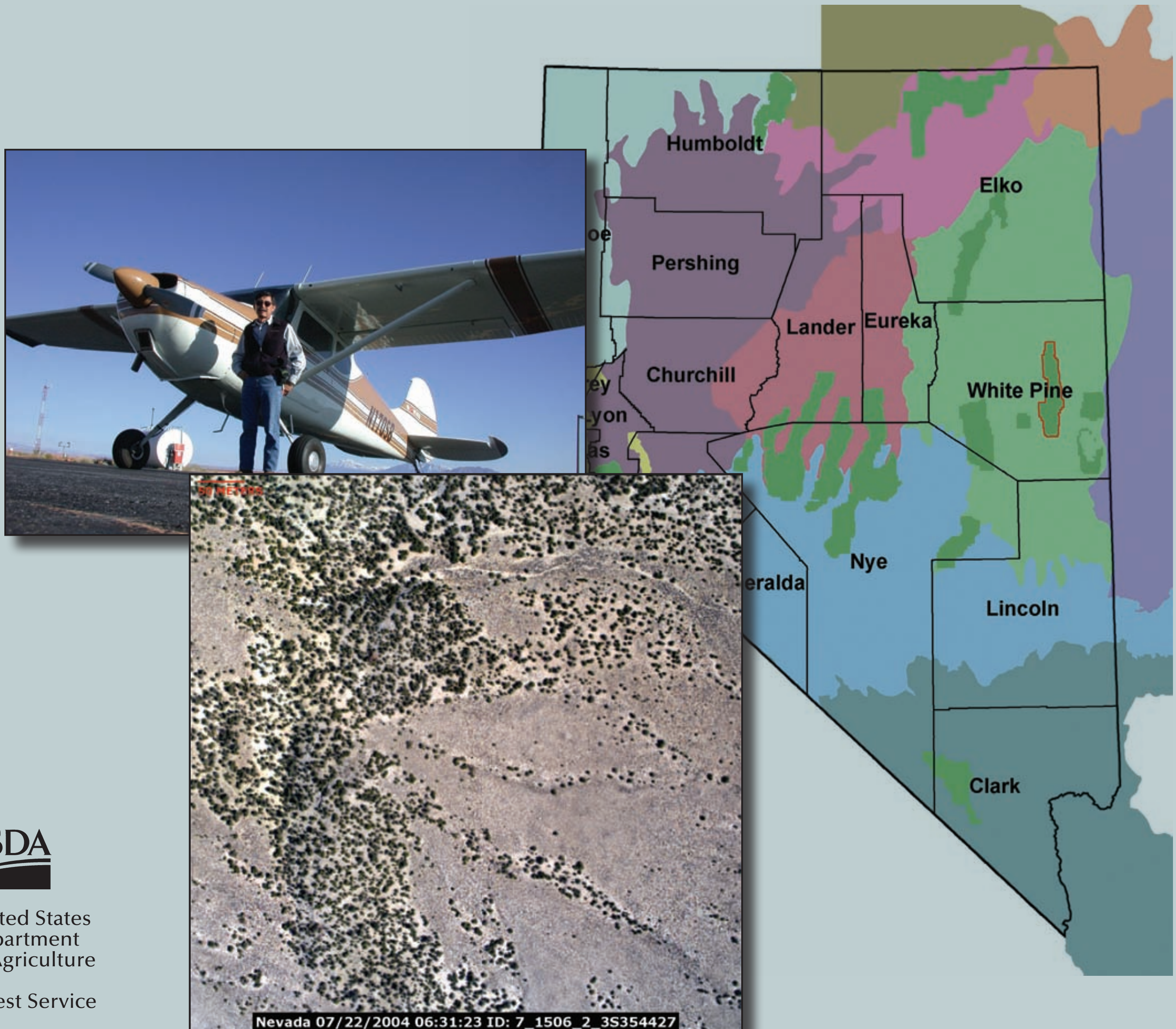
Nevada Photo-Based Inventory Pilot (NPIP) Photo Sampling Procedures

Tracey S. Frescino, Gretchen G. Moisen, Kevin A. Megown,
Val J. Nelson, Elizabeth A. Freeman, Paul L. Patterson,
Mark Finco, Ken Brewer, and James Menlove



USDA

United States
Department
of Agriculture

Forest Service

Rocky Mountain
Research Station

General Technical Report
RMRS-GTR-222

April 2009

Frescino, Tracey S.; Moisen, Gretchen G.; Megown, Kevin A.; Nelson, Val J.; Freeman, Elizabeth A.; Patterson, Paul L.; Finco, Mark; Brewer, Ken; Menlove, James. 2009. **Nevada Photo-Based Inventory Pilot (NPIP) Photo Sampling Procedures**. Gen. Tech. Rep. RMRS-GTR-222. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 30 p.

Abstract

The Forest Inventory and Analysis program (FIA) of the U.S. Forest Service monitors status and trends in forested ecoregions nationwide. The complex nature of this broad-scale, strategic-level inventory demands constant evolution and evaluation of methods to get the best information possible while continuously increasing efficiency. In 2004, the "Nevada Photo-Based Inventory Pilot" (NPIP) was launched and involved the acquisition and processing of large-scale aerial photography (LSP) throughout the State of Nevada. The over-arching goals of this pilot are to exceed information requirements, accelerate inventory timelines, and reduce inventory costs. Meeting these objectives requires the development of several complex and inter-related procedures, including photo-sampling protocol, statistical estimators, cover measurement techniques, and improved methods for mapping forest and nonforest attributes. This report documents the first of these procedures, the photo-sampling protocol for the NPIP project.

Keywords: Nevada, photo-based inventory, photo interpretation, quality control, large-scale aerial photography (LSP)

Authors

Tracey S. Frescino is a Forester/GIS Analyst for the U.S. Forest Service, Rocky Mountain Research Station, Inventory and Monitoring Program, Ogden, UT.

Gretchen G. Moisen is a Research Forester for the U.S. Forest Service, Rocky Mountain Research Station, Inventory and Monitoring Program, Ogden, UT.

Kevin A. Megown is a Remote Sensing Specialist/Forester/Statistical Analyst for the U.S. Forest Service, Remote Sensing Applications Center, Salt Lake City, UT.

Val J. Nelson is an Ecologist for the U.S. Forest Service, Rocky Mountain Research Station, Inventory and Monitoring Program, Ogden, UT.

Elizabeth A. Freeman is an Ecologist/Statistical Analyst for the U.S. Forest Service, Rocky Mountain Research Station, Inventory and Monitoring Program, Ogden, UT.

Paul L. Patterson is a Statistician for the U.S. Forest Service, Rocky Mountain Research Station, Interior-West Forest Inventory and Monitoring Program, Ogden, UT.

Mark Finco is a Remote Sensing Specialist/GIS Analyst for the U.S. Forest Service, Remote Sensing Applications Center, Salt Lake City, UT.

Ken Brewer is the Inventory Analysis and Accuracy Assessment (IAAA) Program Leader for the U.S. Forest Service, Remote Sensing Applications Center, Salt Lake City, UT.

James Menlove is an Ecologist/Analyst for the U.S. Forest Service, Rocky Mountain Research Station, Inventory and Monitoring Program, Ogden, UT.

Acknowledgments

The authors would like to express their gratitude to the pilot and aerial photographer, Paul Ishikawa, Jr., photo interpreters Steven Dale, Alex Hoppus, and Jeb Williamson from the Remote Sensing Applications Center, and to Sara Goeking, Jim Steed, Jennifer Bakken, and others from the Interior-West Forest Inventory and Analysis Program who participated in the prototype analysis. We would also like to thank Anna Broderius for her work rectifying the aerial photographs, Kent Mueller, who assisted with database input and form development for quality control analyses, and to all others who provided input to the process.

You may order additional copies of this publication by sending your mailing information in label form through one of the following media. Please specify the publication title and number.

Publishing Services

Telephone	(970) 498-1392
FAX	(970) 498-1122
E-mail	rschneider@fs.fed.us
Web site	http://www.fs.fed.us/rmrs
Mailing Address	Publications Distribution Rocky Mountain Research Station 240 West Prospect Road Fort Collins, CO 80526

Contents

Nevada Photo-Based Inventory Pilot (NPIP) Photo Sampling Procedures

Tracey S. Frescino, Gretchen G. Moisen, Kevin A. Megown, Val J. Nelson, Elizabeth A. Freeman, Paul L. Patterson, Mark Finco, Ken Brewer, and James Menlove

Introduction

The U.S. Department of Agriculture, Forest Service, Forest Inventory and Analysis program (FIA) is a national program that conducts an annual forest inventory on a permanent grid of plots across the United States (Reams and others 2005). The complex nature of broad-scale, strategic-level inventories, such as those conducted by FIA, demands constant evaluation and evolution of methods to get the best information possible while continually increasing efficiency. This is particularly true for the Interior-West (IW)-FIA, which is not yet fully funded for a complete annual inventory in all states (fig. 1) and is made up of extensive acreages of nonforested land and land dominated by woodland tree species. Woodland tree species, such as pinyon and juniper, are very slow-growing and have long-term successional cycles (Tueller and Clark 1975). Lands dominated by these species typically do not change rapidly and may not need the same frequency of field visits as the more dynamic forested lands dominated by timber species. Therefore, they are prime candidates for examining methods to improve efficiency.

We focused our efforts on Nevada for several reasons: it is one of the states not yet funded for annual inventory; has the most incomplete and outdated periodic data in the Interior West; is predominantly nonforested federal lands (fig. 2a); and the small amount of forest land it contains is dominated by woodland tree species (fig. 2b). Consequently, it offers a good test site for alternative methodologies to improve precision in estimates of forest parameters, reduce field data collection costs, address the potential of strategic-level inventory on lands not traditionally sampled by FIA, and help refine definitions of forest land.

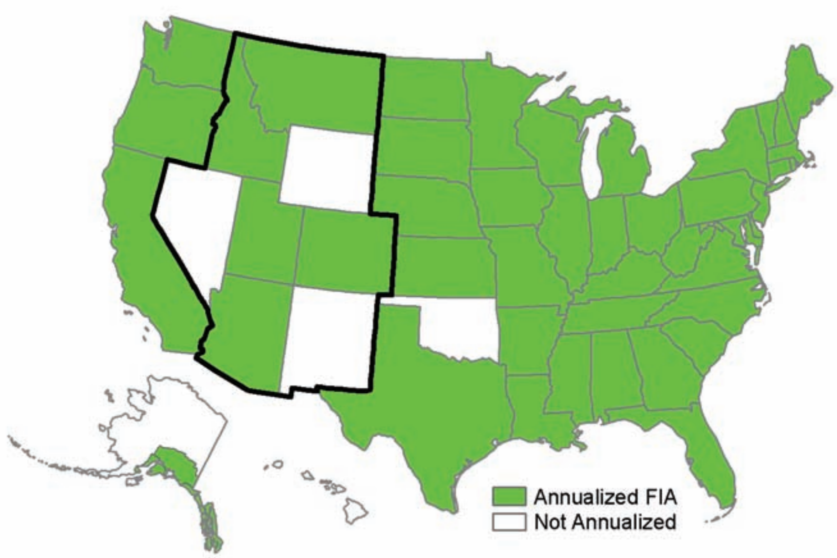


Figure 1. Map of United States displaying the status of FIA's annualized inventory. The Interior-West FIA is outlined in black.

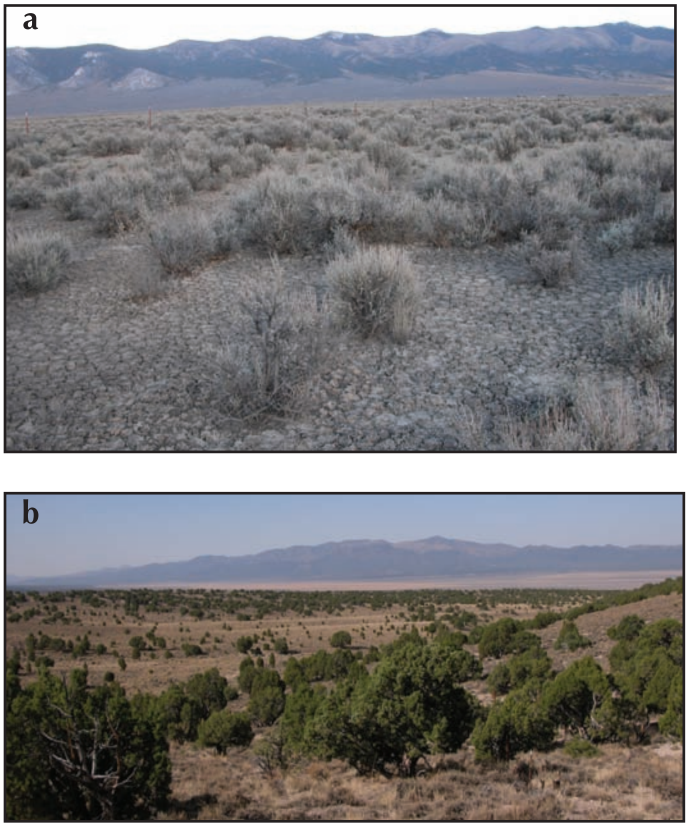


Figure 2. Photos of nonforest land and lands dominated by woodland tree species in Nevada. a. sagebrush community; b. pinyon-juniper community.

Aerial photography has played a role in forest inventories since the 1950s. Pitt and others (2000) successfully used a combination of large- and medium-scale aerial photographs for assessing and mapping a range of early seral vegetation conditions. Other studies showed the utility of aerial photographs as a sampling tool for assessing forest regeneration (Hall and Aldred 1992), estimating conifer mortality rates (Hamilton 1984), estimating tree measurements such as height, diameter, and volume (Aldred and Hall 1975, Aldred and Kippen 1967, MacLean 1963, Megown and others 2003), and delineating rangeland ecosystems (Harris 1951, Knapp and others 1990). As the quality of aerial photography continues to progress, along with the software and computing power for managing the images digitally, aerial photographs are becoming increasingly effective for improving efficiencies in forest inventories.

The Nevada Photo-Based Inventory Pilot (NPIP) project began in 2004 with the acquisition and processing of global positioning system (GPS)-controlled, large-scale aerial photography (LSP) on a subset of FIA plots (both forest and nonforest) throughout the State of Nevada during two seasons. The LSP data were integrated with FIA field plots, ancillary geographic information system (GIS) data, and moderate resolution satellite imagery through a flexible estimation and modeling procedure. The over-arching goals were to enhance the existing annual system and reduce inventory costs. Specific objectives of the pilot included producing more precise and timely estimates of forest resources; characterizing all vegetation types, not just forest types; improving efficiency of pre-field interpretations; refining FIA definitions of forest land; and producing better maps using photos for scale appropriate training data.

Meeting these five objectives requires developing several complex and inter-related procedures, including photo-sampling protocol, statistical estimators, prefield processes, cover measurement techniques, and improved methods for mapping forest and nonforest attributes. This report documents the first of these procedures: the photo-sampling protocol for the NPIP project. Details are included for the various components of the project, including photo sample design, photo acquisition and pre-processing, photo-interpretation, and quality control on photo-interpreted data.

Study Area

The study area for constructing these estimates is the State of Nevada, which consists of 28,629,728.6 ha (70,745,600 acres) (http://dcnr.nv.gov/nrp01/land01.htm), including water but excluding 3,514,290 ha (8,684,000 acres) of restricted air space such as the Department of Defense (fig. 3a), with 86.1 percent of the state publicly owned (http://dcnr.nv.gov/nrp01/land01.htm).

The Great Basin physiographic region comprises most of the state, with its western border reaching the eastern slope of the Sierra Nevada mountain range, its northern border extending into the southern Idaho Snake River Plain, and its southern border bounding the Mojave Desert region (fig. 3b). The Great Basin region has characteristic topography of several block-faulting, north-south oriented mountain ranges with inland-drained valleys or basins between them (Cronquist and others 1972). There are three main ecological provinces within the Great Basin region in Nevada: 1) Intermountain Semi-Desert and Desert; 2) Intermountain Semi-Desert; and 3) Nevada-Utah Mountains Semi-Desert—Coniferous Forest—Alpine Meadow (Bailey 1988). The Intermountain Semi-Desert and Desert and the Intermountain Semi-Desert provinces consist mainly of high desert plateaus dominated by

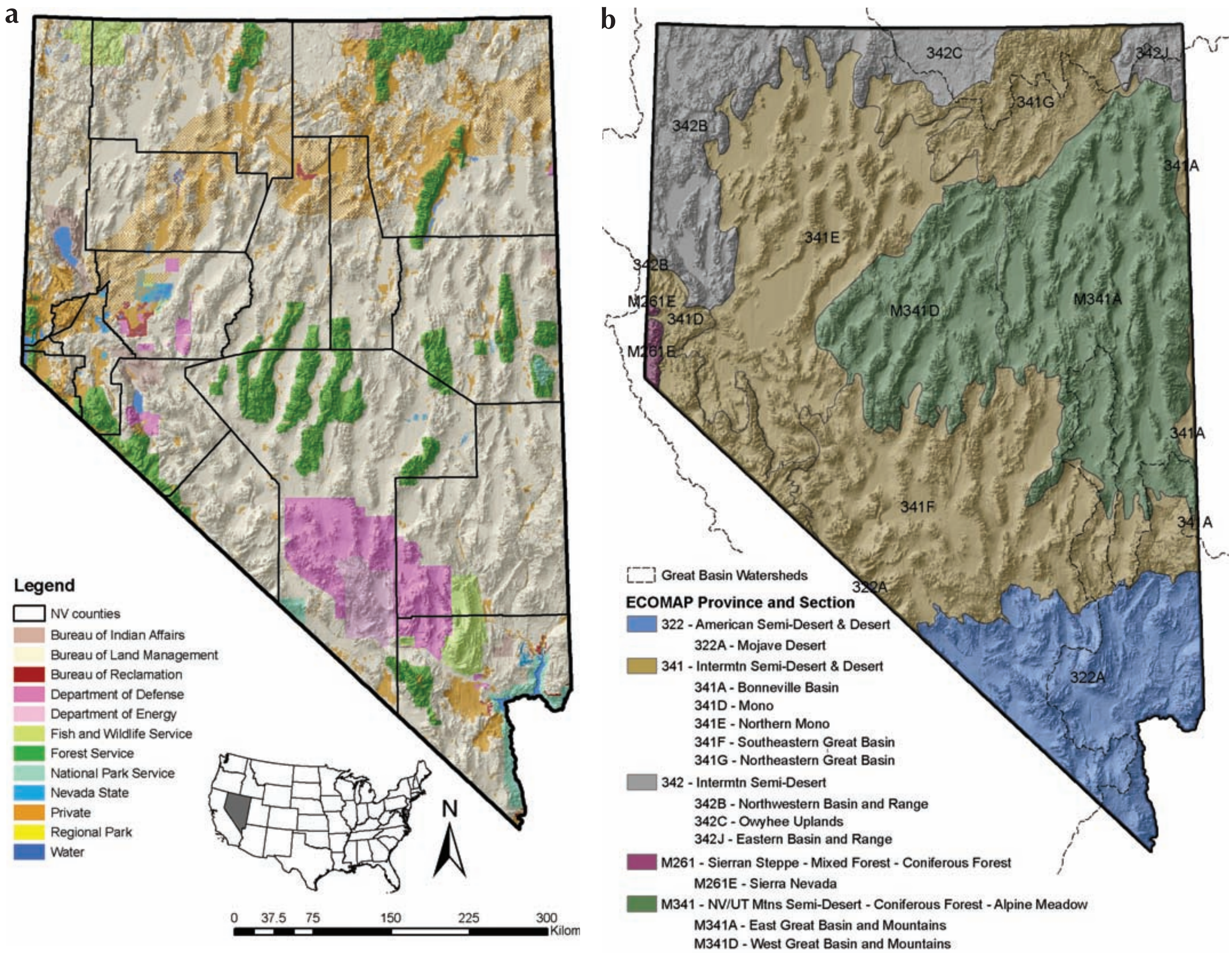


Figure 3. Maps of Nevada. a. Nevada with ownership (U.S. BLM unpublished) and county boundaries. b. Nevada with ecoregion province and section boundaries (Cleland and others 1997, ECOMAP 1993).

sagebrush and other desert shrub species. Interspersed throughout the plateaus are isolated mountain ranges, with pinyon-juniper on the lower slopes leading to mahogany woodland, Douglas-fir, and ponderosa pine, and at the higher elevations, subalpine fir and Engelmann spruce. The western section of the Intermountain Semi-Desert and Desert province along the California Sierra Nevada mountain range has additional species of Jeffrey pine, Western juniper, and bristlecone pine. The Nevada-Utah Mountains Semi-Desert—Coniferous Forest—Alpine Meadow province covers the higher areas of the Great Basin region with species of sagebrush up to subalpine fir and Engelmann spruce. Great Basin bristlecone pine is also scattered across the higher elevations of this region. A very small area of Nevada goes into the Sierra Nevada section of the Sierran Steppe—Mixed Forest—Coniferous Forest province. This area reaches elevations over 10,000 ft and supports species of lodgepole pine, Jeffrey pine, white fir, red fir, and aspen (Bailey 1988).

The Mojave Desert region in southeastern Nevada falls in the American Semi-Desert and Desert province. This area has very low rainfall, ranging from 3 to 10 inches per year. It supports mainly desert shrub species of creosote, saltbush, and Joshua trees in the lower elevations and sagebrush and pinyon-juniper in the higher elevations of the area (Bailey 1988).

Survey Design

The sample survey design for NPIP follows the systematic sampling design of the national FIA program (Reams and others 2005). The national FIA sampling design is based on a nationally consistent and uniform spatial and temporal distribution of field plots across the United States. There is one field plot for approximately every 6,000 acres. These plots are systematically delineated into five panels, each panel representing 20 percent of the data, measured on an annual cycle. In the West, panels are divided again into subpanels with one subpanel measured every year over 10 years.

We pre-stratified the state into three initial strata using a pixel-based, 250-m resolution map of predicted timberland forest, woodland forest, and nonforest areas (fig. 4). We developed this map by modeling FIA field plot data as a function of several predictor variables including MODIS imagery and other digital environmental data using classification trees implemented in See5 (www.rulequest.com) (Blackard and others 2004). Because of FIA's focus on forest land and the primary objective of delivering more timely and efficient information on forest attributes, photo-acquisition dollars were first committed to photo sampling all FIA locations (in other words, all 10 subpanels) within the timberland and woodland strata. With the remaining funds, we photo-sampled 1/10 of the FIA locations (in other words, one subpanel) within the nonforest stratum. There were a total of 2,332 sample locations, 1,455 locations within the timberland and woodland strata combined and 877 within the nonforest stratum.

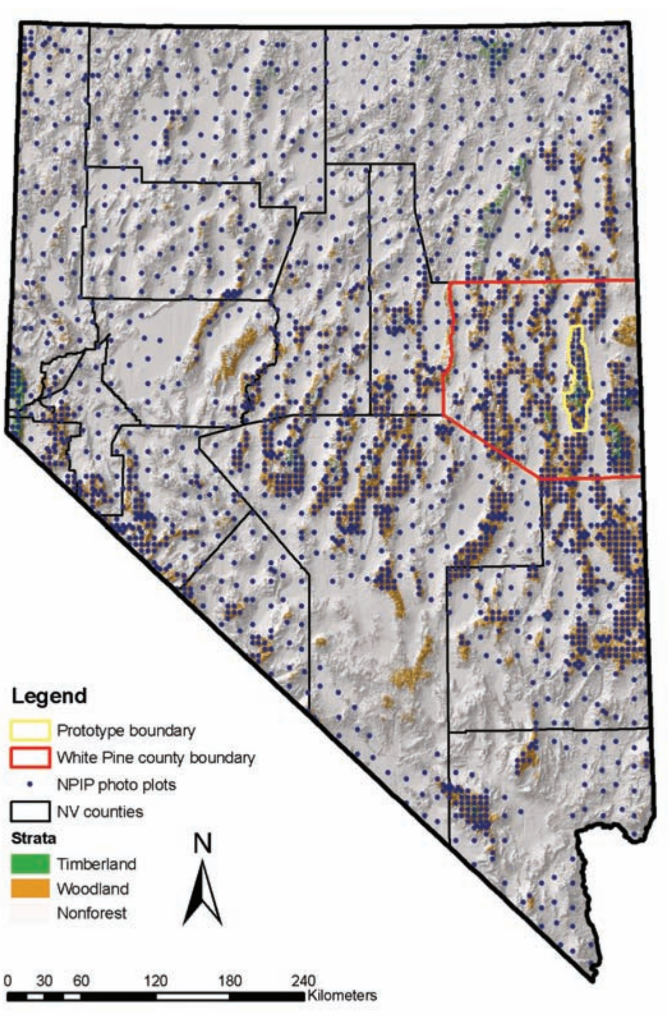


Figure 4. Map of Nevada with strata, prototype boundaries, and the approximate photo sample locations.

The 2,304,382 ha (5,694,050 acres) area delineated by yellow in figure 4 served as a prototype for photo-interpretation procedures. This topographically diverse area, located in the Shell Creek Mountain Range of the Humboldt-Toiyabe National Forest in east-central Nevada, contained a total of 40 sample locations, with 39 photo sample locations in the forested stratum and one in the nonforest stratum. White Pine county, bordered in red, served as a second level prototype for refining photo-interpretation and quality control processes. This county contained a total of 365 plots, with 305 photo samples in the forest stratum and 60 photo samples in the nonforest stratum.

Photographs

We used digital large scale aerial photographs as the medium for interpretation of resource information across all lands in Nevada. The process to obtain and prepare these photos for interpretation included three major components: 1) photo acquisition; 2) photo conversions; and 3) geolocation of plot center locations.

Photo Acquisition

Acquisition of all photos for NPIP locations was completed over 2 consecutive years, 2004 and 2005. In 2004, we acquired 395 locations by contract with the Remote Sensing Application Center (RSAC) using a direct-to-digital camera, DCS645C, with a 55-mm lens. Flights were flown 3,000 ft above ground with a 2,002-ft swath width, resulting in a 0.49-ft ground sample distance (GSD). Each photograph covers approximately 92 acres in area (fig. 5a). In 2005, a contract through the USDA Aerial Photography Field Office (APFO) to Aerial Services, Inc. (ASI) provided photos for 1,937 locations. The ASI photography used natural color 9x9-inch film

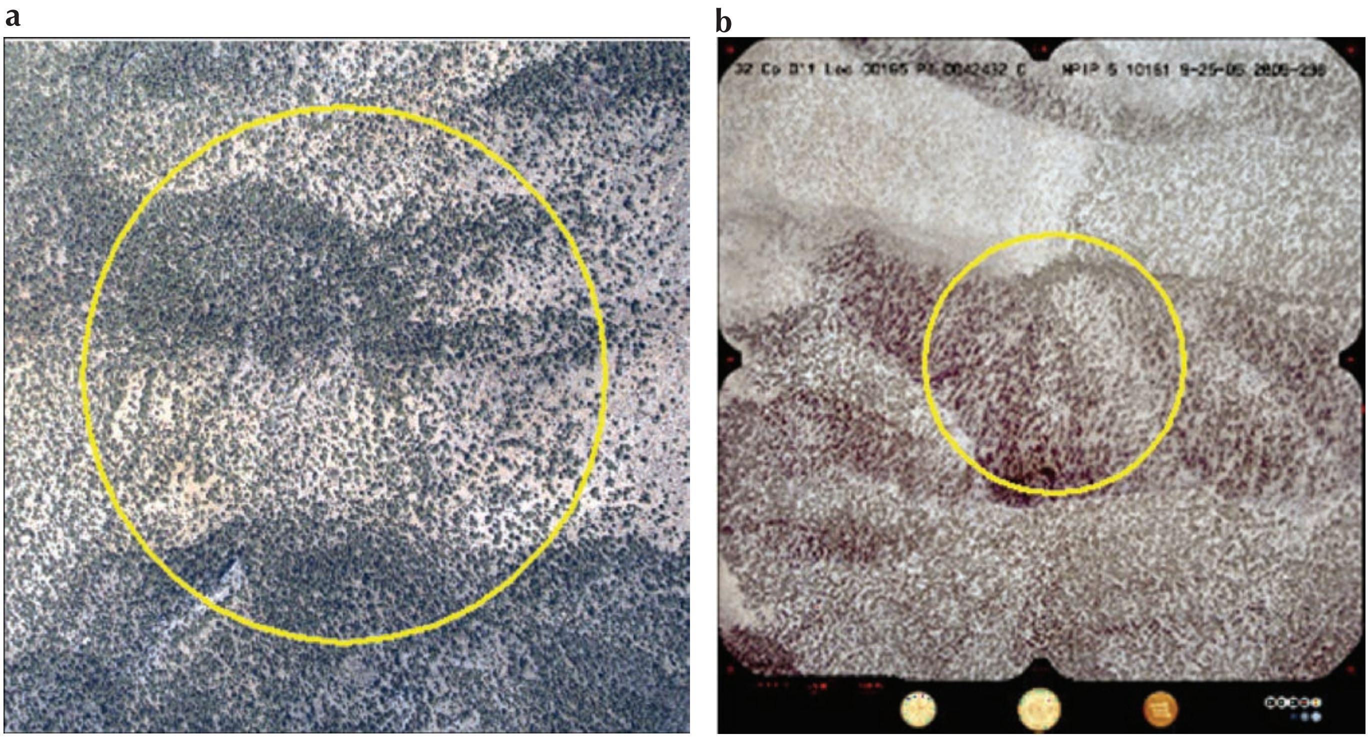


Figure 5. NPIP photo acquisition: a. A direct to digital photo taken in 2004, representing 92 acres on the ground; b. A scanned photo taken in 2005, representing 322 acres on the ground. The yellow circle represents a 250-m radius NPIP photo plot.

and a 6-inch lens. These plots were flown at a scale of 1:5,000 with a 3,750-ft swath width. Each ASI photo covers approximately 322 acres (fig. 5b). Stereo triplicate photographs were acquired for all plots.

Photo Conversions

We converted all photographs to a digital Tagged Image File Format (TIFF) format. The 2004 direct-to-digital images were already in this format and were approximately 45 Mb in size. We scanned 2005 film photograph prints to a TIFF digital format at 28 μ, resulting in a GSD of approximately 6 inches. Each TIFF image was approximately 235 Mb in size. The full set of stereo triplicate photographs in TIFF format for the entire State of Nevada required approximately 1 terabyte of computer storage space.

We produced hardcopy prints for all plots that were within forest strata. This included a stereo triplicate for each plot. We used these hardcopy photographs to assist in the photo interpretation process and made them available to FIA field crews for assistance in navigating to plots.

Geolocation

Photographs were taken at each FIA X-Y location. We targeted this X-Y location as the very center of the photo, but some minor shifting of the points occurred because of topography and/or the imperfect airplane attitude. For the 2,332 photo plots flown, the average shift was 25.6 m (in any azimuth), with 92 percent of the X-Y locations falling within 50 m of the target (fig. 6).

To correct for this horizontal shift, each FIA X-Y plot center location was overlayed on the geolocated photograph and compared to the same FIA X-Y plot location overlayed on a 1-m resolution Digital Orthophoto Quad (DOQ). If there was a difference between the two photos, the position of the NPIP photo was moved to match the DOQ location (fig. 7). A quality assessment of the geolocation procedure included a random selection of 10 percent of the NPIP sample locations and found 99 percent accuracy in the location of the plot center.

The preceding method geometrically corrects the center location. Moving away from the center, the location error increases due to radial displacement and

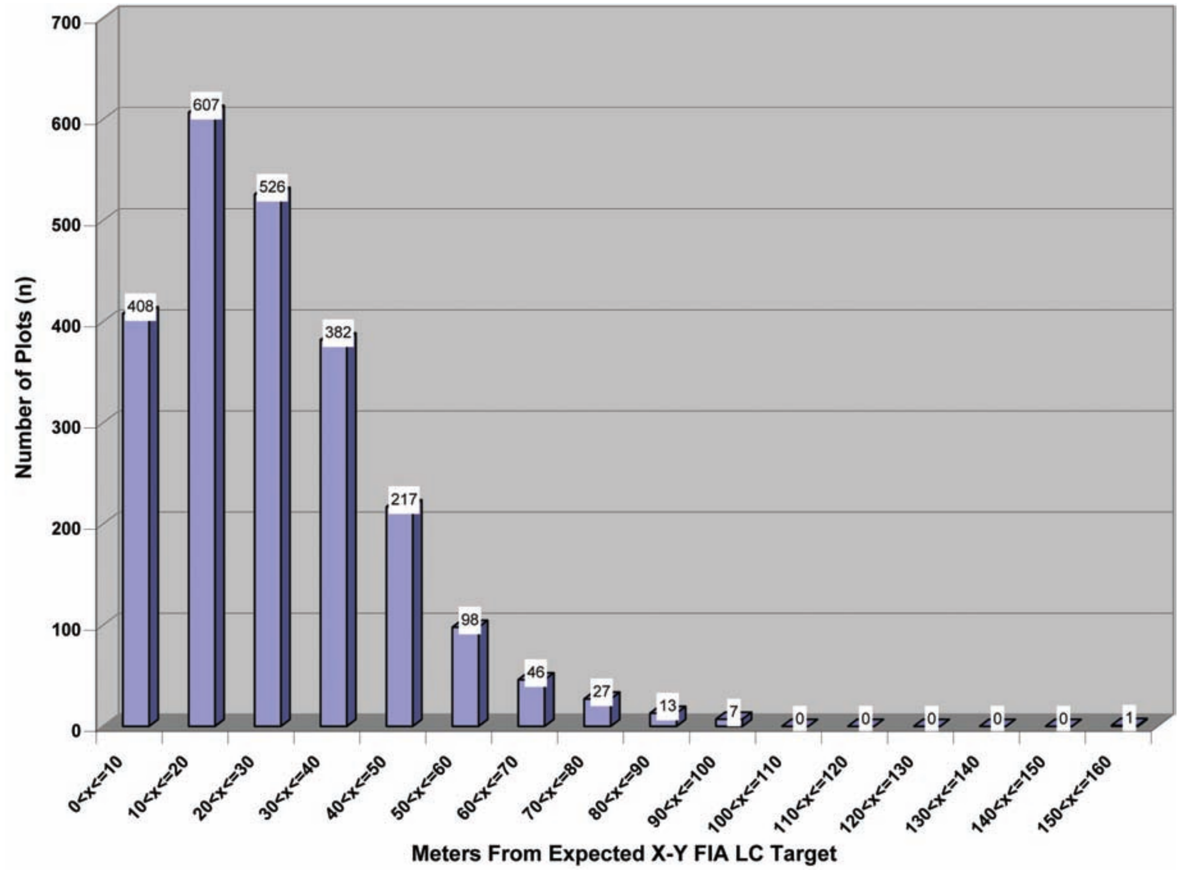


Figure 6. Number of photograph center locations by the distance from the expected X-Y FIA target location.

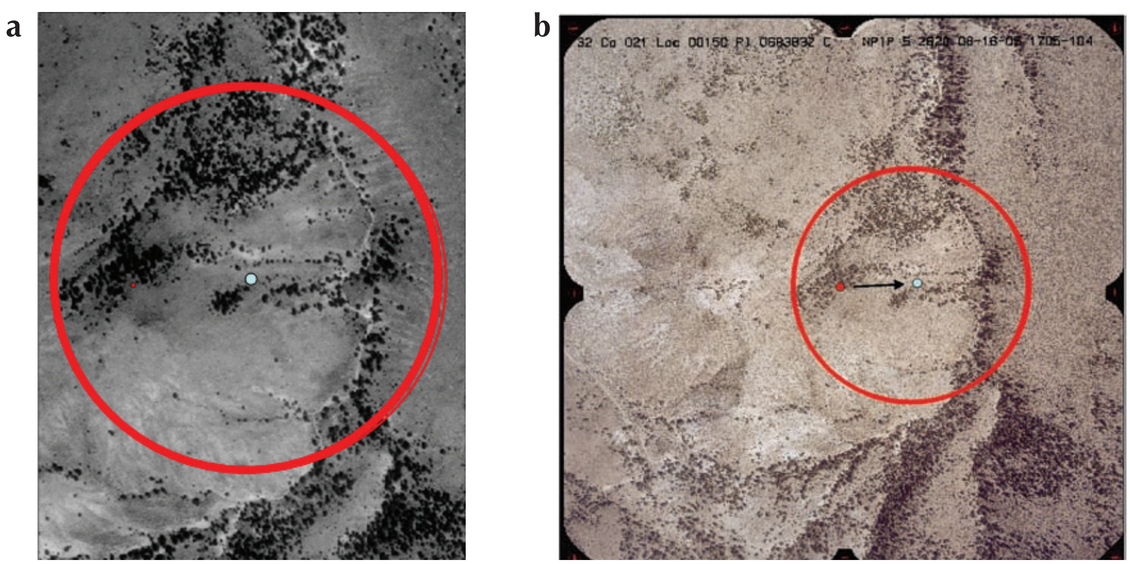


Figure 7. Plot geolocation process. a. Sample ground plot location overlayed on a DOQ. b. Sample plot overlayed on the aerial photograph. The red point shows the photo-interpretation plot center point before the geometric correction. The blue point shows the plot center point after the geometric correction process.

lack of orthometric correction. Because we found this error to be negligible and the time required to perform the orthorectification process was cost-prohibitive, we considered the geolocation of the plot center sufficient.

Plot Design

The NPIP photo plot was a 250.0-m (820.2-ft) radius circle surrounding the theoretical FIA ground plot location. The circle encompassed approximately 19.6 ha (48.5 acres) of land. A systematic dot grid sample of 49 points was established within each plot at a spacing of 62.0 m (203.4 ft) (fig. 8). We created the dot grids in an ArcMap (ESRI Inc., Redlands, CA) environment using the Digital Mylar Image Sampler tool developed by the Remote Sensing Applications Center (RSAC) (Clark and others 2004), described in greater detail in the next section.

We chose the size of the plot to maximize the effective area sampled by the 2004 aerial photographs. This larger plot size, when contrasted with the standard FIA plot design, increases the effective sampling area for each FIA plot location. This increases the likelihood of sampling rare vegetation types, which would result in better characterization of forest and other vegetation cover. We chose the number of sample points within a plot to minimize photo sampling time without compromising estimates of percent type and cover on photo plots. Figure 9 illustrates how variance in estimates of photo plot proportions decreases rapidly for roughly the first 30 sample points and levels off considerably after 50. This is based on the standard variance equation for estimating population proportions under simple random sampling and is a rough illustration of why 49 was a sensible number of points. Also, 49 points results in each point representing approximately 1 acre of land within the sample circle, which parallels the FIA field definition for condition class minimum size (USDA 2006).

Photo Interpretation

We assigned two types of information to each of the 49 points within each photo plot. The first type, *condition*, was the condition in which the photo point fell, where condition is defined as an area of homogenous vegetation having similar characteristics (USDA 2006). We used this information to construct area estimates by a variety of forest and nonforest types. The second type was the *object* on which the point fell, such as a tree, shrub, or building. This information was used to construct estimates of percent cover of the many object types in the landscape. Further details on condition and object assignment follows. We used the Digital Mylar Image Sampler tool to assign a condition and object class to each of the 49 points on each photo. This tool enables rapid interpretation by automating creation of the dot grid and facilitating condition and object interpretation and attribution. The information for each plot was stored in

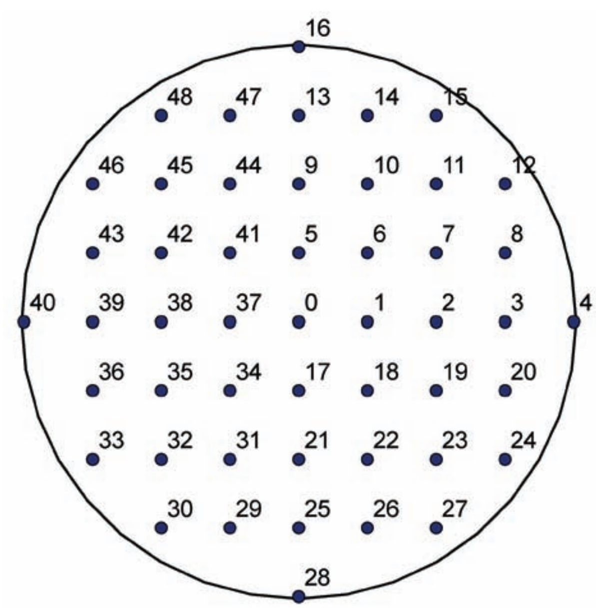


Figure 8. NPIP plot design. The center point (0) is located at the theoretical center point of an FIA plot.

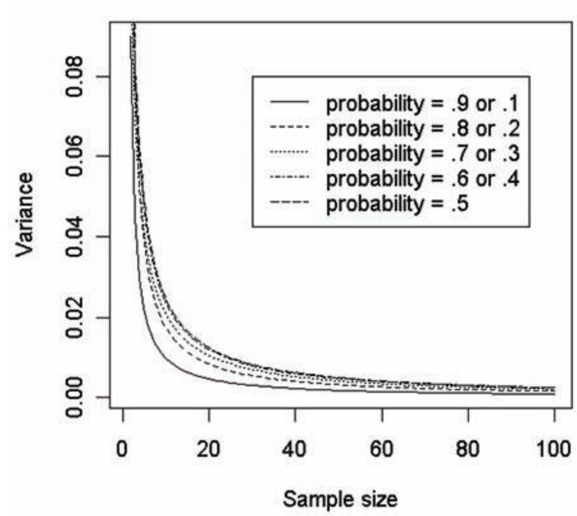


Figure 9. Decreasing variance in estimates of photo plot proportions as a function of the number of sample points.

two files, an ArcGIS shapefile of points with condition and object attributes and an ancillary database table of condition attributes. Each plot was assigned a unique identifier to distinguish it from another plot.

Assigning Condition Information

Condition is a complex variable defined by six photo-interpreted attributes, including condition class, forest and nonforest type, stand size, regeneration status, stand density, and disturbance, all of which were recorded for each photo point using an ancillary form application developed by IW-FIA for Digital Mylar (fig. 10). We considered sample points on a photo to be members of the same condition (in other words, have the same condition number) only if all six attributes were the same. A change in one or more of these attributes constituted a change in condition.

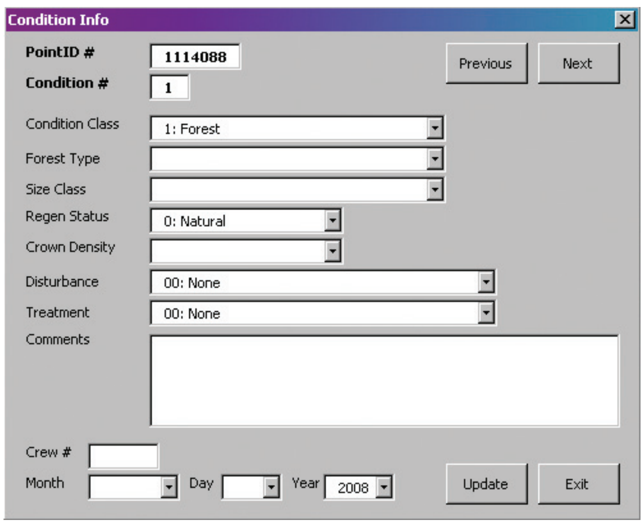


Figure 10. Ancillary form application used to record condition level attributes of NPIP sample points.

Where possible, we used FIA field protocols (USDA 2006) to characterize these six attributes. However, adjustments were made to account for differences between field measured and photo-interpreted data. We also expanded FIA classes and definitions to include NPIP's nonforest component. For example, the first condition-defining attribute, condition class, was expanded to include a nonforest developed class and riparian classes. Table 1 presents a list of the six condition-defining attributes along with two additional condition attributes discussed below, with brief definitions of each included. (See Appendix A for further descriptions of the condition attributes and rules for delineating different conditions.)

The second condition-defining attribute, Forest/Nonforest type (table 1), included FIA-based forest type classes as well as additional nonforest classes. We defined the forest type classes, although similar in names as FIA forest type classes, using the majority of cover of vegetation instead of stocking (USDA 2006). The nonforest types included classes defined by the majority of vegetation, such as the Sage or Grass/Forb classes, or describing the current land use on site, such as the Cropland or Developed classes. (See Appendix B for further details on the forest and nonforest type classes used in this study.)

The third condition-defining attribute, size class (table 1) (applicable only to forested conditions), was also a modification of FIA field protocol. Based on the prototype analyses, it was difficult to distinguish different size classes above 5.0 inches in diameter, therefore all FIA size classes greater that 5.0 inches in diameter were grouped into one size class.

Table 1. Condition attributes.

Condition attribute	Definition
Condition class	A classification of the land based on the current vegetation status.
Forest/nonforest type	A classification of forest or nonforest land based on the vegetation or vegetation communities that constitute the majority of cover on the site. Nonforest types include land use classes, such as cropland and developed lands.
Size class	A classification of forest land based on the predominant size class of all live trees.
Tree density	A classification of forest land based on tree cover.
Disturbance	The presence of a natural or human-caused disturbance.
Treatment	The presence of a human-caused forest treatment.
Owner group	A classification of a land ownership.
Reserved status	An identification of land withdrawn by law(s) prohibiting the management of land for the production of wood products.

The FIA field protocol for tree density (table 1) is used as a condition delineating variable only if the difference in density is 50 percent or greater. For the photo-based inventory, we defined tree density by percent cover classes (see Appendix B for description of classes). As with the FIA field protocol, it was used as a condition-delineating variable only if there was a change of at least two classes.

Disturbance and treatment condition attribute classes (table 1) from the FIA field protocol were grouped or eliminated into seven and six classes, respectively, based on what was identifiable from the aerial photographs (see Appendix B for class descriptions). Similar to FIA protocol, a disturbance should only be identified if the disturbance affects at least 1 acre in size; the disturbance occurred within the last 5 years; and the damage affects greater than 25 percent of all trees in a stand or greater than 50 percent of an individual species' count. For NPIP, we identified damages on nonforest areas as well, where the damage affected greater than 25 percent of the area. Treatment criteria was similar to FIA protocol, where the area affected must be at least 1.0 acre in size and have occurred within the last 5 years.

In addition to the six photo-interpreted condition attributes described above, we extracted two other condition attributes from ancillary digital data layers using GIS techniques: owner group and reserved status (table 1). Owner group is a classification of land ownership and reserved status is an identification of land withdrawn by law(s) prohibiting the management of land for the production of wood products (USDA 2006). According to FIA protocol, owner group and reserved status are condition-defining attributes. Because these are not discernable on photos, or by ground crews, we determined condition changes based on these two variables after all photos were interpreted. We assigned NPIP sample points an owner group class and reserved status class based on GIS layers of ownership (fig. 3a) and reserved status using GIS data extraction techniques.

Assigning Object Information

Along with the condition information, we also assigned object information to each point. Table 2 presents the list of objects, object type, and their definitions used for this pilot study.

Quality Control

The objective of the quality control protocol was to ensure accuracy and consistency in the photo interpreted data. To accomplish this, we developed a quality control process, which included continuous feedback to the photo interpreters throughout the project by an expert quality control person. The four components of quality control focused on: 1) training, 2) data compilation and editing, 3) field validation, and 4) interpreter repeatability. Extensive training procedures conducted throughout the project enhanced the photo interpreter's skills and maintained the quality of the data. Data compilation and editing tools provided opportunities to catch miscellaneous errors from data entry or data transfer. Field validation gave an on-the-ground look at photo interpreter calls and provided timely feedback to enhance the photo interpreter's classification abilities. Interpreter repeatability showed the ability of different photo interpreters to provide consistent information. Each method is discussed in more detail in the following sections.

Training

All photo interpreters completed initial training in photo interpretation methods. These included the details of the data collection standards and protocols, intricacies of using the digital mylar sampling tool, and components of the quality control process.

Photo interpreters also made field reconnaissance visits to each of the ECOMAP sections (fig. 3b) prior to beginning photo interpretation in these areas. For each section, the photo interpreters spent up to a week in the field reviewing different vegetation types visible on the photos with the corresponding ground locations, looking at the object and condition types in different settings, and taking ground photos for use as reference materials. These photos were reevaluated periodically by all photo interpreters to ensure quality and consistency of interpretations for an individual interpreter and between interpreters.

Data Compilation and Edit Checking

Approximately once a week, the photo-interpreted data were delivered for compilation and edit checking prior to import into an Oracle database. The process involved compiling the individual plot information, running the compiled data through an edit program, inspecting a randomly selected subset of the data, and further checking each plot for a quick screening of condition level attributes. The data compilation and edit checking were similar to IW-FIA's process for compiling and edit checking ground crew plots. We developed several tools to accomplish these routine tasks using the Comprehensive R Archive Network (CRAN) R interface (Ihaka and Gentleman 1996; www.cran.r-project.org) and Python (www.python.org).

Table 2. Object definitions.

Object	Object type	Description
Engelmann spruce	tree	*Picea engelmanii*
subalpine fir	tree	*Abies lasiocarpa*
white fir	tree	*Abies concolor, Abies grandis*
California red fir	tree	*Abies magnifica*
Douglas-fir	tree	*Pseudotsuga menziesii*
bristlecone pine	tree	*Pinus longaeva*
limber pine	tree	*Pinus flexilis*
ponderosa pine	tree	*Pinus ponderosa*
Jeffrey pine	tree	*Pinus jeffreyi*
Washoe pine	tree	*Pinus washoensis*
sugar pine	tree	*Pinus lambertiana*
whitebark pine	tree	*Pinus albicaulis*
incense-cedar	tree	*Calocedrus decurrens*
aspen	tree	*Populus tremuloides*
black cottonwood	tree	*Populus trichocarpa*
pinyon spp.	tree	pinyon spp. (*Pinus edulis, Pinus discolor, Pinus monophylla*)
juniper spp.	tree	juniper spp. (*Juniperus osteosperma, Juniperus scopulorum,..)*
mtn. mahogany	tree	*Cercocarpus ledifolius*
Gambel oak	tree	*Quercus gambelii*
other tree	tree	other non-tally tree species (not in list above)
standing dead	tree	dead trees greater than 4.5 inches in height
down dead	tree	down dead trees or stems
mortality	tree	trees that died within the last 5 years (orange/yellow color)
sage complex	shrub	sage species (*Artemisia* spp.)
other shrub	shrub	non-sage shrub species
dry herbaceous	other veg	a grass or form living in dry conditions
wet herbaceous	other veg	a grass or form living in moist conditions
agriculture	other veg	managed vegetation for agricultural use
pasture	other veg	managed vegetation for grazing use
litter	other veg	organic debris on forest floor
other vegetation	other veg	other vegetation not described above
soil or rock	barren	bare soil or rock cover
built (structure)	barren	cultural structure (business, residential, other human activity)
improved road	barren	roads or rights-of-way regularly maintained for long-term use
unimproved road	barren	road not regularly maintained for long-term use
water	barren	streams and canals more than 30 ft wide; lakes and reservoirs more than 1 acre
other barren	barren	other barren land cover not described above
snow or ice	unknown	snow or ice cover preventing view of object
shadow	unknown	shadow preventing view of object
other unknown	unknown	other phenomenon preventing view of object
off photo	unknown	point falls off the photo

Table 3 displays the steps taken for the data compilation and edit checking process.

We compiled the individual plot data using a Python script in Arc Toolbox developed by IW-FIA. As mentioned previously, we stored the information for each plot in two files, an ArcGIS shapefile of points with condition and object attributes and an ancillary database table of condition attributes. The Python script appended the individual shapefiles into one shapefile and appended the individual database files into one database file, additionally producing a list of the files appended and a list of any missing information or errors.

Once compiled, the data were processed through two programs developed in CRAN R and verified by the quality control person. The first program checked for general format errors such as missing pertinent point or condition information, missing attribute values, and mismatching plot and condition identification numbers. The quality control person fixed these errors before running the second program. The second program checked for obscure calls or inconsistencies in the data, many resulting from calculated information not agreeing with condition assignments. The checks included identification of plots containing non-sampled conditions; plots with an excessive number of points falling in a cultural development or a right-of-way; conditions on plots having a calculated tree density different from the assigned condition tree density; conditions on plots with a calculated percentage of dead trees greater than 25 percent but having no disturbance or treatment information recorded; and plots containing water or riparian conditions. The plots with conditions including water or riparian were identified and checked for accuracy in photo interpretation calls. Based on the output of the second program, the quality control person verified and changed data where a disagreement occurred.

We performed a random check on 10 percent of the points within 10 percent of the plots for each photo interpreter. This check looked for more specific errors of point object assignments and photo interpreter inconsistencies that were missed by the edit checking program. If greater than 50 percent of the checked points in a plot were misclassified, another 10 percent were checked, and so on. All points in a plot were checked if 100 percent of the checked points were misclassified. For edit checking, program was developed in CRAN R by IW-FIA to identify the random set of points within the random set of plots for each photo interpreter. This program also produced points to be checked when more than the initial 10 percent of points needed checking. Again, the quality control person verified the output of these points and changed data when there was a disagreement.

As a final edit, all plots not in the random check or previously reviewed were briefly scanned for any major errors related to condition attributes or general mistakes. The final edited data were imported to an Oracle database and the photo interpreters were given feedback on any errors and/or data inconsistencies. The photo interpreters were also given an update concerning the interpretation progress.

Any errors found through the steps in the data compilation and editing process were communicated back to photo-interpreters to enhance training and keep them informed of any patterns in errors.

Table 3. Steps for data compilation and edit checking process.

Step	Description
Backup output files	Make a backup copy of original output shapefiles from photo interpreters.
Append files[a]	Append individual output shapefile to one shapefile.
Check list of files	Check if any files are missing and report back to photo interpreters.
Check for format errors[b]	Check for general plot format errors such as missing values.
Check for data errors[b]	Check for obscure errors and data inconsistencies.
Random check[b]	Check a random set of plots and points per photo interpreter.
Plot scan	Briefly scan plots for major errors or condition inconsistencies.
Update progress[b]	Update shapefile with progress of finished plots.
Update Oracle tables	Update Oracle tables with appended data.

[a]Used a Python script developed by IW-FIA.
[b]Used an R script developed by IW-FIA.

These scripts were customized for NPIP, but are available, upon request, for use as a model to serve other applications.

Field Validation

The third quality control component was validation of the photo interpreted classifications on the ground. The objective of the field validation was to determine the accuracy of our photo interpreted object and condition calls and provide feedback to the interpreters to improve their decisions. Here, the quality control person visited a subset of the photo plots and validated the photo interpreter's classifications for the condition and object at each point.

Field validation plots were determined by purposive selection based on grouping photo-interpreted vegetation types. In order to efficiently visit enough plots to determine a level of accuracy for each vegetation type group, we limited field visits to plots that were on public land and relatively easy to get to, measured by distance to road. Thirteen out of the 49 points were visited at each plot (fig. 11). An Oracle form was developed to assist the quality control field person in reviewing and collecting data in the field (fig. 12). The form displayed the photo interpreted data for each plot and allowed for data entry of any necessary changes.

At each point, the quality control person first determined if the condition classification was correct, accepting minor subjectivity in the photo interpreted boundary placement. Next, the crew determined if the point object classification was correct, accepting the photo interpreter's lifeform class if it fell on the edge of two lifeforms. If the classification was unknown because of a shadow or other photo anomaly, the quality control crew determined the condition and object attribute.

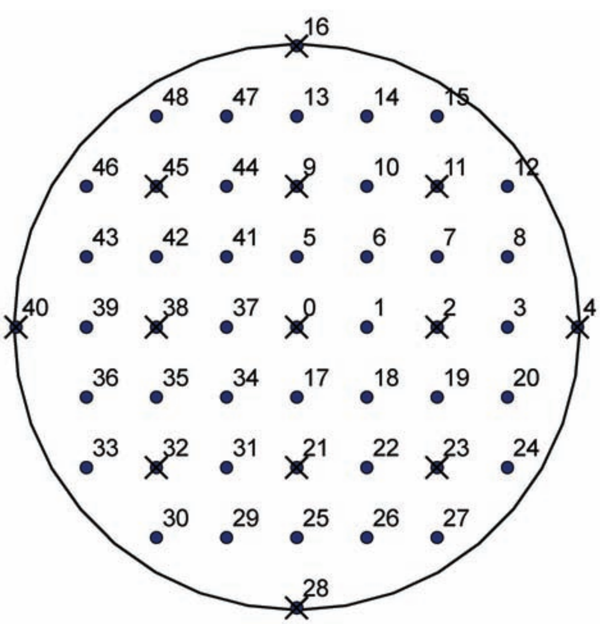


Figure 11. NPIP plot design with validation points. The center point (0) is located at the theoretical center point of an FIA plot.

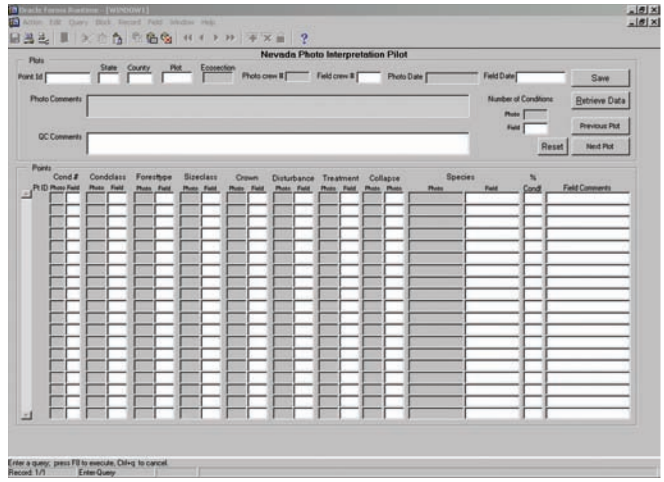


Figure 12. Oracle quality control field form.

Interpreter Repeatability

Another component to quality control was the repeatability, or consistency, of attribute assignment between interpreters. Because White Pine County plots had been photo interpreted by many interpreters, they were excluded from this repeatability component. Outside White Pine County, only two photo interpreters were used. For a repeatability analysis between these two interpreters, a random subset of 10 percent of the plots was selected, totaling 188 plots. Of these, 118 plots originally interpreted by interpreter #1 were re-interpreted by interpreter #2, and 70 plots originally interpreted by interpreter # 2 were re-interpreted by interpreter #1. These plots were assessed at their unedited and edited levels. Error matrices were used to compare both object and condition level plot data for several classes. A CRAN R program was used to generate the error matrices and produce summary statistics on the repeatability between photo interpreters.

Lessons Learned

We learned many lessons through the course of the photo sampling phase of this project. A brief discussion is given for each component of the project for how certain processes might be improved in future applications, including survey design, aerial photography, plot design, photo interpretation, quality control, and project costs.

Survey Design

Pre-stratification of the state into forest and nonforest strata enabled us to concentrate data collection in areas of greatest interest—the forests. However, this pre-stratification could have been refined to further optimize allocation of limited resources or target rare vegetation communities such as riparian. Also, the pixel-based stratification led to some challenges, including photo plots that cross strata boundaries, strata assignments that could vary through time, and visually unappealing and highly fragmented subpopulations.

Aerial Photography

The photo interpreters generally preferred direct-to-digital photographs over scanned photographs. In addition, although they weren't always necessary, the stereo pairs proved useful for some difficult attribute assignments. Orthorectification corrects for distortion caused by camera optics, plane attitude, and topographical differences. Therefore, our sampled aerial photos do not include uniform scale and true geometry. These could affect the ability to match up with other data that have been orthorectified, such as satellite imagery. For some applications (for example, conditions), more course resolution photos might be sufficient and in some cases these photos may be free of cost.

Plot Design

Choosing the best photo-plot size is a complicated task, particularly when project objectives are diverse. From an estimation point of view, there are two considerations:

1) To reduce variances of plot-based estimates, it is best to photo interpret the same area as the ground plot. Larger photo plots, however, increase the likelihood of sampling minor vegetation components and increase precision on more abundant land cover types.
2) From a remote sensing classification point of view, the photo plot should be comparable with the imagery's pixel size to maximize the relationship between the two data sources. Selecting photo plot size will be a compromise between these competing factors. In addition to plot size, the number of dot grid points will vary by objective. Work is underway (Megown and others, In prep.) to understand how best to make these choices.

Photo Interpretation

Finalizing the condition classes and object type classification system for photo interpretation was a difficult and iterative task. The final classification system required understanding the informational needs and tempering these expectations with the practical limitations of the photographs. For example, being able to occasionally see an object on a photo, versus being able to attribute it accurately and consistently, are two different things. The prototype efforts were very valuable for understanding and communicating the capabilities of this type of photo-based inventory.

From our efforts in Nevada, we found a few attributes that were difficult to discern from the aerial photographs: 1) the FIA, condition-level stand-size class attribute has six classes with four of these classes greater than 5.0 inches diameter (USDA 2006) and we found it difficult to segregate size classes larger than 5.0 inches diameter; 2) the object shrub type, littleleaf mountain mahogany was difficult to distinguish from the object tree type, curlleaf mahogany; 3) in sporadic grass areas, it was difficult to see if the point fell on the object other-veg type, dry herbaceous or the object barren type, bare ground; 4) the object shrub type, sagebrush was often confused with the object shrub type, other shrub; and 5) seedlings under other vegetation were not discernable from photos (fig. 13).

Our strategy of interpreting photos by ecosection (fig. 3b) provided a foundation for efficiency and consistency throughout the pilot. The photo interpreters were able to recognize patterns of vegetation types within each ecosection and were therefore able to interpret quickly and consistently.

Quality Control

NPIP quality control process included training, consistent and timely data checks, and frequent feedback to the photo interpreters. Even though we followed the quality control protocol throughout the project, the project did not have a dedicated, full-time quality control person. This may have negatively impacted the quality of the interpretation and the consistency between interpreters.

We were able to conduct an exploratory analysis on data quality for many different vegetation types throughout the state, although a randomly selected independent field data set to make data quality inferences concerning the entire sample would have been better. If resources had been available, collecting a probability sample of field data,

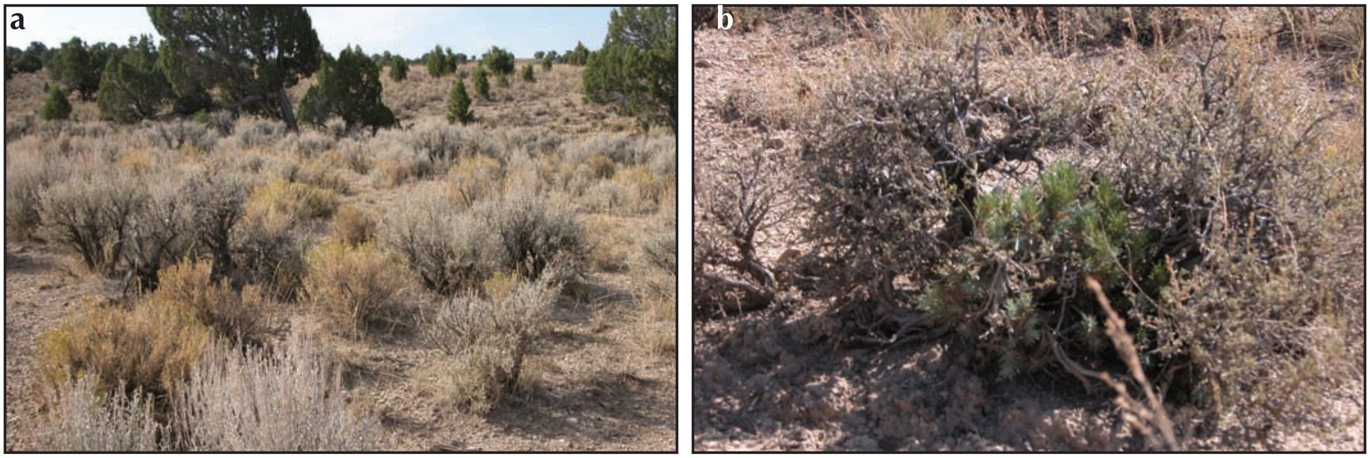


Figure 13. Examples of objects on the ground that are confused or not easily discernable on aerial photographs. a. Object shrub type, sagebrush and object shrub type other shrub; b. Seedling surrounded by sagebrush.

particularly in the nonforest strata, would have been quite useful for a number of purposes, including: 1) to make inferences about the accuracy of photo-interpreted data statewide; 2) to serve as a ground phase in sub-sampling nonforest plots to further characterize details in the nonforest vegetation that are not discernable on photos; 3) to provide additional training to improve interpreter accuracy and consistency in future projects; and 4) to further collapse or create condition and object classes to achieve yet-to-be determined measurement quality objectives.

Final Costs

At the project's outset, we made decisions not knowing how long various activities would take and ultimately what they would cost once we entered into a production mode. Based on experiences with the NPIP, costs per plot, along with some general costs for all phases, are summarized in table 4. A total cost of $260 per plot was estimated, with an initial cost of $4,000 for acquiring additional computer space needed for storing the digital photos. The total cost for the entire photo-based state inventory was an estimated $610,320.

Table 4. Cost and time constraints for the photo sampling components of NPIP, and costs of per plot estimates.

Description	Cost	Time constraints
Photo acquisition	$120 per triplicate (direct to digital)	Photo acquisition should be initiated before the desired flight month.
Photo-to-digital	$20 (scanning)	
Hard copy printing (8x8)	$5 (per image)	Local, professional photo shop.
Geolocation	$5	
Interpretation	$80 (includes field training) (average >one plot per hour)	Difficult to interpret more than 6 hours per day.
Quality control	$30 (includes data compilation and editing and minimal field validation)	Sharing tasks led to timing and feedback issues.
General cost		
1 Tb of computer storage space	$2,000 (per each; two were purchased, one for back-up)	
Total	$260 per plot + $4,000 storage space = $610,320	

Recommendations

We designed NPIP to evaluate the use of large-scale real time GPS-controlled aerial photography to improve efficiencies and enhance FIA's annual inventory. The pilot targeted the generally slower-growing, arid ecosystems in the Interior-West woodland and rangeland vegetation types of Nevada. This technology provided an efficient and alternative platform for collecting resource data ancillary to the traditional field-based inventory data and could have applications to ecosystems worldwide, particularly those dominated by woodland types. Current studies are underway to test sampling large scale aerial photographs in other regions of the Interior-West supporting different ecosystems and forest types, such as Douglas-fir, spruce-fir, grand fir, ponderosa pine, and lodgepole forest types in the Idaho Panhandle National Forest and in the Lubrecht Experimental Forest near Missoula, Montana. These studies also experiment with different photo resolutions and sampling designs and will provide valuable information for future studies.

The purpose of this paper was to document photo sampling procedures that others may follow for similar applications. Based on our lessons learned above, we also provide the following recommendations to consider before designing similar studies using large scale aerial photographs for an extensive inventory.

- Survey design—Choose a pre-stratification method that is reliable and stable and provides the best information for meeting the objectives of the study. Some alternatives to the fragmented, pixel-based map used in this study might be to smooth (resample) the pixel-based map, rely on a satellite-product that is vector-based, or rely on a more stable owner-based or geographic boundary-based stratification scheme.
- Aerial photography—Use the best available photography keeping in mind the objectives of the study, time and money available, and skill level of the photo interpreters. These factors will determine the resolution, quality, and type of photos needed (for example, infrared vs. natural color; digital vs. scanned; rectified vs. orthorectified).
- Plot design—Select a photo plot and sample size with consideration of all objectives of the study (for example, in this study, our objectives included variance reduction in estimation strategies and matching resolution of ancillary information).
- Photo interpretation—We recommend defining attributes for photo interpretation based on a full understanding of the types of vegetation encountered in the survey, information needed to meet the objectives of the project, and potential limitations of the aerial photographs. We also recommend using ecosections or similar ecological boundaries to subset photo plots into groups of similar vegetation types, providing a basis for efficiency and consistency for the photo interpreters.
- Quality control—We recommend designing the quality control process simultaneous with the design of the study and dedicating a full-time quality control person to provide training, check plots, and provide feedback concurrent with the photo interpretation process. Also, consider budgeting for a field validation.

References

Aldred, A.H.; Hall, J.K. 1975. Application of large-scale photography to a forest inventory. The Forestry Chronicle 51(1):9-15.

Aldred, A.H.; Kippen, F.W. 1967. Plot volume from large scale 70mm air photographs. Forest Science 13(4):419-426.

Bailey, R.G. 1988. Ecogeographic analysis: a guide to the ecological division of land for resource management. Misc. Publ. 1465. Washington, DC: U.S. Department of Agriculture, Forest Service. 18 p.

Blackard, J.A.; Moisen, G.G; Tymcio, R.P. 2004. Modeling investigations into mapping of forest attributes with FIA data for the state of Wyoming. *In:* Proceedings of the tenth Forest Service remote sensing applications conference, April 5-9, 2004, Salt Lake City, UT. Bethesda, Maryland: American Society for Photogrammetry and Remote Sensing. Unpaginated CD-ROM.

Clark, J.; Finco, M.; Warbington, R.; Schwind, B. 2004. Digital Mylar: a tool to attribute vegetation polygon features over high-resolution imagery. RSAC-4013-RPT1. Salt Lake City, UT: U.S. Department of Agriculture, Forest Service, Remote Sensing Applications Center. 8 p.

Cleland, D.T.; Avers, P.E.; McHab, W.H.; Jensen, M.E.; Bailey, R.G.; King, T.; Russel, W.W. 1997. National hierarchical framework of ecological units. *In*: M.S. Boyce and A. Haney (eds), Ecosystem management: applications for sustainable forest and wildlife resources. New Haven, CT: Yale University Press: 181-200.

Cronquist, A.; Holmgren, A.H.; Holmgren, N.H.; Reveal, J.L. 1972. Intermountain flora: vascular plants of the intermountain west, U.S.A., Vol. 1. Bronx, New York: New York Botanical Garden. 84 p.

ECOMAP. 1993. National hierarchical framework of ecological units. Washington, DC: U.S. Department of Agriculture, Forest Service. 20 p.

Hall, R.J.; Aldred, A.H. 1992. Forest regeneration appraisal with large-scale aerial photographs. The Forestry Chronicle 68(1):142-150.

Hamilton, D.A., Jr. 1984. Sampling and estimation of conifer mortality using large-scale color aerial photography. Forest Science 30(2):333-342.

Harris, R. W. 1951. Use of aerial photographs and sub-sampling in range inventories. J. Range Manage. 4:270-278.

Ihaka, R.; Gentleman, R. 1996. R: A language for data analysis and graphics. Journal of Computational and Graphical Statistics 5(3):299-314.

Knapp, P.A.; Warren, P.L.; Hutchinson, C.F. 1990. The use of large-scale aerial photography to inventory and monitor arid rangeland vegetation. Journal of Environmental Management 31(1):29-38.

MacLean, C.D. 1963. Improving forest inventory area statistics through supplementary photo interpretation. Journal of Forestry 61(7):512-516.

Megown, K. and others. In prep. Determining theoretical optimized dot grid spacing and plot radius from interpreted condition and point attributes.

Megown, K.; Caylor, J.; Callejas, J.; Finco, M.; Moisen, G.; DeBlander, L. 2003. Application of large scale GPS controlled aerial photos for forest inventory. *In*: Proceedings of the ninth forest service remote sensing applications conference in San Diego, CA [CD-ROM], April 2002. Bethesda, MD: American Society for Photogrammetry and Remote Sensing.

Pitt, D.G.; Runesson, U.; Bell, F.W. 2000. Application of large- and medium-scale aerial photographs to forest vegetation management: a case study. The Forestry Chronicle 76(6):903-913.

Reams, G.A.; Smith, W.D.; Hansen, M.H.; Bechtold, W.A.; Roesch, F.A.; Moisen, G.G. 2005. The forest inventory and analysis sampling frame. *In*: Bechtold, W.A.; Patterson, P.L. eds. The enhanced forest inventory and analysis program-national sampling design and estimation procedures. Gen. Tech. Rep. SRS-80. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 15 p.

Tueller, P.T.; Clark, J.E. 1975. Autecology of pinyon-juniper species of the Great Basin and Colorado Plateau. *In*: The Pinyon-Juniper Ecosystem: A Symposium. Utah State Univ., Utah Agr. Exp. Sta., Logan: 27-40.

U.S. BLM. Unpublished. Nevada Landownership (1998-2005) U.S. Department of Interior, Bureau of Land Management. Reno, NV.

U.S. Department of Agriculture. 2006. Interior West Forest Inventory and Analysis field procedures V3.0. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, Utah.

Appendix A: Rules for Defining Condition Class

Condition Class Status

A condition class status is an area of relative (to the rules) uniform cover that is not sampled and consists of: noncensus water, census water, and forest and nonforest lands. In general, condition classes are easily identified, although there are unique minimum areas/sizes and unique caveats for each condition class status. The **basic rules** for forest and nonforest land are simply:

- ≥ 1 acre[a] and
- ≥ 120 ft wide (measured from stem to stem)[b]

See area/size rules for more details on the condition classes' area/size rules and some important caveats.

While delineating condition classes from aerial photographs, it is important to recognize how the area outside the sample plot influences interpretation for unique conditions. The plot boundary is not the "end of the world" for the sample, and <u>interpreters should consider the area outside the sample radius</u> when discerning a potential condition class status to ensure each possible unique condition is of the area/size standard.

Aerial photographs can reveal more variation at a different scale on a landscape as contrasted to standing at the same spot on the ground. Only split out conditions if there is a real difference. There are two general rules to follow:

- <u>Distinct</u> boundaries between two or more condition class features delineate distinct condition classes.
- <u>Indistinct</u> boundaries (in other words, transition zones) between two or more condition features do not delineate distinct condition classes unless the necessary measures and rules are used.

If in doubt, measure the necessary features and in the notes, document the measures and rules used to make the decision toward creating a unique condition.

[a]To ensure each possible unique condition is of area/size standards for each condition, interpreters should consider the area outside the sample radius when discerning condition classes.

[b]At least 120 ft wide (stem to stem), the length must be 363 ft to meet an acre threshold.

Rule Key for Defining Condition Classes

1. The point falls off the center photo image.
A. Yes: .... NOT SAMPLED.
B. No: The point is visible on the digital image .... 2.

2. The point is found inside water, where the water feature is ≥1 acre and ≥30 ft wide (meeting the minimum definition of a polygon or a linear water feature).
A. Yes: The water feature is linear in nature.
i. Yes: The linear water feature is <200 ft wide (at its largest)?
1. Yes: the point is .... NONCENSUS WATER (linear).
2. No: the point is .... CENSUS WATER (linear).
ii. No: A polygon water feature is <4.5 acre?
1. Yes: the point is .... NONCENSUS WATER (polygon).
2. No: the point is .... CENSUS WATER (polygon).
B. No: No water feature meets the minimum definition of a linear or polygon water feature .... 3.

3. The point falls on developed/maintained land use type visible (note: can be < basic rules).
A. Yes: There are developed/maintained land use types .... NONFOREST Developed.
B. No: There are no developed/maintained land use types present .... 4.

4. The point falls in a riparian area.
A. Yes: The riparian area is ≥120 ft and ≥1 acre in size.
i. Yes: The riparian area is **forested***.
1. Yes: .... FOREST (riparian).
2. No: .... NONFOREST (riparian).
ii. No: The riparian area is linear (for example, stream).
1. Yes: .... 5.
2. No: .... 6.
B. No: .... 7.

5. The adjacent linear water feature is <30 ft.
A. Yes: The sum of both sides of the riparian feature is ≥30 ft.
i. Yes: The riparian area is **forested***.
1. Yes: There is a nonforest condition on all sides of the forest riparian feature.
a) Yes: .... FOREST (riparian type A).
b) No: .... FOREST (riparian type B).
2. No: There is a forest condition on both sides of the nonforest riparian feature.
a) Yes: The sum of total width of riparian area plus the stream is <120 ft.
a. Yes: .... NONFOREST (riparian type A).
b. No: .... NONFOREST (riparian type B).
b) No: .... NONFOREST (riparian type B).
ii. No: The total width of riparian area from both sides is <30 ft .... See Most Similar Rule.
B. No: Either width of the 2 widths of riparian area is ≥30 ft.
i. Yes: The riparian area is **forested***.
1. Yes: There is a nonforest condition on both sides of the riparian feature.
a) Yes: .... FOREST (riparian type A).
b) No: .... FOREST (riparian type B).
2. No: There is a forest condition on both sides of riparian feature.
a) Yes: .... NONFOREST (riparian type A).
b) No: .... NONFOREST (riparian type B).
ii. No: The total width of riparian area from both sides is <30 ft .... See Most Similar Rule.

6. The polygon water feature (adjacent to the riparian area), is <1 acre.
A. Yes: The riparian feature is forested.
i Yes: The forest riparian area is completely surrounded by forest condition(s).
1. Yes: The forest riparian area is ≥30 ft, ≥1 acre (include water in measurement).

a. Yes: .... FOREST (riparian type B).
b. No: .... See Most Similar Rule.
2. No: The forest riparian area is ≥30 ft, ≥1 acre (include water in measurement).
a. Yes: .... FOREST (riparian type A).
b. No .... See Most Similar Rule.
ii. No: The nonforest riparian area is completely surrounded by forest condition(s).
1. Yes: The nonforest riparian area is ≥30 ft, ≥ 1 acre (include water in measurement).
a. Yes: .... NONFOREST (riparian type B).
b. No: .... See Most Similar Rule.
2. No: The nonforest riparian area is ≥30 ft, ≥1 acre (include water in measurement).
a. Yes: .... NONFOREST (riparian type B).
b. No: .... See Most Similar Rule.
B. No: The riparian feature is forested.
iii. Yes: The forest riparian area is completely surrounded by forest condition(s).
1. Yes: The forest riparian area is ≥30 ft, ≥1 acre (exclude water in the measurement).
a. Yes: .... FOREST (riparian type B).
b. No: .... See Most Similar Rule.
2. No: The forest riparian area is ≥30 ft, ≥1 acre (exclude water in the measurement).
c. Yes: .... FOREST (riparian type A).
d. No: .... See Most Similar Rule.
iv. No: The nonforest riparian area is completely surrounded by forest condition(s).
1. Yes: The forest riparian area is ≥30 ft ≥1 acre (exclude water in the measurement).
a. Yes: .... FOREST (riparian type A).
b. No: .... See Most Similar Rule.
2. No: The forest riparian area is ≥30 ft ≥1 acre (exclude water in the measurement).
a. Yes: .... FOREST (riparian type B).
b. No: .... See Most Similar Rule.

7. The point is in a non-riparian condition ≥120 ft wide and ≥1 acre.
A. Yes: The condition is **forested***.
i Yes: .... FOREST.
ii No: .... NONFOREST.
B. No: The condition is **forested*** (≥30 ft and ≥1 acre) and is adjacent to a forest riparian condition and the sum of both widths of the forest and adjacent forest riparian is ≤150 ft.
i Yes: .... FOREST.
ii No: Something is wrong, or collapse with most similar neighbor (see following AREA/SIZE RULES, Three Exceptions, Most similar rule for forest/nonforest), or start over .... 1.

*See rules for Forest/Nonforest conditions

Rule Key for Defining Forest/Nonforest Condition Classes

1. The area has ≥5 percent crown cover of "tree" species... FOREST CONDITION.
A. Yes: .... FOREST CONDITION.
B. No: .... 2.
2. The area has ≥40 percent from any combination of seedlings/saplings/trees per acre of "tree" species.
A. Yes: .... FOREST CONDITION.
B. No: .... 3.
3. The area has evidence of ≥5 percent historical crown cover.
A. Yes: The area has NO evidence of a nonforest land use practice.
i. Yes: .... FOREST CONDITION.
ii. No: .... NONFOREST CONDITION.
B. No: .... NONFOREST CONDITION.

Condition Class Definitions

The following condition classes are similar to the traditional FIA field sample condition classes with the exception of the Nonforest developed and Riparian condition classes. The traditional FIA field sample was designed to estimate accessible forest land whereas the FIA photo-based sample is designed to estimate all lands. The Nonforest developed and Riparian classes were added to further characterize the nonforest and riparian lands.

Condition Classes

FIA Field Sample Condition Classes

- Forest
- Nonforest
- Noncensus water
- Census water
- Not sampled

Nonforest Developed Condition Class

- Nonforest developed

Riparian Condition Classes

- Forest riparian
- Forest riparian type A – (collapse)
- Forest riparian type B
- Nonforest riparian
- Nonforest riparian type A – (collapse)
- Nonforest riparian type B

Riparian lands are lands associated with but not limited to streams, rivers, lakes, sloughs, seeps, springs, marsh, bogs, beaver ponds, sink holes, cypress domes and ponds, man-made ditches, and canals. The FIA field sample does not currently accommodate the production of estimates for riparian populations. Due to the configuration of the FIA sample design, riparian lands are often missed. The photo-based design samples a larger extent on the ground and may therefore capture more riparian area. Riparian condition classes were added to characterize these lands surrounded by both forest and nonforest land. The riparian type A conditions are those conditions that would otherwise be classified as a different condition class based on the traditional FIA rules. For these conditions, the photo interpreter must discern an alternative condition to otherwise collapse to based on Most Similar Rule. The riparian type B conditions are those conditions that would be classified similarly to the traditional FIA rules. An alternative condition class is not necessary.

Forest

A forest condition is land within the sample area[a] that meets the definition of forest land (fig. A1). To qualify, an area must be:

- ≥1 acre
- ≥120 ft wide[b]

Exception: The forest condition size rules can be modified in a special case. When a forest condition is adjacent to a forest riparian condition (≥30 ft, <120 ft, and ≥1 acre in size) and the total width of both conditions is ≥120 ft but <150 ft in width.

Do <u>not</u> consider speculative evidence of possible or future developments. For further details concerning area/size qualifiers, see Area/Size Rules. For further discussion on forest condition rules, see Forest Condition Rules.

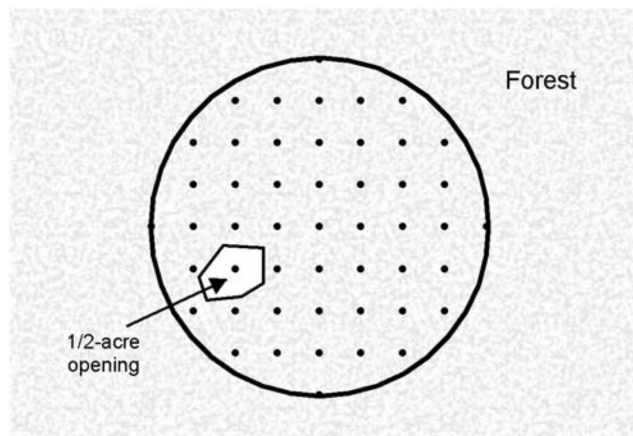


Figure A1. The point falls in an opening less than 1 acre in size; the opening does not meet the definition of nonforest land (1 acre in size, 120 ft wide). Therefore, in this example, the point occurs in a FOREST LAND condition class.

Nonforest

A nonforest condition is land within the sample area[a] that does not meet the definition of forestland or any of the other Condition Class Status values. To qualify, an area of nonforest must be:

- ≥1 acre
- ≥120 ft wide[b]

Do <u>not</u> consider speculative evidence of possible or future developments. For further details concerning area/size qualifiers, see Area/Size Rules. For further discussion on nonforest conditions, see Nonforest Condition Rules.

Nonforest Developed

Nonforest developed condition areas are visible polygon or linear features that do not need to meet the basic rule area[a] or size requirement (≥1 acre and ≥120 ft wide[b]), but are unique features on a landscape. These are roughly defined as any developed or maintained area containing human activity. For further details concerning area/size qualifiers, see Area/Size Rules. For further discussion on nonforest conditions, see Nonforest Condition Rules.

Noncensus Water (Linear and Polygon)

Noncensus water is:

- lakes, reservoirs, ponds, and similar polygon water features, ≥1 and <4.5 acres

or

- rivers, streams, canals, and similar linear water features, ≥30 and <200 ft wide

where the determination of water coverage includes the area/line segment where the water (including erosion) impacts the establishment and survival of trees.

Census Water (Linear and Polygon)

Census water is:

- lakes, reservoirs, ponds, and similar polygon water features, ≥4.5 acres

or

- rivers, streams, canals, and similar linear water features ≥200 ft wide

where the determination of water coverage includes the area/line segment where the water (including erosion) impacts the establishment and survival of trees.

Not Sampled

A point is to be given a "NOT SAMPLED" condition <u>only</u> if it is not visible on the digital aerial photo center image being interpreted.

Forest (Riparian)

A forest riparian condition is a riparian area that is riparian by definition and meets the definition of forest land but does not have any other Condition Class Status attributes. To qualify, an area of forest riparian must be:

- ≥1 acre
- ≥120 ft wide[b]
- riparian

Do <u>not</u> consider speculative evidence of possible or future developments. For further details concerning area/size qualifiers, see Area/Size Rules. For further discussion on forest conditions, see Forest Condition Rules.

Forest (Riparian Type A)

A forest riparian, type A, condition is a riparian area that is riparian by definition and meets the definition of forest land but does not have any other Condition Class Status attributes. To qualify, an area of forest riparian must be:

- ≥1 acre
- ≥30, but <120 ft wide[b]
- surrounded on all sides by a nonforested condition

Do <u>not</u> consider speculative evidence of possible or future developments. For further details concerning area/size qualifiers, see Area/Size Rules. For further discussion on nonforest conditions, see Nonforest Condition Rules.

Forest (Riparian Type B)

A forest riparian, type B, condition is a riparian area that is riparian by definition and meets the definition of forest land but does not have any other Condition Class Status attributes. To qualify, an area of forest riparian must be:

- ≥1 acre
- ≥30, but <120 ft wide[b]
- have at least one forest condition with a shared segment of at least 120 ft

Do <u>not</u> consider speculative evidence of possible or future developments. For further details concerning area/size qualifiers, see Area/Size Rules. For further discussion on nonforest conditions, see Nonforest Condition Rules.

Nonforest (Riparian)

A nonforest riparian condition is a riparian area that does not meet the definition of forest land or any of the other Condition Class Status attributes. To qualify, an area of nonforest riparian must be:

- ≥1 acre
- ≥120 ft wide[b]

Do <u>not</u> consider speculative evidence of possible or future developments. For further details concerning area/size qualifiers, see Area/Size Rules. For further discussion on nonforest conditions, see Nonforest Condition Rules.

Nonforest (Riparian Type A)

A nonforest riparian, type A, condition is a riparian area that does not meet the definition of forest land or any of the other Condition Class Status attributes. To qualify, an area of nonforest riparian must be:

- ≥1 acre
- ≥30, but <120 ft wide[b]
- surrounded on all sides by a forested condition

Do <u>not</u> consider speculative evidence of possible or future developments. For further details concerning area/size qualifiers, see Area/Size Rules. For further discussion on nonforest conditions, see Nonforest Condition Rules.

Nonforest (Riparian Type B)

A nonforest riparian, type B, condition is a riparian area that does not meet the definition of forest land or any of the other Condition Class Status attributes. To qualify, an area of nonforest riparian must be:

- ≥1 acre
- ≥30, but <120 ft wide[b]
- have at least one nonforest condition with a shared segment of at least 120 ft

Do <u>not</u> consider speculative evidence of possible or future developments. For further details concerning area/size qualifiers, see Area/Size Rules. For further discussion on nonforest conditions, see Nonforest Condition Rules.

Area/Size Rules

Basic rules for Forest and Nonforest (fig. A1):

- ≥1 acre in size
- ≥120 ft wide (measured from stem to stem)[b]

A forest condition size can be modified in a special case.

- ≥30 ft but <120 ft
- ≥1 acre
- next to a forest riparian condition (≥30 ft, <120 ft, and >1 acre) where the forest riparian plus the forest condition is <150 ft in width

Basic rules for Census Water:

- lakes, reservoirs, ponds, and similar polygon water features ≥4.5 acres

or

- rivers, streams, canals, and similar linear water features >200 ft wide

Basic rules for Noncensus Water:

- lakes, reservoirs, ponds, and similar polygon water features ≥1 and <4.5 acres

or

- rivers, streams, canals, and similar linear water features ≥30 and ≤200 ft wide

Basic rules for Not Sampled:

- point(s) is not visible on the center digital photo being interpreted.

Basic rules for Nonforested Developed:

- There is no minimum area or size limit.
- There is a developed and maintained land use feature.

Developed/maintained nonforest land use type polygon and linear features that <u>do not</u> meet the Basic Rules for area/size are still considered NONFOREST (figs. A2, A3). Examples include linear features such as improved roads, railroads, and maintained rights of way (ROW: for example, power lines, gas lines) <120 ft in width, and polygon features such as home/cabin, communication tower site, barns/sheds, and other structures (and the maintained area around the structure) <1 acre in size.

Basic rules for Riparian:

- the size is ≥30 and <120 ft wide and ≥1 acre size
- there are riparian features present
- forest riparian type A: An alternative condition class is required to collapse to:
    - o ≥30 ft but <120 ft
    - o ≥1 acre
- forest riparian type B: Type B does not require an alternative condition.
    - o ≥30 ft but <120 ft
    - o ≥1 acre

A riparian area must contain at least one distinct and obvious change in a condition class delineation attribute from its adjacent condition class(es). Figures A4 – A11 provide examples of when to delineate a riparian area. The examples pertain to a change in condition between a forest riparian or nonforest riparian area and a forest or nonforest condition in situations surrounding a polygon or linear water feature.

Three exceptions to area/size rule:

1. Alternating Strips
2. 90° Corner Rule
3. Most Similar Rule for Forest/Nonforest

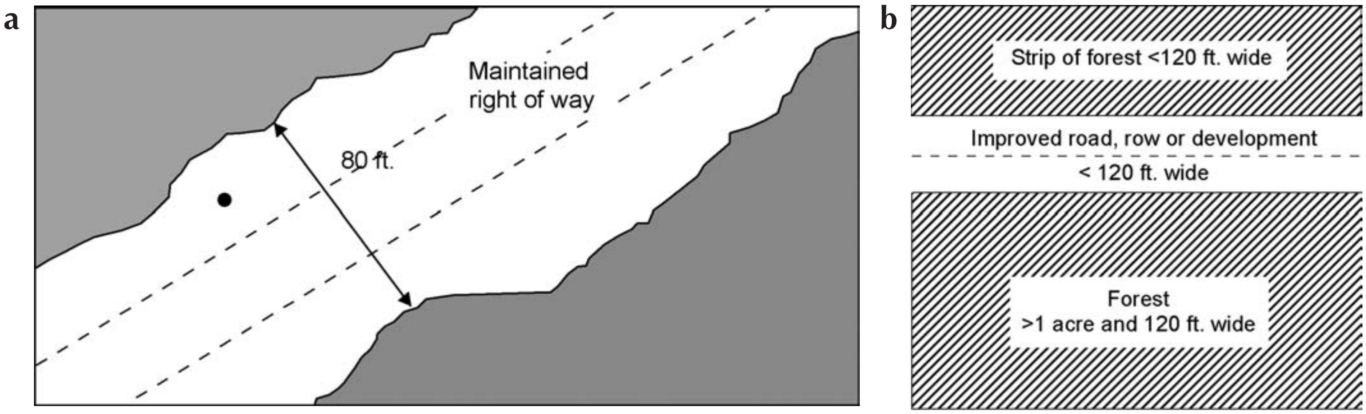


Figure A2. Two examples of a DEVELOPED NONFOREST LAND (CODE 32) that do not have to meet the area and width requirements to qualify as a separate condition: a. An improved road <120 ft wide; b. The area above the road, while <120 ft wide, is still the same condition as below the road.

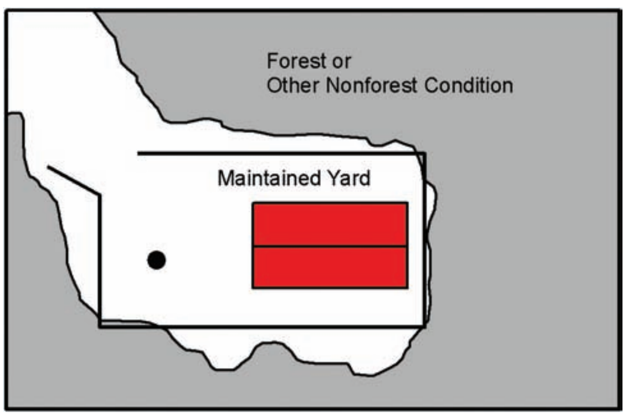


Figure A3. An example of a DEVELOPED NONFOREST LAND (Code 31) that does not have to meet the area width requirements to qualify as a separate condition; a maintained yard <1 acre in size.

Alternating Strips

- group of forest/nonforest features are each <120 ft in width
- only applies to forest/nonforest features

Distinct, alternating strips of forest and nonforest land (fig. A12): this situation occurs when a point/s samples a group of forest/nonforest features that is <120 ft in width. The condition class is one of a series of parallel strips of forest and nonforest land in which none of the strips meet the minimum width requirement. Determine the majority condition class in the area where these strips occur.

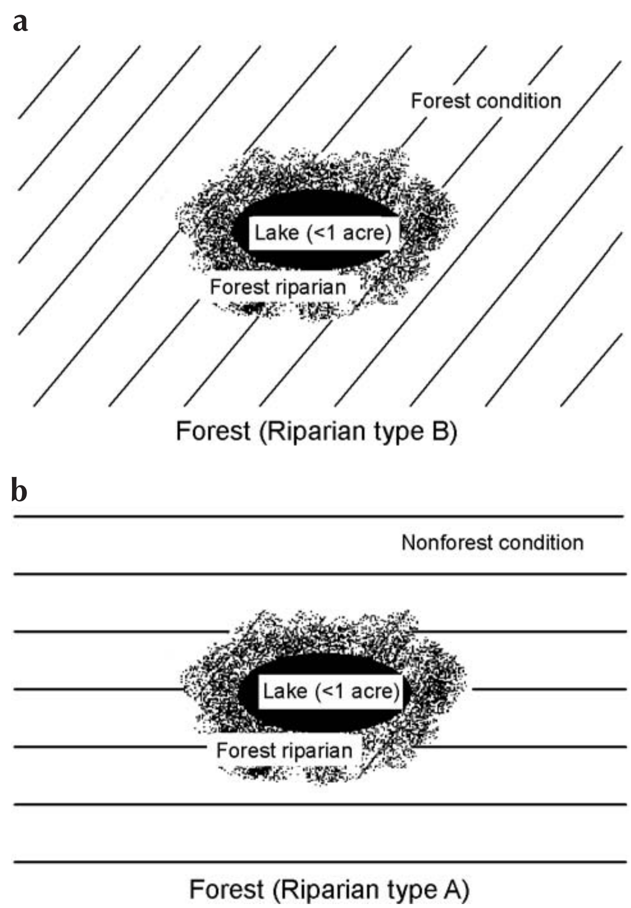


Figure A4. The riparian area is forested (≥30 ft but <120 ft, and ≥1 acre in size, including water feature) and surrounding a polygon feature <1 acre in size: a. At least one forest condition is adjacent to the riparian area, the forest riparian area is a type B; b. At least one nonforest condition is adjacent to the riparian area, the forest riparian area is a type A. *Collapse to the most similar alternative condition class.

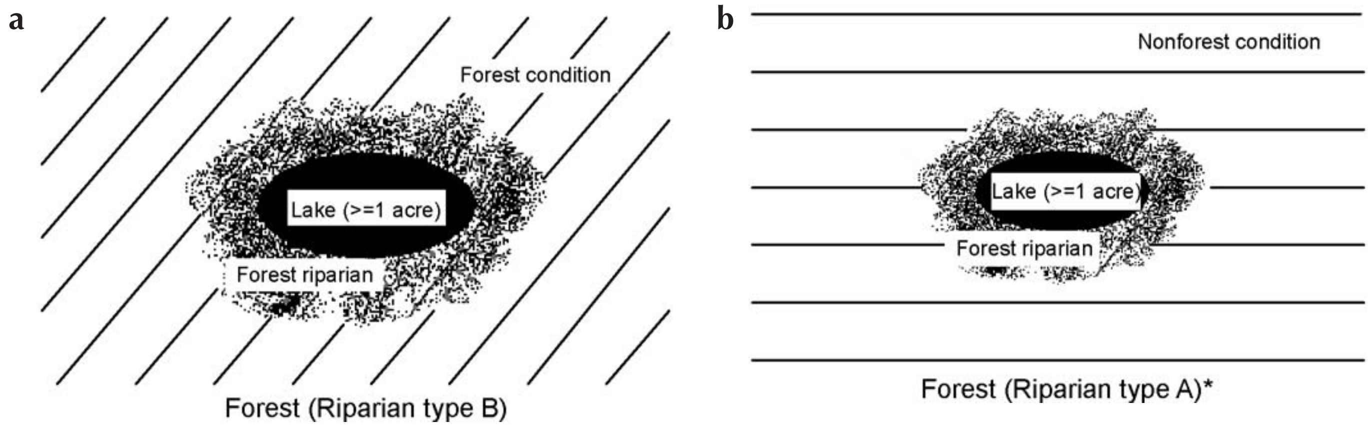


Figure A5. The riparian area is forested (≥30 ft but <120 ft, and ≥1 acre in size, excluding water feature) and surrounding a polygon feature ≥1 acre in size: a. At least one forest condition is adjacent to the riparian area, the forest riparian area is a type B; b. At least one nonforest condition is adjacent to the riparian area, the forest riparian area is a type A. * Collapse to the most similar alternative condition class.

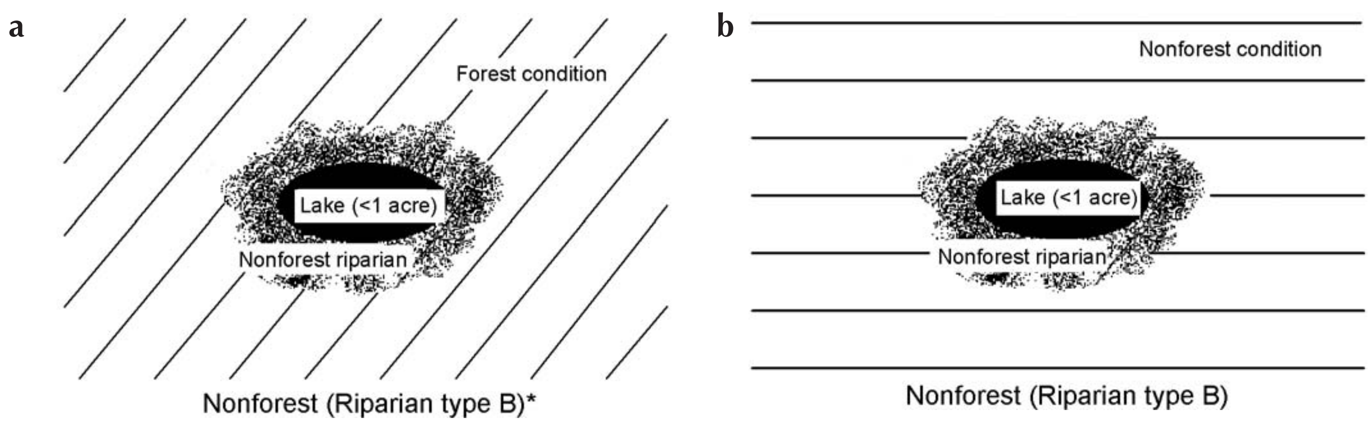


Figure A6. The riparian area is nonforested (≥30 ft but <120 ft, and ≥1 acre in size, including water feature) and surrounding a polygon feature <1 acre in size: a. At least one forest condition is adjacent to the riparian area, the forest riparian area is a type B; b. At least one nonforest condition is adjacent to the riparian area, the forest riparian area is a type B.

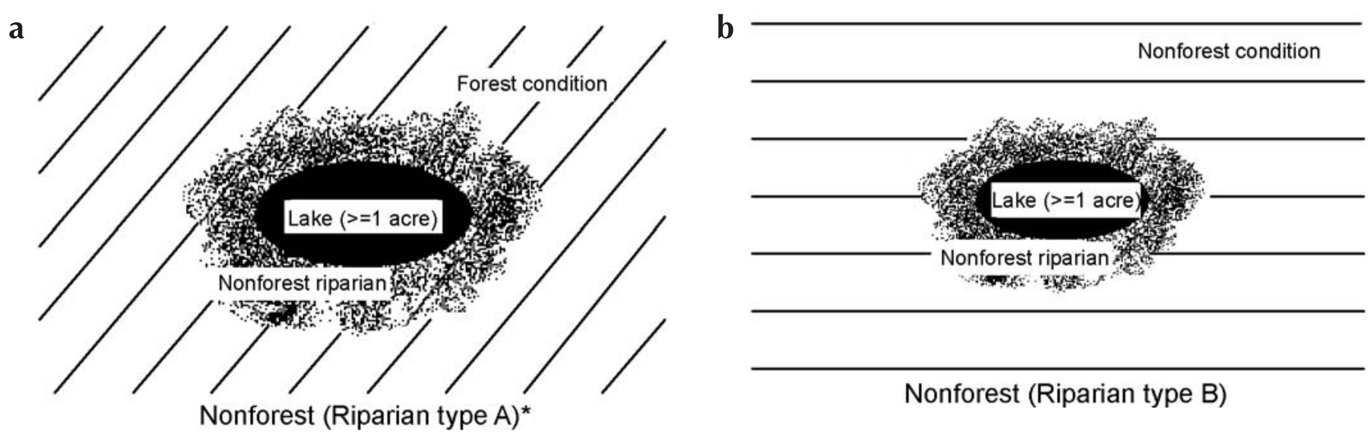


Figure A7. The riparian area is nonforested (≥30 ft but <120 ft, and ≥1 acre in size, excluding water feature), and surrounding a polygon feature ≥1 acre in size: a. At least one forest condition is adjacent to the riparian area, the forest riparian area is a type A. * Collapse to the most similar alternative condition class; b. At least one nonforest condition is adjacent to the riparian area, the forest riparian area is a type B.

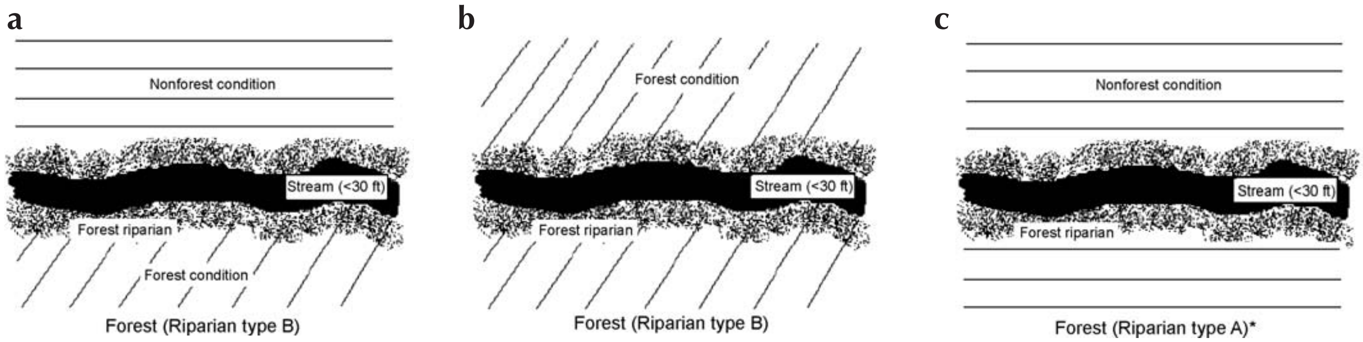


Figure A8. The riparian area is forested (the sum of the two widths is ≥30 ft but <120 ft, and ≥1 acre in size), and surrounding a linear feature <30 ft wide: a. At least one forest condition is adjacent to the riparian area on one side and a nonforest condition is adjacent to the riparian area on the other side, the forest riparian area is a type B; b. At least one forest condition is adjacent to the riparian area on both sides, the forest riparian area is a type B; and c. A nonforest condition is adjacent to the riparian area on both sides, the forest riparian area is a type A. * Collapse to the most similar alternative condition class.

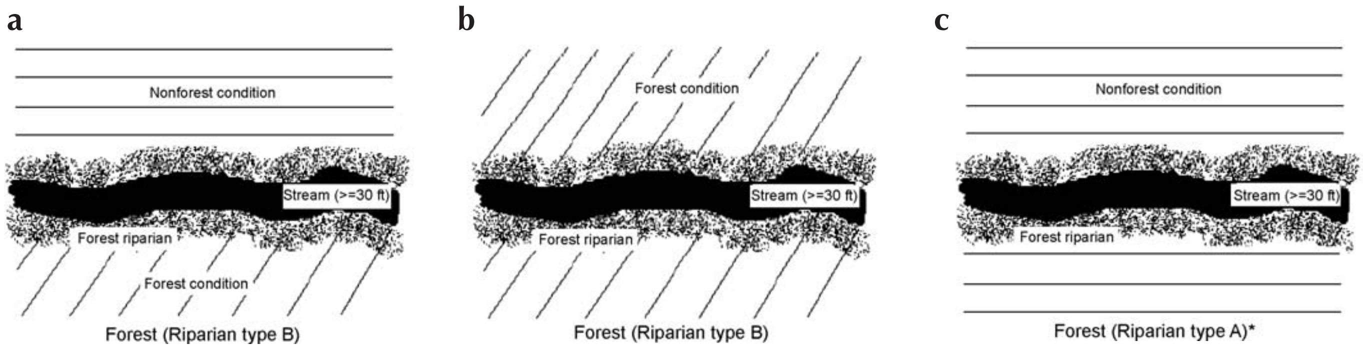


Figure A9. The riparian area is forested (either of the two widths is ≥30 ft but <120 ft, and ≥1 acre in size), and surrounding a linear feature ≥30 ft wide: a. At least one forest condition is adjacent to the riparian area on one side and a nonforest condition is adjacent to the riparian area on the other side, the forest riparian area is a type B; b. At least one forest condition is adjacent to the riparian area on both sides, the forest riparian area is a type B; and c. A nonforest condition is adjacent to the riparian area on both sides, the forest riparian area is a type A. * Collapse to the most similar alternative condition class.

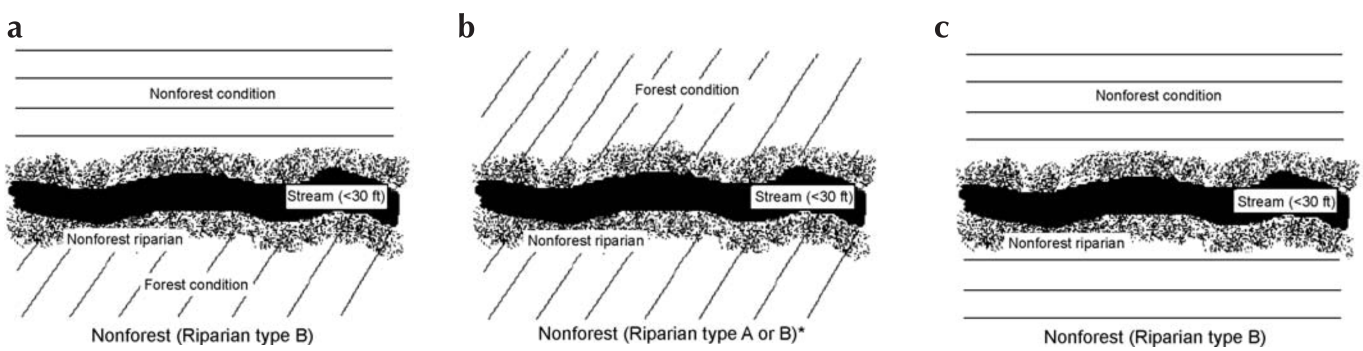


Figure A10. The riparian area is nonforested (the sum of the two widths is ≥30 ft but <120 ft, and ≥1 acre in size), and surrounding a linear water feature <30 ft wide: a. At least one forest condition is adjacent to the riparian area on one side and a nonforest condition is adjacent to the riparian area on the other side, the nonforest riparian area is a type B; b. At least one forest condition is adjacent to the riparian area on both sides. *If the sum of the total width of riparian area plus the stream is <120 ft then Nonforest (riparian type A), collapse to the most similar alternative condition class, otherwise, Nonforest (riparian type B); and c. A nonforest condition is adjacent to the riparian area on both sides, the nonforest riparian area is a type B.

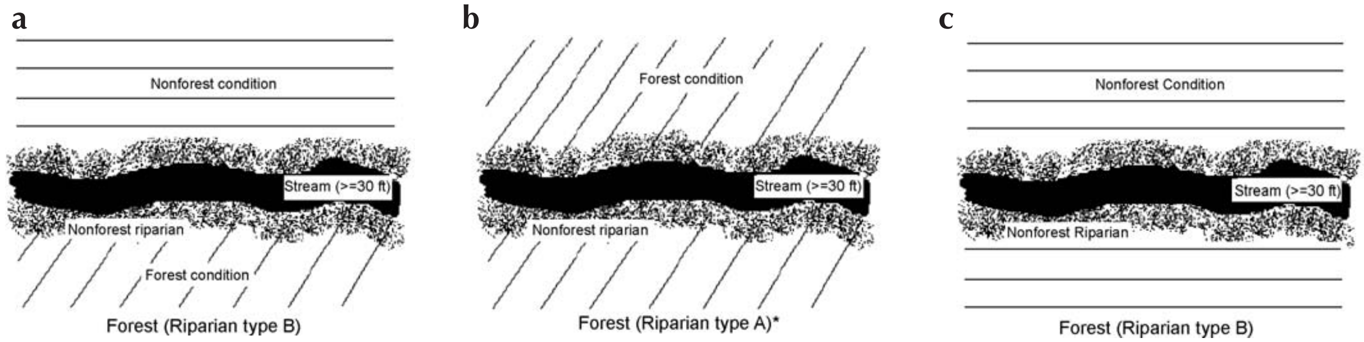


Figure A11. The riparian area is nonforested (either of the two widths is ≥30 ft but <120 ft, and ≥1 acre in size), and surrounding a linear feature ≥30 ft wide: a. At least one forest condition is adjacent to the riparian area on one side and a nonforest condition is adjacent to the riparian area on the other side, the nonforest riparian area is a type B; b. At least one forest condition is adjacent to the riparian area on both sides, the nonforest riparian area is a type A, collapse to the most similar alternative condition class.; and c. A nonforest condition is adjacent to the riparian area on both sides, the nonforest riparian area is a type B.

90° Corner Rule

- corner <90 degrees has a ≥120- or ≥30-ft line placed inside the angle
- corner ≥90 degrees has no length limits

The 90° corner rule directs the 120-ft length minimum when dealing with forest/nonforest issues at boundaries with corners (fig. A13) and is similarly reflected in the application of the 30-ft rule for nonforest other natural (riparian) and noncensus water features.

Most Similar Rule for Forest/Nonforest

- A unique forest/nonforest feature does not meet the ≥1 acre or ≥120-ft width requirements. Combine the smaller feature to the most similar feature meeting basic requirements.
  - o There is a skip rule that allows a forest or a nonforest condition that does not meet the basic size rule to be attributed to a nearby condition (of the same qualities) only if separated by another alternate condition that is in a similar predicament (fig. A14).
- For forest/nonforest only.

If prospective contrasting condition classes do not each meet the minimum size and width requirements, the most similar prospective conditions should be combined until these are attained (fig. A15).

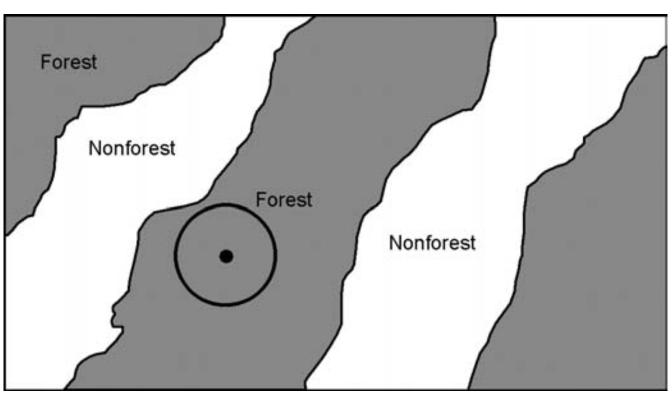


Figure A12. The point falls in an area of alternating strips of forest and nonforest, none of which meet the 120-ft wide criteria. Examine the overall area and classify the land according to whatever cover occupies the most area. In this example, there is more forest, so the point occurs in FOREST.

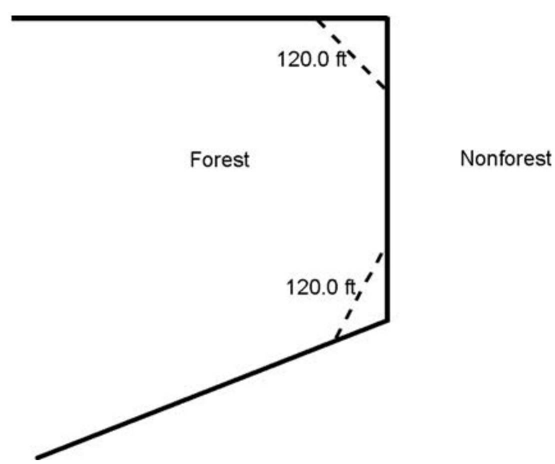


Figure A13. The angles found in nature and in man made features are sometimes very visible. The dotted lines do not create a nonforest condition unless the angle is <90 degrees.

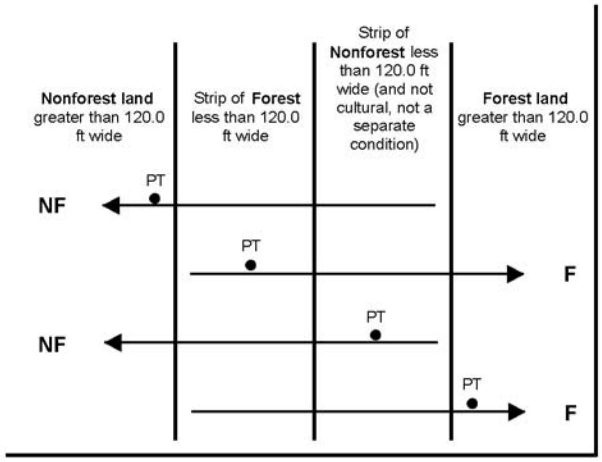


Figure A14. Example of the skip rule, with alternating strips of forested and nonforested conditions.

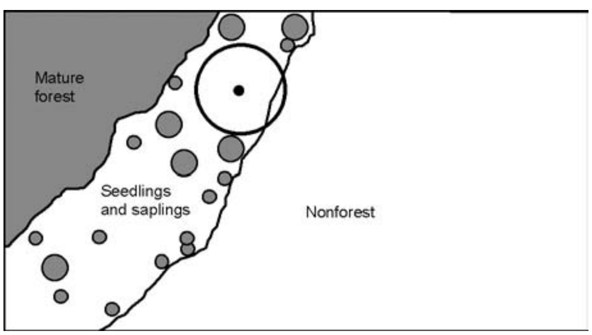


Figure A15. Combining conditions that do not meet minimum size criteria. The point falls in a strip of seedling/sapling <120 ft wide. Although the strip meets the definition of forest by the 40 seedling-stocking rule, this strip is too narrow to be its own condition. However, the strip is adjacent to a larger area of forestland that does meet the minimum forestland size criteria. Therefore, the strip is combined with the mature forest and the point occurs in FOREST LAND.

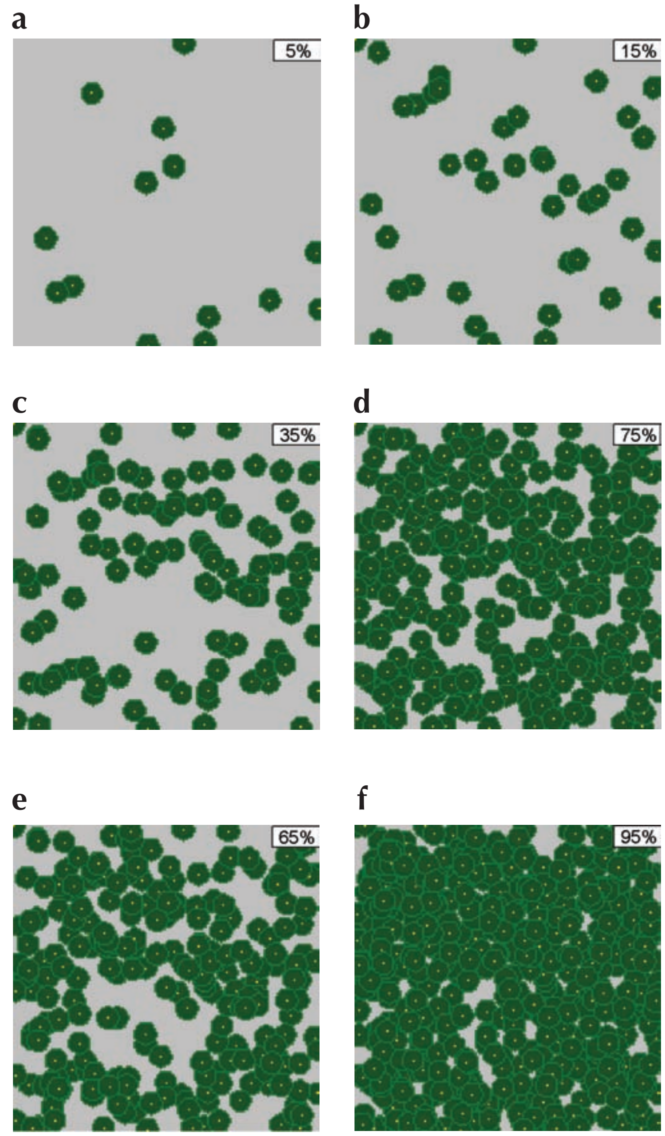


Figure A16. Simulated examples of crown cover at different percentages: a. 5 percent; b. 15 percent; c. 35 percent; d. 75 percent; e. 65 percent; and f. 95 percent.

Appendix B: Condition Codes

Condition Class

From the condition form (fig. 10), select the code that describes the sampling status of the condition class (table B1).

Condition-Defining Variables

Forest Type (Forest Conditions)

Select the code corresponding to the FOREST TYPE that best describes the species with the plurality of cover for all live trees in the condition class (table B2). For forested conditions, if STAND SIZE CLASS is nonstocked, then use your professional judgment to determine FOREST TYPE.

Table B1. Condition class codes.

Code	Description
1	Forest
2	Nonforest
3	Noncensus water
4	Census water
5	Not sampled
6	Nonforest developed
7	Forest riparian
8	Forest riparian type A
9	Forest riparian type B
10	Nonforest riparian
11	Nonforest riparian type A
12	Nonforest riparian type B

Nonforest Type (Nonforest Conditions)

Select the code corresponding to the NONFOREST TYPE that best describes the condition (table B3). For rangeland type, choose the NONFOREST TYPE based on the plurality of cover.

Size Class (Forest Conditions Only)

Size Class is abbreviated from the field stand size classes to minimize unrepeatable measures. Select the code that best describes the predominant size class of all live trees in the condition class (table B4). Table B5 displays estimates of crown width by species for trees 5 inches in diameter. Use this information to help make the decision between classes.

Table B2. Forest type codes.

Code	Description
Pinyon/juniper group	
182	Rocky Mountain juniper
183	western juniper
184	juniper woodland
185	pinyon-juniper woodland
Douglas-fir group	
201	Douglas-fir
Ponderosa pine group	
221	ponderosa pine
222	incense cedar
223	Jeffery pine/Coulter pine/bigcone Douglas-fir
224	sugar pine
Western white pine group	
241	western white pine
Fir/spruce/mountain hemlock group	
261	white fir
262	red fir
263	Noble fir
265	Engelmann spruce
266	Engelmann spruce/subalpine fir
268	subalpine fir
269	blue spruce
Lodgepole pine group	
281	lodgepole pine
Other western softwoods group	
365	foxtail pine/bristlecone pine
366	limber pine
367	whitebark pine
Riparian group	
703	cottonwood
706	sugarberry/hackberry/elm/green ash
709	cottonwood/willow
Aspen/birch group	
901	aspen
Western oak group	
925	deciduous oak woodland
Other western hardwoods group	
953	Cercocarpus woodland
954	intermountain maple woodland

Table B3. Nonforest type codes.

Code	Description
Agriculture	
10	Unclassified agriculture (stockyard, facilities, etc.)
11	Cropland
12	Pasture (improved through agricultural practices)
13	Idle farmland
14	Orchard/vineyard
15	Christmas tree plantation
16	Nursery
Rangeland	
20	Unclassified shrub
21	Sage dominant
22	Other shrub dominant
23	Grass/forb
24	Desert complex
Developed	
30	Unclassified (non-farm)*
31	Cultural (business, residential, other intense human activity)*
32	Rights-of-way (improved roads, railway, power line)*
33	Recreation (park, golf course, ski run)*
34	Mining (pits, tailings, conveyors, etc.)*
35	Military (firing ranges, bombed areas, airstrips)*
Other natural	
50	Unclassified other natural
51	Sand/dunes
52	Beach/shoreline
53	Rock outcrops/scree slopes
54	Wetland (veg dominant)*
55	Riparian zone (willow, other non-tally)*

* The class does not have to meet the 1.0 acre in size and 120.0 ft width requirements to be classified as a separate condition.

Table B4. Size class codes.

Code	Description
0	Nonstocked: Meeting the definition of forestland and where less than 5 percent cover of trees any size.
1	Seedlings/saplings (0-4.9 inches). At least 2/3 of the crown cover is in trees less than 5 inches in diameter.
2	5 + inches. At least 1/3 of crown cover is in trees over 5 inches in diameter and the plurality of crown cover is in trees of this size.

Table B5. Estimates of crown width (CW) by species for trees 5 inches in diameter (DIA).

Species	CW if DIA = 5
Utah juniper	4
Rocky Mountain juniper	4.9
single leaf pinyon	6
limber pine	6.7
bristlecone pine	6.9
white fir	7.4
subalpine fir	5.5
Engelmann spruce	5.4
Douglas-fir	7.3
quaking aspen	6.8
mountain mahogany	4.3

Regeneration Status (Stand Origin) (Forest Conditions Only)

Select the code that best describes the artificial regeneration that occurred in the condition (table B6).

For a forest land condition to be delineated and/or classified as artificially regenerated, the condition must show distinct evidence of planting or seeding. If it is difficult to determine whether a stand has been planted or seeded, use code 0. In many regions of the West, trees are not planted in rows, and planted stands do not differ in physical appearance from natural conditions. In these cases, there is no need to differentiate conditions based on stand origin.

Crown Density (Forest Conditions Only)

Select the density code that best describes the percent cover of live trees (table B7). Condition delineation by density should only be done when the less-dense condition is less than half as dense as the more dense condition.

Table B6. Regeneration status codes.

Code	Description
0	Natural: present stand shows no clear evidence of artificial regeneration. Includes unplanted, recently cut lands.
1	Artificial: present stand shows clear evidence of artificial regeneration.

Table B7. Crown density codes.

Codes	Description
1	0 to 25 percent crown cover
2	25 to 50 percent crown cover
3	50 to 75 percent crown cover
4	75 to 100 percent crown cover
5	Nonstocked

See fig. A16 for simulated examples of percent crown cover. Do not distinguish between low-stocked stands or stands of sparse and patchy forest.

In order to qualify as a separate condition based on density, there MUST be a distinct, easily observed change in the density of an area's tree cover.

Non-delineating Forest/Nonforest Condition Variables

Artificial Regeneration Species (Forest Conditions)

Select the species code of the predominant tree species for which evidence exists of artificial regeneration in the stand. This attribute is ancillary; that is, contrasting condition classes are never delineated based on variation in this attribute.

Disturbance (Forest and Nonforest Conditions)

Select the code corresponding to the presence of a disturbance (table B8). Disturbance can have positive or negative effects. The area affected by any natural or human-caused disturbance must be at least 1 acre in size. This attribute is ancillary; that is, contrasting conditions are never delineated based on variation in this attribute.

The following disturbance codes require "significant threshold" damage, which implies mortality and/or damage to 25 percent of all trees in a stand or 50 percent of an individual species' count. Additionally, some disturbances affect forests but initially may not affect tree growth or health (for example, grazing, browsing, flooding, and so forth). In these cases, a disturbance should be coded when at least 25 percent of the soil surface or under story vegetation has been affected. This attribute is ancillary; that is, contrasting condition classes are never delineated based on variation in this attribute.

Table B8. Disturbance codes.

Codes	Description
00	None, not observable
10	Insect/disease/drought damage
30	Fire
40	Animal damage (for example, beaver)
50	Weather damage
52	Wind
53	Flooding (weather induced)
55	Earth movement/avalanches
70	Unknown/not sure/other, describe in NOTES
80	Human-caused damage. Anything NOT listed under TREATMENT, describe in NOTES.

Treatment (Forest and Nonforest Conditions)

Select the code corresponding to the presence of a forestry treatment (table B9). Forestry treatments are a form of disturbance. These human disturbances are recorded separately for ease of coding and analysis. The term treatment further implies that a silvicultural application has been prescribed. This does not include occasional stumps of unknown origin or sparse removals for firewood, Christmas trees, or other miscellaneous purposes. The area affected by any treatment must be at least 1 acre in size. Record up to three different treatments per condition class, from most important to least important, as best as can be determined. This attribute is ancillary; that is, contrasting conditions are never delineated based on variation in this attribute.

Table B9. Treatment codes.

Codes	Description
00	None, not observable
10	Cutting
20	Site preparation
30	Artificial regeneration
40	Natural regeneration
50	Other silvicultural treatment (includes chaining)

The Rocky Mountain Research Station develops scientific information and technology to improve management, protection, and use of the forests and rangelands. Research is designed to meet the needs of the National Forest managers, Federal and State agencies, public and private organizations, academic institutions, industry, and individuals. Studies accelerate solutions to problems involving ecosystems, range, forests, water, recreation, fire, resource inventory, land reclamation, community sustainability, forest engineering technology, multiple use economics, wildlife and fish habitat, and forest insects and diseases. Studies are conducted cooperatively, and applications may be found worldwide.

Station Headquarters
Rocky Mountain Research Station
240 W. Prospect Road
Fort Collins, CO 80526
(970) 498-1100

Research Locations

Flagstaff, Arizona	Reno, Nevada
Fort Collins, Colorado	Albuquerque, New Mexico
Boise, Idaho	Rapid City, South Dakota
Moscow, Idaho	Logan, Utah
Bozeman, Montana	Ogden, Utah
Missoula, Montana	Provo, Utah