Prefield Methods: Streamlining Forest or Nonforest Determinations To Increase Inventory Efficiency

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Abstract.—Interior West Forest Inventory and Analysis has developed prefield protocols to distinguish forested plots that require field visits from nonforested plots that do not require field visits. Recent innovations have increased the efficiency of the prefield process. First, the incorporation of periodic inventory data into a prefield database increased the amount of information available for making accurate forest or nonforest determinations. Second, acquisition of low-altitude aerial photography proved to be a cost-effective method of verifying forest or nonforest status. Third, tools based on geographic information system technology have decreased the time required to complete the prefield process. Comparisons of field data with prefield determinations verify the prefield process as a cost-effective method of focusing data collection efforts on forested plots.

Introduction

The Forest Service, U.S. Department of Agriculture's (USDA's) Forest Inventory and Analysis (FIA) program, Interior West (IW-FIA) is currently implementing the annual measurement protocol following the national grid design described by Reams *et al.* (2005). FIA's primary mandate is to inventory only those lands that meet its definition of forest. Previous inventories show that less than 50 percent of all IW-FIA plots were actually forested (fig. 1); in 2005, only 34 percent of all plots were found to be forested. Visiting every plot in the inventory grid, including nonforest plots, as part of a forest inventory is logistically and economically infeasible be-

cause of the rugged terrain, the patchy access networks, and the sheer amount of nonforest area in the IW-FIA. The cost of data acquisition could be reduced, however, by focusing field efforts on plots that are known, or likely, to be forested. IW-FIA has developed processes, referred to as prefield protocols, to distinguish forested plots that require field visits from nonforested plots that do not require visits.

Figure 1.—*Number of forested, field-visited, and total Interior West Forest Inventory and Analysis plots, 2004–06.*
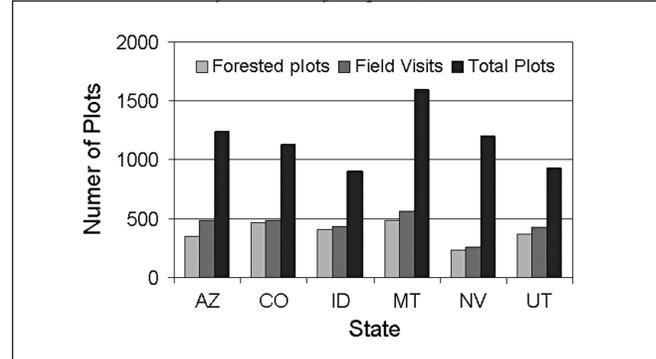
Prefield Protocols: An Overview

The primary purpose of prefield operations is to reduce unnecessary visits to plots that are known to lie within developed land, rangeland, sparse woodland, agricultural land, remote areas above treeline, or other nonforest lands. A second purpose is the preparation of field materials to aid in field crews' navigation and data collection efforts. Addressing both purposes require the compilation of aerial imagery; topographic maps; previous periodic inventory data, if available; and any other relevant ancillary data, such as species distribution maps. Once these data have been compiled, prefield observers determine whether each plot might meet the definition of forested land. Forest or nonforest determinations are based largely on photo-

interpretation with some consideration of aspect, elevation, and available ancillary information. In addition, prefield observers have experience in collecting FIA field data and thus possess a great deal of local knowledge of forest types and tree species' distributions. Within a prefield database, each plot is classified into one of three categories: (1) forest plots, (2) nonforest plots, and (3) checker plots. IW-FIA's definition of forest land includes areas that meet minimum width and area requirements and that (1) are 10 percent or more stocked by trees of any size now or in the past or (2) have at least 5 percent canopy cover of tree species now or in the past. A checker plot is defined as a location that does not appear to be forest, but the observer cannot tell with certainty that the plot is nonforest. All plots classified as either forest or checker plots will be visited by field crews, while plots that are unquestionably nonforest will not be visited.

Although prefield procedures traditionally involved interpretation of hard-copy aerial photographs and topographic maps, recent innovations have greatly increased the efficiency of the prefield process. Technological tools based on relational databases, low-altitude photography of marginal forest plots, and geographic information system (GIS) tools have all increased the amount of information available for making forest or nonforest determinations while increasing the efficiency of the prefield process, thus decreasing inventory costs.

Database Tools

IW-FIA has developed two database tools that increase the amount of available information for making accurate forest or nonforest determinations and decrease the time required to make such determinations. First, the prefield database includes active links to aerial imagery databases. Many plots in the annual inventory design were never visited during previous periodic inventories, and these locations will be established during the first annual inventory cycle. The quality and accessibility of imagery influences the ability of prefield observers to minimize unnecessary field visits to nonforest plots. The prefield database currently includes links to digital orthoquads (DOQs) with 1-m resolution. An extension of this innovation is the use of the ArcGIS-based Nationwide Select Image Server (ESRI 2006a), which provides access to the most current high quality imagery available for the contiguous 48 States, coupled

with advances in ArcGIS software that allow rapid display of precise coordinates at a specified scale (ESRI 2006b).

Second, IW-FIA recently incorporated periodic inventory data into the prefield database. For plots that were visited during periodic inventories in the past, these legacy data include information about tree species' presence, understory vegetation, disturbance, and land use. Both of these database tools enable prefield observers to quickly and easily access useful information for making forest or nonforest determinations.

Low-Altitude Photography

The use of low-altitude aerial photography has refined observers' ability to remotely differentiate forest from nonforest plots. While DOQs and the BOTUS Image Server provide adequate resolution for making initial forest or nonforest determinations, their typical 1-m resolution is insufficient for conclusively separating questionable checker plots into forest or nonforest categories. The acquisition of low-altitude aerial photography for specific plots in the Nevada Photo-Based Inventory Pilot (Moisen 2006) has provided a cost-effective source of high-resolution imagery for verifying forest or nonforest status, thereby reducing the number of field visits to questionable plots.

IW-FIA has also used aerial photography to further refine forest or nonforest classifications. In 2004 and 2005, low-altitude photography with a resolution of about 2 in (15 cm) was acquired and digitally georeferenced for 77 checker plots in Nevada at a cost of $200 per plot for a total cost of $15,400. These 77 plots were categorized as checker plots because they could not conclusively be categorized as forest or nonforest using available DOQs. Based on photointerpretation, 26 plots were identified as nonforest and therefore did not require field visits; 51 plots were verified as forest and were visited at an estimated average cost of $2,000 per plot for a total of $102,000. Thus, the total cost of the imagery acquisition and processing, plus the field costs of visiting verified forest plots, was $117,400. Visiting all 77 plots, at an average cost of $2,000 per plot, would have been $154,000. Therefore, the net savings of acquiring low-altitude photography to reduce unnecessary visits to checker plots was estimated at $36,600. This preliminary cost-benefit analysis shows that low-altitude photography may be a cost-effective tool for refining forest or

nonforest determinations. Further study is needed to perform quality control on these plots and to refine our cost estimates for visits to checker plots since data collection at low-tally plots and nonforest plots typically requires less time than at high-tally plots.

Geographic Information System Tools

One of the most time-consuming parts of the prefield process has been the compilation of aerial photograph stereopairs that field crews use for navigation and plot documentation. Within IW-FIA, most plot locations require aerial photographs from the Aerial Photograph Field Office, which is a division of the Farm Service Agency within USDA, typically consisting of either Forest Service Resource Photography or the photos from the U.S. Geological Survey National Aerial Photography Program (USGS 2007). Until recently, customers of these programs received hard-copy flightline indices or internet-based tools that required the user to individually identify the appropriate flightlines and frames for each plot location. Each year, this process took, on average, 80 person-hours per State, or more than 500 person-hours for all of IW-FIA.

IW-FIA has automated this process by using GIS tools to compile lists of relevant aerial photographs by flightline and station number. Based on proximity analysis in ArcGIS, the flightline and adjacent stations nearest to each plot are identified. This output comprises a list of stereopairs for each plot. The entire process consumes roughly 10 person-hours per State and thus has greatly decreased the time required to prepare field materials.

Quality Assurance Program

The integrity of forest inventory data depends on the ability to accurately distinguish forested from nonforested areas in the context of a specific definition of forested lands. Errors in the classification of plots into forest and nonforest categories can translate into large errors in estimates of total forest area. Errors of commission in the prefield process should be rectified during field data collection because plots that are classified as forest in the office may be found to actually be nonforest; the data are then correctly recorded as nonforest. On the other hand, if a plot is classified as nonforest but is actually forested,

it will not be visited during field data collection. This type of error would go unnoticed, and the effect is that total forest area will be underestimated. For this reason, IW-FIA has proposed a quality assurance program for prefield protocols. The design would consist of a random sample, stratified by ecoregion, of a certain percentage of plots that were categorized as nonforest by prefield observers. Ecoregions are meaningful strata for sampling because the sources of error in pinyon-juniper woodland in the Great Basin Desert, for example, are different than those in heavily timbered and logged areas in the northern Rocky Mountains.

A recent nonforest pilot inventory, the Forest Service Region 1 All Condition Pilot (ACP) (O'Brien 2006), provided preliminary data concerning the accuracy of prefield assessments that categorize plots as nonforest. The purpose of the ACP project was to visit all nonforest plots on National Forest System (NFS) lands and collect vegetation data from these plots; the ACP used prefield observations from IW-FIA to identify the sample. Within NFS lands in Montana in Region 1, 126 plots from the existing annual inventories (2003–2006) were classified as nonforest by prefield observers. Field crews found three of these plots to be forested in 2006; these three plots represent errors in the prefield process. During the same inventory period (2003–2006), field crews visited 1,067 forest plots on NFS lands in Montana. Since the prefield assessment for the ACP would have omitted three forest plots from this inventory of 1,067 plots, the error rate was 0.28 percent. This information provides analysts with an estimate of the error associated with forest estimates based on IW-FIA data on NFS lands in Montana.

One goal of the quality assurance program is to calculate error rates for each ecoregion within IW-FIA; another is to use the results to further refine prefield methods. Detection of errors affords the opportunity to identify and rectify sources of error in prefield forest or nonforest determinations. In the case of the ACP, two of the three plots that were classified as nonforest but were actually forest had been clearcut before the previous field visit. Field crews had erroneously determined the plots to be nonforest when they should have recorded them as nonstocked forest plots. When prefield observers considered the previous field data, they assumed that the field observations were correct despite the evidence of timber harvest on aerial imagery. The

lesson from this analysis is that individual pieces of information, including previous inventory data, are insufficient to eliminate plots from the inventory unless the information is interpreted in the context of all available information.

Discussion

The prefield protocols employed by IW-FIA have decreased inventory costs by minimizing unnecessary field visits to nonforest plots, thereby focusing field efforts on forested plots. Recent innovations have increased the efficiency of the prefield process. Incorporating periodic inventory data within a prefield database and acquiring high quality imagery have both increased the amount and quality of information available to prefield observers. Tools based on GIS technology have also decreased the time required to complete the prefield process. Comparisons of field data with prefield determinations based on these procedures show that the overall prefield process is a cost-effective and reliable method of focusing data collection efforts on forested plots.

The prefield methods described here can be applied to any vegetation inventory that would experience cost savings by differentiating forest and nonforest plots. Other forest inventory projects could use these methods in conjunction with more locally appropriate methods, such as the Common Land Unit information used by Liknes and Nelson (2009) in the Northern Research Station FIA unit. Nonforest vegetation inventories, such as the Forest Service Region 1 ACP, could compile their samples based on FIA prefield data. Finally, prefield methods may also streamline data collection efforts as both the definition of forest lands and the designation of tally species evolve. If these definitions change in the future, the periodic inventory data, which includes information about plant species present and site history, will aid in designation of plots as forest or nonforest under the new definitions.

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