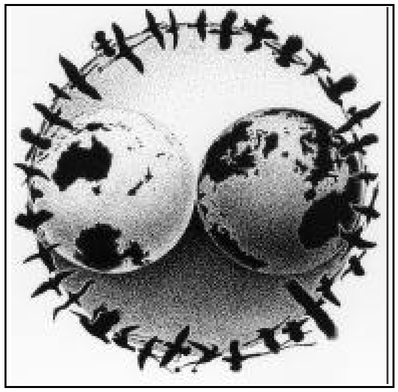

Monitoring Avian Productivity and Survivorship (MAPS) In Denali National Park

A Handbook of the Field and Analytical Techniques Needed to Monitor
Primary Demographic Parameters of Landbirds

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PREFACE AND ACKNOWLEDGMENTS

This is a handbook for monitoring primary demographic parameters, including productivity (birth rate) and survivorship (death rate), of landbirds in national parks through the Monitoring Avian Productivity and Survivorship (MAPS) Program. The field and analytical protocols described in this handbook were tested in Denali National Park and Preserve during the five years 1992-1996.

MAPS utilizes constant-effort mist netting and banding at multiple stations within a national park to provide:

(a) annual indices of adult population size and post-fledging productivity for each of the stations (or for all or various subgroups of the stations pooled) from data on the numbers and proportions of young and adult birds captured; and

(b) annual estimates of adult survivorship, adult population size, and recruitment into the adult population from modified Cormack-Jolly-Seber CJS) mark-recapture analyses of data on the adult birds captured at all stations pooled.

This handbook consists of three major Parts:

I. The MAPS Program in Denali National Park (IBP Contribution No. 82), which provides an introduction to the MAPS Program, a summary of its goals and objectives, a description of the experimental design and manner in which stations are to be sited in a national park, and the specifics of the design of the MAPS Program in Denali National Park and Preserve;

II. The MAPS Manual (IBP Contribution No. 25), which provides detailed instructions for the operation of MAPS stations; and

III. The MAPS Analytical Manual (IBP Contribution No. 61), which provides detailed instructions for: (a) the computerization, verification, and editing of MAPS data; includes MAPSPROG Version 2.0: User's Guide and Manual (IBP Contribution No. 106); (b) the preparation of MAPS data for analysis; and (c) the analytical techniques used to analyze MAPS data.

A draft version of the handbook was submitted to the Alaska Science Center, Biological Resources Division of the U.S. Geological Survey, January 28, 1997, and was sent out for peer-review. We deeply appreciate the critical and constructive comments received from the three anonymous reviewers of the draft handbook. We thank Daniel K. Rosenberg, Peter Paton, Tom Pogson, and the Alaska Bird Observatory for assistance, advice, and many helpful discussions regarding this work. We thank Dale L. Taylor, Lyman K. Thorsteinson, Karen Oakley, and William K. Seitz, at (or formerly at) USGS/BRD Alaska Biological Science Center, and Joe Van Horn, Pat Owen, and Gordon Olson at NPS Denali National Park for their kind assistance with all of the logistic and administrative aspects of operating the Denali MAPS stations and for their enthusiastic support of the program. Financial support for the Denali MAPS stations was provided by the National Park Service (Denali National Park and Preserve) during 1992-1993 and 1997 and by the National Biological Service (Alaska Biological Science Center) during 1994-1996, for which we are very grateful. We also thank Denali National Park for

providing housing for IBP field crews while they were at on-site at Denali National Park.

Part I

The MAPS Program in Denali National Park

An Introduction to and Description of the Monitoring Avian Productivity and Survivorship (MAPS) Program in Denali National Park and Preserve

David F. DeSante

The Institute for Bird Populations

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1. INTRODUCTION

The National Park Service (NPS) has been charged with the responsibility of managing natural resources on lands under its jurisdiction in a manner that conserves them unimpaired for future generations. In order to carry out this charge, the NPS intends to initiate an integrated long-term program for inventorying and monitoring the natural resources in national parks and other NPS units. A pilot study to develop and evaluate field and analytical techniques to accomplish these objectives has been implemented in several national parks across the United States; Denali National Park and Preserve has been selected as one of them. The goals of the pilot program in Denali National Park and Preserve are to develop quantitative sampling and analytical methods that can provide relatively complete inventories and long-term trends for many components of biological diversity, as well as effective means of monitoring the ecological processes driving the trends (Van Horn et al. 1992). An additional goal is that the methods evaluated at Denali be useful in other national parks in Alaska and, if possible, across the United States. The Denali component of this program is called the Long-term Ecological Monitoring Program.

The development of an effective long-term inventory and monitoring program in the national parks can be of even wider importance than aiding the NPS in managing its resources. Because lands managed by the NPS provide large areas of relatively pristine ecosystems that promise to be maintained in a relatively undisturbed manner indefinitely into the future, studies conducted in national parks can provide invaluable information for monitoring natural ecological processes and for evaluating the effects of large-scale, even global, environmental changes. The importance of the national parks for monitoring the environmental effects of global climate change and non-point-source pollution, for example, should not be underestimated. The national parks and other NPS units can also serve as critical control areas for monitoring the effects of relatively local land-use practices. Thus, long-term monitoring data from the national parks can provide information that is crucial for efforts to preserve natural resources and biodiversity on a continental or even global scale.

1.1. Landbirds

Landbirds, because of their high body temperature, rapid metabolism, and high ecological position on most food webs, may be excellent indicators of the effects of environmental change in terrestrial ecosystems (Temple and Wiens 1989). Furthermore, their abundance and diversity in virtually all terrestrial habitats, diurnal nature, discrete reproductive seasonality, and intermediate longevity facilitate the monitoring of their population and demographic parameters. It is not surprising, therefore, that landbirds have been selected by the NPS to receive high priority for monitoring because they may be sensitive indicators of regional and global environmental change. Nor is it surprising that several large-scale monitoring programs that provide annual population indices and long-term population trends for landbirds are already in place on this continent. They include the North American Breeding Bird Survey (BBS), the Breeding Bird Census and Winter Bird Population Study, and the Christmas Bird Count.

Recent analyses of data from several of these programs, particularly the BBS, suggest that populations of many landbirds, including forest-, scrubland-and grassland-inhabiting species, appear to be in serious decline (Peterjohn et al. 1995). Indeed, populations of most landbird species appear to be declining on a global basis. Nearctic-Neotropical migratory landbirds (species that breed in North America and winter in Central and South America and the West Indies; hereafter, Neotropical migratory birds) constitute one group for which pronounced population declines have been documented (Robbins et al. 1989, Terborgh 1989). In response to these declines, the Neotropical Migratory Bird Conservation Program, "Partners in Flight - Aves de las Americas", was initiated in 1991 (Finch and Stangel 1992). The major goal of Partners in Flight (PIF) is to reverse the declines in Neotropical migratory birds through a coordinated and cooperative program of monitoring, research, management, education, and international cooperation. As one of the major cooperating agencies in PIF, the NPS has defined its role in the program to include the establishment of long-term avian monitoring programs at NPS units using protocols developed by the Monitoring Working Group of PIF. Clearly, the long-term inventory and monitoring goals of the NPS and the monitoring and research goals of PIF share many common elements.

1.2. Primary Demographic Parameters

Existing population-trend data on Neotropical migrants, while suggesting severe and sometimes accelerating declines, provide no information on primary demographic parameters (productivity and survivorship) of these birds. Thus, population-trend data alone provide no means for determining at what point(s) in the life cycle problems are occurring, or to what extent the observed population trends are being driven by causal factors that affect birth rates or death rates or both (DeSante 1995). In particular, large-scale North American avian monitoring programs that provide only population-trend data have been unable to determine to what extent forest fragmentation and deforestation on the temperate breeding grounds versus that on the tropical wintering grounds are causes for declining populations of Neotropical migrants. Without critical data on productivity and survivorship, it will be extremely difficult to identify effective management and conservation actions to reverse current population declines (DeSante 1992).

The ability to monitor primary demographic parameters of target species must also be an important component of any successful long-term inventory and monitoring program that aims to monitor the ecological processes leading from environmental stressors to population responses (DeSante and Rosenberg in press). This is because environmental factors and management actions affect primary demographic parameters directly and these effects can be observed over a short time period (Temple and Wiens 1989). Because of the buffering effects of floater individuals and density-dependent responses of populations, there may be substantial timelags between changes in primary parameters and resulting changes in population size or density as measured by census or survey methods (DeSante and George 1994). Thus, a population could be in trouble long before this becomes evident from survey data. Moreover, because of the vagility of many animal species, especially birds, local variations in secondary parameters (e.g., population size or density) may be masked by recruitment from a wider region (George et al. 1992) or accentuated by lack of recruitment from a wider area (DeSante 1990).

1.3. MAPS

In 1989, The Institute for Bird Populations (IBP) established the Monitoring Avian Productivity and Survivorship (MAPS) program, a cooperative effort among public agencies, private organizations, and individual bird banders in North America to operate a continent-wide network of constant-effort mist-netting and banding stations to provide long-term demographic data on landbirds (DeSante et al 1995). The design of the MAPS program was patterned after the very successful British Constant Effort Sites (CES) Scheme that has been operated by the British Trust for Ornithology since 1981 (Baillie et al. 1986, Peach et al. 1996). The MAPS program was endorsed in 1991 by both the Monitoring Working Group of PIF and the USDI Bird Banding Laboratory, and a four-year pilot project (1992-1995) was approved and funded by the USDI Fish and Wildlife Service and National Biological Service (now the Biological Resources Division 〈BRD〉 of the U.S. Geological Survey 〈USGS 〉) to evaluate its utility and effectiveness for monitoring changes in demographic parameters of landbirds.

Now in its ninth year (sixth year of standardized protocols), the MAPS program has expanded considerably from 17 stations in 1989 to 38 in 1990, 66 in 1991, 178 in 1992, 236 in 1993, 326 in 1994, 391 in 1995, 413 in 1996, and about 450 stations in 1997. The substantial growth of the Program since 1992 was caused by its endorsement by PIF and the subsequent involvement of various federal agencies, including the NPS, USDA Forest Service, Department of Defense, Department of the Navy, and Texas Army National Guard, in PIF. Over the past six to eight years, for example, IBP was contracted to operate five or six MAPS stations each in Denali, Yosemite, and Shenandoah national parks, and two stations in Kings Canyon National Park. Among other reasons, MAPS stations were established in these parks in order to evaluate the usefulness of MAPS methodology as a major component of the NPS's Inventory and Monitoring Program.

1.4. Goals and Objectives of MAPS

The specific goals of the MAPS program are to provide, for a suite of target species including both Neotropical migrant and permanent resident species:

(1) annual indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured; and

(2) annual estimates of adult survivorship, adult population size, and recruitment into the adult population from mark-recapture data on adult birds.

These population and demographic indices and estimates will be used to determine annual changes and long-term trends in the population and demographic parameters of the target species, and to identify and describe interrelationships between the population and demographic parameters and various covariates, including population sub-units for the various species, geographic area (at various spatial scales), landscape-level habitat characteristics, and weather conditions. They will also be used to facilitate comparisons among data obtained from stations located in landscapes subjected to various management practices in order to provide information relating to the effects of management practice on the population and demographic parameters of the target species.

Based on fulfilling these goals, the long-term objectives of the MAPS program then are twofold. First, to provide long-term, large-scale population and demographic information on target landbird species that can be used to:

(1) aid in identifying:
- (a) thresholds and trigger points to notify appropriate agencies and organizations of the need for research and/or management actions,
- (b) the stage(s) in the life cycles at which changes in population dynamics are taking place,
- (c) testable hypotheses regarding the proximate demographic causes of population changes, and
- (d) management actions and conservation strategies to reverse population declines; and

(2) aid in evaluating the effectiveness of the management and conservation actions implemented.

This objective is to be carried out on a large scale, with the North American continent divided into eight functional regions. It is envisioned that the national parks, along with national forests, military installations, and other publicly-owned lands, will provide one subset of sites for this large-scale objective.

A second objective is to provide smaller scale, but still long-term, population and demographic information on target landbird species in specific geographic areas (perhaps based on physiographic strata, such as the Sierra Nevada Mountains, Northern Pacific Rain Forest, Cumberland Plateau, or Southern Piedmont) or specific localities (such as individual national parks or national forests). The sampling strategy utilized at these smaller scales should be hypothesis-driven and should be integrated with other research and monitoring efforts.

1.5. Evaluation of the MAPS Program

In early November, 1996, an extensive evaluation of the MAPS Program was completed. This evaluation was reported in two documents: (1) General Evaluation of the Monitoring Avian Productivity and Survivorship (MAPS) Program -- by David F. DeSante, MAPS Program

Director; and (2) Evaluation of the Statistical Properties of the Monitoring Avian Productivity and Survivorship (MAPS) Program -- by Daniel K. Rosenberg, Post-doctoral Fellow at The Institute for Bird Populations, who was appointed to provide a disinterested evaluation of the MAPS Program. These documents were submitted to a Review Panel on MAPS appointed by USGS/BRD. The Review Panel met at the Patuxent Wildlife Research Center, Laurel, MD, Nov. 21-22, 1996 and reviewed the entire MAPS Program as presented in the two-part evaluation. In early January, 1997, the Review Panel issued its report, which provided a very favorable review of MAPS. The conclusions of the USGS/BRD Review of the MAPS Program (summarized by Paul Geissler) are as follows:

1. MAPS is technically sound and is based on the best available biological and statistical methods.

2. The pilot has substantially exceeded expectations in rapidly expanding the number of sites supported by independent agencies and organizations.

3. MAPS complements other landbird monitoring programs such as the BBS by providing useful information on land bird demographics that is not available elsewhere.

4. The quality, quantity, and usefulness (to Interior agencies and others) of the data generated by MAPS indicates that some level of continued Federal funding is appropriate.

The Review Panel concluded that "MAPS represents a tremendous partnership among many Federal and State agencies, NGOs, and private individuals, who contributed direct financial support and in-kind services to MAPS during the pilot project. MAPS is the most important project in the nongame bird monitoring arena in quite some time (probably since the creation of the BBS)."

The evaluation and review of the MAPS Program also led to recommendations for four changes in MAPS field methods. These changes were incorporated into the field protocol for the MAPS stations operated in Denali National Park in 1997 or earlier, were incorporated into the 1997 MAPS Manual that is included as Part II of this Handbook, and are summarized as follows:

(1) The final two 10-day periods of data collection, Periods 11 and 12 (August 9-28), have been eliminated from MAPS protocol. Examination of fat levels in birds captured by the MAPS Program indicated that small, but substantial, numbers of migrating birds were captured at MAPS stations during these two periods. Elimination of data from these periods will likely have little direct effect on estimates of survival and recapture probabilities of adult birds from CJS mark-recapture analyses, because virtually all returns of previously banded adults are recorded well before these final two periods. It is likely, however, that estimates of the proportion of residents may be increased by elimination of the last two periods, as some fall migrant adults may well be included in the catch during these last two periods. Elimination of such adults will tend to

make estimates of the proportion of transients more biologically useful. More importantly, the geographic representativeness of productivity indices from MAPS should also be improved by elimination of the final two periods, as the capture of birds (both young and adults) originating from farther away from the station will be reduced or eliminated.

Perhaps the most important benefit from the elimination of the final two periods is that the total effort (and expense) of operating a MAPS station will be reduced by amounts ranging from about 17% to 25%. This is a very important consideration for increasing the number of stations (both agency- and non-agency-funded) contributing data to the Program and for the continuity of operation of those stations. This recommendation was put in place at Denali National Park during the 1997 field season.

(2) The collection of point-count data from MAPS stations has been discontinued. Point-count data have not proved very useful for assessing the biases in MAPS capture rates; moreover, they require considerable energy and expense to gather and process. Coming, as they do, during the first few periods of station operation, they also have had a negative effect on the gathering and the accuracy of critical mist-netting and banding data. This recommendation was put in place at Denali National Park MAPS stations during the 1996 field season.

(3) The collection of supplemental breeding status information on all species seen or heard at each station on each day the station was operated has been made mandatory for all stations. Thus, all MAPS station operators are now required to submit a daily breeding-status data sheet, which is simply a list of species with associated behavior codes seen or heard at the station during each day of operation. These daily list greatly facilitate the accuracy of breeding status determinations. The submission of daily breeding-status data was previously considered optional. This recommendation was put in place on a trial basis in Denali National Park during the summer of 1995 and was continued during the 1996 and 1997 field seasons.

(4) The protocol for describing the vegetation at MAPS stations has been revised. The evaluation of MAPS concluded that the previously-used methodology for characterizing the habitat types and vegetation structure present at each MAPS station and for determining whether or not substantial habitat changes were occurring at the station was inadequate and in need of revision to make it simpler, less time-consuming, and more reproducible. A new vegetation description protocol was developed during winter/spring 1996-1997 and was put in place at Denali National Park and elsewhere on a trial basis during the 1997 field season. The new habitat classification protocol is based on the National Vegetation Classification Standard (NVCS), developed by a partnership of agencies and NGOs including, among others, the Ecological Society of America, Environmental Protection Agency, The Nature Conservancy, National Park Service, and Biological Resources Division of the USGS. The NVCS has recently been adopted by the PIF National Monitoring Working Group as one method for classifying the vegetation types for point counts and other avian monitoring schemes.

2. MAPS IN THE NATIONAL PARKS

The major objectives of the MAPS Program are in basic agreement with objectives laid out for the National Park Service's long-term Inventory and Monitoring Program. It is not surprising, therefore, that 38 MAPS stations are or have been operated on the following 15 NPS Units: Denali National Park and Preserve, Kobuk Valley National Park, Noatak National Preserve, Yukon-Charley Rivers National Preserve, Redwood National Park, Yosemite National Park, Kings Canyon National Park, Grand Teton National Park, Capital Reef National Park, Organ Pipe National Monument, Chiricahua National Monument, Tumacacori National Historical Park, Coronado National Memorial, Shenandoah National Park, and Congaree Swamp National Monument. Operation of 12 of the 38 stations has been discontinued (six were moved to other locations within the same park and six were discontinued because of lack of funding), but 26 stations in the various NPS Units were still in operation during 1997.

Specific reasons for the establishment and operation of these 38 stations varied by NPS Unit and operator, but a unifying reason was to contribute to the overall continent-wide MAPS Program. In this section, we provide guidelines for the establishment of MAPS stations on NPS Units by outlining the questions that can be addressed by MAPS within the framework of the NPS Units, the spatial and temporal scales at which these questions can be addressed, the appropriate experimental design by which to address them, and manner in which stations should be sited in order to address them.

2.1. Questions to be Addressed and Hypotheses to be Tested

MAPS is basically a large-scale, long-term biomonitoring program. As such, the basic goals of MAPS are to obtain annual indices and/or estimates of population and demographic parameters, including indices and/or estimates of adult population sizes, indices of the numbers of young that reach independence from their parents, indices of productivity (the proportion of young in the catch), estimates of adult survivorship, and estimates of recruitment into the adult populations.

In order for MAPS data to be maximally useful, the establishment of stations and operation of the program should designed to address specific questions or test specific hypotheses that will provide information as to the potential proximate causes of population change and, thus, information as to potential conservation strategies and management actions to reverse declining populations (DeSante and Rosenberg in press). The optimal way to test such hypotheses may be to include relevant ecological variables as covariates in the particular analytical techniques (e.g., modified Cormack-Jolly-Seber ⟨CJS⟩ mark-recapture models for estimating survival rates; logistic regression models for analyzing productivity indices; and, perhaps, loglinear poisson regression models for indexing long-term trends in captures of young and adult birds) used to provide (or analyze) the indices and estimates of population and demographic parameters identified above.

The spatial and temporal scales at which MAPS data can be used to address questions regarding primary demographic parameters of target landbird species must be clearly understood before appropriate questions can be formulated. The spatial scale at which questions can be addressed must correspond to the geographical scale over which data from stations are pooled. This can range from the local scale, where data are pooled from a cluster of stations in a single well-defined area, such as a single national park or national forest, or from only a subset of the stations in the cluster; to larger scales, such as a physiographic province (e.g., the Sierra Nevada mountains) or a MAPS region (e.g., the Alaska Region or the Northwest Region), or to very large sub-continental (e.g., eastern North America) or continental areas.

Moreover, the appropriate spatial and temporal scales are different for productivity than for survivorship considerations. Productivity indices produced by MAPS are landscape-specific, rather than site- or habitat-specific. This is because the young birds captured at MAPS stations were not necessarily produced within the boundaries of the MAPS station itself, but rather are dispersing individuals that were produced in the surrounding landscape. In this respect, MAPS productivity indices differ strikingly from nest-success estimates obtained from direct nest monitoring, in that the latter are site- or habitat-specific but not landscape-specific unless than particular site is representative of the entire landscape. In addition, productivity is indexed by MAPS by the proportion of young in the catch each year (or, alternatively, by the number of young per adult captured each year). Thus, each year's data produce an annual productivity index for each species.

In contrast to productivity indices, adult survival-rate estimates require three (for non-transient CJS models) or four (for transient CJS models that rely on between-year recaptures to assess residency) consecutive years of data to provide an initial estimate. In addition, because the adults whose survival rate is estimated by MAPS are the adults that are resident on the study area (at least during summer), MAPS survival-rate estimates are site- or habitat-specific, at least as far as their breeding season survival is concerned. However, because survival of migratory individuals may depend primarily upon considerations on their wintering grounds or migratory routes thousands of kilometers away, site-, habitat-, or landscape-specific considerations on the breeding grounds for survivorship may well be moot.

2.1.1. Questions Addressed at Large (Regional or Continental) Scales

MAPS data collected in national parks can be used to address questions at two spatial scales. First, MAPS data from a given park can be pooled with MAPS data from outside the park to provide regional (or even continental) indices and estimates of (and longer-term trends in) these key demographic parameters. Three important types of questions can be addressed using MAPS data pooled over regional or continental scales:

(1) How do productivity indices and adult survival-rate estimates vary spatially, for

example, as a function of latitude or geographical area? A specific question in this regard might be: Do individuals of a given species breeding at higher latitudes produce more young per adult than those breeding at lower latitudes, and, if so, is this balanced by lower survival rates of individuals breeding at higher latitudes? Questions like this are of considerable theoretical importance for understanding the evolution of life history strategies, and of practical importance for understanding the basic manner and limitations by which management actions can affect the population dynamics of birds.

(2) How does spatial variation in productivity indices (or adult survival-rate estimates), if any, correlate with spatial variation in population trends? A specific question in this regard might be: Are productivity indices (or adult survival-rate estimates) for a given species higher in geographical areas where the species is increasing than in areas where it is decreasing? Questions like this are particularly important for aiding in the identification of the proximate demographic causes of observed population declines. A positive answer to the question above would suggest that low productivity (or low adult survival) may be the proximate demographic cause of population declines in the area where the species is declining.

(3) What is the temporal variation (e.g., long-term trends) in productivity indices and adult survival-rate estimates and how does this temporal variation itself vary spatially? Monitoring temporal variation in primary demographic parameters provides a powerful method for evaluating the effectiveness of management actions designed to reverse population trends by effecting productivity and/or survivorship. A specific question in this regard might be: Do regional productivity indices for a given species increase after the implementation of regional management actions designed to increase nest success of the species? Note that these types of questions can also be addressed at local, as well as regional scales.

There are two additional considerations regarding large-scale indices and estimates from MAPS. The first is the spatial scale at which pronounced variation in demographic parameters actually occurs, compared to the scale under consideration. Productivity indices or survival-rate estimates at large spatial scales obtained by pooling data over many stations may mask important variation at smaller scales. Thus, demographic indices and estimates from MAPS should be examined at the smallest spatial scale that provides adequate precision before pooling data from larger spatial scales. A model-based selection approach at multiple spatial scales using AIC to select the most appropriate model provides a prudent approach to this problem (Rosenberg 1996).

A second concern is how well the collection of stations are representative of the geographic area of interest. This issue is of particular concern if stations are not chosen by means of a probabilistic-based sampling strategy (Rosenberg 1996). Because of the intensive and long-term nature of MAPS data collection, however, a completely randomized selection of study sites is not feasible. Indeed, MAPS stations can fruitfully be sited only where long-term mist netting is both feasible and permissible, and where substantial numbers of birds can be captured. This situation means that some degree of "judgement-based" site selection must occur. A prudent approach to this problem is to pre-select a number of candidate sites where the long-term operation of MAPS stations are feasible and permissible, where substantial numbers of birds may be captured, and where environmental conditions (landscape- and local-level habitat conditions and management strategies) are appropriate for the particular experimental study design, and randomize the actual selection of sites from this pre-selected sample.

2.1.2. Questions Addressed at Smaller (Local) Scales

At smaller scales, MAPS data from a given park can provide local indices and estimates of (and longer-term trends in) productivity and survivorship; these can then be compared with indices and estimates derived from MAPS data from outside the park or from other locations within the park. Several important types of questions can be addressed using MAPS data collected in this manner at these local scales.

(1) How do productivity indices and adult survival-rate estimates differ between stations in the national park and stations in similar landscapes outside of the national park? A specific question here might be: Do individuals of a given species breeding in specific landscapes in the national park where consumptive management actions (e.g., timber harvest or mineral extraction) are minimal, produce more young per adult than those breeding in similar landscapes outside of the park where such management actions are extensive? Questions like this are of considerable practical importance for understanding the manner by which consumptive management actions can affect the population dynamics of birds. Being able to answer such questions underscores the valuable role that monitoring in the national parks can play in establishing controls for evaluating management actions outside the park. Indeed, one private timber company in the Sierra Nevada mountains has established MAPS stations in habitat types similar to those where MAPS stations are operated in Yosemite National Park in order to address questions as to the effects of their timber management practices on landscape-level productivity indices of landbirds.

(2) How do productivity indices differ among stations in different landscapes within the national park itself, or among stations in similar landscapes that are subjected to different management actions? Specific questions in this regard might be: Do individuals of a given species breeding in more forested landscapes in the national park, or in park landscapes subjected to less visitor impacts, produce more young per adult than those breeding in less forested landscapes within the park, or in park landscapes subjected to greater visitor impacts? Questions like these are of considerable practical value for understanding the relative importance of the various landscape-level habitat types within the park for landbird productivity, or for understanding the impact of visitor use on landbird productivity. Such information is crucial for efforts to develop park management strategies that optimize benefits for landbirds. Note that, as will be discussed later, differences in survival-rate estimates are only likely to be detected from

data pooled from about six or more stations, so the determination of within-park differences in survivorship may require the establishment of as many as 12 stations. However, as mentioned previously, survival rates of migratory landbirds are likely to be controlled by factors acting outside the park and, thus, may not be affected substantially by within-park management actions. Productivity of landbirds within the park, on the other hand, is liable to be controlled primarily by management actions within the park (although factors like airborne pollution from outside the park and global climate change can also influence productivity of landbirds within the park).

(3) What is the temporal variation (e.g., long-term trends) in productivity indices and adult survival-rate estimates of landbirds within the park and how are these trends affected by park management practices? Monitoring trends in primary demographic parameters a major objective of MAPS and provides a direct method for evaluating the effect of management actions on landscape-level measures of productivity and/or survivorship. A specific question in this regard might be: Do landscape-level productivity indices for a given species in the park increase after the implementation or modification of park management actions?

2.2. Experimental Design

Several considerations unique to MAPS data must be addressed at the outset. First, the estimation of demographic parameters is much more complex than the estimation of population sizes and trends. This is because the methodology requires the actual capture and banding of individual birds (which is always more difficult than the simple recording of presence/absence or counting of individuals). Second, the models used for indexing or estimating demographic parameters (mark-recapture and loglinear poisson or logistic regression) typically are data-hungry, that is they require large sample sizes for adequate precision (Pollock et al. 1990, Lebreton et al. 1992). Given that most landbirds are territorial during the breeding season, very large or multiple sampling areas are required to obtain the requisite sample sizes. Third, the estimation of survival rates using transient models that rely on between-year recaptures to assess residency requires four years of data to obtain an initial survival-rate estimate (Pradel et al. 1997). Thus, even rough estimation of trends in survival rates are likely to require at least 10 years of data and probably more if survival is strongly influenced by annual fluctuations in weather (Rosenberg 1996). Thus, it is obvious that the monitoring of demographic parameters requires effort at multiple stations in the area under consideration, and requires that the effort be sustained over long time periods (i.e., many years).

Four basic aspects must characterize the experimental design of the MAPS program in a national park (or national forest, military installation, etc.). The first is the selection of the basic landscape-level habitat types, management actions, or questions to be addressed by the study design; second is number and distribution of stations (which must be based upon the resources available to operate the stations); third is the selection of study sites; and fourth is the selection of target species. All four of these aspects must be considered together as they are all interdependent.

2.2.1. Basic Study Design

It is important to keep in mind that the productivity indices generated at a MAPS station provide a landscape-level, rather than site-specific measure of productivity. This is because the young birds captured by the MAPS protocol are dispersing individuals from the surrounding landscape that were not necessarily produced within the boundaries of the 20 ha MAPS station. Data on the dispersal characteristics of young birds after the breeding season but before fall migration are just now being obtained for a very few species from radio telemetry studies. These studies suggest that the landscape from which the dispersing young derive may well be on the order of some few tens of thousands of acres (Anders 1996, Anders et al. 1997, J. Rappole pers. comm.). Thus, it is critical to consider the landscape-level characteristics of the habitat within which MAPS stations are sited. Although management actions occur on a site-specific basis, their effect on bird populations become pronounced only when the specific management actions occur over substantial portions of the landscape. The ability of MAPS to provide landscape-level information on productivity is one of the unique strengths of the program. We suggest that park personnel choose the one (or two) most important broad habitat type(s) that best represent a majority of the area of the park and for which the park can provide "representative control" data for that (those) habitat(s) in the context of a regional or larger-scale monitoring strategy. This will maximize the value of the information obtained as control data for evaluating the affects of management outside of the park. Examples of such broad habitat types might be mixed coniferous forest, spruce taiga, dwarf birch scrub, etc. Park personnel should then determine the specific aspects of this habitat type, or the management actions that occur (or are anticipated to occur) on it, that they intend to monitor and evaluate. Examples of questions or hypotheses that can be addressed at these local spatial scales were presented above in Section 2.1.2.

2.2.2. Number and Distribution of Stations

A MAPS study design should then be established that includes either (a) six stations distributed along a gradient of landscape-level habitat types or management actions (e.g., an elevational gradient, a gradient in extent of forested area, or a gradient in the extent of visitor use); or (b) three stations in landscapes containing a given habitat type or management action and three stations in landscapes containing a different (control) habitat type or management action (or lack thereof). As mentioned above, six stations will permit an evaluation of spatial and temporal variation (or differences) in productivity, but not in survivorship. If within-park differences in survivorship are sought, or if interannual differences in survivorship are required, even for the park as a whole, the study design should include at least two sets of six stations each.

The choice of six stations in the study design derives from two sources, the first involving logistic and personnel considerations. We have found that two trained bird banders, by working an average of five days per week, can operate six MAPS stations for one day each in a ten-day period and have one day to make up missed effort caused by inclement weather or other unavoidable and unpredictable delays. These logistic and personnel considerations have lead us to establish MAPS stations in national parks, on national forests, and on large military installations in clusters of six.

We have also found that data from clusters of five or six stations within a given national park facilitate the analysis of inter-station differences in productivity indices through a logistic-regression approach (Rosenberg 1996, DeSante et al. 1997, Pyle et al. 1997), especially when these data can be pooled among stations with regard to landscape-level habitat or management characteristics. Furthermore, we have found that pooled data from clusters of five or six stations generally provide the minimum sample sizes of marked adults needed to obtain survivorship estimates with an acceptable degree of precision (about CV=20%; Rosenberg 1996, Pyle et al. 1997).

Thus, in the discussion that follows, we assume that the protocol to be followed in the siting of MAPS stations will involve the establishment of six (or multiples of six) stations in a given national park. Using this protocol, we will be able to investigate inter-station differences in productivity indices for target species, but will need to pool data from the six stations to get park-wide estimates of survival rates for the target species. It is important to keep in mind, however, that many, if not most, of the target species in a given park are likely to be migratory species for which survival rates are likely to be controlled by factors outside the park, while productivity indices will be controlled largely by factors within the park. Thus, the ability to obtain productivity indices from individual stations is important, while the inability to obtain survival-rate estimates from individual stations does not seriously detract from the usefulness of the information.

2.2.3. Siting MAPS Stations

It is also important to consider site-specific habitat characteristics when siting MAPS stations as these can influence the extent to which young bird concentrate at various stations. Recent work suggests that most young birds (and many adults as well) tend to desert the interior of forests immediately after attaining independence from their parents (about 16-21 days after fledging) and disperse to edge locations where an abundance of food resources, often fruit, occur (Anders 1996, J. Rappole pers. comm.). We have found that MAPS stations sited in forest-interior locations tend to produce lower productivity indices for most species than stations sited at locations that contain some forest-edge or scrub habitat (DeSante 1996). Thus, in order to minimize site-specific sources of variation in productivity indices, and maximize landscape-level sources of variation, we suggest that MAPS stations not be sited at forest-interior locations. Rather, stations should contain some forest-edge or scrub habitat.

Because of the need to operate each MAPS station once in each of six to ten (depending on latitude) consecutive 10-day periods during the breeding season, a further logistic consideration regarding the siting of stations is that relatively easy access to the stations is needed. Thus, unless extensive (and expensive) logistic support for the operation of the station can be provided (e.g., by helicopter access) stations should be sited within about two km of roads.

With the above considerations in mind, we suggest the following sampling strategy for siting six stations in a single national park (or national forest or large military installation).

(1) Determine, as discussed above, the specific habitat-type or management action (or gradient therein) for which monitoring information is desired.

(2) Identify as many specific candidate sites that meet these requirements and that meet the two additional requirements discussed above (i.e., they contain some forest-edge or scrub habitat and are located within about two km of a road).

(3) Select the actual sites from the candidate sites by a probabilistic-based sampling strategy (e.g., a stratified random sample).

2.2.4. Selection of Target Species

Because of the need to obtain the required large sample sizes of adult and young birds captured in mist nets, target species must generally be relatively common species whose normal foraging and nesting haunts include the ground, shrubs, and/or lower levels of the canopy. In general, species that forage and/or nest high in the canopy usually cannot be captured in sufficient numbers to permit the indexing or estimation of primary demographic parameters with adequate precision. Similarly, uncommon or rare species generally cannot serve as useful target species, although there are exceptions: productivity indices and survivorship estimates from ungrazed meadows in Yosemite National Park suggest that adult Willow Flycatchers, which are rare and threatened in the Sierra Nevada mountains, are producing young and surviving over the winter as well as two other Empidonax species, Dusky and Hammond's flycatchers, that are common and increasing in the Sierra Nevada (DeSante in press).

It is also important that target species be those occur in substantial numbers in both of the habitat types (or under both of the management actions) or throughout most of the gradient in habitat type (or management action) being investigated. In this manner, useful analyses can be conducted, for a given species, using landscape-level habitat information or management action as a covariate.

It is also helpful if the various target species differ among ecological traits including, but not limited to: nest location (cavity, ground, shrub, tree); breeding habitat preference (forest, edge, scrub, riparian 〈grassland, agricultural land, and urban species are not sampled well by MAPS because of the difficulty of operating mist nets in such habitats〉); breeding season foraging strategy/diet (sallying, foliage-gleaning, bark-gleaning, ground-gleaning, seeds and buds); and migration strategy (long-distance 〈Nearctic-Neotropical〉 migrant, short-distance migrant, permanent resident). Analyses of primary demographic parameters among species grouped according to these ecological traits can provide useful hypotheses as to potential causes of differences in these parameters among species groups and the manner by which environmental stressors may affect these parameters (DeSante in press). Indeed, one important goal of an effective monitoring effort should be to suggest testable hypotheses regarding causes of observed population changes (DeSante and Rosenberg in press).

Finally, selection of target species should also include two additional considerations: (a) species which are unique to the individual park or for which the park provides important habitat or a significant proportion of the existing habitat for the species; and (b) species of local, regional, or continental concern for which the park can provide important comparative data.

2.3 Other Considerations

Two other types ecological variables are of great importance in analyzing and interpreting data from the MAPS Program: (1) habitat characteristics and temporal variation of the immediate habitat and, more importantly, of the landscape in which the MAPS stations are sited; and (2) temporal variation in the weather (during and immediately prior to data collection) characterizing the landscapes in which the stations are sited.

2.3.1. Habitat Characteristics

We will not consider here methods for the determination of characteristics of (and temporal variation in) the landscapes in which stations are sited. Such information must be obtained from remote-sensing, ground-truthing, and GIS techniques which are beyond the scope of this protocol. Suffice it to say that landscape-level information regarding (at least) total forest cover, major types and ages of forest cover, degree of fragmentation (e.g., mean 〈and variance〉 patch size, mean 〈and variance〉 distance between patches), and management practices used will need to be determined. These types of data can be used as covariates in logistic regression productivity models or in modified CJS mark-recapture models and can provide invaluable insight into reasons for spatial patterns in productivity indices or survival-rate estimates. Such data and analyses are crucial for testing meaningful hypotheses regarding spatial (and temporal, if landscape-level habitat characteristics change over time) variation in the demographic parameters indexed and/or estimated by MAPS. As such, Denali National Park (and other locations aiming to implement long-term biomonitoring programs) should plan for the collection of such GIS data.

Determination of habitat characteristics and temporal variation in the habitat at the immediate site where a MAPS station is located is also of considerable importance as the habitat at the station can influence the extent to which dispersing individuals (young or adults) are attracted to the station. A new simplified vegetation description and monitoring protocol was developed during winter/spring 1996-1997 as part of the evaluation of the continent-wide MAPS Program, and was put in place at Denali National Park and elsewhere on a trial basis during the 1997 field season. The new habitat classification protocol is based on the National Vegetation Classification Standard (NVCS) and is described in Part II of this handbook, MAPS Manual

(Burton and DeSante 1998). The protocol involves sketch-mapping the primary and (if present) secondary habitats at the station, selecting from the standardized NVCS key the formation that best identifies each habitat, and catagorizing the cover, height, and composition of the vegetation in each of four height layers (ground, shrub, sub-canopy, and canopy) and the moisture regime of each habitat. This procedure is repeated each year at the time of maximum canopy and shrub cover.

2.3.2. Weather Data

It is also important to determine characteristics of (and temporal variation in) the weather associated with the landscapes in which stations or clusters of stations are sited. Examples of appropriate information would include (at least) summary data on the mean temperatures (high, low, and average) and precipitation during the previous winter, previous spring, and current summer; records of unusual weather events (large storms, high winds, major hot or cold spells); and, if appropriate, depth of snowpack and timing of snowmelt. Again, we will not consider here methods for determining such information. These data must be obtained from standardized weather-data-collection centers located as near as possible to the stations. Nevertheless, such data are crucial for testing meaningful hypotheses regarding temporal variation in the demographic parameters indexed and/or estimated by MAPS, as well as hypotheses regarding appropriate information from other biomonitoring programs, such as the Breeding Bird Survey. As such, Denali National Park (and other locations planning to implement long-term biomonitoring programs) should plan for the collection of such weather data.

3. THE DENALI MAPS PROGRAM

The MAPS program in Denali National Park and Preserve was established as part of the development of Denali's Long-term Ecological Monitoring Program. The overall objectives are that information from MAPS will: (1) be capable of aiding research and management efforts within the park to protect and enhance the park's avifauna and ecological integrity; and (2) be capable of aiding local, regional, and continental efforts to determine the proximate demographic causes of population changes in landbirds, identify management actions and strategies to reverse population declines, and evaluate the effectiveness of the management actions and strategies implemented.

3.1. Initial Experimental Design

The initial design of the Denali MAPS Program was to establish five MAPS stations along a gradient of forest cover and elevation from mature, open spruce forest, through mixed spruce forest/spruce-birch or wet willow scrub near treeline, to birch and willow scrub above treeline. This gradient of habitat types, it was deemed, would provide representative samples of the dominant landbird species breeding in Denali National Park, particularly those breeding in landscapes near more heavily-impacted (by visitors) part of the park. It was realized at the onset, that funding for access to remote portions of the park was unrealistic and that, to continue for the long term, MAPS stations needed to be sited within the corridor provided by the main park road. Thus, it was realized that the data from the Denali MAPS stations would only be representative of landscapes along this corridor, and of visitor activity levels along this corridor, and not representative of the park as a whole, or of average human activity levels in the park as a whole. It was also realized at the onset that even this proposed sample of stations would not be representative of the landscape throughout this corridor, but would be biased toward landscapes found along the eastern park of the roadside corridor, that is, biased toward more forested habitats and lower elevations.

These biases were considered acceptable because the resulting study design would provide information on a greater diversity of landbird species than would a design that involved the siting of stations more representative of the overall landscape of the park. The latter design, it was felt, would facilitate the monitoring of only a few species characteristic of tundra scrub habitat. The chosen design, it was felt, would permit the comparison of data from Denali National Park with data from other Alaskan MAPS stations for more species, and thus provide more useful information regarding the responses of birds to potential stressors to the system.

The decision to establish five (rather than six) stations in Denali was based upon initial concerns that the weather at Denali would not permit the operation of six stations within each 10-day period. The initial design, therefore, was to establish two stations in forested landscapes, one station near treeline, and two stations essentially above treeline.

3.2. Initial Siting of Stations

Five MAPS stations were established in Denali National Park in early June 1992 along a habitat gradient of forest cover and elevation from more-heavily forested to less-heavily forested stations. A combination of a judgement-based and probability-based sampling strategy was used to site the stations. Because the Rock Creek watershed was to figure prominently in the Denali Long-term Ecological Monitoring (LTEM) Program, it was decided that one forested station should be sited in the Rock Creek watershed. Two candidate sites in the watershed were deemed acceptable, one north and one south of the main park road. The actual site, 0.4 km north of the main park road at an elevation of 686 m, was determined randomly. The Rock Creek MAPS station appeared to be representative of mature open spruce forest and riparian alder woodland in the Rock Creek watershed.

Four candidate sites were selected for the second more-heavily forested station: near the park headquarters, near the "Permafrost" interpretive sign, near the Teklanika Campground, and near the Igloo Creek Campground. Again a randomized selection was made and the selected site was the one located just south of the main park road at the "Permafrost" interpretive sign at about milepost five at an elevation of 716 m. The Permafrost station was characterized by mature spruce forest, riparian alder, and wet willow scrub.

Three candidate sites were selected for the "near treeline" station: at milepost seven along the main park road, near the Sanctuary Creek Campground, and near the Teklanika Campground. The Mile Seven site, located just north of the main park road at milepost seven at an elevation of 838 m, was selected randomly. The Mile Seven station, was characterized by patchy treeline spruce forest, spruce-birch scrub, and wet willow scrub.

Five candidate stations were selected for the two "above treeline" stations: where Hogan Creek crossed the main park road, about 1.5 km west of the Savage Creek Campground, about 4.5 km north and east of the Teklanika Campground, about 2.2 km north of the Igloo Creek Campground, and about 2.5 km southwest of the Igloo Creek Campground. The two sites randomly selected were the Hogan Creek site, located just north of the main park road where it crosses Hogan Creek at an elevation of 853 m; and the Igloo Creek site, located along the west (north) side of the main park road along Igloo Creek about five km south of the Igloo Creek campground at an elevation of 945 m. The Hogan Creek station represented spruce-birch scrub and wet willow scrub and included a small patch of spruce trees. The Igloo Creek station, represented tall riparian willow scrub.

3.3. Subsequent History of the Denali MAPS Program

The operation of the Hogan Creek station was discontinued after two periods of operation in 1992 because of a family of Northern Shrikes, whose presence drastically reduced the breeding bird populations at the station and caused unacceptable mortality levels among birds netted at the station. The four remaining stations established in 1992 were operated for each of the six years 1992-1997.

The Lost Forest station was established in 1993 to "replace" the discontinued Hogan Creek station. The habitat type of the Lost Forest station was spruce forest, open mossy field, and riparian alder/spruce woodland; the station was located in the upper Rock Creek watershed, approximately 2.2 km north of the main park road. The strategy for the establishment of the Lost Forest station was to provide more effort in the Rock Creek watershed, rather than attempt to replace the habitat-type represented at Hogan Creek. The decision to place a second MAPS station in the Rock Creek watershed was prompted by a change in policy regarding the Denali LTEM which focused on concentrating additional monitoring activity in the Rock Creek watershed. The Lost Forest station was operated for each of the four years 1993-1996.

Another change in policy regarding the Denali LTEM was suggested to us early in 1997, to reduce the emphasis on monitoring in the Rock Creek watershed and increase the emphasis on more widespread monitoring in the park. Accordingly, the operation of the Lost Forest station was discontinued in 1997 and two new stations were established farther west along the main park road toward Wonder Lake. Because only one (Igloo Creek) of the four continuing Denali MAPS stations represented above-treeline habitat, the decision was made to establish two new stations in birch or willow scrub habitats. Again four candidate stations were selected, all between the Eielson Visitor Center and Wonder Lake, and two stations were randomly selected from the four. The two stations established in 1997 were: the Buhach Creek station, located about one km southwest of the main park road at an elevation of 884 m where Buhach Creek meets the Thoroughfare River; and the Strangler Hill station, located just south of the main park road about three km east of the intersection with the Wonder Lake Campground Road at an elevation of 686 m. The habitat present at the Buhach Creek station represents willow/tundra scrub, while that present at the Strangler Hill station represents alder/birch scrub hillside.

The operation of each of the Denali MAPS stations began each year during 1992-1996 in Period 5 (June 10-19) and continued for eight consecutive 10-day periods through Period 12 (August 19-28). Following recommendations resulting from the evaluation of the MAPS Program (DeSante 1996), the operation in 1997 began in Period 5 and continued for just six consecutive 10-day periods through Period 10 (July 30-August 8). Otherwise, operation of each of the stations during each of the six years followed MAPS protocol which is described in detail in Part II of this Handbook, MAPS Manual. Analyses of MAPS data collected at Denali during each of the six years also followed MAPS protocol which is described in detail in Part III of this Handbook, MAPS Analytical Manual. An annual report of the each year's results was produced after each of the six years of operation (the 1997 report is currently in preparation and will be issued in February, 1998).

3.4. Evaluation and Refinement of the Denali MAPS Program

The specific goals for the initial operation of the MAPS Program in Denali were to:

(1) evaluate the ability and effectiveness of MAPS to provide a useful component of the Long-term Ecological Monitoring Program in Denali National Park;

(2) determine the effectiveness of various MAPS stations in Denali National Park to provide reliable demographic information on the landbirds of the Alaskan montane environment; and

(3) develop detailed written protocols for the long-term monitoring of population and demographic parameters of landbirds to be used in Denali's Long-term Ecological Monitoring Program by refining and altering the MAPS protocol to fit the specific needs of Denali National Park.

As discussed in Section 1.5 above, the continent-wide MAPS Program was evaluated by a Review Panel on MAPS appointed by USGS/BRD. The conclusions of the Review Panel indicated that MAPS is technically sound and based on the best available biological and statistical methods; that MAPS complements other landbird monitoring programs such as the BBS by providing useful information on land bird demographics that is not available elsewhere; and that the quality, quantity, and usefulness (to Interior agencies and others) of the data generated by MAPS indicates that some level of continued Federal funding is appropriate. The evaluation and review of the MAPS Program also led to recommendations for four changes in MAPS field methods that were also detailed in Section 1.5 above; all four of these changes have been implemented in the Denali MAPS program and are reflected in this handbook.

The Denali MAPS Program was also evaluated in both the 1995 (DeSante and Walker 1996) and 1996 annual reports (DeSante et al. 1997) of the Monitoring Avian Productivity and Survivorship (MAPS) Program in Denali National Park. These reports concluded that:

(1) Results of the first five years of the MAPS Program in Denali National Park indicate that important information on the annual indices, between-year changes, longer-term trends, and between-station variation in adult population size and productivity can be obtained for many of Denali's landbird species;

(2) Results of the first five years of the Denali MAPS Program also indicate that important park-wide information on adult survival-rate estimates can also be obtained for a number of Denali's landbird species;

(3) These results also indicated that population trend indices, calculated from mean productivity indices and time-constant annual survival-rate estimates for target species were capable of predicting short-term population trends in target species fairly accurately, thus suggesting that the indices and estimates of primary demographic

parameters from MAPS could provide useful management information at the scale of the national park;

(4) In addition, MAPS data from Denali National Park will provide an invaluable contribution to the determination of precise indices of adult population size and productivity and estimates of survivorship on a region-wide basis for Alaskan landbirds; and

(5) Based on the above information, it is recommended that the MAPS Program be included as an integral part of Denali's Long-term Ecological Monitoring Program.

The results of these two evaluations of the MAPS Program -- both continent-wide and Denali-specific -- fulfill the first goal of the initial MAPS Program in Denali National Park: to evaluate the ability and effectiveness of MAPS to provide a useful component of the Long-term Ecological Monitoring Program in Denali National Park.

The evaluation of the Denali MAPS Program presented in the 1995 annual report also found that, with the possible exception of the Lost Forest station, the Denali MAPS stations were capable of providing sufficient data demographic information on the landbirds of the Alaskan montane environment and recommended that their operation be continued indefinitely into the future. These results fulfilled the second goal of the initial MAPS Program in Denali National Park: to determine the effectiveness of various MAPS stations in Denali National Park to provide reliable demographic information on the landbirds of the Alaskan montane environment.

The development and revision of the Denali MAPS Handbook fulfills the third objective of the initial MAPS Program in Denali National Park: to develop detailed written protocols for the long-term monitoring of population and demographic parameters of landbirds to be used in Denali's Long-term Ecological Monitoring Program by refining and altering the MAPS protocol to fit the specific needs of Denali National Park. This handbook describes in detail all of the procedures utilized in the Denali MAPS Program, including study design, field methods, and methods of data verification, preparation, and analysis.

3.5. The Denali MAPS Program -- 1997 and Beyond

The following sections present the current strategy and design of the Denali MAPS program and suggestions for expansion in the future and for expansion to other national parks in Alaska.

3.5.1. Stations Operated and Area Sampled

The six MAPS currently in operation in Denali National Park provide a stratified, pseudo-random sample of two major types of montane habitat -- spruce forest edge near treeline and willow or dwarf birch scrub -- along the main road corridor in the north eastern portion of Denali National Park. The three forested and more easterly stations provide a gradient in forest cover from the more-heavily forested Rock Creek station (mature spruce forest, riparian alder woodland), through the Permafrost station (mature spruce forest, riparian alder, wet willow scrub), to the less heavily forested Mile Seven station (patchy spruce forest, spruce-birch scrub, wet willow scrub). The three unforested and more westerly stations provide samples of three above-treeline scrub habitats: the Igloo Creek station (tall riparian willow scrub), the Buhach Creek station (willow-tundra scrub), and the Strangler hill station (alder-birch scrub hillside). It must be emphasized that these stations are not representative of the park as a whole; indeed, logistic and resource constraints (access and cost) prohibited a sampling scheme that would produce a truly representative sample of the entire park. Nor do they even provide a truly representative sample of habitats along the roaded corridor. Rather, they provide pseudo-randomized samples of the two major habitat types that occur in the roaded corridor and provide within-park samples that can be compared to other samples of these habitats established outside the park or in other parks. These considerations must be kept in mind when interpreting data from the Denali MAPS program.

It should also be noted that the habitat characteristics of the landscapes in which the Denali MAPS stations are sited have not yet been determined. This is important because the productivity indices generated by MAPS should be habitat-specific at the landscape level. Landscape-level habitat data for the six Denali MAPS stations should be obtained from GIS analyses as soon as possible and be incorporated as covariates into logistic-regression analyses of productivity indices from the various stations.

In addition, changes in these landscape-level habitat variables should continue to be monitored through GIS means. Temporal changes in primary demographic parameters of Denali's landbirds should be analyzed with respect to temporal changes in the habitat, again by being incorporated as covariates in logistic regression analyses of productivity or mark-recapture analyses of survivorship. The park should be concerned with changes in habitat, and concomitant changes in landbird demographic parameters, at several levels: impacts from increased human visitation along the heavily used road corridor within the park; drastic changes from natural events such as fire; and gradual change from both natural causes (e.g., succession) and anthropomorphic factors (e.g., climate change due to burning fossil fuels). Such concerns should form the basis of Denali's Long-term Ecological Monitoring Program.

3.5.2. Target Species

Ten target species were identified from the four Denali MAPS stations that were operated for all of the six years. These target species were selected by a combination of: (1) a pre-selection process that choose species of interest to Denali National Park itself (e.g., Arctic Warbler) as well as species of interest over Alaska or western North America as a whole (e.g., Swainson's Thrush, Wilson's Warbler, White-crowned Sparrow, and Dark-eyed Junco that are all declining in various areas of western North America); and (2) a post-selection process that choose species that could be captured in sufficient numbers to provide meaningful demographic information. Indeed, to some extent, candidate stations were selected with these target species in mind.

Table 1. Ecological characteristics of target species in the Denali MAPS Program.

Species	Migratory Strategy	Nest Location	Habitat Choice	Foraging Strategy
Alder Flycatcher *	L	S	R	SA
Boreal Chickadee	R	C	F	FG
Arctic Warbler	L	G	R	FG
Gray-cheeked Thrush *	L	S	S	GG
Swainson's Thrush	L	S	F	GG
Orange-crowned Warbler	L	G	S	FG
Yellow-rumped Warbler	S	T	F	FG
Wilson's Warbler	L	G	R	FG
American Tree Sparrow	S	G	S	GG
Savannah Sparrow *	S	G	S	GG
Fox Sparrow *	S	G	S	GG
White-crowned Sparrow	S	S	S	GG
Dark-eyed Junco	S	G	F	GG
Common Redpoll **	S	S	S	SB

Migration Strategy: L--long-distance migrant; S--short-distance migrant; R--permanent resident.
Nest Location: C--cavity; T--tree; S--shrub; G--ground.
Habitat Choice: F--forest; R--riparian scrub; S--non-riparian scrub.
Foraging Strategy/Diet: SA--sallying; FG--foliage gleaning; GG--ground gleaning; SB--seeds and buds.

- Potential target species identified from the first year (1997) of operation of the two new stations.

** Because of lack of site-fidelity, cannot be used for survivorship analyses.

Four additional target species were pre- and post-selected concomitant with the establishment of the two new stations established in 1997. A complete list of the 14 Denali target species, along with their pertinent ecological characteristics (i.e., migratory strategy, nest location, breeding habitat preference, breeding season foraging strategy/diet), is presented in Table 1. The inclusion of these characteristics as covariates in future analyses of adult population trends, productivity indices, and survival-rate estimates should allow interesting hypotheses to be tested regarding the population dynamics of Denali's landbirds. 3.5.3. Specific Questions to be Addressed

The following are the set of six basic types of questions to be addressed by the Denali MAPS program as currently established.

3.5.3.1. Questions at large spatial scales

(1) How do population trends of target species sampled at the Denali MAPS stations compare to population trends of these species from MAPS stations in other part of North America, and how do these trends compare to BBS trends from the same areas?

(2) How do productivity indices and adult survival-rate estimates for target species generated from Denali MAPS data, and trends in these indices and estimates, compare to analogous indices and estimates for these species from MAPS stations in other part of North America? In particular, do individuals of a species breeding in Denali National Park show higher productivity indices than individuals of the species breeding at lower latitudes, and is this higher productivity compensated for by lower adult survival?

(3) What insight do the spatial and temporal patterns in productivity indices and survival-rate estimates of the various target species provide with regard to the spatial pattern of population trends in these species? Data from the Denali MAPS program, when compared to analogous data from elsewhere in North America, can provide valuable insight as to potential proximate causes of population change in these species.

3.5.3.2. Questions at smaller spatial scales

(1) How do population trends and productivity indices and adult survival-rate estimates (and trends in these indices and estimates) for target species differ between stations in Denali National Park (where consumptive management practices, such as timber harvest or mineral extraction, are minimal) and stations located in similar landscapes in Alaska outside of Denali National Park, including both those located within and outside of other national parks, where consumptive management practices are more extensive and pervasive?

(2) How do population trends and productivity indices differ among stations in different

landscapes within Denali National Park itself, or among stations in Denali National Park that are subjected to different management actions or different levels of visitor impact? In order to address this question in Denali National Park with regard to survival-rate estimates, it is likely that at least 12 MAPS stations would need to be established in the park.

(3) What are the population trends and temporal trends in productivity indices and adult survival-rate estimates for target landbirds within Denali National Park and how are these trends affected by landscape-level habitat changes or changes in park management practices? An important related question is how do population trends of target landbirds in Denali National Park relate to patterns of productivity and survivorship in these species in Denali National Park?

3.5.4. Expansion of MAPS in Denali and Expansion to Other Alaskan Parks

If resources are available, the MAPS program could fruitfully be expanded in Denali National Park by establishing a second set of six MAPS stations. Guidelines presented in Section 2 above, MAPS in the National Parks, should be followed for expanding the program and siting the new stations. One strategy would be to site stations in more remote parts of the park that are less subject to visitor impacts. A second strategy would be to site stations in other major habitat types in the park so that park-wide demographic indices and estimates would be more representative of the park itself.

Even more fruitful might be the establishment of MAPS stations in similar landscapes in other national parks in Alaska. This could provide insight as to spatial variation in demographic patterns within Alaska. Wrangell-St. Elias National Park and Yukon-Charley Rivers National Preserve might provide optimal situations for establishing additional MAPS stations. Again, the guidelines presented in Section 2 above, should be followed for establishing MAPS in other parks and for siting the new stations.

3.5.5. Future Operation of Stations and Data Analysis

The field and analytical aspects of the operation of the Denali MAPS program have to date been handled by The Institute for Bird Populations under contract from NPS Denali National Park or USGS/BRD Alaska Biological Science Center. Such an arrangement may be the optimal way to proceed and be continued into the future.

If, however, NPS personnel find it appropriate to take over the operation of stations and the analysis of data, some amount training of NPS staff will likely be necessary, both in the field techniques of mist netting and banding landbirds and identifying them to species, age, and sex, and in the analytical techniques of modeling productivity and survivorship using multivariate logistic regression and modified CJS mark-recapture techniques and of model selection using goodness-of-fit and AIC criteria. Personnel from The Institute for Bird Populations can offer formal training courses in all of these aspects of MAPS data collection and analysis.

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