SYNTHESIS OF INFORMATION ABOUT LIMBER PINE IN THE BLM'S ROCK SPRINGS, KEMMERER, AND PINEDALE FIELD OFFICES, WYOMING

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ABSTRACT

Limber pine (*Pinus flexilis*) is known to grow throughout southwestern Wyoming, in the BLM's Rock Springs, Kemmerer, and Pinedale field offices. As they do in other areas, limber pines trees and woodlands in the area no doubt have considerable aesthetic and biological values. Limber pine has been placed on BLM's sensitive species list because of documented threats from white pine blister rust and bark beetles, and the additional likely threat of increased frequency of drought with changing climate. Substantial information about the effects of blister rust and bark beetles on limber pine east of the Continental Divide in Wyoming shows that the species faces a dire situation there. Less information is available about the species in southwestern Wyoming, and the point of this project was to assemble existing information and determine what it can tell about the situation for limber pine in the three field offices.

Limber pine grows throughout the northern half of the project area and in the Rock Springs Uplift in the south-central part but may be missing from the southwestern corner. It grows over a broad elevation range (5,720 feet to 9,670 feet) and with a number of other tree species, most often with Douglas-fir, subalpine fir, and lodgepole pine. Undergrowths in woodlands with limber pine in the overstory generally contain few plant species; chief among them are common juniper, Utah snowberry, and pinegrass. Most trees are in the range of 5 to 12 inches dbh, and trees larger than 16 inches dbh are rare. Trees 400 + years old are known, but most limber pines seem to have been established since 1850.

Information about the effects of white pine blister rust and bark beetles is somewhat dated, but it shows that blister rust is present throughout forests in the project area and was infecting substantial numbers of trees in some stands as early as a decade ago. Likewise, most of the data that document the proportion of dead trees in plots was collected nearly 20 years ago, but it appears that the ratio of dead to live limber pines has increased in recent years. None of the information collected in this project suggests that the situation for limber pine in the project area is any better than its dire situation east of the Continental Divide.

It appears that vegetation treatments are having little, if any, effect on limber pine in the three field offices. There are, though, several potential sources of additional information about management activities that should be investigated before a firm conclusion can be reached.

Limber pine is a BLM sensitive species that almost certainly faces serious threats in southwestern Wyoming. Guidelines have been developed by the BLM and the US Forest Service for developing management plans to promote the conservation of the species, and these guidelines might help resource specialists and managers in the area design and implement a management plan to benefit limber pine.

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INTRODUCTION

Limber pine (*Pinus flexilis*) is common in the foothills throughout Wyoming and adjoining states, where it forms woodlands with considerable biological and scenic value (Means 2011) The species has been designated a BLM Sensitive Species in Wyoming (Link To BLM's Sensitive Species List For Wyoming), and so the Bureau's management must provide for the maintenance of limber pine and its habitat. This management must be done in a multiple-use framework that can present managers with difficult choices, and their job is made harder by the threats posed to limber pine by diseases, insects, and a changing climate (Means 2011).

Limber pine is on the BLM's Sensitive Species List for Wyoming largely because of the threats it faces from blister rust and bark beetles, and the additional likely threat from more-frequent drought in a changing climate. This designation means that the species should receive particular attention from resource managers.

A substantial body of information has been collected in Wyoming, southern Montana, and northern Colorado east of the Continental Divide to document the severe effects that white pine blister rust (*Cronartium ribicola*) and bark beetles have had, and continue to have, on limber pines (Cleaver *et al.* 2015, Cleaver *et al.* 2017, Kearns *et al.* 2014). Considerably less information is available about limber pine in southwestern Wyoming. The BLM and the Wyoming Natural Diversity Database (WYNDD) entered into a cooperative project to collect information about limber pine (*Pinus flexilis*) in the BLM's Rock Springs, Kemmerer, and Pinedale field offices. The species is known to be at least moderately widely distributed in that area, but information about its distribution and condition seems to be limited and dispersed.

The point of this project is to collect and organize the information that exists about limber pine in the three field offices, to provide managers with answers to these questions:

1) Is current management creating or exacerbating problems for limber pine in southwestern Wyoming?
2) If so, what are those problems? What, if anything, can managers do to minimize them?
3) What management practices might help to maintain populations of limber pine in the area?

This report (i) describes the information relevant to understanding the distribution and condition of limber pine in the project area (the three field offices), (ii) summarizes that information, (iii) suggests possible sources of additional useful information, and (iv) identifies management steps that might be taken to increase the likelihood that limber pine populations will be maintained in the project area.

Digital data showing the distribution of limber pine in the area is being provided separately in a geodatabase.

METHODS

The synthesis by Bob Means (2011) of information about low-elevation limber pine woodlands provides a framework that George Jones (ecologist, Wyoming Natural Diversity Database) and Jim Glennon (botanist, BLM's Rock Springs Field Office) used for organizing their search for information for this project. Jones and Glennon knew, from previous work in the field offices, of an initial body of information, primarily about the distribution of limber pine. Glennon also knew of additional, possibly relevant, information scattered through the BLM's files.

In April, 2019, Jones and Glennon organized a meeting in Rock Springs of people who they thought might have or know of information about limber pine in the project area. The list of attendees and a summary of the discussion at the meeting are presented in Appendix 1. The discussion in the meeting, and subsequent communications among attendees and other people whose names came up in the

meeting[1], brought to light additional potential sources of information that Jones (primarily) investigated during the project. The sources that Jones was unable to finish investigating are identified in this report, and following those possible leads is a logical step to come out of this project.

Jones submitted a request to the Colorado Natural Heritage Program for information about limber pine communities and about the species itself in northwestern Colorado adjoining the project area. The Colorado program has no information in its databases about limber pine. Jones reviewed the web sites of the Utah Conservation Data Center and the Idaho Natural Heritage Program, and determined that neither of them provide the sort of information that might be useful in this project.

Jones also conducted internet searches, in the Web Of Science website and through the Google Scholar search engine, for articles, theses, and reports that might be useful in this project. These searches revealed no sources that had not already come to light.

INFORMATION EXAMINED FOR USE IN THIS PROJECT

LIMBER PINE DISTRIBUTION, VEGETATION, CONDITION

1. Rocky Mountain Herbarium Collections

The Rocky Mountain Herbarium at the University of Wyoming provides digital information about specimens in the Herbarium, including the locations at which they were collected (Link To Rocky Mountain Herbarium site). George Jones downloaded the information for all of the limber pine specimens in Wyoming that have been entered into the database. The imprecision of the location coordinates for some specimens is as great as a mile. Moreover, the geodetic data were known for only half of the locations. (Jones assigned a datum of NAD 83 to all 755 locations.) Consequently, these records can be used to show the distribution of limber pine only at fairly small geographic scale.

Jones used a shapefile of the boundaries of the three BLM field offices to clip the 180 limber pine records from the project area. The earliest collection record is 1949, most specimens (156 of the 180) were collected in the 1990s, and 8 were collected after 2000 (Table 1). The latest collection in the Herbarium's database dates from 2009. (Additional specimens may have been collected since then but not yet entered into the Herbarium.) This shapefile is being provided in RM Limber Pine Collections.zip (see Appendix 4).

The collections were made by 20 different people, many of whom probably were collecting opportunistically, so these data do not represent a systematic sampling of the project area.

2. USFS Forest Inventory and Analysis Plots

This information is from the Forest Inventory and Analysis web site (Link To FIA Web Site) and Burrill *et al.* 2018 (see references in this document).

Forest Inventory and Analysis (FIA) is a nationwide program of the U.S. Forest Service designed to determine the extent, condition, volume, growth, and use of timber on the Nation's forest land. The FIA was created to meet a legislative mandate for a single inventory program to include all forested lands in the U.S., regardless of ownership or availability for forest harvesting. FIA uses a uniform sampling design to collect information about species composition, structural attributes, environmental attributes, disturbance, and other features. Sampling points are located in a randomized manner on lands regardless of ownership.

Data are collected annually from a subset of the points in different areas of the country. During some inventories, ground plot data have been collected on timberland only. FIA defines timberland as nonreserved forest land capable of producing at least 20 cubic feet of wood volume per acre per year.

[1] These people and others contacted during the project are listed in Appendix 2. Individuals Contacted During the Project..

Thus, low productivity forest land, reserved lands (areas reserved from timber harvesting), and nonforested areas may not be ground-sampled.

G Jones downloaded plots for Wyoming from the FIA Database (Link To FIA Download Site) on June 10 and 12, 2019. This download includes data collected through 2017. Data collected in 2018 were made available on 7/26/2019 and were not used in this project.

The sample points in the project area were clipped from a shapefile of all Wyoming sample points, with a shapefile of the boundaries of the three BLM field offices used as the clipping layer. For plots that had been sampled in more than one year, the records from the earlier years were deleted, so that the file contained the most recently collected data for each of 2,791 plots. These data had been collected from 1984 through 2017. All but 15 of the plots were sampled using the current standard plot design, which covers a total area of 1 acre (4,047 square meters); four sub-plots covering a total of 0.17 acre (688 square meters) are used for measuring trees $\geq$ 5" dbh, and four microplots covering a total of 0.013 acre (approximately 53 square meters) are used for measuring trees < 5" dbh and undergrowth plants. The data include calculations by the FIA program of tree densities and percent ground cover suitable for each type of plot design.

Trees were documented in 960 of the plots, in the mountains in the northern half of the area and in the far-southern part (Figure 1). Limber pine was recorded in 115 of the plots in or near the Wyoming, Wind River, Gros Ventre, and Teton mountain ranges. The data from the 115 plots with limber pine span the range of inventory years from 2000 to 2017, but 70% of the plots were sampled before 2012 (Table 2).

The shapefile of the plots in the project area is being provided in USFS FIA Plots.zip (see Appendix 4).

3. USFS WPBR Plots

Dr. Kelly Burns, US Forest Service Forest Pathologist, in May 2019 provided George Jones with a shape file of locations in Wyoming of plots sampled as part of the Forest Service's and BLM's research on white pine blister rust (*Cronartium ribicola*). The plots have been sampled in the course of several studies, all aimed at elucidating the distribution and effects of the rust in Wyoming forests.

Jones used a shape file of the 3 BLM field offices to clip out the 32 plots that lie within the project area (Table 3). The data from these plots is dated: 20 were last sampled in 1997, 11 in 2002, and 1 in 2013. In nearly all plots, the five-needle pine present was whitebark pine (*Pinus albicaulis*); limber pine grew in only three plots. The information from these plots, though, is relevant to understanding the condition of limber pine, as explained below.

This shapefile of the plots in the project area is being provided in USFS Blister Rust Plots.zip (see Appendix 4).

4. Plots From WYNDD Survey Of Aspen Woodlands

As part of a study of aspen woodlands in the Rock Springs Field Office (Jones 2015), WYNDD documented the presence of limber pine at 19 locations in 2008 and 2012. These sampling points were intentionally located to lie in aspen stands and do not constitute a systematic or randomized sample. Trees were sampled with belt transects, the length and width of which differed from plot to plot. The largest area sampled was 900 square meters. The dimensions of the transects were chosen based on the density of aspen trees; the transects in sparse stands were longer and wider than those in dense stands. This sampling method probably missed the rare trees in the plots and so the data have limitations for drawing conclusions about tree species other than aspen, including limber pine.

The locations of these plots is being provided in WYNDD Aspen Plots.zip (see Appendix 4).

5. USFS National Insect and Disease Risk Map (NIDRM) Tree Distribution Grid

The U.S. Forest Service's Forest Health Technology Enterprise Team (FHTET) developed raster layers that predict the distribution of trees in the U.S., to support the 2013-2027 National Insect and Disease Forest Risk Assessment (Krist *et al.* 2014; and the National Individual Tree Species Atlas

(Ellenwood *et. al* 2015). For each species, there are two layers for trees ≥ 1" diameter, one showing basal area (BA, square feet/acre) and the other showing stand density index (SDI, trees/acre expressed as equivalent 10-inch diameter trees), both at 240 meters resolution (240-meter pixels).

The layers were produced with CART statistical models that predict tree basal area and density across the landscape (Krist *et al.* 2014). The models use the relationships of tree basal area and density to environmental features (slope, elevation, soil type), known from Forest Inventory and Analysis plots. Because the FIA data used in the model was for trees ≥ 1" diameter, the layers contain no information about tree seedlings. Furthermore, because the minimum basal area that can be measured on an FIA sub-plot is 1.7 square feet/acre of trees over one inch dbh, a single pixel in the raster cannot show the presence of trees if their basal area is < 1.7 square feet/acre.

George Jones downloaded the nation-wide BA and SDI rasters for limber pine from Link To NIDRM Tree Parameter Maps and then extracted the portion of each layer in the project area, using the shape file of the three field offices as a mask. This raster and its associated files are being provided in the folder "NIDRM Limber Pine Tree Grid" (see Appendix 4).

6. 1996 Wyoming Gap Analysis Project Landcover Layer

The 1996 Wyoming Gap Analysis Project (Merrill, Kohley, *et al.* 1996) compared the distributions of animals in Wyoming to the degree of protection afforded by different categories of land ownership. A layer of landcover-types was produced to help in modeling the animal distributions. The landcover layer consists of polygons digitized by an observer on a background of satellite imagery; because the polygons are based on the observer's interpretation of the satellite imagery, the layer should be considered a model. The attributes of each polygon include a primary landcover-type and a secondary landcover-type, and some are also assigned an "Other" type. For upland landcover-types, the minimum mapping unit (that is, the smallest polygon) is 100 hectares (2.47 acres).

The classification scheme used for the landcover map includes 41 types, one of which is *Limber Pine Woodland And Scrub* (Merrill, Driese, *et al.* 1996). This landcover-type is defined as:

> "Forest or woodland dominated by limber pine. This type includes the range of types from closed canopy forest dominated by limber pine to open limber pine woodland where trees constitute more than 25% of the total vegetative cover."

The 25% canopy threshold means that vegetation in which limber pine grows but contributes <25% of the canopy cover is classified as a different landcover-type. For example, shrub stands of Wyoming big sagebrush or mountain big sagebrush with 10% canopy cover of limber pine are classified as the Wyoming big sagebrush or the Mountain big sagebrush landcover-types.

A shape file of the project area (composed of the BLM's Rock Spring, Kemmerer, and Pinedale field offices) was used to clip the polygons from the the GAP's state-wide landcover layer. The areas of the polygons in the project area were re-calculated after the layer was clipped. This shapefile is being provided in 1996 Wyo GAP Polygons.zip (see Appendix 4).

The GAP layer predicts the distribution of limber pine woodlands, not the tree species itself.

7. Landfire Existing Vegetation Type layer

LANDFIRE, the Landscape Fire and Resource Management Planning Tools, is a shared program between the wildland fire management programs of the U.S. Department of Agriculture Forest Service and U.S. Department of the Interior, providing landscape scale geo-spatial products (Link To LANDFIRE Program Background Information). One of these products is a raster dataset showing existing vegetation types, using the classification scheme of ecological systems. Each terrestrial ecological system is a group of plant associations that tend to co-occur within landscapes with similar ecological processes, substrates, and/or environmental gradients. One ecological system is the Rocky Mountain Foothill Limber Pine-Juniper Woodland.

The raster layer was created with a classification and regression tree model that predicts which ecological system occurs in each pixel of satellite images. The model uses the relationships of ecological systems to biophysical variables known from a large set of vegetation plots, and digital layers of those biophysical variables.

G Jones downloaded the raster of existing vegetation types (LF Remap, version 2.0.0) on September 11, from Link To LANDFIRE Data Download Page. The portion of that raster in the project area was extracted with the shapefile of the three field office boundaries as the mask. The pixels for the Rocky Mountain Foothill Limber Pine - Juniper Ecological System were extracted to a new raster, and the pixels from this raster were aggregated to make a layer that can be seen on maps.

The Landfire raster layer is a prediction of the distribution of woodland vegetation in which limber pine may be a dominant species. Like the 1996 Wyoming Gap landcover layer, it does not predict the distribution of limber pine itself. The raster and associated files are being provded in the folder "Landfire Ecological System raster" (see Appendix 4).

8. BLM Timber Polygons

A GIS layer of 32 polygons in the Wind River foothills was provided as a geodatabase by Joshua Jackson, Forestry Program Lead in the state office; and as a shapefile by Trent Bristol, Forester in the Kemmerer Field Office. Neither knew who made the layer or when it was made, and there seem to be no metadata associated with the layer. Six of the 24 attributes of the polygons are timber-related.

This shapefile is being provided in BLM Timber Polygons.zip (see Appendix 4).

9. Rock Springs Field Office vegetation geodatabase

This geodatabase, "RSFO 2004 Vegetation.mdb", contains polygon feature classes for 25 vegetation types. The metadata, dated 3/14/2005, explains that the geodatabase was developed by Richard Adams, GIS Specialist in the Rock Springs Field Office, to provide basic vegetation information within the Rock Springs Field Office; and that the feature classes were were produced by supervised classification of Landsat MS data based on ground-truthed observations. An on-line linkage address in the metadata, "file://wyrs6nas1/gis/Vegetation/RSFO%202004%20Vegetation.mdb", apparently is out of date.

Limber pine is not included in the names of any of the feature classes (i.e., vegetation types), and the metadata for the feature classes contains no information about the species composition or other vegetation features. It seems that this geodatabase contains no useful information about limber pine, and we include it here simply to show that we examined it.

LIMBER PINE AGE

10. USGS Tree Cores

In 2011, Dr. Patrick Anderson (Ecologist, USGS Fort Collins Science Center) had a technician collect cores from limber pines near Superior in the eastern part of the project area, then estimate (from ring counts) the trees' establishment dates. Anderson provided those dates for seven of the trees.

11. Climate Reconstruction Tree Core

Dr. Steve Gray is a USGS scientist formerly at the University of Wyoming who has used dendrochronology data from limber pines to reconstruct climate in the area. He provided the location coordinates of a limber pine on the Louis Lake Road on the Shoshone National Forest in the southern Wind River Range, 5.1 km (3.2 miles) east of the eastern boundary of the project area, with an estimated establishment date of 1017.

MANAGEMENT ACTIVITIES

12. Digital Layer of Vegetation Treatments

Troy Fieseler, Wyoming Game and Fish Department Wildlife Biologist in the Green River Region, provided a shape file of polygons in the central part of the project area, within which various vegetation treatments have been applied from 2014 through 2019. This shapefile is being provided in Wyo Range Vegetation Treatments.zip (see Appendix 4).

SUMMARY OF INFORMATION ABOUT LIMBER PINE IN THE PROJECT AREA

GEOGRAPHIC DISTRIBUTION

The Rocky Mountain Herbarium records show the widest distribution of limber pine and document the tree's presence throughout most of the project area. The majority of records are from the northern half of the area, but significant numbers are from the southern Wyoming Range in Lincoln County and from the Rock Springs Uplift in central Sweetwater County (Figure 2). The absence of collections from a substantial part of the project area comprising western Sweetwater County, far-southern Lincoln County, and Uinta County may indicate that limber pine is very rare or absent there. Botanists have been there, as shown by collection records for other plant species, and it's reasonable to assume that some of them would have collected limber pine if they encountered it. But absence of collection records is highly ambiguous; botanists often focus their efforts on species that interest them for some reason and ignore the common species. Unless it's clear that a botanist was collecting as part of a systematic survey of the flora (and that is not clear in this case), the absence of records for a particular species should not be used as reliable evidence that the species is absent.

The FIA plots also indicate that limber pine is most common in the northern half of the project area (Figure 1). This dataset shows a more limited distribution than do the herbarium records, though; note especially the absence of limber pine from the Rock Springs Uplift, the BLM-managed lands in the upper Green River Basin, and the southern end of the Wyoming Range. Because the FIA plots are located randomly, there is some likelihood that a plot in an area of scattered limber pines will fail to document the tree's presence.

The two small remaining plot datasets contribute no additional understanding of limber pine's distribution in the project area. Of the 19 WYNDD plots, all but one are in the foothills of the Wind River Mountains or in the nearby Prospect and Little Prospect mountains (Figure 3), where many of the herbarium specimens were collected. The southernmost WYNDD plot, at Steamboat Mountain, also is near the locations of herbarium specimens. Of the Forest Service white pine blister rust plots, only three have limber pine and all are within the distribution documented from the other datasets (Figure 4).

The four remaining information sources are predictive layers, produced from interpretation of satellite imagery combined (in 2 cases) with statistical modeling. Only one, the Forest Service NIDRM raster, predicts the distribution of limber pine trees, in contrast to vegetation types or parameters. The model that produced that raster used data from the FIA plots, and the raster indicates a distribution very similar to that from the FIA plots (Figure 5): limber pine is shown in the mountainous northern half of the project area, especially along the foot of the Wind River Mountains and in the Wyoming Range. Areas where limber pine is known at the southern end of the Wyoming Range, the periphery of upper Green River Basin, and the Rock Spring Uplift are not predicted to support at basal area of limber pine > 1.7 square feet/acre, possibly because the environment in those places is outside the environmental range covered by the FIA plots in which limber pine was recorded.

The BLM's timber layer is the most limited of the predictive or interpreted layers. It maps 32 polygons in the southern Wind River foothills that contain limber pine in the sawtimber size-class (Figure 6). Limber pine has been thoroughly documented in that area by the herbarium collections and the plot datasets.

The 1996 Wyoming GAP landcover layer maps limber pine woodlands widely throughout the southern part of the project area (Figure 7). Limber pine woodland is the primary cover-type in polygons

in the Wyoming Range, the Prospect Mountains on the Fremont - Sublette county line near the Wind River Mountains, and in the Kinney Rim - Sand Butte area in the southeast. Limber pine woodland is most common as a secondary type (Table 4), in the Wyoming Range, the Kemmerer area, the Steamboat Mountain - Jack Morrow Hills area, the South Pass area, Kinney Rim, and the Little Mountain area. Polygons with limber pine woodland as another type are widespread, occurring in the Wyoming Range, the foothills of the Wind River Mountains, the Little Mountain area, and in Jackson Hole.

The only substantial addition that the GAP landcover layer suggests to the distribution known from the plot datasets is in the far-southern Wyoming Range west and southwest of Kemmerer. The four GAP polygons there have not been checked on the ground to confirm the mapping of limber pine woodland. The GAP layer also indicates a smaller additional area of limber pine woodland not shown by the plot datasets, in the Kinney Rim - Pine Butte - Sand Butte area in southern Sweetwater County (on the edge of the project area). There are four polygons there as well, none of which have been checked on the ground. Of the 66 polygons in the GAP layer, only 16 have been checked on the ground to confirm the nature of the landcover, so this distribution is based almost entirely on interpretation of satellite images and aerial photographs.

The fourth information source about the possible distribution of limber pine is the Landfire raster layer of existing vegetation types, represented by ecological systems. Landfire maps the Rocky Mountain Foothill Limber Pine - Juniper Ecological System throughout the project area, but only in the far southern end is it projected to occupy a substantial part of the landscape (Figure 8). This ecological system consists of woodland that may be dominated by limber pine, Utah juniper (*Juniperus osteosperma*), or Rocky Mountain juniper (*J. scopulorum*). Thus the Landfire layer shows the area in which the model used to produce the raster predicts the occurrence of woodland in which limber pine may be common.

The Limber Pine - Juniper ecological system is predicted to be most common in Little Mountain area east of Flaming Gorge and south of Rock Springs (Figure 8). The 1996 GAP layer shows some limber pine woodland there, but that layer maps most of the area as juniper woodland (Figure 7). The Rocky Mountain Herbarium database documents the presence of limber pine in that area (Figure 2). The Landfire layer suggests an addition to the distribution of limber pine known from the herbarium records and plot datasets only in the southwestern corner of the project area, on the west side of Flaming Gorge Reservoir and in the hills north of Evanston (Figure 8). Those areas are also mapped by the 1996 GAP layer as juniper woodland, but not as limber pine woodland (Figure 7).

Summary of Geographic Distribution

The information sources that we found show that limber pine is widely distributed in the project area. The Rocky Mountain Herbarium records and the plot datasets indicate that it is most common in the northern half of the area, with many records from BLM-managed lands in an east-to-west band across the middle of the area. The herbarium specimens show that its distribution extends south on the Rock Springs Uplift. The predictive layers of limber pine vegetation (the 1996 Wyoming GAP layer and the Landfire existing vegetation-type layer) suggest that limber pine also grows across the southern half of the area, but these layers apparently have not been ground-truthed.

Elevation Range

The two primary sources of on-the-ground information, the Rocky Mountain Herbarium collections and the FIA plot data, can be used to show the elevation range over which limber pine grows in the project area. The 180 herbarium specimens span the range from 5,720 feet to 9,670 feet. The 115 FIA plots with limber pine lie within that range, from 6,680 feet to 9,660 feet. The plots with limber pine from the other two plot datasets also are within this range, with elevations from 8,105 feet to 8,484 feet for the three US Forest Service white pine blister rust plots and from 7,656 feet to 8,436 feet for the 19 WYNDD plots.

The FIA plots with trees other than limber pine occupy essentially the elevation range of limber pine (Figure 9), indicating that limber pine grows at the same elevation as do other tree species. The large number of FIA plots without trees occupies a very wide elevation range in the project area (Figure 9).

TREE SIZE & AGE

SIZE

The FIA plots provide most of the data on tree size. Diameter was measured on 509 trees in 88 of the plots. Two-thirds of the trees were 5 to 12 inches in diameter. Approximately 1/3 of the trees were 5 to 8 inches in diameter, and another third were 8 to 12 inches (Figure 10). Very few trees (only 6%) were larger than 16" dbh. Approximately 10% of the trees were 1 - 5" dbh, but the data likely are skewed against these smaller trees because they are counted in a smaller area of the sample plots (in the microplots) than are the larger trees (which are counted in the sub-plots).

The WYNDD aspen project provides a bit more information about size of limber pine. In the 19 plots that contained limber pines, seedlings (< breast height, or 4.5 feet tall) accounted for over half of the pines, and saplings (< 2 m tall) were the second-most abundant size (Figure 11). Among trees $\geq$ 1" dbh, the larger the trees, the fewer their number. This appears to differ from the size-class distribution of limber pine trees in the FIA plots (Figure 10), but the small number of limber pines sampled in the aspen project plots prevents the drawing of firm conclusions.

AGE

We found a limited amount of information about ages of limber pines in the project area. The U.S. Forest Service FIA plot dataset includes ages, determined from counts of rings in cores, for 137 live limber pines $\geq$ 5" dbh. (Only trees at least 5" dbh are included in this analysis because they are sampled in the sub-plots of the FIA standard plot design, while trees < 5" dbh are sampled in the smaller microplots.) The oldest tree documented in the FIA plots was established in 1604 (Figure 12). None of the trees were established in the century from 1626 to 1725, then trees were established in every 25-year period through 1975. (Data for trees established after 1975 are excluded because many trees that young likely are smaller than 5" dbh and including the data would present a misleading picture.) The gradual decline in the number of trees established before 1950 probably results from the greater likelihood of trees dying as they age. The decline after 1951 may reflect a substantial number of trees < 5" dbh.

Patrick Anderson (Ecologist, USGS Fort Collins Science Center) provided us with ages of seven limber pines growing east of Superior, in the eastern part of the project area. These ages were determined from counts of rings in cores collected in 2011. Six of these trees were established before 1726 (Figure 12), suggesting that they were selected for their large size.

Stephen Gray, (Director, Alaska Climate Adaptation Science Center, pers. comm.) reports a limber pine on the Louis Lake Road on the Shoshone National Forest in the southern Wind River Range, 5.1 km (3.2 miles) east of the eastern boundary of the project area, with an estimated establishment date of 1017. The date was determined by ring counts. This tree was cored specifically because its large size and the site in which it grew suggested that it would provide a long chronology suitable for climate reconstruction. Gray reports that this tree succumbed to bark beetle attack. It seems reasonable to assume that trees of this age can be found on similar sites within the project area.

CONDITION

USFS FIA Plots

The FIA data include several types of information that reflect the condition of limber pine trees: numbers of live vs. dead trees, cause of death, and damage to live trees. Data collected in the first three sampling years showed a low proportion of dead trees (Figure 13). In later years, fewer plots were sampled and trees tallied, but the data suggest that by 2015, many of the limber pines were dead.

The cause of death was recorded for a smaller number of trees (99 dead limber pines) (Table 5). Three-quarters of the trees had been killed insects, most of which were not identified. Fire was the second-leading cause of death. These results contrast with those presented by Cleaver *et al.* (2015) from

their extensive study of limber pines in central and eastern Wyoming, where bark beetles were the dominant cause of death.

Causes or signs of damage on living trees were recorded for 331 live limber pines in the FIA plots (Table 6). Slightly more than a quarter of the trees were not seriously damaged. On the subset of 23 trees for which the cause of damage was noted, most were affected by stem rusts, stem and butt rot, or suppression by other trees. The most obvious feature of these FIA data are the large numbers of limber pines with forked or misshapen trunks (excessive crook, sweep, or taper); the FIA data thus document the remarkable and well-known windblown, gnarled shapes of limber pines.

When these FIA data are compared to those from the extensive survey by Cleaver *et al.* (2015) of limber pines east of the Continental Divide, they might seem to show that limber pines in the project area suffer remarkably little from blister rust and bark beetles. But note the age of these data: 67% of the plots in which they were gathered, and 81% of the trees on which they were recorded, were sampled 2 decades ago. In contrast, the data presented by Cleaver *et al.* were collected in 2011 and 2012, and they showed substantial increases in damage and death from blister rust and (especially) bark beetles since an earlier survey done from 2002 to 2004.

USFS WPBR Plots

Even as long ago as 1997, white pine blister rust (*Cronartium ribicola*) was widespread in 5-needle pines in the northern part of the project area (Figure 4). The data from that year suggested that rust had not infected trees in the Wind River Mountains. Since then, though, rust has reached those mountains, as shown by the sampling in 2002 and 2013. These data also show that incidence of blister rust in five-needle pines (the percentage of pines infected in a plot) was high early as 1997. In nine of 20 plots, at least one-third of trees were infected; and in six plots, over half of the trees were infected (Table 7).

This documentation by the USFS researchers that blister rust is common throughout the mountainous parts of the project area contrasts with the picture suggested by the data from the FIA plots, that rusts are rare (the FIA data show stem rusts in only 6 of 331 trees). The reasons for the discrepancy are unclear. The white pine blister rust data are roughly contemporaneous with the FIA data so it's unlikely that the former dataset represents a later stage in the spread of the rust. This blister rust dataset was collected from several studies (Table 7) that were focused on identifying rust, so perhaps the researchers collecting these data were more likely than the FIA field crews to recognize infected trees. There is no reason to reject the conclusion from the blister rust dataset that rust is widespread and common among the five-needle pines in the project area.

Data in the blister rust dataset were collected mainly from mid- and high-elevation plots (23 of 32 plots are at elevations > 8.500 feet) in which whitebark pine is the five-needle pine (Table 7). Only three of the plots contained limber pine. Nevertheless, the results are relevant to limber pine throughout the project area because they show that white pine blister rust is widely available to infect limber pines. The species is known to be readily susceptible to infection, and survey of limber pine stands east of the Continental Divide in Wyoming and nearby parts of Colorado and Montana, at elevations of 6,455 feet to 10,719 feet, has shown widespread occurrence and high incidence (Cleaver *et al.* 2015). Consequently, although only limited data have been collected from limber pine in the project area, there can be little doubt that the species is being affected by white pine blister rust.

WYNDD Aspen Survey Project Plots

The great majority of limber pines in these 19 plots, of all sizes, were alive at the time of sampling in 2008 or 2012 (Figure 11). This is substantially the same situation as documented in the FIA plots sampled during the same period (Figure 13).

VEGETATION

Associated Tree Species

The data about the composition of the vegetation in which limber pine grows are largely from the USFS FIA plots. Ten species of trees were documented growing with limber pine in the FIA plots (Table 8). Douglas-fir most often occurred with limber pine, in over half of the 88 plots. Subalpine fir and lodgepole pine were the second- and third-most common tree species in plots with limber pine, each growing in over 40% of the plots. Engelmann spruce grew with limber pine in over 1/5 of all plots. Quaking aspen was the only other tree that grew in > 10% of the plots with limber pine.

A smaller dataset comes from the WYNDD aspen survey project. Plots in that project were sampled only in stands where aspen grew and so the data come from a smaller variety of woodlands and forests. Limber pine grew in 19 sample plots (Table 9). Four additional trees species grew in the plots, and three of them (lodgepole pine, Douglas-fir, and Rocky Mountain juniper) also occurred with limber pine in the FIA plots. The fourth species, Scouler willow, is (like mountain mahogany in the FIA plots) usually considered a tall shrub. Note that the sampling method used in this project was not designed to find all of the tree species growing in a stand, so these data cannot be used as a basis for rigorous conclusions about the association between limber pine and other tree species.

Undergrowth

129 taxa of forbs, graminoids, low shrubs, and tree seedlings were recorded in the undergrowths of 48 FIA plots in the project area (Table 10). (The FIA protocol does not include recording all undergrowth plants, but rather recording up to 4 taxa in growth-form in each layer of the undergrowth and estimating their percent canopy cover, so this dataset does not constitute a complete inventory of undergrowth plants.) The data suggest that, in general, limber pine stands have rather open undergrowths (average canopy cover of 40%, not accounting for overlapping canopies) with few taxa (average of 8 recorded per plot). Twenty-six of the plant taxa were recorded in at least 10% of the FIA plots (Table 11). Tree seedlings contributed substantial amounts of the canopy cover. Other taxa that contribute substantial cover, on average, are pinegrass, grouse whortleberry, and fireweed.

The most common shrubs, graminoids, and forbs were noted in the undergrowth of the 19 WYNDD aspen survey plots (Table 12). Twenty-two taxa were recorded in 2 or more ($\geq$ 10%) of the plots: 6 shrubs, 8 graminoids, and 8 forbs. Only five taxa were recorded in at least half of the plots: the shrubs Common juniper and Utah snowberry; the graminoids Ross's sedge and Idaho fescue; and a single forb, Lupine. Only 6 of the common taxa in these plots were also recorded as common undergrowth taxa in the FIA plots, suggesting that these plots encompass quite a different range in environments than do the FIA plots.

HABITAT VALUE

We found no useful information about the value of limber pine or limber pine-dominated vegetation, specifically, as habitat for wildlife. Andrea Orabona, the Wyoming Game and Fish Department's Nongame Bird Biologist, suggested reviewing two documents, the Wyoming 2017 State Wildlife Action Plan (Wyoming Game and Fish Department, 2017) and the 2003 Wyoming Bird Conservation Plan (Nicholoff 2003). In the State Wildlife Action Plan, limber pine woodlands are included with Ponderosa pine woodlands in Xeric And Lower Montane Forests. The discussion of these forests includes a list of the species found in them, but the species found in limber pine woodlands specifically cannot be identified. Similarly, in the 2003 Bird Conservation Plan, limber pine woodlands are included in the Forest Habitat Group, Low Elevation Conifer type. The discussion of those low-elevation types concentrates on Ponderosa pine and Doug-fir woodlands and barely mentions limber pine.

MANAGEMENT PRACTICES

We discovered no information suggesting that management practices, specifically vegetation treatments, on BLM-managed lands in the project area have significantly affected limber pines. The polygon layer provided by Troy Fieseler shows that tree cutting and prescribed fire have been used in aspen and shrub communities in the foothills of the southern Wyoming Range (Figure 14) in part to

remove conifers. Limber pine is present in these areas but it seems to encroach very little into the aspen and shrub communities that are the targets of these treatments (Fieseler, pers. comm. to Jones). Moreover, the 104 polygons in which the treatments might affect limber pines (Table 13) account for only 3,916 acres of the project area.

Comments were made during our April 24th, 2019 meeting that vegetation treatments of this type are not being conducted in the western foothills of the Wind River Range.

Also at the April 2019 meeting, Trent Bristol, BLM Forester in the Kemmerer Field Office, explained that five-needle pines are not removed during fuel reduction treatments on BLM-managed lands.

We made inquiries with other agency employees in the project area about vegetation treatments but received no additional information.

POSSIBLE SOURCES OF ADDITIONAL INFORMATION

These possible sources of additional information came to light during the project. Jones was unable to finish investigating them and they merit further attention.

1. 2019 PLANNED WALK-THROUGH EXAM OF STANDS IN THE KEMMERER FIELD OFFICE

Trent Bristol, BLM Forester in the Kemmerer Field Office, mentioned at the April 24th meeting that a walk-through exam of stands known or thought to contain five-needle pines (limber pine or whitebark pine) would be conducted during the 2019 field season. This exam would include, at the least, documentation of the presence of five-needle pines.

2. 2018 CONTRACT WALKTHROUGH INVENTORY OF STANDS IN THE KEMMERER FIELD OFFICE

On August 1, 2018, a contract opportunity was posted on the FedConnect® web site (the U.S. Government's acquisition and grants portal, Link To FedConnect Web Site) for an inventory of 14 stands in the Kemmerer Field Office:

- Opportunity Description: KFO WHITEBARK PINE WALKTHROUGH INVENTORY AND DATA COLLECTION
- Opportunity Reference Number: 140L6218Q0074
- Opportunity Issue Date: 08/01/2018
- Contracting Office: BLM Wyoming State Office, Cheyenne
- Period of Performance: 09/01/2018 to 11/01/2018

No mention was made at the April 24th meeting or afterward of information from an inventory conducted in 2018, so it's unclear whether a contract was awarded and any inventory conducted. An inquiry to the contracting officer in the BLM's State Office (see Appendix 3) or to Trent Bristol in the Kemmerer Field Office is in order.

3. 2019 PLANNED FOREST INVENTORY ON PINE MOUNTAIN IN THE ROCK SPRINGS FIELD OFFICE

This inventory also was mentioned by Trent Bristol at the April 24th meeting. The inventory was planned for late summer of 2019, and the information to be collected included tree species composition and, probably, also age class, timber volume, and tree spacing. If the inventory was conducted, the information from it may show whether limber pine is present in the Pine Mountain area. A follow-up inquiry to Bristol is in order.

4. Soil-Vegetation Inventory Method (SVIM) data from southwestern Wyoming

Jim Glennon, at the April 24th meeting, suggested that the BLM's SVIM data for southeastern Wyoming might contain information about limber pine. The location and availability of these data have not been investigated and a follow-up conversation with Glennon is in order.

5. Map of five-needle pines in the Rock Springs, Kemmerer, and Pinedale field offices

This is another potential source of information mentioned by Jim Glennon at the April 24th meetings. No further information came to light during the project and a follow-up inquiry to Glennon is in order.

6. Rock Spring Field Office timber map from the 1990s

Jim Glennon suggested at the April 24th meeting that the BLM has a map of timber resources in the three field offices dating from the 1990s. No further information about the map has come to light and a follow-up conversation with Glennon is in order.

7. Fuel reduction treatments

At the April 24th meeting, Trent Bristol (Forester, Kemmerer Field Office) explained that five-needle pines are not removed during fuel-reduction treatments on BLM-managed lands. Information about vegetation treatments might still be useful, though, in shedding light on limber pine in the project area. E-mail inquiries were made during the project to the three BLM fuels program managers in the project area. Unfortunately the inquiries were made during the field season and so no information had been received as of the writing of this report. Follow-up inquiries should be made.

- Phillip Lockwood, Kemmerer Field Office, 307 828-4549, plockwood@blm.gov
- Rich Howe, Rock Springs Field Office, 307 352-0211, rhowe@blm.gov
- Mark Randall, Pinedale Field Office, 307 367-5350, mrandall@blm.gov

8. Other vegetation treatments

We received useful information from Troy Fieseler of the Wyoming Game and Fish Department's Green River Region about vegetation treatments to benefit wildlife in the central part of the project area (Figure 14). Parts of the project area lie within the Department's Pinedale and Jackson regions and inquiries to biologists in those regions might be useful. Kevin Spence, Terrestrial Habitat Biologist in the Green River Region (Kevin.Spence@wyo.gov) knows the Department's personnel and should be consulted about whom to contact.

Range management specialists in the BLM also may have information about vegetation treatments done to benefit livestock. Jim Glennon can provide information about which BLM personnel to contact.

Discussion

Means (2011), in his synthesis of knowledge about lower-treeline limber pine woodlands, cautioned that management aimed at preventing the spread of pines from rocky slopes and ridges into adjacent shrublands and grasslands is based on a misunderstanding of the nature of these woodlands, and (along with insects and disease) constitutes a threat to the maintenance of this biologically and aesthetically valuable vegetation type. The information that we gathered in this project does not indicate that such management activities are affecting limber pine woodlands on BLM-managed lands in the Rock Springs, Kemmerer, or Pinedale field offices. This conclusion, while reassuring, ought to be considered tentative until the possible additional sources of information about vegetation treatments that we identified are investigated.

Unfortunately, the information that we collected indicates that the other threats to limber pine woodlands that Means identified, bark beetles and blister rust, are affecting the species in the project area. Compared to the substantial body of information about limber pine's situation east of the Continental Divide (Burns *et al.* 2010, Cleaver *et al.* 2015, Cleaver *et al.* 2017, Kearns *et al.* 2014), the information for the project area is scant and rather dated. Still, there is no doubt that white pine blister rust is widespread through the project area and has been seriously affecting at least some stands for a decade, and there is no reason to think that the situation (with blister rust and bark beetles) in the project area is less dire than it is elsewhere. Given this likelihood, and the status of limber pine as a BLM Sensitive Species, systematic survey of limber pine health in the project area seems important to a sound basis for management of the species.

Surveys would be especially useful as a part of a management program for conserving limber pine trees and woodlands in the area. Both Perkins *et al.* (2016) and Burns *et al.* (2008) provide information and describe the components that might go into a management plan. A third reference, Schoettle *et al.* (2019), describes a comprehensive management strategy for limber pine that also would be useful for BLM resources specialists and managers interested in a limber pine management plan to review.

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TABLES

Table 1. Years In Which the Limber Pine Specimens in the Rocky Mountain Herbarium Database Were Collected.

Year Collected	Number of Collections
1949	1
1950	1
1966	1
1973	1
1977	1
1978	1
1979	1
1980	5
1981	4
1990	22
1991	28
1992	19
1993	20
1994	45
1995	18
1996	3
1997	1
2005	2
2006	5
2009	1
All Years	180

Table 2. Numbers of FIA plots with limber pine in the project area, by land ownership and year of sampling.

	Owner				
	BLM	USFS	USNPS	Private	All Owners
Inventory Year					
2000	6	53	4	4	67
2011		9	2	2	13
2012	1	2	2		5
2013	1	4	2		7
2014		3			3
2015		6			6
2016	1	8			9
2017	1	4			5
All Years	10	89	10	6	115
Type of Data*					
Tree Co-occurrence	9	69	5	5	88
Tree Density	9	69	5	5	88
Limber Pine Diameter	9	69	5	5	88
Limber Pine Cause of Damage or Death	9	69	5	5	88
Limber Pine seedlings	3	43	9	3	58
Undergrowth	4	36	6	2	48

*Type of Data: Some types of data were not recorded in some plots, and these rows show the numbers of plots in which data about certain parameters were collected. These are overlapping subsets of the 115 plots with limber pines. For example, limber pine trees were found in 88 plots, so data used in calculating parameters featuring trees were collected on only 88 of the plots. Limber pine seedlings were found in 58 plots; 31 of them had trees as well and so are included in the 88 plots with limber pine trees.

Table 3. USFS White Pine Blister Rust Plots In the Project Area.

Site	Stand ID	Year Sampled	Source of Information	Land Owner	5-needle pine present	Rust Confirmed?	Incidence*
Bacon Ridge, W.	BRI02	1997	Hoffman, Thesis	USFS	Whitebark	no	0
Badger Creek	TET03	1997	Hoffman, Thesis	USFS	Limber & Whitebark	Yes	41
Big Sandy Opening	WIN02	1997	Hoffman, Thesis	USFS	Whitebark	no	0
Buffalo Meadow	GRO01	1997	Hoffman, Thesis	USFS	Whitebark	Yes	6
Camp Loll	TET06	1997	Hoffman, Thesis	USFS	Whitebark	Yes	30
Commissary Ridge	BRI06	1997	Hoffman, Thesis	BLM	Whitebark	no	0
Flagg Ranch Road	TET01	1997	Hoffman, Thesis	USFS	Whitebark	Yes	17
Hominy Peak	TET07	1997	Hoffman, Thesis	USFS	Whitebark	Yes	53
Hominy Peak, W.	WBP05	1997	Hoffman, Thesis	USFS	Whitebark	Yes	78
Jackass Loop	WBP07	1997	Hoffman, Thesis	USFS	Whitebark	Yes	80
McDougal Gap	BRI05	1997	Hoffman, Thesis	USFS	Whitebark	Yes	43
Near Fish Creek	BRI03	1997	Hoffman, Thesis	USFS	Whitebark	Yes	6
Near Fish Creek	WIN03	1997	Hoffman, Thesis	USFS	Whitebark	no	0
Near Gypsum Creek	WIN04	1997	Hoffman, Thesis	USFS	Whitebark	no	0
Spring Creek near	BRI01	1997	Hoffman, Thesis	USFS	Whitebark	Yes	35
Targhee Ski Resort	TET05	1997	Hoffman, Thesis	USFS	Whitebark	Yes	54
Teton Pass-East	TET02	1997	Hoffman, Thesis	USFS	Whitebark	Yes	74
Teton Pass-West	TET04	1997	Hoffman, Thesis	USFS	Limber	Yes	88
Togwotee Pass	BRI04	1997	Hoffman, Thesis	USFS	Whitebark	Yes	18
Upper S. Temple	WIN01	1997	Hoffman, Thesis	USFS	Whitebark	no	0

* Incidence = percent of stand's 5-needle pines infected with white pine blister rust

Table 3 (continued).

Site	Stand ID	Year Sampled	Source of Information	Land Owner	5-needle pine present	Rust Confirmed?	Incidence*
Bald Knoll	Bald Knoll	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Commissary Ridge	Commissary Ridge	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Edmond Lake	Edmond Lake	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Flat Creek	Flat Creek	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Leidy Lake	Leidy Lake	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Middle Piney Lake	Middle Piney Lake	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
North Fork Spread Cr	North Fork Spread Cr	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Rainbow Lake	Rainbow Lake	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Surprise/Amphitheater	Surprise/Amphitheater	2002	Newcomb, Thesis	USNPS	Whitebark	Yes	No data
Swift Creek	Swift Creek	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Upper Hoback River	Upper Hoback River	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
WRS1011	WRS1011	2013	Cleaver, EM/thesis	BLM	Limber	Yes	1.2

* Incidence = percent of stand's 5-needle pines infected with white pine blister rust

Table 4. Numbers and areas of the polygons in the project area (on all lands compared to BLM-managed lands only) in which limber pine woodland is mapped as the primary cover-type, secondary cover-type, or another cover-type.

	# polygons		Area, Ha (Acres)	
Limber Pine Woodland, Status in Polygon	All Owners	BLM Only	All Owners	BLM Only
Primary cover-type	18	18	7,929 (19,585)	5,711 (14,106)
Secondary cover-type	38	36	81,326 (200,876)	56,587 (139,770)
Other cover-type	10	8	19,785 (48,868)	8,068 (19,928)
All Polygons	66	62	109,040 (269,329)	70,366 (173,804)

Table 5. Numbers of dead limber pines in the FIA plots killed by different agents, by sampling year.

	2000	2011	2012	2013	2014	2015	2016	2017	All Years
Number of Plots Sampled	*67*	*13*	*5*	*7*	*3*	*6*	*9*	*5*	*115*
Number of Limber Pines For Which Data Were Recorded	*3*	*7*	*0*	*1*		*59*	*28*	*1*	*99*
AGENT	1							1	1
Bark beetles	1								1
Other and unidentified insects		3		1		55	16		75
Unidentified diseases								1	1
Dwarf mistletoe	1								1
Vegetation (suppression)		1							1
Fire						4	12		16
Wind	1								1
Unidentified/unknown		3							3

Table 6. Numbers of live limber pines in FIA plots exhibiting damage from different causes, or different types of damage, by sampling year.

Live Trees	2000	2011	2012	2013	2014	2015	2016	2017	All Years
Number of Plots Sampled	*67*	*13*	*5*	*7*	*3*	*6*	*9*	*5*	*115*
Number of Limber Pines For Which Data Were Recorded	*231*	*15*	*6*	*13*	*1*	*15*	*10*	*3*	*294*
No serious damage	26	8	5	8	1	9	10	3	70
CAUSE OF DAMAGE									
Dwarf mistletoe				1					1
Lightning	1								1
Stem and butt rots	3								3
Stem rusts	2	3							5
Vegetation (Suppression)	3								3
General diseases				1					1
Sapsuckers	1								1
TYPE OF DAMAGE									
Open wound		1							1
Heartwood scar on bole	21								21
Excessive crook, sweep, or taper	105								105
Excessive lean	3								3
Forked above merchantable top	5								5
Forked below merchantable top	43	1	1	1					46
Broken top	10	1		1		3			15
Dead top	8	1		1		3			13

Table 7. Occurrence and incidence of white pine blister rust in 32 USFS white pine blister rust plots in the project area.

Site	Stand ID	Year Sampled	Source of Information	Land Owner	5-needle pine present	Rust Confirmed?	Incidence*
Bacon Ridge, W.	BRI02	1997	Hoffman, Thesis	USFS	Whitebark	no	0
Badger Creek	TET03	1997	Hoffman, Thesis	USFS	Limber & Whitebark	Yes	41
Big Sandy Opening	WIN02	1997	Hoffman, Thesis	USFS	Whitebark	no	0
Buffalo Meadow	GRO01	1997	Hoffman, Thesis	USFS	Whitebark	Yes	6
Camp Loll	TET06	1997	Hoffman, Thesis	USFS	Whitebark	Yes	30
Commissary Ridge	BRI06	1997	Hoffman, Thesis	BLM	Whitebark	no	0
Flagg Ranch Road	TET01	1997	Hoffman, Thesis	USFS	Whitebark	Yes	17
Hominy Peak	TET07	1997	Hoffman, Thesis	USFS	Whitebark	Yes	53
Hominy Peak, W.	WBP05	1997	Hoffman, Thesis	USFS	Whitebark	Yes	78
Jackass Loop	WBP07	1997	Hoffman, Thesis	USFS	Whitebark	Yes	80
McDougal Gap	BRI05	1997	Hoffman, Thesis	USFS	Whitebark	Yes	43
Near Fish Creek	BRI03	1997	Hoffman, Thesis	USFS	Whitebark	Yes	6
Near Fish Creek	WIN03	1997	Hoffman, Thesis	USFS	Whitebark	no	0
Near Gypsum Creek	WIN04	1997	Hoffman, Thesis	USFS	Whitebark	no	0
Spring Creek near	BRI01	1997	Hoffman, Thesis	USFS	Whitebark	Yes	35
Targhee Ski Resort	TET05	1997	Hoffman, Thesis	USFS	Whitebark	Yes	54
Teton Pass-East	TET02	1997	Hoffman, Thesis	USFS	Whitebark	Yes	74
Teton Pass-West	TET04	1997	Hoffman, Thesis	USFS	Limber	Yes	88
Togwotee Pass	BRI04	1997	Hoffman, Thesis	USFS	Whitebark	Yes	18
Upper S. Temple	WIN01	1997	Hoffman, Thesis	USFS	Whitebark	no	0

* Incidence = percent of stand's 5-needle pines infected with white pine blister rust

Table 7 (continued).

Site	Stand ID	Year Sampled	Source of Information	Land Owner	5-needle pine present	Rust Confirmed?	Incidence*
Bald Knoll	Bald Knoll	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Commissary Ridge	Commissary Ridge	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Edmond Lake	Edmond Lake	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Flat Creek	Flat Creek	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Leidy Lake	Leidy Lake	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Middle Piney Lake	Middle Piney Lake	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
North Fork Spread Cr	North Fork Spread Cr	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Rainbow Lake	Rainbow Lake	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Surprise/Amphitheater	Surprise/Amphitheater	2002	Newcomb, Thesis	USNPS	Whitebark	Yes	No data
Swift Creek	Swift Creek	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
Upper Hoback River	Upper Hoback River	2002	Newcomb, Thesis	USFS	Whitebark	Yes	No data
WRS1011	WRS1011	2013	Cleaver, EM/thesis	BLM	Limber	Yes	1.2

* Incidence = percent of stand's 5-needle pines infected with white pine blister rust

Table 8. Occurrence of limber pine trees with trees of other species in 88 FIA plots in the project area.

Species	Number of Plots	Proportion of Plots	Rank of Species
Limber pine	88	1.00	-
Limber pine ONLY	8	0.09	-
Douglas-fir	51	0.58	1
Subalpine fir	43	0.49	2
Lodgepole pine	38	0.43	3
Engelmann spruce	22	0.25	4
Quaking aspen	17	0.19	5
Rocky Mountain juniper	7	0.08	6
Curlleaf mountain mahogany*	5	0.06	7
Rocky Mountain maple	2	0.02	8
Whitebark pine	2	0.02	9
Bigtooth maple	1	0.01	10

*Curlleaf mountain mahogany (*Cercocarpus ledifolius*) is usually considered to be a shrub but is included in woodland trees by the FIA program.

Table 9. Occurrence of limber pine with trees of other species in 19 WYNDD aspen project plots.

Species	Number of Plots	Proportion of Plots
Limber pine	19	1.00
Quaking aspen	19	1.00
Lodgepole pine	3	0.16
Douglas-fir	2	0.11
Scouler willow*	1	0.05
Rocky Mountain juniper	1	0.05

*Scouler willow (*Salix scouleriana*) is usually considered to be a tall shrub.

Table 10. Summary of number of taxa and percent canopy cover of undergrowth plants in 48 FIA plots in the project area.

Parameter	Value
Number of taxa recorded in all plots	129
Average number of taxa / plot	8.0
Range in number of taxa / plot	1 to 15
Average sum of % canopy cover in plot*	40.0
Range in sum of % canopy cover in plot*	4 to 101

* Sum of estimates for taxa recorded in the plot, not deducting areas of overlap among taxa

Table 11. Common undergrowth plant taxa in 48 FIA plots in the project area.

Scientific Name	Common Name	Number of Plots	Proportion of Plots	Ave. Cover
Abies lasiocarpa (seedlings)	subalpine fir	23	0.48	9.7
Calamagrostis rubescens	pinegrass	15	0.31	10.7
Pinus contorta (seedlings)	lodgepole pine	15	0.31	8.9
Arnica cordifolia	heartleaf arnica	12	0.25	3.3
Mahonia repens\1	creeping barberry	12	0.25	2.3
Geranium viscosissimum\1	sticky purple geranium	10	0.21	1.6
Populus tremuloides (seedlings/suckers)	quaking aspen	10	0.21	13.8
Shepherdia canadensis	russet buffaloberry	10	0.21	4.5
Vaccinium scoparium	grouse whortleberry	10	0.21	10.3
Pinus flexilis (seedlings)	limber pine	9	0.19	2.1
Symphoricarpos oreophilus\1	mountain snowberry	9	0.19	2.8
Carex geyeri	Geyer's sedge	8	0.17	6.7
Chamerion angustifolium	fireweed	8	0.17	8.9
Pseudotsuga menziesii (seedlings)	Douglas-fir	8	0.17	2.9
Lupinus argenteus\1	silvery lupine	7	0.15	2.4
Balsamorhiza sagittata	arrowleaf balsamroot	6	0.13	3.2
Fragaria virginiana	Virginia strawberry	6	0.13	3.8
Geranium richardsonii	Richardson's geranium	6	0.13	4.8
Picea engelmannii (seedlings)	Engelmann spruce	6	0.13	2.0
Poa pratensis	Kentucky bluegrass	6	0.13	2.4
Amelanchier alnifolia	Saskatoon serviceberry	5	0.10	2.2
Carex rossii\1	Ross' sedge	5	0.10	4.0
Juniperus communis\1	common juniper	5	0.10	2.7
Pseudoroegneria spicata ssp. spicata	bluebunch wheatgrass	5	0.10	4.2
Spiraea betulifolia	white spirea	5	0.10	3.1
Thalictrum occidentale	western meadow-rue	5	0.10	2.8

\1 Taxon (or similar one) also in Table 12

Table 12. Plant taxa present in the undergrowths of 2 or more of the 19 WYNDD aspen project plots.

Scientific Name	Common Name	Number of plots	Proportion of plots
SHRUBS			
Juniperus communis\1	Common juniper	14	0.74
Symphoricarpos oreophilus var. *utahensis*\1	Utah snowberry	13	0.68
Artemisia tridentata ssp. *vaseyana*	Mountain big sagebrush	9	0.47
Mahonia repens\1	Oregon grape	8	0.42
Arctostaphylos uva-ursi	Kinnickick	7	0.37
Ribes cereum	Wax currant	4	0.21
GRAMINOIDS			
Carex rossii\1	Ross's sedge	15	0.79
Festuca idahoensis	Idaho fescue	12	0.63
Achnatherum sp. *(A. lettermanii)*	Needlegrass, esp. Letterman's	8	0.42
Elymus sp. *(E. trachycaulus)*	Wheatgrass, mostly thickspike	5	0.21
Leymus cinereus	Great Basin wildrye	3	0.16
Bromus sp. *(B. anomalus)*	Brome, especially Nodding brome	2	0.11
Leucopoa kingii	Spike fescue	2	0.11
Poa wheeleri	Wheeler bluegrass	2	0.11
FORBS			
Lupinus sp.\1	Lupine	10	0.53
Antennaria sp.	Pussytoes	6	0.32
Achillea millefolium	Western yarrow	3	0.16
Geranium sp.\1	Geranium	3	0.16
Eremogone congesta	Ballhead sandwort	2	0.11
Eriogonum sp.	Buckwheat	2	0.11
Osmorhiza sp.	Sweet cicely	2	0.11
Phlox multiflora/P. longifolia	Phlox (Multi-flowered & Longleaf)	2	0.11

\1 Taxon (or similar one) also in Table 11

Table 13. Vegetation treatments applied in polygons in the central part of the project area.

Data provided by Wyoming Game and Fish Department. "Possible Effect" means a treatment might affect limber pines if they are present in the treatment area, and "No Effect" means that a treatment is unlikely to affect pines even if they are present.

Treatment[1]	# polygons	Acres
Possible Effect		
Aspen Cut	2	11
Cut/Pile	20	409
PFO	4	62
RX	38	1848
Slash	40	1586
	104	3,916
No Effect		
Aerator 30% + seed	16	1907
Aerator 30% mosaic	10	968
Aerator 60-80% mosaic	3	1060
Mowing 30% mosaic	76	8784
Mowing 50% mosaic	20	2616
Pitting + seeding	2	78
Seeding	2	66
Spray	3	69
	132	15,548
All Treatments	236	19,464

1. Treatments are the values in the "Treat_Type" attribute table of the shape file.

FIGURES

Figure 1. FIA sample points in the project area.

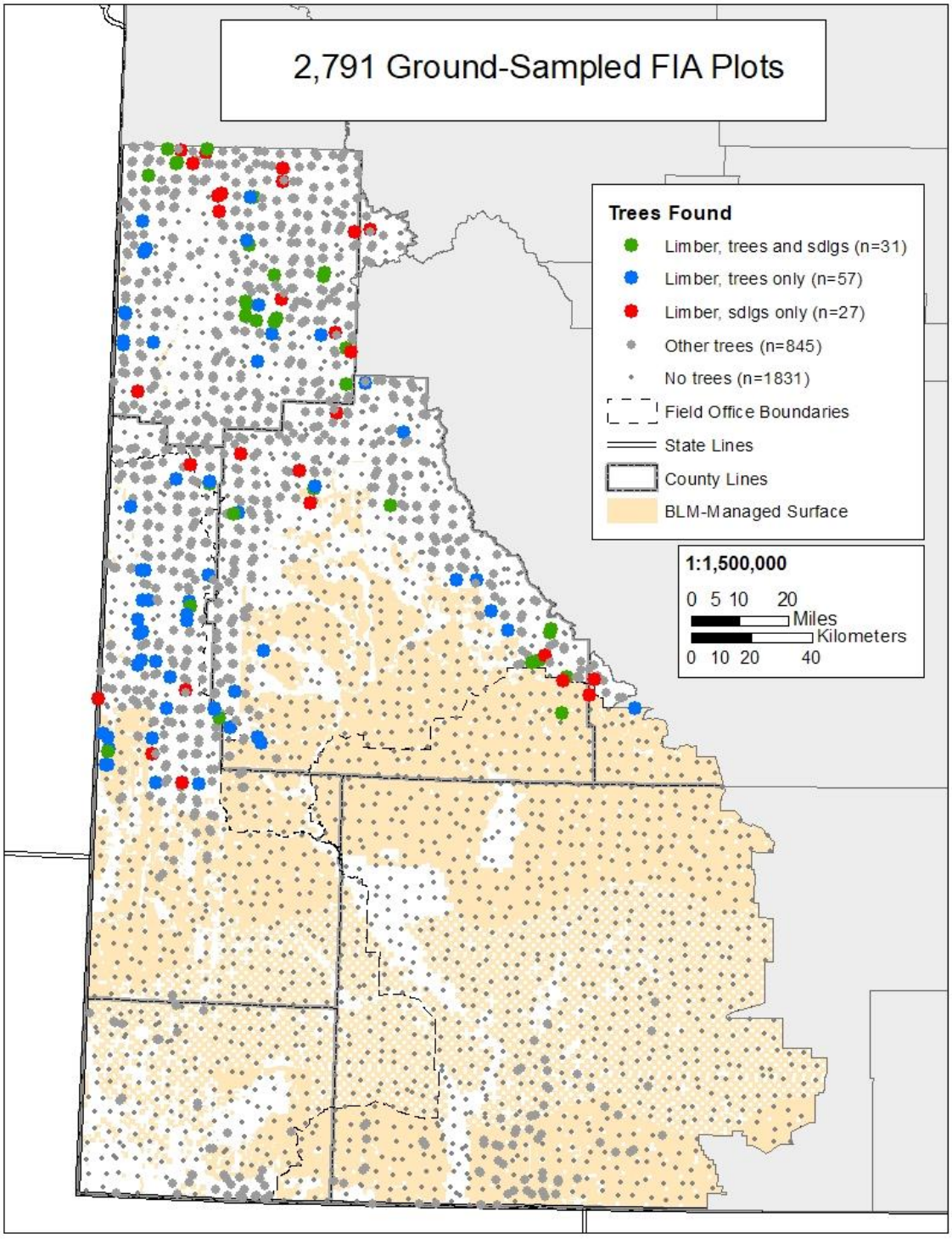


Figure 2. Locations of 180 limber pine specimens in the Rocky Mountain Herbarium collected in the project area.

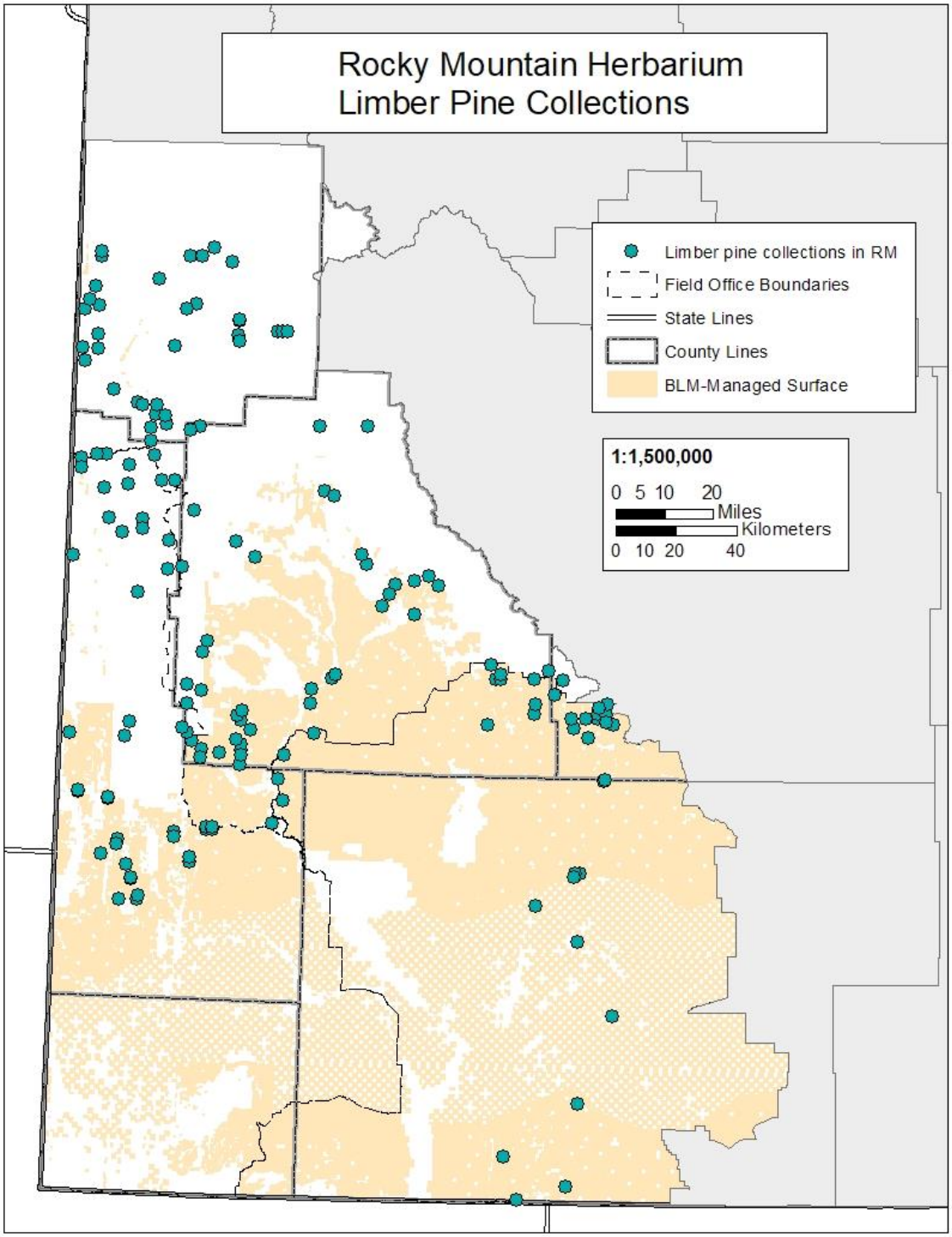


Figure 3. Locations of 19 sample plots from WYNDD's aspen project in which limber pine was found.

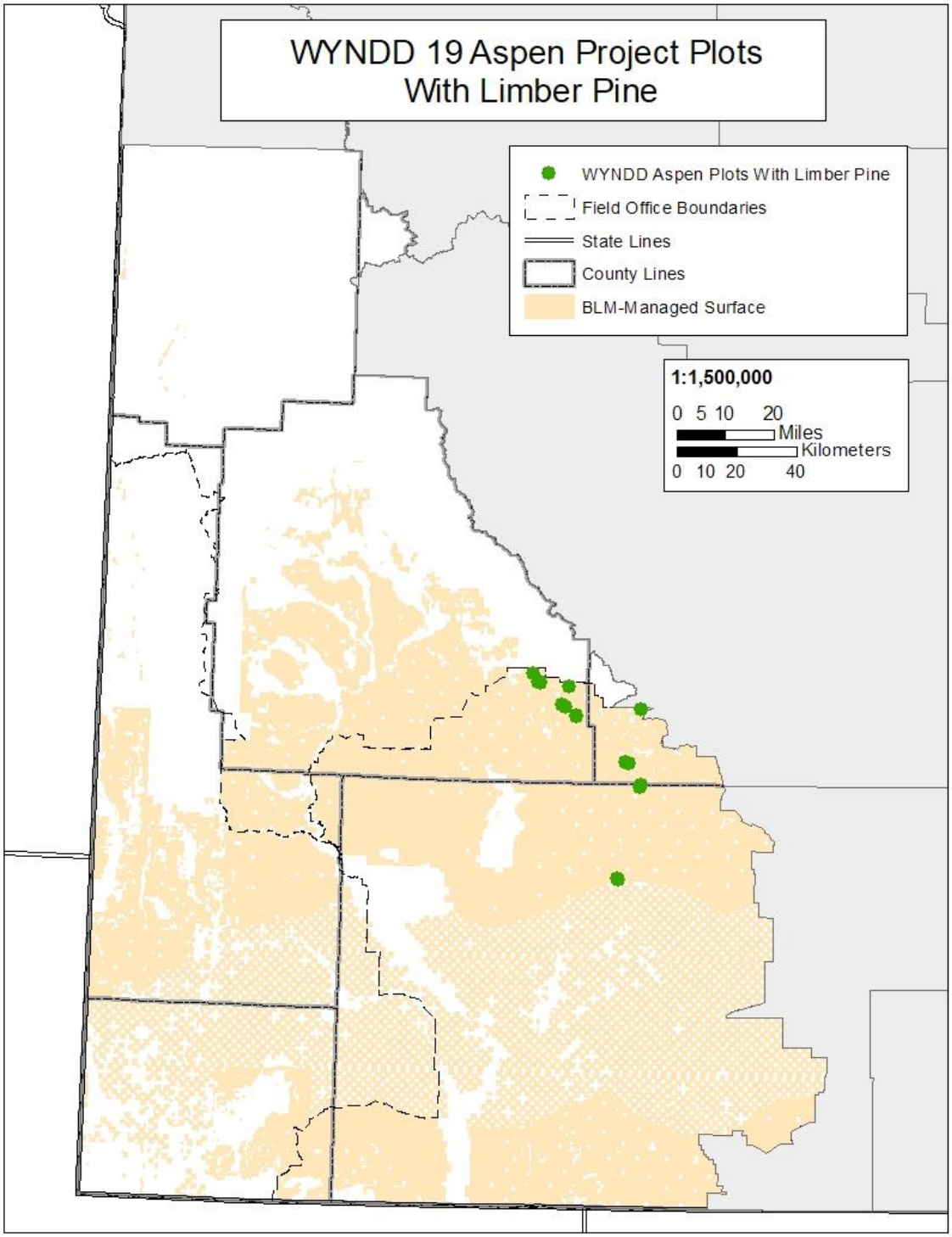


Figure 4. Locations of 32 white pine blister rust sample plots in the project area.
"L" indicates the 3 plots with limber pine.

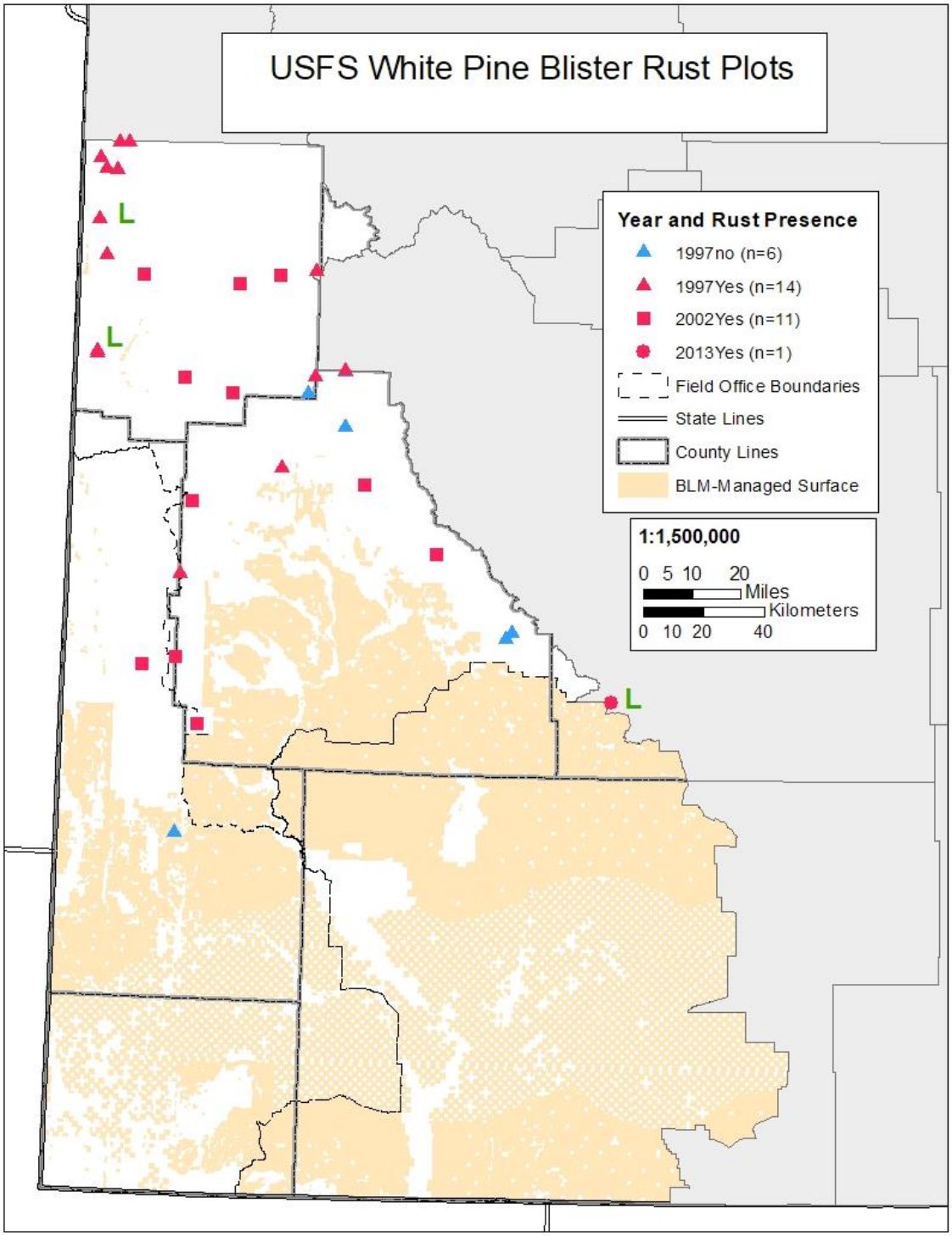


Figure 5. Distribution of limber pine predicted by the Forest Service NIDRM tree raster.

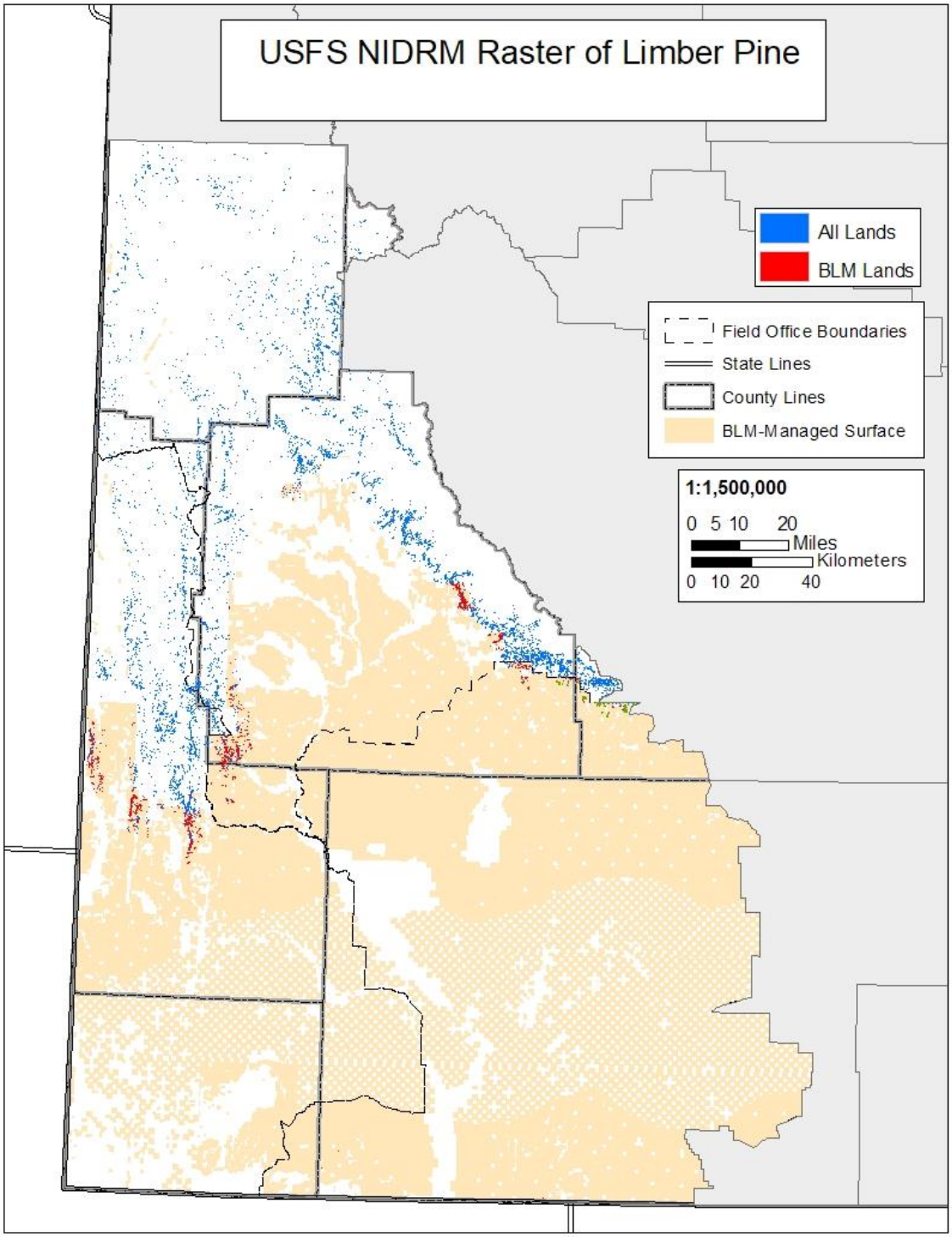


Figure 6. Polygons from the BLM's timber geodatabase.

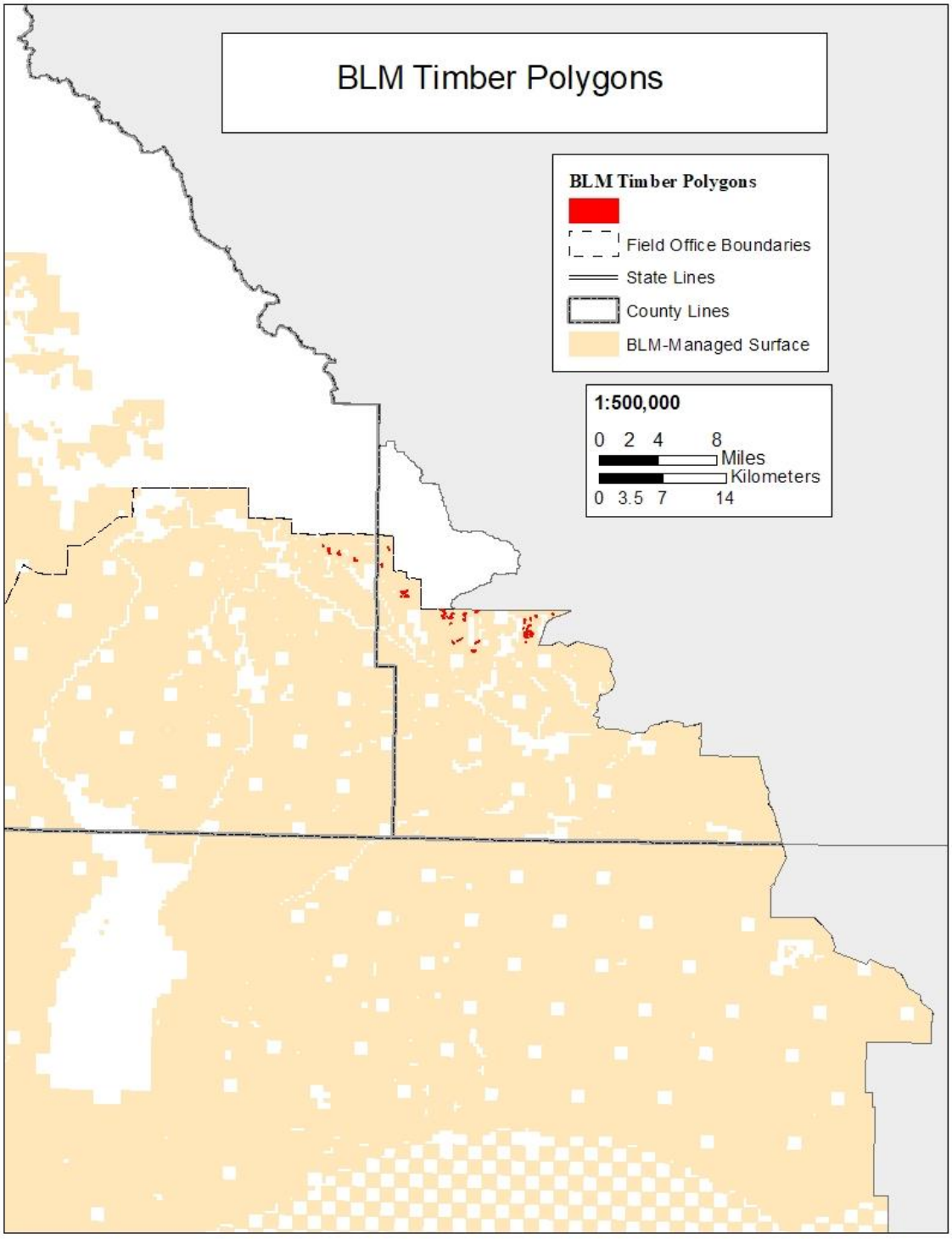


Figure 7. 1996 Wyoming GAP polygons in the project area that are classified as containing limber pine woodland or juniper woodland.

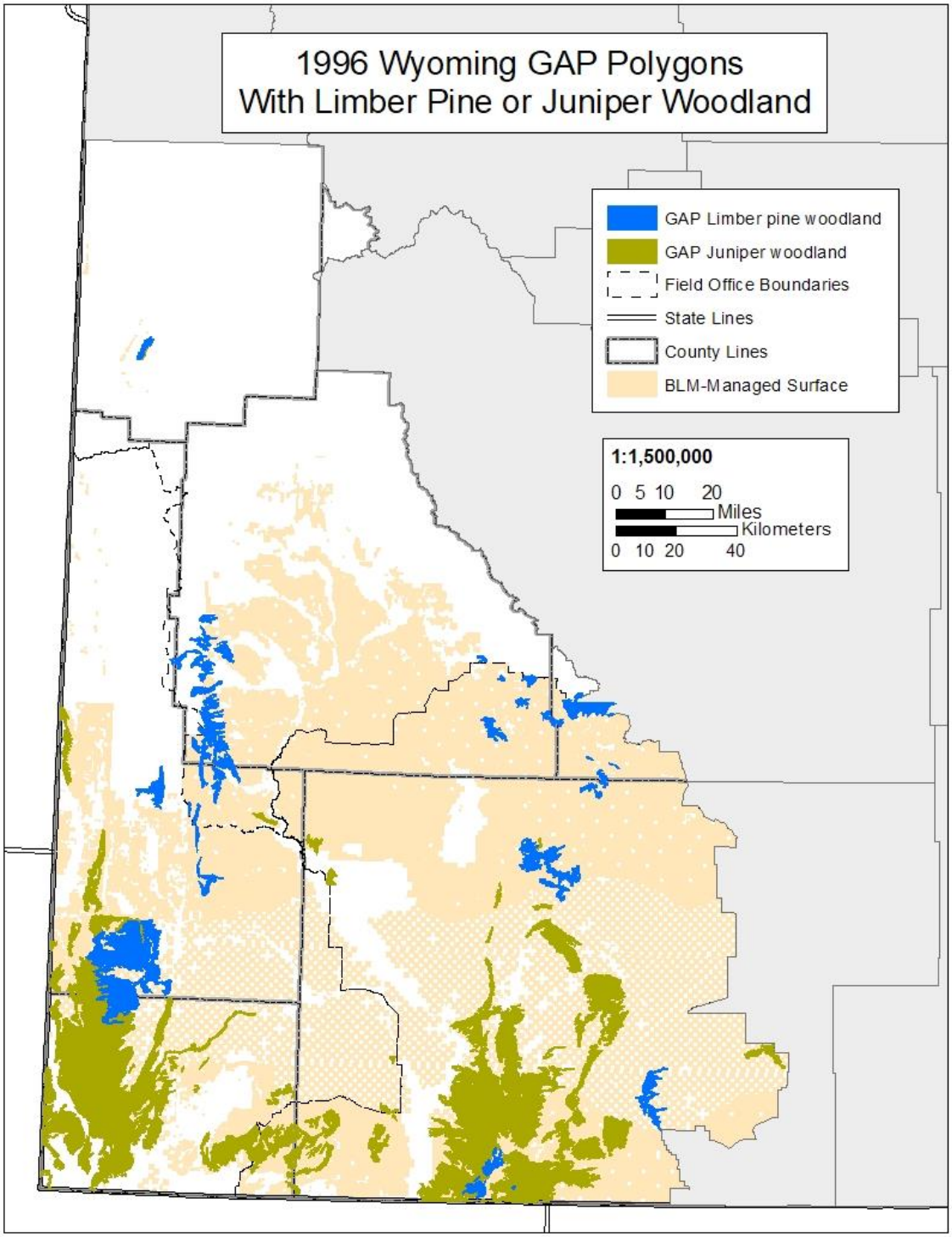


Figure 8. Distribution of the Rocky Mountain Foothill Limber Pine - Juniper Ecological System as mapped in the Landfire existing vegetation type layer.
Density refers to the number of pixels attributed with the ecological system.

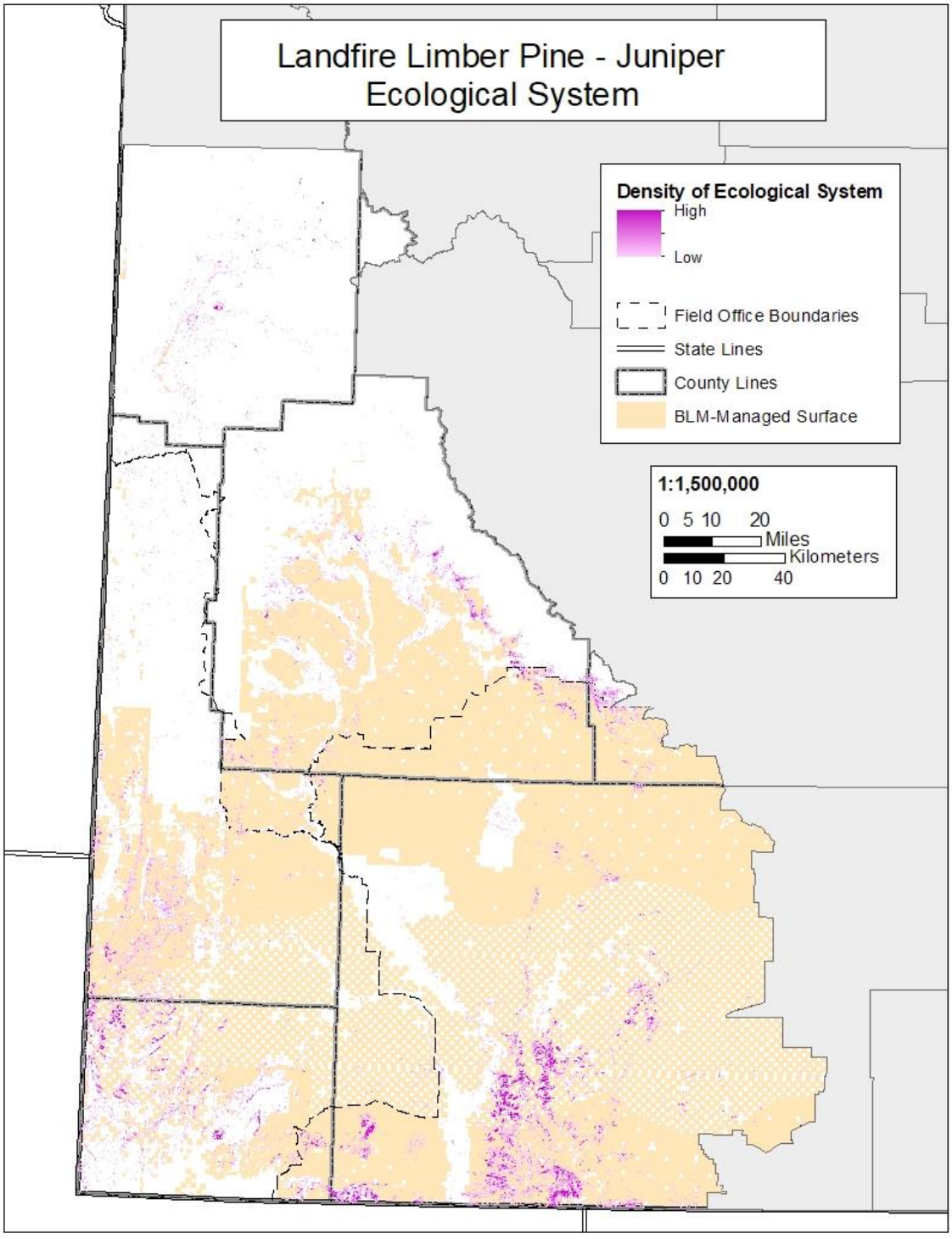


Figure 9. Elevations of Rocky Mountain Herbarium limber pine collections and of FIA plots with limber pine, other trees, or no trees.

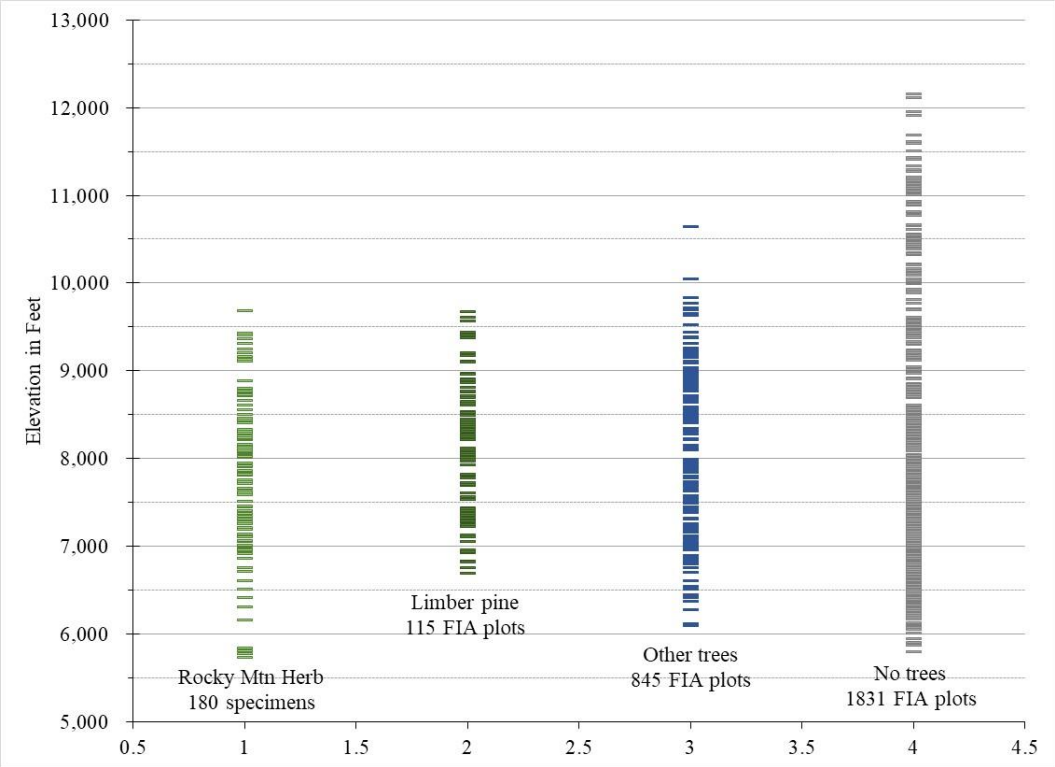


Figure 10. Distribution among diameter classes of live and dead limber pine trees counted in 88 FIA plots.

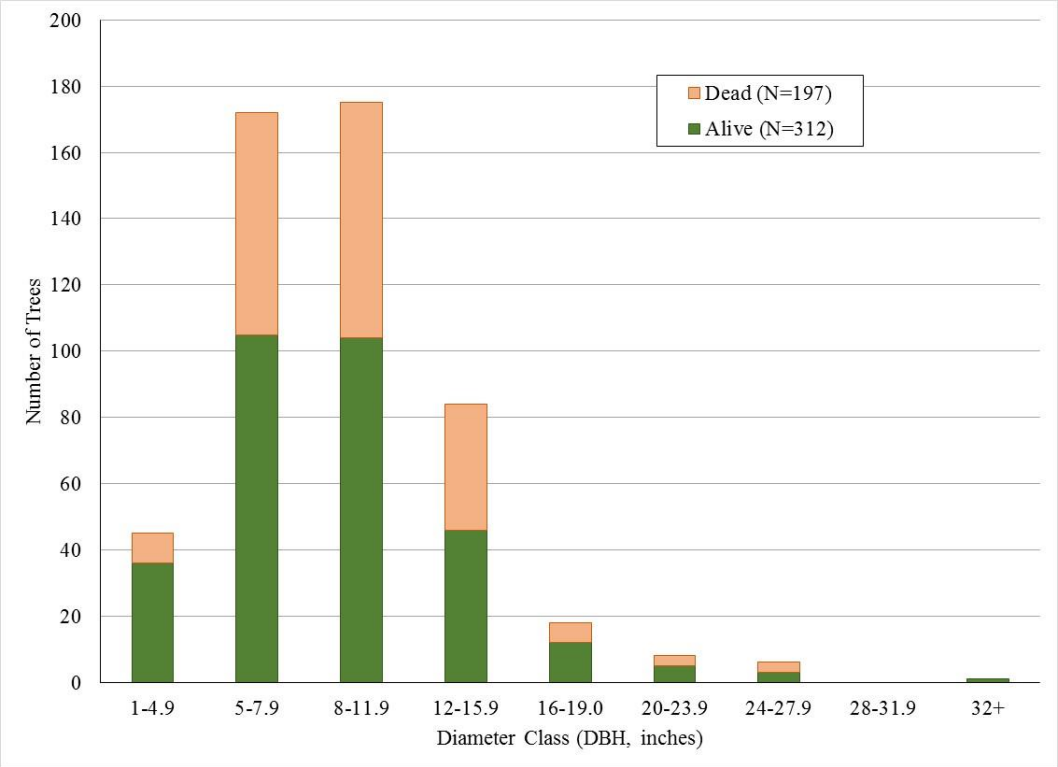


Figure 11. Distribution among size-classes of 52 limber pines sampled in 19 WYNDD aspen project plots.

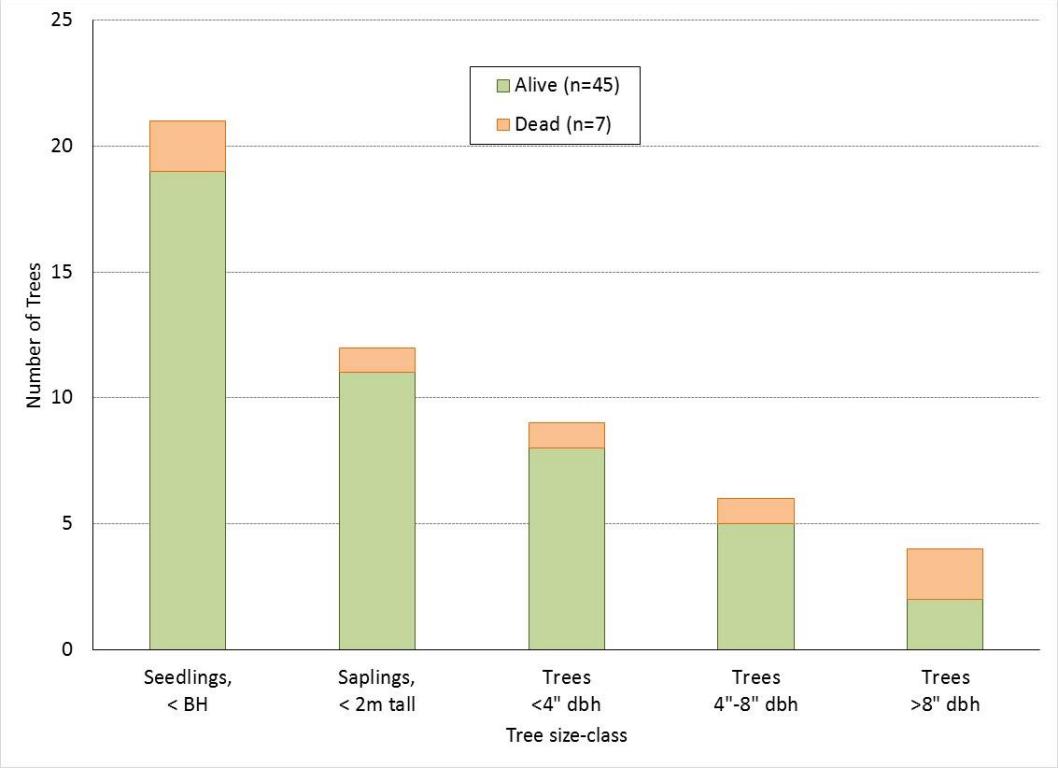


Figure 12. 25-Year Periods Of Establishment Of Limber Pines In the Project Area.
Bars show numbers of live limber pines ≥ 5" dbh in FIA plots. Circles represent trees east of Superior analyzed by USGS

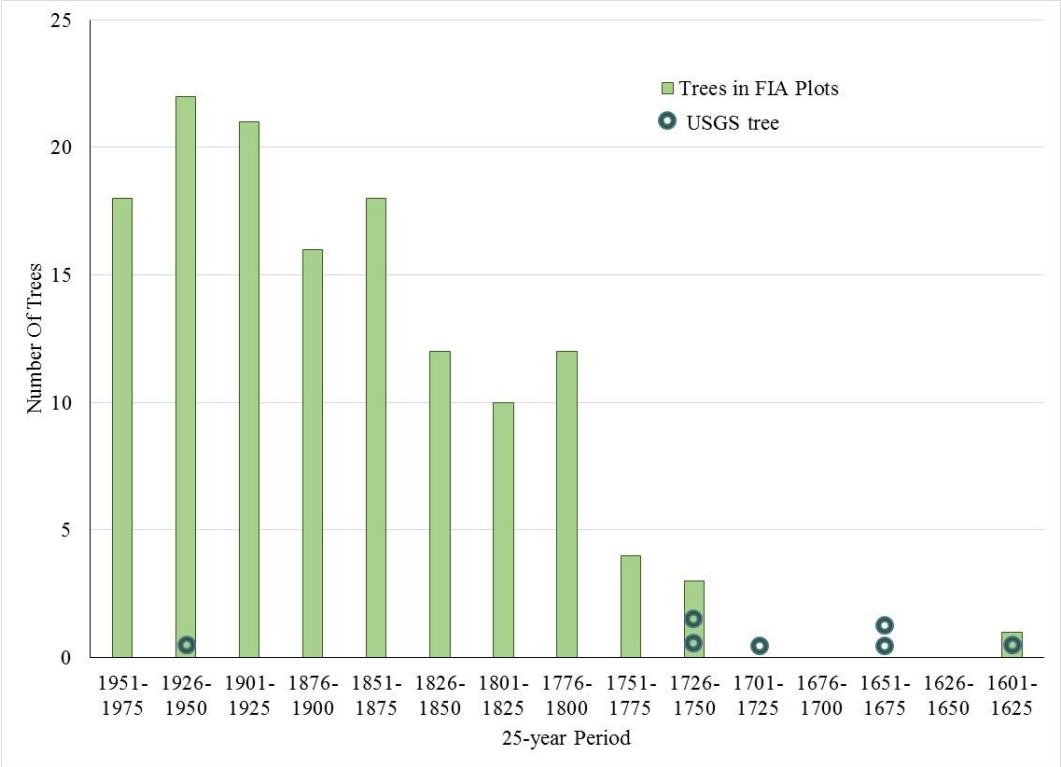


Figure 13. Number of live and dead limber pine trees counted in 115 FIA plots in each sampling year.

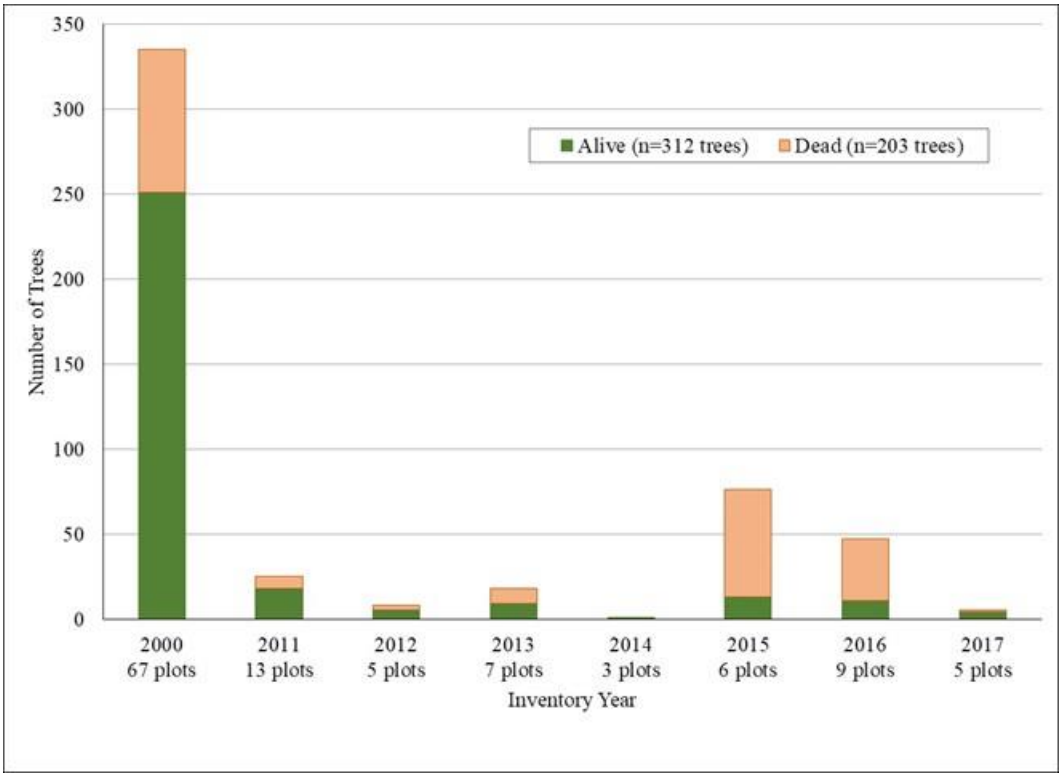
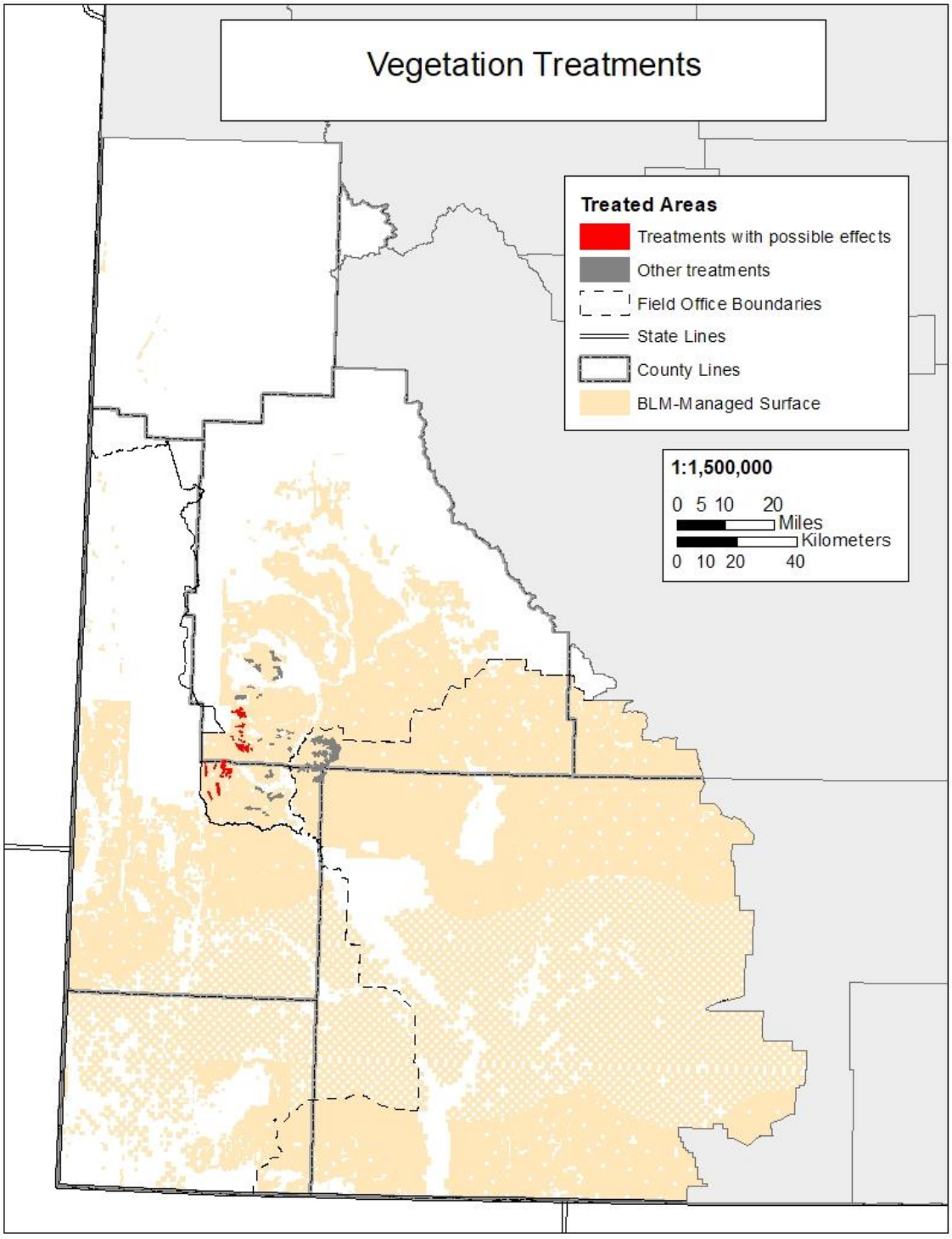


Figure 14. Polygons within which vegetation treatments have been applied to aspen and shrub communities.

Data provided by Wyoming Game and Fish Department. See Table TREAT1 for the list of treatments with possible effects on limber pines.



APPENDIX 1. APRIL 24TH MEETING: LIST OF ATTENDEES AND SUMMARY OF THE DISCUSSION

LIMBER PINE IN SOUTHWESTERN WYOMING

Summary of Meeting April 24th, 2019 at Rock Springs BLM Office
10 a.m. - Noon

George Jones

ATTENDING

- Patrick Anderson, Ecologist, USGS Fort Collins Science Center
- Trent Bristol, Forester, BLM's Kemmerer Field Office
- Jim Glennon, botanist, BLM's Rock Springs Field Office
- George Jones, Vegetation Ecologist, Wyoming Natural Diversity Database (University of Wyoming)
- Mark Kott, Public Lands Planner, Sweetwater County Land Use Department
- Jim Wasseen, Wyoming Game and Fish Department, Green River

Invited But Could Not Attend

- Amy Anderson, Habitat Biologist, Wyoming Game and Fish Department, Lander
- Kevin Spence, Habitat Biologist, Wyoming Game and Fish Department, Green River

BACKGROUND

Glennon and Jones

The BLM and the Wyoming Natural Diversity Database (WYNDD) have entered into a cooperative project to collect information about limber pine (*Pinus flexilis*) in the BLM's Rock Springs, Kemmerer, and Pinedale field offices. There seems to be a dearth of information about the species in the area, and this may be limiting the ability of managers to design and implement sound management plans. (Limber pine is on the BLM's Sensitive Species List for Wyoming and so merits particular attention from resource managers.)

The point of this project is to collect and organize the information that does exist, and perhaps to augment it with a limited amount of field work, to provide managers with answers to these questions:

4) Is current management creating or exacerbating problems for limber pine in SW Wyoming?
5) If so, what are those problems? What, if anything, can managers do to minimize the problems?

In collecting and organizing information, we will use these topics as a framework:

1) Distribution: Where does limber pine grow in SW Wyoming?
2) Stand structure: Does limber pine in SW Wyoming grow mainly in pure stands or in mixed-species stands? With what other species?
3) Age structure: Do limber pines in SW Wyoming span a range of ages or are most of the trees old?
4) Value: What is the role of limber pine in providing habitat for mammals and birds in the area? Does it diminish the quality of habitat for some species?
5) Condition: How seriously is limber pine in SW Wyoming being affected by drought, white-pine blister rust, and bark beetles?

The products that we expect will come out of the project include:

1) A short report describing how we searched for information

2) An annotated bibliography of the sources of information that we find
3) A digital layer showing the distribution of limber pine in the area, and stands or plots from which data or other information have been collected

PURPOSE OF THIS MEETING

We asked several people likely to have an interest in the project, and who might also know of information about limber pine in the area, to give us their thoughts about how we're approaching the project and to let us know about the information they're aware of.

DISCUSSION IN THE MEETING

The discussion among the participants touched on these topics.

Information That We Know About

Limber Pine Generally

- Bob Means's paper gives background on biology and management issues of limber pine at lower elevations and will be useful. *Synthesis of Lower Treeline Limber Pine (Pinus flexilis) Woodland Knowledge, Research Needs, and Management Considerations*. Bob also put together a bibliography about limber pine and related species.
- USFS scientists are studying white pine blister rust in limber pine and other species in the Rocky Mtns and they have study plots in Wyoming and Utah near our project area. Kelly Burns and Anna Schoettle are the leaders. Jones is in contact with them.

Distribution of limber pine in the project area

- Jones: We know of these digital layers but don't know how useful they are.
  - Wyoming GAP Landcover layer
  - USFS Forest Health layers
  - Landfire existing vegetation-type layer
  - Rock Springs Field Office vegetation geodatabase
- Glennon: Rock Springs Field Office timber map from the 1990s
- Glennon also mentioned a map of 5-needle pines in the 3 field offices.
- Bristol: Kemmerer Field Office timber map with ground-truth data
- The forester on the Ashley National Forest may have information about limber pine in the Meek's Cabin area. JONES CANNOT REMEMBER WHO SUGGESTED THIS.

Condition of limber pine in the project area

- White pine blister rust has been documented in SW Wyoming. Glennon and Bristol are aware of data from forest stands on Miller Mountain west of Pinedale that documents blister rust in whitebark pine (*Pinus albicaulis*)

Ages of trees

- Bob Means gave Pat Anderson rounds cut from pines (in the Superior area). Pat had someone in his office count rings, and Pat has a spreadsheet of the estimated ages. He may also have latitude and longitude coordinates for the trees.
- Jones suggested that Steve Gray, formerly the Wyoming State Climatologist, may have determined ages of limber pines at the southeastern end of the Wind River Mtns, within our project area. And he may have sampled trees elsewhere in the area. He will look into this.

Value For Mammals and Birds

- Wasseen suggested that Andrea Orabona, Wyoming Game and Fish Department's Nongame Bird Biologist, is a good source of this information. Jones will contact her.

Management Activities In the Project Area

- Bristol says that the BLM will not remove 5-needle pines as part of fuel-reduction treatments. But Phil Lockwood, in the BLM's Kemmerer Field Office, has thinned whitebark pine stands to try to reduce the incidence of white pine blister rust.

Gathering of Additional Information

- Bristol described a forest inventory project that will be done on Pine Mountain late in the coming summer. Information will be collected on tree species composition, and probably also on age class, timber volume, and tree spacing. QUESTION: Will this inventory be done by the BLM or by Wyoming State Forestry?
- Bristol also mentioned that he will conduct a walk-through exam of forests and woodlands in the Kemmerer area in which he'll record the presence of 5-needle pines.
- Glennon suggested that we examine the BLM's SVIM data
- Glennon asked Jones to send him the sampling protocol used by USFS white pine blister rust researchers (Kelly Burns and others), and he may be able to collect hat information during some of his field work in the coming season.
- Jones will ask the US Forest Service for data from their Forest Inventory and Analysis plots
- Jones also will look into obtaining data from the plots used in the Landfire program
- Anderson recommended that field work in the project area should include the collection of information on age-class structure of limber pine.
- Anderson suggested internet searches for dissertations and theses

WHAT'S NEXT?

- Jones will
  - Organize the information that we discussed in this meeting
  - Send to Glennon and Bristol the protocol used by the USFS researchers in their blister rust research
  - Obtain the digital layers that show limber pine in the project area
  - Contact Barry Tye, Wyoming State Forestry Division District 4 Forester in Lyman, to explain project to him
  - Ask Andrea Orabona for information about the value of limber pine to mammals and birds
- Glennon will
  - As much as practicable, collect information about limber pine during his field work, using the methods of the USFS blister rust research
  - Communicate with Bristol after the field season about the walk-through exam in the Kemmerer area
  - Learn more about the forest inventory on Pine Mountain
- Glennon and Jones will keep the group up to date on the project

APPENDIX 2. INDIVIDUALS CONTACTED DURING THE PROJECT

Name	Organization & Job Title	E-mail address	Note
Anderson, Amy	Wyoming Game and Fish Department, Lander Region, Terrestrial Habitat Biologist	Amy.Anderson@wyo.gov	Provided information about vegetation treatments in Lander area
Anderson, Patrick	US Geological Survey, Fort Collins Science Center, Ecologist	andersonpj@usgs.gov	At April 24th mtg. Provided age estimates
Bristol, Trent	BLM Kemmerer Field Office, Forester	tbristol@blm.gov	At April 24th mtg. Provided shapefile of BLM timber polygons. Follow up on Kemmerer FO walkthrough inventory, Pine Mountain timber inventory
Burns, Kelly	USDA Forest Service, Forest Health Protection, Forest Pathologist	ksburns@fs.fed.us	Provided data from white pine blister rust plots, other information about blister rust, survey protocols
Fieseler, Troy	Wyoming Game and Fish Department, Green River Region, Wildlife Biologist	troy.fieseler@wyo.gov	Provided shape file of and information about treatments in Wyo Range foothills
Gray, Stephen	US Geological Survey, Alaska Climate Adaptation Science Center, Director	sgray@usgs.gov	Provided age of limber pine in southern Wind River Mtns.
Jackson, Joshua	BLM Wyoming State Office, Forestry Program Manager	jjackson@blm.gov	Searched state office files for information
Kott, Mark	Sweetwater County, Public Lands Planner	kotm@sweet.wy.us	At April 24th mtg. County is interested in unusual trees and woodlands
Schoettle, Anna	USDA Forest Service, Rocky Mountain Research Station, Research Plant Ecophysiologist	aschoettle@fs.fed.us	Provided information about blister rust, survey protocols
Spence, Kevin	Wyoming Game and Fish Department, Green River Region, Terrestrial Habitat Biologist	Kevin.Spence@wyo.gov	Interested in project
Tye, Barry	Wyoming State Forestry Division, District 4 Forester	barry.tye@wyo.gov	Interested in project
Wasseen, Jim	Wyoming Game and Fish Department, Wyoming Landscape Conservation Initiative Liaison	jim.wasseen@wyo.gov	At April 24th mtg.

APPENDIX 3. SOLICITATION DOCUMENT FROM 2018 CONTRACTING OPPORTUNITY FOR INVENTORY OF STANDS IN KEMMERER FIELD OFFICE

SOLICITATION/CONTRACT/ORDER FOR COMMERCIAL ITEMS
OFFEROR TO COMPLETE BLOCKS 12, 17, 23, 24, & 30

1. REQUISITION NUMBER	PAGE	OF
0040405568	1	2

2. CONTRACT NO.	3. AWARD/ EFFECTIVE DATE	4. ORDER NUMBER	5. SOLICITATION NUMBER	6. SOLICITATION ISSUE DATE
			140L6218Q0074	08/01/2018

7. FOR SOLICITATION INFORMATION CALL:	a. NAME	b. TELEPHONE NUMBER (No collect calls)	8. OFFER DUE DATE/LOCAL TIME
	Corey Murzyn	(307) 775-6043	08/15/2018 1400 MT

9. ISSUED BY	CODE	10. THIS ACQUISITION IS
BLM WY-STATE OFC BUS MGMT BR(WY951) 5353 YELLOWSTONE RD. CHEYENNE WY 82009	LYA	☐ UNRESTRICTED OR ☒ SET ASIDE: 100.00 % FOR: ☒ SMALL BUSINESS ☐ WOMEN-OWNED SMALL BUSINESS (WOSB) ELIGIBLE UNDER THE WOMEN-OWNED SMALL BUSINESS PROGRAM ☐ HUBZONE SMALL BUSINESS ☐ EDWOSB ☐ SERVICE-DISABLED VETERAN-OWNED SMALL BUSINESS ☐ 8(A) NAICS: 115310 SIZE STANDARD: $7.5

11. DELIVERY FOR FOB DESTINATION UNLESS BLOCK IS MARKED	12. DISCOUNT TERMS	13a. THIS CONTRACT IS A RATED ORDER UNDER DPAS (15 CFR 700)	13b. RATING	14. METHOD OF SOLICITATION
☐ SEE SCHEDULE		☐		☒ RFQ ☐ IFB ☐ RFP

15. DELIVER TO	CODE	16. ADMINISTERED BY	CODE
BLM-WY KEMMERER FIELD OFFICE 430 Highway 189 NORTH KEMMERER WY 83101	0004276761	BLM WY STATE OFC BUS MGMT (WY951) 5353 YELLOWSTONE RD. CHEYENNE WY 82009	LYA

17a. CONTRACTOR/ OFFEROR	CODE	FACILITY CODE	18a. PAYMENT WILL BE MADE BY	CODE
TELEPHONE NO.				

☐ 17b. CHECK IF REMITTANCE IS DIFFERENT AND PUT SUCH ADDRESS IN OFFER

☐ 18b. SUBMIT INVOICES TO ADDRESS SHOWN IN BLOCK 18a UNLESS BLOCK BELOW IS CHECKED ☐ SEE ADDENDUM

19. ITEM NO.	20. SCHEDULE OF SUPPLIES/SERVICES	21. QUANTITY	22. UNIT	23. UNIT PRICE	24. AMOUNT
	Kemmerer Whitebark Pine Walkthrough Inventory and Data Collection EMAIL ALL QUESTIONS TO COREY MURZYN AT cmurzyn@blm.gov SEND ALL QUOTES TO COREY MURZYN BY EMAIL, cmurzyn@blm.gov, FAX 307-775-6317 OR MAIL Buyer: Corey Murzyn 307-775-6043 CO: Kelly Palmer COR: Courtney Pridmore *(Use Reverse and/or Attach Additional Sheets as Necessary)*				

25. ACCOUNTING AND APPROPRIATION DATA

26. TOTAL AWARD AMOUNT *(For Govt. Use Only)*

☒ 27a. SOLICITATION INCORPORATES BY REFERENCE FAR 52.212-1, 52.212-4. FAR 52.212-3 AND 52.212-5 ARE ATTACHED. ADDENDA ☐ ARE ☒ ARE NOT ATTACHED.

☐ 27b. CONTRACT/PURCHASE ORDER INCORPORATES BY REFERENCE FAR 52.212-4. FAR 52.212-5 IS ATTACHED. ADDENDA ☐ ARE ☐ ARE NOT ATTACHED.

☒ 28. CONTRACTOR IS REQUIRED TO SIGN THIS DOCUMENT AND RETURN 1 COPIES TO ISSUING OFFICE. CONTRACTOR AGREES TO FURNISH AND DELIVER ALL ITEMS SET FORTH OR OTHERWISE IDENTIFIED ABOVE AND ON ANY ADDITIONAL SHEETS SUBJECT TO THE TERMS AND CONDITIONS SPECIFIED.

☐ 29. AWARD OF CONTRACT: _____ OFFER DATED _____. YOUR OFFER ON SOLICITATION (BLOCK 5), INCLUDING ANY ADDITIONS OR CHANGES WHICH ARE SET FORTH HEREIN, IS ACCEPTED AS TO ITEMS:

30a. SIGNATURE OF OFFEROR/CONTRACTOR	31a. UNITED STATES OF AMERICA (SIGNATURE OF CONTRACTING OFFICER)

30b. NAME AND TITLE OF SIGNER (Type or print)	30c. DATE SIGNED	31b. NAME OF CONTRACTING OFFICER (Type or print)	31c. DATE SIGNED
		Kelly Palmer	

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Prescribed by GSA - FAR (48 CFR) 53.212

APPENDIX 4. LIST OF THE 9 DIGITAL DATA LAYERS ACCOMPANYING THIS REPORT

The nine digital data layers developed for this project and described in the "Information Examined For Use In This Project" section of this report are being provided separately. Seven of them are shapefiles, and each of those is in a zip file with its accompanying files:

- 1996 Wyo GAP Polygons.zip contains the polygons in which Limber Pine Woodland is the primary or secondary landcover-type or is an other type.

- BLM Timber Polygons.zip contains the polygon shape file of timber polygons that contain limber pine.

- RM Limber Pine Collections.zip contains the point shapefile showing the locations of limber pine collections in the Rocky Mountain Herbarium.

- USFS Blister Rust Plots.zip contains the point shapefile of the plots in which information about white pine blister rust was collected.

- USFS FIA Plots.zip contains the point shapefile of the Forest Inventory & Analysis plots.

- WYNDD Aspen Plots.zip contains the point shapefile of plots in which limber pine was found during WYNDD's survey of aspen woodlands

- Wyo Range Vegetation Treatments.zip contains the polygon shape file of vegetation treatements in the foothills of the Wyoming Range

Two layers are being provided as raster datasets. The files for each are in a folder:

- Landfire Ecological System raster shows the distribution of the Rocky Mountain Foothills Limber Pine – Juniper Ecological Systems

- NIDRM Limber Pine Tree Grid shows the predicted basal area of limber pine

The layers and this report are available on the WYNDD web site, at http://www.uwyo.edu/wyndd/reports-and-publications/