THE 2001 ANNUAL REPORT OF THE MONITORING AVIAN PRODUCTIVITY AND SURVIVORSHIP (MAPS) PROGRAM ON CAPE COD NATIONAL SEASHORE

David F. DeSante, Peter Pyle, and Danielle R. O'Grady

THE INSTITUTE FOR BIRD POPULATIONS
P.O. Box 1346
Point Reyes Station, CA 94956-1346

(415) 663-1436

ddesante@birdpop.org

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EXECUTIVE SUMMARY

Since 1989, The Institute for Bird Populations has coordinated the MAPS (Monitoring Avian Productivity and Survivorship) Program, a cooperative effort among public and private agencies and individual bird banders in North America, to operate a continent-wide network o constant-effort mist-netting and banding stations. The purpose of the MAPS program is to provide annual indices of adult population size and post-fledging productivity, as well as estimates of adult survivorship and recruitment into the adult population, for various landbird species. Broad-scale data on productivity and survivorship are not obtained from any other avian monitoring program in North America and are needed to provide crucial information upon which to initiate research and management actions to reverse the well documented declines in North American landbird populations. A second objective of the MAPS program is to provide standardized population and demographic data for the landbirds found on federally managed public lands, such as national parks and seashores, national forests, and military installations, as part of Long-Term Ecological Monitoring Programs established on many of these federal lands. A third objective of the MAPS program is to model vital rates (productivity and survivorship) of landbirds as a function of both station-specific and landscape-level habitat variables, such as total cover of various forest types, mean forest patch size, and total amount of forest edge. The detection of relationships between vital rates and such habitat variables can lead to formulation and implementation of appropriate management actions within a national park or seashore, especially for species where MAPS data suggest that declines are related to local (e.g., productivity) rather than remote (e.g., overwintering survival in Neotropical migrants) factors.

We established and operated six MAPS stations in 2001 on Cape Cod National Seashore, at the same locations at which they were operated in 1999 and 2000. With few exceptions, the ten ne sites per station were operated for six morning hours per day on one day per 10-day period for seven consecutive 10-day periods between May 31 and August 8, 2001.

A total of 2407.7 net-hours were accumulated during the summer of 2001, during which a total o 372 captures of 28 species were recorded. Newly banded birds comprised 66.4% of the tota captures. The greatest number of total captures was recorded at the Marconi Beach station (94), followed in descending order by Nauset School (71), Longnook Beach (67), Higgins House (64), Oak Dunes (43), and Blueberry Hill (33). The highest species richness was recorded at Blueberr Hill (15 species), followed by Nauset School (14), Higgins House and Marconi Beach (13), and Longnook Beach and Oak Dunes (12). Overall, the most abundant breeding species in 2001 (as determined by the number of adults captured per 600 net-hours), in decreasing order, were Black-capped Chickadee, Chipping Sparrow, Tufted Titmouse, Hermit Thrush, American Goldfinch, Ovenbird, and Pine Warbler.

Numbers of adults of all species pooled captured in 2001 increased non-significantly over 2000 b 11.2%. This increase was neither species-wide nor station-wide (increases were noted at four o six stations). Interestingly, the two species showing significant changes between 2000 and 2001, Gray Catbird and Pine Warbler, each decreased. Changes in numbers of adults captured between 2000 and 2001 at each station were exactly opposite, but generally not as great as,

analogous changes between 1999 and 2000. Productivity (the proportion of young in the catch) in 2001 increased non-significantly over 2000 by +0.065. As with adults captured, the increases were neither species-wide nor station-wide (again, increases were noted at four of six stations). And again, productivity for the three species showing near-significant changes between 2000 and 2001 (Hairy Woodpecker, White-breasted Nuthatch, and Gray Catbird) each decreased. Changes in neither population size nor productivity appeared to be clearly related to habitat type or housing density, although the two stations showing decreases in population size in 2001 (Nauset School and Higgins House) were both in areas of sparse mixed understory and high housing density, and the two stations showing decreases in productivity in 2001 (Longnook Beach and Blueberry Hill) were both in areas of dense blueberry understory.

As in previous years, we identified habitat and housing density types that supported large breeding populations. Mean adults of all species pooled captured per 600 net-hours over the three years 1999-2001 was highest at the two pitch-pine stations (69.7), followed by the two oak forest stations (57.0) and the two mixed pine/oak stations (50.5); mean adults captured of all species pooled were higher at the three sparse mixed understory stations (67.9) than at the three dense blueberry understory stations (60.0); and mean adults captured at the three high-density-housing stations (64.5) was higher than the mean at the three low-density-housing stations (53.6). Multivariate and univariate logistic regression analyses have yielded several important results regarding variation in productivity by year, station, habitat type, and housing density class on Cape Cod National Seashore. First, these analysis confirmed that productivity for all species pooled and for a number of individual species was highest in 1999 and lowest in 2000. Second, these analyses indicated that productivity varied significantly among stations, tending generally to be highest at Blueberry Hill and Nauset School. Third, productivity for all species pooled and for Black-capped Chickadee and Chipping Sparrow was lowest in oak forest habitat; was higher in dense blueberry understory habitat than in sparse mixed understory habitat; and was higher in high than in low housing density areas. Results for the third target species, Tufted Titmouse, were exactly opposite to the other two; that is, productivity tended to be higher in oak forest and in sparse mixed understory habitats and in low housing density areas.

Thus, despite mixed results in 2001, we hypothesize that the presence of blueberries as a food resource provides a boon to productivity and is a driving force for the higher productivity i habitats with a dense blueberry understory. We further suggest that this effect is stronger for those species for which young birds utilize berries in their diet, either before or after fledging. Moreover, we suggest that interannual fluctuations in productivity reflect analogous fluctuations in the abundance of blueberries (which was high in 1999, low in 2000, and higher again in 2001). The addition of the third year of data in 2001 underscores the high interannual variability inheren in the landbird dynamics of Cap Cod. This variability not only occurs in the population size and productivity of the landbirds themselves, but in the relationships of these parameters to the various habitats and housing densities found within the seashore.

Finally, using three years of data, we were able to obtain estimates of adult survival (φ) and recapture probability (p) for three species breeding at Cape Cod National Seashore using non-transient CJS mark-recapture models. With additional years of data, we will be able to estimate survivorship for an increased number of species and will also be able to incorporate transien models in our mark-recapture analyses which will remove the bias in survival estimates caused b transient individuals and provide estimates of the proportions of residents among newly captured birds. Additional years of data will also greatly increase the precision of the survivorship estimates.

In summary, higher landbird breeding populations appear to occur in pure canopy forests with a sparse mixed understory, while higher productivity appears to occur in mixed pine/oak woodland with a dense blueberry understory. These are essentially the same results we noted last year. These results suggest that a mosaic of habitat and understory types should be maintained or restored at Cape Cod National Seashore. Interestingly, controlling for all of these habitat and year variables, our results suggest that both population sizes and productivity tend to be higher in high housing density areas than in low housing density areas. This suggests that the curren housing densities on the seashore, perhaps combined with the fact that most of the houses are older and have yards that generally provide good habitat for birds, do not appear to pose a problem for breeding landbirds.

The long-term goal for the Cape Cod MAPS program is to continue to monitor the primary demographic parameters of the Seashore's landbirds in order to provide critical information that can be used to aid our understanding of the ecological processes leading from environmenta stressors to population responses. When we have at least five years of data from Cape Cod and other locations along the Atlantic Coast, and appropriate funding has been secured, we will attempt to: (1) determine the proximate demographic factors (i.e., productivity or survivorship or both) causing observed population trends of target species; (2) link MAPS data with landscape-level habitat data and spatially explicit weather data in a geographical information system to identify and describe relationships between landscape-level habitat and weather characteristics and the primary demographic responses (productivity and survival rates) of the target species; (3) generate hypotheses regarding the ultimate environmental causes of the population trends; and (4) identify and formulate generalized management guidelines and specific management actions for habitat- and use-related issues on the Seashore and in other Atlantic coastal parks and lands.

Even with only three years of data, it is clear that information from MAPS will be able to aid research and management efforts within Cape Cod National Seashore to protect and enhance the Park's avifauna and ecological integrity. In addition, MAPS data from Cape Cod Nationa Seashore will provide important control information with which to compare data from other parks and areas along the Eastern seaboard. Finally, MAPS data from Cape Cod will provide an invaluable contribution to the determination of precise indices of adult population size and productivity and estimates of survivorship on a regional basis for North American landbirds.

We conclude that the MAPS protocol is very well-suited to provide one component of Cape Cod's long-term ecological monitoring program, and recommend continuing the MAPS progra on the seashore in perpetuity into the future.

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 is implementing integrated long-ter programs for inventorying and monitoring the natural resources in national parks, national seashores, and other NPS units. Pilot programs to develop and evaluate field and analytica techniques to accomplish these objectives have been implemented in national parks across the United States. The goals of these pilot programs are to develop: (1) quantitative sampling and analytical methods that can provide relatively complete inventories and long-term trends for many components of biological diversity; and (2) effective means of monitoring the ecological processes driving the trends (Van Horn et al. 1992). An additional goal is that the methods evaluated be useful in other NPS units across the United States. These programs are referred to as Long-ter Ecological Monitoring (LTEM) Programs, and include the Long-term Coastal Ecosystem Monitoring Program at Cape Cod National Seashore (Roman and Barrett 1999).

The development of effective long-term ecological monitoring programs in national parks and seashores 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 tha promise to be maintained in a relatively undisturbed manner indefinitely into the future, studies conducted in national parks and seashores can provide invaluable information for monitoring natural ecological processes and for evaluating the effects of large-scale, even global, environmental changes. The national parks, seashores, 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 and seashores can provide information that is crucial for efforts to preserve natural resources and biodiversity on multiple spatial scales, ranging from the local scale to the continental or even global scale.

Landbirds

Because of their high body temperature, rapid metabolism, and high ecological position on most food webs, landbirds are excellent indicators of the effects of local, regional, and globa environmental change in terrestrial ecosystems. 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. Nor is it surprising that several large-scale monitoring programs that provide annua population estimates and long-term population trends for landbirds are already in place on thi continent. They include the North American Breeding Bird Survey (BBS), the Breeding Bird Census, the Winter Bird Population Study, and the Christmas Bird Count

Analyses of data from the BBS suggest that populations of many landbirds 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 1993). The major goal of Partners in Flight (PIF) is to reverse the declines in Neotropical migratory birds through a coordinated 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 o long-term avian monitoring programs at NPS units using protocols developed by the Monitoring Working Group of PIF. Clearly, long-term ecological monitoring goals of the NPS and the monitoring and research goals of PIF share many common elements.

The goals of these programs differ, however, in at least one important respect. A major goal of PIF is to reverse population declines, especially in rare or uncommon (although not threatened or endangered) “priority” species, while a major objective of the NPS’ LTEM program is to understand the ecological processes driving population changes. This latter goal often necessitates concentrating on relatively common or even abundant species that are undergoing population changes, rather than rare or uncommon ones. Thus, appropriate target species might be expected to differ somewhat between PIF and LTEM efforts.

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 cycles problems are occurring, or to what extent the observed population trends are being driven by causal factors that affect birth rates, 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 critica 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 1998). This is because environmental factors and management actions generally affect primary demographic parameters directly and these effects usually can be observed over a short time period (Temple and Wiens 1989). Because of the buffering effects o 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 secondar 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). successful monitoring program should be able to account for these factors.

Finally, a successful monitoring program should be able to detect significant differences in productivity as a function of such local variables as landscape parameters, habitat disturbance, or predator abundance. The detection of such differences can lead to immediate managemen implementation within a national park or seashore, especially for species where long-term demographic monitoring suggests that declines are related to local (e.g., productivity) rather than remote (e.g., overwinter survival in Neotropical migrants) factors.

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 ver successful British Constant Effort Sites (CES) Scheme that has been operated by the British Trust for Ornithology since 1981 (Peach et al. 1996). The MAPS program was endorsed in 1991 b both the Monitoring Working Group of PIF and the USDI Bird Banding Laboratory, and a four-year pilot project (1992-1995) was approved 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 demographic parameters of landbirds. A peer review of the program and of the evaluation of the pilot projec was completed by a panel assembled by USGD/BRD (Geissler 1996). The review concluded that: (1) MAPS is technically sound and is based on the best available biological and statistica methods; and (2) it complements other landbird monitoring programs such as the BBS by providing useful information on landbird demographics that is not available elsewhere.

Now in its thirteenth year (tenth year of standardized protocol and extensive distribution o stations), the MAPS program has expanded greatly from 178 stations in 1992 to nearly 500 stations in 2001. The substantial growth of the Program since 1992 was caused by its endorsement by PIF and the subsequent involvement of various federal agencies in PIF, including the NPS, USDA Forest Service, US Fish and Wildlife Service, Department of Defense, Department of the Navy, and Texas Army National Guard. Within the past eight years, for example, IBP has been contracted to operate six MAPS stations on Cape Cod National Seashore, and six in Shenandoah, six in Denali, five in Yosemite, and two in Kings Canyon national parks. MAPS stations were established in these NPS units in order to evaluate the usefulness of the MAPS methodology as a major component of the NPS's Long-Term Ecological Monitoring Programs and, subsequently, to implement its use as part of that program.

Goals and Objectives of MAPS

MAPS is organized to fulfill three tiers of goals and objectives: monitoring, research, and management.

- The specific monitoring goals of MAPS are to provide, for over 100 target species, including Neotropical-wintering migrants, temperate-wintering migrants, and permanent residents:

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

  (B) annual estimates of adult population size, adult survival rates, proportions of residents among newly captured adults, recruitment rates into the adult population, and population growth rates from modified Cormack- Jolly-Seber analyses of mark-recapture data on adult birds.

- The specific research goals of MAPS are to identify and describe:

  (1) temporal and spatial patterns in these demographic indices and estimates at a variety o spatial scales ranging from the local landscape to the entire continent; and

  (2) relationships between these patterns and ecological characteristics of the target species, population trends of the target species, station-specific and landscape-level habita characteristics, and spatially-explicit weather variables.

- The specific management goals of MAPS are to use these patterns and relationships, at the appropriate spatial scales, to:

  (a) identify thresholds and trigger points to notify appropriate agencies and organizations of the need for further research and/or management actions;

  (b) determine the proximate demographic cause(s) of population change;

  (c) suggest management actions and conservation strategies to reverse population declines and maintain stable or increasing populations; and

  (d) evaluate the effectiveness of the management actions and conservation strategies actually implemented through an adaptive management framework.

The overall objectives of MAPS are to achieve the above-outlined goals by means of long-ter monitoring at two major spatial scales. The first is a very large scale — effectively the entire North American continent divided into eight geographical regions. It is envisioned that the national parks, along with national forests, military installations, and other publically owned lands, will provide a major subset of sites for this large-scale objective.

The second, smaller-scale but still long-term objective is to fulfill the above-outlined goals for specific geographical areas (perhaps based on BBS physiographic strata, such as the Glaciated Coastal Plain, Southern New England, Upper Coastal Plain, or Coastal Flatwoods, or the newly described Bird Conservation Regions) or specific locations (such as individual national parks, national forests, or military installations). The objective for MAPS at these smaller scale is to aid research and management efforts within the parks, forests, or installations to protect and enhance their avifauna and ecological integrity. The sampling strategy utilized at these smaller scales should be hypothesis-driven and should be integrated with other research and monitoring efforts.

Both long-term objectives are in agreement with objectives laid out for the NPS's Long-Term Ecological Monitoring Program. Accordingly, the MAPS program was established in Cape Cod National Seashore as part of the development of Cape Cod's LTEM Program. It is expected tha information from the MAPS program will be capable of aiding research and management efforts within the Seashore to protect and enhance the park's avifauna and ecological integrity.

SPECIFICS OF THE CAPE COD MAPS PROGRAM

Goals

Cape Cod National Seashore is an important breeding and migration stopover site for both resident and migratory landbirds, including many state listed rare species (Cape Cod 1992). Indeed, landbirds have been included as a critical component of Cape Cod's LTEM (Roman and Barrett 1999). The specific goals for the initial (first five years) operation of the MAPS Progra on Cape Cod National Seashore are to:

(1) evaluate the ability and effectiveness of MAPS to provide a useful component of the long-term inventory and monitoring program in Cape Cod National Seashore;

(2) determine the effectiveness of various MAPS stations in Cape Cod National Seashore to provide reliable demographic information on the landbirds of the Eastern deciduous forest environment; and

(3) evaluate differences in productivity between stations located in areas of differing habitat type and housing density.

A five-year period has been selected for this initial operation of stations on Cape Cod National Seashore because a minimum of four consecutive years of data are needed to provide unbiased estimates of survival rates from mark-recapture methods using models that account for the presence of transient individuals moving through the populations. In addition, five years will provide a minimum sample of year-to-year variability in avian productivity and population sizes.

MAPS data collected at Cape Cod National Seashore will be used to address questions at three spatial scales. First, at the smallest scale, MAPS data will provide local indices and estimates o productivity at individual stations or groups of stations that can be compared with indices and estimates derived from MAPS data from other stations within the seashore or from stations near to, but outside, the seashore. The MAPS Program in Cape Cod will specifically address two such questions (variation in housing density and habitat) using MAPS data collected in this manner at these local scales. Second, data from all six MAPS stations on Cape Cod can be pooled to provide park-wide productivity indices and survivorship estimates and longer-term trends in these indices and estimates. Pooling data at this level will also allow comparison between Cape Cod National Seashore and other Atlantic coastal parks that may participate in the MAPS program in the future, as well as comparisons between Cape Cod National Seashore and other unprotected areas along the Atlantic coast. Finally, MAPS data from Cape Cod Nationa Seashore 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 demographi parameters.

Two specific questions regarding productivity will be addressed using MAPS data on Cape Cod. First, MAPS data will be used to provide productivity indices for each of: (1) three habitats types based on canopy characteristics (oak forest, mixed pine/oak woodland, and pitch-pine woodland), and (2) two habitat types based on understory categories (dense blueberry understory [>75% lower-layer cover and/or >90% ground cover] and sparse mixed understory [<50% lower-layer cover and/or <60% ground cover]) to determine the differences, if any, between the habitat types. Each habitat supports a different bird community, and as Cape Cod is a highly successiona landscape, the possible succession of one type of habitat to another may negatively or positively affect the ability of target species to produce enough young to prevent population declines.

Second, as Cape Cod is located in the densely populated Eastern Seaboard and is a popular location for summer homes, it is important to understand the effects, if any, of high housing density on the ability of target species to produce adequate numbers of young to preven population declines. We will examine data from three stations in landscapes where the housing density is greater than 40 houses/k ^{2} and compare them to data from three stations in landscapes of less than 15 houses/k ^{2}. The information on productivity that MAPS data can provide will be extremely important for making and implementing management decisions regarding land-use practices and restoration efforts affecting the succession of habitats necessary for breeding landbirds including declining species.

The appropriate temporal and spatial scales are different for survivorship than for productivity considerations. In contrast to productivity indices, adult survival-rate estimates require three (for non-transient Cormack-Jolly-Seber [CJS] models) or four (for transient CJS models that rely on between-year recaptures to assess residency) consecutive years of data to provide initial estimates of survival rates. In addition, because the adults whose survival rates are estimated by MAPS are the adults that are residents on the study area (at least during summer), MAPS survival-rate estimates are site- or habitat-specific, at least in terms of breeding season survival. However, because survival of migratory individuals may depend primarily upon considerations on thei 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. Because only a single survival-rate estimate will be produced by pooling data from all six stations on the Seashore, temporal, rather than spatial, considerations become the focus for survivorship analyses.

Examining the variation over time in survival-rate estimates (and productivity indices) will allow the park to determine the effect that their management actions, or lack thereof, have on the primary demographic parameters of the birds species breeding on Cape Cod. It is also importan to determine characteristics of (and temporal variation in) the weather associated with the landscapes in which stations or clusters of stations are sited. Appropriate local information would include summary data on the mean temperatures and precipitation during the previous winter and spring and current summer, and records of unusual weather events (large storms, high winds, major hot or cold spells, etc.). Important global climate information include various indices (such as the El Niño/Southern Oscillation Precipitation Index, North Atlantic Oscillation Index, and Pacific Decadal Oscillation Index) which measure long-term (several years or more) global weather cycles. Information on both local and global weather should be included as factors for landscape level analyses, as weather may mask or accentuate the affects of management actions on survival-rate estimates or productivity indices. These data can be obtained from standardized local weather-data-collection centers operated as part of the Cape Cod long-term ecologica monitoring program and from national climate institutes (e.g., NOAA) that monitor global climat phenomena.

The long-term goal for the Cape Cod MAPS program is to continue to monitor the primary demographic parameters of Cape Cod's landbirds in order to provide critical information that can be used to aid our understanding of the ecological processes leading from environmental stressors to population responses. To achieve this goal, we will first need to analyze spatial patterns in productivity indices and survival rate estimates as a function of spatial patterns in population trends for target species, in order to determine the proximate demographic factor (i.e., productivity or survivorship) causing the observed population trends (DeSante et al. 2001). We will then need to link MAPS data with landscape-level habitat data and spatially explicit weather data in a geographical information system (GIS) to identify relationships between landscape-leve habitat and/or weather characteristics and the primary demographic responses (productivity and survival rates) of the target species. This will allow hypotheses to be generated regarding the ultimate environmental causes of the population trends. Successful implementation of this approach will necessitate analyses of MAPS stations from areas larger than just Cape Cod National Seashore. For example, Cape Cod data can be compared to data from relatively pristine ecosystems (e.g., other national parks and seashores) at other locations, and from data in more heavily managed or disturbed ecosystems in eastern North America. Successful implementation of this approach will also require generating the necessary funding to undertake these analyses.

Establishment of Stations

Six MAPS stations were established on Cape Cod National Seashore in 1999. The six stations were arranged into three pairs of stations — each pair was situated in a different canopy habita type and each pair contained one station in an area of high housing density and one in an area o low housing density. In addition, three of the stations contained dense blueberry understory, whereas the other three stations contained sparse, mixed understory. The six stations were located (according to habitat and housing density) as follows: (1) the Longnook Beach station in oak forest with dense blueberry understory habitat and high housing density at 46 m elevation to the north of Longnook Road near Longnook Beach; (2) the Oak Dunes station in oak forest with dense blueberry understory habitat and low housing density at 30 m elevation east of Collins Road to the south of Ballston Beach; (3) the Nauset School station in mixed pine/oak woodland with sparse mixed understory and with high housing density at 15 m elevation south of Cable Road near Nauset Light Beach; (4) the Blueberry Hill station in mixed pine/oak woodland with dense blueberry understory and low housing density at 15 m elevation south of Calhoon Hollow Road near Calhoon Hollow Beach; (5) the Higgins House station in pitch-pine woodland with sparse mixed understory and with high housing density at 15 m elevation north of Wellfleet; and (6) the Marconi Beach station in pitch-pine woodland with sparse mixed understory and with low housing density at 12 m elevation near the National Seashore Headquarters northwest of Marconi Beach.

The 2001 Cape Cod MAPS Program

The 2001 Cape Cod field biologist interns, Jennifer Noonan and Kate Roll, received two weeks o intensive training in a comprehensive course in mist netting and bird-banding techniques given b IBP biologists Amy McAndrews and Amy Finfera during the first two weeks of May, 2001, at the Jug Bay Wetland Sanctuary on the shores of the Chesapeake Bay, Maryland. IBP biologist Amy McAndrews supervised the 2001 interns for the duration of the field work at Cape Cod. Amy McAndrews and the two interns arrived on June 2 to re-establish and begin operation of the stations. Six MAPS stations were re-established on Cape Cod National Seashore in 2001 in exactly the same locations where they were established and operated in 1999 and 2000. Data collection at the six stations began during the period June 4-9.

All ten net sites at each station were re-established in the exact same locations as in 1999 and 2000. One 12m, 30mm-mesh, 4-tier, nylon mist net was erected at each of the net sites on each day of operation. Each station was operated for six morning hours per day (beginning at local sunrise), on one day in each of seven consecutive 10-day periods between Period 4 (May 31-Jun 9) and Period 10 (Jul 30-Aug 8). With very few exceptions, the operation of all stations occurred on schedule in each of the seven 10-day periods. A summary of the operation of the 2001 Cape Cod MAPS Program and the major habitats at each of the six stations is presented in Table 1.

METHODS

The operation of each of the six stations during 2001 followed MAPS protocol, as established for use by the MAPS Program throughout North America and spelled out in the MAPS Manua (DeSante et al. 2001). Detailed protocols specific to Cape Cod are also provided in *The Monitoring Avian Productivity and Survivorship (MAPS) Program at Cape Cod National Seashore* (DeSante 2001) produced for the USGS Patuxent Wildlife Research Center, Cooperative Park Studies Unit at the University of Rhode Island. An overview of both the fiel and analytical techniques is presented here.

Data Collection

With few exceptions, all birds captured during the course of the study were identified to species, age, and sex and, if unbanded, were banded with USGS/BRD numbered aluminum bands. Birds were released immediately upon capture (before being banded) if situations arose where bird safety would be comprised. Such situations involved exceptionally large numbers of birds being captured at once, or the sudden onset of adverse weather conditions such as high winds or sudden rainfall. The following data were taken on all birds captured and processed, including recaptures, according to MAPS guidelines using standardized codes and forms. :

(1) capture code (newly banded, recaptured, band changed, unbanded);
(2) band number;
(3) species;
(4) age and how aged;
(5) sex (if possible) and how sexed (if applicable);
(6) extent of skull pneumaticization;
(7) breeding condition of adults (i.e., presence or absence of a cloacal protuberance or brood patch);
(8) extent of juvenal plumage in young birds;
(9) extent of body and flight-feather molt
(10) extent of primary-feather wear;
(11) fat class;
(12) wing chord and weight
(13) date and time of capture (net-run time); and
(14) station and net site where captured.

Effort data, i.e., the number and timing of net-hours on each day (period) of operation, were also collected in a standardized manner. In order to allow constant-effort comparisons of data to be made, the times of opening and closing the array of mist nets and of beginning each net check were recorded to the nearest ten minutes. The breeding status (confirmed breeder, likely breeder, non-breeder) of each species seen, heard, or captured at each MAPS station on each day o operation was recorded using techniques similar to those employed for breeding bird atlas projects.

For each of the six stations operated, simple habitat maps were prepared on which up to four major habitat types, as well as the locations of all mist nets, structures, roads, trails, and streams, were identified and delineated. The pattern and extent of cover of each major habitat type identified at each station, as well as the pattern and extent of cover of each of four major vertica layers of vegetation (upperstory, midstory, understory, and ground cover) in each major habita type were classified into one of twelve pattern types and eight cover categories according to guidelines spelled out in the MAPS Habitat Structure Assessment Protocol, developed by IBP Landscape Ecologist, Philip Nott (Nott, 2001).

Computer Data Entry and Verification

The computer entry of all banding data was completed by John W. Shipman of Zoological Data Processing, Socorro, NM. The critical data for each banding record (capture code, band number, species, age, sex, date, capture time, station, and net number) were proofed by hand against the raw data and any computer-entry errors were corrected. Computer entry of effort and vegetation data was completed by IBP biologists using specially designed data entry programs. All banding data were then run through a series of verification programs as follows:

(1) Clean-up programs to check the validity of all codes entered and the ranges of a numerical data;
(2) Cross-check programs to compare station, date, and net fields from the banding data with those from the summary of mist netting effort data;
(3) Cross-check programs to compare species, age, and sex determinations against degree of skull pneumaticization, breeding condition (extent of cloacal protuberance and brood patch), and extent of body and flight-feather molt, primary-feather wear, and juvena plumage;
(4) Screening programs which allow identification of unusual or duplicate band numbers or unusual band sizes for each species; and
(5) Verification programs to screen banding and recapture data from all years of operation for inconsistent species, age, or sex determinations for each band number.

Any discrepancies or suspicious data identified by any of these programs were examined manually and corrected if necessary. Wing chord, weight, station of capture, date, and any pertinent notes were used as supplementary information for the correct determination of species, age, and sex in all of these verification processes.

Data Analysis

To facilitate analyses, we first classified the landbird species found at each station into five groups based upon their breeding or summer residency status. Each species was classified as one of the following: a regular breeder (B) if we had positive or probable evidence of breeding or summer residency within the boundaries of the MAPS stati *during all years* that the station was operated; a usual breeder (U) if we had positive or probable evidence of breeding or summer residency within the boundaries of the MAPS stati *during more than half but not all of the years* that the station was operated; an occasional breeder (O) if we had positive or probable evidence of breeding or summer residency within the boundaries of the MAPS station*during hal or fewer of the years* that the station was operated; a transient (T) if the species was *never* a breeder or summer resident at the station, but the station was located within the overall breeding range of the species; and a migrant (M) if the station was not located within the overall breeding range of the species. Data for a given species from a given station were included in productivity analyses if the station was within the breeding range of the species; that is, data were included from stations where the species was a breeder (B, U, or O) or transient (T), but not where the species was a migrant (M). Data for a given species from a given station were included in survivorship analyses only if the species was classified as a regular (B) or usual (U) breeder at the station.

<u>A. Population-size and productivity analyses</u> -- The proofed, verified, and corrected banding data from 2001 were run through a series of analysis programs that calculated for each species and for all species combined at each station and for all stations pooled:

(1) the numbers of newly banded birds, recaptured birds, and birds released unbanded;
(2) the numbers and capture rates (per 600 net-hours) of first captures (in 2001) of individual adult and young birds; and
(3) the proportion of young in the catch.

Following the procedures pioneered by the British Trust for Ornithology (BTO) in their CES Scheme (Peach et al. 1996), the number of adult birds captured was used as an index of adult population size, and the proportion of young in the catch was used as an index of post-fledging productivity.

For all six stations we calculated changes between 2000 and 2001 in the indices of adult and young population sizes and post-fledging productivity and determined the statistical significance of any changes that occurred according to methods developed by the BTO in their CES scheme (Peach et al. 1996). These year-to-year comparisons were made in a "constant-effort" manner b means of a specially designed analysis program that used actual net-run (capture) times and net-opening and -closing times on a net-by-net and period-by-period basis to exclude captures tha occurred in a given net in a given period in one year during the time when that net was no operated in that period in the other year. For species captured at several stations in Cape Cod National Seashore, the significance of park-wide annual changes in the indices of adult and young population sizes and post-fledging productivity was inferred statistically using confidence intervals derived from the standard errors of the mean percentage changes. The statistical significance o the overall change at a given station was inferred from a one-sided binomial test on the proportion of species at that station that increased (or decreased). Throughout this report, we use an alpha level of 0.05 for statistical significance, but we also use the terms "near-significant" or "nearly significant" for differences for which $0.05 \leq P < 0.10$.

B. Logistic Regression Analyses -- The use of logistic regression provides an analytica framework for examining productivity in a multivariate manner as a function of year (in multi-year data sets), station, and various habitat variables, including canopy type, understory type, and housing density class. Logistic regression, when used in productivity analyses, estimates the probability of an individual bird captured at random being a young bird. The "odds ratio", the term used for the probability value produced by logistic regression, is the probability of a captured individual being a young bird after the variables incorporated into the model (e.g., year, habita type, housing density) have been accounted for. If, for example, the odds ratio calculated for a given species from a model incorporating year and two habitat types was 1.2, then the probability, in one habitat type, of a captured individual being a juvenile instead of an adult was 1.2 times as great as in the other habitat type. Any number of variables can be incorporated into the logistic regression analyses, but here we concentrate on how productivity was affected by year, station, canopy type, understory type, and housing density class.

Because station, canopy type, understory type, and housing density class are incorporated into the logistic regression model as non-continuous variables, the analysis format requires the designation of a reference station or reference group against which the odds ratios are compared. For each logistic regression analysis we chose the station (Longnook Beach, or, if there were no birds capture there, Marconi Beach, Higgins House, and Blueberry Hill, in that order), canop type (oak), understory type (dense blueberry), or housing density class (low density) which produced an intermediate value when all species were pooled and for which data were available for the largest number of individual species. In all cases, we used the current year (2001) as the reference year.

Data preparation for the logistic regression analyses was completed using data-managemen programs in dBASE4. The logistic regression analyses themselves were completed using the statistical-analysis package STATA (Stata Corporation 1995). For all species pooled and for each of three individual species (Black-capped Chickadee, Tufted Titmouse, Chipping Sparrow), we ran multivariate logistic regression analyses for productivity. These analyses were first run on the variables year and station (i.e., without controlling for canopy type, understory type, or housing density class) to see if significant differences occurred between years (when controlling for station) and among stations (when controlling for year). Then, for all species pooled and for each of the three individual species, we ran multivariate logistic regression analyses for productivity on the variables year, canopy type, understory type, and housing density class. Because each station has a unique combination of canopy type, understory type, and housing density class, we could not also include the variable station in these latter multivariate logistic regression analyses. Statistical significance in all these multivariate models was determined b means of the z-statistic (or Wald Statistic) which equates to the maximum-likelihood estimate based on the odds ratio divided by the standard error (Stata Corporation 1995).

We also ran univariate logistic regression analyses for productivity separately on the variables year (without controlling for station) and station (without controlling for year) for all species pooled, the three species for which we already ran multivariate analyses (Black-capped Chickadee, Tufted Titmouse, and Chipping Sparrow), and for eight additional individual species (Down Woodpecker, Blue Jay, Red-breasted Nuthatch, Hermit Thrush, American Robin, Pine Warbler, Common Yellowthroat, and Eastern Towhee). We suspect that, when five or more years of data have been collected, we may have sufficient data to run multivariate logistic regression analyses on productivity for several of the eight additional species.

<u>C. Survivorship Analyses</u> -- Modified Cormack-Jolly-Seber mark-recapture analyses (Pollock e al. 1990, Lebreton et al. 1992) were conducted using the computer program SURVIV on three years of banding data (1999-2001) for species for which, on average, at least seven individua adults per year were captured at all stations combined. For each of the target species, we calculated maximum-likelihood estimates and standard errors (*SE*) of adult survival probability φ) and adult recapture probability (p) obtained by use of a non-transient model. Recapture probability is defined as the conditional probability of recapturing a bird in a subsequent year that was banded in a previous year, given that it survived and returned to the place it was originally banded. These estimates were derived from the capture histories of all adult birds of each targe species captured at all stations at which they were classified as regular (B) or usual (U) breeders. Once four years of data become available, we will be able to use a transient model (Pradel et al. 1997, Nott and DeSante 2002) to provide survival estimates that are less biased with respect to transient individuals and to estimate the proportion of residents among newly captured adults (τ).

RESULTS

A total of 2407.7 net-hours was accumulated at the six MAPS stations operated in Cape Cod National Seashore in 2001 (Table 1). Data from 2199.0 of these net-hours could be compared directly to 2000 data in a constant-effort manner.

Indices of Adult Population Size and Post-fledging Productivity

A. 2001 values -- The 2001 capture summary of the numbers of newly-banded, unbanded, and recaptured birds in Cape Cod National Seashore is presented for each species at each of the six stations individually in Table 2 and for all stations combined in Table 4. A total of 372 captures of 28 species was recorded during the summer of 2001. Newly banded birds comprised 66.4% o the total captures. The greatest number of total captures was recorded at the Marconi Beach station (94), followed in descending order by Nauset School (71), Longnook Beach (67) Higgins House (64), Oak Dunes (43), and Blueberry Hill (33). The highest species richness was recorded at Blueberry Hill (15 species) and the lowest species richness was recorded at Longnook Beach and Oak Dunes (12 species each). Among individual species, Black-capped Chickadee was the most frequently captured, followed by Chipping Sparrow, Tufted Titmouse, Hermit Thrush, Ovenbird, Common Yellowthroat, American Goldfinch, and Pine Warbler (Table 4).

The capture rates (per 600 net-hours) of individual adult and young birds and the percentage o young in the catch are presented for each species and for all species pooled at each station (Table 3) and for all stations combined (Table 4). We present capture rates (captures per 600 net-hours) of adults and young in this table so that the data can be compared among stations which, because of the vagaries of weather and accidental net damage, can differ from one another in effor expended (see Table 1). The following is a list of the common breeding species (captured at a rate of at least 3.0 adults per 600 net-hours), in decreasing order, at each station in 2001 (see Table 3):

Longnook Beach
Common Yellowthroat
Black-capped Chickadee
Cedar Waxwing
Ovenbird
Hermit Thrush
Tufted Titmouse
Eastern Wood-Pewee
Eastern Phoebe

Blueberry Hill
Tufted Titmouse
Black-capped Chickadee

Oak Dunes
Black-capped Chickadee
Ovenbird
Black-and-white Warbler

Higgins House
Black-capped Chickadee
Chipping Sparrow
American Robin
Pine Warbler
Hermit Thrush
American Goldfinch

Nauset School
Tufted Titmouse
Black-capped Chickadee
Hermit Thrush
Gray Catbird
Ovenbird

Marconi Beach
Chipping Sparrow
Black-capped Chickadee
American Goldfinch
Pine Warbler
Hermit Thrush

Overall, the most abundant breeding species at the six Cape Cod MAPS stations in 2001 (captured at a rate of at least 2.0 adults per 600 net-hours), in decreasing order, were Black-capped Chickadee, Chipping Sparrow, Tufted Titmouse, Hermit Thrush, American Goldfinch, Ovenbird, Pine Warbler, Common Yellowthroat, and American Robin (Table 4).

The indices of adult captures presented in Table 3 indicate that the total adult population size in 2001 was greatest at Marconi Beach, followed in descending order by Longnook Beach, Higgins House, Nauset School, Oak Dunes, and Blueberry Hill (Table 3). In contrast to last year, mean adults captured at the two pitch-pine stations (73.0; Higgins House and Marconi Beach) was higher than that at the two oak-forest stations (54.8; Longnook Beach and Oak Dunes) and at the two mixed-woodland stations (46.7; Nauset School and Blueberry Hill). As with last year, mean adults captured at the three sparse-understory stations (67.7; Nauset School, Higgins House, and Marconi Beach) was higher than at the three dense-understory stations (48.6; Longnook Beach, Oak Dunes, and Blueberry Hill), and mean adults captured at the three high-density-housing stations (65.1; Longnook Beach, Nauset School, and Higgins House) was higher than the mean at the three low-density-housing stations (51.1; Oak Dunes, Blueberry Hill, and Marconi Beach). Thus, in 2001, it appeared that pitch pine supported the highest breeding bird populations, followed by oak forest and mixed pine/oak woodland, there were more breeding adults in habitats with sparse than with dense understory, and there were more breeding adults in higher than in lower housing density.

Captures of young (Table 3) of all species pooled at each station in 2001 followed a somewha different sequence to that of adults, being highest at Nauset School, followed by Marconi Beach, Higgins House, Oak Dunes, Longnook Beach, and Blueberry Hill. As for adults, mean young captured at the two pitch-pine stations (20.9) was the highest, but in contrast with adults, young-captured was higher in the mixed-woodland stations (14.3) than at the oak-forest stations (7.8). Again as for adults, mean young captured at the three dense-understory stations (6.1) was substantially less than at the three sparse-understory stations (22.5), while mean young captured at the three high-density-housing stations (17.6) was greater than at the three low-density-housing stations (10.9). Thus, in 2001, more young birds occurred in pitch-pine than in mixed woodlands or oak forests, more young were found in areas with sparse rather than dense understory, and more young were found in high-density than in low-density-housing areas.

Given the variation in adults and young captured by station, the index of productivity (Table 3), as determined by the percentage of young in the catch, also varied among stations, from a high of 0.31 at Nauset School, followed by 0.23 at Higgins House, 0.21 at Marconi Beach, 0.18 at Oak Dunes, 0.09 at Longnook Beach, and 0.07 at Blueberry Hill. As with young captured, mean productivity at the two pitch-pine stations (0.22) was highest, followed by productivity at the two mixed-woodland stations (0.19) and productivity at the two oak-forest stations (0.14), mean productivity at the three sparse-understory stations (0.25) was substantially higher than at the three dense-understory stations (0.11), while mean productivity at the three high-density-housing stations (0.21) was greater than at the three low-density-housing stations (0.15). Thus, productivity in 2001 tended to be higher in pitch-pine and mixed-woodland than in oak-fores areas, it tended to be higher in areas with sparse understory, and it tended to be higher in high-density than in low-density-housing areas.

B. Comparisons Between 2000 and 2001 -- Constant-effort comparisons between 2000 and 2001 were undertaken at all six Cape Cod National Seashore MAPS stations for numbers of adult birds captured (adult population size; Table 5), numbers of young birds captured (Table 6), and proportion of young in the catch (productivity; Table 7).

Adult population size for all species pooled for all stations combined increased between 2000 and 2001 by a non-significant +11.2% (Table 5). Sixteen of 28 (57.1%) species at all stations combined showed increases; this proportion was not significantly greater than 0.50 (P=0.286). The change in overall adult population size for all species pooled showed increases at four stations, by amounts ranging from +12.5% at Oak Dunes to +52.8% at Marconi Beach, but decreased at Higgins House by -5.6% and at Nauset School by -23.1%. This is precisely the opposite pattern to changes recorded between 1999 and 2000. These increases and decreases did not seem related to habitat type or housing density, although the two stations showing decreases were both of sparse understory and in a high-density housing areas. The proportion of increasing or decreasing species was not significantly greater than 0.50 at any station. The number of adult Gray Catbirds and Pine Warblers captured for all stations combined each decreased significantly, while no species showed a significant or near-significant increase.

The number of young birds captured of all species pooled for all stations combined in Cape Cod National Seashore showed a near-significant increase of +77.4% between 2000 and 2001 (Table 6). Ten of 17 species at all stations combined showed increases, a proportion not significantly greater than 0.50 (P=0.315). The number of young birds captured, of all species pooled, showed increases at four of the six stations, ranging from +38.5% at Nauset School to +200.0% at Higgins House (and an infinite increase at Oak Dunes, where no young were captured in 2000) and it decreased by -25.0% at Longnook Beach and by -33.3% at Blueberry Hill. The proportion of increasing species was nearly significantly greater than 0.50 at Higgins House, and no species showed significant or near significant changes between 2000 and 2001 in number of young captured.

Productivity (the proportion of young in the catch) in 2001 increased non-significantly by an absolute +0.065 from 0.136 in 2000 to 0.201 in 2001(Table 7). Nine of 22 species increased overall, a non-significant proportion (P=0.857). Productivity increased at four of the six stations, ranging from +0.052 at Marconi Beach to +0.161 at Higgins House, whereas it decreased b -0.046 at Blueberry Hill and by -0.056 at Longnook Beach. As with adults captured, the increases and decreases in young captured and productivity did not seem related to habitat type or housing density, although the two stations showing decreases were both of dense understory. No station showed significant or near-significant proportions of increasing or decreasing species. Three species (Hairy Woodpecker, White-breasted Nuthatch, and Gray Catbird) showed a near-significant decreases in productivity whereas no species showed significant or near-significan increases in productivity across stations.

Thus, the numbers of adults and young captured and productivity all generally increased between 2000 and 2001, the opposite of changes between 1999 and 2000, when all three parameters decreased non-significantly. In general, however, these changes were neither station-wide nor species wide, although, interestingly, all of the near-significant and significant changes in adults captured and productivity involved decreases. No strong patterns emerged as to effects of habita or housing density on changes between 2000 and 2001.

C. Mean values for the three years, 1999-2001 -- Table 8 presents mean annual numbers o individual adults captured, numbers of young captured, and proportions of young in the catch on Cape Cod National Seashore during the three-year period 1999-2001 for each of the six stations and for all stations pooled. Examination of all-species-pooled values at the bottom of the table indicates that the highest breeding populations at Cape Cod during the three-year period occurred at Marconi Beach, followed by Higgins House, Nauset School, Longnook Beach, Oak Dunes, and, finally, Blueberry Hill. Three-year productivity values showed a different pattern, being highest at Nauset School and Blueberry Hill, followed by Higgins House and Marconi Beach, Longnook Beach, and, finally, Oak Dunes. Among forest types, breeding populations tended to be highest in pitch pine (mean 69.7 adults captured per 600 net-hours), followed by oak fores (57.0) and mixed woodland (50.5), whereas productivity showed a different pattern, tending to be highest in the mixed woodland (mean 0.23 proportion of young), followed by pitch pine (0.17) and oak forest (0.14). Among understory types, both breeding populations and productivity were higher in sparser understory (means 67.9 and 0.21, respectively) than in denser understory (60.0 and 0.15). Among housing densities, both breeding populations and productivity tended to be higher in high-density housing areas (means 64.5 and 0.19, respectively) than in low-density housing (53.6 and 0.17).

D. Logistic Regression Analyses of Productivity -- Figure 1 presents the results for multivariate logistic regression analyses of productivity using the design variables year and station for a species pooled and for three target species (Black-capped Chickadee, Tufted Titmouse, and Chipping Sparrow). As shown in Figure 1aA, productivity for all species pooled, controlling for station, was significantly greater in 2001 than in 2000, but was less in 2001 than in 1999, although not significantly less. Among stations, productivity for all species pooled was significantly higher at Blueberry Hill than at Longnook Beach, the reference station, and tended also to be higher, although not significantly so, at Nauset School than at Longnook Beach (Fig. 1aB). Productivity at the other three stations tended to be similar to that of Longnook Beach, none of the differences being significant. Figure 1bA shows that productivity for Black-capped Chickadee, controlling for station, was significantly lower in 2001 than in 1999, and was slightly higher, but not significantly so, in 2001 than in 2000. In addition, productivity for Black-capped Chickadee was near-significantly lower at Oak Dunes that at Longnook Beach but generally similar to Longnook Beach at the other four stations (Fig. 1bB). Figures 1c shows that no significant or near-significant differences in productivity occurred between years (controlling for station) or among stations (controlling for year) for Tufted Titmouse. Nevertheless, productivity for Tufted Titmouse over the three years had the same pattern as for Black-capped Chickadee and for a species pooled: highest in 1999, lowest in 2000, and intermediate in 2001. Productivity for Chipping Sparrow also tended to be higher in 2001 than in 2000, but productivity in 1999 was significantly lower than in 2001 (Fig. 1dA), a pattern very different from those for all species pooled and the other two species.

Figure 2 presents results for multivariate logistic regression analyses on productivity for all species pooled and for the three target species using four design variables: year, canopy type, understory type, and housing density class. Controlling for the other three variables, patterns and significant differences in productivity over the three years for the three species and for all species pooled were identical to the patterns found when controlling simply for station; that is, productivity was always higher in 2001 than in 2000 (significantly so for all species pooled; Fig. 2aA) and was lower in 2001 than in 1999 for all species pooled and for two of the three targe species (significantly so for Black-capped Chickadee; Fig. 2bA). In contrast, productivity in 2001 for Chipping Sparrow was significantly higher than in 1999 (Fig. 2dA).

Controlling for the other three variables, productivity in oak forest habitat always tended to be less than that in all other habitats for all species pooled and for two of the target species. For Tufted Titmouse, however, which specializes on oks and acorns to some extent, productivity tended to be higher in oak forest than in other habitats (Fig. 2cB). The only significant difference among all of these comparisons, however, was that productivity for all species pooled was highl significantly lower in oak forest than in pine/oak habitat (Fig. 2aB).

Although no significant differences were found, productivity in dense blueberry understory tended to be higher than in sparse mixed understory for all species pooled and for Black-capped Chickadee, but was slightly lower in dense blueberry understory than in sparse mixed understor for Tufted Titmouse (Fig. 2cC). Similarly, productivity at stations located in low housing densit areas tended to be lower than stations in high housing density areas for all species pooled and for two of the three target species; Tufted Titmouse again showed the opposite tendency with productivity tending to be higher in the low housing density areas (Fig. 2cD). None of these differences, however, were significant.

Univariate logistic regression analyses comparing years and stations are shown for all species pooled and for eleven species in Figure 3. Results for all species pooled and the three targe species differ slightly from results from the multivariate analysis shown in Figure 1, because the effect of the other variable (year or station) is not controlled. Significant or near-significant year differences were found for all species pooled (Fig. 3aA; 2000 lower than 2001), Black-capped Chickadee (Fig 3bC; 1999 higher than 2001), and Chipping Sparrow (Fig. 3fC; 1999 lower than 2001). Among ten species for which year-specific analysis could be performed, productivity was highest in 1999 for five species, highest in 2000 for no species, and highest in 2001 for five species; in contrast, productivity was lowest in 2000 for nine species and lowest in 1999 for one species.

Significant or near-significant station differences were shown using univariate analyses by a species pooled (Longnook Beach lower than Blueberry Hill; Fig. 3aB) and Black-capped Chickadee (Longnook Beach higher than Oak Dunes; Fig. 3bD). Among ten species for which station-specific analysis could be performed, productivity was highest for four species a

Blueberry Hill, two species each at Oak Dunes and Higgins Hill, one species each at Longnook Beach and Nauset School, and no species at Marconi Beach. In contrast, productivity was lowes for four species at Marconi Beach, for two species each at Oak Dunes and Blueberry Hill, for one species each at Longnook Beach and Higgins House, and for no species at Nauset School. Note that not all stations were represented for each species.

Estimates of Adult Survivorship

Using three years of data (1999-2001), estimates of annual adult survival rate (φ) and recapture probability *p*) could be obtained for three species breeding at Cape Cod National Seashore (Black-capped Chickadee, hermit Thrush, and Common Yellowthroat). Survivorship estimates for the three species, using the non-transient models, ranged from 0.291 for Black-capped Chickadee to 0.615 for Common Yellowthroat, with a mean of 0.467, while recapture probabilities varied from 0.309 for Common Yellowthroat to 0.613 for Hermit Thrush, with a mean of 0.487. These parameter estimates, particularly those for survival probability, are likely biased low because of the inclusion of transient individuals in the sample of birds analyzed. Thus there is no way to ascertain whether or not these estimates are unusually low or high. Because they are based on the minimum number of years of data (three) for which mark-recapture models can be run, the precision of the survival rate estimates was also rather poor (all CVs were greater than 30%). With four years of data, however, the precision of the estimates will increase greatly and we will be able to employ a transient model that will remove the bias in the survival rate estimates caused by the presence of transient individuals.

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DISCUSSION OF RESULTS

Both breeding population sizes and productivity on Cape Cod National Seashore rebounded i 2001 from the relatively low values recorded in 2000, but these rebounds generally did not quite match the decreases recorded between 1999 and 2000; thus, both population sizes and productivity in 2001 were generally a bit lower than they were in 1999. Rebounds in breeding population were observed at both of the oak forest stations, Longnook Beach and Oak Dunes, offsetting the substantial declines noted at these stations between 1999 and 2000. It is possible that the large-scale gypsy-moth defoliation noted at Longnook Beach in 2000 has been alleviated somewhat in 2001, although defoliation continued to be noted there by IBP interns. Interestingly, population sizes of all species pooled increased in 2001 at all four stations where it decreased in 2000, and decreased in 2001 at both of the stations where it increased in 2000, creating a consistent see-saw pattern.

Productivity, on the other hand, rebounded substantially in 2001 at only one (Oak Dunes) of the three stations with dense blueberry understory at which it decreased substantially in 2000. Thus, productivity has decreased for two successive years at both Longnook Beach and Blueberry Hill. On the other hand, productivity has increased for two consecutive years at two of the sparse understory stations, Nauset School and Marconi Beach. With additional years of data, we will be able to determine whether or not the decrease in productivity at dense-blueberry-understor stations and the increase at sparse-mixed-understory stations represent short- or long-term trends.

By determining the mean number of adults captured during all three years combined, we can identify the habitat types and housing density class that support larger breeding populations. Similar to patterns observed with just two years of data, mean adults captured at the two pitch pine stations (69.7) was highest, followed by the two oak forest stations (57.0) and the two mixed pine/oak stations (50.5); adult populations were also higher at the three sparse mixed understor stations (67.9) than at the three dense blueberry understory stations (60.0); and mean adults captured at the three high density housing stations (64.5) was higher than the mean at the three low density housing stations (53.6). Productivity showed a different pattern, being highest in the mixed woodland (mean 0.23 proportion of young), followed by pitch pine (0.17) and oak fores (0.14); productivity was higher at sparser understory (0.21) than at denser understory (0.15) stations, and it was higher in high density (0.19) than in low-density housing areas (0.17). These are all univariate patterns, however, and do not take into account the other variables.

Multivariate logistic regression analyses on productivity do take all of the variables and year into account and thus provide a better measure of the effects of these variables on productivity. These analyses are yielding several important preliminary results regarding variation in productivity by year, station, habitat type, and housing density class on Cape Cod National Seashore. First, these analysis confirmed that productivity for all species pooled and for two target species, Black-capped Chickadee and Tufted Titmouse, was highest in 1999 and lowest in 2000. Interestingly, productivity for Chipping Sparrow showed a substantially different result, being lowest in 1999 and highest in 2001. The habitat requirements and food preferences of Chipping Sparrow differ from those of the other two species and this could relate to this difference in annual variation in productivity. Univariate logistic regression analyses for seven species in addition to the three main target species also indicated that productivity tended to be highest in 1999 (or 2001) and lowest in 2000.

As noted last year for all species pooled, multivariate logistic regression analyses continued to indicate that productivity varied significantly among stations, generally tending to be highest at the Blueberry Hill and Nauset School stations. Multivariate logistic regression analyses did not show such a station-specific effect for any of the three target species, except to point to low productivity of Black-capped Chickadees at Oak Dunes. Univariate logistic regression analyses for seven species in addition to the three main target species also indicated that productivity often tended to be high at the Blueberry Hill station.

Multivariate logistic regression analyses for all species pooled showed that productivity was lowest in oak forest habitat and was highly significantly lower in oak forest than in pine-oak woodland. Productivity also was non-significantly higher in dense blueberry understory than in sparse mixed understory, a result that contradicts the univariate result mentioned above. Finally, productivity was slightly and non-significantly higher in high than in low housing density areas. Similar results were found for two of the target species, but opposite results were found for

Tufted Titmouse which had higher productivity in oak forest and sparse understory habitats and low housing density areas.

Thus, despite mixed results in 2001, we continue to hypothesize that the presence of blueberries as a food resource provides a boon to successful productivity and is a driving force for the higher productivity in habitats with a dense blueberry understory. This result is supported by analyses with all three years combined, although the pattern was stronger in 1999 than in either 2000 or 2001. We further suggest that this effect is much stronger for those species for which young birds utilize berries in their diet, either before or after fledging. Moreover, we suggest that the interannual fluctuations in productivity reflect analogous fluctuations in the abundance o blueberries (which was high in 1999, low in 2000, and somewhat higher again in 2001), as noted by IBP interns. The addition of the third year of data in 2001 underscores the interannua variability inherent in the landbird dynamics of Cap Cod. This variability not only occurs in the population size and productivity of the landbirds themselves, but in the relationships of these parameters to the various habitats and housing densities found within the seashore.

Using three years of data, we were able to obtain estimates of adult survival (φ) and recapture probability p) for three species breeding at Cape Cod National Seashore using non-transient CJS mark-recapture models. With additional years of data, we will be able to estimate survivorship for an increased number of species and will also be able to incorporate transient models in our mark-recapture analyses which will remove the bias in survival estimates caused by transient individuals and provide estimates of the proportions of residents among newly captured birds. Additional years of data will also greatly increase the precision of our survivorship estimates.

In summary, higher landbird breeding populations appear to occur in pure canopy forests with a sparse mixed understory, while higher productivity appears to occur in mixed pine/oak woodland with a dense blueberry understory. These are essentially the same results we noted last year. These results suggest that a mosaic of habitat and understory types should be maintained or restored at Cape Cod National Seashore. Interestingly, controlling for all of these habitat and year variables, our results suggest that both population sizes and productivity tend to be higher in high housing density areas than in low housing density areas. This suggests that the curren housing densities on the seashore, perhaps combined with the fact that most of the houses are older and have yards that generally provide good habitat for birds, do not appear to pose a problem for breeding landbirds.

Although Cape Cod MAPS stations have been operated for only three years, important data have been gathered on breeding populations and productivity for a number of summer residen landbird species on the seashore. In 1999 we were able to pool data from six MAPS stations on Cape Cod National seashore to provide the first station-specific and park-wide indices of breeding population size and productivity for a number of target species and for all species pooled. With the addition of a second year of data in 2000, we were able to compare these indices between two years using constant-effort data. Now, with three years of data, we are able to assess interannual variation in breeding populations and productivity more fully, provide more robust analyses on the effects of habitat type and housing density on the population dynamics of landbirds on the seashore, and provide estimates of annual adult survival rates and capture probabilities for three species using a non-transient model. With more years of data we will be able to estimate survival rates for more species using a transient model, begin to examine trends in breeding populations, and analyze the effects of climatological and landscape variables on breeding populations and productivity at Cape Cod. The power of our multivariate analyses w increase substantially with more years of data and with the addition of landscape-level habitat and climatological data. This will allow us to combine these results with those of constant-effort year-to-year comparisons, long-term trends in population size and productivity, and estimates of adult survival, capture probability, and proportion of residents as well. In addition, by including data from stations operated outside of the Cape Cod National Seashore, we will be able to make comparison between Cape Cod and other Atlantic coastal parks that may participate in the MAPS program in the future, as well as comparisons between Cape Cod and other unprotected areas along the Atlantic coast. Finally, MAPS data from Cape Cod National Seashore will be pooled with MAPS data from outside the seashore to provide regional (or even continental) indices and estimates of (and longer-term trends in) these key demographic parameters.

The long-term goal for the Cape Cod MAPS program is to continue to monitor the primary demographic parameters of Cape Cod 's landbirds in order to provide critical information that can be used to aid our understanding of the ecological processes leading from environmental stressors to population responses. When we have at least five years of data from Cape Cod and appropriate funding has been secured, we will use these data along with other data fro elsewhere along the Atlantic Coast in an attempt to: (1) determine the proximate demographi factors (i.e., productivity or survivorship or both) causing observed population trends of the various target species by modeling spatial variation in their productivity indices and survival rate estimates as a function of spatial patterns in their population trends; (2) link MAPS data wit landscape-level habitat data and spatially explicit weather data in a geographical information system (GIS) in order to identify and describe relationships between landscape-level habitat and/or weather characteristics and the primary demographic responses (productivity and survival rates) of the target species; (3) generate hypotheses regarding the ultimate environmental causes of the population trends; and (4) identify and formulate generalized management guidelines and specific management actions for habitat and use-related issues on the seashore and in other Atlantic coastal parks and lands.

We conclude, therefore, that the MAPS protocol is very well-suited to provide one component of Cape Cod's long-term ecological monitoring program (Roman and Barrett 1999), and recommend continuing the MAPS program on the seashore in perpetuity into the future, as has been recommended in an extensive review of monitoring protocols for the Channel Islands Nationa Park (McEachern 2001).

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Table 1. Summary of the 2001 MAPS program on Cape Cod National Seashore.

Station						2001 operation		
Name	Code	No.	Major Habitat Type	Latitude-longitud	Avg. Elev. (m)	Total number of net-hours[1]	No. of periods	Inclusive dates
Longnook Beach	LOBE	15610	Oak forest with dens blueberry understory; kettles; high housing density[1]	42º01'08"N,70º02'57"W	46	360.0 (324.2)	7	6/06-8/02
Oak Dunes	OADU	15609	Oak forest with dens blueberry understory; lo housing density[1]	41º58'39"N,70º00'41"W	30	409.3 (377.0)	7	6/08-8/03
Nauset School	NASC	15605	Mixed pine/oak woodland with sparse mixed understory; kettles; high housing density[1]	41º51'21"N,69º57'59"W	15	420.0 (396.8)	7	6/05-8/01
Blueberry Hill	BLHI	15607	Mixed pine/oak woodland with dense blueberry under-story; low housing density[1]	41º56'16"N,69º59'45"W	15	414.8 (384.8)	7	6/04-7/30
Higgins Hous	HIHO	15608	Pitch-pine woodland with sparse mixed understory; kettles; high housing density[1]	41º57'25"N,70º03'38"W	15	378.0 (305.8)	7	6/07-8/04
Marconi Beach	MABE	15606	Pitch-pine woodland with sparse mixed understory; lo housing density[1]	41º53'37"N,69º58'21"W	12	425.5 (410.3)	7	6/09-8/06
ALL STATIONS COMBINED						2407.7 (2199.0)	7	6/04-8/06

[1] Total net-hours in 2001. Net-hours in 2001 that could be compared in a constant-effort manner to 2000 are shown in parentheses.

Table 2. Capture summary for the six individual MAPS stations operated on Cape Cod National Seashore in 2001.
N = Newly Banded, U = Unbanded, R = Recaptures of banded birds.

	Longnook Beach			Oak Dunes			Nauset School			Blueberry Hill			Higgins Hous			Marconi Beach		
Species	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R
Ruby-throated Hummingbird					1						1							
Red-bellied Woodpecker							1											
Downy Woodpecker				1			3			1						1		
Hairy Woodpecker				2			1		1									
Northern Flicker										1							1	
Eastern Wood-Pewee	1		2															
Eastern Phoeb	4		1															
Red-eyed Vireo													1					
Blue Jay							2			3	1		2					
Black-capped Chickadee	7		4	8		5	9	3	2	6		2	14	2	3	13	2	10
Tufted Titmouse	2		1	1			16		6	2			1			2	1	
Red-breasted Nuthatch										1	1		2					
White-breasted Nuthatch	2											1						
Brown Creepe										1			1					
Hermit Thrush	2		6	3		1	1		6	1			2	1	1	3		1
American Robin			1				2			1			6			1		
Gray Catbird							3		2						1			
Cedar Waxwing	5												1					
Pine Warbler				1		1	1			2			3		1	5		5
Black-and-white Warbler				2		2												
Ovenbird	4		5	2		7	3		1	2		1						
Common Yellowthroat	8		9			1				2	1							
Eastern Towhee				2		1										1		1
Chipping Sparro	2						1						15	2	2	23	1	6
Field Sparro																1		
Northern Cardinal							4		1							1		
Brown-headed Cowbird	1			1	1												2	
American Goldfinch							2			2			3			10	1	2

Table 2. (cont.) Capture summary for the six individual MAPS stations operated on Cape Cod National Seashore in 2001.
N = Newly Banded, U = Unbanded, R = Recaptures of banded birds.

	Longnook Beach			Oak Dunes			Nauset School			Blueberry Hill			Higgins Hous			Marconi Beach		
Species	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R	N	U	R
ALL SPECIES POOLED	38	0	29	23	2	18	49	3	19	25	4	4	51	5	8	61	8	25
TOTAL NUMBER OF CAPTURES		67			43			71			33			64			94	
NUMBER OF SPECIES	11	0	8	10	2	7	14	1	7	13	4	3	12	3	5	11	6	6
TOTAL NUMBER OF SPECIES		12			12			14			15			13			13	

Table 3. Numbers of aged individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated on Cape Cod National Seashore in 2001.

	Longnook Beach			Oak Dunes			Nauset School			Blueberry Hill			Higgins Hous			Marconi Beach		
Species	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.
Red-bellied Woodpecker							1.4	0.0	0.00									
Downy Woodpecker				1.5	0.0	0.00	2.9	1.4	0.33	0.0	1.4	1.00				1.4	0.0	0.00
Hairy Woodpecker				2.9	0.0	0.00	1.4	0.0	0.00									
Northern Flicker										1.4	0.0	0.00						
Eastern Wood-Pewee	3.3	0.0	0.00															
Eastern Phoeb	3.3	3.3	0.50															
Red-eyed Vireo													1.6	0.0	0.00			
Blue Jay							2.9	0.0	0.00	4.3	0.0	0.00	1.6	0.0	0.00			
Black-capped Chickadee	13.3	0.0	0.00	11.7	4.4	0.27	10.0	5.7	0.36	10.1	0.0	0.00	20.6	4.8	0.19	18.3	7.1	0.28
Tufted Titmouse	5.0	0.0	0.00	1.5	0.0	0.00	12.9	14.3	0.53	2.9	0.0	0.00	1.6	0.0	0.00	1.4	1.4	0.50
Red-breasted Nuthatch										1.4	0.0	0.00	1.6	1.6	0.50			
White-breasted Nuthatch	1.7	1.7	0.50							1.4	0.0	0.00						
Brown Creepe										1.4	0.0	0.00	1.6	0.0	0.00			
Hermit Thrush	6.7	0.0	0.00	2.9	2.9	0.50	5.7	0.0	0.00	1.4	0.0	0.00	4.8	0.0	0.00	4.2	0.0	0.00
American Robin	1.7	0.0	0.00				2.9	0.0	0.00	1.4	0.0	0.00	6.3	3.2	0.33	1.4	0.0	0.00
Gray Catbird							4.3	0.0	0.00				1.6	0.0	0.00			
Cedar Waxwing	8.3	0.0	0.00										1.6	0.0	0.00			
Pine Warbler				1.5	0.0	0.00	1.4	0.0	0.00	2.9	0.0	0.00	6.3	0.0	0.00	7.1	1.4	0.17
Black-and-white Warbler				4.4	0.0	0.00												
Ovenbird	8.3	0.0	0.00	7.3	0.0	0.00	4.3	0.0	0.00	2.9	0.0	0.00						
Common Yellowthroat	15.0	0.0	0.00	1.5	0.0	0.00				1.4	1.4	0.50						
Eastern Towhee				2.9	1.5	0.33										2.8	0.0	0.00
Chipping Sparro	1.7	1.7	0.50				1.4	0.0	0.00				14.3	11.1	0.44	24.0	11.3	0.32
Field Sparro																1.4	0.0	0.00
Northern Cardinal							2.9	4.3	0.60							1.4	0.0	0.00
Brown-headed Cowbird	1.7	0.0	0.00	1.5	0.0	0.00												
American Goldfinch							2.9	0.0	0.00	2.9	0.0	0.00	4.8	0.0	0.00	14.1	0.0	0.00

Table 3. (cont.) Numbers of aged individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated on Cape Cod National Seashore in 2001.

	Longnook Beach			Oak Dunes			Nauset School			Blueberry Hill			Higgins Hous			Marconi Beach		
Species	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.	Ad.	Yg.	Prop. Yg.
ALL SPECIES POOLED	70.0	6.7	0.09	39.6	8.8	0.18	57.1	25.7	0.31	36.2	2.9	0.07	68.3	20.6	0.23	77.6	21.2	0.21
NUMBER OF SPECIES	12	3		11	3		14	4		13	2		13	4		11	4	
TOTAL NUMBER OF SPECIES		12			11			14			14			13			11	

Table 4. Summary of results for all six Cape Cod National Seashore MAPS stations combined in 2001.

Species	Birds captured: Newly banded	Un-banded	Recap-tured	Birds/600net-hours: Adults	Young	Prop. Young
Ruby-throated Hummingbird		2				
Red-bellied Woodpecker	1			0.2	0.0	0.00
Downy Woodpecker	6			1.0	0.5	0.33
Hairy Woodpecker	3		1	0.7	0.0	0.00
Northern Flicker	1	1		0.2	0.0	0.00
Eastern Wood-Pewee	1		2	0.5	0.0	0.00
Eastern Phoeb	4		1	0.5	0.5	0.50
Red-eyed Vireo	1			0.2	0.0	0.00
Blue Jay	7	1		1.5	0.0	0.00
Black-capped Chickadee	57	7	26	14.0	3.5	0.20
Tufted Titmouse	24	1	7	4.2	2.7	0.39
Red-breasted Nuthatch	3	1		0.5	0.2	0.33
White-breasted Nuthatch	2		1	0.5	0.2	0.33
Brown Creepe	2			0.5	0.0	0.00
Hermit Thrush	12	1	15	4.2	0.5	0.11
American Robin	10		1	2.2	0.5	0.18
Gray Catbird	3		3	1.0	0.0	0.00
Cedar Waxwing	6			1.5	0.0	0.00
Pine Warbler	12		7	3.2	0.2	0.07
Black-and-white Warbler	2		2	0.7	0.0	0.00
Ovenbird	11		14	3.7	0.0	0.00
Common Yellowthroat	10	1	10	2.7	0.2	0.08
Eastern Towhee	3		2	1.0	0.2	0.20
Chipping Sparro	41	3	8	7.0	4.0	0.36
Field Sparro	1			0.2	0.0	0.00
Northern Cardinal	5		1	0.7	0.7	0.50
Brown-headed Cowbird	2	3		0.5	0.0	0.00
American Goldfinch	17	1	2	4.2	0.0	0.00
ALL SPECIES POOLED	247	22	103	57.8	14.2	0.20
TOTAL NUMBER OF CAPTURES		372				
NUMBER OF SPECIES	27	11	17	27	13	
TOTAL NUMBER OF SPECIES		28			27	

Table 5. Percentage changes between 2000 and 2001 in the numbers of individual ADULT birds captured at six constant-effort MAPS stations on Cape Cod National Seashore.

							All six stations combined				
								No. adults			
Species	Long-Nook B.	Oak Dunes	Nauset School	Blue-berry H.	Higgins House	Marconi Beach	n [1]	2000	2001	% change	SE[2]
Red-bellied Woodpecker			++++[3]				1	0	1	++++[3]	
Downy Woodpecker		++++[3]	+100.0	-100.0		0.0	4	3	4	+33.3	70.3
Hairy Woodpecker		++++	++++	-100.0	-100.0		4	2	3	+50.0	178.0
Northern Flicker				++++[3]			1	0	1	++++	
Eastern Wood-Pewee	0.0					-100.0	2	3	2	-33.3	44.4
Eastern Phoeb	++++[3]						1	0	2	++++	
Red-eyed Vireo					0.0		1	1	1	0.0	
Blue Jay		-100.0	0.0	+50.0			3	6	5	-16.7	44.1
Black-capped Chickadee	+700.0	+166.7	-46.2	+16.7	+25.0	+44.4	6	40	53	+32.5	35.5
Tufted Titmouse	+200.0	0.0	+125.0	+100.0	-100.0	++++[3]	6	8	16	+100.0	38.7
Red-breasted Nuthatch				++++	-50.0	-100.0	3	3	2	-33.3	50.9
White-breasted Nuthatch	++++			0.0			2	1	2	+100.0	200.0
Brown Creepe				++++	++++[3]		2	0	2	++++	
Hermit Thrush	+300.0	0.0	-20.0	++++	-66.7	+50.0	6	16	16	0.0	36.2
American Robin	-66.7		-50.0	++++	+300.0	-50.0	5	10	9	-10.0	45.7
Gray Catbird			-62.5		-100.0	-100.0	3	11	3	-72.7	11.4**
Cedar Waxwing	++++				++++	-100.0	3	1	4	+300.0	624.5
Pine Warbler		-75.0	-66.7	0.0	-42.9	-28.6	5	23	13	-43.5	9.6**
Black-and-white Warbler	-100.0	+50.0					2	3	3	0.0	66.7
Ovenbird	+66.7	+25.0	0.0	0.0			4	12	15	+25.0	14.8
Common Yellowthroat	0.0	0.0		++++			3	8	9	+12.5	20.4
Scarlet Tanage	-100.0	-100.0		-100.0			3	4	0	-100.0	88.9
Eastern Towhee	-100.0	0.0	-100.0	-100.0	-100.0	+100.0	6	8	4	-50.0	30.6
Chipping Sparro	-50.0		0.0		+16.7	+240.0	4	14	26	+85.7	75.9
Field Sparro						++++	1	0	1	++++	
Northern Cardinal			+100.0			0.0	2	2	3	+50.0	50.0

Table 5. (cont.) Percentage changes between 2000 and 2001 in the numbers of individual ADULT birds captured at six constant-effort MAPS stations on Cape Cod National Seashore.

Species	Long-Nook B.	Oak Dunes	Nauset School	Blue-berry H.	Higgins House	Marconi Beach	n[1]	All six stations combined: No. adults 2000	No. adults 2001	% change	SE[2]
Brown-headed Cowbird	-50.0	0.0		-100.0			3	4	2	-50.0	21.7
Baltimore Oriole							0	0	0		
American Goldfinch	-100.0	-100.0	-60.0	0.0	++++	+150.0	6	14	17	+21.4	60.4
ALL SPECIES POOLED	+40.7	+12.5	-23.1	+13.6	-5.6	+52.8	6	197	219	+11.2	14.1
No. species that increased[4]	7(3)	5(2)	5(2)	9(6)	6(3)	7(2)				16(5)	
No. species that decreased[5]	7(4)	4(3)	7(1)	5(5)	7(4)	6(4)				9(1)	
No. species remained same	2	5	3	4	1	2				3	
TOTAL NUMBER OF SPECIES	16	14	15	18	14	15				28	
Proportion of increasing (decreasing) species	0.438	0.357	(0.467)	0.500	(0.500)	0.467				0.571	
Sig. of increase (decrease [6]	0.773	0.910	(0.696)	0.593	(0.605)	0.696				0.286	

[1] Number of stations at which at least one adult bird was captured in either year.
[2] Standard error of the % change in the number of adult birds captured.
[3] Increase indeterminate (infinite) because no adult was captured during 2000.
[4] No. of species for which adults were captured in 2001 but not in 2000 are in parentheses.
[5] No. of species for which adults were captured in 2000 but not in 2001 are in parentheses.
[6] Statistical significance of the one-sided binomial test that the proportion of increasing (decreasing) species is not greater than 0.50.
*** $P < 0.01$; ** $0.01 \le P < 0.05$; * $0.05 \le P < 0.10$.

Table 6. Percentage changes between 2000 and 2001 in the numbers of individual YOUNG birds captured at six constant-effort MAPS stations on Cape Cod National Seashore.

							All six stations combined				
								No. young			
Species	Long-Nook B.	Oak Dunes	Nauset School	Blue-berry H.	Higgins House	Marconi Beach	n[1]	2000	2001	% change	SE[2]
Red-bellied Woodpecker							0	0	0		
Downy Woodpecker	-100.0		0.0	++++[3]			3	4	2	-50.0	57.3
Hairy Woodpecker				-100.0		-100.0	2	2	0	-100.0	88.9
Northern Flicker							0	0	0		
Eastern Wood-Pewee				-100.0			1	1	0	-100.0	
Eastern Phoeb	++++[3]						1	0	2	++++[3]	
Red-eyed Vireo							0	0	0		
Blue Jay			-100.0				1	1	0	-100.0	
Black-capped Chickadee		++++[3]	0.0		+200.0	+25.0	4	9	15	+66.7	58.3
Tufted Titmouse	-100.0		+400.0			++++[3]	3	3	11	+266.7	189.5
Red-breasted Nuthatch					++++[3]		1	0	1	++++	
White-breasted Nuthatch			-100.0	-100.0			2	4	0	-100.0	88.9
Brown Creepe							0	0	0		
Hermit Thrush		++++					1	0	2	++++	
American Robin					++++		1	0	2	++++	
Gray Catbird			-100.0				1	1	0	-100.0	
Cedar Waxwing							0	0	0		
Pine Warbler						++++	1	0	1	++++	
Black-and-white Warbler							0	0	0		
Ovenbird							0	0	0		
Common Yellowthroat				++++			1	0	1	++++	
Scarlet Tanage							0	0	0		
Eastern Towhee							0	0	0		
Chipping Sparro	++++				+100.0	+300.0	3	5	15	+200.0	91.7
Field Sparro							0	0	0		
Northern Cardinal			++++[3]				1	0	3	++++	

Table 6. (cont.) Percentage changes between 2000 and 2001 in the numbers of individual YOUNG birds captured at six constant-effort MAPS stations on Cap Cod National Seashore.

Species	Long-Nook B.	Oak Dunes	Nauset School	Blue-berry H.	Higgins House	Marconi Beach	All six stations combined: n[1]	No. young 2000	No. young 2001	% change	SE[2]
Brown-headed Cowbird							0	0	0		
Baltimore Oriole			-100.0				1	1	0	-100.0	
American Goldfinch							0	0	0		
ALL SPECIES POOLED	-25.0	++++	+38.5	-33.3	+200.0	+114.3	6	31	55	+77.4	36.9*
No. species that increased[4]	2(2)	2(2)	2(1)	2(2)	4(2)	4(2)				10(7)	
No. species that decreased[5]	2(2)	0(0)	4(4)	3(3)	0(0)	1(1)				7(6)	
No. species remained same	0	0	2	0	0	0				0	
TOTAL NUMBER OF SPECIES	4	2	8	5	4	5				17	
Proportion of increasing (decreasing) species	(0.500)	1.000	0.250	(0.600)	1.000	0.800				0.588	
Sig. of increase (decrease[6]	(0.688)	0.250	0.965	(0.500)	0.063 *	0.188				0.315	

[1] Number of stations at which at least one young bird was captured in either year.
[2] Standard error of the % change in the number of young birds captured.
[3] Increase indeterminate (infinite) because no young was captured during 2000.
[4] No. of species for which young were captured in 2001 but not in 2000 are in parentheses.
[5] No. of species for which young were captured in 2000 but not in 2001 are in parentheses.
[6] Statistical significance of the one-sided binomial test that the proportion of increasing (decreasing) species is not greater than 0.50.
*** $P < 0.01$; ** $0.01 \leq P < 0.05$; * $0.05 \leq P < 0.10$

Table 7. Absolute changes between 2000 and 2001 in the PROPORTION OF YOUNG in the catch at six constant-effort MAPS stations on Cape Cod National Seashore.

Species	Long-Nook B.	Oak Dunes	Nauset School	Blue-berry H.	Higgins House	Marconi Beach	n[1]	All six stations combined: Prop. young 2000	Prop. young 2001	Absol. change	SE[2]
Red-bellied Woodpecker			+-+-+[3]				1	------[4]	0.000	+-+-+[3]	
Downy Woodpecker	+-+-+[3]	+-+-+[3]	-0.167	+1.000		0.000	5	0.571	0.333	-0.238	0.287
Hairy Woodpecker		+-+-+	+-+-+	+-+-+[3]	+-+-+[3]	+-+-+[3]	5	0.500	0.000	-0.500	0.198*
Northern Flicker				+-+-+			1	------	0.000	+-+-+	
Eastern Wood-Pewee	0.000			+-+-+		+-+-+	3	0.250	0.000	-0.250	0.286
Eastern Phoeb	+-+-+						1	------	0.500	+-+-+	
Red-eyed Vireo					0.000		1	0.000	0.000	0.000	
Blue Jay		+-+-+	-0.333	0.000			3	0.143	0.000	-0.143	0.122
Black-capped Chickadee	0.000	+0.273	+0.128	0.000	+0.120	-0.030	6	0.184	0.221	+0.037	0.071
Tufted Titmouse	-0.500	0.000	+0.193	0.000	+-+-+	+-+-+	6	0.273	0.407	+0.135	0.134
Red-breasted Nuthatch				+-+-+	+0.500	+-+-+	3	0.000	0.333	+0.333	0.192
White-breasted Nuthatch	+-+-+		+-+-+	-0.500			3	0.800	0.000	-0.800	0.208*
Brown Creepe				+-+-+	+-+-+		2	------	0.000	+-+-+	
Hermit Thrush	0.000	+0.500	0.000	+-+-+	0.000	0.000	6	0.000	0.111	+0.111	0.105
American Robin	0.000		0.000	+-+-+	+0.333	0.000	5	0.000	0.182	+0.182	0.105
Gray Catbird			-0.111		+-+-+	+-+-+	3	0.083	0.000	-0.083	0.032*
Cedar Waxwing	+-+-+				+-+-+	+-+-+	3	0.000	0.000	0.000	0.000
Pine Warbler		0.000	0.000	0.000	0.000	+0.167	5	0.000	0.071	+0.071	0.053
Black-and-white Warbler	+-+-+	0.000					2	0.000	0.000	0.000	0.000
Ovenbird	0.000	0.000	0.000	0.000			4	0.000	0.000	0.000	0.000
Common Yellowthroat	0.000	0.000		+-+-+			3	0.000	0.100	+0.100	0.131
Scarlet Tanage	+-+-+	+-+-+		+-+-+			3	0.000	------[4]	+-+-+	
Eastern Towhee	+-+-+	0.000	+-+-+	+-+-+	+-+-+	0.000	6	0.000	0.000	0.000	0.000
Chipping Sparro	+0.500		0.000		+0.128	+0.034	4	0.263	0.366	+0.103	0.073
Field Sparro						+-+-+	1	------	0.000	+-+-+	
Northern Cardinal			+0.600			0.000	2	0.000	0.500	+0.500	0.167

Table 7. (cont.) Absolute changes between 2000 and 2001 in the PROPORTION OF YOUNG in the catch at six constant-effort MAPS stations on Cape Cod National Seashore.

								All six stations combined			
								Prop. young			
Species	Long-Nook B.	Oak Dunes	Nauset School	Blue-berry H.	Higgins House	Marconi Beach	n[1]	2000	2001	Absol. change	SE [2]
Brown-headed Cowbird	0.000	0.000		+-+-+			3	0.000	0.000	0.000	0.000
Baltimore Oriole			+-+-+				1	1.000	------	+-+-+	
American Goldfinch	+-+-+	+-+-+	0.000	0.000	+-+-+	0.000	6	0.000	0.000	0.000	0.000
ALL SPECIES POOLED	-0.056	+0.156	+0.110	-0.046	+0.161	+0.052	6	0.136	0.201	+0.065	0.047
No. species that increased	1	2	3	1	4	2				9	
No. species that decreased	1	0	3	1	0	1				6	
No. species remained same	7	7	6	6	3	6				7	
TOTAL NUMBER OF SPECIES[5]	9	9	12	8	7	9				22	
Proportion of increasing (decreasing) species	(0.111)	0.222	0.250	(0.125)	0.571	0.222				0.409	
Sig. of increase (decrease [6]	(0.998)	0.980	0.981	(0.996)	0.500	0.980				0.857	

[1] Number of stations at which at least one aged bird was captured in either year.
[2] Standard error of the change in the proportion of young.
[3] The change in the proportion of young is undefined at this station because no aged individual of the species was captured in one of the two years.
[4] Proportion of young not given because no aged individual of the species was captured in the year shown.
[5] Species for which the change in the proportion of young is undefined are not included.
[6] Statistical significance of the one-sided binomial test that the proportion of increasing (decreasing) species is not greater than 0.50.
*** $P < 0.01$; ** $0.01 \leq P < 0.05$; * $0.05 \leq P < 0.10$

Table 8. Mean numbers of aged individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated on Cape Cod National Seashore averaged over the three years, 1999-2001. Only data from species where the station lies within the breeding range of the species were included.

	Longnook B.			Oak Dunes			Nauset School			Blueberry Hill			Higgins House			Marconi Beach			All stations pooled		
Species	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.
Red-bellied Woodpecke							0.5	0.0	0.00										0.1	0.0	0.00
Downy Woodpecke	0.0	1.6	1.00	1.5	0.5	0.17	1.5	1.5	0.61	0.5	2.0	0.67	0.5	0.5	0.50	0.9	0.0	0.00	0.8	1.0	0.52
Hairy Woodpecke	0.5	0.0	0.00	1.0	0.0	0.00	0.5	0.0	0.00	1.5	0.5	0.25	0.6	0.0	0.00	0.0	0.5	1.00	0.7	0.2	0.17
Northern Flicke				0.5	0.0	0.00				0.5	0.0	0.00							0.2	0.0	0.00
Eastern Wood-Pewee	4.1	0.0	0.00				1.0	0.0	0.00	0.0	0.5	1.00				0.5	0.0	0.00	0.9	0.1	0.07
Acadian Flycatcher				0.5	0.0	0.00													0.1	0.0	0.00
Eastern Phoebe	1.1	1.1	0.50										1.0	0.0	0.00				0.3	0.2	0.25
Great Crested Flycatcher							0.5	0.0	0.00	1.5	0.0	0.00							0.3	0.0	0.00
Red-eyed Vireo													1.1	0.0	0.00				0.2	0.0	0.00
Blue Jay	1.0	0.0	0.00	2.5	0.0	0.00	2.0	0.5	0.17	2.5	0.5	0.33	1.0	0.0	0.00	1.0	0.0	0.00	1.7	0.2	0.08
Tree Swallo							0.5	0.0	0.00										0.1	0.0	0.00
Black-capped Chickadee	7.9	4.4	0.20	10.8	1.5	0.09	13.2	3.9	0.20	9.5	4.6	0.20	15.6	5.8	0.27	15.7	6.7	0.30	12.1	4.5	0.26
Tufted Titmouse	5.1	3.0	0.32	2.5	4.4	0.25	9.2	6.7	0.37	1.5	0.5	0.33	1.1	0.0	0.00	0.5	0.5	0.50	3.3	2.6	0.40
Red-breasted Nuthatch							0.0	1.0	1.00	0.5	1.0	0.50	2.2	1.0	0.33	0.5	0.5	0.50	0.5	0.6	0.40
White-breasted Nuthatch	0.6	0.6	0.50	0.0	0.5	1.00	0.0	1.5	1.00	1.0	1.5	0.50							0.3	0.7	0.71
Brown Creepe										1.0	3.1	0.43	0.5	0.0	0.00				0.2	0.5	0.43
Hermit Thrush	4.2	0.0	0.00	4.9	1.0	0.17	5.4	0.0	0.00	1.0	0.0	0.00	6.0	0.0	0.00	3.8	0.5	0.08	4.2	0.2	0.05
American Robin	3.1	0.5	0.11				4.9	0.0	0.00	0.5	0.0	0.00	4.8	1.1	0.11	5.7	0.5	0.03	3.2	0.3	0.09
Gray Catbird				1.0	0.0	0.00	9.3	1.9	0.13				3.2	0.0	0.00	0.5	0.0	0.00	2.3	0.3	0.09
Cedar Waxwing	3.3	0.0	0.00										0.5	0.0	0.00	0.5	0.0	0.00	0.7	0.0	0.00
Yellow Warble													0.5	0.0	0.00				0.1	0.0	0.00
Pine Warble	0.5	0.0	0.00	5.0	0.0	0.00	3.4	0.0	0.00	3.5	0.5	0.08	10.8	0.0	0.00	10.0	0.5	0.06	5.5	0.2	0.04
Black-and-white Warble	1.0	0.0	0.00	3.0	0.0	0.00							1.0	0.0	0.00				0.8	0.0	0.00
Ovenbird	8.3	1.0	0.07	7.9	0.0	0.00	3.9	0.0	0.00	3.0	0.0	0.00	0.5	0.0	0.00	1.4	0.0	0.00	4.2	0.2	0.03
Common Yellowthroat	12.1	1.0	0.07	2.5	0.0	0.00				2.0	0.5	0.25							2.7	0.2	0.07
Scarlet Tanager	1.0	0.0	0.00	0.5	0.0	0.00				1.0	0.0	0.00							0.4	0.0	0.00
Eastern Towhee	2.5	0.0	0.00	3.5	1.0	0.19	1.0	0.0	0.00	2.5	0.0	0.00	1.1	0.0	0.00	1.9	0.0	0.00	2.1	0.2	0.09
Chipping Sparrow	1.6	0.6	0.25				1.0	0.0	0.00				10.7	5.4	0.26	15.7	5.2	0.23	4.8	1.8	0.23
Field Sparrow																0.5	0.0	0.00	0.1	0.0	0.00
Northern Cardinal							1.9	1.4	0.20	0.5	0.0	0.00	0.5	0.0	0.00	1.4	0.0	0.00	0.7	0.2	0.17
Brown-headed Cowbird	1.6	0.0	0.00	1.0	0.0	0.00				0.5	0.0	0.00				1.0	0.0	0.00	0.7	0.0	0.00

Table 8. Mean numbers of aged individual birds captured per 600 net-hours and proportion of young in the catch at the six individual MAPS stations operated on Cape Cod National Seashore averaged over the three years, 1999-2001. Only data from stations where the species was not a migrant were included.

	Longnook B.			Oak Dunes			Nauset School			Blueberry Hill			Higgins House			Marconi Beach			All stations pooled		
Species	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.	Ad.	Yg.	Prop.[1] Yg.
Baltimore Oriole							0.0	0.5	1.00										0.0	0.1	1.00
American Goldfinch	3.5	0.0	0.00	2.5	0.0	0.00	4.9	0.0	0.00	2.0	0.0	0.00	2.6	0.0	0.00	11.9	0.0	0.00	4.7	0.0	0.00
ALL SPECIES POOLED	62.9	13.6	0.16	51.0	8.8	0.12	64.5	19.0	0.23	36.5	15.3	0.23	66.1	13.8	0.17	73.2	14.7	0.17	59.0	14.2	0.19
NUMBER OF SPECIES	19	9		17	6		18	9		20	11		21	5		18	8		32	20	
TOTAL NUMBER OF SPECIES		20			18			21			21			21			19			33	

[1] Years for which the proportion of young was undefined (no aged birds were captured in the year) are not included in the mean proportion of young.

Table 9. Estimates of adult survival and recapture probabilities using a temporally constant model for three species breeding at MAPS stations on Cape Cod National Seashore obtained from three years (1999-2001) of mark-recapture data.

Species	Num. sta[1]	Num. ind.[2]	Num. caps.[3]	Num. ret.[4]	Survival probability[5]	Surv. C.V.[6]	Recapture probability[7]
Black-capped Chickadee	6	130	170	15	0.291 (0.134)	46.0	0.540 (0.283)
Hermit Thrush	6	39	72	11	0.495 (0.191)	38.6	0.613 (0.281)
Common Yellowthroat	3	27	48	5	0.615 (0.421)	68.5	0.309 (0.292)

[1] Number of stations where the species was a regular or usual breeder at which adults of the species were captured.
[2] Number of adult individuals captured at stations where the species was a regular or usual breeder (i.e., number of capture histories).
[3] Total number of captures of adult birds of the species at stations where the species was a regular or usual breeder.
[4] Total number of returns. A return is the first recapture in a given year of a bird originally banded at the same station in a previous year.
[5] Survival probability presented as the maximum likelihood estimate (standard error of the estimate).
[6] The coefficient of variation for survival probability
[7] Recapture probability presented as the maximum likelihood estimate (standard error of the estimate).

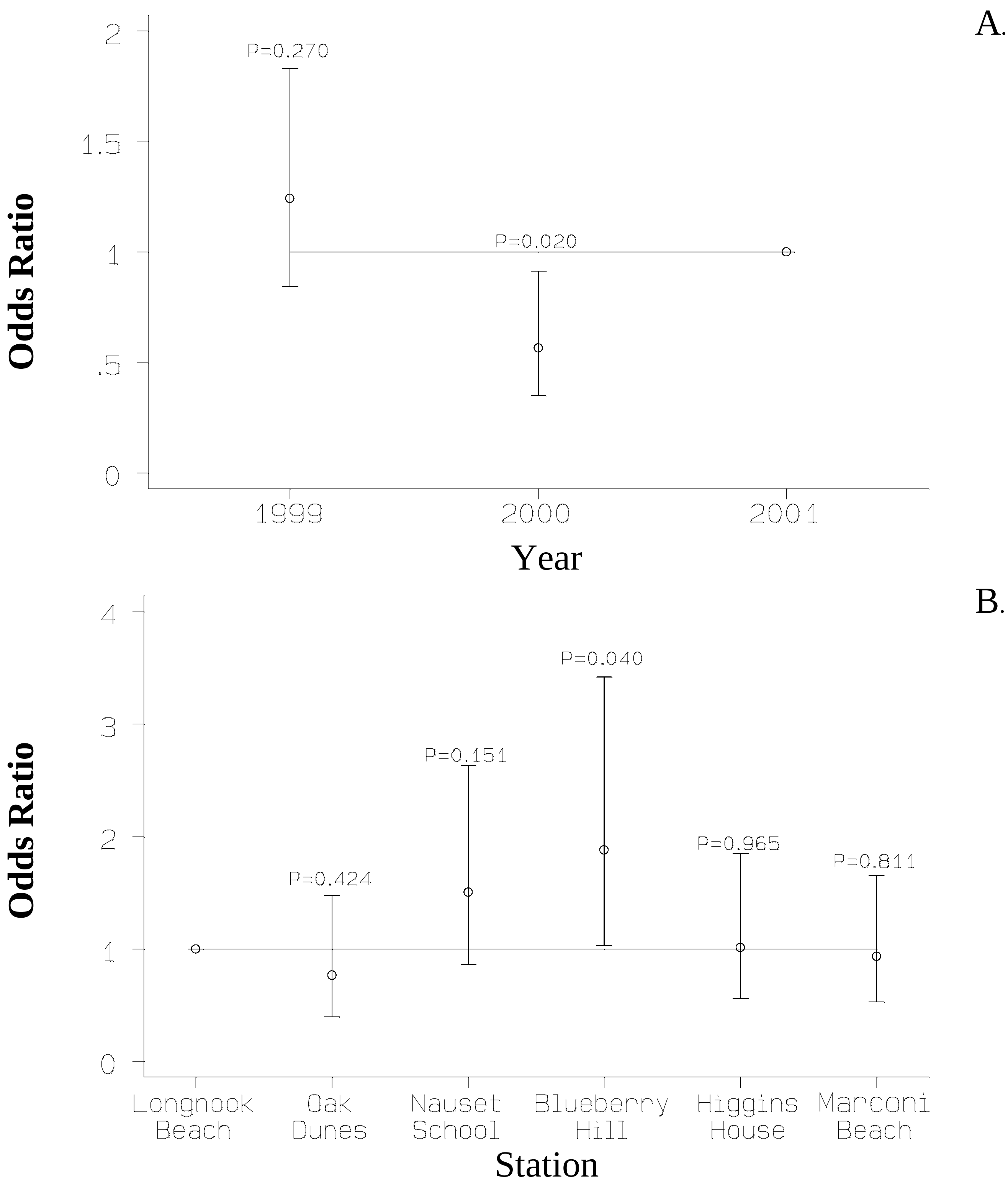


Figure 1a. The odds ratios for productivity indices (with 95% confidence intervals) for all species pooled a Cape Cod National Seashore for the design variables: A. year and B. station. The odds ratios for each design variable were estimated using multivariate logistic regression including the factors year and station. Each design variable is compared to a reference variable; the reference point (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.

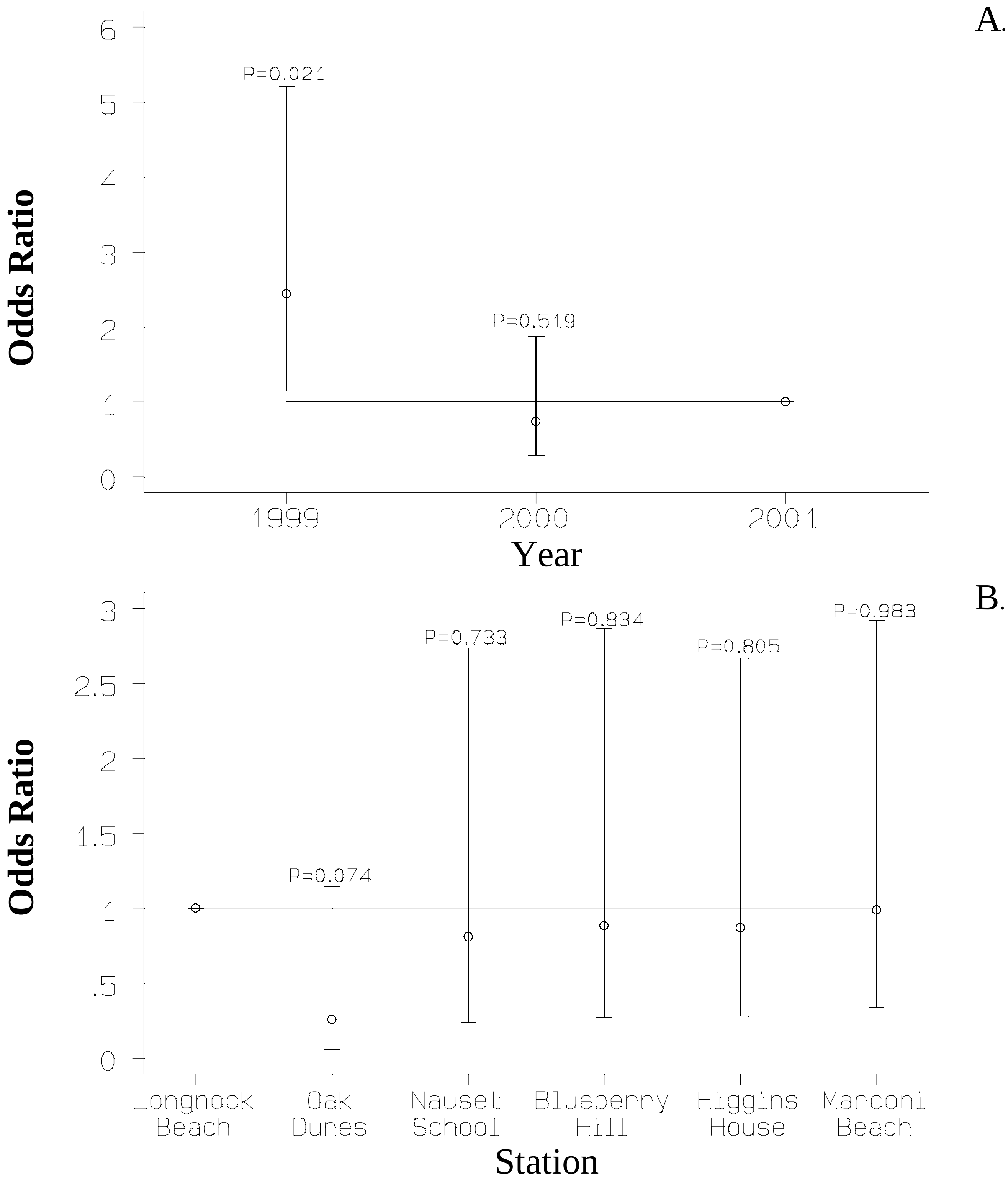


Figure 1b. The odds ratios for productivity indices (with 95% confidence intervals) for Black-capped Chickadee at Cape Cod National Seashore for the design variables: A. year and B. station. The odds ratios for each design variable were estimated using multivariate logistic regression including the factors year and station. Each design variable is compared to a reference variable; the reference point (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.

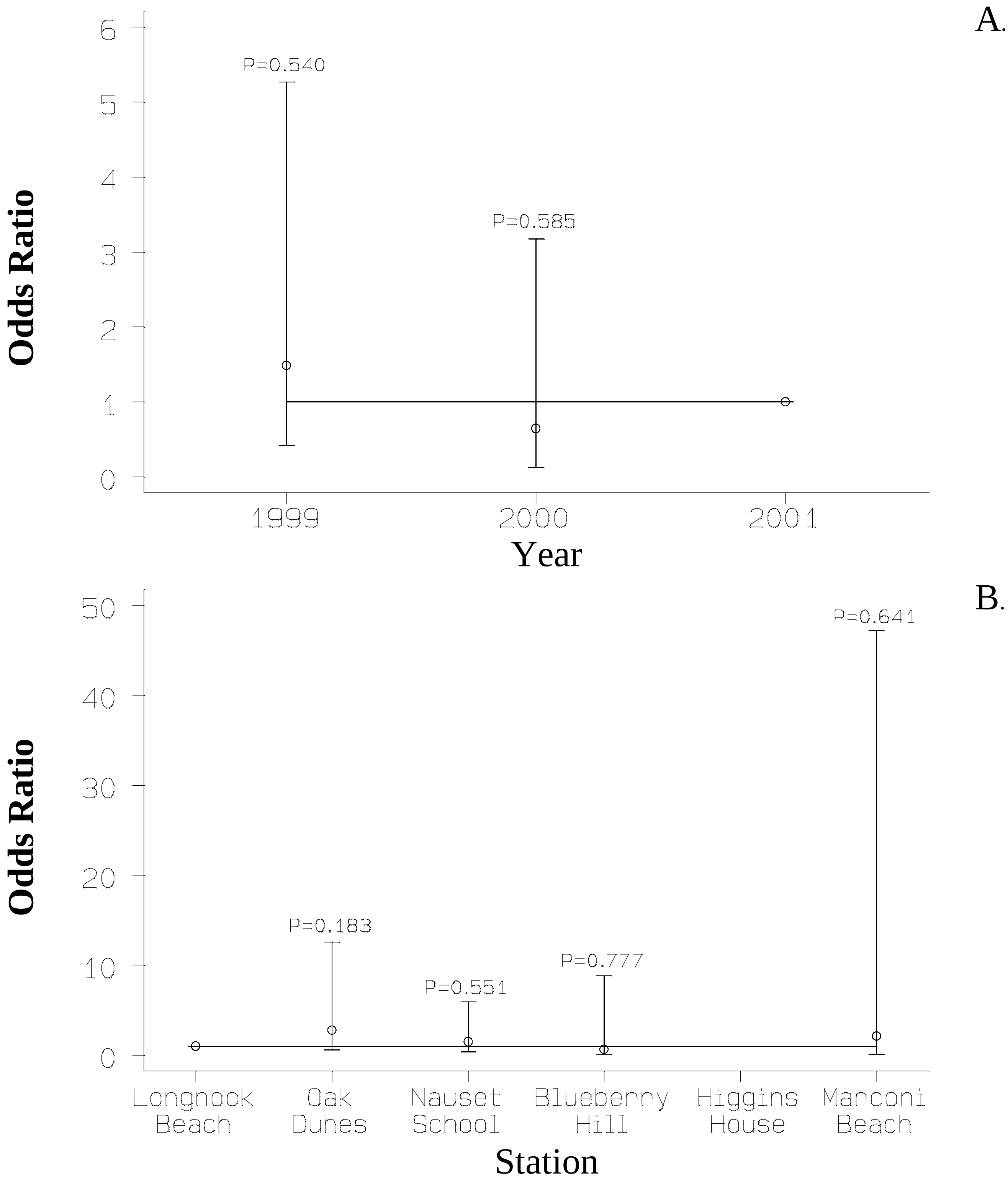
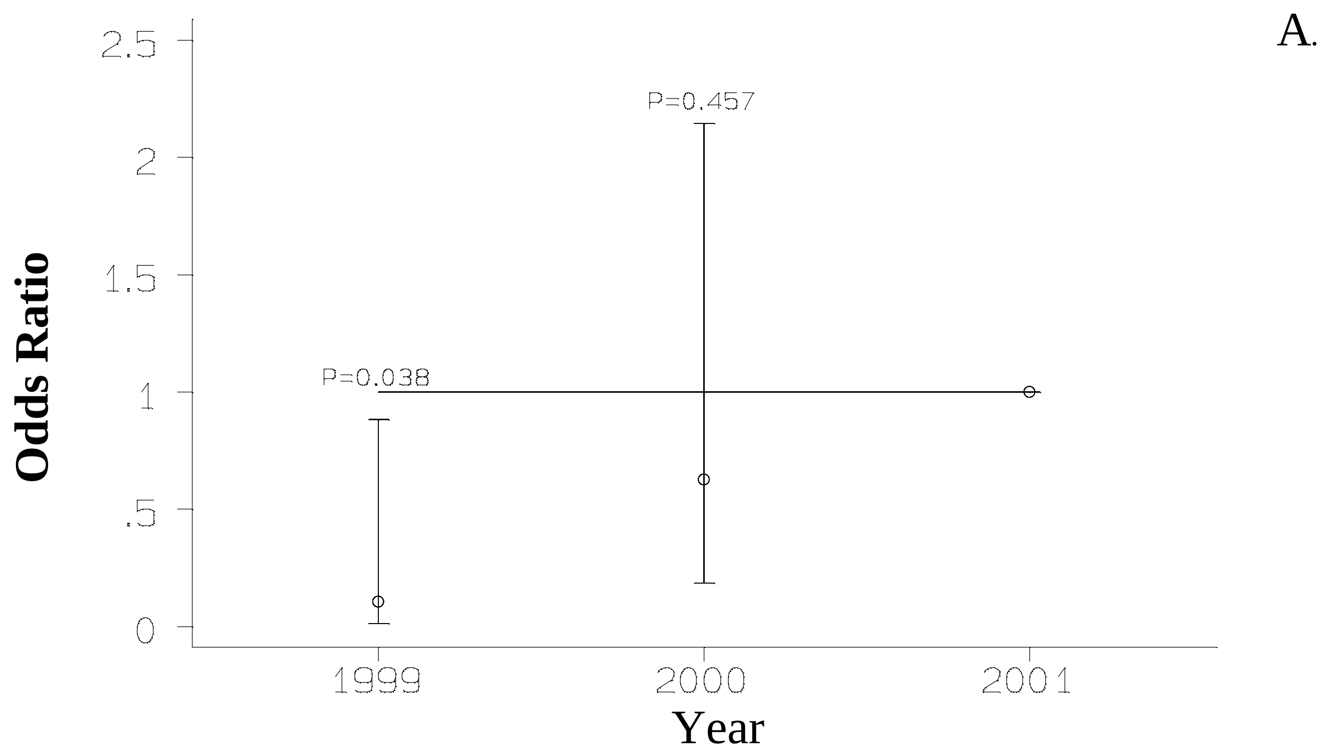


Figure 1c. The odds ratios for productivity indices (with 95% confidence intervals) for Tufted Titmouse at Cape Cod National Seashore for the design variables: A. year and B. station. The odds ratios for each design variable were estimated using multivariate logistic regression including the factors year and station. Each design variable is compared to a reference variable; the reference point (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.



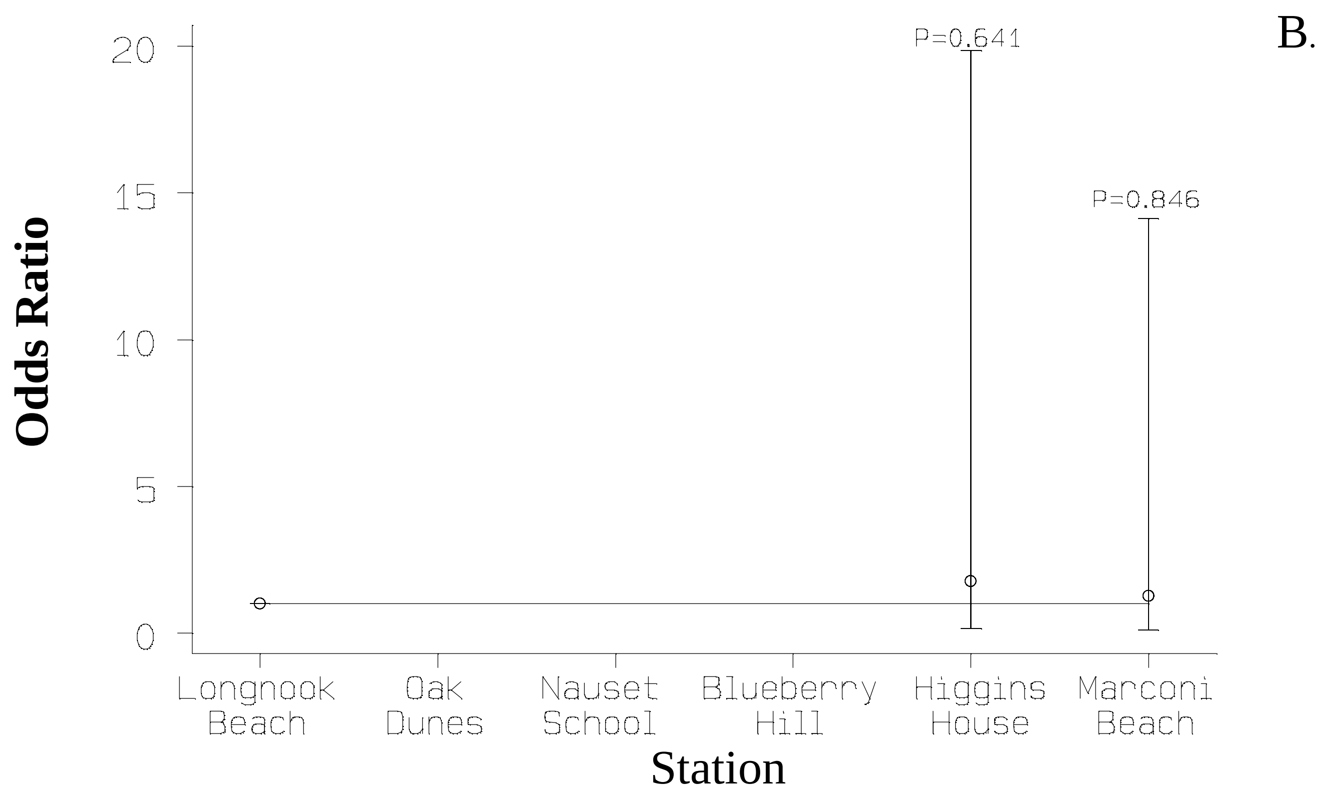


Figure 1d. The odds ratios for productivity indices (with 95% confidence intervals) for Chipping Sparrow a Cape Cod National Seashore for the design variables: A. year and B. station. The odds ratios for each design variable were estimated using multivariate logistic regression including the factors year and station. Each design variable is compared to a reference variable; the reference point (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.

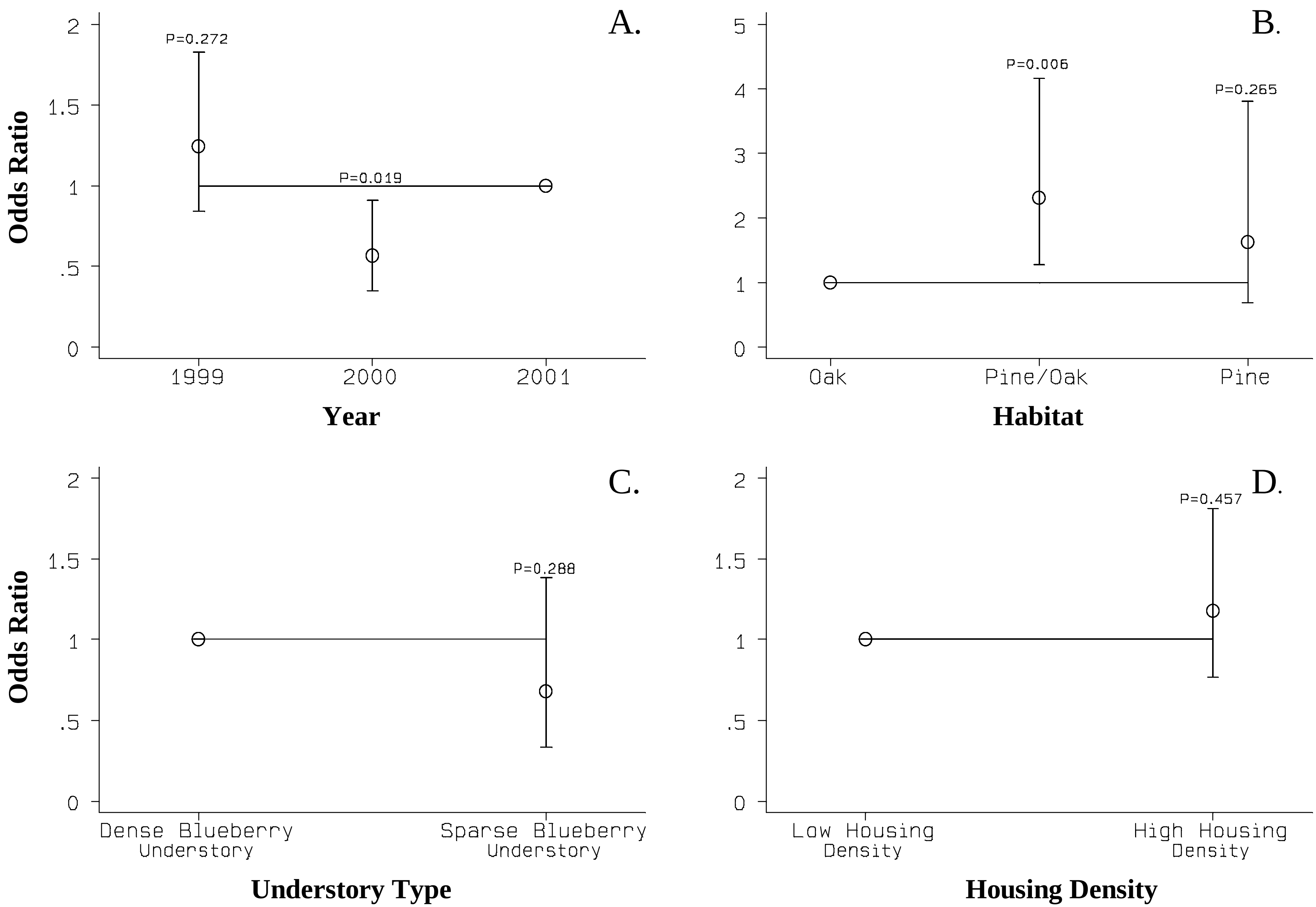


Figure 2a. The odds ratios for productivity indices (with 95% confidence intervals) for all species pooled at Cape Cod National Seashore for the design variables: A. year; B. canopy type; C. understory type; and D. housing density class within a 2 km radius circle around the center of the station. The odds ratios for each design variable were estimated using multivariate logistic regression including the factors year, canopy type, understory type, and housing density class. Each design variable is compared to a reference variable; the reference point (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.

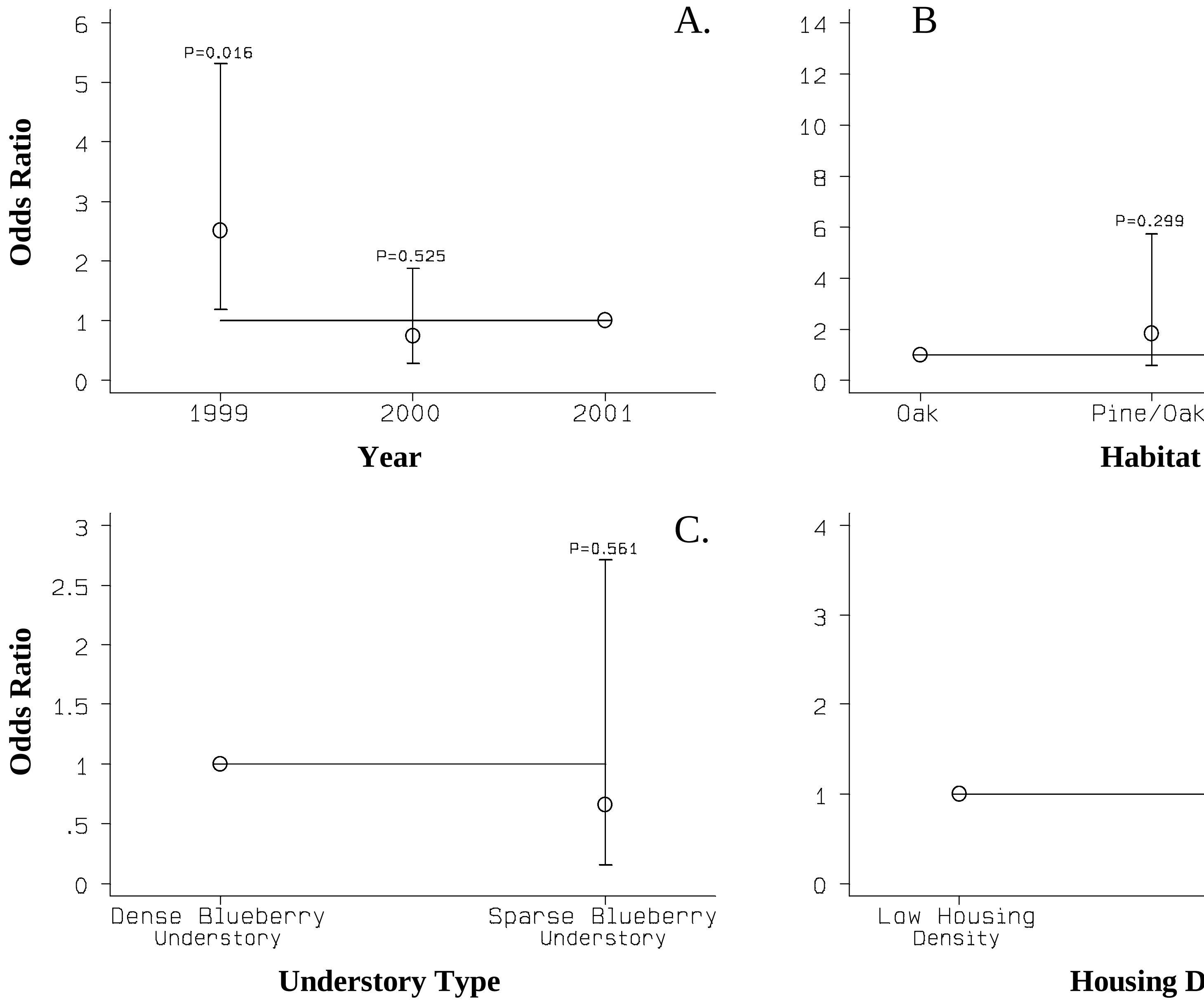


Figure 2b. The odds ratios for productivity indices (with 95% confidence intervals) for Black-capped Chickadee at C Seashore for the design variables: A. year; B. canopy type; C. understory type; and D. housing density class circle around the center of the station. The odds ratios for each design variable were estimated using multivar including the factors year, canopy type, understory type, and housing density class. Each design variable is c variable; the reference point (lacking 95% confidence intervals) and a reference line are plotted for ease of cor

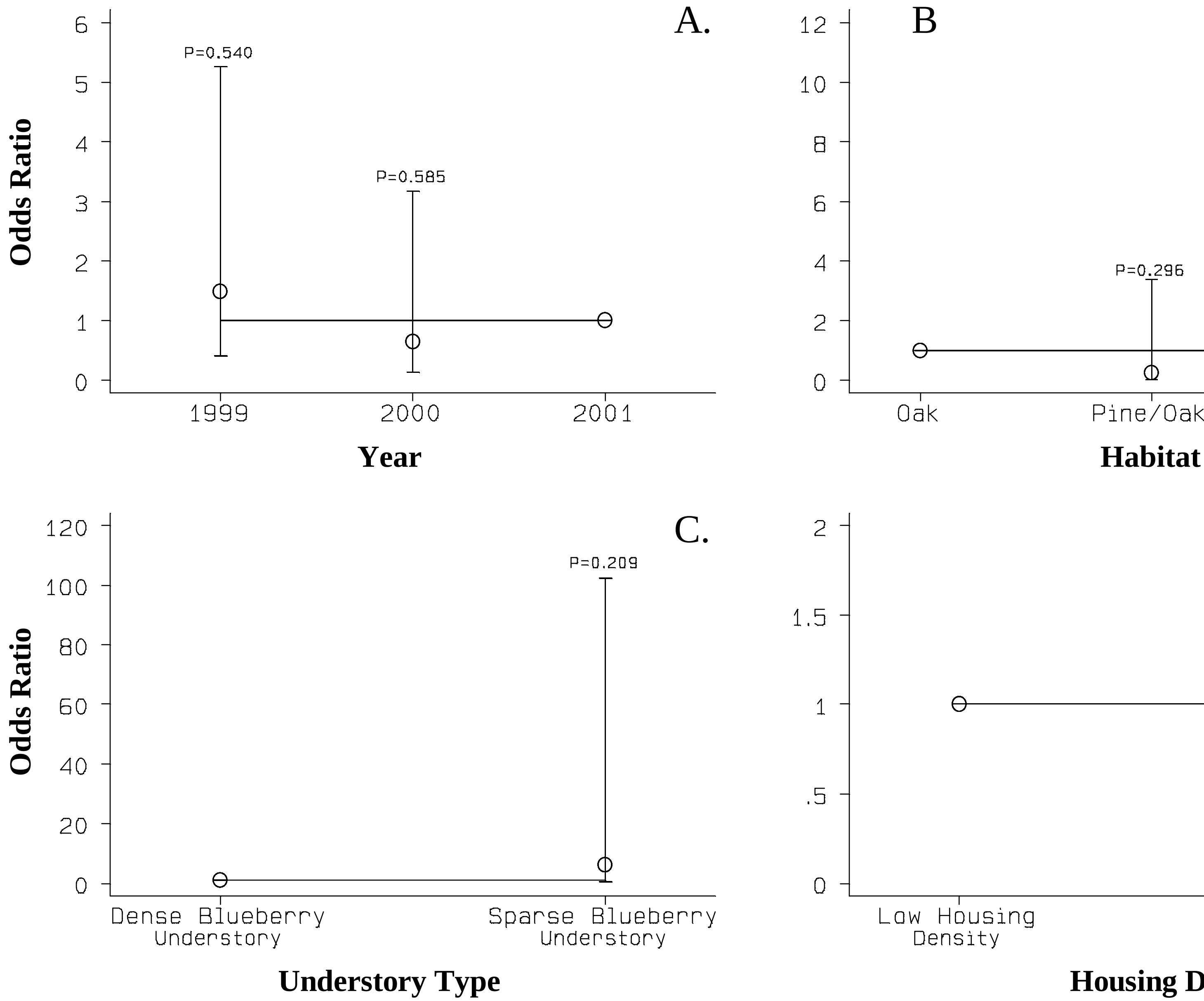


Figure 2c. The odds ratios for productivity indices (with 95% confidence intervals) for Tufted Titmouse at Cape Coo the design variables: A. year; B. canopy type; C. understory type; and D. housing density class within a 2 km center of the station. The odds ratios for each design variable were estimated using multivariate logistic regre factors year, canopy type, understory type, and housing density class. Each design variable is compared to a reference point (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.

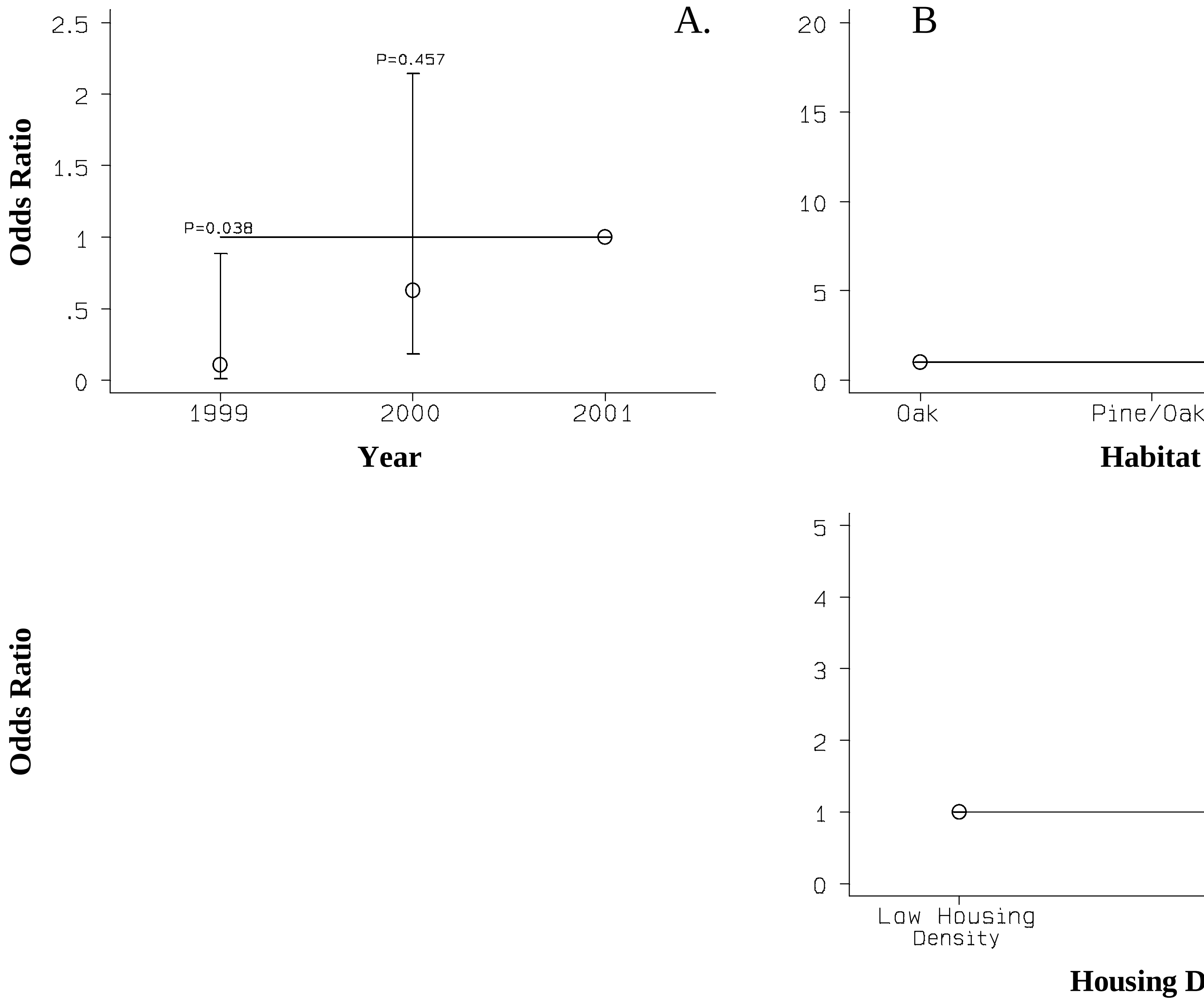


Figure 2d. The odds ratios for productivity indices (with 95% confidence intervals) for Chipping Sparrow at Cape C
the design variables: A. year; B. canopy type; and C. housing density class within a 2 km radius circle around
The odds ratios for each design variable were estimated using multivariate logistic regression including the fa
and housing density class. Each design variable is compared to a reference variable; the reference point (lack
intervals) and a reference line are plotted for ease of comparison.

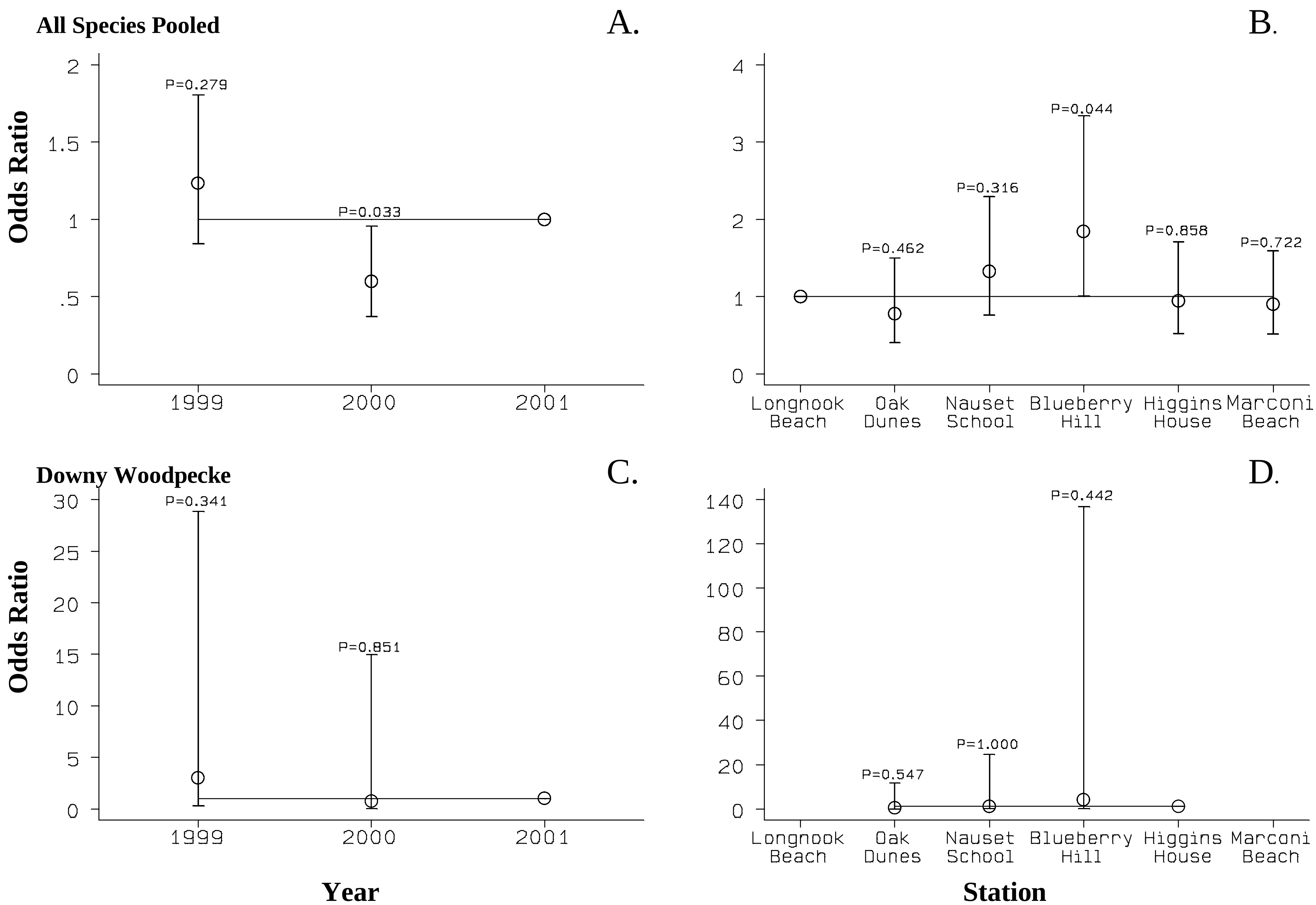


Figure 3a. The odds ratios for productivity indices (with 95% confidence intervals) for all species pooled and Downy Woodpecker a Cape Cod National Seashore for the design variables: A. year and B. station. The odds ratios for each design variable were estimated using univariate logistic regression. Each design variable is compared to a reference variable; the reference poin (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.

Blue Jay

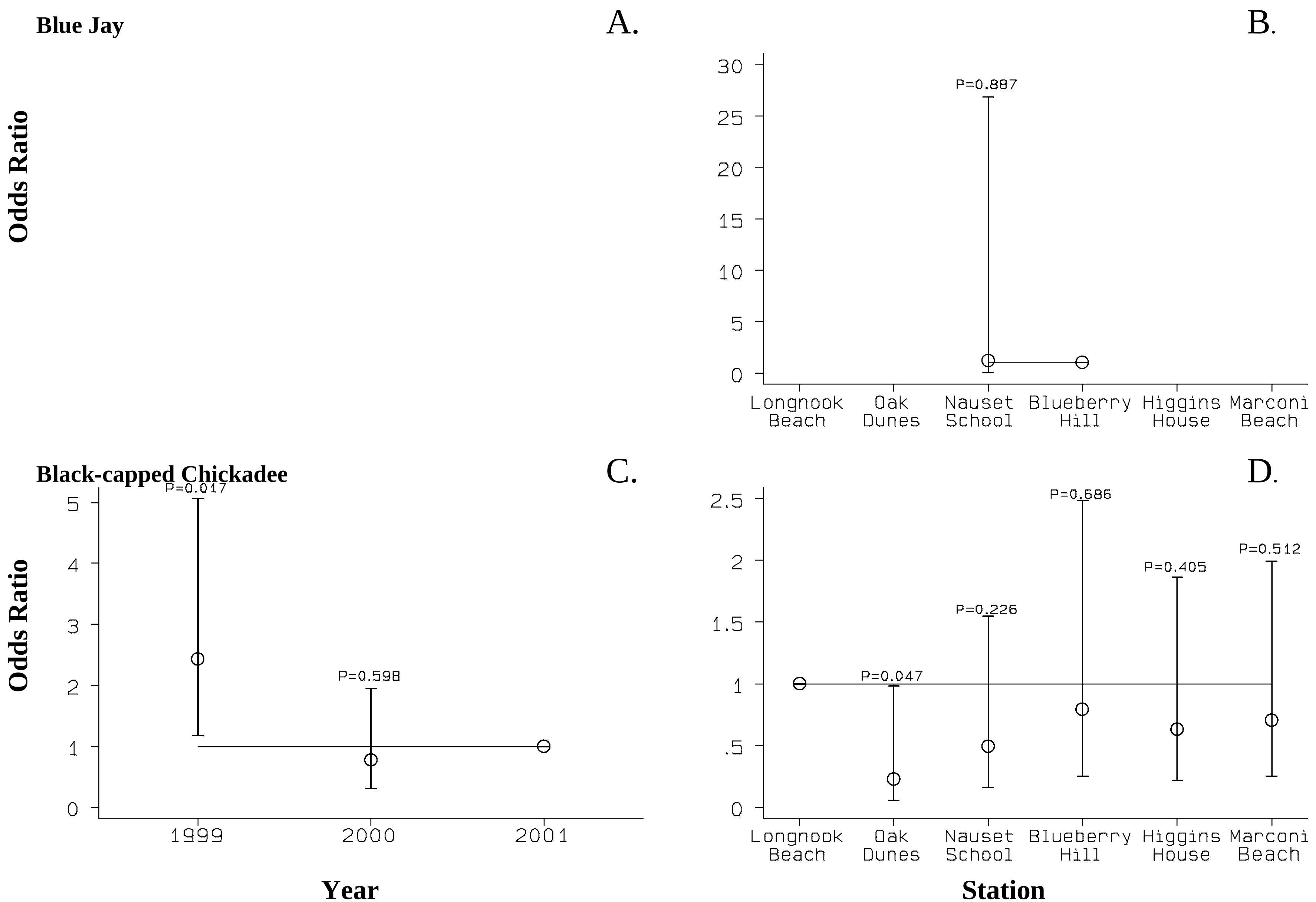


Figure 3b. The odds ratios for productivity indices (with 95% confidence intervals) for Blue Jay and Black-capped Chickadee at Cape Cod National Seashore for the design variables: A. year and B. station. The odds ratios for each design variable were estimated using univariate logistic regression. Each design variable is compared to a reference variable; the reference point (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.

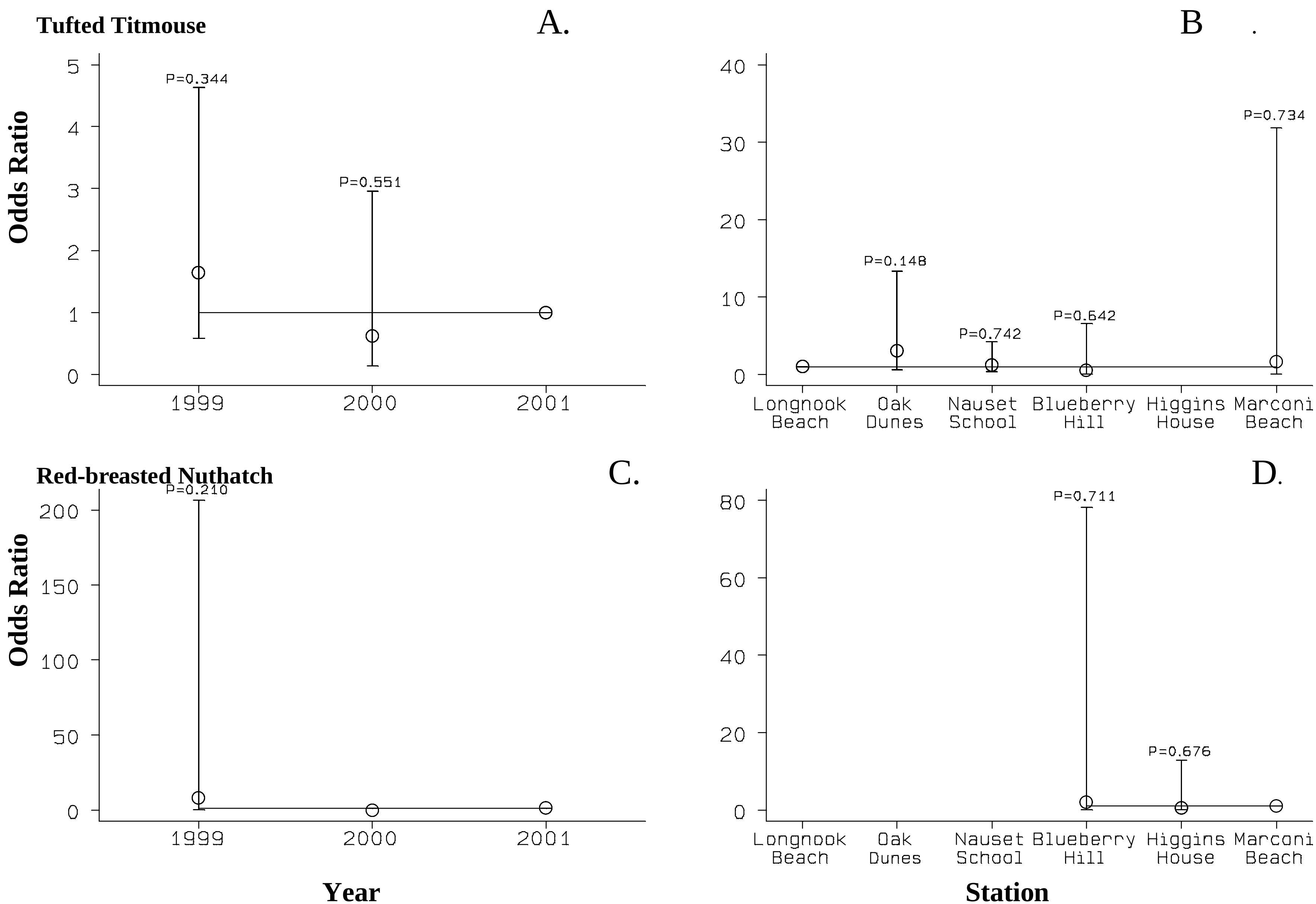


Figure 3c. The odds ratios for productivity indices (with 95% confidence intervals) for Tufted Titmouse and Red-breasted Nuthatch a Cape Cod National Seashore for the design variables: A. year and B. station. The odds ratios for each design variable were estimated using univariate logistic regression. Each design variable is compared to a reference variable; the reference poin (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.

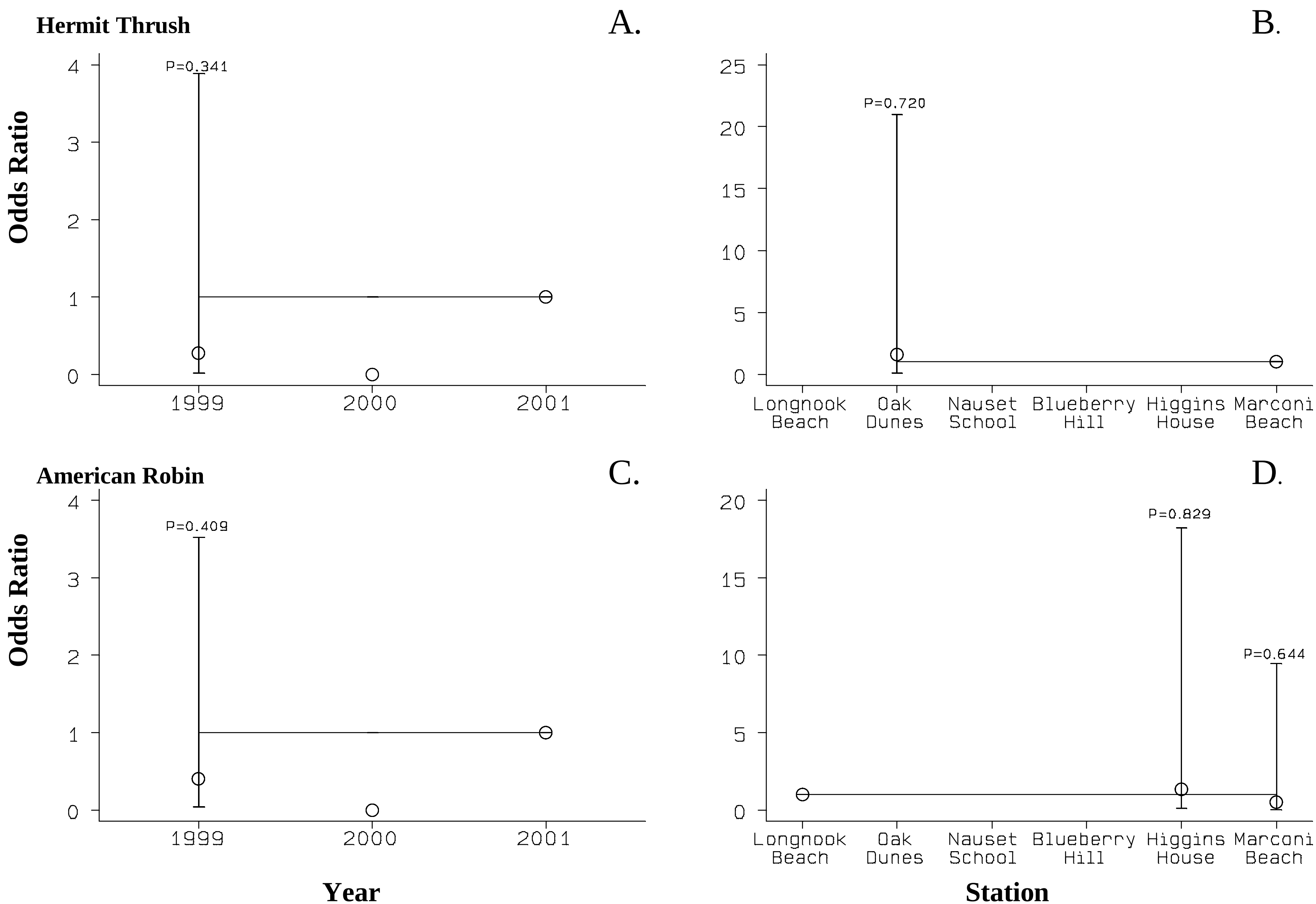


Figure 3d. The odds ratios for productivity indices (with 95% confidence intervals) for Hermit Thrush and American Robin Nuthatch at Cape Cod National Seashore for the design variables: A. year and B. station. The odds ratios for each design variable were estimated using univariate logistic regression. Each design variable is compared to a reference variable; the reference poin (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.

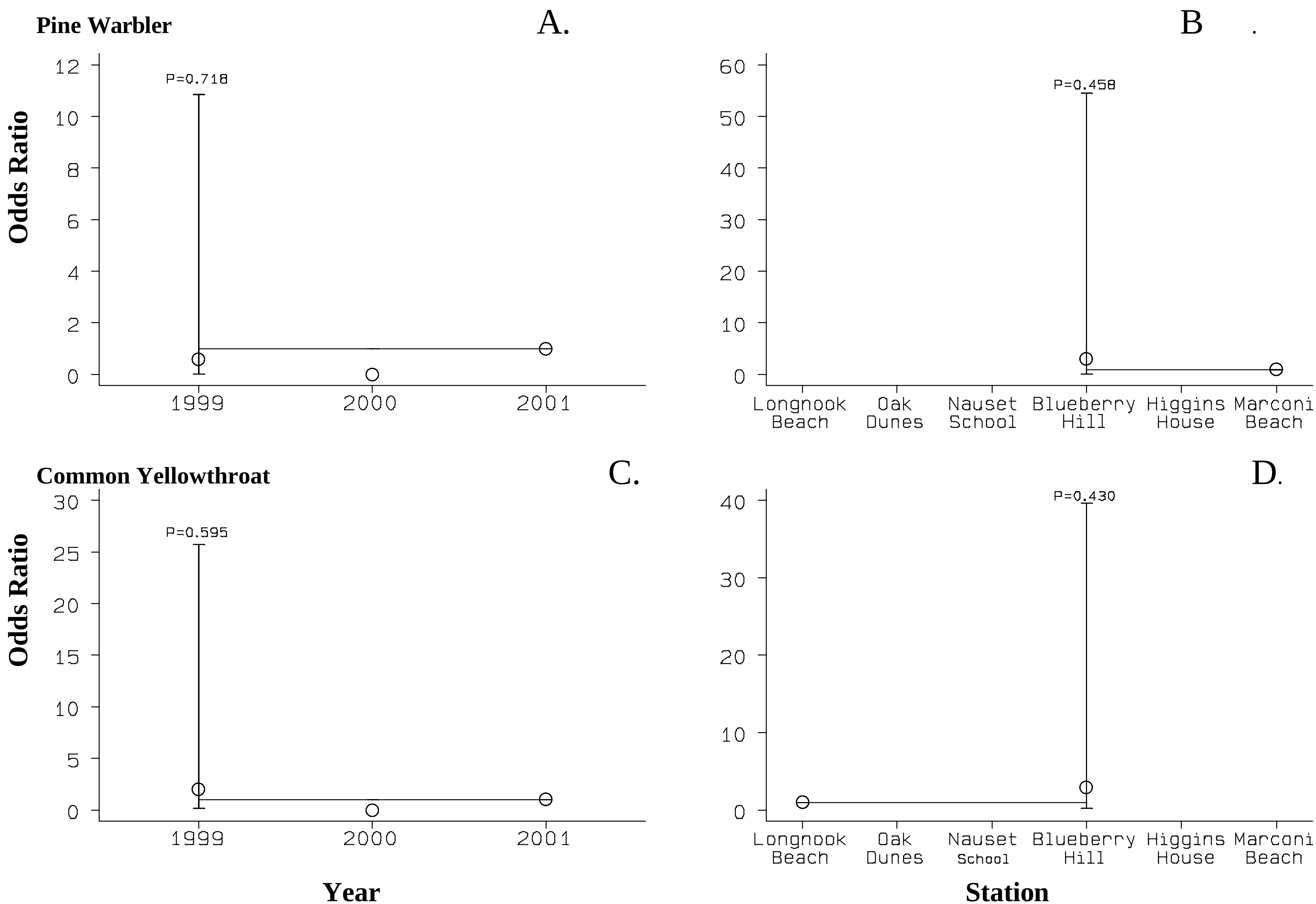


Figure 3e. The odds ratios for productivity indices (with 95% confidence intervals) for Pine Warbler and Common Yellowthroat a Cape Cod National Seashore for the design variables: A. year and B. station. The odds ratios for each design variable were estimated using univariate logistic regression. Each design variable is compared to a reference variable; the reference poin (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.

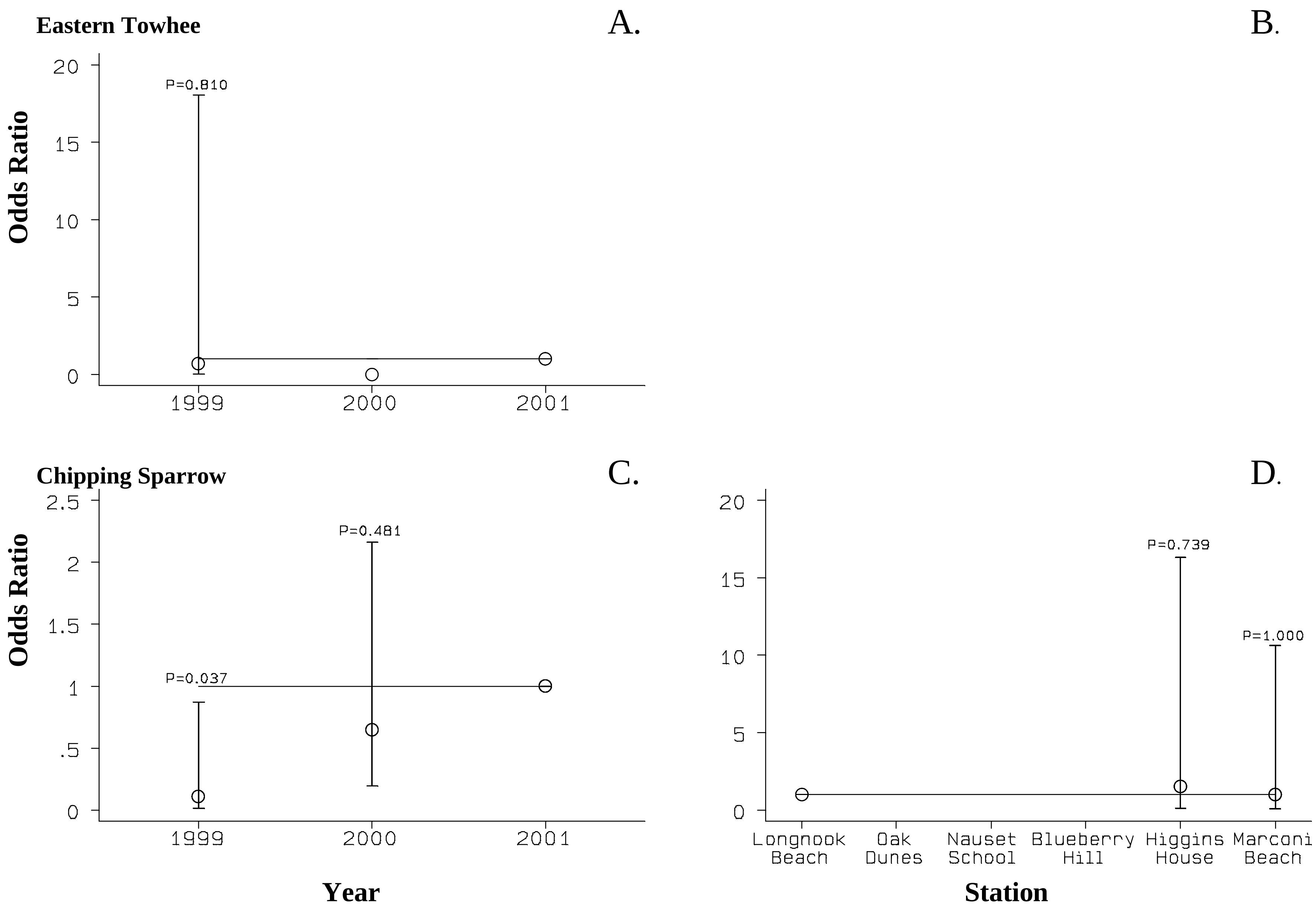


Figure 3f. The odds ratios for productivity indices (with 95% confidence intervals) for Eastern Towhee and Chipping Sparrow at Cape Cod National Seashore for the design variables: A. year and B. station. The odds ratios for each design variable were estimated using univariate logistic regression. Each design variable is compared to a reference variable; the reference point (lacking 95% confidence intervals) and a reference line are plotted for ease of comparison.