DEMOGRAPHIC RESPONSE OF GOLDEN-WINGED WARBLER TO HABITAT AND MANAGEMENT ACROSS A CLIMATE CHANGE GRADIENT IN THE CORE OF THE SPECIES' RANGE[1]: 2012 SUMMARY REPORT

31 December 2012

HENRY M. STREBY, Minnesota Cooperative Fish and Wildlife Research Unit[2], Department of Fisheries, Wildlife, and Conservation Biology, 200 Hodson Hall, 1980 Folwell Avenue, St. Paul, Minnesota, USA.

SEAN M. PETERSON, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology, 200 Hodson Hall, 1980 Folwell Avenue, St. Paul, Minnesota, USA.

DAVID E. ANDERSEN, U.S. Geological Survey, Minnesota Cooperative Fish and Wildlife Research Unit, 200 Hodson Hall, 1980 Folwell Avenue, St. Paul, Minnesota, USA.

---

[1] Research Work Order No. 87, Minnesota Cooperative Fish and Wildlife Research Unit

[2] Cooperators: U.S. Geological Survey, Minnesota Department of Natural Resources, University of Minnesota, The Wildlife Management Institute, and the U.S. Fish and Wildlife Service

DEMOGRAPHIC RESPONSE OF GOLDEN-WINGED WARBLER TO HABITAT AND MANAGEMENT ACROSS A CLIMATE CHANGE GRADIENT IN THE CORE OF THE SPECIES' RANGE: 2011 SUMMARY REPORT

HENRY M. STREBY and SEAN M. PETERSON, Minnesota Cooperative Fish and Wildlife Research Unit, Department of Fisheries, Wildlife, and Conservation Biology, 200 Hodson Hall, 1980 Folwell Avenue, St. Paul, Minnesota, USA.

DAVID E. ANDERSEN, U.S. Geological Survey, Minnesota Cooperative Fish and Wildlife Research Unit, 200 Hodson Hall, 1980 Folwell Avenue, St. Paul, Minnesota, USA.

Abstract: In 2012 we repeated our 2011 efforts with a substantial increase in data collected. This was the second and final full field season investigating population ecology of Golden-winged Warblers (*Vermivora chrysoptera*; hereafter GWWA) at Tamarac National Wildlife Refuge (NWR) and Rice Lake NWR in Minnesota and Sandilands Provincial Forest (PF) in Manitoba. We assessed nesting habitat use, nest productivity, fledgling survival, and post-fledging habitat use by GWWA at all three sites. We color banded 107 adult female and 112 adult male GWWA and we attached radio transmitters to 108 adult females. By tracking radio-marked females and by nest searching, we found and monitored 149 nesting attempts including 2 nests found by others conducting research at Tamarac NWR (see acknowledgments). The 66% increase over the 2011 nest sample was partly due to increased effort to radio-mark adult females, but mostly to the return of many experienced nest searchers from 2010 and 2011. We banded 311 nestlings and fledglings and radio-tracked 175 fledglings. We collected data on habitat characteristics and GWWA behavior at >2,400 adult, nest, and fledgling locations. Including renesting, we estimated that 58%, 74%, and 79% of females successfully nested and that 53%, 49%, and 48% of fledglings survived to independence from adult care at Tamarac NWR, Rice Lake NWR, and Sandilands PF, respectively. Interestingly, the increases (over 2011) in successfully nesting females at Rice Lake NWR and Sandilands PF were accompanied by considerable decreases in fledged brood size due to many partial-brood nest predation events, and the decrease in successfully nesting females at Tamarac NWR was accompanied by a considerable increase in fledged brood size. Similar to 2011, nest failure and fledgling mortality were due nearly entirely to predation at the Minnesota sites, whereas weather exposure and blowfly infection accounted for a relatively high percentage (23%) of fledgling mortalities at Sandilands PF. Unlike previous years, we tracked at least one (total = 6) nestling or young fledgling at each site to a garter snake (i.e., inside the snake), possibly reflective of the warmer, dryer early spring weather. Consistent with 2011, 30% of radio-marked females nested in older forest stands traditionally not considered GWWA habitat, and fledged family groups moved into and spent much of the post-fledging period in those older forest areas. Early findings from this project have been disseminated in 2 peer reviewed scientific journal articles and 2 more are currently in review. Detailed analyses for manuscripts about transmitter effects, population dynamics, micro- and macro-scale habitat associations, nest-site choice, parental care of fledglings, and interesting natural history observations are all underway.

Many migratory songbirds that breed in North America are experiencing long-term population declines (Dettmers 2003). These declines are thought to be largely associated with alteration and loss of habitat in North American breeding grounds. Loss of early-successional forest and shrub-scrub habitat is particularly dramatic, and conservation of those habitats and the birds that use them is critical (Hunter et al. 2001, Dettmers 2003). There is currently considerable discussion and debate about how to best develop and implement conservation and management strategies to reverse songbird population declines. A pervasive limitation of songbird conservation planning is the lack of sufficient demographic information about most species to make informed management and conservation decisions. Although there is a large body of literature about nesting ecology of migratory songbirds, there is far less information about survival on the breeding grounds, and very little information about fledgling survival and habitat use. Recent studies have demonstrated the importance of the post-fledging period (the time between nesting and migration) to songbird population productivity (e.g., Streby and Andersen 2011). Large-scale studies of breeding habitat associations, adult breeding survival, and seasonal productivity (i.e., from egg to independence from adult care) are necessary to make informed decisions about the management and conservation of migratory songbirds.

One species declining at such dramatic rates that informed conservation initiatives are imperative is the Golden-winged Warbler (*Vermivora chrysoptera*). Golden-winged Warbler populations have been declining precipitously across their range for at least 40 years (Sauer et al. 2005), and the species is listed as Threatened, Endangered, or of high management concern in 10 states (Buehler et al. 2007) and designated as Threatened in

Canada. The cause of range-wide declines, and some local extinctions, appears to be a complex combination of habitat loss, hybridization and competition with Blue-winged Warblers (*Vermivora pinus*), brood-parasitism by Brown-headed Cowbirds (*Moluthrus ater*), and likely global climate change (Buehler et al. 2007). Although Golden-winged Warbler range is contracting from the south, it is expanding to a lesser degree to the west and north. However, even in some areas of recent range expansion populations have been declining over the past 15 years, and range expansion will soon be limited by lack of suitable habitat to the north and west. The Golden-winged Warbler Working Group (http://www.gwwa.org) has identified demographic research as a pressing need for the conservation of this species. In 2010, the U.S. Fish and Wildlife Service was petitioned to consider the Golden-winged Warbler for listing under the Endangered Species Act, accelerating the urgent need for this demographic information.

Golden-winged Warblers primarily depend on early-successional forest stands, open forested wetlands, and lowland shrubby areas for nesting (Confer 1992). Golden-winged Warbler nesting habitat is in decline as abandoned farmlands regenerate to mature forest, timber harvest declines, and wetlands are drained for development. The northern hardwood-coniferous forests of northern Minnesota, Wisconsin, Michigan, and south-central Canada host the highest remaining densities of breeding Golden-winged Warblers (Sauer et al. 2005). Predicted to be a bioregion among the earliest and most dramatically affected by global climate change (Frelich and Reich 2009), there is currently considerable debate about the desired future composition and juxtaposition of habitats within these forests. Considerations for wildlife, including songbirds of conservation concern, are an important part of this conversation (e.g., Zollner et al.

2008). Information about Golden-winged Warbler survival and habitat use throughout the nesting period is limited, and almost nothing is known about these parameters during the post-fledging period (Buehler et al. 2007). Assessing the demographic response of Golden-winged Warbler populations to land management and other habitat alterations is critical for the conservation of this species (Buehler et al. 2007). In addition, detailed knowledge of habitat-specific demographic parameters is necessary to predict Golden-winged Warbler population responses to climate change.

In 2009, in collaboration with the U.S. Fish and Wildlife Service and the Golden-winged Warbler Working Group, we designed a study to address the immediate information needs listed above. This study is designed to address Golden-winged Warbler adult survival and seasonal productivity in the species' main breeding habitat types: early successional forests and forested wetlands in the core of the species' range, the western Great Lakes region. The objectives of this work are to: (1) compare Golden-winged Warbler (GWWA) density and seasonal productivity (nest productivity and fledgling survival) between two main breeding habitat types, (2) compare adult GWWA survival and habitat use during the nesting and post-fledging period between two main breeding habitat types, (3) use habitat characteristics to build a predictive model of GWWA seasonal productivity to provide management recommendations for maximizing GWWA population growth, (4) replicate the study at three locations across a climate-change gradient over 2 yrs to include critical spatial and temporal variation in analyses, maximizing the inference of results and applicability of management recommendations, and (5) combine demographic data with models of predicted habitat response to climate change for the western Great Lakes region to predict climate-change effects on GWWA population growth.

STUDY AREA

We collected data at three sites that span a 400-km southeast to northwest climate-change gradient and what was thought to be a gradient of Blue-winged Warbler (BWWA) genetic introgression, although genetic introgression now appears to be similar across the range of our study sites. Study locations included Rice Lake National Wildlife Refuge (NWR) in east-central Minnesota, Tamarac NWR in northwest Minnesota, and Sandilands Provincial Forest (PF) in southeast Manitoba.

METHODS

***Nest searching* --** We selected 3 – 5 upland early-successional stands and 3 – 5 shrubby wetland stands to search for nests at each study site. We searched for nests using two methods: (1) we captured females in mist nets during the first week after their arrival and tracked them to their nests using telemetry, and 2) we systematically searched potential nest stands by watching adult activity (building nests, carrying food to nestlings), by visually identifying nest locations during searching, and by flushing incubating females from nests.

Demography Methods

Nest Survival – We searched for nests following methods described above. When we discovered a nest during construction we did not approach the nest location for 2 – 4 days to avoid causing nest abandonment; females in this region often abandon nests if approached by humans during nest construction (J. Loegering personal communication). We monitored discovered nests at 3 – 4-day intervals (more often when hatching and fledging were expected) and recorded adult activity and nest contents and condition during each visit. After completion of the field season, we were made aware that another research crew made 30 visits ($\bar{x}$ = 1.7 visits per nest) to the Manitoba nests with 1 – 4 observers per visit, which increased human activity at those nests by ~30%. We assumed that this increase in human disturbance did not affect the probability of predation at those nests because nest predation in the Sandilands PF sample was similar to that at the other sites. A few nest visitation intervals were 5 – 7 days at Rice Lake NWR because we had to evacuate from the refuge for 4.5 days during an extreme flooding event including the highest water levels recorded since the establishment of the refuge in 1935.

On the seventh day (sometimes one day earlier or up to 2 days later) of the nestling stage for each nest we removed all nestlings and carried them in a soft cloth bag 10 – 15 m from the nest. We weighed and banded each nestling, attached a transmitter to 1 – 5 nestlings, and returned the brood to the nest within 15 minutes. We determined the fate of each nest that contained nestlings on the seventh day of the nestling stage by monitoring nestlings/fledglings and adult females using radio telemetry through the expected fledge date. We checked those nests every day (often twice daily) by tracking the nestlings/fledglings and the female from >5 m from the nest. We determined a nest to be successful if we observed radio-marked fledglings alive after we observed the nest empty. We assumed the number of fledged young from a successful nest was equal to the number of nestlings observed during the last nest visit when we didn't track entire broods. When we found a nest empty and we found radio-marked nestlings dead near the nest we tracked the adult female to confirm nest failure based on her behavior (i.e., not feeding non-radiomarked fledglings).

Fledgling Survival – We used radio telemetry to monitor survival of fledglings (Fig. 1) we marked as nestlings and some we captured after they fledged from nests of unknown location. We estimated survival for fledglings during the dependent post-fledging period (i.e., the first 25 days after fledging and before independence from adult care).

RESULTS

Nest Searching – We found and monitored 149 GWWA nests (including 2 nests found by others conducting research at Tamarac NWR): 90 at Tamarac NWR, 41 at Rice Lake NWR and 18 at Sandilands PF. We found an additional 20 GWWA nests that apparently were abandoned during construction or failed before we found them. The 2012 nest sample was 66% larger than the 2011 sample, and increased at all 3 sites despite fewer technicians searching for nests. The increase was partly due to greater effort to capture and radio-mark females before the nesting season, but was mostly due to a substantial increase in nests found by experienced technicians returning from 2010 and 2011. The nest sample likely would have been larger yet if not for unexplained failure to relocate females whose signals were lost immediately after marking early in the season. In 2011, many such females were re-found from fixed wing aircraft, but only one bird was re-found via aerial searching in 2012.

Demography Results

Nest Success **–** We monitored 149 nesting attempts (Table 1), discovered via radio-tracking females, nest searching, and from nests found by other researchers. Most nest failure was due to predation, and predation was more common during the nestling stage than during incubation. Females we monitored renested up to 2 times after initial failure, but no females renested after loss of fledglings. Third nesting attempts were rare at

Sandilands PF due to the relatively short nesting season. Including renesting, we estimated that 58%, 74%, and 79% of females successfully nested, producing an average of 4.4, 4.0, and 3.9 fledglings per successful nest at Tamarac NWR, Rice Lake NWR, and Sandilands PF, respectively (Table 1). Interestingly, the large increases (over 2011) in successfully nesting females at Rice Lake NWR and Sandilands PF were accompanied by considerable decreases in fledged brood size due to many partial-brood nest predation events, and the decrease in successfully nesting females at Tamarac NWR was accompanied by a considerable increase in fledged brood size.

***Fledgling Survival* –** We monitored 175 radio-marked fledglings: 68 at Tamarac NWR, 54 at Rice Lake NWR, and 53 at Sandilands PF (Table 1)--a 77% increase over the 2011 sample, primarily due to the increased sample of nests. We estimated that 53%, 49%, and 48% of fledglings survived to independence from adult care at Tamarac NWR, Rice Lake NWR, and Sandilands PF, respectively. At Tamarac NWR fledgling mortality was due to predation (94%), exposure to cold and wet weather (3%), and blunt force trauma during a hail storm (3%). At Rice Lake NWR fledgling mortality was due to predation (88%) and drowning during an extreme flooding event (12%; Fig. 2). At Sandilands PF fledgling mortality was due to predation (77%), exposure to cold and wet weather (8%; Fig. 3), blow fly (*Protocalliphora* sp.) infection combined with exposure (12%) and exposure or starvation after loss of parental care due to apparent adult mortality (3%). Most fledgling predators were similar to those in 2011, including primarily small mammals and secondarily hawks. However, this year we tracked 6 nestlings and young fledglings (≥1 at each site) to garter snakes (*Thamnosis radix* and *T. sirtalis*). As in 2011, most fledglings we monitored in 2012 left early-successional stands or shrubby wetlands within 10 days of fledging and spent the remainder of the post-fledging period in dense understory or canopy of mature forest and along edges of shrubby wetlands.

DISCUSSION

In 2012, we continued to find that GWWA in the western Great Lakes region do not follow stereotypes from research in other portions of the species' range. Similar to 2011, we found that 30% of females nested in mature forest when we found their nest using radio telemetry to follow the female. In contrast, the nests we found during traditional nest searching were in locations typical of GWWA in other regions, even when we expanded our search area into mature forest. Also as in 2011, we found that most fledglings left their stand of origin and spent most of the post-fledging period in dense understory and canopy of mature forest and sometimes along edges of shrubby wetlands. Based on our sample of nests from tracking females it is apparent that relatively few birds nest in wetlands compared to uplands in our study sites. Most birds that nested in wetlands nested along upland edges or in dry upland areas within a larger wetland. However, many breeding adults and fledged family groups used edges of shrubby wetlands, suggesting an importance of wetlands throughout the season even if not for nesting. Our 2012 results were consistent with those from our 2010 pilot season and our 2011 season, and suggest that in the western Great Lakes region the label of "early-successional specialist" is not appropriate for GWWA: territories, home ranges, nest locations, and post-fledging habitat use all suggest an importance of a landscape composed of diverse cover types including shrubby uplands and wetlands, mature forest, and regenerating forest stands of multiple seral stages. No one family group we monitored used only 1 cover type throughout the season. The only available cover type that was not used was open grassland.

Interesting differences in 2012 from 2011 included increased nest success but decreased fledged brood size at Rice Lake NWR and Sandilands PF, and the addition of garter snakes as predators of old nestlings and young fledglings. We speculate that both of these phenomena were related to the difference in spring weather. Early spring was considerably warmer and dryer in 2012 than in 2011, and those conditions favor survival and productivity for small rodents and snakes. Anecdotally, both of those groups were much more abundant in 2012, and might have contributed to the increase in partial-brood nest predation events. Another noteworthy event was the flood at Rice Lake NWR, which forced our crew to evacuate from the refuge for 4.5 days, 20 – 24 June. The lost days had little effect on our ability to estimate survival for nests and fledglings because it only caused an increase in one observation interval. However, the loss of at least one nest and multiple young fledglings due to drowning was something we had not previously observed. If the flood had occurred one-to-two weeks earlier in the season, or if birds had not started nesting earlier because of the warm spring, the resulting loss of nests could have been catastrophic for the Rice Lake population. We plan to censor the nest and fledglings with flood-related mortalities when we develop detailed demography models for Rice Lake NWR because the flood was the largest in the 77-year history of the refuge, and those losses were therefore not representative of normal events. Fledgling mortalities associated with cold and wet nights will not be considered outliers like those associated with the Rice Lake flood because the cold and wet nights observed in 2011 (colder than average) and 2012 (warmer than average) at Sandilands PF (Fig. 3) were consistent with long-term weather records.

Detailed analyses of transmitter effects, population dynamics, habitat associations and landscape composition, nest-site choice, parental care of fledglings, and interesting natural history observations are all currently underway.

PRODUCTS

Future products of this project will include a final project report in the form of a graduate student thesis; presentations of results at state, regional, and national conferences; and multiple publications in primary peer-reviewed scientific journals. Information resulting from this study can be used to inform management of this species of highest conservation concern, and the habitats on which they rely. We presented preliminary results in 2012 at the North American Ornithological Conference and the Midwest Fish and Wildlife Conference. This project has produced 3 annual reports including the 2010 pilot study, the 2011 annual report, and the current report, in addition to 2 peer-reviewed publications, 2 manuscripts in review at scientific journals, and 6 manuscripts in preparation. The final report in the form of a graduate student thesis will be provided to all partners by 31 December 2013 and peer reviewed publications will continue to be published throughout 2013 and beyond.

RESEARCH SCHEDULE

May – July 2010 – Pilot study at Tamarac National Wildlife Refuge (completed)

May – August 2011 – Full field study at all 3 locations (completed)

May – August 2012 – Full field study at all 3 locations (completed)

September 2012 – 2013 – Data analysis; modeling of population growth, habitat effects, and predicted climate change population response, and preparation of final report and manuscripts for publication.

ACKNOWLEDGMENTS

We are grateful for logistical support, housing assistance, and/or equipment loans from Walt Ford and Michelle McDowell (U.S. Fish and Wildlife Service, Rice Lake National Wildlife Refuge), Neil Powers and Wayne Brininger (U.S. Fish and Wildlife Service, Tamarac National Wildlife Refuge), Todd Roggenkamp (Long Lake Conservation Center), Bill Faber (Central Lakes College), John Loegering (University of Minnesota-Crookston), and Rachel Vallender (Environment Canada). We thank David Buehler (University of Tennessee), Tom Will (U.S. Fish and Wildlife Service), and many other Golden-winged Warbler Working Group members for input on study design and advice about field methods. We thank Rich Baker and Steve Lewis for assistance with grant proposal preparation. We thank Danner Bradshaw, Marianne Dawson, Alexander Fish, Mike Johnson, Ashley Jensen, Justin Lehman (co-site leader), Elizabeth Pokrivka, Renae Poole, Andrew Rehmann, Nick Seeger, and Ben Vernasco for tireless effort in field data collection, Amber Roth, Jeanine Refsnider, and Ronald Refsnider for expert volunteer field work, and others engaged in research on our study areas who found nests included in this sample: Kyle Daly (University of Minnesota) and Jake Nelson (University of Minnesota). Finally, we are most grateful to Gunnar Kramer for his strong leadership of our Rice Lake National Wildlife Refuge crew and to Tara McAllister for her support and mentoring of Gunnar and his crew. This research was supported through Research Work Order no. 87 at the Minnesota Cooperative Fish and Wildlife Research Unit funded by the U.S. Fish and Wildlife Service and the U.S. Geological Survey. Field work at Tamarc NWR in 2012 was funded in part via a State Wildlife Grant to the Minnesota Department of Natural Resources from the U.S. Fish and Wildlife Service. This research was approved by the University of Minnesota Animal Care and Use Committee (Protocol no. 1004A80575.

LITERATURE CITED

Beuhler, D.A., A.M. Roth, R. Vallender, T.C. Will, J.L. Confer, R.A. Canterbury, S. Barker Swarthout, K.V. Rosenberg, and L.P. Bullock. 2007. Status and conservation priorities of Golden-winged Warbler (*Verminora chrysoptera*). Auk 124:1439-1445.

Confer, J.L. 1992. Golden-winged Warbler (*Vermivora chrysoptera*). The Birds of North America Online (A. Poole Ed.). Ithaca: Cornell Lab of Ornithology.

Dettmers, R. 2003. Status and conservation of shrubland birds in the northeastern US. Forest Ecology and Management 185:85-93.

Frelich, L.E. and R.B. Reich. 2009. Wilderness conservation in an era of global warming and invasive species: a case study from Minnesota's boundary waters canoe area wilderness. Natural Areas Journal 29:385-383.

Hunter, W.C., D.A. Buehler, R.A. Canterbury, J.L. Confer, and P.B. Hamel. 2001. Conservation of disturbance-dependent birds in eastern North America. Wildlife Society Bulletin 29:440-455.

Mayfield, H. 1961. Nesting success calculated from exposure. Wilson Bulletin 73:255-261.

Mayfield, H.F. 1975. Suggestions for calculating nest success. Wilson Bulletin 87:456-466.

Sauer, J.R., J.E. Hines, and J. Fallon. 2005. The North American breeding bird survey, results and analysis 1966-2005, version 6.2.2006. U.S. Geological Survey Patuxent Wildlife Research Center, Laurel, Maryland.

Streby, H.M. 2010. Survival and habitat use of fledgling forest nesting songbirds in a managed forest landscape. Dissertation. University of Minnesota, St. Paul, USA.

Zollner, P.A., L.J. Roberts, E.J. Gustafson, H.S. He, and V. Radeloff. 2008. Influence of forest planning alternatives on landscape pattern and ecosystem processes in northern Wisconsin, USA. Forest Ecology and Management 254:429-444.

Table 1. Summary of Golden-winged Warbler demography data collected during the 2012 field season Tamarac National Wildlife Refuge (NWR), Rice Lake NWR, and Sandilands Provincial Forest (PF). Asterisk (*) indicates data collection supported entirely by a State Wildlife Grant from the Minnesota Department of Natural Resources and the U.S. Fish and Wildlife Service.

	Tamarac NWR	Rice Lake NWR	Sandilands PF	Total or grand mean
No. adults color-banded (M/F)	80 (35/45)*	98 (51/47)	41 (26/15)	219 (112/107)
No. females radio-marked[1]	44*	46	21	111
No. nesting attempts monitored[2]	90*	41	18	149
Successful females (%, with renesting)	58*	74	79	65
No. fledglings per successful nest	4.4*	4.0	3.9	4.2
No. nestlings/fledglings banded	153*	92	66	311
No. fledglings radio-tracked	68	54	53	175
No. fledgling locations recorded[3]	1006	562	649	2217
Fledgling survival to independence (%)	53	49	48	50

[1] Many radio signals were lost after females made pre-nesting long-distance movements and far fewer of those signals we relocated from a plane compared to 2011.
[2] We found an additional 20 GWWA nests that were apparently abandoned during construction or failed before we found them.
[3] Data collected at each fledgling location included GPS location, occupied cover type, occupied vegetation strata, canopy cover, vegetation density, fledgling and parental activity, other birds present, and other behavioral observations.

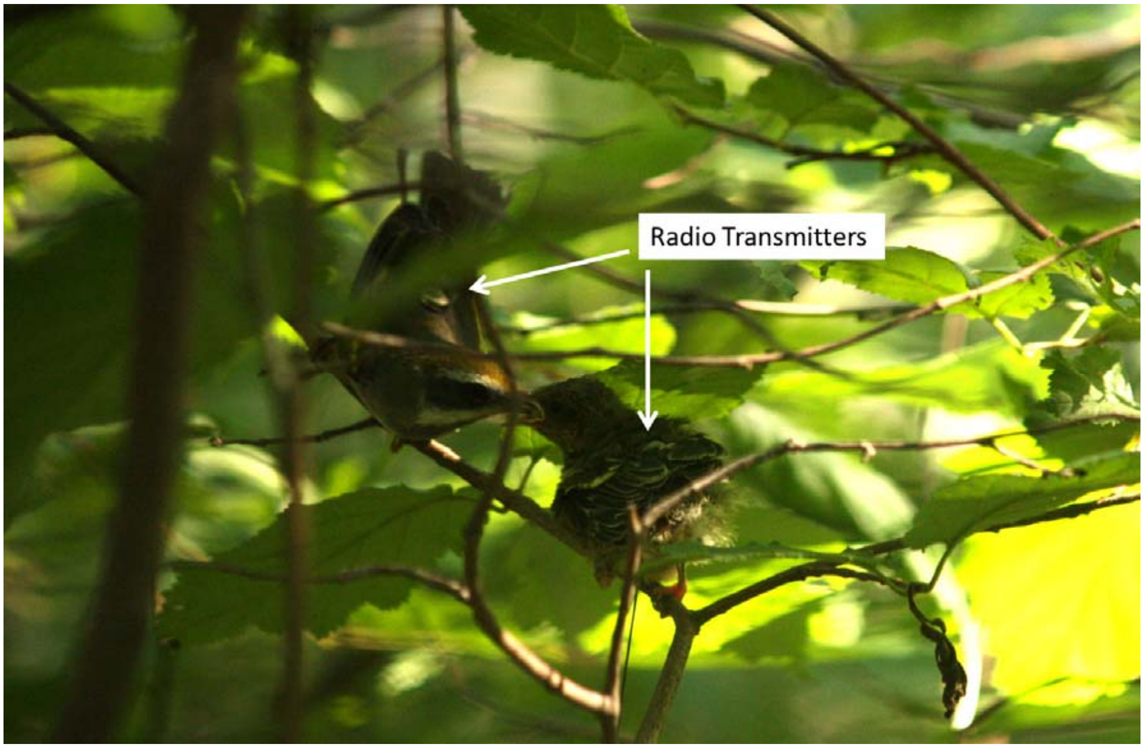

Figure 1. A female GWWA feeding a fledgling 4 days after it left its nest in Sandilands Provincial Forest, Manitoba, Canada. Both birds are carrying radio transmitters. Photo by Ben Vernasco.

Figure 2. Flooding at Rice Lake National Wildlife Refuge, Minnesota, 22 June 2012. Much of the refuge is lowland forest and shrubland. However, many areas (like that pictured) that are nearly always dry were under >1 m of water for 3 – 5 days during 20 – 24 June 2012 due to persistent extremely heavy rainfall. Waters reached the highest levels recorded since the establishment of the refuge in 1935. The flood took 3 weeks to completely recede due backup from downstream flooding. We attributed failure of 1 nest and mortalities of 3 fledglings to drowning during this flood. Typically, water levels in Minnesota wetlands are highest during early spring, and slowly decline throughout the spring and summer. However, rare June flooding events like this are potentially detrimental to survival and productivity of ground-dwelling animals (especially ground nesting birds) and many plants like wild rice, for which this flood caused a total loss of the 2012 crop in and around the refuge. Photo by Danner Bradshaw.

Figure 3. Frost-covered mist-nets and vegetation at Sandilands Provincial Forest, Manitoba, Canada. Below-freezing temperatures occurred during multiple mornings well after tree leaf out and well into the GWWA breeding season, even in 2012 which was warmer than average. Cold, wet nights contributed to more fledgling mortalities at Sandilands Provincial Forest than at the Minnesota sites in 2011 and 2012. Photo by Sean Peterson.

Appendix 1. Peer-reviewed study plan for ongoing project on Golden-winged Warbler demography in the core of the species' range.

Demographic Response of Golden-Winged Warbler to Habitat and Management across a Climate Change Gradient in the Core of the Species Range

Proposed Study Plan

20 January 2010

Henry M. Streby and David E. Andersen
Minnesota Cooperative Fish and Wildlife Research Unit
200 Hodson Hall
1980 Folwell Avenue
St. Paul, MN 55108
612 626-1222
dea@umn.edu

Introduction

Golden-winged Warbler (*Vermivora chrysoptera*) populations have been declining across their distribution for at least 40 years (Sauer et al. 2005). This Nearctic-Neotropical migratory species is listed as "threatened," "endangered," or "of management concern" in 10 states, and is described by the U.S. Fish and Wildlife Service as a "species of management concern" (Buehler et al. 2007). The cause of range-wide declines, and some local extinctions, is a complex combination of habitat loss, Blue-winged Warbler (*Vermivora pinus*) hybridization and competition, brood-parasitism by Brown-headed Cowbirds (*Moluthrus ater*), and likely global climate change (Buehler et al. 2007). Although Golden-winged Warbler range is contracting from the south, it is expanding to a lesser degree to the west and north. However, in areas of recent range expansion, populations have been declining over the past 15 years, and range expansion will soon be limited by lack of suitable habitat to the north and west.

Golden-winged Warblers depend on early successional forest stands, open forested wetlands, and lowland shrubby areas for nesting (Confer 1992). The northern hardwood-coniferous forests of northern Minnesota, Wisconsin, Michigan, and south-central Canada host the highest remaining densities of breeding Golden-winged Warblers (Sauer et al. 2005). Predicted to be a bioregion among the earliest and most dramatically affected by global climate change (Frelich and Reich 2009), there is currently considerable debate about the desired future composition and juxtaposition of habitats within these forests. Considerations for wildlife, including species associated with early successional forests, are an important part of this conversation (e.g., Jaakko Pöyry Consulting, Inc. 1992). Golden-winged Warbler nesting habitat is in decline as abandoned farmlands regenerate to mature forest, timber harvest declines, and wetlands are drained for development. Assessing the demographic response of Golden-winged Warbler populations to land management and other habitat alterations is critical for this species to be included in future management planning (Buehler et al. 2007). Detailed knowledge of habitat-specific demographic parameters is necessary to predict Golden-winged Warbler population responses to climate change.

Little is known about Golden-winged Warbler survival and habitat use throughout the nesting period in this region, and less is known about these parameters during the post-fledging period anywhere in the species' range (Buehler et al. 2007). To our knowledge, survival and reproductive success have not been compared among breeding habitat types, and fledgling survival has not been directly estimated for this species.

To address these information needs, we propose to investigate Golden-winged Warbler adult survival and annual productivity between the species' main breeding habitat types: early successional forests and forested wetlands. The objectives of this work are to:

1) Compare Golden-winged Warbler (GWWA) density and annual productivity (nest productivity and juvenile survival) between two main breeding habitat types.
2) Compare adult GWWA survival and habitat use during the nesting and post-fledging period between two main breeding habitat types.
3) Use habitat characteristics to build a predictive model of GWWA reproductive success to provide management recommendations for maximizing high quality GWWA habitat.
4) Replicate the study at 3 locations across a climate change gradient over 2 years to include critical spatial and temporal variation in analyses, maximizing the inference of results and applicability of management recommendations.
5) Combine demographic data with models of predicted climate change for the western Great Lakes region to predict climate-change effects on Golden-winged Warbler population viability.

Study Area

We will conduct this research in the core of Golden-winged Warbler range, at 3 sites that span a 450-km northwest to southeast global climate change gradient, and a gradient of Blue-winged Warbler genetic introgression. Specific study plots have not yet been selected, but will be located within Tamarac National Wildlife Refuge (north-west Minnesota), Rice Lake National Wildlife Refuge (east-central Minnesota), and Chequamegon National Forest (north-west Wisconsin). Tamarac NWR, and Rice Lake NWR have offered in-kind support (e.g., housing) for the duration of the project. These 3 study sites have relatively high GWWA abundance, and are located outside areas of Blue-winged Warbler (BWWA) sympatry, but along a gradient of BWWA genetic introgression in northern Wisconsin and northern Minnesota. Levels of genetic introgression generally decrease with distance from areas of sympatry. Therefore, these sites have been chosen to cover a range of relatively high to low genetic introgression from southeast (Chequamegon National Forest, WI) to northwest (Tamarac National Wildlife Refuge, MN).

Methods

The objectives will be addressed through a combination of field methods including nest searching, nest monitoring, radio telemetry, vegetation sampling, and invertebrate sampling. In addition, we will use GIS software to further assess habitat, and statistical software to model population growth and habitat relationships.

<u>Nest Searching</u>
We will establish nest searching plots in known Golden-winged Warbler nesting areas at each study site. We will use an all-inclusive approach to ensure an adequate sample of nests (GWWA nest on the ground in dense vegetation);

1) We will have 4 fulltime field technicians and 1 project leader at each site, with 3 additional assistants at each site for 3 weeks of peak nest searching. These workers will search for nests following procedures described by Martin and Geupel (1993) and Martin et al. (1997), and used on previous studies of forest-nesting birds in north-central Minnesota (Perry 1998, Manolis 1999).
2) We will capture adult female birds with mist nets to radio track them to nests, and we will capture and track females from known nests to enable monitoring of subsequent nesting attempts in cases of initial nest failure.
3) We will have 1-2 dog handlers train pointer hunting dogs to identify and locate songbird nests.
4) We will use sensitive thermal imaging cameras to locate well hidden nests using temperature differences between nests and surrounding vegetation.

We will evaluate the utility of nest-searching methods 3 and 4 during the first season, and increase or exclude their use during years 2 and 3 of the project accordingly.

<u>Nest Monitoring</u>
We will record the location of each nest using a handheld GPS unit (100 points averaged). We will monitor each discovered nest following procedures described by Martin and Geupel (1993) and Martin et al. (1997), and used on previous studies of forest-nesting birds in north-central Minnesota (Perry 1998, Manolis 1999). We will visit nests at 4-day intervals, and more often when transitional events (i.e. hatching and fledging) are expected. That schedule will result in nests being visited at intervals averaging 2 – 3 days as suggested by Golden-winged Warbler Working Group protocols. During each visit, we will record adult activity and nest contents (i.e. number of eggs, number of nestlings) and the condition of those contents (i.e. age of nestlings). We will band nestlings 3 days prior to the expected fledge date following methods we used in previous work (Streby and Andersen 2007). We will use radio telemetry to monitor adults and fledglings and thereby determine the fate of each nest found empty on or near the expected fledge date. We will use the Logistic Exposure method (Shaffer 2004) to estimate nest productivity, and to model the effects of habitat parameters on nest productivity.

Radio Telemetry
We will monitor birds using radio telemetry methods described by Anders et al. (1998), Vega Rivera et al. (1998, 2003), Lang et al. (2002), Fink (2003), and Cohen and Lindell (2004) that we used in a previous study (Streby and Andersen 2007). We have confirmed the availability of 0.4g (<5% of average body mass) transmitters with ≥30-day battery life. We will attach transmitters to birds using a figure-eight harness design for passerines (Rapolle and Tipton 1991). We will capture female birds from monitored nests by setting mist nets near nests and flushing the female into the net. We will capture and handle females only after the onset of incubation to reduce the probability of nest abandonment. We will indirectly monitor fledgling survival by monitoring radio-marked adult birds during the first week after young leave the nest. After that week, we expect that fledglings will be large enough to carry transmitters. We will relocate fledglings by tracking adults that are regularly feeding young. Once fledglings are located, we will set mist nets and flush fledglings into those nets, a method that has been used successfully in previous studies of Golden-winged Warblers (Rachel Vallender personal communication). We will monitor the adult female from each nest and ≥1 fledgling from each successful nest using radio telemetry to monitor survival, habitat use, and parental care. During the first year of the study, we will also monitor adult male habitat use and survival. Males will be captured using mist nets and call playback within active territories. We will relocate each bird ≥1 time daily, using radio telemetry to triangulate its position, and then approaching to confirm specific microhabitat use and survival. We will record locations of monitored birds using handheld GPS units (100 points averaged). When birds move beyond the range of our ground-tracking capabilities, we will relocate them from the air using standard aerial telemetry techniques (Mech, 1983). We will use the Logistic Exposure method to estimate adult and fledgling survival, and to model the effects of habitat parameters on survival.

Sample Sizes
During the pilot season at Tamarac NWR, we plan to monitor 25 – 50 nests, and monitor with radio telemetry >20 male, >20 female, and >20 fledgling GWWA.
During the full study at all 3 sites during 2011 and 2012 we plan to monitor 200 – 400 nests, and monitor with radio telemetry 150 – 200 adult females, and 150 – 200 fledgling GWWA. We will determine after the pilot year whether we will continue to monitor adult males with radio telemetry.

Habitat Assessment
Two main breeding habitat types will be investigated at each site; (1) Lowland (e.g., tamarack bogs, alder thickets, and other shrubby wetlands) and (2) Upland successional (e.g., regenerating clearcuts and open shrubby managed areas).

We will survey sites using vegetation sampling protocols established by the Golden-winged Warbler Working Group. In addition, we will sample food availability throughout the season for comparison between habitats and study sites following procedures we have used during previous research (Streby and Andersen 2007). Food availability will be compared with stomach samples from recovered mortalities during telemetry to investigate food-type preferences. Vegetation structure and food availability variables will be used to model habitat quality for GWWA across the geographic range of the study.

Population Modeling
We will build stochastic models of GWWA population growth including habitat variables across the geographic range of the study. These models will be used with predicted future habitat changes to predict the effects of climate change on GWWA populations.

Climate Change
In years 2 and 3 of this study, we will investigate population dynamics of GWWA across a gradient from southeast to northwest. This gradient represents a range of climatic conditions and corresponds with the perceived northwest range expansion of GWWA. We will evaluate reproduction and influences of habitat on population dynamics across this gradient. We will combine these data with models of future climate change for the western Great Lakes region to predict climate-change effects on Golden-winged Warbler population viability.

Timeline

Spring 2010 – Select graduate student and hire research associate
May – August 2010 – Pilot study at Tamarac National Wildlife Refuge
May – August 2011 – Full study at all 3 sites
May – August 2012 – Full study at all 3 sites

Expected Products

Products will include annual project reports, a final project report, a graduate student thesis, and primary literature publications presenting project results.

Literature Cited

Anders, A.D., J. Faaborg, and F.R. Thompson, III. 1998. Postfledging dispersal, habitat use, and home-range size of juvenile wood thrushes. Auk:349-358.

Beuhler, D.A., A.M. Roth, R. Vallender, T.C. Will, J.L. Confer, R.A. Canterbury, S. Barker Swarthout, K.V. Rosenberg, and L.P. Bullock. 2007. Status and conservation priorities of golden-winged warbler (Verminora chrysoptera) in North America. The Auk 124:1439-1445.

Cohen, E.B. and C.A. Lindell. 2004. Survival, habitat use, and movements of fledgling white-throated robins (*Turdus assimilis*) in a Costa Rican agricultural landscape. Auk 121:404-414.

Confer, J.L. 1992. Golden-winged Warbler (Vermivora chrisoptera). In The Birds of North America, no. 20 (A. Poole, P. Stetterheim, and R. Gill, Eds.). American Ornithologists' Union, Washington, D.C.

Fenske-Crawford, T. and J.G. Niemi. 1997. Predation of artificial ground nests at two types of edges in a forest-dominated landscape. Condor 99:14-24.

Fink, M.L. 2003. Post-fledging ecology of juvenile wood thrush in fragmented and contiguous landscapes. Dissertation, University of Missouri-Columbia, Columbia, Missouri, USA.

Frelich, L. E. and R. B. Reich. 2009. Wilderness conservation in an era of global warming and invasive species: a case study from Minnesota's boundary waters canoe area wilderness. Natural Areas Journal 29:385-383.

Jaakko Pöyry Consulting, Inc. 1992. Forest wildlife: a technical paper for a generic environmental impact statement on timber harvesting and forest management in Minnesota. Minnesota Environmental Quality Board, St. Paul, Minnesota, USA.

Lang, J.D., L.A. Powell, D.G. Krementz, and M.J. Conroy. 2002. Wood thrush movements and habitat use: effects of forest management for red-cockaded woodpeckers. Auk 119:109-124.

Manolis, J.C. 1999. Clearcut edge effects on avian nesting success in extensively forested, northern hardwood-coniferous landscapes. Dissertation. University of Minnesota, St. Paul, Minnesota, USA.

Martin, T.E., C.J. Conway, W.M. Hochackaka, P. Allen, and J.W. Jenkins. 1997. BBIRD field protocols. Montana Cooperative Wildlife Research Unit, University of Montana, Missoula, Montana, USA.

Martin, T.E. and G.R. Geupel. 1993. Nest monitoring plots: methods for locating nests and monitoring success. Journal of Field Ornithology 64:507-519.

Mech, L. D. 1983. Handbook of animal radio-tracking. University of Minnesota, Minneapolis, USA.

Perry, E.F. 1998. Clustered nesting of least flycatchers (Empidonax minimus) in north-central Minnesota. Thesis. University of Minnesota, St. Paul, Minnesota, USA.

Sauer, J.R., J.E. Hines, and J. Fallon. 2005. The North American breeding bird survey, results and analysis 1966-2005, version 6.2.2006. U.S. Geological Survey Patuxent Wildlife Research Center, Laurel, Maryland.

Shaffer, T.L. 2004. A unified approach to analyzing nest success. The Auk 121:526-540.

Streby, H.M. and D.E. Andersen. 2007. Habitat use of post-fledging forest-nesting songbirds in northern hardwood-coniferous forests in northern Minnesota: 2007 summary report. U.S. Geological Survey, Minnesota Cooperative Fish and Wildlife Research Unit research work order 73.

Vega Rivera, J.H, J.H. Rappole, W.J. McShea, and C.A. Haas. 1998. Wood thrush postfledging movements and habitat use in northern Virginia. Condor 100:69-78.

Vega Rivera, J.H., W.J. McShea, and J.H. Rappole. 2003. Comparison of breeding and postbreeding movements and habitat requirements for the scarlet tanager (*Piranga olivacea*) in Virginia. Auk 120:632-644.