# A MANAGEMENT HANDBOOK FOR NONGAME BIRDS
## from the BBIRD (Breeding Biology Research and Monitoring Database) program

Penn Lloyd, Thomas E. Martin, Melissa M. Hart, Ronald D. Bassar and Roland L. Redmond
USGS Biological Resources Division, Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, MT 59812

Effective management of forested habitats for the persistence of forest-dependent bird populations requires an understanding of (1) the environmental and demographic causes of population problems; (2) the habitat requirements necessary for sufficient reproductive success and survival to ensure population maintenance; (3) how demographic and habitat factors interact to create population sources and sinks; and (4) how forest management practices may impact on the above.

The habitat requirements of species are most often determined by correlating bird abundance with features of occupied habitat. Such indirect methods might not identify appropriate features for management efforts, given that they do not directly quantify how different habitat features influence reproduction and survival, the two demographic factors that ultimately regulate bird populations (Martin 1992). Thus, practical management is better served by additional knowledge of the minimum levels of nesting success required to ensure population maintenance, and how nesting success may be influenced by habitat features.

The nesting success of most North American land birds is influenced primarily by the negative effects of nest predation and, for some species, brood parasitism by the Brown-headed Cowbird (*Molothurus ater*). The relative severity of these two sources of reproductive mortality is known to be strongly influenced by habitat features at a variety of spatial scales, from the small scale of the micro-habitat surrounding the nest site (Martin & Roper 1988; Larison et al. 2001), to the medium scale of, for example, distance from forest edge (Andren & Angelstam 1988; Burke & Nol 2000), to the large scale of landscape-level habitat configurations (Robinson et al. 1995; Tewsbury et al. 1999).

A number of studies have investigated the relationship between habitat features and nesting success at small and medium scales for individual species at usually single sites, but very few have investigated larger-scale influences. A notable exception is the study of Robinson et al. (1995), which quantified levels of nest predation and cowbird parasitism for nine species across a gradient of forest fragmentation spanning nine landscapes within six mid-western states of the United States. Furthermore, although regional variation in the relationship between habitat and nesting success is suspected on the basis of variation in the results of site-specific studies (Tewksbury et al. 1999), no study has examined regional variation in nesting success using a standardized methodology applied at multiple sites within regions. Yet, larger-scale habitat influences generally (1) have the greatest impact in altering population dynamics; (2) are more amenable to extrapolation across species and geographic locations; and (3) are more readily defined and translated into practical management objectives. Only a handful of studies, usually species- and site-specific, have attempted to estimate seasonal fecundity or the finite rate of population increase. Fewer still have related variation in these two critical parameters to variation in habitat features. Finally, although excellent species-specific reviews of breeding biology and habitat preferences exist in the form of the Birds of North America series, the information is not directly interpreted into specific management guidelines in a format useful for habitat managers.

This handbook is specifically directed at meeting the information needs of habitat managers and conservation planners by:

1. using the BBIRD program database to relate species-specific variation in nest predation, cowbird parasitism, seasonal productivity and finite rate of population increase to variation in habitat features at multiple spatial scales from the nest site (5 – 11 m radii around nests) to medium (1, 5 and 10 km radii around study plots) and large (50-100 km radii around study sites) landscape scales;
2. providing our best estimates (based on current data) of the target rates of nesting success and seasonal productivity needed to maintain self-sustaining populations, and identifying the habitat features that are required to meet these target rates;
3. Combining this information with a comprehensive literature review to outline a series of guidelines for the management of individual species in the context of current forest management practices and broad-scale conservation planning.

It is important to note that we focus very specifically on the relationship between habitat features and breeding success. The BBIRD database is not designed to address questions related to a species' breeding density or presence/absence in relation to habitat features. Thus, apart from brief summaries in the "Distribution and habitat preference" and "Effects of silviculture …" sections for each species, we do not attempt a comprehensive consolidation of the considerable literature that addresses the effects of habitat features, and particularly their alteration through forest management practices, on the presence/absence and breeding density of forest birds. Although such information is equally critical for successful management, it is beyond the scope of our review at the present time.

We have structured the handbook such that each species account begins with a summary overview of the species' breeding habitat, demography, target rates of nesting success to maintain viable populations, critical habitat features for management, and management guidelines. This overview is then followed by detailed text explaining the assumptions and results of the analyses using BBIRD data, and discussing these results in relation to existing literature relevant to the relationship between habitat features and breeding productivity.

### *Background to the BBIRD program*

The BBIRD program was initiated in 1992 to standardize data acquisition among researchers to allow replicated examination of breeding habitat requirements of nongame birds. The program's electronic database currently contains valid data on approximately 32,000 forest-bird nest records for breeding performance and associated habitat features at 400 plots within 30 sites distributed across the length and breadth of the continental United States (Figure 1). Within each site, between 1 and 33 plots, each incorporating an area of approximately 10-50 ha, are separated by distances of 1-50 km from one another. Study sites were not selected randomly within the United States, reflecting the opportunistic nature of the database. Individual contributing investigators selected sites and plots to meet the needs of their own research agendas, but used the standardized BBIRD protocol (see Martin & Guepel 1993) for collecting the nest data. In some cases, we combined the plots of more than one investigator into a single site if these plots were less than 50 km apart.

For the purpose of regional comparisons, we recognize four regions on the basis of major discontinuities in forest cover between regions (see Figure 1):

1. **West** - from Washington to Montana in the north, south to California and New Mexico (10 sites);
2. **Northern Midwest** – incorporating the states of Minnesota, Wisconsin and Michigan (6 sites);
3. **Southern Midwest** – incorporating the states of Missouri, Arkansas, Louisiana, Oklahoma and Texas (5 sites); and
4. **East** – from Ohio to Maine in the north, south to Mississippi and Florida (9 sites).

The locations of the study sites in each region, together with the years in which data were collected for each, are listed in Appendix 1. Although we include multiple sites within each region, there are some gaps in our coverage of forested landscapes across the United States, notably the southeast and Pacific northwest. Furthermore, Alaska and Hawaii are excluded from this assessment. Extrapolation of the results of the BBIRD assessment to these unrepresented areas should therefore be done with caution.

In addition to clutch size, nest success, nest predation and cowbird parasitism data, detailed data on habitat features were gathered at nest sites (5 m and 11 m radii circles centered on the nest – from a limited number of sites) and at differing landscape scales (1-150 km radii circles centered on plots or sites – from all sites). Landscape-scale habitat features and fragmentation indices were derived from the National Land Cover Dataset (NLCD) of the United States Geological Survey (http://landcover.usgs.gov/nationallandcover.html). The NLCD recognizes the following 21 different land cover types plotted at a 30x30 m pixel resolution:

- **1 Open Water**
- **2 Perennial Ice/Snow**
- **3 Low-Intensity Residential**
- **4 High-Intensity Residential**
- **5 Commercial/Industrial/Transportation**
- **6 Bare Rock/Sand/Clay**
- **7 Quarries/Strip Mines/Gravel Pits**
- **8 Transitional** - areas of sparse vegetative cover (<25% cover) that are dynamically changing from one land cover to another, often because of land use activities e.g. forest clearcuts, a transition phase between forest and agricultural land, the temporary clearing of vegetation, and changes due to natural causes (e.g. fire, flood, etc.).
- **9 Deciduous Forest** - areas dominated by trees (generally >6 m tall, constituting 25-100% of cover) where 75% or more of the tree species shed foliage simultaneously in response to seasonal change.
- **10 Evergreen Forest** - areas dominated by trees where 75% or more of the tree species maintain their leaves all year i.e. canopy is never without green foliage.

- **11 Mixed Forest** - areas dominated by trees where neither deciduous nor evergreen species represent more than 75% of the cover present.
- **12 Shrubland** - areas dominated by shrubs; shrub canopy accounts for 25-100% of the cover. Shrub cover is generally >25% when tree cover is <25%. Shrub cover may be <25% in cases when the cover of other life forms (e.g. herbaceous or tree) is <25% and shrub cover exceeds the cover of the other life forms.
- **13 Orchards/Vineyards/Other non-natural woody vegetation**
- **14 Grasslands/Herbaceous** - areas dominated by upland grasses and forbs. In rare cases, herbaceous cover is <25%, but exceeds the combined cover of the woody species present. These areas are not subject to intensive management, but they are often utilized for grazing.
- **15 Pasture/Hay**
- **16 Row Crops**
- **17 Small Grains**
- **18 Fallow**
- **19 Urban/Recreational Grasses**
- **20 Woody Wetlands** - areas where forest or shrubland vegetation accounts for 25-100% of the cover and the soil is periodically saturated or covered with water.
- **21 Emergent Herbaceous Wetlands.**

For our analyses, we grouped NLCD land cover types to recognize the following three land cover types of principal interest:
- **Forest** – includes cover types 9-11 and 20 above
- **Grassland** – includes cover types 14-15 above
- **Cropland** – includes cover types 13 and 16-18 above

We then extracted a number of landscape-level habitat metrics at three principal spatial scales:
- The forest patch within which individual study plots were embedded
- Local landscape - within radii of 1 km, 5 km and 10 km of each study plot center; and
- Broad landscape - within radii of 50 km, 100 km and 150 km of each study site center.

These landscape-level habitat features included:
- Patch area, patch core area, edge density, distance between plot center and nearest forest edge of any type, and distance between plot center and nearest agricultural edge (developed land cover type)
- Percent forest cover within fixed radius
- Percent grassland cover within fixed radius
- Percent cropland cover within fixed radius
- Percent developed cover within fixed radius (grassland, cropland, and other anthropogenic cover types)
- Mean forest patch size (all sizes) and mean forest patch size of patches >10 ha in area within fixed radius

- Mean core-forest patch size within fixed radius
- Mean edge density for forest within fixed radius
- The following indices of landscape structure within fixed radius: angular second moment (a measure of texture, ranging from 0.0 for a landscape with many cover types and little clumping, to 1.0 for a landscape with a single cover type); landscape aggregation index (ranges from 0.0 when habitat patches are narrow in one direction and long in another, to 1.0 when the landscape consists of a single square habitat patch); contagion (a measure of the degree to which cover classes are clumped into patches – large values arise from landscapes that are predominantly made up of a few cover classes, whereas small values arise from landscapes that are made up of many different cover classes in approximately equal proportions); landscape edge density (total edge length involving all cover types divided by the total landscape area); landscape fractal (double log) dimension (ranges from 1.0 for landscapes made up of patches whose outlines are very regular, to 2.0 for landscapes made of patches whose outlines are very irregular); Shannon-Weaver diversity (a measure of landscape diversity – low values reflect a landscape dominated by a single cover class, whereas high values reflect a landscape that contains many cover classes in approximately equal proportions).

To determine which landscape-level habitat feature(s) and which spatial scale best predicted a relationship between habitat characteristics and each of nest predation rate, cowbird parasitism rate and finite rate of population increase, we used a multiple regression approach. To meet the requirements of normality, percentile metrics were arcsine square-root transformed where necessary (Zar 1998). All continuous habitat variables were ln-transformed.

### *General assumptions for demographic analyses*

For multi-brooded species, the annual production of fledglings per female (*P*) was calculated using the following equations of Ricklefs and Bloom (1977):

$$\mathrm{P} = \mathrm{F} \times \mathrm{L}$$

where *F* = expected rate at which young are fledged in a large population (young fledged/pair/day) and *L* = the length of the laying season (days).

The length of a species' laying season (*L*) was estimated from the number of nests initiated each week using the MacArthur index (MacArthur 1964; Ricklefs 1966):

$$L = 7\exp\left(-\sum p_i \log_e p_i\right)$$

where *e* = base of natural logarithms, $p_i$ = proportion of clutches laid by a population during week *i*. The number of weeks of clutch initiation is multiplied by 7 to give the number of days during which clutches are initiated. Because the timing and length of the laying season likely varies with latitude, laying season length was calculated independently for each of the following latitude zones if there were at least 100 nest initiation dates for a zone: (1) 30-35°N; (2) 35-40°N; (3) 40-45°N; and (4) 45-50°N. When more than one laying season length was calculated for a species distributed across these latitude zones, the average of these values was used in the calculations of annual production for each site. We used this average for two reasons. Firstly, this approach is preferable to an estimate based on pooling all the data, as the latter tends to overestimate laying season length. Secondly, we were primarily interested in relating annual production of fledglings to habitat features, so did not want to complicate the analyses by introducing an additional source of variation in annual production between sites (from usually minor differences in laying season length) that was unconnected to habitat.

The rate at which young are fledged (*F*) is calculated by:

$$F = C \times S \times I$$

where *C* = clutch size, *S* = breeding success (proportion of individuals that fledge), *I* = rate of nest initiation (clutches/pair/day). The rate of nest initiation is calculated by an equation that takes into account rate of nest failure, rate of nest success, and intervals between nestings:

$$I = \frac{m}{p_f + m(p_s r_s + p_f r_f)}$$

where *m* = nest mortality rate (proportion of nests failing per day), $p_s$ = probability that a nest successfully fledges at least one young, $p_f$ = probability that a nest fails before fledging ($p_f = 1 - p_s$), $r_s$ = delay before a new clutch is laid after successful fledging (days), $r_f$ = delay before a new clutch is laid after nest failure (days). Nesting success ($p_s$) and daily nest mortality rate (*m*) were calculated using the method of Mayfield (1975).

For single-brooded species, the annual production of fledglings per female (*P*) at each site was calculated using a simple, individual-based model (one million simulations) with the following rules:

1. All individuals begin laying on day 1 of the laying season (*L*)
2. Nests fail with a probability equal to the site-specific daily mortality rate (*m*) each day
3. Nests that survive the length of the nesting period fledge the average number of young per successful nest for that site
4. All individuals whose nests fail relay after $r_f$ days (delay before a new clutch is laid after nest failure), unless the end of the laying season (*L*) has been reached
5. All individuals that fledge one nest do not initiate a second brood.

The finite rate of population increase (λ) was calculated as:

$$\lambda = P_A + P_J \beta$$

where $P_A$ is the probability of annual adult female survival, $P_J$ is the probability of juvenile female survival from fledging to the following breeding season, and β is the production of female fledglings per pair per breeding season (Pulliam 1988). We made some assumptions (detailed for each species) about the lengths of periods between re-nesting attempts and annual survival rates based on the best available data.

***Caveats – PLEASE NOTE***

The data and completeness for each species account will vary with data availability, with a complete absence of data for some species. The data absences will be useful for identifying high priority future research needs in addition to those obtained in our analyses and such as described in this first species account. In addition, we are working on developing an interactive dynamic web site with Cornell Lab of Ornithology. This web site will allow land managers to access the database to obtain any newly added or updated data and to examine data with respect to clutch size, nest success, nest predation and cowbird parasitism rates in a dynamic, interactive context; the user will be able to use pull-down lists to grab species of interest at sites of interest and obtain metrics by year, by habitat, by site, by species or any combination thereof that is of interest. This interactive web site is expected to be fully functional and operational by the end of summer 2002.

APPENDIX 1: BBIRD study site locations within each region, together with the years in which data were collected.

**West region:**

1. Priest Lake (north-western shore), Idaho (1992-1995)
2. Payette National Forest, Idaho (1994-1996)
3. Snake River (South Fork), Idaho (1992-1994)
4. Lolo National Forest (Henry Peak), Montana (1997-1999)
5. Chamberlin Creek (south-west of Ovando), Montana (1997-1999)
6. Bitterroot – includes Bitterroot Valley, Montana (1995-1998); Ward Mountain, Montana (1997-1999); Selway Bitterroot Wilderness Area (Warrior's Face), Idaho (1997-1999)
7. Sierra National Forest, California (1995)
8. San Bernadino National Forest (south of Big Bear Lake), California (1992-1993)
9. Coconino National Forest (Mogollon Rim), Arizona (1996-2001)
10. North-western Colfax County, New Mexico (1992-1996)

**Northern Midwest region:**

1. Chippewa National Forest, Minnesota (1992-1998)
2. St Croix River Valley, Minnesota (1991-1993)
3. Upper Mississippi – includes the floodplain and adjoining forests between Winona and Prairie du Chien, Minnesota, Wisconsin and Illinois (1996-1998), and the surroundings of Preston to Houston, south-eastern Minnesota (1997)
4. Chequamegon National Forest, Wisconsin (1991-1993)
5. Nicolet – includes Nicolet National Forest (1996), Northern Highland State Forest, E of Boulder Junction (1996), and Lola (between Forest Lake and Mamie Lake), Wisconsin (1997-2000)
6. Pewaukee Lake (north-western shore), Wisconsin (1997-1999)

**Southern Midwest region:**

1. Columbia, Missouri (1991-1996)
2. Ozarks (north-west of Van Buren), Missouri (1991-1995)
3. Ozark National Forest, Arkansas (1991-1993)
4. Ouachita National Forest, Arkansas (1993-1995)
5. White River National Wildlife Refuge (1996-1999)

**East region:**

1. Mount Mansfield and Lake Emerald State Park, Vermont (1992-1996)
2. Cayuta Lake and Finger Lakes National Forest, New York (1992-1993)
3. Northern Ohio (1993-1995; 1997)
4. Western Maryland (Environs of Washington D.C. to Annapolis: 1993-1995)

5. NW Monongahela - North-western Monongahela National Forest (1993-1998) and Westvaco Wildlife and Ecosystem Research Forest (1996-1998), West Virginia
6. SE Monongahela - South-eastern Monongahela National Forest, West Virginia (1997-1999) and George Washington National Forest, Craigsville, Virginia (1996-1999)
7. Nantahala National Forest, North Carolina (1992-1994).
8. Wayne National Forest, Ohio (1992-1996)
9. Hoosier National Forest, Indiana (1991-1997)