2017 Report

Assessing Avian Response to NRCS Conservation Programs Targeting Early-successional Habitats in the Appalachian Mountains and Western Great Lakes Regions

A Conservation Effects Assessment Project (CEAP)
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Project Synopsis

The Golden-winged Warbler (*Vermivora chyrsoptera*) is one of the most critically threatened, non-federally listed vertebrates in eastern North America. The implementation of science-based best management practices that create or maintain Golden-winged Warbler breeding habitat is thought to be an important step to reversing the species decline. In 2012, NRCS and USFWS initiated a joint conservation program called *Working Lands for Wildlife* (WLFW). This program specifically targets the creation or enhancement of habitat for imperiled species, including the Appalachian population of the Golden-winged Warbler. Additionally, the American Bird Conservancy and its partners were awarded funding for a Regional Conservation Partnership Program (RCPP) project in Minnesota, Michigan, and Wisconsin to assist NRCS with landowner outreach, coordination, and technical assistance to benefit Golden-winged Warbler, American Woodcock (*Scalopax minor*), and associated species. To date, between the Appalachians and Great Lakes efforts, >6,650 acres and >14,000 acres of Golden-winged Warbler nesting habitat have been produced on public (MN and PA) and private lands (MN, WI, PA, NJ, and MD), respectively. Herein, we describe methods and some preliminary results for each of six projects concerning the habitat management initiatives that target habitat for Golden-winged Warbler, American Woodcock, and associated passerines. These include 1) monitoring of vegetation structure within habitats managed across both regions; 2) monitoring and analysis of Golden-winged Warbler response to habitat management across both regions; 3) monitoring and analysis of American Woodcock response to habitat management across both regions; 4) development of an online tool to evaluate the effectiveness of actions taken to improve habitat conditions for Golden-winged Warblers, American Woodcock, and associated breeding birds; 5) evaluation of landowner response to NRCS conservation programs targeting early successional habitat; and 6) Golden-winged Warbler post-fledging survival and habitat selection in managed forest.

We monitored vegetation across 896 individual locations, many of which were monitored multiple times over 2-3 years. This allowed us to evaluate vegetation conditions within sites and to assess the extent to which ecological succession occurred within managed sites. We observed succession among all management types/regions and variable attainment of management goals: timber harvests, on average, attained 4/5 vegetation targets while shrub management sites attained 2/5 management targets. We conducted point counts (n=896 locations) for Golden-winged Warblers and other early-successional songbirds. The results of occupancy modeling indicated that, among sites monitored across all three years, Golden-winged Warbler occupancy steadily increased over time on both private (11-32% occupancy, 2015-17, respectively) and public lands (18-45% occupancy, 2015-17, respectively). Like within Appalachia, Great Lakes timber harvests (all on private lands) monitored across all three years had consistent increases in occupancy over time from 77% in 2015 to 87% in 2017. We conducted woodcock surveys (n=1,644 surveys across three years) at sites that were recently managed to create habitat for Golden-winged Warblers. Woodcock were detected at 23.6 – 49.5% and 81.3 – 86.9% of locations across the Appalachian and Great Lakes regions, respectively (varying by year). Woodcock density was higher on public lands compared to private lands within the Appalachians, but was equal between ownership types/management type within the Great Lakes.

Our partnership has completed a data management tool that links avian, vegetation, and management treatment datasets though further work is required to refine this tool for other datasets, even within this study. It is our hope that the tool we have produced will serve as a

template for both ourselves moving forward as well as for NRCS and state agency efforts in the future.

Understanding stakeholder satisfaction and future motivations is important for the long-term success of programs like WLFW and RCPP. Using the above biological data collected from monitored properties, we summarized bird response to habitat management efforts in site-specific 'result mailing packets' for each private landowner we monitored in 2015 and 2016. Of the 189 landowners we called, 102 completed surveys for a response rate of 57.9%. Across a range of possible outcomes within the survey, respondents reported that the outcomes with the highest mean importance were 'improving the forest health' and 'benefiting other birds that use young forest'. A high proportion of respondents expressed that participating in the program had 'positive' or 'very positive' effects on their forests. Respondents generally had high trust in the expertise of NRCS employees and partners, felt that NRCS employees and partners shared their values, and felt the program policies and procedures ensured they were treated fairly. Most respondents said 1) money and 2) time would most limit the extent to which they managed for young forest in the future if further cost share payments were not available.

Finally, because it is well known that habitat needs for many forest nesting songbirds shift within the full breeding season (nesting – post-fledging periods), we completed a 4-yr study to better understand post-fledging habitat use and movements of Golden-winged Warblers. Ultimately, such information can be incorporated in to management guidelines that consider full breeding habitat needs. We located 162 Golden-winged Warbler nests and radio-tagged 149 fledglings across two managed forest landscapes in northern Pennsylvania. Golden-winged Warbler fledglings experienced most mortality early (Days 1-5) in the post-fledging period but the length of the high-risk period varied between the two study areas. We found almost no clear impacts of vegetation on fledgling survival between either region. By the end of the 30-day monitoring period, fledglings from both regions moved on average nearly 1 km from their nests and <u>used</u> a variety of forest cover types. Fledglings <u>selected</u> for young forest conditions similar to nesting habitat and slightly older sapling-aged stands throughout the post-fledging period in both landscapes. These results suggest that management focusing on creating nesting habitat (i.e., overstory removals with 15-30 ft^2/acre RBA) will provide habitat for Golden-winged Warblers during the post-fledging period especially once stem exclusion occurs (i.e., 10-15 years post-harvest). Strategically, placing new overstory removals in close proximity to regernating sapling stands will better meet the full breeding season needs of Golden-winged Warblers. Collectively, our partnership has successfully completed our initial objectives/goals for this project. Several scientific manuscripts are currently in preparation or have been submitted peer-reviewed journals. We expect to complete additional monitoring and analyses in 2018, and hope to continue on-the-ground monitoring efforts through work with NRCS and other partners beyond 2018.

Introduction

The Golden-winged Warbler (*Vermivora chyrsoptera*) is one of the most critically threatened, non-federally listed vertebrates in eastern North America. This species has become rare and patchily-distributed across its Appalachian breeding range, and many populations in this region are in danger of extirpation unless effective conservation measures can be implemented. The Golden-winged warbler is somewhat more secure in portions of its Great Lakes distribution including Minnesota and northern Wisconsin, but even there it is considered a species of

conservation need and/or a priority stewardship species. In 2010, the Golden-winged Warbler was petitioned to be listed under the Federal Endangered Species Act. The U.S. Fish and Wildlife Service reviewed the petition and determined that it had substantial merit. The implementation of previously developed science-based best management practices that create or maintain Golden-winged Warbler breeding habitat is thought to be an important step to reversing the species decline (Roth et al. 2012).

In 2012, NRCS and USFWS initiated a joint conservation program called *Working Lands for Wildlife* (WLFW). This program specifically targets the creation or enhancement of habitat for 7 imperiled wildlife species across the United States, including the Golden-winged Warbler within the Appalachian states. After 5 years, NRCS and its partners have conducted outreach, site visits, and created/implemented conservation plans for many private landowners within WLWF target areas. To date, over 14,000 acres of habitat have been contracted/created on private lands in association with the WLFW-Golden-winged Warbler effort. Additionally, the American Bird Conservancy and its partners were awarded funding for a Regional Conservation Partnership Program (RCPP) project in Minnesota, Michigan, and Wisconsin to assist NRCS with landowner outreach, coordination, and technical assistance to benefit Golden-winged Warbler, American Woodcock (*Scalopax minor*), and associated species, mirroring the WLFW effort.

American Bird Conservancy and Indiana University of Pennsylvania-Research Institute (IUP-RI) have also work closely with several state and federal agencies to fill capacity needs in order to implement GWWA and AMWO guidelines on public lands in several states. For example, IUP-RI employed a forester who worked with the Pennsylvania Game Commission staff to identify and prepare areas for habitat management on State Game Lands. Additionally, American Bird Conservancy fills a similar position in Minnesota whereby a forester works with USFWS, MN-DNR, and County land managers to identify and prepare areas on public lands for early successional habitat management. In 4 years, this partnership has resulted in >4,900 acres of young forest habitat being contracted on private lands in MN and WI. An additional 2,200 acres of shrublands have been managed on public lands in Minnesota since 2013. To date, between the Appalachians and Great Lakes efforts, >6,650 acres and >14,000 acres of early successional habitat have been created/managed on public (MN and PA) and private lands (MN, WI, PA, NJ, and MD), respectively.

In 2015, our partnership initiated work under a Conservation Effects Assessment Project (CEAP) to evaluate the effectiveness of WLFW and RCPP efforts intended to benefit Golden-winged Warbler. This project consists of six primary components that couple aspects of evaluation and adaptive management. These components include: i) describing structural vegetation characteristics among habitats managed using NRCS- WLFW, RCPP and comparable public lands; ii) monitoring Golden-winged Warbler occupancy and habitat associations among sites managed using NRCS- WLFW, RCPP and comparable public lands; iii) monitoring American Woodcock density among sites managed using NRCS- WLFW, RCPP and comparable public lands; iv) developing a data management tool that links NRCS's implementation database with the avian and vegetation monitoring results for each NRCS contracted project under these two programs; v) gaining an understanding of how participation in such voluntary incentive programs affects landowners; and vi) quantifying post-fledging survival and habitat selection in managed forests of the central Appalachians. The components outlined here are ultimately

essential to help ensure an effective, and ever-evolving, long-term conservation strategy for breeding season habitat for species like the Golden-winged Warbler and American Woodcock on forest lands across the eastern US.

Part I. Attainment and succession of vegetation within habitats managed using two NRCS conservation programs that target Golden-winged Warbler nesting habitat: Working Lands For Wildlife and Regional Conservation Partnership Program

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Introduction

Since 2012, NRCS and several partners have been implementing management effort across the Western Great Lakes and Appalachian portions of the Golden-winged Warbler's breeding range. These efforts, aimed at creating/improving early successional habitat, are the primary node between conservation documents such as the 'Golden-winged Warbler Status Review and Conservation Plan' or 'American Woodcock Management Guidelines' and target species. The Golden-winged Warbler Conservation Plan and other companion documents were published in 2011-12 in order to guide habitat prescriptions for Golden-winged Warbler. Because NRCS, state agencies, and NGO's have now spent several years implementing shrubland/young forest habitat management (2012-17), the next key step in the adaptive management process is to evaluate the conservation actions to determine the extent to which these actions yield the desired vegetation conditions. Within this first chapter of this annual report, we define 'desired vegetation conditions' as those outlined within the Golden-winged Warbler Status Review and Conservation Plan (detailed below).

A previous CEAP funded study completed a smaller-scale attempt to examine vegetation attainment of goals across select study sites in NC, TN, PA, and WV (McNeil et al. 2017, NRCS Conservation Insights). Although that study marked an important first examination of conservation practice ability to achieve the vegetation goals outlined by the Golden-winged Warbler Status Review and Conservation Plan, these management practices have yet to be examined at larger regional scales at the hundreds of private and public lands sites that have been enrolled in NRCS programs.

Objectives

1. Quantify vegetation within timber harvests and shrub management sites treated with practices used by NRCS and public agencies to manage for Golden-winged Warbler nesting habitat across the central Appalachians and western Great Lakes.
2. Describe patterns of ecological succession among sites managed using timber harvest and shrub management from 0-5 years, post-treatment

3. Evaluate the extent to which these NRCS and public agency conservation actions attain the recommended habitat conditions as outlined by Golden-winged Warbler 'best management practices'.

Methods

We used the '*create random points*' function in the geographic information system, ArcGIS, to generate point locations for vegetation sampling and associated avian monitoring (point count locations). Whenever possible, we placed survey locations at least 80 m from an un-managed forest edge. We did this to maximize the amount of each treated area sampled. Due to the irregular size/shape of some habitat patches, survey locations were necessarily <80 m from an untreated edge and therefore placed at the center of the patch. These patch centroids were identified using the 'calculate geometry' feature in ArcGIS.

In order to quantify the microhabitat variables among sites managed using NRCS conservation practices, we conducted a vegetation survey at each point location. We surveyed vegetation from 15 June – 15 July, 2015-17. All vegetation data were collected along three radial transects, each 100 m in length and oriented at 0°, 120°, and 240° from the point count location. Along each transect plant strata measurements were taken at 10 "stops" (10 m apart; n=30/point count location). Vegetation strata recorded at each stop consisted of the presence/absence of sapling, shrub, *Rubus*, fern, forb, sedge/grass, leaf litter, and bare ground. Trees > 10 cm in diameter-at-breast-height were classified as "canopy" and those ≤ 10 cm were considered saplings. Trees were quantified using a basal area prism at the 0m, 50m, and 100m locations along each transect (n=7 total/point). Shrubs were considered woody plants with multiple primary stems (in contrast to single-stemmed saplings). Ferns were seedless vascular plants with compound fronds (*e.g.*, bracken fern, *Pteridium aquilinum*). Forbs were broad-leafed dicotyledonous plants (*e.g.*, *Viola* spp.). The plant category 'sedge' included any monocotyledonous plant, however, was frequently *Carex* spp. Plant strata were recorded with an ocular tube such that only strata that intersected with crosshairs in the ocular tube were considered present. While a single stop could include multiple strata types, each stratum could only be represented once/stop and thus each point count location could have a maximum of n=30 occurrences for each stratum. Plant strata values were analyzed as percentages (*i.e.*, % cover) as some sites had outer portions of transects truncated due to irregularly-shaped management boundaries.

We defined the "recommended" vegetation attributes within managed patches using the guidelines outlines within the Golden-winged Warbler Status Review and Conservation Plan. As described therein, recommended vegetation for managed Golden-winged Warbler nest site habitat includes 0-10% bare ground, 2-25% grass, 5-40% *Rubus*, and 5-50% woody vegetation. For forbs, the Conservation Plan recommends 4-45% cover for "non-forest" sites (*i.e.*, Great Lakes shrub management sites) and 45-100% for "silviculturally derived" sites (*i.e.*, timber harvest within both regions). The Conservation Plan recommends levels of residual basal area to be 10-40 ft^2/acre for all conservation practices. To evaluate the attainment of recommended nest site vegetation, we compared mean levels of vegetation features within the most recent growing season (2017) to the levels recommended by the Golden-winged Warbler Status Review and Conservation Plan. We defined "attainment" as a feature (*e.g.*, percent forb cover) lying, on average, within the range of recommended levels outlined within the Conservation Plan. In the

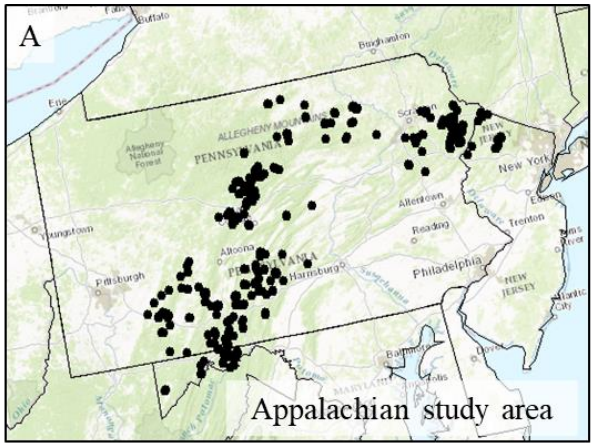
future, we will also evaluate attainment of recommended value of vegetation at the stand-scale (patch).

Results

Appalachian Region

Timber harvests

All of the sites monitored within Appalachia (n= 463; Figure 1a) were managed using timber harvest as the primary conservation practice. The majority of timber harvest included in the study consisted of standard overstory removals although some were managed using other prescriptions (*e.g*., salvage operation post-gypsy moth infestation). Sites contained few trees (basal area = 16.10 ft^2/ac, 95%CI: 14.67-17.53%; Fig. 2) and were typically characterized by varying densities of regenerating understory plants. This level of basal area lies within the recommended value for basal area outlined within the Golden-winged Warbler Status Review and Conservation Plan (Fig. 3) suggesting that this vegetation goal was successfully attained. Residual trees were primarily deciduous hardwoods such as oak (*Quercus* spp.), hickory (*Carya* spp.), and maple (*Acer* spp.). On average, timber harvests in Appalachia contained relatively high cover of woody vegetation (shrubs and saplings; 63% cover, 95%CI: 58-67%) and this habitat feature was also within the boundaries suggested by the Conservation Plan. Timber harvests also contained variable levels of *Rubus* (29%; 95%CI: 24-30%), forbs (33%; 95%CI: 30-36%), and grass (23%; 95%CI: 21-26%) though these were generally less prominent than woody regeneration (saplings and shrubs). Among Appalachian timber harvests, sites fell within all recommendations set by the Golden-winged Warbler Status Review and Conservation Plan with the exception of forbs which were 11% lower than the minimum recommendation of 45% cover (Fig. 3). We also observed consistent ecological succession through time within Appalachian timber harvests (Fig. 4) with sapling and *Rubus* cover increasing over time while shrub and grass cover decreased over time.



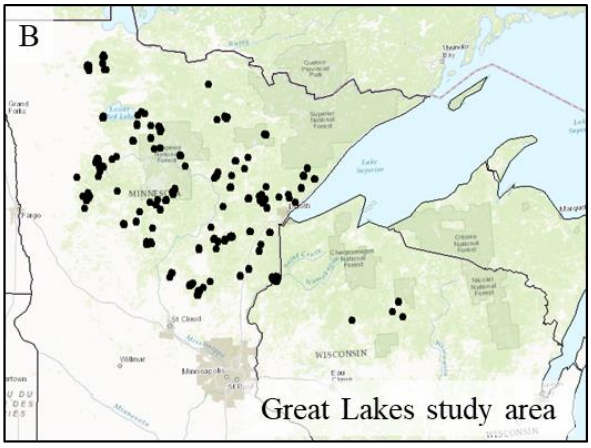


Figure 1. Survey locations (shown as black circles) for vegetation monitored at sites managed for Golden-winged Warblers and American Woodcock through NRCS-WLFW, NRCS-RCPP, and analogous practices on public lands. Surveys were conducted in Appalachia (Pennsylvania, Maryland, and New Jersey; A) and the Western Great Lakes (Minnesota, Wisconsin, B).

Figure 2. A timber harvest in a Pennsylvania managed for Golden-winged Warblers under the NRCS – Working Lands for Wildlife. Appalachian timber harvests were treated with overstory removal and hosted variable levels of understory regeneration.

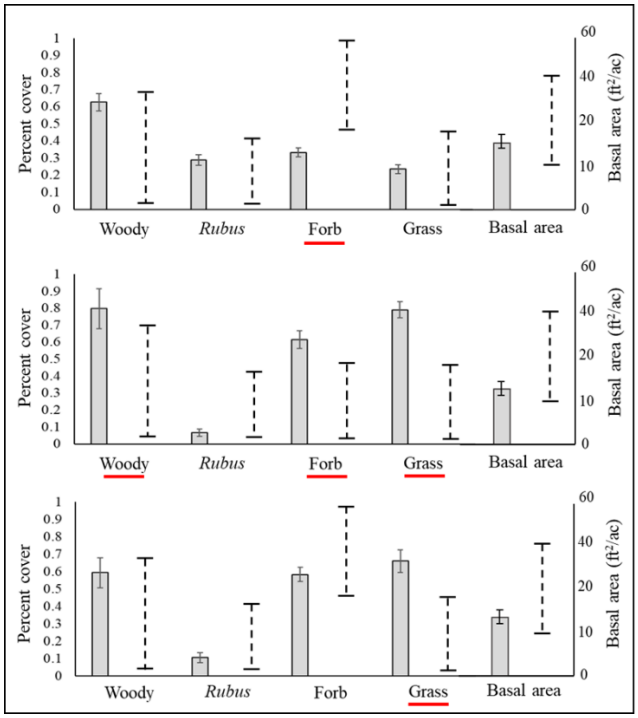


Figure 3. Vegetation levels present within Appalachian timber harvests (top), Great Lakes shrub management sites (center) and Great Lakes timber harvests (bottom). Observed levels of vegetation as recorded in the field are shown as gray bars (error bars represent 95% confidence intervals) while BMP recommendations from the Golden-winged Warbler Status Review and Conservation Plan are shown as dashed brackets to the right of each observed value. Features that *failed* to fall within the recommended boundaries are underlined in red.

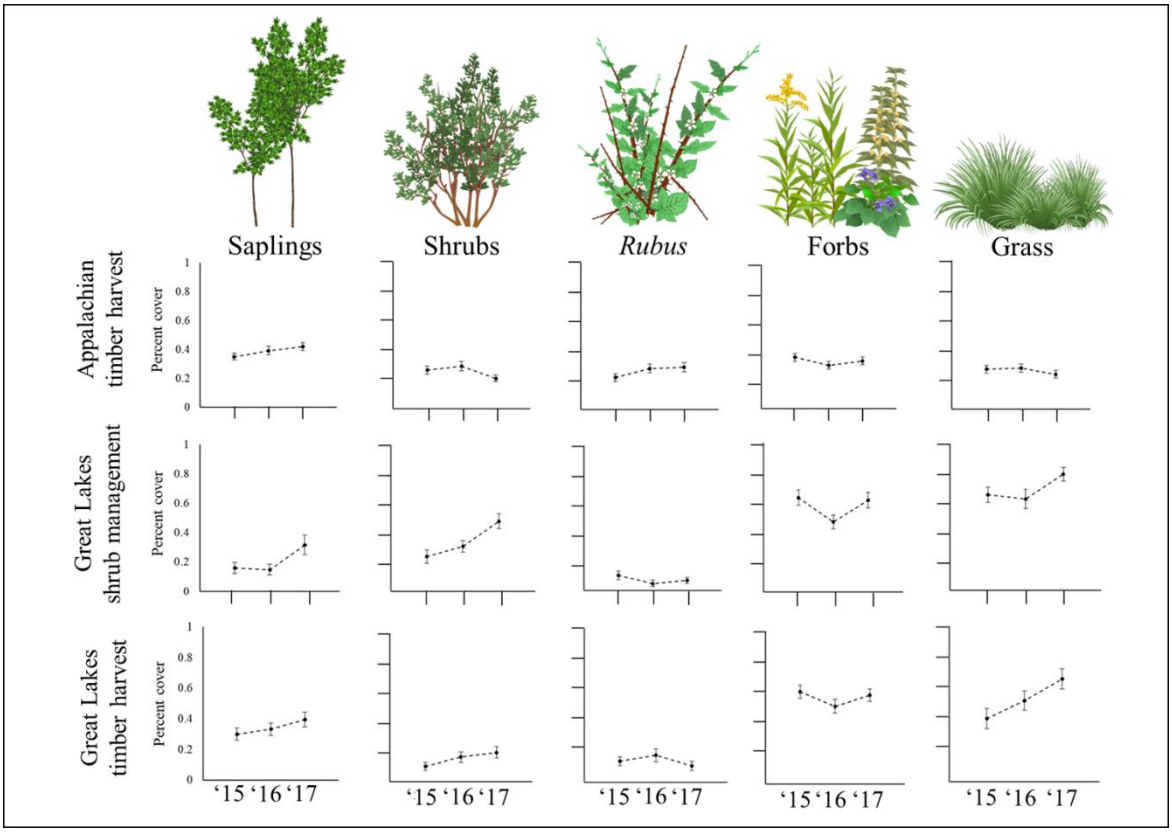


Figure 4. Vegetation levels (saplings, shrubs, *Rubus*, forbs, and grass, left-to-right, respectively) present within Appalachian timber harvests (top), Great Lakes shrub management sites (center) and Great Lakes timber harvests (bottom) as they underwent ecological succession from 2015-17. Error bars represent 95% confidence intervals.

Great Lakes Region

Timber harvests

We monitored n=214 timber harvest sites within the Great Lakes region (Fig. 1b). Like those from Appalachia, the majority of these timber harvests resulted from overstory removal harvests within either aspen (*Populus* spp.) or oak (*Quercus* spp.)-dominated stands. Sites contained few trees (basal area = 13.82 ft^2/ac, 95%CI: 10.24-17.39%; Fig. 5) and were typically characterized by varying densities of regenerating understory plants. This level of basal area lies within the recommended value for basal area outlined within the Golden-winged Warbler Status Review and Conservation Plan (Fig. 3) suggesting that this vegetation goal was successfully attained for timber harvests within both Appalachia and the Great Lakes. On average, timber harvests in the

Great Lakes contained relatively high woody cover (shrubs and saplings; 59% cover, 95%CI: 51-68%) and this habitat feature was also within the boundaries suggested by the Conservation Plan. Timber harvests also contained variable levels of forbs (58%; 95%CI: 54-63%), and grass (66%; 95%CI: 60-72%). These values were much higher than those observed for timber harvests in Appalachia while observed *Rubus* cover was much lower within Great Lakes timber harvests (11%; 95%CI: 8-14%). Among Great Lakes timber harvests, sites fell within all recommendations set by the Golden-winged Warbler Status Review and Conservation Plan with the exception of grass which was 22% higher than the maximum recommendation of 45% cover (Fig. 3). We also observed ecological succession among vegetation variables in Great Lakes timber harvests (Fig. 4) with sapling, shrub, and grass cover increasing over time.

Figure 5. A timber harvest in Minnesota managed for Golden-winged Warblers under the NRCS – Regional Conservation Partnership Program. Great Lakes timber harvests were treated with overstory removal and hosted variable levels of understory regeneration.

Shrub management

We monitored n=219 shrub management sites within the Great Lakes region (Fig. 1b). These shrub management sites were the mostly the result of i) shrub shearing (alder (*Alnus* spp.) / hazel (*Corylus* spp.) /willow (*Salix* spp.), ii) aspen shearing, or iii) hardwood shearing (e.g., oak). As with timber harvests from both regions, sites contained few trees (basal area = 12.82 ft^2/ac, 95%CI: 9.63-16.02%; Fig. 6) and were typically characterized by varying densities of regenerating understory plants. This level of average basal area lies within the recommended value for basal area outlined within the Golden-winged Warbler Status Review and Conservation Plan (Fig. 3) suggesting that even shrub-dominated habitats can achieve appropriate basal area necessary for Golden-winged Warbler habitat. On average, shrub management sites contained high woody cover (shrubs and saplings; 80% cover, 95%CI: 68-91%) and exceeded the recommended values for nest sites provided in the Golden-winged Warbler Status Review and Conservation Plan by. Shrub management sites contained high levels of forbs (61%; 95%CI: 56-

67%), and grass (79%; 95%CI: 75-84%), both of which also exceeded the recommended levels. Although *Rubus* was somewhat uncommon (7%; 95%CI: 5-9%), it was still within the range of recommended levels. In general, shrub management sites meet 2 of the 5 recommended values (basal area and *Rubus*) for nest sites. The recorded values for woody vegetation, grass, and forbs all exceeded levels recommended for nest sites in the Plan. We note here that Golden-winged Warbler occupancy within these managed shrubland sites were among the highest reported, in spite of nest site attainment being low (see Part II of this report). We postulate that shrubland sites will likely exhibit higher levels of attainment when we examine this at the patch level. Finally, we also observed consistent ecological succession through time within shrub management sites (Fig. 4) with sapling and shrubs exhibiting the most dramatic increases over the three years of monitoring (*i.e*., two growing seasons).

Figure 6. A shrub management site in Minnesota managed for Golden-winged Warblers. Shrub management sites were chiefly the result of i) shrub shearing (*i.e*., alder (*Alnus* spp.) / hazel (*Corylus* spp.) /willow (*Salix* spp.), ii) aspen shearing, or iii) hardwood (*e.g*., oak) shearing.

Part II. Monitoring and evaluating Golden-winged Warbler response to habitat management associated with two NRCS conservation programs that target Golden-winged Warbler nesting habitat: *Working Lands For Wildlife* and *Regional Conservation Partnership Program*

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Introduction

The primary goal of our biological survey effort is to initiate a long-term inventory and monitoring program for Golden-winged Warblers and associated bird species across properties enrolled in NRCS conservation programs (*e.g.*, WLFW, EQIP-Wildlife, etc.) and on public lands managed by partner agencies. This year (2017) was the third year of this effort and we focused survey efforts within Pennsylvania, Maryland, New Jersey, Wisconsin, and Minnesota. In 2018, we plan to incorporate sites within additional states such as West Virginia, and potentially others as opportunities arise. This effort builds on a previous (2012-2014) project funded by NRCS-CEAP (Project ID#: 68-7482-12-502) that quantified and compared several Golden-winged Warbler demographic parameters (*i.e.*, nest success, territory size) among NRCS conservation practices.

Standardized monitoring protocols are used across all states included in this project such that basic demographic data (*e.g.*, singing male densities) and relevant habitat features (*e.g.*, residual trees, shrub/sapling cover, and herbaceous cover) can be consistently collected and compared across all managed sites on participating public lands or private lands enrolled in NRCS programs. Monitoring within areas where habitat management has occurred using standard protocols will provide NRCS staff, public land managers, and their partners with an empirical evaluation of how focal species are benefiting from public and private land management efforts. Ultimately, information derived from this project combined with conservation practice-specific Golden-winged Warbler demographic parameters collected during the CEAP-GWWA Phase I will inform future conservation planning and potential modifications to existing conservation practice guidelines that target Golden-winged Warbler and American Woodcock. These data will provide the first broad-scale attempt to quantify avian response to recent NRCS-funded private lands conservation programs and similar efforts on public lands in the eastern U.S.

Objectives

1. Quantify Golden-winged Warbler occupancy and density in areas enrolled in NRCS programs and on public lands in key focal states (PA, NJ, MD, WI, and MN).

2. Relate avian survey data to site-level vegetation and landscape attributes, and to use these findings to inform potential modifications to NRCS ranking criteria or other aspects of program delivery.

Methods

Field methods

To quantify Golden-winged Warbler (and associated songbird) use of sites managed using conservation practices implemented on private and public lands, we conducted passerine point counts from mid-May through June 2015-17 (Fig. 1a). Surveys varied by study region with Appalachian surveys occurring 10 days earlier (15 May-15 June) than within the Great Lakes (25 May – 25 June). These periods were chosen as they correspond to the periods in which most songbird species, including the Golden-winged Warbler, are at maximum daily detection probability. Surveys during the early breeding period also minimized the likelihood of detecting migrant species that may not breed within the managed habitat. Point count locations were surveyed twice annually for Golden-winged warblers and associated bird species. Points were each conducted by a single observer during fair weather and took place from 0.5 hr pre-sunrise and continued for 4.5 hours daily. Each point count survey consisted of a 10-minute passive period, followed by a 2-minute Golden-winged Warbler playback, and a final 1-minute passive period. This method is intended to maximize the detection probability for Golden-winged Warblers to nearly 1.0. Still, these data were collected in an occupancy framework to allow for model-based accounts of detection error.

Within the Appalachians, sites were 0-5 years post-management and <u>all</u> consisted of overstory removal timber harvests (regardless of private/public ownership class). Some sites within the Appalachians were first treated with shelterwood harvests to promote early partial regeneration of understory before final treatment was conducted. In the Great Lakes, we again examined private- and public lands managed for Golden-winged Warblers, however, sites here were treated differently based on ownership domain: all private lands were managed with timber harvest and all public lands were treated with "shrub management". Although we use the term shrub management throughout this report, this prescription included alder shearing, aspen shearing, and other non-commercial shrubland management techniques. We assumed that mature forests treated with timber harvest resulted in new habitat that had been formerly unoccupied because Golden-winged Warblers are obligate early-successional nesting specialists. In contrast, shrub management aims to alter pre-existing shrubland habitat in a manner that enhances occupancy/density within sites that may already harbor Golden-winged Warblers. As such, we also conducted several pre-treatment surveys for sites slated for shrubland management and compared occupancy rates between pre- and post-treatment shrub management sites. Results below are divided among three analyses: i) Appalachian timber harvest, ii) Great Lakes timber harvest, and iii) Great Lakes shrub management.

Data analyses

We modeled these detections using a series of single-season occupancy models in the R package *unmarked*. We created occupancy models in two tiers: a detection probability tier and a state occupancy tier. The detection tier allowed detection probability to vary as a function of survey covariates (date, weather, etc.). To avoid overly-complex modeling (e.g., models with many covariates considered together), we used 0-2 detection covariates in each model and created all possible combinations thereof. Models were ranked in accordance to AIC_c. Once the best model was selected for detection probability, tier 2 included these covariates into subsequent modeling. Tier 2 varied occupancy as a function of microhabitat (*e.g.*, shrub cover, sapling cover, etc.) while accounting for imperfect detection (*e.g.*, windiness, etc.). Again, because our

goal was to ensure that models were not overly-complex, we allowed only 0-1 occupancy covariates to be added to the detection covariate models. The result was AICc-ranked occupancy models that allowed us to assess the impacts of habitat on Golden-winged Warbler occupancy.

To assess the impacts of local landscape on occupancy of sites by Golden-winged Warblers, we employed the occupancy models described above using remote sense covariate data. These landscape-scale data were obtained from the freely-available National Land Cover Database (NLCD) which is a 30 m resolution remotely-sensed dataset of broad cover types (Fig. 7). We buffered each point count using a 1 km buffer and extracted underlying raster values within each using the "tabulate intersection" tool in ArcGIS. Each covariate was then modeled similar to the manner in which microhabitat was modeled with the primary unit was "percent cover", though the scale for these variables was a 1 km radius circle.

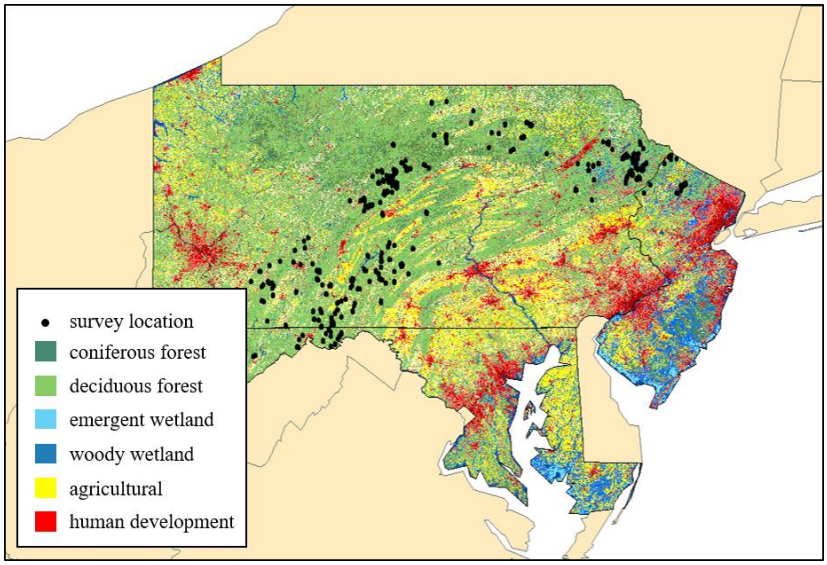

Figure 7. National Land Cover Database values for the Appalachian portion of the study area.

Results

Appalachian Region

Across the Appalachian portion of the study area, we conducted all-species avian point counts across 274-463 locations (2015-17, respectively, adding new sites each year; Fig. 1b). These survey locations spanned 31 counties across the states of Pennsylvania, Maryland, and New Jersey. Among these counties, survey locations were relatively evenly-distributed between private (n=261; 56%) and public (n=202; 44%) ownership. Appalachian states were not evenly sampled with Pennsylvania receiving more sampling effort than Maryland or New Jersey (PA: 90%; MD: 5%; NJ: 5%) due primarily to the limited breeding range of the Golden-winged Warbler within New Jersey and Maryland. Across all 463 Appalachian survey points, Golden-winged Warblers were detected at 49, 85, and 93 locations from 2015-17, respectively. These detections appeared to be heavily concentrated within several regions while other portions of the Golden-winged Warbler conservation region remained seemingly vacant (*i.e.*, zero detections). Regions with concentrated detections included the Poconos and Pennsylvania Wilds though scattered detections were made across southwestern and south-central Pennsylvania (Fig. 8).

Over the first three years of surveys, no Golden-winged Warbler detections were made in New Jersey or Maryland.

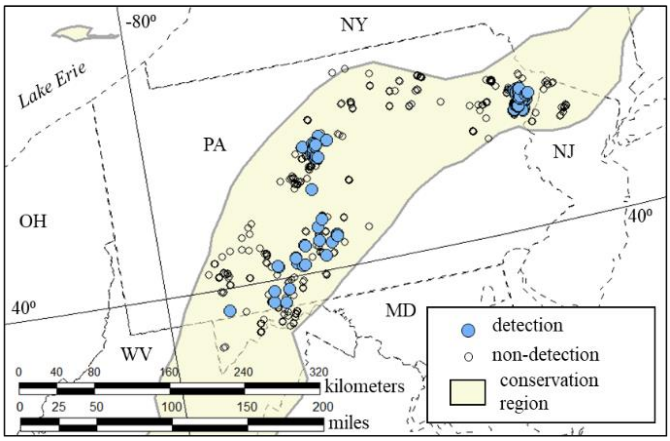

Figure 8. Golden-winged Warbler detections (symbolized using a blue circle) among all surveys conducted for passerines from 2015-17 (open circles). Naïve occupancy for 2017 shown here though all years showed a similar pattern with detections clumped in the Poconos and Pennsylvania Wilds and scattered detections across southwestern- and southcentral Pennsylvania.

Timber harvests

Occupancy models of Golden-winged Warblers within Appalachian sites suggested that detection probability was a function of i) Julian date (negative relationship, 2/3 years), ii) time since sunrise (negative relationship, 2/3 years) and iii) wind index (negative relationship, 1/3 years). That the null model was never well-supported emphasizes the need for a model-based analysis approach like the one applied here. As such, all habitat models (2015-17) included terms for Julian date, time since sunrise, and wind index within their respective years to account for the impact these conditions impose on Golden-winged Warbler detection probability (Fig. 9). For sites monitored across all three years, we observed a consistent increase in occupancy over time from 11 and 32% on private and public lands (respectively) in 2015 to 18 and 45% in 2017 (Fig. 10). Microhabitat models of 2015 data suggested that a wide variety of microhabitat features (all except basal area and *Rubus*) predicted Golden-winged Warbler occupancy among timber harvests, however, the top models were shrub and 1-2m woody regeneration (ΔAIC_c= 0.33). In 2016, we also found a number of features to explain variation in Golden-winged Warbler occupancy. Again, the top-ranked model was related to woody vegetation (‘sapling’). Although there were no competing models, the next best-ranked models were ‘1-2 m woody regeneration’ (ΔAIC_c= 10.98) and ‘shrub’ (ΔAIC_c= 34.18). Occupancy results from 2017 were similar to the two preceding years: the top-ranked model was ‘shrub’ and the next best-ranked models were ‘sapling’ (ΔAIC_c= 10.84) and ‘1-2 m woody regeneration’ (ΔAIC_c= 14.74). Associations with ‘shrub, ‘sapling’, and ‘1-2 m woody regeneration’ were consistently positive (across all years; Fig. 11). These microhabitat results suggest that Golden-winged Warblers are most limited by woody vegetation within timber harvests as sites with the greatest amounts of woody vegetation (shrubs and saplings) had the highest probability of being occupied by a Golden-winged Warbler. This result stresses the importance of allowing enough time to pass post-treatment (*i.e.*,

at least three years) for adequate woody vegetation to develop before judging the success of management.

Landscape-scale occupancy models within the Appalachian region suggested that most NLCD features were important predictors of Golden-winged Warbler occupancy but the top-ranked models were percent woody wetland (positive relationship), percent human development (negative relationship), percent agriculture (negative relationship), and percent coniferous forest (negative relationship; Fig. 12).

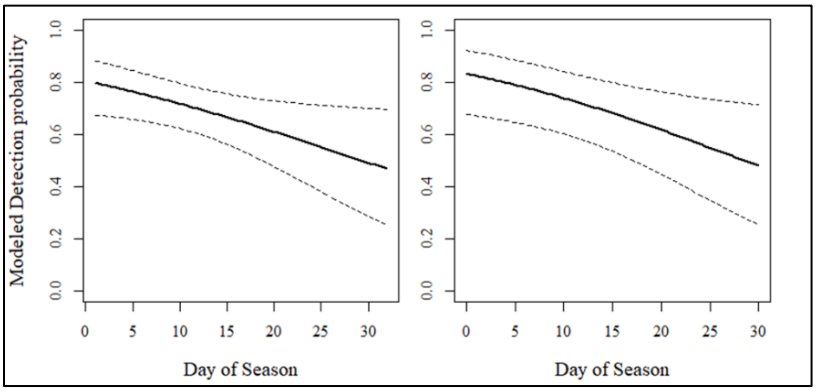

Figure 9. Models of detection probability for Golden-winged Warblers within Appalachian study sites (Pennsylvania, Maryland, and New Jersey). One detection covariate that was important in two of three years was day of season (2015 left, 2017 right). We found that detection probability was nearly halved between the start of surveys (15 May) and the end of surveys (15 June) which highlights the importance of incorporating detection modeling in analyses of site occupancy. Dashed lines represent predicted 95% confidence intervals while solid lines represent estimates of detection probability.

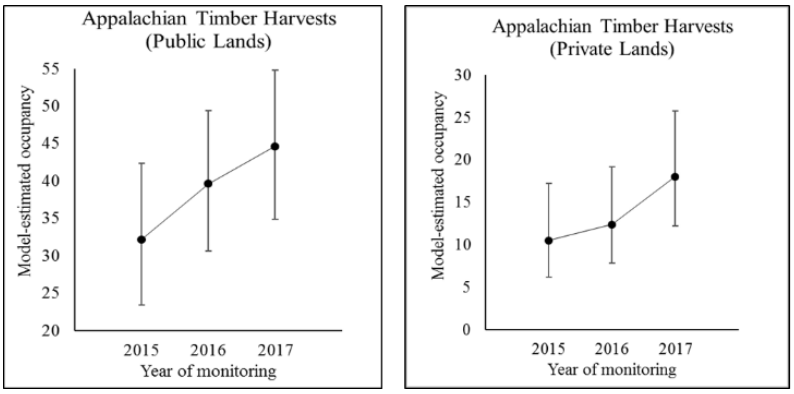

Figure 10. Model-estimated occupancy of managed timber harvests monitored across 2015-17. Sites monitored in all three years are shown. Shown are Appalachian public lands (left), and Appalachian private lands (right). Both private- and public lands monitored in the Appalachian region were timber harvests and both ownership types showed consistent increases in occupancy over time. In general, public sites hosted higher occupancy rates than private sites.

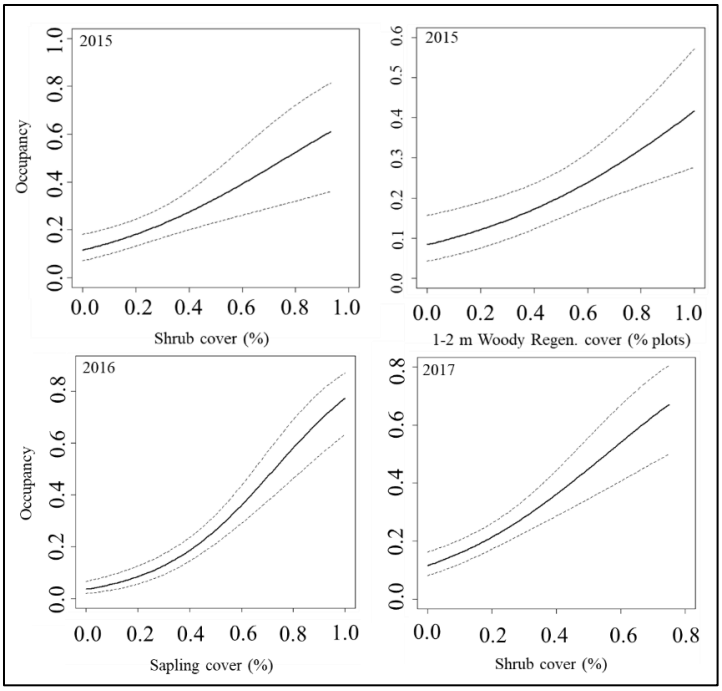

Figure 11. Microhabitat models of occupancy for Golden-winged Warblers within Appalachian sites monitored in 2015-17. Solid lines represent model estimates while dashed lines represent predicted 95% confidence intervals. Models suggested that regenerating woody vegetation (shrubs and saplings) cover was limiting Golden-winged Warbler occupancy of sites across all three years.

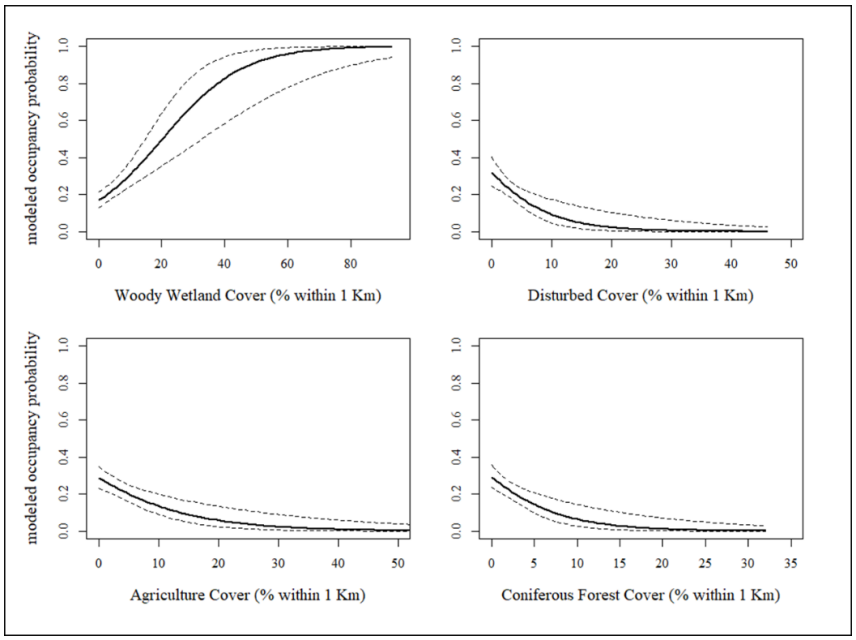

Figure 12. Landscape-scale models of occupancy for Golden-winged Warblers within Appalachian sites monitored in 2015-17. Solid lines represent model estimates while dashed lines represent predicted 95% confidence intervals. Note: "Disturbance Cover" = Human development.

Great Lakes Region

Within the Great Lakes, we conducted all-species avian point counts across 177-433 locations (2015-17, respectively, adding new sites each year as with Appalachia). We surveyed a total of 22 counties across Minnesota and Wisconsin. Across these counties, survey locations were nearly evenly-distributed between private (n=214; 49%) and public (n=219; 51%) ownership. The 214 private sites were all timber harvests while the 219 public sites were all treated with shrub management. The two Great Lakes states were not evenly sampled with Minnesota receiving more sampling effort than Wisconsin (MN: 396; WI: 37) due primarily to the limited availability of managed sites in Wisconsin (Fig. 7). Across these point locations, Golden-winged Warblers were detected at 77%, 81%, and 85% of locations from 2015-17, respectively. Detections were distributed relatively evenly across the surveyed portion of northern Minnesota and Wisconsin (Fig.13).

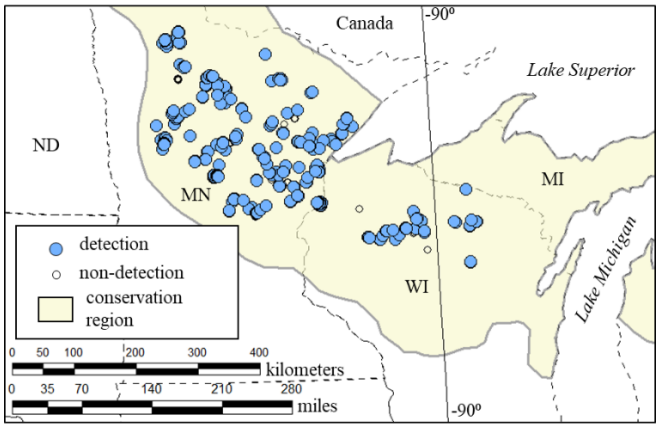

Figure 13. Locations surveyed for Golden-winged Warblers in Minnesota and Wisconsin from 2015-17. Golden-winged Warbler detections were relatively even across the region and sites hosted high rates of occupancy. Blue points show locations where Golden-winged Warblers were detected and hollow circles depict non-detections (2017 shown).

Timber harvests

Occupancy models for Golden-winged Warblers in Great Lakes timber harvests suggested that detection probability was *consistently* a function of i) Julian date (negative relationship) and ii) wind index (negative relationship). As such, habitat models across all three years included terms for Julian date and wind index to account for the impact these conditions impose on Golden-winged Warbler detection probability (Fig. 14). Like within Appalachia, Great Lakes timber harvests monitored across all three years had consistent increases in occupancy over time from 77% in 2015 to 87% in 2017 (Fig. 15). At landscape scales, we found that the only covariate that predicted Golden-winged Warbler occupancy within sites in the Great Lakes was percent deciduous forest cover (positive association; (Fig.16). That few landscape covariates predicted occupancy is relatively unsurprising as the species is largely ubiquitous across the Great Lakes portion of our study area, and all monitored locations were within the boundaries of the Golden-winged Warbler Great Lakes Conservation Region.

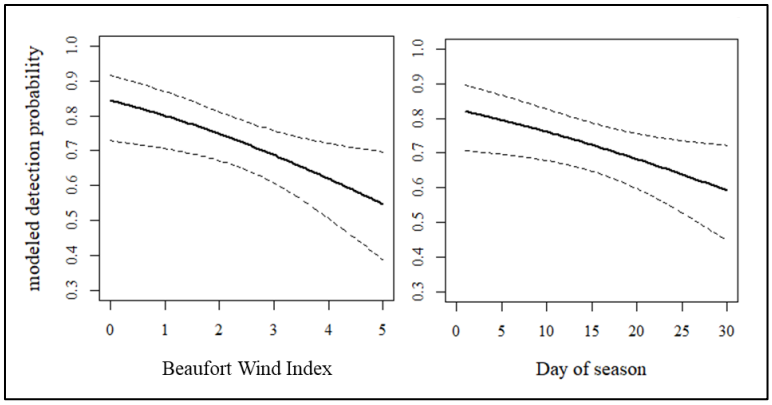

Figure 14. Models of detection probability for Golden-winged Warblers within Minnesota and Wisconsin. The top model across all years was one that included both terms for Beaufort wind index ("wind") and day of season ("date"). Relationships were consistently negative across all years. Predicted 2015 detection probability models are shown. Dashed lines represent predicted 95% confidence intervals.

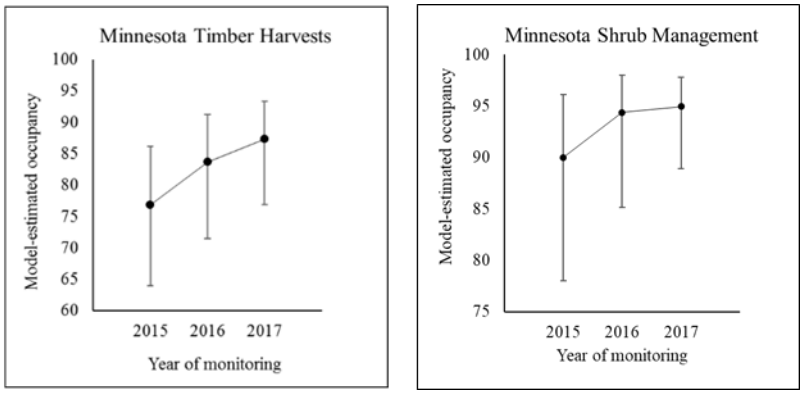

Figure 15. Model-estimated occupancy of managed early-successional habitats monitored across 2015-17. Shown are Great Lakes public lands (right), and private lands (left). Private lands were all timber harvests while public lands were all shrub management sites. Similar to the 'time' trend observed within Appalachian timber harvests, we observed a consistent increase in mean occupancy estimate over time within both Great Lakes timber harvests and shrub management sites. There was a general trend for shrub management sites to host higher occupancy rates than timber harvests.

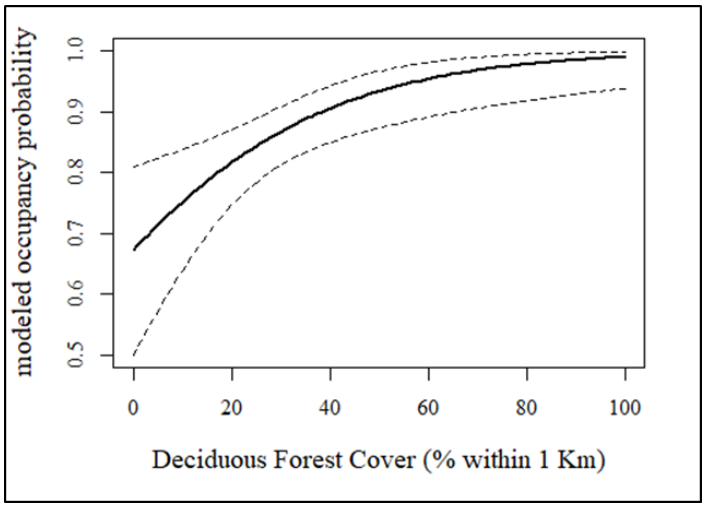

Figure 16. Models of occupancy for Golden-winged Warblers within Minnesota and Wisconsin across all Great Lakes sites monitored in 2015-17. Dashed lines represent predicted 95% confidence intervals. Only the model for deciduous forest (shown) performed better than the null model.

Microhabitat models for 2015 suggested that grass and forb explained variation in occupancy after accounting for imperfect detection and both covariates were positively associated with occupancy (Fig. 17). In 2016 the 'forb' effect no longer persisted but the effect of grass remained (positively) associated with occupancy. There was also a positive association between occupancy and % of plots containing tall (>2 m) woody stems in 2016. This '> 2 m woody stem' covariate was also the only habitat feature associated with occupancy in 2017 (positive). Taken together, these microhabitat results suggest that, immediately after management, Golden-winged Warblers were most limited by herbaceous vegetation. As rapid-growing herbaceous plants like forbs, grasses and sedges begin to proliferate, the effect faded and the species became most limited by the availability by tall woody vegetation. This result also suggests that, within Great Lakes timber harvests, recommended levels of herbaceous vegetation (< 25%) may be too conservative as we observed warblers selecting for maximum grass/forb cover until 2017 when herbaceous ground cover ('grass' + 'fern' + 'forb') reached > 85% within managed sites.

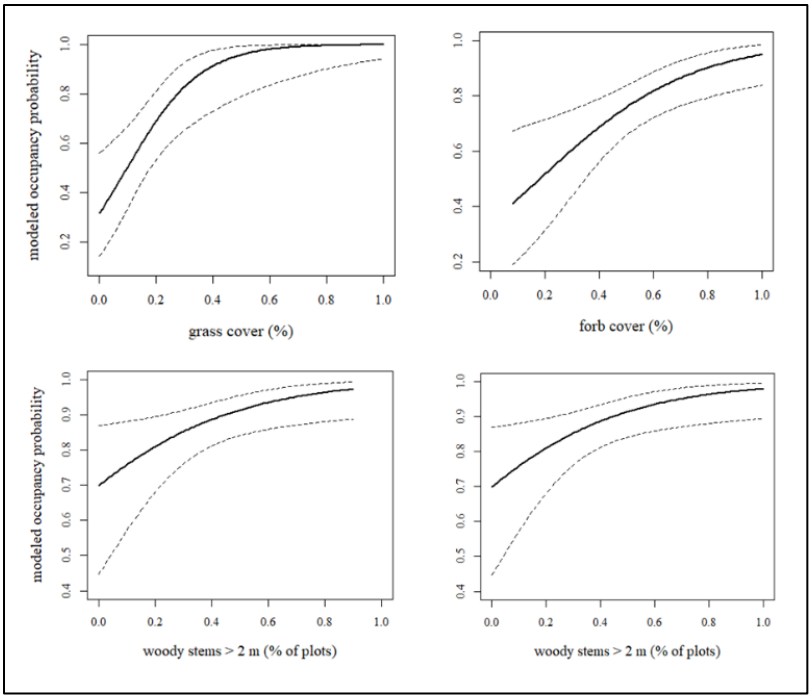

Figure 17. Models of occupancy for Golden-winged Warblers within Minnesota and Wisconsin across timber harvest sites monitored in 2015-17. Dashed lines represent predicted 95% confidence intervals. Models suggested that percent grass cover was limiting Golden-winged Warbler occupancy of sites in 2015-16 (top left, 2015 shown). Forb cover played a similar role in 2015 only (top right). In 2016-17, Golden-winged Warbler occupancy varied positively as a function of % of plots containing tall (> 2 m) woody stems (lower left, right).

Shrub Management

Occupancy models for Golden-winged Warblers in Great Lakes shrub management sites suggested that detection probability varied with Julian date (negative relationship; 2/3 years), time since sunrise (negative relationship; 2/3 years) and wind index (negative relationship; 1/3 years). As such, all habitat models (2015-17) included terms for Julian date, time since sunrise, and wind index within their respective years to account for the impact these conditions impose on Golden-winged Warbler detection probability. Like within Appalachian and Great Lakes timber harvests, shrub management sites monitored across all three years had consistent increases in occupancy over time from 90% in 2015 to 95% in 2017 (Fig. 15). Microhabitat models for 2015 (when all shrub management sites were young) suggested that only shrub cover explained variation in occupancy after accounting for imperfect detection. This model suggested that, for recently-managed sites (<1 growing season), Golden-winged Warblers were most likely to occupy sites with lowest shrub cover (Fig. 18). In 2016, the shrub effect was not detected while a positive association with *Rubus* cover was supported, though most sites had < 20% *Rubus* cover. Finally, in 2017, the only covariate associated with occupancy was grass cover with the grassiest sites most likely to be occupied. In 2017, we also monitored n=40 unmanaged shrubland sites to estimate the impacts of management itself. We found that sites treated with

shrub management had naïve occupancy (0.92, 95%CI: 0.85-1.0) to be greater than at untreated sites (0.83, 95%CI: 0.78-0.87; Fig. 19) though the confidence intervals overlapped. When detections (rather than presence/absence) were considered, this discrepancy became stronger with treated sites (2.0 males/site; 95%CI: 1.9-2.1) hosting nearly double the number of detections as untreated sites (1.1 males/site, 95%CI: 0.9-1.3; Fig. 19)

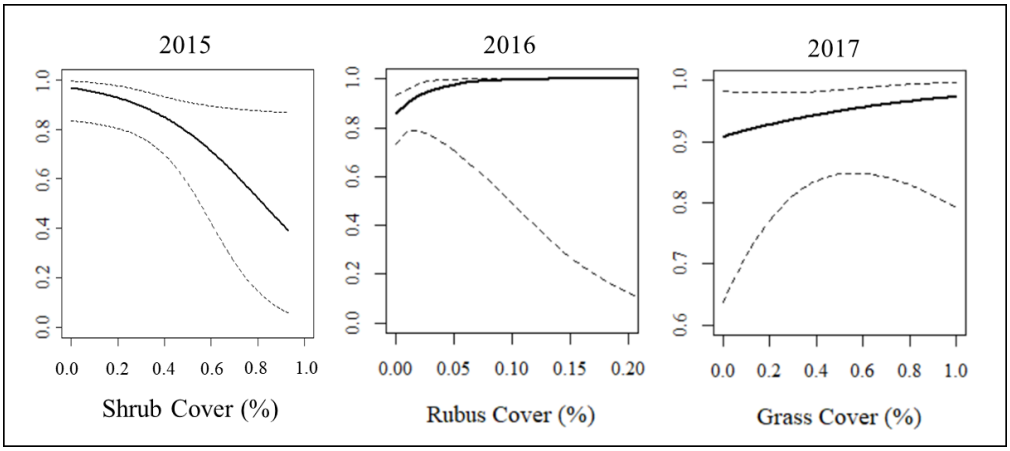

Figure 18. Models of occupancy for Golden-winged Warblers within Minnesota and Wisconsin across shrub management sites monitored in 2015-17. Dashed lines represent predicted 95% confidence intervals. Models suggested that percent shrub explained variation in occupancy during 2015 when all shrub management sites were < 1 year post-management. (left). *Rubus* cover explained variation in occupancy during 2016 (center) but only modestly so and estimates > 20% were unreliable because *Rubus* cover > 20% was very rare. In 2017, grass cover was the only feature associated with occupancy (right).

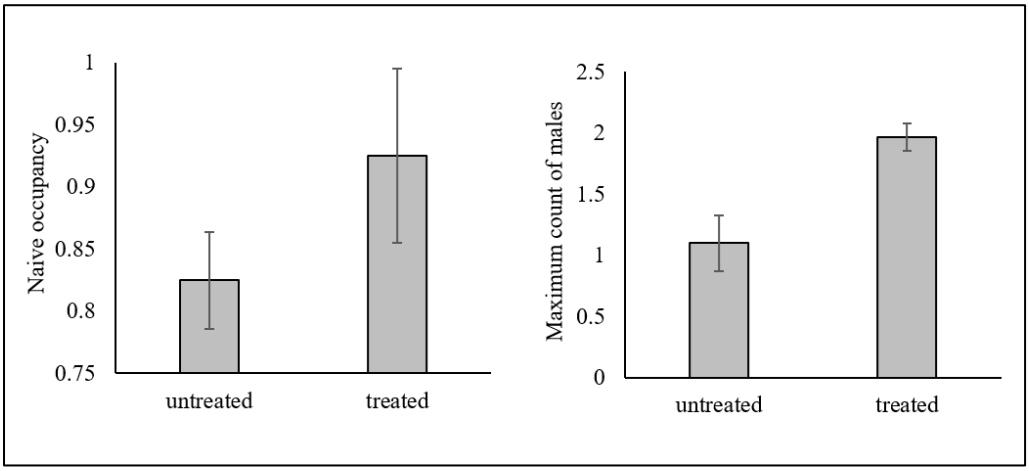

Figure 19. Naïve occupancy (left) and counts (detections) of singing males (right) for Golden-winged Warblers in Great Lakes shrubland habitats. Untreated sites hosted lower naïve occupancy than did treated sites, though confidence intervals overlapped slightly. This discrepancy became stronger when counts were considered as treated sites supported nearly twice as many males/point (2.0 males/point) than untreated sites (1.1 males/point).

Part III. Monitoring and evaluating American Woodcock response to habitat management associated with two NRCS conservation programs that target Golden-winged Warbler nesting habitat: *Working Lands For Wildlife* and *Regional Conservation Partnership Program*

Prepared by: Kirsten E. Johnson, Indiana University of Pennsylvania; Darin J. McNeil, Jr., Cornell Laboratory of Ornithology; Dr. Amanda D. Rodewald, Cornell Laboratory of Ornithology; and Dr. Jeffery L. Larkin, Indiana University of Pennsylvania & American Bird Conservancy

Introduction

Similar to the Golden-winged Warbler, American Woodcock are an early successional forest associate experiencing long-term population declines as a result of habitat loss. Although the American Woodcock is not a long-distance migrant like the GWWA, their declines have both been linked to the loss of their shared breeding habitat. Current knowledge on specific habitat needs of the American Woodcock is largely based on studies conducted in localized areas with limited duration and/or sample sizes. Woodcock response to management may be driven by site-level factors such as management technique and the structure and composition of vegetation post-management. Quantifying response to site-level variation is a critical piece in understanding the effectiveness of habitat management across the species' breeding range.

The breeding distributions of Golden-winged Warbler and American Woodcock overlap considerably and previous work has shown that habitat managed for the Golden-winged Warbler benefits woodcock (i.e., Bakermans et al. 2015). Monitoring efforts that evaluate woodcock response to habitat managed for Golden-winged Warbler through WLFW, RCPP, and on public lands will help quantify the extent to which these efforts benefit woodcock. Additionally, such work constitutes the first effort to directly compare woodcock habitat use patterns between two regions; Appalachians and Great Lakes.

Objectives

1. Quantify American Woodcock density in areas enrolled in NRCS programs and on public lands in key focal states (i.e., PA, NJ, MD, WI, and MN).

2. Relate woodcock survey data to site-level vegetation and landscape attributes, and to use these findings to inform potential modifications to management recommendations or other aspects of conservation delivery.

Methods

Field methods

We conducted American Woodcock singing ground surveys at locations that had been recently managed to create habitat for Golden-winged Warblers. Field technicians were placed strategically throughout our monitoring areas in PA, MD, NJ, MN and WI in a manner that maximized the number of sites that could be surveyed within a single breeding season. We conducted American Woodcock singing ground surveys within the dates and time period permitted under the USFWS American Woodcock Singing Ground Survey protocol: 15 April – 5

May within Pennsylvania/Maryland/New Jersey and 1-20 May within northern Minnesota and Wisconsin. The challenge with monitoring the singing activity of American Woodcock is that the allowable dates for any given region are restricted to only this 20-day window. Moreover, the survey period each evening is only 38 minutes in duration. As such, sites were only surveyed once, annually, for American Woodcock in order to maximize the number of sites surveyed. Surveys were conducted within a distance-removal framework such that the rate of imperfect detection could be incorporated into habitat models.

Data analyses

To model American Woodcock use of managed early-successional habitats, we used hierarchical distance models implemented in the R package *unmarked*. Hierarchical distance models, much like the occupancy models used for Golden-winged Warblers in the previous section, allowed us to model true state of species (*i.e.*, male woodcock density in this case) after accounting for imperfect detection. Unlike occupancy models, this class of model estimates detection probability using 'time at first detection' (*i.e.*, bird availability for sampling) and detection distance (*i.e.*, bird perceptibility by the observer). In essence, if a bird is always 'available' for sampling (*e.g.*, singing nonstop) and perfectly 'perceptible' to the observer when available, detection probability is perfect (p=1.0). Because neither are expected to be true, density modeling was necessary for understanding true habitat associations. We used our detection-adjusted estimates of density to explore how woodcock density within the upper Great Lakes and Appalachians varied as a function of microhabitat features. Similar to the approach used to model Golden-winged Warbler occupancy, woodcock density models allowed us to infer habitat features that best explained variation in male density.

Results

Appalachian Region

In the Appalachian region, the number of surveys increased dramatically from year one to years two and three. Between April 15 and May 5, 2015-2017 we surveyed 257, 420, and 401 sites (Fig. 20) across 31 counties within the study area. Each of the sites was managed according to Best Management Practices for Golden-winged Warblers in the Appalachian region, and management occurred between 2012 and 2015. Public sites accounted for 39-46% of sites surveyed in 2015 (n= 107), 2016 (n=194) and 2017 (n=157). The majority of sites were located throughout PA (n=425 of 474) and fell within the Golden-winged Warbler Conservation Region, as identified by the Golden-winged Warbler Conservation Plan. The remaining 39 sites were located in Maryland (n=22) and New Jersey (n=27).

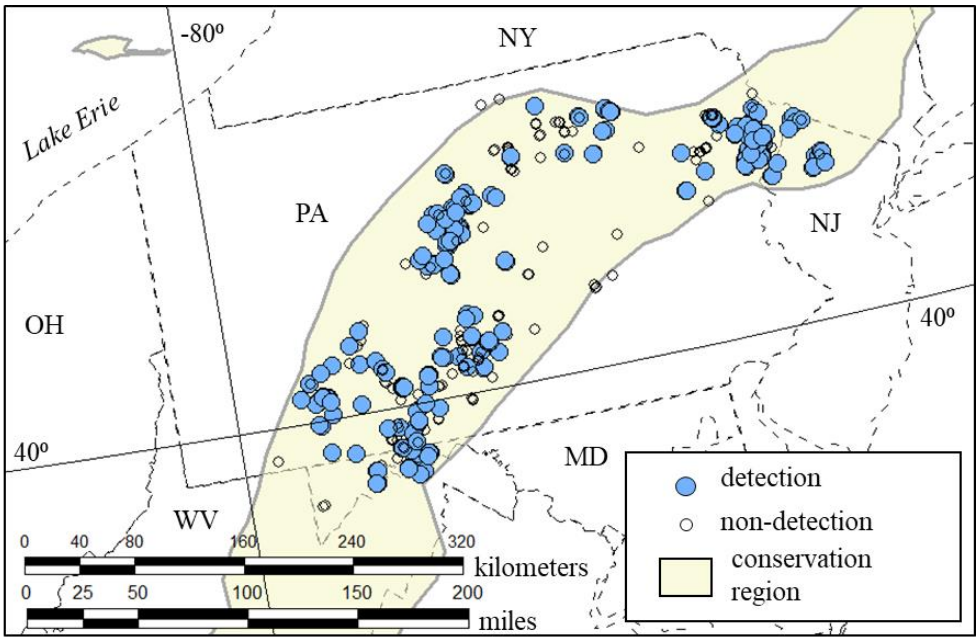

Figure 20. Locations surveyed for American Woodcock in the Appalachians from 2015-17. Blue locations are those that hosted positive detections whereas open circles represent apparent vacant sites.

When we examined patterns of density as a function of 'landscape' scales (500 m, 1 km) within Appalachia, we observed annual variation in those features of importance. Still, several patterns emerged: Across all years, the ratio of young : mature upland forests was a well-supported predictor of the density of singing males. Density was higher in landscapes comprised of a greater amount of forest cover in an early-successional state. (Fig. 21) In multiple years, local slope was an important covariate, and woodcock density was lower in sites with steeper degree of slope. Several other covariates were important in only 1-2 years including mixed forest cover (negative effect) and shrub-scrub wetland cover (negative effect). What appeared to be most important for woodcock density was maintaining adequate amounts of young forest within broadly-forested landscapes. Diversification of forest age classes will likely benefit woodcock within high elevation portions of the central Appalachians.

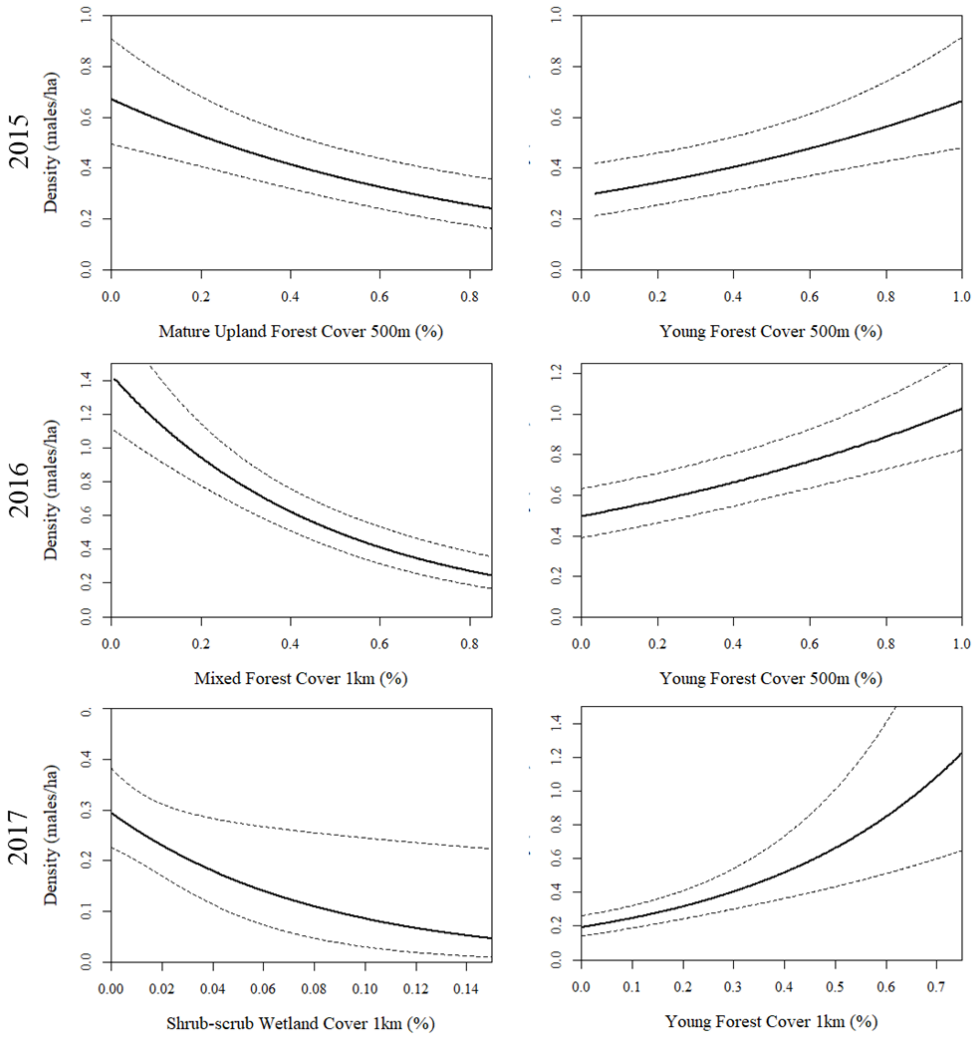

Figure 21. Woodcock density as a function of macro-habitat in the Appalachian Region from 2015-2017. Variation in woodcock density was similarly explained by the proportion of young forest at all scales in 2015 and 2017. In 2016, woodcock density decreased with increasing mixed forest cover, with below average densities in sites where mixed forest cover >50% of the landscape. In 2017, woodcock were nearly absent in sites where wetland cover approached >10% cover at the 1km scale.

Timber harvest

We detected woodcock at 119, 158, and 127, timber harvest locations in 2015, 2016, and 2017 respectively for a naïve occupancy of 46%, 38% and 32%. Detection probability varied most as a function of wind and temperature, and probability of detecting an individual male woodcock ranged from 38.2 to 52% across years over the course of a six-minute survey. While naïve occupancy decreased over the three years monitoring period, density of male woodcock varied substantially. Density was highest in 2016 at 0.82 males/ha, double that of 2015 and 2017, estimated at 0.41 and 0.37 males/ha respectively (Fig. 22). Even at the highest estimated density

in 2016, density of singing males was lower than the lowest density year in the Great Lakes study region (2017; 0.95 males/ha). This stark difference reflects similar disparities between the Central and Eastern populations and associated trends noted in the Breeding Bird Survey (Sauer et. al. 2017) and Annual Singing Grounds Survey (Seamans and Rau 2017).

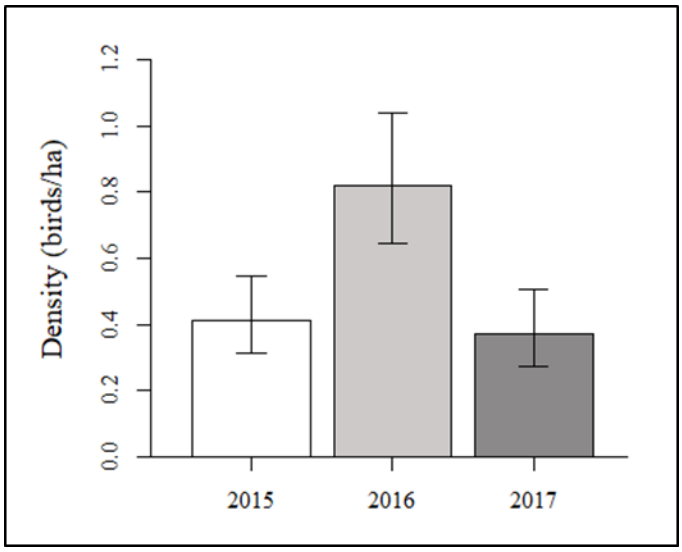

Figure 22. Estimated density of singing male woodcock for Appalachian sites monitored from 2015-2017. Density estimates were highest in 2016 at 0.82 males/ha.

Models suggested that woodcock density was most influenced by the amount of woody regeneration (positive relationship; 2 of 3 years), residual basal area (negative relationship; all years), sapling (positive relationship; 2 of 3 years) and grass cover (positive relationship; 1 year), with weak support for shrub and herbaceous cover (positive relationship; 2 of 3 years). Woody regeneration was important in all survey years and woodcock density was positively associated with woody regeneration 1-2m (Fig. 23). Woodcock density exhibited a consistently negative relationship with residual basal area across survey years with highest density estimated in sites with <15 sq. ft./acre. Models suggest the relationship with sapling cover shifted from year 1 to year 2: In 2015, woodcock density decreased with increasing sapling cover, whereas in 2016 woodcock density was positively associated with saplings (Fig. 23). While shrub cover was not the most important covariate, density was positively associated with shrubs in all years and this may explain the positive relationship with woody regeneration. Model results suggested that, to maximize woodcock density within sites managed for the Golden-winged Warbler, managers should focus on maintaining i) >40% cover of woody regeneration within treatment areas, and ii) tree basal area no greater than the ranges recommended (10-40 sq. ft./acre) within the Golden-winged Warbler best management practices.

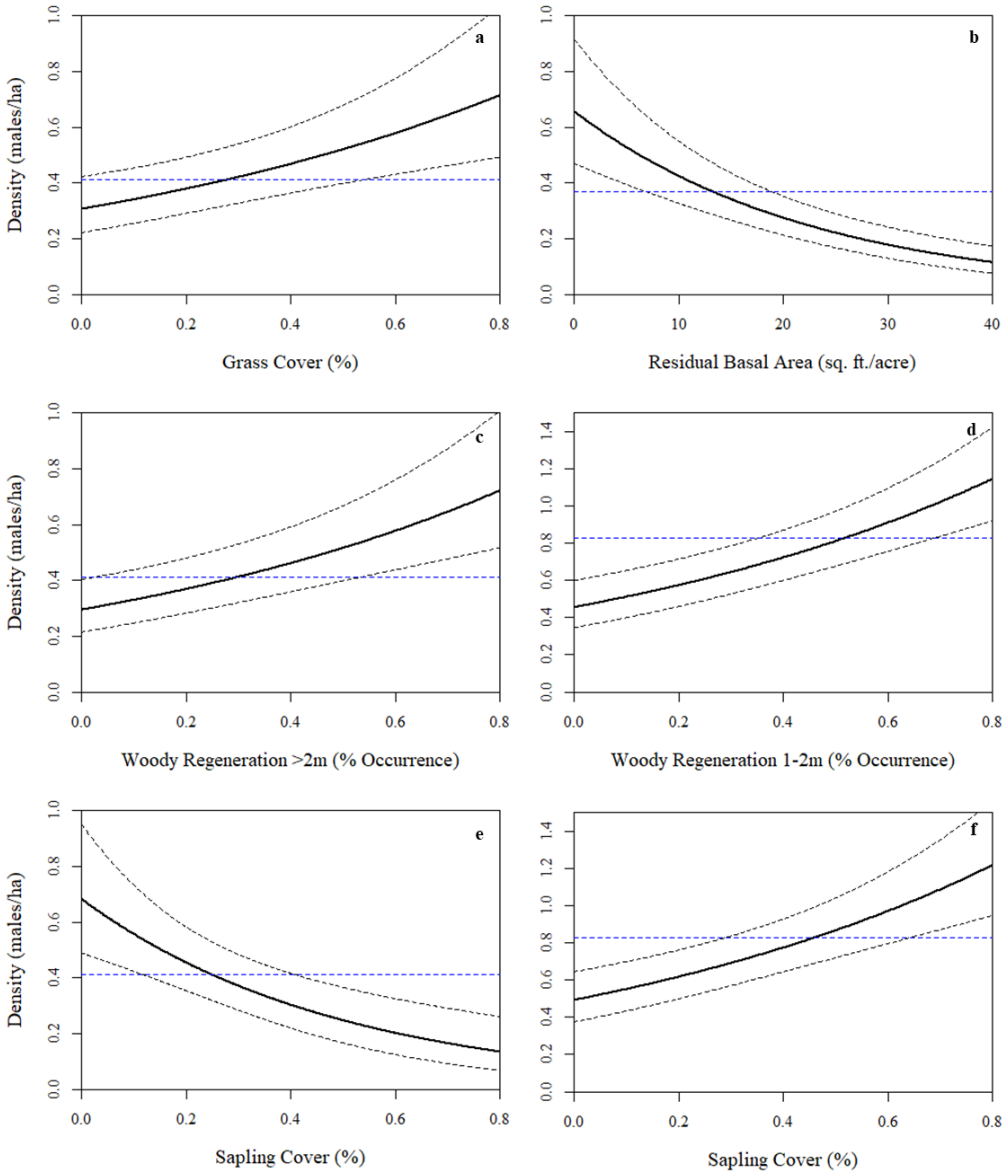

Figure 23. Density models for American woodcock within Pennsylvania, Maryland and New Jersey across sites monitored in 2015-17. Gray dashed lines represent predicted 95% confidence intervals. Models suggested that percent grass cover was limiting woodcock density in 2015 (a) and residual basal area in 2015-2017 (b, 2017 shown). Woody regeneration (% of plots containing 1-2m woody stems) was important in all survey years (c, d, 2016 and 2017 shown left to right). In 2015 woodcock density varied negatively as a function of sapling cover (e), but was positively associated with sapling cover in 2016 (f) when density was significantly higher in the region overall. The dashed blue line represents the mean density for reference.

Great Lakes Region

From 2015-17, we conducted woodcock surveys at 107-230 sites that had been managed between 2014-16. By year three of this study (2017), the total number of potential survey

locations was 433, with roughly half under private ownership (n=214; 49%) and half public (n=219; 51%). Sites surveyed were distributed across 16 counties throughout the northern half of Minnesota and north-central Wisconsin (Fig. 24). In 2015, 60% of the locations surveyed were on private lands (n=65) while ~40% were on publicly owned properties (n=42). In both 2016 and 2017, private lands account for about 70% of sites surveyed (n=164 and 161, respectively) with the remaining 30% on public lands (n=65 and 69). Over the duration of the 3-yr project, only 23 sites were available for survey in Wisconsin, thus the majority of surveys were conducted in Minnesota (n=107, 224, 225 in 2015, 2016, and 2017). Of those sites monitored, we detected woodcock at 93, 195, and 187 survey locations from 2015-2017 (Fig. 25). Naïve occupancy was highest in 2015 at 86.9%, and decreased by 5.6% from 2015 to 2017. Occupancy differed by treatment type, with overall occupancy in timber harvests showing a significant negative trend over time, whereas in shrub management sites, naïve occupancy was highest in 2017 (Fig. 25). Given the differing temporal trends, density estimates as a function of habitat covariates were evaluated separately for timber and shrub management sites.

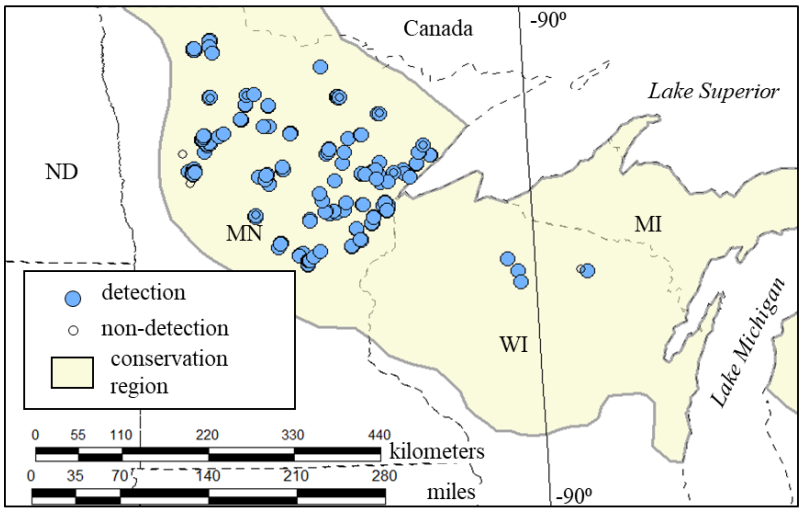

Figure 24. Locations surveyed for American Woodcock in the Great Lakes from 2015-17. Blue locations are those that hosted positive detections whereas open circles represent apparent vacant sites.

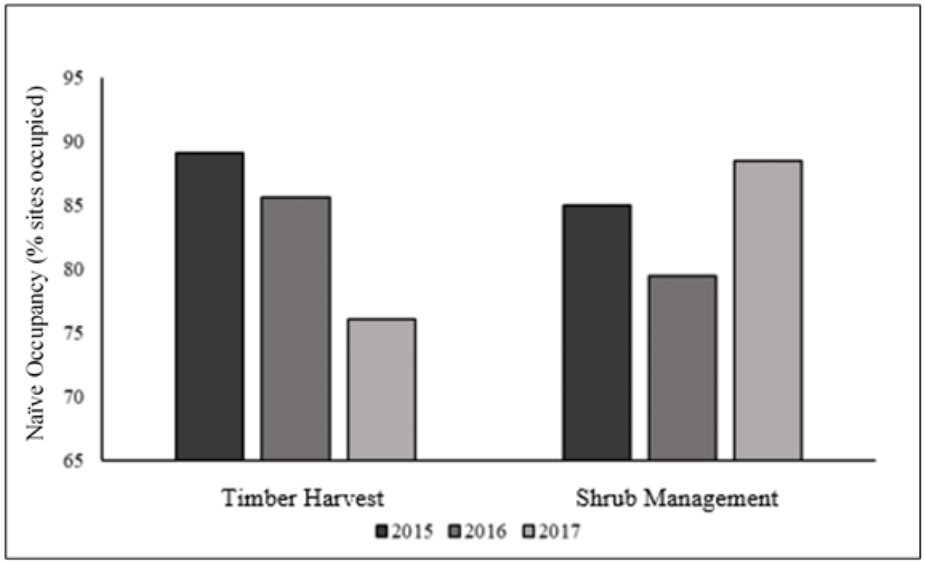

Figure 25. Comparison of woodcock naïve occupancy between timber harvest and shrub management sites surveyed in the Great Lakes from 2015-17. Naïve occupancy decreased in timber harvests from year one to year three, while naïve occupancy was highest in shrub sites during year three.

Overall density showed a slight, but non-significant negative trend from 2015 to 2017, with the average estimate for all sites decreasing from 1.37 to 1.05 males/ha (Fig. 26). Differences in density estimates between treatment types were also non-significant in 2015 and 2016, however woodcock density decreased on both treatment types in 2016, and in 2017 density was significantly higher in shrub sites (1.4 males/ha) than in timber management sites (0.83 males/ha).

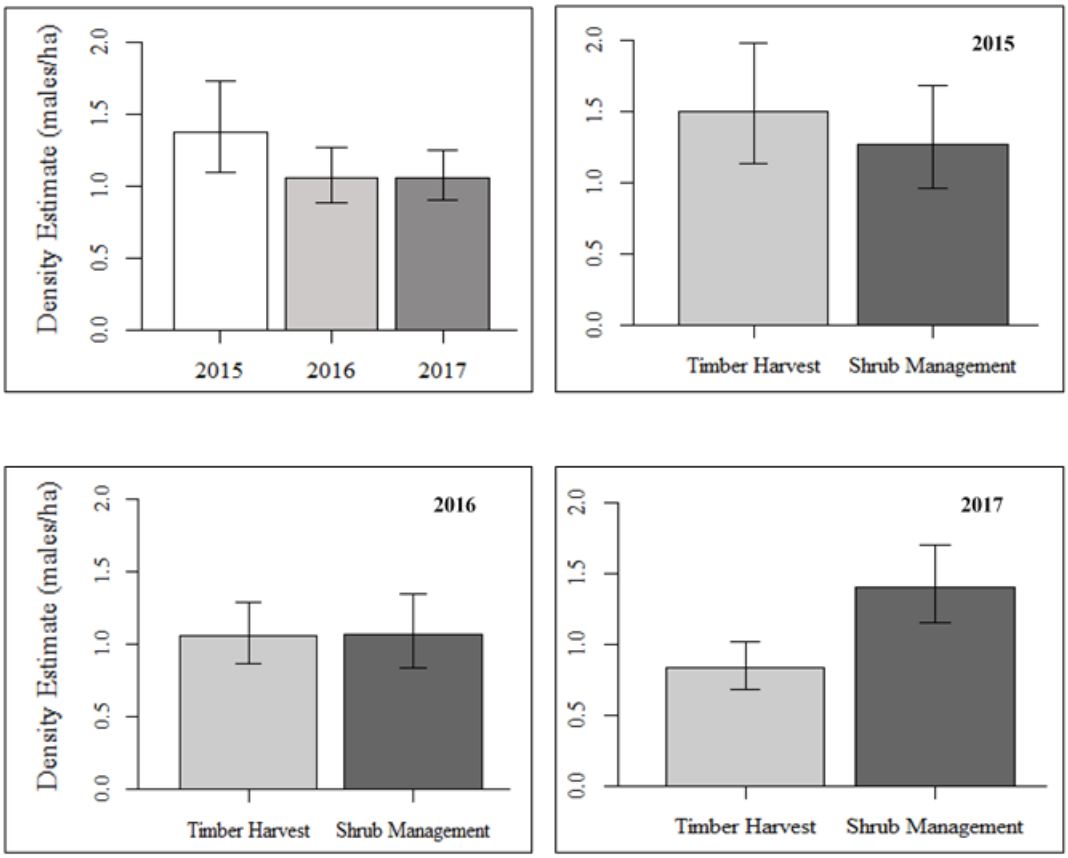

Figure 26 Estimated density of singing males/ha for the Great Lakes region from 2015-2017 (top left) and density estimates by treatment type for each survey year (top right, bottom). Estimated density differed significantly by treatment type in 2017 but not in 2015-16.

When we examined patterns of woodcock density as a function of 'landscape' scales (500 m, 1 km) within The Great Lakes region, we observed annual variation in the features predicting woodcock density. In 2015, woodcock density varied primarily as a function of the proportion of young forest, with density increasing from 1 to 1.75 males/ha as young forest covered 50% of the landscape within 500m. In 2016, woodcock density decreased with increasing deciduous forest cover, with below average densities as deciduous cover exceeded 50%. In 2017, woodcock density was most influenced by the amount of mature forest (negative) and shrub-scrub wetlands (positive) (Fig. 27).

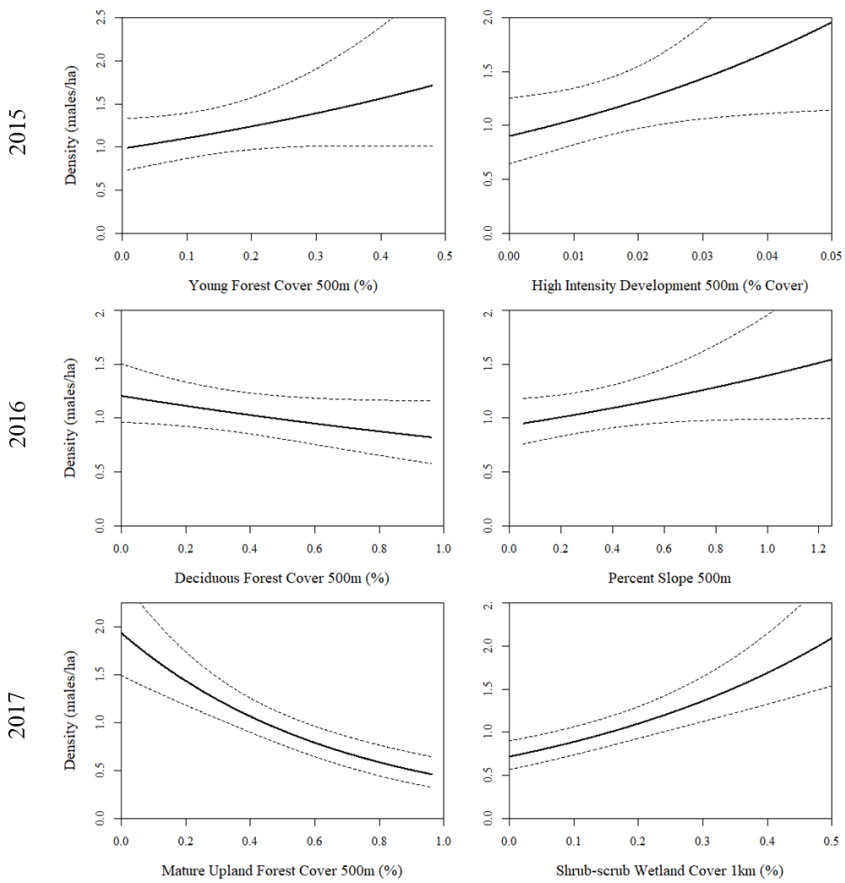

Figure 27. Woodcock density as a function of macro-habitat in the Great Lakes Region from 2015-2017. Density was best explained by proportion of young forest, with density increasing from 1 to 1.75 males/ha as young forest covered 50% of the landscape within 500m in 2015. Areas with small amounts of development supported greater densities of woodcock at the 1km scale. In 2016, woodcock density decreased with increasing deciduous forest cover, with below average densities as deciduous cover exceeded 50%. In 2017, woodcock density was most influenced by the amount of mature forest and shrubby wetlands. Density dropped below 1 male/ha as mature forest covered >40% of the landscape within 500m, and increased from 0.5 to 2.0 males/ha as shrub wetland cover increased to 50% of the area within 1km of recently managed sites.

Timber harvest

Relationships between survey covariates and detection probability varied by year. In timber harvest sites, detection was most affected by sky conditions in 2015, temperature in 2016 and wind in 2017. After accounting for imperfect detection, detection probability ranged from 42.3 to 54.3% with detection probability highest in 2017 (54.3%), and 6.6% higher than in shrub management sites during that year. Naïve occupancy for woodcock in timber harvest decreased across the three years, from 89.1% to 76.1% (Fig. 25), as did modeled density of singing males (Fig. 26). Density in timber sites ranged from 0.76-1.37 males/ha.

Density of singing males in timber harvest sites was negatively associated with shrub cover in 2015, positively related to increasing site age in 2016, and positively associated with regeneration of woody stems in 2017 (Fig. 28). The target level for woody regeneration within managed sites as recommended in the Golden-winged Warbler Conservation Plan was 30-70% coverage. Our results suggest that woodcock are most dense at the upper end of this range in timber sites post-management. Similar to the Appalachians, retaining live standing trees at the lower levels recommended in the Golden-winged Warbler Conservation Plan (10 – 20 ft^2/acre) should not negatively impact densities of singing male woodcock.

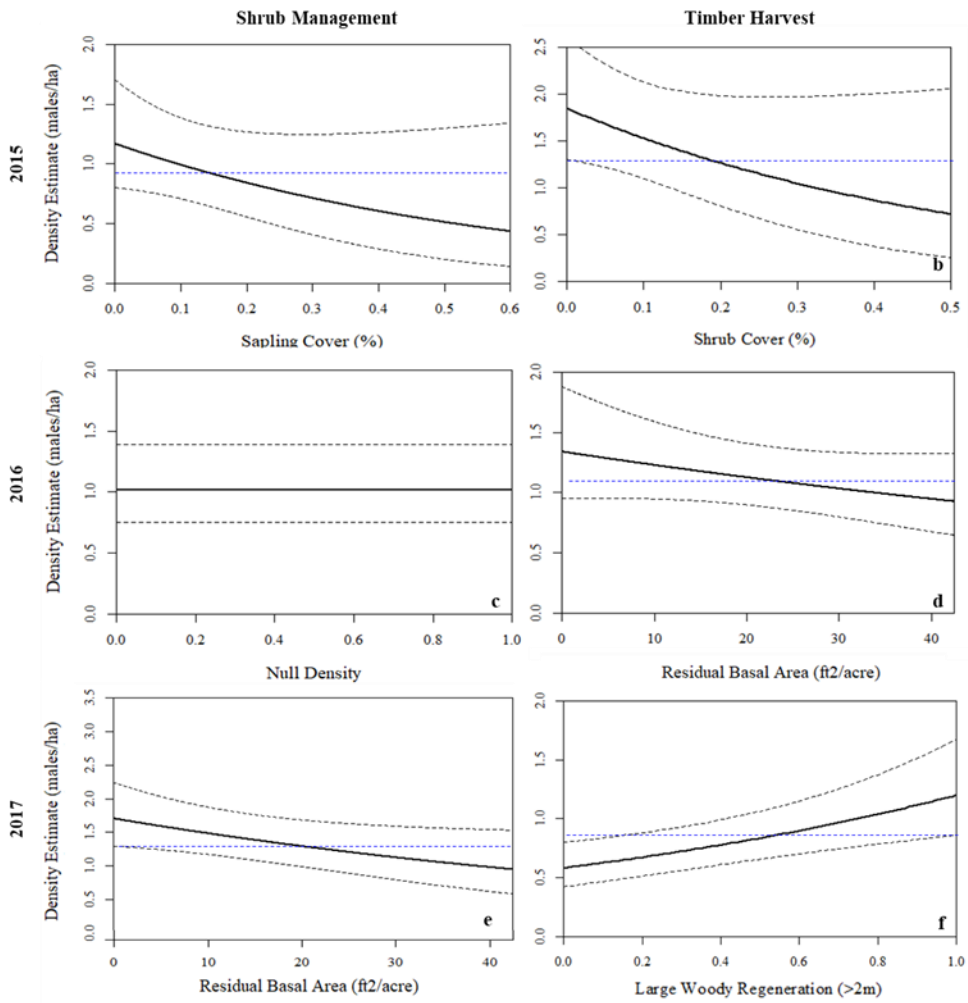

Figure 28. Microhabitat covariate relationships with woodcock density. Percent sapling and percent shrub cover were the top ranked single covariate models for shrub management (a) and timber harvest (b) sites in 2015. Note that this trend was absent in 2016 and somewhat reversed in 2017. No model explained variation in density better than the null model for shrub sites in 2016 (c). Woodcock density was negatively associated with residual basal area in timber harvests in 2016 (d) and within shrub management sites in 2017 (e). Increasing woody regeneration resulted in increasing density of woodcock in all sites across all years, and was particularly limiting in timber harvests during 2017 (f). The dashed blue line represents the mean density for reference.

Shrub Management

Detection probability varied only as a function of wind and ranged from 44-51.4% for shrub management sites. Naïve occupancy exhibited an overall increase from 85% in 2015 to 88.5% in 2017 (Fig. 25). After accounting for imperfect detection, density increased over the three-year study from 0.94-1.37 males/ha (Fig. 26). During the first two years of the study, density in timber harvests was similar to estimates for shrub management sites, however in 2017, woodcock density in shrublands was significantly higher (1.37 vs. 0.76 males/ha).

Within shrub management sites, microhabitat factors that best explained variation in woodcock density were percent shrub cover, size (area) of the managed site, and residual basal area (Fig. 28). In 2015, woodcock had a strong negative association with sapling cover and density was influenced by the overall size of the management site. Smaller shrub management sites (<1 acre) hosted fewer woodcock than larger sites in 2016. Shrub cover had an effect on woodcock density. Shrub management sites that hosted the lowest levels of shrub cover also supported the lowest densities of American Woodcock. However, as Figure 4 in Part 1 of this report illustrates, as succession occurs on shrubland sites post-management, shrub cover increases quickly. In fact, shrub cover was no longer explained woodcock density after 2015. There were no variables which explained variation in woodcock density during the 2016 season better than the null model. In 2017, density varied as a function of residual basal area in shrub management sites, and as with timber harvest sites, woodcock density decreased as basal area approaches the maximum for study sites within the region (Fig. 28).

Part IV. Development of an online tool to evaluate the effectiveness of actions taken to improve habitat conditions for Golden-winged Warblers

Prepared by: Mr. Casey Lott, Indiana University of Pennsylvania; and Dr. Jeffery L. Larkin, Indiana University of Pennsylvania & American Bird Conservancy

Introduction

The objective of this project component is to create a data visualization tool to illustrate the effects of Golden-wined Warbler habitat management on both vegetation and birds. The "biological response" data sets for this tool are bird and vegetation data collected by IUP/Cornell monitoring crews in the Appalachians and Great Lakes from 2015 to 2017 (and planned for 2018) under CEAP. The independent "input" data were expected to come from NRCS and partners for private lands and a variety of partners for public lands. This project started like many others with the simple request of: "send me all your data". When we received the electronic data files to support the construction of the data visualization tool and took the time to review them extensively the following realities became apparent:

1) Each year (and often each region) had its own data table, in Excel, for each type of field data collected (e.g., all bird species point counts, dedicated woodcock counts, vegetation structure data collection, and vegetation composition data collection).
2) Detailed habitat management data were only available for private lands in the Appalachians region while only very basic, and often incomplete, habitat management information was available for public lands in the Appalachians and both public and private lands in the Great Lakes.
3) Individual data sets were not comparable in many ways (e.g., across years, regions, or data types).
4) Thorough proofing and standardization of data were necessary for linking the four individual Excel databases.

How initial data issues could compromise the integrity of a data visualization tool

Given these realities, it became apparent that a fairly major data standardization and restructuring effort would be necessary to build a <u>data visualization tool</u> that has any of the following desired qualities:

1) The tool presents data from more than one year.
2) The tool links habitat management data to field-collected vegetation and bird data.
3) The tool allows comparison of these paired data sets across the two major regions: Appalachians and Great Lakes.
4) The tool allows for comparison of these paired data sets across private and public land domains.
5) The data presented in the visualization tool is accurate.

This initiated some re-thinking that led to the restructuring of project workflow. Our first decision was to try and create a pilot data visualization tool using habitat management information from private lands in the Appalachians (the only region/domain combination where

this data was even close to available, although it still needed lots of structuring and standardizing) paired with multi-year vegetation and bird data from the same region*domain combination. This tool would illustrate the main concepts of the visualization tool and allow for feedback from NRCS and partners, which we received when this pilot tool was presented at the 2017 Wildlife Society (TWS) conference in Albuquerque, NM. Feedback was positive, although given the raw nature of the data sources, bugs negatively affected performance. Additionally, NRCS staff and partners suggested that there should probably be some set of guided analyses to help users extract some of the major insights from the tool (and to get them started exploring relationships between habitat and birds on their own). Most importantly, it was clear that additional data management was necessary for the visualization tool to function reliably according to its purpose.

Course of action for addressing data deficiencies while creating an accurate and fully-functional data visualization tool

At this point, we acknowledged that it would not be possible to pair detailed habitat management data from the Great Lakes (GRLA) (or from public lands in the [APPA] Appalachians) with bird and vegetation data in the visualization tool, since these data were simply not present and would require a time-consuming and dedicated effort (with dedicated funds) in and of itself to compile. However, we decided to include multiple years of field-collected data on vegetation and birds at habitat management sites in a revised version of the data visualization tool that will cover all 4 region * domain combinations (GRLA * private, GRLA * public, APPA * private, and APPA * public). This will allow for regional and public/private comparisons of vegetation and bird data sets; however, habitat management information for everything other than the Appalachian * private lands pairing (GWWA-Working Lands for Wildlife project area) would be missing.

CEAP data collection for vegetation and bird response to habitat management occurred from 2015-2017 for each of these 4 region * domain combinations, and is planned again for the 2018 breeding season. This will create a 4-year data set (2015-2018), which could be valuable for many types of analyses. After looking over data from 2015-2017, it became apparent that:

1) **Problem**: multi-year analyses, cross regional, or cross-domain analyses would not be possible until the existing single-year data files were proofed, consolidated, and standardized. **Solution**: extensive data standardization and file reconciliation would be necessary.
2) **Problem**: The use of discrete Excel files for data entry and storage, as opposed to data entry, with quality control, via the more robust platform of a relational database, resulted in many inconsistencies in field data that needed to be repaired. When truly related data sets are documented in isolated spreadsheets, the absence of relationships among data tables presents challenges for data analysis and visualization. Thus, existing data need to be reorganized into a relational database. **Solution**: the creation of a relational database, with data entry forms that minimize inconsistencies and maximize standardization, was necessary for both long-term data storage and to use as a standard data input to the data visualization tool, which is being created in Tableau.

3) **Problem**: In the original four datasets, the way that sampling sites were named, and values for different levels within categorical fields (e.g., species codes for birds or vegetation, codes or abbreviations for environmental data) were not consistent across all spreadsheets. This made it impossible to accurately link data sets that were recorded in discrete tables. In other words, data collected at vegetation and bird field sampling points could not be reliably associated with habitat management data given the original data structure, since there were no comparable fields to match all of the unique field sampling points with all of the unique management treatment areas. Essentially, without major data manipulation, the comparison of management (i.e., NRCS conservation practices) and management response (i.e., Golden-winged Warbler detections) data sets would be impossible. **Solution**: post-hoc standardization of sampling site naming conventions across data sets, while reviewing spatial data sets in ArcGIS, along with post-hoc standardization of acceptable values for categorical data sets (and the creation of picklists to ensure the same codes are used in the future).

Data proofing, standardization, and reorganization prior to the creation of a data visualization tool

Facing these realities, we decided that it was necessary to step back from pursuing the primary objective of creating the data visualization tool (after the buggy pilot version was produced from poorly linked input data sets and presented at the TWS meeting) and take the time to create a relational data management system that would create the data entry, data storage, and data manipulation infrastructure that is necessary to support each of the desired qualities of a final data visualization tool that are listed at the beginning of this document. Additionally, the presence of high-resolution habitat management data from private lands in the Appalachians, also in need of proofing and file reconciliation, provided the opportunity to build a full database structure for visualization of the effects of habitat management on vegetation and birds for the APPA * private lands combination. This database stores proofed bird and vegetation data from all other region * domain combinations and provides an infrastructure for recording habitat management data for the remaining region * domain combinations: GRLA * private, GRLA * public, and APPA * public) that would easily allow the visualization tool to be easily updated to include this data as it becomes available.

Structuring the database and data visualization tool so that similar products could be created for other NRCS regions, projects, and programs

The basic premises of the data visualization tool to document and evaluate Golden-winged Warbler habitat management are similar to many applied wildlife management programs. For example, many programs attempt to: 1) manage habitat for wildlife, 2) record information on wildlife habitat and various wildlife taxa after management, and 3) present analyses that allow managers to draw inferences about the effectiveness of habitat management on target habitats or wildlife. If done properly, this type of applied science could then inform adaptive management while maintaining program transparency.

While this concept sounds very familiar, the successful implementation of such applied conservation science to management systems is rare. Why is this? Thinking about this issue relative to the Golden-winged Warbler CEAP project resulted in a few "epiphanies" about some of the steps that are critical to the successful construction and use of this type of application that are often short-changed or skipped altogether. Simply stated, linking management data to field data on vegetation and bird response to management requires effective communication and more carefully structured workflows among habitat managers, conservation planners, and field scientists that collect management response data, and data management teams that link all this information together for summary, display, and evaluation. We thought carefully about ways to resolve these issues, at least for private lands in the Appalachians (GWWA-WLFW area), so that this CEAP project could push applied conservation data science forward in two major ways that have been a bit of a philosopher's stone for the field of wildlife management. If done correctly, we should be able to:

1) Accurately document relationships between habitat management and vegetation/animal response for large management programs (e.g., Working Lands for Wildlife) so that the accomplishments and future needs of these programs can be more easily, and transparently, explained to everyone from the general public to program managers in Washington, D.C..
2) Use data visualization to improve the communication of management-related topics across stakeholders, scientists, land managers, and program managers in ways that could lead to true, effective, cost-effective, and collaborative, partner-driven adaptive management.

With these lofty goals in mind, we decided to take the non-trivial time necessary to transform the large number of disconnected and non-standardized excel data sheets described above into an accurate, and highly efficient, relational database. This final CEAP database (once data collection has finished in 2018) will have the following properties:

1) Provide accurate and updatable inputs for the data visualization tool.
2) Provide a long-term data warehouse for any habitat management done for Golden-winged Warblers. At minimum, this would be used for CEAP field data collection and storage in 2018 and would store all vegetation and bird data collected from the CEAP project (2015-2018, Great Lakes and Appalachians, public lands and private lands). It could then be updated in the future to include similar information for this same time period from other partners if so desired.
3) The database could be extended in the future to include habitat management data from other region * domain combinations from 2015-2018 and this information could be used to easily update the data visualization tool to facilitate the comparison of data across all desired pairings of region and domain.

<u>An additional expected outcome of this effort is that the final database and data visualization tool could be relatively easily modified to meet the needs of any type of applied habitat management program that wishes to document the effects of management on wildlife (e.g., other WLFW programs, other agency-specific programs, species-specific programs, and etc.).</u> This database,

and the related data visualization tool, would then provide both a case study and a template to facilitate future work that would significantly advance the data science behind adaptive management.

Major product 1: An Access database for long-term data storage and analysis for the GWWA CEAP project

After extensive proofing and communication among data collection personnel, we have created an accurate, fully-functional, relational database in Access 2013; containing all bird and vegetation data for all region/domain combinations from 2015-2017 and all habitat management data from private lands in the Appalachians through 2017. This database has been placed on a Box.com secure file sharing site hosted by NRCS. Forms have been created to facilitate accurate data entry with data validation rules and pick-lists for all fields with a limited number of categorical values (e.g., bird species names, management treatment details, types of precipitation). This database will store all additional data collected in 2018 and can store any additional long-term data collected on birds, vegetation, and management within this geography. Figure 29 shows a standard entity relationship diagram for this database.

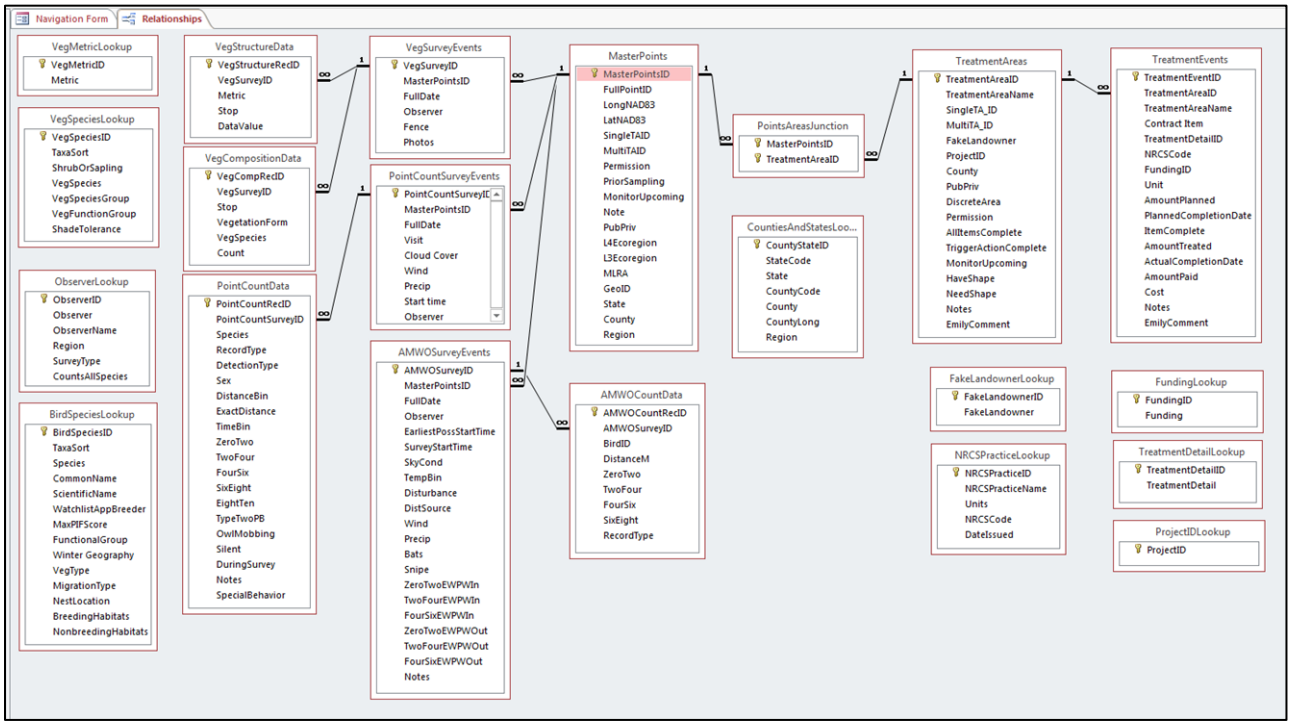

Figure 29. Tables with field lists and relationships among fully normalized tables in the CEAP GWWA Access database.

Major product 2: An ArcMap GIS project for long-term spatial data storage and analysis for the GWWA CEAP project

NRCS does not analyze or present data at the spatial resolution of specific real-world property boundaries. Additionally, NRCS does not divulge landowner names due to privacy laws. This presents a small conundrum for project accounting, which we have overcome in the Access database and the GIS project. First, the GIS project will never be publicly available, and it is only viewed by partners who have signed the "1619 privacy agreement" form. Second, all landowner names have been anonymized in the database (e.g., each real landowner gets a fake landowner name in the database). This allows us to still summarize program success relative to the number of landowners involved, for example, without divulging the real names of any landowners or their property boundaries. Fake landowner names can be linked to real landowner names, to manage the details of real-world projects in tables outside of the Access database that is used for program data summary. Since real-world habitat management projects always have a spatial component, this information must be managed in a spatial database, such as the one provided by ArcGIS. Consequently, we created an ArcGIS project called "CEAP monitoring" that has also been placed on the Box.com file sharing site managed by NRCS. This GIS includes polygons with real project boundaries and points with real bird and vegetation sampling locations. In many cases, due to the un-linked nature of the monitoring projects excel data files, it was necessary to plot sampling points along with property boundaries to associated specific sampling events with specific management events. Again, this was done with anonymized management area and landowner names so that reporting of project results, based on the Access database, does not include any private information. The smallest geographic area for which information can be summarized in the database is the county level.

Figure 30 zooms in to the scale of management treatment areas to illustrate how bird and vegetation survey points have been linked to specific management areas. Figures 31 and 32 illustrate the spatial extent of survey points (at which songbird point counts, American Woodcock surveys, and vegetation surveys) have been completed. Note that orange dots are private lands and green dots are public lands.

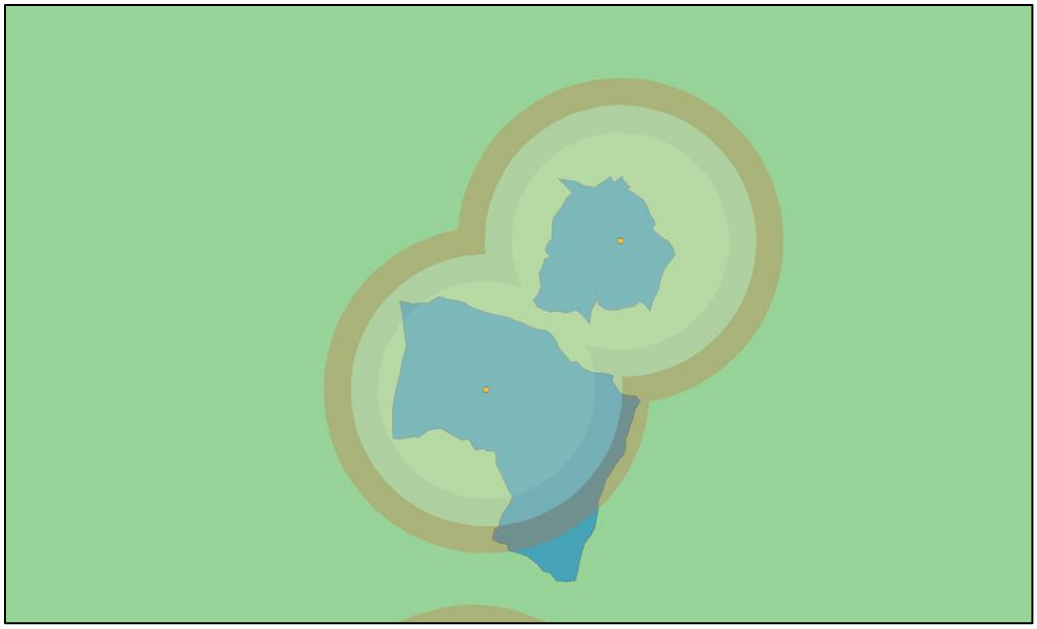

Figure 30. The two polygons in the image above show discrete areas within which documented management actions have occurred. The orange points represent bird survey locations, which are also the center point for paired vegetation measurements. The buffers surrounding these points extend 150 meters (with colored rings at 100, 125, and 150 m) to represent a standard distance across which most observers are expected to be able to detect singing Golden-winged Warblers. In the case of the two management treatment areas at the top, detection buffers overlap each-other significantly, in which case the same individual Golden-winged Warbler could be detected by adjacent surveys. In situations like this, adjacent management treatment areas have been combined (and associated with both survey points) so that the connection between management actions and bird/vegetation response is evaluated for both areas together, rather than on their own, since they may not be independent.

Review of existing datasets

Now that all datasets have been completely proofed and stored in a relational database, and now that all bird and vegetation survey locations have be explicitly linked to specific management areas in GIS, it is finally possible to generate accurate and reproducible, multi-year summaries and analyses of CEAP monitoring data. While very detailed information has been compiled regarding habitat management for private lands in the Appalachians (and this effort could serve as a template/inspiration for similar efforts in other region*domain combinations), similar detailed habitat management information is <u>not readily</u> available for public lands in the Appalachians or either private or public lands in the Great Lakes. While data summaries on existing information can now be made with confidence for all field data sets (multi-species point counts, woodcock surveys, vegetation surveys) that real value of these data sets will only be maximized for private lands in the Appalachians (Golden-winged Warbler-WLFW project area) where surveys can be tied to explicit management actions. The fact that this cannot be done for other region/domain combinations limits our ability to confidently draw inferences about bird and vegetation response to different management treatments across much of the study region illustrated in Figures 31 and 32.

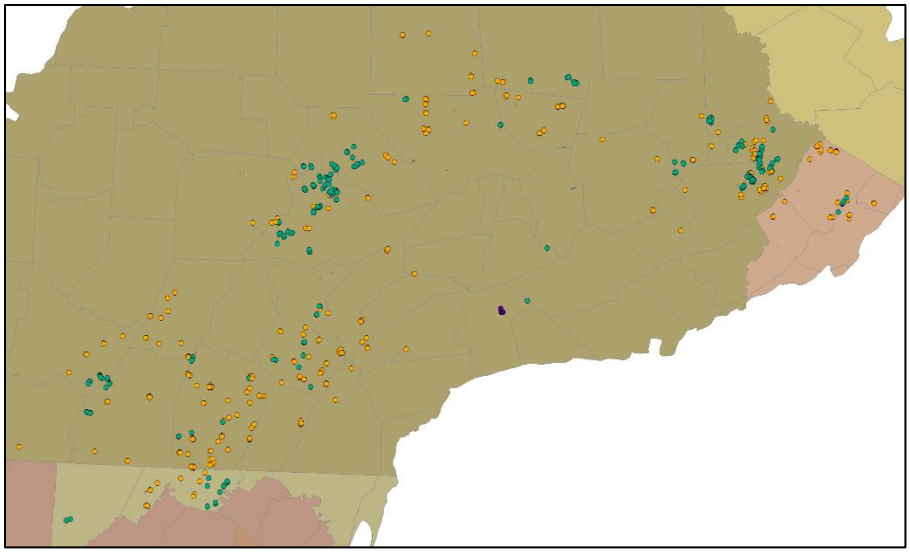

Figure 31. 520 survey points within 3 states in the Appalachians (Pennsylvania, New Jersey, and Maryland) where CEAP monitoring data have been collected to evaluate the response of birds and vegetation to habitat management.

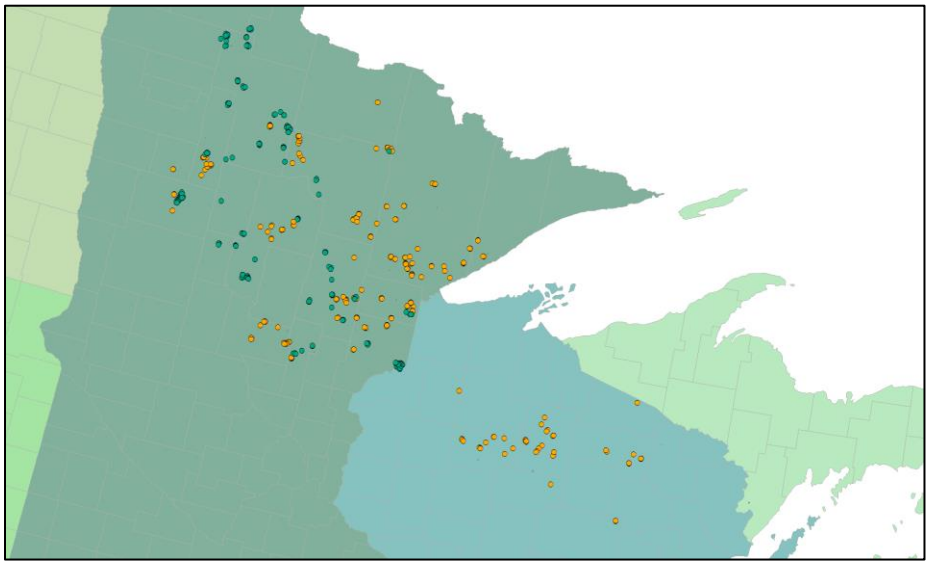

Figure 32. 523 survey points within 2 states in the Great Lakes (Minnesota and Wisconsin) where CEAP monitoring data have been collected to evaluate the response of birds and vegetation to habitat management. Orange points represent private lands while green points represent public lands.

Recommended next steps

The following steps could be taken to increase the value of these datasets for evaluating the effectiveness of management programs like Working Lands for Wildlife or Regional Conservation Partnership Programs:

1. The Access database will be introduced to field personnel who will be doing bird and vegetation monitoring during the 2018 field season. These personnel will be trained on

how to enter data into this database using forms to avoid the numerous errors that occur when seasonal field crews enter information into excel spreadsheets.

2. The interactive data visualization tool that provided the original objective for this project can be completed, now that data sources are reliable, allowing managers and program partners to explore the effects of forest management on forest birds (at least for the Appalachians/Private lands combination). Comparisons of bird and vegetation data will be able to be made across all region*domain combinations. The ability to tie bird and vegetation data to management data for anywhere other than private lands in the Appalachians will depend on how much is done for item 3 below.

3. Detailed information on management actions associated with specific management treatment areas could be sought, and documented in the Access database provided by this project, for any of the following region/domain combinations:
    a. Appalachian public lands. This would facilitate useful comparisons of how forest management on public lands is affecting birds and bird habitat in ways that differ from forest management on private lands. This would help to understand what types (and how much) private and public land efforts contribute to meeting regional forest bird management objectives.
    b. Great Lakes private lands. This would allow for evaluation of the effectiveness of private lands management programs for forest birds that are funded primarily by federal dollars in the part of the geographic range of Golden-winged Warblers where the species is most abundant.
    c. Great Lakes public lands. Similar to letter "a" above, collecting comparable information about habitat management from public and private lands would help to understand how efforts in these different domains might affect regional management targets for forest birds.

Conclusion

We underestimated how much time it would take for our post-hoc effort to bring three years of historic field data and habitat management data together into a format usable for a complex data visualization tool. Many, if not all, of the issues we encountered here can be avoided in future efforts by building strong data management infrastructure prior to field data collection, training NRCS field office partners, seasonal field crews on best practices in data management and standardization, and maintaining strong data governance across the whole temporal span of this project. Now that this work has been done, additional years of data collection will require less proofing, will include fewer errors, and will be easier to include in updated and reproducible analyses linking avian and vegetation response to management actions. We recommend that line items be included in future multi-year monitoring program budgets for data management and that expertise in database design should be consulted very early on in monitoring program design. This is especially true for program evaluating NRCS-funded private lands efforts that span multiple states/regions.

NRCS is funding ongoing efforts to understand the effects of forest management on birds. Any of the recommended next steps that are listed above could be rolled into this work to improve the value of monitoring data (by connecting it explicitly enough with management data to account for successes and inform adaptive management). The data visualization tool listed as number 2 above will be re-built using the final, complete, dataset (GWWA-WLFW area only) within the next three months.

Part V. Landowner Response to NRCS Conservation Programs Targeting Early Successional Habitat: Motivations, Satisfaction, and Future Intentions to Manage Habitat

Prepared by: Dr. Ashley A. Dayer and Seth Lutter, Virginia Tech; and Dr. Jeffery L. Larkin, Indiana University of Pennsylvania and American Bird Conservancy

Introduction

The Working Lands for Wildlife's Golden-winged Warbler Initiative through the Natural Resource Conservation Service (NRCS) in the Appalachian states and a Regional Conservation Partnership Program (RCPP) project between American Bird Conservancy and NRCS in the upper Great Lakes states aim to create and restore early-successional habitat (ESH) for species of conservation concern. Through these two programs, since 2012, 293 private landowners have signed contracts to implement conservation practices for Golden-winged Warbler and American Woodcock habitat on nearly 14,000 acres. While the biological effectiveness of this management (i.e., vegetative and bird responses) is being evaluated, the social effectiveness of these programs, in terms of private landowner response, remains largely unknown. Understanding how social factors mediate outcomes of NRCS conservation programs is essential to ensure long-term management of this ephemeral habitat.

Objectives

1. What factors influence overall program satisfaction of private landowners who enrolled in a wildlife habitat conservation incentive program?

2. What factors influence intentions of private landowners who enrolled in a wildlife habitat conservation incentive program to continue their management post-program?

3. Do result mailings that include property level biological data influence overall program satisfaction and post-program management intentions of private landowners who enrolled in a wildlife habitat conservation incentive program?

Methods

Our study population consisted of 189 landowners that signed conservation program contracts with NRCS between 2012 and 2016 to manage for young forest on properties in Maryland, Minnesota, New Jersey, Pennsylvania, and Wisconsin. After management began, these landowners voluntarily allowed biological technicians onto their properties to monitor for birds and vegetation regrowth as part of the CEAP assessment (as described in Parts 1-3 above). Enrolled properties came from a wide range of ownership types, in cases of group property ownership (e.g., clubs, non-profits, corporations) the contracted individual was asked to respond on behalf of the group.

Using biological data collected from monitored properties, we summarized bird response to habitat management efforts in site-specific result mailing packets for each landowner. Property visitation dates and detection numbers for Golden-winged Warbler and American

Woodcock were detailed explicitly, along with a list of other bird species that were detected on the landowner's property, with at-risk species marked with an asterisk. Results were carefully worded to emphasize the positive effects of management while accurately conveying the monitoring data from the landowner's property. Past research on effective landowner communications in this context was incorporated into the mailings, such as the term 'young forest' rather than the term 'early successional habitat' and a focus on landowner beliefs about young forest management benefits for wildlife. The mailings also referenced the collective accomplishment of landowners in the program and concluded with encouragement to continue to create and maintain young forest habitat. One group of landowners received two personalized result mailings, in October 2015 and December 2016. A second group of landowners who received no result mailings (until after surveys were conducted) served as a pseudo-control group to assess the role of biological result mailings (Research Question 3).

Surveys

A telephone survey was constructed using iterative question design and review by social scientists and graduate students at Virginia Tech. Cooperating NRCS staff and the CEAP team reviewed the survey and discussed edits. The survey was pre-tested with eight private landowners who participated in similar NRCS habitat conservation programs. This research was conducted with approval from, and in accordance with, the Virginia Tech Institutional Review Board (Protocol #16-597). All members of the research team were also covered by current 1619 compliance acknowledgement agreements required by NRCS to protect participant information.

Lutter conducted telephone surveys from January 20 – June 1, 2017. Of the 189 landowners called, 102 completed surveys for a response rate of 57.9%. The pseudo-control landowner group was sent result mailings in April 2017 after this group of landowners had completed the primary survey. A brief follow-up survey was conducted in May 2017 with willing members of this subset of landowners (n=42) to assess repeated measures of selected variables from the main survey. Of 42 landowners called for the follow-up survey, 32 completed surveys for a response rate of 76.2%.

Non-response Bias

To check for non-response bias, several group comparisons (t-tests, Mann-Whitney U tests, chi-square tests) between survey respondents and non-respondents were made using contract data in the CEAP database. The variables used for non-response tests included 'years since contract start', 'acres planned', 'property region', and 'practices contracted'. Practices used by 10 or fewer landowners total were dropped from comparisons to ensure adequate sample sizes for statistical tests. The only significant difference detected between respondents and non-respondents was for the practice 'tree/shrub planting' (one of the nine contracted practices), which respondents were contracted for at a higher rate (10.8% vs. 2.4%). Plantings trees or shrubs is an expensive management practice, and landowners who were contracted for it may have higher commitment to management and be more likely to respond to a survey.

	Statistical Test	Significant at alpha=0.05?
Years Since Contract Start	T-test	No
Acres Planned	Mann-Whitney U	No
Property Region *(Appalachians/Great Lakes)*	Chi-Square	No
Practices Contracted	Chi-Square	
Herbicide		No
Shelterwood Cut		No
Overstory Removal		No
Coppice Management		No
Patch Clearcuts		No
Feathered Edge		No
Clearcut with Reserves		No
Brush Management		No
Tree/Shrub Planting		Yes

Respondent Socio-demographics

Respondent ownership was categorized using forest ownership classes utilized by the National Woodland Owner Survey. The majority (79%) of respondents were Family Forest Owners: classified as either individual, joint, family partnerships, trusts, or estate ownership. The remaining respondents were clubs or associations (11%), corporations or business partnerships (7%), and non-profit organizations (3%).

Survey respondents were primarily male (88%) and averaged 61 years old (standard deviation of 11). Sixty-six percent had a four-year college degree or higher. Twenty-nine percent lived on the property enrolled in the NRCS habitat program. Respondents owned their land for an average of 37 years (standard deviation of 35), and owned a mean of 780 acres (median of 235 acres). Enrolled properties were located in Pennsylvania (59%), Minnesota (30%), New Jersey (7%), Maryland (2%), and Wisconsin (2%).

Results

Respondents were asked about the importance of a range of possible outcomes that their participation in the NRCS habitat program might have for themselves and their property (Fig. 33). Of the range of outcomes in the survey, the outcomes with the highest mean importance were ‘improving the forest health’ and ‘benefiting other birds that use young forest’. Program outcomes with the lowest mean importance to respondents were ‘harvesting timber for income’ and ‘increasing the property value’.

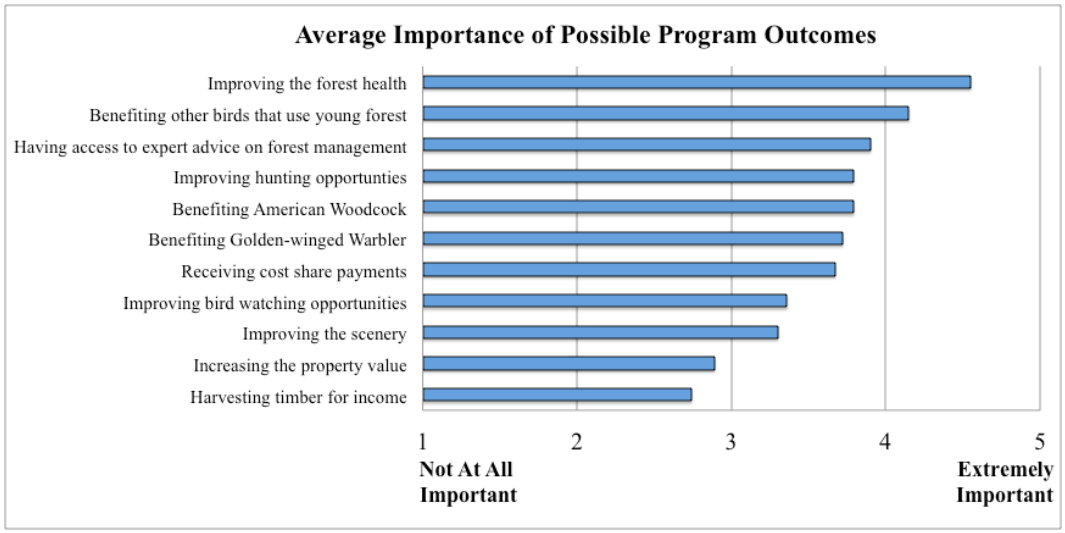

Figure 33. Landowner motivations for NRCS program participation.

Respondents were asked what effect participating in the NRCS program had for a range of possible outcomes on their property (Fig. 34). A high proportion of respondents expressed that participating in the program had positive or very positive effects (light green/dark green) across a range of program outcomes. Some respondents expressed negative or very negative effects (light red/red) for their property's scenery, hunting opportunities, and property value. These responses, while in the minority, suggest participation had varied results for participants. Respondents indicated they were "not sure" (gray) at the highest rates when asked what effect program participation had for American Woodcock, Golden-winged Warbler, other birds that use young forest, and the forest health. This could reflect unfamiliarity with these terms, or respondents could have felt their management was too recent to be sure of final effects at the time of the survey.

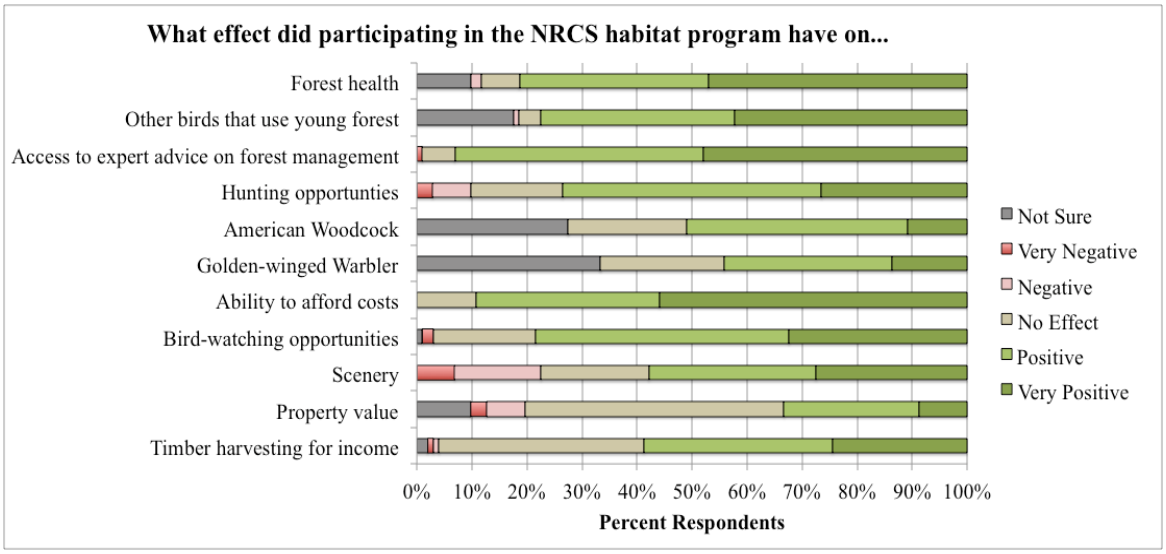

Figure 34. Landowner perceptions of NRCS program effects.

Respondent satisfaction with the conservation program, the cost-share payments, wildlife outcomes, and interactions with NRCS and partners was very high, with a few exceptions (Fig. 35). Unsatisfied landowners had poor experiences with program results and/or negative interactions during the program.

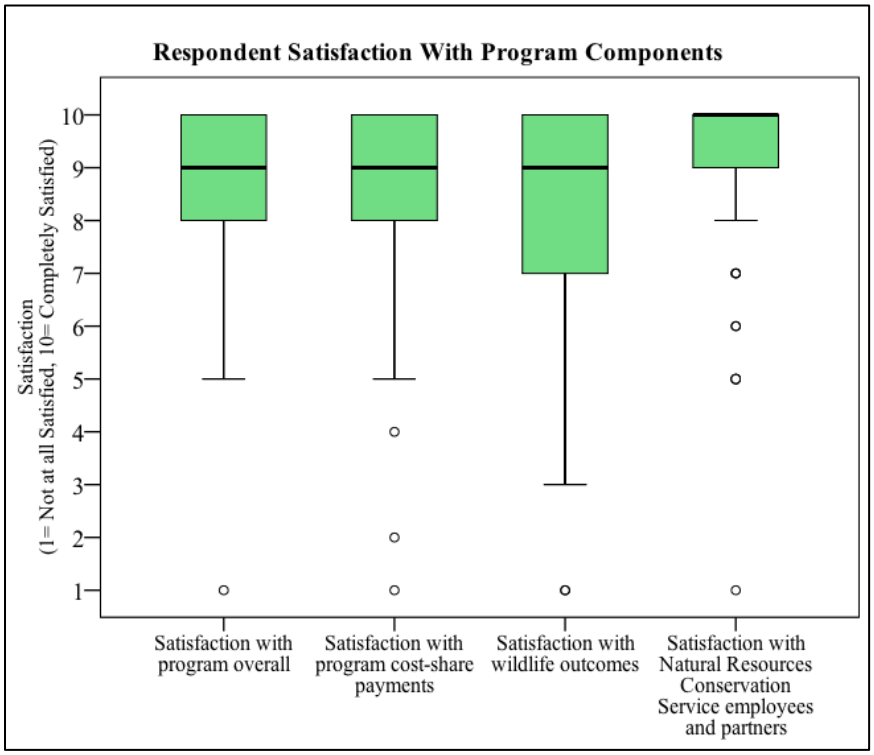

Figure 35. Landowner satisfaction with the NRCS program overall and specific elements.

In addition to looking at respondent satisfaction with the NRCS program and employees, the survey also included questions about trust for NRCS employees and partners (Fig. 36). Respondents generally had high trust in the expertise of NRCS employees and partners, felt that NRCS employees and partners shared their values, and felt the program policies and procedures ensured they were treated fairly.

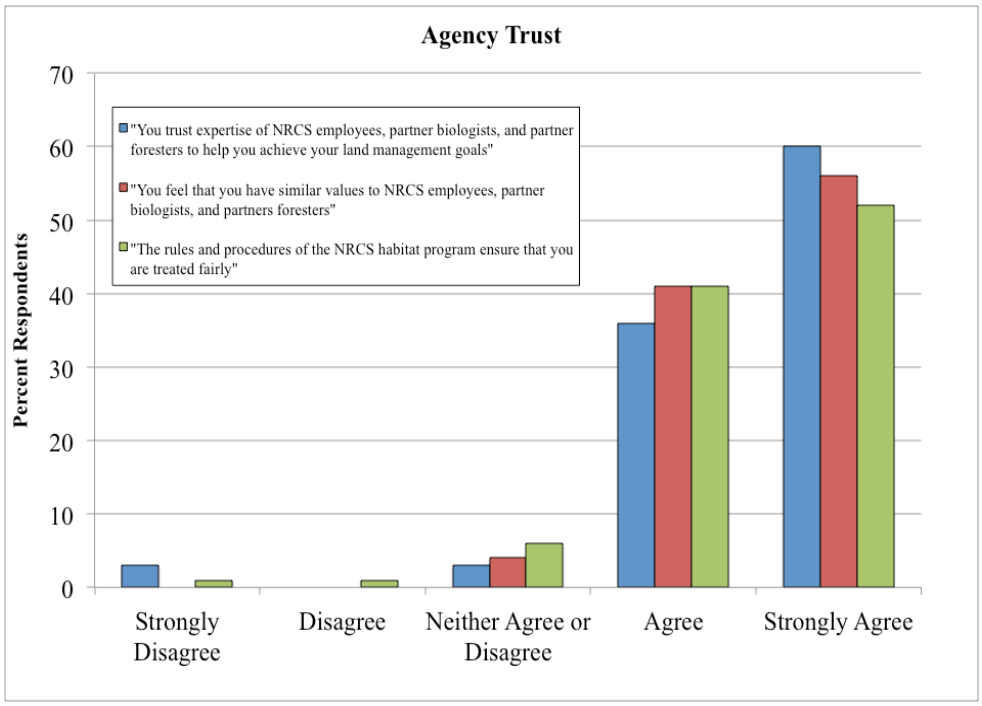

Figure 36. Landowner trust for NRCS employees and partners

A key component of the survey was to examine landowner intentions to manage for young forest after their NRCS contract end date (Fig. 37). Likelihood of managing for young forest within ten years after their contract by re-enrolling in an NRCS program was high, with 64.7% of respondents saying they were either 'Very Likely' or 'Extremely Likely' to re-enroll. On average, respondents were slightly more likely to re-enroll than to manage for young forest if further cost-share was not available. Few respondents said they were 'Not At All Likely' to manage for young forest in the future- whether or not cost-share was available.

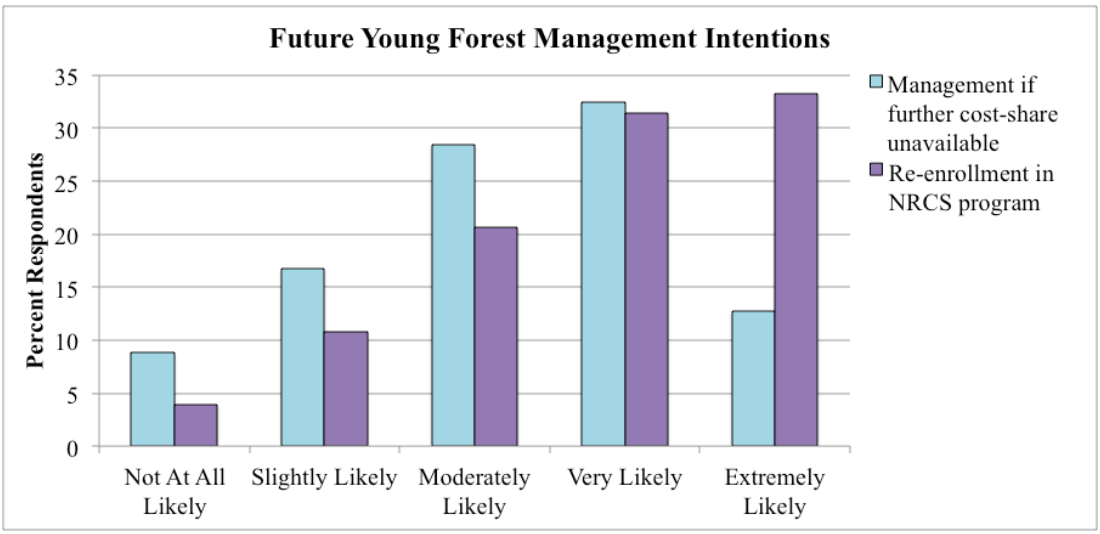

Figure 37. Landowner intentions to manage for young forest within ten years after NRCS contract.

Respondents were also asked what management practices they had already used to manage for young forest since their contracts ended, and what practices they would use if further cost-share was not available (Fig. 38). The management practices with highest use and anticipated use after contracts were ‘establishing or maintaining native tree/shrub plantings’, ‘herbicides for invasive plants’, and ‘brush clearing’. Few respondents said they would conduct prescribed burning or maintain deer fencing without further cost share, or had conducted those practices since their contract ended.

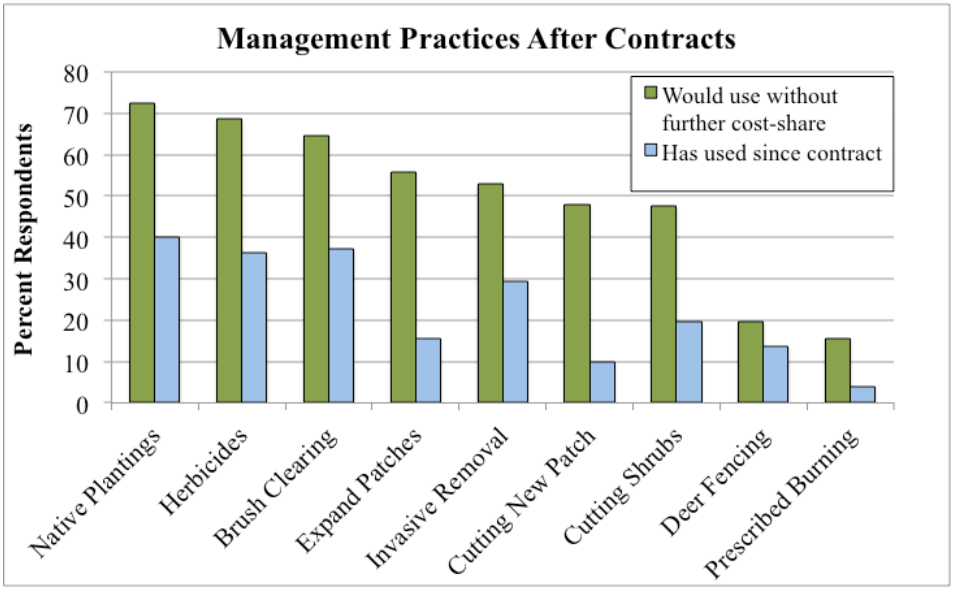

Figure 38. Post-contract management actions and intentions by specific management practice

Most respondents said money and time would limit the extent to which they managed for young forest if further cost share payments were not available (Fig. 39). Not knowing how to

manage for young forest, not having enough acreage, and thinking further management was unnecessary would limit fewer landowners.

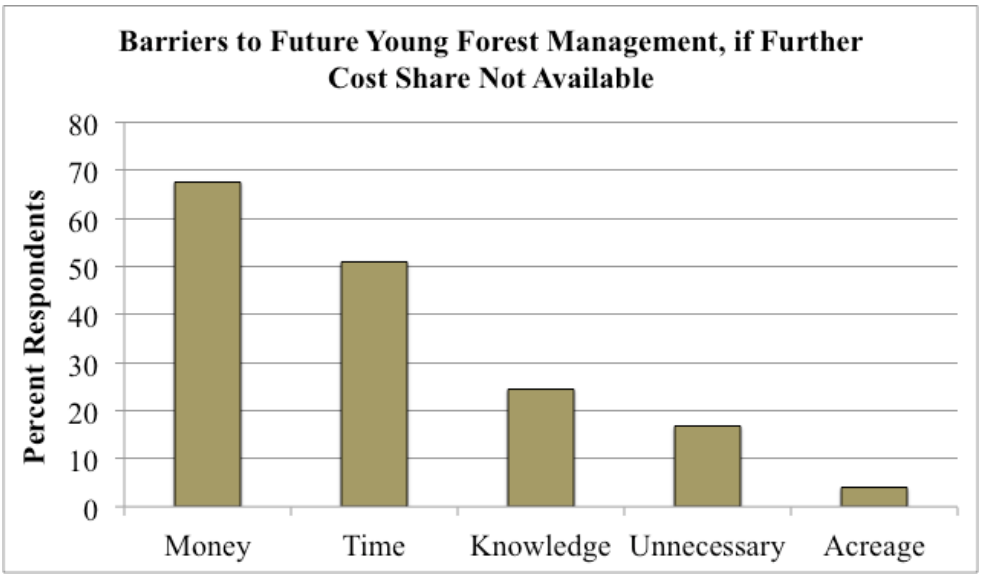

Figure 39. Landowner barriers to future young forest management without further cost-share

Conclusion

While the NRCS initiatives are mainly directed at restoring habitat for Golden-winged Warbler and American Woodcock, our results show that landowners had a diverse range of motivations for participating. 'Benefiting forest health', 'birds that use young forest', 'receiving access to expert advice', and 'improving hunting opportunities' were among the top landowner motivations. With a few exceptions, the habitat program appears successful in fulfilling landowner motivations for participation. Landowners had generally positive perceptions of program outcomes, high levels of trust for NRCS and agency partners, and high satisfaction with the program.

Our results suggest that landowners are broadly interested in continuing management for young forest after participating in the program, either by re-enrolling in a similar program or through management without further cost share. However, it is important to note that some practices are more likely to be used than others post-program. More landowners were interested in continued use of management practices associated with habitat maintenance (e.g., herbicide use, brush clearing) than practices needed for habitat creation (e.g., cutting new patches). In addition, money and time were identified as central barriers to future management for most landowners, so the extent to which landowners continue management for young forest would likely be lessened without further cost share.

Part IV. Fledgling Golden-winged Warbler Habitat Use, Movement and Survival Across Two Managed Forest Landscapes in Pennsylvania

Prepared by: Cameron J. Fiss, Indiana University of Pennsylvania; Darin J. McNeil, Jr., and Amanda D. Rodewald, Cornell Laboratory of Ornithology; and Dr. Jeffery L. Larkin, Indiana University of Pennsylvania & American Bird Conservancy

Introduction

A key breeding cycle component in many songbirds is the post-fledging period – the period between young leaving the nest and before departing on migration. Post-fledging research involving species similar to Golden-winged Warbler has shown high levels of mortality, as well as shifts in habitat use away from typical nesting cover during this critical interval. Thus, we investigated Golden-winged Warbler post-fledging habitat use, movement, and survival in two distinct managed forest to better understand habitat associations for this species across its entire breeding cycle. This study marks the first of its kind to be conducted in the Appalachian segment of the Golden-winged Warblers breeding distribution, where populations have been declining the sharpest. We collected data from fledglings in the Poconos region of northeast Pennsylvania within Delaware State Forest during the 2014 and 2015 breeding seasons, and from the Pennsylvania Wilds region of central PA within Sproul State Forest and an adjacent State Game Lands during the 2016 and 2017 breeding seasons. This information will allow land managers to better understand the habitat needs and space use requirements of Golden-winged Warblers during this short, but critical time period. Ultimately, when considered with current knowledge regarding nesting habitat, this new information will allow for the planning of landscapes that maximize full Golden-winged Warbler breeding season productivity in the Appalachians.

Objectives

1. Quantify nest success of Golden-winged Warblers breeding within two landscapes of the Appalachian segment of the breeding range

2. Estimate and compare Golden-winged Warbler fledgling survival

3. Determine if fledgling Golden-winged Warblers are selective in their use of habitat

4. Quantify the features most heavily selected-for and avoided by fledgling Golden-winged Warblers

Methods

We searched for Golden-winged Warbler nests in 17 timber harvests across both study sites (Fig. 39) from 2014 to 2017 using standard nest searching methods. A greater number of timber harvests were sampled in the Pennsylvania Wilds study region (n=11) than within the Poconos (n=6) due to apparently lower densities of breeding pairs within Pennsylvania Wilds sites. Upon finding nests, we recorded their location and began monitoring their progress thereafter on a three-day interval. As nestlings approached fledging (~7-8 days post-hatch), we randomly removed two from the nest to tag with radio-transmitters. Depending on the juvenile's mass, we used either a 0.35g or a 0.41g radio-transmitter with larger chicks receiving 0.41 g units. We attached transmitters using a figure-eight style harness (Rappole and Tipton 1991), which loops over both of the bird's legs allowing the transmitter to rest on the bird's back (Fig. 40). Both

transmitter and harness together did not exceed 5% of the bird's mass. Additionally, each juvenile was banded with a numbered USGS aluminum leg band and single plastic color band for identification purposes. After attaching both transmitter and leg bands, juveniles were returned to the nest.

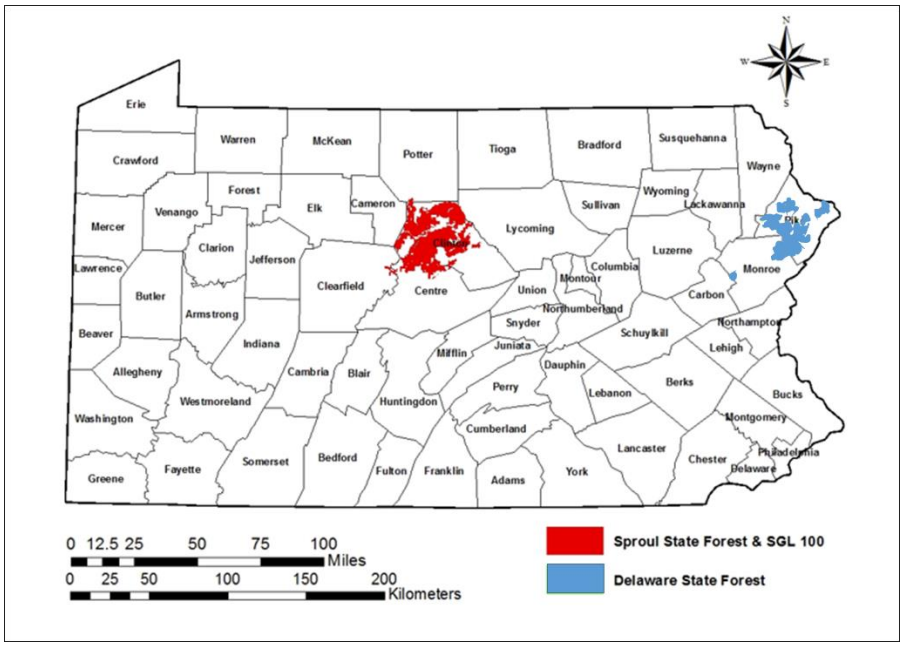

Figure 39. Map of Pennsylvania indicating the location of the two primary study areas of Golden-winged Warbler reproductive ecology from 2014-2017.

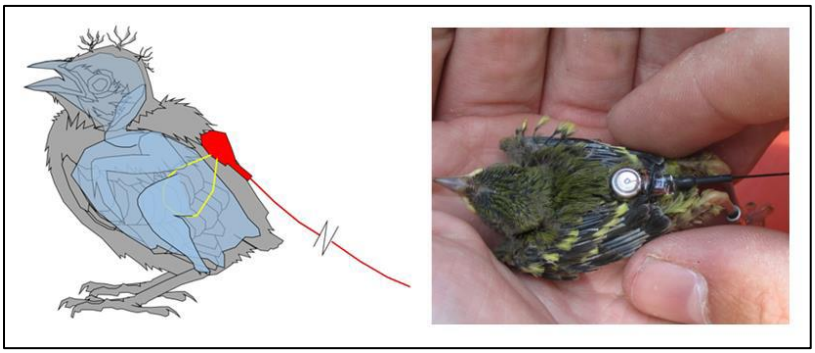

Figure 40. Radio-transmitter attachment diagram for Golden-winged Warbler fledglings. A) Profile view of fledgling with a figure-eight style harness (shown in yellow) looped around the legs. Radio-transmitter and antenna are shown in red resting on the juvenile's back. B) Juvenile Golden-winged Warbler with newly attached radio-transmitter and aluminum USGS leg band.

We began tracking each juvenile daily after fledging to monitor survival and record habitat use variables. We recorded habitat variables at two scales: 1) the macro scale, in which we recorded the forest cover type (*e.g.*, early-successional, pole, mature) used by the juvenile, and 2) the micro scale, in which we recorded within stand features (*e.g.*, sapling height, vegetation density) around juvenile locations. In addition to recording habitat information where we relocated birds, we also recorded habitat variables at paired random locations that were

“available”. Therefore, on each day, every juvenile had a “used” and paired “available” survey location. These used and available data points allowed for analyses which elucidate the extent to which fledglings selected for habitat. In other words, we were able to ask if fledglings used certain cover types or fine scale habitat features disproportionately to the amount at which they occur on the landscape. In addition to habitat for fledglings, we also collected similar microhabitat data at each nest location to allow us to explore factors driving nest survival. Similarly, we applied this approach to fledglings to explore features associated with fledgling survival/mortality.

We modeled survival of Golden-winged Warbler nests using logistic exposure models in program MARK. We included microhabitat features measured in the field as single covariates to potentially explain nest survival. We modeled survival of fledgling Golden-winged Warblers using the known fate module in program MARK. This allowed us to vary survival as a function of habitat used by chicks on each day prior to a mortality event. Like nest survival models, we used habitat features (those measured in the field and remotely) as individual covariates in models of survival. We tested for fledgling habitat selection at the micro-scale with generalized linear mixed models using the package lme4 in program R. Specifically, we modeled the ability of structural habitat variables to explain the variation between “used” and “available” fledgling locations. To investigate whether fledgling Golden-winged Warblers select for different habitat features as they develop, we modeled habitat selection separately for five age classes which we determined based on breaks in daily fledgling movement data. To model fledgling habitat selection at the forest stand scale, we used a Bayesian random effects modeling approach in which selection estimates for each individual informs overall population level habitat selection. We created a set of five a priori candidate models to describe fledgling habitat selection at the stand-scale based on previous findings from passerine post-fledgling habitat research, all of which contained distance moved and edge parameters. We created three models that included, only a single cover type. One model included only early-successional cover to investigate if fledglings were choosing habitat based on proximity to nesting habitat. We created two additional models including only mature cover and only sapling cover, because similar cover was selected by Golden-winged Warbler fledglings in the Great Lakes portion of the breeding range (Streby et al. 2016). We included a global model, which would suggest that fledglings selected habitat based on proximity to every cover type. Finally, we included a null model, which would signify that fledglings were not selecting for cover types at the landscape scale. Bayesian discrete choice models were fit using WinBUGS v1.4.1 and ran through the Program R package R2WinBUGS. Population-level parameter estimates and associated 95% credible intervals based on the posterior distribution for predictor variables were derived from WinBUGS output.

Results

Nest Survival

We studied Golden-winged Warbler productivity within the Poconos from 2014-15. During the 2014-15 breeding seasons, we located 40 and 41 nests, respectively across six timber harvests, managed in accordance to the GWWA BMP throughout Delaware State Forest. Models of nest DSR suggested that daily survival varied within each season (declining linearly as date advanced) but there was no ‘year effect’ on DSR. Within the Poconos region, average DSR regardless of year or day of season was DSR = 0.96 (95%CI = 0.92– 0.98). When we adjusted

for clutch size (also declining with advancing date), DSR estimates equated to total nest success for a single nest = 45% (95%CI = 27– 63%) for a single nest and likelihood of producing a single successful nest of 83% when up to three re-nests are considered for failed initial nesting attempts. When we considered nest survival as a function of microhabitat features at either immediate nest site (≤1 m radius) or local nest habitat (≤ 11.3 m radius), the null model was either the top model or competing-with the top model (≤ 2 ΔAIC_c). This suggests that, among sites selected for nesting by Golden-winged Warblers in Poconos timber harvests, nest success did not vary as a function of microhabitat.

We studied warbler productivity within the Pennsylvania Wilds from 2016-17. During the 2016-17 breeding seasons, we located 39 and 42 nests, respectively across 11 timber harvests, managed in accordance to the GWWA BMP throughout Sproul State Forest and State Game Lands 100. On 31 May 2017, a powerful hail storm destroyed nine of our monitored nests overnight and reduced our sample of usable nests to 31 for the 2017 field season. Nests lost to this hail storm are not considered here or elsewhere in our analyses. Models of nest DSR suggested that daily survival varied within each season (like Poconos, declining linearly as date advanced) but there was no 'year effect' on DSR. Within the Pennsylvania Wilds region, average DSR regardless of year or day of season was DSR = 0.93 (95%CI = 0.88– 0.96). When we adjusted for clutch size (also declining with advancing date), DSR estimates equated to total nest success for a single nest = 24% (95%CI = 13– 38%) for a single nest and likelihood of producing a single successful nest of 57% when three potential re-nests are considered for failed initial nesting attempts. When we considered nest survival as a function of microhabitat features at both aforementioned scales, the null model was again either the top model or competing-with the top model (≤ 2 ΔAIC_c), similar to our finding within the Poconos. This likewise suggests that, among sites selected for nesting by Golden-winged Warblers within Pennsylvania Wilds timber harvests, nest success did not vary as a function of microhabitat.

Fledgling Survival

During the 2014-15 breeding seasons, we attached transmitters to 40 and 43 Golden-winged Warbler fledglings, respectively across the six timber harvests studied within Delaware State Forest. Models of fledgling DSR suggested that daily survival varied within each season (increasing linearly as date advanced) but, like Poconos nests, there was no 'year effect' on fledgling survival. We also found a strong 'age effect' on survival with the survival lowest the first day post-fledging and consistently high thereafter (Fig. 41). Within the Poconos region, average survival to independence (regardless of year or day of season) was 72%. When we considered fledgling survival as a function of microhabitat or "available" stand-level vegetation, the null model was either the top model or competing-with the top model (≤ 2 ΔAIC_c). This suggests that, among sites selected for use by Golden-winged Warbler fledglings in Poconos timber harvests, survival did not vary as a function of habitat features we quantified.

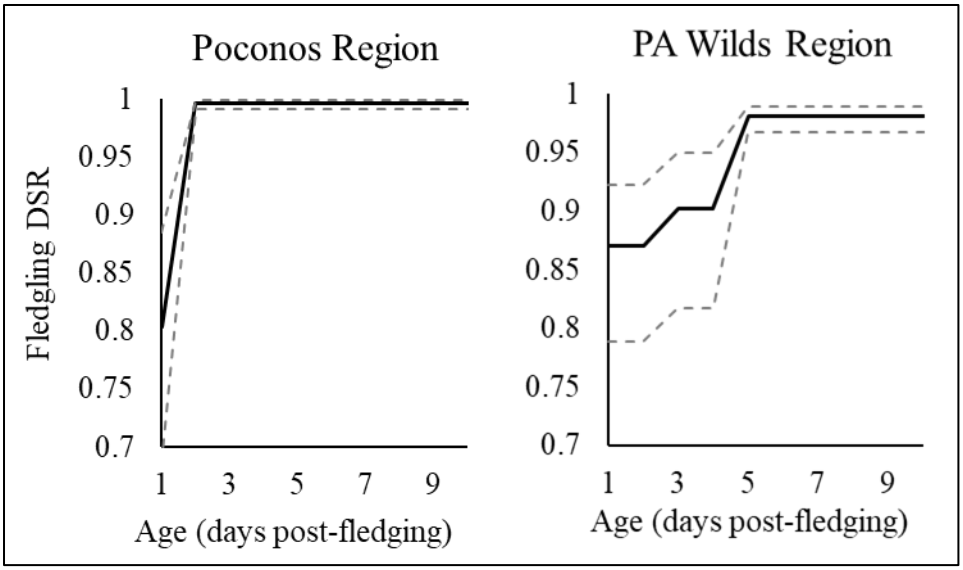

Figure 41. The relationship between daily survival rate of Golden-winged Warbler fledglings and age for both the Poconos and Pennsylvania Wilds. Relationship is based off the top ranked model of fledgling survival from program MARK. Solid black line indicates estimate while dashed gray lines represent 95% confidence intervals.

During the 2016-17 breeding seasons, we attached transmitters to 32 and 34 Golden-winged Warbler fledglings, respectively across the 11 timber harvests studied within Sproul State Forest and State Game Lands 100. Models of fledgling DSR suggested that daily survival remained constant regardless of fledge date. Like fledglings in the Poconos, we found a strong 'age effect' on survival (Fig. 41), but unlike Poconos birds, Pennsylvania Wilds fledglings experienced a much longer period of high mortality (five vs one day) in which sub-optimal survival occurred. Within the Pennsylvania Wilds region, average survival to independence (regardless of year or day of season) was 37%. When we considered fledgling survival as a function of microhabitat or "available" stand-level vegetation, the null model was either the top model or competing-with the top model ($\leq 2\ \Delta AIC_c$). This suggests that, among sites selected for use by Golden-winged Warbler fledglings in Pennsylvania Wilds timber harvests, survival did not vary as a function of habitat features we quantified. Overall, this suggests that fledgling survival varied strongly by region (Poconos > Pennsylvania Wilds) but vegetation had little influence on survival for birds hatched in timber harvests.

Fledgling Habitat Selection

During days 1- 6 post-fledge, fledglings selected for areas with lower basal area, more medium (1-2m) woody regeneration, and taller saplings ($\beta = -0.23$; $\beta = 0.29$, $\beta = 0.24$). Fledglings day 7 to 13 post-fledge selected for areas with more horizontal vegetation density and more vertical vegetation density ($\beta = 0.63$; $\beta = 0.23$). During days 14-20 post-fledge, fledglings selected for areas with more horizontal vegetation density, lower basal area, and higher vertical vegetation density ($\beta = 0.44$; $\beta = -0.25$; $\beta = 0.68$). Fledglings day 21 to 28 post-fledge, continued to select for areas with more horizontal vegetation density, lower basal area, and more vertical vegetation density ($\beta = 0.40$; $\beta = -0.39$; $\beta = 0.65$). Independent fledglings (day 29+) selected for areas with more horizontal vegetation density, more vertical vegetation density, and more snags

(β = 0.62; β = 0.49; β = 0.35). Fledgling movement rate was influenced by basal area, where fledglings moved greater distances in areas with higher basal area (*i.e.*, mature forest). Indicating that fledglings used higher basal area stands (mature forest) to travel between younger, lower basal area stands (Fig. 42).

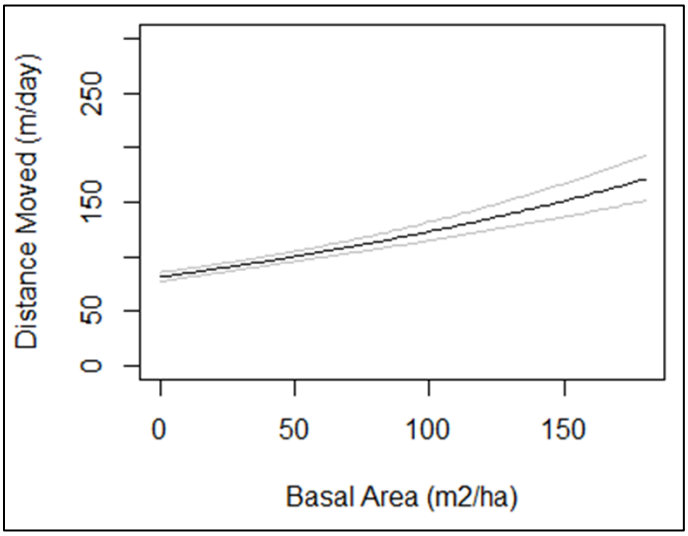

Figure 42. The relationship between movement rate of Golden-winged Warbler fledglings and basal area across both the Poconos and Pennsylvania Wilds. Relationship is based off the top ranked model of fledgling movement and accounts for fledgling age as a fixed effect. Solid black line indicates estimate while light gray lines represent 95% confidence intervals.

In addition to microhabitat selection, we also examined fledgling habitat selection at "stand" scales. In the Poconos region, we observed diverse *use* of forest cover types by fledglings that included early-successional, sapling, forested wetland and mature stands (among others) as they aged. Conversely, fledglings within the Pennsylvania Wilds remained almost exclusively in early-successional cover throughout the entire tracking period (approximately 30 days). However, population level habitat *selection* was similar across both landscapes (Fig. 43). In DSF, fledglings selected for early-successional cover (β = -1.73; 95% Credible Interval = -4.16 to -0.40) from days 1 to 6 post-fledging over all other cover types, which were neither selected for or against. During days 7 to 13 post-fledging in DSF, fledglings selected for early-successional cover (β = -4.92; 95% CI = -8.75 to -2.24) over all other cover types, though they also selected less strongly for mature forest (β = -0.59; 95% CI = -1.13 to -0.05) as well. During days 14 to 20 post-fledging in DSF, fledglings again selected most strongly for early-successional cover (β = -2.44; 95% CI = -4.37 to -0.97), and selected for mature forest (β = -0.59; 95% CI = -1.05 to -0.22) secondarily. Fledglings in DSF then selected most strongly for sapling cover (β = -0.86; 95% CI = -1.98 to -0.04) during days 21 to 28 post-fledging over all other cover types which were neither selected for or against. During days 21 to 28, DSF fledglings also selected for edge between mature forest and young cover types (β = -0.61; 95% CI = -1.11 to -0.18). In SSF during days 1 to 6, days 7 to 13, and days 14 to 20, fledglings selected only for early-successional cover (β = -7.97; 95% CI = -19.91 to -1.91; β = -3.63; 95% CI = -9.69 to -0.78; and β = -4.69; 95% CI = -12.93 to -0.52; respectively). During days 21 to 28 in SSF fledglings did not select for or against any cover types. Across both landscapes, global

models largely outperformed univariate cover type models at the stand scale. This means that all cover types we included in our models were important in explaining the location of fledglings and suggests that landscape complexity, driven by the interspersion of different aged stands and cover types, is important to Golden-winged Warbler fledglings in Pennsylvania. Overall, fledglings from both landscapes moved on average nearly 1km from nest sites during the tracking period. These results suggest that management for Golden-winged Warblers on the breeding grounds needs to consider the structural elements in the forests **surrounding** nesting habitat. Considering both micro-habitat and stand level selection results, management that focuses on creating patches of dense, taller vegetation amongst typical Golden-winged Warbler nesting habitat will provide habitat early in the post-fledging period. Further, interspersing areas of dense vegetation throughout mature stands surrounding early-successional nesting habitat should facilitate movement to other regenerating stands (e.g. sapling stands) and meet the changing habitat requirements of fledgling Golden-winged Warblers as they age.

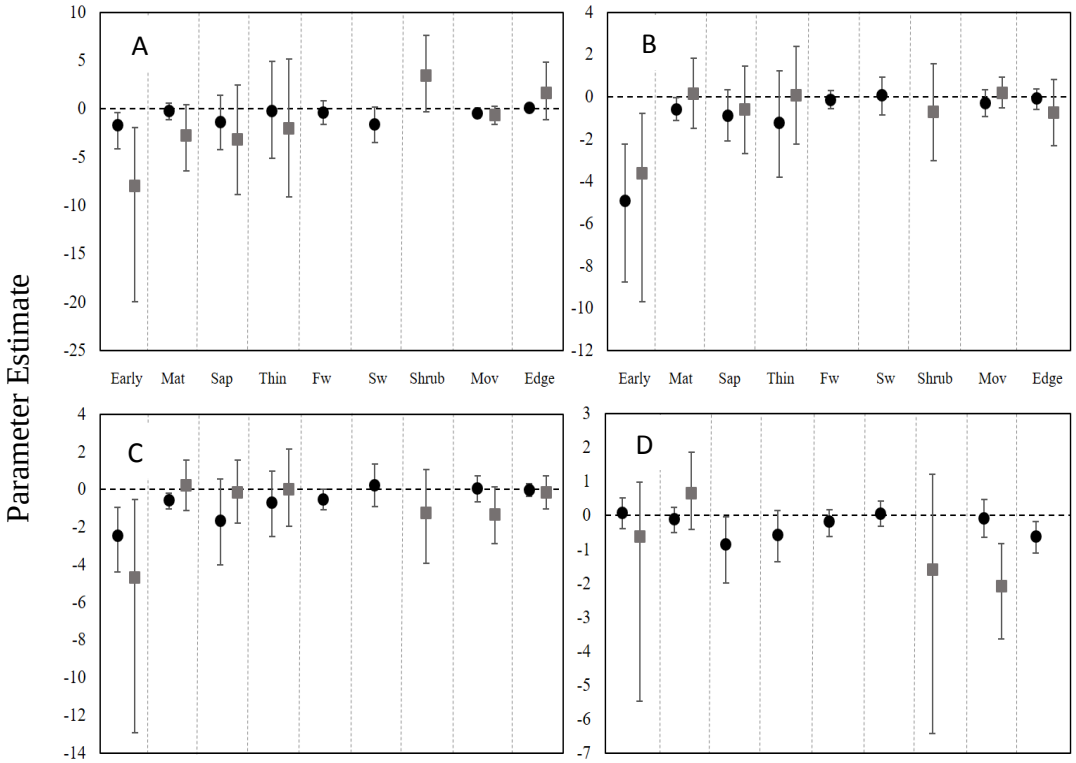

Figure 43. Parameter estimates and 95% credible intervals for selection of seven cover types, proximity to last used location, and edge by radio-tagged Golden-winged Warbler fledglings. Fledglings were monitored at Delaware and Sproul State Forest study areas during June and July 2014-2016. Negative values indicate selection for a feature, while positive values indicate avoidance. Delaware State Forest (DSF) is indicated with black circles. Sproul State Forest (SSF) is indicated with gray squares. A) Parameter estimates for days 1 to 6 post-fledge. B) Parameter estimates for days 7 to 13 post-fledge. C) Parameter estimates for days 14 to 20 post-fledge. D) Parameter estimates for days 21 to 28 post-fledge.

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