

An Objective Method to Determine an Area's Relative Significance for Avian Conservation¹

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Abstract

Land managers are often concerned with providing habitat that affords the “best habitat for songbirds.” However, unless management simply is directed at rare species, it may not be clear which habitats or management options are best. A standard, quantifiable measure to compare the significance of different tracts of land or competing management techniques for avian conservation would benefit managers in decision making. I propose a standard measure that is based on the relative density of each species within a finite area and their respective regional Partners in Flight concern scores. I applied this method to >100 reforested sites in the Mississippi Alluvial Valley that ranged in age from 2 to 32 years. The objectively determined avian conservation significance for each of these reforested sites was correlated with stand age and with my subjective assessment of “habitat quality.” I also used this method to compare the avian conservation significance of forested habitats before and after selective timber harvest. Sites with high significance for avian conservation provided habitat for species of conservation concern. I recommend application of this methodology to other sites, and areas under different management, to determine its usefulness at predicting avian conservation significance among habitats and at various avian densities.

Key words: avian habitat, conservation significance, objective assessment.

Introduction

Determining the relative significance of a tract of land for avian conservation is often subjective. If management is directed at a single species, differences in density or productivity of the target species can be compared among tracts and priorities of management

action set accordingly. However, often managers are not concerned with a single species but desire to manage habitat that will support a community of species. Even so, managers recognize that different species have different habitat requirements and therefore exhibit different responses to habitat manipulations.

Faced with many options, how can managers objectively evaluate various properties as to their contribution to avian conservation? Similarly, how can the response of many species to competing management scenarios be objectively compared? For example, suppose management actions result in a 20 percent increase in the density of species ‘X’ but a concomitant 30 percent decrease in the density of species ‘Y.’ Is this “good” or “bad” for avian conservation? Although total bird numbers declined, if the species that increased in density is of greater management concern, this decline in bird numbers may actually benefit avian conservation!

Criteria that can be used to evaluate the condition of avian habitat and to guide management decisions include observed estimates of species density and Partners in Flight (PIF) concern scores (Carter et al. 2000). Although density may not be indicative of habitat quality (Van Horne 1983), when contrasting avian response to different habitats within similar landscapes or on the same area under different management, it is likely that relative avian densities will reflect the relative value of the habitats or management techniques. Furthermore, reliable estimates of demographic parameters for all avian species on a given tract of land will rarely, if ever, be concurrently available, and density (or at least relative density) is measurable for most species.

Concern Scores as Conservation Ratings

Partners in Flight regional concern scores (<http://www.rmbo.org/pif/pifdb.html>) vary from 7 to 35 (low score = low vulnerability) for a given species based on vulnerability of that species, both regionally and globally, and their need for management action. Thus, species in any geographic area can be ordered from high to low score. But what is the relative scale of the relationship

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among avian concern scores? Should the relationship among these birds be linear, as indicated by their PIF concern scores or does their conservation rating vary relative to their PIF concern score?

If the relationship is linear, an increase of 5 “units of concern” would denote the same increase in conservation significance regardless of the actual concern score. That is, a species with a concern score of 15 would have 5 more units of concern than a species with a concern score of 10 and a species with a score of 30 would have 5 more units of concern than a species with a score of 25.

Within the lower range of concern scores (i.e., lower vulnerability), however, it is likely that the threats to these species are minimal. These species likely are abundant, widespread, and not declining. Generally, increasing the units of concern within this lower echelon of bird species should not engender dramatic changes in habitat management. Conversely, small increases in the units of concern for species with high concern scores (i.e., higher vulnerability) indicate further threats to already vulnerable bird populations. Thus, within the upper echelon of bird species, small increases in the units of concern should warrant a marked increase in management efforts.

Therefore, I suggest that the relationship among PIF concern scores when evaluating their application to conservation of habitats, is not linear but rather an exponential relationship. Within this relationship, each increase in unit of concern generates an increasingly inflated “concern rating” (*fig. 1*). Lower concern scores have corresponding “concern ratings” that are little different, whereas higher concern scores have corresponding “concern ratings” that are widely disparate.

Population Density

What is the optimal density for a given avian species? Obviously, not all species occur in all habitats. However, within appropriate habitats, does a linear increase in the density of a species connote a linear increase in its conservation significance? Even if a linear relationship holds for some range of densities, this is likely not the appropriate relationship at low or high densities. At low densities, at least a single breeding pair is essential for the population to replace itself. However, it is likely that several to many breeding pairs are needed to achieve a reasonable likelihood of sustaining the population (Reed et al. 1988). Thus, I’ve assumed that for avian conservation, the significance of a species’ territory density increases rapidly until this threshold is achieved. Beyond this threshold, I’ve assumed that all optimal territories are occupied and further increases in densities likely contribute little to the conservation

significance of the population. Assuming this asymptotic relationship, with a rapid increase in conservation significance until optimal density is achieved, I used a truncated logarithmic model to express the relationship between observed density and its adjusted density rating (*fig. 2*).

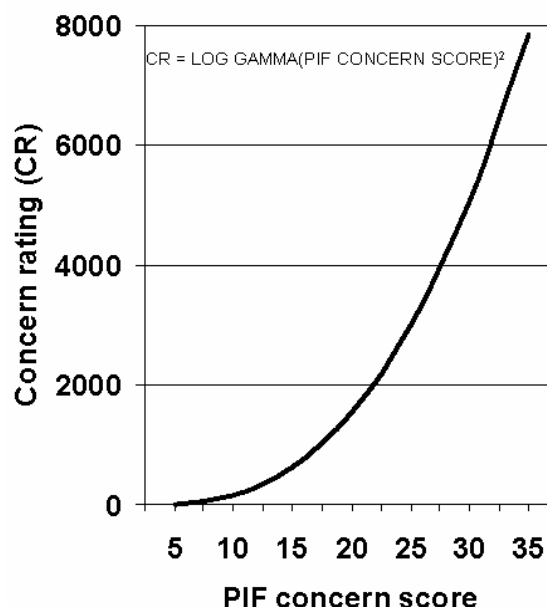


Figure 1—Relative concern ratings (CR), derived from the square of the logarithm of the gamma function [$\Gamma(x)$, SAS Institute Inc. 1985] of Partners in Flight concern scores used to calculate avian conservation significance (ACS) of avian habitat.

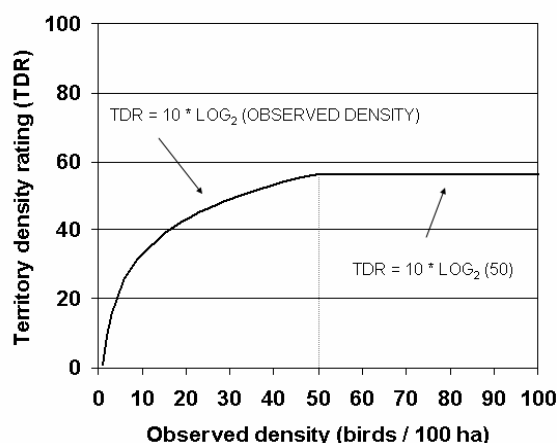


Figure 2— Territory density ratings (TDR) derived as 10 times the logarithm (base 2) of observed density (territories/100 ha) used to calculate avian conservation significance (ACS) of avian habitat. Peripheral or wide-ranging species that were detected, but at densities of <1 territory/100 ha, were assigned a territory density rating of 1.0. Densities were truncated at 50 territories/100 ha, thus species with >50 territories/100 ha were assigned a territory density rating of 56.4.

Calculating Conservation Significance

To calculate the “conservation significance” for each species, I used concern ratings (CR) that I determined from an “exponential type” relationship with PIF concern scores. Specifically, I used the square of the logarithm of the gamma function (SAS Institute Inc. 1985) of PIF concern scores (*fig. 1*).

I obtained territory density ratings (TDR) for each species from its logarithmic relationship with observed territory densities when expressed as birds per 100 ha. Specifically, I used 10 times the logarithm (base 2) of observed territory density when observed densities were ≤50 territories/100 ha. Territory density rating was truncated, and did not increase beyond that for observed densities of 50 territories/100 ha. I assigned a territory density rating of 1 to all species detected at densities of <1 territories/100 ha.

A measure of conservation significance for each species was obtained as the product of that species' concern rating and its territory density rating divided by 1000. The avian conservation significance (ACS) of a tract of land was obtained as the sum of these measures of conservation significance over all species (Equation 1).

$$ASC = \sum_{i=1}^n ((CR_i * TDR_i) / 1000) \quad \text{Equation 1}$$

for species $i = 1$ to n , where:

ACS = Avian Conservation Significance,

CR = Concern Rating derived from regional PIF concern scores as;

CR = $\text{LOG GAMMA}(\text{PIF CONCERN SCORE})^2$,

TDR = Territory Density Rating derived from observed territory densities as;

TDR = $10 * \text{LOG}_2 (\text{OBSERVED DENSITY})$, for observed densities of 1 to 50 territories / 100 ha.

Hypothetical Example

In a hypothetical comparison of two forest tracts, eight species, which held a combined total of 38 territories on each tract, were observed at densities that ranged from 0 to 12 (*table 1*). Using the truncated logarithmic model (*fig. 2*), I converted observed territory densities to territory density ratings (TDR, *table 1*). Similarly, using the exponential model (*fig. 1*), I converted PIF concern scores to concern ratings (CR, *table 1*). Using TDR and CR, I calculated a measure of conservation significance for each species and summed these values over all species (*table 1*). In this example, habitat unit A had a higher conservation significance (ACS = 298.6) than did habitat unit B (ACS = 245.3). Thus, the

Table 1—Hypothetical data on avian species, their Partners in Flight concern score, their transformed concern rating (CR), their observed density (territories / 100 ha), their transformed territory density rating (TDR), and the avian conservation significance (ACS) from two units of habitat, each with identical total avian densities. Species are listed in taxonomic order.

Common name	Scientific name	Concern score	CR	Observed density		TDR		ACS	
				Unit A	Unit B	Unit A	Unit B	Unit A	Unit B
Downy Woodpecker	<i>Picoides pubescens</i>	17	941	4	6	21.0	25.8	19.8	24.3
Acadian Flycatcher	<i>Empidonax virescens</i>	21	1792	10	4	34.2	21.0	61.3	37.6
White-eyed Vireo	<i>Vireo griseus</i>	23	2349	0	8	0	30.0	0	72.8
Carolina Wren	<i>Thryothorus ludovicianus</i>	17	941	12	12	35.8	35.8	34.7	34.7
Prothonotary Warbler	<i>Protonotaria citrea</i>	28	4168	8	2	30.0	10.0	129.2	45.8
Swainson's Warbler	<i>Limothlypis swainsonii</i>	27	3753	2	0	10.0	0	41.3	0
Summer Tanager	<i>Piranga rubra</i>	18	1123	2	0	10.0	0	12.3	0
Indigo Bunting	<i>Passerina cyanea</i>	18	1123	0	6	0	25.8	0	30.1
Totals				38	38			298.6	245.3

conservation significance of habitat unit A is superior to that of B. This could suggest that management of unit A is better for birds than is management of unit B.

Comparison of Reforested Tracts

Using the above methodology, I calculated the avian conservation significance of 141 reforested bottomland tracts. These reforested sites were planted predominantly with oaks (*Quercus* spp.) and ranged in age from 2 to 34 years post-planting. Avian conservation significance of individual sites ranged from 100 to 1600, but average by year class, ranged from 300 to 1600 (fig. 3). A significant correlation ($r^2 = 0.48$) existed between age of reforestation and its significance for avian conservation, with an increase of just over 19 units of conservation significance per year (fig. 3). As these reforested tracts matured, at about 25 to 30 years post-planting, they resembled forested habitat rather than early-successional habitat. Once forested conditions were achieved, the relationship between age and avian conservation significance deteriorated as indicated by the wide range of avian conservation significance among tracts that were >25 years old (fig. 3). Indeed, the relationship between site age and avian conservation significance was markedly more pronounced ($r^2 = 0.78$) when I limited the comparison to sites that were <25 years old (fig. 4).

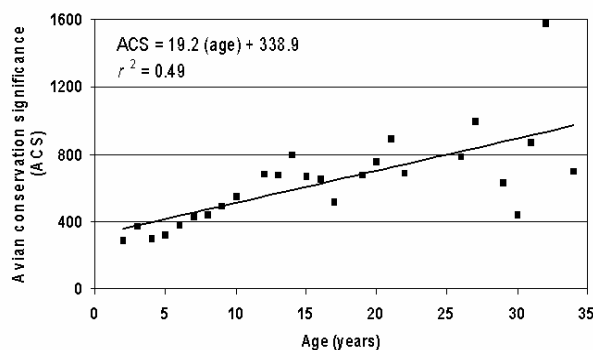


Figure 3— The relationship between age of reforested tracts in the Mississippi Alluvial Valley and their mean avian conservation significance (ACS).

The apparent increase in conservation significance for birds with the maturing of reforested sites conformed to expert opinion as to the conservation significance of mature hardwood forests compared with those in seral stages (Rumble and Gobeille 1998, Twedt et al. 1999, 2002). Degradation of this relationship as these stands mature indicates that factors other than age (e.g., internal forest structure) are influencing bird populations and thereby significance for avian conservation.

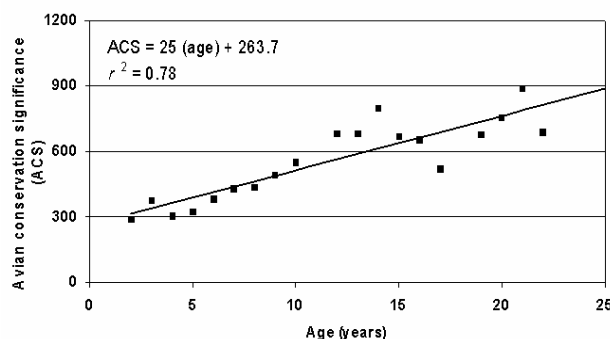


Figure 4— Relationship between age of reforested tracts in the Mississippi Alluvial Valley and their mean avian conservation significance (ACS) when restricted to tracts <25 years post-planting.

Habitat Management

Managers may wish to examine the habitat conditions within stands that have high conservation significance and undertake habitat manipulations within stands that have low conservation significance so as to emulate the conditions of the former. After habitat manipulations, conservation significance can be recalculated to assess changes in the quality of avian habitat.

As an example, I calculated avian conservation significance within second growth bottomland forests (table 2) based on 13 breeding bird censuses (Svensson et al. 1970) in unharvested forests and six breeding bird censuses in forests subjected to recent (within 4 years) selective timber harvest prescribed to improve wildlife habitat (Twedt et al. 1999). For each species, I calculated mean territory density over all breeding bird censuses, and used these to determine the conservation significance associated with each species. These were summed over all species to obtain the avian conservation significance of harvested stands (ACS = 2008) and unharvested stands (ACS = 1839). Although the difference in ACS between harvested and unharvested stands was small (<10 percent), it does suggest that prescribed habitat modifications achieved desired results. Note that the observed densities of birds in unharvested stands (841 territories/100 ha) was greater than that in harvested stands (813 territories/100 ha). Thus, the increase in conservation significance resulted from an increase in higher priority bird species rather than an increase in total numbers of birds.

Table 2— Avian species, Partners in Flight concern score, transformed concern ratings (CR), observed densities (territories / 100 ha), transformed territory density rating (TDR), and avian conservation significance (ACS) calculated from 14 uncut (UNC) and 6 selectively, single tree and group selection, harvested (HAR) bottomland hardwood stands located in northeastern Louisiana from 1994 through 1997. Species are listed in taxonomic order.

Common name	Scientific name	Concern score	CR	Observed density		TDR		ACS	
				HAR	UNC	HAR	UNC	HAR	UNC
Little Blue Heron	<i>Florida caerulea</i>	19	1325	1	1	1	1	1.3	1.3
Wood Duck	<i>Aix sponsa</i>	21	1792	2	1	10	1	17.9	1.8
Mississippi Kite	<i>Ictinia mississippiensis</i>	25	3001	2	1	10	1	30.0	3.0
Red-shouldered Hawk	<i>Buteo lineatus</i>	18	1123	2	1	10	1	11.2	1.1
Wild Turkey	<i>Meleagris gallopavo</i>	18	1123	0	1	0	1	0.0	1.1
Mourning Dove	<i>Zenaidura macroura</i>	13	399	2	1	10	1	4.0	0.4
Yellow-billed Cuckoo	<i>Coccyzus americanus</i>	21	1792	23	29	45.2	48.6	81.0	87.1
Barred Owl	<i>Strix varia</i>	17	941	2	1	10	1	9.4	0.9
Ruby-throated Hummingbird	<i>Archilochus colubris</i>	22	2059	25	11	46.4	34.6	95.5	71.2
Red-headed Woodpecker	<i>Melanerpes erythrocephalus</i>	24	2663	19	3	42.5	15.8	113.2	42.1
Red-bellied Woodpecker	<i>Melanerpes carolinus</i>	20	1548	59	55	56.4	56.4	87.3	87.3
Downy Woodpecker	<i>Picoides pubescens</i>	17	9415	26	21	47	43.9	44.2	41.3
Hairy Woodpecker	<i>Picoides villosus</i>	15	635	4	1	20	1	12.7	0.6
Northern Flicker	<i>Colaptes auratus</i>	17	941	1	0	1	0	0.9	0.0
Pileated Woodpecker	<i>Dryocopus pileatus</i>	17	941	6	10	25.8	33.2	24.3	31.2
Eastern Wood-Pewee	<i>Contopus virens</i>	20	1548	20	7	43.2	28.1	66.9	43.5
Acadian Flycatcher	<i>Empidonax virens</i>	21	1792	82	132	56.4	56.4	101.1	101.1
Great-crested Flycatcher	<i>Myiarchus cinerascens</i>	19	1325	14	12	38.1	35.8	50.5	47.4
White-eyed Vireo	<i>Vireo griseus</i>	23	2349	57	37	56.4	52.1	132.5	122.4
Yellow-throated Vireo	<i>Vireo flavifrons</i>	21	1792	9	10	31.7	33.2	56.8	59.5
Red-eyed Vireo	<i>Vireo olivaceus</i>	17	9415	29	41	48.6	53.6	45.8	50.5
Blue Jay	<i>Cyanocitta cristata</i>	16	778	1	1	1	1	0.8	0.8
American Crow	<i>Corvus brachyrhynchos</i>	10	164	0	1	0	1	0.0	0.2
Carolina Chickadee	<i>Parus carolinensis</i>	21	1792	22	43	44.6	54.3	79.9	97.3
Tufted Titmouse	<i>Baeolophus bicolor</i>	15	635	46	57	55.2	56.4	35.1	35.8
Carolina Wren	<i>Thryothorus ludovicianus</i>	17	941	68	70	56.4	56.4	53.1	53.1
Blue-gray Gnatcatcher	<i>Polioptila caerulea</i>	16	778	38	34	52.5	50.9	40.8	39.6
Wood Thrush	<i>Hylocichla ustulata</i>	25	3001	2	8	10	30	30.0	90.0
Northern Parula	<i>Parula americana</i>	24	2663	4	4	20	20	53.3	53.3
Yellow-throated Warbler	<i>Dendroica dominica</i>	21	1792	2	0	10	0	17.9	0.0
Cerulean Warbler	<i>Dendroica cerulea</i>	27	3753	1	1	1	1	3.8	3.8
Prothonotary Warbler	<i>Protonotaria citrea</i>	28	4168	25	42	46.4	53.9	193.4	224.7
Swainson's Warbler	<i>Limnithyris swainsonii</i>	27	3753	2	5	10	23.2	37.5	87.1
Kentucky Warbler	<i>Oporornis formosus</i>	22	2059	6	14	25.8	38.1	53.1	78.4

Table 2. (contd.)

Common name	Scientific name	Concern score	CR	Observed density		TDR		ACS	
				HAR	UNC	HAR	UNC	HAR	UNC
Common Yellowthroat	<i>Geothlypis trichas</i>	18	1123	4	1	20	1	22.5	1.1
Hooded Warbler	<i>Wilsonia citrina</i>	21	1792	3	15	15.8	39.1	28.3	70.1
Yellow-breasted Chat	<i>Icteria virens</i>	21	1792	12	1	35.8	1	64.2	1.8
Summer Tanager	<i>Piranga rubra</i>	18	1123	19	19	42.5	42.5	47.7	47.7
Northern Cardinal	<i>Cardinalis cardinalis</i>	13	399	73	97	56.4	56.4	22.5	22.5
Indigo Bunting	<i>Passerina cyanea</i>	18	1123	51	9	56.4	31.7	63.3	35.6
Eastern Towhee	<i>Pipilo erythrophthalmus</i>	19	1325	6	5	25.8	23.2	34.2	30.7
Common Grackle	<i>Quiscalus quiscula</i>	16	778	3	2	15.8	10	12.3	7.8
Brown-headed Cowbird	<i>Molothrus ater</i>	16	778	25	34	46.4	50.9	36.1	39.6
Orchard Oriole	<i>Icterus spurius</i>	23	2349	15	2	39.1	10	91.8	23.5
Totals				813	841			2008.1	1839.3

Discussion

This method of comparing the significance of habitats for avian conservation is relatively simple and objective. Although I made comparisons using data from bottomland hardwood forests and PIF concern scores from the Mississippi Alluvial Valley, this methodology should be applicable to other habitats and other geographic regions. PIF concern scores vary among regions but are available for each physiographic area at <http://www.rmbo.org/pif/pifdb.html>.

Relative densities, however, must be obtained from the tracts that are to be compared. These data can be obtained from breeding bird censuses, strip transects (Emlen 1988), or point counts (Ralph et al. 1993).

In development of the methodology presented, I chose to use a gamma and a truncated base 2 logarithm scaling function for conversion of PIF concern scores and observed territory densities, respectively. These functions were chosen based on visual assessment of different scaling functions. However, other functions that produce similar transformations are equally valid and should result in similar relative values of conservation significance. The absolute magnitude of the resultant values will likely differ if other transformation functions are used. Even though the absolute magnitude of the resultant measures of conservation significance are influenced by these transformation functions, they can be scaled to restrict their range. For example, I arbitrarily chose to divide by 1000 (Equation 1) to limit the measure of conservation significance of each species to <250 (table 2).

Using the methods I've outlined to determine an area significance for avian conservation, managers can objectively evaluate and compare avian habitats based on estimates of avian territory density and published PIF concern scores. Comparison of results should provide for more informed decisions for management and conservation of habitats so as to provide the greatest benefit to birds.

Acknowledgments

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