

**Generalists and Specialists Warblers And Their Conservation Statuses in North America**

**by**

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## **Abstract**

Habitat degradation and fragmentation are key processes leading to population decline of many bird species, including several North American warblers (*Parulidae*). Threatened and endangered species are especially vulnerable to habitat change owing to the fact that their populations are small relative to those of *least concern*. I conducted a comparative analysis using the Birds of North America (BNA) and the International Union for Conservation of Nature (IUCN) Red List of Threatened Species. To do so, I classified the feeding, breeding and wintering habits of 50 *Parulidae* in North America and then compared these traits to their current conservation status according to the IUCN Redbook. A score describing *Diet, Habitat, and Migration/ Wintering range* were compiled for each species based on criteria consistently identified in Birds of North America. My results show that species possessing specialist diets, and summer or wintering habitat preferences are most likely to be those now identified as threatened, endangered or extinct species, or those that are currently declining in abundance.

**Keywords:** *generalists, specialists, Parulidae, warblers, IUCN Red List status, threatened, endangered, conservation status, scoring, score*

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## Introduction

Rare and endangered species have been of perennial interest in ecology (Darwin 1859; Preston 1948; Rabinowitz *et al.* 1986) and studies have compared the abundance of species locally to their use of habitat and diets to ask if the generalist versus specialist continuum can predict rarity. Several studies also show that populations of habitat generalists tend to be larger than among specialists, many of which have been identified as threatened species (Codesido *et al.* 2012; Boyes and Perrin 2009; Vergara and Armesto's 2009; Paracuellos 2006; Costello *et al.* 2002). So far however, these comparative studies of diet, habitat, and abundance have focused on relatively small regions rather than to North America generally. The aim of this study is to test if specialist warblers of North American, in terms of the food they eat and habitats they reside in, are more or less related to their rarity compared to their generalist counterparts. Specifically, I considered all the *Parulidae*, or New World warblers occurring in North America and wintering in central or south America. As they are all of the same family, all species in this group share general diet and habitat affinities.

### *General Diet and Habitat of the Parulidae*

Collectively, wood-warblers are known primarily as insectivorous with a broad diversity of habitat affinities and life histories (Lovette *et al.* 2002). Many species thrive throughout North America apart from the harsh environments of the high arctic. The Yellow warbler, Wilson's warbler, Northern waterthrush and Tennessee warbler are examples of species that are recorded as up north as Alaska and the lower regions of the Canadian territories (BNA 2012). Found largely in forests and brushlands, these birds with their thin slender beaks, are skillful at plucking small insects and spiders from even tiny cracks and crevices in tree bark,

between leaves, and other hideaways (Lovette *et al.* 2002). However, many warbler species are habitat or diet specialists which ultimately have a negative effect on their population as will be discussed below.

### *Conservation Status of the Parulidae*

Of 50 species of *Parulidae*, six are currently categorized as near threatened, vulnerable, endangered, critically endangered/ possibly extinct, while the rest are listed as least concern. The near-threatened Kirtland's warbler for example, is described to be rare and difficult to find (Mayfield 1992). Radabaugh (1974) who used playback of recorded song to attract this species of warblers, spent 800 hours searching on 11 islands throughout the span of two winters with a final recording of one single male. Both the Bachman's warbler (*Vermivora bachmanii*) and Semper's warbler (*Leucopeza semperi*) (endemic to Saint Lucia of the Caribbean) for example, are the two species under the family that are officially classified as critically endangered/ "possibly" extinct by the *IUCN Red List of Threatened Species* (2012). Any remaining population of Bachman's warbler is likely to be small with the last "unconfirmed" sighting reported in 1988 (K. Rosenberg *in litt.* 2003 from IUCN Red List 2012). The reason for Bachman's warbler's disappearance may be explained by the drainage of river-bottom swamplands (Curson *et al.* 1994) and the near-total clearance of canebrakes (in which *V. bachmanii* shows a strong association with the bamboo *Arundinaria gigantea*). The Semper's warbler is facing a similar fate having not been recorded with certainty since 1961 and their decline is likely due to habitat loss (Keith 1997; H. Temple *in litt.* 2003 from IUCN Red List 2012).

## *Hypothesis and Predictions*

If the IUCN statuses of North American warblers are linked to the breadth of their feeding habits and their breeding/ wintering habitats, then species that are specialists might be expected to more often be those listed as threatened and endangered. Understanding the relationships between the ecology, abundance and distribution of the *Parulidae* may offer useful information for formulating management strategies for their conservation and identifying those that may become imperiled in the future.

## **Methods**

The metadata for this project was collected from an online resource (BNA 2012) that provides comprehensive life histories of more than 700 different species of birds breeding in the United States and Canada, including for 50 species of particular warblers. I compared Diet, Habitat, and Migration/ Wintering range to test whether specialists were more likely to be listed as near-threatened, vulnerable, endangered or critically endangered/ possibly extinct (hereafter, “threatened” warblers will be used to collectively group these classifications) under the statuses classified by the International Union for Conservation of Nature (IUCN) Red Data List.

The relationship between Diet, Habitat and Migration/ Wintering Range with the warblers’ conservation statuses was achieved by using a scoring system on each of the three variables where a score of 1, 2 or 3 was given for each of the warblers based on a set of “criteria” in reference to the BNA. Because my focus in this paper is to compare “specialists” and “generalists” which I appointed scores of 1 and 3, respectively, only the descriptions used to assign “specialists” and “generalists” are detailed here. Warblers with scores of 2 will be

hereafter be labeled as “intermediates.” A more comprehensive guide can be found in the attached appendices at the end of this paper with the final summarized scoring result of the analysis (Appendix I) and all the descriptions of the diet, habitat, and migration/ wintering grounds used for the scores of each individual species of warblers (Appendix II, III, and IV respectively).

### *Diet*

Under the Diet category, warblers were scored based on the descriptions described on “Main Foods Taken” and “Major Food Items” from the *Food Habits* tab. Many of the times, keywords found in the descriptions are solely what determines the score each warbler was given. For example, species described as “generalists,” “wide variety,” “omnivores,” and “considerable flexibility” were used to describe species, I assumed that they consume a large range prey or vegetation and therefore, awarded a score of three.

I also scored a species as a generalist when it fulfilled two of the four criteria:

- The description states that they are opportunistic fruit eaters during migration and winter when insects may be rare or not readily available.
- The description states that they simply eat “invertebrates” or “arthropods” or “insects,” in which the assumption is made that they eat a broad range of invertebrates.
- The summary lists more than seven specific prey groups in which the warbler eats.
- The summary collectively as a whole, describes that they eat both invertebrates/insects and fruits as part of their diet. For example, it has been noted that the Cape May Warbler feeds on invertebrates during breeding and nonbreeding season but diet includes fruit and nectar during nonbreeding season (Baltz and Latta 1998). The Yellow-



rumped Warbler would also be scored the same, being described eating mostly insects (adults and larvae) and other invertebrates, and on migration and in winter, insects and fruits (Hunt and Flaspohler 1998).

For a score of one, the warbler has to fulfil only one of these points:

- The summary lists four or fewer prey types in the diet
- The summary for the specific warbler has the keywords “essential” or “important food source.” This however, will not apply when the description says “invertebrates,” “arthropods,” or “insects” are “important food sources” since as mentioned above, the assumption is made that when these food groups are stated, the particular warbler eats a broad range of invertebrates. The warbler still has a large variety of items to choose from despite a few invertebrate groups having importance towards its life history.

### *Habitat*

Under the Habitat category, every individual warbler species were scored based on the descriptions described on Breeding Range from the *Habitat* tab. Similar to the process in the Diet variable, a score of three is assigned to the warbler when the authors include keywords such as “forest edges,” “forest clearings,” and “disturbed habitats” in which that particular species utilizes along with being in dense forest interiors. “3” was also awarded when “generalists,” “little habitat specificity,” “broad” habitat category, “wide variety” of habitats over range, “all types” of forests,” “any” tree or shrub and “extremely variable” throughout breeding range are seen in the summary. In addition, when the description outlines specifically that the warbler “breeds in a wider range of forest types than nearly any other bird species” as observed by Hutto (1998) on the Orange-crowned warbler, a score of three is given as well.

A score of 3 can also be given when the warbler fulfills the following two of the four points:

- The warbler is noted to utilize both coniferous and deciduous forests
- The warbler is noted to utilize both middle-aged and mature forests
- The warbler is noted to utilize both scattered and dense forests
- The warbler is noted to utilize various elevations, topography or soil moisture regime; the Townsend's Warbler is found in wet coastal forests at sea level to dry subalpine forests (Rohwer 1994, Hejl et al. 1995).

To assign score for habitat, I searched keywords found if BNA include "area-sensitive," "specialists," "important habitat requirements," "dominant" tree species that are required, "negatively associated" with certain species and "avoids" certain habitats. A score of 1 was given for summaries like the Colima warbler, where it outlines specifically that "weather can modify patterns of breeding distribution" (Beason and Wauver 1998). The Golden-winged warbler was a special case for scoring as it is always out competed by the Blue-winged warbler, especially in drier, upland sites, and woodland sites & borders for food and habitat (Confer 2011) despite Confer's (2011) observations that the Golden-winged nests in a "wide variety" of plant communities. Although the Golden-winged warbler was a "generalist" based on the criteria constructed using the BNA (2012), the Blue-winged warbler greatly limits the options the Golden-winged consumes and resides in; therefore, a score of two was given to this species.

### *Migration/ Wintering Grounds*

Under the Migration/Wintering Grounds category, every individual warbler species was scored based on the descriptions described on spring and Fall Migration and Winter Range from the *Habitat* tab. For this section however, unless otherwise specified, will follow the same

guidelines utilized for the Habitat variable. In addition, the description for the species (BNA 2012) often states that the migration/wintering habitat are near or similar in environment with their breeding habitat; in these cases, the same score would be given between the two categories.

The Migration/Wintering Grounds category contains several descriptions that designated warblers to a score of one not seen in the descriptions for the Habitat category. One was the summary on the *vulnerable* Cerulean warbler which outlines specifically that the warbler is confined to areas of old-growth native forest and that primary forest is thus a habitat requirement as described by (DeGraff and Rappole 1995). A second criteria of “1 scoring” made in the migration/wintering grounds but not in the habitat category was when the summary outlines that the warbler is “habitat-specific during migration” as noted by Power (1971) on the Canada warbler.

After scoring each species for the three categories studied, I constructed 2x3 contingency tables to compare diet, habitat, and migration/wintering ground variables to species abundance and trend. A chi-square test was used to calculate the p-values for test using VassarStats (<http://www.vassarstats.net/newcs.html>; accessed on October 28 2012).

While building the scoring criteria, semantic uncertainties are bound to arise as there will always be vagueness in the definition of terms or lack of consistency in different assessors’ usage of them (Akçakaya *et al.* 2000). Fifty species of warblers is also a lot to cover in a meta-database even with the contribution of a large group of researchers from all over the world. After reading through the descriptions of *Diet, Habitat and Wintering/Migration Ground* variables for each of the 50 warblers (BNA 2012), points or details outlined in some species are

not found on other warblers. This may simply mean those particular data have not been studied upon or collected, or there is merely insufficient sampling for those specific species.

## Results

Table 1: Scoring distribution of Near Threatened/Vulnerable/Endangered/Critically endangered and Least Concern warblers for *Diet*

Count of Fit IUCN Red List Status	Score			Grand Total
	1	2	3	
Near Threatened/Vulnerable/Endangered/Critically endangered	2	3	1	6
Least Concern	1	25	18	44
<b>Grand Total</b>	<b>3</b>	<b>28</b>	<b>19</b>	<b>50</b>

Table 2: Scoring distribution of Near Threatened/Vulnerable/Endangered/Critically endangered and Least Concern warblers for *Habitat*

Count of Fit IUCN Red List Status	Score			Grand Total
	1	2	3	
Near Threatened/Vulnerable/Endangered/Critically endangered	5	1	0	6
Least Concern	12	12	20	44
<b>Grand Total</b>	<b>17</b>	<b>13</b>	<b>20</b>	<b>50</b>

Table 3: Scoring distribution of Near Threatened/Vulnerable/Endangered/Critically endangered and Least Concern warblers for *Migration/Wintering Grounds*

Count of Fit IUCN Red List Status	Score			Grand Total
	1	2	3	
Near Threatened/Vulnerable/Endangered/Critically endangered	5	1	0	6
Least Concern	5	6	33	44
<b>Grand Total</b>	<b>10</b>	<b>7</b>	<b>33</b>	<b>50</b>

I found an association between the feeding habits and habitats of North American *Parulidae* and their IUCN status. Specifically, specialists tended to be the species linked as “threatened” warblers whereas those classified as generalists were more often listed as least concern.

For the *Diet* variable, I found that 43/44 (98%) species listed as being of least concern did not land a specialist spot (score of 1) (Table 1). My data also revealed that only a lone species (Black-throated Grey warbler) scored as a specialist while 18 of 44 (41%) of the common species were still categorized as a generalist (score of 3). Additionally only one of six threatened species (Kirtland’s warbler) scored as a generalist. These results support my predictions that the dietary breadth of warblers are linked with their respective IUCN statuses ( $\chi^2 = 9.35$  and  $p = 0.0093$ ).

Similarly the *Habitat* variable (Table 2) showed that although (12/44) 27% *least concerns* were scored as a specialist, no threatened warblers were scored as habitat generalists. 20 of 44 (45%) of least common species were still labelled as generalists with 32/44 (72%) *least concerns* not deemed as a specialist. Therefore, in terms of broadness of habitat selection, warblers scored as specialists were more likely to be listed as threatened species ( $\chi^2 = 7.84$  and  $p = 0.0198$ ).

Further, no threatened warblers were scored as habitat generalists on the *Migration or Wintering Grounds* variable (Table 3). As with *Habitat*, five of six “threatened” species were classified as specialists and the bird who received a score of two (intermediate) for both variables was the Golden-winged warbler. A total of 33 of 44 (75%) *least concerns* species ended up being categorized as a generalist along with only 5 of the 44 scored as

specialists. These results, like the previous two variables, follow the trend that winter/migration grounds are associated with the warblers' respective IUCN statuses:  $\chi^2 = 18.21$  and  $p < 0.0001$ ).

## **Discussion**

### *Diet*

The results of my analyses support the predictions that the selectivity in diet of the warblers is strongly correlated with their IUCN red list statuses. Warblers that are associated as "generalists," "opportunists," or having a "wide variety" or "considerable flexibility" in terms of food that they consume are identified as diet generalists. Tennessee warblers eat all types of invertebrates but most importantly, they are also opportunistic fruit eaters during migration (Bent 1953). Likewise, the Prothonotary warbler can be more opportunistic in nonbreeding season (feeding on seeds, fruit, and even nectar in addition to its wide selection of insects and spiders) (Petit 1999). American Redstarts are outlined to show considerable foraging and dietary flexibility, and similarly obtains small berries and fruits when insects are not abundant (Bent 1953).

The black-throated warbler was the only species out of 44 "least concerns" that was scored a specialist (Table 1). This species is very specific with the insects it consumes as it selects small green caterpillars of 2 to 4cm and the only plant-like matter it eats are cord-grass seeds (Guzy and Lowther 2012). The reason why it is currently listed as a "least concern" may be due to the warbler's relatively broad preference for breeding habitat which included open coniferous and mixed woodland, shrubs and thickets (Guzy and Lowther 2012).

In addition, although Kirtland's warbler is classified as a near-threatened species under the IUCN, it had a "generalist" scoring for its Diet variable (Table 1). A score of three was given to this species as it consumes a large variety of insects including sawflies (either adult or larvae form), grasshopper nymphs, moths, dipterans and avidly feeds on blueberries during the winter season when the previous stated preys are unavailable (Mayfield 1992). The reason for its "threatened" status may be explained by its need for extensive stands of jack pine and homologous tracts of great size sometimes up to 200ha (Mayfield 1992).

These findings matched closely with a study in which the flexibility in feeding ecology between Steller's Eiders and Long-tailed Ducks was examined (Bustnes and Systad 2001). The "vulnerable" Steller's eider appears to be a specialist as it has limited ability to exploit different food resources, observed only capturing prey via surface techniques (upending and dabbling) within shallow waters (Petersen 1980; Fox and Mitchell 1997; Bustnes and Systad 2001). On the other hand, the "least concern" Long-tailed duck is an opportunistic generalist, being able to dive down to 70m (Johnsgaard). Therefore, the Long-tailed duck seems to have access to a much wider benthic habitat than its counterpart whenever profitable food is available in deeper waters. Thus, one possible explanation for specialists' narrow diet spectrum may be due to having lesser physiological capabilities in comparison to others.

Work had also been done recently on the genus *Poicephalus* where linkages between distributional range, niche breadth and utilization of food resources were evaluated on the parrots. Based on the ecological specialization hypothesis, species with the widest niche breadth should be more widespread and locally abundant than specialized species (Gaston and Lawton 1990, Pomeroy and Ssekabiira 1990). The most common species of parrot in the

research, the Meyer's parrot was recorded to have 37 items in their diet and is categorized as a generalist (Boyes and Perrin 2010) and "least concern" under the IUCN Red List. On the contrary, the Cape parrot is only associated with 7 items of food which illustrates why it is "critically endangered" and its feeding system classified as specialist (Wirringhaus *et al.* 2002).

### *Habitat*

Patterns of habitat use shown by warblers also confirm my hypothesis that their degree of specialization is associated to their Red List status. Warblers that have broader habitat tolerances or that thrive in forest edges, clearings or disturbed habitats were more often identified as habitat generalists (Appendix III). Examples include the Blue-winged warbler, described as using forest edges and clearings and dense shrubs and thickets (Gill *et al.* 2001). Similarly, Noss (1991) recorded high abundances of Pine warblers close to edges as well as deep within the forest interior during breeding season suggesting that they are habitat generalists. Moreover, the Orange-crowned warbler, which was observed by Hutto (1998) to be able to breed in a wider range of forest types than nearly any other bird species, is also abundant in harvested forests including group selection areas of varying sizes.

As reflected by Costello *et al.* (2002) who have studied the chestnut-sided warbler, common yellowthroat, and mourning warbler as well, found that out of the 50 songbirds surveyed in the White Mountain National Forest, New Hampshire, these "common" species were the most abundant species observed in group selection openings, and were also observed in group openings of all sizes. Interestingly, 13 of the songbirds they studied were members of the *Parulidae* family and their findings matched closely with my results. The northern Parula for example, were absent in clear-cuts and every form of group selection but were found in mature



forested areas; under *Habitat*, this bird was scored a 1. They also did not find a single Black-and-white Warbler, Blackburnian, Black-throated Blue Warbler and Ovenbird (a habitat score of 2) in open areas of group selections but were observed abundantly in forested regions. The ecological strategy of being generalists as we will see has made them more successful and widespread compared to the threatened ones.

The results from my research were consistent with a similar study which evaluated whether the rarity of land bird species in central Argentina's diverse agroecosystems is influenced by their specialisation in nesting habitat. The findings of Codesido *et al.* (2012) showed there is indeed a relationship between the ecology, abundance and distribution of land birds; most rare species (9 of 14) were specialists, whereas 15 of the 21 common species who uses a wide variety of habitats were generalists. Further, like the specialist warblers of North America, the woodland and grassland specialists of the study had smaller areas of occupancy than the generalist species leading them to be correlated with the "threatened" statuses. Because of their already limited distribution of natural habitat, the ecologically specialized species are especially vulnerable to habitat changes since their population sizes are typically small to begin with (Owens and Bennett 2000; Fordham and Brook 2010). Thus, the rarity of the woodland and grassland species was expected because the fragmentation of these natural habitats from the increase in agriculture provides little chance for settlement of those birds (Baldi and Paruelo 2008).

Therefore, unlike specialist species which are constrained to use a small habitat spectrum, generalist warblers may switch their habitat selection pattern over time and usually behave as opportunists where they always prefer the habitats offering more resources (Medel

and Jaksic 1988; Magura *et al.* 2003). As in the case of Vergara and Armesto's (2009) studies, they worked with two South American birds: the green-backed firecrown and austral thrush. Both have a wide geographic distribution, high local abundance and use a wide variety of habitats, including mature forest, degraded forest, forest plantations as well as agricultural and urban areas. These descriptions are parallel with those points detailed for warblers scored as a "generalist" or "three" under *Habitat and Migration/ Wintering Grounds*, and the hummingbird and thrush are also currently listed as "least concern" under the IUCN Red List.

Area and size of occupancy for species of birds is a factor that contributes to their respective statuses on the IUCN red list (Paraacuellos 2005). The globally endangered white-headed duck (categorized as endangered), a specialist and area-dependent, saw their population rates declining from their wetland complex at the same rate as the ponds diminished in size (Paraacuellos 2005). Waterbirds such as the Mallard, Little Grebe and Common Coot are least concerned, generalists and area-independent; they all have a very wide feeding-niche width since on top of feeding in ponds, they also capture prey close to the shore (Paraacuellos 2005). As a result, the birds that feed only in calm standing water would have to compete with the already limited resource which is only bound to shrink even more in size while the "generalists" still have an abundance of food to be found alongside the shore.

The loss of specialist habitats has undoubtedly been tied into anthropogenic activities (Codesido *et al.* 2012); species of birds with specific habitat requirements are especially sensitive to those degradations (Codesido *et al.* 2012). The Cerulean warbler for example, is a "vulnerable" species highly dependent on old-growth bottomland hardwood forests and once, was found abundantly along the Mississippi Alluvial Valley (Widmann 1895; Wildmann 1897).

Both these forests and those on the mesic uplands around this area have continuously been replaced by harvesting and farmland in the past century which would explain their sharp decline of this species; it is estimated there were 9,700,000ha in the valley before human activities took place that reduced it to approximately 1,600,000ha today (The Nature Conservancy 2009). Similarly, the Northern waterthrush which was scored a one (specialist) under *Habitat*, has been recorded to have dense cover near ground level, combined with presence of water as the two most important habitat requirements throughout its breeding range (Eaton 1995). Since the 1600's, over half of the 220 million acres of wetlands that existed in the lower 48 states have been lost and degraded due to agriculture, commercial and residential development, road construction, impoundment and resource extraction (USEPA 1994; Dahl and Johnson 1991; USEPA 1993). Moreover, mangroves in the Caribbean and coastal areas of Venezuela provide crucial wintering areas for the Northern waterthrush (Lefebvre *et al.* 1992, Wunderle and Waide 1993). Unfortunately, many of these habitats have been decimated for fuel and paper making and more recently for shrimp culture farms (Lefebvre *et al.* 1992).

#### *Migration/ Wintering Grounds*

The different uses of Migration/Wintering grounds presented by warblers further confirm my hypothesis that their degree of specialization is associated to their Red List status. Migration requires birds to exert a great amount of energy during the journey and being already at high stress once they reach their destination, the birds are also allocated throughout a space much less than their breeding grounds. This is not surprising as all the warblers migrate from Canada and the United States to Mexico, Central America, and the Caribbean where the land mass are smaller (BNA 2012).

As mentioned under the discussion for the *Habitat* variable, area and size of occupancy for species of birds is a factor that contributes to their respective statuses on the IUCN red list (Paraacuellos 2005). Since wintering grounds are smaller than breeding areas in size, it is likely that the former has a more limited breadth of habitat selection for the warblers compared to the latter. Kirtland's warbler (near-threatened), who already breeds in a fairly limited space throughout Michigan, U.S. migrates to the Bahamas Islands where they are even more scattered (Mayfield 1992); both their habitat and migration/ wintering range are scored a 1. Similarly, the Colima warbler (near-threatened and also scored a 1 for the two variables) breeds only in the Chisos Mountains of western Texas and the Sierra Madre Oriental of northeastern Mexico (Beason and Wauver 1998). It then winters on the Pacific slope of southeast Mexico (range equally as small compared to the breeding but more scattered) between specific elevations of 1500 and 3600m (Beason and Wauver 1998). Correspondingly, the Cerulean warbler, Golden-cheeked warbler, Bachman's warbler all share similar trends with appointed IUCN red list statuses of vulnerable, endangered, critically endangered (possibly extinct) respectively- all with scores of 1 for the two separate seasonal grounds. The Golden-winged warbler, having scores of 2 is representative of its much wider geographic distribution of breeding and wintering range in comparison with their threatened counterparts (Ladd and Gass 1999).

#### *Potential Limitations*

It is important to keep in mind that many other factors may influence the status of species, such as the distances traveled from breeding to wintering grounds. Long-distance travellers may exert more energy compared than residents or short-distance migrators and be

more prone to the effects of habitat destruction and/ or disease. In addition, the variation of each individual species' daily time budget on how they spend their time on activities such as sleeping, vocalizations, resting, foraging, maintenance, locomotion and pair-bonding (BNA 2013) may have a significant role on their conservation status designations as those that invest more hours on particular activities over others may possibly lead to their decline in abundance over time. However, since time budgets are not fixed, in order to obtain the most reliable results if one were to test this variable against the warblers' abundance, ideally they will have to be observed all at once within the same time period.

As mentioned before, uncertainties will arise within researches like the one presented in this paper where all sources are collected from a meta-data base. Despite efforts to reduce these types of errors, it is inevitable in some cases without loss of generality. Regardless of these uncertainties, this study still gave us evidences that show a correlation between the threatened species and their limited dietary and habitat selection.

Furthermore, as with any research analysis, there will also be uncertainties such as natural variability and measurement error (Akçakaya *et al.* 2000). Natural variability occurs when species' life histories and the environments in which they live change over time and space (IUCN 2012); it is simply too difficult and time-consuming if all fifty species of warblers were to be tracked all year wherever they venture. Also measurement errors may result from misinterpretation and lack of precise information about the parameters used in the criteria (IUCN 2012) as the identification of certain warblers high up in a canopy or dense shrub may be real hard to discern. This type of error may be reduced by acquiring more data. Sampling intensities among the species are most certainly not going to be the same for all; it is quite

possible that some of the data collected for particular species was taken from one or a few individuals due to “chance” alone and not representative of their true nature. For these reasons, an important assumption that needs to be made is the fact that the entirety of the sources from the BNA used in this paper is credible, reliable, and sampled to the best ability.

## **Conclusions**

There are many essential variables that play important roles in identifying threatened species of birds and there have already been studies and evidence that show the association of diet and habitat specialization of those birds with their abundance and conservation. I found with this research that there is indeed a linkage between the breadth of North American warblers’ feeding habits and breeding/wintering habitats with their IUCN statuses. With the knowledge of the theory and ideas behind the ecology, abundance and distribution of the *Parulidae* may offer useful information to formulate management strategies for their conservation as well as to identify other species of warblers and birds that may decline in the future. As dramatic species loss in recent decades have been observed (Thomas *et al.* 2004), it is clear that these studies should be one of the fundamental aspects of current nature conservation, preventing further damages to wildlife and birds, such as the warbler populations. This could potentially prevent the extinction of threatened species and ultimately increase biodiversity.

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## Appendix I:

The fifty species of warblers of North America with their respective scoring for the variables *Diet*, *Habitat*, and *Migration/ Wintering grounds*. Species in bold print are those that are the collectively termed “threatened” species. NT: Near Threatened, VU: Vulnerable, EN: Endangered, CE: Critically Endangered, and PE: Possibly Extinct.

	Diet	Habitat	Migration/Winter
American Redstart ( <i>Setophaga ruticilla</i> )	3	3	3
<b>Bachman's Warbler (<i>Vermivora bachmanii</i>) (CE/ PE)</b>	1	1	1
Bay-breasted Warbler ( <i>Setophaga castanea</i> )	3	3	3
Black-and-white Warbler ( <i>Mniotilta varia</i> )	2	2	3
Blackburnian ( <i>Setophaga fusca</i> )	2	2	3
Blackpoll Warbler ( <i>Setophaga striata</i> )	2	2	3
Black-throated Blue Warbler ( <i>Setophaga caerulescens</i> )	2	2	3
Black-throated Green Warbler ( <i>Setophaga virens</i> )	2	3	3
Black-throated Grey Warbler ( <i>Setophaga nigrescens</i> )	1	2	2
Blue-winged Warbler ( <i>Vermivora cyanoptera</i> )	2	3	3
Canada Warbler ( <i>Wilsonia canadensis</i> )	2	3	1
Cape May Warbler ( <i>Setophaga tigrina</i> )	3	2	3
<b>Cerulean Warbler (<i>Setophaga cerulea</i>) (VU)</b>	2	1	1
Chestnut-sided Warbler ( <i>Setophaga pensylvanica</i> )	2	1	3
<b>Colima Warbler (<i>Oreothlypis crissalis</i>) (NT)</b>	2	1	1
Common Yellowthroat ( <i>Geothlypis trichas</i> )	2	3	3
Connecticut Warbler ( <i>Oporornis agilis</i> )	3	3	3
<b>Golden-cheeked Warbler (<i>Setophaga chrysoparia</i>) (EN)</b>	2	1	1
<b>Golden-winged Warbler (<i>Vermivora chrysoptera</i>) (NT)</b>	1	2	2
Grace's Warbler ( <i>Setophaga graciae</i> )	2	2	3
Hermit Warbler ( <i>Setophaga occidentalis</i> )	2	1	1
Kentucky Warbler ( <i>Oporornis formosus</i> )	2	1	3
<b>Kirtland's Warbler (<i>Setophaga kirtlandii</i>) (NT)</b>	3	1	1
Louisiana Watertrush ( <i>Parkesia motacilla</i> )	3	2	2
Lucy's Warbler ( <i>Oreothlypis luciae</i> )	2	1	2
MacGillivray's Warbler ( <i>Oporornis tolmiei</i> )	2	2	2
Magnolia Warbler ( <i>Setophaga magnolia</i> )	3	3	3
Mourning Warbler ( <i>Oporornis philadelphia</i> )	3	3	3
Nashville Warbler ( <i>Oreothlypis ruficapilla</i> )	2	1	3
Northern Parula ( <i>Setophaga americana</i> )	3	1	3
Northern Watertrush ( <i>Parkesia noveboracensis</i> )	3	1	1
Orange-crowned Warbler ( <i>Oreothlypis celata</i> )	2	3	3
Ovenbird ( <i>Seiurus aurocapilla</i> )	3	2	3
Painted Redstart ( <i>Myioborus pictus</i> )	2	1	1
Palm Warbler ( <i>Setophaga palmarum</i> )	3	3	3
Pine Warbler ( <i>Setophaga pinus</i> )	3	3	3

Prairie Warbler ( <i>Setophaga discolor</i> )	3	3	3
Prothonotary Warbler ( <i>Protonotaria citrea</i> )	3	2	3
Red-faced Warbler ( <i>Cardellina rubrifrons</i> )	2	2	2
Swainson's Warbler ( <i>Limnothlypis swainsonii</i> )	2	3	3
Tennessee Warbler ( <i>Oreothlypis peregrina</i> )	3	3	3
Townsend's Warbler ( <i>Setophaga townsendi</i> )	3	3	3
Tropical Parula ( <i>Setophaga pitiayumi</i> )	2	1	1
Virginia's Warbler ( <i>Oreothlypis virginiae</i> )	2	1	2
Wilson's Warbler ( <i>Wilsonia pusilla</i> )	2	1	3
Worm-eating Warbler ( <i>Helmitheros vermivorum</i> )	2	3	3
Yellow Warbler ( <i>Setophaga petechia</i> )	2	1	3
Yellow-breasted Chat ( <i>Icteria virens</i> )	3	3	3
Yellow-rumped Warbler ( <i>Setophaga coronata</i> )	3	3	3
Yellow-throated Warbler ( <i>Setophaga dominica</i> )	2	3	3

## Appendix II:

Descriptions of the *Diet* variable used for the scores of the 50 species of warblers in North America extracted from *the Birds of North America Online*: <http://bna.birds.cornell.edu/bna>. Species in bold print are those that are collectively termed “threatened” species. NT: Near Threatened, VU: Vulnerable, EN: Endangered, CE: Critically Endangered, and PE: Possibly Extinct.

American Redstart ( <i>Setophaga ruticilla</i> )	3	Species shows considerable foraging and dietary flexibility; 9 prey groups in description + berries and fruits
<b>Bachman's Warbler (<i>Vermivora bachmanii</i>)</b>	1	Caterpillars and spiders
Bay-breasted Warbler ( <i>Setophaga castanea</i> )	3	Mainly insects and spiders; insects in rainy season & mostly fruits in dry season when insects become scarce
Black-and-white Warbler ( <i>Mniotilta varia</i> )	2	Lepidopterans, especially caterpillars; 8 other prey groups in description
Blackburnian ( <i>Setophaga fusca</i> )	2	Largely or entirely insectivorous during the breeding season; 3 main prey group and eats some fruits in winter
Blackpoll Warbler ( <i>Setophaga striata</i> )	2	Predominately adult and larval insects; 8 other prey groups + some fruits & seeds taken during fall migration
Black-throated Blue Warbler ( <i>Setophaga caerulescens</i> )	2	Insectivorous + small berries, fruits and nectar
Black-throated Green Warbler ( <i>Setophaga virens</i> )	2	Largely or entirely insects during breeding season; takes poison ivy berries and other berries during migration
Black-throated Grey Warbler ( <i>Setophaga nigrescens</i> )	1	Insects; Only small [2–4 cm] green caterpillars; cordgrass ( <i>Spartina</i> sp.) seeds
Blue-winged Warbler ( <i>Vermivora cyanoptera</i> )	2	Arthropods; Lepidoptera moths and larvae, crickets and grasshoppers, ants, flies, bugs, and spiders
Canada Warbler ( <i>Wilsonia canadensis</i> )	2	Mostly winged insects; mosquitoes, flies, moths, beetles, small hairless caterpillars, and spiders
Cape May Warbler ( <i>Setophaga tigrina</i> )	3	Invertebrates; diet includes fruit and nectar during nonbreeding season
<b>Cerulean Warbler (<i>Setophaga cerulea</i>)</b>	2	Insects during breeding season; also eats small amounts of plant material during migration
Chestnut-sided Warbler ( <i>Setophaga pensylvanica</i> )	2	Almost wholly insectivorous, mainly larvae of Lepidoptera and Diptera; also spiders and some seeds and fruit
<b>Colima Warbler (<i>Oreothlypis crissalis</i>)</b>	2	Primarily of spiders, and adult & larval insects
Common Yellowthroat ( <i>Geothlypis trichas</i> )	2	Spiders, flies, beetles, ants & termites, various larvae, bees & wasps, grasshoppers and small seeds
Connecticut Warbler ( <i>Oporornis agilis</i> )	3	Gleans spiders and insects from vegetation; also eats fruits, seeds and berries during summer
<b>Golden-cheeked Warbler (<i>Setophaga chrysoparia</i>)</b>	2	Feeds on wide variety of insects; soft-bodied caterpillars are important food source during breeding season
<b>Golden-winged Warbler (<i>Vermivora chrysoptera</i>)</b>	1	Most often seen carrying Tortricid moths and their larvae; also other moths and their pupae + spiders
Grace's Warbler ( <i>Setophaga graciae</i> )	2	Arthropods; caterpillars, winged insects, spiders and beetles
Hermit Warbler ( <i>Setophaga occidentalis</i> )	2	Primarily invertebrates; small spiders, caterpillars, beetles, flies, wasps, stone flies and true bugs
Kentucky Warbler ( <i>Oporornis formosus</i> )	2	Insects; caterpillars and small spiders; parts of bugs, beetles, ants and other hymenopterans
<b>Kirtland's Warbler (<i>Setophaga kirtlandii</i>)</b>	3	Insects; sawfly adults & larvae, grasshopper nymphs, moths & dipterans; avidly feeds on blueberries in winter
Louisiana Waterthrush ( <i>Parkesia motacilla</i> )	3	Aquatic invertebrates; 9 prey groups in description
Lucy's Warbler ( <i>Oreothlypis luciae</i> )	2	Caterpillars, beetles, leafhoppers, true bugs, spiders, ants, bees and wasps

MacGillivray's Warbler ( <i>Oporornis tolmiei</i> )	2	True bugs, leaf hoppers, beetles, bees, wasps, ants, beetles, alfalfa weevil and caterpillars
Magnolia Warbler ( <i>Setophaga magnolia</i> )	3	Arthropods; takes appreciable numbers of spruce budworms; eats some fruit and/or nectar during winter
Mourning Warbler ( <i>Oporornis philadelphia</i> )	3	Largely insectivorous; beetles, spiders & other insect larvae; omnivorous during wintering grounds
Nashville Warbler ( <i>Oreothlypis ruficapilla</i> )	2	Almost entirely insects (breeding/winter); 6 prey groups in description
Northern Parula ( <i>Setophaga americana</i> )	3	Mostly insects; 10+ prey groups + berries, seeds and nectar when available
Northern Waterthrush ( <i>Parkesia noveboracensis</i> )	3	Predominantly consumes insects; 7 main prey groups + seeds
Orange-crowned Warbler ( <i>Oreothlypis celata</i> )	2	Chiefly invertebrates, but also takes berries, fruits, suet, sap, nectar, beetles, ants, spiders and caterpillars
Ovenbird ( <i>Seiurus aurocapilla</i> )	3	Invertebrates; ants, seeds, beetles, Curculionidae, Coleoptera, Formicidae, Lepidoptera, Diptera & Hemiptera
Painted Redstart ( <i>Myioborus pictus</i> )	2	Predominantly insectivorous, but will drink sugar water and sap; Dipterans, moths, leafhoppers and caterpillars
Palm Warbler ( <i>Setophaga palmarum</i> )	2	Largely or entirely insectivorous; 6 large prey groups + seeds and berries in winter
Pine Warbler ( <i>Setophaga pinus</i> )	3	Arthropods + fruits and seeds, especially during fall and winter; 8 major prey groups in description
Prairie Warbler ( <i>Setophaga discolor</i> )	3	Insects and spiders; soft-bodied arthropods and mollusks; occasionally fruits; Prairie Warbler is a generalist.
Prothonotary Warbler ( <i>Protonotaria citrea</i> )	3	In nonbreeding season opportunistic, feeds on some seeds, fruit and even nectar in addition to insects & spiders
Red-faced Warbler ( <i>Cardellina rubrifrons</i> )	3	Takes insects, especially Lepidopteran larvae and also Diptera and Homoptera
Swainson's Warbler ( <i>Limnothlypis swainsonii</i> )	2	Ground-dwelling arthropods, including ants, beetles, centipedes, hemipterans, lepidopterans and spiders
Tennessee Warbler ( <i>Oreothlypis peregrina</i> )	2	Invertebrates; Lepidopteran caterpillars important; opportunistic fruit and nectar consumer in winter
Townsend's Warbler ( <i>Setophaga townsendi</i> )	3	Western spruce budworm; caterpillars, moths, winged insects and other invertebrates; seeds and leaf galls
Tropical Parula ( <i>Setophaga pitiaiyumi</i> )	3	Insects; bees and wasps, flies, caterpillars; other small arthropods and berries
Virginia's Warbler ( <i>Oreothlypis virginiae</i> )	2	Mainly or entirely insectivorous; no records of vegetable material; spiders, carpenter ants, stinkbugs and weevils
Wilson's Warbler ( <i>Wilsonia pusilla</i> )	2	Terrestrial invertebrates such as bees, flies, mayflies, spiders, beetles and caterpillars; occasionally eats berries
Worm-eating Warbler ( <i>Helmitheros vermivorum</i> )	2	Primarily on arthropods; spiders, slugs and caterpillars
Yellow Warbler ( <i>Setophaga petechia</i> )	2	Mostly insects and other arthropods; may take wild fruits occasionally
Yellow-breasted Chat ( <i>Icteria virens</i> )	2	Small invertebrates (mainly insects and spiders) and take fruits and berries when available; same in winter
Yellow-rumped Warbler ( <i>Setophaga coronata</i> )	3	Mostly insects and other small invertebrates. On migration in winter- equal amounts of insects and fruits
Yellow-throated Warbler ( <i>Setophaga dominica</i> )	3	Beetles, moths and larvae, flies, bugs, grasshoppers and crickets, grouse locusts, scale insects and spiders
American Redstart ( <i>Setophaga ruticilla</i> )	3	Species shows considerable foraging and dietary flexibility; 9 prey groups in description + berries and fruits

### Appendix III:

Descriptions of the *Habitat* variable used for the scores of the 50 species of warblers in North America extracted from *the Birds of North America Online*: <http://bna.birds.cornell.edu/bna>. Species in bold print are those that are collectively termed “threatened” species. NT: Near Threatened, VU: Vulnerable, EN: Endangered, CE: Critically Endangered, and PE: Possibly Extinct.

American Redstart ( <i>Setophaga ruticilla</i> )	3	Does not avoid edges
<b>Bachman's Warbler (<i>Vermivora bachmanii</i>)</b>	1	Dependent on old-growth stands of bottomland hardwoods; cane specialists.
Bay-breasted Warbler ( <i>Setophaga castanea</i> )	3	Breeds mainly in dense, boreal spruce-fir forests and mixedwoods; can be found in swamps and bogs
Black-and-white Warbler ( <i>Mniotilta varia</i> )	2	Mature and second-growth deciduous and mixed forests, with a possible preference for swampy forests
Blackburnian ( <i>Setophaga fusca</i> )	2	Characteristically associated with coniferous and mixed forests but inhabits largely deciduous forests at southern end of range
Blackpoll Warbler ( <i>Setophaga striata</i> )	2	Across n. Canada, found primarily in boreal black spruce forest; in western part of range also occurs regularly in spruce-alder-willow thickets in riparian areas or the transition zone between taiga and tundra
Black-throated Blue Warbler ( <i>Setophaga caerulescens</i> )	2	Breeds mainly in large, more or less continuous tracts of relatively undisturbed deciduous or mixed deciduous/coniferous forests; forests occupied are usually dominated by maples, birches, beech, and other northern hardwoods, with varying amounts of eastern hemlock, spruce, and fir
Black-throated Green Warbler ( <i>Setophaga virens</i> )	3	Occupies wide variety of habitats over range; characteristic inhabitant of boreal coniferous forest and transitional area between coniferous & deciduous forests; completely deciduous forests in several parts of range. May inhabit both middle-aged and mature forests
Black-throated Grey Warbler ( <i>Setophaga nigrescens</i> )	2	Open coniferous or mixed woodland with brushy undergrowth, piñon-juniper & pine-oak associations
Blue-winged Warbler ( <i>Vermivora cyanoptera</i> )	3	Usually nests in early to midsuccession habitat; most habitat descriptions refer to use of saplings or forest edge or forest clearings and dense shrub or dense thickets
Canada Warbler ( <i>Wilsonia canadensis</i> )	3	Wide range of deciduous and coniferous forests; most abundant in moist, mixed coniferous-deciduous forests with well-developed understory; in the Great Lakes/St. Lawrence river valley, one of the most common warblers
Cape May Warbler ( <i>Setophaga tigrina</i> )	2	Variety of medium to old-aged coniferous habitats with spruce and balsam fir; trees may be scattered or dense
<b>Cerulean Warbler (<i>Setophaga cerulea</i>)</b>	1	Usually considered an area-sensitive species; up to >8,000ha may be required to support breeding populations
Chestnut-sided Warbler ( <i>Setophaga pensylvanica</i> )	1	Common in early successional deciduous habitats in the ne. U.S.; highly specialized in its habitat and diet
<b>Colima Warbler (<i>Oreothlypis crissalis</i>)</b>	1	Unusual weather can modify pattern of breeding distribution.
Common Yellowthroat ( <i>Geothlypis trichas</i> )	3	Occupies thick vegetation in wide range of habitats from wetlands to prairie to pine forest
Connecticut Warbler ( <i>Oporornis agilis</i> )	3	Habitat preferences extremely variable throughout breeding range; observed in 15 different forest types, wetland bogs and sedge meadows during the summer in the U. S.
<b>Golden-cheeked Warbler (<i>Setophaga chrysoparia</i>)</b>	1	Slight preference for forest interior; dominant tree species in nesting habitat is nearly always Ashe juniper, the bark of which is the main construction material of nests

<b>Golden-winged Warbler (<i>Vermivora chrysoptera</i>)</b>	2	Nests in a wide variety of plant communities; often in competition with blue-winged warblers in which the blue-wings predominate; found almost exclusively in tamarack swamps
Grace's Warbler ( <i>Setophaga graciae</i> )	3	Across pine and pine-oak forests of n. Arizona; 5th-most common bird species: 22/ 23 stands in one study
Hermit Warbler ( <i>Setophaga occidentalis</i> )	2	Positively correlated with percentage of conifer tree cover, negatively with percentage of deciduous tree cover; preferred trees >31 cm dbh; avoided areas with high percentage of shrub cover; sensitive to edges
Kentucky Warbler ( <i>Oporornis formosus</i> )	1	Bottomland hardwoods and woods near streams with dense understory, often at low elevations + well-developed ground cover for ground nesting, and a thick understory, are essential; studies of forest fragmentation in Missouri indicate that blocks of suitable habitat (at least 500 ha) are necessary for successful breeding
<b>Kirtland's Warbler (<i>Setophaga kirtlandii</i>)</b>	1	Nests in extensive stands of jack pine. Prefers homogeneous tracts of great size, most successful tracts >200 ha
Louisiana Waterthrush ( <i>Parkesia motacilla</i> )	2	Most frequently breeds along medium to high-gradient clear, perennial streams flowing through closed-canopy, hilly, mixed-evergreen forest; found in late-successional forest but not in mid- or early-successional forests
Lucy's Warbler ( <i>Oreothlypis luciae</i> )	2	Breeds most often in dense lowland riparian mesquite woodlands; especially where trees are large enough to provide adequate nest sites
MacGillivray's Warbler ( <i>Oporornis tolmiei</i> )	2	Requires dense undergrowth and moderate cover
Magnolia Warbler ( <i>Setophaga magnolia</i> )	3	Presence of young conifers is most predictable aspect of habitat; despite use of young stands and forest openings
Mourning Warbler ( <i>Oporornis philadelphia</i> )	3	Prefers disturbed woodlands and second growth
Nashville Warbler ( <i>Oreothlypis ruficapilla</i> )	1	Prefers second growth, open deciduous, or mixed-species forests, with high level of light penetration; preferably with shrubby undergrowth; never found in unbroken forest
Northern Parula ( <i>Setophaga americana</i> )	1	Primarily a riparian species; usually associated with mature forest with epiphytic growth; most abundant in 40-yr-old stands of trees, less numerous in younger and older-aged stands
Northern Waterthrush ( <i>Parkesia noveboracensis</i> )	2	Dense cover near ground level + presence of water: two most important habitat requirements at breeding range
Orange-crowned Warbler ( <i>Oreothlypis celata</i> )	3	Breeds in a wider range of forest types than nearly any other bird species
Ovenbird ( <i>Seiurus aurocapilla</i> )	3	Found in relatively mature, contiguous tracts of deciduous or mixed deciduous/coniferous closed-canopy forests
Painted Redstart ( <i>Myioborus pictus</i> )	1	Occupies oak and oak-pine riparian woodlands with dense overstories, thick undergrowth and permanent or semipermanent water; found in oak-juniper woodland and riparian woodland
Palm Warbler ( <i>Setophaga palmarum</i> )	3	On breeding and wintering grounds, prefers bogs, relatively open habitats with scattered trees; habitats commonly have dense shrubs (1–2 m tall) and usually near water
Pine Warbler ( <i>Setophaga pinus</i> )	2	Variety of upland pine and pine-hardwood forest types are used throughout range; higher abundances closer to edges than in forest interior during the breeding season
Prairie Warbler ( <i>Setophaga discolor</i> )	3	Breeds in various shrubby associations lacking closed canopies; topography ranges from flat surfaces to steep hillsides; led all other species in preference for xeric, upland, low-biomass, open-country habitat
Prothonotary Warbler ( <i>Protonotaria citrea</i> )	2	Exhibits area sensitivity, avoiding forests <100 ha in area and waterways with wooded borders <30 m wide
Red-faced Warbler ( <i>Cardellina rubrifrons</i> )	2	Montane fir, pine, and open pine-oak forests; Douglas-fir, spruce, and deciduous vegetation mixed with conifers



Swainson's Warbler ( <i>Limnothlypis swainsonii</i> )	3	Variety of habitats including bottomland hardwood forests, mixed montane forests, and early-seral pine stands
Tennessee Warbler ( <i>Oreothlypis peregrina</i> )	3	Associated with open areas that contain grasses, dense shrubs, and scattered clumps of young deciduous trees; prefers coniferous bogs dominated by black spruce tamarack, with some white cedar, birch, poplar, and alder
Townsend's Warbler ( <i>Setophaga townsendi</i> )	3	Tall coniferous and mixed forests at various elevations, from wet coastal forest at sea level to the dry subalpins
Tropical Parula ( <i>Setophaga pitiayumi</i> )	1	Rarely found where epiphytes required for nesting are absent; suitable habitat limited in s. Texas; tends to avoid extremely humid lowlands in South America; likes secondary growth, forest border, and riparian habitat
Virginia's Warbler ( <i>Oreothlypis virginiae</i> )	2	May also occur in high-altitude life zones dominated by large conifers, but tends to select patches of shrubby vegetation for breeding; never occurs in coniferous forests where there is not a deciduous mix
Wilson's Warbler ( <i>Wilsonia pusilla</i> )	2	Restricted to mesic shrub thickets of riparian habitats, edges of beaver ponds, lakes, bogs, and overgrown clear-cuts of montane and boreal zone; may reach into alpine zone
Worm-eating Warbler ( <i>Helmitheros vermivorum</i> )	3	Occurs regularly where large tracts of mature deciduous or mixed deciduous-coniferous forest overlap. Suggested minimum area requirements range from 21 ha to 340 ha; may be found through a continuum of moist to dry environments
Yellow Warbler ( <i>Setophaga petechia</i> )	2	Breeds most commonly in wet, deciduous thickets, especially those dominated by willows, and in disturbed and early successional habitats with canopy 1–2 m; avoids grassland
Yellow-breasted Chat ( <i>Icteria virens</i> )	3	Largely confined to riparian and shrubby habitats; a generalist compared with other species in its use of available nesting habitat; occurs in forest edges and openings, and occupies openings in any forest type
Yellow-rumped Warbler ( <i>Setophaga coronata</i> )	3	Predominantly mature coniferous and mixed coniferous-deciduous habitats throughout range, but little habitat specificity within this broad habitat category
Yellow-throated Warbler ( <i>Setophaga dominica</i> )	3	Occupies a variety of habitats: wooded stream bottomlands, swamps, dry upland pine and mixed forests

#### Appendix IV:

Descriptions of the *Migration/Wintering Grounds* variable used for the scores of the 50 species of warblers in North America extracted from *the Birds of North America Online*: <http://bna.birds.cornell.edu/bna>. Species in bold print are those that are the collectively termed “threatened” species. NT: Near Threatened, VU: Vulnerable, EN: Endangered, CE: Critically Endangered, and PE: Possibly Extinct.

American Redstart ( <i>Setophaga ruticilla</i> )	3	Uses variety of shrubby and wooded habitats during migration; winter habitats are diverse
<b>Bachman's Warbler (<i>Vermivora bachmanii</i>)</b>	1	Gundlach (1876) noted the association of the birds with forests, plantations, or gardens of majaguas- further noted that the birds disappeared from his usual locations of observing them when the majaguales were cut
Bay-breasted Warbler ( <i>Setophaga castanea</i> )	3	Found in wide range of habitats during migration; not limited to coniferous trees as during the breeding season
Black-and-white Warbler ( <i>Mniotilta varia</i> )	3	Considered a broad and strong habitat generalist, the most common migrant of the study of (Robbins et al. 1992)
Blackburnian ( <i>Setophaga fusca</i> )	3	Migrant individuals regularly use all woody habitats, including forest edge; both deciduous and coniferous
Blackpoll Warbler ( <i>Setophaga striata</i> )	3	Found in a wide variety of habitats, although often partial to spruces; found in virtually any vegetated habitat including residential areas, mesquite savannah, mangrove forest, and dry forest
Black-throated Blue Warbler ( <i>Setophaga caerulescens</i> )	3	Forest edges, riparian woodlands, and other well-vegetated habitats, including parks and gardens; in spring, often inhabits well-developed upland or riparian forests, feeding at intermediate (5–10 m) heights
Black-throated Green Warbler ( <i>Setophaga virens</i> )	3	All woody habitats, including forest edge; both deciduous and coniferous forests
Black-throated Grey Warbler ( <i>Setophaga nigrescens</i> )	2	Similar to breeding-range habitats; also in variety of forest, woodlands, scrub, and thickets
Blue-winged Warbler ( <i>Vermivora cyanoptera</i> )	3	Near breeding grounds, generally reported in open forest and shrub habitat similar to breeding habitat
Canada Warbler ( <i>Wilsonia canadensis</i> )	1	Very habitat-specific during spring migration in N. Carolina compared to 18 other warblers; 76.5% of foraging birds observed in one (floodplain forest) of 7 habitat types (Power 1971)
Cape May Warbler ( <i>Setophaga tigrina</i> )	3	Variety of forest, woodland, scrub, and thicket
<b>Cerulean Warbler (<i>Setophaga cerulea</i>)</b>	1	During migration, individuals rarely occurred in the lower temperate zone; some (Terborgh 1989, Robbins et al. 1992, DeGraaf and Rappole 1995) believe that this species is confined to areas of old-growth native forest and that primary forest is thus a habitat requirement
Chestnut-sided Warbler ( <i>Setophaga pensylvanica</i> )	3	Occupies a wide array of forested or shrubby habitats; during migration through Texas, inhabits all types of thickets and woods, even deep forests, deciduous or evergreen; in Illinois, found in woodlands of all types
<b>Colima Warbler (<i>Oreothlypis crissalis</i>)</b>	1	Little information; tree canopy, shrub, and ground vegetation cover similar to those of breeding habitat
Common Yellowthroat ( <i>Geothlypis trichas</i> )	3	Similar to breeding habitat
Connecticut Warbler ( <i>Oporornis agilis</i> )	3	Woodlands, forest edge, and dense, shrubby second growth; also in cultivated fields, parks, and gardens
<b>Golden-cheeked Warbler (<i>Setophaga chrysoparia</i>)</b>	1	Found most often in pine forest and pine-oak forest; also found in oak forests, mixed forests and shrublands
<b>Golden-winged Warbler (<i>Vermivora chrysoptera</i>)</b>	2	Most numerous in foothills and lower highlands; not reported from drier, more open lowlands on Pacific slope

Grace's Warbler ( <i>Setophaga graciae</i> )	3	Habitat similar to breeding range, pine forest to pine-oak woodland.
Hermit Warbler ( <i>Setophaga occidentalis</i> )	1	Uses primarily pine-fir and pine forests; during winter, uses primarily pine-fir, pine-oak, and pine communities
Kentucky Warbler ( <i>Oporornis formosus</i> )	3	Also noted for Panama as fairly common, although inconspicuous inhabitant of "thickets of shrubbery"
<b>Kirtland's Warbler (<i>Setophaga kirtlandii</i>)</b>	1	Rare and difficult to find in winter
Louisiana Watertrush ( <i>Parkesia motacilla</i> )	2	Similar to breeding habitat — anywhere water is available
Lucy's Warbler ( <i>Oreothlypis luciae</i> )	2	Wider range of habitats used by Lucy's here than on breeding grounds
MacGillivray's Warbler ( <i>Oporornis tolmiei</i> )	2	Observed in submontane shrubland, montane and desert riparian woodlands, parks, and residential areas
Magnolia Warbler ( <i>Setophaga magnolia</i> )	3	Low trees and shrubs in dense stands at forest edges, woodlots, and parks. In Pennsylvania, spring migrants used young forest; prefers mature forest, especially agricultural edge or suburban woodlands
Mourning Warbler ( <i>Oporornis philadelphia</i> )	3	Open habitat and forest generalist during migration in the lowlands of El Salvador
Nashville Warbler ( <i>Oreothlypis ruficapilla</i> )	3	In both deciduous and coniferous trees, along forest edges, and in bands of conifers containing pines and firs
Northern Parula ( <i>Setophaga americana</i> )	3	In Pennsylvania, migrants most abundant in forest edge habitat; in Wisconsin, can be found in any tree or shrub
Northern Watertrush ( <i>Parkesia noveboracensis</i> )	1	Mangroves ( <i>Rhizophora</i> , <i>Avicennia</i> , <i>Laguncularia</i> ) provide key habitat
Orange-crowned Warbler ( <i>Oreothlypis celata</i> )	3	One of seven most common warblers migrating through Middle Rio Grande Valley, New Mexico in spring and fall; in spring tend to forage in budding trees at forest edges, but in fall prefer brushy areas and weedy fields
Ovenbird ( <i>Seiurus aurocapilla</i> )	3	Less specific than during breeding; observed in a wide variety of habitat types, including mature forest, forest/agriculture edge, suburban forest, pole stage forest
Painted Redstart ( <i>Myioborus pictus</i> )	1	Similar to breeding habitat
Palm Warbler ( <i>Setophaga palmarum</i> )	3	In a variety of woodland, second-growth, and thicket habitats, on the ground in savannas and open fields
Pine Warbler ( <i>Setophaga pinus</i> )	3	The large majority of migrant seem to occur in pine habitats similar to those used during breeding season
Prairie Warbler ( <i>Setophaga discolor</i> )	3	Migrating Prairie Warblers are seen in almost all their breeding habitats
Prothonotary Warbler ( <i>Protonotaria citrea</i> )	3	One of the most abundant migrants through citrus groves in Belize during spring
Red-faced Warbler ( <i>Cardellina rubrifrons</i> )	2	Birds largely use the same kinds of habitats during migration as during breeding, but they will range to much lower elevations during migration, especially spring migration
Swainson's Warbler ( <i>Limnothlypis swainsonii</i> )	3	Wide spectrum of habitats used on winter range; species does not appear to be restricted to particular elevations
Tennessee Warbler ( <i>Oreothlypis peregrina</i> )	3	All types of woodland
Townsend's Warbler ( <i>Setophaga townsendi</i> )	3	Uses wide variety of habitats
Tropical Parula ( <i>Setophaga pitayumi</i> )	1	Similar to breeding habitat
Virginia's Warbler ( <i>Oreothlypis virginiae</i> )	2	Hutto (1992) classified this species as a 2-zone generalist
Wilson's Warbler ( <i>Wilsonia pusilla</i> )	3	Habitat generalist, occupying at least 4 habitat types in w. Mexico and ranging from coastal lowlands into high-altitude cloud forest; also, the only migrant that regularly occupies paramo (high-altitudes plains)

Worm-eating Warbler ( <i>Helmitheros vermivorum</i> )	3	Probably restricted to deciduous and mixed deciduous-coniferous forests
Yellow Warbler ( <i>Setophaga petechia</i> )	3	Variety of wooded and scrubby habitats, including gardens, town plazas, second growth, forest edge, streamside (riparian) woodlands, wooded marshes, agricultural lands, and other semiopen areas
Yellow-breasted Chat ( <i>Icteria virens</i> )	3	Generally keeps to same low, dense vegetation used on breeding grounds, although spring migrants occasionally found in suburban habitat
Yellow-rumped Warbler ( <i>Setophaga coronata</i> )	3	Variety of habitats, although generally less common in forest interiors; in deserts of sw. U.S., avoids arid lowland habitats and tends to occur at higher elevations
Yellow-throated Warbler ( <i>Setophaga dominica</i> )	3	Occurs in almost any woodland area with tall trees, including parks and suburban areas