The Monitoring Avian Productivity and Survivorship (MAPS) Program: Overview and Progress

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Abstract — It is generally agreed that populations of many North American landbird species, especially forest-inhabiting Neotropical migratory species in eastern North America, are declining. Existing population-trend data, however, provide no information on primary demographic parameters (productivity and survivorship) and thus provide no means for determining at what point in the life cycle problems are occurring or to what extent observed population trends are driven by causal factors that affect avian birth rates (e.g., temperate forest fragmentation) or death rates (e.g., tropical deforestation), or both. Data on primary demographic parameters of these species are crucial for the implementation of effective management practices to reverse their population declines. The Monitoring Avian Productivity and Survivorship (MAPS) program, a cooperative effort among public agencies, private organizations, and bird banders in North America, was designed to provide these critical long-term demographic data.

MAPS uses constant-effort mist netting, banding, and intensive point counts during the breeding season at a continent-wide network of stations. It provides, for a suite of target landbird species in each of seven major regions of the continent: (1) annual regional indices of adult population size and post-fledging productivity from data on the numbers and proportions of young and adult birds captured; (2) annual regional estimates of adult population size, adult survivorship and recruitment into the adult population from capture-recapture data on adult birds; and (3) additional annual regional indices of adult population size from point-count data collected in the immediate vicinity of the mist-netting stations.

MAPS has grown from 17 stations in 1989 to about 165 stations in 1992. Data from the first three years suggest that post-fledging productivity decreased from 1989 to 1990 over much of the continent. This was followed in 1991 by a significant decrease in the adult population sizes of several target species and all species combined in northeastern North America, where productivity tended to increase in 1991 compared to 1990. An opposite pattern was suggested in northwestern North America, where populations sizes tended to increase from 1990 to 1991 but productivity tended to decrease.

Capture-recapture analyses of data from the first three years of MAPS provide estimates of capture probability of about 0.3 and estimates of survival probability of about 0.5 for various species in both the Northeast and Northwest regions. These analyses suggest that a network of 40 or more stations in a region will produce estimates of adult population size and adult survivorship with sufficient precision (a CV of 20% for the mid-year annual estimate or a CV of about 5% for the mean annual estimate in a 10-year study) to provide reliable information on demographic trends of some 12-18 target species in the region.

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INTRODUCTION

Recent analyses of long-term population-trend data from the North American Breeding Bird Survey suggest that populations of many landbird species, especially forest-inhabiting Neotropical migratory species in eastern North America, are declining (Robbins et al. 1989). Analyses of other more limited and local datasets and considerable anecdotal information provide additional support for this large-scale decline (e.g., Morton and Greenberg 1989, Terborgh 1989). The Neotropical Migratory Bird Conservation Program ("Partners in Flight"), was established to reverse the apparent population declines of these Neotropical migratory birds.

Unfortunately, however, existing population-trend data on Neotropical migrants provide no information on the primary demographic parameters (productivity and survivorship) of these birds. As a result, the existing data provide no means for determining at what point in the life cycle problems are occurring or to what extent observed population trends are driven by causal factors that affect birth rates or death rates or both (Temple and Wiens 1989). In particular, the existing population-trend data on Neotropical migratory landbirds has generally not permitted a determination of the causes for the declining populations of these species (Wilcove 1985, Holmes and Sherry 1988, Hutto 1988). Suggested causes range from forest fragmentation on the temperate breeding grounds to deforestation on the tropical wintering grounds. Indeed, without critical data on productivity and survivorship, it will be extremely difficult, if not impossible, to identify effective management and conservation actions to reverse the current population declines.

Clearly, an integrated avian monitoring system that can supply accurate annual estimates of demographic parameters as well as detailed information on population trends is a real necessity. The Monitoring Working Group (MWG) of Partners in Flight voiced this need in its recent document, "Needs Assessment: Monitoring Neotropical Migratory Birds", (Monitoring Working Group 1992), as did the U.S. Fish and Wildlife Service (USFWS) in its document, "Conservation of Avian Diversity in North America" (Office of Migratory Bird Management 1990). Establishment of an integrated population-monitoring system for North America is a realistic and achievable goal. In fact, such a scheme already has been pioneered for the breeding birds of Britain and Ireland and implemented by the British Trust for Ornithology (BTO).

Baillie (1990) described the requirements for an effective integrated population-monitoring scheme. He asserted that effective wildlife-monitoring programs must be capable of identifying changes in population variables that call for conservation action. This implies establishment of some pre-defined threshold to trigger further research and/or management action, a concept that was also stressed in the MWG Needs Assessment document. Baillie pointed out that such thresholds must be based on a thorough understanding of "normal" patterns and dynamics of population variability and must also take into account life-history characteristics of individual species. Thus, an ideal integrated monitoring scheme should provide data on stage(s) of the life cycle during which changes are taking place as well as indications of possible or probable causes of these changes.

Baillie (1990) described the Integrated Population Monitoring Programme that has been undertaken by BTO for breeding populations of birds in Britain and Ireland. This scheme involves the standardized collection of data on the numbers, productivity and survival rates of birds through the Common Bird Census, Waterways Bird Survey, Nest Record Scheme, Constant Effort Sites Scheme, and Ringing Scheme and interpretation of these data using population-modelling techniques. The program involves routine data gathering and analysis by region and habitat to provide annual indices of, abundance, productivity, survival rates and, in some cases, dispersal. Models are then developed to describe interrelationships between population variables and readily measured environmental co-variables. These models are used to assist in establishing action thresholds and to compare observed population trends with those predicted from environmental data and from preceding population levels. This facilitates identification of changes caused by anthropogenic factors.

It must be emphasized that it is unrealistic to expect any monitoring system, even a well-integrated population monitoring scheme like that established in Britain, to identify positively the causes of population changes in birds. A well-designed monitoring system can, however, identify those factors most likely responsible, thereby allowing unlikely hypotheses to be rejected quickly. A well-designed system that monitors demographic parameters can also point to the stages of the life cycle that are being affected. Such information will allow subsequent limited research resources to focus on those factors most likely to yield an explanation.

Many elements of an integrated avian population monitoring system are already in place in North America. They include the North American Breeding Bird Survey, Breeding Bird Census, Winter Bird Population Study, Christmas Bird Count, and North American Nest Record Cards Program. Until recently, however, the means for monitoring both post-fledging productivity and survivorship of landbirds were conspicuously missing from the North American program. The Monitoring Avian Productivity and Survivorship (MAPS) Program fills this need.

THE MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP PROGRAM

Background

One component of the British scheme, also recommended by the MWG (1992), is a program to monitor demographic parameters of common landbirds through constant-effort mist netting and banding during the breeding season at a network of stations. The British program, in operation since 1981, is called the Constant Effort Sites (CES) Scheme. In 1986, CES was endorsed by the BTO and became one of the cornerstones of its integrated avian biomonitoring strategy (Baillie et al. 1986). By 1990, more than 100 constant-effort sites were in operation in Great Britain (Peach and Baillie 1991). Other constant-effort banding projects are being established in Finland, France, Netherlands, and Denmark, and are being considered by ornithologists in New Zealand, Australia, Spain, and Israel.

The value of constant-effort mist netting at even a single station was confirmed in a now 17-year on-going study at the Point Reyes Bird Observatory's Palomarin Field Station, in central coastal California. Data from this study elucidated the relationship between landbird productivity and annual rainfall and documented massive and unprecedented reproductive failures of most landbird species in 1986 (DeSante and Geupel 1987). This study showed that the apparent driving force behind much of the annual variation in the number of young birds produced at Palomarin between 1976 and 1985 was the amount of annual (winter) rainfall that occurred in this Mediterranean ecosystem. In particular, numbers of young birds captured peaked in years of relatively average rainfall, and decreased as annual rainfall either increased or decreased from average levels. Productivity thus tended to be lowest in both very dry years (the 1976-1977 drought) and in very wet years (the 1983 El Nino Southern Oscillation). Determining whether this relationship of maximum productivity at average weather conditions holds in other landbird communities and in other areas of the continent is especially important.

In 1989, The Institute for Bird Populations initiated MAPS, a cooperative effort among federal, state, and private agencies and organizations and among individual bird banders in North America to operate a continent-wide network of constant-effort mist-netting stations to capture and band landbirds during the breeding season. Patterned after the successful British CES Scheme, MAPS has been endorsed recently by both the MWG (1992) and the Bird Banding Laboratory as a potentially important tool for determining changes in productivity and survivorship of landbirds. As a follow-up to these endorsements, a four-year pilot project (1992-1995) was approved by the USFWS to evaluate the utility and effectiveness of MAPS in both the Northeast and Northwest.

Now in its fourth year, MAPS has expanded from 17 stations in 1989 and 38 stations in 1990 (DeSante 1991, 1992) to 64 stations in 1991. In 1992, The Institute for Bird Populations established partnerships with: Regions 1 and 6 of the USDA Forest Service to establish and operate 42 MAPS stations in Oregon, Washington, and Montana (six stations on each of seven national forests); Denali National Park to establish five stations there; Shenandoah National Park for six stations; Kings Canyon National Park for two stations; Yosemite National Park for one station; and the Department of the Navy (through the National Fish and Wildlife Foundation) for five stations on three Navy installations in Maryland and Virginia. More than 100 additional stations were operated independently by various governmental and non-governmental agencies and organizations and by individual bird banders, so that about 165 stations were operated across the continent in 1992.

Objectives and Goals

The primary objective of MAPS is to provide long-term population and demographic information on target landbird species that can be used to: (a) aid in establishing thresholds and trigger points to notify appropriate agencies and organizations of the need for further research and/or management actions; (b) aid in identifying stage(s) in life cycles at which changes in population dynamics are taking place; and (c) assist in identifying causes of population changes.

A second objective is to provide a means whereby the public can participate directly in conservation efforts for landbirds. Specifically, MAPS provides a rigorous framework that encourages bird banders to collect capture-recapture data in a manner that can be used to provide critical information on landbird survivorship and productivity.

The third objective is to use public lands as critical locations for large-scale, long-term monitoring efforts. National forests, national parks, and other federal and state lands can provide one subset of ideal sites for a network of stations because they provide large areas of diverse and often pristine ecosystems that promise to remain accessible for long-term monitoring. MAPS thus aims to forge cooperative partnerships among federal and state agencies, avian researchers, and bird banders by facilitating the operation of MAPS stations on public lands. Establishment of such partnerships underlies the basic strategy of Partners in Flight.

The specific, narrowly-defined goals of MAPS are to:

a. Provide annual regional indices of adult population size and post-fledging productivity for 15 to 25 target species in each region from analysis of numbers and proportions of adult and young birds captured at a network of constant-effort mist-netting stations operated during the breeding season.
b. Provide annual regional estimates of adult survivorship, adult population size, and recruitment into the adult population for about 12 target species in each region from analysis of capture-recapture data gathered at the network of constant-effort mist-netting and banding stations.
c. Provide independent, annual regional indices of adult population size for target (and other associated) species in each region from analysis of point count data taken in the vicinity of the mist-netting stations.

These indices and estimates are used to determine annual changes and longer-term trends in population and demographic parameters of target species in each region. They also will be used in statistical models to identify and describe interrelationships between population and demographic variables and readily measured environmental co-variates. Population and demographic indices and estimates can also be used to refine current population models and to develop new models for population processes. Finally, data from various stations will be analyzed in a comparative manner to provide information regarding the effects of habitat type and management practice on population and demographic parameters of target species.

Design of the Program and Analysis of Data

To facilitate the analysis of MAPS data, North America (north of Mexico) was divided into eight major regions (Fig. 1) based on both biogeographic and meteorological considerations, including the apparent east-west periodicity of the jet stream. Political boundaries were ignored in forming these regions, but may be important for management-related aspects of landbird

Figure 1. — Map showing eight major regions into which North America is divided for MAPS.

conservation. If so, MAPS data can be analyzed easily using different regional boundaries. The long-term goal for MAPS is the operation of at least 260 stations across North America, with at least 40 stations in each of the six more southerly regions of the continent and at least 20 stations in Alaska (none is expected to be established in the Boreal and Arctic Canada region).

A major assumption of MAPS (and of the British CES effort) is that significant changes in population and demographic parameters between a given pair of years or over a longer time period tend to be similar for a given species at many banding stations within a region. This is because seasonal weather in a given year generally tends to be rather uniform within a region, although it often varies considerably among regions. This assumption is testable using constant-effort mist-netting data and, in fact, has been verified in Great Britain by CES data (Baillie et al. 1986, Peach and Baillie 1991). If this assumption is also verified by MAPS data in North America, then data on a given species can be combined from all stations in the region, thereby greatly increasing sample sizes and precision of the resulting population and demographic indices and estimates.

Indices of post-fledging productivity for each target species are obtained from the number and proportion of young birds captured at each station. Annual regional changes in these indices are inferred statistically from confidence intervals calculated from the standard errors of the mean percentage changes for target species captured at several stations within the region. This analytical method has been applied successfully to constant-effort mist-netting data generated by the CES Scheme (Baillie et al. 1986).

Estimates of adult survival rate for each target species are obtained from modified Jolly-Seber capture-recapture analyses. Major advances have been made in recent years in both theory and application of data from capture-recapture experiments (Pollock et al. 1990, Lebreton et al. 1992). Recent advances provide for increased precision in the resulting estimates, allow age and/or time dependence to be built into survival and capture rates, permit some parameters to be set equal to fixed *a priori* values, and allow any of the parameters to be related to external variables (Clobert et al. 1987). This approach has been applied successfully to capture-recapture data from Great Tits (*Parus major*) and Common Black-headed Gulls (*Larus ridibundus*) in Europe (Clobert et al. 1987) and from Sedge Warblers (*Acrocephalus schoenobaenus*) and Reed Warblers (*A. scirpaceus*) in Britain (Peach et al. 1991).

Analyses of MAPS data do not provide direct survival estimates for young birds during their first year of life. First-year survivorship may be a key factor in the population dynamics of some landbirds, but because first-year landbirds have poorly-known, but typically quite large, natal dispersal distances, it is virtually impossible to determine first-year survival rates from capture-recapture techniques alone. However, by simultaneously using recruitment estimates (obtained from capture-recapture analysis) and indices of post-fledging productivity, it may be possible to infer useful information about first-year survivorship.

The MAPS program provides three measures for adult population size. The first is an index obtained simply from the number of adult birds captured. This index has been shown to correlate well with density estimates obtained from spot-mapping color-banded individuals of several species of coastal scrub birds (M. Silkey, G. R. Geupel, S. J. Dougill, and N. Nur, unpubl. data) and with density estimates obtained from the Common Bird Census for several species of British birds (Peach 1991). The second is an estimate obtained from capture-recapture analysis that is expected to correlate closely with the above index since it is derived from the same data. The third is an independent index obtained from point count data collected in the vicinity of the mist-netting stations. Comparison of results obtained from each method will provide valuable information about the efficacy of each.

Analyses of 1989-1991 MAPS data have identified suites of target species for both the Northeast and Northwest Regions that can be captured in adequate numbers and at an adequate proportion of the stations in the region to provide sufficiently precise indices and estimates for various population and demographic parameters. These target species include a mix of both Neotropical migrant and temperate-zone wintering species. Target species for the Northeast are Black-capped Chickadee (*Parus atricapillus*), Veery (*Catharus fuscescens*), Wood Thrush (*Hylocichla mustelina*), American Robin (*Turdus migratorius*), Gray Catbird (*Dumetella carolinensis*), Red-eyed Vireo (*Vireo olivaceus*), Yellow Warbler (*Dendroica petechia*), American Redstart (*Setophaga ruticilla*), Ovenbird (*Seiurus aurocapillus*), Common Yellowthroat (*Geothlypis trichas*), Northern Cardinal (*Cardinalis cardinalis*), and Song Sparrow (*Melospiza melodia*). Target species for the Northwest are Dusky Flycatcher (*Empidonax oberholseri*), Western Flycatcher complex (*E. difficilis* and *E. occidentalis*), Swainson's Thrush (*Catharus ustulatus*), American Robin, Warbling Vireo (*Vireo gilvus*), Orange-crowned Warbler (*Vermivora celata*), Yellow Warbler, MacGillivray's Warbler (*Oporornis tolmiei*), Wilson's Warbler (*Wilsonia pusilla*), Song Sparrow, Lincoln's Sparrow (*Melospiza lincolnii*), and Dark-eyed Junco (*Junco hyemalis*). As the number of stations contributing to MAPS grows, additional target species may be added to this list.

METHODOLOGY FOR ESTABLISHING AND OPERATING A MAPS STATION

Because a major objective of MAPS is to obtain estimates of annual variations in productivity and survivorship, standardization from year-to-year and continuation for a number of years at each station are critical. Continuity is also important for minimizing fluctuations in population parameters that may result from year-to-year changes in geographical composition of the sample of stations. The protocol summarized here is in complete agreement with that described in Ralph et al. (in press).

Siting a MAPS Station

Two different spatial scales must be considered when siting a MAPS station: first, the large-scale landscape or general region within which the station is located, and second, the smaller-scale habitat where the station is actually sited. The large-scale landscape should be representative of the general habitat and/or management practice for which local information is desired. The specific site location should adhere to the following requirements: (1) a location that will allow long-term operation, at least five to ten years; (2) a location that will permit capture of substantial numbers of many common species of landbirds breeding in the area, including, in the Northeast or Northwest, at least one of the above-mentioned target species; (3) a location where floating, transient, and migrant birds do not tend to concentrate (so that derived population and demographic estimates will best reflect actual productivity and survivorship parameters); (4) a location in (or on the edge of) upland woodland or forest habitat, lowland forest or riparian habitat, or scrub habitat (because the target species tend to be forest- or scrub-inhabiting species); and (5) a location in (or on the edge of) a relatively mature habitat or a habitat held in a lower successional stage by active management (because population and demographic parameters are likely to be highly sensitive to successional changes in the habitat sampled). Managed, successional-stage locations are particularly desirable for monitoring species that inhabit scrub and/or second growth habitats.

Number, Density, and Distribution of Net Sites at Each Station

The number of nets should be the maximum number that can be operated safely and efficiently given available personnel. Thus, station operators should only establish the number of nets they will be able to operate in a standardized manner over the long term. We suggest that about ten 12-meter mist nets might be the optimal number that can be operated at a single station by one or two people. With more people and fewer birds, 15 or even 20 nets might be operated. With fewer people and more birds, only five or six nets might be operated. It is unlikely that useful data can be obtained from a station that operates fewer than five nets; thus, five is recommended as the minimum number of nets that may be operated at any given station.

Size of the study area covered by nets and net density are important variables affecting precision of the results obtained from capture-recapture analyses. Area covered by nets will affect the number of different individuals captured, thus the population size sampled. Net density will affect capture probability which is defined as the conditional probability of capturing a bird in any one year, given that it is still alive in that year. Spreading nets as widely as possible will tend to increase the number of territories intersected, thus the population size sampled, but will tend to decrease capture probability for the birds on any single territory, and vice versa. Thus, there must be an optimal intermediate density of nets that will maximize precision by simultaneously optimizing both capture probability and population size sampled. Furthermore, this optimal density may vary from species to species and from station to station depending upon average densities and territory sizes of various species.

Analyses of 1989-1991 MAPS data indicated that stations that used about ten nets and captured large numbers of birds while producing high capture probabilities operated with net densities of about one to two nets per hectare. We suggest optimal net density is about 1.25 to 1.5 nets per hectare. Thus, ten nets should be placed in a study area of about seven or eight hectares (about 17 to 20 acres). This is predicated on the ability of station operators to run the nets safely. Nets should be close enough to each other that a person can visit all net locations within about 10-15 minutes walking time if no birds are caught. This can easily be accomplished on relatively flat terrain with ten nets covering about seven or eight hectares. On steep or rough terrain with difficult walking, nets should be closer together and the area covered less.

Nets should be placed opportunistically at sites where target species can be captured efficiently, such as brushy portions of wooded areas, forest breaks or edges, and near water. Establishment of net sites at a station must strike a balance between conflicting needs of capturing substantial numbers of breeding birds and their young, and of not capturing large numbers of migrant, floating, and transient birds. To optimize both number of birds captured and capture probabilities, nets should be placed relatively uniformly over the available habitat at each station. Because all net sites should be kept constant throughout all years of operation, new stations must be set up carefully.

Net Operation

It is strongly recommended that all MAPS nets be 12-meter, 30-mm mesh, four-tier, black, tethered, nylon mist nets. Nets may be stacked two-high at any given site, provided at least five to ten sites are established. Each 12-meter net operated for one hour, however, should be counted as 1.0 net-hour. If 6-meter nets are used, their operation for one hour should be counted as 0.5 net-hour. Although net size, mesh, stacking, color, material and source are ultimately the prerogative of each station operator, these variables must be standardized for each net site at each station. Tape-recorded playbacks of birds' calls or songs, and the use of bait or water to lure birds to net sites are not permitted because they make standardization among stations impossible.

The breeding season, in general, is divided into twelve 10-day periods from May 1 through August 28. Each station should be operated for all consecutive 10-day periods beginning with the first period when transient or migrant individuals of the locally-breeding species are no longer passing through the area, and continuing until substantial numbers of fall migrant individuals of the locally-breeding species begin to inundate the area. The specific 10-day periods of operation will vary, therefore, from station to station depending on timing of the breeding season at each station. The number and timing of 10-day periods, however, should be held constant at each station for all years.

It is important not to begin operation of a MAPS station before spring migrant individuals of target species have finished moving through the area because such individuals will bias survivorship and productivity estimates. In general, stations located in mid-latitudes of the United States should begin operation during Period 3, May 21-30. Stations in more northerly states and southern Canada should begin in Period 4, May 31-June 9, while far northerly stations may not want to begin until Period 5, June 10-19. Stations in more southerly states should, in general, begin in Period 2, May 11-20, while only those stations in extreme southern U.S. should begin in Period 1, May 1-10 (or earlier). It is not so important to stop the operation in late summer before fall migrants begin passing through, because data from these periods can be eliminated after the fact. This is because very few, if any, breeding adults are captured late in the season that were not already captured earlier in the season. This is not the case early in the season when most breeding adults are captured and when net-avoidance by adults can become an issue.

Because of possible net-avoidance, it is important that MAPS net sites not be operated before the start of MAPS data collection, nor be operated on non-MAPS days during the MAPS data collection period. This is because locally-breeding adults of a given species are often the first individuals to arrive at a location and, if captured before the start of MAPS data collection (or on non-MAPS days), may learn to avoid nets later during the MAPS data collection period. Capture-recapture analysis of 1989-1991 MAPS data suggested that apparent survival rates and capture probabilities may have been lowered substantially for stations that operated MAPS nets prior to the start of the MAPS data collection period. As a result, banders or agencies that wish to operate MAPS and a migration monitoring program at the same location should use different net sites for each program.

It is recommended that nets be operated for only one day during each 10-day period and the interval between dates of operation in consecutive 10-day periods normally be at least six days. While increasing the number of days of operation in each 10-day period will tend to increase resulting capture probabilities, pay-off from this increase seem to fall off rapidly after two or three days of operation. Although two days per 10-day period may offer the best return on capture probability per effort spent, the two days in each 10-day period will certainly be better spent by operating two different stations for one day each and thereby effectively doubling the total number of birds handled. Thus, if personnel at a given station have the ability to operate on multiple days in each 10-day period, we strongly recommend they operate multiple stations for one day each. Long-established stations that must operate on more than one day per 10-day period must keep both timing of their operation and total effort constant from year to year.

The number of nets operated and their location and timing should, if possible, be standardized for all days of operation, but must be kept constant from year to year at each station. The first net should be opened beginning at a specified time relative to local sunrise or the clock, and a standardized route should be followed in opening the nets. Nets should be closed in the same order they were opened, beginning at a specified time after the first net was opened. We recommend opening the first net at about local sunrise and running the nets for about six hours during each day of operation. If ten net-sites were operated and each net site contained one 12-meter net, a total of 60 net-hours would be accumulated during each day of operation. At staions in hot climates, it may be necessary to close nets earlier than six hours after opening. Nets should not be operated if average wind speed exceeds ten knots or gusts exceed 20 knots, or if other weather variables (e.g., precipitation, extreme heat or cold) are likely to endanger captured birds. If nets are closed early or opened late (relative to the station standard) and more than half of a normal day's operation is lost, operators should try to recover the missing hours on another day within the same 10-day period. If the missing hours amounted to less than half of a normal day's operation, making up the missing hours is not recommended.

Determination of Breeding Species

Including capture data for a species from stations where it is not a summer resident and attempting to breed will both bias and lower the precision of survivorship estimates from capture-recapture analyses. It is important, therefore, to include data on a species only from those stations where the species is actually a breeding summer resident. This does not mean that species that do not breed in the study area should not be banded, but rather that each station must submit a list of species that are actually resident and probably breeding in the study area. This list should be compiled like a Breeding Bird Atlas, that is, by gathering anecdotal information concerning the breeding and residency status of the species (i.e., nest found; adult seen carrying nesting material, food, or fecal sacs; male singing on territory throughout the breeding season, etc.). This information can be gathered during the course of normal banding and point count operations and no special effort should be needed to verify breeding in most cases.

Collection of Banding Data

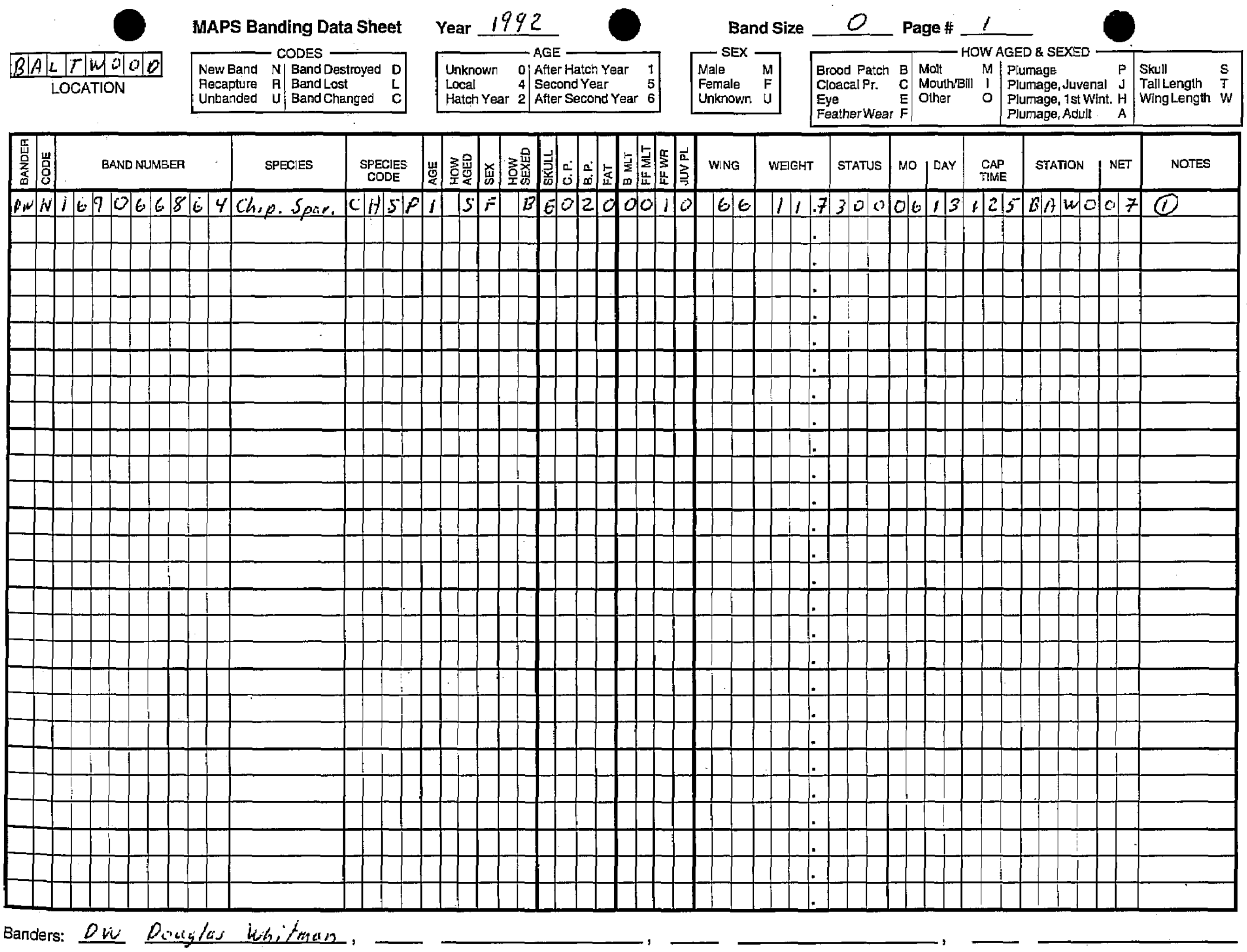
All birds captured, including recaptures, must be identified to species and correctly aged, if possible, by the extent of skull pneumatization and/or other appropriate plumage, mensural or molt characters (Bird Banding Offices 1977, Pyle et al. 1987). If unbanded, they also must be banded with a U.S. Fish and Wildlife Service numbered aluminum band.

The following data must be taken on all birds captured, including recaptures: capture code (e.g., newly banded, recaptured, band replaced); date; time of capture; net site; band number; species; age; how aged; sex; how sexed. Information on capture time and net site will allow screening of data taken at non-standardized times or locations. Information on how aged and how sexed will allow screening of improperly aged or sexed birds. It is also highly recommended that extent of skull pneumatization, breeding condition of adults (presence or absence of a cloacal protuberance or brood patch), extent of juvenal plumage in young birds, extent of body and flight feather molt, extent of primary feather wear, and wing chord also be recorded. These data are used in verification programs to assure accuracy of species, age, and sex determinations. Other data, such as weight, fat content, and tail length, may also be taken but are not required. All data should be taken according to standardized guidelines using standardized codes (Ralph et al. in press), and should be recorded on standardized banding data sheets (Fig. 2). All personnel should be required to use a binocular magnifier or other form of optical magnification to examine skull pneumatization and to read band numbers.

In addition to capture data described above, station operators are required to record dates and timing of operation, number of nets operated, and total net-hours each day, and total numbers of newly banded and recaptured birds of each species in each 10-day period.

Collection of Point Count Data

To provide additional information on population sizes of birds at each station and to sample species not captured efficiently by mist nets, a series of standardized point counts should be conducted along a route following the rough outline of a rectilinear grid centered on the constant-effort mist-netting study area. All participating MAPS stations are strongly encouraged to conduct these point counts, but their completion is not an absolute requirement for the operation of a MAPS station.



MAPS Banding Data Sheet Year 1992 Band Size 0 Page # 1

LOCATION: BALTWOOD

CODES: New Band N, Recapture R, Unbanded U, Band Destroyed D, Band Lost L, Band Changed C

AGE: Unknown 0, Local 4, Hatch Year 2, After Hatch Year 1, Second Year 5, After Second Year 6

SEX: Male M, Female F, Unknown U

HOW AGED & SEXED: Brood Patch B, Cloacal Pr. C, Eye E, Feather Wear F, Molt M, Mouth/Bill I, Other O, Plumage P, Plumage, Juvenal J, Plumage, 1st Wint. H, Plumage, Adult A, Skull S, Tail Length T, Wing Length W

BANDER	CODE	BAND NUMBER	SPECIES	SPECIES CODE	AGE	HOW AGED	SEX	HOW SEXED	SKULL	C.P.	B.P.	FAT	B MLT	FF MLT	FF WR	JUV PL	WING	WEIGHT	STATUS	MO	DAY	CAP TIME	STATION	NET	NOTES
PW	N	169066864	Chip. Spar.	CHSP	1	S	F	B	6	0	2	0	0	0	1	0	66	11.7	300	06	13	125	BAWO	07	①

Banders: DW Douglas Whitman, ______ ______, ______ ______, ______ ______

Figure 2. — Sample MAPS Banding Data Sheet with the first line of data filled out.

The methodology for these point counts follows guidelines recommended at the symposium and workshop on point counts held at the Patuxent Wildlife Research Center in November 1991 and summarized by Ralph et al. (in press). These guidelines call for counting at 9 to 12 points spaced at least 75 (preferably about 150) meters apart for either a 5- or 10-minute count period, and replication of these points three or four times during the first three or four 10-day periods of the season.

Counting should commence at about local sunrise. Because 10 or 15 minutes will be required for each count (assuming about 5 minutes walking time between points and 5 or 10 minutes counting time at each point), the series of 9 to 12 counts will take between one and one-half and three hours to complete. The starting point on subsequent replications should be varied so that each part of the census area will be counted, on average, at the same time of morning. The exact location of points, order of visiting the points, and order of replication, however, should remain constant from year to year.

All individual adult birds seen or heard for unlimited distances from each point should be tallied, although individuals already counted at previous points should be indicated as such. Care should be taken not to tally the same individual twice at the same point. Individuals should be tallied separately for distances from the point of less than 50 meters and greater than 50 meters and all flyovers should also be tallied separately.

Collection of Habitat Mapping Data

Type and structure of vegetation at a station can affect number of breeding birds present, productivity, and survivorship, as well as the efficiency with which birds can be monitored by mist nets. Because changes in vegetation at a station can cause changes in population and demographic parameters, standardized habitat maps and descriptions must be prepared that will identify, locate, and characterize major habitat types present in an area extending at least 100 m beyond the outermost net sites. Rough habitat maps, sketched at a scale of 1:2500 (1 cm = 25 m), should delineate boundaries of major habitat types in the study area and should show exact locations of all net sites, point counts, bodies of water, structures, roads and trails (Fig. 3).

The following information should be estimated for each habitat type identified and for an approximately 25-m-radius plot centered around each census point (Ralph et al. in press): major tree species present and approximate canopy cover and average canopy height of each species; major shrub species present and approximate cover and average height of each species; major ground cover types present (e.g. grasses, rushes, forbs, bare ground, litter, water) and approximate cover and average height (if appropriate) of each type. Maps and descriptions should be prepared each year at the time when maximum canopy and shrub covers have first been reached so that changes in vegetation can be monitored.

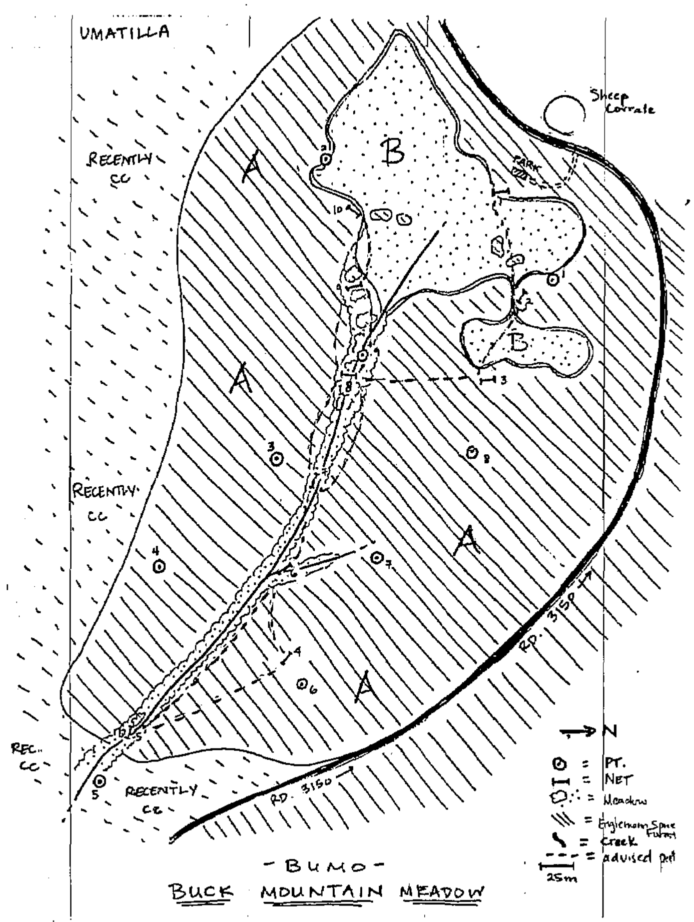


Figure 3. — Sample habitat map for Buck Mountain Meadow on the Umatilla National Forest in Oregon. Area A = Engelmann spruce forest; Area B = Meadow.

RESULTS

Constant-effort data on numbers of adult and young birds captured per 600 net-hours and proportion of young in the catch for all species combined were obtained for 1989 and 1990 from 12 MAPS stations spread across the continent (Tab. 1). Strikingly different values among stations for numbers and proportions of birds captured may relate primarily to widely differing netting regimes rather than actual differences in bird density or productivity. Many of these initial MAPS stations were bird observatories and research stations that already had long-established constant-effort mist-netting operations in place differing from recommended MAPS protocol. Despite lack of uniformity in procedures from station to station, meaningful information on annual changes in adult population size and post-fledging productivity can be extracted because operations at each station were kept constant from year to year.

Number of adults captured per 600 net-hours for all species combined increased between 1989 and 1990 at five stations and decreased at seven. Most changes were relatively small,

Table 1. — **Changes between 1989 and 1990 in number of birds captured and in proportion of young in the catch for all species combined at twelve MAPS stations across North America.**

Station[1]	Adults 1989	Adults 1990	Adults Percent change	Young 1989	Young 1990	Young Percent change	Proportion of young 1989	Proportion of young 1990	Change in proportion of young
	Number of birds captured per 600 net-hours								
Northwest									
A	103.7	75.9	-26.8	51.9	33.3	-35.8	.333	.305	-.028
B	306.7	293.3	- 4.3	360.0	190.0	-47.2	.540	.393	-.147
C	20.9	18.4	-12.0	36.0	36.1	0.4	.633	.663	.030
Southwest									
D	32.4	28.4	-12.3	37.8	38.8	2.7	.538	.577	.072
North-central									
E	150.2	152.8	1.7	114.6	129.9	13.4	.433	.460	.062
F	97.7	102.6	5.0	34.6	13.9	-59.8	.262	.119	-.143
G	53.0	57.1	7.7	24.3	7.4	-69.4	.314	.115	-.199
H	113.7	88.3	-22.3	73.6	60.0	-18.4	.393	.404	.028
South-central									
I	19.4	22.9	18.2	18.2	18.2	0.0	.484	.443	-.041
Northeast									
J	50.0	46.4	- 7.1	6.8	4.3	-37.4	.120	.085	-.035
K	80.0	63.6	-20.5	17.9	3.6	-80.0	.182	.053	-.129
Southeast									
L	75.3	93.2	23.8	29.2	13.3	-54.4	.279	.125	-.154
Total	1102.9	1043.0	- 5.4	804.8	549.0	-31.8	.422	.345	-.077
SE[2]			4.3			10.4*			.066

[1] Stations: A. Seventeen Mile Creek, MT, mixed coniferous forest, montane meadow;, B. Siskiyou National Forest, OR, mixed conifer-hardwood forest, montane meadow; C. Point Reyes Bird Observatory, CA, mixed evergreen forest, coastal scrub; D. Coyote Creek Riparian Station, CA, willow riparian woodland, scrub; E. Beaverhill Bird Observatory, AB, aspen parkland; F. Crow Wing, MN, northern hardwood forest, riparian; G. Schlitz Audubon Center, WI, mixed wooded "islands" in grassland; H. Rogers City, MI, aspen-cedar woodland, brush; I. Driftwood Wildlife Association, TX, oak-juniper and riparian woodlands. J. Hubbard Brook Experimental Forest, NH, northern hardwood forest; K. Mount Moosilauke, NH, northern hardwood forest; L. Shawnee National Forest, IL, eastern deciduous forest.

[2] Standard error of the change. See Tab. 2 for how calculated.

* Statistically significant: P < 0.02

generally less than about 25%. The overall combined change in number of adults captured was a non-significant decrease of only 5.4% between 1989 and 1990 (P>0.2).

In contrast, however, number of young birds captured per 600 net-hours for all species combined decreased substantially between 1989 and 1990 across most of the continent. Decreases ranging from 18.4% to 80.0% were recorded at eight of 12 stations, while increases of less than 13.4% were recorded at three stations and no change was recorded at one. The overall combined decrease of 31.8% in number of young birds captured was significant (P<0.2). This decrease in productivity may have been particularly severe in the Northeast region where the number of young captured at two constant-effort stations declined by 68.2%.

This same general result was evident in changes between 1989 and 1990 in proportion of young for all species combined, which decreased at eight stations and increased at four. The overall combined change in proportion of young was a decrease of 0.077 young from 0.422 young in 1989 to 0.345 in 1990. This overall trend was not significant (P>0.2), however, possibly because of the small sample size of just 12 stations.

We suggest, however, that the significant decrease in number of young birds captured and the decreasing trend in proportion of young in the catch for all species combined may represent a real and widespread decline in productivity in 1990 compared to 1989. This productivity decrease may have been caused by extremes in weather conditions that characterized spring and early summer of 1990 all across North America, when severe droughts were recorded over much of the West and locally excessive rainfall occurred over much of the East.

The decrease in productivity in 1990 was followed by a significant decrease (P<0.02) of 19.3% in 1991 adult population size for all species combined at ten constant-effort stations in the Northeast (Tab. 2). Moreover, nine of 12 target species in the Northeast independently showed decreases in adult population size in 1991; four of these (Black-capped Chickadee, Wood Thrush, Gray Catbird and Common Yellowthroat) showed significant (P<0.05 to P<0.001) decreases that ranged from 25.5 to 58.7%. Because these four species have widely differing winter ranges and winter habitat preferences (one is a temperate-wintering permanent resident, two are scrub-wintering Neotropical migrants, and one is a forest-wintering Neotropical migrant), we suggest decreased adult population sizes in the Northeast in 1991 may have resulted directly from low productivity in 1990 rather than from low adult survivorship during the winter of 1990-91. These data support a growing body of evidence on single species and local avian communities suggesting that productivity in a given year can have a major effect on population sizes and population dynamics in subsequent years (Holmes et al. 1991, 1992, Sherry and Holmes 1992). The MAPS data, however, are among the first in North America to suggest that observed decreases in adult population size for many landbird species over a large geographical area could be caused by decreases in productivity in the preceding year.

Changes between 1990 and 1991 in number of young captured in the Northeast (Tab. 2) varied greatly among 12 target species with 6 species increasing (Gray Catbird increased significantly) and 6 decreasing (Black-capped Chickadee decreased significantly). Number of young captured for all species combined showed a non-significant decrease of 2.7%. Productivity, as determined by proportion of young in the catch, increased from 1990 to 1991 for eight species (Wood Thrush increased significantly) and decreased for four species. The proportion of young for all species combined increased by 0.045

Table 2. — Changes between 1990 and 1991 in number of birds captured and in proportion of young in the catch at ten MAPS stations in the Northeast Region.

	Number of birds captured per 600 net-hours														
	Adults					Young						Proportion of young			
Spec[1]	Num sta[2]	1990	1991	% change	SE[3]	Num sta	1990	1991	% change	SE[3]	Num sta	1990	1991	Change in prop of young	SE[3]
BCCH	10	85.8	35.9	-58.2	6.5***	9	62.0	35.7	-42.4	16.7*	9	.422	.499	.076	.097
VEER	8	65.6	66.1	0.7	15.3	5	29.7	19.3	-34.9	31.9	7	.320	.226	-.094	.145
WOTH	8	50.0	20.6	-58.7	14.3**	5	1.2	11.8	850.7	1055.0	7	.024	.367	.342	.079*
AMRO	7	61.0	48.1	-21.3	14.0	7	32.1	14.2	-55.6	23.7	8	.344	.229	-.116	.119
GRCA	8	240.4	179.1	-25.5	9.9*	8	116.6	157.2	34.8	9.7**	8	.327	.467	.141	.092
REVI	8	42.6	45.8	7.6	35.8	5	12.5	20.8	66.0	51.9	7	.236	.312	.076	.122
YEWA	7	86.8	66.3	-23.6	15.3	5	233.6	258.5	10.6	7.4	6	.749	.796	.047	.101
AMRE	7	25.8	25.3	- 1.8	10.1	7	23.2	10.4	-55.1	31.7	8	.473	.291	-.182	.148
OVEN	7	31.0	39.2	26.6	26.4	7	24.0	37.7	56.6	27.4	8	.437	.490	.053	.082
COYE	9	95.7	47.0	-50.9	12.3**	8	68.1	55.8	-18.1	14.2	8	.424	.543	.120	.210
NOCA	6	19.3	18.3	- 5.1	25.0	6	7.2	12.9	79.3	126.4	6	.215	.413	.197	.173
SOSP	7	66.0	54.6	-17.3	17.0	7	116.2	77.1	-33.6	18.6	6	.647	.586	-.062	.081
All sp.	10	1538.3	1241.6	-19.3	6.1*	10	997.0	970.0	- 2.7	7.6	10	.393	.439	.045	.135

[1] Target Species: BCCH - Black-capped Chickadee, VEER - Veery, WOTH - Wood Thrush, AMRO - American Robin, GRCA - Gray Catbird, REVI - Red-eyed Vireo, YEWA - Yellow Warbler, AMRE - American Redstart, OVEN - Ovenbird, COYE - Common Yellowthroat, NOCA - Northern Cardinal, SOSP - Song Sparrow.

[2] Number of stations (out of the total of 10) where that age class of that species was captured.

[3] Standard error of the change in number of adult (or young) birds was determined from Baillie et al. (1986) as:

$$SE(r_i) = \sqrt{\left(n\sum_{j=1}^{n}(d_{ij} - r_i a_{(i-1)j})^2\right) / \left((n-1)\left(\sum_{j=1}^{n} a_{(i-1)j}\right)^2\right)} \text{ where}$$

$$r_i = (a_i - a_{(i-1)})/a_{(i-1)} \text{ and } d_{ij} = a_{ij} - a_{(i-1)j} \text{ and where}$$

a_i is the number of adult birds captured (per 600 net hours) at all stations in year i, a_{ij} is the number of adult birds captured (per 600 net hours) at the jth station, and n is the number of stations.

Standard error of the change in proportion of young determined from Baillie et al. (1986) as:

$$SE(V_i - V_{(i-1)}) = \sqrt{(SE(V_i))^2 + (SE(V_{(i-1)}))^2} \text{ where}$$

$$SE(V_i) = \sqrt{\left(n\left(\sum_{j=1}^{n} b_{ij}^2 - 2V_i\sum_{j=1}^{n} b_{ij}(a_{ij}+b_{ij}) + V_i^2\sum_{j=1}^{n}(a_{ij}+b_{ij})^2\right)\right) / \left((n-1)\left(\sum_{j=1}^{n}(a_{ij}+b_{ij})\right)^2\right)} \text{ where}$$

$V_i = b_i/(a_i+b_i)$ and where

b_i is the number of young birds captured (per 600 net hours) at all stations in year i, b_{ij} is the number of young birds captured (per 600 net hours) at the jth station, and a_i, a_{ij}, and n are as defined above.

* P < 0.05, ** P < 0.01, *** P < 0.001.

from 0.393 to 0.439. Although this increase was not significant, these data suggested some 1991 recovery from low 1990 productivity may have occurred in the Northeast.

In contrast to the Northeast, number of adults captured at six constant-effort stations in the Northwest in 1991 increased from 1990 for nine of 12 target species and all species combined, although none of the changes was significant (Tab. 3). Number of young captured at six Northwest stations, however, decreased for seven of 12 target species and all species combined. Decreases for Western Flycatcher and Oregon Junco were significant (P). Proportion of young in the catch also decreased at six Northwest stations for nine of 12 target species and all species combined. The decrease for Oregon Junco was significant (P<0.05). This trend toward decreased productivity in 1991 may have been caused by unusually cool summer weather that characterized much of western North America, especially in higher elevation interior areas. Thus, changes in population and demographic parameters from 1990 to 1991 for species in the Northwest were opposite those in the Northeast.

Because three years of capture-recapture data are required to calculate estimates for capture probability, adult survivorship, and adult population size, and four years of data are required for an estmate for recruitment into the adult population (Pollock et al. 1990), little information regarding these parameters is yet available from the MAPS program. Three years of capture-recapture data from the 1989-1991 MAPS program were available, however, for eight stations across the country, three in the Northwest, three in the North-Central, and one each in the Northeast and South-Central regions. We used the capture histories of each bird banded at the station and the program SURVIV to calculate maximum likelihood estimates for both 1990 capture probability and 1989 to 1990 survival rate for select species from each of these stations and for regional combinations of stations. Six target species captured at two stations operated according to strict MAPS protocol averaged about 0.3 for 1990 capture probability and 0.5 for 1989 to 1990 adult survival rate and produced an annual return rate of about 0.15. These values are comparable to those calculated from longer term capture-recapture studies of passerine birds (Loery et al. 1987, Pollock et al. 1990).

Because of small sample sizes and a very small number of stations, estimates of capture and survival probabilities, as expected, had very little precision. Coefficients of variation (CVs) for 1990 capture probability and 1989 to 1990 survival rate estimates averaged 96% and 82% respectively. Capture rate and return rate data from various species banded at many additional stations operated in 1990 and 1991 (but not 1989), however, suggest that capture probability and adult survivorship estimates with adequate precision (a CV of 20% for the mid-year annual estimate or a CV of about 5% for the mean annual estimate in a ten-year study) will be obtained for 12 to 18 species by using a network of about 40 MAPS stations in a region. Based on these analyses, 12 target species each were listed for the Northeast and Northwest.

Table 3. — Changes between 1990 and 1991 in number of birds captured and in proportion of young in the catch at six MAPS stations in the Northwest Region.

	Number of birds captured per 600 net-hours														
	Adults					Young						Proportion of young			
Spec[1]	Num sta[2]	1990	1991	% change	SE[3]	Num sta	1990	1991	% change	SE[3]	Num sta	1990	1991	Change in prop of young	SE[3]
DUFL	2	20.2	21.4	6.1	16.5	1	11.7	4.3	-63.0	----	1	.368	.180	-.187	----
WEFL	4	12.7	17.9	40.7	16.3	4	21.0	11.6	-45.0	9.4*	4	.624	.393	-.231	.199
SWTH	6	20.6	27.6	33.8	61.3	4	12.9	13.5	4.8	18.5	6	.385	.329	-.056	.128
AMRO	6	13.4	14.5	8.1	43.9	2	1.9	0.1	-94.8	10.5	5	.144	.007	-.137	.106
WAVI	5	78.1	72.0	- 7.8	10.8	4	29.3	28.1	- 4.1	4.1	4	.283	.281	-.002	.048
OCWA	5	26.7	30.2	13.2	20.3	4	98.2	75.9	-22.7	12.8	4	.786	.733	-.053	.213
YEWA	5	12.5	12.7	1.3	33.1	5	5.2	7.6	44.6	79.0	5	.295	.374	.079	.130
MGWA	4	74.4	60.3	-19.0	22.2	4	51.1	49.3	- 3.5	25.7	3	.431	.450	.019	.099
WIWA	4	14.7	23.5	59.1	90.7	4	9.4	13.8	46.6	64.9	4	.390	.371	-.019	.213
SOSP	5	29.3	23.0	-21.3	28.9	5	53.5	62.7	17.3	20.5	5	.646	.731	.085	.117
LISP	3	9.6	11.8	23.1	16.0	3	4.1	4.8	17.6	40.5	2	.295	.289	-.007	.115
DEJU	5	25.9	36.6	41.5	23.0	4	44.0	24.4	-44.6	10.1*	4	.630	.418	-.212	.005*
All sp.	6	740.7	871.5	17.7	14.7	6	574.3	542.4	- 5.6	18.2	6	.437	.384	-.053	.007

[1] Target Species: DUFL - Dusky Flycatcher, WEFL - Western Flycatcher (complex), SWTH - Swainson's Thrush, AMRO - American Robin, WAVI- Warbling Vireo, OCWA - Orange-crowned Warbler, YEWA - Yellow Warbler, MGWA - MacGillivray's Warbler, WIWA - Wilson's Warbler, SOSP - Song Sparrow, LISP - Lincoln's Sparrow, DEJU - Dark-eyed Junco.

[2] Number of stations (out of the total of six) where that age class of that species was captured.

[3] Standard error of the change. See Tab. 2 for how calculated. * P < 0.05, ** P < 0.01, *** P < 0.001.

DISCUSSION AND CONCLUSIONS

The limited number of stations established during the first three years of MAPS (17 in 1989 to 64 in 1991) was insufficient to evaluate the program's ability to detect differences in population or demographic parameters as a function of habitat type or management practice. As MAPS expands, its ability to determine habitat-specific differences will increase. About 165 stations were operated in 1992, of which about 70 were located in the Northwest. This level of effort should produce precise indices of population size and post-fledging productivity for the target species and should at least permit habitat and management relationships to be explored.

It must be conceded, however, that productivity indices derived from constant-effort mist netting and banding can never be completely habitat-specific because the dispersing young sampled are drawn from areas larger than the habitat-specific area where nets are located. Rigorous habitat-specific estimates for productivity can only be derived from a program of direct nest monitoring, such as the Breeding Biology Research Database (BBIRD) program coordinated by T. E. Martin. In some cases, however, the information of most value to managers is how productivity varies over larger areas (landscapes) subjected to differing management practices, rather than how productivity varies among specific habitat types. Constant-effort mist netting and banding is well-suited to determine some of these landscape-scale differences, provided enough stations can be established to provide valid comparisons.

Another limitation of MAPS, and of virtually all broad-scale monitoring programs, is that it is inherently suited for common, widely-distributed species rather than rare or endangered species. Because rare species are often associated with rare or declining habitats, every effort should be expended to augment MAPS by establishing additional stations in these limited habitats. Demographic data on the more common species in these habitats can be compared to data on these same species in more widespread habitats to provide some indication of the overall health of these limited habitats.

A final limitation of MAPS is that productivity data generated by constant-effort mist netting cannot be partitioned into different parts of the reproductive cycle (e.g., clutch size, egg and nestling mortality) as can data from nest monitoring. On the other hand, the index of post-fledging productivity obtained from constant-effort mist netting takes into account the sometimes severe mortality suffered by recently fledged juvenile birds both while under parental care and immediately after they become independent. These aspects of fledgling mortality cannot be detected by nest monitoring. As a result, constant-effort mist netting and banding may provide a better indicator of future recruitment than direct nest monitoring for some species. This possibility was recently confirmed in a study of locally-fledged juvenile Wrentits, a non-migratory species, in coastal California. Post-fledging productivity of Wrentits, as determined by constant-effort mist netting and banding, was found to be highly correlated with total number of nestlings fledged each year as determined by direct nest monitoring and was actually a better indicator of future recruitment than were productivity estimates based on nest monitoring (Geupel G. R., N. Nur, and D. DeSante, unpubl. data).

An ideal integrated avian population monitoring program, therefore, should include both constant-effort mist-netting and banding to provide a large-scale approach and to integrate post-fledging mortality into the equation, and direct nest monitoring to provide habitat-specific information on clutch size, hatching success, and fledging success. These two approaches are complementary.

The first three years of MAPS data detected regional and continental year- to-year differences in adult population size and post-fledging productivity for select target species. The data further suggest that post-fledging productivity may be highly sensitive to weather conditions prior to and during the breeding season and, in turn, may be capable of greatly influencing adult population sizes in subsequent years. These weather conditions, moreover, may exert their effects as relatively large-scale, synoptic patterns that extend over areas at least as large as the regions delineated for MAPS. It is possible that the weather extremes of 1990 that promoted low productivity over much of North America may themselves have resulted from the high global temperature that characterized 1990 (now established as the hottest year ever recorded).

Current thinking suggests that one of the most important ecological results of global warming may be a redistribution of moisture regimes such that markedly higher or lower precipitation than usual will be characteristic of most temperate zone localities. If this is the case, and if lowering of productivity by unusual weather (DeSante and Geupel 1987) is a widespread phenomenon, then years of high global temperature would also be years of notably low landbird productivity over much of the temperate zone. It is noteworthy that six of the seven warmest years on record occurred between 1981 and 1990 (Brown 1991). Perhaps documented decreases in landbirds during the past decade may be attributed at least partially to reduced productivity associated with the highly abnormal weather of these same years.

The manner in which adult survivorship and recruitment of adults are affected by such large-scale weather phenomena are only now beginning to be investigated (Peach et al. 1991). Moreover, the manner in which survivorship and recruitment factor into the dynamics of landbird populations, and the manner in which these parameters are affected by habitat characteristics and management practices, are still very uncertain. One thing is certain, however: constant-effort mist-netting and banding programs using modified Jolly-Seber analyses (e.g., Clobert et al. 1987, Lebreton et al. 1992, Peach 1992) offer the only means for obtaining broad-scale information regarding these critical survivorship and recruitment parameters. Such analyses were recently applied to breeding-season mist-netting data on Sedge Warblers in Britain (Peach et al. 1991). They found that breeding population sizes and annual adult survival rates were strongly correlated with indices of wet-season rainfall in the species' west-African, sub-Saharan winter range, indicating that winter habitat availability was probably the main factor controlling Sedge Warbler breeding population sizes in Britain during the 15-year study period, 1969-1984. Modified Jolly-Seber capture-recapture analyses of the limited data available from MAPS suggest that a fully-operational program with at least 40 stations in each of the major regions will also be capable of producing survivorship estimates with sufficient precision to provide useful, statistically powerful, predictive information.

The few data available regarding changes in demographic parameters of North American landbirds are insufficient to allow conclusions regarding either relationships between environmental or management variables and demographic parameters, or causes of population declines in Neotropical migrants. The very paucity of such data underscores the importance of continuing and expanding programs that can provide regional estimates of demographic parameters in landbirds. The data presented here suggest that MAPS can provide critically needed information on productivity and survivorship of target species that will aid in identifying stage(s) in the life cycle at which population changes are taking place and will assist in identifying causes of recently observed population decreases in landbirds. As part of an integrated avian monitoring program, MAPS should play a major role in aiding efforts to conserve avian diversity in North America. In addition, constant-effort mist netting and banding are enjoyable hands-on activities that give people a sense of empathy and empowerment in matters of avian conservation that is difficult to aquire in any other way. Moreover, the results from even a single banding station can provide rapid feedback on important biological issues.

Finally, as with so many aspects of applied ornithology, the provision of useful monitoring results must be based on a sound understanding of population processes. As pointed out by Baillie (1990), appropriate analyses of data from an integrated population monitoring scheme can form the basis for development of sound population models, particularly as statistical modelling methods capable of incorporating environmental and populational co-variates become available. In this respect, population and demographic estimates from MAPS will be useful for refining current population models and for developing new models for population processes. It is important for the development and testing of these models that several methods capable of providing population and demographic indices and estimates be implemented and compared at a series of key monitoring locations. We recommend establishing a hierarchy of monitoring efforts at several key MAPS stations that include the use of point counts, spot-mapping censuses, color marking and resighting of individual birds, constant-effort mist netting, and direct nest monitoring. In addition, research on the applicability, accuracy and interpretation of population monitoring methods and results should be included in an overall integrated population monitoring scheme. Such research could also be conducted in conjunction with key MAPS stations and Partners in Flight. In this way both the tools and the information needed to provide effective managment of Neotropical migratory landbirds can be provided.

ACKNOWLEDGEMENTS

We express our sincere apprciation to the many individuals, organizations, and agencies that have contributed data to MAPS. We thank S. Droege, J. D. Nichols, C. J. Ralph, and T. W. Sherry for many constructive comments on earlier versions of this manuscript. Financial support for MAPS has been provided by the National Fish and Wildlife Foundation, the U.S. Fish and Wildlife Service, Regions 1 and 6 of the U.S.D.A. Forest Service, the Department of Navy, Denali and Shenandoah National Parks, Yosemite Association, and Sequoia Natural History Association. This is Contribution No. 6 of The Institute for Bird Populations.

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