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METHODS FOR EVALUATING WETLAND CONDITION

#13 Biological Assessment Methods for Birds

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#13 Biological Assessment Methods for Birds

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Notice

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http://www.epa.gov/ost/standards

http://www.epa.gov/owow/wetlands/bawwg

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Foreword

In 1999, the U.S. Environmental Protection Agency (EPA) began work on this series of reports entitled *Methods for Evaluating Wetland Condition*. The purpose of these reports is to help States and Tribes develop methods to evaluate (1) the overall ecological condition of wetlands using biological assessments and (2) nutrient enrichment of wetlands, which is one of the primary stressors damaging wetlands in many parts of the country. This information is intended to serve as a starting point for States and Tribes to eventually establish biological and nutrient water quality criteria specifically refined for wetland waterbodies.

This purpose was to be accomplished by providing a series of "state of the science" modules concerning wetland bioassessment as well as the nutrient enrichment of wetlands. The individual module format was used instead of one large publication to facilitate the addition of other reports as wetland science progresses and wetlands are further incorporated into water quality programs. Also, this modular approach allows EPA to revise reports without having to reprint them all. A list of the inaugural set of 20 modules can be found at the end of this section.

This series of reports is the product of a collaborative effort between EPA's Health and Ecological Criteria Division of the Office of Science and Technology (OST) and the Wetlands Division of the Office of Wetlands, Oceans and Watersheds (OWOW). The reports were initiated with the support and oversight of Thomas J. Danielson (OWOW), Amanda K. Parker and Susan K. Jackson (OST), and seen to completion by Douglas G. Hoskins (OWOW) and Ifeyinwa F. Davis (OST). EPA relied heavily on the input, recommendations, and energy of three panels of experts, which unfortunately have too many members to list individually:

- Biological Assessment of Wetlands Workgroup
- New England Biological Assessment of Wetlands Workgroup
- Wetlands Nutrient Criteria Workgroup

More information about biological and nutrient criteria is available at the following EPA website:

http://www.epa.gov/ost/standards

More information about wetland biological assessments is available at the following EPA website:

http://www.epa.gov/owow/wetlands/bawwg

List of "Methods for Evaluating Wetland Condition" Modules

Module # Module Title

Summary

Birds potentially detect aspects of wetland landscape condition that are not detected by the other groups commonly used as indicators. Moreover, birds are of high interest to a broad sector of the public. When using birds as indicators, one must pay particular attention to issues of spatial scale. This requires an understanding of home range sizes of the bird species being surveyed. The development of wetland and riparian bird indices of biological integrity is still in its infancy, but holds considerable promise.

Purpose

This module is intended to suggest study designs and data collection procedures that might be used when constructing and testing a regional index of biological integrity, using birds as indicators.

Introduction: Why Survey Birds?

- The public notices birds and often becomes concerned when they die or disappear.
- Birds can indicate the integrity (health or condition) of a landscape in addition to the integrity of individual wetlands. Assessing integrity of landscapes (watersheds or other areas many square miles in size) is vital to assessing the cumulative effects of human activities.
- Most birds are easy to survey: there is no need to collect and analyze samples or struggle with complex taxonomic keys.
- A relatively large pool exists of interested data collectors, many of whom are proficient at bird identification or can be trained. They often are eager to help with surveys, sometimes on a volunteer basis.

What Can a Bird IBI (Index of Biological Integrity) Tell You?

In contrast to chemical monitoring, a bird IBI can tell you, simply and directly, the condition of living systems at a site (an individual wetland) or in a landscape of interest. Such knowledge is more direct and more integrative than information merely about a site's contamination status. A well-conceived, adequately validated bird IBI considers a whole host of natural and human environmental influences to indicate if a landscape is currently supporting an integrated and adaptive biological system. Such an index is of practical use in several contexts:

- *Protection Priorities, Cleanup Priorities, and Section 305(b) Reporting:* Are wetlands in watershed "X" generally more degraded by human alteration than those in watershed "Y"?
- *Restoration Progress*: Have efforts to restore wetlands A, B, and D succeeded in establishing representative bird communities?
- *Trends*: Over a multiyear period, are we maintaining or improving the biological quality—not just the quantity—of our region's wetlands?

Though not a panacea, IBIs do embody the concept that biological condition, as represented by bird species composition and species characteristics, can reflect the *relative* degree of human alteration. When used together with other assessment tools, IBIs simplify and summarize complex biological information so it can be understood and used more readily by resource managers.

The development of wetland and riparian bird IBIs is, unfortunately, still in its infancy. Thus information in this module is based mainly on a healthy dose of ecological theory, monitoring experience, and just a few studies (notably O'Connell et al. 1998, Rottenborn 1999, Richter and Azous 2001). In contrast to the few IBI-oriented studies of birds, agencies have eagerly supported the development and testing of regional IBIs for fish and stream invertebrates for over 15 years.

What Does a Bird IBI Estimate?

Collectively, birds are sensitive both directly and indirectly to a variety of environmental influences (Adamus and Brandt 1990):

- Vegetation extent, pattern, and structure, especially woody and robust herbaceous vegetation (Finch 1991)
- Water extent, depth, duration, and seasonal frequency (Wakeley and Roberts 1994)
- Salinity (Halse et al. 1993)
- Water quality, i.e., nutrient loads, anoxia, water clarity, acidity, contaminants, sedimentation (Hoyer and Canfield 1994, Rushton et al. 1994, Savard et al. 1994)
- Disturbance by traffic, persistent human visitation, and associated predatory animals (Craig and Barclay 1992, Reijnen et al. 1995, Miller et al. 1998)

It is not always possible to establish with certainty which of the above (or other) environmental influences is causing a bird IBI to have a low value. A bird IBI usually cannot prove cause-effect connections. However, once general impairment has been established using an IBI, more intensive studies may be desired to diagnose specific causes. Moreover, in many situations it is not necessary to define specific causes of impairment. Birds are valuable as an indicator precisely because they are integrators of the cumulative effects of multiple environmental influences in a landscape. For example, based on regionwide surveys, one study (O'Connell et al. 1998) quantified regional landscape integrity in avian terms as follows:

> Among other distinct characteristics, a significantly greater percentage of the species observed at these [highest quality] sites are insectivorous, forage in decaying tree bark, and migrate from distant wintering grounds, than those observed at other sites. This partial profile tells us these habitats support upper levels of the food chain, trees in advancing stages of age and decay, and songbird species with continental range. As such, these habitats exhibit important functional, structural, and compositional elements of biological diversity. At the other end of the spectrum, 27% of the survey sites exhibited low ecological integrity. A significantly greater percentage of species observed at these sites are omnivorous, non-native, reproduce multiple times per season, and parasitize or prey on the nests of other birds. This is a classic profile of opportunistic behavior, and is observed in both plant and animal species when habitats are disturbed by human or other events.

Blue-winged Teal

Because many bird species are long-lived and migrate annually between continents, it is likely that the status of some species in a particular area may be influenced as much or more by the conditions in their wintering or summering areas as by the conditions in the study area (Finch and Stangel 1993). However, this factor's effect on a bird IBI may be lessened by surveying a sufficient number of sites throughout a region during IBI development.

The boundaries of the "landscape" whose condition is being represented by a bird IBI will depend on characteristics of the particular bird species that are present (Hansen and Urban 1992). For example, bird IBI values for a site inhabited mostly by particular small, strongly wetland-dependent birds that wander little during the breeding season (e.g., rails, some sparrows) may reflect more the condition of the particular site than the condition of surrounding uplands,that is, the broader landscape. The opposite is true for sites inhabited mostly by particular large birds that wander greatly (e.g., raptors, shorebirds, waterfowl). Thus, in most instances, a bird IBI should be segregated into components that reflect these two (or more) scales. Alternatively, the IBI should use data only from species that characterize a particular scale, so that the area (or species group) whose integrity the IBI is representing is clear to users.

Steps in Developing an IBI for Birds

1 Within an ecoregion (a region of generally similar physiography, land use, and climate) decide on what basis you will group (classify) wetlands into types (classes). Wetlands may be classified based on vegetation, water regime, or a host of other factors. Choose the factor(s) that best account for the naturally occurring, within-class variability in bird species composition. To accomplish this, consider using the classification of Cowardin et al. (1979, as used on National Wetland Inventory maps), Brinson (1993, the hydrogeomorphic or HGM classification), or others described in the *Classification* module. Then focus your sampling on one class, for example, flow-through riverine wetlands dominated by woody vegetation. The more narrowly you define your target class, the more likely you are to find effective bird metrics (because you have constrained natural variability). However, the utility of the resulting metrics will be limited because they address only that one class.

2 Identify at least 10 sites of that class that seem potentially to be the *most* altered[1] by humans, 10 that seem the *least* altered, and 10 with a potentially intermediate condition (these numbers are arbitrary and it is not essential that they be equal or that 30 sites be selected). Eliminate from further consideration sites that cannot be accessed because of ownership restrictions or hazards. In some situations it may be possible to predict fairly precisely the number of sites that need to be surveyed by using prior estimates of spatial and temporal variability from

[1] The criteria for prejudging which sites are least or most altered necessarily will be subjective, and it may be helpful to prepare and apply a standardized, semiquantitative checklist for systematically evaluating potential impacts at all candidate sites (e.g., Bryce et al. 1999). The inventory of alterations should include indicators of human disturbance thought most likely to have an impact on birds, for example, densities of houses and roads, proximity to houses and roads, percent of land that is nonvegetated or mowed lawn; and habitat patch area, perimeter-area ratio, width, and connectivity to similar patches (Robinson et al. 1995, Miller et al. 1997, Germaine et al. 1998, Helzer and Jelinski 1999). See the *Developing Metrics and Indexes of Biological Integrity* module for further information on characterizing alteration.

similar wetland types in the same region. For some wetland bird metrics, such variance estimates are compiled in Adamus and Brandt 1990 (Tables 15 and 16 of that report) and Adamus 1996 (Appendix N of that report). Visit the selected sites to confirm the accuracy of the ecological classification and apparent alteration.

Alternatively, you may select fewer sites but collect data both during prealteration and postalteration years (e.g., Richter and Azous 2001). Occasionally, it may be feasible to analyze existing databases to identify assemblages of species that are most sensitive to particular types of alterations (e.g., Burdick et al. 1989). For example, if you are aware that economic, legal, or policy factors resulted in a surge in wetland drainage, wetland restoration, landclearing, or construction in a particular county between 1985 and 1990, you might determine if Breeding Bird Surveys (BBS) or Christmas Bird Counts (CBC) were conducted in the county before, during, and after that period (this determination can be made by visiting <http://www.mbr.nbs.gov/bbs/bbs.html> for the BBS data or <http://birdsource.tc.cornell.edu/cbcdata/> for the CBC data). If so, you may be able to download the data and look for trends in individual species and species groups, being careful also to examine the possibility that apparent trends might be the result of interannual changes in the level of precipitation, the observers involved, the survey date, or other factors (Sauer and Droege 1990). From such a review, you may be able to characterize species as "adapters," "exploiters," or "avoiders" (Blair 1996) and then use these designations as bird metrics in a multimetric index to be tested at other sites.

3 Conduct equal-effort surveys of birds, applying the same methods to all chosen sites (see *Field Survey Protocols*, below).

4 During at least one site visit, estimate the extent and condition of structural attributes, both within and around the wetland, that potentially constitute habitat for most expected species (Morrison et al. 1998). If unsure, consult with local birders and ornithologists. Attributes likely to be particularly important are the acreages of standing open water (permanent as opposed to seasonal); woody vegetation (riparian as opposed to upland and various age classes), cropland, and unmanaged fields; proximity to similar wetlands and other natural habitats; the cumulative length of roads, ditches, and streams; presence of fish; and the number of residences and vegetation strata (layers) (Craig and Beal 1992, Lovvorn and Baldwin 1996, Weller 1999). These features should be assessed both within the site and, if possible, through aerial imagery in concentric zones at various distances from the site, up to perhaps 1 mile away. Distribution of surface water should be assessed during both wet and dry seasons whenever possible. Suggestions for assessing many habitat features is provided by Bookhout (1994).

5 From the collected data, identify species and groups of species whose attributes (e.g., presence, abundance, frequency) are clearly skewed towards the most—or least—altered sites, or identify the years with most and least alteration. Do not rely too heavily on statistical correlation; more important is the presence or absence of particular species or groups exclusively at either the least or most altered sites. Also important is the proportional distribution of abundances of species at these sites (i.e., bird community "evenness"). When only one or a few species dominate a site numerically, it sometimes indicates broader degradation of the site's ecological systems. Such a diagnosis depends on the particular species and habitat type. See the *Developing Metrics and Indexes of Biological Integrity* module for further information on interpreting data.

Table 1: Candidate Bird Metric

Attribute	Hypothesized Relationship to Environmental Degradation
Frequency of occurrence of species that are insectivorous aerial foragers	decrease
Percent of species that are long-distance (e.g., Neotropical) migrants	decrease
Proportional abundance (%) of blackbirds and starlings	increase
Ratio of juvenile to adult-plumaged diurnal raptors	decrease
Cumulative frequency of occurrence of all regionally rare species	decrease
Number of species that typically feed on submersed aquatic vegetation	decrease
Proportional abundance (%) of the three most common species	increase
Frequency of occurrence of reputedly egg-predating or parasitizing species (e.g., corvids, cowbirds, marsh wren) (Rogers et al. 1997)	increase
Number of found species that have shown statistically significant declines in the region according to BBS data	decrease
Percent of found species that also are regularly present on >90% of the BBS routes in the same region ("core" species, Collins and Glenn 1997)	increase
Percent of the expected species (based on geographic range, wetland type, vegetated area, and other variables) that were found (e.g., "Avian Richness Evaluation Method" of Adamus 1995, "Index of Avian Integrity" of Schroeder 1996)	decrease
Genetic diversity among found species, as assumed from their phylogenetic relationships ("functional integrity," von Euler 1999)	decrease

6 Try creating "metrics" by pooling data from *groups* of species. Define the groups based on similar life history, home range size, or other behavioral or demographic characteristics (Croonquist and Brooks 1991, Mulyani and DuBowy 1993, Bournaud 1994, Weller 1995, Wiens et al. 1996). Metrics are attributes shown empirically to change in value along a gradient of human disturbance. Examples might include those shown in Table 1 (these are not comprehensive and most have not been validated). Analysis of data from mainly upland landscapes suggests that resident species may be less affected than migrants by habitat structure as measured at a landscape scale (Flather and Sauer 1996).

Be sure that candidate metrics do not, as a whole, imply that sites are in better ecological condition *only* because they are wetter, or have closed canopies. Some wetland bird species are naturally adapted to dryer sites or sites with no trees or no vegetation at all, as in the case of many shorebirds (Rottenborn 1996). Prolonged duration of inundation, or invasion by trees or even low emergents, actually may signal degradation of their associated wetland class. Thus metrics that express only species richness without accounting for the characteristics of the component species, and thus which may reflect only the area of habitat at a site and its natural structural complexity rather than ecological degradation (Findlay and Houlihan 1997, Warkentin and Reed 2000), may yield information that is less useful (Meiklejohn and Hughes 1999, Whitaker and Montevecchi 1999). Moreover, a variety of wetland types, regardless of their internal heterogeneity, is essential to supporting biodiversity at regional scales (Leonard 1994, Haig et al. 1998, Warnock et al. 1998).

7 Using data plots and statistical analysis, verify that the alteration category, rather than a wetland habitat feature such as acreage or seasonal duration of standing water, was associated strongly with the apparent affinity of some birds for most or least altered sites or years. If the alteration category is associated with species affinity, proceed to step 9. If not, go to step 8. This verification step is unnecessary if previously it was demonstrated that the correlated habitat feature's condition is governed entirely by human alteration. Ideally, it is best to examine the relationship of bird metrics to alteration category and habitat structure over a multiyear period (Gibbs et al. 1991, Wilson et al. 1998). Many good sources are available for planning and conducting a statistical analysis of data, for example, Verner et al. (1986), Ramsey and Schafer (1997), and Nur et al. (1999).

8 If your extensive review of data plots and statistical analysis results shows that no species or grouping of species has a consistent tendency to occur at the most or least altered sites, it may be because prolonged alteration has eliminated all sensitive species from the local landscape (Freemark and Merriam 1986). Or, it may be that human factors have not yet begun to affect local bird communities. Either possibility is impossible to prove. You will need to survey additional least-altered sites (if the first situation seems more likely) or additional most-altered sites (in the second situation). To identify these sites, you may need to expand the study region or broaden the wetland class you are examining and then repeat steps 6 through 8. You also will need to survey additional sites if the spatial distribution of all species and groupings seems related more to particular habitat features than to an alteration regime unrelated to these features. An appropriate classification of sites prior to sampling can avoid this situation. Alternatively, you may consider dividing the wetland class into habitat subclasses and calibrating separate IBIs for each (e.g., for shallow and deep wetlands). This, too, would require surveys at additional sites, so it is best to anticipate and address such factors during the study design phase, before beginning the surveys.

9 Propose a simple mathematical formula and try several ways of combining the metricsinto one or more "multimetric indices," after first standardizing each metric with respect to its numeric range. A multimetric index might consist, for example, of the sum of individual metrics such as (a) the number of species that are long-distance migrants and (b) the percent of total abundance consisting of aerial foraging species, divided by (c) the frequency of the European Starling. It is not necessary for the individual metrics to be logically or mechanistically interrelated as in classical ecological models, but alone they should have a relationship to human disturbance of wetlands that is supported at least by ecological theory and ideally by experimental data. Separate multimetric indices may be warranted for different measurement scales (site versus landscape) and different seasons, depending on the particular regional avifauna. Iterative experimentation and adaptation are important in identifying the most sensitive and consistently accurate indices. The best multimetric index will be one that responds most sensitively to the *human* disturbance gradient, independent of habitat conditions that are unrelated to alteration. A multimetric index that comprises at least six bird metrics, each measuring a unique type of avian response to human alteration, is most likely to show adequate sensitivity in future applications.

Applying a Calibrated Bird IBI

Once a bird IBI has been developed, or an existing bird IBI has been calibrated for local conditions, you will apply it during routine site assessments by conducting bird surveys at a probability sample of sites (e.g., a statistically random selection of accessible sites) whose degree of alteration is unknown. The surveys should be conducted using the same methods used when developing the bird IBI, and it may be possible at this point to conserve effort by focusing on a narrower range of species or species groups—those found during IBI development to be most reliable as indicators. Then organize the collected data according to the metrics in the bird IBI, and compare the site's values for these metrics with the range of regional values embodied in the bird IBI previously developed from multisite or multiyear data.

What to Measure

- *Abundance* of each species and number of species—appropriate for reconnaissance-level surveys (one-time visit)
- *Frequency of occurrence*, by species and season—if additional resources are available for more frequent surveys
- *Duration of wetland use* by individual birds—feasible only if professional biologists can distinctively band or otherwise mark individual birds, but potentially the most diagnostic attribute
- *Behavior* of individual birds (e.g., feeding, resting)—feasible only where nearly all individuals can be viewed

Many other features of bird populations can be indicative of wetland degradation, but they are not described here because their requirements for specialized equipment, skills, or time makes them unsuitable for use in routine regional-scale monitoring programs.

Field Survey Protocols

The following are recommendations based partly on accepted bird survey protocols from nonwetland habitats, for example, Ralph et al. (1993, 1995), Bibby et al. (1992), as well as some techniques applied specifically to wetlands (Ribic et al. 1999, Weller 1999). They have been tempered to reflect what we have learned so far from surveying wetland birds. These protocols will not apply equally well in all situations and will likely evolve as we learn more.

Birds in wetlands are best inventoried using area searches or point counts.

Area searches (also called "direct counts," Weller 1999) are appropriate for the parts of wetlands where visibility is unobstructed, such as open water areas, mudflats, and short-grass flats (e.g., Igl and Johnson 1997). Species are counted based on visual, not auditory, identification.

Point counts can include all habitats within a site and are especially appropriate where visibility is partly obstructed by trees, shrubs, and/or tall grasses. Species that are seen or *heard* are counted.

Area searches involve using a spotting scope or binoculars to scan the open area from one or more fixed points, generally viewpoints with the best visibility of the site and whose fields of vision do not overlap. Occasionally, area searches will involve canvassing an area by boat, aircraft, or by walking. Birds should be identified and counted until all individuals within the field of view have been tallied. The time required to complete the count should be recorded and the exact size (hectares) of the scanned area should be measured (e.g., from aerial photographs or field sketches). These estimates of area searched and time spent should be used as covariates in the statistical analysis, or less desirably, used to derive variables such as "birds per minutes searching" and "birds per hectares scanned." To facilitate later data interpretation, the search area (and associated data collection) may be subdivided into individual habitat types. Area searches may be used in wetlands of any size wherever views are unobstructed. They are not effective for surveying most songbirds, which constitute the majority of species in many wetlands.

Point counts also involve tallying birds from fixed points, but require the observer to identify all species by sound as well as sight. Standard protocols for terrestrial point counts specify that birds be tallied for 5 minutes at each point (some biologists prefer 10 minutes). Usually, no two points should be closer than 200 m to each other (Ralph et al. 1995). Thus the number of points allocated to any wetland will depend on wetland size. This requirement also implies that, if the objective is to sample only the wetlands and not the adjoining uplands, ideally, the wetlands must be no less than 8 acres in size (if perfectly round; much larger if not) in order to situate points more than 100 m from the wetland-upland edge.

Some researchers also recommend that observers estimate *distance* to each identified bird regardless of wetland size (Emlen 1971), or at least differentiate between individuals detected within 25, 50, or 100 m and those farther away (Hodges and Krementz 1996). This step may be particularly important if an IBI is to include abundance (density) metrics or if the species that are being surveyed differ greatly with regard to their ability to be detected.

Points may be located along a **transect** (e.g., Dickson 1978, Niemi and Hanowski 1984). With transects, birds detected while the observer was walking or canoeing between points usually are recorded as well. There is no technical or statistical advantage to using transects rather than point counts and area counts alone, and there are significant disadvantages. Using transects reduces the flexibility needed to situate points in the full range of hydrologic zones and vegetation strata within a wetland. Although some transect protocols allow for including individual birds observed between points, such observations must be analyzed separately from observations made at the points, because of the possibility of double-counting of individuals located closer together than the required 200 m separation distance.

Data from area searches and point counts should not be combined. Also, the need to situate point counts no closer than 100 m from the wetland-upland edge is a significant constraint. Researchers who use point counts in smaller wetlands sometimes include upland habitats as well (Smith 1998). Or they attempt to distinguish birds heard from within a wetland from those heard only from the adjoining upland and analyze just the within-wetland data. Surveys of small wetlands also are likely to result in encounters with few species: the usual tendency is for avian richness to increase with patch size. Low richness in wetlands that are very small or that have very simple vegetation structure can distort some of the candidate metrics, for example, calculating the percentage of bird species that are nonnative, when only two species are present. To mitigate this problem, during the data analysis phase it may sometimes be appropriate to analyze data only from sites that meet minimum thresholds for number of species and/or individuals.

Regardless of the methods chosen, all sites should be visited within a few-day period (no more than 1 week). Otherwise, changing weather and migration can make the data almost impossible to interpret correctly. If an IBI will be used later to monitor interannual changes in wetlands, it is preferable to use multiple years of field data to calibrate the IBI initially.

Unless you intend to survey the same microhabitat (e.g., herbaceous plants in permanently inundated areas) in every wetland, point counts and area searches should be used in a complementary manner to survey *each* of the following zones if they are present, accessible, and survey points can be separated by at least 200 m: (1) permanently inundated areas, (2) seasonally inundated areas, (3) areas saturated but seldom inundated. Secondarily, point counts should be located collectively so that they are within (or no more than 100 m from) each of the following vegetation strata (cover types), if present within a site:

- Herbaceous plant communities (aquatic or terrestrial) not under a woody canopy, if not already covered by an area search.
- Herbaceous plant communities (aquatic or terrestrial) under a woody canopy
- Shrub/vine stands not under a tree canopy if not already covered by an area search.
- Shrub/vine stands under a tree canopy
- Open-canopy stands of trees (both deciduous and coniferous)
- Closed-canopy stands of trees (both deciduous and coniferous)

For purposes of IBI development, within these three zones and six strata, points usually should not be located randomly, but rather in a manner that the investigator anticipates will yield cumulatively the most species. Often, this objective can be accomplished by strategically placing points between adjoining vegetation strata (Figure 1). However, if quantitative metrics (e.g., relative abundance) will be used later in multimetric indices, then random or systematic location of sampling or observation points within zones may be justified and a much larger number of samples will be necessitated.

When comparing sites (separate wetlands), data from the sites should represent equal effort. For example, it is inappropriate to make comparisons using seven survey points from a large site but only two survey points from a smaller site, or five visits to one site but only two to another during the same month. In such situations, compare the sites based on a single point or date chosen randomly from those at each site, or include a log of the area as a covariate in the statistical analysis. Alternatively, you might select from each wetland the point or date you found to have the highest counts of birds, or a point believed to be of exactly the same habitat type in all the surveyed sites. Such practices are not recom-

Black Rail by Thomas J. Danielson

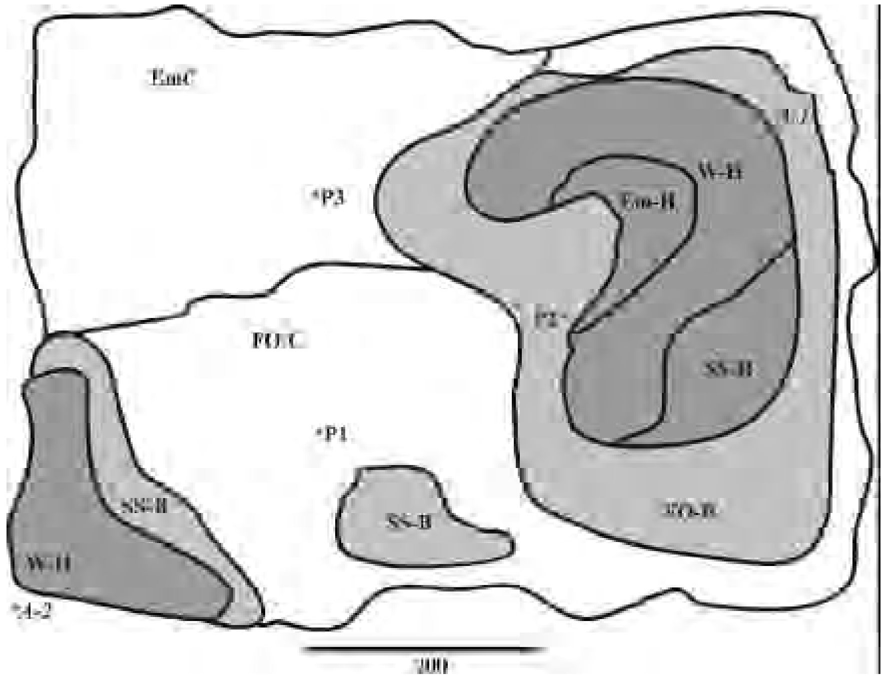

Figure 1: A strategy for locating bird point counts and area counts in a diverse wetland.

Point counts (P1, P2, P3) must be located no closer than 200 m from each other, and preferably at least 100 m from the wetland-upland edge, so point counts cannot be used effectively unless the wetland is at least 8 acres (if round, much more if narrow). They should lie within (preferably) or within 100 m of each of the major hydrologic zones (H = permanently inundated; B = seasonally/ semipermanently inundated; C = saturated only) and each of the major vegetation strata (FO = forest; SS = shrub/scrub; Em = emergent). Point counts are primarily intended to survey passerine species.

Area counts (A1, A2) should be located at the best vantage points for surveying birds on all bodies of open water (W-H) as well as in permanently inundated stands of emergent vegetation within the site. Area counts are intended to survey only the most visible waterbirds (e.g., ducks, herons, shorebirds). Area counts need not be a specific distance apart, so long as observers avoid overlapping the visual count areas. Area counts may be located next to point counts or in adjoining uplands. Abiding by these constraints and considering physical access, observers should attempt to survey as many point counts and area counts as can be fit into a wetland site.

mended for use when statistical confidence is needed from monitoring a probability sample of wetlands, but they may be acceptable in some situations involving IBI development and testing.

If possible, sites in a multiwetland survey should be visited all on the same day, or on consecutive days, unless severe weather conditions intervene. Concentrated visits are necessary because, especially during migration, the numbers and species composition of bird communities shift on a daily or even hourly basis. At the very least, date and time of day (in standardized units) should be included as covariates in statistical analyses. Additionally, sites that are accessed all on the same day should be revisited in a different sequence on each successive visit.

Ideally, all sites could be visited monthly for an entire year and separate IBIs calibrated for each season. However, at a minimum, all sites should be surveyed at least twice per season, with at least 2 weeks elapsed between visits. If data can be collected during only one season, the breeding season (generally May-July) generally is a good time, because dispersal movements of most species are minimal then (Morrison et al. 1998). By detecting species at the same point during repeat visits, probable breeding often can be inferred (Vickery et al. 1992). The same observer should inventory all sites, at least during each survey period. If multiple observers must be used (as often is the case when volunteer birders are assisting), pretesting must verify that their skill levels, especially with regard to auditory-only recognition and identification of a wide range of expected species, are equivalent. If not, new observers should be recruited, or at the very least, "observer" should be included as a variable in any statistical analysis.

Species detection (especially of most songbirds) is greatest during early morning hours so surveys should focus on the 4 hours beginning at sunrise. Night-time coverage may be warranted not only for typically nocturnal species such as owls but also for waterfowl and wading birds, which use different wetland types for roosting and for feeding, especially during the hunting season (Anderson and Smith 1999). Secretive species (e.g., rails, some passerines) can be surveyed effectively by broadcasting tape-recorded calls of the secretive species. A protocol for doing so is described by Ribic et al. (1999). Also, during winter and other nonbreeding seasons, you can induce many species that otherwise do not vocalize then to reveal themselves by playing tapes of small owl, chickadee, and nuthatch calls (in alternating sequence). Counts during the hunting season (generally September-January) should be avoided or, if necessary, some estimation should be made of hunting intensity at each site.

If three points per wetland are surveyed, approximately 100 easily accessible wetlands in a local area or small watershed can be visited three times in a typical field season. Only a fraction of this number of wetlands need be visited to initially develop and calibrate a regional IBI for a single wetland class.

Least Bittern by Thomas J. Danielson

Research Needs

The IBIs that have been developed using fish, algae, and aquatic invertebrates have benefited from field testing in several regions of the world. Similarly, the development of operational IBIs using birds will require commitments to fund studies in several types of wetland landscapes. Such studies should examine spatial changes in bird communities across multiple wetlands that span gradients of identifiable human disturbance, as well as interannual changes in altered and unaltered wetland landscapes. The aim of the studies should be to establish which avian groups and attributes are most regionally suitable as indicators, and at which scales, because of their ability to sensitively distinguish anthropogenic from natural background conditions.

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