 2011–2013, 2011–2014, and 2011–2015). FIA data may be downloaded in table form or summarized using a variety of online tools (http://fia.fs.fed.us/tools-data/default.asp).

Inventory Methods

An important part of the FIA program is a nationally consistent sampling and inventory design. Here we briefly describe the major components of the design: national plot sample design; the three-phase inventory system; configuration of field plots; and possible sources of error, which are consistent among all States. We also describe FIA's quality assurance program and present quality assessment results for the current Wyoming forest inventory and a comparison across all Interior West States. For additional information regarding the design and implementation of the annual inventory, see McRoberts et al. (2005) and Smith (2002).

Sample Design

Based on historic standards, a sampling intensity of approximately one plot per 6,000 acres is necessary to satisfy national FIA precision guidelines for area and volume. Therefore, FIA divided the area of the United States into non-overlapping, 5,937-acre hexagons and established one plot in each hexagon using procedures designed to preserve existing plot locations from previous periodic inventories. These sample plots, designated as the Federal base sample, were divided into five spatially interpenetrating panels and 10 subpanels, where each panel consists of two subpanels. In the Eastern United States, two subpanels are measured each year such that the inventory cycle is on a 5-year rotation, while in the Western United States, including Wyoming, one subpanel is measured each year and inventory cycles are completed on a 10-year rotation (Gillespie 1999). For estimation purposes, the measurement of each subpanel of plots can be considered an independent, equal probability sample of all lands in a State, or all plots can be combined to represent the State.

Three-Phase Inventory

FIA conducts inventories in three phases. In Phase 1, remote sensing data are digitally analyzed to stratify each State into homogeneous groups such as forest and nonforest areas. Phase 2 relates to a permanent network of ground plots, where traditional inventory variables such as forest type and tree diameter are measured. In Phase 3, additional variables associated with forest and ecosystem health are measured on a subset of Phase 2 plots.

Phase 1

Phase 1 uses remote sensing data to delineate homogeneous areas, or strata, throughout the entire State. Currently in the Interior West, only forest and nonforest strata are identified. The purpose of this delineation is to reduce the variance of

FIA estimates through post-sampling stratification of field data. The initial Phase 1 strata map consisted of forest, nonforest, and census water strata (see Appendix A for definitions), which were delineated at a spatial resolution of 250 meters using a combination of 2004 MODIS satellite imagery, other geospatial datasets, and plot-based calibration data (Blackard et al. 2008). Calibration data in Wyoming consisted of periodic plot locations that had been classified as forest, nonforest, or census water, based on field surveys or human interpretation of aerial photographs prior to 2011. In Wyoming, the census water stratum and nonforest stratum are combined.

In most Interior West States, post-sampling stratification is based solely on forest and nonforest strata under the assumption that any Phase 2 nonresponse plots occur randomly across the plot grid. Nonresponse plots are defined as plot locations that cannot be sampled by a field crew. They typically occur when landowners or managers do not grant permission for field crews to access plot locations on their lands, although some plots are not sampled due to hazardous conditions that may be permanent in nature (e.g., sheer cliffs) or temporary hazards (e.g., current wildfires or active logging operations). When nonresponse plots do not occur randomly across the plot grid, the estimates of forest attributes may be biased (Patterson et al. 2012). The nonresponse rate in Wyoming's forest inventory for the period 2011 through 2015 was relatively low at 2.5 percent. When large, the magnitude of the effect of nonresponse on forest estimates can be estimated (Goeking and Patterson 2013), but for the purpose of this report, the effect is assumed to be small.

FIA produces estimates at the scale of individual States, which can then be aggregated into regional estimates, as well as at smaller scales within each State. Within-State population estimates are constructed at two scales: survey units that are comprised of groups of counties, and smaller estimation units that represent individual counties. Wyoming consists of three survey units (i.e., groups of counties) and 23 estimation units (i.e., counties) denoted as g, each containing n_g ground plots. The area of each estimation unit is divided into strata of known size using the State's stratification map, which divides the total area of the estimation unit into 250-meter pixels and assigns each pixel to one of H strata. Each stratum, h, within an estimation unit, g, then contains n_{hg} ground plots where the Phase 2 attributes of interest are observed.

To illustrate, the area estimator for forest land within an estimation unit in Wyoming is defined as:

$$\hat{A}_g = A_{Tg} \sum_{h=1}^{H} W_{hg} \frac{\sum_{i=1}^{n_{hg}} y_{ihg}}{n_{hg}}$$

where:

$\hat{A}_g$ = total forest area (acres) for estimation unit g

A_{Tg} = total land area (acres) in estimation unit g

H = number of strata

W_{hg} = proportion of Phase 1 pixels in estimation unit g that occur in stratum h

y_{ihg} = forest land condition proportion on Phase 2 plot i in stratum h in estimation unit g

n_{hg} = total number of Phase 2 plots in stratum h in estimation unit g

Phase 2

The second phase pertains to FIA's network grid of permanent plot locations, each assigned spatial coordinates, and representing approximately 6,000 acres. To minimize inventory costs, we do not estimate plots that are obviously and entirely nonforest for field sampling, and these plots are recorded as nonforest. A human interpreter examines each plot location using digital imagery from the National Agriculture Imagery Program and distinguishes plots that potentially contain forest or wooded land from those that do not intersect any forest or wooded land. This process is known as prefield interpretation, and it was historically considered part of Phase 1 because both prefield interpretation and Phase 1 relied on remote sensing data. However, Phase 1 delineation of forest and nonforest strata occurs independently of current prefield interpretation of the Phase 2 grid. Therefore, prefield data collection is now considered part of Phase 2 and not part of Phase 1.

The status of each plot in the Phase 2 grid is assigned as accessible forest land, nonforest land, or not sampled (see Appendix A for definitions). Plots that were not designated for field sampling by prefield interpreters are automatically recorded as nonforest plots. For plots that are designated for field sampling, field crews record the plot status as accessible forest land if (a) they can physically visit the plot location, and (b) the plot satisfies FIA's definition of forest land based on field measurements (see Appendix A). Some field plots are recorded as nonforest because the field crew determines that they do not meet FIA's definition of forest land. A field plot may be recorded as nonsampled if a field crew cannot safely measure the plot or if they cannot obtain permission to access the plot location. Before visiting plot locations, FIA crews identify each plot's ownership status by consulting county land records and then seek permission from private landowners to measure plots on their lands. Information about individual landowners and the existence of FIA plots on their property is considered confidential and is never shared with anyone, regardless of whether permission to access the plot location is granted. The total percentage of Phase 2 plot areas that represent forest, nonforest, and nonsampled (response) conditions can be found in table B1 (Appendix B; fig. 1).

Field crews record a variety of data on Phase 2 plots that contain accessible forest land. Crews locate the geographic center of the plot using geographic positioning system receivers and then establish markers to facilitate relocation of the plot for future remeasurement. They record condition-level variables that include land use, forest type, stand origin, stand-size class, stand age, site productivity

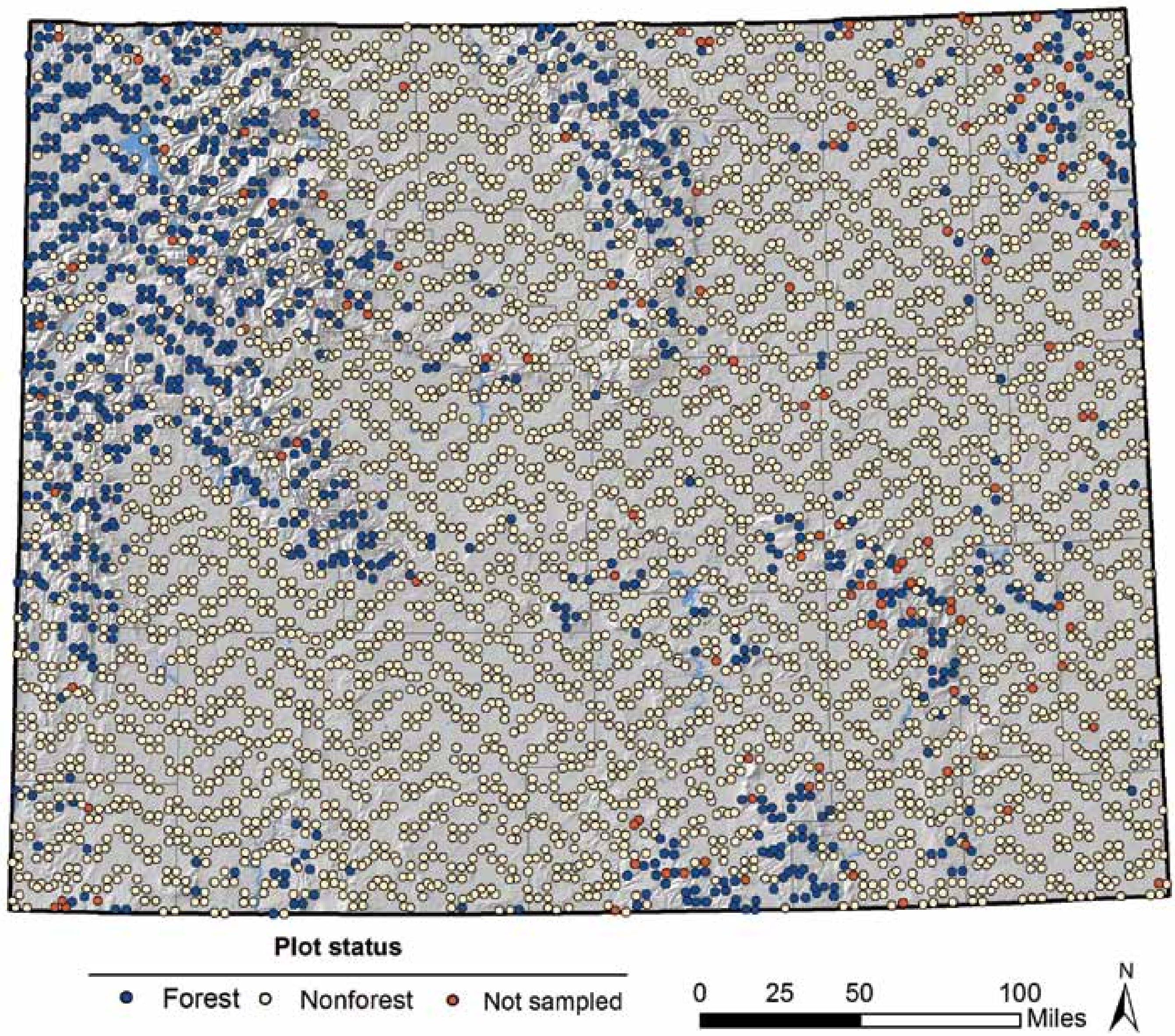

Figure 1—Plot status of the 5,271 Phase 2 plots in Wyoming's annual forest inventory, 2011–2015. (Note: plot locations are approximate; some plots on private land were randomly swapped.)

class, forest disturbance history, silvicultural treatment, slope, aspect, and physiographic class. Some of these area attributes are measured or observed (e.g., regeneration status), some are assigned by definition (e.g., ownership group), and some are subsequently computed from tree data (e.g., percent stocking). For each tree on the plot, field crews record a variety of attributes including species, live/dead status, diameter, height, crown ratio, crown class, damage, and decay status. The field procedures used in Wyoming's forest inventory are described in detail in the FIA field guide (USFS 2013). Data analysts apply statistical models using field measurements to calculate additional variables such as volume and biomass for individual trees, as well as volume, biomass, growth, mortality, and number of trees per unit area.

Phase 3

The third phase of the FIA program inventory focuses on forest and ecosystem health. The Phase 3 sample consists of a 1/16 subset of the Phase 2 plots, which equates to one Phase 3 plot for approximately every 96,000 acres. Nationally, Phase 3 plots include all the measurements collected on Phase 2 plots, plus an extended suite of measurements to characterize down woody materials, lichen communities, tree crowns, and understory vegetation structure. Phase 3 measurements are obtained by field crews during the growing season. The entire suite of Phase 2 measurements is collected on each Phase 3 plot at the same time as the Phase 3 measurements. In the Interior West down woody material and understory vegetation structure are collected on all Phase 2 plots.

Plot Configuration

The national FIA Phase 2 plot design consists of four 24-foot radius subplots configured as a central subplot and three peripheral subplots (USFS 2013; fig. 2). Centers of the peripheral subplots are located at distances of 120 feet and at azimuths of 360 degrees, 120 degrees, and 240 degrees from the center of the central subplot. Each standing tree with a diameter at breast height (d.b.h.) for timber trees, or a diameter at root collar (d.r.c.) for woodland trees (Appendix A), of 5.0 inches or larger is measured on these subplots. Each subplot contains a 6.8-foot radius microplot with its center located 12 feet at 90 degrees from the

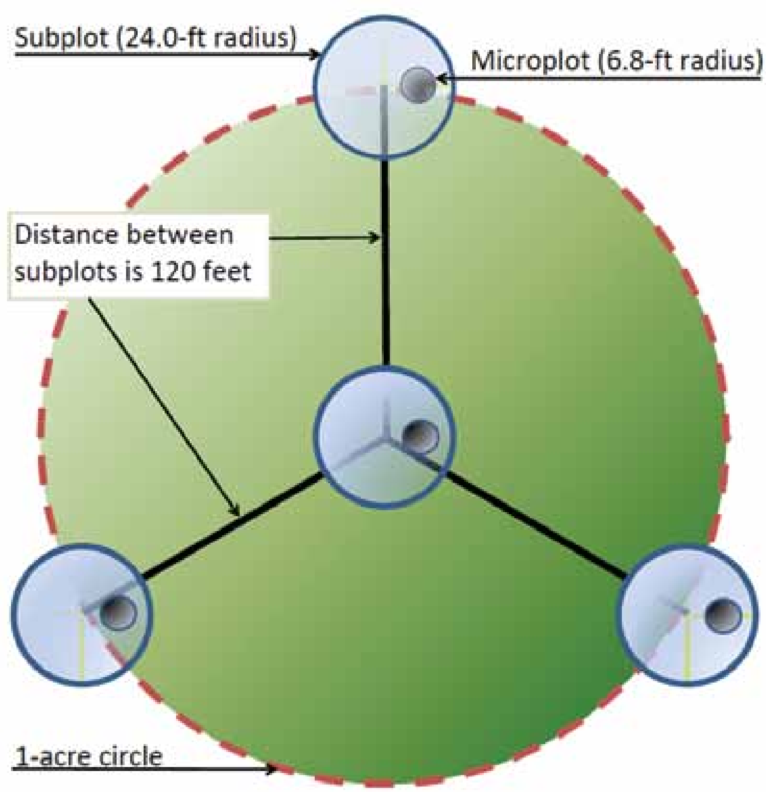

Figure 2—Plot configuration used by the Forest Inventory and Analysis program. Each plot consists of four subplots with a 24-foot radius. The three outer subplots are located 120 feet from the central subplot's center at azimuths of 360 (0), 120, and 240 degrees. Microplots with radii of 6.8 feet are located on each subplot, and the microplot centers are located 12 feet from the subplot center at an azimuth of 90 degrees.

subplot center on which each tree with a d.b.h./d.r.c. from 1 inch to 4.9 inches is measured and seedlings are tallied by species.

To enable division of the forest into various units of interest for analysis, it is important that the tree data recorded on these plots are properly associated with stand-level data. In addition to the tree data recorded on FIA plots, data are also gathered about the condition class in which the trees are located. A condition class (or condition) is the combination of discrete landscape and forest attributes that define and describe the area associated with a plot. The six variables that define distinct condition classes are forest type, stand origin, stand size, ownership group, reserved status, and stand density (Bechtold and Patterson 2005; USFS 2013). In some cases, the plot footprint spans two or more conditions if there is a distinct change in any of these six variables. For example, the four subplots on a plot may intersect both forest and nonforest areas, the plot may include distinct stands differentiated by forest type and/or stand size, or the plot may straddle a boundary between two different ownership groups. All three of these examples would result in more than one condition per plot. Field crews assign numbers to condition classes in the order they are encountered on a plot. Each tree is assigned the number of the condition class in which it stands to enable partitioning of tree data into meaningful categories for analysis.

Sources of Error

Sampling Error

The process of sampling (selecting a random subset of a population and calculating estimates from this subset) causes estimates to contain errors they would not have if every member of the population had been observed. The 2011–2015 FIA inventory of Wyoming is based on a sample of 5,141 plots (not including 130 nonresponse plots) systematically located across the State. The total area of Wyoming is 62.6 million acres, so the sampling rate is approximately one plot for every 12,176 acres. The sampling rate will decrease as the next 5 years of annual data are collected.

The statistical estimation procedures used to provide the estimates of the population totals presented in this report are described in detail in Bechtold and Patterson (2005). Along with each estimate is an associated sampling error that is typically expressed as a percentage of the estimated value, but it can also be expressed in the same units as the estimate or as a confidence interval (the estimated value plus or minus the sampling error). Sampling error is the primary measure of the reliability of an estimate. An approximate 67 percent confidence interval constructed from the sampling error can be interpreted to mean that under hypothetical repeated sampling, approximately 67 percent of the confidence intervals calculated from the individual repeat samples would include the true population parameter if it were computed from a 100-percent inventory. Wyoming sampling errors for State-level estimates of area, volume, net growth, and morality at the 67 percent confidence level are presented in table B37.

Because sampling error increases as the area or volume considered decreases, users should aggregate data categories as much as possible. Sampling errors obtained from this method are only approximations of reliability because homogeneity of variances is assumed. Users may compute statistical confidence for subdivisions of the reported data using FIA's estimation tools (http://fia.fs.fed.us/tools-data/default.asp).

Measurement Error

Measurement errors are errors associated with the methods and instruments used to observe and record the sample attributes. On FIA plots, attributes such as the diameter and height of a tree are measured with specialized instruments, and other attributes such as species and crown class are observed without the aid of an instrument. On a typical FIA plot, 30 to 70 trees are observed with 15 to 20 attributes recorded on each tree. In addition, many attributes that describe the plot and conditions on the plot are observed. Errors in any of these observations affect the quality of the estimates. If a measurement is biased—such as diameters consistently taken at a height other than 4.5 feet from the ground—then the estimates derived from this observation (e.g., volume) will reflect this bias. Even if measurements are unbiased, high levels of random error in the measurements will add to the total random error of the estimation. To ensure that FIA observations meet the highest standards possible, a quality assurance program, described below, is integrated throughout all FIA data collection efforts.

Prediction Error

Prediction errors are associated with using mathematical models (such as volume equations) to provide information about attributes of interest based on sample attributes. Area, number of trees, volume, growth, removals, and mortality are the primary attributes of interest presented in this report. FIA estimates of area and number of trees are based on direct observations and do not involve the use of prediction models; however, estimates of volume, biomass, growth, and mortality use model-based predictions in the estimation process and are thus subject to prediction errors.

Quality Assurance

FIA employs a Quality Assurance (QA) program to ensure the integrity of all collected data. The QA program provides a framework to assure the production of complete, accurate, and unbiased forest information of known quality. There are two primary facets of FIA's QA program: quality control and quality assessment.

Quality control is the first facet of FIA's QA program, and it occurs throughout field data collection and compilation. The field aspect of quality control is conducted by data quality inspectors, who assess individual field crews and then provide timely feedback to improve the crews' performance. This is accomplished by means of hot checks and cold checks. During a hot check, an inspector accompanies a field crew to a plot and provides immediate feedback on the quality of their measurements. Cold checks occur when an inspector visits a recently completed plot, typically in possession of the original crew's data but without the crew present, and then verifies each measurement and provides the crew an overall score as well as feedback on measurements that did not meet FIA specifications. On average, hot checks are done on 2 percent of all field-sampled plots and cold checks are done on 5 percent of field-sampled plots. Quality control is also accomplished via programming of portable data recorders that check for complete, valid, and reasonable values during data collection. Following data collection, information management specialists conduct further logic checks and investigate any unexpected, missing, or inconsistent values.

Quality assessment is the second facet of FIA's QA program, and this process quantifies the overall precision of field measurements by comparing two independent measurements of the same plot. The independent measurements are collected by means of blind checks, where a regular field crew collects measurements and then a second crew collects a second set of measurements, without knowledge of or access to the first crew's measurements (Pollard et al. 2006). Thus, these paired observations provide a means of assessing repeatability of FIA's field measurements.

Quality control and quality assessment both require a data quality standard that defines the target level of precision for field measurements. FIA has specific Measurement Quality Objectives (MQOs) that enumerate data quality standards for individual field-measured variables. These data quality objectives were developed from knowledge of forestry measurement approaches as well as the requirements of the FIA program. MQOs for each variable consist of a measurement tolerance and a compliance standard. Measurement tolerances define the acceptable range of variability between two independent observations, and compliance standards define the target percentage of observations that should be within the measurement tolerance when recorded by two independent observers. The practicality of these MQOs, as well as the measurement uncertainty associated with a given field measurement, can be tested by comparing the results of quality assessments using blind check data.

Quality assessment data for Wyoming's current inventory were collected between 2011 and 2015 from 28 plots comprising 35 conditions and 762 trees. The results of the quality assessment analysis for this period are presented in tables 1 and 2. Each variable and its associated measurement tolerance are followed by the percentage of total paired records that fall within one, two, three, and four times the tolerance. The last four columns show the number of observations that fell outside the tolerance. For example, table 1 shows that there were 35 conditions that were measured independently by two field crews. For the variable "Forest Type," about 97 percent of those conditions fell within the tolerance of having no errors. The percentage of observations that fall within the 1x tolerance level is referred to as the observed compliance rate, which can be compared to the compliance standard for each variable's MQO to determine that variable's performance. Compliance standards and measurement tolerances for FIA's field measurements are listed within the field manual (USFS 2011).

Table 1—Results of quality assessment for condition-level variables, Wyoming, 2011–2015.

Variable	Tolerance	Percentage of data within tolerance				Number of times data exceeded tolerance				Records
		@1x	@2x	@3x	@4x	@1x	@2x	@3x	@4x	
National core variables										
Condition status	No errors	97.1	-	-	-	1	-	-	-	35
Reserve status	No errors	100.0	-	-	-	0	-	-	-	35
Owner group	No errors	100.0	-	-	-	0	-	-	-	35
Forest type	No errors	96.9	-	-	-	1	-	-	-	32
Stand size	No errors	87.5	-	-	-	4	-	-	-	32
Regeneration status	No errors	96.9	-	-	-	1	-	-	-	32
Tree density	No errors	100.0	-	-	-	0	-	-	-	32
Disturbance 1	No errors	81.8	-	-	-	6	-	-	-	33
Disturbance year 1	±1 year	54.5	72.7	72.7	72.7	5	3	3	3	11
Treatment 1	No errors	97.0	-	-	-	1	-	-	-	33
Treatment year 1	±1 year	-	-	-	-	-	-	-	-	-
Physiographic class	No errors	63.6	-	-	-	12	-	-	-	33
Regional variables										
Percent crown cover	±10 %	65.4	96.2	96.2	100.0	9	1	1	0	26
Percent bare ground	±10 %	93.8	96.9	96.9	96.9	2	1	1	1	32
Habitat type 1	No errors	84.8	-	-	-	5	-	-	-	33
Habitat type 2	No errors	87.9	-	-	-	4	-	-	-	33

Results indicate variables have varying degrees of repeatability (tables 1 and 2). For example, one condition-level regional variable that appears to be fairly repeatable is "percent bare ground" (table 1). At the 1x tolerance level, its observed compliance rate was about 94 percent. This represents that 94 percent of 32 paired observations were within plus or minus 10 percent of each other. In contrast, the compliance rate for "percent crown cover," which has ±10 percent tolerance variability, was only 65 percent. This low compliance rate warrants further investigation into the potential repeatability issues associated with evaluating tree crown cover, which is typically done using four transects per subplot (USFS 2011).

The tree measurements that have the biggest influence on estimates of forest volume are species, diameter, and height. As shown in table 2, the compliance rate for the variable "Species" was 99 percent. The variables "diameter at breast height" and "diameter at root collar" represent the respective diameters of timber and woodland tree species (Appendix D). Whereas timber species are measured at breast height (4.5 feet above ground level), woodland species are measured near ground level at root collar. The 1x compliance rate was almost 91 percent for both d.b.h., which has a 0.1-inch tolerance, and d.r.c., which has a 0.2-inch per stem tolerance. The tolerance for root collar diameter is plus or minus 0.2 inches per stem, which allows for larger tolerances on multi-stemmed woodland trees. Tree height is represented by the variables "total length" and "actual length." Both variables

Table 2—Results of quality assessment for tree-level variables, Wyoming, 2011–2015.

Variable	Tolerance	Percentage of data within tolerance				Number of times data exceeded tolerance				Records
		@1x	@2x	@3x	@4x	@1x	@2x	@3x	@4x	
National core variables										
Diameter at breast height	±0.1 /20 inch	90.7	96.0	97.1	97.2	70	30	22	21	751
Diameter at root collar	±0.2 in * no. stems	90.9	100.0	-	-	1	0	-	-	11
Azimuth	±10 º	97.2	98.8	99.2	99.2	21	9	6	6	762
Horizontal distance	±0.2 /1.0 feet	97.2	98.y	98.8	99.1	21	10	9	7	762
Species	No errors	98.8	-	-	-	9	-	-	-	762
Tree status	No errors	98.7	-	-	-	10	-	-	-	762
Rotten/missing cull	±10 %	96.0	99.0	99.9	100.0	28	7	1	0	699
Total length	±10 %	90.4	98.6	99.0	99.3	73	11	8	5	762
Actual length	±10 %	89.2	97.3	98.1	98.9	40	10	7	4	371
Compacted crown ratio	±10 %	100.0	-	-	-	0	-	-	-	490
Uncompacted crown ratio (p3)	±10 %	78.7	95.6	98.6	99.5	91	19	6	2	428
Crown class	No errors	6.9	-	-	-	456	-	-	-	490
Decay class	±1 class	100.0	-	-	-	0	-	-	-	262
Cause of death	No errors	87.2	-	-	-	25	-	-	-	195
Mortality year	±2 year	83.1	95.9	99.0	99.5	33	8	2	1	195
Condition class	No errors	99.6	-	-	-	3	-	-	-	762
Regional variables										
Mistletoe	±1 class	96.9	98.8	99.2	99.8	15	6	4	1	490
Number of stems	±1 stem	100.0	100.0	100.0	100.0	0	0	0	0	11
Percent missing top	±10 %	94.7	94.7	94.7	94.7	37	37	37	37	699
Sound dead	±10 %	64.1	64.1	64.1	64.1	251	251	251	251	699
Form defect	±10 %	43.1	43.1	43.1	43.1	82	82	82	82	144
Current tree class	No errors	96.3	-	-	-	28	-	-	-	762
Tree age	±5 %	47.6	57.1	61.9	61.9	11	9	8	8	21

have a tolerance level of ±10 percent of the observed length, and compliance rates at the 1x level were about 90 percent and 89 percent, respectively.

Compliance rates that fall below compliance standards indicate variables for which either more intensive crew training is required, or that the variable's MQO needs to be adjusted accordingly to better reflect the realistic expectation of quality for that variable. As a result, MQOs are used not only to assess the reliability of FIA measurements and their ability to meet current standards, but also to identify areas of improvement of data collection protocols and training. This ongoing process improves repeatability or may even lead to elimination of variables that prove

Table 3—Comparison of quality assessment results for select tree-level variables by States. Values are percent of observations with 1x compliance rate.

Variable	Arizona	Colorado	Idaho	Montana	Nevada	New Mexico	Utah	Wyoming
Crown class	10.8	4.1	78.4	81.9	11.4	15.8	11.6	6.9
Sound dead	41.5	49.7	85.5	90.1	44.6	57.4	65.1	64.1
Form defect	59.8	11.2	95.4	93.6	na	67.7	61.6	43.1
Tree age	80.2	30.6	12.3	18.0	25.4	38.7	23.2	47.6

to be unrepeatable. For example, crown class was the least repeatable tree-level variable, with a 1x compliance rate of less than 7 percent; the 1x compliance rates for sound dead, form defect, and tree age also fell far below compliance standards (64 percent, 43 percent, and 48 percent, respectively). Quality assessment results from surrounding States (table 3) show that compliance rates for these four variables are typically low in States with high proportions of woodland forest types (Goeking et al. 2014; Menlove et al. 2017; Thompson et al. 2017; Werstak et al. 2016), whereas their compliance rates are much higher in States with high proportions of timber types (Menlove et al. 2012; Witt et al. 2012). This discrepancy suggests that the following actions may improve the repeatability of these variables: (a) provide additional training for crews working in woodland forest types, and/or (b) adjust the variables' definitions with respect to woodland trees.

The low compliance rate for the "Tree age" variable was observed in Wyoming and all other Interior West States and is probably due to the difficulty of obtaining accurate tree ages. Several factors that might contribute to inconsistency among tree ages are: (1) variation in age estimation when cores do not include tree center, or pith; (2) tree rings are too close together or too faint to read accurately in the field; and (3) trees are too large for increment borers to reach the center. These situations are particularly prevalent in the old and slow-growing trees that are typical in Wyoming's forests, and they could be mitigated through better field procedures and/or processing tree cores in a dedicated tree-ring laboratory that uses sandpaper, microscopes, and sometimes modeling techniques to obtain more accurate age estimates. FIA is currently collecting a subsample of tree cores to be processed in a dedicated tree-ring laboratory, and this process will likely help increase the repeatability of FIA's tree age variable in the future.

Overview of Wyoming's Forests

Ecoregion Provinces of Wyoming

Ecological units characterize areas of similar vegetation, climate, soils, hydrologic processes, disturbance regimes, topography, geology, and other processes such as nutrient cycling and plant community succession (Cleland et al. 1997). Ecoregions in the United States are hierarchically subdivided, in descending order of extent, into domains, divisions, provinces, sections, and subsection. Provinces

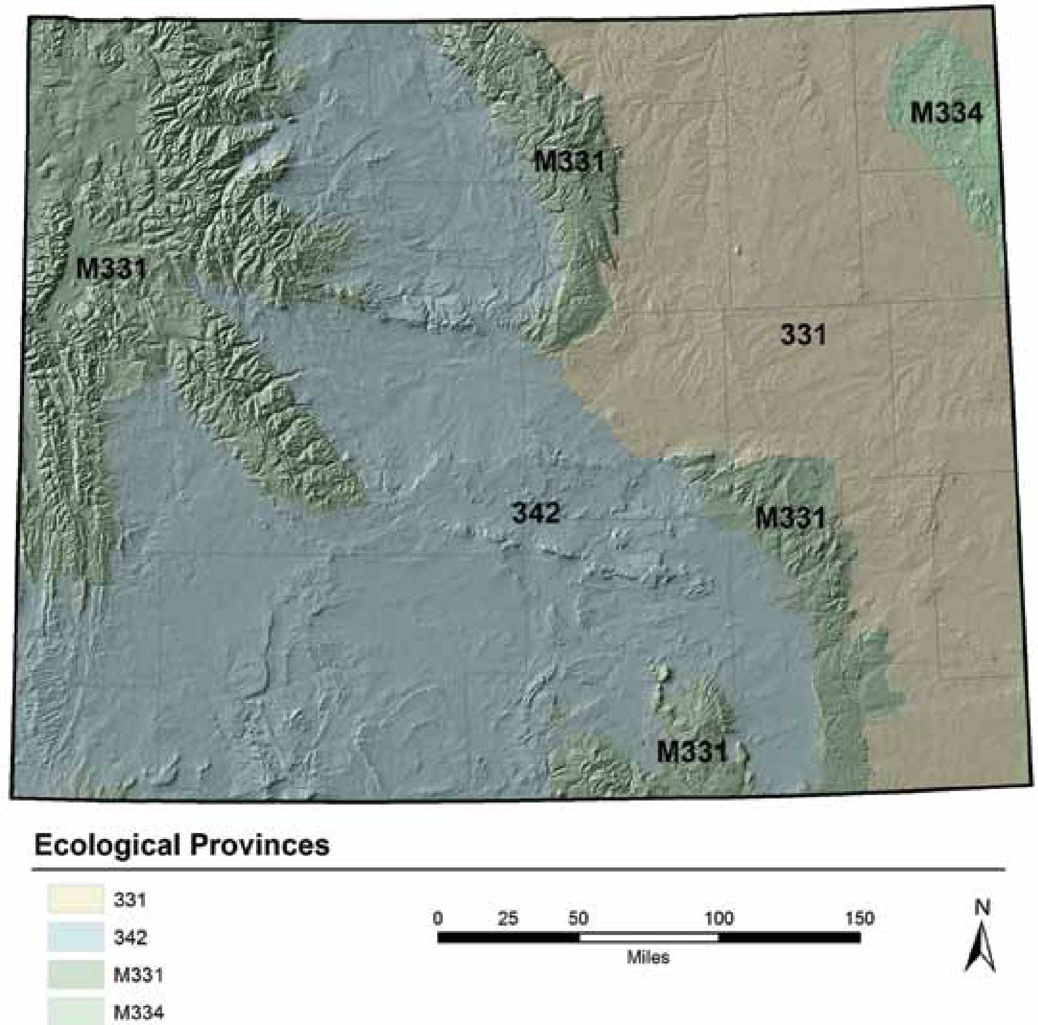

Figure 3—The four ecological provinces in Wyoming; background shows shaded relief and county boundaries. M331: Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Province, M334: Black Hills Coniferous Forest Province, 331: Great Plains-Palouse Dry Steppe Province 342: Intermountain Semi-Desert Province.

are defined largely by major floristic composition and are therefore the most relevant units for characterizing forested land. Elevation, landform, and climate are distinct drivers of the characteristic vegetation occupying each ecoregion. Wyoming is very dry, with a large portion of steppe environment centered in the semiarid west. The vast majority of annual precipitation at high elevations is delivered in the cool season (e.g., winter) and comes in the form of snow. Spatial variability in spring and summer rains at lower elevations helps explain the occurrence of a diversity of forest tree species throughout the region. The mountainous western portion of Wyoming receives summertime moisture from convective thunderstorms, whereas the eastern portion of the State is influenced by rainstorms originating from the Gulf of Mexico and the Great Plains throughout the year (Mock 1996).

Four ecoregion provinces cover Wyoming (fig. 3) and are discussed in decreasing area of coverage. The Intermountain Semi-Desert Province (342) encompasses a large portion of central Wyoming (44 percent of the State) but only includes 9 percent of the State's forests. This ecoregion extends from the north in the Bighorn Basin, south to the Utah and Colorado border (fig. 3). The major vegetation in this province includes what is colloquially called sagebrush steppe, but it also includes the largest proportion of the State's Pinyon/juniper forest-type group (624,000 acres).

The second most extensive province is the Great Plains-Palouse Dry Steppe Province (331), encompassing 25 percent of the State. The major vegetation that describes this province is shortgrass prairie characteristic of the Great Plains. Pinyon/juniper and Ponderosa pine forest-type groups make up the majority of forests present in this ecoregion, each accounting for approximately 37 percent.

Third, the Southern Rocky Mountain Steppe-Open Woodland-Coniferous Forest-Alpine Meadow Province (M331) encompasses the highest elevations and mountainous areas of Wyoming, including the Greater Yellowstone Ecosystem, the Bighorn Mountains, and the Medicine Bow-Routt National Forests in southeastern Wyoming (fig. 3). While this ecoregion covers only 25 percent of the State, 80 percent of the forested land occurs here.

Finally, the Black Hills Coniferous Forest Province (M334) encompasses a small area (1.7 percent) in the northeastern part of Wyoming that is generally higher in elevation than the surrounding Great Plains. Given the higher precipitation, the Black Hills support forested vegetation that is unique in that there are western, eastern, and boreal species present. Indeed, much of Wyoming's forest tree diversity occurs in this ecoregion. For example, white spruce (*Picea glauca*) is present, and is typical of boreal forests much farther north. Ponderosa pine is the most abundant species in the Black Hills, representing 63 percent of the forested area, and represents the eastern edge of a genetic sub-species that has been rapidly expanding its range since the last glacial maximum (Norris et al. 2016). The presence of bur oak (*Quercus macrocarpa*) in the Black Hills represents the western edge of this typically eastern species.

Forest Land Classification

FIA uses a nationally consistent standard for defining different categories of forest land. These categories were originally developed for the purpose of separating forest land deemed suitable for timber production from forest land that was either not suitable or unavailable for timber harvesting activity. Reserved forest land is considered unavailable for any type of wood utilization management practice through administrative proclamation or legislation. Unreserved forest land is considered available for harvesting activity where wood volume can be removed for wood products. Unreserved forest land is further divided into timberland and unproductive forests. Timberland is forest land considered capable of producing at least 20 cubic feet of wood per acre per year from trees designated as a timber species and is not withdrawn from timber production. Unproductive forests are not capable of producing 20 cubic feet of wood per acre per year from trees designated as a timber species on forest land designated as a timber forest type, typically because of species and/or site conditions (see Appendix A for definitions). Reserved forest land can also be divided into productive and unproductive classes (table B2).

The State of Wyoming encompasses over 62.6 million acres. Seventeen percent, or 10.5 million acres (table B2), of the area meets the definition of forest land. Unreserved forest land accounts for 68 percent of the total forest land in Wyoming with 75 percent classified as timberland and 25 percent classified as unproductive. Approximately 32 percent of the forest land in Wyoming is reserved and almost 94 percent of this reserved forest land is classified as productive (table B2, and see *National Forest System Inventory* below).

Forest Land Ownership

The majority of forest land in Wyoming is administered by the USDA National Forest System (NFS), which manages 5.8 million acres (table B2). This represents almost 56 percent of the State's total forest land area (fig. 4). NFS land in Wyoming consists of six different national forests and a National Grassland. Bridger-Teton National Forest and the Uinta-Wasatch-Cache National Forest of Region 4 occur in western Wyoming, and Shoshone National Forest, Bighorn National Forest, Black Hills National Forest, the Medicine Bow-Routt National Forest and the Thunder Basin National Grassland occur in Region 2. Seventy-one

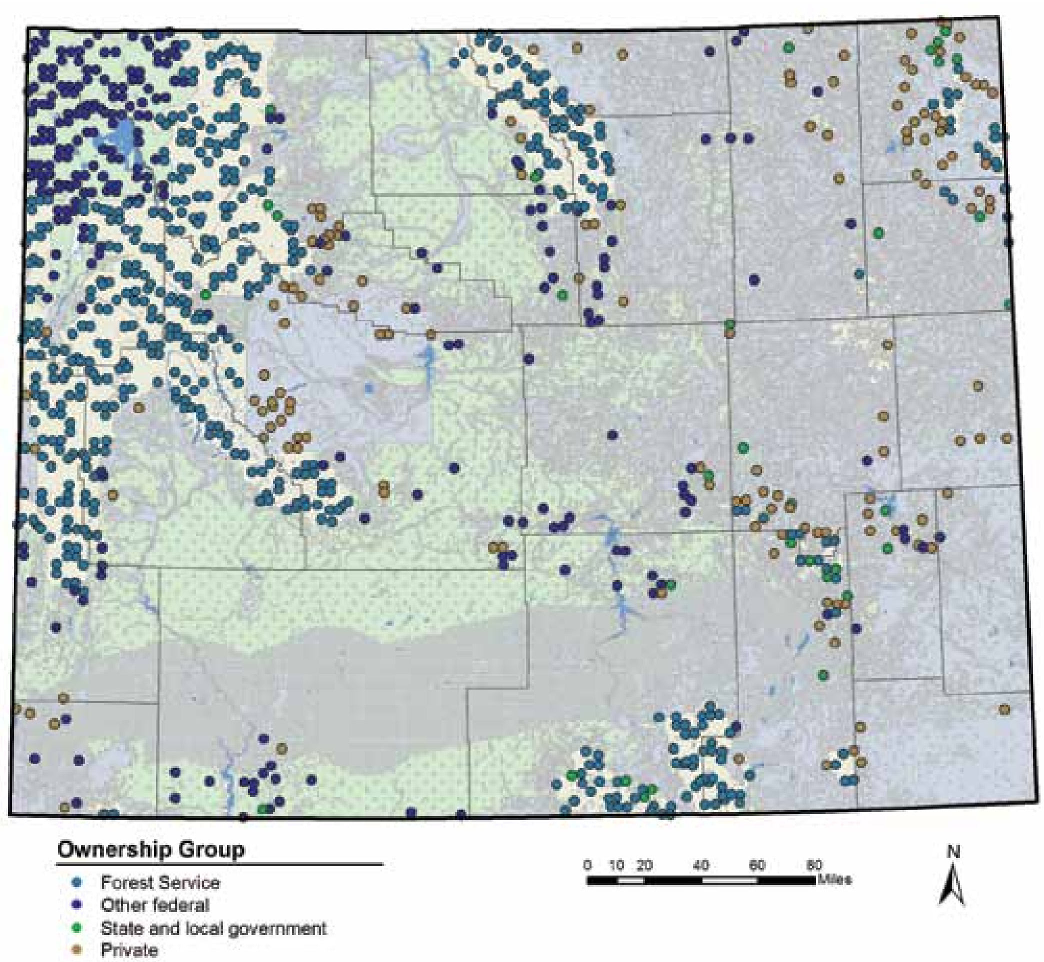

Figure 4—Distribution of inventory plots on forest land by ownership group, Wyoming, 2011–2015. (Note: plot locations are approximate; some plots on private land were randomly swapped.)

percent of NFS forest land is classified as unreserved forest land of which the majority (91 percent) is timberland (but see *National Forest System Inventory* below).

The National Park Service (NPS) is the second largest administrator of forest land in Wyoming, overseeing just over 15 percent that occurs primarily in Yellowstone National Park and Grand Teton National Park. Another agency that controls a significant amount of forest land in Wyoming is the Bureau of Land Management (BLM). Forest land administered by the BLM totals just over 1.1 million acres, or 10 percent of the forest land in the State. The entirety of forest land under BLM jurisdiction is classified as unreserved, and almost 33 percent of BLM forest land meets the criteria for timberland. Privately owned forest land totals just over 1.1 million acres. Private landowners are a diverse group in Wyoming consisting of private individuals/families, tribes, unincorporated local associations, and corporations. All private forest land is in the unreserved owner class with 63.3 percent classified as timberland and 36.6 percent classified as unproductive. The remaining forest land area in Wyoming is controlled by State and local government (3.4 percent), and the Department of Defense, U.S. Fish and Wildlife Service, and other Federal controlling less than 1 percent each.

Forest Types and Forest-Type Groups

Forest type is a classification of forested land based on the species forming a majority of live tree stocking in most cases. Names assigned to forest types may be based on a single species or groups of species. The distribution of forest types across the landscape is influenced by factors such as climate, soil, elevation, aspect, disturbance history, and succession. The loss or gain of a particular forest type over time can help assess the impact of successional changes, major disturbances related to fire, weather, climate, insects, disease, and human-caused disturbances such as timber harvesting or restoration.

The FIA program aggregates forest types into forest-type groups to simplify interpretation of large-scale forest trends nationally and by State. Forests in Wyoming are represented by 11 forest-type groups that are further classified into distinct forest types (see Appendix C). Some forest-type groups contain only one forest type, while other forest-type groups include several individual forest types. For example, a common forest-type group in Wyoming with multiple forest types is the Fir/spruce/mountain hemlock forest-type group, which consists of the Blue spruce forest type, the Engelmann spruce forest type, the Engelmann spruce/subalpine fir forest type, and the Subalpine fir forest type.

In Wyoming, the Fir/spruce/mountain hemlock forest-type group is the most extensive, covering 2.9 million acres, accounting for 27.8 percent of total forest area in the State (table B3). Within the Fir/spruce/mountain hemlock forest-type group, the Engelmann spruce/subalpine fir forest type accounts for nearly half the acreage (49.5 percent) and the Subalpine fir forest type accounts for another 33 percent. The second most abundant forest-type group is Lodgepole pine, which encompasses over 2.5 million acres, almost 24 percent of the State's forest land. The Lodgepole pine forest-type group consists of only the Lodgepole pine forest type.

The Pinyon/juniper forest-type group is third in abundance at almost 1.1 million acres (10.3 percent), and is comprised primarily of the Rocky Mountain juniper forest type (54.4 percent) and the Juniper woodland forest type (43.6 percent). Fourth in abundance is the Nonstocked forest-type group at 0.86 million acres (8.2 percent). The economically important Ponderosa pine (8 percent) and Douglas-fir (7.7 percent) forest-type groups each occupy approximately 0.8 million acres in Wyoming. The remaining forest land in the State is classified as: Other western softwoods forest-type group (6 percent), which includes the important wildlife species whitebark pine; the Aspen/birch forest-type group (5.9 percent); the Oak/hickory forest-type group (1 percent), the Elm/ash/cottonwood forest-type group (0.7 percent), which occur primarily in the eastern portion of the State; and the Woodland hardwoods forest-type group (0.2 percent).

Forest Growth, Mortality, and Removals

To monitor changes in tree volume over time, the relationships between growth, mortality, and removals can be quantified. Growth is typically expressed as net growth and is defined as average annual net growth in tree volume minus the volume lost through mortality. Mortality is the average annual volume of trees dying over a given time period due to natural causes, and excludes the volume removed through harvesting. Tree mortality normally occurs at low, "background" rates due to insects and disease, competition, or advanced tree age. Occasionally, highly concentrated and relatively localized mortality occur due to insect and disease epidemics, wildfire, or severe weather events. Removals represent the net volume of growing-stock trees removed from the inventory by harvesting or other cultural operations (such as timber stand improvement), by land clearing, or by changes in land use (such as an administrative change to wilderness).

Ideally, growth, mortality, and removals would be analyzed using measurements of the same plot at two points in time. It is also possible to estimate growth and mortality rates based on a single inventory, as is described below. In contrast, removals cannot be reliably estimated without having two measurements of the same set of plots. Because of these differences in estimation procedures, growth and mortality are analyzed and discussed separately from removals (see the *Removals for Timber Products* section below). Average annual growth and mortality, as reported here, are estimated using the combination of two approaches, which depends on the remeasurement status of the plot. In Wyoming, the last complete periodic inventory (conducted from 1998 thru 2002) utilized the national mapped-plot design, and when implementation of the annual inventory began in 2011, many of the same plots were incorporated into the grid. Of the 951 forested plots measured from 2011–2015 in Wyoming, 803 (84 percent) were established at the same locations as periodic inventory plots. The implications for this are that the remeasurement time period can be anywhere from 9 years (e.g., 2002–2011) to 17 years (e.g., 1998–2015), or any other combination in between, where the average remeasurement time period was 13.2 years. Therefore, average annual net growth on 84 percent of the plots is estimated using remeasurement data, whereas the remaining 16 percent of plots were calculated from 10-year radial increment, measured from ring widths sampled using increment bores, on plots during their first visit. Similarly, mortality, as reported here, is estimated using remeasurement data on 84 percent of the plots, and on the remaining plots, the average annual net volume of trees estimated to have died in the 5 years prior to the year of measurement, based on field calls was used. This extended remeasurement period, on average, can influence estimates of growth and mortality. Only when complete remeasurement for the State—where the status of the plot and all trees on the plot are known at two, pre-determined, points in time (10-year measurement interval)—will temporal trends of growth and mortality reflect the probabilistic nature of the annual sample design.

The annual estimate of gross growth of all live trees 5.0 inches diameter and greater on forest land in Wyoming totaled nearly 270.4 million cubic feet (MMCF). This is the sum of growth on all survivor and ingrowth trees. Survivor trees are live trees 5.0 inches and larger in diameter 10 years before the current measurement. Ingrowth trees are live trees 5.0 inches and larger in diameter that grew over the 5.0-inch threshold during the previous 10 years. While this annual increase appears large in absolute terms, it is relatively small; average annual net growth as a percentage of net volume of all live trees 5.0 inches and larger in diameter was approximately -2 percent per year, and has been averaging about -2 percent over the annual inventory (fig. 5). These data suggest that relatively high levels of tree mortality are currently drawing down live tree growing stock.

The average annual mortality of trees 5.0 inches in diameter and larger on forest land in Wyoming was 578.3 MMCF (table B25). The difference between the live tree, or gross growth and mortality indicates an average annual net growth estimate of -307.9 MMCF (tables B21–B24). A negative estimate of net growth in Wyoming signifies an inventory of live trees that is decreasing annually in the absence of trees removed from human-caused activities. High levels of tree mortality are offsetting gains in live tree growth. The Forest Service ownership group had the largest negative estimate of net growth, -309.6 MMCF, whereas undifferentiated private was much lower -1.7 MMCF (table B21). The National Park Service had the largest net growth of any owner class at 9.1 MMCF (table B21), which likely reflects the relatively large acreage of young, postfire lodgepole pine stands in Yellowstone National Park (see the *Fire in Wyoming's Forests* section below).

Gross growth and mortality for the eight species with the greatest total volume in Wyoming indicated that annual mortality exceeded growth for over half of the species (fig. 6). This resulted in negative net growth for most major softwood species in the State: lodgepole pine, Engelmann spruce, whitebark pine, Douglas-fir, and limber pine. Positive net growth occurred for subalpine fir and ponderosa pine (fig. 6).

High mortality rates over the last 5 years in Wyoming are the driving force behind the large differences between gross and net growth and warrants further examination. Converting the State-level estimates of mortality into per-acre estimates removes the effect of differences in the amount of forest land administered

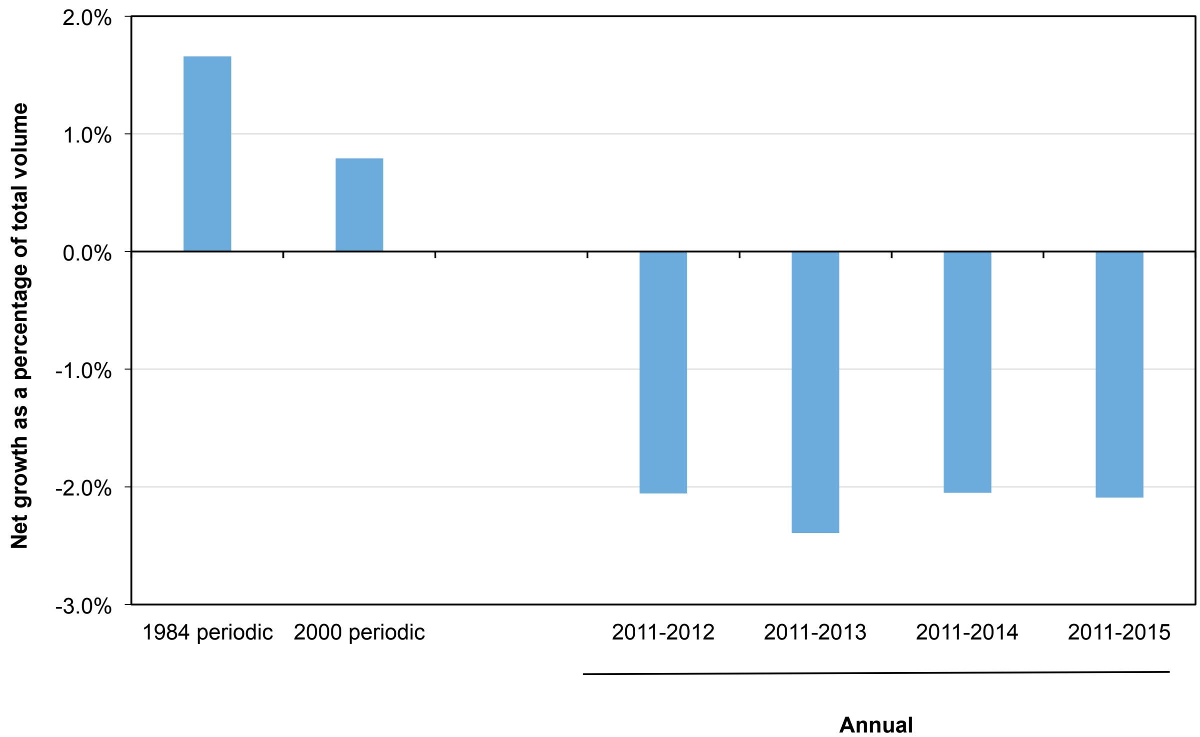

Figure 5—Net growth of all live trees (>5 inches diameter) as a percentage of total live volume (>5 inches diameter) for the State of Wyoming for evaluation periods from 2011–2012 to current (2011–2015), including two previous periodic inventories.

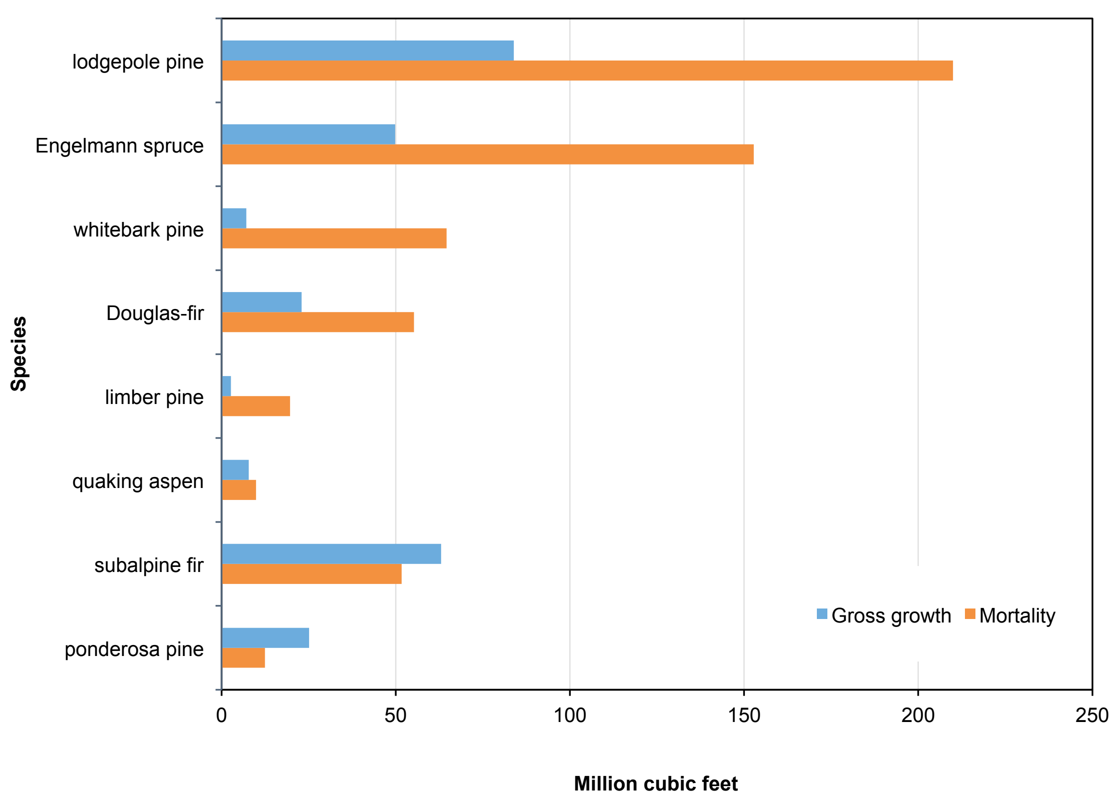

Figure 6—Annual gross growth and mortality on forest land for eight major species, Wyoming, 2011–2015. Net annual growth equals gross growth minus mortality.

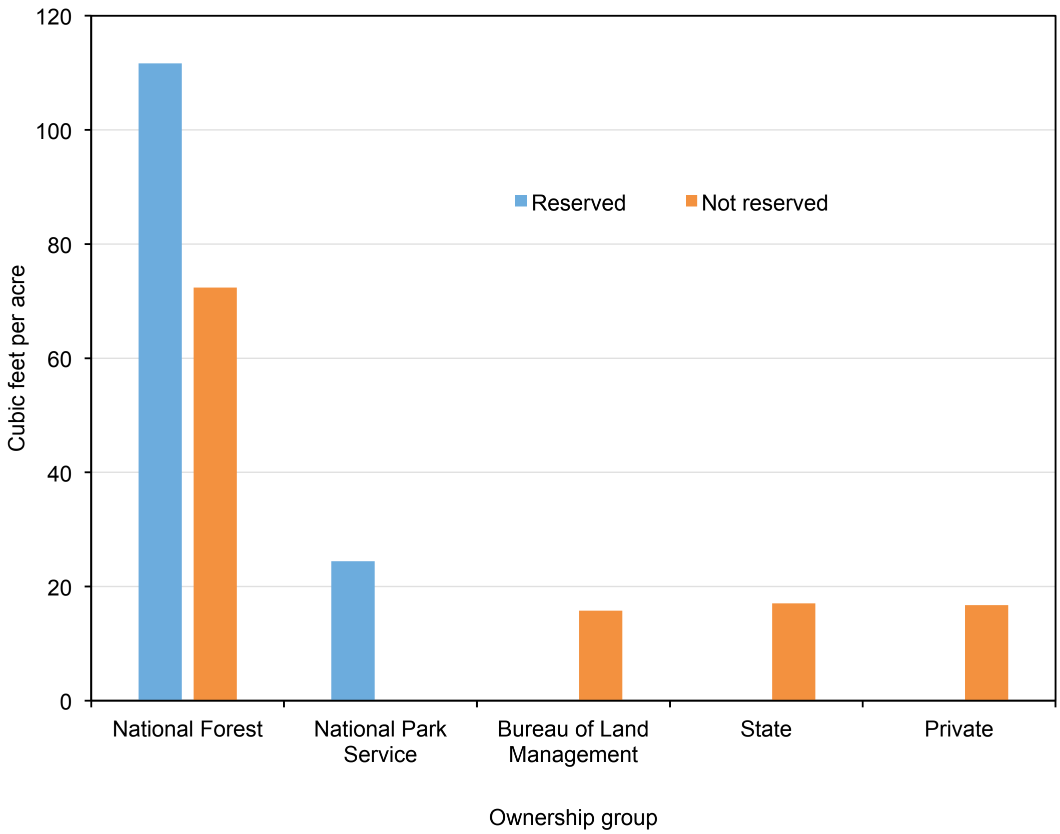

Figure 7—Average annual per-acre mortality on forest land by two major owner categories and reserved status, Wyoming, 2011–2015.

by different ownership groups. Across all ownerships, and reserve status, the Statewide per-acre estimate of annual mortality volume was 55.1 cubic feet per year on forest land (fig. 7). Average annual mortality on reserved land was 68.2 cubic feet per acre, compared to 49.1 cubic feet per acre, on average, on unreserved forest land across all ownerships (see Appendix A for definitions). Regardless of reserve status, national forest land in Wyoming exhibited higher per-acre estimates of mortality (fig. 7).

All trees classified as mortality trees are assigned a primary cause of death in the field. Drawing conclusions from mortality estimates by cause of death should be done with caution because the actual causal agent may be difficult to interpret. Interactions between insects and diseases are complex and can make identification of proximate causes of mortality difficult (see the *Bark Beetle Infestation* section). Mortality due to insects accounted for the vast majority in the State, while fire was the second leading contributor to mortality (fig. 8). The "Other" cause of death category includes trees that have died due to animals, weather, silviculture, or reasons the field crews were unable to determine. The differences in levels of tree mortality by reserved status found in Wyoming has also been observed in other State inventories (Goeking et al. 2014; Menlove et al. 2012; Witt et al. 2012). In Wyoming, nearly twice as much mortality volume attributable to insects occurred on land that is not reserved, whereas fire-caused mortality was almost twice as common on reserved land status (fig. 8). Interestingly, the volume of disease- and weather-caused mortality was nearly equal between reserved and not reserved land status (fig. 8).

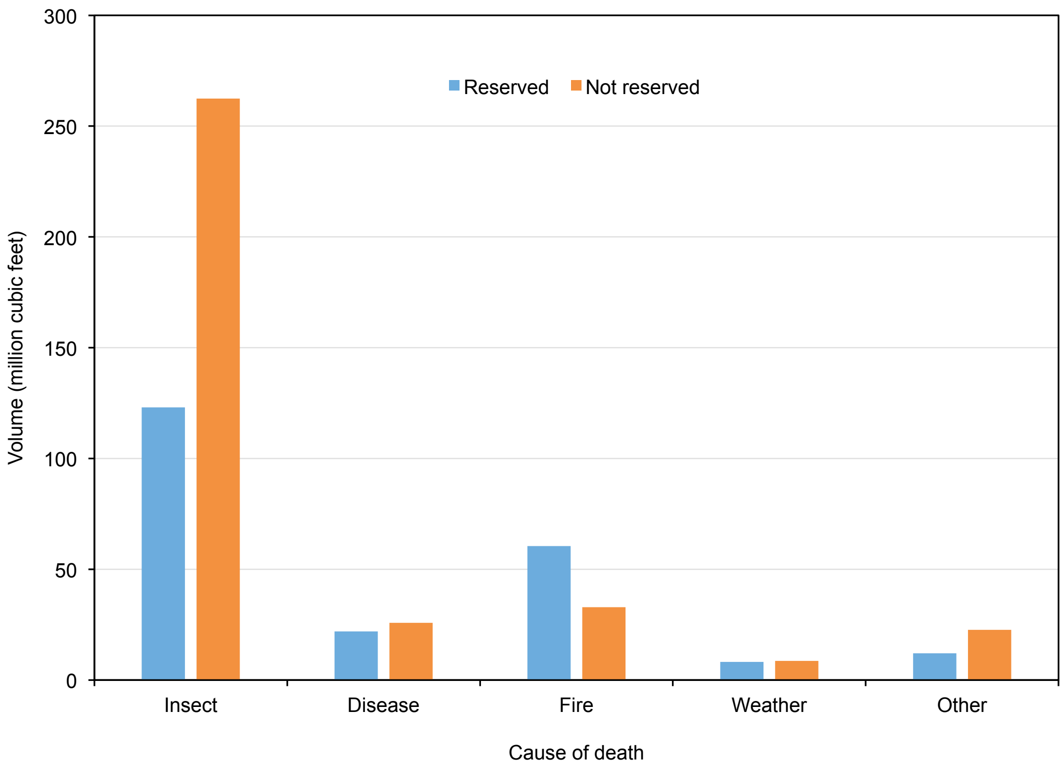

Figure 8—Average annual per-acre mortality on forest land by reserved status and cause of death, Wyoming, 2011–2015.

Numbers of Trees

Estimates of the numbers of trees, when combined with information about the size and species, can be used to provide meaningful summaries of forest stand dynamics, structure, and composition. Young or dense forest stands usually consist of relatively large numbers of small-diameter trees, whereas older forest stands contain small numbers of large-diameter trees. FIA classifies individual tree species into species group and also categorizes each species and species group as either softwood or hardwood (Appendix D).

There are an estimated 4.6 billion live trees 1.0 inch in diameter or larger (table B10) on Wyoming's forest land area. Softwoods species total 4.3 billion trees or 94 percent of the State's live trees whereas hardwoods (mostly cottonwoods and quaking aspen) make up the remaining 6 percent. The most abundant species group is Lodgepole pine, which totaled 1.8 billion trees and accounted for 39 percent of live trees in the State. An additional 25 percent of the trees (1.2 billion trees) fall within the True fir species group, which consists of subalpine fir in the State. As shown in table B10, the third most abundant species group was the Engelmann and other spruces group, which totaled 4.5 million trees and accounted for over 9 percent of the total number of live trees. The trend in the three most predominant tree species groups was reflected in the growing stock trees (live trees greater than 5 inches in diameter) as well, with Lodgepole pine accounting for 32 percent, followed by True fir (22 percent) and Engelmann and other spruces (13 percent; table B11).

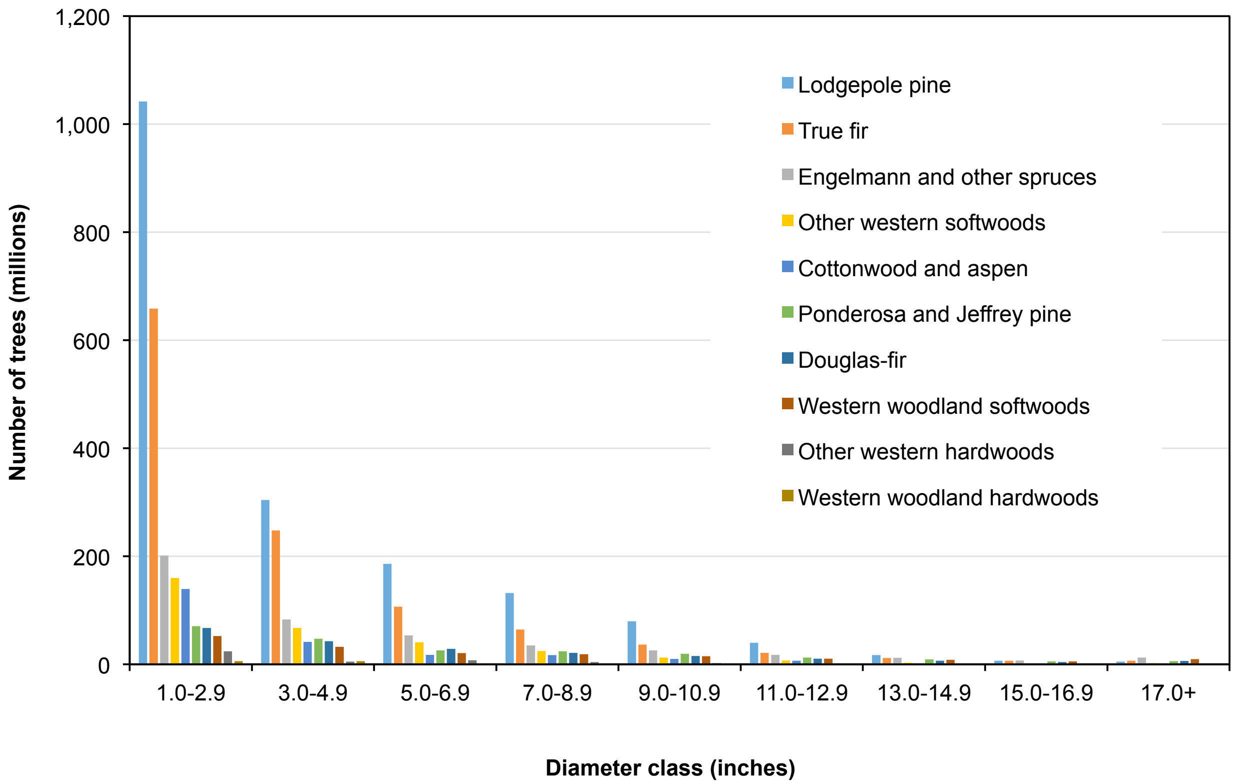

Figure 9—Number of live trees on forest land, by diameter class and species group, Wyoming, 2011–2015.

The distribution of live trees by diameter class revealed a typical inverse j-shape for all trees in Wyoming (fig. 9). The distribution of individual species groups across diameter classes reflects their life history traits (e.g., relative shade tolerance, seed storage, dispersal strategy). For example, lodgepole pine is known to regenerate prolifically after large-scale fires such that densities exceed many thousands per acre. Similarly, subalpine fir is very tolerant of low light conditions and commonly perpetuates itself in the understory of spruce-fir and lodgepole pine forests. Conversely, the distribution of two important commercial timber species, Douglas-fir and ponderosa pine, is much flatter across diameters reflecting lower tolerance to low light conditions and individual longevity.

Live and Dead Tree Volume and Biomass

The quantity of wood volume in trees can be important for determining stocking and the sustainability of current and future wood utilization. The forest products industry and forest managers can use assessments of tree species composition, size distribution, and wood volume, as well as the geographic location and ownership status of land parcels to plan for harvest activities. Additionally, estimates of volume and biomass are becoming increasingly important for assessments of wildlife habitat and other societal values such as carbon accounting. Estimates of gross and net volume include only the merchantable portion or sawlog portion (e.g., cubic-foot or board-foot) of live trees 5.0 inches in diameter and larger. Net volumes are computed by deducting rotten, missing, or form defects from gross volume. Net volume is reported below as net volume of all live trees, net volume of growing-stock trees, net volume of sawtimber, and net volume of saw-logs (Appendix A). Biomass estimates are based on gross volumes and describe aboveground tree weight (oven-dry) by various components (merchantable bole and bark, tops and limbs, saplings) (Appendix E).

The net volume of all live trees on Wyoming's forest land totals 14.5 billion cubic feet (table B12). Almost 65 percent, or 9.4 billion cubic feet, is located on lands administered by the NFS. About 21.2 percent of the live volume on NFS lands exists on reserved lands and is unavailable for harvest (table B12). The vast majority of the net volume on NFS ownership is composed of lodgepole pine, Engelmann spruce, subalpine fir, and Douglas-fir (table B14). Forest land controlled by the National Park Service accounts for 19.7 percent of total live volume, or 2.9 billion cubic feet (table B12), which occurs entirely in reserved forest status and is dominated by lodgepole pine (55 percent, table B14). Privately owned forests contain 8.4 percent of the State's total live volume, or 1.2 billion cubic feet (table B12), which is predominately ponderosa pine (table B14).

The Lodgepole pine species group has the highest amount of live tree volume, at 4.6 billion cubic feet (32 percent of the total), of any species group. Second in abundance, the Engelmann and other spruces species group accounts for 21 percent, or 3.1 billion cubic feet. Third in abundance, the True fir species group accounts for 17 percent, or 2.5 billion cubic feet. Douglas-fir and Ponderosa pine species groups follow with 10 percent and 8 percent, respectively (table B14, fig. 10). The net volume of growing-stock trees on timberland in Wyoming totals 8.7 billion cubic feet (table B17), or 60 percent of the total live volume on forest land. Growing-stock trees are live, merchantable trees that occur on timberland and represent timber that is potentially available for harvest. The availability of timber volume for harvest is affected by three primary factors: reserved status, productivity, and merchantability (see Appendix A for definitions).

Live volume is also reported for sawtimber trees, which are defined as softwood trees 9.0 inches in diameter or larger, or hardwood trees 11.0 inches in diameter or larger (International ¼-inch rule). The net volume of sawtimber trees on timberland totals 33.6 billion board feet, with most of that volume existing in the Engelmann and other spruces and the True fir species groups (table B19).

The pattern of standing dead stocking varied from live tree stocking across species groups (fig.10). The ratio of standing dead tree to live tree stocking was highest for the Other western softwoods species group, which had a substantially higher ratio than any other group. The high levels of standing dead in this group were driven by relatively recent mortality of the whitebark pine component (see the *Whitebark Pine Status and Trends* section below). All other species groups had less standing dead trees than live trees, but the ratio varied from 66 percent for the Lodgepole pine species group, to nearly half (49 percent) for Douglas-fir, and only 7 percent for the Ponderosa and Jeffrey pine species group (fig. 10). See the *Snags as Wildlife Habitat* section below for an in-depth analysis of standing dead trees in Wyoming.

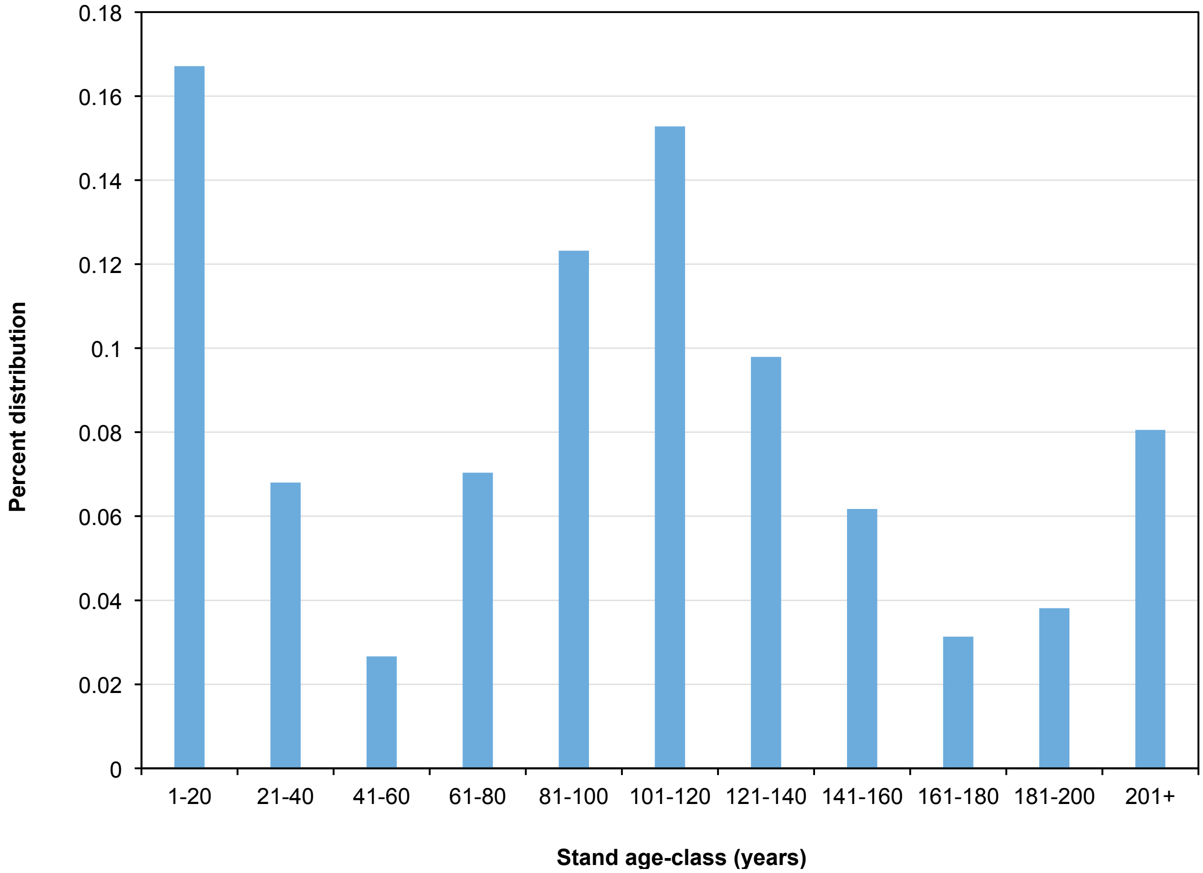

Figure 10—Net cubic-foot volume of trees 5.0 inches in diameter or larger on forest land, cubic-foot volume of growing-stock trees on timberland, and cubic-foot volume of standing dead trees on forest land, by species group, Wyoming, 2011–2015. Note: Ponderosa pine is the only species in Wyoming in the Ponderosa and Jeffrey pine species group.

The relationship between the growing stock volume on timberland and all live volume on all forest land by species group indicates possible species available for timber harvest in Wyoming. Over 93 percent, or 1.1 billion cubic feet, of the total live volume in the Ponderosa and Jeffrey pine species group is growing stock volume on timberland (fig. 10). The Cottonwood and aspen (79 percent), Douglas-fir (77 percent), True fir (70 percent), and Engelmann and other spruces (60 percent) species groups also had relatively high ratios of growing-stock volume to live tree volume. The relatively low ratio of the Lodgepole pine species group (46 percent), the most common tree in the State by number of trees (fig. 9), indicates a large portion of this species type group occurs in younger, small-diameter stands.

Biomass is typically sold by green weight; however, the water content of wood is highly variable geographically, seasonally, and even across portions of a single tree. Therefore, live tree inventory estimates of green biomass may be unreliable or even misleading. In contrast, oven-dry weight does not change due to fluctuations in tree water content. The total weight of oven-dry aboveground biomass on Wyoming's forest land is 255 million dry short tons, and approximately 61 percent (155 million dry short tons) occurs on timberland (table B29). Forty-eight percent, or 122 million dry short tons, occurs on NFS timberland.

Table 4—Net volume (cubic feet per acre) of live trees 5.0 inches diameter and larger, and biomass (tons per acre) of live trees 1.0 inches diameter and larger, averaged by common forest types, Wyoming, 2011–2015. Because estimates obtained for forest-type groups with a small number of plots have high standard errors, only forest types with greater than 20 plots are included.

Forest-type group	Number of plots	Net volume (cubic feet per acre)	Biomass (tons per acre)
Douglas-fir group	75	1831	35.7
Fir / spruce / mountain hemlock group	264	2116	33.9
Lodgepole pine group	215	1693	30.5
Ponderosa pine group	81	1292	24.0
Aspen / birch group	60	802	15.9
Other western softwoods group	53	563	10.6
Pinyon / juniper group	103	429	8.2
Nonstocked	41	53	1.0

The highest per-acre estimate of biomass occurs in the Douglas-fir forest-type group, followed by Fir/spruce/mountain hemlock, and Lodgepole pine (table 4). Highest per-acre estimates of volume occurred in the Fir/spruce/mountain hemlock forest-type group at 2,116 cubic feet per acre, followed by Douglas-fir. The four highest per-acre estimates of volume and biomass occurred in timber types. Aspen/birch, Other western softwoods, and the Pinyon/juniper forest-type groups had much lower estimates per acre (table 4).

Stand Age

The age structure of forest land provides insight into shifts in stand structure, composition, and succession. On every FIA plot that samples forest land, and includes suitable trees for increment core extraction, stand age is estimated based on the average age of only those trees that fall within the calculated size-class category. For example, if an FIA plot occurred in a softwood forest type where about 30 percent of the live trees were in the large-diameter size-class (trees at least 9.0 inches in diameter and larger), and 70 percent were in the medium diameter size-class (trees between 5.0 and 9.0 inches in diameter), the stand would be classified as a medium diameter stand size class, and therefore only the medium-size trees would be used in determining stand age.

The age-class distribution of forest land in Wyoming is strongly centered around the 81–120 year age classes, with a notable peak of very young stands (1–20 years), and a less notable peak of very old (201+ years) stands (fig. 11). Thirty-seven percent of Wyoming's forest land, or 3.8 million acres, are between 81 and 140 years of age, likely reflecting a combination of settlement-era harvesting and species longevity. Young stands represent the single largest 20-year age class and comprise about 1.7 million acres of Wyoming's forest land. Another 8 percent, or just under 1 million acres of Wyoming's forest land, are in stands over 201 years of age. Twenty percent of the 201+ age class is in the Pinyon/juniper forest-type group, the only group with the largest percentage of stands in the oldest age class.

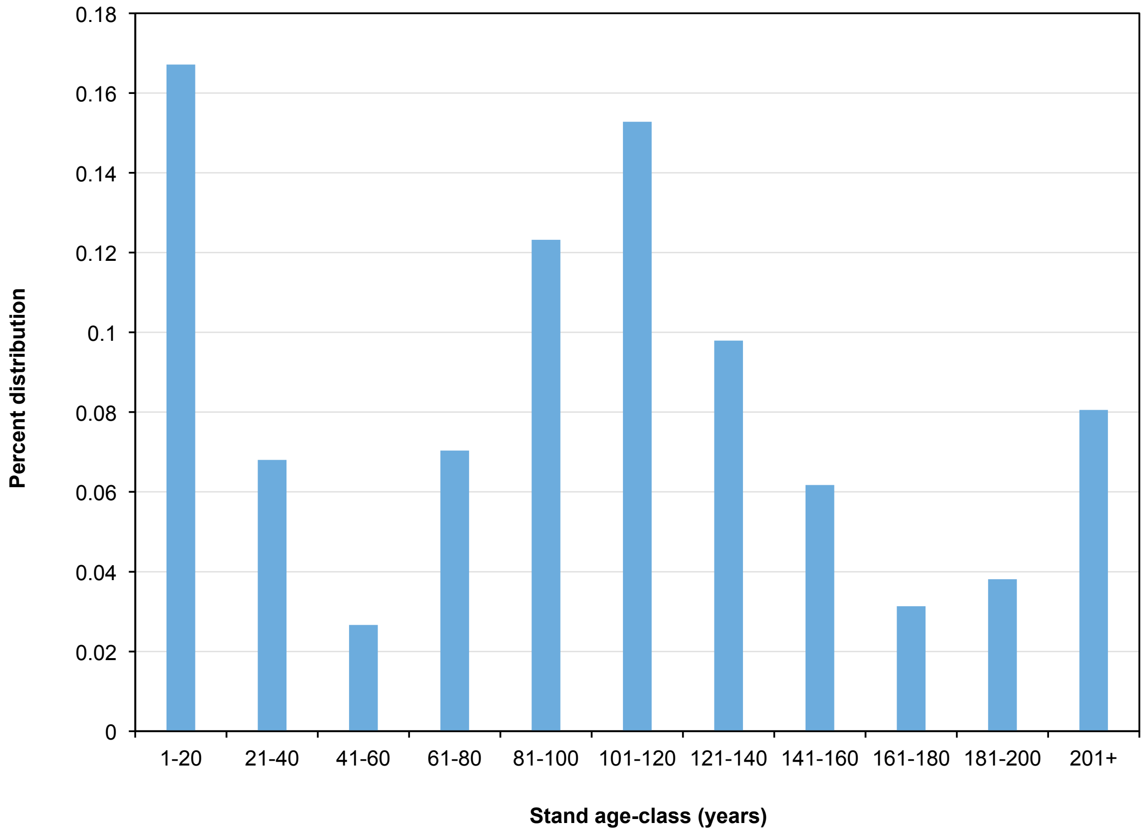

Figure 11—Stand-age class distribution of forest land in Wyoming, 2011–2015.

Considerable differences are apparent in stand-age distribution among the major forest-type groups in the State (fig. 12). The Pinyon/juniper and Elm/ash/cottonwood forest-type groups have the most even distribution of forest area across all age-class groups, whereas the Aspen/birch and the Ponderosa pine forest-type groups have strong unimodal distributions. Furthermore, the Aspen/birch group has two peaks, one in the 1–20 year age class, which is the single largest 20-year age class, and one in the 81–100 year class. The Ponderosa pine forest-type group exhibited a substantial peak in the 81–120 year age classes. This peak represents 60 percent of the forest-type group across the State. The Douglas-fir, Fir/spruce/hemlock, and Lodgepole pine forest-type groups also exhibit a characteristic peak in the 81–120 year age classes, but include stands more evenly distributed across all age classes. These groups also have peaks in the 1–20 year age class, presumably a result of fires and insect infestation over the past few decades.

Stand Density Index

Stand density index (SDI; Reineke 1933) is a relative measure of stand density, based on quadratic mean diameter of the stand and the number of trees per acre. In the western States, silviculturists often use SDI as one measure of stand structure to meet diverse objectives such as ecological restoration and wildlife habitat (e.g., Lilieholm et al. 1994; Long and Shaw 2005; Shaw and Long 2007; Smith and Long 1987). Originally developed for even-aged stands, SDI can also be

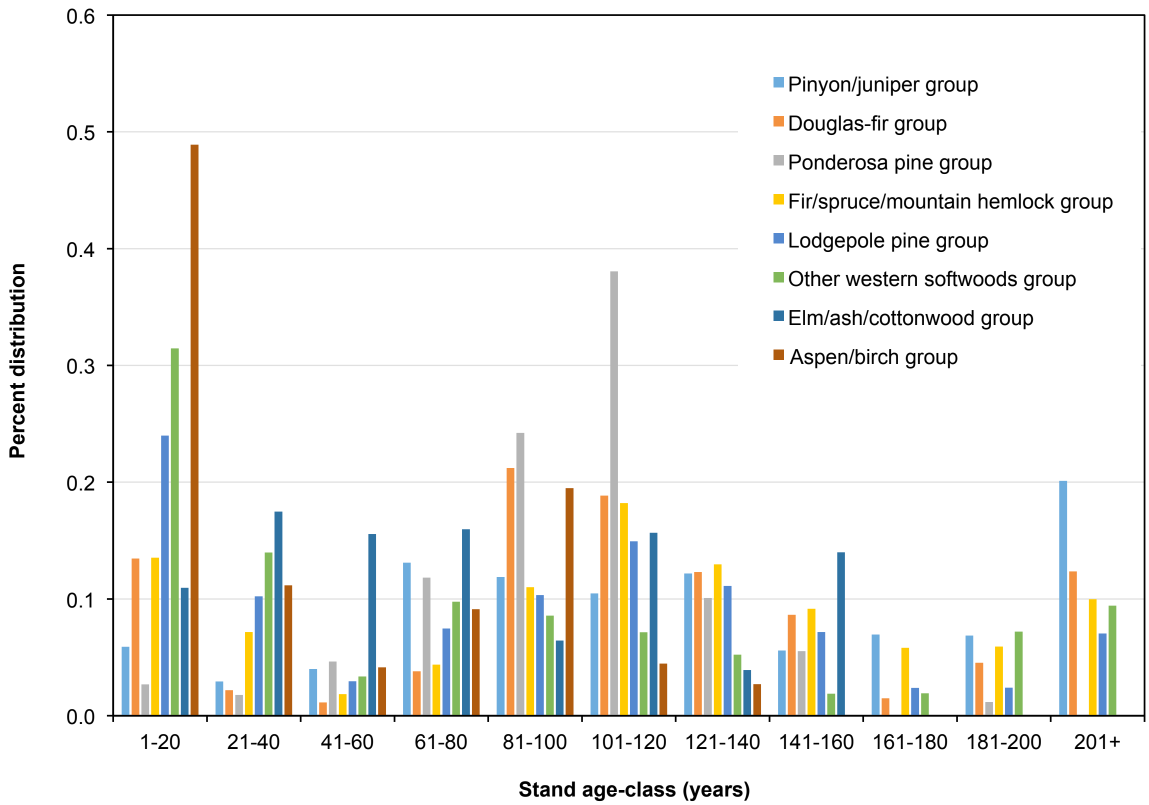

Figure 12—Stand-age class distribution by major forest-type groups for Wyoming, 2011–2015.

applied to uneven-aged stands (Long and Daniel 1990; Shaw 2000). Stand structure can influence the computation of SDI, so the definition of maximum SDI must be compatible with the computation method. SDI was computed for each condition that sampled forest land using the summation method (Shaw 2000), and the SDI percentage was calculated using the maximum SDI for the forest type found on the condition.

Maximum SDI is rarely, if ever, observed in nature at the stand-scale because the onset of competition-induced (self-thinning) mortality occurs at about 60 percent of the maximum SDI (Long and Smith 1984). Within-stand variability of density results in the average stand density being well below that of the densest patches. A site is considered to be fully occupied at 35 percent of maximum SDI (Long 1985). Below about 25 percent of maximum SDI, individual trees are considered "free to grow." At these lower densities, individual tree growth is maximized but stand growth is below potential, while at higher densities, individual tree growth is below potential, but stand growth is maximized (Long 1985). There are several reasons why stands may have low SDI. For example, low SDI is typical following major disturbances, such as fire, insect attack, or harvesting. These stands remain in a low-density condition until regeneration fills available growing space. Stands that are over-mature can also have low SDI, because growing space may not be reoccupied as fast as it is released by the mortality of large, old trees. Finally, stands that occur on very thin soils or rocky sites may remain at low density indefinitely, because limitations on physical growing space do not permit full site occupancy.

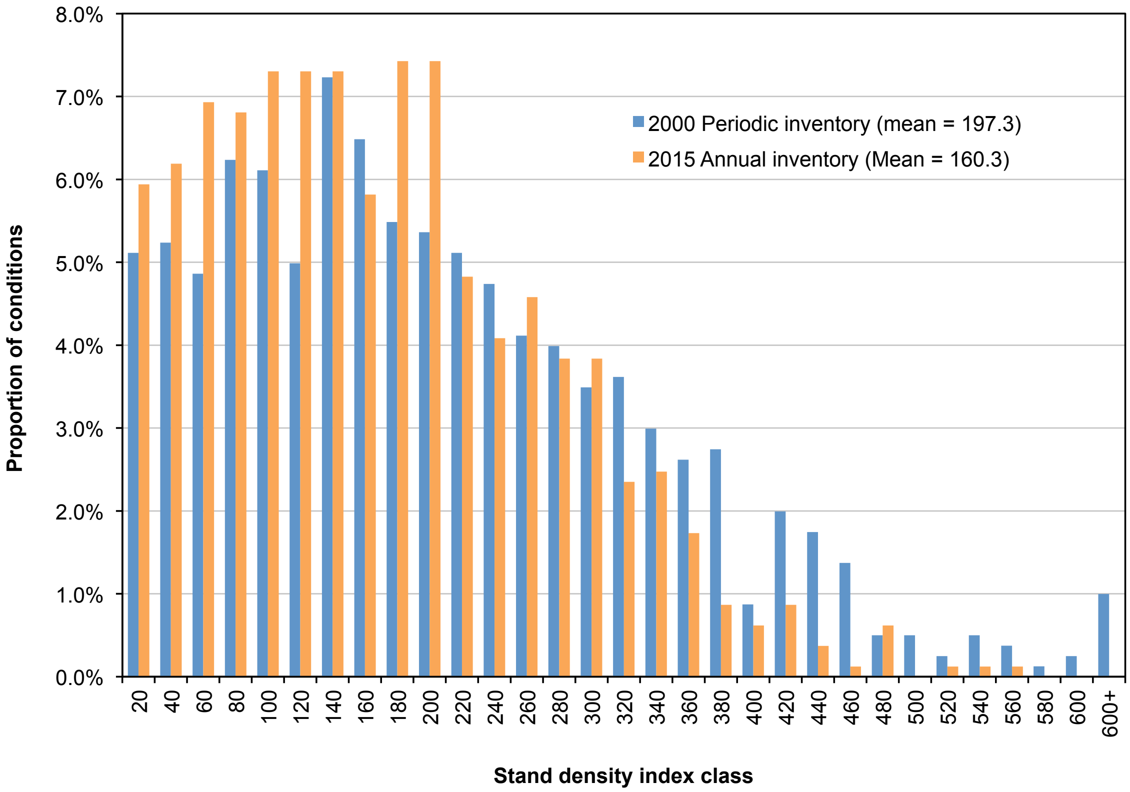

Figure 13—Distribution and average of stand density index (SDI) for the 2000 periodic inventory and first half cycle (2011–2015) of annual inventory in Wyoming.

Because the periodic inventory of Wyoming used the annualized plot design, and most of the plot locations were carried over to annual inventory, it is possible to look at changes in stand density over this time period. For this analysis, conditions measured during the 2000 periodic inventory (measured 1998–2002) are compared to conditions measured during the first half of the inventory cycle (2011–2015). Each condition-level SDI value was binned at 20-unit intervals, and then the number of conditions in each bin was normalized to account for the differing numbers of observations in each inventory. After normalization, values from the two periods can be plotted together in each bin for direct comparison (fig. 13).

The distribution of SDI values in Wyoming is generally more even across density classes than in other Interior West States, probably due to the predominance of forest types that normally occur as high-density stands (e.g., Lodgepole pine). Comparison of SDI means and distributions (fig. 13) suggests that there had been an overall lowering of stand density since the early 2000s. Mean SDI was 197.3 for conditions measured during the periodic inventory and 160.3 for conditions measured during the annual inventory (significantly different, $P < 0.01$). During the periodic inventory just over 51 percent of conditions had a SDI of 200 or lower, whereas during annual inventory the proportion of conditions in this density range is over 68 percent. In the middle density classes (SDI greater than 200 and up to 300), the proportions of conditions are nearly identical for both inventory periods, at just over 21 percent. The number of conditions with SDI greater than 300 in the annual inventory is about half of what it was during the periodic inventory, falling from 21 to 10 percent. This shift is among the largest observed in Interior West States.

The overall reduction of stand density is consistent with other results of the inventory. Many species have experienced a period of negative net growth (tables B21–B24, fig. 6), which means that mortality is freeing up growing space faster than the surviving trees on a site can re-occupy that space. While disturbances such as insects, fire, and drought have substantially reduced the overall density of Wyoming's forests, these changes have opened growing space for new regeneration. Although the impacts to the current, aging forest are widespread and relatively severe, the younger, incoming cohorts of trees will be more resistant in the next few decades to many of the stressors (i.e., bark beetles) that contributed to mortality in older stands.

Periodic to Annual Inventory Comparisons

One purpose of Wyoming's annual forest inventory is to provide information about changes in forest attributes over time. If the definitions and methods used during the periodic inventories were compatible with those used during the annual inventory, we could quantify trends over the past 30 years. However, the sampling and field procedures used during the periodic inventories were different enough from those of the annual inventory to preclude reliable trend analysis, and doing so may produce misleading results (Goeking 2015). This section describes the primary differences between the periodic and annual inventories. It also presents an appropriate method for comparing periodic and annual inventory data from plots that were measured during both inventories, or co-located plots. Using co-located plots some changes in forest attributes are summarized.

The primary differences between Wyoming's periodic and annual forest inventories pertain to the plot configuration, sample design, and operational definitions used during field data collection. The periodic inventory of 1983 used a variable-radius plot configuration with five subplots. In contrast, the plot configuration of the periodic inventory of 1998–2002, as well as the current annual inventory, consists of four fixed-radius subplots, as described in the *Inventory Methods* section of this report. Sample designs also changed appreciably, from samples that omitted national forest lands and targeted high-productivity stands in 1983, to a spatially representative plot grid with consistent sample intensity across all forest types and management categories in the annual inventory. Wyoming's 1983 inventory also used an operational definition of "tree" that differentiated between tree-form and shrub-form trees. For example, junipers that were less than 6 feet tall and were not expected to eventually produce a straight, 8-foot trunk section were not considered to be trees and were not measured, so they were not included in volume-based estimates such as biomass, growth, and mortality. In contrast, the annual inventory identifies trees strictly by their species, regardless of growth form. Therefore, trees on many woodland plots in the current annual inventory would not have been measured under previous definitions.

Due to these differences in forest inventories over time, users of FIA data should be aware of appropriate methods for evaluating trends and avoid inappropriate methods. Examples of inappropriate comparisons between periodic and annual inventories range from comparing the tree volume on a specific forest type to directly comparing the total area of forest land. Instead, an appropriate method of quantifying trends is to first identify forest plots that were measured during both periodic and annual inventories, and then assess trends at only those plots. FIA refers to such plot locations as co-located plots, which represent a subset of the annual inventory plots that were established at the same locations as a subset of periodic inventory plots in order to allow for temporal comparisons. Although this type of analysis can be complicated when different plot designs were used during the periodic and annual measurements of co-located plots, each plot design allows estimation of volume, growth, and mortality per acre. Therefore comparisons of multiple measurements at co-located plots are useful for quantifying trends in attributes on a per-acre basis.

Wyoming Forest Attribute Change

This section presents the results of two analyses of co-located plot data collected during periodic versus annual inventories in Wyoming. The first analysis compares data collected from co-located plots that were measured once between 1998 and 2002 and again after 2011. The second analysis compares a smaller sample of co-located plots that were measured three times: first in 1983, second during 1998–2002, and third during 2011–2015. The geographic distribution of all plots in the 1983 inventory, all plots in the 1998–2002 inventory, all plots in the annual inventory (2011–2015), and the co-located plots from the two analyses varied widely (fig. 14).

The comparison of plot measurements between 1998–2002 and 2011–2015 consisted of 803 co-located plots that were measured during both inventories. During this time period, mean total net volume decreased, live net volume decreased, and dead net volume increased (fig. 15). Mean annual mortality increased from 14 to 58 cubic feet per acre per year, and mean annual net growth decreased from 19 to -32 cubic feet per acre per year (fig. 16). A paired t-test showed that all of these changes were statistically significant ($P < 0.001$). The magnitude of the change in net growth is greater than the magnitude of the change in mortality (because net growth = gross growth – mortality). Therefore, the change in net growth reflects a large increase in mortality accompanied by a decrease in gross growth.

The second analysis consisted of 152 co-located plots that were measured three times: in 1983, during the 1998–2002 inventory, and during the annual inventory (2011–2015). The results show the same patterns as those from the first comparison for the period 1998–2002 to 2011–2015 comparison: a decrease in live

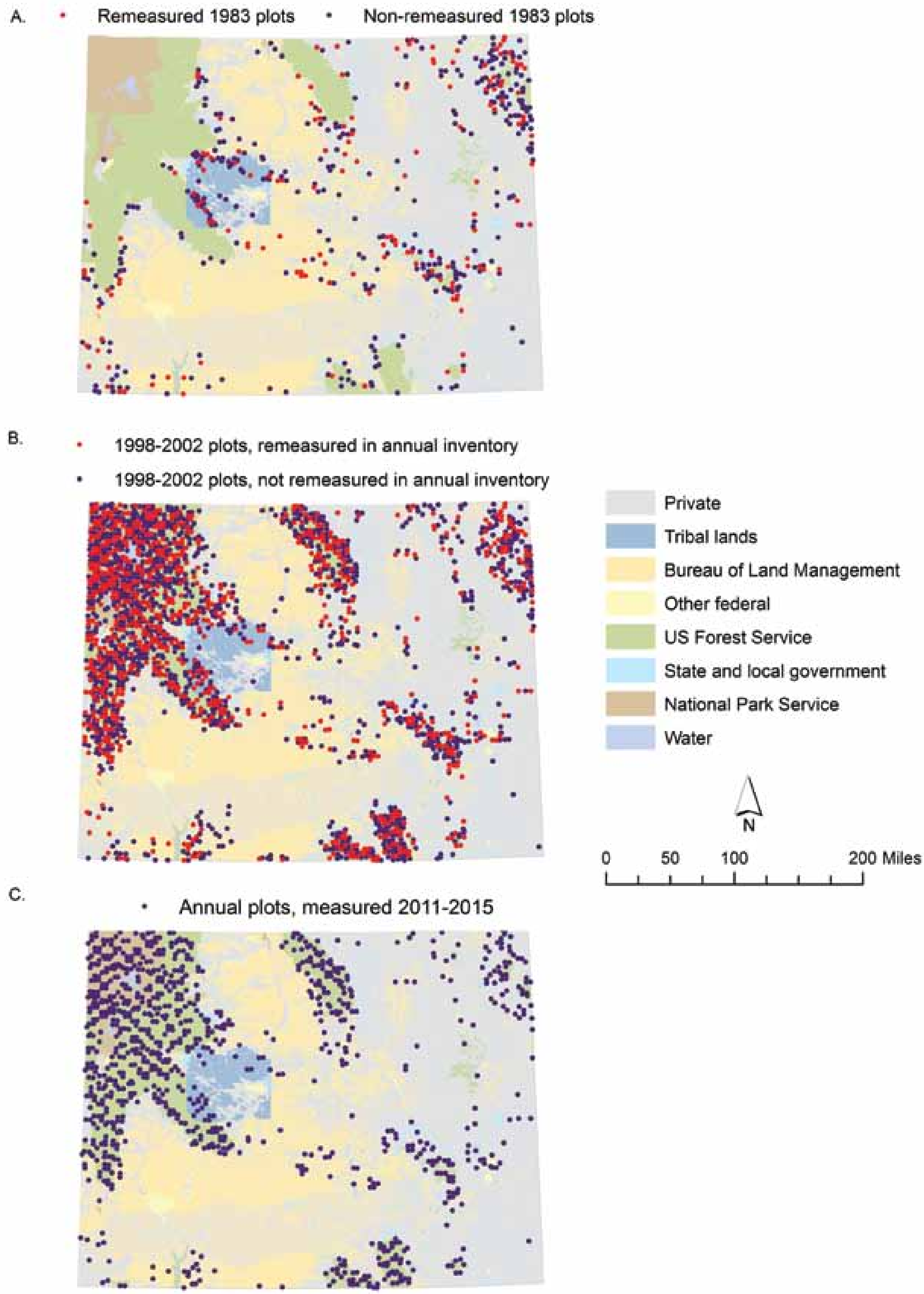

Figure 14—Approximate locations of periodic inventory forest plots measured in 1983, some of which were remeasured during 1998–2002 and 2011–2015 (A); periodic inventory forest plots measured during 1998–2002, some of which were remeasured during 2011–2015 (B); and all annual inventory forest plots measured in 2011–2015 (C). Plot locations are approximate.

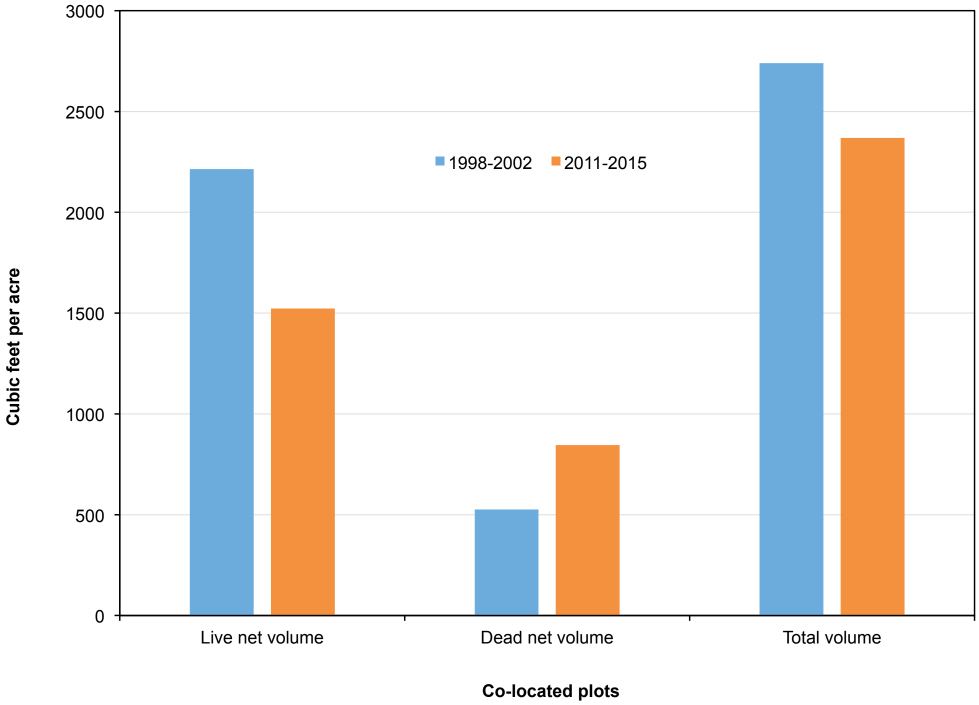

Figure 15—Live net volume, dead net volume, and total net volume, in cubic feet per acre, at 803 plots measured during 1998–2002 and remeasured during 2011–2015.

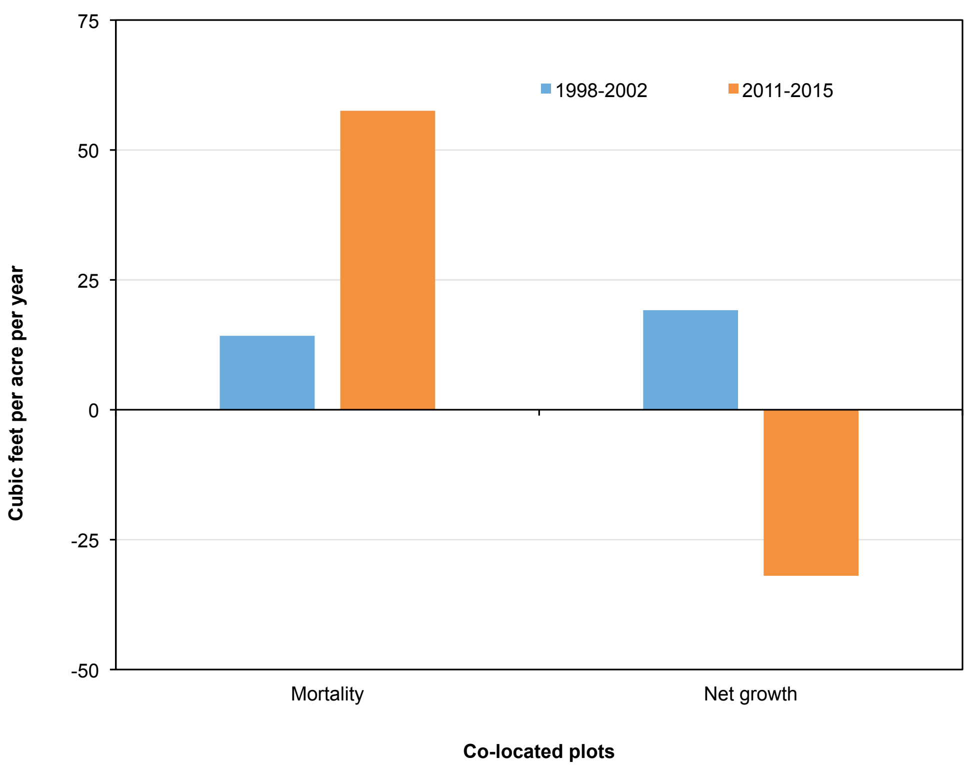

Figure 16—Mean annual mortality and net growth, in cubic feet per acre per year, at 803 plots measured during 1998–2002 and remeasured during 2011–2015.

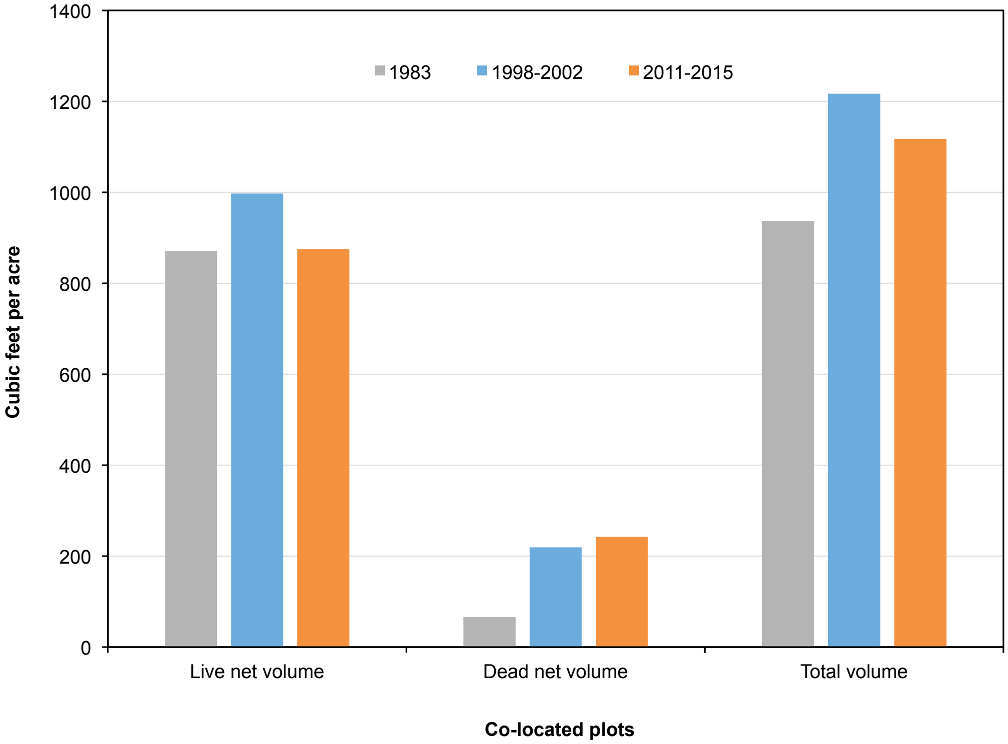

Figure 17—Live net volume, dead net volume, and total net volume, in cubic feet per acre, at 152 plots measured three times: 1983, 1998–2002, and 2011–2015.

and total volume, and an increase in dead volume (fig. 17). However, because this analysis included only plots that were measured in 1983 as well as the two more recent inventories, it provides a longer-term historical context for these changes. Compared to 1983 conditions, total volume and dead volume in 2011–2015 have increased. Live net volume per acre increased in the late 1990s/early 2000s, but current live volume is approximately at the same level as it was in 1983 (fig. 17).

To investigate changes for individual tree species, we quantified live basal area, dead basal area, mean annual growth, and mean annual mortality, as measured at co-located plots in 1998–2002 and again in 2011–2015, for the seven species that have the highest abundance and volume in Wyoming. In descending order of live volume, these are: lodgepole pine, Engelmann spruce, subalpine fir, Douglas-fir, ponderosa pine, whitebark pine, and quaking aspen. In 2011–2015, all major species except ponderosa pine had lower live basal area per acre, and more dead basal area per acre, than in 1998–2002 (fig. 18), which is consistent with the results of the *Forest Growth, Mortality, and Removals* section (above). Similarly, all major species except for ponderosa pine showed increases in mean annual mortality and decreases in mean annual net growth (fig. 19). By comparing the magnitudes of change in mortality and net growth, we can determine whether the decreases in net growth are entirely due to increases in mortality, or in other words, whether gross growth has changed. Based on the magnitudes of these changes, all seven species have experienced decreases in gross growth with concomitant increases in mortality (figs. 18 and 19).

These results are consistent with a previous analysis based on only 2 years' worth of annual inventory data from Wyoming, which found a decrease in live net volume, increase in dead net volume, an increase in mortality, and decrease in net growth (Goeking 2015). The caveat of the co-located plot analysis presented here is that results cannot be scaled to the entire State and cannot overcome the limitations of the periodic sample design. For example, if the periodic inventory under-sampled a particular forest type, an analysis of co-located plots will still under-represent that forest type. As mentioned above, the 1983 inventory omitted reserved lands and national forest lands. Therefore, the results of the second analysis reflect long-term trends that may be related to land management practices or geographic factors associated with the different land ownership groups that were targeted during the first periodic inventories. Nonetheless, these results provide an indication of the direction of change in Wyoming's forests. As Wyoming's annual forest inventory continues and plots are remeasured at a consistent 10-year interval, FIA's ability to quantify trends in forest attributes will expand from analyses of co-located periodic plots to robust Statewide estimates of change based on the spatially representative annual plot design.

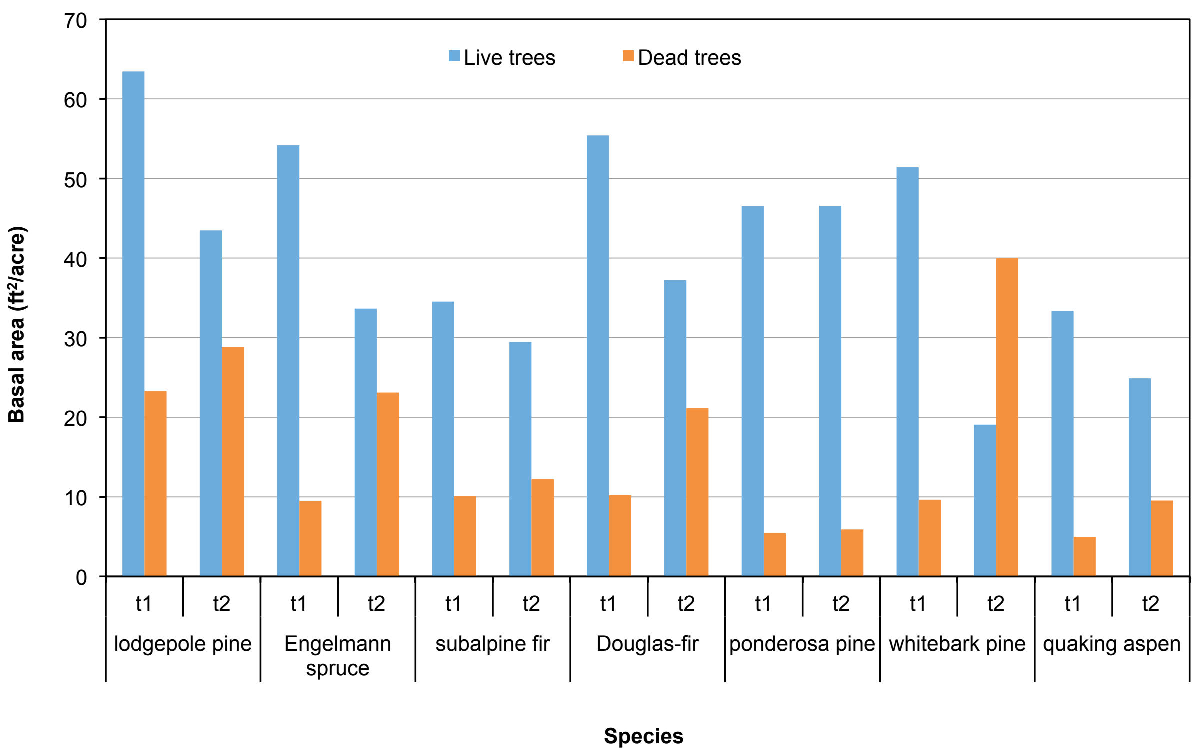

Figure 18—Mean basal area for seven major tree species of Wyoming, as measured at co-located plots that were measured during the 1998–2002 inventory (t1) and again between 2011 and 2015 (t2). The number of plots varied by species.

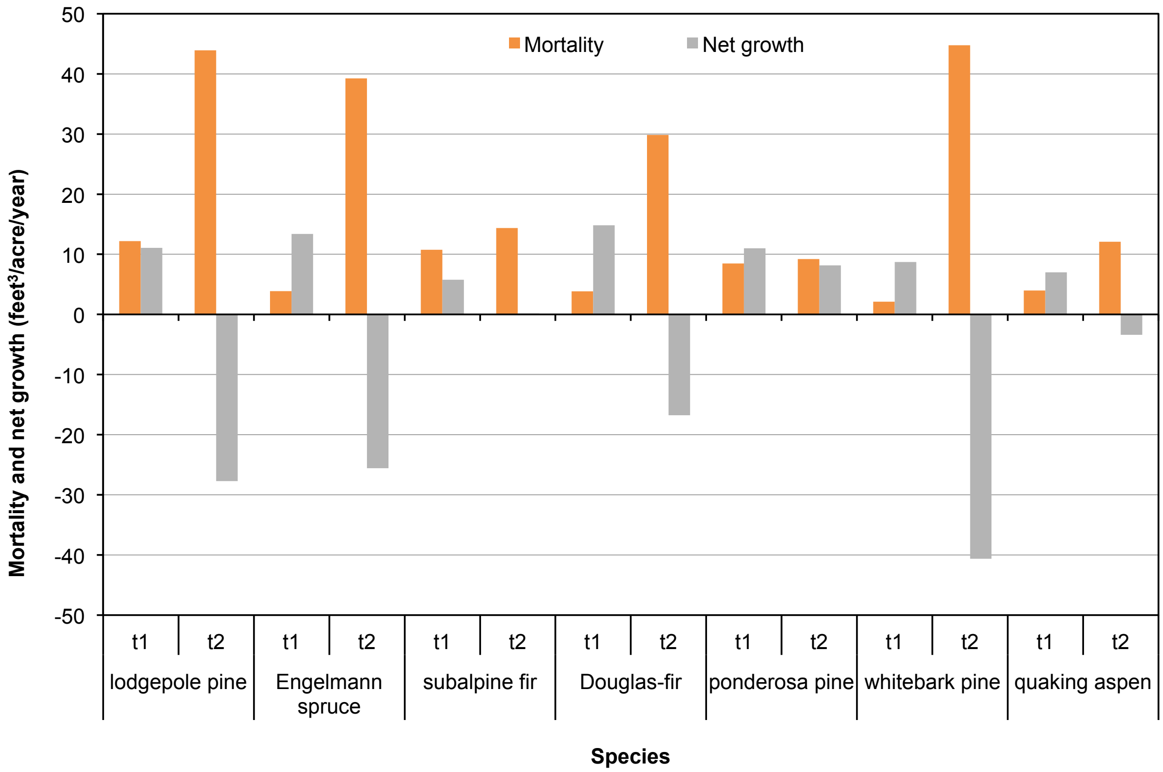

Figure 19—Mean annual mortality and net growth, in cubic feet per acre per year, for seven major tree species in Wyoming, as measured during the 1998–2002 inventory (t1) and again between 2011 and 2015 (t2). The number of plots varied by species.

Wyoming's Forest Resources

Removals for Timber Products

Volume removed from forest inventory during the harvesting of timber is referred to as removals. Removals are an important indicator of the sustainability of timber harvest levels. Removals exceeding net growth over an extended period could indicate over-harvesting and decreasing forest inventory. Conversely, growth or mortality greatly exceeding removals could signal a need for increased vegetation management to decrease risks from tree mortality, insect outbreaks, or wildfire.

Removals can come from two sources: growing-stock (portions of live, commercial tree species meeting specified quality or vigor standards), or dead trees and other non-growing stock sources (e.g., tree limbs and tops). The two general types of removals are timber products and logging residue (i.e., volume cut or dead but not utilized). Removals, as reported here, are based on a survey of Wyoming's primary forest products industry's 2014 operations (McIver et al., in review) and the U.S. Energy Information Administration data for residential fuelwood consumption (EIA 2016). More detailed timber products and logging residue data for Wyoming and other States are available from FIA's Timber Products Output (TPO) website: https://www.fs.usda.gov/srsfia/php/tpo_2009/tpo_rpa_int1.php.

Table 5—Volume of removals by source of material, species group, and removal type, Wyoming, 2014.

Removal type	Source of material: Growing stock Softwoods	Growing stock Hard-woods	Growing stock Total	Other sources Softwoods	Other sources Hard-woods	Other sources Total	All sources Softwoods	All sources Hard-woods	All sources Total
	---------*Thousand cubic feet*---------								
Industrial Products									
Saw logs	11,404	32	11,436	2,394	1	2,395	13,798	33	13,831
Industrial fuelwood	2	0	2	451	1	451	453	1	454
Posts and poles	627	0	627	421	0	421	1,048	0	1,048
Miscellaneous products	234	4	238	79	0	79	313	4	317
Total industrial products	12,267	36	12,303	3,345	2	3,346	15,612	38	15,650
Residential fuelwood[a]	-	-	-	-	-	5,200	-	-	5,200
Total all products	12,267	36	12,303	3,345	2	8,546	15,612	38	20,850
Logging residue	677	2	679	3,378	7	3,385	4,055	9	4,064

[a] Residential fuelwood consumption reported by the U.S. Energy Administration (EIA) http://www.eia.gov/state/seds/seds-data-compete.crm?sid=US#Consumption

Total removals in Wyoming during 2014 were nearly 25 million cubic feet (MMCF). Total removals included 20.8 MMCF of timber products, including industrial and residential fuelwood, and 4.1 MMCF of logging residue left in the forest (table 5). Growing-stock sources accounted for approximately 13 MMCF of total removals. A relatively small amount of growing-stock volume (0.7 MMCF) was unutilized and left in the forest as logging residue, with approximately 95 percent of growing-stock removals used to produce wood products. Nearly 98 percent of growing-stock removals in Wyoming came from softwood tree species. Ponderosa pine was the predominant species, accounting for approximately 41 percent (5.3 MMCF) of growing-stock removals, followed by lodgepole pine representing 36 percent (4.7 MMCF). Engelmann spruce and Douglas-fir each accounted for approximately 11 percent (1.5 MMCF and 1.4 MMCF, respectively) of growing-stock removals.

The Statewide growing-stock removals for timber products and logging residue in 2014 represent about 8 percent of the average annual gross growth (172 MMCF) and 4 percent of average annual mortality (328 MMCF) between 2011 and 2015. The relationships between removals, growth, and mortality vary substantially by land ownership. Growing-stock removals on private lands account for about 21 percent of the annual gross growth and 24 percent mortality, whereas removals on national forest timberlands account for just 8 percent of gross growth and only 2 percent of annual mortality (table 6). The total volume of growing-stock trees on Wyoming timberland is about 8.73 billion cubic feet, so annual removals represent approximately 0.15 percent of growing stock[1].

[1] The proportion of annual removals of the total growing-stock volume is roughly equivalent to a 670-year rotation, if all harvests were performed under even-aged management.

Table 6—Average annual growth and mortality from 2011–2015 and 2014 timber removals, by ownership, for Wyoming growing-stock trees.

	Total	National Forest	Other public	Private
2011–2015: Growing-stock trees		---------*million cubic feet*---------		
Gross growth (MMCF)	171.64	136.96	14.12	20.56
Mortality	328.11	290.42	20.11	17.58
Net growth	-156.47	-153.46	-5.98	2.97
2014: TPO removals	**12.98**	**7.04**	**1.70**	**4.24**
Products	12.30	6.68	1.61	4.02
Logging residue	0.68	0.37	0.09	0.22
Removals as % of gross growth	8%	5%	12%	21%
Removals as % of mortality	4%	2%	8%	24%

In 2014, removals for all timber products (including industrial and residential fuelwood) totaled 20.8 MMCF, accounting for 84 percent of the total removals for the year (table 7). The remaining volume was comprised of logging residue, 83 percent of which came from non-growing stock material. Of the 15.6 MMCF of removals for commercial products, approximately 88 percent were sawlogs (for producing lumber), making it the leading timber product in 2014. Posts and small poles accounted for 1.0 MMCF (almost 7 percent) of commercial product removals. Logs for miscellaneous wood products accounted for approximately 2 percent, with logs for industrial fuelwood accounting for the remaining 3 percent of commercial product removals. Nearly all (99.8 percent) of removals for commercial wood products consisted of softwood species.

Across Wyoming's nearly 6 million acres of unreserved timberland, 67.5 million board feet (MMBF) Scribner, or about 15.6 MMCF, of commercial timber products (excluding residential fuelwood) were harvested in 2014. The volume of commercial timber products for 2014 is roughly 62 percent higher than the 2010 harvest and 5 percent higher than in 2005 (McIver et al. 2014). National forests supplied 52 percent of the 2014 harvest while private and tribal lands supplied 34 percent. State lands provided the majority of the remaining harvest accounting for 12 percent, while the Bureau of Land Management supplied 1.6 percent of the volume (table 8).

The geographic sources of Wyoming's timber harvest can be divided into five resource areas: northeast, north central, northwest, southeast, and southwest (fig. 20). The Southeast Resource Area experienced the largest shift, increasing from only 9.5 percent of the harvest in 2010 to 34.7 percent of the harvest in 2014. The North Central Resource Area experienced a slight decline in its proportionate harvest from 14.4 percent in 2010 to 12.7 percent, while the volume nearly doubled to 8.6 MMBF Scribner in 2014. The Northwest and Southwest resource areas experienced declines in their proportions as well as their actual volumes. The Northwest Resource Area harvested only 5.8 MMBF in 2014 compared to 6.4 MMBF in 2010, while the Southwest declined from 7.4 MMBF to 5.9 MMBF.

Table 7—Total roundwood output by product, species group, and source of material, Wyoming, 2014.

Products and species group	Source of material: Growing-stock trees: Sawtimber	Poletimber	Other sources	All sources
	---------*Thousand cubic feet*---------			
Sawlogs				
Softwood	10,083	1,321	2,394	13,798
Hardwood	28	4	1	33
Total	10,111	1,325	2,395	13,831
Industrial fuelwood				
Softwood	2	0	451	453
Hardwood	0	0	1	1
Total	2	0	451	454
Posts and poles				
Softwood	63	564	421	1,048
Hardwood	0	0	0	0
Total	63	564	421	1,048
Other miscellaneous				
Softwood	207	27	79	313
Hardwood	4	1	0	4
Total	211	28	79	317
Total industrial products				
Softwood	10,354	1,913	3,345	15,612
Hardwood	32	4	2	38
Total	10,387	1,917	3,346	15,650
Residential fuelwood[a]			5,200	5,200
All products	**10,387**	**1,917**	**8,546**	**20,850**

[a] Represents residential fuelwood consumption as reported by U.S. Energy Information Administration (EIA) http://www.eia.gov/state/seds/seds-data-complete.cfm?sid=US#Consumption.

Table 8—Wyoming timber harvest volume by ownership source and product type, 2014.

Ownership source	Saw logs	Post and pole	Fuelwood[a]	Other products[b]	All products
		---------------------*Thousand cubic feet*--------------------			
Nonindustrial and tribal	4,742	450	68	53	5,313
National forests	7,169	470	339	258	8,237
Other Federal and public	1,919	127	47	6	2,100
Total	**13,831**	**1,048**	**454**	**317**	**15,650**

[a] Fuelwood does not include residential firewood as reported by EIA (2016).
[b] Other products include house logs, log furniture and biomass.

The other region that experienced a significant increase in its timber harvest was the Northeast. The resource area's proportion of the State timber harvest remained relatively stable at 35 percent; however the volume of timber harvested more than doubled to 23.8 MMBF in 2014. Overall, the geographic source of timber in 2014 shifted away from the western half of the State and was heavily concentrated in the eastern half, where the majority of milling infrastructure and capacity resides.

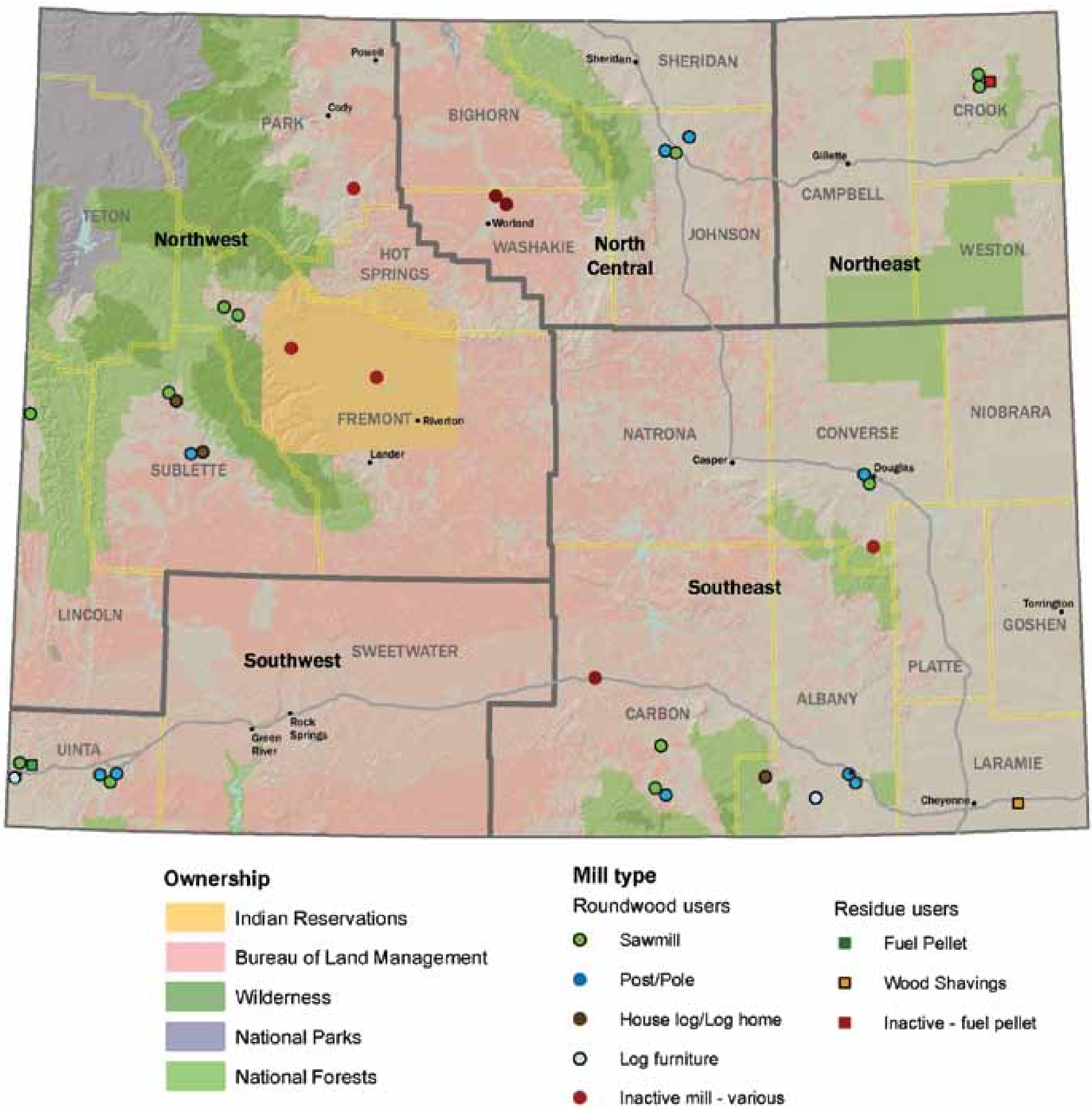

Figure 20—Wyoming's resource areas and active primary manufacturers, 2014.

Wyoming's Timber Industry

The 2014 census, conducted by the Bureau of Business and Economic Research at the University of Montana, identified 28 active primary forest products manufacturers in Wyoming (fig. 20). These facilities produced an array of products from timber including lumber and other sawn products, wood pellets, house logs, posts, poles and rails, firewood, log furniture, and animal bedding. Total sales of finished products exceeded $62.4 million in 2014, a 100 percent (inflation-adjusted) increase from 2010.

While the total number of mills was one fewer than reported in the 2010 census (McIver et al. 2014), the industry experienced a significant increase in its capacity to process timber. Most of the additional capacity was added in the Southeast Resource Area, where two inactive sawmills had restarted. The post and pole sector also added one new and one reactivated facility in southeast Wyoming. Net losses in the number of mills occurred primarily in the house log, firewood and fuel pellet sectors. Geographically, many of the mills that were closed or inactive during 2014 were located in the northern half of the State. Park County, which contained the most (13) facilities in 2005 (McIver et al. 2014), had no active facilities in 2014. The Northwest Resource Area had a decline from a high of 28 facilities operating in 2000, to just seven in 2014 (fig. 20).

In contrast to the volume of timber harvested in the State, timber receipts refer to the volume of timber delivered to Wyoming mills from in-State and out-of-State sources. In 2014, Wyoming mills received 91.4 MMBF Scribner of timber for processing. Over half (49.3 MMBF) of the timber processed in Wyoming came from outside the State. Wyoming mills relied heavily on out-of-State timber from public lands in 2014, of which 89 percent (43.9 MMBF) came from NFS lands in adjacent States. The distribution of Wyoming's mills near the State's borders with South Dakota, Colorado, and Montana contributed to the large proportion of out-of-State timber being used in-State.

Wyoming timber processors produced almost 211,000 bone dry tons (BDT[2]) of mill residue in 2014, with 96 percent utilized. Fine wood residues (e.g., sawdust) accounted for nearly 41 percent of total mill residue (approximately 86,000 BDTs), followed by coarse residues suitable for chipping (e.g., slabs, edging) at 35 percent, and finally bark residues around 24 percent (51,000 BDTs).

Long-term sustainability of Wyoming's timberlands depends on several inter-related factors such as active management of lands available for timber production, the presence of a forest products industry capable of processing harvested timber, and harvest levels that meet societal demands while fostering continual site productivity. To ensure sustainable forests and communities, careful consideration should be given not only to growth, removals, and mortality across Wyoming's available timberlands, but also to the forest industry and employees who conduct management activities and utilize timber in Wyoming and surrounding States.

[2] A bone dry ton (BDT) consists of 2,000 oven-dry pounds of wood.

Canada Lynx Habitat

Some of Wyoming's forested landscapes are home to a population of Canada lynx (*Lynx canadensis*), a reclusive forest carnivore that lives primarily in areas that accumulate and retain high amounts of snow. Lynx were listed as "threatened" under the Endangered Species Act in 2000 (USFWS 2000) and as such, resource managers are responsible for adopting management plans that protect lynx habitat in Wyoming. Primary lynx habitat includes areas that support high densities of snowshoe hares (*Lepus americanus* or "hare" hereafter), the lynx's primary prey (Ruggiero et al. 2000). Snowshoe hares in Wyoming frequent both multi-storied spruce-fir forests with dense horizontal cover as well as young lodgepole pine stands with high stem densities (Berg et al. 2012). In Wyoming's spruce-fir forests, stands having over 20 percent shrub cover (including small trees such as seedlings and saplings) and over 42 percent canopy cover have a higher likelihood of supporting populations of hares than forest land that does not meet these criteria (Berg et al. 2012). Lodgepole pine stands that support hares tend to have stem densities exceeding 1,130 stems per acre and horizontal cover greater than 60 percent at approximately 6.5 feet in height (Shaw 2002). Shaw (2002) also notes that horizontal cover targets are generally achieved in lodgepole pine stands that meet or exceed the stem density thresholds. These stands tend to be young enough (30–70 years old) that advanced self-pruning has not yet begun and low branches still provide hares with forage as well as thermal and security cover during winter months when snowpack is greatest. Similarly, shrub cover within thick stands of spruce-fir provide these important features as well.

FIA stand data were used to estimate the acreages of spruce-fir and lodgepole pine-dominated forests in Wyoming that meet the structural preferences of hares described above. For the Engelmann spruce, Blue spruce, Subalpine fir, and Engelmann spruce/subalpine fir forest types, acreages that had more than 42 percent canopy cover, and also shrub cover exceeding 20 percent, were estimated. For the Lodgepole pine forest type, the acreage in the 30–70 year age class that exceeded 1,130 stems per acre were estimated. These estimates provide an idea of how much potential snowshoe hare habitat exists in these forest types in Wyoming.

Figure 21 shows the proportion of acreage in each forest type that met canopy and shrub cover preferences. Across all of the forest types analyzed, 14 percent of the acreage met cover thresholds for canopy and understory shrubs. The Engelmann spruce/subalpine fir type had both the largest total amount of acreage that met the cover criteria (251,078 acres) and the largest proportion of its acreage (17.4 percent). Subalpine fir was next in both total and proportion of acreage meeting hare cover needs. Of the estimated 415,337 acres that have adequate canopy and shrub cover for hares, 272,295 acres (66 percent) occurred in the 101–200 year age class, with 130,158 acres (31 percent) occurring in the 0–100 year age class. Together, these two age classes had 97 percent of the acreage meeting structural preferences across the examined forest types. No potential habitat was indicated in the Blue spruce forest type, but with only about 12,000 acres estimated to be in

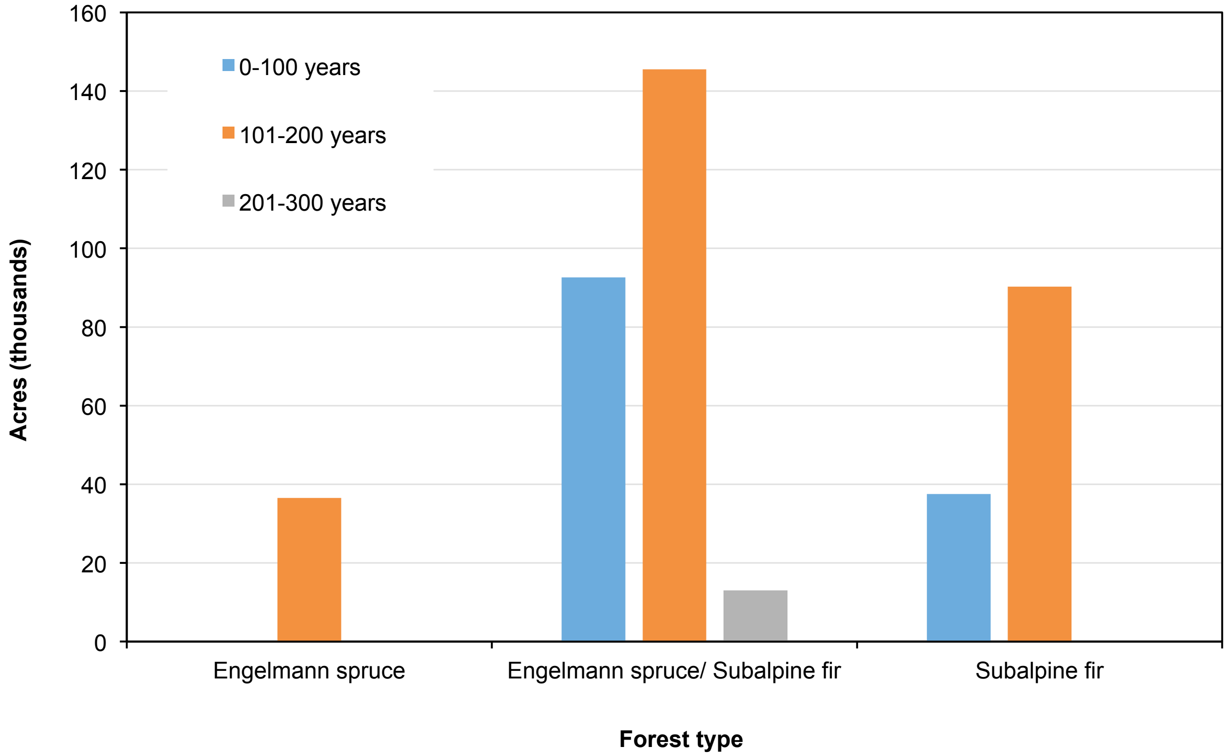

Figure 21—Acres of spruce and fir forest types by stand age categories in Wyoming that meet canopy cover and shrub cover preferences for snowshoe hares, Wyoming, 2011–2015.

Wyoming, this forest type is fairly rare and should not be expected to contribute much in the way of habitat.

The area of the Lodgepole pine forest type with the potential to provide snowshoe hare habitat was restricted to a stem density criterion. FIA does not yet have a metric for horizontal cover, but an effort is being made to enable estimation of horizontal cover using standard FIA measurements. Stem density was calculated on a per-acre basis for all conditions classified as lodgepole pine by field crew observation, and area was calculated for all lodgepole pine stands with 1,130 or greater stems per acre. In addition, stand age was used to sum cumulative area by increasing stand-age class. This calculation was done for the 2000 periodic inventory and the current (2015) annual inventory (fig. 22).

In the 2000 inventory, only about 25,000 acres met the density threshold and were age 30 or younger. In the 2015 inventory, just over 250,000 acres met the same criteria. However, in both inventories relatively little additional area in stands aged 30 to 70 met the density threshold. Note: explanation for the large differences in estimates from the two inventories can be found in the *Periodic to Annual Inventory Comparisons* section.

Results from the comparison of inventories are consistent with the recovery of lodgepole pine forests following the fires of 1988 (see the *Fire in Wyoming's Forests* section), which burned much of Yellowstone National Park and surrounding areas. The majority of forest area (about 70 percent) discussed below is located in Fremont, Park, and Teton counties, which were heavily affected by the

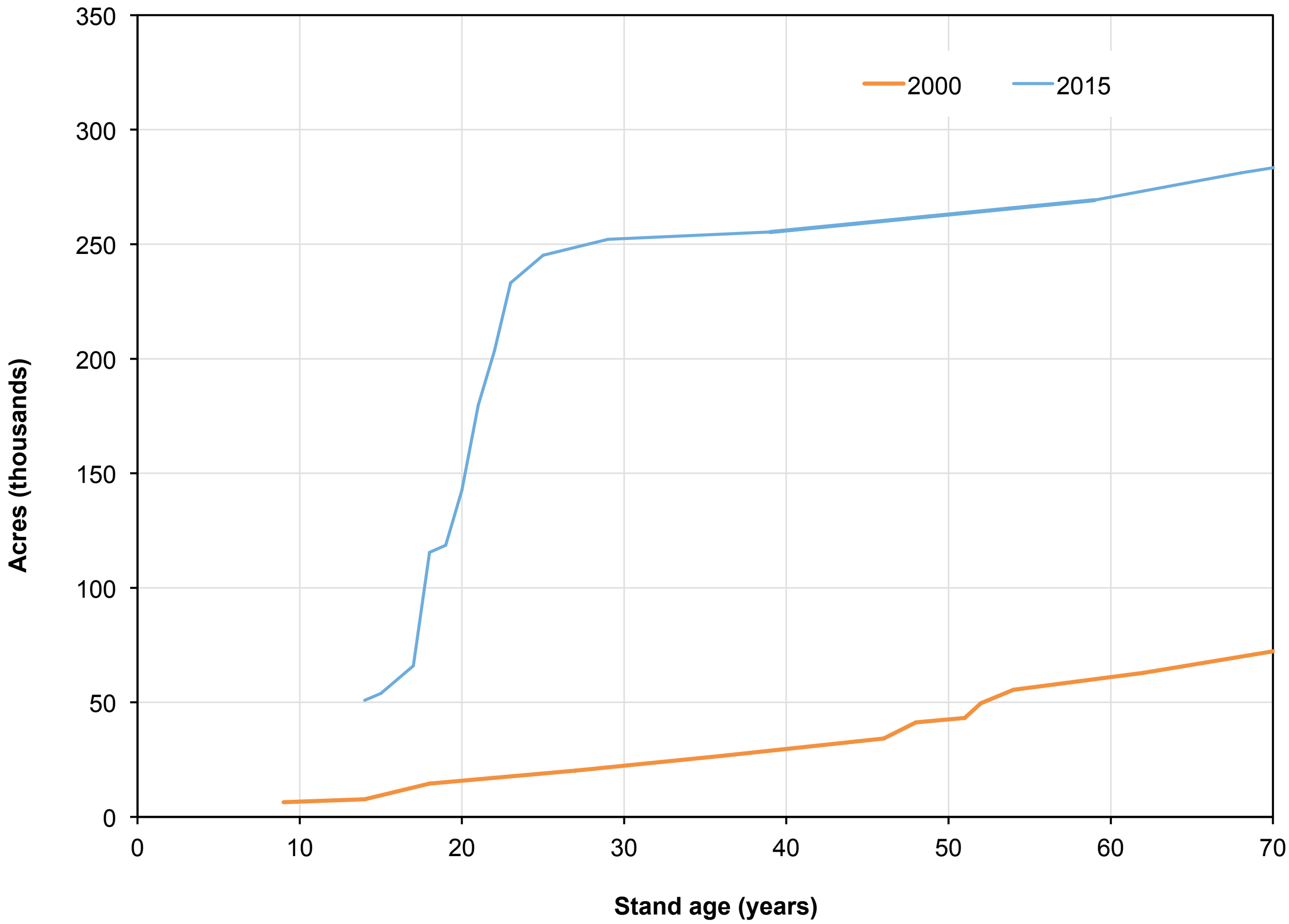

Figure 22—Cumulative area for stands meeting the density criterion of 1,130 trees per acre, ordered by stand age.

1988 fires. Figure 22 shows that in the 2000 inventory there was a relatively small amount of Lodgepole pine forest type that met the stand density criterion of 1,130 trees per acre—less than 75,000 acres. About one-third of the area was in stands younger than 25 years old, which means that some portion of stands probably did not have sufficient height to provide the adequate foliage density snowshoe hares use for cover during the peak of winter snowpack. This is consistent with the timing of the 2000 inventory and the 1988 fires, because much of the regenerating lodgepole pine area was only 10 to 12 years old at the time of inventory. Stem density might have been sufficient to meet the criterion used here, but many of the stems were probably too small to be captured in the tree-size tally.

During the 2015 inventory, lodgepole pine stands that were 10 to 12 years old when sampled in the 2000 inventory were now 22 to 28 years old, or entering the prime phase of structure that could provide good snowshoe hare habitat (Shaw 2002). This is the result of increasing height and diameter growth, but the stands have not yet developed to such an extent that self-thinning has reduced stem density below the minimum considered to provide good snowshoe hare habitat. There are approximately 250,000 acres in this condition. The self-thinning effect is evident in the shape of the line for the 2015 inventory. While there are stands with greater than 1,130 trees per acres that are greater than 30 years old, these are likely so-called "dog-hair" stands, which are even-aged but slow-growing and have small mean diameter, or stands with complex structure, where age is determined by a relatively small number of residual trees and trees per acre is dominated by regeneration in the understory. In the case of older "dog-hair" stands, competition results in the bases of live crowns lifting with age, which in turn results in lower horizontal cover and less suitable snowshoe hare habitat. It is necessary to look at stands with more complex structure in detail to assess their potential value as hare habitat. However, comparison of stand age and structure from the two inventories shows that potentially valuable habitat conditions in lodgepole pine stands have become much more abundant since 2000.

The results presented here should be considered a liberal estimate of potential hare habitat in Wyoming. Habitat attributes such as spatial location, patch size, and connectivity are not considered in this analysis and are also important components of lynx and hare habitat. However, this analysis does provide resource managers with reliable estimates of forest land meeting structural preferences as well as a baseline for future monitoring of these habitats.

Whitebark Pine Status and Trends

Whitebark pine is an iconic, high-elevation conifer that occurs throughout the northern Rocky Mountains to the Pacific Coast. It has a mutualistic relationship with the Clark's nutcracker (*Nucifraga columbiana*), which caches seeds in sites that can be favorable for establishment (Hutchins and Lanner 1982). Whitebark pine provides food for numerous other wildlife species including red squirrels and grizzly bears. Due to recent declines caused by a combination of factors, including mountain pine beetle (*Dendroctonus ponderosae*), changing fire regimes, white pine blister rust (*Cronartium ribicola*), (Keane et al. 2012; Raffa et al. 2008), the U.S. Fish and Wildlife Service considered protecting whitebark pine under the Endangered Species Act (USFWS 2011).

To illuminate broad-scale status and trends in whitebark pine populations in Wyoming, several attributes of whitebark pine were estimated Statewide and then compared among forest types and ownership groups. Attributes included forest land area with a whitebark pine component, size-class distribution of live and dead trees, mean annual growth, and mean annual mortality. Due to recent elevated levels of mortality for whitebark pine, the causal agents of mortality and damage to live trees were summarized as well. The estimates reported here were produced using the EVALIDatorPC tool, which is available from the FIA DataMart (USFS 2016; Miles 2016). Note that EVALIDatorPC does not constrain estimates of forest land area to the presence of an individual tree species. To calculate ratio estimates of density attributes, such as trees per acre, we wrote custom queries within EVALIDatorPC that estimate the area of forest land with a whitebark pine component. Thus, the denominator in our ratio estimates was constrained to the area of forest land with a whitebark pine component rather than total forest land area. We defined the whitebark pine component as having at least one whitebark pine tree that meets at least one of the following conditions: live and at least 1.0 inch in

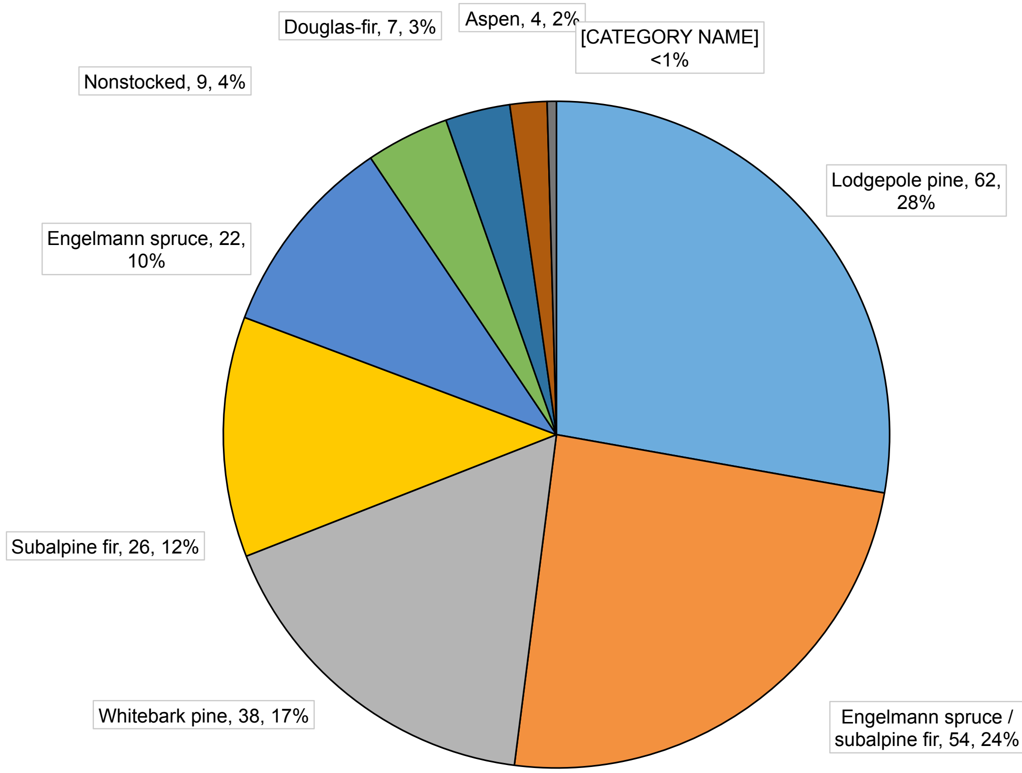

Figure 23—Percentage of 222 plots with a whitebark pine component that occurred in each forest type, Wyoming, 2011–2015.

diameter, dead and at least 5.0 inches in diameter, or live and less than 1.0 inch in diameter but at least 6 inches tall (i.e., a seedling).

There were 222 FIA plots measured between 2011 and 2015 in Wyoming that had a whitebark pine component. Only 38 plots with a whitebark pine component were classified as Whitebark pine forest type; thus 184 plots were classified as a forest type other than Whitebark pine (fig. 23). The vast majority of plots with a whitebark pine component occurred on NFS lands (151 plots or 68 percent). Of the remaining 71 plots, 60 occurred on NPS lands (27 percent), 2 on BLM lands (about 1 percent), and 9 on private lands (about 4 percent). Because of the small sample size on BLM and private lands, the remainder of this analysis focused only on whitebark pine on NFS and NPS lands when land ownership group was considered.

The Whitebark pine forest type covers 397,000 acres in Wyoming, and forests with a whitebark pine component cover more than 2.4 million acres (table 9). However, the density of whitebark pine varies across this acreage. Therefore, the number and density of live and dead whitebark pine across all forest types and ownership groups were examined. Density was calculated as the number of trees in a particular category divided by the area of forest land with a whitebark pine component in that category (e.g., the number of whitebark pine in National Parks divided by the National Park area with a whitebark pine component). The mean density of whitebark pine seedlings (stems at least 6 inches tall but less than 1.0 inch in diameter) is greatest in the Lodgepole pine forest type (fig. 24a). Density of all size classes larger than 1.0 inch in diameter is greatest within the Whitebark pine forest type (fig. 24b).

Table 9. Area (acres) represented by plots with a whitebark pine component, by forest type and ownership group. Percent standard errors are shown in italics in parentheses.

Forest type	Ownership group								Total	
	National Forest System		National Park Service		Bureau of Land Management		Private			
Lodgepole pine	272,491	*(19.9)*	403,880	*(16.4)*	0	NA	23,842	*(71.3)*	700,213	*(12.2)*
Engelmann spruce / subalpine fir	500,490	*(14.8)*	104,537	*(33.3)*	0	NA	0	NA	605,026	*(13.4)*
Whitebark pine	282,962	*(19.4)*	72,186	*(40.8)*	0	NA	41,852	*(50.5)*	397,000	*(16.3)*
Subalpine fir	203,541	*(23.6)*	65,349	*(41.6)*	9,411	*(98.3)*	0	NA	278,302	*(19.9)*
Engelmann spruce	193,228	*(23.7)*	6,059	*(100.2)*	0	NA	23,842	*(71.3)*	223,129	*(21.9)*
Nonstocked	54,381	*(43.6)*	12,118	*(100.2)*	5,587	*(104.2)*	11,921	*(101.4)*	84,007	*(35.3)*
Douglas-fir	51,568	*(45.8)*	24,235	*(70.6)*	0	NA	0	NA	75,803	*(38.2)*
Aspen	47,690	*(50.3)*	0	NA	0	NA	0	NA	47,690	*(50.3)*
Limber pine	11,858	*(101.2)*	0	NA	0	NA	0	NA	11,858	*(101.2)*
Total	**1,618,209**	***(7.3)***	**688,363**	***(12.1)***	**14,999**	***(72.9)***	**101,458**	***(32.5)***	**2,423,029**	***(5.5)***

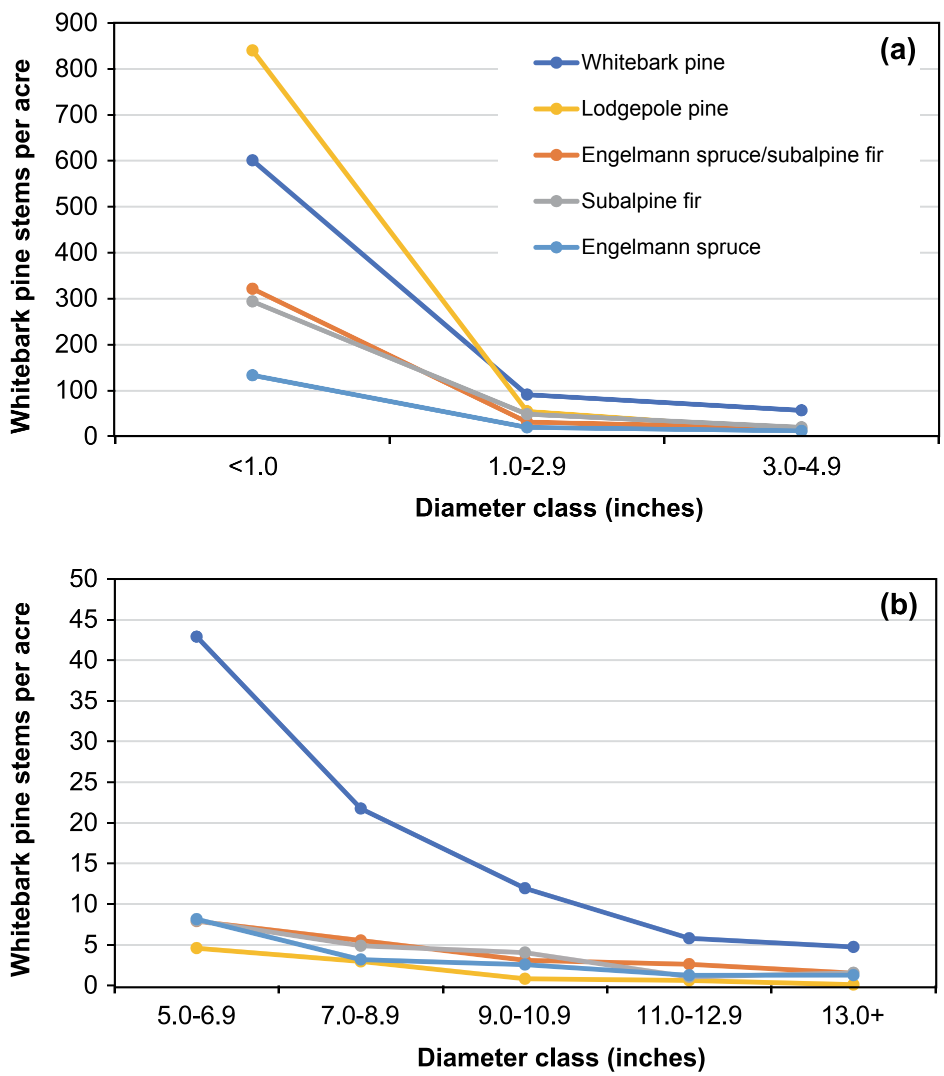

Figure 24—Mean density of live whitebark pine (number of trees per acre) by forest type, (a) for trees measured less than 5.0 inches in diameter, and (b) those larger than 5.0 inches in diameter.

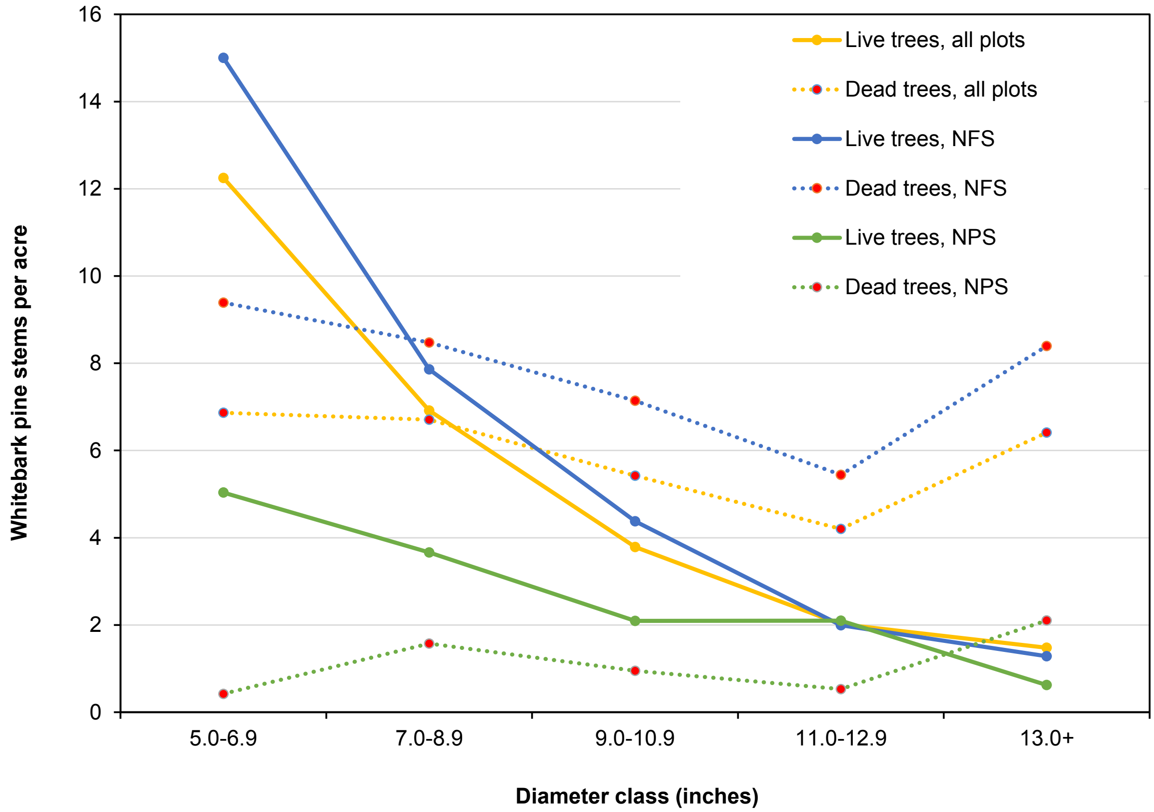

Figure 25—Mean density of live and dead whitebark pine (number of trees per acre) for trees at least 5.0 inches in diameter, by ownership group. Data are based on measurements from 222 plots Statewide (all plots), 151 plots on National Forest System lands (NFS plots), and 60 plots on National Park Service lands (NPS plots).

Mean density of live and dead whitebark pine by size class and by major ownership group was also compared (fig. 25). Throughout Wyoming, there are more live than dead whitebark pines in the smallest size class (5.0–6.9 inches diameter), approximately equal densities of live and dead whitebark pines in the 7.0–8.9 inch size class, and more dead trees than live in size classes above 9.0 inches. However, this pattern varies by ownership. In all size classes smaller than 13.0 inches in diameter, there are more live than dead whitebark pines on NPS lands, although the density of live trees in most size classes is lower than Statewide estimates. This is consistent with the results presented in the *Periodic to Annual Inventory Comparisons* section of this report, which found that basal area of live whitebark pine in Wyoming has declined by more than half since the early 2000s while basal area of dead whitebark pine has increased nearly four-fold (figs. 18 and 19).

One way to assess the overall trends within a tree population is to compare rates of mean annual growth and mortality. FIA quantifies growth and mortality in terms of the volume that was added by live trees and the volume lost in the form of trees that recently died. Whitebark pine in Wyoming experienced mean annual gross growth of 7.1 million cubic feet per year during 2011–2015, compared to 64.6 million cubic feet per year of mortality. Thus, Wyoming's whitebark pine have experienced a net loss of 57.5 million cubic feet per year. This is equivalent to about 24 cubic feet per acre per year, given that there are 2.4 million acres in Wyoming with a

Table 10—Number of whitebark pine that were estimated to have likely died no more than 5 years prior to measurement on 222 FIA plots, by causal mortality agent and field-designated forest type.

Forest type	Mortality agent				Total by forest type
	Insects	Disease	Fire	Other[a]	
Douglas-fir	2	0	0	0	2
Engelmann spruce	99	0	0	3	102
Engelmann spruce/subalpine fir	164	30	0	1	195
Subalpine fir	23	12	12	0	47
Lodgepole pine	39	4	16	6	65
Whitebark pine	175	44	84	6	309
Total by causal agent	**502**	**90**	**112**	**16**	**720**

[a] Includes weather, competition/suppression, and unknown causes.

whitebark pine component (table 9). A longer-term perspective on these growth and mortality rates can be found in the *Periodic to Annual Inventory Comparisons* section of this document, which reported that mortality rates have increased by an order of magnitude, and net growth has declined from a slightly positive net growth to a large, negative net growth rate, since the early 2000s (fig. 19). Negative net growth indicates that mortality rates are higher than gross growth rates on a volumetric basis, and thus declines may continue to be observed in the coming years.

To examine the causes of recent mortality on FIA plots, we examined the causal agents for all whitebark pine that recently died (table 10). Out of a total of 720 trees that likely died no more than 5 years prior to measurement, 502 were determined to have been attacked by insects, primarily bark beetles. Other important mortality agents were fire (112 trees) and disease (90 trees, primarily rust). To illuminate the extent to which these mortality agents continue to affect live trees in Wyoming, the various damaging agents that were recorded on live trees were examined (table 11). Of the 1,075 live whitebark pine that were measured on 222 plots in Wyoming, 822 had no damages recorded. Less than 5 percent of live trees showed evidence of

Table 11—Number of live whitebark pine trees on 222 FIA plots, by damaging agent and field-designated forest type. Damaging agents that were recorded on less than 30 trees are not shown. Insects were primarily bark beetles. Disease was primarily rust. Causes of dead or broken tops were unknown. Form defects include crooks and forks in the tree bole.

Forest type	Damaging agent							Total by forest type
	No damage	Insects	Rust and other diseases	Dead or broken top	Form defect	Open wound	Other damages	
Douglas-fir	3	0	0	0	0	0	0	3
Engelmann spruce	36	2	0	3	4	2	1	48
Engelmann spruce/subalpine fir	217	11	11	15	18	8	1	281
Subalpine fir	40	0	9	2	3	1	1	56
Lodgepole pine	156	0	5	8	4	3	0	176
Whitebark pine	370	19	25	15	56	14	12	511
Total by damaging agent	**822**	**32**	**50**	**43**	**85**	**28**	**15**	**1,075**

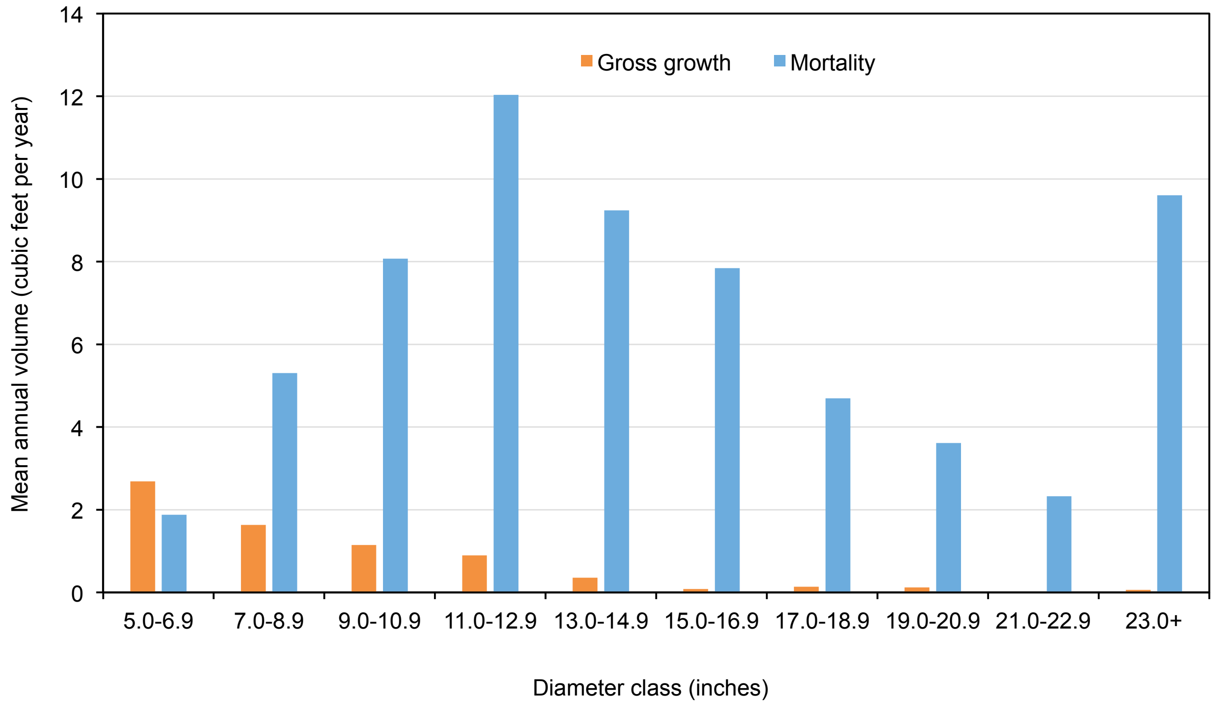

Figure 26—Mean annual gross growth and mortality of whitebark pine at least 5.0 inches in diameter.

insects or disease damage. This may indicate that the high recent mortality of whitebark pine was episodic rather than constant, and future remeasurement of these plots will help clarify the ongoing rate and direction of trends in growth and mortality.

The smallest size classes of whitebark pine show patterns in growth, mortality, and density that do not mirror those observed in the larger size classes. First, the highest seedling densities were observed within stands dominated by lodgepole pine (fig. 24a), and the area of the Lodgepole pine forest type with a whitebark pine component is nearly twice as large as the area covered by the Whitebark pine forest type (table 9). Given the high mortality rates in larger size classes across all forest types and ownership groups, efforts to manage for whitebark pine may benefit from focusing on areas with high densities of seedlings and small trees. Second, whitebark pine smaller than 7.0 inches in diameter continue to have positive net growth, or gross growth rates that exceed mortality rates (fig. 26). The positive net growth in this small size class, relative to negative net growth in larger size classes, reinforces previous studies showing that both blister rust and mountain pine beetle shift stands toward smaller size classes (Field et al. 2012; Meyer et al. 2016).

A recent evaluation of the relative impacts of mountain pine beetle and white pine blister rust on whitebark pine population growth found that areas without mountain pine beetle had positive growth in terms of numbers of stems, even when blister rust was present (Jules et al. 2016). Therefore, if the recent mountain pine beetle epidemic is episodic and beetle populations return to endemic levels, it is possible that the dramatic declines observed thus far may slow or eventually cease. However, it is possible that the mortality up to this point has diminished the ability of whitebark pine to reproduce sufficient cones, and future population viability may be determined more by survival of seedlings and small trees (McCaughey et al. 2009). To date, the FIA program has measured half of the annual plots in Wyoming and will collect more data during 2016–2020 to help answer questions such as these.

Snags as Wildlife Habitat

Standing dead trees (snags) are important habitat features in forested landscapes. A multitude of organisms utilize snags at some point in their life history, including at least one-fourth of all western bird species (Hutto 2006; McClelland et al. 1979). A handful of bird species act as primary excavators of nest sites in snags. These birds create a cavity during one breeding season but often abandon it and create a new cavity the following year. The old cavities are then occupied by secondary cavity-nesting birds. Secondary cavity-nesters do not excavate their own nest sites and are dependent on primary excavators for their nest cavities. The suitability of an old cavity for a secondary cavity-nester often depends on the species of primary cavity-nester that created it. Several mammal species, such as fishers, bats, and black bears, also use old cavities for denning and resting (Bull 2002).

The size of a snag is an important feature for many species, as larger snags tend to have a longer retention time, provide better thermal insulation, and can provide better protection from predators than smaller snags (Bull 2002 in Hutto 2006; Thomas et al. 1979). The height of a snag is also an important attribute for predator avoidance and thermal regulation. The Wyoming Game and Fish Department (WGFD) recommends one snag larger than 20 inches in diameter, four snags between 10 and 20 inches in diameter, and two snags between 6 and 10 inches in diameter per acre of forested land, with the 20+ inch trees being important for most species of wildlife. In addition, WGFD suggests all snags retained for wildlife should be taller than 6 feet (Oneale 2002).

Estimates of densities by stand age and forest-type group were assessed based on WGFD recommendations for small (6–9.9 inches diameter), medium (10–19 inches diameter), and large (greater than 20 inches diameter) snags. We only report forest-type groups that met snag density requirements in at least one age class. Missing data in a given age class either reflects no snags found in that forest-type group and age class or that there were no FIA plots sampled in that age class for that forest-type group. All density estimates were confined to snags that are equal to, or greater than, 6 feet in height. In addition, the acreages of forest-type group by age class that met all snag size-class densities thresholds were estimated.

Recommended small snag densities were met by almost all forest types and age classes (fig. 27). The recommended densities for medium diameter snags were not met in some of the younger age classes of the Ponderosa pine, Pinyon/juniper, and Aspen/birch forest-type groups. In addition, Pinyon/juniper in the 161–200 year age class does not meet medium-size snag recommendations (fig. 28). The Other western softwoods group, which includes both limber pine and whitebark pine, met target densities for large-size snags in the two oldest age classes, as well as the youngest (fig. 29). The Douglas-fir group met recommended densities for large-size snags in three age classes (fig. 29).

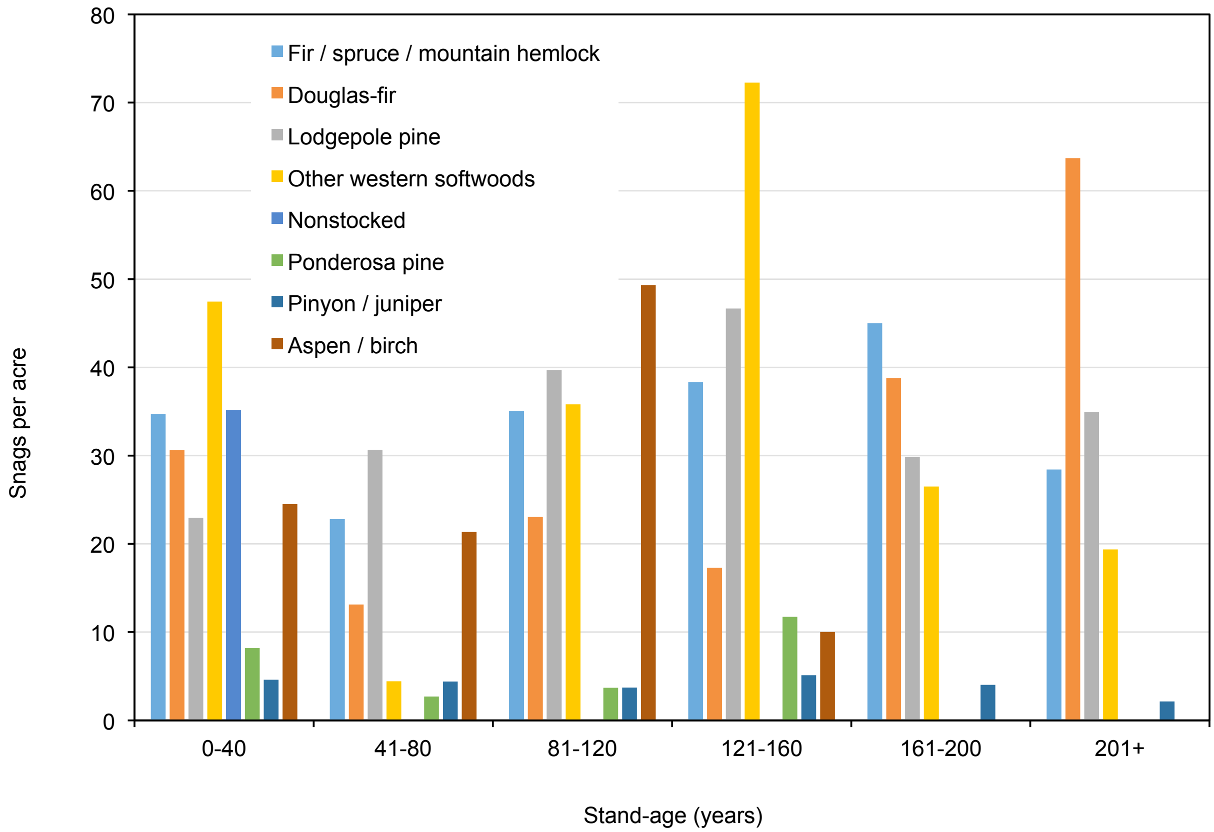

Figure 27—Density of small snags (6.0–9.9 inches diameter) by forest-type group and age class, Wyoming, 2011–2015. Minimum recommended density for small snags is 2. Only those forest-type groups that had at least one FIA plot record of a suitably sized snag are represented.

Large acreages of sufficient density of all size classes of snags were found across five important forest-type groups, and across all but one age class (fig. 30). There is very little acreage with sufficient snags of any size in the 41- to 80-year age class, with the exception of the Fir/spruce/mountain hemlock forest-type group, which met all snag targets in every age class (fig. 30). Younger stands in the 41- 80-year range are still relatively productive, where snags are less likely. Also, there are many fewer stands in 41- to 80-year stand-age classes than would be expected (see the *Stand Age* section).

Snags suitable for a large suite of cavity-nesting birds are found in a wide range of forest types and age classes, but the highest density of these snags are found in older (over 120 years) stands of softwoods. The species lodgepole pine, subalpine fir, and Engelmann spruce are presently providing the majority of snags for wildlife. An exception to this trend is the high density of snags found in the Aspen/birch forest-type group. Aspen forests are particularly important for some primary and secondary nesting birds because of the relationship between diseased aspen, primary excavators, and secondary nesters (Hart and Hart 2001). Nonstocked forests (age class of zero), where large stand-replacing events such as fire or insect infestation have created an abundance of snags, are meeting recommended densities in all but the largest diameter class.

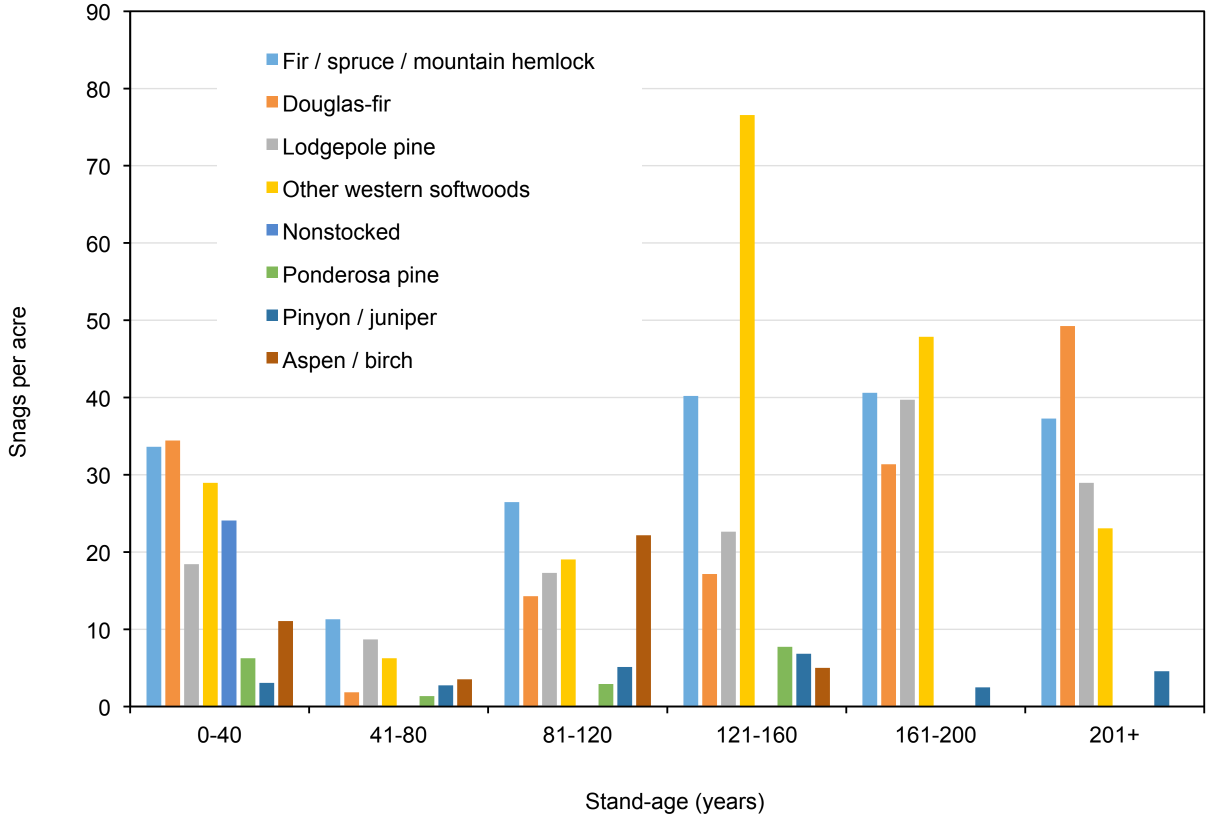

Figure 28—Density of medium snags (10.0–19.9 inches diameter) by forest-type group and age class, Wyoming, 2011–2015. Minimum recommended density for medium snags is 4. Only those forest-type groups that had at least one FIA plot record of a suitably sized snag are represented.

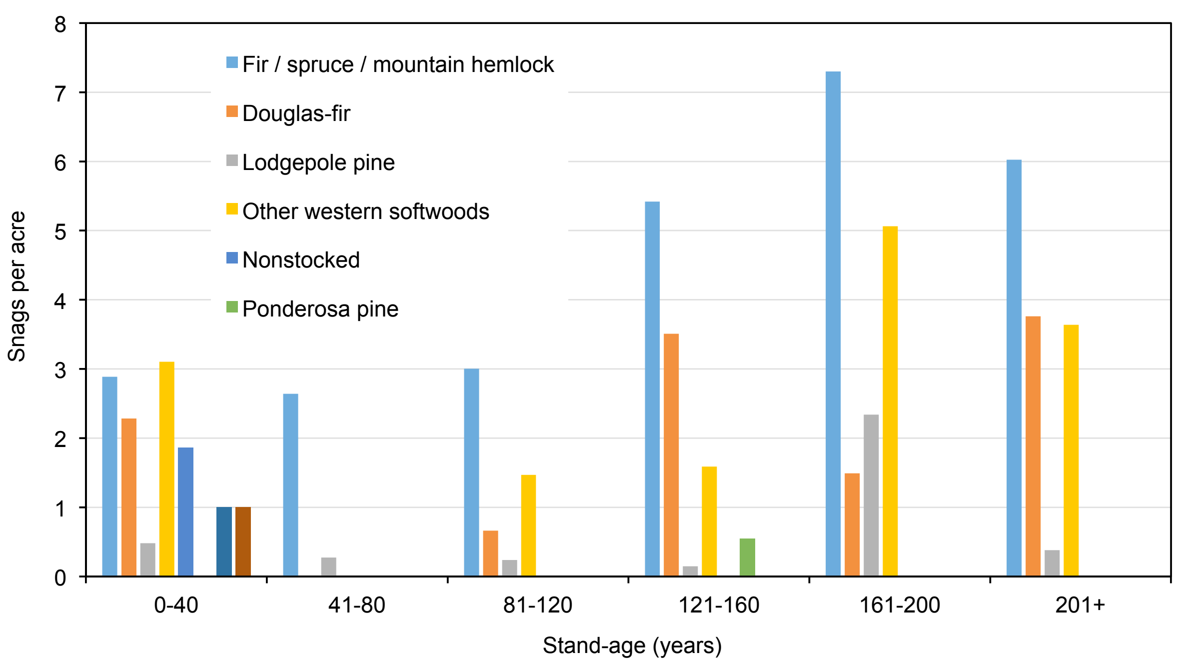

Figure 29—Density of large snags (greater than 20 inches diameter) by forest-type group and age class, Wyoming, 2011–2015. Minimum recommended density for large snags is 1. Only those forest-type groups that had at least one FIA plot record of a suitably sized snag are represented.

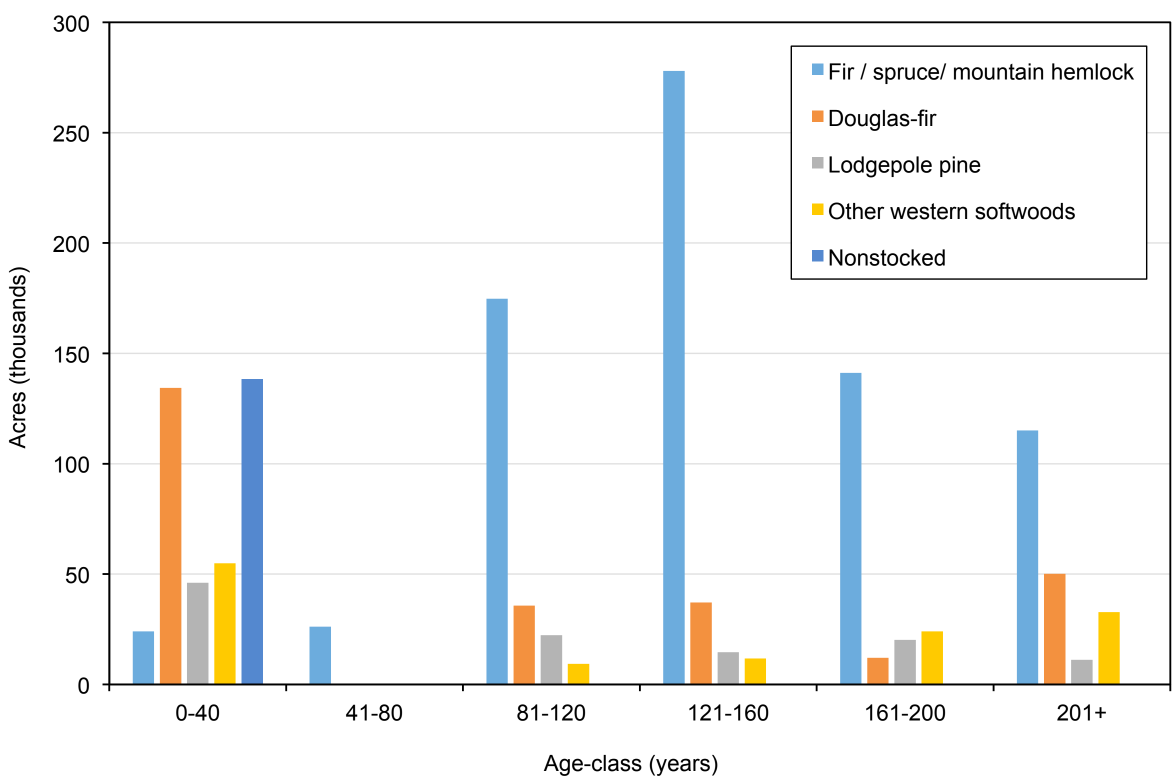

Figure 30—Estimates of forest land area that meets recommended snag densities for all three size classes (6–9.9 inches, 10–19.9 inches, and greater than 20 inches diameter) concurrently, by age class, Wyoming, 2011–2015.

Variables other than snag diameter and stand age need to be considered when predicting suitable wildlife habitat for forest-dwelling species. Proximity to forest edge and density of live trees is important to many cavity-nesting birds. The state of decay of a tree and its distance to foraging also plays a role in nest site suitability. As such, these estimates should be considered a liberal estimate of potential habitat for cavity-nesting species in Wyoming.

Understory Vegetation

The structure and composition of understory vegetation can characterize the diversity, productivity, and potential wildlife habitat structure in forest ecosystems. FIA collects understory vegetation data using two distinct protocols that characterize overall vegetation structure as well as species composition. Under the vegetation structure protocol, field crews record the height class and percent cover that is occupied by each of four plant growth habits: forbs, graminoids, shrubs, and understory trees, which are defined as trees less than 5 inches in diameter. Under the species composition protocol, height class, growth habit, and percent cover are recorded for plant species that individually occupy at least 3 percent of the ground area. If more than four species in a growth habit occupy greater than 3 percent of the surface area of a plot, then only the four most abundant species are recorded.

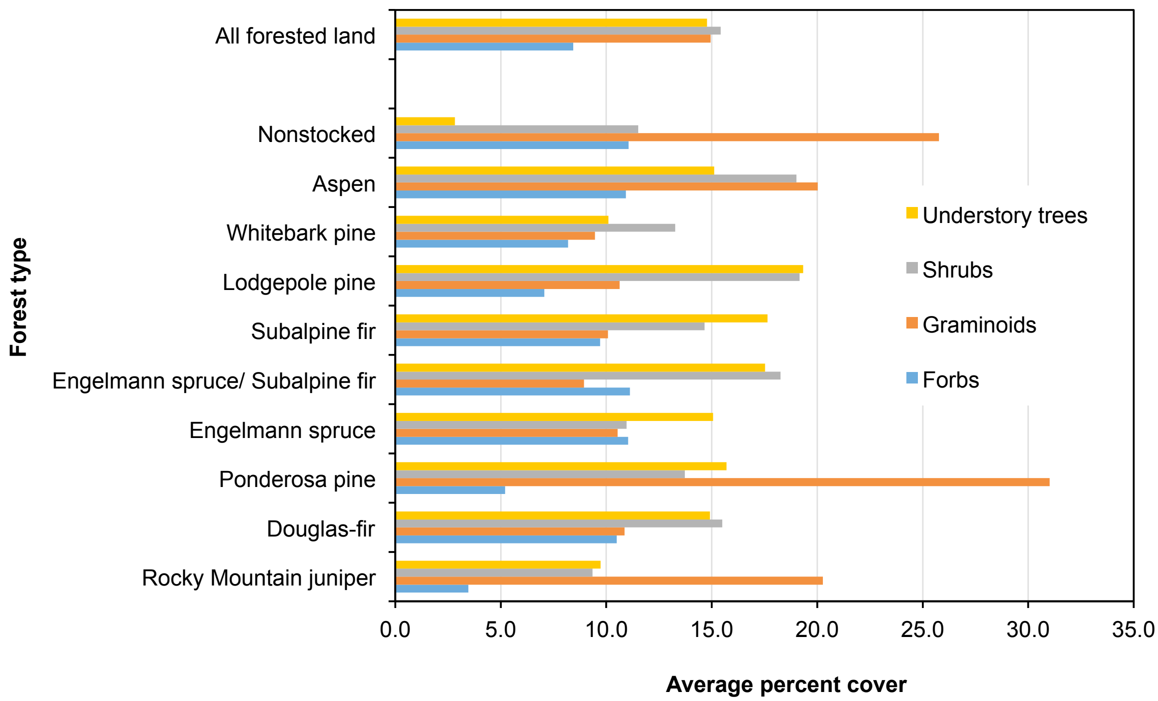

Figure 31—Average percent cover of understory vegetation by growth habit and forest type, Wyoming, 2011–2015.

The average percent cover varies among each plant growth habit across all forested land, among forest types, and among the 10 most abundant forest types in Wyoming (fig. 31). Graminoids made up more understory cover than the other three growth habits in four of the forest types analyzed. Graminoid cover ranged from 8.9 percent in the Engelmann spruce/subalpine fir forest type to 31 percent in the Ponderosa pine forest type. Shrubs and understory trees both dominated understory cover in three other forest types each. Shrub cover averaged 9.3 percent (Rocky Mountain juniper) to 19.2 percent (Lodgepole pine) and provided the highest understory cover among all forest types. Understory trees were most prevalent in Lodgepole pine and Subalpine fir forest types, and ranged from 2.8 percent in nonstocked forests to 19.3 percent in Lodgepole pine. On average, forbs were not a dominant cover in any forest type in Wyoming. Forbs were more abundant in nonstocked areas than any other forest type and covered the least amount of area in the Rocky Mountain juniper forest type.

Almost 600 individual plant species were recorded on Wyoming's forest inventory subplots. While subalpine fir was by far the most frequently encountered understory species, grouse whortleberry (*Vaccinium scoparium*) covered more area on average where it was found (table 12). Forbs were found on the fewest subplots (n = 3,088) but showed the greatest diversity of the growth habits with 295 species measured at 3 percent cover or greater. Conversely, trees showed the least diversity with only 32 species being measured in the understory. Shrubs were found most frequently, having been recorded on 3,907 subplots.

Table 12—The most frequently recorded understory plant species in each growth habit the number of subplots where they occurred, and average percent cover, Wyoming, 2011–2015.

Growth habit	Species	Common name	Number of subplots	Average percent cover
Forbs	*Arnica cordifolia*	heartleaf arnica	399	6.4
	Fragaria virginiana	Virginia strawberry	164	5.0
	Lupinus argenteus	silvery lupine	154	6.4
	Thalictrum occidentalis	western meadow-rue	111	5.3
Graminoids	*Carex geyeri*	Geyer's sedge	334	11.0
	Carex spp.	sedge species	333	16.8
	Calamagrostis rubscens	pinegrass	315	13.4
	Poa spp.	bluegrass	259	14.5
Trees	*Abies lasiocarpa*	subalpine fir	1031	14.2
	Pinus contorta	lodgepole pine	735	17.3
	Picea engelmannii	Engelmann spruce	450	6.9
	Pinus albicaulis	whitebark pine	250	7.2
Shrubs	*Vaccinium scoparium*	grouse whortleberry	935	25.9
	Juniperus communis	common juniper	357	9.0
	Artemisia tridentata	big sagebrush	327	12.6
	Mahonia repens	creeping barberry	187	6.4

Invasive and Noxious Species

FIA field crews record any instance where a noxious weed is found on a plot that contains a forested condition. This allows the spatial and temporal extent of these species to be documented when plots are revisited. Of the 951 plots sampled in Wyoming (2011–2015), 118 (12.4 percent) plots harbored an invasive plant (table 13). Eleven different invasive species were recorded, with Canada thistle (*Cirsium arvense*) accounting for 60 percent of the occurrences. Canada thistle was also found in the most diverse suite of forest types, occurring in every forest type in which an invasive was found. Gypsyflower (*Cynoglossum officinale*) was a distant second with 15 total occurrences, almost half (n = 7) of which were found in the Bur oak forest type. The Nonstocked forest type had by far the highest occurrence of invasive species, containing 29 percent (n = 34) of the occurrences. This is not surprising considering nonstocked forests are often created by disturbances that can facilitate invasion of undesirable plant species. Bur oak and Lodgepole pine were the next most infested forest types, with presence in 16 and 14 plots, respectively. The number of plots with invasive species was too small to permit analysis of site factors that may allow or facilitate invasion by weedy species. However, as Wyoming's forest inventory completes its first annual cycle, additional data may illuminate such factors. For example, specific forest types may be more prone to noxious plant infestation than others. Factors that may affect a site's propensity for infestation include soil conditions, accessibility to livestock grazing, road and foot traffic, or high frequency of both natural and human-induced disturbance such as burning or flooding, and/or edge effects.

Table 13—List of invasive species found in Wyoming's forest by forest type and number of occurrences. Wyoming, 2011–2015.

Scientific name	Common name	Forest type											
		Rocky Mountain juniper	Douglas-fir	Ponderosa pine	Engelmann spruce	Engelmann spruce/ subalpine fir	Subalpine fir	Lodgepole pine	Limber pine	Whitebark pine	Bur oak	Aspen	Non-stocked
Cirsium arvense	hardheads	-	1	-	-	-	-	-	-	-	-	-	3
Carduus acanthoides	spiny plumless thistle	-	-	-	-	-	-	-	-	-	-	-	1
Carduus nutans	nodding plumless thistle	-	-	-	-	-	-	1	-	-	-	1	3
Cardaria pubescens	hairy whitetop	-	-	-	-	-	-	-	-	-	3	-	-
Centaurea diffusa	diffuse knapweed	-	-	-	-	-	-	-	-	-	-	-	3
Cirsium arvense	Canada thistle	3	6	3	6	7	7	13	6	2	-	4	14
Convolvulus arvensis	field bindweed	-	-	-	-	-	-	-	-	-	3	-	-
Cynoglossum officinale	Gypsyflower	-	1	5	-	-	-	-	-	-	7	-	2
Linaria dalmatica	Dalmatian toad flax	-	-	-	-	-	-	-	-	-	-	-	4
Linaria vulgaris	butter and eggs	-	-	2	-	-	-	-	-	-	-	-	4
Onopordum acanthium	Scotch cotton thistle	-	-	-	-	-	-	-	-	-	3		-

Current Issues in Wyoming's Forests

Bark Beetle Infestation

Increased bark beetle populations have been a significant contributor to tree mortality in the western United States over the past few decades. Recent State reports for Colorado and Utah have indicated elevated levels of at least four important tree-killing bark beetles: spruce beetle (*Dendroctonus rufipennis*) on Engelmann spruce; mountain pine beetle on lodgepole pine, ponderosa pine, limber pine, and whitebark pine; Douglas-fir beetle (*Dendroctonus pseudotsugae*) on Douglas-fir; and western balsam bark beetle (*Dryocoetes confusus*) on subalpine fir (Thompson et al. 2017; Werstak et al. 2016). Species-level causal mortality agents are not recorded by FIA field crews; however, many of these insects are species- or genus-specific and attack multiple trees per plot during epidemics. Therefore, it is reasonable to speculate they are the primary drivers of insect-caused tree mortality.

Insect-caused mortality in Wyoming was highest (by acres of forest land) in the Fir/spruce/mountain hemlock forest-type group, where 24 percent was affected, which indicates elevated levels of spruce beetle and probably western balsam bark beetle (table B8). Mortality of Engelmann spruce was much higher than subalpine fir (fig. 6), suggesting that spruce may be much more affected by beetles. The second highest insect-caused mortality (by acres of forest land) was in the Lodgepole pine forest-type group, where 14 percent was affected (table B8). Of particular note is the other western softwoods group, which includes the important wildlife species of whitebark pine, and limber pine, where 21 percent has been affected, most likely by the mountain pine beetle (see the *Whitebark Pine Status and Trends* section). In addition, approximately 13 percent of the Douglas-fir forest-type group has been affected by insects (table B8).

Spruce Beetle

The spruce beetle is native to the Engelmann spruce forests of the Interior West, including Wyoming. At endemic population levels the spruce beetle prefers mature, large individual Engelmann spruce in stands of high density, and on productive sites (Schmid and Frye 1976). However, when spruce beetles successfully mass-attack individual spruce, their populations may increase to epidemic levels where mortality levels of greater than 90 percent are possible at scales much larger than individual stands (Schmid and Frye 1977).

Surprisingly, reported insect-caused mortality in the Fir/spruce/mountain hemlock group from the previous Wyoming report was very low, approximately 3 percent of the area (Thompson et al. 2005). While the most recent periodic data are not strictly comparable to the annual design, this still represents considerable additional mortality that has occurred over a decade later (2011–2015). The average annual mortality for the Fir/spruce/mountain hemlock forest-type group was substantial, the highest of any forest type, at approximately 283 million cubic feet (table B26). Nearly 87 percent of that mortality occurred on NFS ownership,

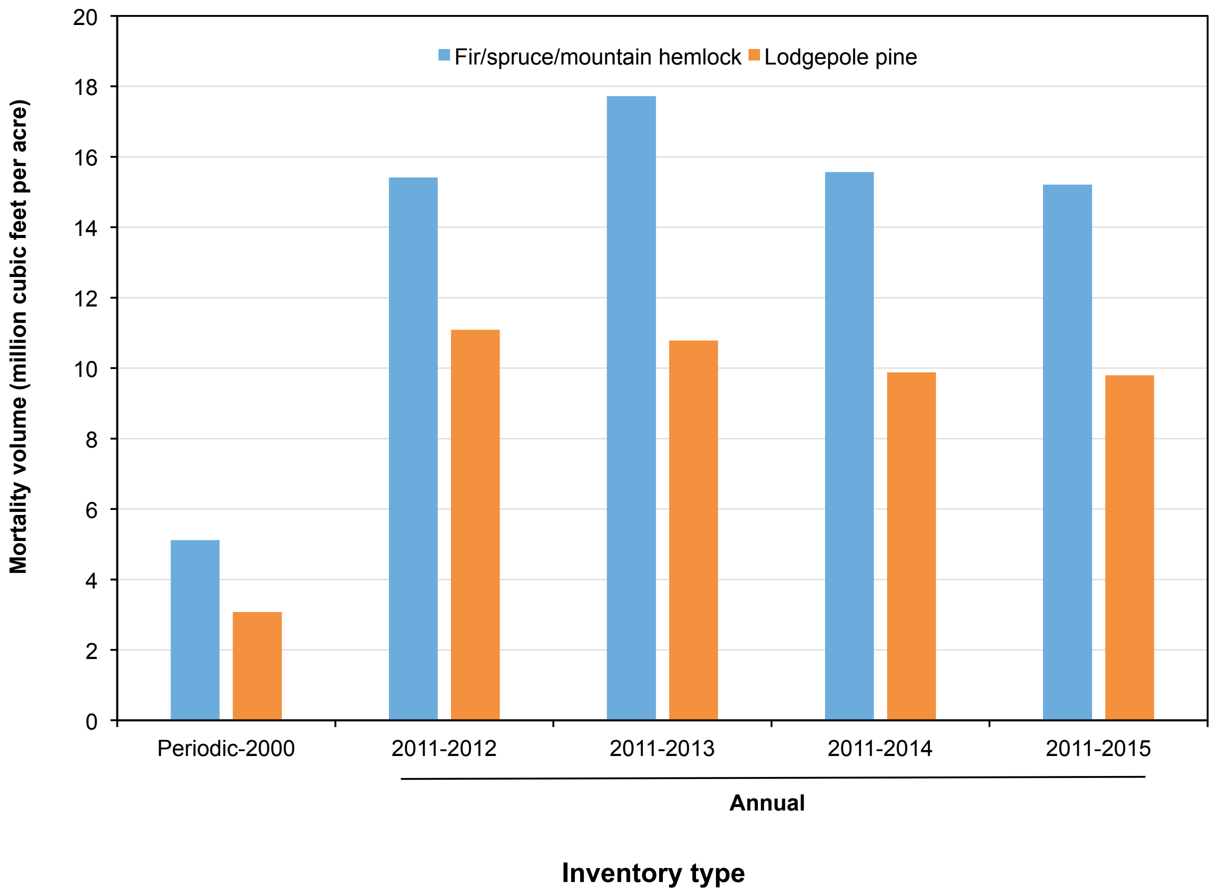

Figure 32—Insect-caused mortality of all trees on forest land (million cubic feet per year) for the two most-impacted forest-type groups: Fir/spruce/mountain hemlock, where the causal agents were likely spruce beetle and western balsam bark beetle; and Lodgepole pine, where the primary contributor to mortality was likely mountain pine beetle. Wyoming, 2011–2015.

where approximately 81 percent of the area of the Fir/spruce/mountain hemlock forest-type group occurs.

Mortality attributable to insects in the Fir/spruce/mountain hemlock forest-type group appears to have been constant since the first annual reporting period, averaging approximately 16 million cubic feet (fig. 32). With only 4 years of evaluations (and 5 years of data) it is hard to conclude that there is any trend in insect-caused mortality in Wyoming. Some insect-caused mortality of subalpine fir within this forest-type group is likely attributable to the western balsam bark beetle; however, given the large differences in mortality between the True fir and Engelmann spruce species groups (table B27), it is likely that the spruce beetle has caused the most mortality. Engelmann spruce and subalpine fir mortality caused by insects appears to be fairly ubiquitous across the State (fig. 33).

Mountain Pine Beetle

The mountain pine beetle is a native insect hosted by most species of pine. In Wyoming, mountain pine beetle populations have been elevated for the entire

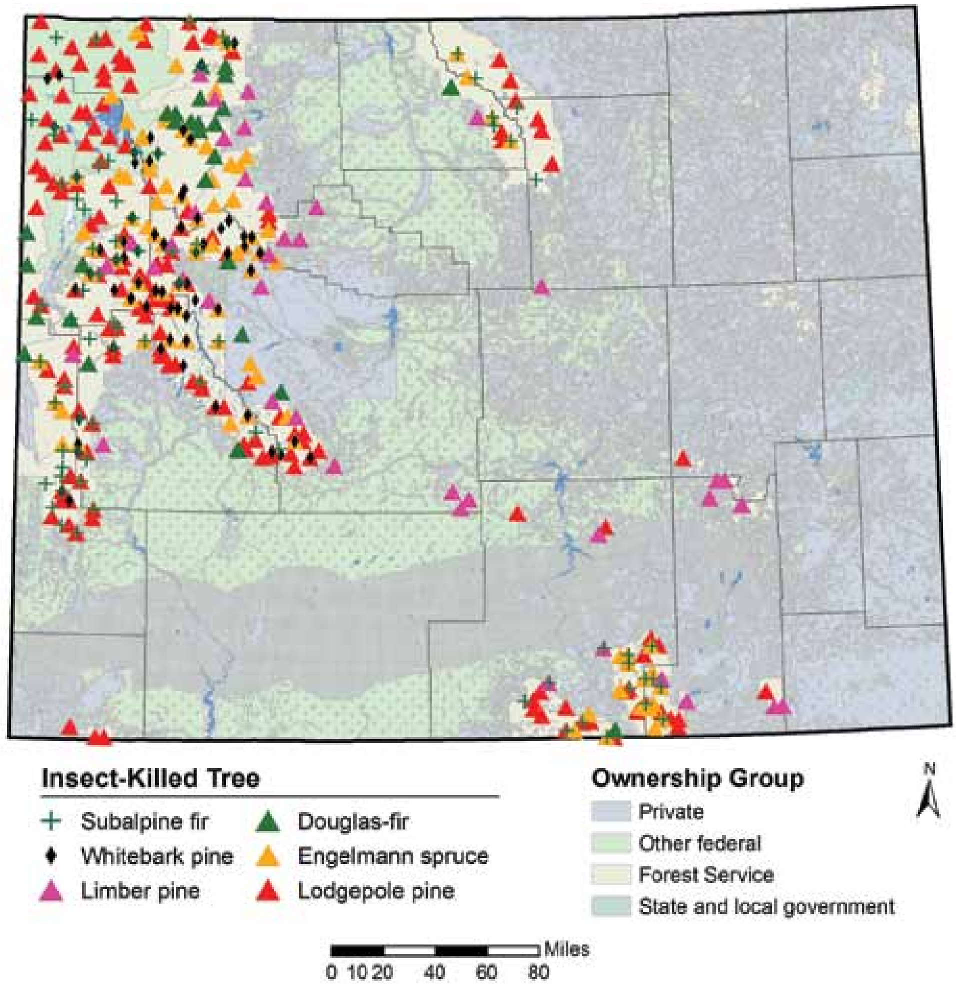

Figure 33—Plot locations where individual trees, by species, were noted in the field to have been killed by insects, Wyoming, 2011–2015. This methodology differs from Forest Health Protection, Aerial Detection Surveys. (Note: plot locations are approximate; some plots on private land were randomly swapped.)

annual reporting period (2011–2015), which is consistent with outbreak timing in neighboring States, such as Colorado (Thompson et al. 2017), Idaho (Witt et al. 2012), and Montana (Menlove et al. 2012) (fig. 32). Four important pine species in Wyoming host mountain pine beetle: lodgepole pine, ponderosa pine, whitebark pine (see the *Whitebark Pine Status and Trends* section), and limber pine. While risk factors indicating susceptibility of pines to mountain pine beetle are less well-known than risk factors for Engelmann spruce susceptibility to spruce beetle, it is thought that stands of high density and large individual trees are where beetles are most likely to successfully rear a brood (Fettig et al. 2013).

Low levels of lodgepole pine mortality attributable to insects were reported in the previous periodic report, and the first four evaluations for the annual inventory in Wyoming indicate just over 10 million cubic feet were killed, on average (fig. 32). Mortality of lodgepole pine appears to be occurring across the State, with particularly strong prevalence in the Greater Yellowstone Ecosystem, Wind River Range, and Wyoming Range (fig. 33). Interestingly, plots with limber pine mortality occur primarily in the interior basins of the State where it commonly occurs, in particular on the eastern slopes of both the Wind River Range and Greater Yellowstone Ecosystem (fig. 33).

Aspen Status and Trends

Aspen is the widest-ranging species in North America. It is present in all States in the Interior West and occupies a wide elevational range—from 2,000 feet in northern Idaho to 11,700 feet in Colorado. It is also found on a diverse range of sites and is present in 26 of the forest types that occur in the Interior West. The species is intolerant of shade and relatively short-lived, which makes it prone to replacement by conifers through successional change. In the Interior West, aspen also reproduces infrequently by seeding but likely relies primarily on root sprouting for reproduction. Aspen responds well to fire and cutting, and it is able to dominate heavily disturbed sites. In addition, there is some evidence that aspen is able to persist in conifer-dominated forests by exploiting gaps in the conifer canopy that are caused by insects, disease, windthrow, and other smaller-scale disturbances.

In recent years there has been concern about the future of aspen on the landscape, primarily due to the characteristics of aspen and how they relate to changes in disturbance regimes. The earliest concerns were related to successional change in the Interior West, where fire suppression has decreased disturbance rates and, as a result, aspen regeneration rates. In addition, it has been shown that large populations of herbivores can inhibit aspen regeneration (Hessl and Graumlich 2002). The lack of disturbance allows conifers to gain dominance where they are present, and in pure aspen stands, damage of regeneration by ungulates could lead to loss of senescing overstory trees without replacement. More recent concerns are related to a period of drought that has had an impact on aspen and other forest types (Shaw et al. 2005; Thompson 2009). Drought appears to have contributed to mortality in many low-elevation stands (Worrall et al. 2008), and in some of these regeneration is either lacking or suppressed by herbivores.

The current inventory of Wyoming shows that there are over 619,000 acres of the Aspen forest type in Wyoming (table B3), as compared to nearly 694,000 acres found during the 2000 periodic inventory (Thompson 2005). When considering all acres where aspen occurs, the current inventory shows that aspen is currently present on over 1.59 million acres, as compared to over 1.85 million acres during the 2000 inventory. This result suggests a decrease in the area of aspen over the past 15 years, with the aspen type currently occupying about 89 percent of the former area, and all land with aspen present occupying about 86 percent of the former area. However, the two inventories are not directly comparable because of a change between inventories in the lower threshold of what is considered forest land (from a minimum of 5 percent cover previously, to a minimum of 10 percent cover currently). When considered as a percentage of total forest area, the Aspen forest type accounted for 6.0 percent of Wyoming forest land in 2000, as compared to 5.9 percent in the current inventory. When considering all area with aspen present, the comparable percentages are 16.2 in the 2000 inventory and 15.1 in the current inventory. While these differences suggest some decline in aspen area, both as a forest type and in area present, they are relatively small, not statistically significant, and may change because only 50 percent of the annual inventory cycle has been completed.

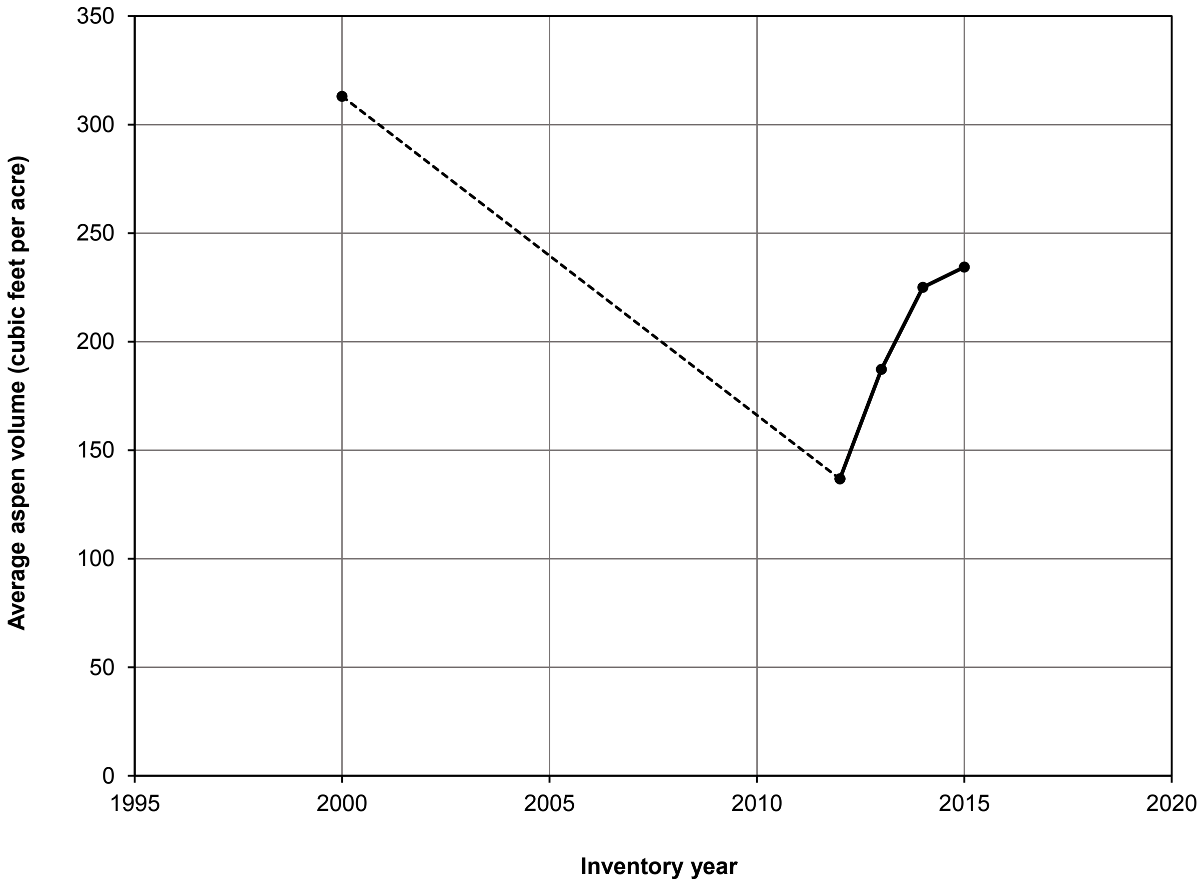

Figure 34—Trend in average aspen volume (cubic feet per acre) between the periodic inventory (2000) and the first 5 years (2011–2015) of the annual inventory.

Another way to normalize between inventories is to compare volume or biomass density. Using the 2000 values of 1.85 million acres with aspen present and 580 million cubic feet of live aspen volume results in an average volume of 313.0 cubic feet of live aspen per acre (fig. 34). The equivalent computation in the current inventory gives 234.4 live cubic feet per acre, or just under 75 percent of the 2000 average (fig. 34). This comparison also suggests a relative decline in aspen across Wyoming. However, the estimates produced from only the annualized inventory for the past 4 years indicated a current increasing trend, from a low of 136.8 cubic feet per acre in 2012 to the estimate of 234.4 cubic feet per acre in 2015 (fig. 34). This interpretation is made with caution, though, because the 2012 estimate was made using only 20 percent of the plots in the State, and the current estimate is based on half of a full inventory cycle.

Assuming that the current trend is sustained through the remainder of the inventory cycle, there are at least two possible interpretations of the pattern. One possibility is that the pattern is an artifact of the inventory and, during the first 1 or 2 years of annual inventory, sampling noise among the plots included in the sample under-sampled aspen by chance. In this scenario, the pattern is mostly attributable to sampling noise. An alternative interpretation is that there was a relatively large decline in aspen volume during the period between inventories, and that annual inventory is capturing the recovery of aspen volume. It is possible that both mechanisms are involved, precluding any definitive explanation at this time. Aspen volume trend will be monitored closely as future annual panels are added to the current inventory.

Whether this fluctuation is due to sampling error or represents a real trend will require additional years of monitoring. However, even with the limited amount of information available, it is possible to develop some expectations about possible future trends. The difference between the low estimate of 136.7 cubic feet per acre and the previous estimate of 313.0 cubic feet per acre represents an average annual decrease of about 26 cubic feet per acre per year. The apparent trend of the past 4 years of annual inventory represents an increase of volume of over 24 cubic feet per acre per year—nearly an offsetting rate. This would suggest that recovery to the 2000 volume density would require between 3 and 4 years from the present in the absence of unusual levels of disturbance.

Is 24 cubic feet per acre per year a realistic expectation for aspen, given that recovery rate is limited by the amount of live standing volume and inherent site quality, while decline has no limits on the speed of change (e.g., stand-replacing fire)? This question is difficult to answer with any certainty for the aspen population. It is worth noting that the definition of timberland is that which has the potential to produce at least 20 cubic feet per acre per year of wood volume. Aspen is a relatively productive forest type in the Interior West, and 77 percent of the Aspen forest type in Wyoming is classified as timberland. Furthermore, just under 18 percent of the Aspen forest type in Wyoming is classified as being able to produce at least 50 cubic feet of wood per acre per year at the age of culmination of mean annual increment. So, while there is much uncertainty with respect to future trends, aspen has the capacity to recover volume quickly after a period of decline.

Fire in Wyoming’s Forests

Fire is an important disturbance that influences the structure and dynamics of Wyoming’s forests. In some forest types, such as Ponderosa pine, fire can maintain open stands and stimulate the growth of grasses and forbs in the understory. In other forest types, such as Aspen and Lodgepole pine, fire is an important agent of regeneration. Throughout the Interior West, a century of fire suppression has led to a buildup of fuels and stand densification, which may lead to uncharacteristically intense fires (Reinhardt et al. 2008). Areas that burn intensely may experience slow regeneration, but others may recover relatively quickly—this depends in part on species’ life history traits. For example, the area inside the boundary of the large 1910 fires in Idaho and Montana (Cohen and Miller 1978; Egan 2009; Pyne 2008) now carries about the same amount of live tree volume per acre as areas outside the fires, although the mean stand age is somewhat lower and the volume is generally distributed among smaller trees (Wilson et al. 2010).

To characterize fire in Wyoming, data from the Monitoring Trends in Burn Severity (MTBS) project were used. MTBS is an interagency effort, conducted and maintained by the USDA Forest Service Remote Sensing Applications Center and the U.S. Geological Survey National Center for Earth Resources Observation and Science. The purpose of the MTBS project is to map the perimeters and severities of large wildland fires (including wildfire, wildland fire use, and prescribed fire) across all lands of the United States. In the western States, the project includes all fires larger than 1,000 acres (Eidenshenk et al. 2007) but usually captures some patches that are below that threshold. The analysis presented here is based on fire perimeters identified by the MTBS program between 1984 and 2015 and FIA plot data collected in Wyoming under the periodic inventory (1998–2002) and the annual inventory (2011–2015).

The MTBS program mapped 334 fires and fire complexes in Wyoming between 1984 and 2015, with named fire areas ranging from near the minimum mapped area of 1,000 acres to over 500,000 acres. The total area burned over the 32-year period, determined by summing all mapped fires, was 3,757,266 acres. After accounting for overlap (areas burned two or more times), the unique burned area was 3,671,199 acres. The mean burned area was 11,249 acres and the median was 3,058 acres. Of the FIA plot locations measured between 2011 and 2015, 315 fell within 109 of these burned areas (fig. 35). Although the number of plots falling inside fire perimeters is expected to increase substantially as the full inventory cycle is completed, the fact that over half of the mapped areas are smaller than 6,000 acres results in the expectation that many of them will never be sampled by an FIA plot. However, the systematic sample provided by the FIA inventory makes

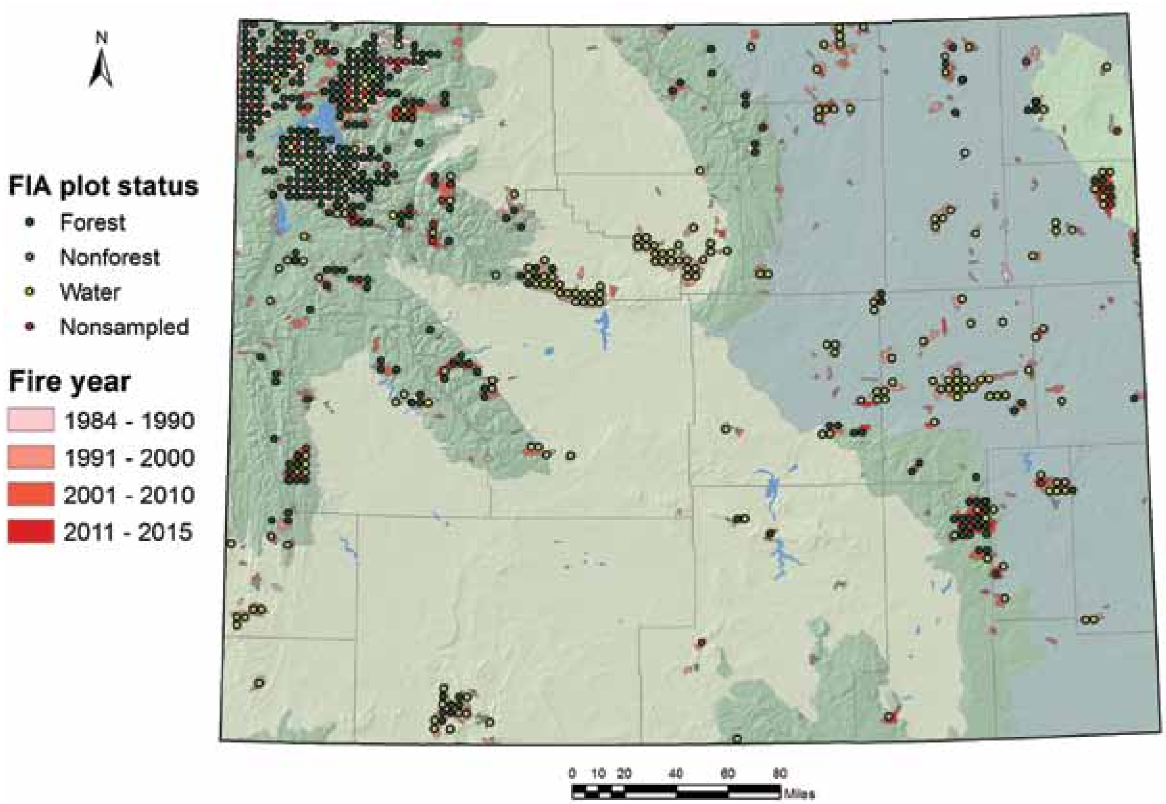

Figure 35—Fire boundaries mapped for the period 1984–2015, with FIA plot locations and status from Wyoming, 2011–1015.

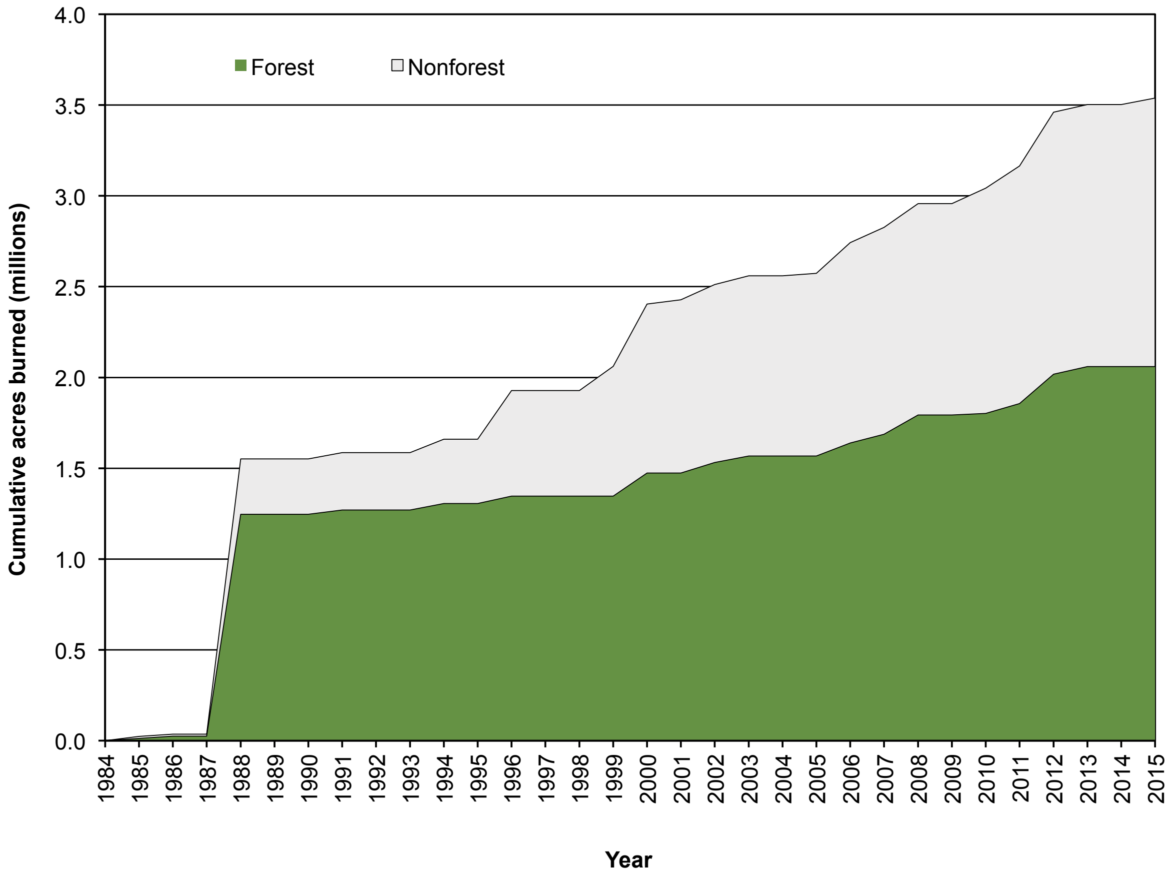

Figure 36—Cumulative area of forest land and nonforest land burned in Wyoming, 1984–2015.

it possible to make estimates of forest/nonforest status, forest type, and other characteristics of burned areas. The FIA plot-based estimate of unique burned area was 3,594,433 acres, which was within approximately 2 percent of the MTBS perimeter-based calculation.

Wyoming has a somewhat unusual fire history within the MTBS record, as compared to other Interior West States. In the beginning of the MTBS record (1984–1987), relatively little burned area was mapped—only 36,296 acres. However, the large fires and fire complexes of 1988, most of which are known collectively as the Yellowstone Fires, brought the cumulative area burned in Wyoming to 1.59 million acres in 1 year. During the 27 years following the large 1988 fires, burned area in Wyoming has accumulated at a relatively steady pace, totaling 2.0 million additional acres and averaging almost 74,000 acres per year (fig. 36). Of the 27-year total area burned, nearly 814,000 acres (41 percent) were on forest land and nearly 1.2 million acres (59 percent) were on nonforest land. If the current annual rate of acres burned and the forest:nonforest ratio remain steady, by the year 2025 over 800,000 additional acres could be burned in Wyoming, with about 330,000 acres of that in forest land status, and about 470,000 acres on nonforest status.

Because the fires of 1988 make up such a large portion of the total area burned in Wyoming over the past 31 years, the area affected by them is worth discussing separately. First, in contrast to the long-term forest:nonforest ratio of about 41:59,

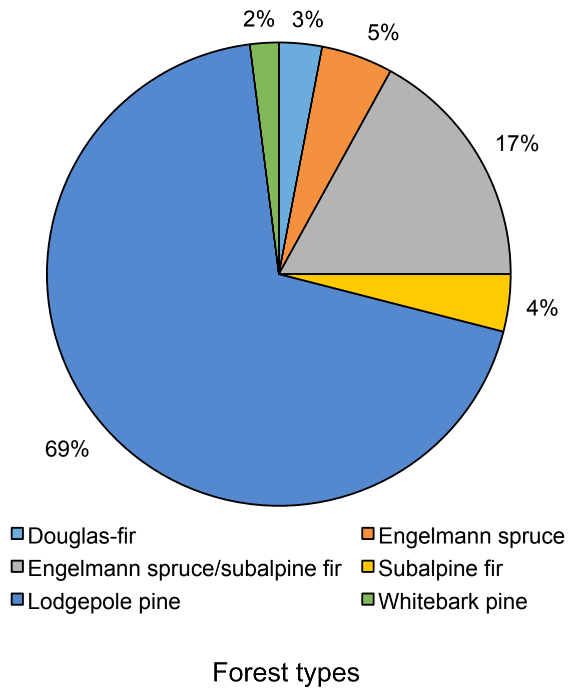

Figure 37—Proportions of area burned in 1988 in Wyoming, by forest type.

over 80 percent of the area burned in 1988 was forest land. Second, forest land in the Greater Yellowstone Ecosystem occurs in much different abundance than across Wyoming overall (fig. 4). Instead of using calculated forest type, as in much of this report, this analysis uses the crew-identified forest type. This is useful in the case of disturbed forest because stands of many forest types with low stocking will be represented in the calculated "nonstocked" type. In the field, crews identify the forest type regardless of stocking or tree tally, so they identify nonstocked forest as the likely future forest type. By this method, Lodgepole pine is the most abundant forest type in the State, occupying nearly 29 percent of forest area. The allied forest types of Engelmann spruce, Engelmann spruce/subalpine fir, and Subalpine fir collectively make up another 29 percent. However, the Lodgepole pine forest type occupies 69 percent of the area burned in the 1988 fires (fig. 37).

There are no data available to compare prefire conditions to the current inventory; however, it is likely that lodgepole pine's adaptation to fire resulted in acreage gains. It is also possible that most of the postfire lodgepole pine area was dominated by lodgepole pine prior to the fire. In contrast, the allied spruce and fir types in the burned area added up to 27 percent, close to the Statewide proportion. At about 3 percent of the 1988 burned area, Douglas-fir occurred at a much lower proportion than Statewide (8.8 percent). Whitebark pine was also an exceptional case. Although whitebark pine is considered to benefit from fire (Keane et al. 2017), the whitebark pine proportion of the burned area (2 percent) was lower than the Statewide proportion (3 percent) and much lower than the proportion in Yellowstone National Park (10 percent; Thompson et al. 2005), even though the large fires burned areas surrounding many whitebark pine stands.

Finally, the current inventory reveals a trajectory of recovery from the 1988 fires. Based on 1998–2002 periodic inventory plots that occur within 1988 fire boundaries, an estimated 1.07 billion cubic feet of live volume occurred on 1.36 million acres of forest land, for an average of 787.8 cubic feet per acre. The same calculation using the current inventory results in 1.08 billion cubic feet of live volume on 1.22 million acres of forest land, giving an average of 885.5 cubic feet per acre. Although the two estimates of area differ by about 10 percent, normalizing to per-acre values should provide a close approximation to the actual change within the burned area. This calculation also suggests that stands in the burned area are not yet near full stocking—the Statewide average for the unburned portion of forest land was 1876.1 cubic feet per acre in 2002.

The analysis of fire and fire effects in this section should be considered only a first approximation of fire effects on Wyoming's forests, because the State is only half through the current inventory cycle. Completion of the current inventory cycle, which will occur in 2020, should allow a relatively detailed comparison of pre- and postfire conditions, using plots that were measured during both the current inventory cycle and the 2002 periodic inventory.

National Forest System Inventory

The National Forest System (NFS) controls over 5.8 million acres of land in Wyoming (table B2), which was previously described in terms of reserved and unreserved status in the *Forest Land Ownership* section. In practice, there are several administrative jurisdictions imposed within NFS lands that can affect the type of management being conducted, such as for timber harvesting. Land that is suitable for timber harvesting typically must exhibit reasonable growth rates, but it must also not be limited by other designations that restrict timber harvest activities. The "suitable timber base," or areas suitable for timber harvest as categorized here, includes NFS land that is not already designated as wilderness, inventoried roadless, and other. The other category in Wyoming includes practical limitations—such as low productivity, steep slopes, and riparian buffers—and administrative limitations such as management objectives, wilderness study areas, and grasslands (see *Forest Land Ownership* section). In Wyoming, the relatively recent inventoried roadless ruling also resulted in a substantial portion of what was once considered suitable for timber production falling within the "suitable within roadless" land status (fig. 38, table 14).

Because FIA field crews do not collect information about land status within the NFS, this analysis represents a post-hoc assessment based on the overlap of multiple spatial layers in a geographic information system (GIS) provided by Regions 2 and 4, with FIA plot locations from the 2011–2015 Wyoming inventory. Using these layers, area, net volume, and mortality by land status within NFS national forests and grasslands were tabulated. Overlap between various GIS layers, and the inability of the layers to capture a few plots, resulted in estimates that were very close but not exactly the same as those produced by the core FIA tables (Appendix B).

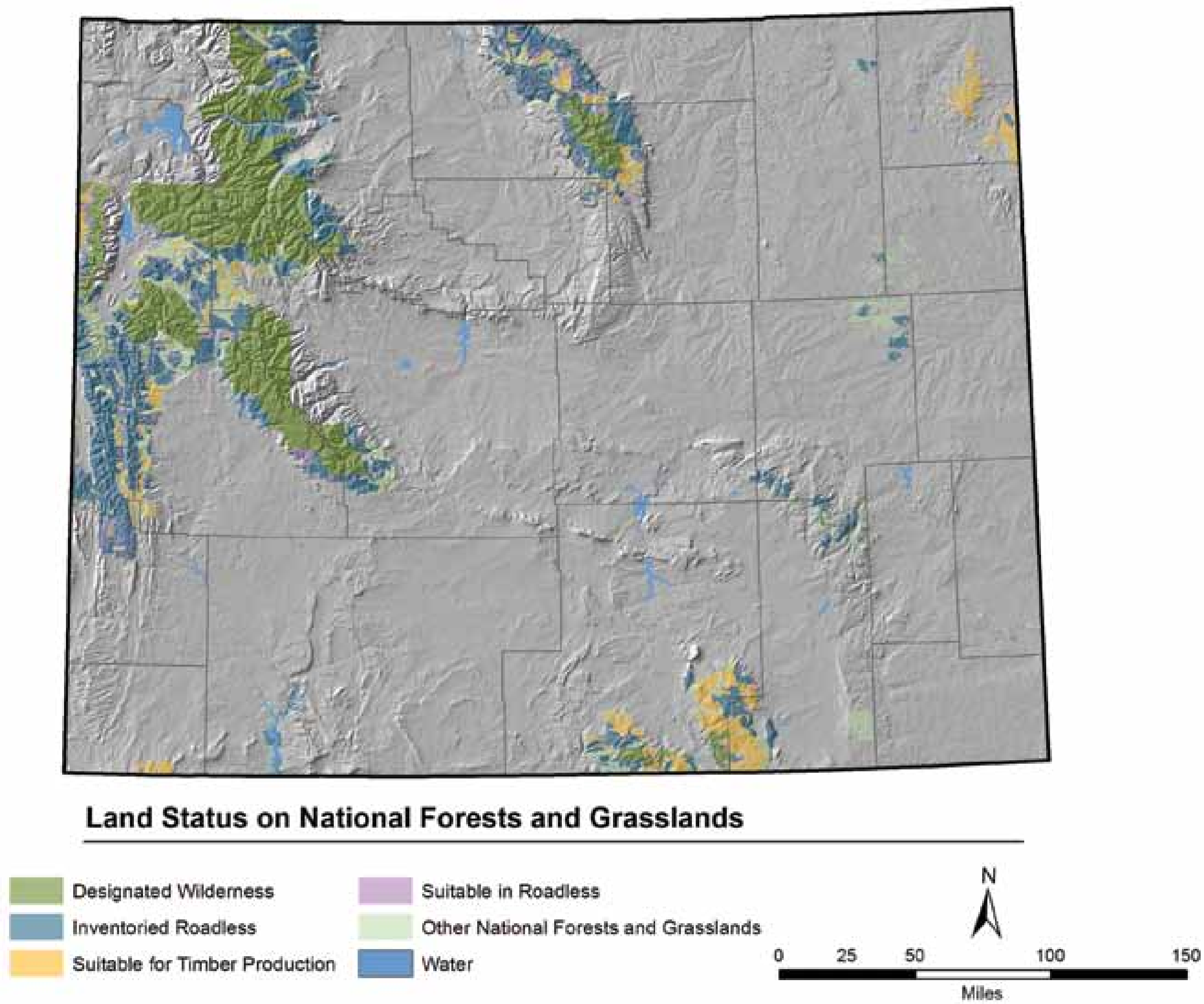

Figure 38—Areas of suitable/unsuitable, reserved roadless National Forest Systems land, Wyoming.

Table 14—Area of forest land, in acres, by land status on National Forest Systems forest land in Wyoming, 2011–2015.

Land status	Acres
Suitable for timber production	797,298
Suitable inside roadless	354,795
Total suitable	1,152,094
Inventoried roadless	2,400,354
Designated wilderness	1,655,024
Other	996,326
Total not suitable	**5,051,705**

Of the over 5.8 million acres of forest land under NFS ownership in Wyoming, the vast majority (approximately 81 percent) was categorized as unsuitable for timber production (table 14). Similarly, approximately 78 percent of net volume found on NFS ownership falls within the not suitable land status (table 15). While there are over a million suitable acres available for harvest in Wyoming, roughly one-fourth of that area falls within the inventoried roadless designation, potentially precluding those areas from harvest that requires road-building. The suitable land base falls largely within the Black Hills and Medicine Bow-Routt National Forests, with smaller portions also occurring in the Bighorn and Bridger-Teton National Forests (fig. 38).

Because NFS ownership makes up over half of the forest land in Wyoming, it is not surprising that the pattern of elevated mortality caused primarily by insects and fire is mirrored on NFS lands (table 16). Insects account for the largest percentage of volume mortality on both suitable and not suitable land status. As a percentage of acreage, on land that is suitable for timber production, both insects and disease have a similar proportion of mortality compared to all not suitable forest land (approximately 6 percent). This is not true of fire-caused mortality, where

Table 15—Net volume of live trees (at least 5 inches in diameter), in million cubic feet, by land status on National Forest Systems forest land in Wyoming, 2011–2015.

Land status	All forest land
Suitable for timber production	1,349
Suitable inside roadless	912
Total suitable	2,261
Inventoried roadless	4,566
Designated wilderness	1,928
Other	1,576
Total not suitable	**8,070**

Table 16—Average annual mortality of trees (at least 5 inches in diameter), in thousand cubic feet, by land status on National Forest System forest land in Wyoming, 2011–2015.

	Mortality (cause of death)							
Land status	Insect	Disease	Fire	Animal	Weather	Vegetation	Unknown/ other	Logging/ human
Suitable for timber production	50.55	7.31	1.03	-	0.97	0.08	4.77	0.04
Suitable inside roadless	23.94	1.29	3.27	-	1.59	0.22	0.80	-
Total suitable	74.50	8.60	4.30	-	2.57	0.30	5.57	0.04
Inventoried roadless	149.33	9.39	13.82	0.04	4.54	0.95	7.95	-
Designated wilderness	101.54	19.72	53.05	0.03	2.72	0.05	9.24	-
Other	39.30	5.14	1.75	0.15	2.03	0.17	2.43	0.78
Total not suitable	**290.17**	**34.24**	**68.62**	**0.22**	**9.29**	**1.16**	**19.63**	**0.78**

there is proportionally more on unsuitable lands than on suitable lands. This is likely due, in part, to the ability to access and fight fires that start on the suitable land base.

Because of high levels of mortality, average annual net growth for the State (see the *Forest Growth, Mortality, and Removals* section) was negative for the 2011–2015 time period. This pattern was also reflected on NFS lands for a number of important softwood species. For example, Engelmann spruce and lodgepole pine both exhibited negative net growth, irrespective of the land status (table 17). Important wildlife species such as whitebark pine and aspen exhibited negative growth in the not suitable land base. Across land status, subalpine fir and ponderosa pine both exhibited positive net growth. In contrast, on not suitable lands both blue spruce and Rocky Mountain juniper exhibited positive net growth. In areas that are suitable for timber production ponderosa pine, subalpine fir, and quaking aspen all exhibited a higher rate of growth than mortality (table 17).

Pinyon/Juniper Forest-Type Group

The Pinyon/juniper forest-type group is the third most abundant in Wyoming, encompassing 1.1 million acres (10.3 percent of forested area; table B4). Two forest types—Rocky Mountain juniper and Juniper forest types—make up the vast majority of acreage within the Pinyon/juniper forest-type group. Unlike other States in the Interior West that have large areas of the Pinyon/juniper forest-type group (Arizona, Colorado, Nevada, New Mexico, and Utah), where common pinyon (*Pinus edulis*) or singleleaf pinyon (*Pinus monphylla*) are widespread, in Wyoming there have only been two plots recorded with common pinyon. Therefore, in Wyoming this forest-type group characterizes almost entirely juniper species.

There is concern that juniper is encroaching into sagebrush steppe communities, which may have implications for sage grouse habitat. Because FIA considers lands with at least 10 percent tree canopy cover as forested, juniper issues in truly sagebrush or sagebrush-juniper ecotone areas cannot be assessed; that is, areas with less than 10 percent canopy cover. However, distributions of juniper ages for any forested plots with a juniper component can be investigated. The geographic distribution of juniper in Wyoming is highly varied (fig. 39) with subgroups occurring in the southwest corner, on the fringes of mountain ranges, and in the eastern plains. Stands classified as Juniper forest types include trees that exceed many centuries in age, with few plots less than 100 years old (fig. 40). On the other hand, juniper ages from trees located in other forest types are much younger (fig. 40). Many juniper ages in the eastern and southwestern portion of the State are less than 100 years old, which suggests the possibility that they are younger stands. Another possibility is that they are re-establishing after settlement-era exploitation, which is impossible to tell in the absence of historical documentation or stand history reconstructions.

Table 17—Average annual net growth of live trees (at least 5 inches in diameter), in million cubic feet, by species and land status on National Forest System forest land in Wyoming, 2011–2015.

	Species									
Land status	**Subalpine fir**	**Engelmann spruce**	**Blue spruce**	**Whitebark pine**	**Lodgepole pine**	**Limber pine**	**Ponderosa pine**	**Douglas-fir**	**Aspen**	**Rocky Mountain juniper**
Suitable for timber production	2.71	-10.39	-	-1.95	-28.79	-0.29	4.67	0.05	0.26	-
Suitable inside roadless	0.15	-1.90	-	-3.18	-9.71	0.03	-	-3.12	-0.03	-
Total suitable	**2.86**	**-12.30**	**-**	**-5.13**	**-38.51**	**-0.26**	**4.67**	**-3.07**	**0.24**	**-**
Inventoried roadless	2.91	-35.19	0.13	-12.36	-52.39	-2.33	1.61	-4.81	-0.98	0.07
Designated wilderness	-2.41	-64.61	0.02	-29.18	-27.40	-	0.00	-26.92	0.21	0.03
Other	3.55	3.31	0.68	-5.00	-17.44	-	1.90	-0.27	0.15	0.05
Total not suitable	**4.05**	**-96.49**	**0.84**	**-46.54**	**-97.22**	**-2.33**	**3.50**	**-32.00**	**-0.63**	**0.15**

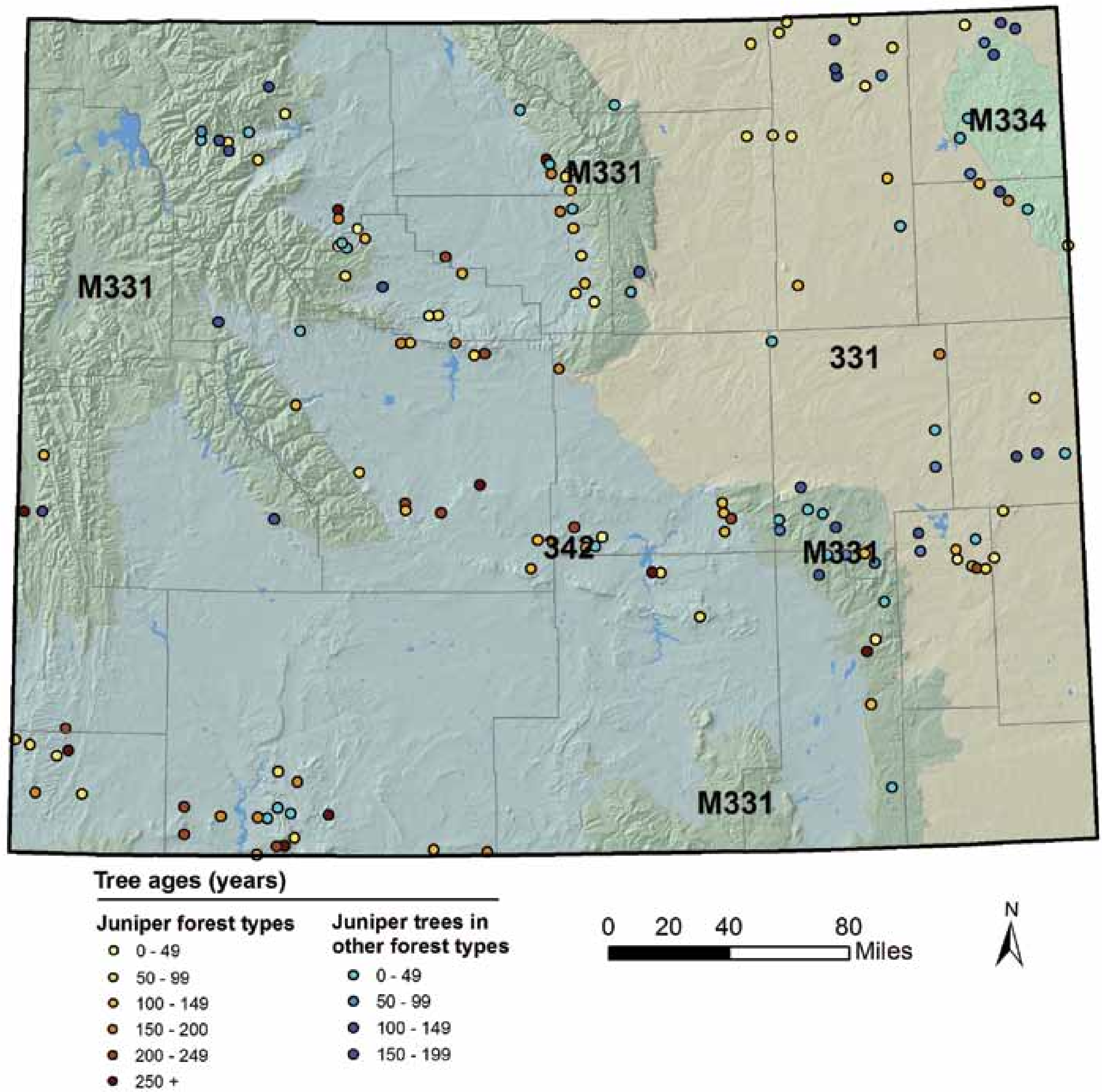

Figure 39—Tree ages for junipers that occur on juniper forest types, and junipers that occur on other forest types (primarily Douglas-fir and ponderosa pine).

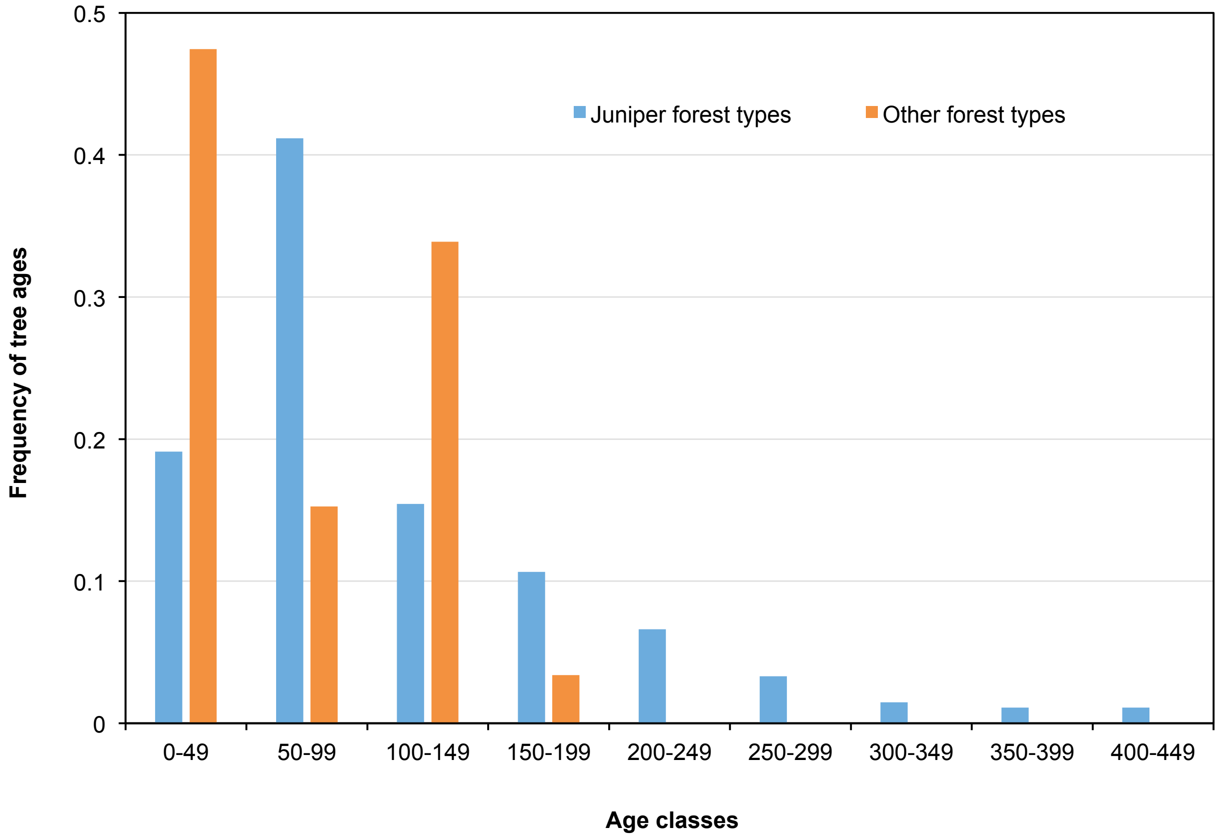

Figure 40—Frequency distribution of tree ages for juniper that occur in juniper forest types (Rocky Mountain juniper and pinyon/juniper) and tree ages for juniper that occur in other forest types (primarily Douglas-fir and ponderosa pine).

Conclusions

Wyoming's 10.5 million acres of forest land encompasses a large array of ecosystems, forest types, and species, with a relatively diverse mixture of coniferous and deciduous tree species. The major forest-type groups in Wyoming by order of abundance are Fir/spruce/mountain hemlock, Lodgepole pine (which occur primarily in the Southern Rocky Mountain Steppe (M331) ecoregion province), followed by the Pinyon/juniper forest-type group, which occur primarily in the Intermountain Semi-Desert Province (342) ecoregion (fig. 1; table B4).

Of the forested area in Wyoming, the vast majority (82 percent) is administered by Federal agencies (table B2). Nearly 56 percent of Wyoming forest land is controlled by National Forest Systems and 1.5 million acres, and 14 percent is owned by private landowners. This large amount of public land indicates a forest resource that is managed to meet the diverse needs of the people of Wyoming. These needs include wildlife, water quality, recreation, pollution control, and timber products that furnish jobs and strengthen local economies.

The most striking estimates in Wyoming's forest inventory are the high ratio of mortality to growth, causing large reductions in net growth and negative net growth in some of the major forest types in the State. Negative net growth was recorded Statewide for the Lodgepole pine, Fir/spruce/mountain hemlock, Other western softwoods, Douglas-fir, and Aspen/birch forest types. The only commercially important softwood to exhibit positive net growth was the Ponderosa pine forest type. Per-acre mortality was higher on National Forest Systems lands than other ownerships, and in that owner group, mortality was higher on reserved when compared to lands in unreserved status. The opposite was true for non-NFS owner groups; that is, per-acre mortality was higher on unreserved lands.

Insects and fire are the major contributing factors for the elevated levels of mortality over the 2011–2015 period in Wyoming. The peak in the 0–20 year stand-age class suggests much of the stand-replacing mortality is resulting in forest regeneration. A second peak in the 101–120 year age class suggests there are still many aging forests in the State that may become susceptible to insect outbreaks over time. Mountain pine beetle, spruce beetle, and Douglas-fir beetle, along with the spruce budworm, are important native disturbance agents that are currently exhibiting elevated populations in Wyoming. With 5 years of continuous inventory data, it is hard to say whether any of these populations are currently an "epidemic." Clearly, mortality attributed to these insects will continue to shape the composition and structure of Wyoming's forests.

Wyoming's commercial timber harvest volume has continued to increase compared to 2010 and 2005 estimates. However, Statewide removals represent only about 8 percent of annual gross growth and vary widely by ownership group (table 6). For example, private landowners' removals account for approximately 21 percent of annual gross growth, whereas removals from national forests account for about 8 percent. Removals also vary by geographic area, with the southeast portion of the State exhibiting the largest increase in percentage of the harvest, from 9.5 in 2010 to 34.7 in 2014. Over the same time period, the western portion of the State declined in removals while the northwest remained relatively constant.

Large areas of forest in Wyoming have been deemed unsuitable for harvesting, whether due to administrative or physical barriers. This can have large implications for managing bark beetle infestation, and also for wildlife habitat. For example, there is considerable area of spruce-fir and lodgepole pine forest in the State that could be considered snowshoe hare habitat, which is an important prey species for Canada lynx. While much of this area will remain protected in the short-term from harvesting, as forests grow they mature out of desirable habitat, so that in the long-term these same "protected" forests will be off limits to harvesting that could create future suitable habitat.

The systematic interpenetrating panel design of the FIA annual inventory presents opportunities to assess trends in inventory estimates never before possible with previous periodic inventories. Therefore, the information presented in this report serves as a baseline and might indicate opportunities for further investigation. Inferences about temporal trends require consideration of independent estimates of the population status each year, each of which uses completely different sample plots from different panels. These estimators can be used to track mortality events and lead to better monitoring of forest growth and tree harvest activity. As the annual plots in Wyoming converge on their full representation in 2020, a complete and representative accounting of the contemporary forest resource will be completed. Furthermore, as the annual inventory effort extends into the second measurement cycle in Wyoming, the power to detect trends and significant effects related to growth, mortality, removals, and other parameters of interest will be realized. In this way, the FIA program fills the need for accurate and consistent long-term monitoring procedures and data that analysts, managers, and researchers can rely on for monitoring forest status and trends and for studying forest dynamics over time.

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Appendix A: Standard Forest Inventory and Analysis Terminology

Average annual mortality—The average annual volume of trees 5.0 inches d.b.h./d.r.c. and larger that died from natural causes.

Average annual net growth—Average annual net change in volume of trees 5.0 inches d.b.h./d.r.c. and larger in the absence of cutting (average annual gross growth minus average annual mortality).

Basal area—The cross-sectional area of a tree stem/bole (trunk) at the point where diameter is measured, inclusive of bark. Basal area is calculated for trees 1.0 inch and larger in diameter, and is expressed in square feet. For timber species, the calculation is based on diameter at breast height (d.b.h.); for woodland species, it is based on diameter at root collar (d.r.c.).

Biomass—The quantity of wood fiber, for trees 1.0 inch d.b.h./d.r.c. and larger, expressed in terms of oven-dry weight. It includes aboveground portions of trees: bole/stem (trunk), bark, and branches. Biomass estimates can be computed for live and/or dead trees.

Board-foot volume—A unit of measure indicating the amount of wood contained in an unfinished board 1 foot wide, 1 foot long, and 1 inch thick**.** Board-foot volume is computed for the sawlog portion of a sawtimber-size tree; the sawlog portion includes the part of the bole on sawtimber-size tree from a 1-foot stump to a minimum sawlog top of 7 inches diameter outside bark (d.o.b.) for softwoods, or 9 inches d.o.b. for hardwoods. **Net board-foot volume** is calculated as the gross board-foot volume in the sawlog portion of a sawtimber-size tree, less deductions for cull (note: board-foot cull deductions are limited to rotten/missing material and form defect—referred to as the **merchantability factor—board-foot**). Board-foot volume estimates are computed in both Scribner and International ¼-inch rule, and can be calculated for live and/or dead (standing or down) trees.

Census water—Streams, sloughs, estuaries, canals, and other moving bodies of water 200 feet wide and greater, and lakes, reservoirs, ponds, and other permanent bodies of water 4.5 acres in area and greater.

Coarse woody debris—Down pieces of wood leaning more than 45 degrees from vertical with a diameter of at least 3.0 inches and a length of at least 3.0 feet.

Condition class—The combination of discrete landscape and forest attributes that identify, define, and stratify the area associated with a plot. Such attributes include: reserved status; owner group; forest type; stand-size class; stand origin, and; tree density.

Crown class—A classification of trees based on dominance in relation to adjacent trees in the stand as indicated by crown development and amount of sunlight received from above and the sides.

Crown cover (Canopy cover)—The percentage of the ground surface area covered by a vertical projection of plant crowns. Tree crown cover for a sample site includes the combined cover of timber and woodland trees 1.0 inch d.b.h./d.r.c. and larger.

Maximum crown cover for a site is 100 percent; overlapping cover is not double counted.

Cubic-foot volume (merchantable)—A unit of measure indicating the amount of wood contained in a cube 1 by 1 by 1 foot. Cubic-foot volume is computed for the merchantable portion of timber and woodland species; the merchantable portion for timber species includes that part of a bole from a 1-foot stump to a minimum 4-inch top d.o.b, or above the place(s) of diameter measurement for any woodland tree with a single 5.0-inch stem or larger or a cumulative (calculated) d.r.c. of at least 5.0 inches to the 1.5-inch ends of all branches. **Net cubic-foot volume** is calculated as the gross cubic-foot volume in the merchantable portion of a tree, less deductions for cull.

Diameter at breast height (d.b.h.)—The diameter of a tree bole/stem (trunk) measured at breast height (4.5 feet aboveground), measured outside the bark. The point of diameter measurement may vary for abnormally formed trees.

Diameter at root collar (d.r.c.)—The diameter of a tree stem(s) measured at root collar or at the point nearest the ground line (whichever is higher) that represents the basal area of the tree, measured outside the bark. For multi-stemmed trees, d.r.c. is calculated from an equation that incorporates the individual stem diameter measurements. The point of diameter measurement may vary for woodland trees with stems that are abnormally formed. With the exception of seedlings, woodland stems qualifying for measurement must be at least 1.0 inch in diameter or larger and at least 1.0 foot in length.

Diameter class—A grouping of tree diameters (d.b.h. or d.r.c.) into classes of a specified range. For some diameter classes, the number referenced (e.g., 4”, 6”, 8”) is designated as the midpoint of an individual class range. For example, if 2-inch classes are specified (the range for an individual class) and even numbers are referenced, the 6-inch class would include trees 5.0- to 6.9-inches in diameter.

Diameter outside bark (d.o.b.)—Tree diameter measurement inclusive of the outside perimeter of the tree bark. The d.o.b. measurement may be taken at various points on a tree (e.g., breast height, tree top) or log, and is sometimes estimated.

Field plot/location—A reference to the sample site or plot; an area containing the field location center and all sample points. A field location consists of four subplots and four microplots.

- **Subplot—**A 1/24-acre fixed-radius area (24-foot horizontal radius) used to sample trees 5.0 inches d.b.h./d.r.c. and larger and understory vegetation.
- **Microplot—**A 1/300-acre fixed-radius plot (6.8-foot radius), located at the center of each subplot, used to inventory seedlings and saplings.

Fixed-radius plot—A circular sample plot of a specified horizontal radius: 1/300 acre = 6.8-foot radius (microplot); 1/24 acre = 24.0-foot radius (subplot).

Forest industry land—Land owned by a company or an individual(s) operating a primary wood-processing plant.

Forest land—Land that has at least 10 percent cover of live tally tree species of any size, or land formerly having such tree cover, and not currently developed for a nonforest use. The minimum area for classification as forest land is 1 acre. Roadside, stream-side, and shelterbelt strips of trees must be at least 120 feet wide to qualify as forest land. Unimproved roads and trails, streams and other bodies of water, or natural clearings in forested areas are classified as forest if less than 120 feet in width or 1 acre in size. Grazed woodlands, reverting fields, and pastures that are not actively maintained are included if the above qualifications are satisfied.

Forest type—A classification of forest land based on the species forming a plurality of live tree stocking.

Gross growth—The annual increase in volume of trees 5.0 inches d.b.h. and larger in absence of cutting and mortality. Gross growth includes survivor growth, ingrowth, growth on ingrowth, growth on removals before removal, and growth on mortality prior to death.

Growing-stock trees—A live timber species, 5.0 inches d.b.h. or larger, with less than 2/3 (67 percent) of the merchantable volume cull, and containing at least one solid 8-foot section, now or prospectively, reasonably free of form defect, on the merchantable portion of the tree.

Growing-stock volume—The cubic-foot volume of sound wood in growing-stock trees at least 5.0 inches d.b.h. from a 1-foot stump to a minimum 4-inch top d.o.b. on the central stem.

Hardwoods—Dicotyledonous trees, usually broadleaf and deciduous.

Hexagonal grid—A grid in the shape of a hexagon formed from intersecting equilateral triangles for the purpose of tessellating the FIA inventory sample. Each hexagon in the base grid has an area of 5,937 acres (2,403.6 hectares) and contains one inventory plot. The base grid can be subdivided into smaller hexagons to intensify the sample.

Indian Trust lands—American Indian lands held in fee, or trust, by the Federal Government, but administered for tribal groups or as individual trust allotments.

Inventory year—The year in which a plot was scheduled to be completed. Within each subpanel, all plots have the same inventory year. Inventory year may differ from measurement year.

Land use—The classification of a land condition by use or type.

Litter—The uppermost layer of organic debris on a forest floor; that is, essentially the freshly fallen, or only slightly decomposed material, mainly foliage, but also bark fragments, twigs, flowers, fruits, etc. Humus is the organic layer, unrecognizable as to origin, immediately beneath the litter layer from which it is derived. Litter and humus together are often termed duff.

Logging residue/products—

- **Bolt—**A short piece of pulpwood; a short log.
- **Industrial wood—**All commercial roundwood products, excluding fuelwood.

- **Logging residue—**The unused sections within the merchantable portions of sound (growing-stock) trees cut or killed during logging operations.
- **Mill or plant residue—**Wood material from mills or other primary manufacturing plants that is not used for the mill's or plant's primary products. Mill or plant residue includes bark, slabs, edgings, trimmings, miscuts, sawdust, and shavings. Much of the mill and plant residue is used as fuel and as the raw material for such products as pulp, palletized fuel, fiberwood, mulch, and animal bedding. Mill or plant residue includes bark and the following components:
- **Coarse residue**—Wood material suitable for chipping, such as slabs, edgings, and trim.
- **Fine residue**—Wood material unsuitable for chipping, such as sawdust and shavings.
- **Pulpwood**—Roundwood, whole-tree chips, or wood residues that are used for the production of wood pulp.
- **Roundwood**—Logs, bolts, or other round sections cut from trees.

Mapped-plot design—A sampling technique that identifies (maps) and separately classifies distinct "conditions" on the field location sample area. Each condition must meet minimum size requirements. At the most basic level, condition class delineations include forest land, nonforest land, and water. Forest land conditions can be further subdivided into separate condition classes if there are distinct variations in forest type, stand size class, stand origin, and stand density, given that each distinct area meets minimum size requirements.

Measurement year—The year in which a plot was completed. Measurement year may differ from inventory year.

Merchantable portion—For trees measured at d.b.h. and 5.0 inches in d.b.h. and larger, the merchantable portion (or "merchantable bole") includes the part of the tree bole from a 1-foot stump to a 4.0-inch top (d.o.b.). For trees measured at d.r.c., the merchantable portion includes all qualifying segments above the place(s) of diameter measurement for any tree with a single 5.0-inch stem or larger or a cumulative (calculated) d.r.c. of at least 5.0 inches to the 1.5-inch ends of all branches; sections below the place(s) of diameter measurement are not included. Qualifying segments are stems or branches that are a minimum of 1 foot in length and at least 1.0 inch in diameter; portions of stems or branches smaller than 1.0 inch in diameter, such as branch tips, are not included in the merchantable portion of the tree.

Mortality tree—All standing or down dead trees 5.0 inches d.b.h./d.r.c. and larger that were alive within the previous 5 years (in most States).

National Forest System (NFS) lands—Public lands administered by the Forest Service, U.S. Department of Agriculture, such as National Forests, National Grasslands, and some National Recreation Areas.

National Park Service (NPS) lands—Public lands administered by the Park Service, U.S. Department of the Interior, such as National Parks, National Monuments, National Historic Sites (such as National Memorials and National Battlefields), and some National Recreation Areas.

Noncensus water—Portions of rivers, streams, sloughs, estuaries, and canals that are 30 to 200 feet wide and at least 1 acre in size; and lakes, reservoirs, and ponds 1 to 4.5 acres in size. Portions of rivers and streams not meeting the criteria for census water, but at least 30 feet wide and 1 acre in size, are considered noncensus water. Portions of braided streams not meeting the criteria for census water, but at least 30 feet in width and 1 acre in size, and more than 50 percent water at normal high-water level are also considered noncensus water.

Nonforest land—Land that does not support, or has never supported, forests, and lands formerly forested where tree regeneration is precluded by development for other uses. Includes areas used for crops, improved pasture, residential areas, city parks, improved roads of any width and adjoining rights-of-way, power line clearings of any width, and noncensus water. If intermingled in forest areas, unimproved roads and nonforest strips must be more than 120 feet wide, and clearings, etc., more than 1 acre in size, to qualify as nonforest land.

Nonindustrial private lands—Privately owned land excluding forest industry land.

Nonstocked stand—A formerly stocked stand that currently has less than 10 percent stocking, but has the potential to again become 10 percent stocked. For example, recently harvested, burned, or windthrow-damaged areas.

Other Federal lands—Public lands administered by Federal agencies other than the Forest Service, U.S. Department of Agriculture, or the Bureau of Land Management, U.S. Department of the Interior.

Other private lands—Privately owned lands other than forest industry or Indian Trust.

Other public lands—Public lands administered by agencies other than the Forest Service, U.S. Department of Agriculture. Includes lands administered by other Federal, State, county, and local government agencies, including lands leased by these agencies for more than 50 years.

Poletimber-size trees—For trees measured at d.b.h, softwoods 5.0 to 8.9 inches d.b.h. and hardwoods 5.0 to 10.9 inches d.b.h. For trees measured at d.r.c., all live trees 5.0 to 8.9 inches d.r.c.

Primary wood-processing plants—An industrial plant that processes roundwood products, such as sawlogs, pulpwood bolts, or veneer logs.

Private lands—All lands not owned or managed by a Federal, State, or other public entity, including lands owned by corporations, trusts, or individuals, as well as Tribal lands.

Productive forest land—Forest land capable of producing 20 cubic feet per acre per year of wood from trees classified as a timber species (see Appendix D) on forest land classified as a timber forest type (see Appendix C).

Productivity—The potential yield capability of a stand calculated as a function of site index (expressed in terms of cubic-foot growth per acre per year at age of culmination of mean annual increment). Productivity values for forest land provide an indication of biological potential. Timberland stands are classified by the potential net annual growth attainable in fully stocked natural stands. For FIA reporting, Productivity Class is a variable that groups stand productivity values into categories of a specified range.

Removals—The net volume of sound (growing-stock) trees removed from the inventory by harvesting or other cultural operations (such as timber stand improvement), by land clearing, or by changes in land use (such as a shift to Wilderness designation).

Reserved land—Land withdrawn from management for production of wood products through statute or administrative designation; examples include Wilderness areas and National Parks and Monuments.

Sampling error—A statistical term used to describe the accuracy of the inventory estimates. Expressed on a percentage basis in order to enable comparisons between the precision of different estimates, sampling errors are computed by dividing the estimate into the square root of its variance.

Sapling—A live tree 1.0-4.9-inches d.b.h./d.r.c.

Sawlog portion—The part of the bole of sawtimber-size trees between a 1-foot stump and the sawlog top.

Sawlog top—The point on the bole of sawtimber-size trees above which a sawlog cannot be produced. The minimum sawlog top is 7 inches d.o.b. for softwoods, and 9 inches d.o.b. for hardwoods.

Sawtimber-size trees—Softwoods 9.0 inches d.b.h. and larger and hardwoods 11.0 inches and larger.

Sawtimber volume—The growing-stock volume in the sawlog portion of sawtimber-size trees in board feet.

Seedlings—Live trees less than 1.0 inch d.b.h./d.r.c.

Site index—A measure of forest potential productivity for a timberland tree/stand. Expressed in terms of the expected height (in feet) of trees on the site at an index age of 50 (or 80 years for aspen and cottonwood). Calculated from height-to-age equations.

Site tree—A tree used to provide an index of site quality. Timber species selected for site index calculations must meet specified criteria with regards to age, diameter, crown class, and damage.

Snag—A standing, dead tree.

Softwood trees—Coniferous trees, usually evergreen, having needle- or scale-like leaves.

Stand—A community of trees that can be distinguished from adjacent communities due to similarities and uniformity in tree and site characteristics, such as age-class distribution, species composition, spatial arrangement, structure, etc.

Stand density—A relative measure that quantifies the relationship between trees per acre, stand basal area, average stand diameter, and stocking of a forested stand.

Stand density index (SDI) —A widely used index developed by Reineke (1933) that expresses relative stand density based on a comparison of measured stand values with some standard condition; **relative stand density** is the ratio, proportion, or percent of absolute stand density to a reference level defined by some standard level of competition. For FIA reporting, the SDI for a site is usually presented as a percentage of the maximum SDI for the forest type. Site SDI values are sometimes grouped into SDI classes of a specified percentage range. Maximum SDI values vary by species and region.

Standing dead tree—A dead tree that is at least 5.0 inches in diameter, has a bole that has an unbroken actual length of at least 4.5 feet, and leans less than 45 degrees from vertical as measured from the base of the tree to 4.5 feet. Portions of boles on dead trees that are broken have greater than 50 percent of the bole unattached to the original source of growth (either above or below 4.5 feet), and are considered severed and are included in Down Woody Material (DWM) if they otherwise meet DWM tally criteria. For western woodland species with multiple stems, a tree is considered down if more than 2/3 of the volume is no longer attached or upright. For western woodland species with single stems to qualify as a standing dead tally tree, dead trees must be at least 5.0 inches in diameter, be at least 1.0 foot in unbroken actual length, and lean less than 45 degrees from vertical.

Stand-size class—A classification of forest land based on the predominant diameter size of live trees presently forming the plurality of live tree stocking. Classes are defined as follows:

- **Sawtimber stand (large-tree stand)—**A stand at least 10 percent stocked with live trees, in which half or more of the total stocking is from live trees 5.0 inches or larger in diameter, and with sawtimber (large tree) stocking equal to or greater than poletimber (medium tree) stocking.
- **Poletimber stand (Medium-tree stand)—**A stand at least 10 percent stocked with live trees, in which half or more of the total stocking is from live trees 5.0 inches or larger in diameter, and with poletimber (medium tree) stocking exceeding sawtimber (large tree) stocking.
- **Sapling/seedling stand—**A stand at least 10 percent stocked with live trees, in which half or more of the total stocking is from live trees less than 5.0 inches in diameter.
- **Nonstocked stand—**A formerly stocked stand that currently has less than 10 percent stocking, but has the potential to again become 10 percent stocked. For example, recently harvested, burned, or windthrow-damaged areas.

Stockability (Stockability factor)—An estimate of the stocking potential of a given site; for example, a stockability factor of 0.8 for a given site indicates that the site is capable of supporting only about 80 percent of "normal" stocking as indicated by yield tables. Stockability factors (maximum site value of 1.0) are assigned to sites based on habitat type/plant associations.

Stocking—An expression of the extent to which growing space is effectively utilized by live trees.

Timber species—Tally tree species traditionally used for industrial wood products. These include all species of conifers, except pinyon and juniper. Timber species are measured at d.b.h.

Timber stand improvement—A term comprising all intermediate cuttings or treatments, such as thinning, pruning, release cutting, girdling, weeding, or poisoning, made to improve the composition, health, and growth of the remaining trees in the stand.

Timberland—Unreserved forest land capable of producing 20 cubic feet per acre per year of wood from trees classified as a timber species (see Appendix D) on forest land designated as a timber forest type (see Appendix C).

Unproductive forest land—Forest land not capable of producing 20 cubic feet per acre per year of wood from trees classified as a timber species (see Appendix D) on forest land designated as a timber forest type and all forest lands designated as a woodland forest type (see Appendix C).

Unreserved forest land—Forest land not withdrawn from management for production of wood products through statute or administrative designation.

Wilderness area—An area of undeveloped land currently included in the Wilderness System, managed to preserve its natural conditions and retain its primeval character and influence.

Woodland species—Tally tree species that are not usually converted into industrial wood products. Common uses of woodland trees are fuelwood, fence posts, and Christmas trees. These species include pinyon, juniper, mesquite, locust, mountain-mahogany (*Cercocarpus* spp.), Rocky Mountain maple, bigtooth maple, desert ironwood, and most oaks (note: bur oak and chinkapin oak are classified as timber species). Because most woodland trees are extremely variable in form, diameter is measured at d.r.c.

Appendix B: Standard Forest Resource Tables

Table B21—Average annual net growth of live trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, by owner class and forest land status.

Table B22—Average annual net growth of live trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by forest-type group and stand-size class.

Table B23—Average annual net growth of live trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by species group and ownership group.

Table B24—Average annual net growth of growing-stock trees (at least 5 inches d.b.h.), in million cubic feet, on timberland by species group and ownership group.

Table B25—Average annual mortality of trees (at least 5 inches d.b.h.), in million cubic feet, by owner class and forest land status.

Table 26—Average annual mortality of trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by forest-type group and stand-size class.

Table B27—Average annual mortality of trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by species group and ownership group.

Table B28—Average annual mortality of growing-stock trees (at least 5 inches d.b.h.), in million cubic feet, on timberland by species group and ownership group.

Table B29—Aboveground dry weight live trees (at least 1 inch d.b.h./d.r.c.), in thousand dry short tons, by owner class and forest land status.

Table B30—Aboveground dry weight of live trees (at least 1 inch d.b.h./d.r.c.), in thousand dry short tons, on forest land by species group and diameter class.

Table B31—Area of forest land, in thousand acres, by inventory unit, county and forest land status.

Table B32—Area of forest land, in thousand acres, by inventory unit, county, ownership group and forest land status.

Table B33—Area of timberland, in thousand acres, by inventory unit, county and stand-size class.

Table B34—Area of timberland, in thousand acres, by inventory unit, county and stocking class.

Table B35—Net volume of growing-stock trees (at least 5 inches d.b.h.), in million cubic feet, and sawtimber trees, in million board feet (International 1/4 inch rule), on timberland by inventory unit, county, and major species group.

Table B36—Average annual net growth of growing-stock trees (at least 5 inches d.b.h.), in million cubic feet, and sawtimber trees, in million board feet (International 1/4 inch rule), on timberland by inventory unit, county, and major species group.

Table B37—Sampling errors by inventory unit and county for area of timberland, volume, average annual net growth, average annual removals, and average annual mortality on timberland.

Table B1—Percentage of plot area by land status, Wyoming, 2011–2015.

Land status	Percentage of sample
Accessible forest land	
Unreserved forest land	
Timberland	8.1
Unproductive	2.8
Total unreserved forest land	10.9
Reserved forest land	
Productive	4.8
Unproductive	0.3
Total reserved forest land	5.1
Total accessible forest land	**16.0**
Nonforest and other areas	
Nonforest land	80.8
Water	0.9
Census	0.7
Non-Census	0.2
Total nonforest and other areas	**81.6**
Non-response	
Access denied	1.8
Hazardous conditions	0.4
Other	0.2
Total non-response	**2.4**
All land	**100.0**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the percentage rounds to less than 0.1 percent. Columns and rows may not add to their totals due to rounding.

Table B2—Area of accessible forest land, in thousand acres, by owner class and forest land status, Wyoming, 2011–2015.

Owner class		Unreserved forests			Reserved forests			All forest land
		Timberland	Unproductive	Total	Productive	Unproductive	Total	
Forest Service								
	National forest	3,796	356	4,153	1,565	103	1,668	**5,821**
	National grassland	15.6	12.5	28.1	- -	- -	- -	**28.1**
Other Federal								
	National Park Service	- -	- -	- -	1,521.4	95.6	1,617.0	**1,617.0**
	Bureau of Land Management	360.7	744.9	1,105.6	- -	- -	- -	**1,105.6**
	U.S. Fish and Wildlife Service	- -	- -	- -	9.7	- -	9.7	**9.7**
	Departments of Defense and Energy	- -	24.1	24.1	- -	- -	- -	**24.1**
	Other Federal	- -	- -	- -	- -	12.1	12.1	**12.1**
State and local government								
	State	250.4	106.6	357.0	- -	- -	- -	**357.0**
	County and Municipal	- -	- -	- -	6.8	- -	6.8	**6.8**
Private								
	Undifferentiated private	958.0	553.6	1,511.6	- -	- -	- -	**1,511.6**
All owners	**Total**	**5,380.8**	**1,798.2**	**7,179.1**	**3,103.1**	**210.6**	**3,313.8**	**10,492.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres.
Columns and rows may not add to their totals due to rounding.

Table B3—Area of accessible forest land, in thousand acres, by forest-type group and productivity class, Wyoming, 2011–2015.

Forest-type group	Site-productivity class (cubic feet/acre/year)							Total all classes
	0-19	20-49	50-84	85-119	120-164	165-224	225+	
Pinyon / juniper group	1,081.7	- -	- -	- -	- -	- -	- -	1,081.7
Douglas-fir group	21.6	574.5	154.6	60.7	- -	- -	- -	811.4
Ponderosa pine group	- -	784.6	63.2	- -	- -	- -	- -	847.8
Fir / spruce / mountain hemlock group	14.1	1,368.6	1,389.3	146.6	- -	- -	- -	2,918.6
Lodgepole pine group	215.1	2,119.6	151.0	23.0	- -	- -	- -	2,508.7
Other western softwoods group	266.4	303.5	60.9	- -	- -	- -	- -	630.8
Oak / hickory group	19.3	89.1	- -	- -	- -	- -	- -	108.4
Elm / ash / cottonwood group	20.6	50.8	9.8	- -	- -	- -	- -	81.1
Aspen / birch group	139.2	371.0	97.3	11.9	- -	- -	- -	619.4
Woodland hardwoods group	22.6	- -	- -	- -	- -	- -	- -	22.6
Nonstocked	208.4	566.4	87.5	- -	- -	- -	- -	862.3
All forest-type groups	**2,008.8**	**6,228.1**	**2,013.7**	**242.2**	**- -**	**- -**	**- -**	**10,492.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their totals due to rounding.

Table B4—Area of accessible forest land, in thousand acres, by forest-type group, ownership group, and land status, Wyoming, 2011–2015.

	Forest Service		Other Federal		State and local government		Undifferentiated private		
Forest-type group	Timber-land	Other forest land	Timber-land	Other forest land	Timber-land	Other forest land	Timber-land	Other forest land	All forest land
Pinyon / juniper group	- -	55.2	- -	629.6	- -	49.9	- -	347.1	1,081.7
Douglas-fir group	442.2	170.6	62.9	45.4	18.2	- -	72.1	- -	811.4
Ponderosa pine group	244.2	- -	65.6	- -	148.1	- -	390.0	- -	847.8
Fir / spruce / mountain hemlock group	1,578.1	793.1	64.9	388.0	13.9	- -	80.6	- -	2,918.6
Lodgepole pine group	951.2	398.8	50.2	1,011.7	13.9	- -	59.1	23.8	2,508.7
Other western softwoods group	103.1	231.4	18.0	102.3	- -	35.5	79.9	60.7	630.8
Oak / hickory group	12.9	- -	- -	- -	12.9	- -	63.4	19.3	108.4
Elm / ash / cottonwood group	- -	11.2	6.3	8.9	- -	13.0	38.7	3.2	81.1
Aspen / birch group	357.0	142.4	41.8	32.4	9.6	3.0	3.1	30.1	619.4
Woodland hardwoods group	- -	10.4	- -	12.1	- -	- -	- -	- -	22.6
Nonstocked	123.2	224.2	51.1	177.5	33.9	12.0	171.1	69.4	862.3
All forest-type groups	**3,811.8**	**2,037.2**	**360.7**	**2,407.8**	**250.4**	**113.4**	**958.0**	**553.6**	**10,492.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres.
Columns and rows may not add to their totals due to rounding.

Table B5—Area of accessible forest land, in thousand acres, by forest-type group and stand-size class, Wyoming, 2011–2015.

	Stand-size class				
Forest-type group	**Large diameter**	**Medium diameter**	**Small diameter**	**Nonstocked**	**All size classes**
Pinyon / juniper group	928.4	70.7	82.7	- -	1,081.7
Douglas-fir group	590.9	93.5	127.0	- -	811.4
Ponderosa pine group	713.1	87.7	47.0	- -	847.8
Fir / spruce / mountain hemlock group	1,772.7	513.4	632.5	- -	2,918.6
Lodgepole pine group	907.3	740.7	860.7	- -	2,508.7
Other western softwoods group	213.3	108.0	309.5	- -	630.8
Oak / hickory group	25.6	32.0	50.9	- -	108.4
Elm / ash / cottonwood group	51.8	9.3	20.1	- -	81.1
Aspen / birch group	68.6	178.8	372.0	- -	619.4
Woodland hardwoods group	- -	10.4	12.1	- -	22.6
Nonstocked	- -	- -	- -	862.3	862.3
All forest-type groups	**5,271.6**	**1,844.5**	**2,514.4**	**862.3**	**10,492.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their totals due to rounding.

Table B6—Area of accessible forest land, in thousand acres, by forest-type group and stand-age class, Wyoming, 2011–2015.

Forest-type group	Non-stocked	Stand-age class (years) 1-20	21-40	41-60	61-80	81-100	101-120	121-140	141-160	161-180	181-200	201+	All classes
Pinyon / juniper group	- -	63.8	31.7	43.3	141.8	128.5	113.4	131.8	60.3	75.3	74.3	217.6	1,081.7
Douglas-fir group	- -	109.3	17.7	9.2	30.9	172.1	152.9	99.9	70.2	12.1	36.8	100.2	811.4
Ponderosa pine group	- -	22.7	15.1	39.4	100.3	205.3	322.6	85.5	47.0	- -	9.9	- -	847.8
Fir / spruce / mountain hemlock group	- -	395.2	209.0	54.0	127.5	321.3	531.7	378.3	267.4	169.6	173.1	291.4	2,918.6
Lodgepole pine group	- -	601.8	256.4	74.0	187.4	259.2	374.6	278.9	179.6	59.8	60.4	176.7	2,508.7
Other western softwoods group	- -	198.4	88.2	21.3	61.6	54.1	45.1	33.0	11.9	12.1	45.5	59.5	630.8
Oak / hickory group	- -	50.9	- -	- -	19.3	15.9	22.4	- -	- -	- -	- -	- -	108.4
Elm / ash / cottonwood group	- -	8.9	14.2	12.6	13.0	5.2	12.7	3.2	11.4	- -	- -	- -	81.1
Aspen / birch group	- -	302.8	69.1	25.7	56.5	120.8	27.6	16.7	- -	- -	- -	- -	619.4
Woodland hardwoods group	- -	- -	12.1	- -	- -	10.4	- -	- -	- -	- -	- -	- -	22.6
Nonstocked	862.3	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	862.3
All forest-type groups	**862.3**	**1,753.8**	**713.5**	**279.5**	**738.3**	**1,292.9**	**1,603.0**	**1,027.3**	**647.9**	**328.9**	**399.9**	**845.4**	**10,492.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their totals due to rounding.

Table B7—Area of accessible forest land, in thousand acres, by forest-type group and stand origin, Wyoming, 2011–2015.

Forest-type group	Stand origin		All forest land
	Natural stands	Artificial regeneration	
Pinyon / juniper group	1,081.7	- -	1,081.7
Douglas-fir group	808.4	3.0	811.4
Ponderosa pine group	847.8	- -	847.8
Fir / spruce / mountain hemlock group	2,906.7	11.9	2,918.6
Lodgepole pine group	2,496.8	11.9	2,508.7
Other western softwoods group	630.8	- -	630.8
Oak / hickory group	108.4	- -	108.4
Elm / ash / cottonwood group	81.1	- -	81.1
Aspen / birch group	609.7	9.7	619.4
Woodland hardwoods group	22.6	- -	22.6
Nonstocked	862.3	- -	862.3
All forest-type groups	**10,456.5**	**36.4**	**10,492.8**

All table cells without observations in the inventory sample are indicated by --.
Table value of 0.0 indicates the acres round to less than 0.1 thousand acres.
Columns and rows may not add to their totals due to rounding.

Table B8—Area of forest land. In thousand acres, by forest-type group and primary disturbance class, Wyoming, 2011–2015.

	Disturbance class											
Forest-type group	None	Insects	Disease	Fire	Wild animals	Domestic animals	Weather	Vegetation	Other	Human	Geological	All forest land
Pinyon / juniper group	1,056.7	- -	12.9	12.1	- -	- -	- -	- -	- -	- -	- -	1,081.7
Douglas-fir group	668.5	110.0	12.1	8.9	- -	- -	- -	- -	- -	11.9	- -	811.4
Ponderosa pine group	796.1	11.9	13.6	26.2	- -	- -	- -	- -	- -	- -	- -	847.8
Fir / spruce / mountain hemlock group	1,999.7	688.3	105.1	62.7	3.0	- -	- -	11.9	3.0	- -	44.9	2,918.6
Lodgepole pine group	2,000.2	363.1	98.2	26.3	- -	- -	- -	11.8	9.1	- -	- -	2,508.7
Other western softwoods group	430.5	129.9	52.5	11.9	- -	- -	- -	- -	- -	- -	6.0	630.8
Oak / hickory group	92.4	- -	- -	12.9	- -	3.2	- -	- -	- -	- -	- -	108.4
Elm / ash / cottonwood group	74.8	- -	- -	- -	- -	6.4	- -	- -	- -	- -	- -	81.1
Aspen / birch group	433.1	67.3	79.3	36.8	- -	- -	- -	- -	- -	- -	2.8	619.4
Woodland hardwoods group	22.6	- -	- -	- -	- -	- -	- -	- -	- -	- -	- -	22.6
Nonstocked	553.8	44.8	9.1	248.6	- -	6.0	- -	- -	- -	- -	- -	862.3
All forest-type groups	**8,128.3**	**1,415.3**	**382.8**	**446.3**	**3.0**	**15.6**	**- -**	**23.6**	**12.1**	**11.9**	**53.7**	**10,492.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their totals due to rounding.

Table B9—Area of timberland, in thousand acres, by forest-type group and stand-size class, Wyoming, 2011–2015.

Forest-type group	Stand-size class: Large diameter	Medium diameter	Small diameter	Nonstocked	All size classes
Douglas-fir group	432.4	93.5	69.5	- -	595.4
Ponderosa pine group	713.1	87.7	47.0	- -	847.8
Fir / spruce / mountain hemlock group	1,037.8	378.1	321.7	- -	1,737.6
Lodgepole pine group	299.8	483.4	291.2	- -	1,074.3
Other western softwoods group	38.8	33.1	129.1	- -	200.9
Oak / hickory group	25.6	12.7	50.9	- -	89.1
Elm / ash / cottonwood group	35.7	9.3	- -	- -	44.9
Aspen / birch group	65.3	126.9	219.2	- -	411.4
Nonstocked	- -	- -	- -	379.2	379.2
All forest-type groups	**2,648.5**	**1,224.6**	**1,128.5**	**379.2**	**5,380.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their totals due to rounding.

Table B10—Number of live trees (at least 1 inch d.b.h./d.r.c.), in thousand trees, on forest land by species group and diameter class, Wyoming, 2011–2015.

	Diameter class (inches)														
Species group	**1.0-2.9**	**3.0-4.9**	**5.0-6.9**	**7.0-8.9**	**9.0-10.9**	**11.0-12.9**	**13.0-14.9**	**15.0-16.9**	**17.0-18.9**	**19.0-20.9**	**21.0-24.9**	**25.0-28.9**	**29.0-32.9**	**33.0-36.9**	**37.0+**	**All classes**
Softwood species groups																
Western softwood species groups																
Douglas-fir	67,242	42,779	28,588	21,117	15,267	10,545	6,445	4,054	2,819	1,968	2,297	879	147	71	- -	204,219
Ponderosa and Jeffrey pine	70,617	47,417	25,707	23,948	19,298	12,275	9,012	5,219	3,430	2,090	822	391	- -	- -	- -	220,225
True fir	658,513	247,642	106,762	64,240	36,674	21,229	11,537	6,696	3,804	2,037	1,539	231	76	- -	- -	1,160,977
Engelmann and other spruces	201,327	82,904	53,580	35,038	25,749	17,248	12,046	7,164	5,448	4,396	4,195	2,483	777	71	71	452,498
Lodgepole pine	1,041,851	304,316	185,903	131,916	79,471	39,681	17,201	6,783	3,221	1,521	450	146	- -	- -	- -	1,812,460
Other western softwoods	159,823	67,184	40,497	24,666	12,497	6,963	2,739	1,144	1,453	506	139	146	73	- -	- -	317,829
Other																
Western woodland softwoods	52,340	32,168	20,933	18,826	14,936	10,292	8,280	5,370	3,908	2,978	3,190	1,088	641	496	142	175,589
All softwoods	2,251,713	824,410	461,970	319,751	203,893	118,231	67,261	36,430	24,082	15,495	12,633	5,364	1,714	639	213	4,343,798
Hardwood species groups																
Western hardwood species groups																
Cottonwood and aspen	139,542	41,542	17,494	17,064	10,137	6,506	1,592	1,096	365	377	153	306	- -	- -	71	236,245
Other western hardwoods	24,055	4,788	7,299	3,990	2,131	1,671	604	77	- -	- -	- -	- -	- -	- -	- -	44,615
Other																
Western woodland hardwoods	5,857	5,822	824	398	227	76	- -	- -	- -	- -	- -	- -	- -	- -	- -	13,203
All hardwoods	169,454	52,152	25,617	21,452	12,494	8,253	2,196	1,174	365	377	153	306	- -	- -	71	294,063
All species groups	**2,421,167**	**876,563**	**487,587**	**341,202**	**216,387**	**126,484**	**69,457**	**37,603**	**24,447**	**15,872**	**12,786**	**5,670**	**1,714**	**639**	**284**	**4,637,861**

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates the number of trees rounds to less than 1 thousand trees. Columns and rows may not add to their totals due to rounding.

Table B11—Number of growing stock trees (at least 5 inches d.b.h.), in thousand trees, on timberland by species group and diameter class, Wyoming, 2011–2015.

	Diameter class (inches)													
Species group	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-24.9	25.0-28.9	29.0-32.9	33.0-36.9	37.0+	All classes
Softwood species groups														
Western softwood species groups														
Douglas-fir	22,193	17,224	11,438	9,018	4,924	2,808	2,086	1,600	1,940	515	147	71	- -	73,966
Ponderosa and Jeffrey pine	21,189	20,828	17,155	11,747	8,251	4,992	3,212	1,852	751	232	- -	- -	- -	90,209
True fir	67,205	40,600	24,438	13,445	8,168	4,241	3,011	1,520	1,467	231	76	- -	- -	164,402
Engelmann and other spruces	32,520	21,576	16,187	10,066	7,302	4,294	2,860	2,877	2,547	1,701	490	- -	- -	102,420
Lodgepole pine	103,436	74,400	38,652	17,747	7,064	2,037	1,013	455	226	- -	- -	- -	- -	245,030
Other western softwoods	14,162	8,105	3,322	1,575	951	645	365	73	72	- -	- -	- -	- -	29,269
All softwoods	260,705	182,732	111,193	63,598	36,660	19,017	12,547	8,377	7,004	2,679	712	71	- -	705,295
Hardwood species groups														
Western hardwood species groups														
Cottonwood and aspen	12,726	11,197	7,032	5,323	1,367	940	220	304	77	230	- -	- -	71	39,487
Other western hardwoods	4,674	2,600	1,668	1,145	385	77	- -	- -	- -	- -	- -	- -	- -	10,549
All hardwoods	17,400	13,797	8,701	6,468	1,752	1,017	220	304	77	230	- -	- -	71	50,036
All species groups	**278,105**	**196,530**	**119,894**	**70,066**	**38,412**	**20,034**	**12,766**	**8,681**	**7,080**	**2,908**	**712**	**71**	**71**	**755,330**

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates the number of trees rounds to less than 1 thousand trees. Columns and rows may not add to their totals due to rounding.

Table B12—Net volume of all live trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, by owner class and forest land status, Wyoming, 2011–2015.

	Unreserved forests			Reserved forests			All
Owner class	Timberland	Unproductive	Total	Productive	Unproductive	Total	forest land
Forest Service							
National forest	7,113.5	293.2	7,406.7	1,919.6	74.2	1,993.8	9,400.5
National grassland	13.7	5.4	19.1	- -	- -	- -	19.1
Other Federal							
National Park Service	- -	- -	- -	2,785.2	83.4	2,868.7	2,868.7
Bureau of Land Management	400.0	292.0	692.0	- -	- -	- -	692.0
U.S. Fish and Wildlife Service	- -	- -	- -	0.3	- -	0.3	0.3
Departments of Defense and Energy	- -	1.8	1.8	- -	- -	- -	1.8
Other Federal	- -	- -	- -	- -	2.4	2.4	2.4
State and local government							
State	298.2	48.3	346.5	- -	- -	- -	346.5
County and Municipal	- -	- -	- -	19.6	- -	19.6	19.6
Private							
Undifferentiated private	1,038.7	191.4	1,230.1	- -	- -	- -	1,230.1
All owners	**8,864.1**	**832.2**	**9,696.3**	**4,724.8**	**160.0**	**4,884.9**	**14,581.1**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B13—Net volume of all live trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by forest type group and stand-size class, Wyoming, 2011–2015.

	Stand-size class				
Forest-type group	Large diameter	Medium diameter	Small diameter	Nonstocked	All size classes
Pinyon / juniper group	442.3	18.2	3.5	- -	464.0
Douglas-fir group	1,371.3	81.4	33.2	- -	1,485.9
Ponderosa pine group	1,019.3	66.7	9.2	- -	1,095.1
Fir / spruce / mountain hemlock group	5,122.6	764.6	288.3	- -	6,175.5
Lodgepole pine group	2,547.6	1,451.4	249.1	- -	4,248.1
Other western softwoods group	221.3	86.9	46.9	- -	355.1
Oak / hickory group	33.6	22.5	8.3	- -	64.4
Elm / ash / cottonwood group	140.2	3.8	1.2	- -	145.2
Aspen / birch group	125.3	264.7	107.0	- -	497.0
Woodland hardwoods group	- -	1.4	3.9	- -	5.3
Nonstocked	- -	- -	- -	45.4	45.4
All forest-type groups	**11,023.5**	**2,761.7**	**750.5**	**45.4**	**14,581.1**

All table cells without observations in the inventory sample are indicated by --.
Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet.
Columns and rows may not add to their totals due to rounding.

Table B14—Net volume of all live trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by species group and ownership group, Wyoming, 2011–2015.

	Ownership group				
Species group	Forest Service	Other Federal	State and local government	Undifferentiated private	All owners
Softwood species groups					
Western softwood species groups					
Douglas-fir	1,195.9	193.5	9.1	109.5	1,508.1
Ponderosa and Jeffrey pine	430.9	103.9	201.0	467.7	1,203.5
True fir	2,043.1	415.1	46.1	35.2	2,539.5
Engelmann and other spruces	2,517.5	508.6	- -	108.5	3,134.6
Lodgepole pine	2,556.3	1,931.3	2.7	154.0	4,644.2
Other western softwoods	361.7	141.2	9.5	76.8	589.2
Other					
Western woodland softwoods	24.9	221.5	40.7	107.7	394.9
All softwoods	9,130.3	3,515.1	309.1	1,059.5	14,014.0
Hardwood species groups					
Western hardwood species groups					
Cottonwood and aspen	284.3	48.3	41.8	132.7	507.1
Other western hardwoods	2.4	1.8	15.2	37.9	57.4
Other					
Western woodland hardwoods	2.6	0.1	- -	- -	2.7
All hardwoods	289.3	50.2	57.1	170.7	567.1
All species groups	**9,419.6**	**3,565.3**	**366.2**	**1,230.1**	**14,581.1**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B15—Net volume of all live trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by species group and diameter class, Wyoming, 2011 –2015.

	Diameter class (inches)													
Species group	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-24.9	25.0-28.9	29.0-32.9	33.0-36.9	37.0+	All classes
Softwood species groups														
Western softwood species groups														
Douglas-fir	60	116	161	197	192	155	155	129	184	114	28	16	- -	1,508
Ponderosa and Jeffrey pine	36	101	158	173	206	171	143	118	59	39	- -	- -	- -	1,204
True fir	236	374	420	404	342	272	192	138	120	27	16	- -	- -	2,540
Engelmann and other spruces	105	195	288	321	347	310	309	315	403	336	157	22	27	3,135
Lodgepole pine	555	1,002	1,110	859	537	278	158	99	31	14	- -	- -	- -	4,644
Other western softwoods	63	109	111	103	56	32	56	31	12	10	7	- -	- -	589
Other														
Western woodland softwoods	15	26	35	36	43	40	39	37	47	24	22	26	6	395
All softwoods	1,069	1,925	2,282	2,093	1,723	1,258	1,051	867	856	565	230	63	33	14,014
Hardwood species groups														
Western hardwood species groups														
Cottonwood and aspen	29	85	103	105	40	32	12	18	7	25	- -	- -	51	507
Other western hardwoods	10	12	11	16	8	2	- -	- -	- -	- -	- -	- -	- -	57
Other														
Western woodland hardwoods	1	1	1	0	- -	- -	- -	- -	- -	- -	- -	- -	- -	3
All hardwoods	40	97	115	121	47	34	12	18	7	25	- -	- -	51	567
All species groups	**1,109**	**2,022**	**2,397**	**2,214**	**1,770**	**1,292**	**1,063**	**885**	**863**	**590**	**230**	**63**	**84**	**14,581**

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates the volume rounds to less than 1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B16—Net volume of all live trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by forest type group and stand origin, Wyoming, 2011–2015.

	Stand origin		
Forest-type group	Natural stands	Artificial regeneration	All forest land
Pinyon / juniper group	464.0	- -	464.0
Douglas-fir group	1,485.7	0.2	1,485.9
Ponderosa pine group	1,095.1	- -	1,095.1
Fir / spruce / mountain hemlock group	6,175.5	0.1	6,175.5
Lodgepole pine group	4,246.7	1.4	4,248.1
Other western softwoods group	355.1	- -	355.1
Oak / hickory group	64.4	- -	64.4
Elm / ash / cottonwood group	145.2	- -	145.2
Aspen / birch group	496.6	0.3	497.0
Woodland hardwoods group	5.3	- -	5.3
Nonstocked	45.4	- -	45.4
All forest-type groups	**14,579.1**	**2.0**	**14,581.1**

All table cells without observations in the inventory sample are indicated by --.
Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet.
Columns and rows may not add to their totals due to rounding.

Table B17—Net volume of growing stock trees (at least 5 inches d.b.h.), in million cubic feet, on timberland by species group and diameter class, Wyoming, 2011–2015.

	Diameter class (inches)													
Species group	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-24.9	25.0-28.9	29.0-32.9	33.0-36.9	37.0+	All classes
Softwood species groups														
Western softwood species groups														
Douglas-fir	48	95	124	170	144	107	109	101	154	68	28	16	- -	1,166
Ponderosa and Jeffrey pine	31	91	144	167	192	166	139	110	54	26	- -	- -	- -	1,119
True fir	153	246	283	256	244	175	154	107	115	27	16	- -	- -	1,775
Engelmann and other spruces	67	125	182	190	210	184	159	212	246	226	96	- -	- -	1,896
Lodgepole pine	309	552	528	372	215	82	48	27	17	- -	- -	- -	- -	2,150
Other western softwoods	23	37	33	23	21	18	17	2	6	- -	- -	- -	- -	180
All softwoods	631	1,147	1,293	1,178	1,025	733	625	559	593	347	141	16	- -	8,287
Hardwood species groups														
Western hardwood species groups														
Cottonwood and aspen	23	59	76	90	35	29	6	15	3	18	- -	- -	51	405
Other western hardwoods	7	8	9	13	5	2	- -	- -	- -	- -	- -	- -	- -	42
All hardwoods	30	67	85	103	40	31	6	15	3	18	- -	- -	51	448
All species groups	**661**	**1,214**	**1,378**	**1,281**	**1,065**	**763**	**631**	**574**	**596**	**365**	**141**	**16**	**51**	**8,735**

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates the volume rounds to less than 1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B18—Net volume of growing stock trees (at least 5 inches d.b.h.), in million cubic feet, on timberland by species group and ownership group, Wyoming, 2011–2015.

	Ownership group				
Species group	**Forest Service**	**Other Federal**	**State and local government**	**Undifferentiated private**	**All owners**
Softwood species groups					
Western softwood species groups					
Douglas-fir	976.5	71.6	8.5	109.5	1,166.1
Ponderosa and Jeffrey pine	421.4	65.9	200.1	432.0	1,119.3
True fir	1,597.5	97.7	46.0	33.7	1,774.9
Engelmann and other spruces	1,794.3	5.5	- -	96.6	1,896.3
Lodgepole pine	1,910.2	91.6	2.7	145.5	2,150.0
Other western softwoods	115.4	21.1	1.1	42.6	180.2
All softwoods	6,815.2	353.4	258.3	859.9	8,286.9
Hardwood species groups					
Western hardwood species groups					
Cottonwood and aspen	237.7	33.6	20.6	113.6	405.5
Other western hardwoods	2.0	0.9	10.8	28.7	42.5
All hardwoods	239.8	34.5	31.4	142.3	447.9
All species groups	**7,055.0**	**387.9**	**289.7**	**1,002.2**	**8,734.9**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B19—Net volume of sawtimber trees, in million board feet (International 1/4 inch rule), on timberland by species group and diameter class, Wyoming, 2011–2015.

	Diameter class (inches)											
Species group	**9.0-10.9**	**11.0-12.9**	**13.0-14.9**	**15.0-16.9**	**17.0-18.9**	**19.0-20.9**	**21.0-24.9**	**25.0-28.9**	**29.0-32.9**	**33.0-36.9**	**37.0+**	**All classes**
Softwood species groups												
Western softwood species groups												
Douglas-fir	495	805	739	567	593	562	868	419	160	101	- -	5,309
Ponderosa and Jeffrey pine	372	662	914	871	751	627	291	154	- -	- -	- -	4,641
True fir	1,168	1,232	1,257	921	835	607	670	165	104	- -	- -	6,960
Engelmann and other spruces	750	922	1,083	993	875	1,213	1,456	1,381	618	- -	- -	9,292
Lodgepole pine	1,998	1,658	1,073	434	252	145	94	- -	- -	- -	- -	5,654
Other western softwoods	105	86	89	77	85	5	32	- -	- -	- -	- -	478
All softwoods	4,887	5,363	5,156	3,863	3,392	3,159	3,412	2,119	882	101	- -	32,334
Hardwood species groups												
Western hardwood species groups												
Cottonwood and aspen	- -	429	185	148	27	74	15	82	- -	- -	251	1,210
Other western hardwoods	- -	17	8	2	- -	- -	- -	- -	- -	- -	- -	27
All hardwoods	- -	446	193	150	27	74	15	82	- -	- -	251	1,237
All species groups	**4,887**	**5,809**	**5,349**	**4,013**	**3,418**	**3,232**	**3,426**	**2,201**	**882**	**101**	**251**	**33,570**

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates the volume rounds to less than 1 million board feet.
Columns and rows may not add to their totals due to rounding.

Table B20—Net volume of sawlog portion of sawtimber trees, in million cubic feet, on timberland by species group and ownership group, Wyoming, 2011–2015.

Species group	Ownership group: Forest Service	Other Federal	State and local government	Undifferentiated private	All owners
Softwood species groups					
Western softwood species groups					
Douglas-fir	778.2	54.7	6.4	74.3	913.6
Ponderosa and Jeffrey pine	337.1	54.0	158.8	313.3	863.2
True fir	1,090.0	63.6	28.6	25.7	1,207.9
Engelmann and other spruces	1,450.0	3.6	- -	73.5	1,527.0
Lodgepole pine	1,071.4	52.9	- -	48.7	1,173.1
Other western softwoods	63.9	13.6	0.7	32.4	110.5
All softwoods	4,790.6	242.4	194.5	567.8	5,795.3
Hardwood species groups					
Western hardwood species groups					
Cottonwood and aspen	83.9	8.5	14.9	89.6	196.9
Other western hardwoods	0.4	- -	4.9	9.3	14.6
All hardwoods	84.4	8.5	19.8	98.9	211.6
All species groups	**4,874.9**	**250.9**	**214.2**	**666.7**	**6,006.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B21—Average annual net growth of all live trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, by owner class and forest land status, Wyoming, 2011–2015.

	Unreserved forests			Reserved forests			All
Owner class	**Timberland**	**Unproductive**	**Total**	**Productive**	**Unproductive**	**Total**	**forest land**
Forest Service							
National forest	-154.2	-5.6	-159.8	-144.5	-5.6	-150.1	-310.0
National grassland	0.4	0.1	0.4	- -	- -	- -	0.4
Other Federal							
National Park Service	- -	- -	- -	7.7	1.4	9.1	9.1
Bureau of Land Management	-5.8	-0.4	-6.2	- -	- -	- -	-6.2
U.S. Fish and Wildlife Service	- -	- -	- -	0.0	- -	0.0	0.0
Departments of Defense and Energy	- -	-1.1	-1.1	- -	- -	- -	-1.1
Other Federal	- -	- -	- -	- -	0.0	0.0	0.0
State and local government							
State	0.2	0.3	0.5	- -	- -	- -	0.5
County and Municipal	- -	- -	- -	0.9	- -	0.9	0.9
Private							
Undifferentiated private	3.0	-4.7	-1.7	- -	- -	- -	-1.7
All owners	**-156.5**	**-11.3**	**-167.8**	**-135.9**	**-4.2**	**-140.1**	**-307.9**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B22—Average annual net growth of all live trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by forest-type group and stand-size class, Wyoming, 2011–2015.

	Stand-size class				
Forest-type group	Large diameter	Medium diameter	Small diameter	Nonstocked	All size classes
Pinyon / juniper group	1.4	-0.8	-0.4	- -	0.2
Douglas-fir group	-2.0	-3.6	-12.0	- -	-17.6
Ponderosa pine group	13.7	2.2	0.2	- -	16.1
Fir / spruce / mountain hemlock group	-65.7	-43.4	-60.6	- -	-169.6
Lodgepole pine group	-9.9	-18.3	-13.9	- -	-42.1
Other western softwoods group	-7.5	-2.4	-13.1	- -	-23.1
Oak / hickory group	0.6	0.3	0.1	- -	0.9
Elm / ash / cottonwood group	2.9	0.1	0.0	- -	3.1
Aspen / birch group	-2.7	0.3	-9.0	- -	-11.3
Woodland hardwoods group	- -	0.0	0.1	- -	0.1
Nonstocked	- -	- -	- -	-64.5	-64.5
All forest-type groups	**-69.2**	**-65.7**	**-108.5**	**-64.5**	**-307.9**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B23—Average annual net growth of all live trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by species group and ownership group, Wyoming, 2011–2015.

Species group	Ownership group: Forest Service	Other Federal	State and local government	Undifferentiated private	All owners
Softwood species groups					
Western softwood species groups					
Douglas-fir	-31.9	1.9	-0.7	-1.5	-32.3
Ponderosa and Jeffrey pine	8.2	-2.1	1.0	5.5	12.6
True fir	6.8	3.0	0.5	1.0	11.3
Engelmann and other spruces	-106.1	5.5	- -	-1.5	-102.1
Lodgepole pine	-126.0	-0.9	0.0	0.8	-126.1
Other western softwoods	-60.4	-5.9	-0.1	-8.0	-74.4
Other					
Western woodland softwoods	0.2	0.7	0.2	0.3	1.4
All softwoods	-309.3	2.3	1.0	-3.4	-309.5
Hardwood species groups					
Western hardwood species groups					
Cottonwood and aspen	-0.2	-0.5	0.1	1.1	0.5
Other western hardwoods	0.0	0.1	0.3	0.6	1.1
Other					
Western woodland hardwoods	0.0	0.0	- -	- -	0.0
All hardwoods	-0.2	-0.4	0.5	1.7	1.5
All species groups	**-309.5**	**1.8**	**1.4**	**-1.7**	**-307.9**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B24—Average annual net growth of growing stock trees (at least 5 inches d.b.h.), in million cubic feet, on timberland by species group and ownership group, Wyoming, 2011–2015.

Species group	Ownership group: Forest Service	Other Federal	State and local government	Undifferentiated private	All owners
Softwood species groups					
Western softwood species groups					
Douglas-fir	-5.4	1.2	-0.7	-1.5	-6.4
Ponderosa and Jeffrey pine	7.8	-0.9	1.0	5.3	13.2
True fir	8.8	-1.0	0.5	1.1	9.3
Engelmann and other spruces	-41.2	0.0	- -	-1.6	-42.8
Lodgepole pine	-94.9	-5.1	0.0	3.2	-96.8
Other western softwoods	-28.2	-0.3	-0.2	-5.5	-34.2
All softwoods	-153.0	-6.2	0.6	0.9	-157.7
Hardwood species groups					
Western hardwood species groups					
Cottonwood and aspen	-0.5	0.1	-0.8	1.6	0.5
Other western hardwoods	0.0	0.1	0.2	0.4	0.7
All hardwoods	-0.4	0.2	-0.6	2.1	1.2
All species groups	**-153.5**	**-6.0**	**0.0**	**3.0**	**-156.5**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B25—Average annual mortality of trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by owner class and forest land status, Wyoming, 2011–2015.

	Unreserved forests			Reserved forests			All
Owner class	Timberland	Unproductive	Total	Productive	Unproductive	Total	forest land
Forest Service							
National forest	292.0	10.5	302.5	179.0	7.3	186.3	488.8
National grassland	- -	0.0	0.0	- -	- -	- -	0.0
Other Federal							
National Park Service	- -	- -	- -	39.3	0.2	39.5	39.5
Bureau of Land Management	14.3	3.2	17.5	- -	- -	- -	17.5
U.S. Fish and Wildlife Service	- -	- -	- -	0.0	- -	0.0	0.0
Departments of Defense and Energy	- -	1.1	1.1	- -	- -	- -	1.1
State and local government							
State	5.9	0.2	6.1	- -	- -	- -	6.1
Private							
Undifferentiated private	18.2	7.1	25.3	- -	- -	- -	25.3
All owners	**330.4**	**22.0**	**352.5**	**218.4**	**7.5**	**225.8**	**578.3**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B26—Average annual mortality of trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by forest-type group and stand-size class,Wyoming, 2011–2015.

	Stand-size class				
Forest-type group	Large diameter	Medium diameter	Small diameter	Nonstocked	All size classes
Pinyon / juniper group	2.4	1.1	0.5	- -	3.9
Douglas-fir group	22.9	5.1	12.9	- -	40.9
Ponderosa pine group	6.0	0.3	0.1	- -	6.4
Fir / spruce / mountain hemlock group	150.4	64.5	68.0	- -	282.9
Lodgepole pine group	47.2	51.5	24.4	- -	123.1
Other western softwoods group	10.6	5.3	14.6	- -	30.5
Oak / hickory group	0.2	0.2	0.4	- -	0.8
Elm / ash / cottonwood group	0.0	- -	0.0	- -	0.0
Aspen / birch group	5.8	6.5	11.9	- -	24.2
Woodland hardwoods group	- -	0.0	- -	- -	0.0
Nonstocked	- -	- -	- -	65.6	65.6
All forest-type groups	**245.4**	**134.4**	**132.9**	**65.6**	**578.3**

All table cells without observations in the inventory sample are indicated by --.
Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet.
Columns and rows may not add to their totals due to rounding.

Table B27—Average annual mortality of trees (at least 5 inches d.b.h./d.r.c.), in million cubic feet, on forest land by species group and ownership group, Wyoming, 2011–2015.

	Ownership group				
Species group	Forest Service	Other Federal	State and local government	Undifferentiated private	All owners
Softwood species groups					
Western softwood species groups					
Douglas-fir	51.2	0.2	0.8	3.0	55.2
Ponderosa and Jeffrey pine	1.5	3.5	2.2	5.3	12.5
True fir	41.6	8.7	1.3	0.1	51.7
Engelmann and other spruces	146.4	3.7	- -	2.7	152.9
Lodgepole pine	175.0	31.3	0.3	3.3	210.0
Other western softwoods	66.5	8.5	0.4	8.9	84.2
Other					
Western woodland softwoods	0.0	0.7	- -	0.6	1.3
All softwoods	482.2	56.7	5.0	23.8	567.8
Hardwood species groups					
Western hardwood species groups					
Cottonwood and aspen	6.5	1.4	1.0	1.2	10.1
Other western hardwoods	0.0	- -	- -	0.3	0.4
Other					
Western woodland hardwoods	0.0	- -	- -	- -	0.0
All hardwoods	6.6	1.4	1.0	1.5	10.5
All species groups	**488.8**	**58.1**	**6.1**	**25.3**	**578.3**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B28—Average annual mortality of growing stock trees (at least 5 inches d.b.h.), in million cubic feet, on timberland by species group and ownership group, Wyoming, 2011–2015.

Species group	Ownership group: Forest Service	Other Federal	State and local government	Undifferentiated private	All owners
Softwood species groups					
Western softwood species groups					
Douglas-fir	21.1	- -	0.8	3.0	24.9
Ponderosa and Jeffrey pine	1.5	1.9	2.2	4.9	10.4
True fir	28.5	3.9	1.3	- -	33.7
Engelmann and other spruces	70.7	0.2	- -	2.6	73.4
Lodgepole pine	132.7	7.2	0.3	0.7	140.9
Other western softwoods	30.2	0.7	0.2	5.9	37.1
All softwoods	284.7	13.8	4.9	17.1	320.4
Hardwood species groups					
Western hardwood species groups					
Cottonwood and aspen	5.7	0.4	1.0	0.2	7.4
Other western hardwoods	0.0	- -	- -	0.2	0.3
All hardwoods	5.7	0.4	1.0	0.5	7.7
All species groups	**290.4**	**14.2**	**5.9**	**17.6**	**328.1**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic feet. Columns and rows may not add to their totals due to rounding.

Table B29—Aboveground dry weight of all live trees (at least 1 inch d.b.h./d.r.c.), in thousand dry short tons, by owner class and forest land status, Wyoming, 2011–2015.

	Unreserved forests			Reserved forests			All
Owner class	**Timberland**	**Unproductive**	**Total**	**Productive**	**Unproductive**	**Total**	**forest land**
Forest Service							
National forest	122,444	5,681	128,125	32,532	1,619	34,152	162,276
National grassland	274	96	370	- -	- -	- -	370
Other Federal							
National Park Service	- -	- -	- -	48,042	1,749	49,791	49,791
Bureau of Land Management	7,061	5,812	12,873	- -	- -	- -	12,873
U.S. Fish and Wildlife Service	- -	- -	- -	33	- -	33	33
Departments of Defense and Energy	- -	41	41	- -	- -	- -	41
Other Federal	- -	- -	- -	- -	34	34	34
State and local government							
State	5,640	954	6,594	- -	- -	- -	6,594
County and Municipal	- -	- -	- -	343	- -	343	343
Private							
Undifferentiated private	19,431	3,748	23,179	- -	- -	- -	23,179
All owners	**154,851**	**16,331**	**171,182**	**80,951**	**3,402**	**84,353**	**255,535**

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates the aboveground tree biomass rounds to less than 1 thousand dry tons. Columns and rows may not add to their totals due to rounding.

Table B30—Aboveground dry weight of all live trees (at least 1 inch d.b.h./d.r.c.), in thousand dry short tons, on forest land by species group and diameter class, Wyoming, 2011–2015.

Species group	Diameter class (inches) 1.0-2.9	3.0-4.9	5.0-6.9	7.0-8.9	9.0-10.9	11.0-12.9	13.0-14.9	15.0-16.9	17.0-18.9	19.0-20.9	21.0-22.9	23.0-24.9	25.0-26.9	27.0-28.9	29.0+	All classes
Softwood species groups																
Western softwood species groups																
Douglas-fir	190	734	1,261	2,398	3,276	3,964	3,834	3,081	3,067	2,550	2,039	1,585	1,079	1,165	863	31,086
Ponderosa and Jeffrey pine	109	455	674	1,858	2,858	3,112	3,673	3,031	2,535	2,087	528	505	334	343	- -	22,102
True fir	1,481	3,569	3,432	5,327	5,901	5,619	4,726	3,750	2,630	1,885	826	807	63	297	219	40,531
Engelmann and other spruces	433	1,049	1,625	2,960	4,299	4,751	5,108	4,550	4,503	4,580	3,177	2,663	3,112	1,742	2,969	47,520
Lodgepole pine	2,930	5,769	9,186	16,236	17,751	13,604	8,442	4,350	2,466	1,539	312	170	220	- -	- -	82,977
Other western softwoods	221	633	1,213	2,052	2,070	1,890	1,019	581	973	544	93	118	- -	174	111	11,690
Other																
Western woodland softwoods	138	286	234	432	586	637	742	679	691	662	645	225	383	68	1,075	7,484
All softwoods	5,502	12,494	17,625	31,263	36,741	33,578	27,544	20,022	16,864	13,848	7,618	6,073	5,191	3,789	5,237	243,390
Hardwood species groups																
Western hardwood species groups																
Cottonwood and aspen	463	794	592	1,595	1,857	1,828	677	543	202	293	113	- -	198	217	810	10,181
Other western hardwoods	93	132	296	336	301	415	187	44	- -	- -	- -	- -	- -	- -	- -	1,804
Other																
Western woodland hardwoods	35	77	17	15	11	4	- -	- -	- -	- -	- -	- -	- -	- -	- -	160
All hardwoods	592	1,003	905	1,946	2,169	2,247	864	587	202	293	113	- -	198	217	810	12,145
All species groups	**6,093**	**13,497**	**18,530**	**33,209**	**38,911**	**35,825**	**28,408**	**20,610**	**17,067**	**14,141**	**7,731**	**6,073**	**5,389**	**4,005**	**6,046**	**255,535**

All table cells without observations in the inventory sample are indicated by --. Table value of 0 indicates the aboveground tree biomass rounds to less than 1 thousand dry tons.
Columns and rows may not add to their totals due to rounding.

Table B31—Area of accessible forest land, in thousand acres, by Forest Survey Unit, county and forest land status, Wyoming, 2011–2015.

Inventory unit and county	Unreserved forests			Reserved forests			All
	Timberland	Unproductive	Total	Productive	Unproductive	Total	forest land
Western							
Fremont	490.4	337.2	827.6	490.4	337.2	827.6	1,000.6
Hot Springs	54.0	94.9	149.0	54.0	94.9	149.0	161.7
Lincoln	664.2	60.1	724.3	664.2	60.1	724.3	736.8
Park	318.5	148.1	466.6	318.5	148.1	466.6	1,922.7
Sublette	476.4	50.3	526.7	476.4	50.3	526.7	720.5
Sweetwater	- -	188.1	188.1	- -	188.1	188.1	188.1
Teton	493.2	11.9	505.0	493.2	11.9	505.0	1,841.9
Uinta	30.9	64.9	95.9	30.9	64.9	95.9	95.9
Total	2,527.5	955.6	3,483.1	2,527.5	955.6	3,483.1	6,668.2
Central and Southeastern							
Albany	440.6	105.9	546.5	- -	- -	- -	546.5
Big Horn	159.5	69.1	228.6	12.9	- -	12.9	241.5
Carbon	599.7	83.1	682.8	48.7	- -	48.7	731.5
Converse	190.1	44.5	234.6	- -	- -	- -	234.6
Goshen	- -	25.1	25.1	- -	- -	- -	25.1
Johnson	323.5	56.8	380.3	36.4	- -	36.4	416.7
Laramie	32.8	- -	32.8	- -	- -	- -	32.8
Natrona	39.5	127.4	166.9	- -	- -	- -	166.9
Niobrara	27.8	12.4	40.2	- -	- -	- -	40.2
Platte	54.3	54.3	108.6	6.8	12.1	18.8	127.4
Sheridan	306.0	38.3	344.2	11.8	- -	11.8	356.0
Washakie	26.3	85.6	111.9	- -	- -	- -	111.9
Total	2,200.1	702.4	2,902.5	116.6	12.1	128.7	3,031.2
Northeastern							
Campbell	76.5	70.4	146.9	- -	- -	- -	146.9
Crook	474.6	35.3	509.9	- -	- -	- -	509.9
Weston	102.1	34.5	136.6	- -	- -	- -	136.6
Total	653.2	140.2	793.4	- -	- -	- -	793.4
All counties	**5,380.8**	**1,798.2**	**7,179.1**	**3,103.1**	**210.6**	**3,313.8**	**10,492.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres. Columns and rows may not add to their totals due to rounding.

Table B32—Area of accessible forest land, in thousand acres, by Forest Survey Unit, county, ownership group and forest land status, Wyoming, 2011–2015.

	Forest Service		Other Federal		State and local government		Undifferentiated private		
Inventory unit and county	Timber-land	Other forest land	Timber-land	Other forest land	Timber-land	Other forest land	Timber-land	Other forest land	All forest land
Western									
Fremont	289.2	271.4	53.9	93.0	3.0	- -	144.3	145.8	1,000.6
Hot Springs	12.7	22.2	- -	40.9	- -	- -	41.3	44.5	161.7
Lincoln	563.1	52.1	76.0	8.8	- -	- -	25.1	11.7	736.8
Park	285.2	741.3	12.1	790.5	18.2	12.0	3.0	60.4	1,922.7
Sublette	436.3	244.1	19.7	- -	- -	- -	20.4	- -	720.5
Sweetwater	- -	- -	- -	164.6	- -	11.8	- -	11.8	188.1
Teton	493.2	479.2	- -	869.4	- -	- -	- -	- -	1,841.9
Uinta	15.5	- -	12.4	27.8	- -	- -	3.1	37.1	95.9
Total	2,095.0	1,810.5	174.1	1,995.1	21.2	23.8	237.2	311.3	6,668.2
Central and Southeastern									
Albany	323.5	29.0	- -	12.0	33.6	39.2	83.5	25.6	546.5
Big Horn	137.3	22.1	- -	40.9	- -	12.9	22.1	6.1	241.5
Carbon	508.0	76.6	54.2	31.9	37.4	11.3	- -	12.1	731.5
Converse	51.9	- -	12.4	- -	29.0	6.2	96.9	38.3	234.6
Goshen	- -	- -	- -	12.5	- -	- -	- -	12.5	25.1
Johnson	186.5	62.9	74.2	30.3	- -	- -	62.9	- -	416.7
Laramie	- -	- -	- -	- -	- -	- -	32.8	- -	32.8
Natrona	- -	- -	15.2	115.3	12.2	- -	12.2	12.2	166.9
Niobrara	- -	- -	- -	- -	- -	- -	27.8	12.4	40.2
Platte	- -	- -	12.1	36.2	6.0	6.8	36.2	30.2	127.4
Sheridan	282.8	23.6	- -	8.8	- -	- -	23.1	17.7	356.0
Washakie	26.3	- -	- -	72.4	- -	13.2	- -	- -	111.9
Total	1,516.4	214.2	168.1	360.3	118.1	89.6	397.5	167.0	3,031.2
Northeastern									
Campbell	3.1	- -	12.2	39.8	12.2	- -	49.0	30.6	146.9
Crook	173.6	- -	- -	- -	64.3	- -	236.7	35.3	509.9
Weston	23.8	12.5	6.3	12.5	34.5	- -	37.6	9.4	136.6
Total	200.4	12.5	18.5	52.3	111.0	- -	323.3	75.3	793.4
All counties	**3,811.8**	**2,037.2**	**360.7**	**2,407.8**	**250.4**	**113.4**	**958.0**	**553.6**	**10,492.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres.
Columns and rows may not add to their totals due to rounding.

Table B33—Area of timberland, in thousand acres, by Forest Survey Unit, county and stand-size class, Wyoming, 2011–2015.

Inventory unit and county		Stand-size class Large diameter	Medium diameter	Small diameter	Nonstocked	All size classes
Western						
	Fremont	163.9	152.3	128.4	45.8	490.4
	Hot Springs	25.4	3.2	22.2	3.2	54.0
	Lincoln	391.4	92.5	156.0	24.3	664.2
	Park	90.9	109.0	94.3	24.2	318.5
	Sublette	221.5	87.9	147.4	19.6	476.4
	Teton	346.8	20.8	91.9	33.7	493.2
	Uinta	- -	18.6	12.4	- -	30.9
	Total	1,240.0	484.1	652.6	150.7	2,527.5
Central and Southeastern						
	Albany	147.4	125.8	121.1	46.3	440.6
	Big Horn	102.7	21.8	34.9	- -	159.5
	Carbon	223.4	228.9	147.4	- -	599.7
	Converse	117.8	10.2	- -	62.1	190.1
	Johnson	173.0	119.1	25.4	6.1	323.5
	Laramie	20.9	- -	- -	11.9	32.8
	Natrona	15.2	- -	9.1	15.2	39.5
	Niobrara	15.5	- -	- -	12.4	27.8
	Platte	15.1	9.0	12.1	18.1	54.3
	Sheridan	149.8	106.0	50.1	- -	306.0
	Washakie	13.2	13.2	- -	- -	26.3
	Total	993.9	634.1	399.9	172.1	2,200.1
Northeastern						
	Campbell	39.8	- -	12.2	24.5	76.5
	Crook	334.0	54.4	63.7	22.5	474.6
	Weston	40.8	52.0	- -	9.4	102.1
	Total	414.5	106.4	76.0	56.4	653.2
All counties		**2,648.5**	**1,224.6**	**1,128.5**	**379.2**	**5,380.8**

All table cells without observations in the inventory sample are indicated by --.
Table value of 0.0 indicates the acres round to less than 0.1 thousand acres.
Columns and rows may not add to their totals due to rounding.

Table B34—Area of timberland, in thousand acres, by Forest Survey Unit, county and stocking class, Wyoming, 2011–2015.

Inventory unit and county		Stocking class of growing-stock trees					
		Nonstocked	Poorly stocked	Moderately stocked	Fully stocked	Over-stocked	All classes
Western							
	Fremont	45.8	163.9	208.9	71.7	- -	490.4
	Hot Springs	3.2	25.4	12.7	12.7	- -	54.0
	Lincoln	24.3	158.6	267.4	205.0	8.8	664.2
	Park	24.2	142.8	100.0	51.5	- -	318.5
	Sweetwater	19.6	130.1	194.0	115.4	17.3	476.4
	Teton	33.7	139.3	219.4	100.8	- -	493.2
	Uinta	- -	27.8	- -	- -	3.1	30.9
	Total	150.7	788.0	1,002.4	557.1	29.2	2,527.5
Central and Southeastern							
	Albany	59.9	175.3	173.0	32.4	- -	440.6
	Big Horn	- -	34.8	47.8	76.9	- -	159.5
	Carbon	- -	128.0	237.2	189.6	44.8	599.7
	Converse	62.1	59.7	37.3	31.0	- -	190.1
	Johnson	6.1	103.4	93.8	108.1	12.1	323.5
	Laramie	11.9	20.9	- -	- -	- -	32.8
	Natrona	15.2	12.2	- -	12.2	- -	39.5
	Niobrara	12.4	12.4	3.1	- -	- -	27.8
	Platte	18.1	27.1	9.0	- -	- -	54.3
	Sheridan	- -	73.6	173.4	58.9	- -	306.0
	Washakie	- -	- -	- -	26.3	- -	26.3
	Total	185.7	647.4	774.6	535.4	56.9	2,200.1
Northeastern							
	Campbell	24.5	39.8	12.2	- -	- -	76.5
	Crook	35.4	134.7	260.3	44.3	- -	474.6
	Weston	9.4	92.7	- -	- -	- -	102.1
	Total	69.2	267.2	272.5	44.3	- -	653.2
All counties		**405.7**	**1,702.6**	**2,049.6**	**1,136.9**	**86.2**	**5,380.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the acres round to less than 0.1 thousand acres.
Columns and rows may not add to their totals due to rounding.

Table B35—Net volume of growing stock trees (at least 5 inches d.b.h.), in million cubic feet, and sawtimber trees, in million board feet (International 1/4 inch rule), on timberland by Forest Survey Unit, county, and major species group, Wyoming, 2011–2015.

Inventory unit and county	Growing stock: Major species group: Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Sawtimber: Major species group: Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species
	(In million cubic feet)					(In million board feet)				
Western										
Fremont	185.5	344.8	2.9	- -	533.1	487.2	1,241.4	6.2	- -	1,734.8
Hot Springs	1.6	35.2	33.0	- -	69.8	5.8	136.3	136.4	- -	278.4
Lincoln	234.0	1,273.9	61.9	- -	1,569.8	781.6	6,240.0	98.9	- -	7,120.5
Park	139.4	156.7	2.4	- -	298.5	282.4	577.5	1.0	- -	860.9
Sublette	177.1	706.4	35.1	- -	918.6	522.8	3,613.2	81.5	- -	4,217.5
Teton	171.5	863.3	25.2	- -	1,060.0	611.1	4,267.9	100.4	- -	4,979.4
Uinta	30.5	1.6	11.6	- -	43.7	19.2	- -	19.0	- -	38.2
Total	939.5	3,381.9	172.0	- -	4,493.4	2,710.0	16,076.3	443.5	- -	19,229.8
Central and Southeastern										
Albany	180.8	190.5	29.2	- -	400.5	447.4	591.6	96.6	- -	1,135.6
Big Horn	148.0	250.7	0.7	- -	399.4	570.1	1,066.8	- -	- -	1,636.9
Carbon	235.6	570.6	138.1	- -	944.3	426.1	2,034.0	410.5	- -	2,870.7
Converse	187.5	12.1	1.0	- -	200.6	668.2	33.5	3.2	- -	704.9
Johnson	564.8	119.4	1.9	- -	686.1	1,483.4	498.4	- -	- -	1,981.8
Laramie	11.1	- -	- -	- -	11.1	21.6	- -	- -	- -	21.6
Natrona	19.2	27.1	0.1	- -	46.4	87.5	111.1	- -	- -	198.5
Niobrara	11.2	- -	- -	- -	11.2	34.9	- -	- -	- -	34.9
Platte	19.2	- -	- -	- -	19.2	31.1	- -	- -	- -	31.1
Sheridan	417.8	168.6	52.5	3.9	642.8	1,178.7	692.5	250.8	1.7	2,123.8
Washakie	2.5	116.4	- -	- -	118.9	9.5	456.1	- -	- -	465.6
Total	1,797.7	1,455.4	223.5	3.9	3,480.5	4,958.5	5,484.0	761.1	1.7	11,205.4
Northeastern										
Campbell	32.7	- -	- -	- -	32.7	119.6	- -	- -	- -	119.6
Crook	625.4	- -	9.5	37.2	672.0	2,839.7	- -	5.0	25.3	2,870.1
Weston	54.3	- -	1.9	- -	56.1	145.5	- -	- -	- -	145.5
Total	712.4	- -	11.4	37.2	760.9	3,104.8	- -	5.0	25.3	3,135.2
All counties	**3,449.6**	**4,837.3**	**406.9**	**41.0**	**8,734.9**	**10,773.4**	**21,560.3**	**1,209.6**	**27.0**	**33,570.4**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic or board feet. Columns and rows may not add to their totals due to rounding.

Table B36—Average annual net growth of growing stock trees (at least 5 inches d.b.h.), in million cubic feet, and sawtimber trees, in million board feet (International 1/4 inch rule), on timberland by Forest Survey Unit, county, and major species group, Wyoming, 2011–2015.

Inventory unit and county	Growing stock					Sawtimber				
	Major species group					Major species group				
	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species	Pine	Other softwoods	Soft hardwoods	Hard hardwoods	All species
	(In million cubic feet)					(In million board feet)				
Western										
Fremont	-23.2	-3.8	0.2	- -	-26.8	-105.7	-9.2	0.2	- -	-114.7
Hot Springs	-2.3	-1.1	0.7	- -	-2.7	-11.7	-4.9	3.0	- -	-13.6
Lincoln	-8.1	10.9	-0.1	- -	2.8	-21.9	77.8	10.1	- -	66.0
Park	-6.4	-14.7	0.0	- -	-21.1	-19.5	-63.7	1.0	- -	-82.2
Sublette	-27.4	0.9	0.3	- -	-26.2	-110.4	22.6	6.7	- -	-81.1
Teton	-21.1	2.7	-0.2	- -	-18.6	-96.6	40.9	0.5	- -	-55.3
Uinta	-3.1	0.1	0.2	- -	-2.8	-8.3	-	0.5	- -	-7.9
Total	-91.7	-5.0	1.2	- -	-95.5	-374.1	63.5	21.9	- -	-288.7
Central and Southeastern										
Albany	-14.7	-26.4	0.4	- -	-40.7	-46.1	-132.0	1.5	- -	-176.7
Big Horn	-0.3	-8.3	-0.1	- -	-8.7	1.1	-36.6	- -	- -	-35.6
Carbon	-33.8	-2.9	-1.9	- -	-38.6	-125.7	10.8	2.2	- -	-112.7
Converse	1.8	0.2	0.0	- -	2.0	8.0	2.8	3.2	- -	14.0
Johnson	4.8	0.6	0.0	- -	5.4	34.5	11.1	- -	- -	45.6
Laramie	-0.9	- -	- -	- -	-0.9	-3.3	- -	- -	- -	-3.3
Natrona	-0.6	0.6	0.0	- -	0.0	-2.4	5.2	- -	- -	2.7
Niobrara	-0.2	- -	- -	- -	-0.2	-0.3	- -	- -	- -	-0.3
Platte	0.3	- -	- -	- -	0.3	2.2	- -	- -	0.0	2.2
Sheridan	4.5	-0.2	0.5	0.1	5.0	32.6	-0.5	2.7	0.1	34.9
Washakie	0.0	1.5	- -	- -	1.6	0.2	6.3	- -	- -	6.5
Total	-39.0	-35.0	-1.1	0.1	-74.9	-99.4	-133.0	9.6	0.1	-222.6
Northeastern										
Campbell	0.1	- -	- -	- -	0.1	4.2	- -	- -	- -	4.2
Crook	11.8	- -	0.4	0.6	12.7	70.5	- -	0.2	2.0	72.6
Weston	1.1	- -	0.1	-	1.1	6.7	- -	0.0	- -	6.7
Total	12.9	- -	0.4	0.6	13.9	81.4	- -	0.2	2.0	83.5
All counties	**-117.7**	**-39.9**	**0.5**	**0.7**	**-156.5**	**-392.1**	**-69.5**	**31.7**	**2.0**	**-427.8**

All table cells without observations in the inventory sample are indicated by --. Table value of 0.0 indicates the volume rounds to less than 0.1 million cubic or board feet. Columns and rows may not add to their totals due to rounding.

Table B37—Sampling errors (percent) by Forest Survey Unit and county for area of timberland, volume, average annual net growth, average annual removals, and average annual mortality on timberland, Wyoming, 2011–2015.

Inventory unit	Forest	Timberland	Growing stock (on timberland)				Sawtimber (on timberland)			
and county	area	area	Volume	Growth	Removals	Mortality	Volume	Growth	Removals	Mortality
Western										
Fremont	5.34	11.79	17.64	29.34	- -	21.62	20.59	31.53	- -	23.90
Hot Springs	24.90	46.60	64.99	99.02	- -	72.71	66.22	94.58	- -	74.46
Lincoln	7.74	8.44	12.15	100.00	- -	20.75	13.09	50.16	- -	24.06
Park	3.27	17.69	26.94	40.32	- -	34.69	31.53	43.73	- -	36.80
Sublette	5.73	10.92	19.58	36.93	- -	22.89	23.83	55.93	- -	26.36
Sweetwater	23.66	- -	- -	- -	- -	- -	- -	- -	- -	- -
Teton	2.88	13.40	18.00	51.38	- -	25.24	19.42	84.20	- -	26.57
Uinta	32.75	57.78	53.25	63.70	- -	58.30	57.10	65.37	- -	60.93
Total	2.08	5.26	7.80	19.98	- -	10.97	9.08	31.19	- -	12.14
Central and Southeastern										
Albany	7.99	9.83	15.02	33.42	- -	28.66	18.92	38.89	- -	32.80
Big Horn	15.16	21.50	26.57	52.38	- -	36.65	28.15	64.39	- -	38.64
Carbon	4.70	6.48	11.06	27.13	- -	16.95	13.82	41.07	- -	19.80
Converse	14.87	16.51	27.02	100.00	- -	55.38	30.64	51.50	- -	44.93
Goshen	70.40	- -	- -	- -	- -	- -	- -	- -	- -	- -
Johnson	10.32	13.72	18.62	47.20	- -	47.27	21.44	45.03	- -	52.18
Laramie	57.81	57.81	69.31	92.21	- -	83.94	77.38	100.00	- -	83.38
Natrona	25.92	53.61	92.10	100.00	- -	100.00	91.28	100.00	- -	100.00
Niobrara	53.36	63.48	68.30	100.00	- -	100.00	78.08	100.00	- -	100.00
Platte	27.23	41.43	51.76	54.84	- -	65.45	59.15	56.15	- -	100.00
Sheridan	7.37	9.62	16.69	52.95	- -	37.42	21.61	42.45	- -	49.35
Washakie	32.29	70.38	71.27	70.90	- -	100.00	74.36	72.30	- -	- -
Total	3.86	4.63	7.37	24.56	- -	13.24	8.96	40.59	- -	15.84
Northeastern										
Campbell	25.97	37.28	59.76	100.00	- -	57.85	66.87	66.16	- -	62.18
Crook	7.14	8.55	14.18	19.16	- -	35.03	17.23	18.77	- -	41.14
Weston	27.40	31.91	36.23	73.82	- -	78.61	45.32	39.77	- -	91.36
Total	8.15	9.08	13.06	18.65	- -	29.02	16.11	16.96	- -	33.95
All counties	1.83	3.30	5.10	17.02	- -	8.37	6.19	30.01	- -	9.60

All table cells without observations in the inventory sample are indicated by --. Sampling errors that exceed 100% are reported as 100%.

Appendix C: Wyoming Forest-Type Groups and Forest Types, With Descriptions and Timber (T) or Woodland (W) Designations

Forest-type groups and forest types are usually named for the predominant species (or group of species) on the condition. In order to determine the forest type, the stocking (site occupancy) of trees is estimated by softwoods and hardwoods. If softwoods predominate, then the forest type will be one of the softwood types and if hardwoods predominate, then the forest type will be one of the hardwood types. Some other special stocking rules apply to individual forest types and are described below.

Associate species are defined as those that regularly form the majority of the non-predominant species stocking of mixed-species conditions. These descriptions are applicable to the current Wyoming inventory. Species importance, including predominance in some cases, will vary for other States or inventory years. When species are listed, they are in decreasing order of overall forest type stocking.

ASPEN/BIRCH GROUP (T)

Aspen

Predominant species: quaking aspen

Associate species: Engelmann spruce, Douglas-fir, ponderosa pine, blue spruce

Other species: Gambel oak, limber pine, Rocky Mountain juniper, subalpine fir, common or two-needle pinyon

DOUGLAS-FIR GROUP (T)

Douglas-fir

Predominant species: Douglas-fir

Associate species: ponderosa pine, quaking aspen, Gambel oak, limber pine, Engelmann spruce

Other species: Rocky Mountain juniper, common or two-needle pinyon, blue spruce

ELM/ASH/COTTONWOOD GROUP (T)

Cottonwood

Predominant species: Plains cottonwood, narrowleaf cottonwood

Associate species: ponderosa pine, boxelder, green ash

Other species: Rocky Mountain juniper, common or two-needle pinyon

Special rules: Stocking of cottonwoods must be at least 50 percent of total stocking.

EXOTIC HARDWOODS GROUP (T)

Other exotic hardwoods

Predominant species: No tree species recorded greater than or equal to 1.0 inches in diameter

Associate species: none identified

Special rules: A "catch-all" type for non-native hardwood species.

FIR/SPRUCE/MOUNTAIN HEMLOCK GROUP (T)

Blue spruce

Predominant species: blue spruce

Associate species: quaking aspen

Other species: Douglas-fir, Engelmann spruce, Gambel oak

Engelmann spruce

Predominant species: Engelmann spruce

Associate species: subalpine fir, Douglas-fir, quaking aspen

Other species: lodgepole pine, limber pine, whitebark pine

Engelmann spruce/subalpine fir

Predominant species: Engelmann spruce, subalpine fir

Associate species: quaking aspen, Douglas-fir, lodgepole pine,

Other species: whitebark pine, limber pine

Special rules: The combined stocking of Engelmann spruce and subalpine fir is predominant. Stocking of both Engelmann spruce and subalpine fir must each be between 5 and 74 percent of the total.

Subalpine fir

Predominant species: subalpine fir

Associate species: Douglas-fir, Engelmann spruce, limber pine, lodgepole pine, whitebark pine

LODGEPOLE PINE

Lodgepole pine

Predominant species: lodgepole pine

Associate species: quaking aspen, subalpine fir, Engelmann spruce, Douglas-fir

Other species: whitebark pine, limber pine

NONSTOCKED

Nonstocked

Predominant species: various, but many nonstocked conditions have no live tree stocking.

Associate species: various, frequently ponderosa pine, Utah juniper, or Rocky Mountain juniper

Other species: seldom more than two species on a condition

Complete species list: Blue spruce, boxelder, bur oak, common or two-needle pine, curlleaf mountain-mahogany, Douglas-fir, Engelmann spruce, Gambel oak, green ash, limber pine, lodgepole pine, narrowleaf cottonwood, paper birch, plains cottonwood, ponderosa pine, quaking aspen, Rocky Mountain juniper, subalpine fir, Utah juniper, whitebark pine

Special rules: Used when all live stocking is less than 10 percent. Implies disturbance, but may be used for sparse stands with no disturbance, especially with woodland species.

OAK/HICKORY GROUP (T)

Other hardwoods

Predominant species: bur oak

Associate species: none

Other species: boxelder, green ash, paper birch

Special rules: A "catch-all" type, typically for species with a limited geographical range.

OTHER WESTERN SOFTWOODS GROUP (T)

Limber pine

Predominant species: limber pine

Associate species: Douglas-fir, ponderosa pine, quaking aspen

Other species: Engelmann spruce, Gambel oak, whitebark pine

PINYON/JUNIPER GROUP (W)

Juniper woodland

Predominant species: Utah juniper, Rocky Mountain juniper

Associate species: limber pine, ponderosa pine, common or two-needle pinyon

Other species: Gambel oak

Pinyon/juniper woodland

Predominant species: common or two-needle pinyon, Utah juniper

Associate species: Rocky Mountain juniper, ponderosa pine, Gambel oak

Other species: Douglas-fir, plains cottonwood

Special rules: Any combination of pinyons and junipers other than Rocky Mountain juniper predominate. Pinyons must be present.

Rocky Mountain juniper

Predominant species: Rocky Mountain juniper

Associate species: common or two-needle pinyon, Gambel oak, ponderosa pine

Other species: Douglas-fir, Utah juniper, limber pine

PONDEROSA PINE GROUP (T)

Ponderosa pine

Predominant species: ponderosa pine

Associate species: Gambel oak, Douglas-fir, common or two-needle pinyon, Rocky Mountain juniper, Utah juniper

Other species: Engelmann spruce, lodgepole pine, limber pine

WOODLAND HARDWOODS GROUP (W)

Deciduous oak woodland

Predominant species: Gambel oak

Associate species: ponderosa pine, Rocky Mountain juniper, Douglas-fir, common or two-needle pinyon

Other species: Utah juniper, quaking aspen, narrowleaf cottonwood, limber pine

Cercocarpus woodland

Predominant species: curlleaf mountain-mahogany

Associate species: Gambel oak

Other species: Rocky Mountain juniper, common or two-needle juniper, Utah juniper

Appendix D: Tree Species Groups and Tree Species Measured in the Wyoming Annual Inventory With Common Name, Scientific Name, and Timber (T) or Woodland (W) Designation

HARDWOODS

Cottonwood and aspen group (T)

Narrowleaf cottonwood (*Populus angustifolia*)

Plains cottonwood (*Populus deltoids*)

Quaking aspen (*Populus tremuloides*)

Other western hardwoods group (T)

Boxelder (*Acer negundo*)

Bur oak (*Quercus macrocarpa*)

Green ash (*Fraxinus pennsylvanica*)

Paper birch (*Betual papyrifera*)

Woodland hardwoods group (W)

Curlleaf mountain-mahogany (*Cercocarpus ledifolius*)

Gambel oak (*Quercus gambelii*)

SOFTWOODS

Douglas-fir group (T)

Douglas-fir (*Pseudotsuga menziesii*)

Engelmann and other spruces group (T)

Blue spruce (*Picea pungens*)

Engelmann spruce (*Picea engelmannii*)

Lodgepole pine (T)

Lodgepole pine (*Pinus contorta*)

Other western softwoods group (T)

Limber pine (*Pinus flexilis*)

Whitebark pine (*Pinus albicaulis*)

Ponderosa and Jeffrey pines group (T)

Ponderosa pine (*Pinus ponderosa*)

True fir group (T)

Subalpine fir (*Abies lasiocarpa*)

Woodland softwoods group (W)

Common or two-needle pinyon (*Pinus edulis*)

Rocky Mountain juniper (*Juniperus scopulorum*)

Utah juniper (*Juniperus osteosperma*)

Appendix E: Volume, Biomass, and Site Index Equation Sources—Wyoming

Volume

Chojnacky (1985) was used for common or two-needle pinyon pine, curlleaf mountain-mahogany, Rocky Mountain juniper, and Utah juniper volume estimation.

Chojnacky (1992) was used for Gambel oak volume estimation.

Edminster et al. (1980) was used for western Wyoming ponderosa pine volume estimation.

Edminster et al. (1982) was used for aspen volume estimation.

Kemp (1956) was used for plains and narrowleaf cottonwood volume estimation.

Myers (1964) was used for lodgepole pine, limber pine, and eastern Wyoming ponderosa pine volume estimation.

Myers and Edminster (1972) was used for blue spruce, Douglas-fir, Engelmann spruce, and subalpine fir volume estimation.

Biomass

Chojnacky (1984) was used for curlleaf mountain-mahogany biomass estimation.

Chojnacky (1992) was used for Gambel oak biomass estimation.

Chojnacky and Moisen (1993) was used for common or two-needle pinyon pine, Rocky Mountain juniper, and Utah juniper biomass estimation.

Van Hooser and Chojnacky (1983) was used for all timber (T) species biomass estimation.

Site Index

Brickell (1970) was used for blue spruce, Douglas-fir, Engelmann spruce, limber pine, lodgepole pine, ponderosa pine, and subalpine fir site index estimation.

Edminster et al. (1985) was used for aspen, and plains and narrowleaf cottonwood site index estimation.

Stage (1966) was used for white fir site index estimation. [Original equations were reformulated by J. Shaw; documentation on file at U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Inventory Monitoring, Ogden, UT.]

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