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Visitor Sample Surveys

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ABSTRACT

This paper discusses the design of visitor surveys. To illustrate, two recent surveys are described. The first is a survey of visitors to National Park Service areas nationwide throughout the year (1992). The second is a survey of recreational users of the three-river basin around Pittsburgh, Pennsylvania, during a twelve-month period. Both surveys involved sampling in time with temporal as well as spatial stratification. Sampling units had the form of site-period pairs for the stage before the final, visitor sampling stage. Random assignment of sample sites to periods permits the computation of unbiased estimates for the temporal strata (*e.g.*, monthly and seasonal estimates) as well as estimates for strata defined by region and by type of use.

KEY WORDS: Recreational user; Sampling in time; Site-period.

1. INTRODUCTION

Surveys of visitors present unique challenges that are rarely discussed in the statistical literature. This paper attempts to fill this gap by describing the design and emphasizing the common features of two surveys recently conducted by the Research Triangle Institute (RTI). We hope that the lessons learned in these efforts will be beneficial to researchers planning similar surveys.

The first survey was a study of visitors to National Park Service (NPS) areas jointly conducted for the National Park Service by RTI and HBRS, Inc. This study involved a probability sample of park visitors that represented visitors to 323 NPS areas nationwide (except Alaska) throughout the year (1992). We will refer to NPS areas as parks for simplicity while pointing out that the NPS areas include locations of historical and cultural parks. The main objective of the NPS study was to assess the visitors' experiences and problems with particular attention to those related to aircraft overflights (*e.g.*, noise and other possible annoyances). A variety of data were also collected in a mail survey for a subsample of selected visitors.

The second survey was a study of recreational users of the Pittsburgh-area three-river basin along the Monongahela, Allegheny and Ohio Rivers in 1992 (or more precisely, between February 1992 and January 1993). This survey was jointly conducted for the Ohio River Valley Sanitation Commission by RTI and Terrestrial Environmental Specialists. The study area included a 40-mile segment of the Ohio River, a 24-mile segment of Monongahela River and a 7-mile segment of the Allegheny River. The primary objective of the Three-River Study was to construct a baseline profile of recreationists in the area and to model the economic value they assign to various activities. Three basic types of recreational activities were distinguished: boating, fishing and park use.

The Three-River Study is the most comprehensive of a series of studies conducted by RTI to assess environmental impact in a number of states. These studies estimate possible reductions in economic or recreational value assigned by actual and potential recreational users to areas that have been or might be affected. While a wider survey of potential users of such areas may consider a telephone sample design, a visitor intercept survey design is found necessary to capture users at a point in time close to actual use.

A discussion of design issues in visitor surveys such as these has been recently provided in Kalton (1991) including issues related to sampling in time and space that are crucial in our framework. In its simplest form, a prototype, two-stage sample design for a visitor survey considers site-period pairs as primary sampling units (PSUs) from which visitors are selected in the second stage. Examples include exit polls (see, for example, Levy 1983), shopping mall intercept surveys (see, for example Sudman 1980) and other transportation and traffic surveys (Gough and Ghangurde 1977; Kish, Lovejoy and Rackow 1961). Among the design issues salient in visitor surveys, the following general problems may be singled out:

- It is desirable to select with greater probabilities those site-periods with larger numbers of visitors; stratification and PPS selection are then effective design features.
- Data collection arguments are key for the specification of the period length and of sampling rates within site-periods; *e.g.*, trade-offs occur between the potential for the field staff to be too busy (short periods, high sampling rates) or not busy enough (long periods, low sampling rates).
- Analytic objectives as well as efficiency suggest temporal stratification dimensions as season, month, weekend versus weekday, and even time-of-day; *e.g.*, the need for seasonal estimates suggests the use of seasons or months as strata for the selection of periods.

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The two surveys discussed in this paper share the primary objective of characterizing the visitor population in the area or the nation over an entire year. They differ, however, in the priority estimates that lead to the basic design features in each case. In the Three-River Study but not in the NPS study, reasonably precise monthly estimates needed to be computed. For the former study, then, the temporal sampling units - days - were stratified into months. Spatial stratification of the Three-River Study sites was geographic and by recreation type (boating, fishing or park sites).

For the NPS study, primary stratification was by park type. Some park areas needed to be included with certainty into the sample to satisfy legislative requirements. In these and other selected parks, it was further desired to compute park-specific estimates. In these park areas, labelled intensive parks, we then decided to select relatively more site-periods. The initial design optimization problem was how to allocate the sample size to the sampling stages, *i.e.*, to decide how many parks and how many site-periods per park should be selected. Section 3 discusses a solution for this problem which is a function of the intracluster correlations within parks and within periods. The design optimization for the NPS survey also applied to the temporal and spatial strata at the intermediate sampling stages, between park areas at the first stage and site-periods at the penultimate stage (keeping in mind that visitors are selected at the final stage).

These two surveys illustrate issues such as temporal stratification, the choice of appropriate sampling units, and random assignment of spatial units to temporal units. Section 2 outlines the common aspects of the two studies as well as their basic differences. Sections 3 and 4 describe the design of the NPS Visitor Survey and of the Three-River Study, respectively. Section 5 discusses the weighting procedures used for the surveys. A brief overview and some conclusions are presented in Section 6.

2. OVERVIEW OF SAMPLE DESIGNS: PARALLELS AND CONTRASTS

For both surveys, the ultimate visitor samples were selected via intercept sampling as visitors left the sample locations at the selected time periods. Exit interviews were necessary to reflect their attitudes immediately following their recreational experiences. Also, in both studies, visitors were selected from sample site-period pairs. The use of site-period pairs as sampling units dates back to Kish, Lovejoy and Rackow (1961). This sampling unit definition permits the selection of visitors according to a data collection schedule that specifies which sites will be covered at which points in time. Unlike the Three-River Study, the selection of site periods was not the first stage for the NPS Study. The primary sampling units (PSUs) for this study were NPS areas, or parks. The NPS survey involved several stages of selection described in the next section.

Additionally, both studies used temporal frames of days, and eligible data collection periods within days, to permit inferences about the entire year. The designs included the selection of time periods so that each eligible period has a known, positive probability of selection. Although both studies involved temporal frames, the structure of the frames and selection of days for each study were quite different.

For example, the sample for the Three-River Study was selected as twelve independent monthly samples. Each monthly sample has essentially the same, stratified random sampling design but a different sample allocation and different sample sizes were used in different months. This design took into account seasonal variations in recreational patterns, and enabled estimation for each month and stratum (*e.g.*, by type: boating, fishing or park). Both spatial and temporal frames were allowed to vary from month to month. The stratification and allocation for this sample are discussed in Section 4.

In contrast, the temporal frame for the NPS visitor survey first considered two-month blocks for each sample park (PSU). The use of two-month periods as (second-stage) sampling units in time efficiently met the survey objectives for two basic reasons. First, it allows the effective (geographic) concentration of staffing resources and staggered data collection throughout the year. Second, this choice of period permitted capturing seasonal fluctuations in park visitation across the park system, resulting from some parks having relatively higher visitation in the spring, others in the fall months, and so on.

One two-month block was selected for each sample park so that data collection could be effectively concentrated in time. Then, at the next stage of temporal selection, days were selected from within the two-month block for each sample park. Like the parks themselves at the first stage, these two-month blocks were selected with probabilities proportional to size (PPS), with the size measure being the aggregate visitation.

The sample sizes and allocation to the several sampling stages were carefully balanced to minimize clustering effects associated to clusters in time and space. For the Three-River Study, this clustering occurs at the first stage of selection where sampling units are sites and time periods. The allocation also considered the varying sample sizes used in successive, independent monthly samples. For the NPS survey, clusters in time were a result of the two-month blocks and sample days periods selected at different stages. Spatial clusters resulted from the use of parks and park exits as sampling units for this survey.

The next section describes in more detail the design of the NPS survey.

3. NPS SURVEY SAMPLE DESIGN

The design of NPS visitor survey capitalized on auxiliary information of various kinds and sources:

- Information obtained in previous studies (*e.g.*, park rankings based on noise exposure and NPS staff classifications).
- Information available in NPS data bases (*e.g.*, park visitation data by month).
- Information collected from NPS staff specifically for design purposes (*e.g.*, an inventory of the park exits for each sample park and number of vehicles leaving each of the exits).

The next subsections describe the various stages of selection for the visitor intercept survey. This survey component will also be designated the frontcountry survey to distinguish it from a survey of backcountry users that was conducted in tandem in the sample parks. Subsection 3.5 describes the backcountry survey as well as a mail survey administered to a subsample of frontcountry respondents and to sample backcountry users.

The fourth-stage selection for the mail survey involved additional stages (and phases) of selection. For the visitor intercept survey, groups (*i.e.*, vehicles) were selected as an ultimate cluster: all persons in a sample group were solicited for an interview. For the mail survey, groups were subsampled, and one person was subsampled from each subsampled group.

3.1 Frame Construction and First-Stage Sampling

We constructed a sampling frame for the selection of parks by compiling NPS information on park visitation (monthly and annual) and on noise exposure, information that was used in the sample design in two distinct ways: for stratification and for assigning size measures. The latter information was based on two different sources: (a) a previous NPS study which ranked parks according to potential exposure, and (b) a classification of parks performed independently by NPS staff (park superintendents, regional staff *etc.*).

In consultation with NPS, RTI combined these two classifications for noise exposure to construct eleven strata. The stratification partitioned parks into categories - very high, high, low and very low. Strata were divided into two substrata using the rankings in the stratum. (Note that the "medium" stratum was not subdivided due to its small park count.)

In addition to noise exposure, these strata incorporate three classes of parks that deserve separate treatment: (1) urban and suburban park areas, (2) parks with missing data on visitation (needed for PPS selection), and (3) parks whose elongated shapes present unique problems of access and reduce the meaning of prior exposure assessments. These classes were sampled at a much lower rate than the other strata; the lowest sampling rate is in the urban stratum (1 in 79).

The certainty stratum included the seven parks that were mandated by legislation to be included in the study. In addition, it included those parks whose aggregate (annual) visitation rates were so large as to ensure selection into the first-stage sample. The 39 sample parks are listed in Exhibit 1; a 40th selected park (Grand Teton) was dropped from the sample for political reasons.

Design optimization calculations led to a first stage sample size of about 40 sample parks, yielding a total of 405 site-periods (or exit-days in this case) selected across intensive and non-intensive parks. As described in Section 3.3, 15 exit-days were selected in each of the three intensive parks, and 10 exit-days were selected in each of the 36 non-intensive parks in the sample. An accurate optimization would require variance components for the between-park and within-park variances. These variance components were approximated using data from a previous study as well as monthly visitation data available for all NPS areas.

3.2 Selection of Two-Month Blocks

While the selection of two-month blocks was with probability proportional to size (PPS), practical requirements were also taken into consideration.

First, training local park staff immediately before data collection was desired. Geographic clusters of parks were formed so that trainers could visit parks in one cluster in one trip. Specifically, the 39 sample parks were grouped into 14 such clusters. This requirement led to the selection of a two-month period for each park cluster. Thus, fourteen two-month blocks were selected, one for each cluster. The size measure used for each selection was the aggregate visitation over the parks in the cluster.

Exhibit 1 shows the sample parks in each cluster, and the sample two-month block selected for the cluster (*i.e.*, for every park in the cluster). Three strata - groups of clusters and hence of parks - were formed for the selection of two-month blocks:

(a) In the "very-high summer" stratum-1 (with 3 clusters), the frame of two-month blocks contained only the summer-peak period, July-August, which was then selected with certainty for these clusters;

(b) In the "high-summer" stratum-2 (with 7 clusters), the frame of two-month blocks contained 11 overlapping two-month blocks;

(c) In the "low-summer" stratum-3 (with 4 clusters), the frame of two-month blocks contained 5 non-overlapping two-month blocks.

The rationale for this temporal stratification was two-fold: it ensured that the data collection was spread throughout the year, and it distinguished parks where a vast majority of the visitation occurs during the summer from those with a more uniform visitation pattern.

Exhibit 1

Park Clusters, Second-stage Strata and Selected Two-month Blocks

	Selected Period
Stratum 1: Very High Summer*	
Cluster 2: Mount Rainier, N. Cascades, Olympic	July-August
Cluster 4: Glacier, Yellowstone	July-August
Cluster 10: Sleeping Bear, Perry's Victory	July-August
Stratum 2: High Summer	
Cluster 3: Lassen, Yosemite, Kings Canyon/Sequoia	August-September
Cluster 5: Dinosaur, Rocky Mtn., Mt. Rushmore	June-July
Cluster 6: Glen Canyon, Grand Canyon, Walnut Canyon	June-July
Cluster 8: Bandelier, Lake Meredith	May-June
Cluster 11: Cape Cod, Delaware Gap, Gettysburg	August-September
Cluster 12: Shenandoah, Fredericksburg, Assateague	June-July
Cluster 13: Great Smoky, Cape Hatteras, Fort Sumter	June-July
Stratum 3: Low Summer	
Cluster 1: Haleakala, Hawaii Volcanoes	March-April
Cluster 7: Lake Mead, Saguaro, Casa Grande	March-April
Cluster 9: Hot Springs, Wilson's Creek, Buffalo	October-November
Cluster 14: Cumberland Isd., Canaveral, Everglades, Gulf Island	March-April

*Certainty selection of July-August for each cluster in this stratum.

We selected two-month blocks with different procedures in the two strata as described below.

(1) For park clusters in the former (high-summer) stratum, eleven overlapping periods were included in the temporal frame; January-February, February-March, . . . , November-December. One such period was then selected with probability proportional to size (PPS). Note that for this stratum each month was included in two frame periods except for January and December. The probability of selection for these two winter months was thus reduced even further (beyond the already small probability assigned to the winter periods with the PPS procedure).

(2) For park clusters in the latter (low-summer) stratum, five non-overlapping two-month periods constituted the temporal frame: January-February, March-April, May-June, September-October, November-December. Note that the two-month summer period, July-August, was excluded from the frame for these parks to ensure the selection of other, non-summer months. For each cluster in this stratum, one of these five two-month periods was selected with PPS.

3.3 Third-stage Sampling

Sampling units at the third stage were exit-day pairs. The third-stage sampling is easier to envisage as the combination of two independent selections: (a) selecting days from the temporal window (2-month block) drawn at the second stage for the park, and (b) selecting exits from a list of exits specified for the park. A final step consisted of the random assignment of sample days to sample exits.

The sample of days was stratified by weekdays versus weekend days (including major holidays). Sample days were selected with equal probabilities within each of these two strata. The sample of exits was selected with probabilities proportional to size (PPS). The size measure assigned to each exit was the relative use of the exit among all the exits listed for the selected park. This usage measure was derived with the aid of local park staff.

The third-stage sample design distinguished two groups of parks designated as intensive (3 parks: Grand Canyon and the two Hawaii parks) and non-intensive (36 remaining parks in the sample). Sample sizes in non-intensive parks were 10 exits and 10 days, and hence 10 exit-day pairs. In the three intensive parks, 15 exits and 15 days were selected. Equal allocation to weekend/weekday strata was used in non-intensive parks: 5 weekend days and 5 weekdays were independently selected in each of these (36) sample parks. The allocation was approximately equal in intensive parks with the selection of 7 weekend days and 8 weekdays.

3.4 Fourth-stage Sampling

At the fourth stage, park visitors were intercepted in the selected exit-days. A systematic random sample of visitors or (visitor groups) exiting the park was selected with a fixed sampling interval for each selected third-stage unit (exit-day). The interval was allowed to vary from day to day to capitalize on the experience of previous days and on the variability in visitation across days and exits. Each visitor found in the selected eligible groups was screened for eligibility, and interviewed if eligible (adult visitor).

3.5 Backcountry and Mail Surveys

The same sample of parks (PSUs) was used for a mail survey of frontcountry and backcountry users in the two-month period selected for the park. The sample for the backcountry survey was restricted to the subset of sample parks with some backcountry use. Within each such sample park, the (third-stage) sampling frame for this survey component was based on backcountry permits issued during the data collection time window (two-month block) established for the park. The ultimate sample of backcountry users was then selected with equal probabilities from permit lists provided by park staff. A subsample of visitors selected in the intercept survey were also selected for the mail survey.

The mail survey sample was based on the same third-stage sample of exit-days selected for the intercept survey. For each selected exit-day, a fixed number of groups was subsampled from groups responding to the intercept survey (this number was 15 in intensive parks and 10 in non-intensive parks). A further stage of subsampling was that of one person from within the respondents in each group subsampled. This subsampling of groups and persons was with stratified random sampling to control the demographic composition of the final sample.

4. SAMPLE DESIGN FOR THREE-RIVER SURVEY

4.1 Frame Construction and Stratification

First, RTI and Terrestrial Environment Specialists (TES) constructed a sampling frame based on an inventory of all sites in the Three-River Study area. Then a stratified multistage sample was selected independently for each of the twelve months of the study. First-stage sampling units were site-periods, and second-stage units were individuals engaged in recreation in the selected site-periods. Temporal and spatial stratification were used for the first-stage sampling of time periods and sites.

Primary stratification along the temporal dimension was by month, and primary stratification of sites was by use type: sites (access points) were classified as boating, fishing, or parks. Each primary stratum was divided into six geographic areas, or pools, defined as the river areas between locks. The fishing stratum was further substratified by the presumed use intensity as low or high use: high-use sites are those below locks and dams.

Each monthly sample of site periods was selected with stratified random sampling. Advantages of selecting independent monthly samples included: monthly and seasonal estimates can be computed, and some design features may be changed from month to month.

For example, this design permitted altering the spatial frame from one month to the next with the addition or deletion of sites. In particular, the boating stratum for the winter months (November through April) was restricted to boat ramps open that season. Further, several fishing sites included in the frame for the first few months were found inaccessible and deleted from the frame for the subsequent monthly samples.

Other design features that changed in successive months include: the second-stage sampling rates for selecting eligible users, and the data collection windows used in the morning, afternoon and evening periods for sites of each type. Varying data collection windows were used in different months of the study. These periods were defined using sunrise and sunset information as well as expected patterns of use of the various types. The winter months (November-April) included two periods per day while the summer months (May-October) included three periods per day.

The temporal (sub)stratification of each monthly sample was by weekend days versus weekdays. It is worth noting that the weekend stratum also included major holidays.

4.2 Sample Selection

As noted above, we selected an independent first-stage sample of site-periods for each of the 12 months of the study. Each monthly sample had two components: (a) a stratified random sample of "n" sites, and (b) a stratified random sample of "n" periods.

Following selection of the sample periods for each month, the sample sites were randomly assigned to the selected periods. The assignment of sites to periods was entirely at random for the months of February through June but was modified in subsequent months. From July on, a sample of time periods was independently selected for each type stratum with the random assignment taking place within stratum. The allocation of the sample time periods (*e.g.*, the number of morning periods and the number of evening periods included in the sample) varied from stratum to stratum. With this more flexible method, relatively more fishing sites could be assigned to morning period and more boating sites to afternoon periods, for example. Exhibit 2 shows the sample sizes - sites and periods - used in random assignment each month.

Exhibit 2

Sample Sizes Used in Random Assignment of Sites to Periods for each Monthly Sample of Three-River Study

Month	Overall*	Sample Size		Parks	Marinas	Regattas	
		Boating	Fishing			Boating	Marinas
1		8	12	4			
2	20						
3	28						
4	28						
5	36						
6	36						
7		17	22	6	12		
8		10	22	6	6	6+	6+
9		10	14	6	6		
10		10	12	4			
11		8	12	4			
12		8	12	4			

* For these (5) months, the assignment took place for the entire collection of sample sites and periods (NOT blocked by site type). For the remaining months the assignment was within each type stratum, a process which involved the selection of independent samples of time periods for each type.

\+ In August, the assignment of regatta sites to periods was performed first, separately. Following the assignment, the sample site-periods associated with regattas were shifted either to the boating or to the marina strata depending on the site type.

Second-stage sampling rates were specified for each of the three primary strata prior to each month of data collection. These stratum-specific rates were determined based on the experience of the previous months, and were distributed to the field interviewers along with the month's data collection schedule. Individuals were selected with systematic random sampling within each site-period.

4.3 Marina Survey and Special Events

A marina survey was conducted in the months of June to September. A sampling frame of 48 marinas was based on the TES inventory that was updated in late May 1992.

The sampling method for the phase-in month of June differed slightly from that used for the subsequent monthly samples for marina sites. The June sample was a supplement of 12 marina sites coupled with a sample of 12 days. The marina samples for the months of July to September were selected considering the marina frame as a fourth stratum. The selection procedures were then similar to those in the other three type strata; specifically, (a) a sample of "*n*" marina sites was selected, (b) a sample of "*n*" time periods was selected, and (c) the sample sites were randomly assigned to the selected periods.

It is worth pointing out that some of the marina sites were also included in the boating stratum. In such cases, two distinct frame units were created for the same site. This situation also arose for some sites used for both boating and fishing, and such sites were included in both strata.

In addition to the marina survey, we identified special events taking place in the study area over the 12-month study period. Most of these events were handled in a way similar to weekends and holidays by assigning them to a stratum to be oversampled. A special category of interest was comprised of the regattas occurring in the summer months. For two monthly samples (July and August), we identified the regatta dates as well as the sites affected by each regatta. We then constructed a separate (fifth) stratum to include these site-periods. The first-stage sample allocation to the regatta stratum reflected the oversampling desired for this stratum. As shown in Exhibit 2, the sampling procedure used to select site-periods (first-stage units) from the regatta stratum also differed to that used in the other four strata. Sample site-periods were directly selected in one step from the subset of site-periods in the stratum, *i.e.*, no random assignment was needed.

5. SURVEY WEIGHTING

5.1 NPS Survey Weighting

Sampling weights were first computed for each of the first three stages of selection. The first-stage sampling weight for each sample park was the reciprocal of the selection probability for the park. The second-stage sampling weight for each sample two-month block was similarly computed. The sum of the first-stage sampling weights overall (or in a stratum) was the number of parks in the frame (or in a stratum).

Third-stage weights for sample exit-days were the product of two factors associated with the selection of days and exits. Note that for each selected park and two-month block, the sum of the former set of weights in a temporal stratum (weekend *vs.* weekdays) is the number of days in the stratum, and the sum of the latter set of weights is the number of exits listed in the park. These weights were adjusted for nonresponse which arose at the third stage because in a few parks, data collection did not take place in some selected exit-days. In a given park with this data collection shortcoming, the sum of the adjusted third-stage weights over the active exit-days was made equal to the sum of the sampling weights over all selected exit-days in the park.

Fourth-stage weights were computed at a group-level and at a person-level. Group-level weights are assigned to all participating groups in a sample exit-day, and have the same value for the groups in the same exit-day. Similarly, person-level weights are assigned to all persons intercepted in a sample exit-day. The fourth-stage sampling weights were computed as the reciprocal of the sampling rate specified for the sample exit-day. These weights were then adjusted for group and person-level nonresponse.

The mail survey sample was based on the same third-stage sample of exit-days selected for the intercept survey. For each selected exit-day in non-intensive parks, 10 groups were first selected with equal probabilities from among the participating groups; then, one person was subsampled from all intercept survey respondents in each selected group. A similar procedure was used in intensive parks with the exception that the number of selected groups per exit-day was 15 rather than 10.

The sampling weight for each mail survey record is the product of WTB = number of intercept respondents in the group, and WTA = number of participating groups/10 [non-intensive parks]. For intensive parks, the denominator of WTA is 15 rather than 10.

These weights were adjusted for mail survey nonresponse using exit-days (within park) as weighting classes. Thus, the sum of the adjusted weights for all respondents coming from the same exit-day is the same as the sum of the (unadjusted) weights for all persons intercepted in the exit-day.

For the backcountry survey, the sampling frame for each eligible park (in the subset of sample parks with backcountry use) was based on lists of permits issued during the data collection period: eligible permits were associated with exit dates in this period. A sample of 5 groups per day was selected within each park from the set of permits linked to that day. One person was subsampled from each group. The weight computation parallels that for the mail survey with

$$\text{WTBACK} = \text{BACKA}*\text{BACKB},$$

where for each day:

BACKA = (number of groups linked to the day)/5

BACKB = number of persons in group.

Analysis weights for the backcountry survey resulted from nonresponse adjustments made using days as weighting classes.

5.2 Three-River Survey Weighting

As each monthly sample of site-period units was selected, we computed sampling weights that reflected the selection probabilities for the site-period pairs. Initial weights were the product of two sets of weights computed for each monthly sample: (a) weights assigned to each site in the stratified random sample of sites of the given type (boating, fishing, marina and park), and (b) weights assigned to each period in the stratified random sample of periods. These weights were then inflated to take into account the random assignment of sample sites to periods (or vice-versa). Thus for each month, the sum of the site-period weights was equal to the number of site-period combinations in the frame.

The weight adjustment process started with the sampling weights associated with the selected site-days. An initial adjustment was made to the first-stage weights to account for site-periods that were found ineligible or that had missing sampling forms (*e.g.*, not sent by field staff). For this first-stage adjustment, we used the type-by-month strata as weighting classes. That is, the sum of the adjusted weights over the reduced set was made equal to the sum of the unadjusted weights over the entire sample within the type-by-month class. A final adjustment was made at the respondent-level to reflect (a) the systematic sampling interval used within site-periods, and (b) the survey non-response at the individual level.

As part of the weight check procedures, we computed the sum of the final analysis weights over the entire file, and also by month and by type of site. The weight sum should approximate the estimated total number of recreational users leaving the inventory sites during the data collection time window for each month and type of site.

6. CONCLUSION

This paper described the design of two surveys of recreational users that share a number of useful features. The sample designs include sampling in time as well as in space; site-periods are selected at the stage prior to sampling visitors. A spatial frame is then constructed side by side with a temporal frame. After sites are selected from the former and periods are selected from the latter frame, sample sites are randomly assigned to sample periods (or conversely). Sampling weights need to take into account this additional step of randomization. The findings of the NPS visitor survey are described in the study final report (National Park Service 1994). This analysis included a variety of regression models that investigate the impact of hearing and seeing aircraft flying over NPS areas.

Temporally, both studies represent periods throughout the year, that is, a user will have a positive probability of selection for any time of the year. Both studies also include temporal stratification to reflect patterns of use and increase sampling efficiency.

Spatially, while the sample for the National Park Service study was a national sample of visitors to NPS areas, the sample for the Three-River Study was more restricted in spatial scope. Both studies, however, distinguished users of different types. For the NPS study, backcountry and frontcountry users were selected in two separate (third-stage) strata at the point where the two components branch out with the selection of permits for the backcountry survey. For the Three-River Study, visitors were classified by primary fishing, boating, or park use, and sites were stratified in a similar way. This design permitted the computation of precise estimates by type and by season.

The ultimate sampling unit for a survey of recreational users is the specific visit; thus, visitors may have multiple chances of inclusion in the sample to the extent that they use the target areas multiple times. It is worth noting that this structure is consistent with the objectives of such surveys.

Sampling weights accounted for the selection of time and space units at each stage and also for the random assignment step. The samples were designed to minimize the effects of unequal weighting on survey variances. The potential for severe unequal weighting effects was considered in combining different survey components. Examples in the two surveys include combining:

(a) Backcountry and frontcountry components of NPS mail survey, and

(b) Fishing, boating and park users in the Three-River Study.

Some disadvantages of this type of study design should also be pointed out. While sampling in time and random assignment introduce an element of statistical rigor and extend the range of valid statistical inferences, the methodology may be disrupted if field interviewers change the date assigned for a sample location because access may be difficult in the specified period or for other reasons. Noteworthy examples in the NPS study included hurricanes, park closed due to fugitives from justice, space shuttle launches, and severe snowstorms. While some of these occurrences may be minimized with the temporal stratification and allocation, others are clearly beyond the control of the statistician. However, the sampling statistician should be involved in interviewer training to stress that modifications in the sample schedule should be avoided at all costs, and should monitor any changes that do occur.

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