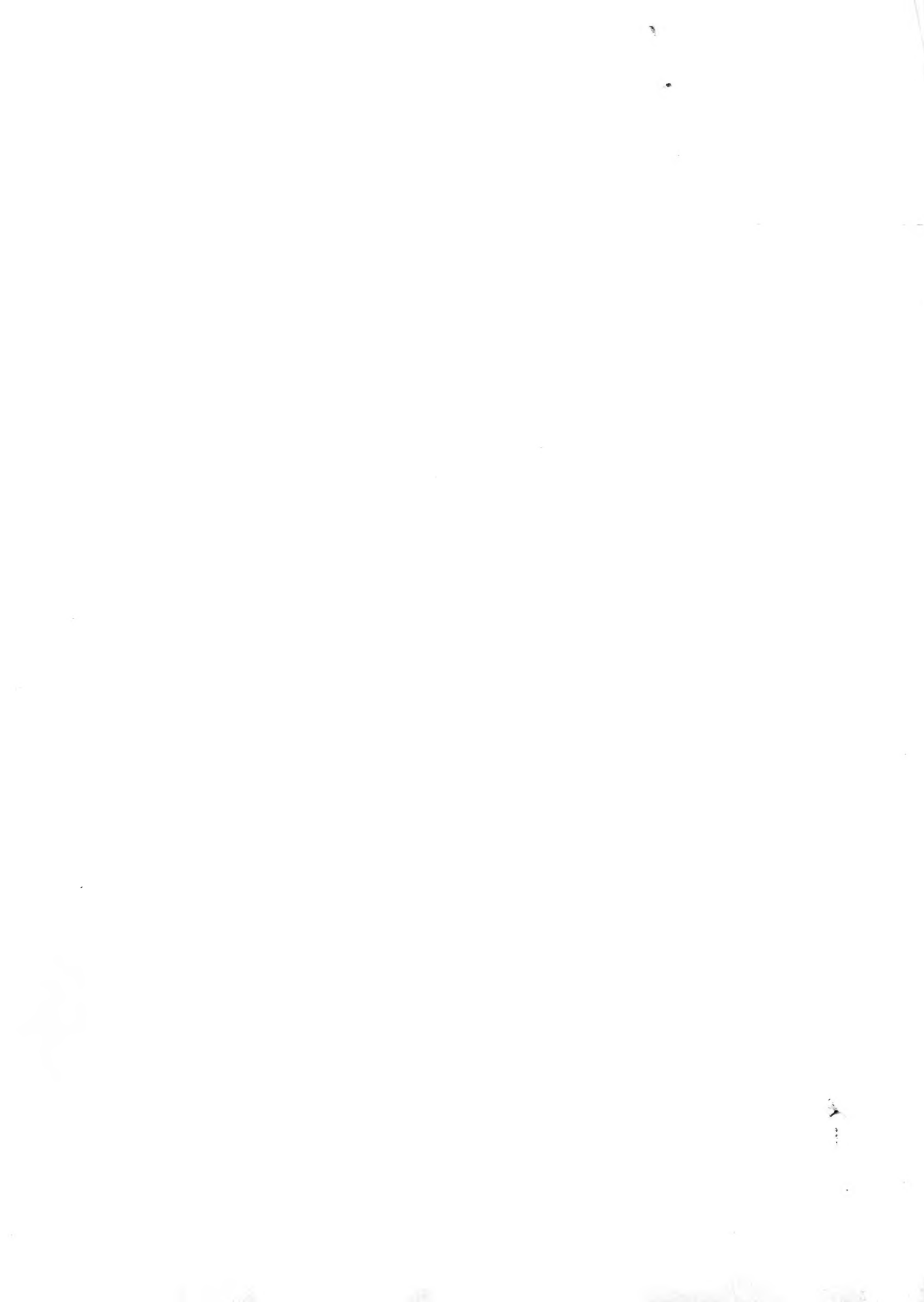


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Area-Specific Recreation Use Estimation Using the National Visitor Use Monitoring Program Data

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Abstract

Estimates of national forest recreation use are available at the national, regional, and forest levels via the USDA Forest Service National Visitor Use Monitoring (NVUM) program. In some resource planning and management applications, analysts desire recreation use estimates for subforest areas within an individual national forest or for subforest areas that combine portions of several national forests. In this research note we have detailed two approaches whereby the NVUM sampling data may be used to estimate recreation use for a subforest area within a single national forest or for a subforest area combining portions of more than one national forest. The approaches differ in their data requirements, complexity, and assumptions. In the “new forest” approach, recreation use is estimated by using NVUM data obtained only from NVUM interview sites within the area of interest. In the “all-forest information” approach, recreation use is estimated by using sample data gathered on all portions of the national forest(s) that contain the area of interest.

Keywords: Recreation visits, National Visitor Use Monitoring program, recreation use estimation, recreation area.

Introduction

Recreation use estimates from the National Visitor Use Monitoring (NVUM) program, which are developed at the national, regional, and forest levels, are useful for many administrative and management analyses. However, for some situations, analysts desire recreation use estimates for areas below the level of a national forest

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or for areas that encompass subforest portions of more than one national forest. In this research note, we describe two approaches that can be used to develop these area-specific NVUM recreation use estimates.

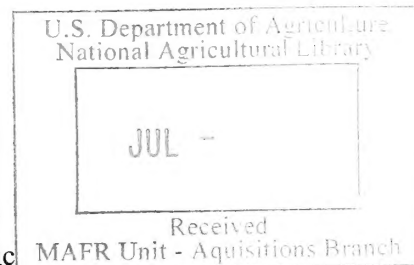
We intend for the approaches to be applied in estimating recreation use for geographically large areas. The approaches are not appropriate for estimating recreation use at individual recreation sites, a collection of a few recreation sites, or small portions of the undeveloped areas of the national forest. Some appropriate applications include (1) estimating the national forest recreation use for a large watershed that is of particular management interest, (2) estimating recreation use for a large separate unit of a national forest (e.g., the western unit of the Hiawatha National Forest), or (3) developing an estimate of recreation use for a national forest that is part of a multiple-forest administrative unit (e.g., an estimate for the Huron National Forest portion of the Huron-Manistee National Forest). For example, the approaches described in this paper have been considered for use in estimating national forest recreation visitation within the Chattooga River Watershed, which is located along the borders of South Carolina, Georgia, and North Carolina and encompasses portions of three national forests. Before undertaking area-specific estimation, we urge analysts to familiarize themselves with the NVUM sampling program and to discuss their analysis with NVUM national-level staff.

We intend for the approaches to be applied in estimating recreation use for geographically large areas.

National Visitor Use Monitoring Program

The foundations of the NVUM program were initiated in 1996 as a pilot project (Zarnoch et al. 2002) and officially implemented across the entire National Forest System (NFS) starting in calendar year 2000 (English et al. 2002). During NVUM round 1 (lasting from January 2000 through September 2003), each national forest in the NFS underwent NVUM sampling for 1 year. We include a brief description of the NVUM program and sampling approach; while a more detailed description is available in English et al. (2002).

Under NVUM, recreation use is quantified in terms of “site visits” and “national forest visits.” A site visit is defined as “one person entering and exiting a recreation site or area on a national forest for the purpose of recreation” and a national forest visit is defined as “one person entering and exiting a national forest for the purpose of recreation” (English et al. 2002). In the course of a single national forest visit, an individual may complete multiple site visits (e.g., an individual recreating at two day-use sites during a single national forest visit or an individual recreating in the undeveloped portion of a forest and at a campground during a single national forest visit). Based on NVUM round 1, the NFS had 246 million site visits and 205 million national forest visits annually (USDA Forest Service 2004).



NVUM Sampling Approach

The NVUM sampling approach estimates recreation use by combining traffic counts with information gathered via surveys of national forest visitors. Traffic counts are completed for a 24-hour period and visitor questionnaires are administered at selected interview locations on selected days (termed **sample days**) within individual national forests. Sample days within a given national forest are selected via a stratified random sample from the population of all possible interview locations and days (termed **site days**) identified for that national forest.

Site days (and their subset sample days) are stratified by the type of recreation area (termed the **site type**) and by the expected level of last-exiting recreation use (termed the **use level**). Four site types are recognized in the NVUM sampling protocol: day use developed sites (DUDS), overnight use developed sites (OUDS), general forest area (GFA), and designated wilderness (wilderness).² A detailed definition of the four site types can be found in English et al. (2002). In the first round of NVUM, each site day was classified into one of four use levels (high, medium, low, and closed) based on the expected level of last exiting recreation traffic. Beginning in NVUM round 2, a fifth use level, “very high,” was added. The levels of last-exiting recreation traffic that distinguish one use level from another within specific site types are identified by personnel on the respective national forest. The combination of site type and use level (e.g., DUDS-medium) form the **strata** for the nonproxy NVUM sample.

Visitation to some recreation sites and areas (e.g., campgrounds, wilderness areas, etc.) requires users to pay a fee, obtain a permit, or both to recreate at the individual site or in the specific area. For some of these sites and areas, the amount of “traffic” can be determined via fee or permit data, and an NVUM traffic count is not required. Under NVUM, these sites are termed proxy sites. The proxy count is combined with data from the visitor questionnaires to estimate the recreation use at the proxy sites. Proxy sites are classified based on site type (i.e., DUDS, OUDS, GFA, or wilderness) and the type of proxy employed (e.g., a fee envelope, a permit, etc.). These sites are not classified by the level of last-exiting recreation use. Under the NVUM protocols and in the approaches described in this research note, proxy sites are treated separately from nonproxy sites when estimating recreation use. The NVUM proxy sites are identified in the prework analysis completed by national forest personnel.

²An additional site type recognized under NVUM is “viewing corridor.” Use of this type of site or area is not treated as national forest recreation use and this site type is not considered here.

Estimates of recreation use in the various nonproxy and proxy strata (e.g., DUDS-medium, OUDS-fee envelope, etc.) are constructed from the NVUM sampling on a given national forest within the respective strata. The NVUM recreation use estimate for that national forest is then developed by summing the estimates of use (site visits and national forest visits) for all the nonproxy and proxy strata of the forest. Regional and national estimates are computed, in turn, by aggregating the visitation estimates of forests within a region and all forests in the Nation, respectively.

Estimating Area-Specific Recreation Use

We label the two approaches to estimating area-specific recreation use as the “new forest” approach and the “all-forest information” approach. In the former approach, recreation use is estimated for the area of interest (AOI) by using NVUM sample days and NVUM visitor surveys completed only at NVUM interview locations within the AOI. In the latter approach, recreation use for the AOI is estimated based on information obtained from sample days and visitor interviews completed on all portions of the forest(s) containing the AOI.

The new forest approach is feasible only with an appropriate number of sample days and visitor interviews within each stratum (i.e., DUDS-high, GFA-low, etc.) in the AOI. This restriction may preclude the use of this approach in many situations. Application of the new forest approach requires access to the prework data, the daily summary data, the proxy data, and the last-exiting recreation visitor survey data for the forest(s) involved (see “Glossary” for further information on these data).

The all-forest information approach does not require that a minimum number of sample days or last-exiting recreation visitor surveys were completed within the AOI because data from all observations on the forest(s) are incorporated in estimating AOI recreation use. However, adoption of this approach requires the assumption that the patterns of recreation use within the AOI are similar to recreation use patterns on the entire national forest(s). To complete the all-forest information procedures, an analyst must have access to the prework data, the forest strata sampling results, the proxy data, and the last-exiting recreation visitor survey data for the forest(s) involved (see “Glossary” for definitions of these data).

Much of the information required to complete either approach is available in the Natural Resource Information System Human Dimensions-NVUM (NRIS HD-NVUM) application. The NRIS HD-NVUM application is available for download by USDA Forest Service personnel from the NRIS intranet Web site. The NRIS HD-NVUM application contains some information from the prework data, the daily summary data, the forest strata sampling results, and the proxy

The new forest approach is feasible only with an appropriate number of sample days and visitor interviews within each stratum in the area of interest (AOI).

data. Particularly useful tables and records include table 31 “Summary Results by Sampling Stratum,” table 32 “Proxy Summary Results,” table 33 “Results From Each Completed Nonproxy Survey Day,” and the interview site records. We recommend that analysts obtain the most recent version of this application when completing area-specific recreation use estimation.

Initial Steps in Area-Specific Recreation Use Estimation

Three initial steps are required regardless of which estimation approach is adopted: (1) identification and mapping of the AOI, (2) identification of AOI NVUM interview locations, and (3) determination of the population of site days within site type/use level strata for nonproxy sites and site type/proxy type strata for proxy sites within the AOI. Step 1 is completed by using applicable forest maps and/or spatial databases, and steps 2 and 3 are completed by using the prework that was completed by personnel on the national forest(s) prior to NVUM sampling.

Identify and map the area of interest—

The AOI should be delineated based on the management activity, planning issue, or the research question being addressed. The adopted spatial boundaries should be mapped either on paper map(s) or via a geographic information system (GIS).

Identify AOI NVUM interview locations—

In the NVUM prework, forest personnel have identified locations throughout the national forest for visitor interviews and traffic counts. From the NVUM interview locations included in the prework, those that can be used to measure recreation use within the AOI should be identified. These AOI NVUM interview locations will be used both in estimating the population of site days for the AOI and in identifying the NVUM sample days that can be used to estimate area-specific recreation use via the new forest approach. In selecting the AOI interview sites, the goal is to identify NVUM interview locations that “capture” visitors who have recreated in the AOI and do not “capture” (or capture very few) recreation users who have not recreated within the AOI (fig. 1). In cases where an interview site captures both a large number of AOI and non-AOI visitors, analysts must use judgment in deciding whether to include the site as an AOI interview location.

All DUDS and OUDS interview locations that fall within the boundaries of the AOI should be identified as AOI interview locations. All GFA and wilderness interview locations within the AOI should also be included as long as they exclusively (or nearly exclusively) measure AOI recreation use. The NVUM interview locations located near but outside the AOI boundary should be examined to determine if they primarily capture recreation users exiting from the AOI and should thus be

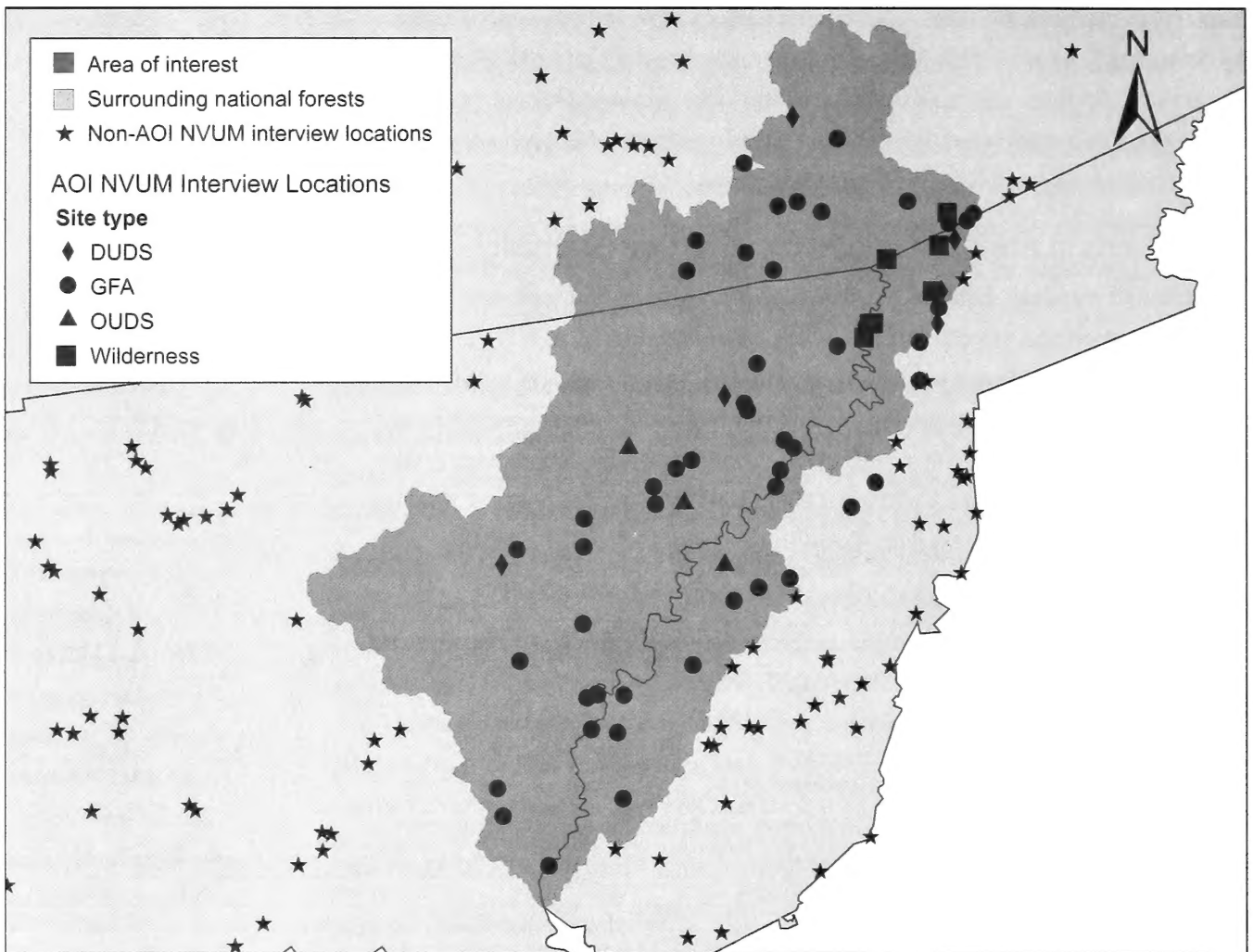


Figure 1—Area of interest (AOI) and non-AOI National Visitor Use Monitoring (NVUM) interview locations for an example AOI. DUDS = day use developed sites, GFA = general forest area, OUDS = overnight use developed sites, wilderness = designated wilderness.

included as AOI interview locations. For example, a GFA site located outside the AOI boundary but on a road used exclusively (or nearly exclusively) by recreation users from the AOI should likely be included as an AOI interview location (see GFA sites located outside the AOI boundary in fig. 1). Similarly, a wilderness interview location outside the AOI that primarily captures recreation users leaving a wilderness area located within the AOI should likely also be included as an AOI interview location.

In standard NVUM forest-level applications, interview sites are identified by individual forests to measure recreation use on the forest being sampled. In some cases, an interview location established for one forest's NVUM sampling may also

have been established for NVUM sampling by an adjacent national forest, and both forests may measure the same recreation use at this location (regardless of whether or not the forests were sampled in the same year). When estimating AOI recreation use in multiple forest applications, interview sites that have been established by more than one forest and that measure the same recreation use will lead to a double counting of recreation visits if no corrective action is taken (see examples in the next paragraph). To avoid double counting, these duplicate interview locations must be identified and the number of site days adjusted, as described in the next step.³

Several examples may help to clarify what situations may result in duplicate interview locations and the double counting of recreation visits. The most clear duplicate interview location situation (and likely the rarest) is one in which two or more forests have identified the same OUDS or DUDS site as an interview location and measure the same recreation use at that site. For example, if a DUDS picnic ground was located in the AOI on the border of two forests and both forests identified this as an interview location, these interview locations would clearly represent duplicates and should be identified. In some cases, the same DUDS or OUDS AOI interview site may have been identified by multiple forests but may in fact measure different recreation use and would not represent duplicates. For example, a DUDS site identified by two forests may have two trailheads, each serving trails on the respective forests. In this case, the interview location does not measure the same recreation use (recreation use on the trail on forest B would not be counted in the recreation use estimate of forest A) and the established NVUM interview locations are not duplicates. Less straightforward is the identification of duplicate GFA and wilderness interview locations. The key to correct identification is determining if the GFA and wilderness interview locations established by the forests measure the same recreation use. For example, two interview locations established at a single GFA parking lot located on the border of two forests would represent duplicates if the parking lot is used by canoeists and kayakers taking-out after recreating on a river that forms the boundary of the forests. Ultimately, many situations will likely be unique, and the analyst will have to use judgment in consultation with national-level NVUM personnel to determine if duplicate interview locations are present.

³ In some instances, a particular recreation site may be identified as two NVUM interview locations, both having different site types. For example, both an OUDS interview location and a DUDS interview location may have been identified within a developed campground that also provides day use lake access. Similarly, a DUDS location and a wilderness location may be identified within a single day use site with picnic grounds and a trailhead into a wilderness area. These are valid NVUM interview locations and should not be considered duplicates.

When more than one national forest is involved, it is advantageous to identify the number of site days within strata separately for each forest involved.

Determining the population of site days—

Using the calendar that was constructed for each AOI interview location in the NVUM prework, determine the number of site days identified within each stratum (e.g., DUDS-medium, OUDS-fee envelope, etc.), keeping proxy and nonproxy sites separate, for the AOI NVUM interview locations (table 1). Operationally, this involves determining the number of site days identified in the NVUM prework for each AOI NVUM interview location, then summing across AOI interview locations within strata. When more than one national forest is involved, it is advantageous to identify the number of site days within strata separately for each forest involved (table 2).

Table 1—Determining the NVUM site day population for an example area of interest

Site type^a	Use level	Site days
Nonproxy locations:		
DUDS	High	175
	Medium	334
	Low	1,195
	Closed	121
OUDS	High	1
	Medium	37
	Low	207
	Closed	120
GFA	High	1,063
	Medium	3,351
	Low	6,382
	Closed	7,454
Wilderness	High	70
	Medium	300
	Low	888
	Closed	1,297
Proxy locations:		
DUDS	Fee envelope (open)	71
	Fee envelope (closed)	294
OUDS	Fee envelope (open)	143
	Fee envelope (closed)	587
GFA	Fee envelope (open)	275
	Fee envelope (closed)	90
Total		24,455
Total (excluding closed site days)		14,492

^aDUDS = day use developed sites, OUDS = overnight use developed sites, GFA = general forest area, and wilderness = designated wilderness.

When duplicate NVUM interview locations have been identified for the same physical location, site days at the duplicates that correspond to measurement of the same recreation use should be counted only once. Generally, analysts will simply include the site days at the interview location established by one of the forests and discard the site days established by the other forests. In some cases, the open season (the nonclosed site days) established by one forest may be longer than that established by the other forests. In these cases, it is likely best to use the longer open season site days and exclude the site days established by the other forests to ensure that recreation use is estimated based on the longest season.

Table 2—Determining the NVUM site day population for an example area of interest involving multiple forests

Site type ^a	Use level	Forest A	Forest B	Forest C	All three
Nonproxy locations:					
DUDS	High	22	0	153	175
	Medium	177	35	122	334
	Low	45	1,060	90	1,195
	Closed	121	0	0	121
OUDS	High	0	1	0	1
	Medium	0	37	0	37
	Low	0	207	0	207
	Closed	0	120	0	120
GFA	High	895	168	0	1,063
	Medium	1,123	883	1,345	3,351
	Low	599	3,718	2,065	6,382
	Closed	3,588	3,261	605	7,454
Wilderness	High	0	70	0	70
	Medium	37	263	0	300
	Low	77	597	214	888
	Closed	251	895	151	1,297
Proxy locations:					
DUDS	Fee envelope (open)	71	0	0	71
	Fee envelope (closed)	294	0	0	294
OUDS	Fee envelope (open)	143	0	0	143
	Fee envelope (closed)	587	0	0	587
GFA	Fee envelope (open)	275	0	0	275
	Fee envelope (closed)	90	0	0	90
Totals		8,395	11,315	4,745	24,455
Totals (excluding closed site days)		3,464	7,039	3,989	14,492

^aDUDS = day use developed sites, OUDS = overnight use developed sites, GFA = general forest area, and wilderness = designated wilderness.

In rare cases, the established site days on forest A and forest B may measure duplicate recreation use for part of the year and unique recreation use during another part of the year (e.g., an interview location at a trailhead for a single trail that is open on forest A all year but closes on forest B during part of the year owing to snow conditions). In these cases, the site days that measure duplicate recreation use should be counted only once. The site days that measure unique recreation use at this duplicate location should then be added to the duplicate site day total. Again, many duplicate interview location situations will be unique, and the analyst should use judgment and consult national-level NVUM personnel.

Estimating Area-Specific Recreation Use Via the New Forest Approach

Determining the Adequacy of the NVUM Sample

Under the new forest approach, NVUM sample days and visitor interviews within the AOI are used to develop estimates of the number of site visits within the AOI and the number of AOI visits (AOI visits are analogous to national forest visits). To develop reliable estimates of AOI recreation use, there must be both a reasonable number of sample days and a reasonable number of visitor interviews within each stratum in the AOI.

Based on the NVUM sampling protocol, we recommend a minimum of 8 sample days for each nonproxy stratum and a minimum of 4 sample days for each proxy stratum (English et al. 2002). When the population of site days in a stratum is less than 8 or otherwise small, it is more important to ensure that the number of sample days is reasonable and the sampling fraction (site days to sample days) is adequate rather than being constrained solely by the 8-sample-day minimum. For example, if there are only 7 site days in a given stratum, then 4 sample days may be appropriate. Similarly, if just 16 site days exist within a stratum, then 7 sample days may be reasonable.

Having a reasonable number of visitor interviews within each stratum is likely more restrictive than meeting the NVUM minimum number of sample days. At nonproxy sites, data gathered via visitor interviews are used to estimate (1) the percentage of visitors who are last-exiting recreationists, (2) the average party size of last-exiting recreation parties, and (3) the number of sites visited per national forest visit. At proxy sites, data from last-exiting recreation visitors are used to “calibrate” the proxy in order to estimate recreation use. Because the NVUM protocols do not identify the minimum number of recreation visitor interviews within each stratum, analysts must determine what is reasonable for their specific application.

Having a less than adequate number of sample days and/or a limited number of visitor interviews in one or more nonproxy strata does not immediately preclude using the new forest approach. However, if several nonproxy strata have a small number of sample days, or a very limited number of visitor interviews, the new forest approach is likely not appropriate or may need to be modified (see the later section entitled “Options for Meeting Minimum Sample Size Requirements”). Individual analysts will have to use judgment as to whether the number of sample days and visitor interviews are reasonable given the specific situation.

Although it is preferable to have at least 4 sample days and a reasonable number of visitor interviews in every proxy stratum, it is not entirely necessary (and probably not likely). At proxy sites, the proxy provides a known count of the “traffic” at the site and only a conversion factor (obtained from surveys of last-exiting recreation visitors) is needed to convert this proxy count to an estimate of recreation use. If necessary, the proxy count can be converted to a recreation use estimate based on data from visitor interviews completed at interview locations within the same proxy stratum but outside the AOI. The proxy counts themselves are still obtained for the individual proxy sites within the AOI. Analyst judgment and local knowledge are necessary to determine whether the proxy conversion factor obtained from the larger geographic area is appropriate to the proxy sites in the AOI.

General Discussion of Recreation Visit Calculations

The formulas in the following sections are adapted from English et al. 2002. In the new forest approach, only data gathered from sample day observations at the AOI interview locations are used in estimating recreation use. The use of AOI-specific data is designated in the formulas below by the symbol “*”. Estimation of visits (both site visits and visits to the AOI in general) is achieved through (1) developing estimates of visits in the nonproxy strata, (2) developing estimates of visits in the proxy strata, and (3) combining nonproxy and proxy visit estimates into a single total visit estimate. Calculations for site visit estimation are detailed first, followed by the calculations for AOI visit estimation.

Calculating Site Visits Within the AOI for Nonproxy Strata

The first step in estimating the number of site visits in the nonproxy strata is to estimate the mean number of site visits for given nonproxy stratum h within the AOI (\overline{SV}_h^*);

If necessary, the proxy count can be converted to a recreation use estimate based on data from visitor interviews completed at interview locations within the same proxy stratum but outside the AOI.

$$\overline{SV}_h^* = \overline{C}_h^* \overline{P}_h^* \overline{V}_h^* ,$$

where \overline{C}_h^* is the mean number of cars counted on the NVUM traffic counter adjusted for the number of axles and two-way traffic in stratum h as estimated from the daily summary data, \overline{P}_h^* is the proportion of exiting traffic that is last-exiting recreationists averaged across all sample days in stratum h (also estimated from the daily summary data), \overline{V}_h^* is the number of persons in last-exiting recreation parties averaged across all sample days in stratum h within the AOI as estimated from the last-exiting recreation visitor survey data, and * designates that this information is drawn from the AOI interview locations. The total number of site visits in nonproxy stratum h is computed as

$$SV_h^* = N_h^* \overline{SV}_h^* , \quad [1]$$

where N_h^* is the known population of site days in stratum h within the AOI.

An estimate of the total number of site visits to nonproxy sites within the AOI is calculated as

$$TOTALSV_{NP}^* = \sum_{h=1}^H N_h^* \overline{C}_h^* \overline{P}_h^* \overline{V}_h^* ,$$

where H is the total number of nonproxy strata within the AOI. The total site visit equation comes from a summation over the strata of equation 1. Assuming independence of \overline{C}_h^* , \overline{P}_h^* , and \overline{V}_h^* , the variance of the total nonproxy estimate is

$$V(TOTALSV_{NP}^*) = \sum_{h=1}^H N_h^{*2} \left[\left(\overline{P}_h^* \overline{V}_h^* \right)^2 V(\overline{C}_h^*) + \left(\overline{C}_h^* \overline{V}_h^* \right)^2 V(\overline{P}_h^*) + \left(\overline{C}_h^* \overline{P}_h^* \right)^2 V(\overline{V}_h^*) \right] ,$$

where $V(\overline{C}_h^*)$, $V(\overline{P}_h^*)$, and $V(\overline{V}_h^*)$ are variances calculated in the usual manner.

Calculating Site Visits Within the AOI for Proxy Strata

Site visit estimates for the proxy strata within the AOI are developed from the following: (1) the annual total proxy count for a given site k within a given proxy stratum h (AP_{hk}) as identified in the proxy data, (2) the percentage of visitors complying with the proxy requirement (e.g., percentage obtaining a wilderness permit, etc.) for a given site k within a given proxy stratum h (CR_{hk}) as reported in the proxy data, and (3) a conversion factor estimated by using the last-exiting recreationists visitor survey data (\overline{A}_h^*).

The first two components (AP_{hk} and CR_{hk}) are combined to develop the “compliance-based proxy count” for each proxy site (PC_{hk}):

$$PC_{hk} = \frac{AP_{hk}}{CR_{hk}} .$$

In many instances, PC_{hk} will be directly available as part of the proxy data contained within the NRIS HD-NVUM application.

Using PC_{hk} , the average daily proxy count (\overline{PC}_h^*) for a given proxy stratum h is calculated as follows:

$$\overline{PC}_h^* = \frac{\sum_{k=1}^{K_h} PC_{hk}}{\sum_{k=1}^{K_h} N_{hk}} , \quad [2]$$

where N_{hk} is the known number of proxy site days for site k in stratum h , and K_h is the total number of proxy sites in stratum h within the AOI. \overline{PC}_h^* is a known constant and, thus, has no variance. This fact is used advantageously later in the variance equation for the total proxy estimate.

The conversion factor \overline{A}_h^* is constructed incorporating the sum of group size for all groups surveyed in stratum h of the AOI on given sample day i (SG_{hi}^*) and the sum of the number of proxies completed by all groups surveyed in stratum h of the AOI on sample day i (SR_{hi}^*) (both estimated from the last-exiting visitor survey data by using responses to the proxy-specific questions) via the following formula:

$$\overline{A}_h^* = \frac{\sum_{i=1}^{n_h} SG_{hi}^*}{\sum_{i=1}^{n_h} SR_{hi}^*} ,$$

where n_h is the number of sample days in stratum h within the AOI.

The average number of site visits across all sample days in proxy stratum h (\overline{SV}_h^*) is then calculated as

$$\overline{SV}_h^* = \overline{A}_h^* \overline{PC}_h^* . \quad [3]$$

The total number of site visits in proxy stratum h can be computed by expanding in a similar manner as was done in equation 1.

An estimator for the total number of site visits to all proxy sites within the AOI is

$$TOTALSV_p^* = \sum_{h=1}^H N_h^* \bar{A}_h^* \bar{PC}_h^* ,$$

where all variables are as defined previously. The variance of this estimator is then

$$V(TOTALSV_p^*) = \sum_{h=1}^H N_h^{*2} \bar{PC}_h^{*2} V(\bar{A}_h^*) ,$$

where the variance of \bar{A}_h^* is based on the ratio of means and is computed as

$$V(\bar{A}_h^*) = \frac{1}{n_h(n_h - 1) \left(\frac{\sum_{i=1}^{n_h} SR_{hi}^*}{n_h} \right)^2} \left[\sum_{i=1}^{n_h} SG_{hi}^{*2} + \bar{A}_h^{*2} \sum_{i=1}^{n_h} SR_{hi}^{*2} - 2\bar{A}_h^* \sum_{i=1}^{n_h} (SG_{hi}^* SR_{hi}^*) \right] .$$

Calculating the Total Number of Site Visits Within the AOI

The total number of site visits within the AOI, combining proxy and nonproxy sites, is

$$TOTALSV^* = TOTALSV_{NP}^* + TOTALSV_p^* ,$$

with variance calculated as

$$V(TOTALSV^*) = V(TOTALSV_{NP}^*) + V(TOTALSV_p^*) .$$

Area of Interest Visits

In most applications, the AOI will likely contain a number of recreation sites and areas (i.e., DUDS, OUDS, GFA, and wilderness). Because typically some visitors will recreate at multiple locations within the AOI, the number of site visits in the AOI will generally be greater than the number of AOI visits. The AOI visits are calculated by using, in part, the number of sites visited and whether or not recreation occurred in the GFA or in wilderness areas as reported by individual NVUM survey respondents in the last-exiting recreationist survey data. Respondents to the NVUM visitor survey identified the number of sites visited, the number of days spent in the GFA, and the number of days spent in wilderness areas on their current trip to the entire national forest. In some cases, the sites visited, the GFA recreation, or wilderness recreation that were reported by individual respondents may have occurred outside the AOI. Lacking other information, it is assumed that

Because some visitors will recreate at multiple locations within the AOI, the number of site visits in the AOI will generally be greater than the number of AOI visits.

the reported site visits and GFA and wilderness recreation all occurred within the AOI. If violated, this assumption could yield an underestimation of AOI visits. The number of AOI visits would be underestimated because the number of sites visited is used to adjust the site visit estimate downward. In rare instances, when the AOI contains only GFA or only wilderness areas, the number of AOI visits will equal the number of site visits.

Calculating AOI Visits for Nonproxy Strata

The first step in estimating AOI visits for nonproxy strata is to estimate the number of AOI visits on sample day i in stratum h ($AOIV_{hi}^*$). This is computed as follows:

$$AOIV_{hi}^* = C_{hi}^* \overline{P}_h^* CBAR_{hi}^* ,$$

where C_{hi}^* the number of cars obtained on the NVUM traffic counter adjusted for the number of axles and two-way traffic on sample day i in stratum h within the AOI as reported in the daily summary data and \overline{P}_h^* is as defined previously. $CBAR_{hi}^*$ is computed as

$$CBAR_{hi}^* = \frac{1}{n_{hi}^*} \sum_{j=1}^{n_{hi}^*} \frac{V_{hij}^*}{NS_{hij}^*} ,$$

where n_{hi}^* is the number of last exiting vehicles in stratum h on sample day i , V_{hij}^* is the number of visitors in vehicle j in stratum h on sample day i , and NS_{hij}^* is the number of sites visited by individuals in vehicle j in stratum h on sample day i , all within the AOI.

Recreation that was reported to have occurred in the GFA or in wilderness areas during the visit (i.e., days in the GFA > 0, days in wilderness > 0) is counted as one site visit for that site type regardless of the number of days in the GFA or days in wilderness. For example, if a respondent reported visiting 2 DUDS, spending 2 days in the GFA, and spending 3 days in a wilderness area during the national forest visit, NS_{hij}^* equals 4 (2 for DUDS visited + 1 for GFA recreation + 1 for wilderness recreation).

The average number of AOI visits across all sample days within nonproxy stratum h is computed as

$$\overline{AOIV}_h^* = \sum_{i=1}^{n_h} \frac{AOIV_{hi}^*}{n_h} .$$

The number of AOI visits in nonproxy stratum h is then computed as

$$AOIV_h^* = N_h^* \overline{AOIV_h^*}, \quad [4]$$

where N_h^* is the known number of site days in stratum h of the AOI.

An estimate of the total number of AOI visits associated with the nonproxy sites in the AOI is calculated as

$$TOTALAOI_{NP}^* = \sum_{h=1}^{N_h} N_h^* \overline{AOIV_h^*},$$

with variance

$$V(TOTALAOI_{NP}^*) = \sum_{h=1}^{N_h} N_h^{*2} V(\overline{AOIV_h^*}),$$

where $V(\overline{AOIV_h^*})$ is calculated in the usual manner.

Calculating AOI Visits for Proxy Strata

The AOI visits for proxy strata are estimated following the same general approach as used in estimating site visits for the proxy strata. However, an adjustment factor ($\overline{AF_h^*}$) is used to account for the number of sites visited per AOI visit. The conversion factor $\overline{AF_h^*}$ is developed as

$$\overline{AF_h^*} = \frac{\sum_{i=1}^{n_h} SC_{hi}^*}{\sum_{i=1}^{n_h} SR_{hi}^*},$$

where SR_{hi}^* is as defined previously and SC_{hi}^* is computed as

$$SC_{hi}^* = \sum_{j=1}^{J_{hi}} \left(\frac{V_{hij}^*}{NS_{hij}^*} \right),$$

where V_{hij}^* is the number of visitors in stratum h on sample day i in party j , NS_{hij}^* is the number of sites visited by party j in stratum h on sample day i , and J_{hi} is the total number of parties in stratum h on sample day i , all within the AOI. Reported recreation in the GFA or wilderness area during the visit (i.e., days in the GFA > 0, days in the wilderness > 0) is counted as one site visit for that site type regardless of the number of days in the GFA or wilderness area. The average number of AOI visits in proxy stratum h ($\overline{AOIV_h^*}$) is computed as

$$\overline{AOIV_h^*} = \overline{AF_h^*} \overline{PC_h^*},$$

where \overline{AF}_h^* is as computed above and \overline{PC}_h^* is the mean daily proxy count for proxy stratum h as calculated by using equation 2. The number of AOI visits in proxy stratum h within the AOI (\overline{AOIV}_h^*) is then computed by expansion as in equation 4.

An estimate of the total number of AOI visits associated with the proxy sites in the AOI is

$$TOTALAOI_p^* = \sum_{h=1}^H N_h^* \overline{AF}_h^* \overline{PC}_h^* ,$$

with variance

$$V(TOTALAOI_p^*) = \sum_{h=1}^H N_h^{*2} \overline{PC}_h^{*2} V(\overline{AF}_h^*) .$$

where $V(\overline{AF}_h^*)$ is calculated based on the ratio of means in a similar way as $V(\overline{A}_h^*)$ was as detailed in the previous section.

Calculating the Total Number of AOI Visits

The total number of AOI visits is then

$$TOTALAOI^* = TOTALAOI_{NP}^* + TOTALAOI_p^* ,$$

with variance

$$V(TOTALAOI^*) = V(TOTALAOI_{NP}^*) + V(TOTALAOI_p^*) .$$

Options for Meeting Minimum Sample Size Requirements

Several options are available to meet the minimum sample size necessary to complete the new forest estimation approach. In some cases, it may be possible to combine adjacent use levels within a given site type (e.g., DUDS-medium and DUDS-low), allowing for pooling of sample day observations and last-exiting recreation visitor interviews within the pooled stratum. This option may be particularly appropriate if two adjacent use levels (e.g., low and medium) within a single site type have small numbers of site days, sample days, or visitor interviews or if one use level within a site type has few site days, sample days, or visitor interviews and another has many site days, sample days, or visitor interviews. When pooling across use levels, the analyst should be cognizant of the potential for introducing bias into the visit estimates and for increasing the variance of the resulting recreation use estimate. A biased visit estimator may result if the numbers of sample days occurring within the pooled use levels are not proportional to the population of site days within the use levels. For example, a biased estimator could result in cases where

Several options are available to meet the minimum sample size necessary to complete the new forest estimation approach.

a similar number of site days exist in two use levels but vastly dissimilar number of sample days occurred in the two use levels. Additionally, if the visit behavior of recreationists (e.g., party size, number of sites visited, etc.) in the two use levels is different, then the resulting estimate could be biased.

As the second NVUM round is completed, there may be opportunities to increase the number of sample days and/or the number of last-exiting visitor interviews within AOI strata by pooling data across NVUM rounds. Significant changes within the use level breakpoints or the classification of NVUM interview locations within the involved forest(s) may preclude this pooling. Pooling across NVUM rounds is not appropriate if there have been significant changes in the amount of recreation use on the forest between NVUM rounds. Cross-round pooling will also make it impossible to identify trends in recreation use levels between the sample years. Analysts should consult national-level NVUM personnel to determine the feasibility of pooling across sampling rounds.

Sample day observations and visitor interviews completed at NVUM interview locations near the boundary of the AOI could be combined with sample day observations and visitor interviews within the AOI (within strata). Site days from these nearby interview locations should **not** be included in the total number of site days for the AOI (i.e., N_h^*). Incorporation of sample day data and interviews completed at nearby interview locations should occur only if recreation use levels (within strata) at the nearby interview locations are similar to recreation use levels within the AOI.

In some cases, the new forest approach may become feasible only if information from all portions of the forest can be used in estimating recreation use for specific strata (as done in the all-forest information approach presented next). Information from outside the AOI could include the average site visit (\overline{SV}_h) or average national forest visit (\overline{NFV}_h) estimates for a specific stratum as determined for the entire forest, the average number of sites visited per national forest visit in stratum h (\overline{NS}_h), or the average number of people per vehicle in stratum h (\overline{V}_h). As more information from outside the AOI is used, the recreation use estimate becomes more dependent on the assumption that recreation use patterns within the AOI do not differ significantly from recreation use patterns outside the AOI, within strata.

Estimating Area-Specific Recreation Use Via the All-Forest Information Approach

The all-forest information approach involves less complex calculations and does not require the analyst to have access to the daily summary data. Analysts must still have access to the prework data, the forest strata sampling results, the proxy count

reports, and last-exiting recreationist survey data for all of the national forests involved.

The all-forest information approach assumes that recreation use patterns within the AOI do not differ, within strata, from recreation use patterns on the forest(s) in general. This approach is likely inappropriate when (1) the level of recreation use, within strata, in the AOI is known to differ substantially from the level of use on the forest in general within the same strata; or (2) the pattern of site visits per national forest visit differs markedly between the AOI and the forest in general. The former restriction is not meant to preclude use of this approach in an AOI that has lower total levels of recreation use as result of a longer closed season or more low-use site days, as this difference is accounted for in the use level stratification of site days.

Calculating Site Visits Within the AOI for Nonproxy Strata

In the all-forest information approach, the average site visits per sample day for stratum h (\overline{SV}_h) is gathered from the forest strata sampling results reported for the entire national forest (table 3).⁴ In multiple-forest applications, the appropriate \overline{SV}_h are gathered separately for each forest involved (table 4).

⁴For comparison, in the “new forest” approach \overline{SV}_h^* was calculated by using data gathered only from within the AOI.

Table 3—Example average number of site visits within nonproxy strata applied to the area of interest

Site type ^a	Use level	Average number of site visits
DUDS	High	236.1
	Medium	85.8
	Low	47.6
OUDS	High	41.3
	Medium	32.7
	Low	10.7
GFA	High	187.7
	Medium	54.9
	Low	11.1
Wilderness	High	85.3
	Medium	31.6
	Low	13.6

^aDUDS = day use developed sites, OUDS = overnight use developed sites, GFA = general forest area, and wilderness = designated wilderness.

Table 4—Example average number of site visits within nonproxy strata for a multiple-forest area of interest

Site type ^a	Use level	Forest A	Forest B
DUDS	High	<i>b</i>	53.7
	Medium	187.1	42.5
	Low	35.5	11.5
OUDS	High	41.3	<i>b</i>
	Medium	32.7	<i>b</i>
	Low	10.7	<i>b</i>
GFA	High	61.2	<i>b</i>
	Medium	46.5	45.5
	Low	5.5	24.2
Wilderness	High	85.3	<i>b</i>
	Medium	67.3	<i>b</i>
	Low	30	13.6

^aDUDS = day use developed sites, OUDS = overnight use developed sites, GFA = general forest area, and wilderness = designated wilderness.

^bNo site days exist within the area of interest on this national forest.

In single forest applications, equation 1 is used to compute the total number of site visits in nonproxy stratum h (SV_h^*) of the AOI. This calculation uses the average site visit estimate for stratum h (\overline{SV}_h) (as estimated for the whole forest) and the known number of site days in stratum h occurring in the AOI (N_h^*).

An estimate of the total number of site visits for all nonproxy sites can be computed as

$$TOTALSV_{NP}^* = \sum_{h=1}^H N_h^* \overline{SV}_h ,$$

with variance

$$V(TOTALSV_{NP}^*) = \sum_{h=1}^H N_h^{*2} V(\overline{SV}_h) ,$$

where $V(\overline{SV}_h)$ is obtained from the forest strata sampling results and H is the total number of nonproxy strata in the AOI.

In multiple-forest applications, the total number of site visits for nonproxy AOI stratum h (SV_h^*) is calculated as

$$SV_h^* = \sum_{f=1}^F N_{hf}^* \overline{SV}_{hf} , \quad [5]$$

where N_{hf}^* is the number of site days in stratum h of forest f , \overline{SV}_{hf} is the average site visit estimate per sample day in stratum h estimated for all of forest f , and F is the total number of forests in the AOI. The total number of site visits for nonproxy sites (in the multiple-forest application) is computed as

$$TOTALSV_{NP}^* = \sum_{h=1}^H \sum_{f=1}^F N_{hf}^* \overline{SV}_{hf} ,$$

with variance

$$V(TOTALSV_{NP}^*) = \sum_{h=1}^H \sum_{f=1}^F N_{hf}^{*2} V(\overline{SV}_{hf}) ,$$

where H is the total number of strata within the AOI, $V(\overline{SV}_{hf})$ is obtained from the forest strata sampling results for forest f , and all other variables are as defined previously.

Calculating Site Visits Within the AOI for Proxy Strata

Site visit estimates for proxy sites within the AOI are estimated by using (1) the “compliance-based proxy count” for each proxy site k in stratum h (PC_{hk}), (2) the number of site days for proxy site k in stratum h (N_{hk}), and (3) the conversion factor

for proxy stratum h (\bar{A}_h) as estimated from proxy sites in stratum h both within and outside the AOI and reported in the proxy data. PC_{hk} and \bar{A}_h are available as part of the proxy data contained within the NRIS HD-NVUM application. Items 1 and 2 are used to calculate the average daily proxy count (\overline{PC}_h^*) for a given proxy stratum h by using equation 2.

Using the average daily proxy count \overline{PC}_h^* and the proxy conversion factor \bar{A}_h , the average site visit estimate for proxy stratum h (\overline{SV}_h^*) can then be computed by employing equation 3. As with nonproxy sites, in single-forest applications, the total number of site visits for proxy stratum h (SV_h^*) is computed by multiplying the average site visits for proxy stratum h (\overline{SV}_h^*) by the number of site days in proxy stratum h within the AOI (N_h^*) (equation 1).

An estimator for the total number of site visits at proxy sites in the AOI is

$$TOTALSV_P^* = \sum_{h=1}^H N_h^* \bar{A}_h \overline{PC}_h^* .$$

The variance is

$$V(TOTALSV_P^*) = \sum_{h=1}^H N_h^{*2} \overline{PC}_h^{*2} V(\bar{A}_h) ,$$

where $V(\bar{A}_h)$ is based on the ratio of means as described previously.

In multiple-forest applications, the total number of site visits for proxy strata h in the AOI (SV_h^*) is calculated by using equation 5 and the \overline{SV}_{hf} values for the respective forests.⁵ An estimate of the total number of site visits for the proxy sites in the multiple-forest AOI is then calculated as

$$TOTALSV_P^* = \sum_{h=1}^H \sum_{f=1}^F N_{hf}^* \bar{A}_{hf} \overline{PC}_{hf}^* ,$$

where N_{hf}^* , \bar{A}_{hf} , and \overline{PC}_{hf}^* are as defined previously and determined for the respective forest f . The variance of the total site visit for proxy sites is then calculated as

$$V(TOTALSV_P^*) = \sum_{h=1}^H \sum_{f=1}^F N_{hf}^{*2} \overline{PC}_{hf}^{*2} V(\bar{A}_{hf}) ,$$

where all variable are as defined previously.

⁵If proxy strata occur on only one forest in a multiple-forest application, the “single-forest application” calculations can be followed rather than the multiple-forest calculations.

Calculating the Total Number of Site Visits Within the AOI

The total number of site visits within the AOI is

$$TOTALSV^* = TOTALSV_{NP}^* + TOTALSV_P^* ,$$

with variance calculated as

$$V(TOTALSV^*) = V(TOTALSV_{NP}^*) + V(TOTALSV_P^*) .$$

Calculating AOI Visits for Both Nonproxy and Proxy Strata

The AOI visits for proxy and nonproxy strata are calculated by using the same formulas and are presented together. We present formulas for the multiple-forest application, as the single-forest application is simply a special case.

First, the average number of national forest visits within each nonproxy and proxy stratum h (\overline{NFV}_{hf}) is computed separately for each forest f as

$$\overline{NFV}_{hf} = \overline{SV}_{hf} \times \frac{1}{\overline{NS}_{hf}} ,$$

where \overline{SV}_{hf} is the average number of site visits in stratum h within forest f . \overline{NS}_{hf} is the average number of sites visited per national forest visit in stratum h within forest f and is computed as the arithmetic mean

$$\overline{NS}_{hf} = \frac{\sum_{j=1}^J NS_{hjf}}{J_{hf}} ,$$

where NS_{hjf} is the number of sites visited as reported by individual j in stratum h within forest f . Reported recreation in the GFA or wilderness during the visit (i.e., days in the GFA > 0, days in wilderness > 0) is counted as one site visit for that site type regardless of the number of days in the GFA or wilderness. J_{hf} is the number of individuals sampled within stratum h of forest f . The total number of AOI visits for nonproxy strata h (NFV_h^*) is computed as

$$NFV_h^* = \sum_{f=1}^F N_{hf}^* \overline{NFV}_{hf} ,$$

where N_{hf}^* is the number of site days in stratum h of forest f within the AOI and F is the total number of forests within the AOI.

An estimate of the total number of AOI visits calculated for either proxy ($TOTALAOI_p^*$) or nonproxy strata ($TOTALAOI_{NP}^*$) is

$$TOTALAOI^* = \sum_{h=1}^H \sum_{f=1}^F N_{hf}^* \overline{NFV}_{hf}$$

with variance

$$V(TOTALAOI^*) = \sum_{h=1}^H \sum_{f=1}^F N_{hf}^{*2} V(\overline{NFV}_{hf}) ,$$

where $V(\overline{NFV}_{hf})$ is the variance of \overline{NFV}_{hf} and is calculated in the usual manner and all variables are as defined previously.

Calculating the Total Number of Visits to the AOI

An estimate of the total number of AOI visits for proxy and nonproxy strata combined is

$$TOTALAOI^* = TOTALAOI_{NP}^* + TOTALAOI_p^*$$

with variance

$$V(TOTALAOI^*) = V(TOTALAOI_{NP}^*) + V(TOTALAOI_p^*) .$$

Multiple Forest AOI Visit Adjustment

The NVUM visitor survey respondents complete the questionnaire in regard to the current visit they are completing to the national forest on which they were sampled. When completing the questionnaire, respondents report the number of sites visited and recreation in the GFA and wilderness that occurred during the current national forest visit. This information is used to determine the number of site visits occurring per national forest visit. Respondents do not report visits to sites, GFA recreation use, or wilderness recreation use on adjacent national forests that may have occurred during the respondent's current recreation trip. Because the borders within the AOI between the multiple forests now represent internal divisions that are being assumed away, visits to the AOI that include unreported site visits, GFA recreation use, or wilderness recreation use on land within the AOI managed by another forest during the same trip will yield an inflated AOI visit estimate. To correct for this, the final AOI visit estimate should be divided by the mean number of forests visited during an AOI visit (this mean should be greater than or equal to 1.0). These data are not available in the NVUM data, and thus local information and analyst judgment must be used to determine the appropriate value

When completing the questionnaire, respondents report the number of sites visited and recreation in the GFA and wilderness that occurred during the current national forest visit.

for the adjustment. Note that the potential overestimation of AOI visits owing to unreported site visits and GFA recreation on other AOI forests may be offset by a potential underestimation of AOI visits resulting from the assumption that all reported site visits and GFA recreation use occurred within the AOI (when it may have in fact occurred outside the AOI). In some cases, it may be best to assume that these balance and no multiple-forest AOI visit adjustment be taken.

If a site day adjustment for duplicate interview locations has already been taken, a multiple-forest AOI visit adjustment does not need to be adopted for that portion of recreation use associated with the duplicate interview locations, as it has already been accounted for by ensuring that the site days are counted only once. The remaining recreation use not associated with the duplicate interview locations is still subject to the multiple-forest AOI visit adjustment.

Summary

Currently, NVUM-based recreation visitation estimates are reported at the national, regional, and forest levels. In this research note, we have described two approaches for estimating recreation use within large subforest areas by using NVUM data. These subforest areas may fall within a single forest or within multiple forests. The two approaches differ in data requirements, complexity of estimation, and assumptions required. The new forest approach requires access to more of the NVUM data and is more analytically complex than the all-forest information approach. Although the all-forest information approach requires less data and is less complex, it requires the assumption that recreation-use patterns within the area of interest are similar to those found on the forest in general, within strata. Regardless of the approach adopted, analysts are strongly encouraged to coordinate their area-specific recreation use estimation with national-level NVUM personnel.

Glossary

daily summary data—These data, available in the Natural Resources Information System Human Dimensions-National Visitor Use Monitoring (NRIS HD-NVUM) application and from NVUM national-level personnel, identify the calculated traffic count, number of visitor contacts, and number of last-exiting visitor interviews for each sample day.

forest strata sampling results—Data available in the NRIS HD-NVUM application and from national-level NVUM personnel that identify the average number of site visits, number of visitor contacts, and the number of last-exiting visitor interviews, by strata.

interview location—A location where NVUM sampling could occur, identified and classified into one of the four site types by local forest personnel.

last-exiting recreation traffic—Vehicles or visitors leaving the site or general forest area for the last time during the current visit.

last-exiting visitor survey data—Data from NVUM questionnaires completed by individuals contacted during sample days at NVUM interview locations who were recreating on the national forest and who were exiting the site or general forest area for the last time that day.

national forest visit—One person entering and exiting a national forest for the purpose of recreation (English et al. 2002).

prework data—Information developed by forest personnel in preparation for NVUM sampling and available to a limited extent in the NRIS HD-NVUM application. These data include the identification of NVUM interview locations and the classification of those locations by site type and use levels for every day of the year. This classification yields the sampling frame, which is used to develop the sample calendar. Analysts are urged to contact forest-level personnel who completed the prework.

proxy data—Available in the NRIS HD-NVUM application and from NVUM national-level personnel, these data include the forest-reported proxy count, the number of site days at the proxy site, the compliance-adjusted proxy count, and the conversion factor to adjust the proxy count to number of site visits.

proxy sites—Recreation sites or areas where some other information (e.g., permits, fee envelopes, ski lift tickets, etc.) exists that can be used to quantify the amount of recreation visitation. The type of “other information” (i.e., fee envelopes, permits, etc.) determines the “proxy type” of the interview site.

sample day—An interview location and date selected by stratified random sample when NVUM sampling occurs.

site days—The population of all possible interview locations and days on a national forest.

site type—One of four types of recreation sites as defined for NVUM sampling: day use developed sites (DUDS), overnight use developed sites (OUDS), general forest area (GFA), designated wilderness (wilderness).

site visit—One person entering and exiting a recreation site or area on a national forest for the purpose of recreation (English et al. 2002).

strata—The combination of site type and use level (e.g., DUDS-high, OUDS-low, etc.) for nonproxy sites or the combination of site type and proxy type (e.g., OUDS-fee envelope, DUDS-ticket) for proxy sites.

use level—The expected level of last-exiting recreation traffic at a given interview location on a given day as identified by local forest personnel in the prework. Four use levels were recognized in NVUM round 1: high, medium, low, and closed. In NVUM round 2, a fifth use level, very high, was also included.

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