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Understory Vegetation Data Quality Assessment for the Interior West Forest Inventory and Analysis Program

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Abstract

The Interior West Forest Inventory and Analysis (IW-FIA) program of the USDA Forest Service collects field data on understory vegetation structure that have broad applications. In IW-FIA one aspect of quality assurance is assessed based on the repeatability of field measurements. The understory vegetation protocol consists of two suites of measurements; (1) the structure by lifeform and (2) the structure for individual species with cover greater than five percent. The measurements of structure by lifeform and species are highly repeatable; however, since species identification is confounded with cover threshold, the repeatability of species identification cannot be evaluated using FIA's tolerance and compliance rate protocol for measuring repeatability. The protocols used to collect the data analyzed in this paper are specific to IW-FIA. A standardized national understory vegetation procedure that is very similar to the IW-FIA procedure described here will be implemented in 2011 for all FIA units.

Keywords: understory, vegetation, species, cover, forest inventory

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Contents

Research Summary

There are two major conclusions from this research: (1) the ocular estimates of the percent crown canopy cover by a lifeform and layer are very repeatable; and (2) the species protocol is structured in such a way that it is not currently possible to conduct a quality assessment of the species variable using the standard FIA MQO of a specified compliance rate for a given tolerance level.

Understory Vegetation Data Quality Assessment for the Interior West Forest Inventory and Analysis Program

Paul L. Patterson and Renee A. O'Brien

Introduction

The Forest Inventory and Analysis (FIA) program of the USDA Forest Service conducts forest inventories to meet the requirements for national assessments mandated by the Forest and Rangeland Planning Act of 1974 and other legislation. FIA inventories provide a statistically defensible, probability-based sample of forest resources across all ownerships that can be used for planning and analysis at the National Forest, State, regional, or national level. The FIA sample was designed to meet national standards for precision in state and regional estimates of forest attributes. Field crews conduct the field phase of the inventory on forest land and on some non-forest land. The sampling intensity is approximately one field plot every 5900 acres.

The Interior West FIA (IW-FIA) program of the Forest Service's Rocky Mountain Research Station, as part of its national inventory activities, collects data on understory vegetation (O'Brien and Van Hooser 1983). Ocular estimates of percent crown canopy cover and height layer are recorded for four lifeforms and for some individual species on all FIA plots. Hereafter "crown canopy cover" is called "cover" and "height layer" is called "layer". Percent cover is the area of ground surface covered by the canopy of a plant, presented as a percent of the total area sampled. Understory information, in combination with other data collected on FIA field plots, provides a structural picture of the total plant community that can be used in many applications such as estimating wildlife habitat, fuel characteristics, grazing potential, or presence of noxious or invasive plants. The FIA understory vegetation data have been used to predict indicators of rangeland health and functionality (O'Brien and others 2003), estimate biomass (Mitchell and others 1987), estimate forest fuels (Gebert and others 2008), inform vegetation types and maps of canopy cover for LANDFIRE (Toney and others 2007), and quantify woodpecker habitat (Witt 2009).

FIA's quality assurance program entails extensive crew training and nationally consistent protocols. Quality control (QC) procedures include direct feedback to the field staff to provide continual real-time assessment and improvement of crew performance. In addition to extensive QC activities, data quality is assessed and documented using performance measurements and post-survey assessments. The quality assessment measurements are stated as measurement quality objectives (MQOs) and are designed to provide a range of accuracy that is allowable for any given field measurement. The MQOs are used to identify areas of the data collection process that need improvements or refinements in order to meet the quality objectives of the FIA program. Quality assessment analysis has been conducted for all FIA national core variables (Pollard and others 2006) and for all forest health variables (Westfall 2009); and at the time of this paper, it is being conducted on IW-FIA variables.

Quality assurance of IW-FIA understory vegetation data is based on a second, independent measurement called a "blind check" that is conducted on a random subset of IW-FIA field plots. The blind check allows for the difference between the measurements to be compared against a pre-specified tolerance, and it allows for the calculation of an overall compliance rate that is used to assess the repeatability of the understory vegetation measurements. The MQOs for the IW-FIA understory vegetation protocols are stated in terms of tolerance and compliance rate.

The purpose of this paper is to (1) present a quality assessment of the IW-FIA understory vegetation protocols using quality assurance data and the stated MQOs; and (2) show if a quality assessment of the protocol to measure species variables can be conducted using the current MQOs. All data collection experts and users of IW-FIA understory vegetation data will find the results on the repeatability important and useful. The protocols used to collect the data analyzed in this paper are specific to IW-FIA. A standardized national understory vegetation procedure that is very similar to the IW-FIA procedure described here will be implemented in 2011 for all FIA units. The analyses in this paper can be used in establishing the MQO standards for the national protocols.

Methods

Data

There are two types of data; the first is data collected using the IW-FIA understory vegetation protocols, and the second is data used to conduct the quality assessment of the understory vegetation protocols. The IW-FIA understory vegetation variables are measured on all forested FIA plots; the FIA plot is comprised of four subplots. Percent cover is estimated for the tree, shrub, forb, and graminoid lifeforms by three layers (figure 1) on each sampled subplot. Crews also estimate and record a summary percent "aerial" cover for each lifeform, that is, all the height layers are collapsed and the crew estimates the percent cover from a bird's eye view. For example, in figure 1, the tree lifeform has 5 percent cover for Layer 1, 6 percent cover for Layer 2, 9 percent cover for Layer 3, and 16 percent aerial cover (for the aerial, the trees on the right side of the subplot have 12 percent aerial cover, not 15 percent); while the grass lifeform has 9 percent cover in Layer 1, 0 percent cover in Layers 2 and 3, and 9 percent aerial cover. In addition to the lifeform estimates, percent cover and layer estimates are recorded for each species with 5 percent or greater cover on each sampled subplot; the layer assigned is the one where the bulk of the cover occurs. For another example, in figure 1, there are two tree species with cover greater than 5 percent. For tree species 1, the cover is 11 percent and the bulk of the

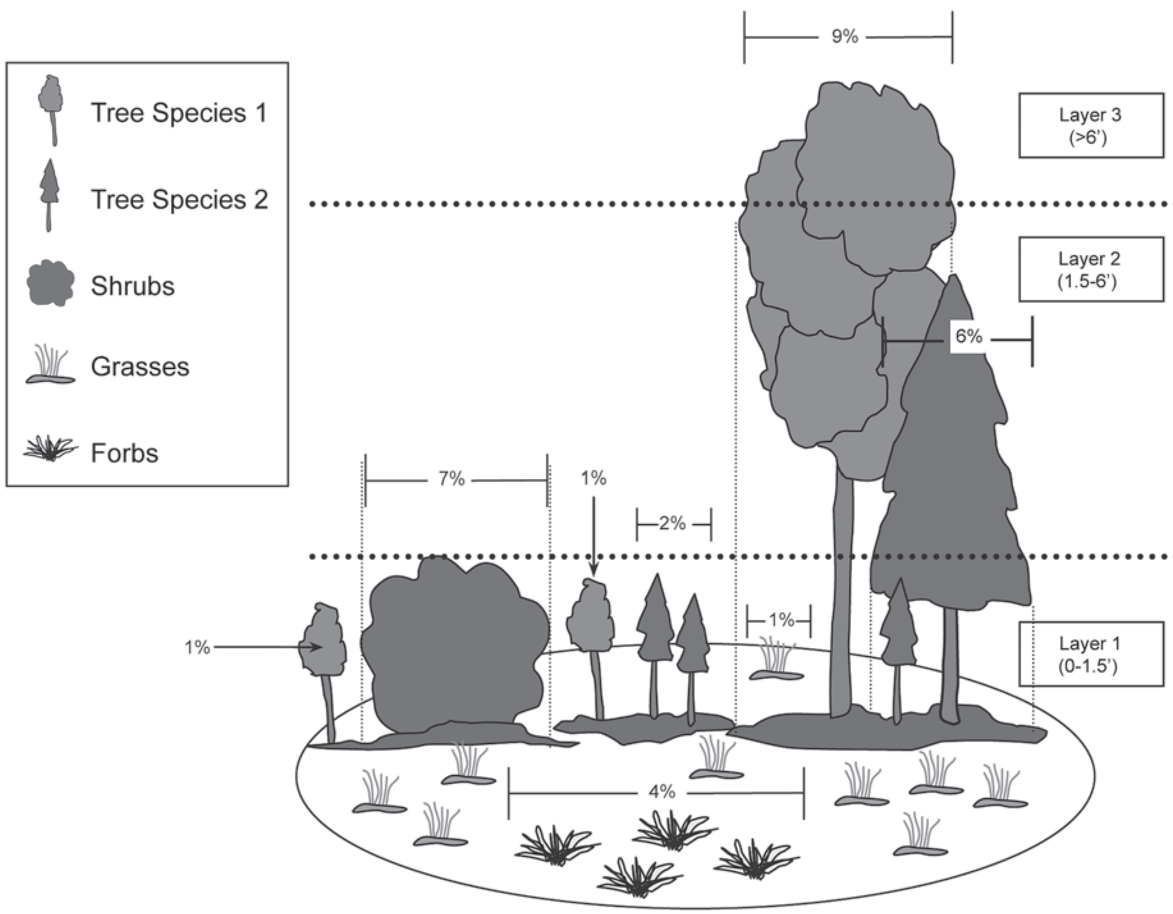

Figure 1. Adapted from the FIA field manual (USDA 2008), this figure shows how percent crown canopy cover for vegetation on a subplot is estimated by layer.

cover occurs in Layer 3; for tree species 2, the cover is 8 percent and the bulk of the cover occurs in Layer 2. As one last example, in figure 1, the forb lifeform would have 4 percent cover for both Layer 1 and the aerial and 0 percent cover for Layer 2 and 3, but since the cover is less than 5 percent, no forb species would be listed. More detailed field protocols are documented in the IW-FIA Field Procedures manual (USDA 2008).

The data used for data quality assessment of any FIA variable are generated by a second independent measurement of a field plot called a blind check. This involves the re-installation of an inventory plot by another field crew without the first field crew's data in hand. The first measurement of the plot by the field crew is referred to as the field measurement (FM), and the second measurement by another crew is referred to as the quality assessment (QA). This QA measurement is considered to be a "blind" measurement because the QA crew does not have knowledge of the FM crew's original measurement. In addition, FM crews do not know when or which of their plots will be re-measured by a QA crew and, therefore, cannot alter their performance on a given plot. This type of blind measurement provides a direct, unbiased observation of measurement precision from two independent crews. Blind check plots are randomly selected to be a representative sub-sample of all plots measured.

Typically, the blind check plots are measured within two weeks of the FM crew measurement to avoid the confounding effects of seasonal changes. The FM data for all plots usually go through more edit checks than QA data. For this analysis, so that the data are comparable, we used the version of the FM data that had not gone through the additional edit checks. The blind check data used in this study are from the annual inventory system for the following states and years: Arizona (2001 to 2008), Colorado (2002 to 2008), Idaho (2004 to 2008), Montana (2003 to 2008), and Utah (2001 to 2008). There is a total of 493 plots or 1972 subplots.

Analysis

Quality assessment is accomplished by calculating the differences between the FM crew and QA crew data and comparing the differences to pre-established MQOs. The standard FIA model for an MQO of a data element is a combination of a tolerance limit and a compliance rate for each data element. The tolerance limit or acceptable measurement error is selected based on a balance between the accuracy necessary for scientific or analytical purposes and the ability of the crews to make repeatable measurements or observations within the assigned tolerance. In the analysis of blind check data, an observation is within tolerance when the difference between the FM crew and QA crew observations does not exceed the assigned tolerance for that data element. The compliance rate is the minimum percentage of observations that should be within tolerance. For example, the tolerance for the diameter of a tree at breast height (DBH) is ± 0.1 inch for each 20.0 inches in diameter of a live tree, and the compliance rate is 95 percent. The objective is that 95 percent or more of the DBH observations are within ± 0.1 inch for each 20.0 inches of diameter for all live trees measured by both the FM and QA crews. Results can be displayed as a simple percent of the computed differences that fall within the program tolerances. This percentage is referred to as the observed compliance rate. The tolerance limits and compliance rates are documented in the IW-FIA field procedures manual (USDA 2008). Tolerance limits have been established for understory variables, but there are no established compliance rates for the understory variables.

The first step in analyzing blind check data is to match the FM and QA measurements. Because of the blind aspect of the protocols there is the possibility of "extra" observations, that is, one crew records an observation that the other crew does not. For example, in the understory vegetation protocols, a species is recorded if it covers at least 5 percent of the plot, so either the FM or QA crew may assess a species cover at 7 percent and record the species while the other crew assesses the species cover at 4 percent and does not record the species. The extra observations are analyzed separately for each crew type (FM and QA). The extra records are presented as total and as a percentage of the recorded observation, that is, the number of recorded observations is equal to the sum of the matched records and extra records. In equation form, the percentage extra is:

$$\text{Percent extra} = \left[\frac{\text{Number of extras}}{(\text{Number of extras}) + (\text{Number of matches})}\right] * 100$$

The understory data are collected in two general groups—a lifeform suite of variables and a species suite of variables; the two suites use different identifiers in the matching process, so the matching process is described separately.

Lifeform Suite of Variables—For each of the four lifeforms, percent cover by three layers plus the percent aerial cover is recorded. The FM and QA measurements can be matched for the 16 variables using a unique identifier number for each subplot. There is a possibility of some unmatched subplots; this occurs when either the FM or QA crew records lifeform data for a subplot but the other crew does not. There are two reasons why this can occur. First, the blind check protocols do not require that the QA crew collects data on all of the subplots, even though the FM crew sampled them. The subplots that the QA crew does not collect data for are recorded as non-sampled. Second, one crew may record the subplot center condition as "non-forested," which means the crew won't measure the lifeform variables, while the other crew may record the subplot center condition as "forested," which means they will sample the subplot. In this paper, the extra lifeform observations are subplots that one crew recorded as non-forest and the other crew recorded as forest. For this paper, only the subplots that were jointly measured were used in the analysis of the MQOs for the lifeform suite of variables. The stated tolerance for all lifeform variables is ± 10 percent (USDA 2008); there is no stated compliance rate. To better understand and formulate a possible compliance rate, we analyzed the matched data using tolerances of ± 5 percent, ± 10 percent, ± 15 percent, and ± 20 percent.

Species Suite of Variables—Crews only record species data on subplots where they record lifeform data, so the analysis of the species suite of data was restricted to the subplots where both crews recorded lifeform data. The species suite of variables consists of four variables: species, lifeform, cover, and vegetation layer. For each subplot, the crew records up to four of the most dominant plant species within each lifeform that have at least 5 percent cover. The plants are recorded using the alphanumeric code, as listed in the USDA Natural Resources Conservation Service PLANTS database (USDA 2000). Because the FIA protocols were developed to be easily implemented by non-botanists and because the FIA inventory field work is conducted in early spring and late fall, concessions have been made regarding species identification. Some plants require identification only at the genus level; for example, all graminoids are coded at the genus level only; while for trees, only Salix (willow) is recorded at the genus level—all other trees are recorded at the species level. For a complete list of plants identified at only the genus level see USDA (2008). For the purposes of this report, there are two uses of the word species; one use designates the species suite of variables, and the other is for the variable whose value is the species or genus code of the plant. The unique identifier for a species suite record is comprised of state, county, plot, and subplot numbers, plus the species code. We refer to this unique identifier as species-within-subplot or genus-within-subplot, depending on the level of identification required. Because the crews identify species within the lifeforms, the matching of the species suite records is conducted separately for each lifeform. Also, the records are further divided into those species that are to be identified at the species level and those that are to be identified at the genus level. For each lifeform, after the initial matching, there are five data sets: (1) the matched records, (2) the FM unmatched species-within-subplot, (3) the FM unmatched genus-within-subplot, (4) the QA unmatched species-within-subplot, and (5) the QA unmatched genus-within-subplot.

If a crew is not able to identify a plant in the field, the species is recorded as UNKN1, UNKN2, etc., and a specimen is obtained to send to a specialist. If the specialist cannot identify the plant, the record remains in the database as an unknown species. For this analysis, any unknown species was compared by a plant identification specialist to any unmatched plant records to determine if the records with unknown species could be matched. This process is based on the percent cover and the vegetation layer and is compared to one of the remaining unmatched records with the same lifeform and opposite crew type. These "manual" matches were added to the data set of matched records.

The remaining QA unmatched species-within-subplot and FM unmatched species-within-subplot records are compared for matches based on the identifier genus-within-subplot. Any genus-level matches of species-within-subplot are added to the matched data set and are removed from the appropriate unmatched data set; these genus-level matches of species-within-subplot are considered to be out of tolerance for the species variable.

At this point, all possible matches have been made directly by species, indirectly by genus, or by manual estimation, and the matching process is concluded. We refer to the data set of matched records as the matched species data set even though some were matched at the genus level. When the matching process is concluded, there are three data sets: the matched species, the extra FM species, and the extra QA species. Compliance rates for the variables lifeform, percent cover, and vegetation layer are analyzed using the matched species data set. There are no compliance rates for these variables. To better understand and formulate a compliance rate, the percent cover variable was analyzed using tolerances of ± 5 percent, ± 10 percent, ± 15 percent, and ± 20 percent. The vegetation layer was analyzed using tolerances of zero layers, ± one layer, and ± two layers. The lifeform variable was analyzed using a tolerance of zero.

In the FIA protocols, the species variable has a tolerance of no errors on species identification, but this tolerance level is confounded by the cover threshold. For example, if a crew estimates the cover of a species to be less than 5 percent, they won't record that species. But the other crew may estimate the cover to be greater than 5 percent and will record the species. As a result, the standard FIA MQO model of a tolerance limit and compliance rate is not strictly applicable. There are two reasons for an extra species record: (1) the other crew determined the cover for the species to be less than 5 percent and did not record the species, or (2) the species was not identified correctly by one crew and, therefore, does not show up as a match. The former is within the tolerance of the species variable while the latter is outside of the tolerance of the species variable. Therefore, the extra records contribute to whether the compliance rate for the species variable is met.

The closer the cover percent of the extra record is to 5 percent, the more likely that the record will be within tolerance. For example, it is more likely for 6 percent cover to be within tolerance than 15 percent cover. As an indication of the level of non-repeatability for the species variable, we compared the number of matched records to a frequency distribution of cover for each set of extra records.

Results

Matched Records

The term "compliance rate" refers to the compliance rate at a tolerance of 5 percent; when referring to the compliance rate for the other tolerances, the tolerance is stated along with the compliance rate.

Lifeform Suite of Variables—Data from 1723 subplots where both the FM and QA crews recorded lifeform data were used to analyze the compliance rates for the 16 lifeform variables. Due to the lack of a compliance rate, the data were analyzed using tolerances of ± 5 percent, ± 10 percent, ± 15 percent, and ± 20 percent (table 1). The compliance rate ranged from 77 percent to 100 percent. For a ± 10 percent tolerance, the compliance rate ranged from 87 percent to 100 percent, and all but two layers had a compliance rate above 90 percent. The minimum compliance rate for a tolerance of ± 15 percent was 93 percent with the majority of layers above 96 percent. Note that for graminoids, forbs, and trees, the compliance rate for the percent aerial cover estimate was close to the compliance rate where most of the vegetation occurred—Layer 1 for the graminoids and forbs and Layer 3 for the trees. The lowest compliance rates at any tolerance were for graminoid percent aerial cover, which were 76 percent, 87 percent, 93 percent, and 95 percent at tolerances ± 5 percent, ± 10 percent,

Table 1—Percent observed compliance rate with a tolerance of 5 percent for 12 lifeform variables from 1723 matched subplots.

	Percent observed compliance rate at tolerance level				
Variable	**±5%**	**±10%**	**±15%**	**±20%**	**Records**
Tree Cover Layer 1	97.1%	99.1%	99.8%	99.9%	1714
Tree Cover Layer 2	91.2%	96.9%	98.6%	99.3%	1720
Tree Cover Layer 3	80.9%	91.2%	95.5%	97.4%	1720
Tree Cover Aerial	77.7%	88.7%	93.9%	96.3%	1714
Shrub Cover Layer 1	87.0%	95.1%	97.4%	98.4%	1703
Shrub Cover Layer 2	88.3%	94.5%	97.5%	98.6%	1713
Shrub Cover Layer 3	98.0%	99.2%	99.6%	99.8%	1713
Shrub Cover Aerial	77.9%	88.8%	93.6%	96.4%	1703
Forb Cover Layer 1	87.3%	94.3%	97.3%	98.5%	1688
Forb Cover Layer 2	95.9%	98.1%	98.9%	99.2%	1701
Forb Cover Layer 3	99.9%	100.0%	1704		
Forb Cover Aerial	85.0%	92.7%	96.2%	97.8%	1688
Graminoid Cover Layer 1	77.0%	87.7%	93.4%	95.9%	1689
Graminoid Cover Layer 2	94.2%	96.9%	98.2%	98.9%	1701
Graminoid Cover Layer 3	100.0%				1704
Graminoid Cover Aerial	75.8%	86.8%	92.8%	95.4%	1689

± 15 percent, and ± 20 percent, respectively. Not all records were used for each variable; the last column of table 1 shows the number of records used. The number of records used was often less than 1723 subplots because there was snow on some of the subplots, which sometimes restricted the estimates.

When considering the compliance rates in table 1, a combination of the lifeform and the layer should be taken into consideration. For example, the compliance rate for graminoid cover in Layer 3 was 100 percent due to the fact that very few graminoids grow to that height, so the crews agreed the cover was zero.

Species Suite of Variables—Analysis of compliance rates for three of the species suite variables (percent canopy cover, vegetation layer, and lifeform) was restricted to the records that were matched by the process detailed in the Methods section. The fourth variable, species, could not be analyzed using the standard FIA MQO structure; aspects of quality assurance for the species variable are addressed in the Species Variable section.

There were 2509 matched species suite records across 1723 subplots. A breakdown of type of matches by lifeform is shown in table 2. There was 100 percent agreement between the crews for the lifeform variable. For the predominate vegetation layer of a species (that is, the "layer" variable), the tolerance levels were in agreement, ± 1 layer, and ± 2 layers, with compliance rates of 87.2 percent, 99.7 percent, and 100 percent, respectively. Due to the lack of a compliance rate, the percent cover was analyzed using tolerances of ± 5 percent, ± 10 percent, ± 15 percent, and ± 20 percent (table 3). In addition to the compliance rate for all lifeforms, the compliance rates are also given for the percent cover by individual lifeform (table 3). The compliance rate for percent cover was 71 percent, and the compliance rate by lifeform ranged from 66 percent for graminoids to 82 percent for forbs. At a tolerance of ± 10 percent, the compliance rate for all species was 86 percent, and the compliance rate by lifeform ranged between 82 percent and 92 percent. The highest compliance rate, regardless of tolerance level, was for forbs and the lowest was for graminoids.

Table 2—The number of matches by type of match and by lifeform, where "Species" are matches at the species-within-subplot level; "Genus" are matches at the genus-within-subplot level; "Manual" are species that are listed as unknown and matched by an expert based on other attributes such as cover; and "Genus-species" are matches at the genus-within-subplot level for species that were supposed to be matched at the species-within-subplot level.

	Type of match				
Lifeform	**Species**	**Genus**	**Manual**	**Genus-species**	**Total**
Graminoids	—	518	25	—	543
Forbs	178	20	12	9	219
Shrubs	707	10	11	35	763
Trees	940	11	0	33	984

Table 3—Percent observed compliance rate at tolerances of ± 5 percent, ± 10 percent, ± 15 percent, and ± 20 percent for the species percent crown canopy cover variable. The compliance rate is given for all lifeforms as well as separately for each lifeform.

	Percent observed compliance rate at tolerance level				
Variable	**±5%**	**±10%**	**±15%**	**±20%**	**Records**
All lifeforms	70.7%	86.4%	92.5%	95.5%	2509
Graminoids	65.9%	81.6%	89.1%	91.9%	543
Forbs	81.3%	92.2%	95.0%	98.2%	219
Shrubs	71.3%	87.0%	92.4%	95.9%	763
Trees	70.5%	87.2%	93.8%	96.5%	984

Extra Records

Lifeform Suite of Variables—Out of 1972 subplots where at least one of the crews recorded lifeform data, 225 subplots were non-sampled by the QA crew and one subplot was non-sampled by the FM crew, which was due to snow that had melted off by the time the QA crew arrived. For the 1746 subplots that both crews sampled, 23 were extra lifeform subplots, leaving 1723 matched lifeform subplots. The 23 extra lifeform subplots consisted of 13 QA extra subplots and 10 FM extra subplots, with an extra percentage of 0.86 and 0.58, respectively.

Species Suite of Variables—A frequency distribution of extra species records based on four categories of cover is shown in table 4; the four categories are (1) 5 to 9 percent, (2) 10 to 14 percent, (3) 15 to 19 percent, and (4) greater than 19 percent. Although the percentage of extra records for each crew type was between 17 percent (QA—trees) and 49 percent (FM—forbs), the majority were in the 5 to 9 percent cover category.

Species Variable

As mentioned, the analysis of compliance rates for the species variable was confounded because of the 5 percent cover threshold. In an attempt to facilitate more discussion on the QA of the species suite of variables, we took a closer look at various aspects of the data. The usual MQO for FIA consists of a tolerance and a compliance rate. Because species are only listed if they are at least 5 percent cover, there are two characteristics that are measured for the one variable: (1) the fact that it meets the 5 percent cover threshold, and (2) the species that are present. The MQO structure of a compliance rate at a stated tolerance for the species name does not take into account the "at least 5 percent cover" requirement. Neither the FM nor QA crew listed any species for 202 (12 percent) of the 1723 subplots. In the standard FIA MQO analysis of the species variable, these subplots would not contribute to the repeatability of the measurement of the species variable even though there was complete agreement between crews that none of the plant species on the subplots covered 5 percent of the ground surface. Any additional attempt to quantify the similarity of the sets of species recorded by the FM crew versus the sets recorded by the QA crew (for example, using similarity coefficients) will always be constrained by the 5 percent threshold for recording or not recording species, which will cause the coefficient to be low due to the number of extra species records.

The matched records are a source of data for determining the probability that an extra record occurred because the other crew correctly identified the species but determined that the cover was less than 5 percent; using the matched records is complicated, since the joint distribution of QA and FM cover variables—is a censored distribution with no values below the 5 percent level.

With the exception of forbs, the numbers of extra FM and QA species records were approximately the same (table 4), indicating that the extra records did not occur due to an artifact of whether the crew was an FM or QA crew. For all lifeforms, a majority of the extra records were in the 5 to 9 percent category.

Table 4—The number of extra FM and QA species or genus records along with the percentage calculated as 100%*(number extra records)/(number matches + number extra records).

		Cover				
Lifeform		**5% to 9%**	**10% to 14%**	**15% to 19%**	**≥20%**	**Total**
Graminoids	FM extra records	183 (22.2%)	43 (5.2%)	15 (1.8%)	39 (4.7%)	280 (34.0%)
	QA extra records	195 (23.3%)	41 (4.9%)	27 (3.2%)	31 (3.7%)	294 (35.1%)
Forbs	FM extra records	163 (42.7%)	26 (6.0%)	11 (2.6%)	12 (2.8%)	212 (49.2%)
	QA extra records	104 (32.2%)	14 (4.0%)	6 (1.7%)	6 (1.7%)	130 (37.2%)
Shrubs	FM extra records	199 (20.7%)	22 (2.2%)	12 (1.2%)	10 (1.0%)	243 (24.2%)
	QA extra records	215 (22.0%)	15 (1.4%)	6 (0.6%)	7 (0.7%)	243 (24.2%)
Trees	FM extra records	170 (14.7%)	19 (1.6%)	8 (0.7%)	8 (0.7%)	205 (17.2%)
	QA extra records	165 (14.4%)	19 (1.6%)	6 (0.5%)	7 (0.6%)	197 (16.7%)

Discussion/Conclusions

Lifeform Suite of Variables

For all lifeforms, the compliance rate for the percent aerial cover was lower than the compliance rate for all other layers (regardless of the tolerance); this is likely a result of the difficulty of combining the vegetation at various heights to obtain total aerial cover. For the percent aerial cover estimate, crews are not supposed to double count overlapping crowns, which may further contribute to differences between estimates. The percentage of extra lifeform subplots was low and occurred at approximately the same rate for each crew type. The observed compliance rates for the lifeform suite of variables indicated that the cover variable is very repeatable at either the ± 5 or ± 10 percent tolerance level for all lifeforms and layers. These data, in combination with other data collected on FIA field plots, provide a structural picture of the total plant community that has many uses, such as estimating wildlife habitat, fuel characteristics, biomass, and forage availability; validating vegetation maps; and assessing ecosystem health.

Species Suite of Variables

The species (and sometimes genus) detail of the FIA understory vegetation protocol was originally intended to supplement the lifeform estimates by providing more specific detail on the genus and/or species that make up the lifeforms present on an FIA subplot. The ± 5 percent threshold for recording species detail was added to limit the time and expertise needed by FIA field crews while still capturing basic, general information. The species protocol was intended to get information on common, abundant, or habitat indicator plants throughout forested ecosystems. The results for the matched species (table 3) indicate that, for species that meet the 5 percent cover threshold, the lifeform, percent cover, and layer variables are highly repeatable at zero tolerance, ± percent tolerance, and ± one layer, respectively. For all tolerance levels (with the exception of the ± 20 percent tolerance level for forb and tree percent aerial cover), the compliance rate by lifeform for the species cover (table 2) was less than the compliance rate for the percent aerial cover (table 3) of the corresponding lifeform. The higher percentage of extra records in table 4 for graminoids and forbs indicates that species identification is less repeatable for these lifeforms. The identification of graminoids to even the genus levels seemed to be problematic. In addition, the percentage of extra species records with cover greater than 10 percent for forbs was quite high. We recommend emphasizing the assessment of graminoids and forbs cover during field crew training.

The species protocol is structured in such a way that it is not possible to conduct a quality assessment of the species variable using the standard FIA MQO of a specified compliance rate for a given tolerance level. If this part of the understory protocol is intended to be assessed the same way as all other FIA variables within the FIA MQO system, we recommend (1) that additional analyses be performed to determine exactly what kind and level of repeatability is needed for the species variable to be of use and (2) that a method for quality assessment be devised. That method must take into account proposed uses of the species suite of variables; what level of accuracy is needed for the proposed uses; and how to measure that accuracy in terms of a single, independent re-measurement of the species variable, that is, a blind check measurement.

References

Gebert, K.M.; Schuster, E.G.; Woudenberg, S.; O'Brien, R. 2008. Estimating forest fuels in the Southwest using forest inventory data. Gen. Tech. Rep. PSW-GTR-189. Albany, CA: U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: 39-48.

Mitchell, J.E.; Bartling, P.; O'Brien, R.; 1987. Understory cover-biomass relationships in the Front Range ponderosa pine zone. Res. Note. RM-471. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 5 p.

O'Brien, R.A.; Van Hooser, D.D. 1983. Understory vegetation inventory: an efficient procedure. Res. Pap. INT-323. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station. 6 p.

O'Brien, R.A.; Johnson, C.M.; Wilson, A.M.; Elsbernd, V.C. 2003. Indicators of rangeland health and functionality in the Intermountain West. Gen. Tech. Rep. RMRS-GTR-104. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 13 p.

Pollard, J.E.; Westfall, J.A.; Patterson, P.L.; Gartner, D.L.; Hansen, M.H.; Kuegler, O. 2006. National forest inventory and analysis data quality assessment report. Gen. Tech. Rep. RMRS-GTR-181. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 43 p.

Toney, C.; Rollins, M.; Short, K.; Frescino, T.; Tymcio, R.; Peterson, B. 2007. Use of FIA plot data in the LANDFIRE Project. Pages 309-319 in: McRoberts, R.; Reams, G.A.; Van Deusen, P.C.; McWilliams, W.H., eds. Proceedings of the Seventh annual Forest Inventory and Analysis symposium; October 3-6, 2005; Portland, ME. Gen. Tech. Rep. WO-77. Washington, DC: U.S. Department of Agriculture, Forest Service.

U.S. Department of Agriculture [USDA]. 2008. Interior West forest inventory and analysis, field procedures, version 3.02. Ogden, UT: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Forestry Science Laboratory. Available: http://www.fs.fed.us/rm/ogden/data-collection/pdf/p2_manual_08.pdf. [March 2008].

U.S. Department of Agriculture, Natural Resources Conservation Service [USDA NRCS]. 2000. The PLANTS database. National Plant Data Center, Baton Rouge, LA. For copy contact Arlington, VA: U.S. Department of Agriculture, Forest Service, National Office Forest Inventory and Analysis, 1601 North Kent Street, Suite 400.

Westfall, James A., ed. 2009. FIA national assessment of data quality of forest health indicators. Gen. Tech. Rep. NRS-53. Newtown Square, PA: U.S. Department of Agriculture, Forest Service, Northeastern Research Service. 80 p.

Witt, Chris. 2009. Quantification of Lewis's woodpecker habitat using Forest Inventory and Analysis data. In: McWilliams, Will; Moisen, Gretchen; Czaplewski, Ray, comps. 2008 Forest Inventory and Analysis (FIA) symposium; October 21-23, 2008; Park City, UT. Proc. RMRS-P-56CD. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 1 CDROM.

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