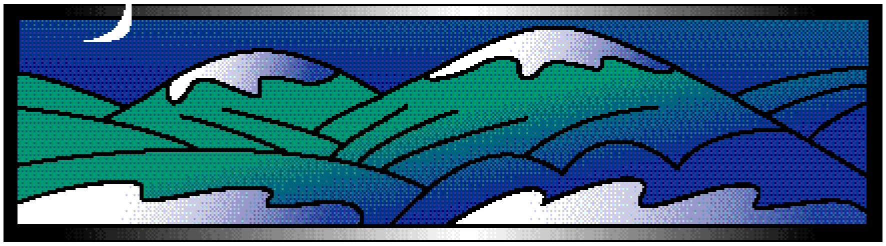
MANAGING LANDBIRD POPULATIONS IN FORESTS OF THE PACIFIC NORTHWEST:

FORMULATING POPULATION MANAGEMENT GUIDELINES FROM LANDSCAPE-SCALE ECOLOGICAL ANALYSES OF MAPS DATA FROM AVIAN COMMUNITIES ON SEVEN NATIONAL FORESTS IN THE PACIFIC NORTHWEST

A REPORT TO THE

Pacific Northwest Region (Region 6), USDA Forest Service



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INTRODUCTION

The Pacific Northwest Region of the USDA Forest Service contains 19 National Forests that provide timber, forage for cattle and wildlife, and numerous recreational opportunities. These and similar activities on lands surrounding national forests affect avian communities through alteration or removal of their preferred habitats. In 1993, the Pacific Northwest Forest Plan emerged for managing federal forests; providing local economic aid to businesses, and communities; and coordinating forest management actions with federal agencies and state, local, and tribal governments in Oregon, Washington, and California. The plan includes strategies for adaptive forest management, conservation and restoration of riparian habitat, and the protection of sensitive species on nonfederal forestlands. Such species include two federally listed species, Northern Spotted Owl and Marbled Murrelet. Achieving the ecological goals and objectives of the PNFP requires cooperation among multiple federal agencies, academia, and other organizations that research individual species, natural communities, and ecosystems. Since its inception, the PNFP has become a model for regional implementation of the Healthy Forests Restoration Act of 2003.

We analyzed 10 years (1992-2001) of Monitoring Avian Productivity and Survivorship (MAPS) data collected by The Institute for Bird Populations (IBP) from 42 MAPS stations on seven USDA Forest Service national forests in the Pacific Northwest region of North America. These analyses produced estimates (or indices) of avian demographics at regional-, national forest-, and individual MAPS station-scales. We combined these data with spatially explicit land cover data to construct species-landscape models. In turn, these allowed us to identify and formulate management actions that can be implemented on these (and other) forests, aimed at reversing population declines and maintaining stable or increasing populations of Neotropical migratory birds and other resident and migratory landbirds. We intend to make the findings of this research available to multiple bird conservation plans currently under development for forests of the Pacific Northwest region including the Pacific Northwest Forest Plan (PNFP).

Bird conservation and monitoring efforts in Pacific Northwest forests

In 2001, by executive order 13186 of the president of the United States and in furtherance of the purposes of five conservation Acts of Congress, including the Migratory Bird Treaty Act, all federal agencies were mandated to protect migratory birds. More specifically, this order emphasizes the importance of protecting "species of concern" as those priority species identified in the Endangered Species Act and in physiographic regional lists provided by the North American Bird Conservation Initiative (NABCI) or the Neotropical Migratory Bird Conservation Initiative, "Partners in Flight" (PIF). More recently in 2002, the U.S. Fish and Wildlife Service (FWS) published a list of 131 "Birds of Conservation Concern" (BCC) as a guide to prioritizing candidate species for research, monitoring, and management initiatives. Although the Pacific Northwest region forests support some of the highest densities of breeding landbirds in North America, including many Neotropical migrants, few of these are listed as BCC species. The unique habitats and avian diversity of Pacific Northwest forests require a more detailed regional conservation effort aimed at reducing the potentially deleterious effects of multiple land-use management activities on ecosystem function and on important landbird breeding habitat.

Conservation plans for the Pacific Northwest

In January 2004, PIF published the North American Landbird Conservation Plan which includes conservation priorities for birds of North American regional biomes, each formed from three or more NABCI Bird Conservation Regions (BCR). These include two biomes that cover Oregon and Washington States; the Pacific Avifaunal Biome which covers Northern Pacific Rainforests, Coastal California, and Sierra Nevada (Pacific Slope); and the Intermountain West Avifaunal Biome which covers the Great Basin, Northern Rockies and Southern Rockies BCRs.

Within this regionally-organized landbird conservation strategy, the Oregon and Washington chapter of Partners In Flight developed hierarchical Landbird Conservation Plans (LCP), for each of five sub-regions of Washington and Oregon, to ensure long-term maintenance of healthy populations of native landbirds. These plans will eventually quantify the ecological requirements of "focal species" i.e., those species strongly associated with particular forest (or non-forest) conditions and specific habitat attributes. The major objective of these plans is to "recommend management actions that can be implemented by various entities at multiple scales to achieve the biological objectives", such that, "when this ecosystem-driven conservation strategy is fully implemented at large geographic scales, the aggregated effect will be the creation of landscapes that should function to conserve landbird communities."

Overall, the USDA Forest Service is committed to avian conservation as outlined in their Landbird Conservation Program. A recent list of accomplishments includes monitoring and estimation of demographic parameters using MAPS stations located in individual forests. The MAPS program and other landbird research conducted by The Institute for Bird Populations in the Pacific Northwest are critical to the development of successful regional avian conservation strategies.

The role of monitoring

Monitoring is an important early stage in developing an adaptive management strategy towards ecosystem conservation and, especially with regard to bird monitoring, the value of the various monitoring protocols is a topic of debate. Several organizations collect and analyze bird-monitoring data that can be used to quantify the avian demographics and the ecological requirements of landbirds that breed in the Pacific Northwest. Among these and critical to the continental monitoring effort is the North American Breeding Bird Survey (Sauer et al. 2004) that collects and analyzes adult breeding landbird point count data to provide quantitative estimates of regional (or finer scale) population trends. In fact, many of the focal species chosen in the Landbird Conservation Plans are species with significantly declining populations according to Breeding Bird Survey (BBS ; Sauer et al. 2004) data at the regional- or ecosystem-scale.

Although continental scale long-term point count data are critical monitoring requirements, local conservation efforts based on numbers of adults alone may be counter-productive because high densities of adults are not necessarily correlated with high reproductive success. Because of confounding effects of population sources and sinks, information on presence/absence or even relative abundance or population size can provide misleading indicators of habitat quality (Van Horne 1983, Pulliam 1988). There is also concern that some management strategies may attract high numbers of adults but create an “ecological trap” in which adult density is high but reproductive success is low (Manolis 2002).

Quantitative information on avian demographic parameters (including survival and reproductive success), such as that derived from constant-effort mist netting protocols (MAPS, CES in Britain), may better indicate the quality of the habitat at the local scale for several reasons. Constant-effort mist netting and banding stations are visited multiple times during the breeding season thereby reducing the bias of daily variation in environmental conditions. The MAPS stations in the national forests of PNW are generally located away from the roadside and therefore less affected by ecological edge effects, including pollution, predation, and parasitism. We know, from other studies, that the strength of the relationships between of MAPS-derived avian demographics and landscape attributes (e.g. forest cover) generally increases with radius from the banding station, up to some maximum value, after which it decreases (unpublished data). This threshold radius varies among species but ranges from two to eight kilometers, representing areas of between 1257 - 20130 hectares, perhaps dependent upon the size, vagility, and behavioral traits of the species. This strongly suggests that the MAPS data, as assumed in the original protocol (DeSante 1995), are sampling the post-breeding and post-fledging dispersal of adults and young from the surrounding landscape as well as sampling the individuals that breed within or close to the station (i.e., those individuals that are captured multiple times in a year and/or in multiple years). It is therefore likely that the effect of management actions developed from species-landscape modeling of this kind and applied over spatial extents of 100’s to 1000’s of hectares will be detectable in future monitoring data (effectiveness monitoring).

Developing species-landscape models

In this study, we followed the general approach of the Landbird Conservation Plans by defining the parameters of species-landscape models in an attempt to quantify the ecological requirements of “focal species”; those species strongly associated with particular forest (or non-forest) conditions and specific habitat attributes (e.g. Rich 2002). First, we identified a suite of species of “conservation concern” including those species:

a) classified by PIF as Species of Continental Importance (SCI) in the Pacific Avifaunal Biome comprising Bird Conservation Regions 5 (Northern Pacific Rainforests), 15 (Sierra Nevada), and 32 (Coastal California),
b) classified as SCI in the Intermountain West Avifaunal Biome comprising Bird Conservation Regions 9 (Great Basin), 10 (Northern Rockies), and 16 (Southern Rockies),
c) listed as focal species in Partners in Flight Bird Conservation Plans for four (of five) ecological sub-regions of Washington and Oregon, or in the PIF Bird Conservation Plan for Montana,
d) exhibited negative population trends in BBS data (1980-2003) in any of four PIF Bird Conservation Regions (i.e. Northwestern Interior Forest, Northern Pacific Rainforest, Great Basin, and Northern Rockies), and
e) exhibited significantly declining demographic variables from MAPS data collected on one or more national forests.

We also categorized each species as a Neotropical migrant, short-distance migrant (or permanent resident) of forested or scrub-successional habitats.

For each species, we processed the entire western region MAPS dataset (represented by nearly 200 stations) using a suite of programs that extract the various demographic variables later used as dependent variables in the construction of species-landscape models. This extensive analysis includes estimation of the effort-adjusted numbers of adults and young, detection of temporal trends among a set of demographic parameters, estimation of adult survival rates, indexing of reproductive success, and a *station x species* breeding status matrix that categorizes the frequency with which a species breeds at a station. Some of these demographic parameter estimates satisfy the research and monitoring requirements stated in the Northwest Forest Plan, NatureServe species accounts, and PIF documentation.

We then constructed species-landscape models by combining the demographic data for species of conservation concern with “landscape metrics” derived from spatial analyses of land coverages surrounding those MAPS station at which the species was captured in sufficient numbers. Critical to this process was the prior development of software routines to automate the process of spatially analyzing 42 landscapes at multiple spatial scales between 1km and 8km radius areas and vertical resolutions (grid value aggregations). The final step was to perform multiple regression analyses and select statistically defensible models by incorporating selection criteria based on the principles of maximum-likelihood estimation and information complexity.

Spatial datasets

We obtained and modified appropriate GIS layers from which we calculated landscape statistics to reflect the ecological requirements of focal species (e.g. deciduous forest area) - with particular attention to critical attributes of important habitats (e.g. riparian buffer width) emphasized in the Northwest Forest Plan and regional PIF conservation plans. For instance, to investigate the importance of riparian habitat we created a grid layer in which 30m-resolution cells are categorized as proximal riparian habitat if a perennial stream passes through it. We derived this layer from a region wide hydrographic database provided by StreamNet; a cooperative venture of the Pacific Northwest's fish and wildlife agencies and tribes that is administered by the Pacific States Marine Fisheries Commission. In addition, we downloaded a land cover layer into our GIS system featuring broad categories of cover (forest, grassland, shrub etc.), which was created between 1988 and 1991 by Forest Service Region Six researchers. More importantly, this coverage categorizes multiple classes of percent canopy cover - an important variable for many landbirds of coniferous, deciduous, and mixed forest. These forest categories are themselves differentiated in another regional land cover layer used in these analyses - the National Land Cover Dataset (NLCD 1992). Lastly, using the National Elevation Dataset, we calculated several altitudinal parameters and indices of topographic complexity for landscapes surrounding each MAPS station.

For each national forest, we identified a list of species of conservation concern that the MAPS protocol effectively monitored. We also identified the monitoring stations at which populations of these birds declined over the ten-year period 1992-2001. We provide forest-specific recommendations concerning which species and existing stations should become the focus of future demographic monitoring efforts. “Slow” stations, at which few birds of interest are captured, will be discontinued in favor of relocating them to areas where they can more effectively monitor one or more species of conservation concern. Finally, we discussed many of these recommendations and suggestions with silviculturalists and wildlife biologists working in national forests of particular conservation value.

Management of Pacific Northwest forested landscapes

National forests of the Pacific Northwest region are moderately to highly fragmented as a consequence of both the region's complex topographical diversity and the patchiness superimposed by post-settlement patterns of logging, development, managed fire history, and extensive forest pest outbreaks. The resultant heterogeneous landscapes are seral mosaics comprised mainly of patches of sparse vegetation, grassland, shrub distributes throughout extensive tracts of forest. The forest stands might be natural or cultivated; coniferous, deciduous, or mixed, and with various levels of canopy closure. For many species, the type and level of canopy closure in a forest stand may be critical to providing suitable nesting habitat. For example, two focal species of the Northwest Forest Plan require specific canopy conditions; the hermit warbler (*Dendroica occidentalis*) prefers a closed canopy whereas MacGillivray's Warbler (*Oporornis tolmiei*) prefers the dense shrub understory normally provided by a more open forest. In forests of the Pacific Northwest appropriate silvicultural techniques and rotations can be used to manage for the forest understory and canopy attributes attractive to particular landbirds or landbird communities (Busing and Garman 2002), both in the breeding season and in the winter.

The major management issues in the Pacific Northwest forests concern maintaining ecosystem function whilst allowing multiple land usage, including agricultural diversion, watercourse alteration, logging, grazing, and recreation.

Riparian habitat

Riparian corridors, wet meadows, and lacustrine habitats are ecologically critical features of the PNW forested landscapes because they provide a spatially extensive and relatively contiguous habitat for diverse communities of mammals, birds, fish and amphibians. Riparian corridors also help maintain a stable microclimate in the surrounding forest.

Consequently, many conservation recommendations for the PNW avifuana concern the health and viability of moister forested and shrub habitats. For many species, healthy riparian forest/woodland provides critical "source habitats" in which the birth rate exceeds the death rate. These "high productivity" habitats drive species' metapopulation dynamics by producing enough individuals to disperse to poorer quality habitats and by increasing the chances that individuals will discover unoccupied habitat patches and establish breeding populations. In the coniferous dominated forests of the Pacific Northwest, they provide the deciduous canopy trees attractive to many landbird species that breed in those forests and critical to a few species such as Black-headed Grosbeak (*Pheucticus melanocephalus*).

Generally speaking, riparian habitats in western North America are continuously affected by timber removal, livestock grazing, watercourse modification and diversion, fire suppression, and recreational activities. This has led to loss and fragmentation of riparian habitats, shifts in plant species composition, establishment of invasive species propagules, as well as increased fuel loads and altered microclimates (Dwire and Kaufmann 2003). To successfully restore and maintain riparian systems, it is critical that we gain a deeper understanding of their fire ecology (Bisson et al. 2003), the effects of logging, and the structural characteristics required to maintain healthy populations of species of conservation concern.

Forest fragmentation

Forest fragmentation, riparian or otherwise, is another major management issue that has long been the focus of landscape-scale avian ecological research. Many birds are considered "area sensitive" or "edge avoiding" and can be termed "forest interior" species, which means that their population levels will respond to the sizes and shapes of remnant forest patches. So, although a logging rotation will inevitably create a checkerboard landscape of uneven aged stands, it is the "grain" of that checkerboard pattern that is critical to forest interior species. For many species, the critical patch size thresholds that define breeding presence, and the difference between source and sink habitat, have not previously been quantified. This information is critical to avian conservation efforts in actively logged forests to define the grain of cutting patterns and of regeneration stands.

Silvicultural practices increasingly impact the highly productive bird communities of riparian forests of the Pacific Northwest; consequently, many landbirds associated with riparian habitat are listed by multiple agencies as species of conservation concern. The biggest potential threat to riparian bird communities is the removal, alteration, or degradation of deciduous riparian habitat associated with larger rivers (67-140m wide) that support area-sensitive species such as warbling vireo (*vireo gilvus*) and probably represents source habitat for numerous other species. Pearson and Manuwal (2001) found that riparian bird species responded negatively to reductions in riparian buffer widths of second- and third-order streams within managed Douglas fir forests. They found that reducing the riparian buffer width to less than 45m either side of the stream caused declines in the abundances of black-throated gray warbler, golden-crowned kinglet (*Regulus satrapa),* and brown creeper (*Certhia americana*). Also, in western Oregon, Hagar (1999) found that abundances of brown creeper, Pacific-slope flycatcher (*Empidonax difficilis*), chestnut-backed chickadee (*Poecile rufescens*), and winter wren (*Troglodytes troglodytes*) increased with forested riparian buffer width.

Invasive plants

Riparian habitat tends to promote high species diversity, species richness, densities, and reproductive success among breeding birds, especially at lower elevations. Unfortunately, lower elevation habitats of this kind are threatened by diminishing water flow (due to impoundment and diversion), property development, increasing recreational pressure, fire suppression, and more recently, the spread of exotic plants. Japanese knotweed (*Polygonum cuspidatum*) is a rhizomatous perennial that poses a potentially serious threat to riparian habitats in the Pacific Northwest. Currently expanding its range into Wyoming and the Upper Snake River in Idaho, Japanese knotweed spreads downstream, by seed or fragment propagule, and once rooted spreads locally by vegetative reproduction to produce a monoculture that chokes existing native vegetation. It has no known benefits for birds.

Russian-olive (*Elaeagnus angustifolia*) is an exotic tree species that is spreading west of the Great Plains and typically replaces willow and cottonwood stands. According to Weber and Whitman in Colorado Flora Western Slope, "*This tree is rapidly replacing native riparian* *species and eliminating valuable nesting sites for birds. It should be eliminated whenever possible*."

Tamarisk (*Tamarix spp.*) has also successfully invaded many parts of the southwestern states and can be found as far north as Montana. Typically, tamarisk spreads by wind-borne seed and establishes itself in riparian and lacustrine habitats where it will gradually replace stands of native cottonwood and willow that provide valuable nesting and foraging habitat for riparian bird communities. Tamarisk transpires high volumes of water (up to 1,000 liters of water per day), depletes groundwater supplies (or stream flow), and leaves behind salt deposits in the soil in concentrations that only itself and a small community of native salt-tolerant plants can tolerate.

Montane wet meadows provide another critical and threatened breeding habitat for many species, especially Lincoln's Sparrow (*Melospiza lincolnii*), Willow Flycatcher (*Empidonax traillii*), and Song Sparrow (*Melospiza melodia*). Equally importantly, montane wet meadows provide post-breeding, dispersal, and migratory habitat for many other species. These unique habitats, and birds that utilize them, are threatened by the effects of multiple factors, including grazing, exotic plant invasion, and shifting climate (De Valpine and Harte 2001). However, habitat damage due to livestock grazing is the most likely reason for local population declines and extirpations of these species (Cicero 1997).

The role of insect outbreaks in forest ecology

Native forest insects are considered a problem by commercial foresters in the Pacific Northwest because large outbreaks of beetle and moth pests can devastate large tracts of valuable timber. In recent decades the extensive defoliation was caused by two irruptive species: the western spruce budworm (*Choristoneura occidentalis*) and the Douglas-fir tussock moth (*Orygia pseudotsugata*). Both of these species are common prey for many bird species (Torgersen *et al.*, 1990). In addition, outbreaks of aphis, adelgids, and scale insects can retard annual growth and provide food for birds that glean growing tips of conifer trees. However, there is growing evidence that these "pests" are beneficial to forest ecosystems (Schowalter 2001) in that they remove the weaker trees, thin the forest out, and allow the larger healthier trees to gain more nutrient and light resources. In these forests, stand type and age heterogeneity may be driven by pestilence and disease. Consequently, pine forests can appear healthier 10-15 years after an outbreak of mountain pine beetle than they were before the outbreak. In this respect native forest insects may be considered forest ecosystem engineers. This may be especially true in moister forest ecosystems that rarely burn, whereby senescence and stress can facilitate outbreaks that kill a large proportion of trees across 100's of hectares. Such outbreaks can also thin the canopy and allow more dense understory vegetation to develop, providing nesting and foraging habitat for many bird species not adapted to forest interior habitats.

It also appears that there is a direct link between climate phenomena, insect outbreaks, and avian reproductive success in the Pacific Northwest (Nott et al. 2002). At the regional scale, annual forest defoliation correlates with North Atlantic Oscillation induced mild winters. After such winters resident species and short-distance migrants have higher reproductive success suggesting pest outbreaks benefit these populations (Torgersen et al. 1990). For these reasons we analyzed USFS historical spatial datasets to quantify cumulative pest damage in the vicinity of each MAPS station and added these values to the suite of predictive variables.

The ecological importance of edge in the Pacific Northwest

Not all landbirds that breed in the national forests require forested habitat. Logging practices in many areas of these national forests have created a patchy "checkerboard" featuring relatively uniformly sized patches at different successional stages. Through time, as logging continues and previously harvested patches succeed towards forest, the landscape resembles a shifting mosaic of seral habitats. The grain of this "managed" mosaic is likely much finer than that of a natural mosaic in which historical fires and large outbreaks of defoliating insects (or disease) would have created larger patches of even-aged vegetation. One ecological consequence of managing for a fine-scale checkerboard landscape is that it creates more edge per area of forest in comparison to a coarser scale (natural or managed) mosaic. Contemporary management guidelines for clearcutting suggest that a few larger habitat patches have greater conservation value than many small habitat patches (e.g. Swanson and Franklin 1992), whether the target habitat is forest, shrub or grassland. It will be difficult to maintain larger patches of similar treatment in forests of the Pacific Northwest without synchrony among and within neighboring timber interests regarding rotation, thinning and clearcut methods. A successful strategy would maintain a maximum number of stands larger than the minimum recommended size for forest interior species, especially those that breed exclusively in riparian habitats dominated by deciduous tree species. However, few minimum stand sizes for species of concern have been quantified.

Historically, the bulk of landscape-scale avian ecological research has concerned the effects of habitat fragmentation in terms of patch size, core-area, connectivity, isolation and other spatial parameters associated with isolated habitat patches. In an increasingly fragmented world an increasing portion of the ecological literature is now concerned with the influence of edge on population dynamics and persistence. Although avian responses to “ecological edges” have been studied for over 50 years many of the numerous kinds of “edge effects” described in the literature seem to vary geographically by species.

Sisk and Battin (2002) reviewed published research relating to habitat edges and avian ecology and revealed that only 4 such studies have been conducted in western North America. They noted that a) the response of bird populations to increasing amounts of edges in the western United States is poorly understood because most of our knowledge of “edge effects” is derived from studies of forest birds in the eastern half of the United States, b) western landscapes are generally more heterogeneous than eastern landscapes and therefore edge is a more significant natural component of the landscape, c) riparian habitat provides extensive edge in western landscapes, and d), because predominant management practices are concerned with boundary delineation and management avian conservation in the Pacific Northwest should adopt management guidelines based on a better understanding of the responses of bird populations to both edge and matrix. A more recent review of ecological responses to habitat edges (Ries et al. 2004) emphasizes the importance of developing management tools that consider ecological responses to edge.

Fragmentation and edge habitat

Any disturbance of a landscape, natural or human-caused, generally alters both a) the size and shape of one or more habitat patches, and b) the length, shape, and relative amounts of different types of edge. For many landbird species, the availability of suitable nesting habitat and subsequent reproductive success depends upon the attributes of both matrix and edge. For instance, as forest fragmentation increases above 50% the abundances of many "edge-avoiding" or "area-sensitive" forest-dwelling species decrease exponentially because the mean size of forested patches in the landscape decreases exponentially after 50-55% fragmentation occurs. At these high levels of fragmentation, the number and shape of the larger patches becomes critical to providing high quality habitat. Obviously, for non-forest (or scrub-successional) species the mean patch size of their preferred habitat increases with increasing levels of forest fragmentation.

Edge habitat is not only a more significant component at higher levels of fragmentation, but edge metrics are very sensitive at those levels; a small change in the landscape can have a large effect on one or more edge statistics and the overall ecology. For instance, the creation of a small edge might join two other edges together. The resultant long edge can then act as a corridor for the dispersal of previously unknown predators or exotic plants to a new area, or become a suitably sized habitat for an "edge specialist". It is therefore essential that we investigate the relationships between the amount and type of edges and the ecology of landbirds that breed in the national forests of the Pacific Northwest.

Overall, species richness and abundance of plants and animals is highest in such heterogeneous landscapes because more different kinds of habitat are represented and because there are many different kinds of edge habitat as defined by pairs of adjacent habitats (e.g. forest-shrubland). Along an edge between two habitats, we would expect to find high abundances and species richnesses greater than the sum of half the number of species that prefer the habitat type on each side of the edge (Odum 1971). Importantly, some of those species may not commonly occur in the adjacent habitats. They are so-called "edge specialists", such as Cassin's Vireo (*Vireo cassinii*) and purple finch (*Carpodacus purpureus*) that flourish in heterogeneous landscapes and rely upon disturbance regimes and perturbations of the landscape to create preferred edge habitat type(s). A number of other species might breed in the interior of a patch but forage on the edges where invertebrate density and diversity is greatest. Because of the relatively high levels of fragmentation within the national forests of the Pacific Northwest, edge habitat is a significant component of the landscape. This is another reason why the predictive potential of edge habitat analyses in demographic models requires investigation.

Investigating species-edge relationships

Analyzing MAPS data in the context of available land cover datasets provides us with an opportunity to investigate landscape-level relationships between avian demographics and the amount and pattern of unique edge types. For this, we developed a GIS script in ArcView 3.2 Avenue (ESRI, Inc.) to produce unique edge coverages by analyzing classified grid coverages. We used selected spatial statistics from these coverages and the coverages previously mentioned in predictive "species-edge" models of avian demographics.

Sisk and Haddad (2002) proposed that edge effects occur because edges (and unique edge types) influence movement, mortality, food availability, and the interactions among species of differing communities. Ries et al. (2004), in a broader review of ecological responses to edge, identified four mechanisms that appear to be operating: ecological flows, access to spatially seperated resources, resource mapping, and species interactions. At the scale and method of investigation described here it is likely impossible to fully understand the nature of the ecological mechanisms behind an identifiable species-edge relationship. This does not necessarily mean we cannot successfully "macro manage" the landscape in favor of a given species by using an appropriate species-edge model.

Recommended management actions from these models might include maintaining large tracts of particular forest types, restoring lost or degraded riparian forest, rotating thinning or cutting techniques in existing forest, and maintaining early seral habitats through seasonally appropriate burning or cutting regimes. Although such conservation modeling and management practices are not new; the models presented here are parameterized specifically for national forests of the Pacific Northwest using five regional land cover datasets and multiple regression model selection criteria based on state-of-the-art information theory and likelihood estimation (Bozdogan 1990, 1994).

However, management recommendations made from landscape-scale studies alone may be insufficient to provide an effective avian conservation plan at the local level. Micromanagement of the finer-scale deleterious effects of fragmentation and management, such as exotic or noxious plant invasion into sensitive habitats and understory overgrowth, may require equal attention.

In consideration of these issues, we identified spatial datasets from which ecologically meaningful parameters could be determined based on the biology and ecology of each species of conservation concern. From these datasets, we calculated spatial statistics relating to land cover (NLCD), elevation (NED), canopy type and cover (USFS), stream density (StreamNet), and damage caused by outbreaks of forest pests (USFS). In addition we created spatial models of unique edge types derived from the canopy type and cover layer.

To summarize, the goals of this project are to a) integrate MAPS monitoring in the Pacific Northwest with continental, regional, and sub-regional bird conservation plans, b) develop species-landscape models that may meet research requirements listed for species of conservation concern, c) collaborate with biologists and foresters in each national forest (or ranger district) in devising management plans to reverse local population declines of one or more bird species of conservation concern, d) devise those plans in consideration of one or more of the species of management concern that are the focus of this report, and e) give due consideration to the fact that actions intended to benefit one species of management concern will impact other species or guilds. Also, we will provide the findings of this report to the US Forest Service's Research and Development Office.

METHODS

In this investigation we constructed species-landscape models to guide management decisions designed to reverse declining population trends among landbirds that breed in national forests administered by the U.S. Department of Agriculture, Forest Service, especially in the Pacific Northwest Region Six. We analyzed multiple years of MAPS bird banding data from 42 monitoring stations. Among a list of 21 species for which we recorded an average of at least 2.5 aged individuals per year and at least one hatching-year individual, 16 species have been identified as species of conservation concern (SCC) in Washington and Oregon. Station-specific analyses of the banding data allowed us to quantify six demographic parameters for each of 12 (of the original 16) SCC species. From extensive literature searches we provide a synopsis of the management issues relating to each of these species. We then collated multiple spatial statistics associated with a two-kilometer radius area centered on each MAPS station by spatially analyzing reclassified portions of the publicly available datasets including a) National Land Cover Dataset (NLCD 1992), b) USGS National Elevation Dataset (NED), c) USFS Region 6 canopy cover classification (1988-1991), d) Riparian Corridor Surrogate (RCS) derived from StreamNet 100K hydrographic layers (OR/WA/MT), and e) reclassified USFS aerial pest survey data (1991-2001). Combining multiple ecologically meaningful elements of these spatial data (independent variables) with each avian demographic parameter (dependent variable) allowed us to construct species-landscape models by applying information theory and maximum likelihood principles to numerous multivariate regression analyses.

MAPS data

The Institute for Bird Populations (IBP), through its Monitoring Avian Productivity and Survivorship (MAPS) program, collected breeding season mist-netting and banding data from 42 constant-effort monitoring stations on seven US Forest Service national forests in Washington (2), Oregon (4), and Montana (1). Six MAPS stations have been operated in each forest since 1992 (Table 1, Figure 1). We collected and analyzed banding data from each station to obtain study-wide, forest-specific, and station-specific demographic parameters for 21 species.

Table 1. Location codes, station numbers, station codes, and names, state, geographic coordinates, mean elevation (m) of 1kilometer radius (USGS 30m NED) habitat type and first year of operation ('-' denotes still in operation) pertaining of 42 Monitoring Avian Productivity and Survivorship (MAPS) bird-banding stations located on seven national forests of the Pacific Northwest states of Washington, Oregon, and southwest Idaho: Mount Baker NF (MTBA), Wenatchee NF (WENA), Siuslaw (SIUS), Willamette NF (WILL), Fremont NF (FREM), Umatilla NF (UMAT), and Flathead NF (FLAT).

Location	Station number	STA	Station Name	State	Latitude	Longitude	Mean NED elevation (m)	Habitat	Operation
MTBA	11139	FRLA	Frog Lake	WA	48 12 20	-121 37 30	659	dry mixed coniferous forest	92-
MTBA	11140	MUCR	Murphy Creek	WA	48 11 50	-121 31 30	300	disturbed coniferous forest	92-
MTBA	11141	BELA	Beaver Lake	WA	48 09 40	-121 26 50	342	mixed coniferous forest	92-
MTBA	11908	BETH	Bench Thin	WA	48 09 50	-121 27 00	336	mixed coniferous forest	93-
MTBA	11143	PECR	Perry Creek	WA	48 03 30	-121 31 00	650	coniferous rainforest	92-
MTBA	11144	MCLA	Monte Cristo Lake	WA	48 02 50	-121 25 30	786	wet meadow	92-
WENA	11148	TIME	Timothy Meadow	WA	47 04 50	-121 15 20	1012	marsh	92-
WENA	11149	TWPO	Two Point	WA	46 57 40	-120 55 20	1486	montane meadow	92-
WENA	11150	PLVA	Pleasant Valley	WA	46 56 50	-121 18 50	1084	open meadow	92-
WENA	11902	RASP	Rattlesnake Spring	WA	46 48 20	-121 02 40	894	riparian grove	92-
WENA	11151	DECR	Deep Creek	WA	46 46 40	-121 20 20	1317	fir/spruce bog	92-
WENA	11152	QCR2	Quartz Creek 2	WA	47 01 10	-121 07 50	868	riparian alder riverbottom	93-
SIUS	11163	MAPE	Mary's Peak	OR	44 30 50	-123 29 40	310	mature mixed coniferous forest	92-
SIUS	11903	SAME	Salvation Meadow	OR	44 15 30	-123 44 30	216	wet meadow	93-
SIUS	11165	HOME	Homestead	OR	44 30 20	-123 37 40	221	douglas-fir forest	92-
SIUS	11166	BERI	Beaver Ridge	OR	44 18 40	-123 50 20	157	disturbed douglas-fir forest	92-
SIUS	11167	COUC	Cougar Creek	OR	44 16 20	-123 51 40	248	douglas-fir forest	92-
SIUS	11168	CRCR	Crab Creek	OR	44 15 20	-123 51 30	209	disturbed douglas-fir forest	92-
WILL	11157	IKEN	Ikenik	OR	44 22 00	-122 01 00	1042	open meadow	92-
WILL	11158	FIPR	Fingerboard Prairie	OR	44 11 50	-121 57 10	1241	meadow complex	92-
WILL	11159	STFL	Strube Flat	OR	44 08 40	-122 15 10	436	riparian woodland	92-
WILL	11160	CLCU	Clear Cut	OR	43 57 10	-122 12 10	1259	open mixed coniferous forest	92-
WILL	11161	MAPR	Major Prairie	OR	43 53 10	-122 15 50	726	meadow	92-
WILL	11162	BRCR	Brock Creek	OR	43 52 50	-122 12 20	776	buckthorn scrub	92-

Table 1 (continued)

FREM	11169	SYRI	Sycan River	OR	42 40 20	-120 49 00	2042	riparian meadow	92-
FREM	11170	DEAD	Deadhorse	OR	42 35 30	-120 48 50	1984	willow-dominated meadow	92-
FREM	11171	COLC	Cold Creek	OR	42 35 00	-120 55 10	1940	wet meadow	92-
FREM	11172	AUCR	Augur Creek	OR	42 31 10	-120 42 40	1846	riparian meadow	92-
FREM	11173	ISLA	Island	OR	42 30 20	-120 39 40	1661	riparian meadow	92-
FREM	11174	SWCR	Swamp Creek	OR	42 25 50	-120 34 00	1705	riparian meadow	92-
UMAT	11151	BUCR	Buzzard Creek	OR	45 50 00	-117 57 20	1471	open mixed coniferous forest	92-
UMAT	11152	BRME	Brock Meadow	OR	45 48 50	-117 51 40	1257	meadow complex	92-
UMAT	11153	FRME	Fry Meadow	OR	45 47 40	-117 50 30	1285	meadow complex	92-
UMAT	11154	CORI	Coyote Ridge	OR	45 44 50	-118 10 10	1227	mixed coniferous forest	92-
UMAT	11155	BMME	Buck Mt. Meadow	OR	45 40 40	-118 06 40	1418	moist-dry meadow	92-
UMAT	11156	PHCR	Phillips Creek	OR	45 35 20	-118 02 10	1092	coniferous forest	92-
FLAT	11133	CEFO	Coram Forest	MT	48 23 10	-113 58 00	1295	undisturbed mixed forest	92-
FLAT	11134	HIME	Hillary Meadow	MT	48 20 50	-113 58 30	1132	wet meadow	92-
FLAT	11135	SIMO	Sixmile Mountain	MT	47 56 40	-113 50 50	1101	mixed forest	92-
FLAT	11136	SWOX	Swan Oxbow 2	MT	47 53 10	-113 51 40	952	dry meadow	92-
FLAT	11137	SRNA	Swan	MT	47 52 00	-113 48 30	1008	wet meadow	92-
FLAT	11138	SICR	Simpson Creek	MT	47 35 30	-113 41 40	1245	mixed woodland	92-

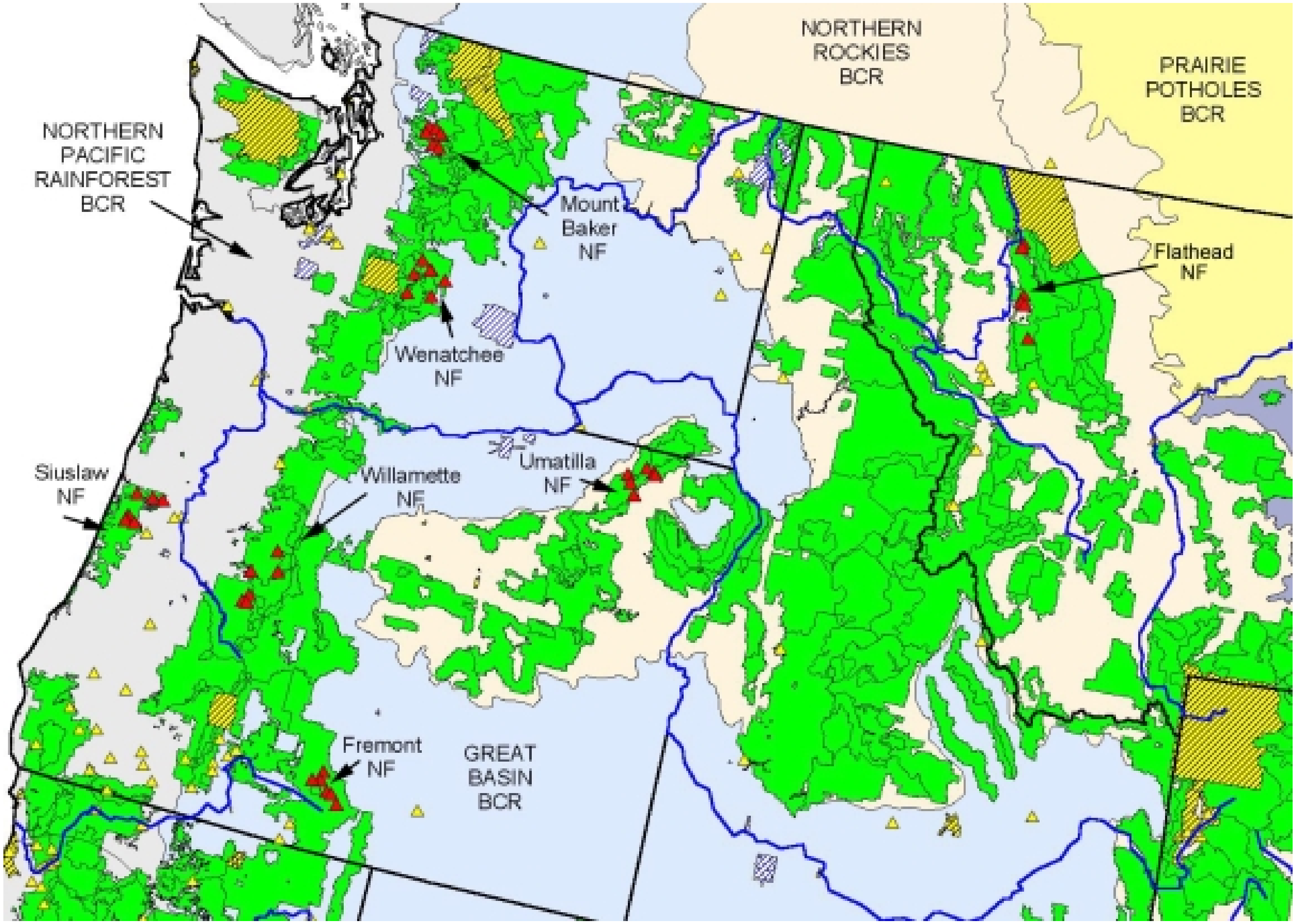

Figure 1. Map of seven groups of MAPS stations (red triangles) operated within seven US Forest Service national forests of Washington, Oregon, and Montana. Two forests lie within the Pacific Northwest Rainforest Bird Conservation Region (BCR), two forests lie within the Great Basin BCR, and two forests lie within the Northern Rockies BCR. USFS lands are shown in green, national parks are shown in hatched yellow, and Dept. of Defense properties are shown in hatched blue.

Study sites

We defined two sets of PNW MAPS stations in this investigation. A "Northwest Forests" set included those MAPS stations operated on national forest lands with the financial and logistical support of the U.S. Forest Service (Table 1, Figure 1). A more spatially extensive "Pacific Northwest Regional" set (not shown) included the Northwest Forest set as well as other "independent" stations operated by public agencies, academic institutions, private organizations, and individual bird ringers (Appendix 1). We used the Pacific Northwest Regional set to correct the raw MAPS data for missed banding effort according to the MAPS constant-effort mist netting protocol. The methodology for correcting missed effort is outlined below and described in detail in Appendix 1. The diurnal- and seasonal-correction models were then applied to the less extensive Northwest Forests dataset to determine the forest-specific avian demographics subsequently used to parameterize landscape/management models for birds of conservation/management concern.

Correcting for missed banding effort

We have developed a reliable methodology and corresponding software algorithms for adjusting productivity indices to account for missing effort in constant-effort mist-netting data (Nott & DeSante 2000; Appendix 1). Minor adjustments were applied to the numbers of individual adult and young birds captured each year to reflect the small amounts of effort that were missed at each station each year due to inclement weather and unforeseen problems with logistics. To do this, we used a modification to the approach suggested by Peach et al. (1998). Our approach involved pooling effort and age-specific capture data for each year for each species from all stations in the region (Appendix 1), in this case, the Pacific Northwest MAPS Regions. The annual temporal pattern of the proportion of effort completed (effort expended/effort expected) in the region is expressed as a two-dimensional matrix of 10-day-period by 10-minute-capture-time-block for that year. The temporal patterns of age-specific captures for each species for the region are also expressed in analogous two-dimensional matrices of 10-day-period by 10-minute-capture-time-block and are converted to annual species- and age-specific matrices expressing the proportion of the total regional captures of that species in each 10-day-period by 10-minute-capture-time-block. The annual station-specific numbers of captures of each age of each species are then adjusted by comparing the annual station-specific effort profile to the annual regional effort profile and regional age- and species-specific capture profiles and inflating the captures of that age class of that species at that station in that year.

In a preliminary study we applied the methodology to an analysis of banding data collected at 40 Alaskan MAPS stations over a ten-year period (1992-2001). The results supported our expectations. For stations and years in which effort was missed early in the season (when most captures are adults) the expected productivity was lower than that calculated from the raw data. For stations and years in which effort was missed late in the season (when many captures are juveniles) the expected productivity was greater than that calculated from the raw data. The model conveys greater precision to models that relate MAPS data to population trends, landscape structure and climate/weather data because it obviates the need to include numerous effort parameters in those models. Because the annual number of visits to each station varies across the study, and in some cases the number of nets varies, we corrected parameters to reflect 600 net hours of annual effort (i.e. 10 nets x 10 visits x 6 hours per visit) at each station. We applied this methodology to acquire less effort-biased estimates of adult captures, young captures, and indices of reproductive success.

Demographic parameter descriptions

From the corrected MAPS data we calculated a suite of demographic parameters that represent useful metrics for identifying the meso-scale effects of landscape pattern on avian populations. Many studies correlate landscape indices with numbers of birds detected during point count surveys. However, as Villard et al. (1999) suggested, such studies should also consider the reproductive output of populations. Basing conservation efforts on numbers of adults alone may be counter-productive because high densities of adults are not necessarily correlated with high reproductive output unless the population conforms to the concept of an ideal free distribution (Sutherland 1983) in which the numbers of individuals in a given area are proportional to the resources available. Many bird species conform to a despotic distribution in which primary breeding habitat is competed for and subsequently inhabited by the fittest individuals that hold large territories. Reproductive output per individual is normally higher in such areas than it is in areas of secondary habitat in which the rest of the population is found in high densities occupying small territories. Also, information on vital rates provides a clear index of habitat quality. Because of confounding effects of population sources and sinks, information on presence/absence or even relative abundance or population size can provide misleading indicators of habitat quality (Van Horne 1983, Pulliam 1988). Thus, consideration of the following parameters in the landscape models may offer more insight into the ecological processes operating on avian populations.

AHYmean – the mean number of after-hatch-year (adult) individuals (unique band numbers) captured per year.

YNGmean – the mean number of hatch-year individuals (young) captured per year.

RImean – the mean annual reproductive index (RI). Annual reproductive indices are calculated as the ratio of young to adults captured (YNG_t / AHY_t).

AHYtrend – a magnitude-independent adult population trend. The annual rate of change in the adult population is expressed the annual change in adult population density as the percentage change per year relative to the mean annual number of adult individuals captured (AHYmean).

YNGtrend – a magnitude-independent young population trend. The annual rate of change in the young population is expressed the annual change in young population density as the percentage change per year relative to the mean annual number of young individuals captured (YNGmean).

RItrend – The annual rate of change in the reproductive index is expressed the annual change in the annual reproductive indices (YNG_t / AHY_t).

Identifying species of management concern

We selected, for potential inclusion in landscape analyses, a set of 21 species for which effective monitoring could be conducted on at least six MAPS stations (Table 2). For each of the 21 species, we summarized the Breeding Bird Survey trends, Partners in Flight conservation status, and regional MAPS data (Table 2). We listed species of conservation concern a) classified by PIF as Species of Continental Importance (SCI) in the Pacific Avifaunal Biome (i.e. Bird Conservation Regions 5, 15, and 32), b) listed as focal species in PIF Bird Conservation Plans for four ecological sub-regions of Washington and Oregon or in the PIF Bird Conservation Plan for Montana, c) classified as SCI in the Intermountain West Avifaunal Biome (i.e. Bird Conservation Regions 9, 10, and 16), d) exhibited significant ($P<0.10$) negative population trends in BBS data (1980-2003) for any of four PIF Bird Conservation Regions (i.e. Northwestern Interior Forest, Northern Pacific Rainforest, Great Basin, and Northern Rockies) or e) exhibited significantly declining demographic variables at one or more MAPS locations. A subset of 14 species emerged as the focus of management recommendations to reverse adult population declines in Pacific Northwest national forests. These are the species common to the regional list of species of conservation concern. Those species captured in acceptable numbers but declining at MAPS stations are shaded and shown in bold in Tables 2 and 3, respectively.

From extensive literature reviews for each of these species, we summarized and briefly discussed existing management issues and recommendations. Also, for various reasons such as a lack of understory under dense canopy forest, some MAPS stations effectively monitor few species of interest. We identified these "slow" stations and discussed how they could be relocated to help monitor SSC species in control or managed areas.

For each installation we classified the species that met the basic selection criteria for the number of annual individual captures as breeding in forest/woodland or breeding in scrub/successional habitats (Table 3). In addition, for each species and installation, we reported the direction of the population trend and the statistical significance associated with that trend, highlighting those species and installations where MAPS populations of BCC species had declined during the station's period of operation.

Table 2. Summary table of MAPS coverage and adult trends, PIF status, and BBS trends for 12 Neotropical and nine short-distance migrants (each assigned a four character code) on seven US Forest Service national forests in Washington (2), Oregon (4), and Idaho (1). The numbers of MAPS stations from which the study wide adult population trends were estimated are given. Bold ($P<0.10$) and italic ($P<0.05$) type denotes the statistical significance of the direction of the MAPS adult population trends (Dec - declining; Inc - increasing), and the annual percent change in the adult population. This also applies to the annual percentage change in Breeding Bird Survey data (1980-2003) for four relevant PIF Bird Conservation Regions: Northwestern Interior Forest (NIF), Northern Pacific Rainforest (NPR), Great Basin (GB), and the Northern Rockies (NR). Partners in Flight "Species of Continental Concern" (SCI) status is coded to signify the Bird Conservation Region for which the SCI status is assigned: Pacific (P); Intermountain West (IW), and Northern Forests (NF). PIF status for the Washington/Oregon (WA/OR) sub-regional bird conservation plans is coded to signify the sub-region for which the status is assigned: Westside Coniferous (WC); Westside Lowlands and Valleys (WL), and Northern Rockies (NR), and East Slope Cascades (ES). The total numbers of declining and increasing trends (and statistically significant trends) are given for each category of annual percent change.

Common Name	**Code**	**No. MAPS Stations**	**Overall MAPS Trend**	**Annual Percent Change**	**Breeding Bird Survey Annual Percent Change**				**PIF SCI Status**	**PIF WA/OR/MT Status**
					NIF	**NPR**	**GB**	**NR**		
Neotropical migrants										
Hammond's flycatcher	HAFL	16	Inc	+2.53	2.9	***4.7***	0.5	1.7		WC MT
Dusky flycatcher	DUFL	8	**Dec**	**-7.85**	-8.9	***-3.4***	-1.7	-2.3	IW	
Western flycatcher	WEFL	10	**Dec**	**-2.90**	**-1.3**		**-2.2**	1.4	P	WL MT
Warbling vireo	WAVI	15	**Dec**	**-4.50**	0.9		***2.8***	***2.1***		MT
Swainson's thrush	SWTH	27	Inc	+0.78	0.4		0.6	-0.4		WL
Orange-crowned warbler	OCWA	7	**Dec**	**-7.61**	-0.9	***-2.9***	**-1.6**	-0.6		WC
Townsend's warbler	TOWA	10	Dec	-4.14	-5.9	1.6	-0.2	1.6		
Common yellowthroat	COYE	6	Dec	-1.95	10.6	0.3	2.1	***1.8***		
MacGillivray's warbler	MGWA	27	Dec	-1.21	-1.4	***-2.2***	-1.1	1.3		WC NR MT
Wilson's warbler	WIWA	14	Inc	+0.85	***-2.4***	***-1.6***	***-3.2***	***-4.7***		WC
Chipping sparrow	CHSP	6	**Dec**	**-11.16**	1.4	-1.1	-1.1	**-1.4**		ES WL NR MT
Lincoln's sparrow	LISP	14	**Dec**	**-4.48**	-0.2	-3.1	0.7	1.9	NF	
Short-distance migrants										
Mountain chickadee	MOCH	8	Dec	-2.59		-4.7	-1.2	-2.3		
Chestnut-backed chickadee	CBCH	9	Inc	+0.39		0.2	-0.6	***8.6***	P	MT
Winter wren	WIWR	13	Dec	-0.63		0.3	0.7	***5.4***	P	MT
Ruby-crowned kinglet	RCKI	7	Dec	-2.37	**3.6**	1.6	0.3	0.6		
American robin	AMRO	19	Inc	+3.05	**1.8**	-0.3	-0.1	-0.1		
Yellow-rumped warbler	YRWA	18	Inc	+0.36	0.8	0	0.5	***-2.1***		
Song sparrow	SOSP	15	Inc	+1.60	-14.4	**-0.7**	1.7	1.0		MT
Dark-eyed junco	DEJU	28	Inc	+1.44	***-1.4***	***-1.9***	**-3.0**	***-2.2***		
Pine siskin	PISI	14	Dec	-5.03	**10.6**	***-8.3***	***-2.2***	***-2.9***		
Totals										
Declining Neotropical				9 (6)	7 (1)	6 (4)	7 (3)	5 (2)		
Increasing Neotropical				3 (0)	5 (1)	3 (1)	5 (1)	7 (2)		
Declining short-distance				4 (0)	2 (1)	(6)	5 (2)	5 (3)		
Increasing short-distance				5 (0)	4 (3)	(6)	4 (0)	4 (2)		

Table 3. Table of direction and significance in adult population trends for 12 Neotropical migrants and nine short-distance migrants on seven US Forest Service national forests in Washington, Oregon, and Montana. The direction of the trend is indicated as decreasing (-) or increasing (+), and significance is indicated by multiple plus or minus characters (e.g. + non-significant, ++ 0.05≤P<0.10, +++ 0.01≤P<0.05, and ++++ P<0.01). The total numbers of effectively monitored species and the numbers of declining trends (and statistically significant trends) are given for each national forest and migration category with the overall totals of declining and increasing trends. The number of species of conservation concern (SCC) chosen for each forest are also given.

Common Name	Specific Name	MTBA	WENA	UMAT	WILL	SIUS	FREM	FLAT
Neotropical migrants								
Hammond's flycatcher	*Empidonax hammondii*	-	+	---	+++		++	-
Dusky flycatcher	*E. oberholseri*		-	----	---		-	---
Western flycatcher	*E. difficilis / occidentalis*	-			-	---	+	
Warbling vireo	*Vireo gilvus*	+	-	----	+		-	---
Swainson's thrush	*Catharus ustulatus*	++	+	---	+	+		-
Orange-crowned warbler	*Vermivora celata*			-	---		-	-
Townsend's warbler	*Dendroica. townsendi*		+	---				
Common yellowthroat	*Geothlypis trichas*	-			+			-
MacGillivray's warbler	*Oporornis tolmiei*	-	-	---	-		+	+
Wilson's warbler	*Wilsonia pusilla*	+	+	-	+++	+	-	
Chipping sparrow	*Spizella passerina*		-	---				+
Lincoln's sparrow	*Melospiza lincolnii*		---	-	-		-	-
Total Neotropical		7	9	10	10	4	8	9
Number declining		4 (0)	5(1)	10 (7)	5 (2)	2 (1)	5 (0)	7 (2)
Short-distance migrants								
Mountain chickadee	*Poecile gambeli*		-	+			-	
Chestnut-backed chickadee	*Poecile rufescens*	-	+++		-	-		
Winter wren	*Troglodytes troglodytes*	-		+++	++	-		
Ruby-crowned kinglet	*Regulus. calendula*			-			-	+
American robin	*Turdus migratorius*	++	+++	-	+		+	+
Yellow-rumped warbler	*Dendroica coronata*		-	---	+		+	
Song sparrow	*Melospiza melodia*	+	--		+++	+		+
Dark-eyed junco	*Junco hyemalis*	-	++	---	-		++	+++
Pine siskin	*Carduelis pinus.*		+	-	---		-	-
No. SCC species		3	4	8	4	3	3	4
Total short-distance		5	7	7	7	3	6	5
Number declining		3 (0)	3 (1)	5 (2)	3 (1)	2 (0)	3 (0)	1 (0)
Total declining		7	8	15	8	4	8	8
Total increasing		5	8	2	9	3	6	6

Spatial datasets

In previous research of this kind we have used a single landscape coverage; the 21 class, 30-m resolution National Land Cover Dataset available from the U.S. Geological Survey (NLCD, http://landcover.usgs.gov/natllandcover.html, 2002; Table 4). In this study we extracted a set of landscape coverages each incorporating up to six of the 42 MAPS stations from five GIS coverages. This study focused on the results obtained from analyses of 2-kilometer radius landscapes because many stations are so closely clustered such that 4-kilometer radius landscapes would include considerable overlap and introduce aspects of spatial autocorrelation. In addition, 2-kilometer landscapes restrict the spatial extent to areas within the boundaries of the forests where management actions can be realized with minimal involvement of private lands.

We modeled spatially-explicit avian population data (derived from MAPS data) as functions of spatial statistics derived from five basic GIS layers (and an edge model derived from one of those layers):

- 30m USGS National Elevation Dataset (NED)
- National Land Cover Dataset - (NLCD 1992)
- Canopy cover classification for USFS Region 6
- Riparian habitat derived from StreamNet 100K hydrographic layers
- Unique Combination Edge Model (UCEM) derived from USFS canopy cover
- USFS cumulative pest outbreak layers (1980-2001)

These layers are now described in more detail:

National Land Cover Dataset - (NLCD 1992)

21-class, 30m resolution land cover classification available from http://seamless.usgs.gov/ . From this coverage we obtained the following statistics:

- Landscape-level set of Patch Analyst spatial statistics (90m core area buffer).
- Class-level set of Patch Analyst spatial statistics (90m core area buffer).

Table 4.National Land Cover Dataset (NLCD) System Key – (Rev. July 20, 1999) describing 21 cover classes (Code). These classes are aggregated into 7 classes (CL7) for spatial analysis of MAPS data : water sources (1), development (2), barren (3), shrub/scrub (4), forested (5), grassland (6), agricultural (7).

Code	**Classification**	*Abbr.*	**Code**	**Classification**	*Abbr.*
Water			***Shrubland***		
11	Open Water	OW	51	Shrubland	SHRB
12	Perennial Ice/Snow	PIS	***Non-natural Woody***		
Developed			61	Orchards/Vineyards/Other	ORVI
21	Low Intensity Residential	LIR	***Herbaceous Upland***		
22	High Intensity Residential	HIR	71	Grasslands/Herbaceous	GRAS
23	Commerce/Industry/Trans.	CIT	***Herbaceous Planted/Cultivated***		
Barren			81	Pasture/Hay	AGPH
31	Bare Rock/Sand/Clay	BRSC	82	Row Crops	AGRC
32	Quarries/ Mines/Gravel Pits	QMGP	83	Small Grains	AGSG
33	Transitional	TRAN	84	Fallow	AGFW
Forested Upland			85	Urban/Rec. Grasses	AGUR
41	Deciduous Forest	FORDEC	***Wetlands***		
42	Evergreen Forest	FOREVR	91	Woody Wetlands	WETWDY
43	Mixed Forest	FORMIX	92	Emergent Herbaceous Wetlands	WETHRB

30m USGS National Elevation Dataset (NED) - http://seamless.usgs.gov/ .

We downloaded custom areas encapsulating each national forest and reclassified them into 100m resolution categories. From this coverage we obtained the following statistics:

- Standard statistics (i.e., mean elevation and standard deviation etc.) for each buffer radius. [*cite sources*].
- Landscape-level set of Patch Analyst spatial statistics. From these statistics, the number of patches, indices of fragmentation, Shannon's Diversity Index, and Shannon's Evenness Index will quantify the topographical complexity of the area.

Canopy cover classification for USFS Region 6 forests

Land cover and forested canopy cover dataset (collected 1988-1991) obtained from Ken Brewer, Wenatchee NF - projected in UTM Zones 10 and 11, NAD 27 (meters). Coverages for Wenatchee, Fremont, and Umatilla national forests required simple reclassification to aggregate forest canopy cover classes and achieve a common classification across the entire region. The resultant layer features 6 classes of non-forest cover, three classes of forested canopy cover, and a shadow class (i.e. unknown) as numbered below:

1. Open Water (OW)
2. Rock, sparse vegetation (RSV)
3. Snow (SNOW)
4. Grass (GRAS)
5. Shrub (SHRB)
6. Agriculture and development (AGDEV)
17. Forested with 11-40% crown cover (11-50% at Wenatchee) (FORLOW)
21. Forested with 41-70% crown cover (51-70% at Wenatchee) (FORMED)
24. Forested with 71-100% crown cover (FORHI)
25. In shadow area.

We converted these coverages to 30m resolution grids from which we obtained the following statistics:

- Landscape-level set of Patch Analyst spatial statistics.
- Class-level set of Patch Analyst spatial statistics.

In both cases a buffer distance of 90m was set in order to obtain estimates of core areas from the spatial analysis. Such estimates may emerge as determinants of one or other demographic parameters which would be suggestive of ecological edge effects.

In addition, for each forest we created reclassified layers by aggregating the three forest cover classes (17, 21, and 24) into a single forest/woodland category. This layer is used in the Unique Edge Combination Model discussed later.

Unique Combination Edge Model

As discussed earlier, the types and amounts of edge in a landscape may be important determinants of the abundance and reproductive success of many landbirds. We developed a methodology called the Unique Combination Edge Model (UCEM) to a) identify unique edge types in any GIS raster coverage, and b) quantify, using Patch Analyst, a suite of spatial statistics describing the amount, and pattern of each unique edge type. We applied this model to reclassifications of the USFS Region 6 forest (1988-1991) coverages (Table 5).

Table 5. Alternative 30m canopy cover classifications for USFS Region 6 forests (1988-1991) coverages. The original class codes are assigned unique numbers from a binary series (* we aggregated the three tree classifications) as necessitated by the GIS-based edge detection algorithm. We assigned the final cover class code to contiguous patches of the original cover classes whereby they can not coincide with any result of subtractions between any two numbers in the binary classification.

Original Cover Class Description	Original Cover Class Code	Binary Series Reclassification	Final Cover Class Code
Water	1	1	102
Rock/Sparse Vegetation	2	2	103
Snow/Ice	3	4	104
Grass	4	8	105
Shrub	5	16	106
Agricultural/Developed	6	32	107
Tree (11-40%)[1]	17	64	108
Tree (41-70%)[1]	21	64	108
Tree (71-100%)[1]	24	64	108
Shadow	25	128	109

[1] The three tree cover classes were grouped into a single tree cover class before running the edge model.

The model works by overlaying a copy of the (binary series) reclassified landscape on the original but offset by one pixel and taking the unsigned (or absolute) difference between the two layers. As a result, all but the edge pixels of contiguous patches of cover class are assigned a zero value. However, each edge type (e.g. forest/shrubland) is assigned a unique number corresponding to the difference between the class codes of adjacent patch types (Table 6). The resulting (binary series) layer is shifted back one pixel and becomes the initial UCEM layer. The process is repeated but this time the two reclassified layers are offset by one pixel in a different direction. The resulting difference layer is merged with the UCEM layer such that non-zero pixels retain their values. This process is repeated six more times to complete one-pixel shifts representing the eight points of the compass (N, NE, E, SE, S, SW, W, and NW).

The cell values of the resulting grid layer represent all combinations of edge type superimposed on the original single cover patches. Of these, we chose six combinations of greatest ecological interest: grass-shrub, grass-agricultural/development, agricultural/development-shrub, forest/woodland-grass, forest/woodland-shrub, and forest/woodland- agricultural/development.

It is important to note that we analyzed the landscapes at two different levels: the ”landscape” level and the “class” level. At the landscape level, statistics from Patch Analyst reflect the number, size and spatial distribution of all patches (regardless of cover classes) that provide measures of the landscape fragmentation including the total amount of edge, and landscape heterogeneity (alpha diversity and evenness of patch size and class). These parameters were not used in later multivariate models but they are mentioned in the text when appropriate. At the class level, statistics from Patch Analyst reflect the size, shape and distribution (within the rest of the landscape) of each cover class (e.g., deciduous forest) in the context of the rest of the landscape.

Table 6. Unique cover class combination codes representing a) single cover classes and b) the differences between paired binary reclassifications of the 30m USFS Region 6 national forest (1988-1991) coverages (excluding Shadow class). Combinations of ecological interest are shown in bold type.

Cover Class Descriptions	Single cover	Rock/Sparse	Snow/Ice	Grass	**Shrub**	**Ag/Developed**	**Forest/Wood**	Shadow
Water	102	1	3	7	15	31	63	127
Rock/Sparse Vegetation	103	-	2	6	14	30	62	126
Snow/Ice	104		-	4	12	28	60	124
Grass	105			-	**8**	**24**	**56**	120
Shrub	106				-	**16**	**48**	112
Agricultural/Developed	107					-	**32**	96
Forest/Woodland	108						-	64
Shadow	109							-

Riparian habitat derived from StreamNet 100K hydrographic layers

Original shapefiles of perennial streams (OR/WA/MT) derived from 1/100000 scale USGS topographic maps available from www.streamnet.org. For each forest, we downloaded up to five hydrologic units that encapsulated the MAPS stations associated with that forest and merged them into a single shapefile. We added a common value field to each record (stream course) of the hydrographic shapefiles and converted them to 30m resolution grids. The resultant coverages contain two classes of cell; stream habitat and non-stream habitat. From this we can calculate.

- Distance from MAPS station to nearest perennial stream using AV3.2 Avenue script called nearfeat.ave (Jeff Jenness, USFS, Rocky Mountain Research Station).
- Class-level set of Patch Analyst spatial statistics (90m core area buffer). This will provide statistics regarding the amount, shape, and pattern of riparian habitats associated with perennial streams.

Table 7. Classifications of cumulative pest damage the types of insects included in each class.

Classification	Insects
USFS_PEST_CL1	Dipteran and Lepidopteran defoliating larvae
USFS_PEST_CL2	Leaf and needle mining insects
USFS_PEST_CL3	Adelgids, scale insects, mites, and aphids
USFS_PEST_CL4	Beetles - all species
USFS_PEST_134	Classifications 1,3, and 4 above.

USFS cumulative pest outbreak layers (1980-2001)

We spatially analyzed Forest Health Protection Aerial Survey Data collected by the Pacific Northwest Region of the US Forest Service to provide a spatial dataset of cumulative pest damage between 1980 and 2001. This dataset attributes observed damage to many causes including fire, bear damage, disease, and pestilence. There are many categories of insect pest in this database that are too numerous to mention here. We reclassified these into four broader categories (Table 7) that represent four distinct food sources for birds. We calculated the area of damage within a two-kilometer radius around each station in each year. We summed the area damaged in each year to obtain a measure of cumulative pest damage

(USFS_PEST_134) for each station. A final class of damage combined the three most prevalent classifications of damage into one- excluding damage by leaf and needle mining insects.

Availability of data and GIS software

The landscape management models are designed to be easily accessible to national forest (or ranger district) foresters, wildlife biologists, and GIS specialists. As previously mentioned, the land cover databases are publicly available from the sources given (on CD or downloadable from the internet). The spatial analysis techniques are relatively simple and can be conducted using combinations of either ArcInfo (ESRI Inc.) and FragStats (McGarigal and Marks 1994), or ArcView (ESRI Inc.) and Patch Analyst (Elkie et al. 1999). We can provide the following materials to help installation managers and other persons who would like to apply these models:

a) the ArcView/Avenue scripts needed for batch processing spatial analyses of NLCD data within 2-kilometer radii (or larger radii) around a set (or sets) of geographic centers of interest (e.g. approximate geographic center of a forest stand).
b) the ArcView/Avenue scripts needed for mapping unique edge types from coarsely classified grid data within 2-kilometer radii (or larger radii) around a set (or sets) of geographic centers of interest (e.g. approximate geographic center of a forest stand).
c) Instructions on conducting the spatial analysis using these scripts.

Avian Demographic-Landscape Models

We mapped the geographic locations of the 42 Pacific Northwest MAPS stations (Table 1, Figure 1) onto each of five coverages in which the stations are located (Appendix 2). For each coverage we spatially analyzed a two-kilometer radius area around each station using Arcview 3.2 (ESRI 1996) in conjunction with the Patch Analyst 2.2 extension (McGarigal and Marks 1994, Elkie et al. 1999).

Parameter selection and data transformation

Patch Analyst produces too many statistics to be all included in a regression analysis. From the statistics resulting from spatial analysis of each of the five layers (plus the edge model) we selected those landscape parameters that seemed pertinent to the avian ecology and behavior of our target species. Those parameters with many zero values were left out of the analyses because of the tendency for regression models to assign statistical significance to models constructed from datasets containing outliers.

Using multivariate regression techniques we constructed species-landscape models for a) numbers of adults, b) adult population trends (the annual percentage rate of change in the numbers of adults), c) numbers of young, and d) reproductive success as measured by the ratio of young to adults. In these we relaxed the capture rate criterion to an average of 1.5 birds per year for the less widespread species.

Model selection

We constructed the models using multivariate regression techniques, information theory and maximum likelihood principles. Initially, we selected a suite of landscape parameters for inclusion in each model based on known or proposed ecological relationships from the literature. In addition, we inspected the correlation matrix of dependent and independent variables for evidence of other significant correlations. We used custom software (Luh 1994 - modified by Nott in 2003 unpublished) to regress all unique combinations of N parameters plus the intercept term, which for 10 parameters results in 1,023 regression models each with their associated regression statistics. For each model, the software calculates values of Akaike Information Criteria (AIC, Akaike 1973) and the closely related Bozdogan's index of informational complexity (ICOMP) (Bozdogan 1990, 1994). The "best" model minimizes these criteria based on the maximum likelihood and the number of parameters. Thus, a model with a high "goodness-of-fit" may be penalized by AIC for having too many parameters.

Typically, regression analyses of spatial statistics are confounded with high levels of collinearity and dependence among the parameter estimates (Riitters et al. 1997). To account for this problem we selected models using ICOMP that, unlike AIC, penalizes models for which it detects high levels of both overparameterization and covariance. In each case, we reported the top 10 models, that is, the 10 models with the lowest values of ICOMP, and calculated the contribution (proportional representation) of each parameter. We also reported the regression statistics and estimates of each coefficient for the top selected model.

Table 8. List of 29 landscape parameters used in multivariate species-landscape modeling

Parameter	Description	Transform
NED_MEAN1K	Mean elevation of 1-kilometer radius	none
NLCD_LAND_MPI	Mean Patch Interspersion of NLCD landscape	none
NLCD_LAND_SDI	Shannon's Diversity Index of NLCD landscape	none
NLCD_LAND_TCA	Total core area oll patches in NLCD landscape	none
NLCD_FORDEC_CLA	total area of NLCD deciduous class	log
NLCD_FOREVR_CLA	total area of NLCD evergreen (coniferous) class	none
NLCD_FOREVR_TCA	core area of NLCD evergreen (coniferous) class	log
NLCD_FORMIX_CLA	total area of NLCD mixed forest class	sqrt
NLCD_DECMIX_CLA	total area of NLCD deciduous and mixed class	none
NLCD_SHRUB_CLA	total area of NLCD shrub (successional) class	log
NLCD_SHRUB_TCA	core area of NLCD shrub (successional) class	sqrt
NLCD_GRASS_CLA	total area of NLCD grassland class	none
TOPO_STRM_PC	surrogate for stream density	none
USFS_PEST_CL4	cumulative beetle damage	log
USFS_PEST_134	cumulative pest damage (defoliators and beetles)	sqrt
USFS_SHRB_CLA	total area of USFS shrubland class	sqrt
USFS_SHRB_TCA	core area of USFS shrubland class	sqrt
USFS_GRAS_CLA	total area of USFS grassland class	log
USFS_FORLOW_CLA	total area of USFS low canopy cover class	none
USFS_FORLOW_TCA	core area of USFS low canopy cover class	sqrt
USFS_FORMED_CLA	total area of USFS medium canopy cover class	sqrt
USFS_FORMED_TCA	core area of USFS medium canopy cover class	log
USFS_FORHI_CLA	total area of USFS high canopy cover class	none
USFS_FORHI_TCA	core area of USFS high canopy cover class	sqrt
USFS_UCEM_08	area of USFS grassland-shrub (sucessional) edge	sqrt
USFS_UCEM_48	area of USFS forest-shrub (sucessional) edge	sqrt
USFS_UCEM_56	area of USFS grassland-forest edge	sqrt
USFS_UCEM_3CLA	area of USFS grassland-shrub-forest edge	none
USFS_UCEM_IJI	Interspersion Juxtaposition Index of all edges	none

From the model selection process we reported species-landscape models of six demographic parameters for each of 12 species of conservation concern. Of these 72 models, most showed statistical significance at the P<0.05 (or lower probability) level. We then used these models to formulate management strategies for each species of conservation concern.

RESULTS

Overview

The demographic analysis of MAPS data for the 36 species in this investigation provides a large volume of summary results. These include species-specific data whereby demographic estimates are reported a) by the entire study area (all stations pooled), b) by individual national forest, and c) by individual MAPS station. For this reason we present the results both as summary information here in the main report, and as more detailed tables and interpretations in Appendices 4 and 5.

Appendix 4 contains brief descriptions of the conservation status of each species according to analyses conducted by the Breeding Bird Survey, Partners in Flight continental and regional conservation plans, and MAPS data. It also contains tables of species-specific demographic estimates presented by MAPS station and brief reports of species-specific demographic patterns given by national forest. These reports are derived from data presented in Appendix 5 in which species-specific demographic patterns are tabulated by national forest.

Part I of the Results section further summarizes the station- and forest-specific demographic patterns (Appendices 4 and 5, respectively) and outlines avian conservation concerns at each of the seven national forests for those species effectively monitored by the MAPS program. The goal of this section is to identify species of management concern in each national forest, the stations at which they are effectively monitored and the stations at which monitoring might be discontinued. We also identified stations at which management might be applied to reverse declines, however, it is unlikely that such management will be implemented given the need for environmental impact assessments. Instead we hope that existing plans that might affect the station can be brought forward. Otherwise, these stations may be relocated to locations where management has already been implemented or soon will be.

Part II of the Results then provides detailed descriptions and discussion of species-specific management recommendations derived from the species-landscape models constructed in this study (see Appendix 6) as well as a discussion of existing recommendations extracted from the literature. We refer to the kinds of management that might help reverse the observed population declines.

Part I : Summary of demographic analyses

For each national forest a table is provided that includes those species that are effectively monitored, i.e., for which acceptable numbers of individuals were captured each year (see Methods; Appendix 5). Species listed in these tables are categorized depending on a) increasing or decreasing adult population trends within the national forest, b) migratory status – Neotropical- or temperate-overwintering range, and c) preference for forested/wooded habitat or scrub/successional habitat (as categorized by the Breeding Bird Survey). We also reported the statistical significance of the population trends (1992-2001) and highlighted those species that are species of conservation concern (SCC).

We identified a total of 21 species that MAPS effectively monitors across the seven national forests (Table 2). These include priority (SCC) species a) classified by PIF as Species of Continental Importance (SCI) in the Pacific Avifaunal Biome (i.e. Bird Conservation Regions 5, 15, and 32), b) listed as focal species in PIF Bird Conservation Plans for four ecological sub-regions of Washington and Oregon or in the PIF Bird Conservation Plan for Montana, c) classified as SCI in the Intermountain West Avifaunal Biome (i.e. Bird Conservation Regions 9, 10, and 16), d) exhibited significant ($P<0.10$) negative population trends in BBS data (1980-2003) for any of four PIF Bird Conservation Regions (i.e. Northwestern Interior Forest, Northern Pacific Rainforest, Great Basin, and Northern Rockies), ore) exhibited significantly declining demographic variables at one or more MAPS locations.

From this list of 21 species (Table 2) we selected 14 SCC species to which we added mountain chickadee, because of its limited western range, and consistently negative (albeit statistically insignificant) adult population trends in MAPS and BBS. We also added Swainson’s thrush because it is captured at many MAPS stations in the region but, like Hammond’s flycatcher, populations generally increased in the last decade. Landscape analysis of Swainson’s thrush data may reveal an ecological process beneficial to Swanson’s thrush that has negatively affected those Neotropical-wintering forest/woodland species that declined between 1992 and 2001. Thus, a list of 16 priority species emerged for this regional study.

When considering individual national forests, we focused on SCC species as priority species of forest-specific management concern if both acceptable numbers of individual birds were captured, and the adult population trend (as derived from MAPS data) declined. This satisfies the first goal of this project is, for each forest, to identify declining priority species for which we can provide management recommendations to reverse those declines (Table 3). We are collaborating with natural resource managers, foresters, and GIS specialists of each national forest to identify appropriate management actions that may be applied in the vicinity of those MAPS stations for which we reported population declines of a particular species. In future years, funding permitting, MAPS stations will monitor the effects of those actions on both the target species and other species that are captured at those stations.

To assess the effectiveness of management actions in reversing declines, it is necessary to monitor areas that have been managed and compare the resulting demographic estimates with those obtained from a similar “control” area that was not subjected to management. Consequently, for each national forest, we highlight those stations at which the population trends of priority species are declining, thereby identifying the stations and species at which management actions may be directed. We also identify “control” stations that would monitor the target species in the absence of management action. Finally, we identify MAPS stations that are currently in operation but capture few species, especially those stations associated with closed canopy forest and sparse understory or vegetative ground cover. We suggest that these “slow” stations should be re-established in locations where they can better monitor the effects of management actions intended to benefit species of management concern (i.e., capture more individuals of the priority species) or, alternatively, act as control stations.

To summarize, our goals are to a) integrate MAPS monitoring in the Pacific Northwest with continental, regional, and sub-regional bird conservation plans, b) meet monitoring and research requirements listed for species of conservation concern, c) collaborate with biologists and foresters in each national forest (or ranger district) in identifying existing management plans to reverse local population declines of at least one bird species of conservation concern, d) devise those plans in consideration of one or more of the 16 species that are the focus of this report, and e) give due consideration to the fact that actions intended to benefit one species of management concern will impact other species or guilds.

Mount Baker-Snoqualmie National Forest, Washington

Mt. Baker-Snoqualmie National Forest in Washington State covers portions of Whatcom, Skagit, Snohomish, King, and Pierce Counties. The MAPS stations are located in Snohomish County, associated with three federal land parcels (FLP) Mount Baker National Forest (FLP#2385), Henry M. Jackson Wilderness (FLP#2648), and Boulder River Wilderness (FLP#2545). In addition, Glacier Peak Wilderness (FLP#2376) is adjacent (< 5km distant) to two of the stations. All stations are under the jurisdiction of the Darrington Ranger District. Although this location is associated with the Great Basin NABCI Bird Conservation Region the forest is more typical of western-slope forests

Of 12 species (seven Neotropical- and five temperate-wintering species) captured in acceptable numbers 10 are species of conservation concern (Table 5a). Four species show increases in adult populations and eight species show declines. Four significant trends include negative trends for Hammond's flycatcher ($P<0.10$), winter wren ($P<0.10$) and dark-eyed junco, and a positive trend for American Robin ($P<0.05$).

Table 5a. Lists of species captured in acceptable numbers at six MAPS stations operated in Mount Baker national Forest. Species are categorized by the direction of the adult population trend (statistical significance is denoted by: * $0.05\leq P<0.10$, ** $0.01\leq P<0.05$, and *** $P<0.01$), migratory status, and preferred habitat type - either forest (normal typeface) or scrub/successional habitat (italics). Species of conservation concern are highlighted in gray and focal species of management concern are in bold type.

Neotropical wintering species		Temperate wintering species	
Increased	Declined	Increased	Declined
Swainson's thrush	**Hammonds flycatcher***	*American Robin***	Ch.-backed Chickadee
Wilson's warbler	"Western" flycatcher	*Song sparrow*	**Winter wren***
	Warbling vireo		Dark-eyed junco*
	MacGillivray's warbler		
	Common yellowthroat		

Candidate Species of Management Concern

Seven species of conservation concern declined at Mount Baker MAPS stations (Table 5a) and emerge as candidate species for management concern. This includes four Neotropical-wintering species (Hammond's flycatcher, "Western" flycatcher, warbling vireo, MacGillivray's warbler) and three temperate-wintering species (chestnut-backed chickadee, winter wren, dark-eyed junco). Hammond's flycatchers are captured at two stations (Table

5b), and although they show a non-significant decline at the forest level they declined significantly ($P<0.05$) at Perry Creek (PECR). “Western” flycatchers were captured at three stations and declined at one of them. Winter wrens showed non-significant declines at the forest level and at four of five stations at which it was captured. Chestnut-backed chickadees declined at one of the two stations at which it was captured. MacGillivray’s warblers declined at two of the three stations it was captured, significantly ($P<0.10$) at Fry Lake. Dark-eyed junco and Wilson’s warbler each declined at a single station.

Table 5b. Table of adult population trends (annual percentage change derived from MAPS data) for landbirds that can be effectively monitored by MAPS stations Mount Baker national forest. Statistical significance is denoted by: * $0.05\leq P<0.10$, ** $0.01\leq P<0.05$, and *** $P<0.01$. Birds of conservation concern (see criteria above) and associated negative trends are highlighted in gray. Stations are also categorized by the recommendation whether to a) manage (or relocate) for species of conservation concern (SCC), b) relocate the station to better monitor one or more SCC, and c) maintain as control stations

Station	FRLA	MUCR	BELA	PECR	MCLA	BETH
Recommendation	Manage	Relocate	Control	Manage	Control	Relocate
Species						
HAFL				**-19.5	0.31	
WEFL	0.82		3.6			-10.4
WAVI				-15.0	5.80	
CBCH			7.0		-5.93	
WIWR	-5.87	-6.22	-2.70	-15.1		0.40
SWTH	2.02	***8.2	4.66	-2.62	0.52	6.10
AMRO	6.7	4.56	2.60	0.58	*12.1	
MGWA	*-16.95				-4.47	6.53
COYE			0.92		*-11.2	
WIWA	-7.2					
SOSP			0.60		3.14	
DEJU						**-11.4
N(#neg.)	6 (3)	3 (1)	7 (1)	5 (4)	8 (3)	5 (2)

In summary, appropriate management actions could be applied at two Mount Baker stations, Fry Lake (FRLA) and Perry Creek (PECR) to reverse the declines in Hammond's flycatcher, winter wren, and MacGillivray's warbler populations (Table 5b). Recommended management actions could be implemented in three federal land parcels (FLP#2385, 2648, and 2545) within the vicinity of the target MAPS stations, and will likely also benefit other declining forest bird populations at these stations including warbling vireo, Swainson's thrush, and Wilson's warbler. We recommend that the operation of two slow stations, Murphy Creek (MUCR) and Bench Thin (BETH) be discontinued in favor of establishing two new stations to maintain or increase the monitoring coverage of six species (including four Neotropical-wintering species); Hammond's flycatcher, warbling vireo, Swainson's thrush, chestnut-backed chickadee, winter wren and MacGillivray's warbler. The two remaining stations, Monte Cristo Lake and Beaver Lake should be maintained to provide control data for species of conservation concern.

Wenatchee National Forest, Washington

Wenatchee National Forest in Washington State covers portions of Chelan and Kittitas Counties. One MAPS stations is located within Kittitas County, two straddle the border between Kikkitas and Yakima Counties (associated with MT. Baker-Snoqualmie NF) and three of the stations lie at least 15 kilometers inside Yakima County. All stations are under the jurisdiction of the Naches Ranger District and are associated with four federal land parcels (FLP) Wenatchee National Forest (FLP#2530), Snoqualmie National Forest (FLP#3519), and William O. Douglas Wilderness (FLP#3768), and Norse Peak Wilderness (FLP#3515). In addition, Snoqualmie National Forest (FLP#3790) is adjacent (< 5km distant) to one of the stations. Five stations at this location are associated with the Great Basin BCR and one with the Northern Pacific Rainforest BCR.

Of 15 species (eight Neotropical- and seven temperate-wintering species) captured in acceptable numbers, 12 are species of conservation concern (Table 6a). Seven species show increases in adult populations and eight species show declines. Four significant trends include negative trends for warbling vireo (P<0.10) and Lincoln's sparrow (P<0.05), but positive trends for chestnut-backed chickadee (P<0.05) and dark-eyed junco (P<0.10)

Table 6a. Lists of species captured in acceptable numbers at six MAPS stations operated in Wenatchee National Forest. Species are categorized by the direction of the adult population trend (statistical significance is denoted by: * 0.05≤P<0.10, ** 0.01≤P<0.05, and *** P<0.01), migratory status, and preferred habitat type - either forest (normal typeface) or scrub/successional habitat (italics). Species of conservation concern are highlighted in gray and focal species of management concern are in bold type.

Neotropical wintering species		Temperate wintering species	
Increased	Declined	Increased	Declined
Hammonds Flycatcher	Dusky flycatcher	Ch.-backed chickadee**	Mountain chickadee
Swainson's thrush	**Warbling vireo***	*American Robin*	***Song sparrow***
Townsend's warbler	**MacGillivray's warbler**	Yel-rumped warbler	
	Chipping sparrow	Dark-eyed junco*	
	Lincoln's sparrow*	Pine siskin	

Candidate Species of Management Concern

Five species of conservation concern which declined at Wenatchee MAPS stations emerge as candidate species for management concern. These include three Neotropical-wintering species (warbling vireo, MacGillivray's warbler, and Lincoln's sparrow) and two temperate-wintering species (song sparrow and pine siskin). Warbling vireos were captured at four stations and declined significantly at Pleasant Valley and Rattlesnake Springs (Table 6b). MacGillivray's warblers declined significantly (P<0.01) at two of the five stations at which it was captured - Timothy Meadow and Pleasant Valley. Song sparrows were captured at five stations, and declined at four stations, significantly (P<0.01) so at Pleasant Valley and Deep Creek (P<0.10).

Table 6b. Table of adult population trends (annual percentage change derived from MAPS data) for landbirds that can be effectively monitored by MAPS stations within Wenatchee National Forest. Statistical significance is denoted by: * 0.05≤P<0.10, ** 0.01≤P<0.05, and *** P<0.01. Birds of conservation concern (see criteria above) and associated negative trends are highlighted in gray. Stations are also categorized by the recommendation whether to a) manage (or relocate) for species of conservation concern (SCC), b) relocate the station to better monitor one or more SCC, and c) maintain as control stations

Station	TIME	TWPO	PLVA	RASP	DECR	QCR2
Recommendation	Manage	Control	Manage	Control	Relocate	Control
Species						
HAFL	-6.11		-7.08	**16.7	3.50	10.0
DUFL				-16.0		6.54
WAVI		8.62	***-26.4	***-20.0		5.47
MOCH				-10.9		
CBCH					**20.7	
SWTH						2.25
AMRO	10.0	9.42	6.5			-2.99
YRWA	-4.02	10.3	*10.24			-3.89
TOWA	-8.46	*18.8			**25.7	16.9
MGWA	***-31.1	0.99	***-21.0	4.39		0.59
CHSP		10.7		-12.5		
SOSP	-7.21		***-18.9	6.14	*-17.6	-2.53
LISP	**-7.86	*-5.22	***-13.4			
DEJU	10.1	*8.21	1.69	-2.25	2.16	8.80
PISI	-13.7	0.05	*-13.8	-12.2	17.5	-3.41
N(#neg.)	9 (7)	9 (1)	9 (6)	9 (6)	6 (1)	11 (4)

Lincoln's sparrow significantly declined at all three stations at which they were captured - Timothy Meadow, Two Point, and Pleasant Valley. Pine siskins were captured at six stations, and although they show a non-significant increase at the forest level they declined at four stations, significantly ($P<0.10$) so at Pleasant Valley.

In summary, appropriate management actions should be applied at two Wenatchee stations; Timothy Meadow (TIME) and Pleasant Valley (PLVA) to reverse the declines in warbling vireo, MacGillivray's warbler, song sparrow, Lincoln's sparrow and pine siskin populations (Table 6b). Recommended management actions could be implemented in four federal land parcels (FLP#s 2530, 3515, 3519 and 3768) within the vicinity of the two target MAPS stations. We recommend that the operation of one slow station, Deep Creek, be discontinued in favor of establishing a new stations to maintain or increase the monitoring coverage of up to five species (including three Neotropical-wintering species), especially warbling vireo and Lincoln's sparrow. The three remaining stations, Two Point and Rattlesnake Springs and Quartz Creek 2 should be maintained to provide control data for species of conservation concern.

Umatilla National Forest, Oregon

Umatilla National Forest in Oregon State is located in the Blue Mountains and covers portions of Walla-Walla, Columbia, Garfield, Asotin, Umatilla, Wallowa, Union, and Grant Counties. All stations come under the jurisdiction of Walla Walla Ranger District. Four MAPS stations are located within Union County, one in Umatilla County, and one straddling the border between the two. Five of the stations are located in a federal land parcel (FLP#4579) in Umatilla National Forest, and the remaining station is located in North Fork Umatilla Wilderness (FLP#5243). Two stations are adjacent (< 5km distant) to a federal land parcel (FLP#4731) which is designated as the Wenaha-Tucannon Wilderness. This location is associated with the Northern Rockies BCR.

Of 17 species (ten Neotropical- and seven temperate-wintering species) captured in acceptable numbers, 12 are species of conservation concern (Table 7a). Two species increased, mountain chickadee and winter wren (P<0.05), and 15 species declined, including all ten Neotropical-wintering species (significantly so with the exception of Wilson’s warbler and Lincoln’ sparrow). Five of the seven temperate wintering species declined including yellow-rumped warbler (P<0.05) and dark-eyed junco (P<0.05).

Table 7a. Lists of species captured in acceptable numbers at six MAPS stations operated in Umatilla National Forest. Species are categorized by the direction of the adult population trend (statistical significance is denoted by: * 0.05≤P<0.10, ** 0.01≤P<0.05, and *** P<0.01), migratory status, and preferred habitat type - either forest (normal typeface) or scrub/successional habitat (italics). Species of conservation concern are highlighted in gray and focal species of management concern are in bold type.

Neotropical wintering species		Temperate wintering species	
Increased	Declined	Increased	Declined
	Hammond’s flycatcher*	Mountain chickadee	Ruby-crowned kinglet
	Dusky flycatcher***	Winter wren**	American robin
	Warbling vireo* **		Yellow-rumped warbler**
	Swainson’s thrush* **		Dark-eyed junco**
	Orange-crowned warbler		Pine siskin
	Townsend’s warbler**		
	MacGillivray’s warbler*		
	Wilson’s warbler		
	*Chipping sparrow****		
	Lincoln’s sparrow		

Candidate Species of Management Concern

Eleven species of conservation concern declined at Umatilla MAPS stations and emerge as candidate species for management concern (Table 7b). These include nine Neotropical-wintering species (Hammond's flycatcher, dusky flycatcher, warbling vireo, Swainson's thrush, MacGillivray's warbler, Wilson's warbler, chipping sparrow, and Lincoln's sparrow) and two temperate-wintering species (dark-eyed junco and pine siskin).

Table 7b. Table of adult population trends (annual percentage change derived from MAPS data) for landbirds that can be effectively monitored by MAPS stations within Umatilla National Forest. Statistical significance is denoted by: * 0.05≤P<0.10, ** 0.01≤P<0.05, and *** P<0.01. Birds of conservation concern (see criteria above) and associated negative trends are highlighted in gray. Stations are also categorized by the recommendation whether to a) manage (or relocate) for species of conservation concern (SCC), b) relocate the station to better monitor one or more SCC, and c) maintain as control stations.

Station	BUCR	BRME	FRME	CORI	BMME	PHCR
Recommendation						
Species						
HAFL					-2.00	**-15.9
DUFL				***-12.8		
WAVI		-3.94		***-25.2		***-19.7
MOCH					10.2	
WIWR					***18.8	
RCKI	-7.13	-4.54	1.37	-6.89	-3.84	
SWTH		-6.87			-3.25	***-12.8
AMRO		1.08				-2.89
OCWA				-4.54		-6.71
YRWA	-8.79	-1.54	-1.95	-4.39	-2.48	***-29.0
TOWA	-9.47	-10.7	-9.34	3.37	**-9.45	-9.69
MGWA		0.55	-1.75	***-9.60	-1.05	-2.82
WIWA	**-18.6	***12.53			-8.99	***-28.3
CHSP	**-15.6			***-24.8	***-17.1	
LISP		3.29	**-10.1		*-17.7	
DEJU	-5.35	-10.6	***-11.5	0.21	-6.36	-11.96
PISI		-16.4			-8.34	
N(#neg.)	6 (6)	11 (7)	6 (5)	9 (7)	13 (11)	10 (10)

Most species that declined did so at most stations at which they were captured (Table 7b). Notable declines include warbling vireo at three stations (significantly at two); Swainson's thrush at three stations (significantly at one); MacGillivray's warbler at four of five stations (significantly at two); Wilson's warbler at three of four stations (significantly at two); Chipping sparrow at three stations (significantly at all); and dark-eyed junco at five of six stations (significantly at one).

In summary, given the catastrophic declines in most species it is difficult to choose which stations should be managed, used as controls, or become inoperative. It is likely that these declines are associated with the consequences of widespread defoliation of vast areas of the Blue Mountains (including Umatilla NF and neighboring forests) between 1990 and 1992. Tree mortality reached levels of 25-40% due to damage caused by Douglas-fir tussock moth (*Orgyia pseudotsugata*) and Western spruce budworm (*Orgyia pseudotsugata*) outbreaks. We recommend that all stations be continued to see how the avian community changes in the two decades following such an outbreak.

Willamette National Forest, Oregon

Willamette National Forest in Oregon State portions of Marion, Linn, Lane, and Douglas Counties. The Clearcut, Brock Creek, and Major Prairie stations are in the Oakridge Ranger District; Fingerboard Prairie and Ikenick are in the McKenzie Ranger District; and Strube Flat is in the Blue River Ranger District. Four MAPS stations are located within Linn County, and two are located in Douglas County. All the stations are located in a federal land parcel (FLP#6364) in Willamette NF. Two stations are adjacent (< 5km distant) to a federal land parcel (FLP#7188) designated as the Mount Washington Wilderness; three stations are adjacent to a federal land parcel (FLP#7188) designated as the Three Sister's Wilderness; and one station is adjacent to a federal land parcel (FLP#8422) designated as the Waldo Lake Wilderness. This location is associated with the Northern Pacific Rainforest BCR.

Of 17 species (ten Neotropical- and seven temperate-wintering species) captured in acceptable numbers, 14 are species of conservation concern (Table 8a). Ten species show increases in adult populations and seven species show declines. Three of ten Neotropical-wintering species significantly declined (dusky flycatcher, orange-crowned warbler and MacGillivray's warbler) and six Neotropical-wintering species increased, significantly so for Hammond's flycatcher, Swainson's thrush, and Wilson's warbler. Three of the seven temperate wintering species significantly declined (chestnut backed chickadee, dark-eyed junco, and pine siskin), but significant increases were detected for winter wren ($P<0.05$) and song sparrow ($P<0.05$).

Table 8a. Lists of species captured in acceptable numbers at six MAPS stations operated in Willamette National Forest. Species are categorized by the direction of the adult population trend (statistical significance is denoted by: * $0.05 \le P < 0.10$, ** $0.01 \le P < 0.05$, and *** $P<0.01$), migratory status, and preferred habitat type - either forest (normal typeface) or scrub/successional habitat (italics). Species of conservation concern are highlighted in gray and focal species of management concern are in bold type.

Neotropical wintering species		Temperate wintering species	
Increased	Declined	Increased	Declined
Hammond's flycatcher**	"Western flycatcher"	Ch.-backed chickadee	American robin
Warbling vireo	Dusky flycatcher**	Winter wren**	**Dark-eyed junco**
Swainson's thrush	***Orange-crowned warbler****	Yel.-rumped warbler*	**Pine siskin****
*Wilson's warbler***	**MacGillivray's warbler****	*Song sparrow**	
Common yellowthroat			
Lincoln's sparrow			

Candidate Species of Management Concern

Six species of conservation concern declined at Willamette MAPS stations and emerge as candidate species for management concern. These include four Neotropical-wintering species ("Western" flycatcher, dusky flycatcher, orange-crowned warbler, and MacGillivray's warbler) and three temperate-wintering species (American robin, dark-eyed junco, and pine siskin).

Table 8b. Table of adult population trends (annual percentage change derived from MAPS data) for landbirds that can be effectively monitored by MAPS stations within Willamette National Forest. Statistical significance is denoted by: * 0.05≤P<0.10, ** 0.01≤P<0.05, and *** P<0.01. Birds of conservation concern (see criteria above) and associated negative trends are highlighted in gray. Stations are also categorized by the recommendation whether to a) manage (or relocate) for species of conservation concern (SCC), b) relocate the station to better monitor one or more SCC, and c) maintain as control stations.

Station	IKEN	FIPR	STFL	CLCU	MAPR	BRCR
Recommendation	Control	Manage	Relocate	Control	Relocate	Manage
Species						
HAFL	4.9	*12.3			**19.2	
WEFL						-2.06
DUFL				***-11.0		
WAVI				10.8		
CBCH		0.03			2.71	-2.12
WIWR			**17.6			
SWTH	-9.17	7.62	**-6.64		2.57	0.73
AMRO						-4.77
OCWA		**-18.3		-3.78		
YRWA		*13.6				
MGWA	-10.4	-3.73		4.44	-3.82	**-6.74
COYE	0.77					
WIWA		6.09		***26.2		
SOSP	*6.52		6.55		4.44	7.97
LISP	-0.14	0.61				
DEJU	-2.57	**-8.10		*5.16	1.78	4.39
PISI	**-26.6	**-17.6				
N(#neg.)	8 (5)	10 (4)	3 (1)	6 (2)	6 (1)	7 (4)

Few species were captured in acceptable numbers at more than two stations (Table 8b). MacGillivray's warbler was captured at five stations, increased at one and declined at four stations (significantly at Brock Creek). Dark-eyed junco was captured at five stations, increased at three (significantly at one) and declined at two stations (significantly at Fingerboard Prairie). Orange-crowned warbler significantly ($P<0.05$) declined at both stations at which it was captured (significantly at Fingerboard Prairie). Pine siskin significantly ($P<0.05$) declined at Ikenik and Fingerboard Prairie.

In summary, appropriate management actions could be applied at the two Willamette stations; Fingerboard Prairie (FIPR), to reverse the declines in orange-crowned warbler, MacGillivray's warbler, dark-eyed junco and pine siskin populations; and at Brock Creek (BRCR) to reverse the decline in MacGillivray's warbler. Recommended management actions could be implemented in four federal land parcels (FLP#s 6364, 7188, 7398, 8422) within the vicinity of the target MAPS stations. We recommend that the operation of two slow stations, Strube Flat (STFL) and Major Prairie (MAPR), be discontinued in favor of establishing new stations to maintain or increase the monitoring coverage of species of conservation concern, especially orange-crowned warbler, MacGillivray's warbler, dark-eyed junco, and pine siskin. The two remaining stations, Ikenick (IKEN) and Clearcut (CLCU) will be maintained to provide control data for species of conservation concern.

Siuslaw National Forest, Oregon

Siuslaw National Forest in Oregon State covers portions of Tillamook, Yamhill, Lincoln, Polk, Benton, Lane, and Douglas Counties. Three MAPS stations are located within Lincoln County, one near the western portion of Benton, and two in the northern portion Lane County. All stations are under the jurisdiction of the Alsea Ranger District and located in one federal land parcel (FLP#6815) in Siuslaw National Forest. Two land parcels are adjacent (< 5km distant) to the Homestead (HOME) station in Lincoln County. This location is associated with the Northern Pacific Rainforest BCR.

Of six species (three Neotropical- and three temperate-wintering species) captured in acceptable numbers, all are species of conservation concern (Table 9a). Two species show increases in adult populations and four species show declines. "Western" flycatcher significantly (P<0.01) declined as did song sparrow (P<0.10).

Table 9a. Lists of species captured in acceptable numbers at six MAPS stations operated in Siuslaw National Forest. Species are categorized by the direction of the adult population trend (statistical significance is denoted by: * 0.05≤P<0.10, ** 0.01≤P<0.05, and *** P<0.01), migratory status, and preferred habitat type - either forest (normal typeface) or scrub/successional habitat (italics). Species of conservation concern are highlighted in gray and focal species of management concern are in bold type.

Neotropical wintering species		Temperate wintering species	
Increased	Declined	Increased	Declined
Swainson's thrush	**"Western" flycatcher*** **		**Ch.-backed chickadee**
Wilson's warbler			**Winter wren**
			*Song sparrow**

Candidate Species of Management Concern

One Neotropical-wintering species ("Western" flycatcher) significantly declined at Siuslaw MAPS stations and emerged as the only candidate species for management concern. "Western" flycatchers were captured at five stations and significantly declined at the forest level and at four stations, significantly at Mary's Peak (Table 9b).

Table 9b. Table of adult population trends (annual percentage change derived from MAPS data) for landbirds that can be effectively monitored by MAPS stations within Siuslaw National Forest. Statistical significance is denoted by: * 0.05≤P<0.10, ** 0.01≤P<0.05, and *** P<0.01. Birds of conservation concern (see criteria above) and associated negative trends are highlighted in gray. Stations are also categorized by the recommendation whether to a) manage (or relocate) for species of conservation concern (SCC), b) relocate the station to better monitor one or more SCC, and c) maintain as control stations

Station	MAPE	HOME	BERI	COUC	CRCR	SAME	CECR
Recommendation	Lost ‘03	Control	Control	Relocate	Manage	Control	Made‘04
Species							
WEFL	**-7.87	-2.79	4.03		-7.01	-0.32	
CBCH	-11.92	3.09		-6.8			
WIWR	-1.56	-2.88	-3.17	1.61	9.91	2.86	
SWTH	**7.19	1.59	*3.56	0.51	4.98	3.41	
WIWA	-2.82	1.77	4.72	0.41	**15.6	9.17	
SOSP						*-10.5	
N(#neg.)	5 (4)	5 (2)	4 (1)	4 (1)	4 (1)	5 (1)	

In summary, management actions were applied at two Siuslaw stations. Crab Creek was thinned in the fall of 2003, leaving large brushpiles. The net lanes were placed as close to the original positions as possible. Mary’s Peak (MAPE) was not operated in 2004. A new station, Cape Creek (CECR), was established within a stand that used to be similar in structure to the pre-thinned Crab Creek vicinity. However CECR was similarly thinned in 1996 so it represents an eight-year old thinned stand. We recommend that the operation of a remaining slow station, Cougar Creek, be discontinued in favor of establishing a new station to maintain or increase the monitoring coverage of species of conservation concern, especially “Western” flycatcher, chestnut-backed chickadee, and song sparrow. The two remaining stations, Beaver Ridge (BERI) and Salvation Meadow (SAME) will be maintained to provide control data for species of conservation concern.

Fremont National Forest, Oregon

Fremont National Forest in Oregon State covers portions of Klamath and Lake Counties. Five MAPS stations are located within Lake County, and one on the western edge of Klamath County. The stations are under the jurisdiction of the Paisley Ranger District and are located in a single federal land parcel (FLP#9564) in Fremont National Forest. Two of the stations are adjacent (< 5km distant) to a federal land parcel (FLP#12429) which is designated the Gearhart Mountain Wilderness. This location is associated with the Great Basin BCR.

Of 14 species (nine Neotropical- and five temperate-wintering species) captured in acceptable numbers, 11 are species of conservation concern (Table 8a). Seven species show increases in adult populations and seven species show declines. Significant ($P<0.10$) increases were detected in Hammond's flycatcher and dark-eyed junco.

Table 10a. Lists of species captured in acceptable numbers at six MAPS stations operated in Fremont National Forest. Species are categorized by the direction of the adult population trend (statistical significance is denoted by: * $0.05 \le P<0.10$, ** $0.01 \le P<0.05$, and *** $P<0.01$), migratory status, and preferred habitat type - either forest (normal typeface) or scrub/successional habitat (italics). Species of conservation concern are highlighted in gray and focal species of management concern are in bold type.

Neotropical wintering species		Temperate wintering species	
Increased	Declined	Increased	Declined
Hammond's flycatcher*	Dusky flycatcher	American robin	**Mountain chickadee**
"Western" flycatcher	**Warbling vireo**	Yellow-rumped warbler	Ruby-crowned kinglet
MacGillivray's warbler	***Orange-crowned warbler***	Dark-eyed junco*	Pine siskin
	Wilson's warbler		
	Lincoln's sparrow		

Candidate Species of Management Concern

Seven species of conservation concern declined at Fremont MAPS stations (Table 10a) and emerge as candidate species for management concern. These include five Neotropical-wintering species (dusky flycatcher, warbling vireo, orange-crowned warbler, Wilson's warbler, and Lincoln's sparrow) and two temperate-wintering species (mountain chickadee and pine siskin). Dusky flycatchers were captured at two stations and declined at one (Table 10b). Warbling vireos were captured at four stations, increased at two (significantly at one) and significantly declined at Auger Creek and Island. Mountain chickadee declined at four of the six stations at which it was captured. Orange-crowned warblers were captured at two stations and significantly ($P<0.10$) declined at Sycan River. Wilson's warbler declined at a single station. Lincoln's sparrow declined at the three stations at which it was captured, and pine siskin declined at both stations at which it was captured.

Table 10b. Table of adult population trends (annual percentage change derived from MAPS data) for landbirds that can be effectively monitored by MAPS stations within Fremont National Forest. Statistical significance is denoted by: * $0.05 \le P < 0.10$, ** $0.01 \le P < 0.05$, and *** $P < 0.01$. Birds of conservation concern (see criteria above) and associated negative trends are highlighted in gray. Stations are also categorized by the recommendation whether to a) manage (or relocate) for species of conservation concern (SCC), b) relocate the station to better monitor one or more SCC, and c) maintain as control stations.

Station	SYRI	DEAD	COLC	AUCR	ISLA	SWCR
Recommendation	Manage	Control	Relocate	Control	Manage	Relocate
Species						
HAFL	14.2			6.54	10.2	
WEFL						7.04
DUFL	-7.62	1.38				
WAVI	-0.82	**9.13		*-7.94	**-15.7	
MOCH	-6.29	-0.16	-6.87	-3.22	2.23	3.14
RCKI	-3.29					
AMRO	*7.80	6.21	-8.36	-0.15	-1.40	-7.59
OCWA	*-11.0	2.50				
YRWA	2.31	*15.1	-1.94	1.13	1.45	1.20
MGWA	-14.2	-2.91		*14.5		13.1
WIWA	-17.7					
LISP	-5.47	-10.5	-9.00			
DEJU	**10.2	4.89	-2.33	**8.54	5.74	-2.07
PISI	-3.07	-13.3				
N(#neg.)	13 (9)	10 (4)	5 (5)	7 (3)	6 (2)	6 (2)

In summary, appropriate management actions could be applied at two Fremont stations; Sycan River (SYRI), to reverse the declines in warbling vireo, mountain chickadee, orange-crowned warbler, and Lincoln's sparrow (also expected to affect MacGillivray's warbler, Wilson's warbler, and pine siskin populations); and at Island (ISLA) to reverse the decline in warbling vireos. Recommended management actions could be implemented in two federal land parcels (FLP#s 9564, 12429) within the vicinity of the target MAPS stations. We recommend that the operation of two slow stations, Cold Creek (COCR) and Swamp Creek (SWCR), be discontinued in favor of establishing new stations to maintain or increase the monitoring coverage of species of conservation concern, especially warbling vireo, orange-crowned warbler and Lincoln's sparrow. The two remaining stations, Deadhorse (DEAD) and Auger Creek (AUCR) will be maintained to provide control data for species of conservation concern, including dusky flycatcher and pine siskin

Flathead National Forest, Montana

Flathead National Forest in Montana State covers portions of Flathead, Lake, and Missoula Counties. Two MAPS stations are located within Flathead County, two in Lake County and one in Missoula County. All the stations are located in a single federal land parcel (FLP#1978) in Willamette National Forest. One station is adjacent (< 5km distant) to a federal land parcel (FLP#2372) which is designated as the Great Bear Wilderness; and another is adjacent to a federal land parcel (FLP#2604) which is designated as the Bob Marshall Wilderness. This location is associated with the Northern Rockies BCR.

Of 14 species (nine Neotropical- and five temperate-wintering species) captured in acceptable numbers, ten are species of conservation concern (Table 11a). Six species show increases in adult populations and eight species show declines. Seven of the nine Neotropical-wintering species declined, three of them significantly (dusky flycatcher, warbling vireo, and orange-crowned warbler), but two species, MacGillivray's warbler and chipping sparrow increased. One of the five temperate-wintering species declined (pine siskin), and four species increased - significant so ($P<0.05$) for dark-eyed junco.

Table 11a. Lists of species captured in acceptable numbers at six MAPS stations operated in Flathead National Forest. Species are categorized by the direction of the adult population trend (statistical significance is denoted by: * $0.05 \leq P<0.10$, ** $0.01 \leq P<0.05$, and *** $P<0.01$), migratory status, and preferred habitat type - either forest (normal typeface) or scrub/successional habitat (italics). Species of conservation concern are highlighted in gray and focal species of management concern are in bold type.

Neotropical wintering species		Temperate wintering species	
Increased	Declined	Increased	Declined
MacGillivray's warbler	Hammond's flycatcher	Ruby-crowned kinglet	**Pine siskin**
Chipping sparrow	**Dusky flycatcher*** **	American robin	
	Warbling vireo**	*Song sparrow*	
	Swainson's thrush	Dark-eyed junco**	
	*Orange-crowned warbler**		
	Common yellowthroat		
	Lincoln's sparrow		

Candidate Species of Management Concern

Seven species of conservation concern declined at Flathead MAPS stations and emerge as candidate species for management concern. These include six Neotropical-wintering species

(Hammond's flycatcher, dusky flycatcher, warbling vireo, Swainson's thrush, orange-crowned warbler, and Lincoln's sparrow) and one temperate-wintering species (pine siskin).

Table 11b. Table of adult population trends (annual percentage change derived from MAPS data) for landbirds that can be effectively monitored by MAPS stations within Flathead National Forest. Statistical significance is denoted by: * 0.05≤P<0.10, ** 0.01≤P<0.05, and *** P<0.01. Birds of conservation concern (see criteria above) and associated negative trends are highlighted in gray. Stations are also categorized by the recommendation whether to a) manage (or relocate) for species of conservation concern (SCC), b) relocate the station to better monitor one or more SCC, and c) maintain as control stations.

Station	CEFO	HIME	SIMO	SWOX	SRNA	SICR
Recommendation	Relocate	Manage	Manage	Control	Control	Relocate
Species						
HAFL				-5.17		
DUFL		*-23.6	***-28.6			
WAVI			***-14.5			
RCKI				14.3		
SWTH	-2.19	-1.75	-1.21	-0.38	-6.43	**-6.8
AMRO				4.2		
OCWA		*-11.1				
MGWA		-2.27	4.50	4.91	11.3	-4.84
COYE		-9.62		5.15	-4.59	
CHSP					11.1	
SOSP		-4.87		10.7	2.22	
LISP		-2.40			-10.6	
DEJU	**19.8	8.14	7.6		7.29	
PISI			*-24.8		*25.3	
N(#neg.)	2 (1)	8 (7)	6 (4)	7 (2)	8 (3)	2 (2)

Only three species were captured in acceptable numbers at more than three stations (Table 11b). Swainson's thrush declined at all six stations (significantly at one). MacGillivray's warbler was captured at five stations, increased at three and declined at two stations (significantly at none). Dark eyed junco, however, increased at the four stations at which it was captured (significantly at one).

In summary, appropriate management actions could be applied at two Flathead stations; Hillary Meadow (HIME) and Six Mile Mountain (SIMO), to reverse the declines in dusky flycatcher, Swainson's thrush and MacGillivray's warbler, which might also benefit orange-crowned warbler, and pine siskin populations. Recommended management actions could be implemented in three federal land parcels (FLP#s 1978, 2372, 2604) within the vicinity of the target MAPS stations. We recommend that the operation of two slow stations, Coram Forest (CEFO) and Simpson Creek (SICR), be discontinued in favor of establishing new stations to maintain or increase the monitoring coverage of species of conservation concern, especially Swainson's thrush and MacGillivray's warbler, but also orange-crowned warbler, and pine siskin. The two remaining stations, Swan Oxbow 2 (SWOX) and Swan (SRNA) will be maintained to provide control data for species of conservation concern.

Part II : Species-specific management models

Scope and Approach

We constructed species-landscape models to explain spatial variation in avian demographics at 42 MAPS stations located in seven national forests of Washington, Oregon, and Montana, using various landscape variables determined from five different spatial datasets (see Methods) covering the Pacific Northwest. Most of these stations were located in moist (riparian, wet meadow, or lacustrine) forested, or partially forested areas. The models presented here are multivariate, using data mainly associated with 36 of the 42 stations that were operated in six USFS Pacific Northwest Region Six national forests of Washington and Oregon. All five spatial datasets used in these analyses fully encapsulated these 36 stations. The remaining six stations were operated in Flathead N.F., Montana which is administered by USFS Region One. Three of the five spatial datasets encapsulated the Flathead stations.

We constructed the management models using multivariate regression analyses, incorporating parsimonious model selection based on an index of model complexity derived from information theory and maximum likelihood principles, and applied to sets of six demographic parameters (dependent variables) for each of 16 species. These species are classified as "***species of conservation concern***" (SCC) because they satisfy one or more criteria derived from other landbird conservation research and planning programs at the regional or continental scale:

1. Listed as "focal species" in one or more Partners in Flight Landbird Conservation Plans (LCP) for Washington, Oregon, and Montana, in which all the MAPS stations in this study are located. Species in this classification are also assigned to a sub-region(s): Westside Coniferous (four species); Westside Lowlands and Valleys (three species), and Northern Rockies (two species), East Slope Cascades (one species), or Montana (eight species).
2. Listed as "Species of Continental Importance" (SCI) in the Partners in Flight Continental Monitoring Plan for the Intermountain West avifaunal biome (one

species). This includes Bird Conservation Regions 9, 10, and 16 (Great Basin, Northern Rockies, and Southern Rockies/Colorado, respectively).

3. Listed as “Species of Continental Importance” (SCI) in the Partners in Flight Continental Monitoring Plan for the Pacific avifaunal biome (three species). This includes Bird Conservation Regions 5, 15, and 32 (Northern Pacific Rainforest, Sierra Nevada, and Coastal California, respectively).
4. Significantly declining populations in four relevant PIF Bird Conservation Regions: Northwestern Interior Forest (three species), Northern Pacific Rainforest (seven species), Great Basin (five species), and the Northern Rockies (five species) according to analyses of Breeding Bird Survey data (1980-2002).
5. Significantly declining populations on one or more national forests according to analyses of MAPS data (1992-2001).

The independent variables comprised a suite landscape metrics derived from 2-kilometer radius areas surrounding those MAPS stations (out of a set of 42) where each species was effectively monitored (i.e., >2.5 adults and >=1 young were captured each year). The landscape metrics were associated with five unique spatial datasets encapsulating the 36 MAPS stations throughout Washington and Oregon. For each of the 16 species, we summarize the results of a literature review to identify known or proposed ecological relationships describing population responses to various landscape metrics and published management guidelines. We then selected suites of landscape parameters to be included in our species-landscape models based on a) the results of this literature review, and b) careful inspection of correlation matrices that tested for strong correlations between landscape parameters and the demographic parameters described below.

We modeled six demographic parameters as functions of the highly correlating landscape variables to provide us with multivariate models with which to assess the effects of proposed changes in the landscape on the demographics of each of the 16 target species. The mean annual number of individual adults (AHYmean - after hatching-year) captured, provides an index of the adult population density. Over time, the number of adults may increase or decrease because of changes in the amount or quality of suitable habitat, and because of changes in productivity and/or survival. Because adult population densities vary across the region, we expressed the annual change in adult population density as the percentage change per year relative to the mean annual number of adult individuals captured (AHYtrend).

One might argue that as the quality or amount of habitat decreases, the density of adults breeding there should also decrease. Researchers have found, however, that adult densities are sometimes higher in sink habitats (where productivity does not balance mortality and populations are maintained by immigration from source habitats) than in source habitats (where productivity more than balances mortality and the excess young that are produced which subsequently emigrate to other habitats). Thus, it is important to include measures of productivity in the demographic parameters modeled as well as adult population densities and trends. We used the mean annual number of juveniles captured (YNGmean) to provide an index of the size of the juvenile population. Again, because young population densities vary across the region, we expressed the annual change in young population density as the percentage change per year relative to the mean annual number of young individuals captured (YNGtrend).

We also calculated the annual ratios of the number of young individuals captured to the number of adult individuals captured and derived an index of reproductive success (RImean) represented by the mean of these annual ratios. This number indexes all-time reproductive success in terms of young per adult. Clearly, over time the numbers of adults and/or young may change as the breeding habitat succeeds/senesces or is disturbed in some way. We expressed this annual change in reproductive success as the trend in annual ratios of young to adult individuals captured (RItrend).

Importantly, a management action might change the landscape in such a manner as to cause an increase in the number of adults but a decrease in the index of reproductive success. This can happen if the numbers of young produced do not increase at the same rate as adults, or perhaps decrease as adults increase. Therefore, managing to increase adult population size may not be an acceptable conservation goal because it results in the creation of an "ecological trap" whereby the habitat is attractive to adults but leads to low reproductive success (i.e. a sink population). Typically, in a management-induced ecological trap, adults are attracted to a managed habitat in large numbers but fail to be reproductively successful due to intra-specific competition, or elevated risks of nest predation and parasitism. Similarly, a management action might change a landscape in such a way that reproductive success remains constant because both the numbers of adults and young decrease at the same rate; again, this may not be a desirable conservation goal. Ideally, management actions for a particular declining species of concern should effect increases in both the numbers of adults and young such that the reproductive success remains fairly constant or increases.

For each species, our regression analyses created individual species-landscape models for every combination of the six dependent variables and numerous independent variables. We selected the top ten models as those with the ten lowest values of ICOMP, an index of information complexity that, like AIC, penalizes models for over-parameterization but, unlike AIC, also penalizes models with high levels of co-linearity and covariance among landscape parameters. For each of the top ten models, we calculate the contribution (or proportional representation) of each landscape parameter included in the model to give an overall impression of which elements of the landscape appear to drive the particular demographic. We present the detailed results of these analyses in Appendix 6. Then, for the top selected model for each of the six demographic parameters, we perform a multivariate regression using data from all of the stations (N) at which the species was effectively monitored, and report the mean (Mean), standard deviation (S.D.), and regression coefficients of each landscape metric included in the models for each demographic parameter. Finally, we present the overall R-squared value, F-statistic, and P-value for the top-selected model for each demographic parameter.

In some cases the multivariate models were statistically weak ($P>0.05$) because they were based fewer than 10 data points. Typically, such models were saturated with four or more parameters, making them difficult to interpret. These models were not considered reliable or useful in forming management guidelines.

Hammond's flycatcher - *Empidonax hammondii*

Background

Hammond's flycatcher, an obligate aerial forager, prefers to breed in mature coniferous or mixed coniferous-deciduous forests that produce cool shady conditions and an open understory. Typically, such forests are relatively mature with well developed canopies (Manuwal 1970, Mannan 1984, Raphael et al. 1988, USDA Forest Service 1994), and high abundances have been recorded in coniferous riparian habitat (Anthony et al. 1996). There is evidence that Hammond's flycatchers and Dusky flycatchers (*Empidonax oberholseri*) are both sensitive to fragmentation and avoid forest edges. It is suggested that the minimum size fragment (stand) should be 2 hectares (Aney 1984), but preferably between 10 and 20 hectares to sustain populations (Sakai and Noon 1991). Commercial thinning and selection cutting practices that open the understory (and not the canopy) may benefit this species (Hagar et al. 1996) by creating the aerial foraging space it requires. Hammond's flycatchers may also benefit from ground fires which open up the understory for foraging flight paths (Johnson and Wauer 1994). However, clearcuts and regeneration gaps do not provide suitable breeding habitat (Hejl et al. 1995).

Furthermore, because Hammond's flycatcher avoids edges, the core area of mature forest in a stand might be important. For a forest stand of a given size, long thin stands have less forest core area than more uniformly shaped stands. In commercial forests owned by multiple interests, a common ecological management problem lies in the difficulty and complexity of organizing existing cutting regimes to sustain rotations of large contiguous tracts of mature forest. Large forest tracts provide important habitat for many specialist species.

Breeding Bird Survey (BBS) data for the period 1980-2003 shows near-significant annual increases of 1.5% survey-wide ($P<0.10$) and 3.0% in Washington ($P<0.05$). Adult population sizes increased in five of the seven bird conservation regions in which they are monitored. Significant increases have been observed in the Northern Pacific Rainforest BCR (4.7% annually, $P<0.005$), and the entire western BBS region (1.7% annually, $P<0.05$). MAPS data for national forests in USFS Region Six also shows a significantly ($P<0.05$) increasing adult population that is not explained by the observed low and decreasing productivity, neither can it be attributed to a high survival rate relative to body mass (DeSante et al. 2002). Hammond's flycatcher is listed by PIF as of concern in the Western Coniferous forest areas of Washington and Oregon, and in Montana.

Research and monitoring requirements

Generally, we need to know more about the biology and ecology of this species (NatureServe 2004). The PIF Washington/Oregon BCP cites three research and monitoring requirements for the Hammond's flycatcher, all relating to habitats within the Westside Coniferous Forest ecoregion:

1. Determine how forest thinning regimes affect Hammond's flycatchers.
2. Determine the impact of managed forest stands on prey (flying insect) abundance.
3. Determine if riparian management zones provide suitable habitat to support Hammond's flycatchers.

We also need to determine the preferred microhabitat characteristics of mature forest habitat such that management (e.g. thinning) can simulate the natural processes that bring about those characteristics. At a spatially more extensive scale, we need to identify species-landscape relationships relating to forest fragmentation levels, the minimum forest stand size required for successful breeding, and the influence of edge types on abundance and breeding success. For Hammond's flycatcher and other species the amount and quality of riparian habitat within the coniferous forests may be critical to successful breeding.

Although this species is not declining according to BBS data, knowledge of species-landscape relationships is particularly important in the context of mature forest and riparian forest stand management and the effects of alternate management regimes on those habitats (i.e. fire, timber, and pest control) and the population dynamics of this little-studied species. For instance, it is likely that fuel reduction by fire or thinning practices in mature forests will open the understory and improve habitat.

One reason for the lack of biological and ecological information regarding this species is the difficulty in using “sight and song” survey techniques because they are so easily confused with other Empidonax species, especially Dusky flycatcher (*Empidonax oberholsei*). The Hammond’s flycatcher data collected from MAPS mist-netting stations in national forests of Oregon and Washington are likely reliable because it was collected from birds identified “in the hand” by interns trained in correctly identifying adults and young of this species.

Model Interpretations

The models presented here adequately address two of the three research and monitoring requirements of the PIF Washington/Oregon Bird Conservation Plan for this species. The selected models were statistically significant for all six demographic parameters, and landscape variables associated with typical Hammond's flycatcher habitat contributed substantially to the weighted models for more than one demographic parameter.

Inspection of the landscape data associated with the 18 MAPS stations used in these analyses (at which we captured Hammond’s flycatcher) reveals that coniferous forest is the dominant habitat type, covering 50-95% (median 83%) of the 1250 hectare areas that lie within a 2-kilometer radius of each station. The coverage of successional habitat varied between 0 and 15% (0 and 200 hectares) with a median cover of 2%. After comparing these total coverages with the total core areas (TCA) of successional (NLCD Shrubland class) habitat (after defining a 90m buffer within each successional patch) we concluded that the patches associated with high demographic values are few and fairly uniform in shape. These patches likely resulted from forestry practices within the coniferous forests surrounding the MAPS stations and by 2001 had probably developed into mid-successional patches of regenerating trees. We reported statistically significant correlations between demographics and landscape variables. At this sampling level (n=18) two-tailed (n-2) critical values of Pearson’s correlation coefficient (r) lie at 0.400 ($P<0.10$), 0.468 ($P<0.05$), and 0.590 ($P<0.01$).

Table 12. Summary table of Hammond's flycatcher demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY	MPI-			CLA-		TCA+				
YNG						CLA+	CLA-	CLA-		ALL-
RI		HCA+				TCA+		CLA-		ALL+
AHY/t		LCA+				CLA+	CLA-		FS+ SG+	
YNG/t				CLA-						CL4+
RI/t				CLA-	CLA-					

The mean annual population size of adults correlated poorly with the high levels of coniferous forest cover recorded at these stations. However, they correlated negatively with mean patch interspersion (r=-0.579) at the landscape level, and positively with the core area of successional habitat (r=0.518). The best multiple regression model ($R^2 = 0.490$, F=7.198, P=0.006) indicated that the highest adult populations were recorded at stations fragmented by larger patches of successional habitat (e.g. stations 11148 and 11902 in Wenatchee N.F., 11156 in Umatilla N.F., and 11173 in Fremont N.F.). This model also suggests that adult populations were negatively associated with areas of coniferous forest fragmented by deciduous and/or mixed forest or non-successional habitat types (e.g. stations 11140, 11141, and 11143 in Mount Baker N.F.).

Young populations correlated most strongly and negatively with stream density (r=-0.577) and, not surprisingly, with the area of deciduous or mixed forest (r=-0. 237). Again, the multiple regression models show that high young populations are best modeled ($R^2 = 0.476$ F=4.620, P=0.019) as a function of widely distributed patches of successional habitat within contiguous coniferous forest (e.g. stations 11150 in Wenatchee N.F., and 11155 in Umatilla N.F.). In the same model, the population responds negatively to stream density, grassland area, and damage caused by beetle pestilence (e.g. stations 11148, 11156, and 11145, respectively).

Similarly, reproductive success was most strongly and negatively associated with stream density (r=-0.469) and successional/grassland edge (r=-0. 309). However, the multiple regression models again show that high reproductive success is best modeled ($R^2 = 0.626$, F=5.444, P=0.008) as a function of widely distributed patches of successional habitat within contiguous high canopy (USFS 70-100% crown cover classification) coniferous forest (e.g. 11145, 11150, 1158). In the same model the population responds negatively to stream density, but positively to areas damaged by all classifications of defoliating insects. More importantly, high reproductive success is associated with more extensive core areas of high canopy forest, suggesting that reproductive success among Hammond's flycatchers is edge-sensitive within these patches that represent a small percentage of the forest cover

Trends of breeding adults correlated positively with edges of successional habitat and several other habitats, particularly low-density canopy forest (r=0.567) and grassland (r=0.484). The best model ($R^2 = 0.573$, F=6.265, P=0.006) included these variables and described nearly 60% of the spatial variation. However, where larger areas of successional habitat and grassland (USFS classification) occur, adult populations declined.

The best model describing young population trends ($R^2 = 0.234$, F=4.851, P=0.043), although lacking descriptive power, suggests declines in areas associated with a high coverage of deciduous forest (r=-0.462) but increases in areas that have suffered defoliation by beetles (r=0.406). These highly productive areas also tend to be associated with higher elevations (r=0.317) and large patches of low percent canopy cover forest (r=0.339).

However, the overriding factor that appears to drive reproductive success is the presence of large contiguous patches of coniferous forest in higher elevation, drier areas. The best model ($R^2 = 0.394$, F=10.410, P=0.005) indicates that 2-kilometer radius landscapes with areas of deciduous forest greater than 10 hectares (~0.9%) were associated with declines in reproductive success.

The relationships between landscape variables and annual rates of change for each of the above three parameters indicate that the effects of the forest fragmentation patterns (observed at the beginning of this study) may have created post-breeding habitat that increasingly attracts both adult and young Hammond’s flycatchers. However, increasing or maintaining large continuous areas of low-density canopy coniferous forest in drier areas should result in more productive populations of Hammond's flycatchers.

Maintaining the amount of successional habitat (at least up to 20%) appears to effect population increases of breeding adults and young, but negatively affects per capita reproductive success. At first glance, the results suggest that to maintain healthy and productive Hammond’s flycatcher populations, land managers should create a shifting mosaic of successional or low crown cover habitat (covering 10-20%) within extensive uniformly shaped coniferous forest or woodland covering 80-90% of each 1000 hectares.

Regarding the research and management requirements mentioned earlier, our results suggest that a) limited coniferous canopy thinning regimes resulting in high percentage cover of high-elevation, open coniferous habitat should affect populations of Hammond's Flycatcher positively, b) that fragmenting contiguous coniferous forest will reduce annual reproductive success, and c) riparian management zones probably do not provide suitable habitat to support this species.

Dusky flycatcher - *Empidonax oberholseri*

Background

The dusky flycatcher prefers to breed in scrub habitats associated with scattered trees and open woodland, especially near riparian areas, where it forages by sallying for flying insects. Populations appear to benefit from forestry practices in the Northern Rockies that leave a shifting mosaic of burned, clearcut, partial-cut and seed-tree patches (Sharp 1996, Hutto and Young 1999). There is, however, some concern that such man-made habitats may attract large numbers of adult dusky flycatchers but may not benefit productivity and survival, thereby creating an "ecological trap" or sink habitat (Hutto and Young 1999). Thus, more information is required to quantify the demographics of this species in different habitats in both the breeding and non-breeding seasons (Nature Conservancy 2004). Threats to more natural riparian habitats, especially at higher elevations, such as habitat removal, recreational disturbance, alteration of water flow, grazing, or exotic shrub invasion will negatively affect this species. Myers (1991) suggests that negative impacts may be alleviated by carefully controlled grazing, rather than complete eradication. In addition, cowbird parasitism, despite low rates, reduces reproductive success in areas proximal to high levels of grazing and agricultural development (Sedgwick 1993, Campbell et al. 1993).

BBS data for the period 1980-2003 show a significant ($P<0.05$) survey-wide decline of 2.1% and population declines in five of the nine bird conservation regions, including a significant ($P<0.01$) 3.4% annual decline in the Northern Pacific Rainforest, and non-significant declines in the Northwestern Interior Forest (8.9%), the Great Basin (1.7%), and the Northern Rockies (2.3%) physiographic provinces. In contrast, MAPS data for the region show a significant ($P=0.01$) annual increase of 6.7%.

PIF classifies this species as a Species of Continental Importance for the Intermountain West Avifaunal Biome which holds an estimated 86% of the breeding population. The objective of continental scale long-term planning and responsibility for this species is to maintain population levels in successional habitat-forest habitats.

Research and monitoring requirements

The PIF Washington/Oregon BCP cites no research and monitoring requirements for the dusky flycatcher (*Empidonax oberholsei*). Surprisingly, only one requirement is listed despite the SCI categorization and the suggestion that forestry practices may have created an ecological trap for this species:

1. Range and habitat use of Dusky Flycatchers in New Mexico.

We suggest the following requirement for dusky flycatcher:

2. Conduct selective monitoring at key riparian sites to determine the factors influencing nest success - California.
3. Determine what constitutes source and sink areas in managed vs unmanaged forests.

Model interpretations

Due to lack of sufficient data no regression models are presented for this species.

“Western” flycatcher - *Empidonax difficilis/occidentalis*

Background

The “western” flycatcher, Pacific-slope (*Empidonax difficilis*) and Cordillieran (*Empidonax occidentalis*) flycatcher data were pooled for this analysis. It is likely that the majority of individuals captured were Pacific-slope flycatchers but may have included Cordillieran flycatchers captured at Umatilla N.F. The sub-species prefer to breed in moist coniferous, deciduous or mixed forests that feature tall trees (Grinnell and Miller 1944). Primary breeding habitat includes unmanaged mature forest stands featuring streams (Raphael et al. 1988, Carey et al. 1991, Gilbert and Allwine 1991, Manuwal 1991, McGarigal and McComb 1992). However, in managed Californian Douglas-fir forests, “western” flycatchers responded positively to fragmentation patterns that produced insular forest stands, or larger stands containing more edge around clearcut areas, despite a tendency to avoid forest edges (Rosenberg and Raphael 1986). This species nests along streams, utilizing tree limbs, cavities, earth banks, or ledges; it is sometimes attracted to human-made structures.

BBS data for the period 1980-2003 show a near-significant ($P<0.10$) survey-wide decline of 0.8% and population declines in six of the ten bird conservation regions, including a 2.2% annual decline ($P<0.10$) in the Great Basin physiographic province, a 3% annual decline ($P<0.10$) in Oregon, and a highly significant ($P<0.005$) 2.3% annual decline in Washington state. MAPS data for the region also show a significant ($P<0.05$) annual decline of 2.9%, perhaps due to relatively low region-wide productivity levels (DeSante et. al. 2002).

PIF classifies this species as a Species of Continental Importance for the Pacific Avifaunal Biome which holds an estimated 91% of the breeding population. The objective of continental scale long-term planning and responsibility for this species is to maintain population levels in mixed forest habitats.

Research and monitoring requirements

The PIF Washington/Oregon BCP cites three research and monitoring requirements for the Pacific-slope flycatcher (*Empidonax difficilis*), all relating to habitats within the Westside Coniferous Forest ecoregion:

1. Determine the reproductive success of Pacific-slope flycatchers in wet old growth sites and in dry upland and riparian sites
2. Determine whether riparian buffer zones can support reproducing populations of Pacific-slope flycatchers.
3. Determine the habitat affinities and reproductive success of several coniferous forest bird species in both structurally complex unmanaged habitats, and in the different-aged stands of managed high canopy plantations.

Model Interpretations

The models presented here address all three research and monitoring requirements of the PIF Washington/Oregon Bird Conservation Plan for this species. The selected models were significant for all six demographic parameters. Although results were somewhat mixed, we are able to interpret them to provide specific management recommendations.

Inspection of the landscape data associated with the 13 MAPS stations with adequate data used in these analyses reveals that coniferous forest is the dominant habitat type covering 60-90% (median 75%) of the 1250 hectares that lie within a 2-kilometer radius of each station. The core coverage of successional habitat was consistently under 1% (i.e. under 12.5 hectares). Areas around these stations also contained 2 - 10% coverage of deciduous forest and between two and ten hectares of riparian habitat (15m buffer for perennial). We reported statistically significant correlations between demographics and landscape variables. At this sampling level (n=13) two-tailed (n-2) critical values of Pearson’s correlation coefficient (r) lie at 0.476 (P<0.10), 0.553 (P<0.05) and 0.684 (P<0.01).

Population sizes of adult “western” flycatcher correlated negatively with the core area of successional habitat (r=-0.676), whereby the lowest adult populations were associated with forests containing ~10-15 hectares of this habitat. Populations were also lower in areas with more extensive deciduous forest. Otherwise, the model selection process nominated an extremely complex, eight parameter model that was too difficult to interpret. However, positive relationships emerged with the core area of high canopy cover forest and coniferous forest area. Coniferous forest coverage should approach 90% (~1100 hectares) which ensures some 900 hectares of core habitat.

Table 13. Summary table of "western" flycatcher demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY[1]	SDI-					TCA-				
YNG[1]	TCA+ SDI-		TCA+ CLA+			TCA-				
RI	MPI-		TCA+ CLA+			TCA+	CLA-[2]		SG+	
AHY/t		HCA- MCA+ LCA+					CLA+ CLA+[2]		ALL+ FG+	CLA+
YNG/t	MPI-		TCA-	CLA+	CLA+ CLA+					
RI/t							CLA-			

[1] Regression model overparameterized
[2] USFS class

Population sizes of young "western" flycatcher correlated positively with the core area of coniferous forest habitat (r=0.543), whereby the lowest numbers of young were associated with coniferous forests covering only 55% of the landscape (e.g. stations 11161 and 11168). This suggests the highest populations of young were recorded at stations with greater than 80% coniferous coverage (e.g. stations 11162 and 11163). In these cases, most of the remaining landscape was covered in deciduous or mixed forest. The model selection process nominated a complex, five parameter model ($R^2 = 0.714$, F=4.381, P=0.044) in which populations responded positively to coniferous core habitat and successional habitat (USFS), but negatively to overall fragmentation (NLCD_LAND_SDI), the core area of shrub, and the amount of woodland-shrub edge.

Reproductive success correlated negatively with the area of grassland (r=-0.668), grassland-shrub edge (r=-0.492), and overall fragmentation (r=-0.526), and positively with coniferous forest area (r=0.496). However the best model ($R^2 = 0.743$, F=13.831, P=0.002) reveals that the coniferous core area is the driving factor in levels of reproductive success, and a negative contribution from grassland-shrub edge.

These last two results strongly suggest "western" flycatcher is sensitive to proximal edges (and/or patch size dependency) of coniferous habitat. First, the capture rate criteria with which we selected the stations for this species revealed no stations with less than 55% coniferous coverage. As fragmentation levels of a given habitat type approach 45% (i.e., 55% coverage) the total core area of that habitat type diminishes exponentially. So, therefore it is not surprising that the numbers of young and reproductive success (young per adult) are higher at those stations associated with a high total core area of coniferous forest habitat totaling some 900 hectares (72%).

Increasing adult population trends correlated positively with the amount of forest/shrub/grassland edge (r=0.618), especially forest-successional habitat edge (r=0.526), low coverage of high canopy cover forest (r=-0.568), pest damage from defoliating insects (r= 0.452), and high coverage of medium canopy cover forest (r=0.531). Increasing trends were detected at only four stations (i.e., stations 11139, 11141, 11166, and 11174) with these characteristics. The best model ($R^2 = 0.498$, F=4.457, P=0.045), however, describes adult trends as a positive function of both the core area of medium canopy cover forest, and the area of grassland.

Increasing young population trends correlated negatively with the area of coniferous forest (r=-0.517), and positively with the area of mixed deciduous-coniferous forest (r=0.504). Increasing trends were detected at only four stations with these characteristics (i.e., station 11161, and three Siuslaw N.F. stations 11165, 11166, and 11168). The best model ($R^2 = 0.498$, F=4.457, P=0.045), however, describes trends in young populations as a positive function of both the area of deciduous or mixed forest, and a negative function of overall fragmentation. Increasing trends in reproductive success correlated negatively with the area of coniferous forest (r=-0.455), and more mixed deciduous-coniferous forest (r=0.449). The best model, although lacking predictive power ($R^2 = 0.167$, F=2.000, P=0.188), describes increased reproductive success as a negative function of the amount of successional habitat.

Thus, whereas higher populations and greater reproductive success of “western” flycatchers were associated with large areas (>55% coverage) of evergreen forests, population sizes and reproductive success seem to be increasing over time in areas that were classified approximately ten years ago as thinner forest with successional habitat and a deciduous component. These increases may simply reflect the development of more suitable breeding habitat as the successional habitats mature. Overall, these results suggest that the best way to manage for “western” flycatcher would be to maintain large (>1000 hectares) and uniform patch sizes of thinner-canopy evergreen forests, interspersed with smaller patches of mixed deciduous forests.

Regarding the research and management requirements, our results suggest that components of both large, old-growth forests (large core areas of evergreen forest) and dry-upland and riparian sites (thinner canopy and some mixed habitats) are beneficial for the reproductive success of “western” flycatchers. The data strongly suggest that the areas of thinner canopied forest may result from (or be associated with) defoliation events (r=0.853), however these areas also tend to be located at high elevations where forests tend to be more open.

Our data also support the idea that riparian buffer zones may lead to increases in “western” flycatchers and would help support healthy populations, although clearly, thin-canopy and successional evergreen forests are more important. It appears that managed, closed-canopy forests may not be beneficial to this species; however, a mosaic of large (>1000 hectares) different-aged stands were associated with increasing populations of both young and adults.

Warbling vireo - *Vireo gilvus*

Background

Warbling vireos prefer to breed in open deciduous or mixed deciduous-coniferous woodland, especially in riparian woodland or thickets, but may also breed in parks and orchards where it is likely to select the larger shade trees in which to nest (AOU 1983). As forest fragmentation increases, cowbird parasitism is cited as a potential threat to populations of this and many other riparian species. Indeed, cowbird parasitism rates can be so high (up to 80%) as to create “sink” populations in otherwise suitable habitat (Ward and Smith 2000). However, the same logging practices responsible for fragmentation also help create warbling vireo habitat in the more open thinned forest and along the edges of clearcut areas.

The Breeding Bird Survey (1980-2003) reports positive short-term population trends in all but five of the bird conservation regions in which it is monitored. Extensive deforestation and other more selective logging practices may explain recent (1980-2003) warbling vireo population increases (Breeding Bird Survey) in western North American of 2.5% annually ($P<0.005$) in the Great Basin BCR, 2.1% annually in the Northern Rockies BCR and 5.2% annually ($P<0.005$) across the state of Washington. Populations are considered stable in other regions except in coastal California where populations have significantly declined by 3.4% annually ($P<0.05$). In contrast to the BBS regional population increases, MAPS data show a significant ($P=0.001$) 3.1% annual decline in the adult population trend (1992-2001) which is attributed to relatively low region-wide productivity levels (DeSante et el. 2002).

Research and monitoring requirements

The PIF Montana and California state BCPs cite nine research and monitoring requirements for the warbling vireo, but none for Oregon and Washington:

1. Conduct selective monitoring at critical sites to determine the effects of cowbird parasitism on this and six other species of concern - in Californian riparian habitats.
2. Conduct selective monitoring at key riparian sites to determine the factors influencing nest success - California.

3. Determine what constitutes source and sink areas in riparian deciduous forests - Montana.
4. Develop statewide bird monitoring efforts to include riparian shrub habitats - MT.
5. Monitor birds and habitats in hardwood draws - Montana.
6. Investigate the effects of different grazing strategies and prescribed burning on hardwood vegetation- Montana.
7. Determine the effects of habitat condition and cowbird parasitism on breeding birds in hardwood forests - Montana.
8. Assess effectiveness of fire at re-establishing vigorous aspen stands - Montana.
9. Conduct demographic monitoring of shrub-dependent species - MT.

We will highlight any results, from analyses of USFS Region Six MAPS data that might meet, or partially meet, these research and monitoring requirements.

Model Interpretations

The models presented here directly address none of the research and monitoring requirements of the PIF Washington/Oregon Bird Conservation Plan for this species. The selected models were significant for all six demographic parameters and consistent with warbling vireo habitat preferences.

Inspection of the landscape data associated with the 18 MAPS stations with adequate data used in these analyses reveals that coniferous forest is the dominant habitat type covering 40-95% (median 75%) of the 1250 hectares that lie within a 2-kilometer radius of each station. The core coverage of successional habitat averaged under 3% (i.e. ~40 hectares). Areas around these stations also contained an average of 1% coverage of deciduous forest, between two and five hectares (mean ~3 hectares) of riparian habitat , and an average of ~75 hectares of grassland. These stations were predominantly at higher elevations (>1000m) especially the stations between 1660m and 2045m that operated on Fremont N.F. We reported statistically significant correlations between demographics and landscape variables. At this sampling level (n=18) two-tailed (n-2) critical values of Pearson’s correlation coefficient (r) lie at 0.400 (P<0.10), 0.468 (P<0.05) and 0.590 (P<0.01).

Population sizes of adult warbling vireo correlated positively with elevation (r=0.565) such that the highest numbers were associated with Fremont N.F. They correlated positively with the amount of successional-grassland edge (r=0.507) but negatively with the core area of high canopy cover forest (r=-0.497). The model selection process nominated a single parameter model ($R^2 = 0.319$, F=7.496, P=0.014) in which populations responded positively to elevation only.

Table 14. Summary table of warbling vireo demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY	NED+	HCA-							SG+	
YNG^1							CLA+		FS+	
RI		LCA-	TCA+				TCA-^{2} CLA-^{2} CLA+		FS+ FG-	
AHY/t	MPI+						CLA-			ALL-
YNG/t			TCA+	CLA-			CLA+		IJI-	
RI/t				CLA-			CLA-		IJI-	

^{1} P<0.01
^{2} USFS class

Population sizes of young warbling vireos correlated positively and very strongly with forest-grassland edge habitat (r=0.659), and grassland area (r=0.615), whereby the highest numbers of young were associated with areas of grassland in excess of 150 hectares with a grassland-forest edge in excess of 15 hectares (e.g. stations 11150 in Wenatchee N.F., 11156 in Umatilla N.F., and 11170 in Fremont N.F.). The model selection process nominated a single parameter model ($R^2 = 0.434$, F=12.286, P=0.003) in which populations responded positively to forest-grassland edge only.

Reproductive success correlated positively with forest-grassland edge habitat (r=0.493), but correlated negatively with the total area and core area of grassland (r=-0.631, r=-0.560, respectively), forest-successional edge (r=-0.640), and the core area of low canopy cover forest (r=-0.494). However the best model ($R^2 = 0.707$, F=18.364, P<0.001) reveals that the coniferous core area is the driving factor in levels of reproductive success, and a negative contribution from successional habitat area.

Adult population trends correlated negatively with cumulative pest damage (r=-0.498) whereby positive trends were associated with landscapes containing less than 35 hectares of cumulative pest damage. The best model ($R^2 = 0.549$, F=9.074, P=0.003), however, describes adult population trends as a negative function of cumulative pest damage and grassland area, and as a negative function of mean patch interspersion at the landscape level.

Young population trends correlated negatively with the interspersion juxtaposition index of all edge types (r=-0.500), suggesting that numbers of young are increasing in a coarsely fragmented landscape that have low IJI values associated with them. The model selection process nominated a four parameter model ($R^2 =0.434$, F=12.286, P=0.003) in which populations responded positively to coniferous forest core area and grassland area but negatively to interspersion juxtaposition index of all edge types and grassland area.

Similarly, reproductive success trends correlated negatively with interspersion juxtaposition index of all edge types (r=-0.483) suggesting that that reproductive success increased in the coarsely fragmented landscapes but decreased in more finely fragmented landscapes. Overall, however the numbers of young decreased in 11 of the 18 cases and were rarely captured in four other cases.

Surprisingly, warbling vireo demographics show no strong relationships with the deciduous forest cover or stream density land classes which might indicate the presence of preferred riparian habitat. In fact, there was significantly less (ANOVA: F=10.92, P>0.005) deciduous habitat associated with this set of stations (mean = 15 hectares) than with the remaining 18 stations (mean = 67 hectares). We attribute this to the preference for high elevation sites where deciduous habitat is less common but the proportion of low and medium canopy cover coniferous forest are more extensive.

Clearly, vireos benefit from the presence of forest-successional and forest-grassland edge, which suggests that logging could create good habitat. However, the pattern of the logging may be important. Our results suggest that at these elevations large tracts of open coniferous forest interspersed with larger patches of successional habitat create good vireo breeding habitat.

Further inspection of the data reveals that the vicinities of 7 of the 18 stations were either logged in the last few decades or currently support grazing. We compared reproductive success between this group and the remaining 11 stations and revealed a significant difference (ANOVA: F=6.497, P=0.021) whereby reproductive success was nearly five times lower among the managed stations (mean = 0.026) than among the unmanaged stations (mean = 0.124). We conclude that warbling vireos are sensitive to grazing and/or logging practices and propose grazing exclusion as a management guideline to increase reproductive success of warbling vireos in higher elevation coniferous forests and woodlands.

Mountain chickadee - *Poecile gambeli*

Background

The mountain chickadee prefers to breed in high-elevation coniferous forests, especially those dominated by pine, spruce-fir, and pinyon-juniper (NatureServe 2004). In the Rocky Mountains, mountain chickadees fairly commonly occur in young forest, though somewhat less commonly in harvested forest types (Hutto and Young 1999, Hejl et al. 1995). They nest in existing cavities in the ground, on earthen banks, and in natural or woodpecker-bored holes of living trees and snags, generally low but observed up to 25m above the ground (NatureServe 2004).

BBS data for the period 1980-2003 show a significant ($P<0.01$) survey-wide decline of 1.5% and population declines in eight of the ten bird conservation regions, including a significant ($P<0.01$) 2.3% annual decline in the Sierra Nevada and non-significant declines in the Northwestern Interior Forest (37.3%), the Great Basin (1.2%), and the Northern Rockies (2.3%) physiographic provinces. MAPS data showed a near-significant positive trend of 5.2% in adults (1992-2001) but inter-annual variability is extremely high (DeSante et al. 2002).

PIF attaches no continental or regional conservation status to this species, however little appears to be known of its ecology and biology.

Model interpretations

Due to lack of sufficient data no regression models are presented for this species.

Chestnut-backed chickadee - *Poecile rufescens*

Background

Chestnut-backed chickadees prefer to breed in moist coniferous and mixed deciduous-coniferous forests, especially those dominated by Douglas-fir (Brennan and Morrison 1991) or Cedar/Grand Fir (Hutto and Young 1999). This species is tolerant of human-altered landscapes, occurring in planted Monterey pine stands in California and residential areas in British Columbia (Kleintjes and Dahlsten 1994, Campbell et al. 1997). Chestnut-backed chickadees nest in existing cavities, natural or woodpecker holes, and also make their own cavities.

BBS data for the period 1980-2003 show that adult populations were stable in most of the five bird conservation regions in which they are monitored, including the Northern Pacific Rainforests and the Great Basin. However, populations in the Northern Rockies increased by 8.6% ($P<0.005$) annually, and coastal California populations decreased by 4.2% ($P<0.005$) annually. This pattern of regional increases and decreases is similar to that described for warbling vireos. Oregon populations significantly increased by 3.6% annually ($P<0.05$). MAPS data showed no significant positive trends in adult or young populations (1992-2001) but inter-annual variability is extremely high (DeSante et al. 2002).

PIF classifies this species as a Species of Continental Importance for the Pacific Avifaunal Biome which holds an estimated 90% of the breeding and overwintering populations. Their continental long-term planning and responsibility objective is to maintain population levels, especially in coniferous forest habitats.

Research and monitoring requirements

The PIF Alaska and Montana state BCPs cite three research and monitoring requirements for the chestnut-backed chickadee, but none for Oregon and Washington:

1. Conduct point counts for birds in southeastern Alaska across the Forest Service's 21 geographic provinces.

2. Monitor changes in mature forest cover and construct bird-habitat models in southcoastal Alaska.
3. Determine effects of land-use activities on priority birds in cedar-hemlock forest - in Montana.

Model Interpretations

No research and monitoring requirements have been proposed for this species in the PIF Washington/Oregon Bird Conservation Plan and our data do not address the requirements listed for Cedar-Hemlock habitats mentioned in the Alaska and Montana BCPs. The selected models were significant for five of six demographic parameters, all but those of mean adult population size.

Inspection of the landscape data associated with the 13 MAPS stations used in these analyses reveals that coniferous forest is the dominant habitat type covering 70-90% (875-1125 hectares) of the 1250 hectares that lie within a 2-kilometer radius of each station. The USFS data shows that dense forest accounts for 40-85% of this forest with low percentages of thin- (100-200 hectares) and medium-canopied (60-150 hectares) forest. The next important habitat type, successional habitat (USFS-SHRB) covers 60 to 150 hectares but creates between 30 and 280 hectares of forest-shrub edge (90m wide). We reported statistically significant correlations between demographics and landscape variables. At this sampling level (n=18) two-tailed (n-2) critical values of Pearson's correlation coefficient (r) lie at 0.476 ($P<0.10$), 0.553 ($P<0.05$) and 0.684 ($P<0.01$).

The mean annual population size of adults showed little correlation with the high levels of coniferous forest cover mentioned above. The best multiple regression model ($R^2=0.630$, $F=6.584$, $P=0.028$) indicated that the highest adult populations were recorded at stations associated with coniferous forest fragmented by small patches of successional habitat (e.g. stations 11158 in Willamette N.F. and 11167 in Siuslaw N.F.). Low adult populations were associated with areas of coniferous forest fragmented by a) larger patches of successional habitat (e.g. station 11140 in Mount Baker N.F.), b) smaller areas of successional habitat (e.g. station 11145), or c) where the patches of successional habitat abut non-forested habitat (e.g. station 11139).

Table 15. Summary table of chestnut-backed chickadee demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY									FS+ IJI-	
YNG	NED+	LTA+ LCA+ HTA-				TCA+ TCA+[1]			SG-	ALL+
RI	NED-	LCA+ HTA-		CLA-	CLA-	TCA+	CLA-		SG-	ALL+
AHY/t[2]	NED+	MTA- HCA+		CLA-					SG- ALL-	ALL+
YNG/t		MCA-		CLA+	CLA+			CLA+		CL4-
RI/t		HTA+ MCA-		CLA+	CLA+	CLA-		CLA+		CL4-

[1] USFS classification
[2] Regression model overparameterized

Young chickadee populations correlated strongly and positively with the total area and core area of thin-canopied forest (r=0.749 and 0.740, respectively), elevation (r=-0.537), and historical defoliation (r=0.497). Negative correlations existed for the amount of successional habitat-grass edge (r=-0.609), dense-canopied forest (r=-0.554), and stream density (r=-0. 237). The multiple regression models show that high young populations are best modeled (R^2 = 0.699, F=12.957, P=0.002) as a function of extensive core areas of thin-canopied forest (e.g. station 11158) that has been regularly or extensively defoliated, and feature smaller areas of grassland-successional habitat edge.

Reproductive success correlated strongly and positively with higher elevations, (r=0.691), the total and core area of thin-canopied forest (r=0.673 and 0.603, respectively). The best model (R^2 = 0.731, F=18.445, P=0.002) reveals that reproductive success is greatest among large core areas of thin-canopied coniferous forest in landscapes lacking mixed forest.

Increased adult populations of chestnut-backed chickadees correlated positively with historically heavily defoliated areas (e.g. stations 11150 in Wenatchee N.F. and 11158 in Willamette N.F.). However, closer inspection showed that outlying trend data was responsible for this and other strong correlations, which made inference difficult. This fact was reflected in the ICOMP selection of a six parameter model.

However, increased young populations correlated negatively (r=-0.581) with the area of historical beetle damage, and correlated positively with stream density (r=0.547). This was reflected in the chosen model (R^2 = 0.526, F=10.995, P=0.008), which specified both parameters.

Similarly, increased reproductive success correlated negatively (r=-0.707) with the area of historical beetle damage, and positively correlated with stream density (r=0.570). This was reflected in the chosen model (R^2 = 0.572, F=13.226, P=0.005), which specified both parameters.

Thus, chestnut-backed chickadee populations are best managed through the creation or maintenance of open (thin-canopied) forest and forest-successional habitat edge, especially at higher elevations. However, extensive riparian habitat, as reflected in stream density, was associated with increasing trends in the numbers of young and with reproductive success. The effects of pest outbreaks, on forested habitat may be another factor in the observed patterns of chickadee demographics. Although higher numbers of young occur in defoliant-sensitive areas, the numbers of young are decreasing in those areas recently attacked by bark beetles. The reason may be that bark beetles tend to kill the host trees while defoliation by other defoliating invertebrates is only temporary. Other research (Logan and Powell 2001) suggests that increased magnitude and extent of bark beetle damage at higher elevations is likely a result of recent climate change and reduces the core area of forests. Our results confirm the elevational effect in strong positive correlations between mean elevation, the extent of successional habitat (r=0.717), and cumulative bark beetle damage (r=0.754).

Winter wren - *Troglodytes troglodytes*

Background

Winter wrens prefer to breed in moist coniferous forest with a dense understory, preferably near water (Hutto and Young 1999), or in more open habitats associated with logged areas featuring slash piles and brushy vegetation (NatureServe 2004). They also breed along rocky coasts, cliffs, islands, or in high elevation habitats. They nest in a variety of cavity types including holes in trees, banks, or walls. Winter wrens are strongly associated with old growth forests in Montana, where, in one study, they were more than twice as likely to be detected in old growth as in mature forests (Hutto and Young 1999). This species may also be sensitive to forest fragmentation (Hejl and Paige 1994).

BBS data for the period 1980-2003 show that adult populations were stable or increasing in all of the 13 bird conservation regions in which they are monitored, including the Northern Pacific Rainforests, Great Basin, and Coastal California. However, in the Northern Rockies, populations increased significantly ($P<0.005$) by 5.4% annually, and by 3.1% annually in the Boreal Softwood Transition zone. Interestingly, adult populations of this and two other species of conservation concern (Pacific-slope flycatcher and warbling vireo) significantly increased in the Northern Rockies BCR. Regional MAPS data show non-significant declines (1992-2001) in adult and young populations and inter-annual variability is extremely high (DeSante et al. 2002).

Research and monitoring requirements

The PIF Alaska and Montana state BCPs cite three research and monitoring requirements for the chestnut-backed chickadee, but none for the Oregon and Washington BCRs:

1. Conduct point counts for birds in southeastern Alaska across the Forest Service's 21 geographic provinces.
2. Monitor changes in mature forest cover and construct bird-habitat models in southcoastal Alaska.
3. Determine effects of land-use activities on priority birds in cedar-hemlock forest - in Montana.

Model Interpretations

No research and monitoring requirements have been proposed for this species in the PIF Washington/Oregon Bird Conservation Plan and our data do not address the requirements listed by the Alaska and Montana BCPs. The selected models were statistically significant for five of six demographic parameters, all but that of mean adult population size.

Table 16. Summary table of winter wren demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY[1]		MCA- LTA-				TCA- CLA-				CL4-
YNG	MPI+	MCA-		CLA+	CLA+ CLA+	CLA-				CL4-
RI				CLA+						
AHY/t		MTA+	TCA-				CLA-		FS+	
YNG/t[1]		MTA-		CLA+						
RI/t[1]							CLA+		IJI+	

[1] Regression model overparameterized

Inspection of the landscape data associated with the 13 MAPS stations used in these analyses reveals that coniferous forest is the dominant habitat type covering 50-90% of the 1250 hectares that lie within a 2-kilometer radius of each station. Deciduous and mixed forest coverage, combined, accounted for up to 500 hectares (approx. 40%) of the remaining areas (e.g. station 11166 in Siuslaw N.F.). The coverage of successional habitat was consistently under 35 hectares (approx. 3%) except for stations 11155 (170 hectares or ~15%) and 11156 (415 hectares or ~35%) in Umatilla N.F.. Areas around these stations also featured between 20 and 125 hectares (2 - 10%) coverage of deciduous forest and between two and ten hectares (<1%) of riparian habitat. The amount of riparian habitat was approximated using a 15m buffer each side of perennial streams. We reported statistically significant correlations between demographics and landscape variables. At this sampling level (n=18) two-tailed (n-2) critical values of Pearson's correlation coefficient (r) lie at 0.476 (P<0.10), 0.553 (P<0.05) and 0.684 (P<0.01).

Population sizes of adult winter wrens correlated positively with the amount of mixed forest habitat (r=0.581), whereby the highest adult populations were associated with forests containing >150 hectares (>12%) of mixed forest habitat. Populations were lower in areas with greatest successional habitat cover. Unfortunately, the model selection process nominated a complex, five parameter model that was difficult to interpret.

Population sizes of young wrens correlated positively (r=0.655) with forest fragmentation (as measured by NCLD_LAND_MPI), stream density (r=0.565), and deciduous and mixed forest (r=0.551). The highest numbers of young were recorded at stations surrounded by fragmented landscapes that contained over 100 hectares (>8%) of deciduous and mixed forest and >35 hectares (>3%) of riparian habitat (e.g. 11165 and 11166 in Siuslaw N.F.). The model selection process nominated a three parameter model ($R^2 = 0.661$, F=6.715, P=0.014) in which populations responded positively to deciduous forest habitat, but negatively to deforestation and the core area of medium cover forest. Deciduous forest habitat contributed 40% to the top 10 (and roughly equivalent) models. Reproductive success correlated positively with deciduous forest area (r=0.484), this landscape variable being chosen as the sole parameter in the best model ($R^2 = 0.235$, F=3.371, P=0.093). These last two results suggest a strong association between winter wren reproductive success and the amount of riparian habitat.

An inspection of the landscape data relative to adult population trends revealed outliers among the highest correlating landscape variables, without which the relationships were not significant. For young population trends the strong relationship between increasing trends and deciduous forest area reveals a threshold of 60-100 hectares (5-8%) above which the young population trends increased. Increasing trends in reproductive success were observed at stations surrounded by naturally fragmented coniferous forest as suggested by high values of USFS_UCEM_IJI (e.g. stations 11140 and 11908 in Mount Baker N.F.) where the fragmentation pattern resembled a mosaic of larger patches of different habitat types. For instance, station 11908 in Mont Baker N.F. is surrounded by mostly coniferous forest bisected by a stream, which in turn, is surrounded by patches of deciduous and some mixed deciduous-coniferous forest.

Thus, whereas higher populations and greater reproductive success of winter wrens are associated with large areas of evergreen forests, population sizes and reproductive success seem to be increasing over time in areas that were classified approximately ten years ago as thinner forest with successional habitat and a deciduous component. These results suggest that the best way to manage for winter wrens would be to maintain large uniformly shaped patches of thinner-canopy evergreen forests in stream-dense areas. In addition, smaller patches of mixed or deciduous forests (associated with riparian areas) must be maintained to cover greater than 10% of the area.

Ruby-crowned kinglet - *Regulus calendula*

Background

Ruby-crowned kinglets prefer to breed in coniferous forests and woodlands where they nest in coniferous trees. They forage by gleaning invertebrates from deciduous and coniferous foliage and hawking aerial insects. More information is needed on the sensitivity of this species to logging; kinglets were commonly found in partially logged forests in one study (Hutto and Young 1999), while another study found limited ruby-crowned kinglet use of managed forests (Hejl et al. 1995).

BBS data (1980-2003) show a survey-wide stable adult population and stable or increasing populations in all of the 14 bird conservation regions in which they were effectively monitored, including the Northwestern Interior Rainforests, Northern Pacific Rainforests, Great Basin, and Northern Rockies. However, in Washington state, populations increased significantly (P=0. 05) by 3.6% annually. Regional MAPS data (1992-2001) showed non-significant declines in adult populations and extremely high inter-annual variability (DeSante et al. 2002).

PIF attaches no continental or regional conservation status to this species, however little appears to be known of its ecology and biology.

Model interpretations

Due to lack of sufficient data no regression models are presented for this species.

Swainson’s thrush - *Catharus ustulatus*

Background

Swainson’s thrushes prefer to breed in moist habitats near standing or running water including open deciduous, coniferous, or deciduous-coniferous woodland with a well developed shrub layer, especially in riparian/lacustrine woodland or willow and alder thickets (Grinnell and Miller 1944, Bent 1949, Thomas 1979). It usually nests less than 2m from the ground in a tree or shrub. This edge-sensitive species may be affected by the pattern of forest fragmentation and the shape of the remnant stands because nest predation is highest within 150m of the forests edge (Andren and Angelstam 1988). This suggests that the minimum stand size for sustaining populations is approximately 10 hectares. Timossi (1990) also reported Swainson’s thrush in a range of moist ecotones between trees and shrubs, and suggests that a dense understory and canopy closure of 40-100% provides the necessary food supply and protection from predators.

The amount and type of understory is critical for the Swainson's thrush. Forest management practices that reduce understory to 20-30% cover (including coniferous saplings) may benefit this species. However, disturbance of the breeding habitat may interrupt continuous breeding. For example, in a southern Californian study (Weaver 1992) floodwaters scoured the understory in a riparian habitat causing a local extirpation of Swainson’s thrush within a couple of years. Breeding activity resumed five years later.

The biological objectives of the Swainson’s thrush conservation strategy for the Westside Lowlands and Valleys sub-plan are to maintain riparian deciduous woodland with a canopy closure greater than 50% (after Timossi 1990), and a shrub cover greater than 50% (including over 60% native shrubs). Importantly, for this and other riparian birds, grazing activity must be controlled to ensure the development of dense woodland understory. This strategy, applied throughout the planning area, should help maintain stable or increasing population trends over the next ten years. Actions that benefit this species should also benefit other riparian deciduous woodland species such as Wilson’s warbler, Bewick’s wren, song sparrow, orange-crowned warbler and spotted towhee.

BBS data for the period 1980-2003 show that adult populations were stable in most of the sixteen bird conservation regions in which they are monitored, including the Northern Pacific Rainforests, the Great Basin, and the Northern Rockies. Oregon populations declined 1.7% annually ($P<0.05$), but no trend was observed in Washington populations. MAPS data show very stable adult and young populations. However, the adult population size in any year was strongly and positively correlated with reproductive success in the previous year (DeSante et al. 2002), suggesting that population levels are strongly driven by reproductive success. This emphasizes the need to maintain deciduous riparian woodland and restore quality breeding habitat therein.

Although Swainson's thrush does not meet the criteria for continental conservation importance it is widespread and easily captured by placing mist nets in the understory. Therefore, this species is a good demographic monitoring representative of the deciduous riparian woodland bird community.

Research and monitoring requirements

The PIF Oregon/Washington state BCP cites two research and monitoring requirements for Swainson's thrush breeding in the Westside Lowlands and Valleys:

1. Study nesting ecology and habitat relationships of Swainson's thrush.
2. Determine the effects of understories dominated by native vs. exotic species for Swainson's thrush and wrentit.

A further four requirements are outlined for the Arizona state plan to determine the breeding suitability characteristics and distribution of spruce-fir habitats.

Model Interpretations

The models presented here partially address one research requirement of the PIF Washington/Oregon Bird Conservation Plan for this species. The selected models were significant for all six demographic parameters and clearly delineate the habitat requirements for healthy breeding populations.

Table 17. Summary table of Swainson's thrush demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY[1]	NED- MPI+	MCA- HTA+		CLA+	CLA+ CLA+					ALL- CL4-
YNG	NED-	HTA+		CLA+	CLA+					
RI									SG-	
AHY/t[1]		HTA+ HCA- MTA-							ALL-	ALL-
YNG/t		LCA+							IJI-	ALL-
RI/t	MPI-	LTA+							IJI-	ALL-

[1] P<0.01

Inspection of the landscape data associated with the 25 MAPS stations used in these analyses reveals that coniferous forest is the dominant habitat type covering 50-90% of the 1250 hectares that lie within a 2-kilometer radius of each station. Deciduous and mixed forest coverage, combined, accounted for up to 500 hectares (approx. 40%) of the remaining areas (e.g. station 11166) and averaged 13% of the cover. The coverage of successional habitat was consistently under 35 hectares (approx. 3%) except for stations 11143 (~9%) in Mount Baker N.F., 11154 (~40%), 11155 (~15%), and 11156 (~35%) in Umatilla N.F. We reported statistically significant correlations between demographics and landscape variables. At this sampling level (n=25) two-tailed (n-2) critical values of Pearson's correlation coefficient (r) lie at 0.337 (P<0.10), 0.462 (P<0.05) and 0.505 (P<0.01).

Population sizes of adult Swainson's thrushes correlated positively with the amount of deciduous, and mixed forest habitat (r=0.716), and negatively with elevation (r=-0.744). A strong inverse relationship existed between elevation and the amount of deciduous and mixed forest habitat (r=-0.744), whereby the highest adult populations were associated with low elevation (<500m) forested areas containing >100 hectares (>8%) of deciduous mixed forest habitat. The model selection process nominated a powerful two parameter model ($R^2 = 0.564$, F=14.258, P<0.0009) in which populations responded positively to the amount of deciduous forest, and negatively to the core area of medium canopy cover. The top models also suggest a positive relationship with the core area of high canopy cover forest.

Population sizes of young thrushes correlated positively with deciduous (r=0.518), combined deciduous and mixed forest (r=0.499), but negatively with elevation (r=-0.559). The highest numbers of young were recorded at low elevation stations (<500m) surrounded by fragmented landscapes that contained over 100 hectares (>8%) of deciduous and mixed forest and >35 hectares (>3%) of deciduous (riparian) habitat (e.g. 11165 and 11166 in Siuslaw N.F.). However, the model selection process nominated a two parameter model ($R^2 = 0.320$, F=9.931, P=0.004) in which populations responded negatively to elevation, but positively to high canopy cover forest (USFS_FORHI_CLA).

Deciduous and mixed forest habitat contributed 24%, and high canopy forest contributed 35% to the top 10 (and roughly equivalent) models. The model associated with the second highest ICOMP value (difference of 0.331 units) is more useful in terms of management application because it includes terms for deciduous and mixed forest cover as well as high canopy cover. Both of these habitat variables can be manipulated by forest management and mapped, whereas in the top model the elevation term is an inverse correlate for mixed and deciduous cover and can not be manipulated.

Mean annual reproductive success correlated negatively but weakly with the amount of successional habitat-grass edge (r=0.383), this landscape variable being chosen as the sole parameter in the best model ($R^2 = 0.147$, F=3.954, P=0.059). This model suggests that reproductive failure was associated with landscapes where in excess of 25 hectares (2%) of successional habitat-grassland edge was present.

Adult population trends correlated positively with the core area of high canopy cover forest (r=0.613), and the total area of high canopy cover forest (r=0.609), but correlated negatively with cumulative pest damage (r=0.583), which in turn, increased as a function of elevation. These results suggest that populations increased in landscapes featuring extensive patches of high canopy cover forest possessing a total core area greater than 400 hectares (~35%). The model selection process nominated a two parameter model ($R^2 = 0.379$, F=14.082, P=0.001) in which increasing adult population trends were associated with landscapes featuring extensive core areas of high canopy cover forest (USFS_FORHI_CLA), and lower cumulative pest damage (higher cumulative damage tends to open the canopy).

In contrast, trends in the young population correlated positively but weakly (r=0.342) with the total core area of medium canopy forest cover. Positive trends were associated with landscapes that contained more than 36 hectares of core medium canopy cover, which equates to some 200 hectares of total area (e.g. stations 11160 and 11161 in Willamette N.F.). The model selection process nominated a three parameter model ($R^2 = 0.257$, F=3.812, P=0.038) in which increasing young population trends were associated with larger core areas of high canopy cover forest, lower cumulative pest damage (suggesting lower elevations), and low levels of fragmentation as suggested by USFS_UCEM_IJI. Trends in reproductive success showed a similar relationship with the same three landscape variables ($R^2 = 0.230$, F=3.268, P=0.057).

Population sizes of adult Swainson's thrushes were clearly largest in areas of dense deciduous and mixed deciduous-coniferous forests, whereas higher numbers of young and higher reproductive success correlated with more open forest and forest edge. Areas with substantial fragmentation and damage from defoliation correlated negatively with reproductive success of this species. Likewise, increasing populations were associated with areas of larger patch sizes and core areas of dense forests, whereas increases in young and reproductive success were correlated with areas of deciduous forest, with a lesser component being edges of deciduous forest.

Regarding the research and management requirements for this species, our results have successfully revealed habitat criteria required for nesting Swainson's thrushes. Our models clearly indicate that within coniferous forests large patches (representing 10% or more of the landscape) of dense low elevation deciduous and mixed-deciduous forests with high canopy cover (i.e. mature lowland forests) are required to maintain healthy adult populations of Swainson's thrushes, whereas young and reproductive success benefit from large patches (>200 hectares or 16%) of more open deciduous and mixed habitat forests. The selection of strongly correlating total core area variables in these models supports previous findings of edge sensitivity for this species (Andren and Angelstam 1988). This emphasizes the need to conserve large tracts of contiguous forest in lowland areas where moister forests and riparian areas occur. The presence of grassland and successional habitat is deleterious to population dynamics.

Evidence from banding data collected in coastal riparian areas in Northern California suggests that adult densities are dependent upon productivity levels in the previous year and subsequent recruitment. An adult male Swainson’s thrush was captured at station 11167 in Siuslaw N.F. in the summer of 1992 and was subsequently captured each breeding season up to and including that of 2004. This bird is estimated to be at least 12 years old at the time of the writing of this report and has retained its breeding territory within a station that catches more adults than any other station. It is a lowland station (~250m elevation) dominated by 70% high canopy cover forest comprising ~75% coniferous forest fragmented by ~25% deciduous and mixed forest. Such habitat patterns also benefit winter wren populations.

As Timossi (1990) noted, thrushes are also found in moist ecotones; however, our results suggest that reproductive success decreases sharply as a function of grassland/successional habitat edge. The model suggests that no reproductive success occurs if more than 25 hectares of successional habitat-grassland edge (estimated at 60 meters wide) is present in a 1250 hectare landscape (2%). Reproductive success is benefited by maintaining a minimum of16% cover of medium canopy cover (40-70%) forest.

American Robin - *Turdus migratorius*

Background

American robins are habitat generalists and can be found in forest, woodland, scrub, thickets, gardens, parks, cultivated lands, savanna, swamps, and suburbia. Populations generally benefit from forest fragmentation, urbanization, and agricultural expansion but reproductive success can be low in highly fragmented landscapes (Sallabanks and James 1999).

BBS data for the period 1980-2003 show a significant ($P<0.05$) survey wide increase of 0.5% annually. Populations are stable or increasing in most of the 29 bird conservation regions but significantly ($P=0.05$) declined by 1.8% annually in the Northern Pacific Rainforests and by 1.1% annually in Coastal California. Populations significantly ($P<0.001$) declined by 1.8% in Oregon, but increased significantly ($P<0.001$) by 1.3% annually in Washington. MAPS data showed a highly significant ($P<0.005$) 8.6% annual population increase and, similar to Swainson’s thrush, a strong positive relationship between the adult population size in any year and reproductive success in the previous year (DeSante et al. 2002).

PIF attaches no conservation status to this species.

Research and monitoring requirements

No research or monitoring requirements are cited for the American robin.

Model interpretations

Due to lack of sufficient data no regression models are presented for this species.

Orange-crowned warbler - *Vermivora celata*

Background

Orange-crowned warblers breed in coniferous and mixed woodland habitats, or scrub, chaparral and thickets in riparian areas. Breeding habitat differs slightly across the range and between subspecies, though all orange-crowned warblers prefer brushy areas and deciduous thickets. Boreal orange-crowned warblers nest in deciduous shrubs, thickets, and second growth, while Pacific Coast birds prefer riparian thickets and mature chaparral, often with an oak component (Dunn and Garrett 1997). In the Rocky Mountains, this species is commonly found in shrubby patches within intact forest, and is most common in early successional harvested forest stands. Further investigation into orange-crowned warbler demographic rates in early successional forests is needed, as such habitats may be “ecological traps” (Hutto and Young 1995). They nest on or low to the ground and forage on invertebrates in the understory, or berries in eastern North America (Sogge et al. 1994).

BBS data for the period 1980-2003 show a significant ($P<0.01$) survey-wide decline of 1.3%, a significant ($P<0.01$) 6.5% annual decline in Oregon, a significant ($P<0.01$) 3.5% annual decline in Washington. Population declines have also been observed in seven of the eleven bird conservation regions in which it is effectively monitored, including a significant ($P<0.01$) 2.9% annual decline in the Northern Pacific Rainforest, and non-significant declines in the Northwestern Interior Forest (0.9%) and the Great Basin (1.6%) physiographic provinces. Although MAPS data (1992-2001) showed a significant ($P<0.02$) negative trend of 6.9% in adults, the adult survival rate and productivity were higher than expected (given mass) suggesting that there is a problem elsewhere in the life cycle (e.g. juvenile survival and immigration).

PIF attaches no continental-scale conservation status to this species.

Research and monitoring requirements

The PIF Oregon/Washington state BCP cites three research and monitoring requirements for orange-crowned warblers breeding in the Westside Coniferous Forests:

1. Determine the effects of habitat composition and size on the reproductive success of orange-crowned warblers.
2. Determine the effects of vegetation management on the reproductive success of Orange-crowned warblers.
3. Determine how various treatments in early-successional stages affect shrub-associated bird species (including MacGillivray's warbler).

Model interpretations

Due to lack of sufficient data no regression models are presented for this species.

Yellow-rumped warbler - *Dendroica coronata*

Background

Yellow-rumped warblers breed in clearings of coniferous and mixed forest or in woodland habitats and nest anywhere from the understory to the canopy. In Montana, yellow-rumped warblers are most common in open, dry conifer forest habitat, while generally avoiding dense, shady forest. This species is also fairly common in managed forest types, including harvested stands, plantations, and even Christmas tree farms (Dunn and Garrett 1997, Hutto and Young 1995).

BBS data for the period 1980-2003 show that populations are stable at the continental scale. Populations are stable or increasing in Washington, Oregon, and 18 of the 20 bird conservation regions. A significant ($P=0.05$) decline occurred in the Northern Rockies where populations declined by 2.1% annually. Regional MAPS data showed a very stable adult population and a non-significantly declining trend in productivity (DeSante et al. 2002).

PIF attaches no conservation status to this species.

Research and monitoring requirements

No research or monitoring requirements are cited for the yellow-rumped warblers.

Model interpretations

Due to lack of sufficient data no regression models are presented for this species.

Townsend's warbler - *Dendroica townsendii*

Background

Townsend's warblers breed in mature and old-growth coniferous and mixed forest or in woodland habitats, particularly in dense, moist forests dominated by spruce, fir, Douglas-fir, hemlock, and cedar (Dunn and Garrett 1997, Hutto and Young 1999). This species appears to be sensitive to logging and forest fragmentation Townsend's warbler abundance is notably lower in harvested stands, and greatest in large patches of old growth (Dunn and Garrett 1997, Hutto and Young 1999, Hejl et al. 1995). Townsend's warblers prefer to nest in conifers and places nests well above the ground, often between 2.7-4.5m (Terres 1980).

BBS data for the period 1980-2003 show that populations are stable at the continental scale. Populations are increasing non-significantly in Washington, Oregon, and two of the four bird conservation regions. A significant ($P=0.05$) 3% increase occurred in the Northern Rockies over the longer term period 1966-2003. However, regional MAPS data showed a significant ($P<0.05$) adult population decline of 6% annually and highly variable annual productivity (DeSante et al. 2002).

PIF attaches no continental-scale conservation status to this species but it is listed as a focal species for mesic mixed coniferous forests in the landbird conservation strategy for the Northern Rockies. The plan recommends maintaining stable or increasing populations over the next ten years (by 2010) by maintaining or restoring mesic mixed coniferous stands greater than 40 hectares in area with >50% canopy cover. This strategy will likely benefit populations of other species including chestnut-backed chickadee.

Research and monitoring requirements

No research or monitoring requirements are cited for Townsend's warbler in Washington or Oregon, two requirements are cited in the Alaskan conservation plan:

1. Monitor changes in mature forest cover and construct bird-habitat models in southcoastal Alaska.

2. Monitor changes in mature forest cover and construct bird-habitat models for central Alaska.

This investigation may contribute to these required modeling efforts.

Model interpretations

Due to lack of sufficient data no regression models are presented for this species.

MacGillivray's warbler - *Oporornis tolmiei*

Background

MacGillivray's warbler occurs in a wide variety of natural and managed forest habitats, including dense, deciduous, shrubby riparian habitats dominated by willow, cottonwood or aspen; coniferous forest undergrowth and edge; brushy hillsides; clearcuts; successional habitat; and chaparral. Nesting habitat varies across the Pacific Northwest, but always includes dense shrub cover (AOU 1998, Douglas et al. 1992, Mosconi and Hutto 1982, Hutto 1995, Dunn and Garrett 1997). This shrub cover may occur naturally along streams or in open woodlands, or may develop as second-growth in gaps within the forest canopy, after burns, or as a result of timber harvesting (Morrison and Meslow 1983, Hutto and Young 1999). MacGillivray's warblers do not breed in heavily grazed areas, but have occurred in areas where light grazing did not eliminate the necessary shrub cover (Mosconi and Hutto 1982, Page et al. 1978, Medin and Clary 1991). It nests low between 0.6-1.5 meters above ground, in bushes, saplings, and clumps of ferns, forbs, or grasses (Terres 1980). Threats to riparian habitats such as removal, recreation, loss of water flow, heavy grazing, or exotic shrub invasion will negatively affect this species. In addition, cowbird parasitism reduces reproductive success in areas proximal to high levels of grazing and agricultural development.

BBS data for the period 1980-2003 show that populations are stable at the continental scale. Populations are declining non-significantly in Washington (1.0%), Oregon (1.4%), and four of the four bird conservation regions, especially the Northern Pacific Rainforest region where populations significantly ($P<0.005$) declined by 2.2% annually. A significant ($P=0.05$) 1.6% decrease occurred in the Great Basin over the longer term period 1966-2003. Regional MAPS data showed non-significantly declining trends in both the adult population and annual productivity (DeSante et al. 2002).

PIF attaches no continental scale conservation status to MacGillivray's warbler but it is listed as a focal species for mesic mixed coniferous forests in the landbird conservation strategy for the Northern Rockies. The plan recommends maintaining stable or increasing populations over the next ten years (by 2010) by maintaining or restoring the dense shrub layers in forest openings and understory. Shrub layers should be dominated by native species (e.g. Salix spp.) with >40% cover. Tree canopy cover and herbaceous ground cover should each be less than 25%. This strategy will likely benefit populations of other species including song sparrow and Wilson's warbler. Grazing of the understory should also be controlled to allow shrub density to increase.

Research and monitoring requirements

However, state-level conservation plans for the species cite 12 research and monitoring requirements three of which apply to Washington/Oregon. The other nine requirements, mainly basic monitoring, emerge from Arizona, Montana, and Nevada state plans.

1. Determine how various treatments in early-successional stages affect shrub-associated bird species - Westside Coniferous Forest.
2. Study MacGillivray's warbler nesting ecology and habitat use - Northern Rocky Mountains.
3. Define the factors that affect predation and parasitism rates such as proximity to edge, amount of shrub cover, and adjacent land uses.

This investigation may contribute to these requirements.

Model Interpretations

The models presented here partially address one research requirement of the PIF Washington/Oregon Bird Conservation Plan for this species. The selected models were significant for all six demographic parameters and clearly delineate the habitat requirements for productive breeding populations.

Inspection of the landscape data associated with the 24 MAPS stations used in these analyses reveals that coniferous forest is the dominant habitat type covering 40-90% of the 1250 hectares that lie within a 2-kilometer radius of each station. Deciduous and mixed forest coverage, combined, accounted for up to 250 hectares (approx. 20%) of the remaining areas (e.g. station 11908) and averaged ~5% of the cover. The coverage of

Table 18. Summary table of MacGillivray's warbler demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY[1]		**LCA+** LTA+		CLA-		**TCA+** CLA+				
YNG			CLA-			CLA+ **TCA+** TCA+[2]				
RI			**TCA+[3]** TCA-			**TCA+**				
AHY/t	NED+	**HCA-** MCA+								
YNG/t	**MPI-**	LTA+ HTA- HCA-							**FS+**	ALL+
RI/t[1]	NED+	**MCA+**							**ALL+**	

[1] P<0.10

[2] USFS classification

[3] Sign flipped in model

successional habitat varied between 0% and 40% (500 hectares) at station 11145. We reported statistically significant correlations between demographics and landscape variables. At this sampling level (n=18) two-tailed (n-2) critical values of Pearson's correlation coefficient (r) lie at 0.344 ($P<0.10$), 0.404 ($P<0.05$), and 0.515 ($P<0.01$).

Population sizes of adult MacGillivray's warbler correlated positively with the core area of successional habitat (r=0.472), the total area of successional habitat (r=0.394), and the total core area of low canopy cover forest (r=0.364). The model selection process nominated a two parameter model ($R^2 = 0.450$, F=15.814, P=0.001) in which populations respond positively to the core area of both successional habitat (NLCD) and medium canopy cover forest.

Similarly, population sizes of young warblers correlated positively with the core area of successional habitat (r=0.636), the total area of successional habitat (r=0.424), and negatively with the total area of evergreen forest (r=-0.412). The model selection process nominated a two parameter model ($R^2 = 0.476$, F=20.196, P<0.001) in which populations respond positively to the core area of both NLCD and USFS successional habitat categories.

However, mean annual reproductive success correlated negatively with the total core area of evergreen forest (r=-0.420), positively with the total core area of successional habitat (r=0.407), and the total area of evergreen forest (r=0.339). In contrast, the model selection process nominated a three parameter model ($R^2 = 0.476$, F=20.196, P<0.001) in which populations respond positively to the core area of evergreen forest, the core area of successional habitat, and the total area of mixed forest.

Adult population trends correlated positively with the total area of low canopy cover forest (r=0.578), but negatively with the core area (r=-0.573) and the total area (r=-0.531) of high canopy cover forest. These results suggest that populations have increased in landscapes featuring in excess of 30% low canopy cover forest, which tend to be higher elevation stations (r=0.680). Interestingly, the model selection process nominated a two parameter model ($R^2 = 0.403$, F=14.601, P=0.001) in which increasing adult population trends were associated with small areas of high canopy cover forest and an extensive forest-shrub edge. Increasing trends were associated with landscapes featuring >250 hectares (20%) of forest-shrub edge such that exists in the finely grained fragmented landscape encircling station 11173 in Fremont N.F. Stations in this analysis featured significantly (F=4.029, P=0.051) more riparian habitat (mean 3.13 hectares, variance = 1.05) than the remaining 18 stations in the entire study (mean 2.48 hectares, variance = 1.15).

In contrast, trends in young MacGillivray's warbler populations correlated positively (r=0.482) with the core area of medium canopy forest cover. Positive trends were associated with landscapes that contained more than 50 hectares (4%) of core medium canopy cover, which equates to some 400 hectares of total area (e.g. stations 11155 and 11156). The model selection process nominated this term (and a constant) in which increasing young population trends were associated with larger core areas of high canopy cover forest ($R^2 = 0.224$, F=6.343, P=0.020). Trends in reproductive success showed correlations with the core area of medium cover forest that occur at higher elevations where cumulative pest damage is greatest. However, a two parameter model was chosen ($R^2 = 0.222$, F=6.007, P=0.023) in which positive trends were associated with complex edges (USFS_UCEM_3CLA) in a coarse grained (larger varied habitat patches) landscape typified by a low mean patch interspersion (NLCD_LAND_MPI).

These results suggest that MacGillivray's warbler is best managed at higher elevations by maintaining large patches of successional habitat in low to medium canopy cover coniferous forest. Such a coarsely grained habitat should feature extensive successional habitat-forest edge. Although no strong correlations were found between stream density (indicative of the extent of riparian habitat) and demographic variables, stream density was generally high among the stations used in this study, consistent with known preferences.

Common yellowthroat - ***Geothlypis trichas***

Background

Common yellowthroats commonly breed in the shrubby thickets associated with marshy, boggy areas, and the undergrowth of moist or riparian forest undergrowth. It is also found in moister shrubby habitats that develop in cut, burned or oldfield areas. It nests low to the ground or water, in shrubs, saplings, and grasses and reeds. Threats to riparian and wetland habitats such as removal, recreation, channelization, grazing, or exotic shrub invasion will negatively affect this species, as it is almost entirely restricted to shrubby mesic and riparian habitats (AOU 1983, Dunn and Garrett 1997, Hutto and Young 1999).

BBS data (1980-2003) show a significant ($P<0.01$) survey-wide annual decline of 0.7%, a significant ($P<0.01$) 3.1% annual decline in Washington, and population declines in 15 of the 30 bird conservation regions in which it is effectively monitored. Populations are stable or increasing in the four Pacific Northwest physiographic provinces. MAPS data (1992-2001) showed a significant ($P<0.02$) negative trend of 3.6% in adults.

PIF attaches no continental- or regional-scale conservation status to common yellowthroat.

Model interpretations

Due to lack of sufficient data no regression models are presented for this species.

Wilson’s warbler - *Wilsonia pucilla*

Background

Wilson’s warbler breeding habitat varies across its geographic range, but always prefers dense ground and shrub cover in mesic environments. In the Pacific Northwest, Wilson’s warbler commonly breeds in dense, coniferous or deciduous forests where gaps or harvesting allow sufficient light to promote shrub growth. This species also breeds in shrubby riparian habitats dominated by willow and alder, rhododendron thickets, dense young coniferous or deciduous stands, and those shrubby habitats that develop in cut or burned areas (Dunn and Garrett 1997, Morrison 1981, Hutto and Young 1999). In coastal lowland areas of Oregon and Washington it nests above ground in low shrubs, but nests on or near the ground at higher elevations (Dunn and Garrett 1997). The most obvious threat to Wilson’s warbler populations is riparian habitat degradation caused by grazing, recreation, watercourse diversion or impoundment, or exotic shrub invasion. In addition to the direct and destructive effects of grazing on shrub habitats, especially those in moist or riparian areas, high levels of grazing and agricultural development attract brown-headed cowbirds that further reduce reproductive success in surrounding populations (Goguen and Mathews 1999).

Survey-wide BBS data for the period 1980-2003 show that populations significantly ($P<0.05$) declined by 2.5% annually. Populations are declining significantly ($P<0.05$) in Washington by 2.6% annually, and in Oregon by 2.3% annually. Of great concern are reported declines in ten of eleven bird conservation regions, seven of which are significant ($P<0.05$). These include declines in four BCRs relevant to this report: the Northern Interior Rainforest region where populations significantly ($P<0.05$) declined by 2.4% annually; the Northern Pacific Rainforest region where populations significantly ($P<0.05$) declined by 1.6% annually; the Great Basin region where populations significantly ($P<0.05$) declined by 3.2% annually; and the Northern Rockies region where populations significantly ($P<0.05$) declined by 4.7% annually. Regional MAPS data, however, showed stable trends in both the adult population and annual productivity.

There is evidence that productivity is a very strong indicator of subsequent population levels in national forests of the Pacific Northwest and that annual apparent survival estimates (0.459

+/- 0.028) for the region are below that expected for a bird of its mass (DeSante et al. 2002). Population studies using matrix projection models suggest that population levels in Montana are extremely sensitive to changes in the rates of first-year survival and subsequent adult survival (Johnson and Anderson 2003). Those models attributed a range of adult annual survival rates between 0.50 and 0.59, the minimum of which is 8% higher than the mean value estimated from the Pacific Northwest MAPS (IBP/NBII website) data which suggests a range from 0.434 to 0.474, inclusive of one standard error either side of the mean estimate. The matrix population model should be re-parameterized using the MAPS adult survival rate range estimate, a proportionately adjusted first year survival estimate, and fecundity estimates derived from Pacific Northwest populations of Wilson's warbler. We also know that temporal variation in Wilson's warbler populations is strongly linked to climate/weather through effects of climate on reproductive success (Nott et al. 2002) and survival rates (unpublished data). Given this information it is possible to construct stochastic or deterministic models that explore the effects of different climate scenarios on population levels (using a variable maximum clutch size) and the effects of habitat removal (using a variable proportion of maximum clutch size).

It is surprising, given the high percentage of regional declines reported by BBS, that PIF attaches no continental scale conservation status to Wilson's warbler and neither is it listed by Washington-Oregon PIF as a focal species in existing (July 2004) landbird conservation strategies for the region. However, conservation strategies for MacGillivray's warbler outlined earlier, especially grazing control, are expected to also benefit this species.

Research and monitoring requirements

State-level conservation plans for the species cite five research and monitoring requirements three of which apply to the Westside Coniferous Forest sub-region in Washington/Oregon:

1. Determine the habitat components important to Wilson's warbler abundance and reproductive success.
2. Determine if riparian management zones provide suitable habitat to support Wilson's warblers.

3. Determine stand-level thresholds of patch size for successful Wilson's warbler nesting.

The other two requirements emerge from the Nevada state plan:

4. Establish monitoring methodologies for Wilson's warblers.
5. Establish methodologies for determining the importance of riparian habitats to migrating Wilson's warblers.

This investigation may satisfy one or more of these requirements.

Model Interpretations

The models presented here adequately address all three research and monitoring requirements of the PIF Washington/Oregon Bird Conservation Plan for this species. Significance values of the models were not as high as in other species; however, the models selected habitats known to be important for Wilson's Warblers and adequately described landscape-related requirements for this species.

Inspection of the landscape data associated with the 18 MAPS stations used in these analyses reveals that coniferous forest is the dominant habitat type covering 50-90% of the 1250 hectares that lie within a 2-kilometer radius of each station. Deciduous and mixed forest coverage, combined, accounted for up to 500 hectares (approx. 40%) of the remaining areas (e.g. station 11166) and averaged ~13% of the cover. The remaining stations not used to study this species only averaged 4% cover (ANOVA $F=10.89$, $P<0.005$). We reported statistically significant correlations between demographics and landscape variables. At this sampling level ($n=18$) two-tailed ($n-2$) critical values of Pearson's correlation coefficient (r) lie at 0.400 ($P<0.10$), 0.468 ($P<0.05$), and 0.590 ($P<0.01$).

Table 19. Summary table of Wilson's warbler demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY	MPI+			**CLA+**	CLA+ CLA+	**CLA-**				
YNG				**CLA+**		**CLA-**				
RI[1]										
AHY/t		HCA+ HTA+ MTA-				TCA- **CLA-** **CLA+[2]**			FG- FS+	
YNG/t		HCA+ **MTA-** HTA+				TCA- CLA+[2]				
RI/t[3]		HCA+	**TCA-**			**TCA-**			FS+	

[1] No significant correlations - regression models overparameterized

[2] USFS classification

[3] P<0.10

Population sizes of adult Wilson's warbler correlated positively with the area of mixed forest (r=0.581), deciduous and mixed forest habitat combined (r=0.576), and deciduous forest alone (r=0.554). The model selection process nominated a two parameter model (R^2 =0.469, F=11.988, P=0.003) in which populations responded positively to the area of deciduous forest but negatively to successional habitat.

Population sizes of young warblers correlated positively with the area of deciduous forest (r=0.432). The model selection process nominated a two parameter model (R^2 =0.283, F=5.851, P<0.028) in which populations responded positively to the area of deciduous forest but negatively to successional habitat.

However, mean annual reproductive success correlated negatively with stream density (r=0.398) and positively with the amount of successional habitat-forest edge (r=0.292), and area of successional habitat (r=0.259). The model selection process nominated a five parameter model including stream density but this model is considered too complex to interpret.

Adult population trends correlated positively with the core area of high canopy cover forest (r=0.543), suggesting that adult populations increased where high canopy cover forest exceeded 300 hectares (~25%). Population trends also increased where successional habitat cover (USFS_SHRB_CLA) exceeded 50 hectares (~4%). Unfortunately, the model selection process nominated a two parameter model ($R^2 = 0.446$, F=12.843, P=0.002) in which increasing adult population trends were negatively associated with NLCD successional habitat cover but positively associated with core area of USFS successional habitat cover. The reason for this is that the shrubland covers in each database do not match spatially.

Similarly, young population trends correlated positively with the core area of high canopy cover forest (r=0.498), suggesting that young populations increased where high canopy cover forest exceeded 500 hectares (40%). Population trends also increased where successional habitat cover (USFS_SHRB_CLA) exceeded 50 hectares (~4%). The model selection process nominated a two parameter model ($R^2 = 0.285$, F=6.365, P=0.023) in which increasing young population trends were negatively associated with medium canopy cover forest cover but positively associated with successional habitat-forest edge.

Increasing reproductive success trends correlated with landscapes featuring >750 hectares (60%) of core high canopy cover forest (e.g. station 11140). The model selection process nominated a two parameter model ($R^2 =0.201$, F=4.020, P=0.062) in which trends in reproductive success were positively associated with core areas of successional habitat (NLCD) and coniferous forest.

Maintaining larger areas of deciduous and mixed forest will encourage larger population sizes of breeding adults and young. However, we expect management for reproductive success to increase the amount of successional habitat-forest edge in drier areas (low stream density). Likewise, reproductive success appears to be declining most in medium-density canopy forests and shows positive trends in successional habitats. These results again suggest that Wilson's Warblers are not performing well in their optimal habitats.

Thus, increasing the areas and patch sizes of closed-canopy deciduous forests, while continuing to provide sufficient edge, should lead to increased population sizes of breeding adult and young Wilson's Warblers. This suggests that the creation of corridors of this habitat (increasing both total area and total edge) might be the best management approach for this species.

Regarding the research and management requirements, our results suggest that the habitat components most important to Wilson's Warbler abundance are most closely associated with deciduous habitats with lots of successional habitat edge; our results on reproductive success are less clear but suggest that it was higher in successional habitats where the adults were less common. This may be cause for concern. Riparian management zones do not appear to be as important to Wilson's Warblers as extensive high canopy deciduous forests, and in fact, we detected a negative correlation between the stream density (indicative of riparian management zones) and reproductive success. However, if the riparian management zone includes areas of deciduous forest we predict that it will be beneficial to this species. Finally, we recommend the maintenance of high canopy cover deciduous or mixed forest cover in excess of 60% and successional habitat cover in excess of 4% for successful Wilson's warbler nesting, but the successional habitat patches should be long and thin (e.g. corridors) or complex in shape, as opposed to uniform in shape, in order to maximize the amount of edge.

Chipping sparrow- *Spizella passerina*

Background

Chipping sparrows commonly breed in edgy or open woodland habitats, stream and lake edges, parkland, orchards, and grassy fields. This species occurs in coniferous, deciduous, or mixed woodland, and generally prefers dry stands with a grassy understory. Chipping sparrows nest 1-6m high in trees and shrubs, rarely on the ground, and feed low to the ground on seeds and invertebrates (Rising 1996). They may be sensitive to grazing pressure and cowbird parasitism; two studies have shown that chipping sparrows are less common in grazed than ungrazed sites in bottomlands (Saab et al. 1995).

Survey-wide BBS data (1980-2003) show that populations are fairly stable but declining non-significantly in Washington (1.6%), and Oregon (1.5%). BBS reported declines in 18 of 29 bird conservation regions, including six significant ($P<0.05$) declines, and non-significant declines in the Northern Pacific Rainforest, Great Basin, and Northern Rockies ($P<0.10$) conservation regions. Regional MAPS data (1992-2001), showed a highly significant ($P<0.001$) declining adult population trend of 8.7% annually.

PIF attaches no continental scale conservation status to chipping sparrows.

Research and monitoring requirements

However, state-level conservation plans cite six research and monitoring requirements, three of which apply to sub-regions of Washington/Oregon:

1. Study chipping sparrow nesting ecology and habitat use - East Slope Cascades.
2. Determine the effects of grazing on chipping sparrows - East Slope Cascades.
3. Study nesting ecology and habitat relationships of chipping sparrows - Westside Lowlands and Valleys.
4. Determine the level of cowbird parasitism for chipping sparrows - Westside Lowlands and Valleys.
5. Study chipping sparrow nesting ecology and habitat use - Northern Rockies.
6. Determine if grazing affects Chipping Sparrow productivity - Northern Rockies.

This investigation may partially satisfy one or more of these requirements.

Model interpretations

The models presented here adequately address some aspects of the research and monitoring requirements of the PIF Washington/Oregon Bird Conservation Plan for this species. It was not possible to construct multiple regression models for the low number of data points in this study, however, simple correlations adequately described landscape-related requirements for this species.

Table 20. Summary table of chipping sparrow demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type) [1]

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY[2]	MPI+	MTA+		CLA+	CLA+					
YNG	TCA- SDI+	HCA-	TCA- CLA-				CLA+		FG+ ALL+	
RI		HTA-	CLA-			TCA+ CLA+			ALL+	
AHY/t[2]		HTA+ HCA+					CLA-		FG-	
YNG/t[2]		HCA+		CLA-	CLA-		CLA-			ALL-
RI/t							CLA-[3]			

[1] No regression models presented

[2] P<0.10

[3] USFS classification

Inspection of the landscape data associated with the six MAPS stations used in these analyses reveals that coniferous forest is the dominant habitat type covering 30-90% of the 1250 hectares that lie within a 2-kilometer radius of each station. These landscapes are heterogeneous (probably disturbed by extensive logging), featuring numerous patches of forest, successional habitat, grassland, and low to medium canopy cover forest (e.g. station 11155 in Umatilla N.F.). We have not provided multiple regression models because the number of data points is so low. We reported statistically significant correlations between demographics and landscape variables. At this sampling level (n=4) two-tailed (n-2) critical values of Pearson's correlation coefficient (r) lie at 0.729 (P<0.10), 0.811 (P<0.05), and 0.917 (P<0.01).

Population sizes of adult chipping sparrows correlated positively with the area of mixed forest (r=0.856) which varied up to 111 hectares at elevations between 900 and 1500 meters.

Population sizes of young sparrows correlated positively and strongly with a number of landscape variables, including grassland-forest edge (r=0.916), grassland area (r=0.875), and all edge types (r=0.857). Negative correlations included stream density (r=-0.966) and the core area of coniferous forest (r=-0.879). However, mean annual reproductive success correlated positively with the core area (r=0.886) and total area (r=0.877) of successional habitat (NLCD), and with all edge types (r=0.869).

Adult population trends correlated positively with the core area of high canopy cover forest (r=0.543), but negatively with (USFS) grassland (r=-0.859). Young population trends correlated negatively with cumulative pest damage (r=-0.850). No significant relationships emerged for trends in reproductive success.

Overall, managing for coarse-grained heterogeneous landscapes will benefit chipping sparrow populations.

Song sparrow- *Melospiza melodia*

Background

Song sparrows commonly breed in shrubby, grassy habitats associated with coastal and freshwater marshes or watercourses, edgy or open woodland habitats, stream and lake edges, parkland and orchards and grassy fields (Rising 1996). In the Pacific Northwest, however, they are mostly restricted to shrubby, mesic riparian and marshland habitats and bottomlands (Hutto and Young 1999). They nest in grass clumps and weedy clumps and feed low to the ground on seeds and invertebrates. Their dependence on shrubby riparian habitat makes them sensitive to grazing pressure and cowbird parasitism; in one Montana study, cowbirds parasitized approximately 65% of song sparrow nests (Tewksbury et al. 1998).

Survey-wide BBS data (1980-2003) show that populations are near-significantly ($P=0.05$) declining by 0.3% annually, but stable in Washington and Oregon. BBS reported declines in 13 of 26 bird conservation regions, including three significant ($P<0.05$) declines, and a near-significant ($P<0.10$) decline of 0.7% annually in the Northern Pacific Rainforest, and a significant ($P<0.05$) increase of 1.7% annually in the Great Basin. Regional MAPS data (1992-2001), show a non- significant decline in the adult population of 2.2% annually.

PIF attaches no continental scale conservation status to song sparrows.

Research and monitoring requirements

State-level conservation plans for the western United States cite three research and monitoring requirements, none of which apply to sub-regions of Washington/Oregon:

1. Conduct selective monitoring at key riparian sites to determine the factors influencing nest success - California.
2. Determine what constitutes source and sink areas in riparian deciduous forests - Montana.
3. Demographic monitoring for shrub-dependent species - Montana.

This investigation may partially satisfy one or more of these requirements.

Model Interpretations

The models presented here adequately address all three research and monitoring requirements of the PIF Washington/Oregon Bird Conservation Plan for this species. The models selected habitats known to be important for song sparrows and adequately described landscape-related requirements for this species.

Table 21. Summary table of song sparrow demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY[1]		LCA+					CLA-		IJI-	
YNG		LCA+								
RI[1]		HCA+ LTA+ LCA+					CLA+			ALL-
AHY/t[2]									ALL+	CL4-
YNG/t[3]	NED+								FS-	ALL-
RI/t[1]	NED+			CLA-	CLA-	TCA- CLA-		CLA+	FS-	ALL+

[1] P<010

[2] P<0.20

[3] P<0.01

Inspection of the landscape data associated with the 14 MAPS stations used in these analyses reveals that coniferous forest is the dominant habitat type covering 65-95% of the 1250 hectares that lie within a 2-kilometer radius of each station. Low canopy cover forest coverage accounted for up to 500 hectares (approx. 40%) of the areas (e.g. station 11166) and averaged ~250 hectares (~20%) of the cover. We reported statistically significant correlations between demographics and landscape variables. At this sampling level (n=14) two-tailed (n-2) critical values of Pearson's correlation coefficient (r) lie at 0.458 ($P<0.10$), 0.532 ($P<0.05$), and 0.661 ($P<0.01$).

Population sizes of adult song sparrows correlated negatively with the amount of fragmented edge (r=-0.489) such that more adults were captured at stations surrounded by larger contiguous patches of different habitat types. Accordingly, the model selection process nominated a two parameter model ($R^2 = 0.829$, F=14.155, P=0.003) in which populations responded positively to the core area of low canopy cover forest but negatively to grassland. Population sizes of young sparrows correlated positively with the core area of low canopy cover forest (r=0.464). The model selection process nominated a single parameter model ($R^2 = 0.216$, F=3.297, $P<0.094$) in which young, like adults, respond positively to the core area of low canopy cover forest.

Similarly, mean annual reproductive success correlated positively with the core area of low canopy cover forest (r=0.550), the area of grassland (r=0.505), and area of successional habitat (r=0.456). Unfortunately, the model selection process nominated a four parameter model considered difficult to interpret but that included positive responses to low canopy cover forest, grassland, and high canopy cover forest.

Adult population trends (positive in 10 of 14 cases) correlated negatively with cumulative pest damage (r=-0.435), and correlated positively with the total amount of edge between grassland, successional habitat, and forest habitats (r=-0.397), suggesting that adult populations increased where the 90m buffered edges covered more than 100 hectares. This sole landscape variable was nominated in a weak model ($P>0.20$).

Conversely, young population trends (declining in 9 of 14 cases) correlated positively to cumulative pest damage (r=0.774), suggesting that young populations increased where the area of cumulative pest damage exceeded 160 hectares (~13%). Population trends decreased as a function of increasing successional habitat-forest cover. The model selection process nominated a two parameter model ($R^2 = 0.685$, F=22.091, P=0.001) in which young population trends responded positively to cumulative pest damage and negatively to successional habitat-forest edge.

Reproductive success trends correlated negatively with the core area of successional habitat (r=-0.535) such that increasing trends were associated with landscapes featuring <40 hectares (~3%) of successional habitat. The model selection process nominated a three parameter model ($R^2 =0.501$, F=5.469, P=0.022) in which trends in reproductive success were positively associated with stream density, but negatively associated with deciduous forest and large patches of successional habitat. This suggests that song sparrow reproductive success is highest among finely grained non-deciduous forested landscapes that have high stream densities.

Maintaining or creating large patches of low canopy cover evergreen forest in stream dense areas should benefit adult and young populations and lead to high reproductive success. The results also suggest that defoliation events may help create suitable habitat for song sparrows. However, the extent of successional habitat should be kept at less than 3%. It is also possible that mechanical canopy thinning may also benefit song sparrow populations. Correlations between population demographics and the core area of low canopy cover forest suggest that song sparrows are sensitive to edges, and therefore may be sensitive to the risk of cowbird parasitism or predation which is typically higher close to edge habitats. Humple and Burnett (2004) suggest that grazing exclusion and creek restoration will help restore higher elevation song sparrow habitat.

Lincoln's sparrow- *Melospiza lincolnii*

Background

Lincoln's sparrows commonly breed in high elevation shrubby habitats associated with wet meadows, freshwater marshes, riparian thickets, or forest edge. They prefer mesic areas with dense vegetation, often willow, alder, or spruce (Rising 1996). Lincoln's sparrows nest on the ground under vegetation or in low bushes clumps and weedy clumps, and feed low to the ground on seeds and invertebrates. They may be sensitive to grazing pressure and cowbird parasitism, though parasitism rates are generally low due to limited habitat overlap with brown-headed cowbirds (Ammon 1995).

Survey-wide BBS data (1980-2003) show that populations are stable, however, in Oregon populations are significantly ($P<0.05$) increasing by 12.7% annually. BBS reported declines in seven of 12 bird conservation regions, including non-significant declines in the Northern Interior Rainforest (0.2%), Northern Pacific Rainforest (3.1%). Regional MAPS data (1992-2001), show a significant ($P<0.05$) decline in the adult population of 2.4% annually.

PIF classifies this species as a Species of Continental Importance for the Northern Forest Avifaunal Biome which holds an estimated 91% of the breeding populations. Their continental long-term planning and responsibility objective is to maintain population levels, especially in wetland-forest habitats.

Research and monitoring requirements

Despite the PIF continental scale status state and regional conservation plans fail to cite research and monitoring requirements.

Model Interpretations

The models presented here adequately describe landscape-related requirements for Lincoln's sparrow. These requirements are consistent with known habitat preferences.

Inspection of the landscape data associated with the 12 MAPS stations used in these analyses reveals that they are high elevation stations located between 1000 and 2000 meters above sea level (mean = 1425m). Coniferous forest is the dominant habitat type covering 50-95% of the area that lies within a 2-kilometer radius of each station. At this sampling level (n=12) two-tailed (n-2) critical values of Pearson's correlation coefficient (r) lie at 0.497 ($P<0.10$), 0.576 ($P<0.05$), and 0.708 ($P<0.01$).

Table 22. Summary table of Lincoln's sparrow demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant ($P<0.05$ unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY	SDI-	HTA+				CLA- TCA-	CLA-		ALL-	
YNG										CL4+
RI^3	NED+						CLA+		IJI+ SG+	
AHY/t^4	SDI-					CLA- TCA+				
YNG/t^1	SDI-		TCA+			CLA- TCA+^{5}				
RI/t	SDI-			CLA-		TCA-		CLA+		

^{1} $P<0.10$
^{2} No significant correlates
^{3} $P<0.01$
^{4} Regression models overparameterized
^{5} USFS classifications

Population sizes of adult Lincoln's sparrow correlated negatively with the amount of grassland cover (r=-0.704) such that no adults were captured at stations surrounded by more than 200 hectares of grassland (~16%). Adult population sizes also correlated negatively with the amount of combined grassland-successional habitat-forest edge (r=-0.650) and habitat diversity (NLCD_LAND_SDI, r=-0.604). This suggests that adult populations are lowest in areas that are greatly fragmented (e.g. station 11147) and highest in areas where different habitat patches are large (e.g. station 11148). The model selection process nominated a two parameter model (R^2 =0.829, F=14.155, P=0.003) in which populations respond negatively to the area of successional habitat and habitat diversity.

Population sizes of young sparrows correlated positively with cumulative pest damage (r=0.619) suggesting that open forested habitats that result from defoliation events may provide suitable breeding habitat. The model selection process nominated a six parameter model that was too difficult to interpret. However, reproductive success correlated positively with the amount of grassland-successional habitat edge (r=0.857), the area of grassland (r=0.856), and the interspersion-juxtaposition index of combined grassland-successional habitat-forest edge (USFS_UCEM_IJI, r=0.733). This value increases as it approaches 0 when edge adjacencies are unevenly distributed (fine-grained heterogeneity); IJI = 100 if all patch types are equally adjacent to all other patch types (coarse-grained heterogeneity). The model selection process nominated a two parameter model (R^2 =0.856, F=35.191, P<0.001) in which populations respond positively to the area of grassland and interspersion-juxtaposition index of combined grassland-successional habitat-forest edge. These results suggest that reproductive success is highest in coarse-grained landscapes that feature extensive grassland-successional habitat edge.

Adult population trends showed no significant correlations, and therefore the model was not considered. Young population trends correlated positively to habitat diversity (NLCD_LAND_SDI, r=-0.590). Again, the nominated model was too complex to interpret but featured positive associations with the core area of shrub and coniferous forest. This also suggests that forested landscape with larger isolated patches of successional habitat benefit this species.

Reproductive success trends correlated negatively with the amount of deciduous forest (r=-0.609) suggesting that reproductive success is declining in landscapes containing more than 1% deciduous forest cover. In addition, reproductive success trends correlated negatively with habitat diversity (NLCD_LAND_SDI, r=-0.585), and positively with stream density (r=0.521). The model selection process nominated a three parameter model (R^2=0.656, F=8.174, P=0.009) in which trends in reproductive success were negatively associated with deciduous forest and the core area of shrub, but positively associated with stream density.

Clearly, maintaining coarse grained heterogeneity (meadow and successional habitat) among high elevation moist coniferous forests is beneficial to this species. At these elevations, frequent natural disturbances such as defoliation events may be responsible for the development of dense scrubby patches and edge habitats where Lincoln's sparrows prefer to breed. It is interesting that adults respond negatively to grassland area but young respond positively. Perhaps the larger patches represent better quality habitat in which individual territory holders defend larger territories and produce more offspring, whereas smaller patches are available to non-breeders or less fit individuals. This situation results from an ideal despotic distribution which is commonly associated with population dynamics of many sparrow species.

There is, however, an alternative explanation for high numbers of young to be associated with landscapes containing more grassland, represented by wet meadows at the higher elevations. In the Sierras, such meadows provide molt and pre-migration staging areas for juvenile birds of many species. In this study, grassland/meadow cover was found to be an increasing function of elevation (r=0.784). Coincidentally, cumulative pest damage was also an increasing function of elevation. Perhaps the higher elevations have higher invertebrate populations that attract juveniles.

Dark-eyed Junco - *Junco hymenalis*

Background

Dark-eyed juncos are habitat generalists that will commonly breed in coniferous, deciduous, or mixed forests, forest edge, open woodland, clearings and brushy habitats in burned or cleared areas. They nest on the ground in a scrape or under downed logs or low vegetation, or occasionally in low trees, ledges, river banks, or niches in buildings (Rising 1996, Hutto and Young 1999). This species may be sensitive to grazing pressure and cowbird parasitism. Although once reported to be an infrequent cowbird host (Friedmann 1963), later studies found parasitism rates as high as 39% (Wolf 1987, White 1973). Dark-eyed juncos feed on seeds and invertebrates.

Survey-wide BBS data (1980-2003) show that populations are significantly ($P<0.05$) declining by 2.7% annually. BBS reported declines in 11 of 17 bird conservation regions, including significant ($P<0.05$) declines in the Northern Interior Rainforest (1.4% annually), and the Northern Pacific Rainforest (1.9%), and a non- significant decline in the Great Basin. Regional MAPS data (1992-2001), show a stable adult population.

PIF attaches no continental scale conservation status to dark-eyed juncos.

Research and monitoring requirements

State and regional conservation plans fail to cite research and monitoring requirements.

Model Interpretations

The models presented here adequately describe landscape-related requirements for dark-eyed junco. These requirements are consistent with known habitat preferences.

Inspection of the landscape data associated with the 24 MAPS stations used in these analyses reveals that all but five stations were high elevation stations located between 1000 and 2000 meters above sea level (overall mean elevation ~1300m). Coniferous forest is the dominant habitat type covering 55-95% of the area that lies within a 2-kilometer radius of each station. However, shrub cover reached maximum coverages of ~20% and low canopy cover forest accounted for up to 50% of the coverage. We reported statistically significant correlations between demographics and landscape variables. At this sampling level (n=24) two-tailed (n-2) critical values of Pearson's correlation coefficient (r) lie at 0.344 (P<0.10), 0.404 (P<0.05), and 0.515 (P<0.01).

Table 23. Summary table of dark-eyed junco demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY[1]	NED+	LTA+ LCA+				**CLA+**		**CLA-**	FS+	**CL4+**
YNG[1,2]	NED+					CLA+				**CL4+**
RI[3]			**TCA+**			**TCA+**				
AHY/t				CLA-	CLA- **CLA-**					
YNG/t[3]					CLA- **CLA-**				**08+**	
RI/t						**TCA+**				

[1] P<0.01

[2] Regression models overparameterized

[3] No significant correlates - model results only

Population sizes of adult dark-eyed junco correlated positively with the amount of shrub-forest edge (r=0.680) which occupied up to 2% of the landscape or 25 hectares (90m buffer). Adult population sizes also correlated positively with the area of low canopy cover forest (r=0.653), elevation (r=0.649), successional habitat (r=0.644), and the core area of low canopy cover forest. This suggests that adult populations are highest at high elevation areas featuring more open coniferous woodland with shrubby patches totaling up to 20% of the landscape (e.g. station 11147 in Wenatchee N.F.) and lowest in low elevation areas where successional habitat patches covered less than 100 hectares (e.g. station in Wenatchee N.F.). The model selection process nominated a three parameter model (R^2 =0.659, F=19.938, P<0.0005) in which populations respond positively to the area of successional habitat and cumulative pest damage, but negatively to stream density.

Population sizes of young juncos also correlated positively with elevation (r=0.583), the area of successional habitat (r=0.558), and also with the amount of successional habitat-grassland edge (r=0.482). The model selection process nominated a six parameter model that was too difficult to interpret. The model featured positive relationships with elevation and successional habitat area (both USFS and NLCD), but negative relationships with successional habitat-forest edge and stream density.

Reproductive success correlated positively but weakly with the core area of successional habitat (r=0.449), and negatively with the area of coniferous forest (r=-0.432), and core area of coniferous forest. Interestingly, the model selection process nominated a two parameter model (R^2 =0.856, F=35.191, P<0.001) in which populations respond positively to both the core area of successional habitat and the core area of coniferous forest. These results suggest that reproductive success is highest in coarse-grained landscapes that feature larger patches of successional habitat in an open coniferous forest matrix.

Adult population trends correlated negatively with the area of deciduous and mixed forest combined (r=-0.672), suggesting that they are negative in landscapes featuring more than 50 hectares (4%) of deciduous and mixed forest. However, population trends correlated positively with cumulative pest damage (r=0.631). The model selection process nominated a two parameter model (R^2 =0.496, F=21.654, P<0.0009) in which populations respond negatively to the area of deciduous and mixed forest, and positively to cumulative pest damage.

Young population trends correlated negatively but weakly with the area of deciduous and mixed forest combined (r=-0.440). The model selection process nominated a two parameter model (R^2 =0.234, F=6.616, P=0.017) in which populations responded negatively to the area of deciduous and mixed forest, and positively to the area of grassland-successional habitat edge. Unfortunately, reproductive success trends showed very weak correlations and the chosen model was not considered useful.

Clearly, maintaining coarse grained heterogeneity among drier high elevation coniferous forests is beneficial to this species. At these elevations, frequent natural disturbances such as defoliation events may be responsible for the development of dense scrubby patches and edge habitats where junco populations appear to thrive. However, some populations thrived in managed areas where a mosaic of larger regeneration cuts had been created (e.g. station 11161 in Willamette N.F.).

Pine Siskin - *Cardeulis pinus*

Background

Pine siskins are habitat generalists that will commonly breed in coniferous and deciduous forests and woodlands, parkland, and suburban habitats (AOU 1983). They were nearly twice as common in burned-over habitat than in any other habitat in the Rocky Mountains (Hutto and Young 1999). As habitat generalists, pine siskins may not be sensitive to forest fragmentation; in one study the species was more abundant in fragmented stands (Keller and Anderson 1992). Pine siskins often nest halfway up trees and feed on seeds, buds, nectar, sap, and insects (Dawson 1997).

Survey-wide BBS data (1980-2003) show that populations are significantly ($P<0.01$) declining by 3.3% annually. BBS reported declines in 14 of 16 bird conservation regions, including a significant ($P<0.01$) decline in the Northern Pacific Rainforest (8.3% annually), significant ($P<0.05$) declines in the Great Basin (2.2%) and Northern Rockies (2.9%), and a near-significant increase in the Northwestern Interior Forest (10.6%). Regional MAPS data (1992-2001), show a significant ($P<0.05$) decline of 6.7% annually in the adult population.

PIF attaches no continental scale conservation status to pine siskins.

Research and monitoring requirements

State and regional conservation plans fail to cite research and monitoring requirements.

Model Interpretations

The models presented here adequately describe landscape-related requirements for pine siskin. These requirements are consistent with known habitat preferences.

Inspection of the landscape data associated with the 13 MAPS stations used in these analyses reveals that they are mostly high elevation stations located between 900 and 2000 meters above sea level (mean elevation ~1350m). Coniferous forest is the dominant habitat type covering 60-95% of the area that lies within a 2-kilometer radius of each station. However, shrub cover reached maximum coverages of ~15% and grassland accounted for up to 20% of the coverage. We reported statistically significant correlations between demographics and landscape variables. At this sampling level (n=13) two-tailed (n-2) critical values of Pearson's correlation coefficient (r) lie at 0.476 (P<0.10), 0.553 (P<0.05), and 0.684 (P<0.01).

Table 24. Summary table of pine siskin demographic responses (+ positive, - negative) to landscape variables. These variables relate to the entire landscape (MPI -mean patch interspersion, SDI - Shannon's diversity index, and IJI - interspersion juxtaposition index). Canopy cover responses are coded (H - high, M - medium, L - low, TA - total area, CA - core area,). Coniferous, deciduous, mixed forest types and successional and grassland types are coded (CLA - total area, TCA - core area). Edge habitat types are coded (FS - forest/shrubland, SG - successional/grassland, FG - forest/grassland). Responses to pest damage are coded (ALL - all types, CL1 - defoliators, CL3 - adelgids and kin, CL4 - beetles). Responses are recorded for all significant (P<0.05 unless otherwise stated) correlations (normal type) and for those variables selected from the multiple regression model associated with the lowest ICOMP value (bold type).

	Landscape	Canopy Cover	Coniferous	Deciduous	Mixed	Successional	Grassland	Stream Density	Edge type	Pest damage
AHY	SDI-		CLA+				CLA-		ALL- 08-	
YNG		MCA- MTA-		CLA-						
RI[1]	MPI+						CLA+		IJI+	
AHY/t[2]										
YNG/t	SDI- TCA+	HCA+ HTA+		CLA-	CLA- CLA-					
RI/t	MPI+ SDI-	HTA+								

[1] P<0.10 and weak regression model

[2] no significant correlates

Population sizes of adult pine siskins correlated negatively with habitat diversity (r=-0.621), the amount of forest-successional habitat-grassland edge (r=-0.619), and the area of grassland (R=-0.562). Importantly, adult populations also correlated positively with the area of coniferous forest (r=0.597). These results suggest that adult populations are highest at high elevations areas featuring large tracts of contiguous coniferous forest (e.g. station 11150 in Wenatchee N.F.) and lowest in areas where the forest is highly fragmented by non-forested habitat (e.g. station 11172 in Fremont national forest). The model selection process nominated a two parameter model (R^2 =0.424, F=7.922, P<0.017) in which populations respond positively to the area of coniferous forest but negatively to forest -grassland-successional habitat edge.

Population sizes of young siskins correlated negatively with the area of deciduous forest (r=-0.572), the core area of medium cover canopy (r=-0.568). The model selection process nominated a weakly supported two parameter model (R^2 =0.396, F=3.277, P=0.080) in which young populations respond negatively to increasing area deciduous forest and core area of medium canopy cover forest.

Reproductive success correlated positively with the area of grassland (r=0.626), and negatively with the interspersion-juxtaposition index of combined grassland-successional habitat-forest edge (r=-0.518). The model selection process nominated a six parameter model which was too complex to interpret.

Adult population trends declined at 11 of the 13 stations and correlated negatively but poorly with the area of deciduous forest (r=-0.422). The model selection process nominated a weakly supported, four parameter model that we considered too complex to interpret.

Young population trends declined in 12 of 13 cases and correlated negatively with the area of deciduous and mixed forest combined (r=-0.521). However, closer inspection of the data revealed two outlying data points that are responsible for the strength of this correlation. The model selection process nominated a two parameter model (R^2 =0.312, F=5.184, P=0.044) in which populations responded negatively to habitat diversity and the area of deciduous forest.

Reproductive success trends correlated negatively with the mean proximity index of the landscape, and negatively with habitat diversity (R=-0.657) suggesting that reproductive success increased in more homogenous landscapes typified by landscape level mean proximity indices of less than 150. In addition, the trends correlated positively with the area of coniferous forest such that the increasing (or slightly decreasing) trends were associated with landscapes surrounding stations 11148, 11150, and 11902 in Wenatchee N.F. that featured large contiguous areas of coniferous forest covering 93%, 95%, and 89% of the landscape, respectively. The model selection process nominated a two parameter model ($R^2=0.510$, $F=11.619$, $P=0.006$) in which trends in reproductive success were negatively associated with mean proximity index and positively with the area of high canopy cover forest.

Clearly, maintaining large contiguous (low levels of fragmentation) tracts of drier high elevation coniferous forests is beneficial to this species. At these elevations, frequent natural disturbances such as defoliation events may be responsible for the development of dense scrubby patches and edge habitats where siskin populations may not thrive as well as they would in “healthy” forests. In fact, cumulative pest damage was significantly higher (ANOVA, $F=4.13$, $P<0.05$), by a factor of approximately 2.4, among the stations used in the siskin study than they were at the other 23 stations. Perhaps the high accumulations of pest damage are responsible for the study-wide declines observed in annual reproductive success, adult and young populations.

DISCUSSION

The model descriptions and management guidelines proposed in this report are based on the relationships between demographic parameters calculated from MAPS data collected on six national forests; two in Washington and four in Oregon. We obtained spatial statistics (landscape metrics) from analyses of two kilometer radius areas of NLCD (1992) data surrounding each station. The study focused on 16 species of conservation concern as classified by one or more criteria derived from other landbird conservation research and planning programs at the regional or continental scale. Species-landscape models were constructed for 13 of these species. Although species-landscape models could be constructed for other landbird species for which sufficient MAPS banding data were available, those species are not listed as birds of conservation concern and, therefore, are not included in this report.

MAPS data

One assumption of our approach is that the MAPS protocol samples the adult and juvenile populations from the landscape surrounding the station. In the early part of the breeding season adults pass through the station looking for new or vacant territories or they are *en route* to reclaim existing territories. In the late part of the breeding season adults and young pass through the station during post-fledging dispersal. In the middle of the season a greater proportion of adults are breeding individuals whose territorial movements encounter a mistnet, floating females seeking unpaired males and extra-pair copulations, or males seeking new/vacant territories. This assumption is supported by the results of an analysis of the seasonal and diurnal patterns of mist-net captures in national forests of the Pacific Northwest (Nott and DeSante 2002). The results showed that captures of “resident” birds (captured in multiple years or multiple times in one year but more 7 days apart) are most likely in the beginning and middle of the season, whereas individuals captured only once are more likely to occur at the beginning and end of the season. There are also differences in the diurnal patterns of captures. Some species are more likely to be captured in the first few hours of banding than towards the end of the banding period, whereas other species exhibit a more uniform pattern of activity during the day, or in the case of flycatchers are less active in the early hours.

Corrections for missed effort

Correcting numbers of captures based solely upon the proportion of the expected banding effort achieved is not sufficient. This is because missed banding effort introduces bias into indices of reproductive success consistent with the species-specific temporal patterns of age-specific activity observed in MAPS data, and the timing of the missed effort. We are confident that the four-dimensional (*net x 20 minute period x visit x year*) missing effort correction model we constructed effectively removes much of the bias. Generally, the corrected numbers of adult and young individuals differ little from the raw numbers except when effort is missed over a time period during which we expect a disproportionate number of adult or young captures of that species. After correcting for missing effort, we use the year-specific corrected numbers of adults and young to calculate the annual reproductive indices. Details of this procedure are given in Appendix 1.

Model selection and parameterization

Typically, a single species-landscape model involved 180 possible relationships among six demographic parameters calculated from MAPS data, and 30 landscape metrics calculated from five spatial datasets. Accordingly, the matrix of covariance among the landscape metrics alone contains 435 correlations. For each species in this study the initial visual inspections of the species-landscape correlation matrices revealed a number of strong relationships between demographic parameters and landscape metrics. For each demographic, we selected up to 10 highly correlated metrics and included them in fully permuted multiple regression models. In these models, we performed multiple regression analyses on all combinations of parameters.

A considerable problem exists with multiple regression models of this type. If the "best" models are chosen based on simple statistical significance (i.e., lowest P values), those models tended to be overparameterized, statistically indefensible, and extremely difficult to interpret given our knowledge of the species' ecology. Although we alleviated the problem to some extent by applying a more advanced method of model selection based on the Akaike Information Criterion (AIC; Akaike 1973), models for some species and demographics still included numerous (>5) parameters. However, by selecting the "best" models using an index of information complexity, or ICOMP (Bozdogan 1990, 1994), we typically reduced the number of parameters in the top selected models to two or three parameters. The advantage of this method is that it considers the matrix of covariance among the independent variables and penalizes those models that contain high levels of covariance. We believe that the models selected by this process are more likely to be statistically defensible, more easily interpreted, and convey more biological and ecological sense.

Species responses to landscape attributes

Several species demographics increased as a function of increasing elevation. Adult warbling vireo populations were highest at higher elevations. Chestnut-backed chickadee young populations were highest at higher elevations but adult populations increased as a function of elevation, thus reducing the ratio of young to adults. Hence, overall reproductive success decreased as a function of increasing elevation. For MacGillivray's warbler, both adult population trends and trends in reproductive success increased with elevation. For song sparrow and dark-eyed junco, trends in young populations and reproductive success increased with elevation. Lincoln's sparrow reproductive success increased with elevation. We attribute these relationships indirectly to habitat types that occur at higher elevations because the relationships between elevation and other components/attributes of the landscape are strongly correlated with elevation. The extent of all forest cover, deciduous, mixed, high canopy cover, and mean patch interspersion correlate negatively ($P<0.005$) with elevation whereas low canopy cover, shrub/successional, grassland, total edge, and cumulative pest damage correlate positively with elevation ($P<0.005$).

Species responses to forested habitat

Overall, selected models for those species that prefer to nest in forests and woodlands suggest that land managers should conserve large areas of contiguous forest (upwards of 700 ha) in a 2-km-radius area (1250 hectares). Clearly, within those patches, canopy cover as well as the density of undergrowth and ground cover should be managed in a manner consistent with published microhabitat management procedures for the species of conservation interest. Possibly the best central source of such information can be found on the NatureServe Explorer website (NatureServe 2003) where species-specific literature, citations and management reviews can be found. We summarized relevant management information for each species and provided that information in the management section of the results.

For many species, the conservation of large tracts of coniferous forest in excess of 900 hectares is essential. Not only is the total amount of forest important but many species are edge-sensitive such that are breed more successfully in tracts of forest large enough to allow them to avoid the increased risk of predation or nest parasitism suffered close to the edge. Predictive models for reproductive success among three species (e.g. “Western” flycatcher, MacGillivray’s warbler, and dark eyed junco) included positive relationships with forested core area (as defined by subtracting a 90m buffer) in preference to total percentage cover. This suggested the existence of edge effects that, for example, negatively impact “Western” flycatcher reproductive success in coniferous forest. Likewise, for Hammond’s flycatcher reproductive success increased as a function of the core area of high canopy cover coniferous forest.

Some species, such as chestnut-backed chickadee, appear to breed more successfully in extensive low canopy cover forested habitats, whereas Swainson’s thrush adults and young populations are highest in large tracts of high canopy cover forest with a deciduous component. Over time, however, the numbers of young and reproductive success increase as a function of increasing low canopy cover forest. Given that the canopy cover estimates were made at the beginning of the study period we can hypothesize that as low canopy cover forest succeeds toward medium and high canopy cover Swainson’s thrushes recruit into these habitats and breed. Song sparrow reproductive success is determined by a negative response to high canopy cover forest and a positive response to the core area of successional habitat. Generally speaking, for interior forest species, the perimeter:area ratio of forest tracts should be minimized, but this may not benefit species that regard forest edge as ideal habitat and typically prefer a “feathered” or complex edge

Forest species appear to benefit from habitat components other than forest. Hammond's flycatcher demographics responded positively to the presence of larger patches of successional habitat, which may provide good foraging habitat or act as a source of flying insects that disperse. Although chipping sparrow adults have increased in areas of high canopy cover, young populations are higher at those stations surrounded by small areas of grassland that abut forest. This result is consistent with their known habitat preferences.

Species responses to successional habitat

Species-landscape models for species that prefer shrubland or early successional habitat typically suggest that maintenance of a heterogeneous mosaic of different habitat types is desirable. These species were captured at those stations surrounded by various levels of forest fragmentation. The fragmentation pattern might result from anthropogenic perturbations (e.g. silviculture, logging, agriculture, recreation, and development) or may exist as natural heterogeneous mosaics such as forest meadow complexes found at higher elevation sites. Early successional habitats also form as a result of natural (e.g. disease, pestilence, senescence, fire and windthrow). MacGillivray's warbler demographics (i.e., adults, young, and reproductive success) are strongly and positively associated with successional habitats and especially the core area of successional habitat, but also show positive relationships with low and medium canopy cover forest and negative relationships with high canopy cover forest. Chipping sparrow and dark eyed junco reproductive success also correlated positively with core area.

Species responses to stream density

Surprisingly few responses to stream densities emerged from these analyses. Hammond's flycatcher mean annual reproductive success declined as a function of increasing stream density suggesting a preference for drier forest habitats. Chestnut-backed chickadee reproductive success decreased over time where stream densities were high, conversely, song sparrow and Lincoln's sparrow reproductive success increased over time where stream densities were high. We conclude that coverage of habitat types normally associated with streams and moister forests may better parameters to measure.

Species responses to edge habitats

For other forest species particular edge types became strong determinants of demographic parameters. For Swainson's thrush, even 2% coverage of successional habitat-grassland edge habitat depresses reproductive success. Successional/grassland edge is associated with low numbers of young and reduced reproductive success in chestnut-backed chickadees. Warbling vireo population dynamics are strongly correlated with the amount of edge between forest and successional habitat. Chipping sparrow young populations and reproductive success responded to all edge types, and young populations also responded positively to forest -grassland edge. This kind of relationship allows predictions of demographic change to be easily made from logging or reforestation/gap filling plans.

Pests, nests, and forest health

Apart from anthropogenic factors windthrow, ice damage, pest infestation and disease determine the age stand patterns and canopy cover attributes of natural and managed forests in the moister areas of the Pacific Northwest where fire is not a major factor in forest dynamics. A growing body of evidence suggests that such infestations, although costly in terms of forest products, can eventually result in a more healthy forest a decade or more later and actually stimulates woody biomass accumulation in surviving trees. Clearly, such outbreaks create important breeding habitat for some species.

Defoliating pests and beetles can kill entire stands of trees, or reduce canopy cover thereby allowing dense undergrowth to develop in the resultant gaps and wherever light can penetrate the canopy. Such undergrowth is important to some birds in providing nesting and foraging habitat and dead trees provide nesting sites, perches, and invertebrate food sources for some species. Numbers of chestnut-backed chickadee young and reproductive success increased as a function of cumulative pest damage among the higher elevation forests it prefers. Similarly, adult and young population sizes of dark-eyed juncos were higher among beetle damaged forests. Conversely, winter wren adult and young population sizes correlated negatively with beetle damage, and song sparrow reproductive success correlated negatively with combined cumulative pest damage.

Landscape change and avian community shifts

Pacific Northwest forests have become increasingly fragmented since European settlement as land use has changed towards agriculture and development. Silvicultural practices have changed the characteristics of natural Pacific Northwest forests and it is quite possible that this has resulted in increased avian diversity. The mosaics of uneven aged stands are more heterogeneous than they would be if only natural disturbances were operating. It is likely that species which prefer more open woodland or successional habitats are now more widespread and numerous than they were a century or so ago.

Natural succession may also bring about shifts in avian communities. A well-developed successional habitat that is not the expected climax community might succeed to young woodland capable of supporting successful breeding among several species. Eventually, succession will increase the effective core area of adjacent forested patches by enlarging them, or by effectively filling gaps between forested patches. However, managers need to consider whether management of those areas should be continued in order to conserve the early- and mid- successional bird communities, or whether the subsequent regeneration of forest better benefits forest species of concern.

Source-sink population dynamics and demographic monitoring

High densities of adults in a habitat do not necessarily indicate healthy population dynamics. Because of confounding effects of population sources and sinks, information on presence/absence or even relative abundance or population size can provide misleading indicators of habitat quality (Van Horne 1983, Pulliam 1988). Both song sparrow and Lincoln’s sparrow adult populations exhibit negative relationships with the area of grassland, but reproductive success correlates positively with the area of grassland. This suggests that the larger patches of grassland are populated by lower numbers of adults that produce more young per capita than populations inhabiting limited grassland habitat. A similar relationship exists for “western” flycatcher adults and reproductive success as functions of the core area of successional habitat.

Concerns and caveats relating to spatial datasets

Clearly, the species-landscape models presented in this study provide cost-effective and useful management tools for some species. However, several problems exist that may affect the accuracy of these models. One problem of the spatial analyses presented here is that the NLCD dataset represents a snapshot of landscape patterns that existed in 1992, at the beginning of this study. We must assume that in the meantime landscape alteration and succession have occurred. Indeed, data from several installations suggested that an avian community shift, consistent with a pattern of natural succession, occurred. When the NLCD 2001 dataset becomes available, we will be able to document changes that occurred since 1992 in the patterns of each landscape. These changes may have been caused by natural phenomena or by human activities such as development, logging, reforestation or changes in management regimes. For instance, curtailing grassland management might have resulted in shrub invasion and a corresponding change in the relative abundance of different bird species. Likewise, abandoned agricultural land that previously supported few species may have become capable of supporting an oldfield community and providing foraging opportunities for adjacent shrubland specialists. Relating demographics to land use changes will allow us to refine these models.

A second problem is that the National Land Cover Dataset is based upon spectral analyses of remotely sensed Landsat 30m resolution cells and the predominance of land cover classification (vertical resolution) within that cell. Thus, although the cell may be predominantly covered by vegetation that resembles trees, there may be gaps between those trees. NLCD documentation defines forest cover as "*Areas characterized by tree cover (natural or semi-natural woody vegetation, generally greater than 6 meters tall); tree canopy accounts for 25-100 percent of the cover*." Considering that the diameter of an average tree crown varies from 5 to 10m, this means that managed forested parkland could be classified the same as open natural/semi-natural woodland or mature forest. The avian communities of these habitat types might differ considerably.

More seriously, the NLCD documentation associated with state coverages describes possible confusion among clear-cuts, regrowth in clear-cuts, forested areas, and shrublands, as well as between certain row crops, and “leaves off” sensing of recent clear-cuts. Without intensive ground-truthing surveys and manual correction, these problems will persist in these data. In this report, we grouped transitional barren cells with shrubland and non-natural woody (e.g. orchards) classification because, according to the NLCD documentation, “the majority of pixels in this class correspond to clear-cut forests in various stages of regrowth”. We decided that, functionally, such coverage is more similar to shrubland than to any other classification.

Canopy closure, while beneficial to some species tends to cause the understory to thin out or disappear, which creates habitat less suitable for those species that prefer to forage and nest in the understory. The National Land Cover Dataset (1992) does not discriminate between open forest/woodland and dense, mature forest with a closed canopy. The MAPS program provides an effective monitoring strategy for many species that nest and forage in the understory of mid- to late-successional forest, but the shortcomings of the NLCD data described here will inevitably lead to unexplained variation in species-landscape models constructed in this way.

The USFS canopy cover GIS layer does provide estimates of canopy closure but does not discriminate between different kinds of forest type. Unfortunately, for some stations this layer does not superimpose exactly upon the NLCD cover layer because it was provided by USFS as a UTM coordinate based layer that had been converted to geographic (latitude-longitude) coordinates upon which the MAPS locations could be mapped. However, the strong relationships between USFS canopy cover-based layers and demographics make ecological sense. As mentioned earlier chestnut-backed chickadee reproductive success is driven by the core area of low canopy cover forest. Several song sparrow demographics are determined by low canopy cover forest and MacGillivray’s warbler demographics show positive relationships with low and medium canopy cover forest but negative relationships with high canopy cover forest.

How seriously do these problems affect the value of the models presented here? Without extensive, expensive ground-truthing this question cannot be answered. One might argue that misclassifications (e.g. between shrubland and forest) work in both directions and therefore by analyzing a sufficient number of large areas they should cancel out. On the other hand, in some areas the misclassification may be unidirectional and consistent due to the spectral signature of a particular species. For example, a consistent and possibly spatially extensive misclassification may occur in a landscape covered by a dense shrubland in which a dominant species spectrally resembles a woodland or forest. Visual inspection of the landscapes surrounding MAPS stations, however, did not reveal such spatially extensive anomalies given our knowledge of those areas. Nevertheless, some small scale errors were noticed in some landscapes.

Monitoring, management, and further research

This document proposes a reorganization of the Washington/Oregon USFS-funded MAPS stations. Some stations will remain as control stations that monitor acceptable numbers of species of management concern. Other stations will be relocated to better monitor those species and a third group might become subject to management in the vicinity of the station to improve habitat quality for species of management concern. Unfortunately, it is difficult to direct federal forest management to the vicinity of existing MAPS stations without the cost and time of preparing environmental impact statements, unless those actions are already proposed and approved. Therefore, for those stations identified as targets for management in this report, we intend to consult with the appropriate district silviculturists concerning any opportunities to thin vegetation (or implement other management) in areas within or adjacent to the station boundary. If this is not possible then we intend to move stations to areas where management actions have already been implemented, or are set to be implemented in the near future.

In order to relocate selected MAPS stations it will be essential to obtain updated land cover maps for each forest and identify areas in which recent management might benefit a species of management concern. Subsequently, by placing a MAPS station in the vicinity we can monitor future demographic changes resulting from management. To assess the effectiveness of the management we will compare these changes with the predictions of our models. Furthermore, to obtain information more quickly we should adopt a space-for-time substitution whereby new stations will be located in areas of different post-treatment age (e.g. one year post clearcut, three years post clearcut, and five years post clearcut.). In this case, after only four years we will have information spanning nine years of successional change.

Future monitoring and research

Future landbird monitoring efforts on Pacific Northwest national forests should focus on the effects of land management on species of conservation concern that are declining across individual forests or ranger districts. Ideally, the network of MAPS stations should be extended to embrace other species of concern for which monitoring data are currently insufficient to construct landscape models (e.g., dusky flycatcher). Future efforts should also include the adoption of an adaptive management approach, whereby appropriate management is encouraged in the vicinity of some existing MAPS stations, or stations are moved to areas where appropriate management is on-going or imminent. These new or existing stations will monitor the effectiveness of the nearby management in improving the health of local populations of target species of management concern. A number of other existing stations should be maintained in areas free of new management to provide long-term background data and to control for the confounding effects of weather.

Future research should also be directed at a number of ecological issues in Pacific Northwest national forests. For instance, our results suggest that grazing activity suppresses reproductive success. Investigations of the effects of grazing exclusion on demographics of species that nest in riparian shrub habitat should be conducted. Furthermore, existing data may allow us to document avian community changes following pest outbreaks around many stations.

Furthermore, the research reported here has revealed important species-landscape relationships, however, other research stemming from Pacific Northwest MAPS data show that climate and weather strongly influence avian demographics across the region (Nott et al. 2002). We can assume that since 1992 the influence of weather patterns and forest management have changed the landscapes used in this study. Thus, it is essential to map temporal changes in land use, vegetation health, and a suite of environmental variables in an attempt to explain the remaining spatial variation in the species-landscape models. Vegetation phenology, length of growing season, and net primary production resulting from climatic changes and variability can be obtained from time series NDVI (Normalized Difference Vegetation Index) data from optical satellites such as AVHRR (Advanced Very High Resolution Radiometer) and MODIS (Moderate Resolution Imaging Spectro-radiometer) from early 1980s to present (Myneni et al., 1998; Tucker et al. 2001).

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