Pre-Euroamerican Distribution of Pine Warblers (*Dendroica pinus*) in Wisconsin: A Tool for Setting Regional Conservation Priorities[1]

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Introduction

A common goal of conservation and management plans is to maintain populations of species of conservation concern at some historic level that was a product of environmental conditions at a time when they were less influenced by humans than at present (e.g., Wade 1993, Reijnders 1994, Polacheck et al. 1999). Conservation planning also includes consideration of the distribution, abundance, and reproductive success of a species, all of which are affected by both the amount and spatial pattern of habitat (Donovan et al. 1995, Trzcinski et al. 1999, Pidgeon et al. 2003). However, in regions like Wisconsin, USA, where land use changes have been rapid and pronounced in the last 150 years (White and Mladenoff 1994, Radeloff et al. 1999), studying population demographics only in the recent period (1965 – present) for which most population trend data are available provides only a narrow view of species-habitat relationships. In this work, we have fused the fields of spatial and historical ecology to provide a perspective that includes an estimate of a bird species' distribution just prior to Euroamerican settlement (~1850).

Although humans had been active in the area covered by Wisconsin for thousands of years, studies have shown that the landscape changed far less during the 2,000 to 3,000 years prior to Euroamerican settlement than during the 150 years following it (Davis 1981, Webb 1986, Cole et al. 1998). The pre-Euroamerican landscape of northern Wisconsin was largely the product of long-term interactions between vegetation, physical factors, and natural disturbance (Cleland 1983, Webb 1986, Schulte and Mladenoff 2001). The influence of Native Americans on the distribution and amount of wildlife habitat was likely more limited here than elsewhere (Cleland 1983), and much less than the influence of the Euroamericans who followed them (Fries 1951, Cole et al. 1998).

Vegetation data for the pre-Euroamerican period are contained in the U.S. General Land Office's original Public Land Survey (PLS) records, collected between 1832 and 1866 in Wisconsin. From these data we have developed digital coverages of dominant land cover type, relative dominance of individual tree species, and overall tree density (Schulte et al. 2002). These maps form the basis of a model that depicts the potential distribution of a bird species, the Pine Warbler (*Dendroica pinus*), during the immediate pre-Euroamerican period.

We selected the Pine Warbler for two reasons. First, the species' preferred breeding habitat, mature pines, has undergone radical change in the last 150 years, making comparison of Pine Warbler potential distribution in the pre-Euroamerican settlement time period with its present distribution of particular interest. Secondly, modeling the species' habitat preferences is relatively straightforward due to its strong association with mature pines, and because the distribution of mature pines appears to have been captured well in the PLS data set.

Methods

We modeled the potential pre-Euroamerican and present day habitat of the Pine Warbler. Then a map of current Pine Warbler locations (Wisconsin Society for Ornithology 1995; *fig. 1*) was compared with the modeled present day habitat distribution to assess the robustness of the habitat modeling technique.

Our unit of analysis was the Land Type Association (LTA) polygon, one level of ecoregion patterning within the U.S. Forest Service Hierarchical Ecoregion Classification System (Keys et al. 1995, Cleland et al. 1997). Wisconsin LTA polygons are 0.1 to 3,847.3 km^2 in extent (WiDNR 1999). Criteria used in deriving the model were developed from modern sources (*table 1*), and applied to the pre-Euroamerican settlement vegetation data available in the PLS records and to present day vegetation data available from Forest Inventory and Analysis plots (1996; Miles et al. 2001). The resulting maps were then compared to assess changes in this species' potential distribution between the mid-1800s and the present (*fig. 1*).

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Table 1— *Criteria used to map pre-Euroamerican settlement Pine Warbler habitat and data sources from which they were derived. Habitat meeting minimum tree density and pine dominance criteria was classified as Pine Warbler habitat, and was weighted according to tree composition and stand age criteria.*

Habitat category	Criteria	Citation
Tree Density	Forest (>47 trees/ha)	Niemi et al. 1997, Haney and Lydic 1999
Pine Dominance	>10% pine species	Robbins et al. 1989, Robbins 1991
Tree Composition	White pine = red pine >jack pine >all else	Howe and Roberts this volume, Hanowski and Niemi 1991a,b
Stand Age	Mature > Non-mature (≥50 cm dbh >40-49 cm >30-39 cm >all else)	Collins et al. 1982, Rodewald et al. 1999

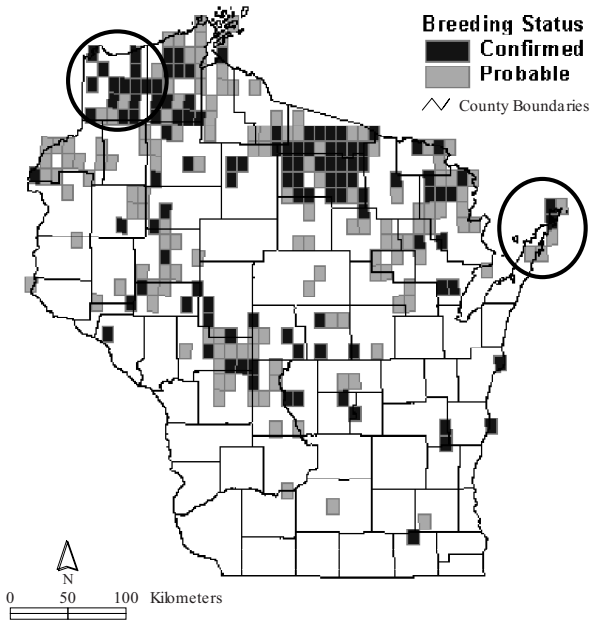

Figure 1— Current distribution of pine warbler habitat, as derived from the Wisconsin Breeding Bird Atlas (Wisconsin Society for Ornithology 1995). *Confirmed breeding status* is defined as one of the following: physiological evidence in adults, physical evidence of nest, nestlings, or fledglings. *Probable breeding status* is defined as specific behavior associated with breeding. Circles indicate areas where our model did not predict current Pine Warbler habitat.

Results and Discussion

The overlap in the present day distribution of Pine Warblers (*fig. 1*) and present day modeled habitat (*fig. 2b*) is strong. This concordance supports the robustness of the modeled pre-Euroamerican settlement potential habitat maps.

Our results suggest that potential Pine Warbler breeding habitat was patchily distributed within the northern portion of Wisconsin prior to Euroamerican settlement (*fig. 2a*), and that this pattern continues today (*figs. 1, 2b*). Historically, the best quality habitat was primarily located on or near sandy glacial outwash plains, where stands of old-growth white and red pine (*Pinus strobus* and *P. resinosa*) forest were common (*fig. 2a; all circled areas*). Overall, the estimated distribution of Pine Warbler habitat in the two time periods is strikingly similar; however habitat quality, and likely the Pine Warbler population, appears to have degraded since the pre-Euroamerican period. In virtually the entire the northern tier of counties, habitat suitability has declined. In this region, where large pines occurred during the pre-Euroamerican period on sandy outwash plains (*fig. 2a, areas 1a - 1c*), subsequent development (i.e., farming) ultimately failed due to poor soils and/or inadequate commodity distribution networks (Gough 1997), and red and white pines have become established once again (WiDNR 1998). Further south (*fig. 2b; area 2*) habitat has contracted since Euroamerican settlement, likely due to the permanent replacement of white pine forest by agriculture (WiDNR 1998).

However, Pine Warbler breeding habitat is currently more broadly distributed in portions of Wisconsin that were previously dominated by herbaceous vegetation (Bolliger et al. 2004), probably due the establishment of pine plantations and successional trends associated with the alteration of the historical fire regime (*fig. 2b, areas designated as 3*). Pine Warblers have also expanded into a localized site in the southeastern portion of the state (*fig. 1*), which is currently state forest, but was in a savanna condition in pre-European settlement times.

Our model failed to predict current Pine Warbler habitat in two northern areas where Breeding Bird Atlas data indicate that Pine Warblers do occur (*fig. 1, circled areas*). A likely reason for the incongruity relates to the scale at which the two maps were derived; our potential habitat map was derived using the LTA as the unit of analysis. LTAs can vary widely in size and can be much coarser than the resolution of Breeding Bird Atlas survey blocks (150 km^2; *fig. 1*). Analysis of large LTAs containing predominantly unsuitable habitat may

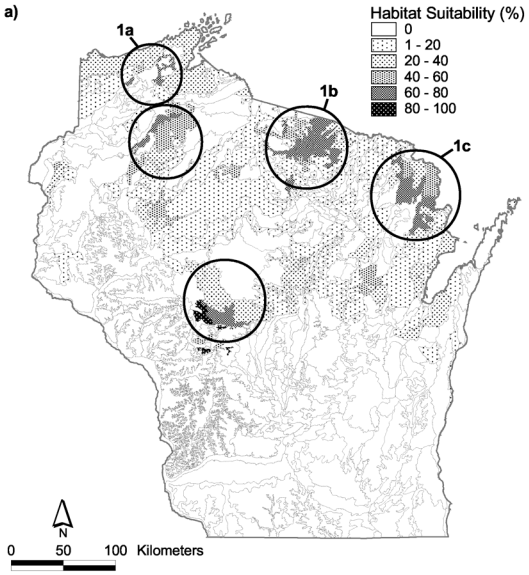

Figure 2a— Percent probability of suitable pine warbler habitat in the period just prior to Euroamerican settlement, as derived from vegetation data in the U.S. General Land Office original Public Land Survey records. Circles indicate sandy glacial outwash plains.

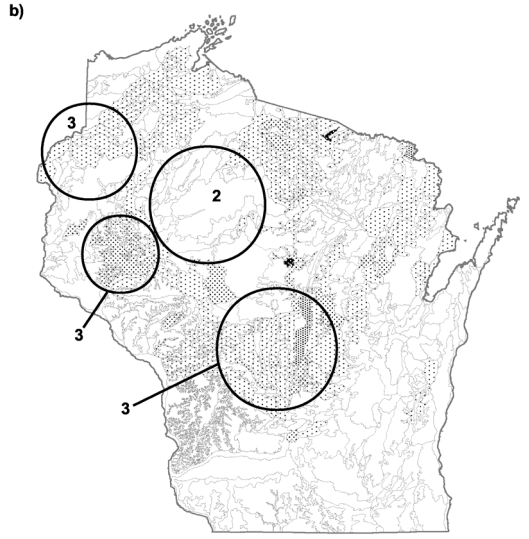

Figure 2b— Percent probability of suitable pine warbler habitat in the current period, as derived from Forest Inventory and Analysis (FIA; Miles et al. 2001) data. Circle designated as "2" indicates an area where Pine Warbler habitat has degraded since the pre-Euroamerican period. Circles designated as "3" indicate areas where Pine Warbler habitat has expanded since the pre-Euroamerican period.

camouflage small, suitable habitat patches that are detected with the Breeding Bird Atlas methodology. Analysis of PLS data at the section level would result in a finer scale map of potential habitat, which would reveal small habitat patches; however FIA data can be summarized only at coarser resolutions. Facing a tradeoff between the level of detail depicted and the transparency of the results, we decided to focus on determining the robustness of the model by being able to directly compare PLS and FIA data while sacrificing finer scale details of potential habitat distribution.

During model development we made two assumptions; that habitat preferences of the Pine Warbler have not changed between the two time periods, and that habitat was occupied during the pre-Euroamerican settlement period in patterns similar to those exhibited by modern Pine Warbler populations. The similarity of potential habitat distribution just prior to the Euroamerican period and current Pine Warbler distribution supports the validity of both the assumptions and the resulting pre-Euroamerican potential habitat map. Advantages of our method include its quantitative approach and replicability; limitations include the uneven availability of quantitative habitat data for various bird species (e.g., habitat criteria of grassland bird species are not captured in the PLS-derived data set) and the lack of additional data for validation of the pre-Euroamerican bird distributions.

Our method provides a spatially explicit assessment of probable changes in bird habitat over a broad temporal window. Such an assessment can provide valuable insight into historical patterns of avian distribution. Moreover, there is considerable interest in using birds as indicator species of both environmental change and habitat quality (e.g., Morrison 1986, Taper et al. 1995, Niemi et al. 1997). Inclusion of information about the historical distribution of indicator species in assessments of habitat conservation needs illuminates the extent of landcover change. Adoption of the probable historic distribution of avian indicator species as an approximate target can provide an ecologically rational approach for current conservation efforts.

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