Golden-winged Warbler

Status Review and Conservation Plan

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Chapter 1: Golden-winged Warbler Status Review

Chapter 2: Golden-winged Warbler Full Life Cycle Conservation Strategy

Chapter 3: Golden-winged Warbler Breeding Season Conservation Plan

Chapter 4: Golden-winged Warbler Non-breeding Season Conservation Plan
(see pdf at gwwa.org)

The Cornell Lab of Ornithology

National Fish and Wildlife Foundation

Golden-winged Warbler Working Group

U.S. Fish & Wildlife Service

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This timber harvest in Pennsylvania depicts excellent breeding habitat for Golden-winged Warblers. It shows ample residual trees, shrubs, and saplings with a large herbaceous component. Photo by: Marja Bakermans.

ACKNOWLEDGMENTS

The Golden-winged Warbler Status Review and Conservation Plan was developed and reviewed under the guidance of the Golden-winged Warbler Working Group, a consortium of more than 140 biologists and managers engaged in research and conservation of this species (**www.gwwa.org/**). Funding for the initiative was provided by the National Fish and Wildlife Foundation and U. S. Fish & Wildlife Service, with more than $1 million in matching contributions provided by numerous partner organizations including American Bird Conservancy, Appalachian Mountains Joint Venture, Audubon North Carolina, Cornell Lab of Ornithology, Fundacion Proaves-Colombia, Indiana University of Pennsylvania, Ithaca College, Michigan Technological University, University of Minnesota, University of Tennessee, Wisconsin Department of Natural Resources, Tennessee Wildlife Resources Agency, and The Ruffed Grouse Society. We are grateful to the many individuals who contributed significant effort to specific portions of this document, as follows:

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PREFACE: A HISTORY OF INSPIRED RESEARCH AND CONSERVATION

As measured by the Breeding Bird Survey (BBS) over the last 45 years, Golden-winged Warbler (*Vermivora chrysoptera*) has experienced one of the steepest declines of any North American forest songbird. It has also been one of the most intensely studied songbirds. Together with its sister species, Blue-winged Warbler (*V. cyanoptera*), it has been the subject of numerous research projects by a host of talented field ornithologists beginning in the 1960s with Frank Gill, Lester Short, and especially Millicent and Robert Ficken, and continuing to the present day. Several ornithologists have devoted their entire careers to elucidating the knotty problems the species poses. Over the last 150 years, the range of Golden-winged Warbler has geographically shifted more than that of almost any other avian species. It has been labeled as a habitat specialist as well as an early successional pioneer generalist. It has been reported more commonly from low-lying wetlands in some regions and from uplands in other regions. It has been identified as a shrubland edge species associated with abandoned farmland succession and as a species of dynamic forested landscapes. It mates with Blue-winged Warbler where the two species come into secondary contact and forms readily identifiable hybrids in a hybrid mosaic zone, yet one can still find extensive areas where the two species remain at least phenotypically distinct. Despite the characteristic visual features signaling its distinct identity, introgression of Blue-winged Warbler mitochondrial genes is widespread; yet geneticists have been hard-pressed to find nuclear markers that reliably distinguish the two species. Golden-winged Warbler behavior relative to Blue-winged Warbler is puzzling at best: it overlaps territories with the other species yet still engages in aggressive interspecific interactions; individuals that appear to be clearly one species can sometimes sing the song characteristic of the other, or both songs; hybrids may sing the song of either parental type.

Because of the tantalizing science questions it poses, its rapidly declining populations, and its intrinsic aesthetic appeal, Golden-winged Warbler has attracted a large and dedicated group of passionate ornithologists and conservationists over the last decade. Except for the hybridization question, research on Blue-winged Warbler has essentially ground to a halt while work on Golden-winged Warbler has increased exponentially. The formation of the Golden-winged Warbler Working Group in 2003—and its international sister group, Alianza Alas Doradas, in 2005—has catalyzed a highly coordinated conservation initiative. The Working Group has inspired two major workshops or "summits" (in Siren, Wisconsin, and in Bogotá, Colombia), at least three symposia at major ornithological meetings, dozens of regional and local workshops and presentations, a rangewide Golden-winged Warbler Atlas Project, and a rangewide hybridization study. Most significantly, supported by four years of funding from the National Fish and Wildlife Foundation (NFWF) beginning in 2008, the Working Group's Rangewide Golden-winged Warbler Conservation Initiative coordinated a multi-scale study at eight sites in seven states from Minnesota to New York and south to Tennessee. This coordinated research project was to provide the science base for developing regionally specific guidelines for restoring and enhancing productive Golden-winged Warbler breeding habitat. The results of that work form the core of Chapter 3 of this document—the **Golden-winged Warbler Breeding Season Conservation Plan**.

In 2000, David Buehler, John Confer, and Ronald Canterbury were commissioned by the U.S. Fish and Wildlife Service to develop what was originally the *Status Assessment and Conservation Recommendations for the Golden-winged Warbler (Vermivora chrysoptera) in North America*. Over time, that original project received input from others and underwent numerous stalls, revisions, and reviews. The fact that the continuous arrival of new information so rapidly outpaced the writing and review schedule of the *Status Assessment* is fundamentally a tribute to the tremendous dedication and energy of the Golden-winged Warbler Working Group and its partners. However, the deadlines imposed by the NFWF-funded *Breeding Season Conservation Plan*—coupled with the listing of Golden-winged Warbler as a Threatened species in Canada and a pending petition to list the species under the Endangered Species Act in the U.S.—have finally pushed what has now become the *Status Review* to the finishing line. The core of the original assessment, although with much new information, now forms the basis of Chapter 1 of this document—the **Golden-winged Warbler Status Review**. In this version, survey and trend estimates have been updated to include 2009 BBS data and to incorporate the currently preferred and more robust Bayesian approach for analyzing BBS trend information. Genetic data were updated to include birds sampled during the 2010 breeding season. The conservation and research recommendations of the original *Status Assessment* have been integrated with the results of the two summits, three 2009 regional Working Group meetings, and the business plan developed for NFWF; these now form the comprehensive framework of goals and objectives outlined in Chapter 2—the **Golden-winged Warbler Full Life Cycle Conservation Strategy**.

Finally, recognizing that all parts of the annual cycle of a long-distance migratory bird are inextricably linked to one another—and recognizing that conservation actions on the breeding grounds should be complemented by conservation during the non-breeding season—we have included in this document a placeholder for a fourth chapter. We anticipate that Chapter 4, the **Golden-winged Warbler Non-breeding Season Conservation Plan**, will be completed a few years after analysis of the 2011–2012 non-breeding season survey results and a site-specific review of Neotropical non-breeding season threats.

EXECUTIVE SUMMARY

In 2012, the Golden-winged Warbler Working Group (GWWG) published the *Golden-winged Warbler Status Review and Conservation Plan* (hereafter, referred to as "the plan") through the GWWG's website at **www.gwwa.org**. Since publication, significant new research has produced insights into Golden-winged Warbler nesting and post-fledging habitat use, migratory connectivity, and habitat segregation among the sexes on the wintering grounds. Much of this research is available in *Golden-winged Warbler Ecology, Conservation, and Habitat Management* (Streby et al. 2016. Studies in Avian Biology).

Federal and state agencies in cooperation with non-governmental organizations and many landowners have invested millions to create, restore, and conserve habitat across the breeding grounds. Local projects in Central and South America funded by the Neotropical Migratory Bird Conservation Act Grant program have protected and restored winter habitat.

The population impact of this substantial investment range-wide is difficult to assess. The USGS Breeding Bird Survey (BBS) is unable to detect Golden-winged Warbler in the Appalachian region and has notable problems with discerning an accurate population trend throughout the Great Lakes region. Though the BBS indicates stabilization of the Great Lakes subpopulation over the past decade, this should be interpreted with caution in light of trend analysis assumptions. A new spatially-balanced population monitoring program in the Appalachians has confirmed continuing steep population declines throughout the region that have been poorly tracked by BBS. In spite of these regional declines, positive response of territorial males to local habitat management based on systematic evaluation in parts of the breeding range provide support for continued investment in Golden-winged Warbler conservation.

Summary of 2019 Revisions

The plan was intended to be revised after five years. In 2018, the Steering Committee undertook revisions of some parts of the plan with assistance from species experts. Revisions related to Golden-winged Warbler habitat best management practices were funded by the National Fish and Wildlife Foundation. These and additional sections of the plan were revised through the generous donation of time by Kyle Aldinger, Christian Artuso, Sara Barker Swarthout, Ruth Bennett, David Buehler, Katie Koch, Jeff Larkin, Katie Loucks, D.J. McNeil, Jr., Laurel Molton, Ron Rohrbaugh, Amber Roth, and Tom Will.

Since 2012, the layout of Chapter 1 (Golden-winged Warbler Status Review) was completed and added to the plan. Chapter 4 (Golden-winged Warbler Nonbreeding Season Conservation Plan) was completed in 2016, but has not yet been added to this document due to lack of resources for the layout. Chapter 4 is available as a stand-alone PDF at **www.gwwa.org**.

Many typos and wording errors were addressed throughout the document. Substantial revisions were made to the following sections in Chapters 2 and 3 to update them with new information and activities:

Chapter 2

- Canadian Recovery Strategy (page 2–8)
- Table 2–2 (page 2–10 to 2–13)
- Conservation Actions (pages 2–12 to 2–17)

Chapter 3

- Introduction (pages 3–4 to 3–5)
- Sidebar (page 3–8)
- Management Guidelines (page 3–9)
- Quick Start Guide for Land Managers (pages 3–10 to 3–15)
- Part I: Comprehensive Management Guide (pages 3–16 to 3–37)
- Evaluating Accomplishments (introductory paragraph) (page 3–72)
- Table 3–16 (pages 3–75 to 3–77)

To mirror changes to the habitat management guidelines in Chapter 3, the stand-alone best management practice guides to the Appalachian and Great Lakes regions and the 11 associated habitat supplements were also updated and can be found at **www.gwwa.org**.

Other sections of the plan will be revised in the future as funding becomes available.

Blue-winged Warbler and Management for Golden-winged Warbler

New research suggests that Golden-winged Warbler and Blue-winged Warbler share extensive genetic code (Toews et al. 2016). The mitochondrial genome differs by ~3% between these species; the nuclear genome differs by only 0.03% including 4 of 6 genes related to plumage color and pattern (Toews et al. 2016). Despite this small genetic difference, the two species remain distinct species as recognized by the American Ornithological Society. Moreover substantial anatomical, behavioral, and ecological differences do exist between these two species which convey the evolutionary significance of these two forms. These anatomical, behavioral, and ecological differences are likely quite important to the differentiation of species within genus *Vermivora* (e.g. Bennett et al. 2017). For the purposes of the plan, we will continue to recognize Golden-winged Warbler as a distinct species and make management and conservation recommendations for locations where the phenotype is present.

We recognize that there is substantial overlap in the habitat use and geographic areas used by both species. Habitat management efforts to maintain spatially and genetically distinct populations is unlikely to be successful. Therefore, managers should continue to implement Golden-winged Warbler best management practices in places where good opportunities remain for a positive response from Golden-winged Warbler. A positive response to these activities by Blue-winged Warbler and other associated species experiencing population declines (see Table 2–2) should be deemed a management success especially if Golden-winged Warblers are maintained or increased at these sites. Management activities will not always have the desired outcome for Golden-winged Warbler, but a positive response by other young forest species is still a successful result.

Amber Roth
Golden-winged Warbler Working Group Co-chair

David Buehler
Former Golden-winged Warbler Working Group Chair

Illustration by Bartels Science
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CHAPTER 1.

GOLDEN-WINGED WARBLER STATUS REVIEW

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The *Golden-winged Warbler Status Review* was initiated over a decade ago when David Buehler, John Confer, and Ron Canterbury were funded by the U.S. Fish and Wildlife Service to elaborate on what was originally a status assessment begun by Chuck Hunter in 1999. Over time, that original project received input from others and underwent numerous stalls, revisions, and reviews. The continuous stream of new information that so rapidly outpaced the writing of the document is actually a tribute to the tremendous dedication and energy of the Golden-winged Warbler Working Group and its partners. In this version of the Status Review, survey and trend estimates have been updated to include 2009 Breeding Bird Survey (BBS) data and to incorporate the currently preferred and more robust Bayesian approach for analyzing BBS trend information. Genetic data were updated to include birds sampled during the 2010 breeding season. We are pleased finally to release the Status Review, at the same time acknowledging that new research and conservation action will just as quickly outdate much of the information it summarizes. We of course believe that such a level of conservation science commitment is a good thing, and we would prefer to think of this document as a *Status Transition* to a more hopeful future. We are grateful for the very many individuals who devoted time and energy to the surveys that provided the basis for inference about Golden-winged Warbler status—volunteers for the BBS, Breeding Bird Census, Golden-winged Warbler Atlas Project, individual State and Provincial atlas projects, Goldenwinged Warbler Non-breeding Season Survey, and Chicago Bird Collision Monitoring project, to name just a few. We are especially grateful to those who made significant contributions to specific sections of this document and to those who reviewed the final product, as follows:

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Photo by Donald Mullaney

CHAPTER 1 SUMMARY

Golden-winged Warbler (*Vermivora chrysoptera*) is one of the most rapidly declining forest songbirds breeding north of Mexico, having lost an estimated two-thirds of its population since 1970. The species has been petitioned for listing as threatened under the *Endangered Species Act* in the U.S. and is currently listed as Threatened under the *Species at Risk Act* in Canada. It is a long-distance Nearctic/Neotropical migrant that breeds from May through July mainly in the Great Lakes and Lawrence/Champlain provinces and states from Manitoba to Vermont and in the Appalachian Mountains from New York to Tennessee; it spends the northern winter mostly in the tropical highlands of Central America and the northern Andes of Colombia and Venezuela.

Golden-winged Warbler also has seen one of the most substantial recent range shifts of any North American passerine. Over the last 150 years in the Upper Midwest, the southern limit of the species range has shifted northward some 340 miles (550 km) and expanded perhaps 500 miles (800 km) northwestward into Manitoba; the breeding range has contracted substantially in the Appalachians and in New England such that Golden-winged Warbler now may be extirpated as a breeding species from Georgia, South Carolina, Connecticut, Massachusetts, Rhode Island, Illinois, Indiana, and Ohio. With the recent loss of persistent populations in central New York, the species breeding population is now divided into a Great Lakes and an Appalachian Mountains range segment.

Golden-winged Warbler is dependent on dynamically changing forested landscapes in which disturbance patterns create patches of regenerating forest dominated by shrubs, small trees, and a grassy herbaceous layer. Such young forest openings are heavily utilized for nesting, but breeding adults also forage widely in mature deciduous or mixed forest and may even prefer adjacent mature upland forests or northern forested wetlands during the post-fledging period.

Overall declines in young forest acreage and loss of shrubby breeding habitat as abandoned fields become reforested have been identified as a major cause of range-wide Golden-winged Warbler population declines. However, complex interactions with its very closely related and more southerly distributed congener, Blue-winged Warbler (*V. cyanoptera*), have also been blamed for its demise; in a given area, the Golden-winged Warbler phenotype tends to be replaced by that of Blue-winged Warbler over a period of 40–60 years after secondary contact. Cryptic hybridization (presence of mitochondrial Blue-winged Warbler DNA in individuals otherwise resembling Golden-winged Warbler) is widespread. But as introgression also occurs in the reverse direction, and as recent research suggests very little nuclear divergence between the two forms, the dynamics of the species phenotype replacement remain puzzling.

During the stationary non-breeding (winter) season in Central and northern South America, Golden-winged Warbler prefers mid-elevation moist premontane forested slopes, generally below 8200 feet (2500 meters), with numerous vine tangles, hanging dead leaves, and epiphytes—conditions caused by some form of disturbance and also available in advanced secondary and agroforestry systems (e.g., shade coffee plantations). Individuals join mixed-species foraging flocks, but are otherwise territorial with large home range sizes. Thus large areas of tropical forest may be needed to support wintering Golden-winged Warbler populations. Recent demographic analysis suggests that winter survival may be an important factor contributing to observed breeding season population declines—highlighting the need for habitat conservation action throughout the annual cycle, including the non-breeding season.

Regional and state status summaries indicate widespread differences in population trajectory. Goldenwinged Warbler populations currently appear stable to slightly increasing in Manitoba, Ontario, Minnesota, and to a lesser extent in Wisconsin. In other states in which the species now occurs, extirpation is a possibility in the absence of conservation action if current trends continue.

GOLDEN-WINGED WARBLER: A SONGBIRD IN TROUBLE

Golden-winged Warbler (*Vermivora chrysoptera*) is a Nearctic/Neotropical long-distance migrant songbird that breeds from May through July mainly in the Great Lakes and St. Lawrence/Champlain states and provinces from Manitoba to Vermont and in the Appalachian Mountains from New York to Tennessee. From October/November through February/March, it spends the northern hemisphere winter in tropical habitats from Central America to the northern Andes of Colombia and Venezuela (Figure 1–1). Although specific connectivity between breeding and non-breeding populations has yet to be determined, it is possible that at least some individuals make annual round trips of more than 6,000 miles (9600 km)—quite a remarkable achievement for a bird that weighs a third of an ounce (9–10 g).

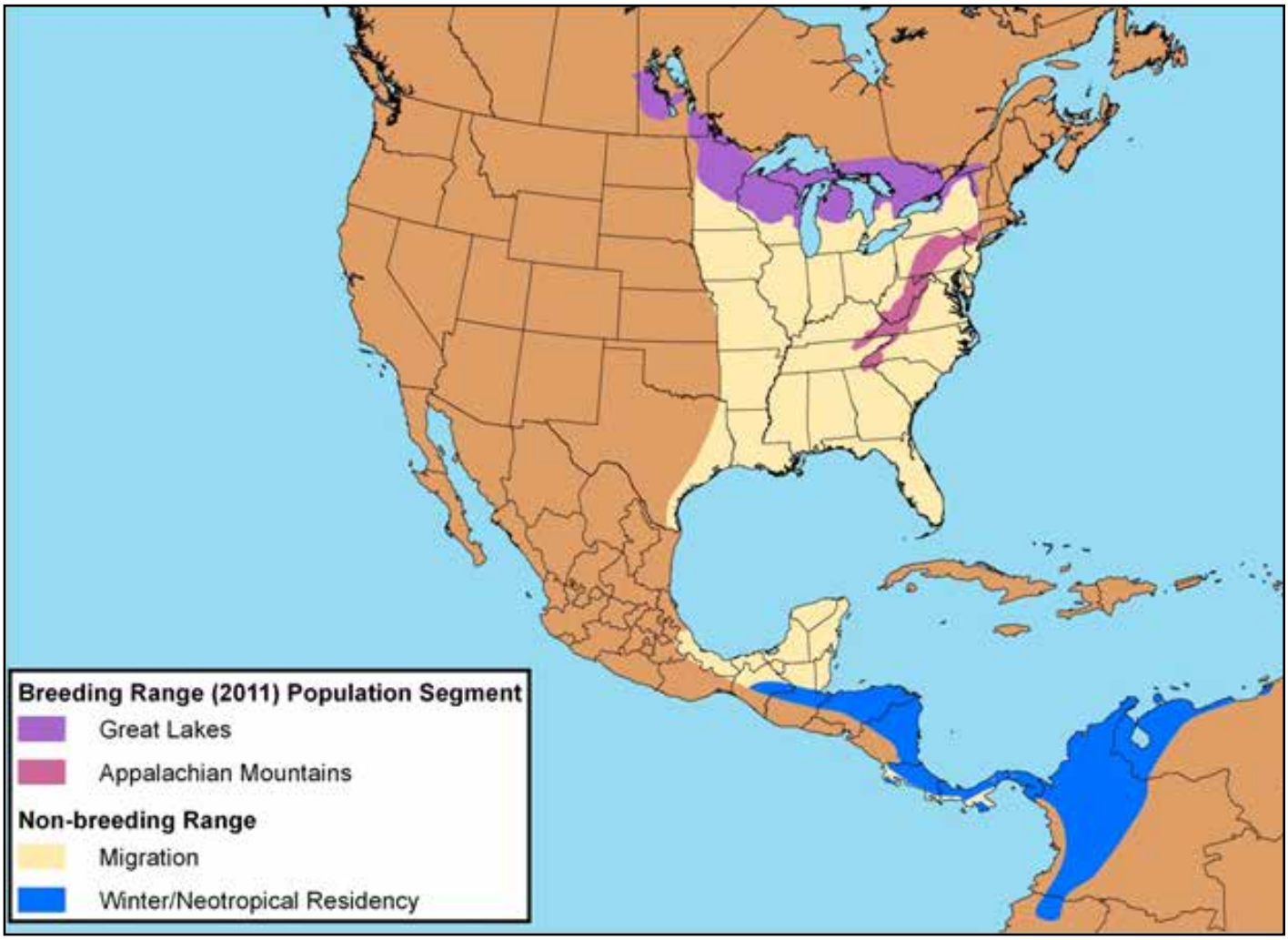

Figure 1–1. Golden-winged Warbler breeding and wintering (resident non-breeding) range. The breeding season range is based on expert knowledge of persistent breeding populations as of 2011. The primary known migratory range is inferred from concentrations of recent eBird records; regions with only a few scattered records (e.g., east-central Mexico and Caribbean islands) are excluded. Winter range is based on NatureServe (2011).

Taxonomy and Identification

Golden-winged Warbler belongs to the order Passeriformes (perching birds), the family Parulidae (wood warblers), and the genus *Vermivora*, which contains only three species in North America (Chesser et al. 2010), one of which is now believed to be extinct (Bachman's Warbler, *V. bachmanii*). Classic Golden-winged Warblers are gray-backed and whitish-bellied, with a yellow crown and large yellow wing patches; males have a black and females a gray facial mask and throat (Figure 1–2). Although Golden-winged Warbler is described as a distinct species in the 7th Edition of the Check-list of North American Birds (AOU 1998), it is closely related to and hybridizes with Blue-winged Warbler (*V. cyanoptera*). Parkes (1951) suggested that phenotypically distinct first-generation hybrids (Brewster's Warbler) displayed the dominant plumage characters of a white belly and reduced head patterning; backcrosses between hybrids and Golden-winged or Bluewinged warblers were thought to produce the distinct Lawrence's Warbler, which expressed recessive traits of a yellow belly and more extensive head patterning. (Figure 1–2).

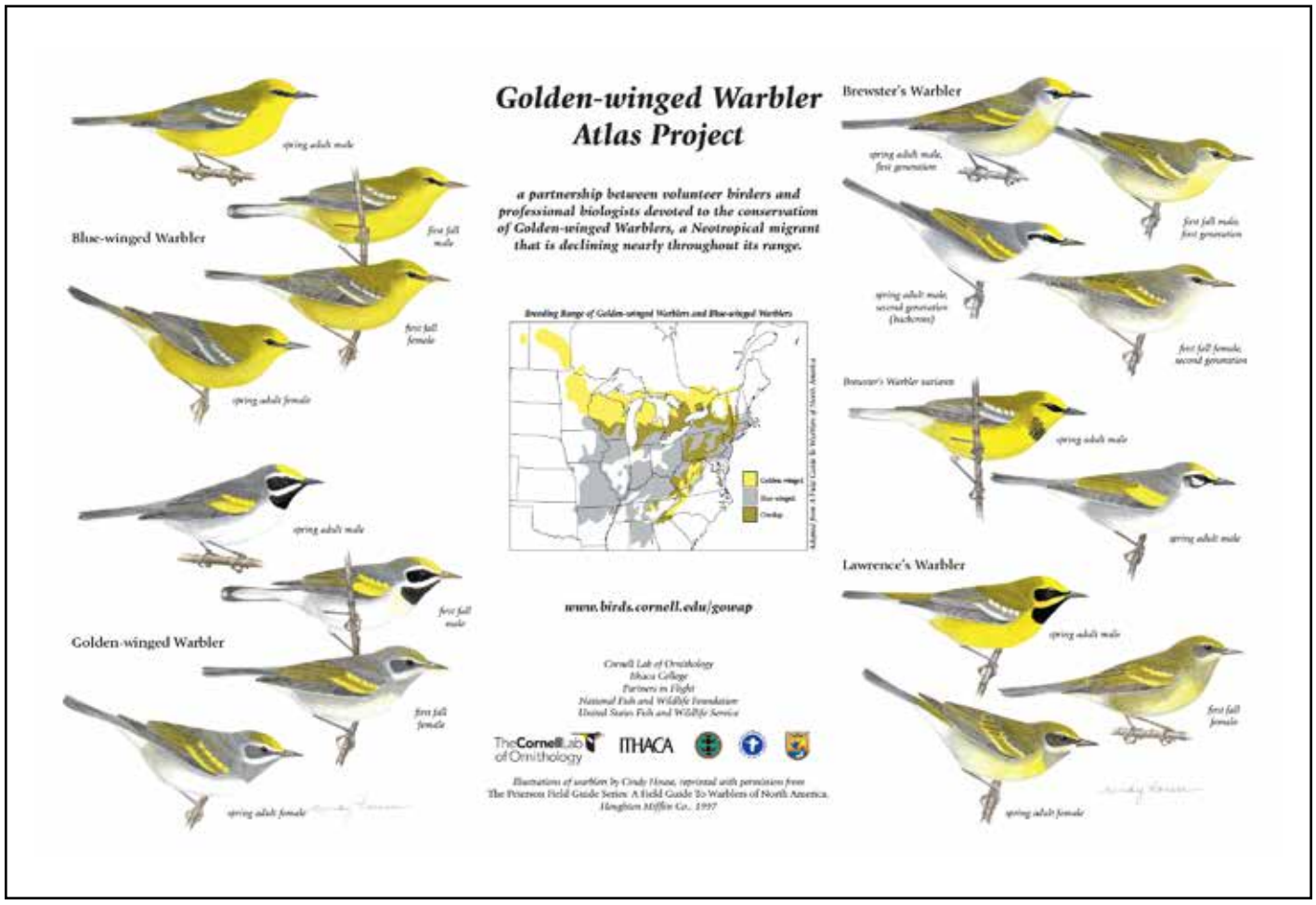

Figure 1–2. Plumages of Golden-winged Warbler, Blue-winged Warbler, and hybrids.

However, many individuals which appear at first glance to be clearly one species can, on closer inspection, show color flushes typical of the other. In addition, recent mitochondrial DNA (mtDNA) sequencing work reveals that genetic mixing appears to be much more extensive than is suggested by the identification of classical Brewster's and Lawrence's forms, producing an array of introgressed birds (i.e., that exhibit plumage intermediate between the parental types but do not conform to either the Brewster's or Lawrence's classification) as well as "cryptic hybrids" that resemble the parental types phenotypically but which carry genes of the other species (Vallender et al. 2007b, 2009). Since birds that appear phenotypically pure may occasionally sing the song characteristic of the other species (Gill and Murray 1972), visual confirmation of heard birds is necessary, especially in zones of known overlap and hybridization (see Figure 1–3).

Legal Status in the United States

Golden-winged Warbler is one of the highest conservation concern landbird species not yet listed as a federally Threatened or Endangered species in the United States. However, the U.S. Fish and Wildlife Service (USFWS) received a petition in February 2010 to list the species as threatened under the *Endangered Species Act* (ESA) and on 2 June 2011 published a 90-day Finding in the Federal Register indicating that the petition was considered to be substantial (76 FR 31920). A substantial 90-day Finding initiates information gathering and evaluation leading to a 12-month Finding and a decision as to whether listing under the ESA is warranted. Progress on the 12-month Finding is dependent on specific allocation of funding and priorities within the USFWS Division of Ecological Services; at this point, it appears that a final listing decision may not occur for several years.

Golden-winged Warbler is a USFWS bird of Conservation Concern at the national scale; at the Regional scale in USFWS Regions 3, 4, and 5; and at the Bird Conservation Region (BCR) scale in BCRs 12, 13, 23, and 28 (USFWS 2008). It is also a focal species in the USFWS Focal Species Strategy program. Partners in Flight ranked Golden-winged Warbler as a Watch List Species in need of Immediate Action (Rich et al. 2004), and it was subsequently included in the joint American Bird Conservancy and National Audubon Society WatchList of Birds of Conservation Concern. The species is state-listed as Endangered in Connecticut, Georgia, Indiana, Massachusetts, and Ohio; is considered Threatened in Kentucky; and is of Special Concern or a Species of Greatest Conservation Need in State Wildlife Action Plans for an additional 15 states (see also the state-level status reviews beginning on p. 1–46).

Like most other native songbirds, Golden-winged Warbler is also protected in the United States by the *Migratory Bird Treaty Act of 1918*, which makes it "unlawful at any time, by any means or in any manner, to pursue, hunt, capture, kill.... any migratory bird, any part, nest, or egg of any such bird... included in the terms of the convention." At a global scale, the International Union for Conservation of Nature (IUCN 2011) lists the species as Near Threatened (may be considered threatened with extinction in the near future).

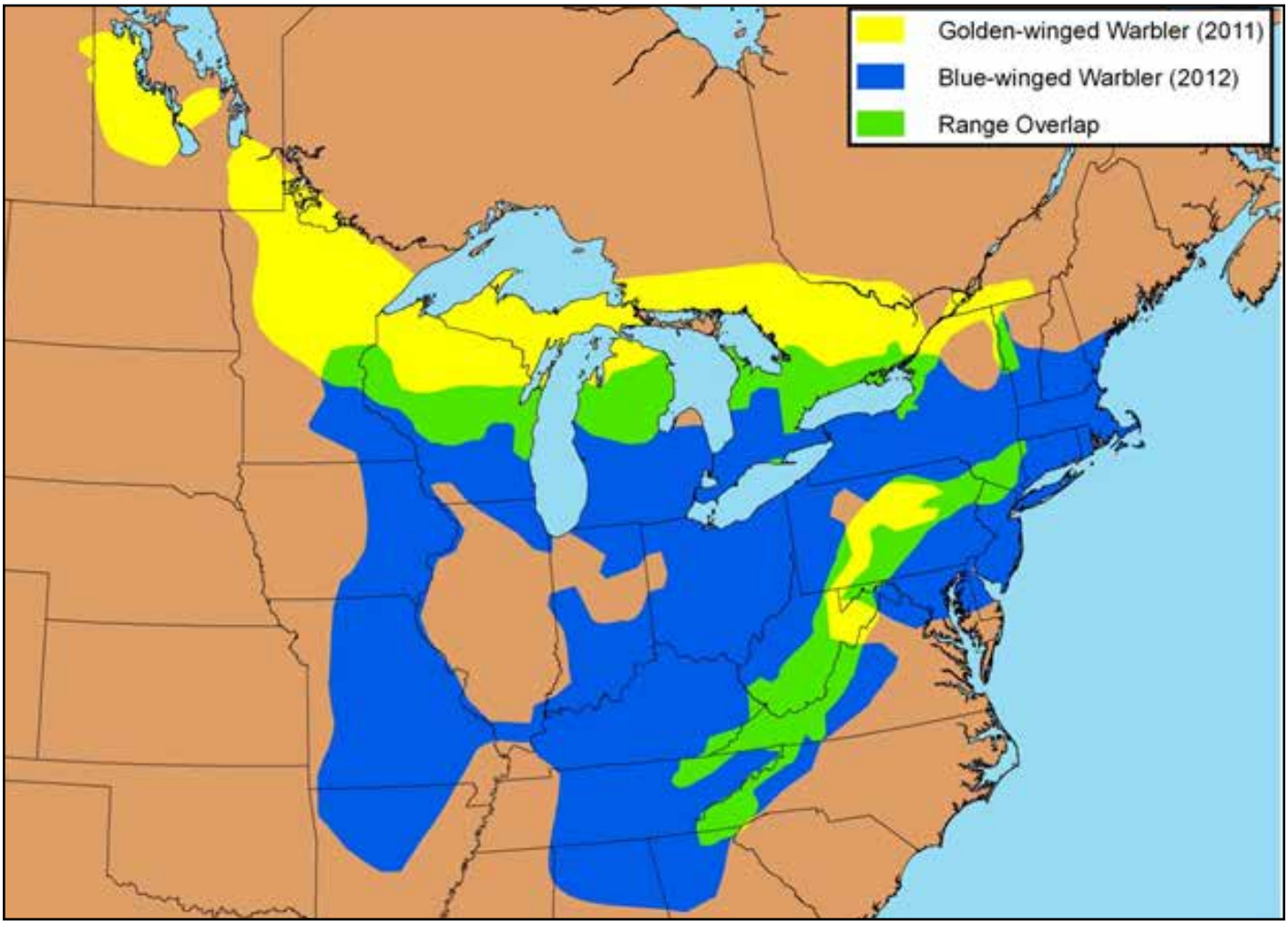

Figure 1–3. Approximate current breeding range overlap between Golden-winged and Blue-winged warbler. The Golden-winged Warbler range is based on expert knowledge of persistent breeding populations as of 2011. The Blue-winged Warbler range is inferred from GOWAP (Barker Swarthout et al. 2009), recent eBird records, and recent state breeding bird atlas detections, when available. Consequently the range overlap is approximate; particularly in the Appalachians, local distribution resulting from elevation and habitat differences would result in a much more patchy representation at a finer scale of resolution.

Legal Status in Canada

Golden-winged Warbler is protected under Schedule 1 of Canada's *Species at Risk Act* (SARA) and by the *Migratory Birds Convention Act, 1994*. Under SARA, the species is listed as Threatened (likely to become an endangered species if nothing is done to reverse factors leading to its extirpation or extinction) throughout its Canadian range (Quebec, Ontario, Manitoba, and Saskatchewan), although provincial at-risk designations vary. The purpose of SARA is to prevent wildlife species, subspecies, and distinct populations from becoming extirpated or extinct; to provide for the recovery of wildlife species that are extirpated, endangered, or threatened as a result of human activity; and to encourage the management of species of special concern to prevent them from becoming endangered or threatened.

Under provincial species at risk legislation, Golden-winged Warbler is listed in Ontario as Special Concern (sensitive to human activities or natural events which may cause it to become endangered or threatened) under the *Endangered Species Act, 2007*, and in Quebec as Likely to be Designated as Threatened or Vulnerable under the *Act respecting threatened or vulnerable species (Espèce susceptible d'être désignée menacée ou vulnérable)*. There is no current designation for Golden-winged Warbler in Manitoba or Saskatchewan under provincial legislation.

Currently, a Canadian multi-agency recovery team is developing the federal recovery strategy for Golden-winged Warbler in Canada with an estimated completion date of mid-2012. A landscape approach is being developed and tested for the identification of critical habitat necessary to maintain the current abundance of Golden-winged Warblers across the Canadian breeding range (see Chapter 2, pages 2–8-9 for more details).

BREEDING SEASON DISTRIBUTION

Historic Distribution

Lack of a fossil record makes discussion about prehistoric distributions largely conjectural. Short (1963) speculated that the advance and retreat of glaciers led to isolated populations of ancestral Golden-winged and Blue-winged warblers. A 3% (cytochrome B) to 4.5% (NDII) divergence between the mtDNA of these two species (Gill 1997, Dabrowski et al. 2005) suggests that isolation occurred about one to two million years before present. Short (1963) speculated that there was an east-west division after the last Ice Age, with Golden-winged Warbler restricted to the southeastern coastal plain and Blue-winged Warbler restricted to west of the Mississippi Embayment—a water barrier stretching several hundred kilometers from Illinois to the Gulf. The combination of the Mississippi Embayment and ice sheets to the north effectively separated the ancestral warbler species.

With the warming of the continent and the retreat of the glaciers, both species moved northward but likely remained isolated until after European settlement. Extensive forest clearing in the Great Lakes states and Appalachians during the late 1800s and early 1900s undoubtedly increased habitat availability for Golden-winged Warbler in those regions. Golden-winged Warbler was first documented nesting in the northeastern U.S. during the mid to late 1800s, a period of extensive farm abandonment. Maximum abundance and extent of distribution peaked for Golden-winged Warbler in this region between 1930 and 1950. The conversion of native prairie to agriculture during European settlement may have facilitated first contact between Blue-winged and Golden-winged warblers in the Upper Midwest (Short 1963). Woodland and savanna on the southern Michigan, Wisconsin, and Minnesota landscape has been replaced with dairy farms, other forms of agriculture, and extensive suburban development. Since 1950 there has been a marked shift in distribution away from the developed southern portions of these states to the extensive wetland shrub communities farther north.

Recent Changes

For nearly 150 years, the known breeding range of Golden-winged Warbler has been changing substantially. A range expansion was first documented into the northeastern U.S. where the species appeared in Massachusetts and Connecticut in the late 1800s before expanding northward into central New York and southern Michigan in the early 1900s. The breeding range expansion continues today into northern New York, eastern and northwestern Ontario, adjacent Quebec and Manitoba, and farther west in Canada, with one confirmed and several probable and possible breeding records for Saskatchewan (Smith 1996). In 2005, two male Golden-winged Warblers were found on territory in the Black Hills National Forest in northeastern Wyoming (A. Panjabi, Rocky Mountain Bird Observatory, pers. comm.). Nesting was not confirmed, however, and subsequent surveys in 2006 and 2008 failed to detect Golden-winged Warbler in the Black Hills.

At least in the Upper Midwest, the Golden-winged Warbler range expansion is best described as a range shift: as the species occurs more frequently to the north and west, it has been disappearing along the southern limits of its range (Figure 1–4), where it appears to be experiencing steep population declines (Table 1–1) associated in part with the loss of shrubby habitat as abandoned fields become reforested. Golden-winged Warbler now may be extirpated as a breeding species from Georgia, South Carolina, Connecticut, Massachusetts, Rhode Island, Illinois, Indiana, and Ohio.

In some regions, locations that have hosted persistent populations now see only scattered, occasional Golden-winged Warbler records, as has been the case in central New York (Figure 1–4). The species has declined in North Carolina, Tennessee, West Virginia, Maryland, Pennsylvania, New York, and Michigan.

Table 1–1. Golden-winged Warbler trend estimates from the North American Breeding Bird Survey 1966–2009 (Sauer et al. 2011). Significant trends (0.95 probability that the trend differs from zero) are indicated in bold font; numbers in parentheses are credible intervals from the hierarchical Bayesian model analysis method.

Region	Number Routes	1966–2009 Trends		1999–2009 Trends	
		Trend (%change/yr)	95% CI[2]	Trend (%change/yr)	95% CI[2]
Survey-wide	434	**-2.3**	**(-3.3, -1.4)**	1.5	(-1.3, 5.0)
United States	374	**-2.9**	**(-3.8, -1.9)**	0.3	(-2.2, 3.6)
Canada	60	2.4	(-1.0, 5.8)	6.2	(-2.1, 16.5)
Bird Conservation Regions					
Boreal Hardwood Transition	127	-0.6	(-1.7, 0.5)	1.3	(-1.8, 5.0)
Prairie Hardwood Transition	51	-2.7	(-4.7, 0.0)	0.0	(-5.5, 7.5)
Appalachian Mountains	164	**-8.3**	**(-9.6, -7.0)**	**-7.4**	**(-10.5, -3.4)**
States/Provinces[1]					
Connecticut	5	**-23.5**	**(-43.6, -7.1)**	**-24.1**	**(-46.9, -3.1)**
Manitoba	6	**40.4**	**(11.9, 91.9)**	**41.5**	**(11.9, 96.4)**
Maryland	9	**-5.5**	**(-8.0, -3.0)**	**-5.8**	**(-11.4, -0.8)**
Massachusetts	9	**-8.7**	**(-17.0, -1.1)**	-8.9	(-25.3, 8.0)
Michigan	46	-5.5	(-8.0, -3.3)	-5.6	(-12.0, 0.1)
Minnesota	36	1.4	(-0.3, 3.1)	3.5	(-0.3, 8.8)
New Hampshire	6	-6.3	(-35.7, 19.9)	-6.3	(-75.0, 177.9)
New Jersey	6	**-9.2**	**(-16.2, -2.3)**	-9.3	(-19.2, 2.0)
New York	56	**-5.2**	**(-7.0, -3.4)**	-4.0	(-8.6, 1.6)
North Carolina	8	**-9.9**	**(-15.5, -4.4)**	**-10.0**	**(-17.9, -1.3)**
Ontario	49	1.8	(-1.6, 5.3)	2.9	(-5.1, 11.5)
Pennsylvania	56	**-6.8**	**(-8.7, -4.9)**	**-7.2**	**(-13.4, -0.9)**
Quebec	5	-1.2	(-10.8, 8.5)	-1.0	(-20.2, 23.6)
Tennessee	7	**-7.7**	**(-11.4, -4.5)**	-7.1	(-15.7, 4.4)
Virginia	9	**-8.6**	**(-12.6, -4.9)**	**-8.7**	**(-15.8, -0.7)**
West Virginia	44	**-8.9**	**(-10.7, -6.8)**	-7.8	(-12.8, 0.7)
Wisconsin	62	**-2.6**	**(-3.9, -1.4)**	-2.9	(-6.8, 1.0)

[1] Listed alphabetically. [2] Bayesian credible interval.

Current Distribution

U.S. Geological Survey (USGS) Breeding Bird Survey (BBS) data provide a helpful but incomplete map of Golden-winged Warbler distribution since BBS routes do not consistently detect low-density populations. Overlays of data from BBS (1966 to 2010), state and provincial breeding bird atlases, Golden-winged Warbler Atlas Project (GOWAP) surveys of Golden-winged and Blue-winged warblers and their hybrids from 1999 to 2006 (Barker Swarthout et al. 2009), Golden-winged Warbler Conservation Initiative collaborative research, and citizen science observations reported in eBird provide the basis for estimating contemporary changes and current distribution of the species (Figure 1–4). Golden-winged Warbler now occurs in two largely isolated regions. The northern portion of the range—the Great Lakes population segment—extends from the extreme eastern edge of Saskatchewan through west-central Manitoba, southern Ontario, and extreme southwestern Quebec and then southward into northern Minnesota, Wisconsin, Michigan, and the St. Lawrence River Valley, with a few individuals in Vermont and rarely New Hampshire. The eastern portion of the range—the Appalachian population segment—extends from the southern Appalachians (northern Georgia, western North Carolina, and eastern Tennessee) northeastward through eastern Kentucky, western Virginia, and West Virginia into Pennsylvania and southern New York, with a few scattered individuals in Connecticut. The Great Lakes population is now separated from the Appalachian population by the near complete absence of Golden-winged Warbler in Illinois, Indiana, Ohio, and central New York (Figure 1–4).

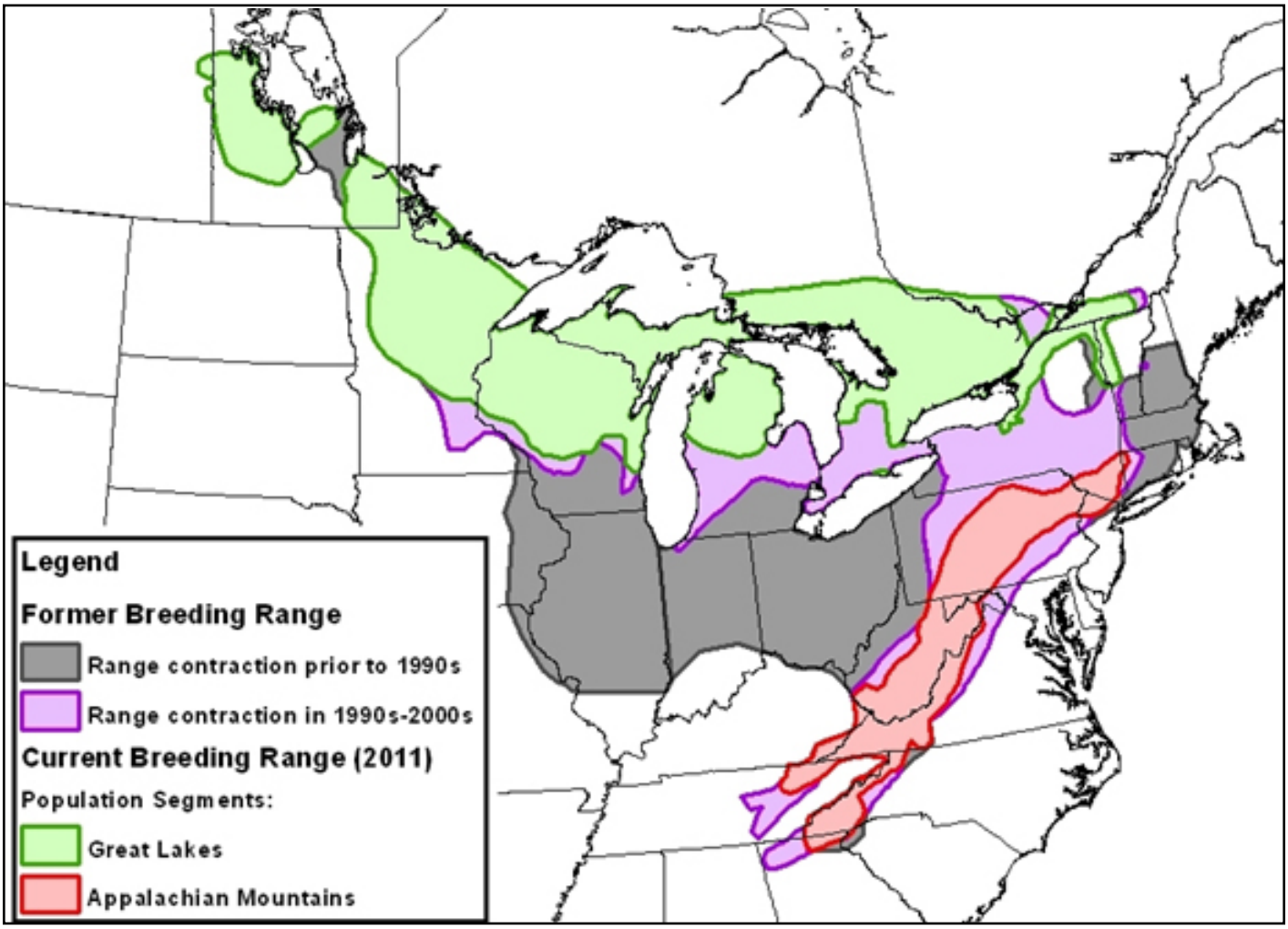

Figure 1–4. Contemporary Golden-winged Warbler breeding season range based on expert knowledge of persistent, breeding populations as of 2011. The current breeding range is divided into two geographically disjunct population segments—Great Lakes and Appalachian Mountains. The former breeding range is represented by two areas of range contraction in which birds no longer breed with temporal or spatial consistency but which potentially contain solitary individuals or sporadic breeding activity.

POPULATION STATUS AND TRENDS

Tracking Population Change: Data Sources

The BBS is the most comprehensive monitoring program tracking Golden-winged Warbler population change rangewide. Because the BBS is a roadside survey, however, it may not adequately monitor response to changing conditions across all habitat types in North America—particularly if higher probability of land development results in disproportionately greater habitat loss along roadsides. The BBS appears to accurately track Golden-winged Warbler population trends throughout the northeastern and north-central states but may not be adequate in the Appalachians and parts of Canada. GOWAP (Barker Swarthout et al. 2009) was designed to provide additional records of Golden-winged Warbler distribution and habitat associations; it supplements the BBS distribution data, but was not designed to track changes in population. As noted above, breeding bird atlas projects completed by many states and Ontario in the past ten years have helped to document recent distribution; these will serve as a baseline for comparison with future second-generation atlases to index range and population change. On-going atlas projects in Minnesota (2009–2013), Quebec (2010–2014), and Manitoba (2010–2014) will further refine our understanding of Golden-winged Warbler distribution. The Breeding Bird Census (BBC), conducted since 1937, represents an additional potential source of information on Golden-winged Warbler population trends. These censuses enlist volunteer observers to map territories of individual birds within a specific habitat type. Although publication of BBC data has been irregular since 1996, surveys have continued, and results from the 2001–2004 surveys are now available (Gardali and Lowe 2006a, 2006b, 2007a, 2007b). Unfortunately, Golden-winged Warbler is rarely detected on sites monitored by BBC. From 1988–1995 and from 2001–2004, Golden-winged Warbler was recorded on only seven BBC sites, none of which had been monitored for more than ten years. Most recently, research partners coordinated through Cornell Laboratory of Ornithology have been developing and testing a spatially-balanced sampling design more suited to regions where Golden-winged Warbler is present in low abundance.

Estimating Population Size

Although the BBS was designed to index population trend and not to estimate actual abundance, Partners in Flight (Rosenberg and Blancher 2005) devised a method to use BBS data from the 1990s decade to estimate current population size. Results were used by Rich et al. (2004) to estimate population size for most U.S. and Canadian landbirds, including Golden-winged Warbler, and the methodology was reviewed by Thogmartin et al. (2006). Some of the analyses reported in this 2012 *Status Review* include Golden-winged Warbler population estimates based on the Partners in Flight method described in Blancher et al. (2007)—but with BBS data from the decade 1998–2007 (Blancher et al. *in prep.*) and with an average maximum detection distance of 125m (Golden-winged Warbler Working Group science team decision, June 2011) rather than the 200m value used in Rich et al. (2004).

Population Trends and Probability of Population Persistence

Most population trends reported in this 2012 *Status Review* utilize BBS data from 1966–2009 (Sauer et al. 2011) and a hierarchical Bayesian analysis for estimating annual indices generally considered to offer a more robust analysis less susceptible to extreme deviations than the route regression analyses formerly reported on the BBS site. The Bayesian approach has the additional advantage of producing *credible intervals* (CIs) that are more intuitively interpretable than traditional confidence intervals; one can say simply, for example, that there is a 95% chance that a true parameter falls within the 95% CI. In general, the hierarchical Bayesian approach results in somewhat lower estimated rates of change for most geographic areas as compared with previous estimates derived using the route regression method.

As measured by the BBS, the rangewide Golden-winged Warbler population has been declining steadily since 1966 at an average annual rate of -2.3% (CI -3.3%, -1.4%)—one of the steepest declines of any U.S.-Canadian landbird (Figure 1–5). However, rates of decline differ substantially among re-

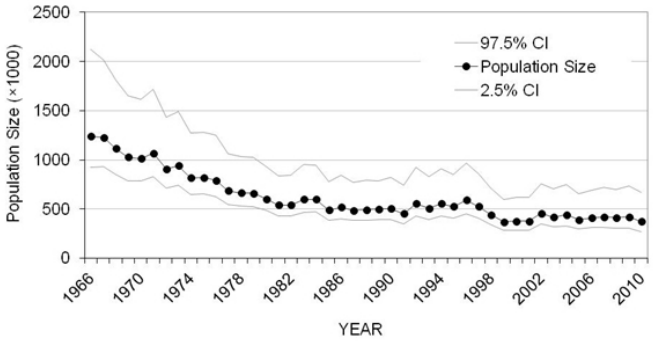

Figure 1–5. Annual rangewide breeding abundance of Golden-winged Warbler as predicted by a hierarchical Bayesian analysis of North American BBS data (1966–2010). Abundance estimates are derived from the Partners in Flight Population Estimates Database: version 2007 (Blancher et al. in prep).

Table 1–2. Percent change in Golden-winged Warbler abundance by Bird Conservation Region (BCR) over the entire period of the BBS (1966–2010) and between the 1990s and 2000s decades. Trend estimates are derived from the BBS (Sauer et al. 2011) and population estimates from the Partners in Flight Population Estimates Database: version 2007 (Blancher et al. in prep). Numbers in parentheses are credible intervals; significant change (0.95 probability that the percent change differs from zero) is indicated in bold font.

Bird Conservation Region	Whole Period	1990s vs. 2000s
Boreal Hardwood Transition (BCR 12)	**-27.5% (-30.3, -25.9)**	**-16.3% (-17.8, -15.2)**
Prairie Hardwood Transition (BCR 23)	**-70.7% (-76.8, -46.3)**	-11.8% (-27.0, +25.9)
Appalachian Mountains (BCR 28)	**-97.8% (-97.9, -97.7)**	**-61.7% (-63.7, -60.5)**
Great Lakes / St. Lawrence Plain (BCR 13)	**-16.0% (-18.1, -10.9)**	+0.9% (-5.5, +8.2)
Boreal Taiga Plains (BCR 6)		**+1,740% (+850, +946,620)**
Total Population Change	**-66.2% (-67.0, -65.5)**	**-17.9% (-20.3, -15.4)**

gions across the species range and when comparing the period spanned by the entire survey (1966–2009) and the last decade only (Table 1–1). Steep population declines occurred in the Appalachian Mountains BCR (-8.3%), West Virginia (-8.9%), Tennessee (-7.7%), Pennsylvania (-6.8%), Maryland (-5.5%), Michigan (-5.5%), New York (-5.2%), and Wisconsin (-2.6%). The steeply increasing trend of 40.4% (especially since 1980) in Manitoba is based on only six routes and a low credibility measure, although recent field surveys support significant recent population expansion and higher abundance than historical estimates.

When population trends are linked to regional (BCR) population estimates and declines are expressed in terms of proportional population loss (Table 1–2), the relative decline in the Appalachian Mountains BCR is especially alarming—a 97.8% population loss from 1966 to 2010 and a 61.7% loss over the last decade. The 1,740% population increase in the Boreal Taiga Plains (BCR 6) in the last ten years reflects new BBS detections in Manitoba, presumably the result of a recent Golden-winged Warbler range expansion.

Using the Partners in Flight method (Rosenberg and Blancher 2005, Rich et al. 2004, Blancher et al. 2007) for calculating population size *based on BBS data from the 1990s decade*—but with an average maximum detection distance of 125m for Golden-winged Warbler (Golden-winged Warbler Working Group science team decision, June 2011)—this means the species will have declined from an estimated 1.25 million breeding adults (95% CI: 950,000; 1.7 million) in 1967 to 386,000 birds (95% CI: 290,000; 520,000) in 2000 and to 383,000 birds (95% CI: 275,000; 565,000) in 2010. Using the same methodology, but *based on hierarchical Bayesian BBS annual indices from the decade 1998–2007*, we would infer a population size of 370,500 in 2010 (95% CI: 267,000; 663,000). *Using the average estimated population size for the 1998–2007 decade* (413,560, Blancher et al. *in prep.*), and assuming the 40-yr BBS trends continued, we would predict a population of only 37,000 adult birds (95% CI: 27,000; 67,000) by 2100. This would represent a predicted loss in population size of 1.2 million birds (97%) in 135 years.

Population size, trend, and variability in trend can be integrated in a count-based population viability analysis to predict the probability of *quasi-extinction* (see Appendix C for a description of methods). According to this analysis, Golden-winged Warbler is at risk of extinction in many areas across its range. *If observed trends and variability in trends persist as they have for the last 40 years* into the next century, Golden-winged Warbler rangewide has a 63.1% (95% CI: 0.5%, 99.95%) risk of a further 90% loss in population by 2100 (Figure 1–6). For currently increasing populations at the state scale, the risk of quasi-extinction is negligible using this technique. For currently declining populations at the state scale, the risk of quasi-extinction is considerable decline from the 2000 population was predicted included Wisconsin (65.9% risk of a 90% decline [0.5%, 99.97%]), Michigan (100% risk [100%, 100%]), Tennessee (100% risk [100%, 100%]), and New York (100% risk [99.5%, 100%]) (Figure 1–7; see also individual state reports, pages 1–34-70).

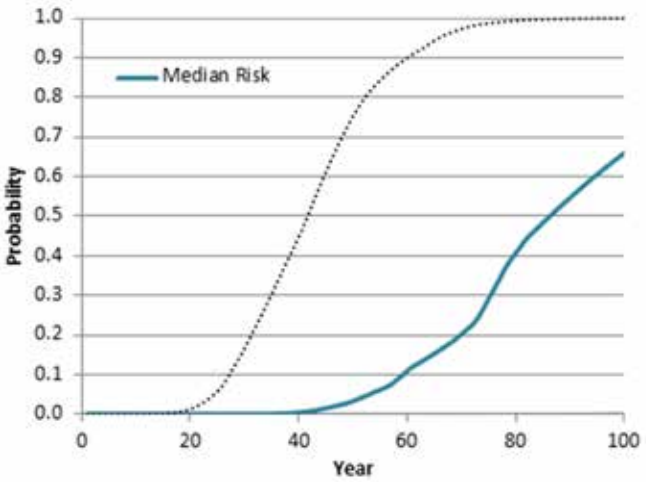

Figure 1–6. Survey-wide risk of quasi-extinction in Golden-winged Warbler, as determined by a 90% decline from the year 2000 population by year 2100. Dashed lines represent the 95% credible interval. See Appendix C for methods.

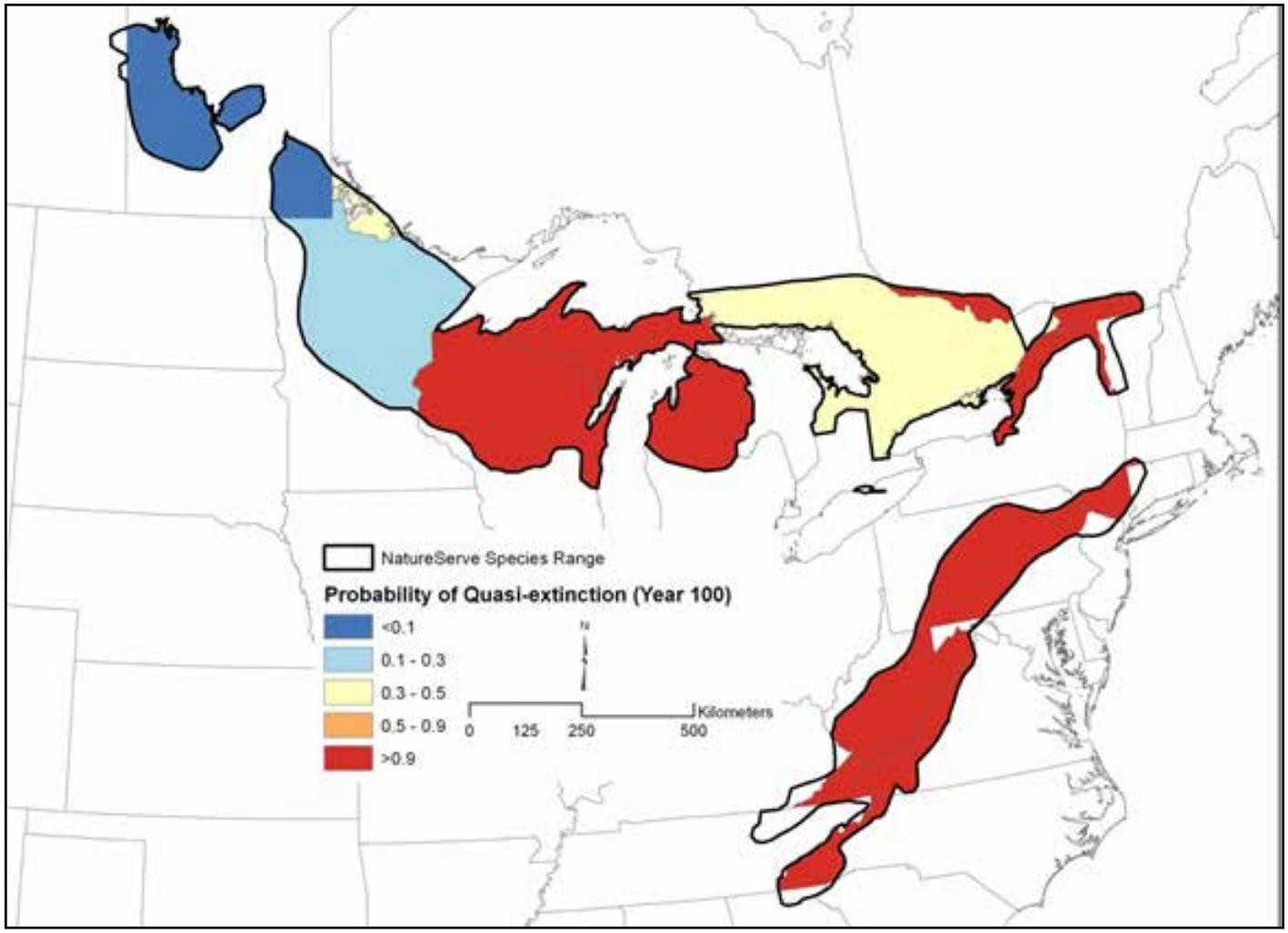

Figure 1–7. Risk of quasi-extinction of Golden-winged Warbler by state and province. See Appendix C for methods.

BREEDING SEASON HABITAT

Golden-winged Warbler is a species of predominantly forested landscapes in which both natural and anthropogenic disturbance patterns create patches of early stages of regenerating forest and/or open areas dominated by shrubs and small trees.

Pre-European settlement breeding habitat of Golden-winged Warbler and other young forest associated species is not well documented (Hunter et al. 2001). Natural disturbances such as fire, wind-throw, ice, and flooding likely generated moderate to large areas of regenerating forest and shrublands that provided most of the breeding habitat for birds that utilized early forest successional stages (DeGraaf and Yamanski 2003). Intentional fires set by Native Americans to clear land undoubtedly also created a mosaic of suitable habitats on the landscape (DeGraaf and Yamanski 2003). Wetland habitats are important to Golden-winged Warbler in some areas; natural swamps and flooded wetlands created by beaver (*Castor canadensis*) activity were formerly far more extensive and probably provided an important pre-settlement habitat for the species (but cf. Chandler et al. 2009 on scrub-shrub birds and beaver meadows). The chestnut blight also may have created appropriate habitat in some areas (Hall 1983).

During the last 140 years, Golden-winged Warbler has expanded into habitats created by human disturbance throughout much of the eastern U.S. and adjacent Canada (Confer et al. 2011). Old field succession on abandoned farmland and regenerating forest clearcuts have provided millions of hectares of forest/shrubland habitat (Lorimer 2001). However, over the past 50 years, especially in the eastern U.S., alteration of natural disturbance regimes coupled with ongoing natural succession to mature forest has resulted in an overall loss of breeding habitat (Hunter et al. 2001). Managed aspen forest with regenerating patches attractive to Golden-winged Warbler generally succeeds to northern hardwoods, eastern hardwoods, or coniferous forest types if it is not harvested on a 40-60 year rotation (Perala 1977, Frelich 2002). Where aspen forest is a climax community, as is generally the case in the Aspen Parklands of Manitoba, Golden-winged Warbler habitat is potentially perpetuated in stands for over a hundred years (Cumming 1998). In the absence of large-scale natural disturbance, human-induced disturbances will be critical for continued creation and maintenance of breeding habitat throughout much of the Golden-winged Warbler range.

Nesting Habitat

Although Golden-winged Warbler utilizes mature forest throughout its annual cycle, even during the breeding season, disturbed patches of habitat within a forested matrix are important for nesting. There appear to be three essential components to Golden-winged Warbler nesting habitat—grassy and herbaceous openings, shrubs or tree saplings (generally <10 cm diameter), and taller deciduous trees (Confer et al. 2011). Golden-winged Warbler habitat thus has a characteristic *gestalt* (Figure 1–8)—fairly open patches of herbaceous vegetation and shrubs of different heights either on the edge of a forested patch, associated with a group of trees in an opening of an otherwise forested landscape, or interspersed with forest trees—either young early successional trees or mature canopy trees (Confer et al. 2011).

Such a structural mosaic can be created in a variety of situations—in upland overgrown fields or pastures, along powerline rights-of-way that are maintained in a shrubby state, on recovering surface mine lands, along edges or openings of forests, in sedge meadows with scattered willows (*Salix* spp.), in moist areas with scattered clumps of alders (*Alnus* spp.), in swamp forests with partially open canopy, or in clearcuts densely stocked with young trees and shrubs and broken by herbaceous logging trails and log landings (Figure 1–9). The characteristic spatial pattern of vegetation structure is more important in defining suitability for Golden-winged Warbler than the general habitat type.

Geographic variation in habitat use was evident from the results of GOWAP (Barker Swarthout et al. 2009). These results reflected the range of habitats where positive occurrences of Golden-winged Warbler were recorded during population and hybrid-index surveys conducted by a large number of volunteer birders and regional biologists. To more clearly examine variation in habitat use, the sites with Golden-winged Warbler detections were divided into five regions, three in the Appalachians and two in the Great Lakes area; the results of this analysis are presented in the Regional Summary section beginning on page 1–34.

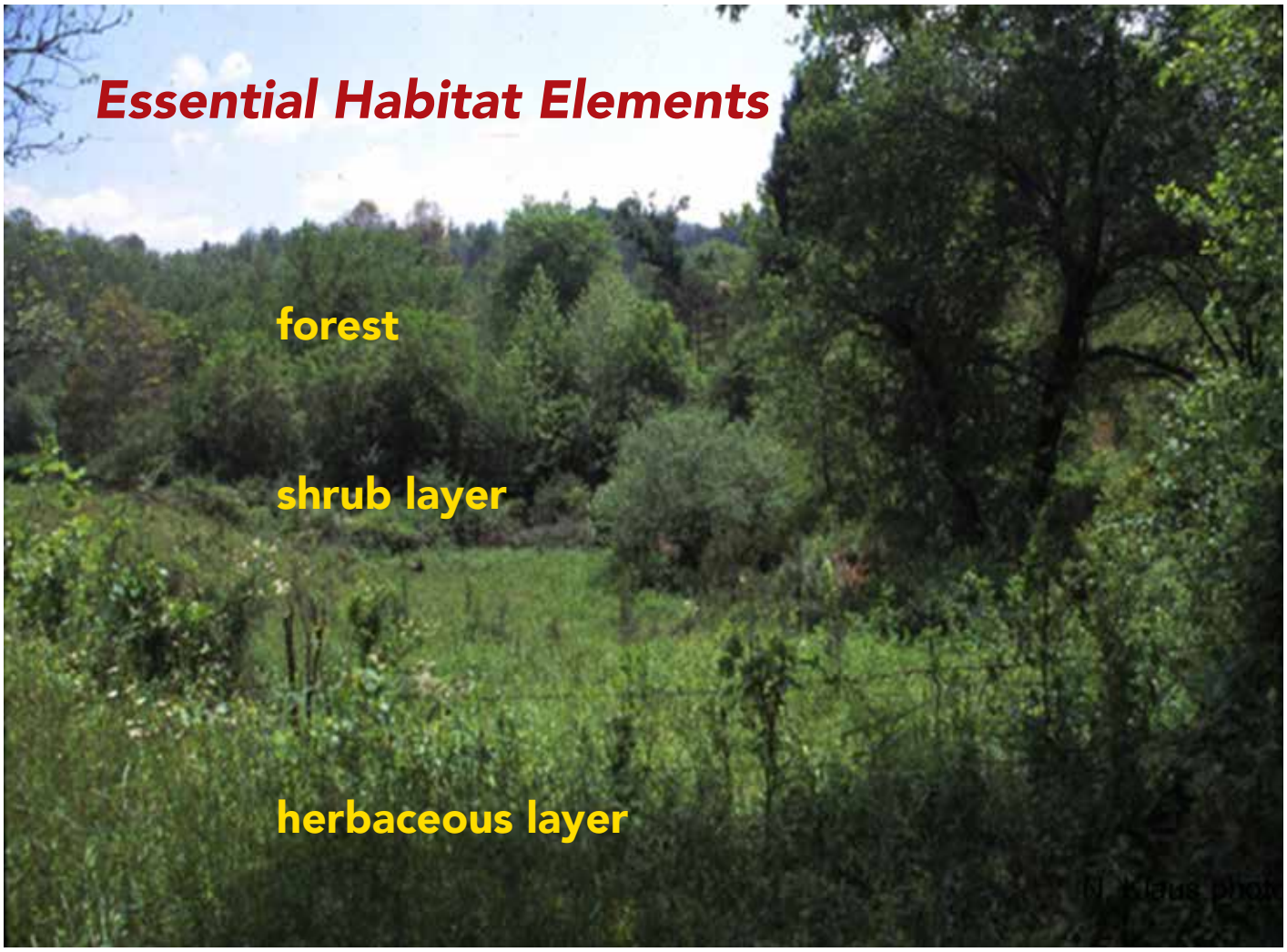

Figure 1–8. Structural components of Golden-winged Warbler nesting habitat—herbaceous vegetation, shrubs or small trees, and a more mature forested backdrop. Photo by Nathan Klaus.

Figure 1–9. Golden-winged Warbler may be found nesting in a variety of habitat types that comprise the basic three structural components pictured in Figure 1–8. Habitat types include: (A) shrub-field (J. Lowe); (B) utility right-of-way (S. Barker Swarthout); (C) abandoned farm (C. Croy); (D) alder swamp (L. Johnson); (E) clear cut (M. Fowlds); (F) reclaimed mine (L. Bulluck); (G) tamarack bog (N. Nelson); (H) beaver wetland (J. Confer).

Patch Size and Landscape Considerations

Little is known about sensitivity of Golden-winged Warbler to landscape-level habitat configuration, although it is typically considered to be a species of largely forested landscapes (but see analysis and models in Chapter 3). In the northeastern U.S., historical expansion of Golden-winged Warbler typically occurred where farmland predominated and subsequent old field successional growth was common (Confer et al. 2011). Golden-winged Warbler nests and defends territories in patches of early successional forest or shrubland habitat. Patches range in size from less than one hectare to 100s of hectares (e.g., Bulluck and Buehler 2008, Kubel and Yahner 2008). The species is often associated with forested edges (Klaus and Buehler 2001; Thogmartin 2010; Confer et al. 2003), and it may not occupy the interior portions of larger patches unless those patches contain embedded mature tree and shrub islands. For example, in Kentucky occupied Golden-winged Warbler sites had a higher percentage of canopy cover, but the sites were located within an early successional matrix (Patton et al. 2010), which is similar to other studies (Huffman 1997, Klaus and Buehler 2001). Roth (2012) found that in Wisconsin timber harvests, Golden-winged Warbler showed a spatial preference for large patches of habitat with scattered residual trees. Nest survival tended to be lower toward the center of large clearcuts. Aspen clearcuts with no or low residual tree densities had low male densities and low mating success. Residual trees, especially mature hardwoods (e.g., oaks), appeared to be critical for attracting groups of breeding birds and not just bachelor males.

Radio telemetry data from Minnesota (Streby et al. 2012) and Pennsylvania (Larkin, pers. comm.) indicated that adult male home ranges included substantial areas of surrounding mature deciduous or mixed forest, probably used primarily for foraging. The Minnesota study also showed that post-fledging habitat comprised these adjacent mature upland forests as well as other community types, such as shrub and forested wetlands. Both studies suggested that breeding habitat for the species may in fact be too narrowly defined by classic studies when it is measured in terms of actual use for all activities throughout the entire breeding cycle from nest site selection through post fledgling.

Golden-winged Warbler probably has minimum area requirements (e.g., >1 ha) related to territory size but has not been shown to be strongly area sensitive. Likewise, patch shape has not been shown to be critically important—Golden-winged Warbler has been documented using linear habitats, such as powerline rights-of-way, and other linear features, like logging roads adjacent to clearcuts (Klaus and Buehler 2001). A minimum width of these linear openings may be important (e.g., a right-of-way >50 m plus additional appropriate adjacent vegetation) but generally has not been fully documented. Chapter 3 provides additional detail on landscape and habitat configuration from the perspective of management potential.

Golden-winged Warbler will not necessarily occupy all suitable breeding habitat patches. Bulluck and Harding (2010) hypothesized that the likelihood of patch occupancy may be dependent upon the distance to other occupied habitat patches because conspecifics indicate high quality habitat and/or provide greater opportunity for extra-pair copulations. Roth (2012) found that aspen clearcuts with low numbers of territorial males (1–2 per clearcut) were associated with low mating success (10%); clearcuts with four or more territorial males resulted in high mating success (≈70%). Thus conspecific attraction may be an important consideration for habitat managers—to increase the likelihood of occupancy, new or improved habitat for Golden-winged Warbler should be managed in or near already occupied sites that have known or likely breeding activity. At least in some regions (e.g., New England), extensive suitable habitat unoccupied by Golden-winged Warbler yet occupied by other early successional bird species suggests local population limitation by nonbreeding season factors (cf. Chandler et al. 2009).

As noted above, regional habitat analyses resulting from GOWAP are presented in the Regional Summary section beginning on page 1–34. More detailed, regionally-specific habitat analysis relevant to particular management actions can be found in Chapter 3.

BREEDING SEASON BEHAVIOR AND ECOLOGY

Territoriality

Territoriality is one of the most intensively studied components of Golden-winged Warbler behavior, and territorial boundaries often are used to infer habitat preference. Traditionally, territorial boundaries have been demarcated largely by mapping singing perches of territorial males, and consequently mapped boundaries of breeding territories frequently follow a forest edge or a row of taller trees along an old fence line. Perches, usually the tallest available trees, are used repeatedly for song display and foraging (Rossell 2001). Where scattered trees are available throughout shrubby habitat (as in aspen clearcuts with canopy tree retention), defended territories often do not include the stand edges (Roth 2012). Recent studies indicate that male Golden-winged Warblers are also highly territorial during the resident non-breeding (wintering) season in the Neotropics (Chandler 2011).

Mean mapped breeding territory size ranged from ~0.6 ha in central New York (Ficken and Ficken 1968), 0.9 ha in north-central New York (Confer and Larkin 1998), 0.9 ha

in Tennessee (Bulluck 2007), 1.4 ha in upland habitats of central Michigan (Will 1986), 0.4–1.6 ha at a wetland site in North Carolina (Rossell et al. 2003), 1.9–2.7 ha at two wetland sites in Michigan (Murray and Gill 1976), and ~2.5 ha at a wetland site in southern New York (J. Confer, unpubl. data). In Wisconsin, mean territory size ranged from 0.18–0.82 ha in aspen forest stands and varied depending on tree size class; in older stands, territory area was defined by the size and shape of openings within the regenerating aspen (Roth and Lutz 2004).

Breeding territories can vary in size depending on intraspecific competition. For example, Confer (pers. comm.) observed one color-banded male that responded to taped playbacks throughout an area of 300 x 200 m. The next season, the territory size of this same individual was halved when a new male established its territory in the same field. In an intensive study of Golden-winged and Blue-winged warblers in central Michigan, Will (1986) mapped weekly territories based on daily song perches of color-banded singing males. He found that such territories were dynamic, shifting constantly depending on the arrival of new males and the intensity of intraspecific and interspecific interactions. Particularly when males shifted their centers of activity with changes in the nesting cycle (especially during the escort of females searching for nest sites and the period immediately following incubation), territorial "boundaries" were highly fluid and territory sizes fluctuated enormously. In a recent study in Minnesota, Streby et al. (2012) found that male defended territories (defined by song perches) estimated using radio telemetry were as much as five times larger than territories derived from traditional spot-mapping; actual use areas (home ranges) covered areas as much as 25 times larger than spot-mapped song-defined territories.

Figure 1–10. Golden-winged Warbler nestlings. Photo by Darin James McNeil.

Reproduction

Confer et al. (2011) provides a general review of Golden-winged Warbler reproductive behavior. The species is single-brooded, with the exception of renesting after early failure of first nests or late second nests by bigamous males (Will 1986). Females appear to select the nest site—usually on the ground, often at the base of leafy herbaceous growth (e.g., *Solidago*) and well-concealed by leafy vegetation or in some cases by tussock grass or sedge (Confer et al. 2011), and sometimes within dense patches of shrubby growth (e.g., *Rubus*). Often the nest site includes a taller and thicker stem on which the adults descend to the nest when visiting or feeding nestlings (Figure 1–10).

Data on clutch size and nest success from selected studies are summarized in Table 1–3. Mean clutch size has ranged from 4.0 in Pennsylvania (Kubel and Yahner 2008) to 5.06 in Ontario (Vallender et al. 2007a). Clutch size may be impacted by interspecific competition; Confer et al. (2003) found that clutch size in New York decreased as territorial overlap with Blue-winged Warbler increased ($P < 0.01$; partial $r^2 = 0.15$; $n = 69$). Mayfield nest success estimates range widely depending in part on the prevalence of Brown-headed Cowbird parasitism. Lowest rates of nest success were reported from north-central New York (<40%), where relatively high rates of hybridization and cowbird parasitism put Golden-winged Warbler below sustainable levels of reproduction; that north-central population is now virtually extirpated. In southern New York, nesting success was low in uplands (41%) but high in swamp forests (62%). The southern Appalachians reported higher rates of nest success—72.5% from North Carolina (Klaus and Buehler 2001), 49% from Tennessee (Bulluck and Buehler 2008), and 61% from West Virginia (Canterbury, unpubl. data)—that may be sufficient to sustain populations in the absence of hybridization.

The impact of Brown-headed Cowbird brood parasitism varies greatly from region to region—perhaps depending on the ratio of agricultural and forest cover and thus the regional density of cowbirds (cf. Table 1–3). In north-central New York, where there is moderately extensive agriculture, cowbird parasitism occurred in 22 of 73 (30%) Golden-winged Warbler nests, with an average of 1.3 (SD = 0.6) cowbird eggs per parasitized nest (Confer et al. 2003). The number of eggs laid by parasitized and non-parasitized Golden-winged Warblers did not differ. The mean number of fledglings was

Table 1–3. Nest success, clutch size, and Brown-headed Cowbird brood parasitism from selected Golden-winged Warbler nest studies.

Location	Sample Size	Years	Nest Success (% ± 2 SE)	Method	Average Clutch Size	% Parasitized
Manitoba[1]	25	2011–2012	42.3%	Raw Data	4.64	8
Ontario[2]	48	2001–2004	55.3%	Raw Data	5.06	4
Michigan[3]	13	1981–1983	85%	Raw Data	4.69	31
New York[4, 5]	69	1988–1994	38% (24–62) [a]	Mayfield	4.39	30
s. New York[6] (uplands)	61	2001–2010	41% [a]	Mayfield	4.79 [c]	11
s. New York[6] (swamp forest)	44	2001–2010	62% [a]	Mayfield	4.48 [c]	0
Pennsylvania[7]	32	2002–2003	37% (18–55) [b]	Mayfield	4.0	0
West Virginia[8]	347	1987–1996	61%	Mayfield		0
West Virginia[9]	77	2008–2011	39.9% [b]	Mayfield	4.5	0
Tennessee[10]	102	2004–2006	49% [a]	Mayfield	4.3	0
North Carolina[11]	23	1997–1998	72.5% [b]	Mayfield	4.5	0

[1]Moulton, unpubl. data; [2]Vallender et al. (2007b); [3]Will (1986); [4]Confer and Larkin (1998); [5]Confer et al. (2003); [6]Confer et al. (2010) and unpubl. data; [7]Kubel and Yahner (2008); [8]Canterbury (1996); [9]Aldinger and Wood, unpubl. data.; [10]Bulluck and Buehler (2008); [11]Klaus and Buehler (2001); a I + N: Nest success calculations include incubation and nestling stages; b L + I + N: Nest success calculations include laying, incubation, and nestling stages; c counting one warbler egg as part of clutch for every cowbird egg detected.

reduced from 2.3 in non-parasitized nests (n = 50) to 1.0 in parasitized nests (n = 22), which reduced the total number of warblers fledged by an estimated 17%. Warblers fledged from 68% (34 of 50) of the non-parasitized nests and 32% (7 of 22) of the parasitized nests. All complete failures were due to predation. A mean of 3.3 warblers fledged from non-depredated, parasitized nests (n = 7). Cowbird nest parasitism reduced the number of fledged warblers by about 7% for upland nests at Sterling Forest State Park in southern New York (n = 28; J. Confer, unpubl. data). In central Michigan (Will 1986), cowbird eggs were found in ten of 32 (31%) *Vermivora* (Blue-winged and Golden-winged warbler) nests, but two of these nests were abandoned by the warblers, and two of six parasitized nests that fledged warblers failed to fledge cowbirds. In west-central Minnesota (Streby, unpubl. data), rates varied from 9% in 2011 (five of 53 Golden-winged Warbler nests, with three failures, one nest fledging a cowbird and a warbler, and one fledging at least one warbler after the cowbird egg failed to hatch) to 2% in 2012 (two of 90 nests, both of which failed during incubation). In 2011–2012 in Manitoba, cowbirds parasitized four of 59 nests (6.8%); one failed during incubation, two during the nestling phase, and one successfully fledged a cowbird and two warblers (Moulton, unpubl. data; Peterson, unpubl. data). Cowbird brood parasitism was not observed in North Carolina (Klaus and Buehler 2001), West Virginia (Canterbury et al. 1996, Aldinger and Wood, unpubl. data), or Tennessee (Bulluck and Buehler 2008), and was minimal in Ontario (Vallender et al. 2007a).

Dispersal

Other than that recently fledged birds wander widely and utilize many different habitat community types, including mature forest (Streby, unpubl. data), virtually nothing is known about dispersal behavior in Golden-winged Warbler (Confer et al. 2011). Out of 88 nestling *Vermivora* banded from 1981 to 1983 in central Michigan, none were ever seen in subsequent years (Will 1986). Similarly, none of 56 Golden-winged Warbler nestlings banded in northwestern Minnesota in 2010 were resighted the following year (Streby, pers. comm.). However, out of 288 nestlings banded in Ontario in 2001–2003, three females and nine males (4%) were relocated 2002–2004 from 300 m to 5 km from their natal sites (Vallender, unpubl. data). Out of 79 Golden-winged Warbler nestlings banded in West Virginia from 2008–2011, eight (10%) were encountered the following year (Aldinger and Wood, unpubl data). Only one of these West Virginia birds returned to the same (180 ha) habitat patch from which it fledged; the others dispersed as far as 4.5–5 km. Adult philopatry, on the other hand, is generally high—for example, in the Michigan study (Will 1986), of 24 banded territorial males that returned from the previous year, 18 (75%) established territories in the same area; and of the six which defended new areas, four established territories immediately adjacent to the areas defended the previous year. More research on dispersal is critical to future conservation and management efforts.

BEHAVIORAL AND GENETIC INTERACTIONS WITH BLUE-WINGED WARBLER

Interspecific Aggression and Territoriality

Will (1986) found that at one site in southern Michigan, Blue-winged Warbler replaced Golden-winged Warbler in upland habitat over a three-year period, but Golden-winged Warbler remained present in tamarack swamp at the same site. In upland habitat in central Michigan, Will (1986) found substantial overlap of Blue-winged and Golden-winged warbler territories, with no significant difference in nesting success between the two species. However, Will (1986) observed and coded 72 interspecific agonistic *Vermivora* behavioral interactions and documented social dominance of Blue-winged Warbler over Golden-winged Warbler—despite the fact that Golden-winged Warbler is slightly larger and heavier on average than Blue-winged Warbler.

During a five-year field study in north-central New York, Confer and Larkin (1998) observed 98 *Vermivora* males at 21 sites and found that male Golden-winged Warblers dominated 62% of the aggressive interactions (n = 87) with male Blue-winged Warblers. In particular, they noted intense and extensive interspecific interactions between three pairs of males. Although substantial territorial overlap brings males of both species into frequent contact, interactions are infrequent or absent for most birds. However, male-female interactions may be more frequent. Male Blue-winged Warblers have been observed pursuing female Golden-winged Warblers of putative Golden-winged x Golden-winged Warbler pairs (Canterbury et al. 1996, Confer and Larkin 1998). Extra-pair copulation resulting from such pursuits may increase hybridization rates (Vallender et al. 2007a). Phenotypic hybrids currently occur in some areas of allopatry and in all areas of sympatry, sometimes accounting for 7–15% of singing males (Gill et al. 2001).

Hybridization with Blue-winged Warbler

Northward range expansion of Blue-winged Warbler has led to widespread secondary contact with the Appalachian Mountains population of Golden-winged Warbler (except at higher elevations) and with the southern portion of the Great Lakes population range (see Figure 1–3). Golden-winged and Blue-winged warblers are genetically very similar (Gill 1997, Vallender et al. 2007b). Initially, Gill found no fixed difference between Golden-winged and Blue-winged warbler in allozymes from 40 loci and only a 3.5% divergence for cytochrome b sequences in mtDNA, a difference that is typical for closely-related bird species (Gill 1987, 1997). Gill's (1997) finding that more Golden-winged Warblers contained Blue-winged Warbler mitochondrial haplotypes than the reverse lead to the conclusion that there was rapid and asymmetrical introgression from Blue-winged to Golden-winged warbler and that cytonuclear extinction of Golden-winged Warbler might be inevitable. Shapiro et al. (2004) contradicted the Gill (1997) findings and suggested that introgression of mtDNA was occurring symmetrically between the two species. Dabrowski et al. (2005) found a significantly higher frequency of mtDNA introgression in Golden-winged Warbler than in Blue-winged Warbler in some samples (e.g., southern New York). Confer and Larkin (1998) in north-central New York and Confer (unpubl. data) in southern New York found that male Golden-winged Warblers mated more frequently with Brewster's Warbler females than did male Blue-winged Warblers—a prezygotic behavioral difference which might contribute to asymmetrical introgression.

Once pairing occurs, hybrid *Vermivora* do not appear to incur a fitness disadvantage relative to individuals in pure parental pairings. Clutch size and fledging rates from pure phenotype and hybrid pairs appear equal (Confer and Larkin 1998). Vallender et al. (2007a) used genetic analyses of parentage and found that hybrid males did not have a postzygotic disadvantage in terms of any measure of reproductive output compared to their Golden-winged Warbler counterparts. In a feeding rate study, Reed et al. (2007) determined that hybrid parents were as capable of raising and fledging young as were phenotypic Golden-winged Warblers. Finally, Neville et al. (2008) compared sex ratios of nestlings produced by Golden-winged Warbler pairs to those produced by pairs with at least one hybrid parent and concluded that females were not mitigating the cost of being mated to a hybrid male by either engaging in copulations with neighboring conspecific males or biasing the sex ratio of their nestlings. On the other hand, hybrids do appear to be disadvantaged as a result of behavioral interactions that occur prior to mating. Ficken and Ficken (1968) described hybrids as having reduced pairing success at New York and Maryland sites and suggested that a prezygotic isolating mechanism lowered fitness of hybrids at these sites. Leichty and Grier (2006) found that Golden-winged Warbler males whose throat patch and facial mask were lightened experimentally lost territories and failed to obtain mates, suggesting sexual selection against the Brewster's facial pattern as an explanation for greater effect of hybridization on Golden-winged than on Blue-winged warbler. In New York, hybrid males were less likely to obtain mates than males of pure phenotypes (Confer and Tupper 2000).

To understand the geographic extent of present-day interactions between Golden-winged and Blue-winged warbler and the distribution of phenotypic hybrids, GOWAP surveyed >7,200 points in 442 (roughly 30 min. x 30 min.) grid-squares throughout the range of both species from 1999–2005 (Barker Swarthout et al. 2009). The results clearly indicated a zone of overlap and hybridization with Blue-winged Warbler at roughly 44–45 degrees north latitude extending from central New York west through central Minnesota (Figure 1–11). At present, the only large phenotypically pure Golden-winged Warbler populations appear to exist north of this hybrid zone in Minnesota and Manitoba. The GOWAP hy brid atlas also indicated a second contact zone throughout the Appalachians where pockets of Golden-winged Warbler persist (usually at high elevations) surrounded by Blue-winged Warbler (Figure 1–11). In the southern Blue Ridge region (e.g. North Carolina), a small phenotypically pure population of Golden-winged Warbler had been recorded until recently, but now hybrids are moving into this zone—indicating how dynamic the interaction is between these two species. Only 4% of the roughly 2800 warblers detected during this survey were phenotypic hybrids, distributed in 95 grid-squares throughout both zones of overlap. An additional 80 squares had both warbler species present, but no hybrids were detected, suggested that even in zones of overlap, hybrids are relatively rare.

In recent genetic work, Vallender et al. (2007b) screened samples of Golden-winged and Blue-winged individuals from regions of both historical and contemporary allopatry

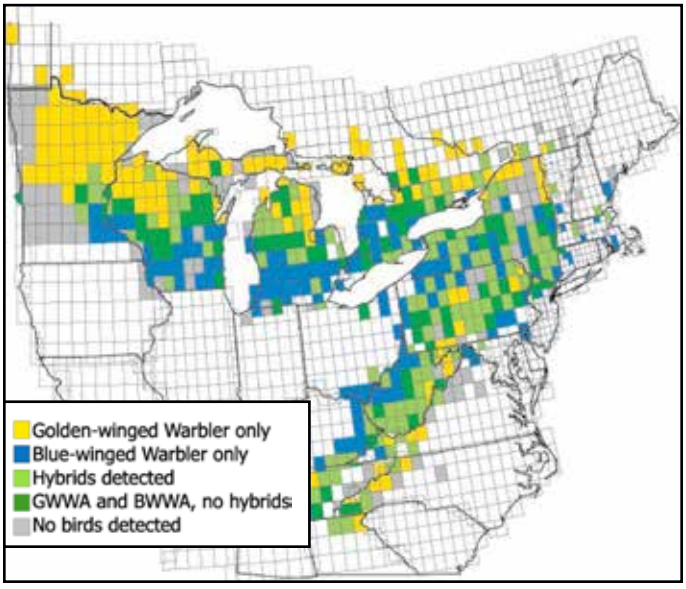

Figure 1–11. Distribution of phenotypic Golden-winged Warbler, Blue-winged Warbler, and zone of hybridization based on 1999–2005 Hybird Index data from the Golden-winged Warbler Atlas Project, Cornell Lab of Ornithology (Barker Swarthout et al. 2009). Each colored grid rectangle represents a Delorme atlas page; twenty 10-minute point counts were conducted within each atlas page, with five point-counts distributed non-randomly in each quadrant of a page.

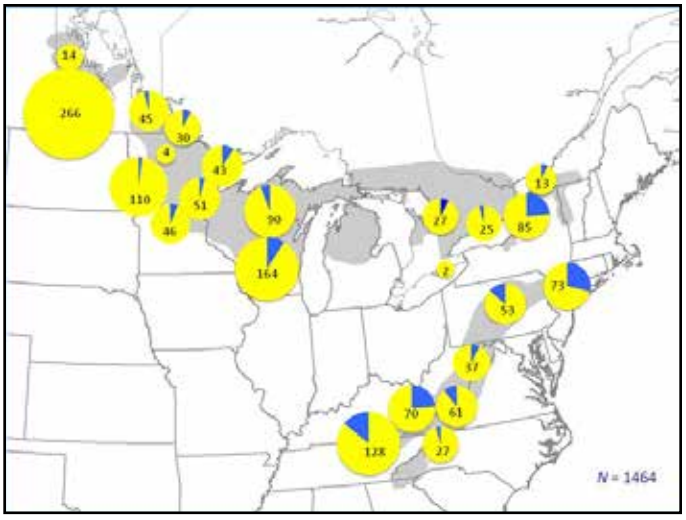

Figure 1–12. Mitochondrial DNA (mtDNA) screening results from 1,464 phenotypic Golden-winged Warblers collected in 8 states (NY, PA, MN, WI, WV, TN, NC, and KY) and 3 provinces (ON, QC, and MB). Numbers in the circles denote sample sizes. The amount of yellow in each circle represents the proportion of Golden-winged Warblers in the sample with Golden-winged Warbler mtDNA haplotypes; the blue represents the proportion of Golden-winged Warblers with Blue-winged Warbler mtDNA haplotypes (i.e., cryptic hybrids). Any circle with blue indicates samples collected in an area not comprised entirely of genetically pure Golden-winged Warblers (Vallender et al. 2009).

using a panel of nuclear markers (microsatellites, introns, and amplified fragment length polymorphisms) to locate genetic differences between the species. In searches for private alleles and assignment test approaches that could differentiate the parental species, no combination of microsatellite or intron markers could separate the parental populations, and only seven of 4000 amplified fragment length polymorphisms weakly (but significantly) could differentiate the species. When used on samples of Golden-winged Warbler from a population in Ontario, these markers provided evidence for extensive cryptic hybridization. These findings suggest that far fewer genetically pure Golden-winged Warblers may remain than has previously been assumed.

Most recently, Vallender et al. (2009, unpubl. 2010 data) screened 1,464 phenotypic Golden-winged Warbler samples from throughout the breeding range with a recently developed mtDNA marker (Figure 1–12). As of 2010, analyses suggested that the only remaining genetically pure populations of Golden-winged Warbler breed in western Manitoba in both Riding Mountain National Park and the Duck Mountains. Other populations in this region of Manitoba remain to be sampled. All other populations—including those sampled in extreme southeastern Manitoba as well as in Minnesota—contained at least some Golden-winged Warblers with Blue-winged Warbler mtDNA (i.e., cryptic hybrids). Vallender and co-workers are continuing the rangewide screening of samples using the mtDNA marker;

nDNA markers are being developed. If additional locations of genetically pure Golden-winged Warbler are identified, extensive sampling will be conducted to elucidate specific relationships between habitat and genetics.

Clearly, teasing apart the complex behavioral and genetic interactions between Golden-winged and Blue-winged warblers and their hybrids comprise one of the most intriguing scientific challenges provided by this sibling species complex. Observed inconsistencies from population to population highlight the importance for rangewide coordination of research. The fact that the cumulative data suggest prezygotic rather than postzygotic selection against hybrids underscores the importance of further elucidating mechanisms of behavioral interaction and social dominance between the two species. Documenting the rangewide extent of genetic introgression and projecting the long-term implications of introgression on population viability of both species remain important conservation research priorities.

Habitat Segregation between Golden-winged and Blue-winged Warbler

The degree of similarity in the nesting habitat of Blue-winged and Golden-winged warbler may control the amount of interaction and rate of hybridization between the two species. For example, interspecific use of wet and dry habitats may be important; or different amounts of forested and non-forested habitat may affect local densities. In either case, proportional use varies considerably among regions and locations.

Berger (1958) summarized observations by many observers and noted relatively equal use of wet and dry habitats by Golden-winged and Blue-winged warbler in Michigan from the 1930s to the 1950s. A few study sites provide evidence that Blue-winged Warbler prefers wetlands (Eaton 1914, Forbush 1929, Short 1962, Canterbury et al. 1996). Ficken and Ficken (1968) observed that 26 of 29 Blue-winged Warblers used wetland habitats in New York. Fowlds (2010) found peak Golden-winged Warbler abundance in clearcuts and peak Blue-winged Warbler abundance in alder wetland /forest transitions in central Wisconsin. In dry hillside forest in the driftless area of southwestern Wisconsin, Blue-winged Warbler has completely replaced Golden-winged Warbler; neither species appears to occupy bottomland hardwood forest (Paulios, pers. comm.) In West Virginia, Golden-winged Warbler won most interspecific aggressive encounters on dry, forested, sloped hillsides (contour mine edges in 15–60 years of secondary succession) whereas Blue-winged Warbler did better in flat, wet territories. Unmated male Blue-winged Warblers that invaded upland nesting territories of Golden-winged Warblers often harassed Golden-winged Warbler pairs nesting in the wetter situations (Canterbury et al. 1996, Canterbury and Stover 1999). Will (1986), on the other hand, found evidence that Blue-winged Warbler is more likely to interact with Golden-winged Warbler in uplands, particularly during later stages of succession (Confer and Knapp 1977).

Differences in the proportion of forested and non-forested habitat used by Golden-winged and Blue-winged warblers have been suggested as important in other regions. In Kentucky, Golden-winged Warbler sites were located at higher elevations and characterized by a greater percentage of canopy and grass cover compared to Blue-winged Warbler sites, despite overlap in the location of territories between the species (Patton et al. 2010). In a New Jersey study, Golden-winged Warbler selected utility rights-of-way (ROWs) with high herbaceous cover, while Blue-winged Warbler seemed to prefer habitat with high shrub density farther from ROWs in more forested habitat (DeFalco and Dey 2003). In Virginia, neither ROWs nor wetlands were documented as important Golden-winged Warbler habitat; instead the species tended to select idle farmland surrounded by a forested matrix (Wilson et al. 2007). Blue-winged Warbler, on the other hand, was documented as occurring in ROWs and wetland habitats (Wilson et al. 2007). Differences in the habitat selected by Golden-winged and Blue-winged warblers in each of these studies may be due to differences in the relative importance of habitat factors at different spatial scales.

If sympatric coexistence is possible between the two species at the site scale, it may occur where habitat segregation occurs. In upland, secondary successional habitats of New York, Blue-winged Warbler used slightly later stages of succession with greater tree cover (Confer and Knapp 1981) and less herb cover than Golden-winged Warbler (Confer et al. 2003). However, the difference in habitat use at upland sites is slight, the range of vegetative characteristics in territories is broad, and the degree of habitat overlap is extensive. Stable coexistence of Golden-winged and Blue-winged warbler populations has been documented only in Hudson Highlands in southern New York (Eaton 1914, Confer and Tupper 2000), in the Appalachian Plateaus and Ridge and Valley Physiographic provinces of Pennsylvania (Bakermans et al. 2011), and in southwestern West Virginia (Shapiro et al. 2004). In Sterling Forest State Park within the Hudson Highlands, both Golden-winged and Blue-winged warblers nested in uplands, and the interspecific nearest-neighbor distance between nests was often ~100 m (Confer et al. 1998). A portion of this Golden-winged Warbler population nesting in wetlands, however, was segregated from most Blue-winged Warblers. Golden-winged and Blue-winged warbler territories seldom overlapped in wetland areas, and Golden-winged Warbler nests were often >200 m from the nearest Blue-winged Warbler nest. A follow-up study confirmed the greater proportion of Golden-winged Warbler breeding pairs in lowland swamp forest compared with Blue-winged Warbler. Based on nine years of survey data at Sterling For-

est State Park, the Golden-winged / Blue-winged warbler phenotypic ratio was 42:2 in hardwood swamp forest vs. 46:40 in uplands, and Golden-winged Warbler nest success was significantly higher in swamp forest (62.1%) than in dry uplands (40.8%) (Confer et al. 2010).

Chapter 3 of this document presents the results of habitat-based spatial modeling predicting areas where conservation action for Golden-winged Warbler might occur with lower probability of genetic interaction with Blue-winged Warbler. Analysis of factors that enhance habitat segregation between Blue-winged and Golden-winged warbler—at site, landscape, and regional scales—remains a critical area for additional research.

NON-BREEDING SEASON ECOLOGY

Golden-winged Warbler spends the majority of the year in tropical forests extending from southern Mexico (Howell and Webb 1995) through Central America to the northern Andes of northwestern Venezuela, Colombia, and northwestern Ecuador (Ridgely and Tudor 1989)(Figure 1–1). In southern Mexico and Honduras, Golden-winged Warbler inhabits humid evergreen and semi-deciduous forest and edge (Howell and Webb 1995). In Costa Rica, the species uses forest canopy and edges, openings of tall second-growth or semi-open forests (Stiles and Skutch 1989), or mid-elevation undisturbed wet forest (Powell 1980). In Panama, Golden-winged Warbler occurs in young woodlands (e.g., Barro Colorado Island; Willis 1980) and forest borders (Ridgely and Gwynne 1989). The species has been reported from subtropical lower montane wet forest in northern Colombia (Johnson 1980), relatively high elevation (1600 m) transitional forest in southwestern Colombia (Orejuela et al. 1980), and undisturbed pre-montane rainforest (1000 m) on the Pacific slopes of western Colombia (Hilty 1980).

The resident non-breeding season (wintering season or Neotropical stationary non-breeding season) can last over seven months, with some individuals arriving as early as late September and maintaining territories until early May. Although the resident non-breeding season is the longest portion of the annual cycle, until very recently very little was known about the ecology and conservation status of Golden-winged Warbler during this important period. Lack of information has hindered conservation efforts because it has not been possible to identify high quality habitat that should be conserved to ensure population viability. To begin to remedy the deficiency, Barker Swarthout et al. (2008) launched Priority Migrant eBird, a web-based system designed to elicit non-breeding season records of priority migrant species, including Golden-winged Warbler. Museum specimen records and records contributed through Priority Migrant eBird formed the basis for a preliminary predictive map of potential Golden-winged Warbler habitat in the Neotropics (Will et al. 2010). This map was used to prioritize areas for a broad-scale survey initiated in 2008 to document the distribution and habitat use of Golden-winged Warbler in Nicaragua, Costa Rica, Panama, Venezuela, and Colombia. The broad-scale survey results were then used to refine the model (see Distribution section below). In addition, an intensive and ongoing study of behavioral ecology and demographics was initiated in Costa Rica in 2006 (Chandler 2010, Chandler and King 2011). A third source of information comes from observations of Golden-winged Warbler reported from bird community-level studies.

Migration

Very little is known about the migration of Golden-winged Warbler. The distribution of eBird records (**www.eBird.org**) during early spring (March–April) suggests a trans-Gulf of Mexico migration, with most records occurring in the western Gulf region of the U.S. and then continuing north through the Mississippi Valley and the Midwest. Fall (August–November) eBird records also suggest a trans-Gulf flight, with a greater concentration of records in Florida compared to spring migration. There are virtually no records along the Gulf coast in central Mexico and very few from Gulf or Caribbean islands. Although Golden-winged Warbler is regularly encountered during migration throughout eastern North America south of the breeding range, there has been little effort to compile information about habitat use (Confer et al. 2011). Throughout the Caribbean region, a few individuals have been recorded as transients in coastal, dry, and wet forests (Arendt 1992). More information about migratory connectivity between breeding season and non-breeding season locations is needed in order to delineate population-specific migration routes, associated stopover habitat use, potential threats, and potential conservation actions during the migratory portion of the annual cycle.

Distribution and Habitat use Segregation between Golden-winged and Blue-winged Warbler

Generalized maps of Golden-winged Warbler winter range (e.g., Figure 1–1) suggest that the entire area from southern Mexico to northern South America is occupied during the resident non-breeding season. Recent non-breeding season point count surveys in Nicaragua, Costa Rica, Panama, and Colombia (2009–2011) and consequent modeling, however, indicate that Golden-winged Warbler is selective in its habitat utilization and is therefore absent from large areas within this region (Figure 1–13). We analyzed the point

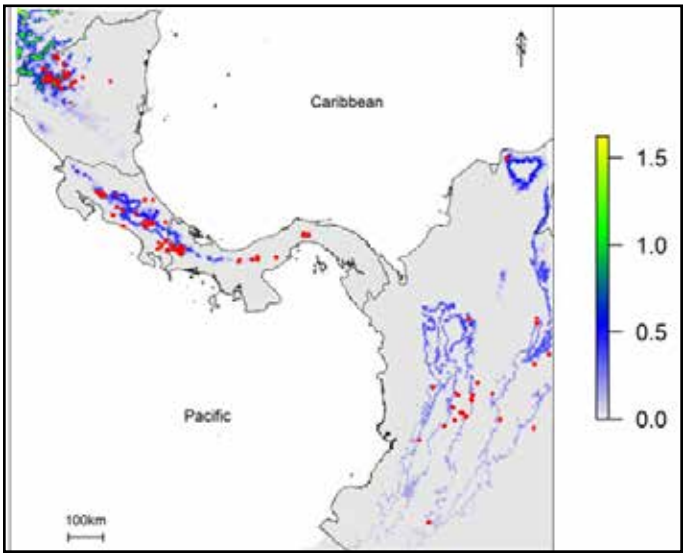

Figure 1–13. Modeled non-breeding season Golden-winged Warbler abundance using survey data from Nicaragua, Costa Rica, Panama, and Colombia. Red dots indicate survey locations. The colors indicate the predicted number of Golden-winged Warblers that would be detected at a survey point at locations within the study region during the resident non-breeding season.

count data using N-mixture models (Royle 2004, Dail and Madsen 2011), which account for imperfect detection probability, and found that the best predictors of abundance were precipitation, temperature, latitude, and elevation. Predicted Golden-winged Warbler abundance increased with precipitation and temperature and was highest at intermediate elevations. The optimal elevation was higher in the southern portion of the non-breeding range than in the north. Because broadcast vocalizations were used to attract Golden-winged Warblers, we did not know the effective area of the survey plots and thus could not reliably convert abundance estimates to density estimates. However, it may be possible to estimate effective survey area using the distance sampling data which were also collected as part of the survey protocol. Density modeling should be a priority for future analyses, as it would allow for the estimation of total population size in each country or for selected regions of the non-breeding range. In addition, more research is needed from the southern and northern extremes of the Golden-winged Warbler resident non-breeding range, and particularly from Honduras, which could host a large portion of the population.

Even within the core of its winter range, Golden-winged Warbler density is often low, and the species is patchily distributed (Johnson 1980, Morton 1980, Orejuela et al. 1980, Powell et al. 1992, Wallace et al. 1996, Komar 1998, Blake and Loiselle 2000). Preferred habitat appears to be wet evergreen forests at intermediate elevations (Bent 1963, Johnson 1980, Tramer and Kemp 1982, Blake and Loiselle 2000, Chandler and King 2011). Tropical dry forests and high elevations (>3000 m) are avoided altogether. This pattern suggests that temperature and precipitation are important determinants of winter distribution. Elevation may also be important, as it can influence both temperature and precipitation, but it is not always an adequate surrogate for the other two variables. For example, in the Cordillera de Tilarán of Costa Rica, Golden-winged Warbler does not occur at 800 m (and below) on the dry Pacific slope, which receives < 2 m annual precipitation, but it is regularly encountered at 800 m on the Caribbean slope, which receives 3–6 m of precipitation annually (Chandler 2010).

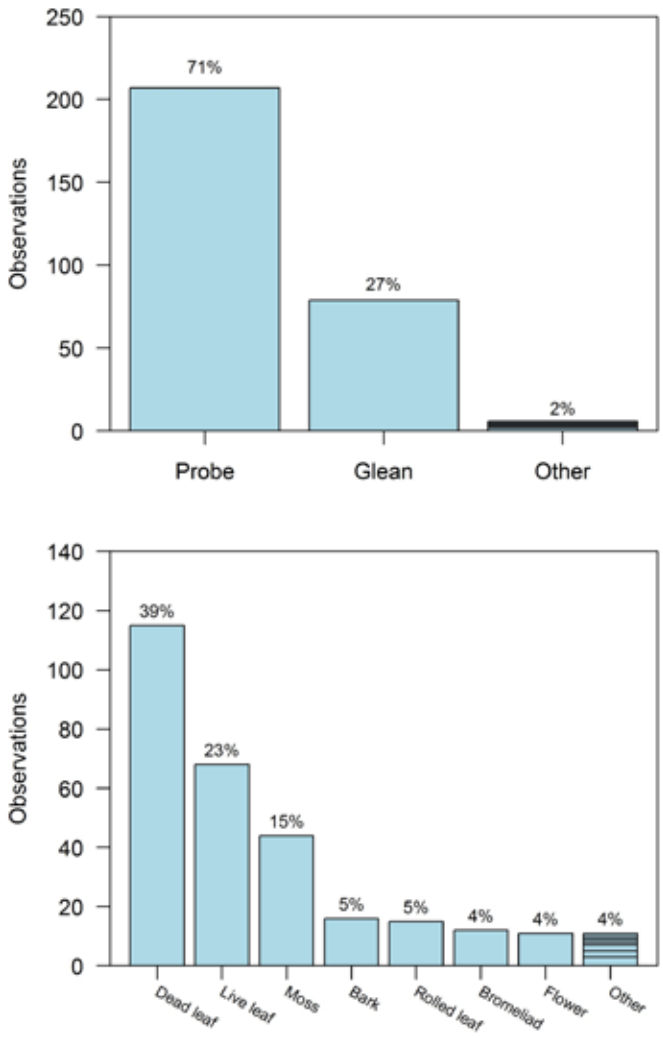

Figure 1–14. Foraging maneuvers and substrates observed for Golden-winged Warbler during the resident non-breeding season in Costa Rica (Chandler and King 2011).

Although precipitation and temperature are useful for predicting Golden-winged Warbler occurrence during the non-breeding season (Figure 1–13), these climatic variables are not likely the proximate factors influencing habitat selection; rather, temperature and precipitation influence the forest characteristics that are required by the species. Specifically, Golden-winged Warbler selects forests characterized by numerous hanging dead leaves and epiphytes, which it probes in search of insects (Rosenberg 1997, Chandler 2010 and Figure 1–14). These micro-habitat characteristics, especially epiphytes, are often absent from dry forests but are relatively common in premontane forests, especially those that have experienced some form of disturbance resulting in intermediate canopy height and numerous vine tangles (Figure 1–15). Its tendency to forage among epiphytes would suggest that Golden-winged Warbler would thrive in high elevation cloud forests which are covered in thick layers of moss; however, the species rarely occurs above 2500 m. It is possible that the moss covering the vegetation in these forests is too thick for the warbler to manipulate; indeed, many of the epiphyte-foraging species in these forests are equipped with specialized, long, powerful bills. Thus, ideal Golden-winged Warbler forests appear to be those with intermediate numbers of epiphytes and many hanging dead leaves (Figure 1–15) (Chandler and King 2011).

Although Golden-winged Warbler requires specific climatic conditions and micro-habitat features, it is encountered in a variety of habitat types in the tropics. During the 2008-2011 rangewide non-breeding season surveys, the species was found most often in secondary forests, followed by agroforestry systems, then primary forest. Species that utilize multiple habitat types are often regarded as generalist species tolerant of human-modified environments. However, it is easier to detect birds in more open habitats, so estimates of detection probability are needed to correct for observation error. Also, some birds encountered in human-modified habitats may be displaced from better habitat or are making brief sojourns from nearby forest patches. For example, results of point count surveys in Costa Rica suggest that Golden-winged Warbler uses shade coffee (Komar 2006), but telemetry data show that Golden-winged Warbler uses shade coffee primarily in transit between forest patches (Chandler 2010). Thus, the inference that shade coffee provides non-breeding habitat for Golden-winged Warbler should be viewed with caution. Nonetheless, Golden-winged Warbler can establish territories and occur at high densities in advanced secondary forest, and its preferred micro-habitat characteristics are not restricted to primary forest. This habitat relationship is important, as it suggests that reforestation may be an effective conservation strategy during the resident non-breeding season.

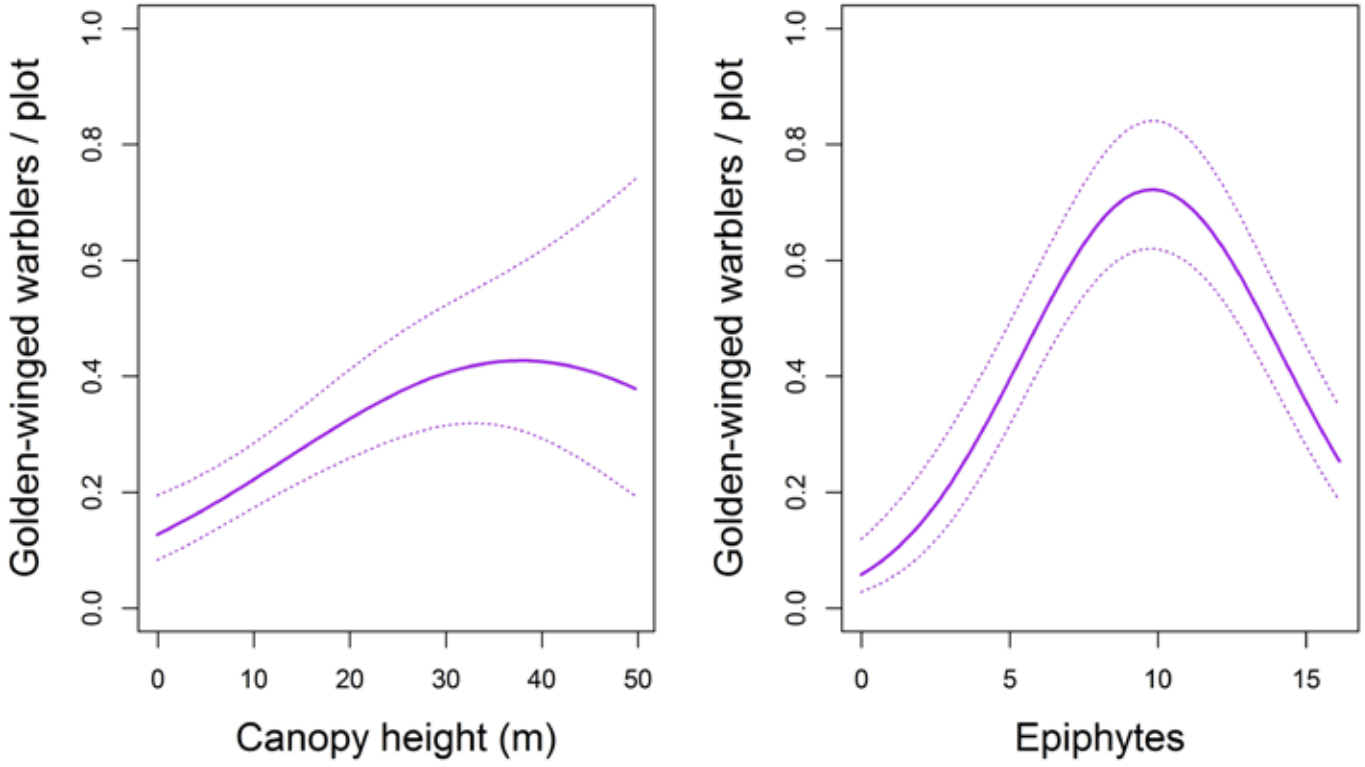

Figure 1–15. Estimated relationships between Golden-winged Warbler abundance and canopy height and between Golden-winged Warbler abundance and epiphytes during the resident non-breeding season in Costa Rica. Epiphytes were measured using an index from 0–16 (Chandler and King 2011).

Non-breeding Foraging and Social Behavior

The specialized foraging behaviors of Golden-winged Warbler affect its social system during the non-breeding season, and this social system has important conservation implications. As with many other Neotropical species that forage in hanging dead leaves, Golden-winged Warbler spends the majority of its time with mixed-species foraging flocks (Rosenberg 1997, Chandler 2010). The association between flocking and dead leaf foraging is believed to result from the vulnerability to predation inherent in the foraging technique, which is noisy and often involves the forager inserting its entire head into a leaf or bromeliad. In most instances, only one Golden-winged Warbler is found with a foraging flock—probably due to prey availability in the foraging substrates and the forager's ability to defend these resources. Golden-winged Warbler is highly territorial during the non-breeding season and aggressively responds to broadcast vocalizations and decoys (Chandler 2010). These behavioral characteristics result in large home range sizes (Table 1–4) and low densities—suggesting that large tropical areas need to be protected to support a population. Furthermore, specialized foraging requirements and association with mixed-species foraging flocks suggest that Golden-winged Warbler will be adversely affected by deforestation and habitat fragmentation, since numerous studies (e.g., Rappole and Morton 1985, Stouffer and Bierregaard 1995, Stratford and Stouffer 1999) have found that mixed-species flocks cannot persist in highly fragmented landscapes.

Table 1–4. Home-range size summary statistics for 20 Golden-winged Warblers radio-tracked during three non-breeding seasons (2006–2009) in the Cordillera de Tilarán, Costa Rica.

Estimator	Level	Mean	SD	Min	Max
Kernel	50%	1.99	0.95	0.44	4.00
	75%	4.13	1.98	1.00	8.75
	95%	8.77	4.69	2.31	19.50
Minimum convex polygon	50%	0.83	0.56	0.13	1.96
	75%	1.56	0.99	0.32	4.00
	95%	3.16	2.13	0.81	9.87

FULL LIFE CYCLE POPULATION DEMOGRAPHY

In general, songbird populations are more sensitive to changes in adult and juvenile survival rates than to changes in reproductive parameters, although reproduction can still determine in part whether a population is increasing, decreasing, or stable (Donovan and Thompson 2001).

Golden-winged Warbler captures at Monitoring Avian Productivity and Survivorship (MAPS) banding stations—43 adults from four stations—were insufficient to meet inclusion criteria for calculating lambda in a 15-year (1992–2006) analysis of MAPS data (D. DeSante, pers. comm.). However, the data could provide some information about adult apparent survival in time-constant capture-mark-recapture models: the 15-year program-wide (continental) time-constant adult apparent survival rate estimate was 0.664 (SE = 0.127, CV = 19.2%) (DeSante and Kaschube 2009). This a very high apparent survival estimate for a warbler, likely due to a very low recapture probability estimate (0.222, SE = 0.124, CV = 55.7%) and high residency estimate (0.540, SE = 0.344, CV = 63.7%), both of which were poorly estimated due to the small sample size. Nevertheless, these limited data suggest that Golden-winged Warbler might not have a particularly low or deficient adult apparent survival rate (DeSante, pers. comm.). MAPS data collected over the same 15 years also provided some information about productivity: the program-wide time-constant MAPS reproductive index (young/adult) estimate for Golden-winged Warbler was 0.151 (95% CI: 0.068–0.334). This was the fourth lowest of 34 warbler species for which estimates were available. Since the mean reproductive index for the other 33 warbler species was 0.316, these limited data suggest that Golden-winged Warbler might be suffering from low productivity (DeSante, pers. comm.).

Studies involving marked *Vermivora* individuals are limited. In one Michigan study, 73% (n = 11) of banded males returned to the same study area (Murray and Gill 1976). In another Michigan study (Will 1986), 52% (n = 41) of males and 10% of females (n = 21) returned. Recent estimates of minimum annual survival rates have been calculated from return rates of color-marked individuals to the breeding grounds in Tennessee and Ontario (Bulluck 2007, Bulluck et al. 2013). Adult male apparent annual survival, corrected for detectability, was 0.62 for both areas (2001–2005 in Ontario, n = 185; 2003–2005 in Tennessee, n = 91). Adult female survival was 0.48 (n = 107) in Ontario and 0.43 in Tennessee (n = 51). The different estimated survival between males and females may reflect either differential survival during mi-

gration or on the wintering grounds or differential site fidelity on the breeding grounds. Apparent survival within the breeding season was assumed to be relatively high. Bulluck (2007) concluded that these annual survival rates, especially for females, were insufficient to sustain the Ontario and Tennessee breeding populations over the long term without immigration of new individuals (i.e., they were population sinks).

Chandler (2010) reported a 0.53 annual apparent survival probability for males and females combined during the non-breeding season in Costa Rica (2006–2010, *n*=31). Survival was lowest during the resident non-breeding season (6.5 months), with a 0.63 apparent within-season survival probability compared to a 0.85 apparent survival probability during the rest of the year (5.5 months including migratory and breeding periods) (Table 1–5). Habitat-specific demographics are needed, however, to evaluate non-breeding season habitat quality and to identify factors affecting survivorship. Density is not always positively correlated with survival probability; thus it is possible that tropical secondary forest could serve as an ecological trap, although Chandler (2010) found no evidence of lowered survivorship in secondary forests in Costa Rica. However, recruitment appeared to be low, as vacated territories were not always replaced in subsequent years.

The Costa Rica study (Chandler 2010, Chandler and King 2011) indicated annual survival rates comparable to the Bulluck (2007) estimates; both studies suggest that survival during the resident non-breeding season may be a factor contributing to observed population declines measured during the breeding season. If non-breeding season conditioning and survival is ultimately limiting Golden-winged Warbler population growth, establishing explicit migratory connectivity for Golden-winged Warbler populations will be essential for targeting appropriate conservation action—especially given the differential predicted population trajectories of the Appalachian and Great Lakes populations.

Table 1–5. Estimates of survival and resight probabilities for Golden-winged Warbler from a Cormack-Jolly-Seber model. Data were collected on 31 individuals monitored for up to five years in the Cordillera de Tilarán, Costa Rica, 2006–2010.

Parameter	Mean	SD	95% CI	
			Lower	Upper
Within season apparent survival (monthly)	0.93	0.033	0.87	0.99
Within season apparent survival (1 Oct – 15 April)	0.63	0.14	0.37	0.90
Annual apparent survival	0.53	0.13	0.29	0.77
Resight probability	0.42	0.058	0.31	0.54

POPULATION THREATS

Golden-winged Warbler population declines have been attributed to a variety of potential sources, including loss of breeding season habitat, interactions with Blue-winged Warbler (both competition and hybridization), Brown-headed Cowbird brood parasitism, and land use changes on the Neotropical wintering grounds. All of these threats, with the possible exception of cowbird parasitism, likely contribute to population-level declines, and the relative impact of each as a limiting factor remains unclear. Threats to the species appear to vary considerably across regions, although loss of early successional habitat has been identified as the principal rangewide breeding season threat, compounded in some areas by hybridization with Blue-winged Warbler.

Past, Present, and Projected Future Breeding Season Habitat

Habitat loss during all stages of the Golden-winged Warbler annual cycle is likely a primary contributor to the decline of the species. Widespread declines in the early successional component of breeding habitat has been noted by numerous authors (e.g., Litvaitis 1993, Hunter et al. 2001, Lorimer 2001, Thompson and DeGraaf 2001, Trani et al. 2001, Confer and Pascoe 2003). The loss of suitable breeding habitat has likely been a factor leading to local extirpations of Golden-winged Warbler, particularly in the eastern United States and southern Ontario.

The U.S. Forest Service (USFS) Forest Inventory and Analysis (FIA) program (Bechtold and Patterson 2005, Woudenberg et al. 2010) can be used to portray coarse-scale patterns in forest composition and structure over large geographic extents. Although these data were not intended to predict wildlife population carrying capacity, we estimated abundance of potential Golden-winged Warbler breeding habitat over the approximate span of the BBS by assessing changes in hardwood forest trees in the small diameter size class (sapling/seedlings <5 in [12.5 cm] DBH) in two regions: the

Great Lakes (Minnesota, Wisconsin, Michigan, and New York) and the northern Appalachians (Pennsylvania, Virginia, and West Virginia). Historical FIA estimates refer to timberland, a subcategory of forested land that excludes reserved (e.g., wilderness) or non-productive forests. In the Midwest and Northeast, timberland comprises the vast majority of all forest lands (typically more than 90–95%) and was therefore assumed to be representative of all forested habitat. Area of forest land with small diameter hardwood trees has decreased both in the Great Lakes states (22%) and in the northern Appalachian states (43%) since the mid-1960s; the decrease varies substantially among states within each region (Figure 1–16).

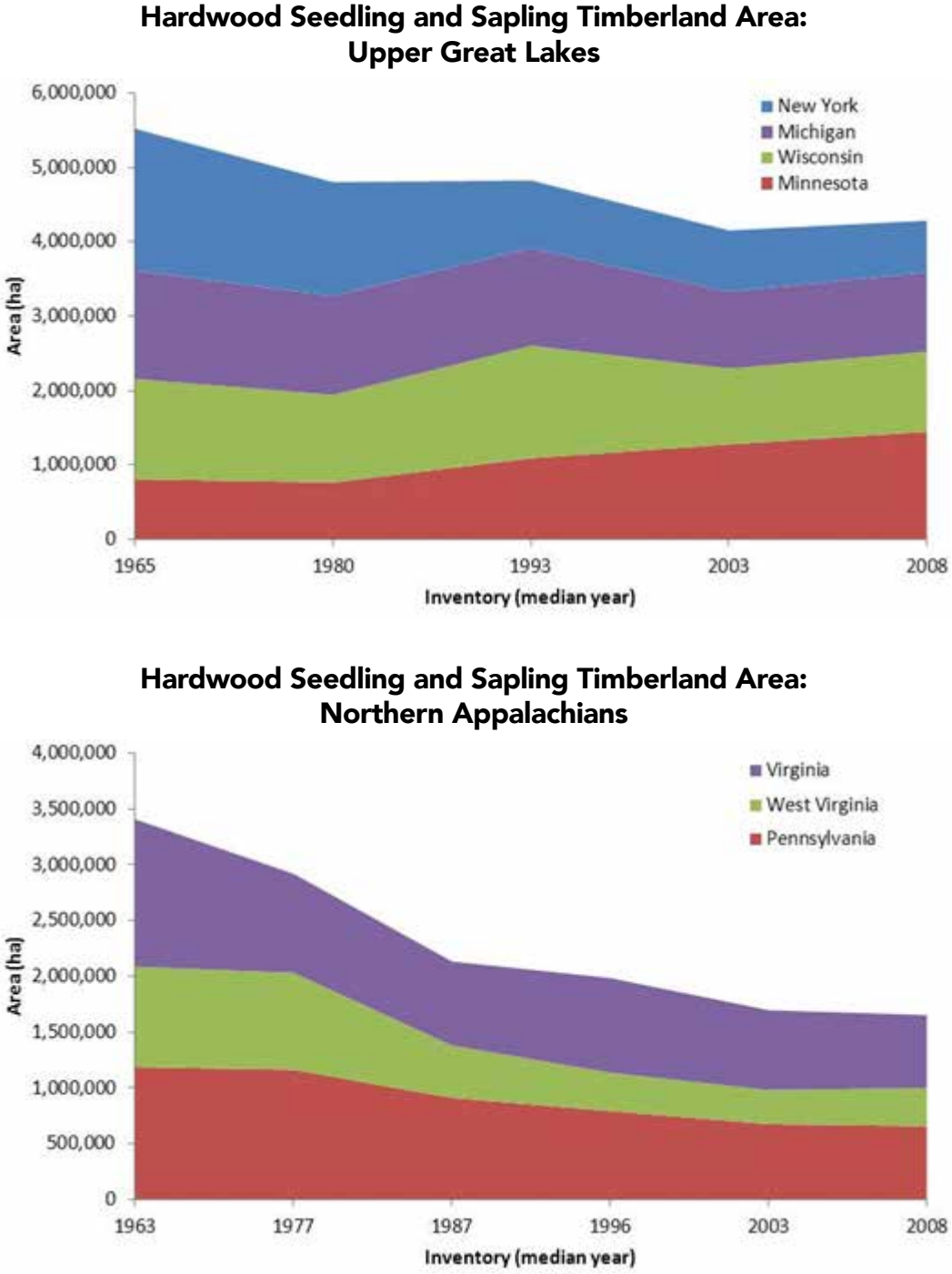

Figure 1–16. Estimates of recent (40–45 year) changes in potential Golden-winged Warbler breeding habitat in Great Lakes and northern Appalachian states using U.S. Forest Service FIA data. Standard forest land area estimators (Scott et al. 2005) were used for small diameter (<12.5 cm DBH) hardwood timberland (FIA forest type codes ≥ 40). FIA's online EVALIDator tool (Miles 2010) was used for timberland area dating back to the late 1970s or mid 1980s; estimates from prior decades came from multiple published state FIA reports.

Projections of future abundance of potential Golden-winged Warbler habitat were derived from the USFS Forest Futures project (U.S. Forest Service 2012a), which projects a range of plausible future forest conditions in the U.S. Midwest and Northeast resulting from changing patterns of land use and climate (represented by Intergovernmental Panel on Climate Change [IPPC] storylines A1B, A2, and B2) (U.S. Forest Service 2012b). We used ecological classification system land units (Cleland et al. 2007) to match areas for future projections as closely as possible with the current Golden-winged Warbler range (Figure 1–4). Total area of forest land is projected to decline by 2–3% in the Great Lakes region and by 6–13% in the northern Appalachian region. Potential future Golden-winged Warbler habitat abundance (again estimated by the small diameter hardwoods class) is projected to decrease under all three scenarios, ranging from a 0.5–12% decline in the in the Great Lakes region and 6–13% in the northern Appalachian region. Potential future Golden-winged Warbler habitat abundance (again estimated by the small diameter hardwoods class) is projected to decrease under all three scenarios, ranging from a 23% decline in the Great Lakes region to a 0.5–12% decline in the northern Appalachian region (Figure 1–17).

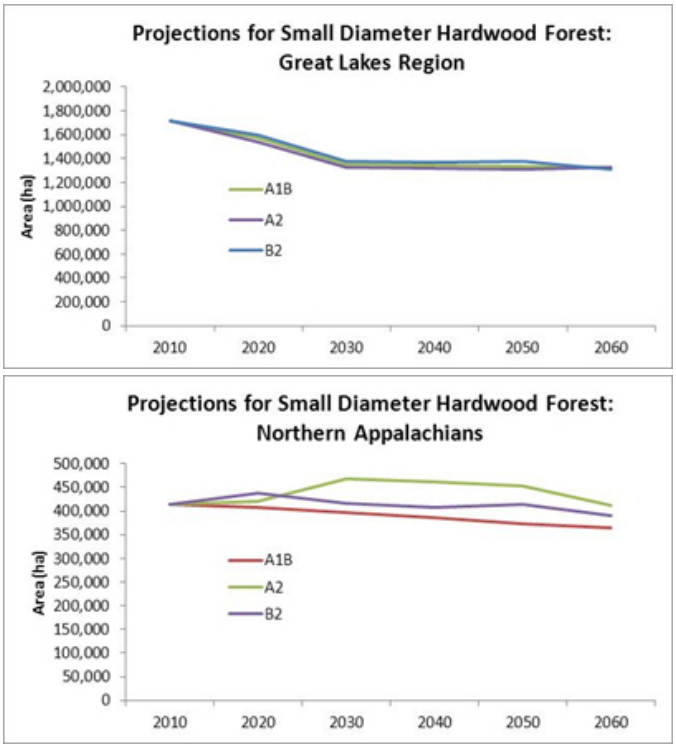

Figure 1–17. Projected declines in potential Golden-winged Warbler habitat in the Great Lakes and northern Appalachians derived from the USFS Northern Forest Futures Projection project (U.S. Forest Service 2012a). Potential habitat was estimated using the small diameter hardwood forest class under three different land use and IPPC GCGM31 storylines (U.S. Forest Service 2012b). The two regions for future projections were based on ecological units (Cleland et al. 2007): Great Lakes included portions of Province 212 in Minnesota, Wisconsin, and Michigan, and Section 212E in New York; the Northern Appalachians region included Pennsylvania, Maryland, and West Virginia portions of Province M221.

In addition to projected loss in the overall amount of suitable dynamic forest habitat, habitat quality may also decline with advancing forest succession. Birds presumably respond by nesting or feeding in marginal or poor habitat where nest success and fledgling survival can be poor. Site abandonment and even low adult survival might then lead to local population declines. We currently know little about Golden-winged Warbler juvenile survival or the proportion of this age class that perishes each year on migration; however, first-year mortality can be high for Neotropical migrants, and loss of appropriate stopover habitat also likely contributes to lower survival during the bird's critical first long-distance journey. For other warbler species, we also know that the quality of winter habitat affects adult breeding condition and nesting success the following spring (Marra et al. 1998, Reudink et al. 2009).

Quality Golden-winged Warbler breeding habitat is being lost as a result of several causes:

Natural Succession and Disturbance Regime Change

Although much loss of young forest habitat is undoubtedly related to changes in human land use, loss can also be attributed to advancing succession due to reduced natural disturbance, especially disturbance due to fire. Succession in the absence of historical natural disturbance regimes leads to closed-canopied forests incapable of supporting species that require imbedded patches of early-successional habitat for some part of their annual cycle. Estimates for New York (Confer and Pascoe 2003) and New Hampshire (Litvaitis 1993) suggest that the loss of natural disturbance-dependent habitat already exceeds the current acreage of early-successional habitat added by anthropogenic disturbance—and the rate of anthropogenic early-successional habitat creation continues to decline.

Wetland loss and removal of beavers (with their ability to create wetland shrub communities within forests) from widespread areas throughout the eastern U.S. may be responsible for significant loss of Golden-winged Warbler nesting habitat (but cf. Chandler et al. 2009). Although lowland shrub community habitats embedded in dynamic forested landscapes in the Upper Midwest may be sufficient to prevent extirpation of Golden-winged Warbler populations (Hanowski 2002), these populations may still decline to a fraction of current levels if wetland habitat suitability diminishes due to natural succession (e.g., over-mature *Alnus*), development impacts, or altered hydrologic regimes resulting from changing climate patterns.

Development and Land Use Change

In some areas, especially the Upper Midwest, second home development may be compromising some Golden-winged Warbler habitat, especially in deciduous forests and near lakeshores (Gonzalex-Abraham et al. 2007). Housing development in forests rangewide is fragmenting the forest at a landscape scale and leads to potential habitat degradation. Housing development is projected to be high in and near

protected areas such as national forests (Stein et al. 2007); such development can result in multiple threats to bird habitat and conservation efforts—reducing fire frequency and scale, increasing brood-parasitic cowbird populations, and increasing introduction of invasive plants (Radeloff et. al 2010). Additionally, mammalian mesopredator populations may increase in both range and abundance due to landscape fragmentation by human development—resulting in decreased nest survival of ground-nesting birds and increased adult bird mortality (Crooks and Soule 1999, Rogers and Caro 1998). Larivière (2004) suggested that northward range expansion of raccoons was attributable in part to increased food availability resulting from changing climate patterns. Direct human activities can also increase local nest predation rates; for example, Roth (pers. comm.) observed people relocating problem raccoons to a Golden-winged Warbler study site while nests were still active.

Public and Private Forested Land Policy

Reduced aspen and other forest management on public lands will reduce the amount of suitable habitat available to Golden-winged Warbler (Roth and Lutz 2004). Public pressure to reduce clearcutting on national forests has led to a gradual decline of young forest habitat on these lands. Additionally, some national forests currently are harvesting aspen at rates below the goals set in their forest plans. Typically, clearcuts provide ephemeral habitat that remains suitable for Golden-winged Warbler for fewer than ten years, so the species is reliant on regular timber harvest regime on a landscape scale more often typical of industrial forests.

Most of the forested lands capable of supporting breeding Golden-winged Warbler are in private ownership—ranging between 38% and 93% of forests as presented in the Subregional analyses in Chapter 3. As increasingly smaller holdings of private forest land are owned by growing numbers of individual land owners (parcelization), it becomes increasingly difficult to reach goals of creating dynamic forests at landscape scales due to administrative challenges in coordinating many individual forest landowner plans, decreasing willingness of landowners to allow timber harvest, and increasing operational expenses when harvesting smaller landholdings. Golden-winged Warbler utilizes different forest seral types throughout its breeding cycle and is essentially a species of dynamic forested landscapes; thus a piecemeal approach to forest management for the species is unlikely to achieve objectives at the population scale. Even if alternative forest product and forest management scenarios arise—e.g., removal of woody biomass (and subsequent forest regeneration) to serve bioenergy markets—private lands management incentive programs may still be necessary to achieve goals at regional scales. Coordination of efforts to achieve dynamically functional forested landscapes will continue to be a challenge.

Interactions with Blue-winged Warbler

Much research attention has focused on understanding the mechanisms underlying the local replacement of Golden-winged Warbler by Blue-winged Warbler in areas of secondary contact (Confer and Knapp 1977, Gill 1980, Confer and Knapp 1981, Will 1986, Confer et al. 1991, Gill 1997, Confer and Larkin 1998, Confer et al. 1998, Confer et al. 2003). Debate continues, however, regarding whether these relationships are causal or at least partly coincidental in nature. Virtual extirpation of Golden-winged Warbler has been documented at well-studied locations (e.g., in Massachusetts, Connecticut, central New York, and at lower elevations in West Virginia) despite the presence of apparently suitable habitat. Blue-winged Warbler has increased in many of these areas coincident with the decline of Golden-winged Warbler. In the southern Appalachians, Golden-winged Warbler has declined in the absence of Blue-winged Warbler, although hybrids do occur; in these situations, habitat loss is likely the limiting factor.

The decline of Golden-winged Warbler following Blue-winged Warbler expansion and the local extirpation of Golden-winged Warbler could be caused by competition, direct behavioral aggression, or hybridization; or the respective range changes may be the result of some other correlated factor, such as climate change, that effects both species. In north-central New York, Golden-winged Warbler dominated Blue-winged Warbler in aggressive interactions; availability of suitable nesting habitat did not appear to limit breeding densities (Confer and Larkin 1998). In contrast, Will (1986) reported behavioral dominance by Blue-winged Warbler over Golden-winged Warbler in central Michigan, and Canterbury (unpubl. data) reported that dominance relationships between the two species varied among habitats. Confer et al. (2002) found that proximity with Blue-winged Warbler accounted for 15% of all variation in Golden-winged Warbler clutch size; going from no overlap to complete overlap with Blue-winged Warbler reduced Golden-winged Warbler clutch size by 0.5 eggs.

Some researchers have suggested that hybridization may be more disadvantageous for Golden-winged Warbler than Blue-winged Warbler for two reasons. Male Blue-winged Warblers occasionally harass female Golden-winged Warblers of putative Golden-winged x Golden-winged warbler pairs, whereas the converse had not been reported (Confer and Larkin 1998). This may lead to extra-species copulation by male Blue-winged Warbler but not by male Golden-winged Warbler, which in turn would increase the frequency of hybrid young for a Golden-winged x Golden-winged warbler pair in comparison to a Blue-winged x Blue-winged warbler pair. In addition, Confer and Larking (1998) found evidence that male Golden-winged Warblers

were more likely to form pair bonds and raise young with Brewster's Warbler females than male Blue-winged Warblers and thus were more likely to produce hybrids than Blue-winged Warbler. In samples from areas of recent secondary contact, introgression of mtDNA appeared symmetrical (Shapiro et al. 2004, Dabrowski et al. 2005). In contrast, in samples from southern New York taken after nearly a century of coexistence, only two of 15 (13%) Blue-winged Warblers had Golden-winged Warbler mtDNA while 12 of 28 (43%) Golden-winged Warblers had Blue-winged Warbler mtDNA (Dabrowski et al. 2005).

In summary, interactions between Blue-winged and Golden-winged warblers are complex, regionally variable, and related to differential habitat use that also varies regionally. Whereas virtually all researchers would agree that introgression of Blue-winged Warbler genes (whether visually apparent or cryptic) into the Golden-winged Warbler population threatens the continued existence of a pure Golden-winged Warbler phenotype, many researchers and conservationists are transitioning from a position of regarding Blue-winged Warbler as a direct threat to Golden-winged Warbler per se to a position that recognizes a strategy of maintaining, to the greatest extent possible, the full genetic diversity represented within the *Vermivora* complex. Such a strategy includes maintaining populations of pure Golden-winged Warbler genotypes where allopatry or habitat segregation in sympatry appears to facilitate genetic isolation.

Brood Parasitism

Golden-winged Warbler populations experience moderate rates of brood parasitism by Brown-headed Cowbird (Confer et al. 2001), especially in more agricultural landscapes. Based on a survey of several hundred nests from across the range of the species, about 30% of nests had at least one cowbird egg (Coker and Confer 1990). In north-central New York, 22 of 73 nests (30%) in 1988–1994 contained at least one cowbird egg or chick (Confer et al. 2003). This rate of parasitism was estimated to reduce fledging by 17%. However, cowbird parasitism in many areas is not presently a problem (cf. Table 1–3) and probably has not contributed to declines of the species. Cowbird parasitism was not recorded during nesting studies in the mountains of North Carolina (Klaus and Buehler 2001) nor in the Cumberland Mountains of Tennessee (Bulluck and Buehler 2008), was not a problem for Golden-winged Warbler populations in West Virginia (Canterbury et al. 1996), and was minimal in Ontario (Vallender et al. 2007a). In a forested landscape in northern Wisconsin, only one of 50 nests (2%) was parasitized (Roth, unpubl. data). Brood parasitism in Manitoba, where Golden-winged Warbler appears to have recently expanded its range, also appears to be relatively low (~7% from two 2011–2012 studies combined: Moulton, unpubl. data; Peterson, unpubl. data). As indexed by the BBS, Brown-headed Cowbird populations are generally declining in forested regions (Sauer et al. 2011), so the current moderate to minimal reproductive threat posed by cowbirds is likely to diminish even more over time in forested landscapes.

Disease and Predation

Although Golden-winged Warbler is susceptible to a variety of avian diseases, the incidence of disease is probably not responsible for recent declines. West Nile virus has not been documented in Golden-winged Warbler but has been documented in 16 other warbler species (CDC 2007).

There are few data on predation rates for Golden-winged Warbler and virtually no data on how population declines may have changed relative to predation rates. Potential mammalian nest predators include raccoon (*Procyon lotor*), coyote (*Canis latrans*), striped skunk (*Mephitis mephitis*), various weasel species (*Mustela* spp.), opossum (*Didelphis marsupialis*), red fox (*Vulpes fulva*), gray fox (*Urocyon cinereoargenteus*), Eastern chipmunk (*Tamias striatus*), red squirrel (*Tamisciurus hudsonicus*), gray squirrel (*Sciurus carolinensis*), mice (*Peromyscus* spp.), voles (*Microtus* spp.), and unrestrained house cats (*Felis catus*). Potential avian nest predators include American Crow (*Corvus brachyrhynchos*) and Blue Jay (*Cyanocitta cristata*). There are many potential herpetofaunal predators, especially snakes; Will (pers. comm.) and Roth (pers. comm.), for example, described sequential predation of Golden-winged Warbler nestlings by eastern garter snake (*Thamnophis sirtalis*).

Nest predation is generally considered to be the leading cause of nest failure in this species (Confer et al. 2011), yet there is no clear indication of how recorded rates of nest predation contribute to overall population change. In some populations (e.g., North Carolina, Klaus and Buehler 2001), nest success was high (72.5%) compared to other passerines, and nest predation was not likely responsible for overall population declines. Following a large mast production, chipmunks and squirrels may increase to the extent that predation significantly impacts nest success. One artificial nest study in Ontario suggested relatively equal predation pressure exerted by mid-sized mammals, squirrels/chipmunks, and mice/voles (Demmons 2000). Kubel and Yahner (2008) speculated that a chipmunk irruption resulted in the high predation rates observed during one year of their study in Pennsylvania. Based on nine years of surveys in Sterling Forest, New York, nest success was significantly higher (62.1%) in swamp forests than in dry uplands (40.8%), possibly due to the more abundant chipmunk populations in the uplands (Confer, unpubl. data).

Overutilization

Golden-winged Warbler is not used consumptively in any known way that would contribute to its population decline, nor are shooting or other forms of intentional human-caused mortality likely to have population-scale impacts.

Climate Change

Price and Root (unpubl. data) have suggested that the northward shift in the distribution of both Golden-winged and Blue-winged warbler in Wisconsin and Minnesota is consistent with patterns of climate change in the region. Under two climate model scenarios, the Golden-winged Warbler breeding range is expected to contract northward and to higher elevations in the Appalachians; tracking range shifts of birch and aspen, the species is expected to disappear from much of its current breeding range in the Midwest. Price and Glick (2001) found that a 2°C increase in temperature resulted in a predicted extirpation of Golden-winged Warbler from Minnesota and Wisconsin. The Canadian Climate Center Model predicts extirpation from the western portions of the breeding range and reduced populations in the eastern U.S. (Matthews et al. 2004). The Hadley Centre Coupled Model Version 3 used by the Wallace Initiative also predicts a northward shift in the breeding range—if suitable habitat exists (Price pers. comm.). Prasad et al. (2009) describe an online database and mapping tool (Matthews et al. 2007-ongoing) in which users can display projected range shifts for bird species under different climate change models and scenarios; results for Golden-winged Warbler corroborate the range shifts described above.

Collectively, the available future climate change projections are concerning, as a majority of the Golden-winged Warbler population breeds in the western half of the range, and the only genetically pure Golden-winged Warbler population in Manitoba is in part associated with an aspen-dominated ecosystem. Range shift and range contraction of the western Great Lakes and Manitoba population, in addition to further reduction of the eastern population, would likely result in local extirpations of small populations and doubtful long-term viability of the global breeding population. In addition, the Hadley Centre Coupled Model Version 3 used by the Wallace Initiative predicts that with a 2°C increase in temperature, much of the wintering grounds in Central America may become unsuitable (Price pers. comm.) From a habitat management perspective, if the pattern of transition from Golden-winged to Blue-winged warbler phenotypes is driven largely by climate change, then habitat manipulations to support pure Golden-winged Warbler populations may not be effective.

Irrespective of future climate scenarios and the uncertainty inherent in their predictions, it seems more likely that the well documented historical pattern of Blue-winged Warbler expansion into the range occupied by Golden-winged Warbler will continue. Blue-winged Warbler has been expanding northward over the last century at a rate of about 4 km/year in New York and 2.4 km/year in Wisconsin (Confer pers. comm.). While the Golden-winged Warbler range has also been shifting generally northward and westward, so has the zone of hybridization following secondary contact with Blue-winged Warbler. Local extirpation of phenotypic Golden-winged Warbler appears inevitable unless habitat segregation can provide refugia to facilitate coexistence in sympatry. It remains unclear whether large amounts of appropriate habitat will continue to be available in Canada to accommodate continued range expansion of genetically pure Golden-winged Warbler populations along the leading edge of a north and northwestward shifting *Vermivora* range.

Migratory Obstacles

Recent analysis suggests that Golden-winged Warbler, for reasons unknown, may be considerably more vulnerable to collisions during the migratory period than most small passerines (Figure 1–18). Golden-winged Warbler was reported killed at 15 of 33 communication towers monitored east of the Mississippi River (Shire et al. 2000). Arnold and Zink (2011) listed Golden-winged Warbler as second only to Bay-breasted Warbler for being at-risk for tower collisions. The study corrected for species population size and range overlap with 39 sites throughout eastern North America; risk was calculated per capita relative to an average landbird. Golden-winged Warbler was 196 times more vulnerable to tower collisions than the average among 188 species of Eastern landbirds in the analysis. The majority of Golden-winged Warbler mortalities were at three sites: Eau Claire, Wisconsin—428 Golden-winged Warbler records out of 118,126 total bird mortalities (Kemper 1996); northwestern Florida—72 records out of 44,007 mortalities (Crawford

Figure 1–18. Golden-winged Warblers killed from collision with a tall (>300 m) guyed communications tower near Madison, Wisconsin, during a single night in September 2005. Five Golden-winged Warblers represented 2.4% of the 206 total bird mortalities detected from this event (Travis, pers. comm.).

and Engstrom 2001); and central Illinois—12 records out of 5,465 mortalities (Seets and Bohlen 1977).

For building collisions in the Arnold and Zink (2011) analysis, Golden-winged Warbler ranked 28 out of 147 species with a vulnerability six times greater than average. Of the three cities examined for building collisions, there were 35 Golden-winged Warbler mortalities in Chicago, none in New York City, and only one in Toronto (Arnold, Zink, and Willard, pers. comm.). Without the per capita correction in Chicago, Golden-winged Warbler mortalities ranked 81st of 154 species at the McCormick Place Conference Center (17 of ~35,000 birds over 33 years) and 76th of 130 species for downtown Chicago (18 of 19,000+ birds over 30+ years) (Willard, pers. comm.). An additional eight live Golden-winged Warblers were recovered from downtown Chicago during a 5.5 year period (2006–2011) and taken to a rehabilitator; of five that survived, at least four were successfully released (Prince, pers. comm.).

Non-breeding Season Habitat Loss

Since rates of deforestation have been well documented for Central and South America (FAO 2001, 2011), winter habitat availability is very likely declining within the tropical residency range of Golden-winged Warbler. For example, Golden-winged Warbler has been reported from the foothills and lower elevation montane forests of western Panama, a zone that receives considerable human disturbance (Ridgely and Gwynne 1989); considerable disturbance and fragmentation has occurred throughout the non-breeding season range in Nicaragua, Costa Rica, and Colombia as well (Rosenberg, pers. comm.). The little demographic information available (see section on demography, page 1–26) points to low annual survival as a limiting factor, particularly for females, so it is reasonable to hypothesize that forest loss in the tropics directly impacts Golden-winged Warbler population trends measured during the breeding season. We know little about non-breeding season habitat quality, however, or how habitat quality of different Neotropical forest types directly influences non-breeding season survival or conditioning.

In Integrated Open Canopy (IOC) coffee production systems (e.g., Figure 1–19), farmers protect or restore forest patches equal to or greater than the size of their coffee plantations (Arce et al. 2009). IOC coffee has been utilized by Golden-winged Warbler (Chandler 2010) and thus could be an important tool for protecting and restoring habitat in human-modified landscapes. If coupled with environmental certification programs and carbon credit payments, IOC coffee production could affect large landscapes through market forces alone, thus reducing dependence on top-down conservation approaches and governmental policy cooperation. The Smithsonian Migratory Bird Center is currently contemplating the inclusion of IOC coffee farms under its Bird Friendly coffee label. However, such strategies do require continual outreach efforts on the part of conservation organizations aimed at maintaining and increasing global consumer market demand for coffee production that benefits birds (cf. Raynolds et al. 2007).

Apart from the data on migratory collisions, little else is known about threats specific to Golden-winged Warbler during its migratory period. Explicit connectivity between breeding and non-breeding subpopulations has yet to be established, but it is possible that some individuals may make round-trip annual flights of over 9,000 km. Survival rates during migration are therefore likely to be important determinants of population growth. As noted in the Migration section on page 1–23, most Golden-winged Warblers are probably trans-Gulf migrants, so loss of stopover habitat along the Gulf coast may comprise a significant threat. Over the past 30 years, human development of coastal stopover habitat has probably increased risk (decreased survival) during migration, and such development in coastal areas is likely to continue into the future.

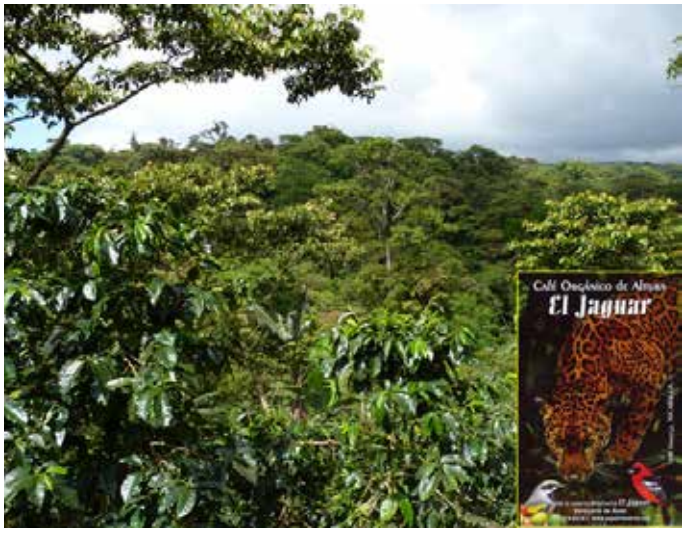

Figure 1–19. An example of an Integrated Open Canopy coffee production system: Reserva el Jaguar, Jinotega, Nicaragua. Due to the frequency of cloud cover and fog in this mountain environment, coffee (foreground) is grown in the open, but 100 ha of cloud forest (65% of the total property area) are preserved in a pristine state (background). Wintering Golden-winged Warbler is one of 280 resident and migrant species recorded at the site.

Interactions with Blue-winged Warbler during winter have not been well documented, so it is not known whether hypothesized threats due to competition continue into the non-breeding season. Winter distributions of Blue-winged and Golden-winged warbler are generally allopatric since Blue-winged Warbler winters farther north in northern Central America and Mexico (Gill et al. 2001). Substantial overlap of the two species may be limited to Guatemala, northern Honduras, and Nicaragua (Confer 1992, Gill et al. 2001); Blue-winged Warbler is scarce in Costa Rica (Stiles and Skutch 1989) and rare in Panama (Ridgely and Gwynne 1989). Little is known about non-breeding season habitat segregation between the two species. Thus it is not known whether differential habitat loss or degradation during the non-breeding season might affect non-breeding season survivorship or linked breeding season productivity leading ultimately to different population trajectories for Golden-winged and Blue-winged warblers.

REGIONAL, STATE, AND PROVINCIAL SUMMARIES

Following the format of previous status assessments for other species, we compiled state- and province-specific information relative to conservation status, historic and current distribution, population trends, habitat use, current research and monitoring efforts, and potential threats. State Heritage ranks were derived from those reported in the NatureServe database (NatureServe 2011) and are defined in Table 1–6. We also summarized BBS, Breeding Bird Atlas (BBA), and BBC data (see page 1–11 for a discussion of BBS). Note that when we reported the total number of BBS routes within a state on which Golden-winged Warbler has been detected over the lifetime of the survey, we included specially designated BBS routes (e.g., 300 or 900 series routes) which may have been excluded for various statistical reasons from BBS trend analyses reported online (Sauer et al. 2012) or elsewhere in the text. In addition to individual published state BBAs, two sources of compiled state atlas data were particularly useful—the USGS North American Breeding Bird Atlas Explorer (cited as USGS BBEA 2012) and the Cornell Lab of Ornithology's bird.atlasing.org online atlas management tool (cited as CLO BBA 2012).

Many of the research and conservation strategies outlined in Chapter 2 of this document—and especially the management guidelines articulated in Chapter 3—were developed in response to the initial habitat analyses and conservation vulnerabilities compiled for these state and regional summaries.

Table 1–6. NatureServe State Heritage ranks (NatureServe 2011).

Ranking Code	Definition
SX	Presumed extirpated from state.
SH	Possibly extirpated from state.
S1	Critically imperiled in the state because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines making it especially vulnerable to extirpation.
S2	Imperiled in the state because of rarity due to very restricted range, very few populations (often 20 or fewer), steep declines, or other factors making it very vulnerable to extirpation.
S3	Vulnerable in the state due to a restricted range, relatively few populations (often 80 or fewer), recent and widespread declines, or other factors making it vulnerable to extirpation.
S4	Uncommon but not rare; some cause for long-term concern due to declines or other factors.
S5	Common, widespread, and abundant in the nation or state.
SNR	State conservation status not yet assessed.
SNA	A conservation status rank is not applicable because the species is not a suitable target for conservation activities.

The state summaries are grouped by USFWS Region and arranged more or less geographically within Regions, west to east and/or north to south. Golden-winged Warbler population size estimates for states and provinces are presented in Table 1–7, following the Partners in Flight methodology described on page 1–12. Note that these estimates are particularly sensitive to the average maximum detection distance assumption (Thogmartin et al. 2006); reducing the detection distance value from 125m to 80m, for example, would more than double the estimates.

Table 1–7. State and province population estimates for Golden-winged Warbler derived from BBS data for the 1998–2007 decade and the Partners in Flight Population Estimates Database, Version 2.0 (PIF Science Committee 2013) using an average maximum detection distance of 125m.

Province/State	Country	Rounded Population Estimate	% Total Breeding Population	SE BBS Average[1] (birds/rte)	SE Population Estimate[2]
Minnesota	USA	194,500	47.0%	0.32	±23%
Wisconsin	USA	109,900	24.4%	0.12	±17%
Ontario	Canada	63,500	15.3%	0.06	±27%
Michigan	USA	19,700	4.8%	0.08	±58%
New York	USA	9,400	2.3%	0.06	±56%
Pennsylvania	USA	7,100	1.7%	0.03	±36%
West Virginia	USA	5,700	1.4%	0.04	±39%
Tennessee	USA	3,900	0.9%	0.09	±93%
Manitoba	Canada	3,700	0.9%	0.03	±73%
Vermont	USA	1,500	0.4%	0.05	±83%
North Carolina	USA	1,200	0.3%	0.03	±49%
Quebec	Canada	800	0.2%	—	—
Virginia	USA	700	0.2%	0.01	±73%
Maryland	USA	500	0.1%	0.06	±50%
Ohio	USA	200	0.05%	—	—
New Hampshire	USA	100	0.03%	—	—
New Jersey	USA	100	0.02%	—	—

[1]Estimated standard errors for BBS data, using only BCR regions within states in which Golden-winged Warblers were detected.
[2]Estimated standard errors for population estimate, assuming that BBS is the only source of error and that there is no roadside bias. Sensitivity analysis suggests, however, that relatively small errors in estimating maximum detection distance (e.g., SE of ±15m) can have an effect equivalent to the SE of the BBS (e.g., in MN BCR 12)

USFWS Midwest Region 3 Summary

Minnesota, Wisconsin, Michigan, Iowa, Missouri, Illinois, Indiana, Ohio

The three northern states in Region 3 currently harbor an estimated 76% of the total global population of breeding Golden-winged Warbler (PIF Science Committee 2013, Table 1–7). Generally, the species now commonly occurs to the north of a line through the center of the Prairie Hardwood Transition Bird Conservation Region (BCR 23) in a band that also includes virtually the entire U.S. portion of the Boreal Hardwood Transition (BCR 12) with the exception of the northeastern-most tip of the "Arrowhead" in northeast Minnesota. Densities increase dramatically from southeast to northwest across BCRs 23 and 12, with 5%, 24%, and 47% of the estimated population in Michigan, Wisconsin, and Minnesota, respectively (Table 1–7). Wetland shrub communities are more extensive in the northwestern U.S. portion of BCR 12 and provide a population stronghold for Golden-winged Warbler. Golden-winged Warbler has been extirpated as a breeding species from Missouri, Iowa, Illinois, and Indiana, where habitat loss has been more concentrated, is virtually extirpated from Ohio, and risks extinction from Michigan and Wisconsin by 2100 (Figure 1–7). Across Region 3 from 1966 to 2010, Golden-winged Warbler declined by -1.48% per year (95% CI: -2.47, -0.45; n = 145 routes). Across the Boreal Hardwood Transition from 1966 to 2010, the species declined by -1.09% per year (95% CI: -2.18, -0.04; n = 127 routes) (Sauer et al. 2012).

In the Upper Midwest, Golden-winged Warbler habitat falls into two very broad classes—upland young forest communities and wetland shrub communities, both in predominantly forested landscapes. Upland communities include both succeeding old fields and pastures (5–30 years after abandonment) and regenerating clearcuts, primarily aspen, from two to ten years after cutting. The Golden-winged Warbler Atlas Project (GOWAP, Barker Swarthout et al. 2009) sam-

pled 1,824 sites from the Upper Midwest region (Michigan, Wisconsin, Minnesota, and Manitoba). Wetland habitats appeared to be the most frequently used of those sampled—wetland shrub sites alone accounted for 25% of sites recording Golden-winged Warbler and all wetland habitats combined accounted for 44% of sites (Figure 1–20). Clearcuts also appeared to be very important, accounting for 20% of all sites with Golden-winged Warbler.

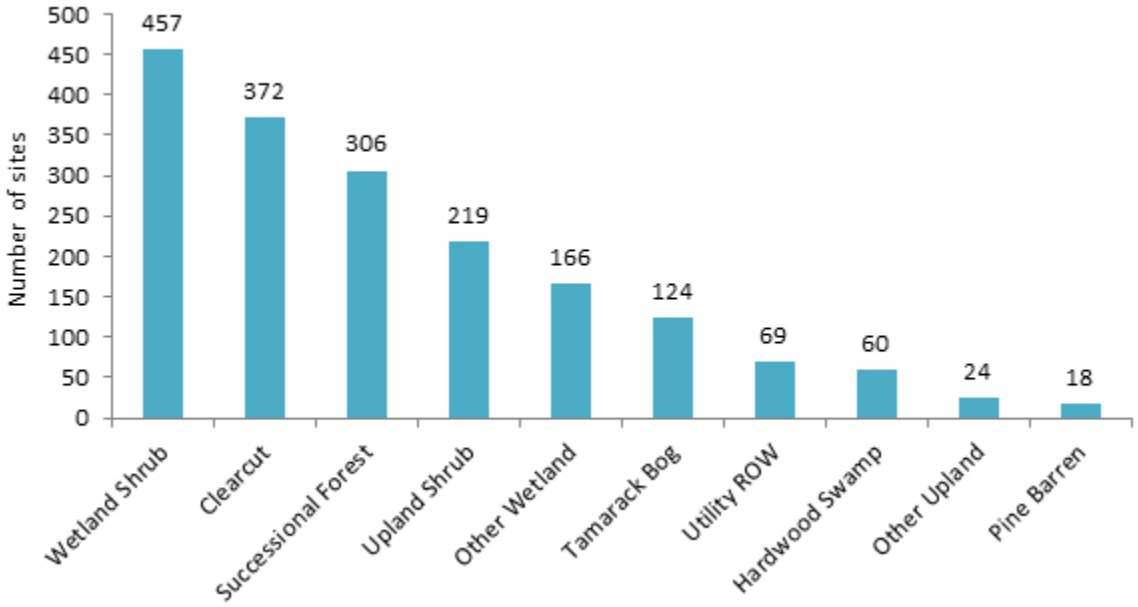

Figure 1–20. Distribution of habitat types at sites in the Upper Midwest region where Golden-winged Warbler was detected. Since sampling was non-random, these data represent only habitats where the species was detected and therefore do not characterize use versus availability of habitat. See Appendix F for habitat definitions. In this figure, Upland Shrub = upland shrubby field + upland abandoned farm; Wetland Shrub = alder swamp + beaver wetland + shrub wetland.

GOWAP collaborators in Minnesota, Wisconsin, and Michigan conducted additional, more quantitative surveys at 1,458 sites to determine finer level habitat associations and to estimate habitat utilization vs. habitat availability (Barker Swarthout et al. 2009). Overall, Golden-winged Warbler was detected at roughly 50% of all sites surveyed. A significantly higher proportion of sites in wetland shrub and clearcut habitats supported at least one Golden-winged Warbler, whereas significantly fewer sites in upland shrub and successional forest habitats supported the species. In the GOWAP survey, sites with a mosaic of habitat types in close proximity were less likely to record Golden-winged Warbler than sites made up of a single habitat type classification. Both aspens in clearcuts and alders in wetland shrub habitats were positively associated with Golden-winged Warbler detections, whereas mixed-conifer and northern hardwood forest vegetation types were negatively associated with warbler presence. Detection rates were 2.68 times greater at sites described as "wetland" (and having "alder" as the primary vegetation type) than at other habitat types. Overall, wetter sites were significantly more likely to record Golden-winged Warbler, as were sites with sparser tree cover and denser shrub and herbaceous layers.

Over the last century, aspen has increased as a forest type across the northern Midwestern landscape and may now exist outside its historic range of variation in this region (Frelich 2000, Host et al. 2001). Golden-winged Warbler has been documented at high densities in aspen clearcuts in northern Wisconsin (Roth and Lutz 2004), although there was no comparison in the same study with densities in other habitat types. Recent research (Roth et al. 2013) in north-central Wisconsin suggested that Golden-winged Warbler reproductive success and adult return rates from aspen clearcuts (with deciduous legacy tree retention) were comparable to those recorded from other habitats elsewhere in the breeding range that are considered optimal for the species. Industrial rotations that would provide substantial acreage in seral stages appropriate for Golden-winged Warbler will likely require fairly large amounts of aspen on the landscape. However, the vast majority of such aspen would be in uplands, where the probability of secondary contact with Blue-winged Warbler might be greater. Some researchers and forest managers have suggested that replacement of Golden-winged Warbler by Blue-winged Warbler may potentially be facilitated by a strategy of extensive upland forest cutting in areas of northern Wisconsin and especially in areas of northern Minnesota not currently heavily populated by Blue-winged Warbler (cf. Hanowski 2002). On the other hand, Fowlds (2010) found that Blue-winged Warbler reached its highest relative abundance in central Wisconsin in swamp edge (e.g., alder/willow shrub) and wetland transitions to mature forest. Research is needed to develop a management strategy for Golden-winged Warbler in areas where Blue-winged Warbler either currently occurs or is likely to occur in the near future. Other researchers (e.g., Streby et al. 2011a, 2011b) have provided evidence that young forest habitat in the context of dynamically changing forest

landscapes will benefit suites of both mature and young forest breeding species, including Golden-winged Warbler. Consequently, some researchers and conservationists in the region stress the importance of facilitating management for seral diversity at landscape scales.

To the extent that Golden-winged Warbler makes use of the shrub layer and associated understory within forests—both when nesting in forest openings or during the post-fledging period (Streby, unpubl. data)—deterioration of understory and shrub layer vegetation caused by invasive non-native earthworms poses a potential threat to Golden-winged Warbler populations in the region. Such understory effects of earthworms have been tied to both local and regional reductions in the abundance of ground-nesting Ovenbirds (Loss and Blair 2011, Loss et al. 2012). Most previous earthworm research has focused on maple and basswood forests (cf. Frelich et al. 2006). However, invasive earthworms could negatively affect Golden-winged Warbler habitat since they are widespread throughout the hardwood woodlands of Region 3 (Holdsworth et al. 2007) and since invasive earthworm habitat impacts have been documented in aspen woodlands (Scheu and Parkinson 1994).

Wetland shrub communities may be particularly important for conservation of Golden-winged Warbler in the region (Hanowski 2002). Upland young forest communities are relatively transient, whereas northern wetlands have slower rates of succession such that lowland herbaceous and shrubby habitat persists for a longer period of time. However, there have been no studies of Golden-winged Warbler persistence relative to lowland shrub community succession; alder wetland stands can become "over-mature" for Golden-winged Warbler, and cutting management may still be necessary to increase herbaceous and smaller shrub cover. There is some evidence that wetland habitat such as tamarack (*Larix laricina*) swamps and sedge (Cyperaceae spp.) meadows with woody islands may provide a refuge in which Golden-winged Warbler may persist in the zone of overlap with Blue-winged Warbler (cf. Will 1986 for southern Michigan) well beyond the 50 years for replacement after secondary contact originally documented by Gill (1980). Thus one of the biggest threat to Golden-winged Warbler in the Upper Midwest may be continued wetland drainage and loss of associated lowland shrub communities, invasion by exotic wetland plants, and lack of lowland shrub community management to remedy disturbed hydrology or to replicate suppressed natural vegetation disturbance regimes. More research is needed to evaluate the role of wetland shrub communities as refugia for Golden-winged Warbler in areas of secondary contact with Blue-winged Warbler in the Upper Midwest.

Minnesota

State Legal Status: Unlisted
Natural Heritage Rank (see Table 1–6 for definitions): SNR

Summary: Historically, Golden-winged Warbler apparently was never abundant in Minnesota. Roberts (1932) reports that during migration "even in the old days, the seeing of 10 or 12 was a rare event." At the beginning of the 20th century, Golden-winged Warbler was found as far south as Fillmore County in the southeast to Itasca County in north-central Minnesota (Roberts 1932 in Hanowski 2002). During the last century, Golden-winged Warbler expanded beyond Itasca Park and Cass Lake (47°30′ latitude) to the Canadian border in Lake of the Woods and Koochiching counties (Janssen 1987, GOWAP) and virtually disappeared as a breeder from Hennepin, Wright, and Stearns counties. Blue-winged Warbler was first recorded breeding in southeastern Minnesota (Fillmore County) in 1885 and 1893 (Roberts 1932). Blue-winged Warbler now breeds primarily in the two tiers of counties along the Mississippi River north to Dakota County; has expanded from the 1940s to 1960s northward into Washington, Hennepin, Anoka, and Scott counties (Janssen 1987); and has more recently reached as far westward as Stearns County. Allopatric phenotypic Golden-winged Warbler populations (outside the range of expanding Blue-winged Warbler) still remain in the far north (Shapiro et al. 2004), but Vallender et al. (2009, unpubl. 2010 data) have found Blue-winged mtDNA (i.e., cryptic hybrids) in some of the phenotypic Golden-winged Warblers in this region (Figure 1–12).

BBS: Golden-winged Warbler has been detected on 38 BBS routes in Minnesota over the length of the survey (1966–2010). Analyses of long-term BBS data (1967–2010) suggest that population trends for Golden-winged Warbler have remained relatively stationary in the state at +0.5%/year (95% CI: -1.2, +2.1; n = 36; Sauer et al. 2012, Figure 1–21). Despite a stationary population trend estimate, the median relative abundance in Minnesota has increased by nearly 50% over the length of the BBS (Figure 1–21).

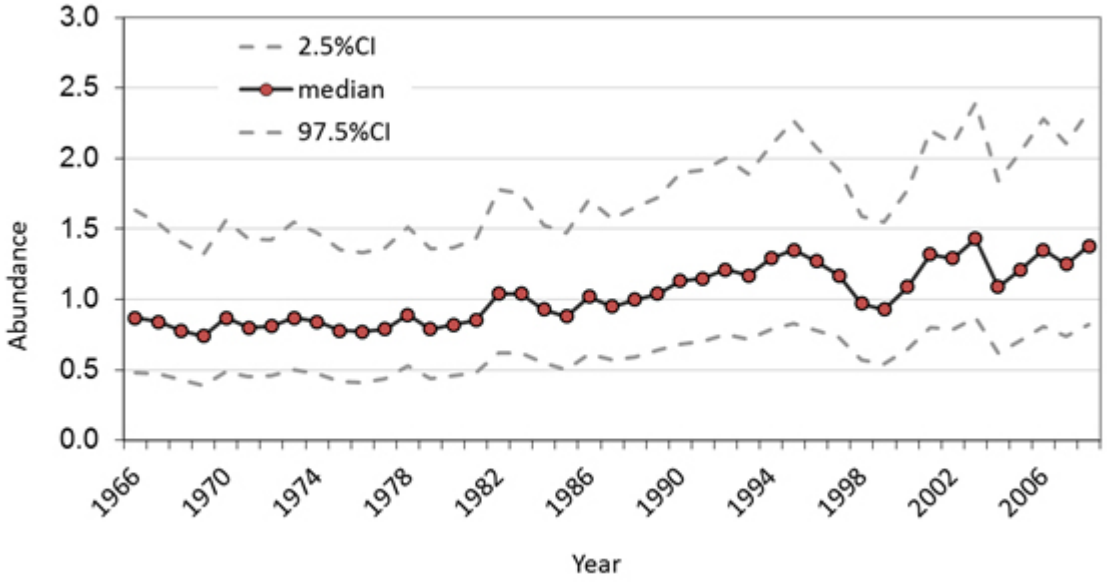

Figure 1–21. Changes in relative abundance of Golden-winged Warbler in Minnesota based on hierarchical Bayesian analyses of BBS data (1966–2009).

Results from a population viability analysis for Minnesota suggest a 4% probability (95% CI: <0.01%, 87.6%) of a 90% decline of Golden-winged Warbler by 2100 from 2000 population levels if current trends were to continue into the future (Figure 1–22).

BBA: Minnesota's first Breeding Bird Atlas project is currently underway; the data collection period is 2009–2013. The atlas will include spatially balanced point counts as well as the typical volunteer survey of priority township blocks.

BBC: Censuses have been conducted in potentially suitable habitat (e.g., young aspen stands), and Golden-winged Warbler was recorded on Minnesota census plots in 1993. However, sites have not been monitored long enough to document population trends.

Habitat Use: Habitat use varies by region. Hanowski (2002) documented habitat associations of the species in Minnesota and Wisconsin national forests; percent lowland shrub cover with a 100 m buffer was the best predictor of Golden-winged Warbler presence, and sites with >10% lowland shrub cover were three times more likely to record Golden-winged Warbler. In Chippewa National Forest, birds were observed in young (<11 year-old) stands of aspen and aspen/mixed forest, white spruce (*Picea glauca*)/balsam fir (*Abies balsamea*) forests, and swamp conifer forests. Alder habitats were not sampled on the Chippewa, but Streby and Andersen (pers. comm.) observed and captured Golden-winged Warbler in mist-nets in alder habitats on the Chippewa in 2009. In the St. Croix region, Golden-winged Warbler similarly used young aspen regeneration areas and swamp conifer forests; alder was also an important habitat type (Hanowski 2002). In Sherburne and Isanti counties, Golden-winged Warbler was recorded in barrens savanna, oak openings, and aspen or willow-dominated wetlands (Au, pers. obs.).

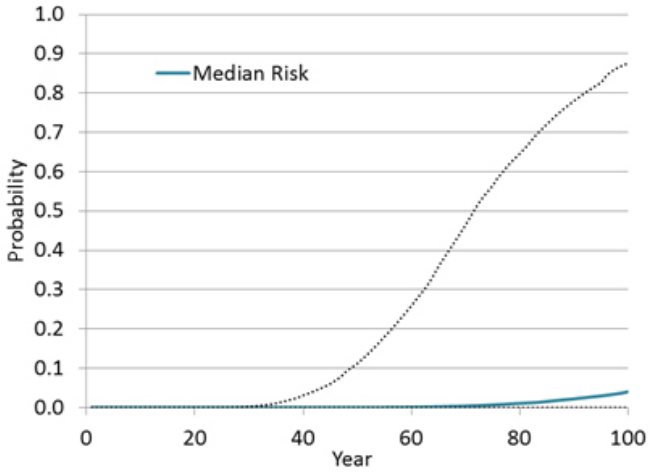

Figure 1–22. Risk of quasi-extinction for Golden-winged Warbler in Minnesota as determined by a 90% decline from the year 2000 population by year 2100. Dashed lines represent the 95% credible interval. See Appendix C for methods.

Huffman (1997) documented vegetative characteristics of Golden-winged Warbler territories in young aspen clearcuts at Tamarac National Wildlife Refuge (NWR) in west-central Minnesota. More recently at Tamarac, Streby and Andersen (unpubl. data) found that most females nested in upland early successional stands, and most females initially netted in shrubby wetland sites ended up nesting in uplands (Streby, pers. comm.). Most breeding pairs used every cover type available at some time during the season; for example, a female nesting in a shrubby upland might forage in nearby mature forest or wetland edges and then accompany fledglings through extensive mature forest and forested wetland edges throughout the post-fledging period (Streby et al. 2012, Streby pers. comm.); whether the fledgling was in a clearcut, mature forest, or along a wetland edge, it usually perched in dense cover (e.g., hazelnut *Corylus* spp.) for

the first weeks after fledging, and after about three weeks, spent more time in taller understory trees and in the canopy of mature forest (Streby pers. comm.). In 2011, (Streby and Andersen unpubl. data) also found that some (~15%) radio-marked females nested in single tree-fall gaps in mature forest and in closed-canopy mature forest with sparse shrub-layer vegetation >50 m from edges at both Tamarac and Rice Lake NWRs.

Golden-winged Warbler landscape models have been developed from Minnesota and Wisconsin national forest data by Howe and Jones (2002) and from BBS data in BCRs 12 and 23 by the USGS Upper Midwest Environmental Sciences Center (UMESC 2003).

Current Research and Monitoring: Minnesota conducts a systematic County Biological Survey. Through 2011, 84 of 87 counties have been surveyed, 26 of which have recorded Golden-winged Warbler (Stucker, pers. comm.). Annual off-road surveys have been used to monitor forest birds in the Chippewa and Superior national forests and along the St. Croix River in northern Minnesota since 1991. An analysis of these data suggested that neither site-level population trends nor the composite regional trend had changed significantly through 2001 (Hanowski 2002).

Tamarac NWR was one of the eight study sites that comprised the 2008–2010 collaborative research project of the Golden-winged Warbler Rangewide Conservation Initiative (Appendix D). Also at Tamarac, Streby et al. (2012 and ongoing) radio-tracked both adult and fledgling birds and found that adult birds utilized much larger areas than those defined by traditional spot-mapping of singing males, especially in the late morning and afternoon, and that parent-fledgling groups were frequently encountered in mature forest away from shrubby edges within a few days of fledging and throughout the remainder of the post-fledging period. Streby and Andersen are currently conducting an intensive study of Golden-winged Warbler reproductive success through the post-fledging period along a climate and hybridization gradient that includes Tamarac, along with Rice Lake NWR to the southeast and provincial forests to the northwest in southeastern Manitoba. An international team (Roth and Flaspohler, Michigan Tech; Hobson, Vallender, and VanWilgenburg, Environment Canada; and multiple cooperators in Latin America) is currently using stable isotopes and DNA to investigate migratory connectivity between Golden-winged Warbler breeding and wintering areas, elucidate patterns of juvenile dispersal on the breeding grounds, and fill gaps in Golden-winged Warbler genetic atlas coverage along a transect from southwest Wisconsin to Manitoba.

Threats: The last ten years of BBS data suggest that Golden-winged Warbler remains relatively common in the state, with stable or even increasing populations. Competition and hybridization with Blue-winged Warbler still is not pronounced in Minnesota, as the zone of contact between these two species appears to be more limited than elsewhere in the Golden-winged Warbler range. Recent work by Vallender et al. (2009), however, documents cryptic mitochondrial introgression in some birds even in the northwestern portion of the state (see Figure 1–12).

Minnesota has seen considerable debate regarding the relative role of increasing upland aspen regeneration acreage versus preserving and enhancing wetland shrub communities as a focus for Golden-winged Warbler conservation; essentials of the discussion are summarized above in the Midwest Regional summary section. Recent revisions of national forest management plans have proposed reductions in the amount of young aspen forest on national forests, and some biologists have assumed that such policies will inevitably lead to decreases in Golden-winged Warbler. In response, collaborative conservation efforts like the Young Forest Initiative (cf. Wildlife Management Institute 2009) have developed strategies for working with private forest landowners to increase young forest acreage for American Woodcock, Golden-winged Warbler, and associated wildlife species. Many state biologists believe that Golden-winged Warbler can be sustained primarily through protection of lowland shrub habitats and that additional loss of early successional upland habitat is not a threat to Golden-winged Warbler population viability in Minnesota (e.g., Richard Baker, MN Department of Natural Resources [DNR], pers. comm.; Bruce Johnson, Leech Lake Band of Ojibwe, pers. comm.). Preliminary results from radio-telemetry research in northern Minnesota suggest that where upland and wetland habitats are both abundant, Golden-winged Warbler forages extensively along edges of wetlands during the nesting and post-fledging periods, but breeds more densely and more successfully in shrubby upland habitats (Streby and Andersen unpubl.data). Preliminary results from the Minnesota demographic study suggest that a landscape including a mix of early successional upland, shrubby wetland, and mature-forest habitats may optimize Golden-winged Warbler productivity; as a result, current management discussions are focusing on strategies for maintaining dynamic forest landscapes that include appropriately balanced mosaics of both mature and regenerating forest habitats, including early seral lowland shrub and forested wetland communities.

Wisconsin

State Legal Status: Special Concern

Natural Heritage Rank (see Table 1–6 for definitions): S4

Summary: Historically, Golden-winged Warbler was broadly distributed across Wisconsin (Robbins 1991). Extensive clear-cutting during the mid-19th to early 20th century created ample suitable habitat for a species dependent on young forest within forested landscapes. More recently, the Golden-winged Warbler breeding range has contracted northward, and the species is now largely extirpated from most historical breeding areas in the southern regions of the state (Cutright et al. 2006). Loss of shrubby habitat to succession and development, genetic introgression with northward-expanding Blue-winged Warbler, and possibly climate change may have played a role in this range shift.

The first Blue-winged Warbler specimen in Wisconsin was taken in 1867, but the species was not reported regularly in the southern tier of counties until the turn of the 20th century (Robbins 1991). By the 1920s, Blue-winged Warbler was numerous in the Wisconsin and Mississippi river watersheds; by the 1950s, it was found consistently in the southern tier of counties. Blue-winged Warbler is now firmly established throughout most of southern Wisconsin.

BBS: Golden-winged Warbler has been recorded on 62 BBS routes in the state, primarily in the northern two-thirds of Wisconsin. Analysis of long-term BBS data (1966–2010) suggests that Golden-winged Warbler populations have declined significantly (-2.8% per year, 95% CI: -4.1, -1.5; n = 62; Sauer et al. 2012)—a decline of approximately 60% over the length of the BBS (Figure 1–23).

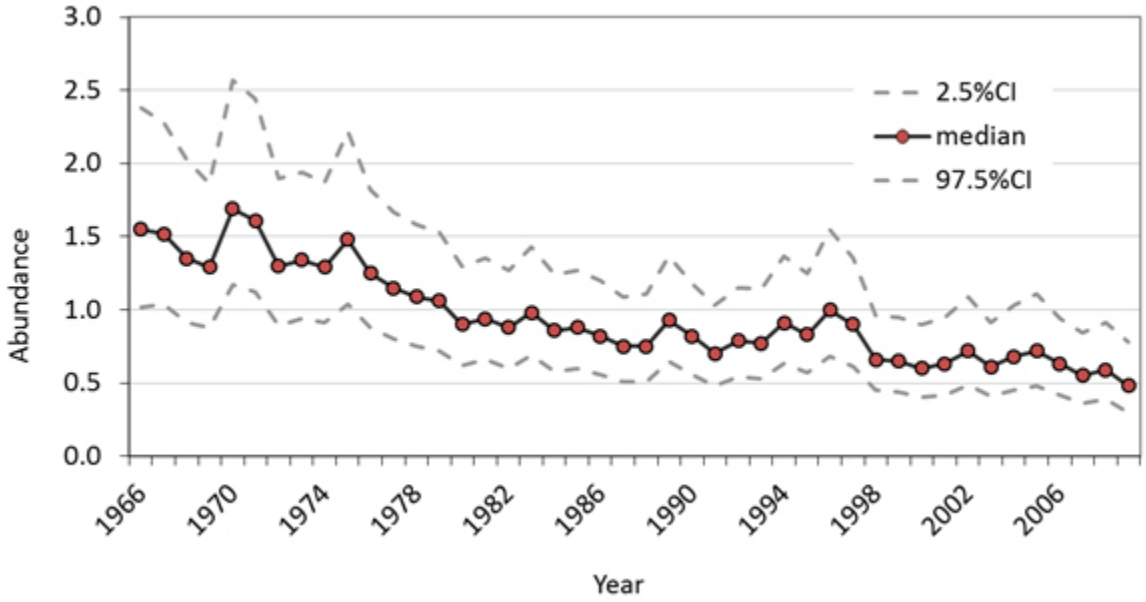

Figure 1–23. Changes in relative abundance of Golden-winged Warbler in Wisconsin based on hierarchical Bayesian analyses of BBS data (1966–2009).

By 2100, if trends and variability in trends persist as they have for the last 40 years, Golden-winged Warbler has a 65.9% (95% credible level: 0.5%, 99.9%) risk of a further 90% loss in Wisconsin's population (Figure 1–24).

BBA: A Breeding Bird Atlas was conducted in Wisconsin from 1995–2000. Golden-winged Warbler was confirmed breeding in a broad band across northern and central Wisconsin, with few blocks reporting the species in the southern third of the state (Cutright et al. 2006). Golden-winged Warbler was detected in 402 priority blocks in Wisconsin, and breeding was confirmed in 161 of those blocks.

BBC: No Golden-winged Warblers have been recorded in Wisconsin Breeding Bird Census plots, although none have been conducted in suitable habitat during the past 30 years.

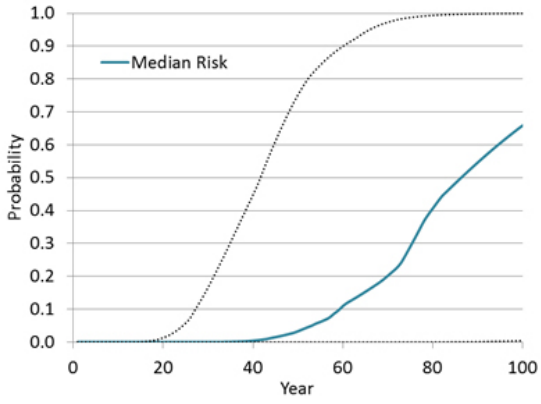

Figure 1–24. Risk of quasi-extinction for Golden-winged Warbler in Wisconsin as determined by a 90% decline from the year 2000 population by year 2100. Dashed lines represent the 95% credible interval. See Appendix C for methods.

Habitat Use: Golden-winged Warbler occurs in a wide variety of early successional habitats within forested landscapes in Wisconsin. It often inhabits brushy clearcuts, shrubby swamps, overgrown abandoned agricultural fields, and edges of deciduous forests, especially aspen (Cutright et al. 2006). Roth and Lutz (2004) found that Golden-winged Warbler densities in aspen clearcuts in northern Wisconsin dropped significantly around ten years after cutting. One to ten year-old aspen stands harbored a higher abundance of Golden-winged Warbler than other early seral habitats in north-central Wisconsin (Martin et al. 2007). In central Wisconsin, Fowlds (2010) found higher abundances of Golden-winged Warbler in aspen clearcuts less than ten years old and also in lowland shrub edges adjacent to mature forest (relative to young hardwood stands under 20 years of age). Tall (>0.5 m) forb cover was associated with higher abundances of Golden-winged Warbler in the aspen clearcuts and the lowland shrub/mature forest edge sites. Fowlds (2010) also found that in shrub/mature forest edge sites, Golden-winged Warbler territories had more ground cover than did Blue-winged Warbler territories; in clearcuts, Golden-winged Warbler territories had a lower mature tree density than did Blue-winged Warbler territories. In the national forests of Minnesota and Wisconsin, Golden-winged Warbler presence was best predicted by the amount of lowland shrub cover within a 100 m buffer area of the survey point (Hanowski 2002). Consistent with observations of radio-tagged birds in Minnesota (Streby et al. 2012, see pages 1–17 and 1–18)—and underscoring the importance of landscape context over patch characteristics only—are two observations from Wisconsin. Golden-winged Warbler has been consistently observed in patches of alder with scattered trees contiguous to a wooded corridor along the Kakagon River in northwestern Wisconsin but has not been found in similar alder patches adjacent to more open areas in the Kakagon Sloughs (Matteson, pers. comm.). Also, at Empire State Wildlife Area in Douglas County, Golden-winged Warblers were found in alder patches containing a few scattered trees adjacent to mature forest stands, while no individuals were detected in alder swamps connected with open sedge meadows or very young forest (Hoffman, pers. comm.).

Current Research and Monitoring: Wisconsin contributed data from two study sites to the 2008–2010 collaborative research project of the Golden-winged Warbler Rangewide Conservation Initiative (see Appendix D)—one from north-central forests (Roth, unpubl. data) and one from the Central Sand Plains (Fowlds 2010). Roth (Michigan Technological University) plans to continue monitoring male Golden-winged Warbler survival on nine additional study sites initially surveyed in 2007 in north-central Wisconsin. Unbanded birds will continue to be color-banded until all sites are abandoned by Golden-winged Warblers. (In 2012, six sites that were still occupied included several males that were at least six years old.) A 2012 study in Langlade and Marathon counties is evaluating alder management as a tool for increasing Golden-winged Warbler use of lowland shrub habitat (Roth and American Bird Conservancy). An international team (Roth and Flaspohler, Michigan Tech; Hobson, Vallender, and VanWilgenburg, Environment Canada; and multiple cooperators in Latin America) is currently using stable isotopes and DNA to investigate migratory connectivity between Golden-winged Warbler breeding and wintering areas, elucidate patterns of juvenile dispersal on the breeding grounds, and fill gaps in Golden-winged Warbler genetic atlas coverage along a transect from southwest Wisconsin to Manitoba.

Monitoring by BBS, BBA, Wisconsin DNR, and the U.S. Forest Service (USFS) appears to be adequate for tracking status in the state. Data have been collected since 1987 for the Nicolet National Forest under a monitoring program coordinated by the University at Wisconsin-Green Bay (UWGB 2002). Analyses from 1987–2001 did not indicate significant population declines (UWGB 2002, as reported by Hanowski 2002). In addition to these monitoring programs, Golden-winged Warbler landscape models have been developed from Minnesota and Wisconsin national forest data by Howe and Jones (2002) and from BBS data in BCRs 12 and 23 by the USGS Upper Midwest Environmental Sciences Center (UMESC 2003).

Threats: Hybridization with Blue-winged Warbler is considered a significant threat to the future genetic integrity of Golden-winged Warbler in Wisconsin because the ranges of the two species overlap substantially in the state (see Figures 1–11 and 1–12). During the last half-century, Blue-winged Warbler has expanded into areas formerly occupied by Golden-winged Warbler, especially in the southern and western portions of Wisconsin (Robbins 1991). Other threats include wetland loss, land development (Kreitinger and Paulios 2007), reduced frequency of natural disturbance regimes, potential overall loss of forested habitat due to climate change, and advancing succession and fragmentation of early seral woodlands—e.g., acres of young aspen/birch (0–19 years) have declined by 38% from 1983 to 2007/2011 in Wisconsin (U.S. Forest Service 2012c, but cf. Figure 1–16 for all hardwood seedling/sapling timberland).

Early seral forest habitat loss has occurred across most ownership types in the Wisconsin portion of BCR 12 despite a strong emphasis on aspen management on state- and county-owned forests. The biggest declines have occurred on private lands, which make up a substantial portion of the forested landscape in the region. In order to address these declines, Wisconsin DNR has partnered with the Wildlife Management Institute to implement the habitat goals of the Young Forest Initiative (WMI 2009). The state's Wildlife Action Plan calls for maintaining large blocks of northern forest that contain a mosaic of upland and lowland shrub communities, especially alder and willow thickets, and, where appropriate, stands of young aspen—in general, a strategy likely to benefit Golden-winged Warbler. In addition, Wisconsin has been a leader (through the Wisconsin Bird Conservation Initiative and with some state DNR support) in efforts to protect and/or restore habitat for long-distance migrants on the Neotropical non-breeding grounds.

Michigan

State Legal Status: Unlisted

Natural Heritage Rank (see Table 1–6 for definitions): S5

Summary. Golden-winged Warbler was fairly common in the state by the early 1900s (Berger 1958), but its distribution has shifted northward over the past century. Although this shift has coincided with the arrival in Michigan of Blue-winged Warbler, it is uncertain to what extent this arrival has influenced the northward expansion of Golden-winged Warbler. Some observers attribute the Golden-winged Warbler range shift to habitat changes related to logging (Brewer et al. 1991), although increased urbanization and inadequate management of private lands are also likely factors in the conversion of early successional habitats (K. Cleveland, Michigan DNR, pers. comm.). The most recent BBA effort documents continued disappearance of Golden-winged Warbler from southern Michigan and continued expansion of the Blue-winged Warbler range into northern portions of lower Michigan. Golden-winged Warbler is reported to occur across the Upper Peninsula (Brewer et al. 1991), although none have been reported on Ottawa National Forest in the western part of the Upper Peninsula in spite of recent surveys of apparently suitable habitat (B. Bogaczyk, pers. comm.). Habitat loss from forest maturation and negative interactions with Blue-winged Warbler are the major threats to Golden-winged Warbler in the state (R. Adams, Kalamazoo Nature Center, pers. comm.).

BBS. Golden-winged Warbler has been detected on only 11 BBS routes in the last 10 years (2001–2010) compared to 25 routes during the 1990s. Analyses of long-term BBS data (1966–2010) suggest that Golden-winged Warbler has experienced relatively steep declines of -5.1% per year in Michigan (95% CI: -7.3, -3.0; *n* = 46 routes; Sauer et al. 2012; Figure 1–25).

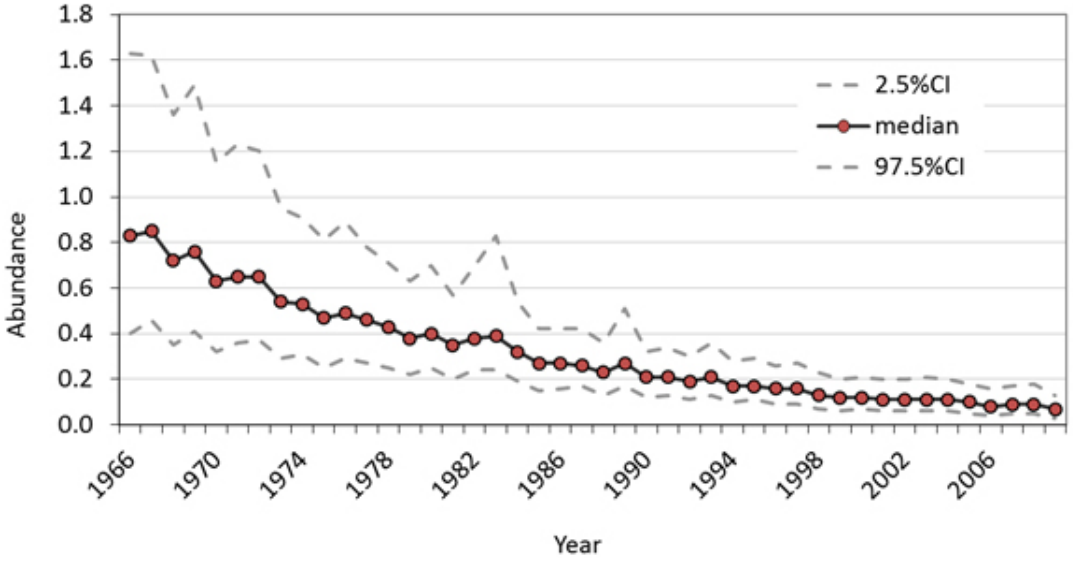

Figure 1–25. Changes in relative abundance of Golden-winged Warbler in Michigan based on hierarchical Bayesian analyses of BBS data (1966–2009).

By 2100, if trends and variability in trends persist as they have for the last 40 years, Golden-winged Warbler has a 100% (95% CI: 100%, 100%) risk of a further 90% loss in Michigan's population (Figure 1–26).

BBA: Field work was conducted from 1983–1988 for Michigan's first Breeding Bird Atlas (Brewer et al. 1991) and from 2002–2008 for the second atlas effort (Chartier et al. 2011). Despite the fact that fewer priority blocks were surveyed in the second atlas, with less overall effort involving fewer volunteers, the results suggested a considerable decline in Golden-winged Warbler breeding activity. Golden-winged Warbler was detected in 508 blocks during the first atlas and in only 298 blocks in the most recent atlas. Blue-winged Warbler, in contrast, does not appear to have experienced substantial change; it was detected in 724 blocks during

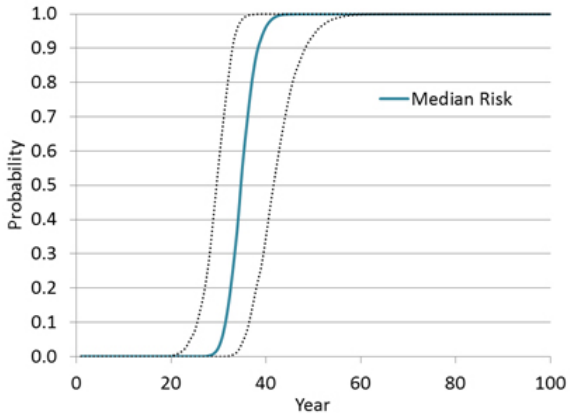

Figure 1–26. Risk of quasi-extinction for Golden-winged Warbler in Michigan as determined by a 90% decline from the year 2000 population by year 2100. Dashed lines represent the 95% credible interval. See Appendix C for methods.

the first atlas and in 731 blocks during the second (Chartier et al. 2011, R. Adams, pers. comm.). In the southern three tiers of counties in the southern Lower Peninsula, Golden-winged Warbler was recorded in 37 townships during the first atlas and in only seven townships during the second (Payne 2011). In the southern Lower Peninsula as a whole they were found in 15% of the townships in the first atlas and in only 4% during the second. In the northern Lower Peninsula, Golden-winged Warbler appeared in 33% of the townships in the first atlas and in 26% in the second. In the Upper Peninsula, the proportion of townships recording Golden-winged Warbler was 16% in the first atlas and 12% in the second; the decrease in distribution occurred mainly in central and western Upper Peninsula in Delta, Marquette, and Ontonagon counties (Payne 2011).

BBC: Although censuses have been conducted in potentially suitable habitat (e.g., tamarack bog), Golden-winged Warbler has not been recorded on Michigan census plots since 1983.

Habitat Use: In Michigan, Golden-winged Warbler inhabits moist swampy woodlands, willow and alder thickets, and upland sites covered with aspen and fire cherry (*Prunus pensylvanica*) saplings (Ewert 1981). In south-central Michigan, it occurs in habitat mosaics with woodland and open areas. In southern Michigan (Washtenaw and Jackson counties north to southern Clinton and Shiawassee counties), the species has been documented nesting in tamarack swamps. In Tuscola County, Golden-winged Warbler occurs in second-growth woodland edges and clearings and dry to poorly drained fields overgrown with aspen and alder. In a study of behavior and nesting ecology of Golden-winged and Blue-winged warbler in southern and central Michigan, Will (1986) found both species in both wetland and upland habitats; however, continued presence of Golden-winged Warbler in tamarack swamps in southern Michigan and relative absence of Blue-winged Warbler from very wet clearcuts overgrown with shrubs or saplings in central Michigan (northern Midland County) suggested that wetland habitat might provide refugia for Golden-winged Warbler phenotypes. Kahl (2003) associated changes in landscape to changes of Golden-winged and Blue-winged warbler populations in the state.

Current Research and Monitoring: Other than the BBS, there are currently no research and/or monitoring projects currently underway in the state.

Threats. Loss of habitat due to forest maturation may be the principle cause for population declines in Michigan. Golden-winged Warbler tends to be segregated from Blue-winged Warbler in wetter habitats, but where the two species co-occur, hybridization likely contributes to Golden-winged Warbler population decline (R. Adams, pers. comm.). Encroachment by autumn olive (*Elaeagnus umbellata*) has destroyed formerly suitable Golden-winged Warbler habitat in the south. In such areas, Blue-winged Warbler has not replaced Golden-winged Warbler, and thus suitable habitat could be restored by managing autumn olive (Payne *in* Brewer et al. 1991). The Golden-winged Warbler decline in the Upper Peninsula detected during the second Michigan Breeding Bird Atlas could not be explained by interaction with Blue-winged Warbler, which was recorded in only four Upper Peninsula township localities as compared to 77 township localities for Golden-winged Warbler (Payne 2011). Other factors may be implicated, such as widespread climatic warming in the region over the last century and increases in more mature forest cover (Payne 2011).

Iowa

State Legal Status: Unlisted

Natural Heritage Rank (see Table 1–6 for definitions): S1

Summary: Golden-winged Warbler is a regular but uncommon migrant in the state, primarily in eastern Iowa (Dinsmore et al. 1984). Possible breeding was reported from Lee County in southeastern Iowa (Jackson et al. 1996). Roberts (1932) claimed that Golden-winged Warbler formerly bred south to southern Iowa, although Kent and Dinsmore (1996) document only three nests in the state, one in the southeast (1888) and two in central Iowa (1898). Blue-winged Warbler also has been reported from Lee County (BBS data), so a recent record could have been a hybrid or a Blue-winged Warbler singing a Golden-winged Warbler song.

BBS: No Golden-winged Warblers have been recorded on BBS routes.

BBA: A Breeding Bird Atlas was conducted from 1985–1990. There was only one possible record of breeding reported from Lee County in southeastern Iowa (Jackson et al 1996).

BBC: Golden-winged Warbler has not been recorded in Iowa Breeding Bird Census plots, although none have been conducted in suitable habitat during the past 30 years.

Habitat Use: Golden-winged Warbler is associated with deciduous forest, edge, and brushy areas (Dinsmore et al. 1984).

Current Research and Monitoring: No research or monitoring specific to Golden-winged Warbler is known to be occurring in Iowa.

Threats: No specific data.

Missouri

State Legal Status: Unlisted

Natural Heritage Rank (see Table 1–6 for definitions): SNA

Summary: Golden-winged Warbler is an uncommon migrant in Missouri (Robbins and Easterla 1992). There is one confirmed 1890 historic nesting record from Mississippi County in the southeast and unconfirmed reports in 1884 from Audrain County in the northeast at a site adjacent to a possible nesting location in Lee County, Iowa (Robbins and Easterla 1992).

BBS: Golden-winged Warbler has not been recorded on Missouri BBS routes.

BBA: A Breeding Bird Atlas conducted from 1986–1992 did not record Golden-winged Warbler (Jacobs and Wilson 1997).

BBC: Golden-winged Warbler has not been recorded in Missouri Breeding Bird Census plots, although none have been conducted in suitable habitat during the past 30 years.

Habitat Use: No specific data.

Current Research and Monitoring: No research or monitoring specific to Golden-winged Warbler is known to be occurring in Missouri.

Threats: No specific data.

Illinois

State Legal Status: Unlisted

Natural Heritage Rank (see Table 1–6 for definitions): S1S2

Summary: Golden-winged Warbler is a fairly common migrant and rare summer resident in northern Illinois (Bohlen 1989). In the late 1800s, breeding was reported from Richland County in southern Illinois (Ridgway 1889) and in the Mississippi River bottoms (Butler 1897). Contemporary records during the breeding season (1980s) are generally from the northern part of the state, including Lake and Will counties (Bohlen 1989) and Henderson County (BBS data). There are no contemporary records from southern Illinois during the breeding season (Robinson 1996). Golden-winged Warbler was reported from three sites (one as confirmed breeder) from Lake and Cook counties during BBA work from 1986–1991 (Kleen et al. 2004). Illinois Natural History Survey currently considers Golden-winged Warbler to be a breeding species in the state.

BBS: Only three Golden-winged Warblers have been recorded on BBS routes: one in Henderson County along the Mississippi River in 1979 and two in Lake County in 1991 and 1995. There have been no subsequent detections on BBS routes through 2010 and thus data are insufficient to determine population trends.

BBA: A Breeding Bird Atlas project was conducted from 1986 to 1991. Confirmed breeding was documented in Cook County in 1986; two other possible breeding records came from Cook and Lake counties in 1991 (Kleen et al. 2004).

BBC: Golden-winged Warbler has not been recorded in Illinois Breeding Bird Census plots, although few censuses have been conducted in suitable habitat during the past 30 years.

Habitat Use: Habitat has not been described in detail from Illinois. Bohlen (1989) characterized habitat generally as deciduous woodlands with thick undergrowth. During the early 1960s, breeding birds in Cook County could be found in abandoned agricultural land converted to mesic hawthorn (*Crataegus* spp.) /crab tree (*Malus* spp.) /plum (*Prunus* spp.)savanna with substantial *Rubus* ground cover (B. Russell, pers. comm.).

Current Research and Monitoring: No research or monitoring specific to Golden-winged Warbler is known to be occurring in Illinois.

Threats: No specific data.

Indiana

State Legal Status: Endangered

Natural Heritage Rank (see Table 1–6 for definitions): S1

Summary: Historically, Golden-winged Warbler was considered a migrant in Indiana and a locally common summer resident in northern Indiana. Mumford and Keller (1984) claimed that almost every large swamp in northern Indiana had its pair of nesting Golden-winged Warblers during the late 1800s, and Butler (1897) reported them breeding "in some numbers" in that region. By the 1980s it was reported as an uncommon to rare migrant statewide and very rare

summer resident, primarily in northern Indiana. Nesting records had been reported up until 1983. Little evidence of breeding has been noted in the past 30 years, however, and thus Golden-winged Warbler may be extirpated from the state as a breeding species (J. Castrale, Indiana DNR, pers. comm.).

BBS: One Golden-winged Warbler was recorded in 1993 from Porter County near Lake Michigan. Blue-winged Warbler was also recorded on this route in the 1990s. Data are insufficient to estimate population trends.

BBA: Indiana's first Breeding Bird Atlas, conducted from 1985 to 1990, contained only six records of Golden-winged Warbler, five of which were from northwestern Indiana. Breeding was not confirmed in any block but was listed as probable in three blocks (Castrale et al. 1998). Field work for the second atlas effort from 2005 to 2011 produced two records in the possible category that may represent late migrants. One Golden-winged Warbler was observed and heard singing a Blue-winged Warbler song on multiple occasions from 10 May through at least 20 June 2008. This record was in a non-priority block on the north-west side of Indianapolis (J. Castrale, pers. comm.).

BBC: Golden-winged Warblers has not been recorded in Indiana Breeding Bird Census plots, although few have been conducted in suitable habitat during the past 30 years.

Habitat Use: Until the 1970s, Golden-winged Warblers nesting across the northern tier of counties utilized scrubby marsh edges, burns, and overgrown fields (Castrale et al. 1998).

Current Research and Monitoring: No research specific to Golden-winged Warbler is known to be occurring in Indiana. This species is occasionally detected on annual May Day counts (Werner 2008) and summer bird censuses (Detamore and Castrale 2008).

Threats: Loss of early successional forested habitats and fens in northern Indiana are likely responsible for decline of this species in the state.

Ohio

State Legal Status: Endangered

Natural Heritage Rank (see Table 1–6 for definitions): S1

Summary: Golden-winged Warbler was described by several ornithologists as locally common in the early 1900s in northwestern Ohio (Ashtabula, Lucas, and Cuyahoga counties) and rare elsewhere (Peterjohn and Rice 1991). Breeding Golden-winged Warbler populations were probably already declining by the late 1930s (Peterjohn 1989), and the species is now at best a casual summer resident in the state (Peterjohn 1989, Peterjohn and Rice 1991). Blue-winged Warbler has expanded into areas formerly occupied by Golden-winged Warbler (Peterjohn and Rice 1991) and has likely contributed to its decline in Ohio. Golden-winged Warbler was not confirmed as a breeding bird in the state during either Ohio's first (Peterjohn and Rice 1991) or second Breeding Bird Atlas (M. Shumar, pers. comm.).

BBS: Golden-winged Warbler has been recorded on three BBS routes in southeastern Ohio—in 1979, 1983, and 1999. During the most recent decade (2000–2010), there have been no Golden-winged Warbler detections (Sauer et al. 2011). BBS data are insufficient to estimate population trends.

BBA: During Ohio's first Breeding Bird Atlas, with field work conducted 1982–1987, 14 singing male Golden-winged Warblers were reported as possible or probable breeders in seven priority blocks and seven supplemental blocks (Peterjohn and Rice 1991). Of seven Golden-winged Warbler observations in the Ohio Breeding Bird Atlas II during 2006–2011, only one occurred in July; the others were from late May to 10 June and may have been migrants. None of these observations confirmed breeding for the species in the state (M. Shumar, pers. comm.).

BBC: Although censuses have been conducted in potentially suitable habitat, including one site that was monitored for 48 years, Golden-winged Warbler has not been recorded on Ohio census plots since 1983.

Habitat Use: Historically, Golden-winged Warbler occupied shrub/sapling stage successional habitats in Ohio. Nests were located on the ground in dense, herbaceous cover (Peterjohn and Rice 1991).

Current Research and Monitoring: No research or monitoring specific to Golden-winged Warbler is occurring in Ohio.

Threats: Main threats to the species are habitat loss in the Oak Openings region and range expansion of potentially competing Blue-winged Warbler (C. Caldwell, Ohio Division of Wildlife, pers. comm.).

USFWS Northeast Region 5 Summary

New York, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, Pennsylvania, New Jersey, West Virginia, Maryland, Virginia

Region 5 supports an estimated 6% of the global Golden-winged Warbler breeding population. Eleven states have historical or current breeding records; Maine and Delaware are not included because they lack recent breeding records for the species. Golden-winged Warbler still breeds in substantial numbers at higher elevations (>700 m) in the southern and eastern mountains of West Virginia, in central Pennsylvania, and in southeastern and northern New York. It has been extirpated as a breeding species from Rhode Island and Massachusetts, and it breeds in small numbers in southwest Virginia, northeast New Jersey, northwest Connecticut, central and western New York, west-central Vermont, and southeast New Hampshire. Given the predominant pattern of replacement of Golden-winged Warbler by Blue-winged Warbler over the last 150 years, these small local populations might soon disappear; the remaining areas of Golden-winged Warbler abundance in the Region are also at risk. As measured by the BBS from 1966 to 2010, Golden-winged Warbler has declined across Region 5 by -7.70% per year (95% CI: -8.94, -6.51; n = 193 routes) (Sauer et al. 2012). According to a population viability analysis, Golden-winged Warbler risks extinction throughout the Region during the next 100 years (see Figure 1–7 and the state summaries below).

A long-term regional decline in early successional habitat over the last 100 years (Lorimer 2001) continues into the present (Trani et al. 2001) and probably has been a major contributor to the steep regional warbler population decline—at least in some areas. The Northeast region, as a whole, currently has about 10% of its land cover in early successional habitat, but the distribution of that habitat is not uniform. Due to its active forest industry, approximately 20% of Maine's land cover consists of early successional habitat, but the rest of the New England states have less than 10% (some states less than 5%) of their land in early successional habitat (Trani et al. 2001). Mid-Atlantic states are at or below the regional average of 10% early successional cover. With current trends toward increasing loss of contiguous forested habitat to human development and relatively low rates of timber harvest (except for Maine), availability of early successional habitat is likely to remain low for the immediate future in much of the region. However, local extirpation of the species from areas that still have apparently suitable habitat—for example on utility rights-of-way in Massachusetts (Confer et al. 2003, Confer and Pascoe 2003)—suggest that habitat limitation is not the only factor in the continuing decline of Golden-winged Warbler in Region 5. Studies by Gill (1980) and Confer et al. (2003) demonstrated that interactions with Blue-winged Warbler are correlated with population declines of Golden-winged Warbler in this region. The pattern of Golden-winged Warbler disappearance from local areas within 50 years of arrival of Blue-winged Warbler (Gill 1980) continues to be observed in the Northeast (see state reports, especially New York and Pennsylvania). Non-breeding season habitat loss may also be a factor, but to date little is known about explicit migratory connectivity between this region and Neotropical wintering areas.

According to GOWAP (Barker Swarthout et al. 2009), a majority of the Golden-winged Warblers detected in the Northeast region (northern New York, New England, Ontario, Quebec) were in upland shrub (48%) and successional forest (23%) habitats (Figure 1–27). Only 15% of sites on which Golden-winged Warbler was detected were in wetland type habitats. In contrast to regions to the south, most of these birds were still found at low elevations. In the Mid-Atlantic region of southern New York to Virginia and eastern West Virginia, a majority of the 526 sites with Golden-winged Warblers also were in upland shrub (37%) and early successional forest (19%)—in a variety of habitats representing ecological succession after farmland abandonment (Figure 1–28). Utility rights-of-way and wetland shrub habitats each accounted for 13% of sites. The importance to Golden-winged Warbler of hardwood swamp forest habitat in the Hudson Highlands of southern New York was not reflected in the GOWAP surveys; Confer and Tupper (2000) and Confer et al. (2010) documented high nesting success and persistence of Golden-winged Warbler in hardwood swamps in close proximity to expanding Blue-winged Warbler populations in adjacent upland habitats.

To supplement Golden-winged Warbler detections on the BBS, a spatially-balanced monitoring program for Golden-winged Warbler is currently being coordinated by the Cornell Lab of Ornithology and implemented throughout the Appalachian region.

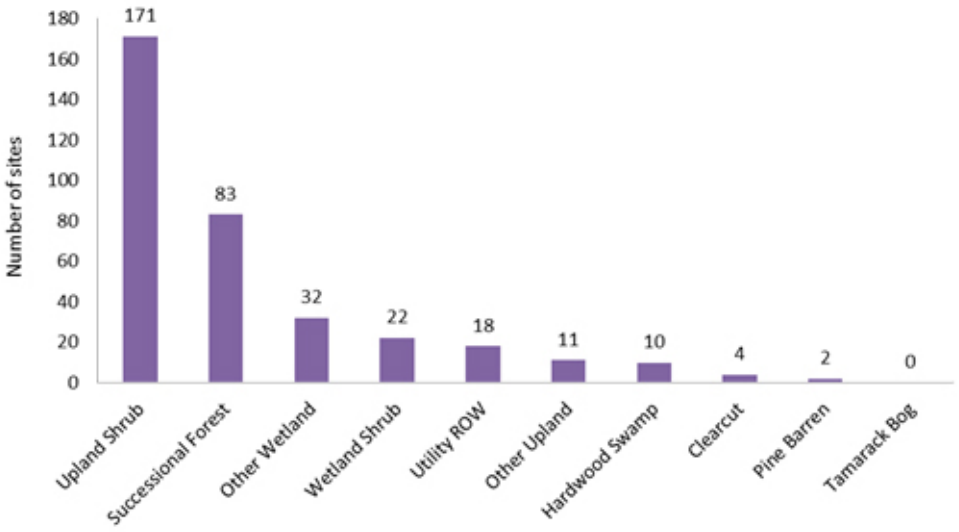

Figure 1–27. Distribution of habitat types at sites in the Northeast region where Golden-winged Warbler was detected. Since sampling was non-random, these data represent only habitats where the species was detected and therefore do not characterize use versus availability of habitat. See Appendix F for habitat definitions. In this graph, Upland Shrub = upland shrubby field + upland abandoned farm and Wetland Shrub = alder swamp + beaver wetland + shrub wetland.

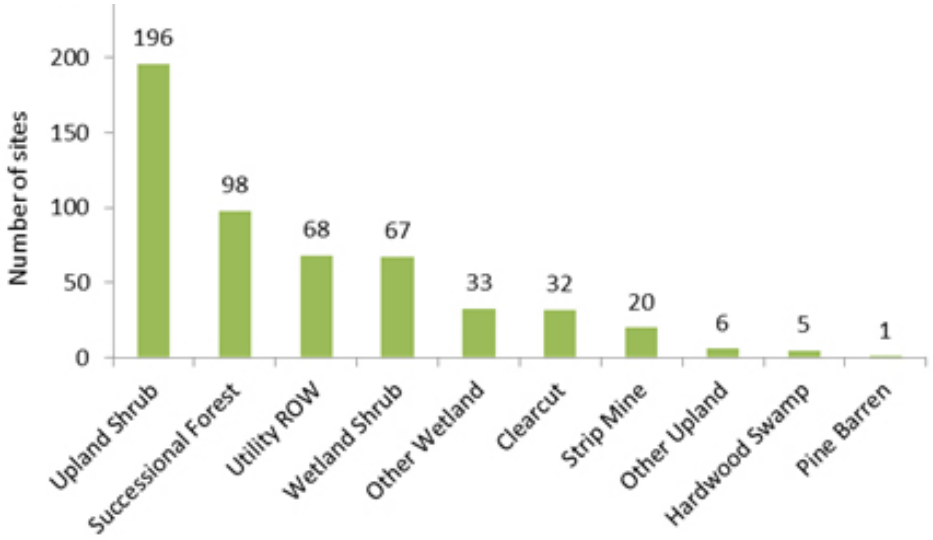

Figure 1–28. Distribution of habitat types at Mid-Atlantic region sites with Golden-winged Warbler detections. Since sampling was non-random, data represent only habitats where the species was detected and therefore do not characterize use versus availability of habitat. See Appendix F for habitat definitions. In this figure, Upland Shrub = upland shrubby field + upland abandoned farm and Wetland Shrub = alder swamp + beaver wetland + shrub wetland.

New York

State Legal Status: Special Concern
Natural Heritage Rank (see Table 1–6 for definitions): S4

Summary: Golden-winged Warbler was first documented in southeastern New York in 1867, but breeding was not confirmed until 1897 (Andrle and Carroll 1988). By the early 1900s it was common on western and northern Long Island and in the lower Hudson Valley, uncommon or local on southern and eastern Long Island and the central Hudson and Delaware valleys, and extremely rare in central and western New York (Eaton 1914). By 1950, the species occurred in moderate abundance throughout the Finger Lakes region and the central and western portions of the state (Andrle and Carroll 1988). Golden-winged Warbler expanded northward in the 1980s and bred in localized clusters throughout most of the state with the exception of the Central Adirondacks, Western Adirondack Foothills, and Coastal Lowlands. Although Golden-winged Warbler may be increasing in the Eastern Ontario Plain, Indian River Lakes, and St. Lawrence Plains regions (Confer et al. 1991, McGowan and Corwin 2008), it has declined in the central and

southern portions of the state and is now virtually absent from the Finger Lakes region (McGowan and Corwin 2008). In the western portion of the Hudson Highlands in the southeast, a moderately dense Golden-winged Warbler population has co-occurred with Blue-winged Warbler for over a century (Confer 1998, Confer and Tupper 2000). However, Confer (2005) questioned the continuing coexistence of this population due to increased introgression. In the Confer (2005) study, 13 of 15 Blue-winged Warbler phenotypes retained ancestral Blue-winged Warbler mtDNA, whereas a lower proportion of Golden-winged Warbler phenotypes, 16 of 28, retained ancestral Golden-winged Warbler mtDNA. Genetic introgression is also a threat in northern New York, which raises concerns about the viability of Golden-winged Warbler as a persisting phenotype in the state.

BBS: Golden-winged Warbler has been recorded on 10 BBS routes across New York in the last 10 years (2001–2010) as compared to 24 routes in the 1990s decade. Analyses of long-term BBS data (1966–2010) suggest that populations of Golden-winged Warbler in New York have experienced significant declines of -5.1% per year (95% CI: -7.0, -3.3; *n* = 56 routes; Sauer et al. 2012; Figure 1–29).

By 2100, if trends and variability in trends persist as they have for the last 40 years, Golden-winged Warbler has a 100% (95% credible level: 99.5%, 100%) risk of a further 90% loss of New York's population (Figure 1–30).

BBA: The first New York Breeding Bird Atlas was conducted from 1980 to 1985. Golden-winged Warbler was reported from 576 blocks and confirmed breeding in 110 blocks (Andrle and Carroll 1988). The second atlas project was conducted from 2000–2005. Golden-winged Warbler was reported from 270 blocks and breeding was confirmed on only 51 blocks. This change represents a 54% decline in the number of blocks with confirmed breeding (McGowan and Corwin 2008).

BBC: Golden-winged Warbler was recorded on seven different New York Breeding Bird Census plots from 1977 to 1994—in abandoned orchard (3 pairs per 16.2 ha); abandoned upland pasture (1 pair per 8 ha, 2 pairs per 30 ha); maple (*Acer* spp.)-oak forest (2 pairs per 72.8 ha, 4 pairs per 72.8 ha); mixed upland forest (1 pair per 142 ha); young mixed forest (1 pair per 4.4 ha); and young white ash (*Fraxinus americana*) /red maple (*A. rubrum*) forest (1 pair per 16.2 ha).

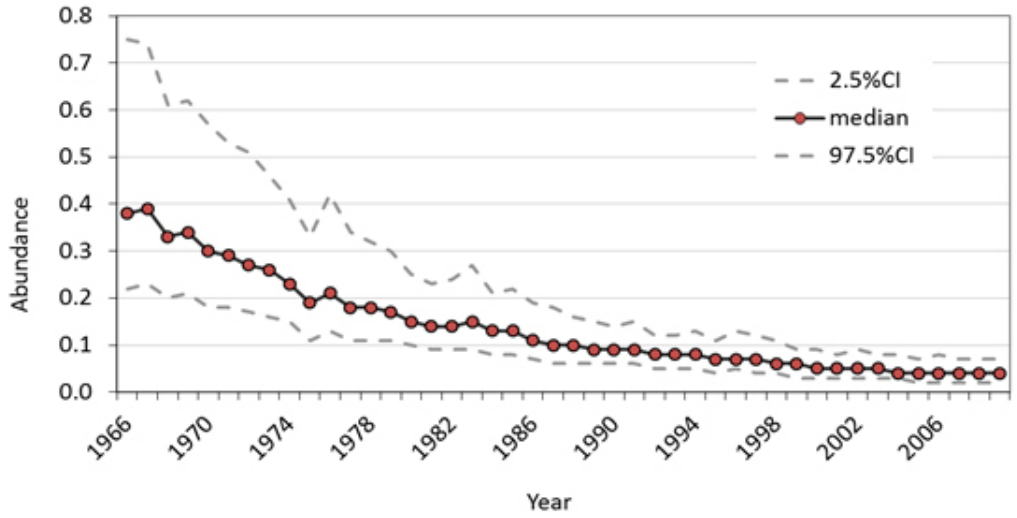

Figure 1–29. Changes in relative abundance of Golden-winged Warbler in New York based on hierarchical Bayesian analyses of BBS data (1966–2009).

Habitat Use: Golden-winged Warbler inhabits regenerating old fields, abandoned pastures, powerline rights-of-way, and forested wetlands—including alder swamps, beaver meadows, and tamarack swamps. In the Hudson Highlands, exclusive use of natural swamp forests by Golden-winged Warbler seems to be an important component of its local coexistence with Blue-winged Warbler, which occupies adjacent upland sites. Similarly, wetland sites at Fort Drum are occupied solely by Golden-winged Warbler, whereas dry upland shrubby habitats support both Golden-winged and Blue-winged warblers (C. Dobony, pers. comm.).

Current Research and Monitoring: Sterling Forest State Park in Orange County in southeastern New York was one of the eight study sites that comprised the 2008–2010 collaborative research project of the Golden-winged Warbler

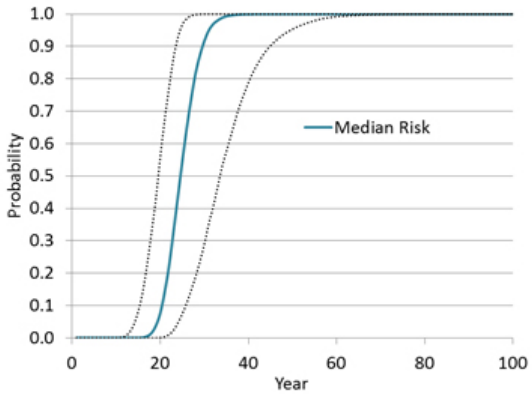

Figure 1–30. Risk of quasi-extinction for Golden-winged Warbler in New York as determined by a 90% decline from the year 2000 population by year 2100. Dashed lines represent the 95% credible interval. See Appendix C for methods.

Rangewide Conservation Initiative (Appendix D). Research on reproductive ecology, behavior, competitive interactions with Blue-winged Warbler, habitat use, and response to management activities has been ongoing since 1977 in New York under the direction of J. Confer, Ithaca College. More recently, extensive surveys and studies of habitat use have been carried out in northern New York by the New York Department of Environmental Conservation, Fort Drum, and Cornell Lab of Ornithology. In addition, R. Vallender (Environment Canada) is studying genetic introgression with Blue-winged Warbler in northern New York in association with I. Lovette (Cornell Lab of Ornithology) as part of a range-wide genetic atlas; 17% of the Golden-winged Warblers sampled showed evidence of genetic introgression.

Threats: The decline of Golden-winged Warbler in New York correlates with the expansion of Blue-winged Warbler into the state. Studies indicate a continual northward movement of Blue-winged Warbler over the last 90 years, with a recent expansion rate of about 8 km per year. In north-central New York, Golden-winged Warbler appears to show behavioral dominance over Blue-winged Warbler, and habitat availability does not appear to limit breeding densities of either species (Confer and Larkin 1998). A recent decline in dairy farming in the St. Lawrence Valley has created a pulse of abandoned farmland, providing a modest boost in available shrubland habitat. However, the recent appearance of Blue-winged Warblers in these areas and signs of genetic introgression in remaining Golden-winged Warblers does not bode well for the future of the Golden-winged Warbler phenotype, even in northern New York. In key wetland habitats, particularly in southeastern New York, invasive phragmites (*Phragmites australis*) is a threat, and some form of invasive control might become necessary to maintain the viability of these wetlands for breeding Golden-winged Warbler (J. Confer, pers. comm.).

Vermont

State Legal Status: Special Concern

Natural Heritage Rank (see Table 1–6 for definitions): S2S3

Summary: Golden-winged Warbler was first reported from Vermont in 1893 (Stearns and Coues 1893), and the species continued as a rare and local breeder throughout the first half of the 20th century (Laughlin and Kibbe 1985). Breeding was reported from southeastern Vermont near the Connecticut River and from Rutland and West Haven at the southern tip of Lake Champlain (Laughlin and Kibbe 1985). Today, Golden-winged Warbler appears to remain as a very rare breeder in the Lake Champlain area and adjacent portions of the Taconic Mountains.

BBS: Golden-winged Warbler has been recorded on two BBS routes in the last 10 years (2001–2010; Sauer et al. 2011). BBS data are insufficient to estimate population trends.

BBA: The first Vermont Breeding Bird Atlas was conducted from 1976–1981 (Laughlin and Kibbe 1985). Golden-winged Warbler was reported from 15 priority blocks and was confirmed breeding in four of those blocks. Field work for a second atlas effort was completed in 2007. Golden-winged Warbler was reported from 14 priority blocks, and breeding was confirmed in five of those blocks (Renfrew *in press*, USGS BBEA 2012).

BBC: The only detection in the past 30 years consisted of one Golden-winged Warbler observed in old field habitat in 1994.

Habitat Use: Golden-winged Warbler inhabits abandoned fields and pastures, forested wetlands, and powerline rights-of-way.

Current Research and Monitoring: No research or monitoring specific to Golden-winged Warbler is known to be occurring in Vermont.

Threats: Loss of available habitat through forest maturation on abandoned farmland is the major threat in Vermont.

New Hampshire

State Legal Status: Unlisted

Natural Heritage Rank (see Table 1–6 for definitions): S2

Summary: In southern New Hampshire, Golden-winged Warbler occurred as far north and west as Manchester and Concord in the 1930s and eastward to just across the border in southwestern Maine (Bent 1963), but breeding was limited to the coastal lowlands by the 1960s (Foss 1994). During the 1990s, Golden-winged Warbler began disappearing from the coastal plain but continued to breed in the central Connecticut Valley near Hanover. The species has since disappeared from that region and may be extirpated from the state (Suomala 2005).

BBS: Golden-winged Warbler has been recorded on six BBS routes, primarily in southern New Hampshire, including only one in the last 10 years, in 2003 (Sauer et al. 2012). Figure 1–31 illustrates a non-credible population trend (-6.3%/year; 95% CI: -35.7, +18.5) derived from hierarchical Bayesian analyses of long-term BBS data (1966–2010; Sauer et al. 2012). The data are insufficient to allow confident inference of the New Hampshire population trend based on BBS data alone.

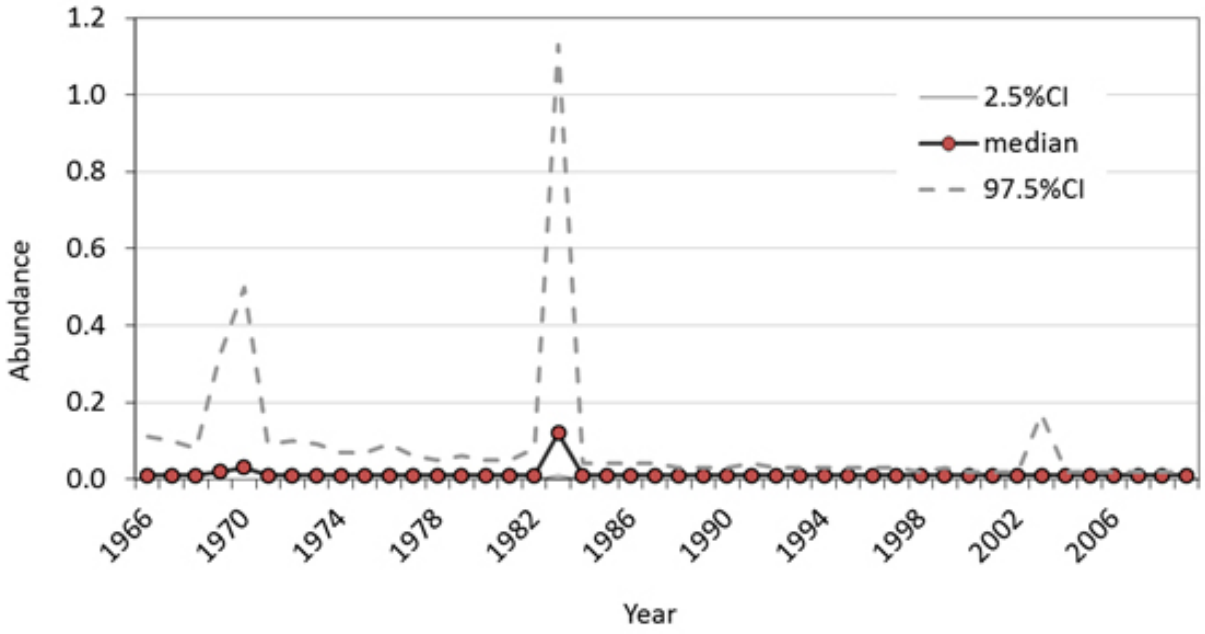

Figure 1–31. Changes in relative abundance of Golden-winged Warbler in New Hampshire based on hierarchical Bayesian analyses of BBS data (1966–2009).

BBA: A Breeding Bird Atlas was conducted in New Hampshire from 1981–1986 (Foss 1994). Golden-winged Warbler was reported from five priority blocks and was confirmed breeding on one of those blocks (Foss 1994, USGS BBEA). Blue-winged Warbler was reported from 10 priority blocks and confirmed breeding in one block.

BBC: Golden-winged Warbler has not been recorded recently in New Hampshire Breeding Bird Census plots, although few have been conducted in suitable habitat during the past 30 years.

Habitat Use: No specific data.

Current Research and Monitoring: No research or monitoring specific to Golden-winged Warbler is known to be occurring in New Hampshire.

Threats: Primary threats include forest maturation on abandoned farmland and hybridization with Blue-winged Warbler.

Massachusetts

State Legal Status: Endangered
Natural Heritage Rank (see Table 1–6 for definitions): S1

Summary: Brewster (1906) recorded breeding in eastern Massachusetts (approx. 16 km west of Boston) in 1874, but Petersen and Meservey (2003), citing Allen (1870), reported 1869 as the first year of documented nesting in the state. Golden-winged Warbler subsequently increased throughout eastern Massachusetts through the early 1900s (Veit and Peterson 1993) and remained fairly common and widely distributed throughout most of the last century. Highest numbers (i.e., 40) were recorded in the early 1940s in Essex County (Bailey 1955, Veit and Petersen 1993), although breeding records existed throughout most of the state with the exception of the southern coastal plain, Cape Cod, Martha's Vineyard, and Nantucket (Griscom and Snyder 1955). By the 1950s, most breeding locations were in eastern Massachusetts; the species had begun to decline elsewhere, with the exception of the Berkshires, where it continued to increase (Bailey 1955).

Golden-winged Warbler continued to decline in much of the state from the 1960s to the early 1990s, by which time the species was considered a very uncommon, local, and declining breeder (Veit and Petersen 1993). Based on data from 1974–1979 (Petersen and Meservey 2003), Essex County in the northeast and Berkshire County in the west were considered to be the last breeding strongholds for the species in Massachusetts. Since 1990, the only confirmed records of breeding activity were of a male and female observed together in Hampden County in 1991, a male and hybrid female provisioning young in Essex County in 1991, a female carrying nesting material in Essex County in 1999, and a male and hybrid female provisioning young in Essex County in 2002. Thus, Golden-winged Warbler may be extirpated as a breeder from the state—or at least reduced to extremely low numbers.

BBS: Golden-winged Warbler has been recorded on ten BBS routes in west-central Massachusetts, but there have been no detections since 1994. Blue-winged Warbler is now detected on routes that formerly recorded Golden-winged Warbler. Analysis of long-term BBS data (1967–2010) suggest a very steep decline in Massachusetts (-9.1% per year; 95% CI: -18.0, -1.9; n = 9; Sauer et al. 2012). However, there are insufficient data to draw conclusions confidently regarding trends in Massachusetts based on BBS data alone.

BBA: The first Breeding Bird Atlas was conducted from 1974–1979 (Petersen and Meservey 2003). Golden-winged Warbler was reported from 67 priority blocks and breeding was confirmed in five of those blocks. Blue-winged Warbler, in contrast, was recorded on 259 priority blocks and breeding was confirmed in 73 of those blocks. Field work for a second atlas effort (2007–2011) resulted in one probable and three possible detections, with no confirmed breeding of Golden-winged Warbler in the state (USGS BBEA 2012).

BBC: No Golden-winged Warblers have been recently recorded in Massachusetts Breeding Bird Census plots, although few have been conducted in suitable habitat during the past 30 years.

Habitat Use: In Massachusetts, documented habitats have included edges and open areas with scattered patches of grasses, forbs (e.g., purple loosestrife, *Lythrum salicaria*; *Solidago* spp.), brambles (e.g., *Rubus* spp.), vines (e.g., *Vitis* sp.), shrubs (e.g., *Cornus* spp.; winterberry *Ilex verticillata*; staghorn sumac, *Rhus typhina*; *Spiraea* spp.; *Vaccinium* spp.; *Viburnum* spp.), and small trees (e.g., gray birch, *Betula populifolia*; quaking aspen, *Populus tremuloides*). Bordering forests tended to consist of eastern white pine (*Pinus strobus*), oak, red maple, and a variety of additional deciduous tree species (Natural Heritage and Endangered Species Program, Massachusetts Division of Fisheries and Wildlife [NHESP-MADFW], unpubl. data). Broader habitat types have consisted of abandoned fields and orchards, old gravel pits, vegetated wetlands (swamps and wet meadows), and utility rights-of-way.

Current Research and Monitoring: Point count surveys conducted from 1998–2000 at six utility right-of-way locations throughout Massachusetts were designed specifically for *Vermivora*, incorporating 10-minute taped vocalizations of song and alarm notes of both Golden-winged and Blue-winged warblers (J. Confer, unpubl. data). In 258 point counts, there were no Golden-winged Warbler detections. No other ongoing research and monitoring specific to Golden-winged Warbler is known to be occurring.

Threats: Approximately 85% of Massachusetts forests were cleared for agricultural and logging in the 19th century; early stages of subsequent farmland abandonment and forest regeneration provided a large amount of suitable Golden-winged Warbler habitat statewide (Petersen and Meservey 2003). Since the mid-1900s, available habitat in Massachusetts has been reduced substantially by ecological succession (Griscom and Snyder 1955) and development, following similar patterns observed throughout much of the eastern United States (Askins 2001, Lorimer 2001, Trani et al. 2001). Several known breeding sites were lost to housing developments and a golf course (NHESP-MADFW, unpubl. data). Public resistance to timber harvesting, prescribed fire, and other management activities that would increase habitat availability and/or suitability is a continuing threat in Massachusetts (J. E. Kubel, MADFW, pers. comm.).

Coincident with habitat loss, expansion of Blue-winged Warbler and genetic introgression has likely contributed to the decline of Golden-winged Warbler in the state. As Blue-winged Warbler became increasingly common in the mid-1900s, Golden-winged Warbler populations began to

decline (Petersen and Meservey 2003). Habitat loss on the wintering grounds and nest parasitism by Brown-headed Cowbirds also may have contributed to decline of Golden-winged Warbler (Confer 1992, Confer et al. 2003), but the significance of these factors in Massachusetts is unknown.

Connecticut

State Legal Status: Endangered
Natural Heritage Rank (see Table 1–6 for definitions): S2

Summary: The first Connecticut record of Golden-winged Warbler breeding was in 1875 at Suffield near the Connecticut River and about 8 km from the Massachusetts border. This record was followed by observations during the late 1800s of populations scattered throughout northern and southern Connecticut, especially along the Connecticut and Naugatuck river valleys (Gill 1980, Bevier 1994). Golden-winged Warbler was also common historically near the Connecticut coast (Gill 1980). During the 1980s, the Connecticut atlas project reported confirmed breeding only from northwestern Connecticut (Bevier 1994). The species is now disappearing from most of these northwestern sites and is currently known from only three locations.

BBS: Golden-winged Warbler has been recorded on five BBS routes in Connecticut, but there have been no detections since 1988. Figure 1–32 shows the population trend (-23.6%/yr; 95% CI: -54.8, -6.7) derived from hierarchical Bayesian analyses of 1966–2010 BBS data (Sauer et al. 2012). However, low abundance along BBS routes do not permit confident inference regarding the Connecticut trend based on BBS data alone.

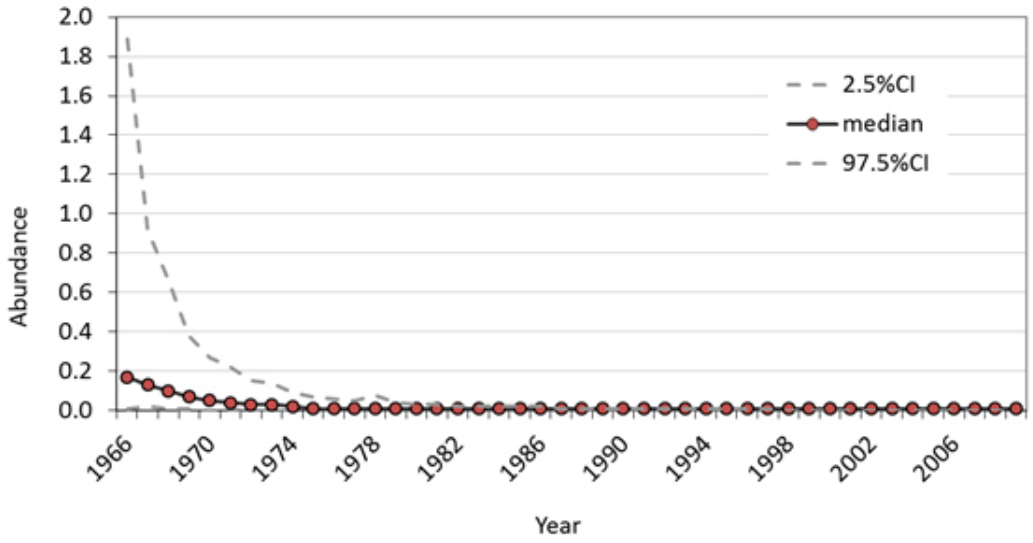

Figure 1–32. Changes in relative abundance of Golden-winged Warbler in Connecticut based on hierarchical Bayesian analyses of BBS data (1966–2009).

BBA: BBA surveys were conducted from 1982–1986. Golden-winged Warbler was detected in 37 blocks, with breeding confirmed in 10 blocks from northwestern Connecticut (Bevier 1994, USGS BBEA 2012). The atlas also documented hybrids scattered throughout the state (Bevier 1994).

BBC: Golden-winged Warbler was recorded on one Breeding Bird Census plot in "mixed habitat" in 1988–1989. There have been no subsequent detections of the species.

Habitat Use: Golden-winged Warbler occurs on abandoned farmland with scattered trees and shrubs bordered by second-growth forest (Bevier 1994). It also occurs on forest clearcuts and pine plantations (S. Kearney-McGee, Connecticut Department of Environmental Protection [CT-DEP], pers. comm.).

Current Research and Monitoring: From 2000–2007, the CTDEP Wildlife Division monitored potential and historic nesting locations using playback recordings. These inventories identified Golden-winged Warbler consistently at only three locations. From 2005–2008, CTDEP Wildlife Division also monitored 35 sites for early successional bird species, including Golden-winged Warbler. Golden-winged Warbler was detected at only one site, and hybrids were detected at two sites.

Threats: Maturation of successional habitats, hybridization with Blue-winged Warbler, and human development are important threats to the persistence of Golden-winged Warbler in Connecticut.

Rhode Island

State Legal Status: Unlisted
Natural Heritage Rank (see Table 1–6 for definitions): SX

Summary: Historically, Golden-winged Warbler occurred as a regular but very local summer resident in the northeastern portion of Rhode Island. Breeding was first confirmed at Wenscott Reservoir, North Providence, where territorial birds were present at least through the period 1931–1943. Three known or suspected breeding locations in Rhode Island were wholly within the towns of Cumberland, Lincoln, and neighboring North Providence, a region characterized by many rocky outcroppings and a generally richer flora than that of more granitic portions of the northwestern part of the state (Ferren 2001). Golden-winged Warbler now appears to be extirpated as a breeder and is only rarely seen as a migrant. Its extirpation occurred approximately 40 years after the arrival of Blue-winged Warbler.

BBS: Golden-winged Warbler has not been recorded on BBS routes in the state.

BBA: The Rhode Island Breeding Bird Atlas was conducted from 1982–1987 (Enser 1992). Golden-winged Warbler was not detected during the atlas period (USGS BBEA 2012).

BBC: Golden-winged Warblers has not been recorded recently on Rhode Island Breeding Bird Census plots, although few have been conducted in suitable habitat during the past 30 years.

Habitat Use: Golden-winged Warbler inhabited old fields with scattered shrubs and black locust (*Robinia pseudoacacia*).

Current Research and Monitoring: No research or monitoring specific to Golden-winged Warbler is known to be occurring in Rhode Island.

Threats: The decline of Golden-winged Warbler in Rhode Island is correlated with the range expansion of Blue-winged Warbler. As Blue-winged Warbler increased in abundance during the 1960s, the remaining Golden-winged Warblers disappeared. Surveys conducted in Cumberland and Lincoln (Providence County) in 1984 failed to detect Golden-winged Warbler but recorded 65 Blue-winged Warblers and one Brewster's Warbler.

Pennsylvania

State Legal Status: Unlisted
Natural Heritage Rank (see Table 1–6 for definitions): S4

Summary: During the late 1860s, Golden-winged Warbler was reported as a rare to uncommon breeder throughout Pennsylvania, with most birds concentrated in the western counties (McWilliams and Brauning 2000). It undoubtedly increased with the subsequent expansion of abandoned farmland and old field habitat in Pennsylvania. By the mid-1950s, the species remained scarce on the high plateau of the Poconos but was a widespread breeding species in the southern part of the Pocono region and throughout the Valley and Ridge Physiographic Province (Street 1956, cited in Brauning 1992). By the 1990s, Golden-winged Warbler had been replaced by Blue-winged Warbler throughout much of Pennsylvania with the exception of higher elevation sites (generally above 600 m) within the Valley and Ridge and Pocono regions (Brauning 1992) and in more forested landscapes of the mountainous Allegheny High Plateau section of the Appalachian Plateau Province (northern Centre and Clinton counties) (J. Larkin, unpubl. data). As there are viable breeding populations of Golden-winged Warbler at lower elevations within all these regions, however, it is not entirely clear whether the current distribution of the species is driven by elevation or by more complex dynamics of extensively forested landscapes (Larkin, pers. comm.).

BBS: Golden-winged Warbler has been recorded on 19 BBS routes in the last 10 years (2001–2010), down from 31 routes in the 1990s and 44 routes from the period 1966–1987. Analyses of long-term BBS data (1966–2010) suggest significant declines of -6.7% per year (95% CI: -8.6, -4.8; n = 56 routes; Figure 1–33; Sauer et al. 2012).

By 2100, if trends and variability in trends persist as they have for the last 40 years, Golden-winged Warbler has a 100% (95% credible level: 99.5%, 100%) risk of a further 90% loss in the Pennsylvania population (Figure 1–34).

BBA: The first Pennsylvania Breeding Bird Atlas was conducted from 1983 to 1989. Golden-winged Warbler was reported in 615 atlas blocks and breeding was confirmed in 86 blocks (Brauning 1992). Data collection for the second atlas effort was begun in 2004 and completed in 2008. Golden-winged Warbler was recorded in 240 blocks and breeding was confirmed in only 36 blocks (Wilson et al. 2012). This change represents a 58% decline in the number of blocks with confirmed breeding.

BBC: Golden-winged Warbler was recorded in aspen clearcuts and abandoned fields during the 1980s and in hardwood forest with scattered pine (*Pinus* spp.) in 1993; there have been no subsequent detections on BBC plots. Reported densities were generally low, although one site in an aspen clearcut had four territories on a 4-ha cutting. Gold-

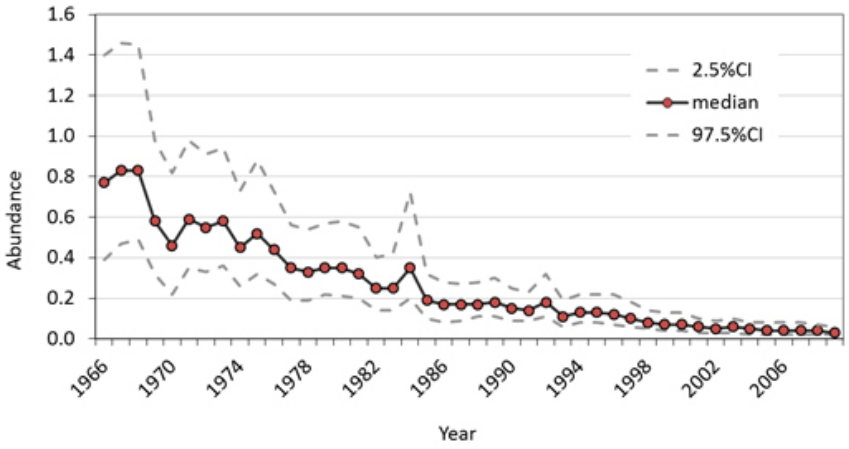

Figure 1–33. Changes in relative abundance of Golden-winged Warbler in Pennsylvania based on hierarchical Bayesian analyses of BBS data (1966–2009).

en-winged Warbler territory densities ranged from 1.3 to 3.7 territories per 10 ha on sites located in north central Pennsylvania (J. Larkin, unpubl. data).

Habitat Use: Golden-winged Warbler in Pennsylvania inhabits abandoned fields, utility rights-of-way, forest regeneration areas, forested wetlands, beaver swamps, managed shrublands, and scrub-oak barrens (Brauning 1992). The species has also been observed in scrub-shrub habitats on and adjacent to reclaimed surface mines in Potter and Clinton counties (J. Larkin, pers. comm.). Extensive forest cover (i.e., >70% forest within 0.5 miles) and high elevation comprise critical habitat elements for Golden-winged Warbler for reducing interactions with Blue-winged Warbler (Bakermans et al. 2011, Larkin and Bakermans 2012, Bakermans and Larkin 2012).

Bellush (2012) found that male Golden-winged Warblers foraged selectively on black locust, pin cherry (*Prunus pensylvanica*), white oak (*Quercus alba*), and *Rubus* spp.; arthropod surveys confirmed that these tree and shrub species also had the highest values for prey availability. Tree and shrub species composition also differed between Golden-winged Warbler territories and adjacent unoccupied areas of similarly-aged habitat; this finding was consistent with patterns of forage site selection and prey abundances (Bellush 2012). Corroborating findings in Minnesota (Streby et al. 2012), Frantz (unpubl. data) also concluded that spot mapping alone does not accurately reflect Golden-winged Warbler space use and habitat needs during the breeding season. Telemetry-delineated use areas in Pennsylvania averaged 3.6 times larger than their respective spot-mapped territories and revealed more space use overlap between males.

Current Research and Monitoring: Sproul State Forest and Bald Eagle State Park in Clinton and Centre counties in central Pennsylvania comprised one of the eight study sites involved in the 2008–2010 collaborative research project of the Golden-winged Warbler Rangewide Conservation Initiative (Appendix D). Kubel and Yahner (2007) studied Golden-winged Warbler density and nesting success along rights-of-ways in Pennsylvania in comparison to 1-ha patch clearcuts. In 2010–2011, J. Larkin and M. Bakermans (Indiana University of Pennsylvania) modeled the density of Golden-winged Warbler in 222 timber harvests across northeastern (Monroe, Pike, Northampton, and Carbon counties), north-central (Clinton, Centre, and Lycoming counties), and southwestern (Bedford, Blair, Fayette, Somerset, and Westmoreland counties) Pennsylvania. The results were used to develop best habitat management practices for Maryland and Pennsylvania (Bakermans et al. 2011). Currently, one year (2012) of a multi-year, multi-state project examining Golden-winged Warbler response to several Natural Resources Conservation Service conservation practices has been completed. The study sites (timber harvests) that are used in the Pennsylvania portion of the study are located in Monroe and Pike counties. Pennsylvania is also participating in the spatially-balanced monitoring program being coordinated by the Cornell Lab of Ornithology and implemented throughout the Appalachian region.

Threats: Primary threats include the loss of early successional habitats due to ecological succession and loss of extensively forested landscapes due to development (including natural gas extraction and wind energy development) as well as interactions with Blue-winged Warbler that may lead to genetic introgression or local replacement.

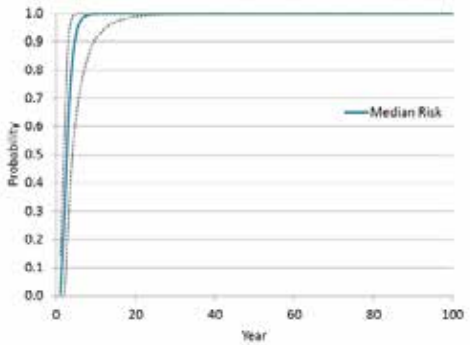

Figure 1–34. Risk of quasi-extinction for Golden-winged Warbler in Pennsylvania as determined by a 90% decline from the year 2000 population by year 2100. Dashed lines represent the 95% credible interval. See Appendix C for methods.

New Jersey

State Legal Status: Endangered
Natural Heritage Rank (see Table 1–6 for definitions): S2

Summary: Golden-winged Warbler is considered an uncommon migrant and rare breeding species in New Jersey (Leck 1984). Based on 2000–2002 surveys by New Jersey Division of Fish and Wildlife biologists (NJDFW), an estimated 80-90 pairs were present in the northwestern part of the state (Ridge and Valley and Southern New England physiographic provinces). However, according to data from 2008 surveys (S. Petzinger, NJDFW, pers. comm.), approximately only one quarter of this population remains in New Jersey. The New Jersey Highlands was once a place where Golden-winged and Blue-winged warbler co-existed for almost a century (Confer and Larkin 1998, Confer and Tupper 2000), but it now seems that the last stronghold for Golden-winged Warbler in the state is in the Newark Watershed within the Highlands. Blue-winged Warbler has expanded through the Delaware River Valley during the last thirty years (Gill 1997) but now may be declining in northwestern New Jersey (S. Petzinger, pers. comm.)

BBS: Golden-winged Warbler has been recorded on only one BBS route in the past 10 years, in 2001 (Sauer et al. 2011). Figure 1–35 shows the population trend (-9.3%/year, 95% CI: -16.3, -2.4) derived from hierarchical analyses of long-term BBS data (1966–2010; Sauer et al. 2012). However, data are insufficient to permit confident conclusions regarding the New Jersey trend based on BBS data alone.

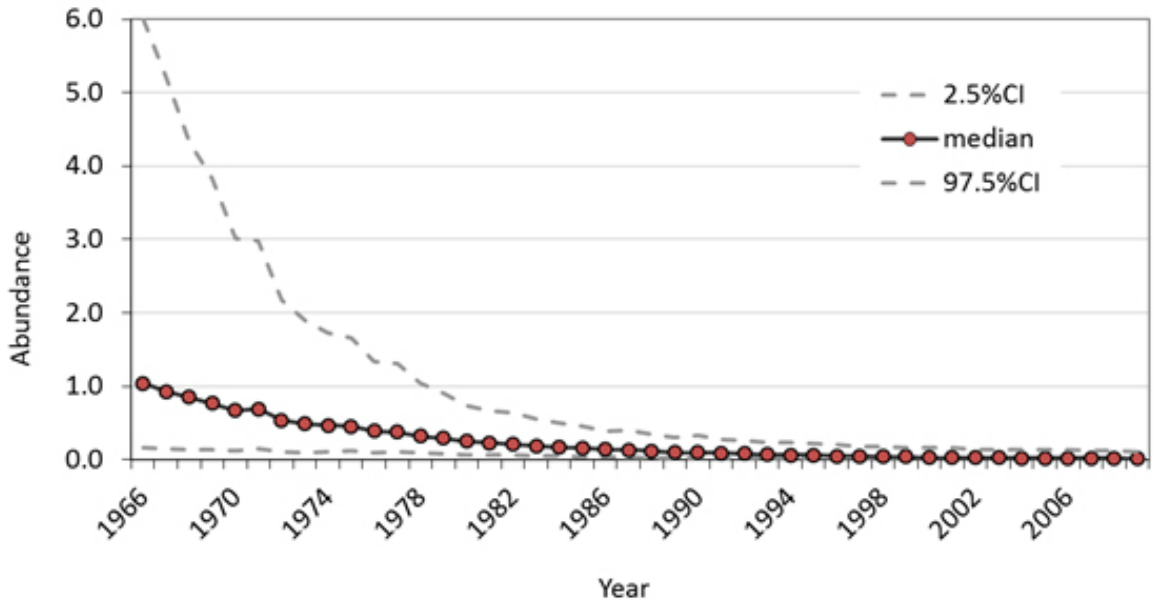

Figure 1–35. Changes in relative abundance of Golden-winged Warbler in New Jersey based on hierarchical Bayesian analyses of BBS data (1966–2009).

BBA: The New Jersey Breeding Bird Atlas project was conducted from 1994 to 1997. Golden-winged Warbler was reported from 66 blocks, and breeding was confirmed on 25 blocks. Blue-winged Warbler, in contrast, was reported from 458 blocks and confirmed breeding on 207 blocks (V. Elia, NJ Audubon, pers. comm.).

BBC: Golden-winged Warbler has not been recorded recently on New Jersey Breeding Bird Census plots despite the fact that some were conducted in areas of suitable habitat.

Habitat Use: In New Jersey, Golden-winged Warbler primarily uses wetland components of utility rights-of-way, but the species also occurs in early- and mid-successional forested wetlands, upland components of utility rights-of-way, and occasionally in old fields. The majority of the Golden-winged Warblers observed during the 2008 survey were in areas with less than 50% tree cover and a mixture of shrubs and herbaceous cover (S. Petzinger, pers. comm.).

Current Research and Monitoring: New Jersey conducts state-wide point counts to monitor avian populations every 5–7 years. The third round of these counts was completed in 2008. A project monitoring Golden-winged Warbler return rates, habitat use, and productivity began in 2003 and was completed in 2007.

Threats: Habitat loss is a major threat in New Jersey, mainly through lack of appropriate active forest management. However, it appears that the New Jersey Golden-winged Warbler population is declining despite the availability of habitat, which suggests that threats outside of the state may be driving declines (S. Petzinger, pers. comm.).

West Virginia

State Legal Status: Unlisted

Natural Heritage Rank (see Table 1–6 for definitions): S2

Summary: While the historical distribution of Golden-winged Warbler in West Virginia is not well documented, its current distribution follows patterns similar to those in other middle Appalachian states. The species breeds in the southern mountainous region of West Virginia (mostly Mercer, Summers, Monroe, Greenbrier, and Pocahontas counties) and in the Appalachian Mountain chain to the northeast (Randolph, Barbour, Tucker, and Preston counties) at elevations above 548 meters (1,800 feet) and primarily between 850 and 915 meters (2,800–3,000 feet). It still breeds at isolated sites in the coalfields (McDowell, Wyoming, and Raleigh counties), almost entirely on reclaimed narrow strip benches at or above 610 meters (R. Bailey, pers. comm.). Throughout the state, however, Golden-winged Warbler has gradually been replaced by Blue-winged Warbler (Canterbury et al. 1993, 1996; Canterbury and Stover 1999) and is now out-numbered by Blue-winged Warbler in most areas of the state with the exception of higher elevations (Canterbury 1997, Gill et al. 2001, P. Wood pers. comm.). Although Golden-winged Warbler increases with elevation to a point of numerical dominance relative to Blue-winged Warbler, there may be no Golden-winged Warbler sites remaining where Blue-winged Warbler is not also present (R. Baily, pers. comm.). Golden-winged Warbler is almost entirely absent above 1200 meters (4,000 feet) even where the forest type is deciduous (R. Bailey, pers. comm.).

BBS: Golden-winged Warbler has been recorded on 10 BBS routes in the last 10 years (2001–2010), down from 23 routes in the 1990s (1991–2000). Analyses of long-term BBS data (1966–2010) suggest steep declines of -9.2%/year (95% CI: -11.0, -7.3; *n* = 44 routes; Figure 1–36, Sauer et al. 2012).

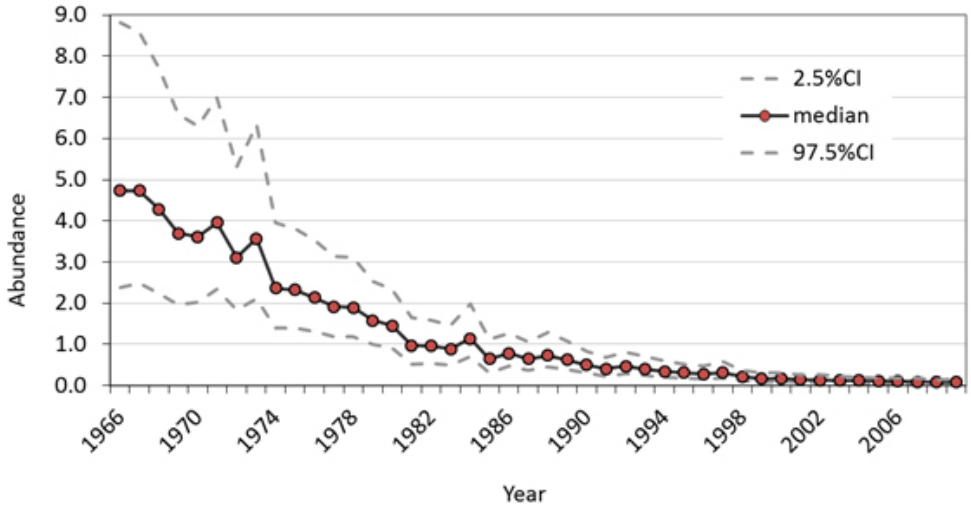

Figure 1–36. Changes in relative abundance of Golden-winged Warbler in West Virginia based on hierarchical Bayesian analyses of BBS data (1966–2009).

BBA: Field work for the first West Virginia Breeding Bird Atlas project was conducted from 1984 to 1989. At that time, Golden-winged Warbler was found to be fairly widely distributed throughout most of the state with the exception of the northern Ohio River Valley and eastern Panhandle (Buckelew and Hall 1994). The species was reported from 172 blocks and breeding was confirmed in 32 of those blocks (USGS BBEA 2012). By contrast, Blue-winged Warbler was reported from 213 blocks with confirmed breeding in 72 of those blocks. West Virginia's second atlas project began in 2009 and is due to be completed in 2014. Effort to date has surpassed that of the first atlas project, and spatial coverage is at least similar (K. Aldinger, R. Bailey, pers. comm.). Preliminary results indicate Golden-winged Warbler detections in 73 blocks, with breeding confirmed in 15 blocks (CLO BBA 2012); in contrast, Blue-winged Warbler has been detected in 249 blocks and confirmed as a breeder in 22 blocks (CLO BBA 2012).

BBC: Golden-winged Warbler has not been recorded recently on West Virginia Breeding Bird Census plots, although few plots were in suitable habitat during the past 30 years.

Habitat Use: Golden-winged Warbler nests in low second-growth and open woodlands, including powerline rights-of-ways (Buckelew and Hall 1994) and abandoned contour strip mines (Canterbury et al. 1996, Canterbury and Stover 1999). The species occurs most frequently in persistent shrubby habitat associated with old fields, abandoned farmland, areas managed for grazing (e.g., Aldinger 2018), reclaimed surface mines (strip benches), and shrubby wetlands, and only rarely in even-age forest harvests (P. Wood, pers. comm.).

Current Research and Monitoring: Parts of Monongahela National Forest in Randolph and Pocohantus counties comprised one of the eight study sites involved in the 2008–

2010 collaborative research project of the Golden-winged Warbler Rangewide Conservation Initiative (Appendix D). P. Wood and colleagues (USGS West Virginia Cooperative Fish and Wildlife Research Unit, West Virginia University) are currently evaluating Golden-winged Warbler habitat, demography, and movements on areas managed for grazing on the Monongahela National Forest and adjacent privately-owned pasturelands. Golden-winged Warbler is monitored through BBS and the spatially-balanced monitoring program being coordinated by the Cornell Lab of Ornithology and implemented throughout the Appalachian region.

Threats: Replacement by Blue-winged Warbler and habitat loss from ecological succession, surface mining, and development for natural gas extraction are seen as significant threats in the state (R. Tallman, WV DNR, pers. comm.). Wind energy development in high elevation areas can result in habitat loss through disturbance of existing shrublands or maintenance of turbine sites as homogeneous grassy habitats. Similarly, mountaintop mining, particularly at higher elevations, removes old mined strip benches where shrubland habitats have supported Golden-winged Warbler; current reclamation practices are not producing new habitat suitable for the species (P. Wood, pers. comm.). Management actions that typically create hard edges (sharp forest/grass transitions) and homogeneity also comprise a threat (or at least an opportunity loss)—for example, state-maintained wildlife openings that are neatly mowed grassy clearings in the middle of a forest or national forest allotments where the shrub component consists mostly of large hawthorns (K. Aldinger, pers. comm.). Informed management actions could increase suitable habitat for the species, but the potential is not always realized.

Maryland

State Legal Status: Unlisted

Natural Heritage Rank (see Table 1–6 for definitions): S3

Summary: Golden-winged Warbler was first documented as a breeding species in western Maryland in 1895. Prior to European settlement in this region, however, it was likely locally common in scattered forest openings such as those associated with large wetland systems, shale barrens, and early successional habitats created through the use of fire by Native Americans (D. Boone, pers. comm.). By the early 1900s, the species was reported as an increasingly common breeder in western Maryland (Eifrig 1904, Robbins and Blom 1996) as shrubby old fields and lightly grazed pasture became more prevalent on the landscape and as forests in some areas recovered from intensive logging and fires (Lorimer 2001). The distribution of Golden-winged Warbler appears to have been contracting westward in recent years, and the species is no longer common in western Maryland (Robbins and Blom 1996).

BBS: Golden-winged Warbler has been detected on nine BBS routes in the state since 1966, but on only four in the last 10 years (2001–2010; Sauer et al. 2011). Blue-winged Warbler is now detected on routes where Golden-winged Warbler formerly had been present. Analyses of long-term BBS data (1996–2010) suggest a steep decline in Maryland (-5.8% per year, 95% CI: -8.3, -3.3; n = 9; Figure 1–37; Sauer et al. 2012). However, the low number of route detections makes it difficult to draw confident conclusions regarding trends in western Maryland based on BBS data alone.

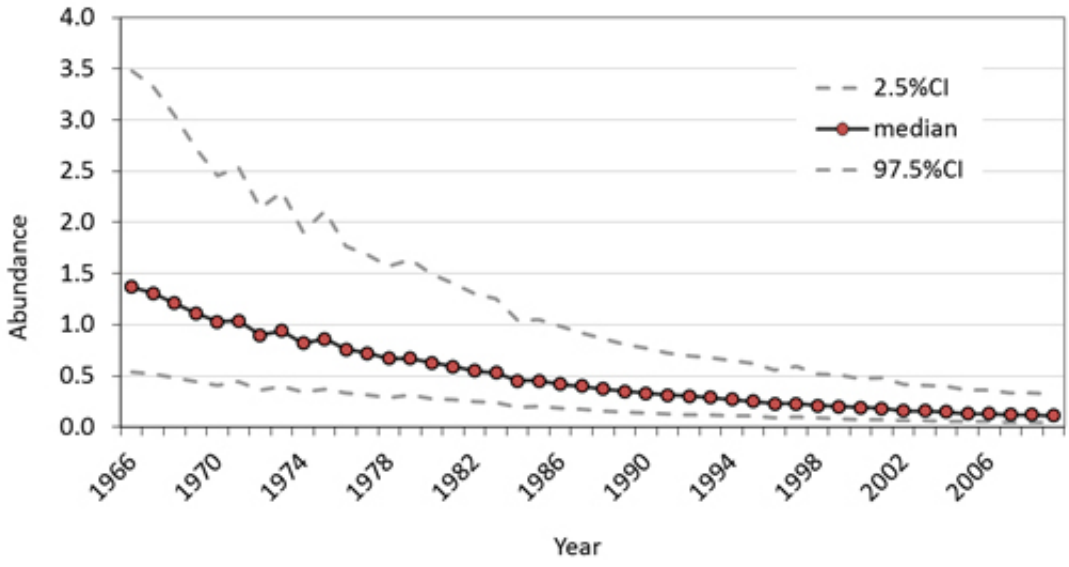

Figure 1–37. Changes in relative abundance of Golden-winged Warbler in Maryland based on hierarchical Bayesian analyses of BBS data (1966–2009).

BBA: Maryland's first Breeding Bird Atlas project was conducted from 1983 to 1987. Golden-winged Warbler was reported from 110 blocks with breeding confirmed on 18 blocks (Robbins and Blom 1996). Breeding was confined to th e western portion of the state, in the Allegheny Plateau and western half of the Ridge and Valley physiographic province. A second atlas project was begun in 2002 and completed in 2006 (Ellison 2010). Golden-winged Warbler was detected on only 38 blocks, a 65% reduction from the first effort, with breeding confirmed in just six blocks (Ellison 2010, USGS BBEA 2012). The species range also contracted approximately 40-50 km to the west, with breeding records now confined to just scattered blocks in the Allegheny Plateau and far western section of the Ridge and Valley (Ellison 2010). The decline was particularly severe in the Ridge and Valley where it occurred in 82% fewer blocks (46 vs. 8). There were 54% fewer blocks with Golden-winged Warbler detections (65 vs. 30) in the Allegheny Plateau between the first and second atlas time periods (Ellison 2010, G. Brewer, pers. comm).

BBC: Golden-winged Warbler has not been recorded on Maryland Breeding Bird Census plots, although few have been conducted in suitable habitat during the past 30 years.

Habitat Use: Golden-winged Warbler occupies brushy oak-hickory (*Carya* spp.) and mixed mesophytic habitats with small openings as well as shrub-meadow ecotones in high-elevation wetlands (Stewart and Robbins 1958). Beavers play a role in maintaining a shifting mosaic of suitable breeding habitat in wetland systems by creating or maintaining shrub-dominated patches (G. Brewer, MD DNR, pers. comm.). Golden-winged Warbler also occurs on old fields in later stages of succession, especially fields with periodic grazing (D. Boone, pers. comm.), and on reclaimed surface mines in the western mountains where a similar vegetation structure of scattered shrubs and small trees persists due to poor growing conditions.

Current Research and Monitoring: Although a number of breeding bird inventory and research projects have occurred in western Maryland since the 1980s, only one has specifically targeted Golden-winged Warbler. In 2011, data were collected as part of a regional study to inform best management practices related to silvicultural treatments. Out of 30 points with potentially suitable habitat in the Allegheny Plateau and western Ridge and Valley, Golden-winged Warbler was detected at only one point. In 2009, Golden-winged Warbler was one of the target species in western Maryland for Audubon Maryland-DC Important Bird Area (IBA) data collection and may be a target for other potential IBAs in the future. Golden-winged Warbler is not actively tracked by the Natural Heritage database, but its status is under review.

Threats: The displacement of Golden-winged Warbler by Blue-winged Warbler is a concern, especially in the Ridge and Valley physiographic province where the two species show the greatest overlap in their breeding distributions. During the late 1800s, Blue-winged Warbler was an uncommon and local breeder, with no nesting records in western Maryland (Kirkwood 1895). In the 1950s, Blue-winged Warbler was still fairly uncommon, and there was no overlap with the Golden-winged Warbler breeding range (Stewart and Robbins 1958). During the 1980s, the first Breeding Bird Atlas revealed a significant westward Blue-winged Warbler range expansion into the Ridge and Valley, with a few isolated blocks in the Allegheny Plateau physiographic province (Robbins and Blom 1996). However, the 2002–2006 atlas data indicate that Blue-winged Warbler has since declined, with 29% fewer block detections statewide as well as 9% fewer block detections in western Maryland where Golden-winged Warbler occurs (Ellison 2010). BBS data also suggest a Blue-winged Warbler decline of 1.8% per year since 1980, although too few birds were detected on BBS routes to produce a significant trend (Ellison 2010).

Other threats include loss of habitat to development, changes in land-use practices, and the loss of former natural disturbance regimes (e.g., fire and beaver activity). The latter would have provided a shifting mosaic of small openings in a predominantly forested landscape (G. Brewer, MD DNR, pers. comm.).

Virginia

State Legal Status: Unlisted
Natural Heritage Rank (see Table 1–6 for definitions): S3

Summary. Golden-winged Warbler breeds in western Virginia but is absent as a breeding species in the Virginia Piedmont and Coastal Plain (Rottenborn and Brinkley 2007). In 2001, GOWAP atlasing (Barker Swarthout et al. 2009) in southwestern Virginia detected about 40 territorial males in four counties (Giles, Grayson, Montgomery, and Wythe). Surveys led by USFS and Virginia Important Bird Area Program (VA IBAP) detected 25 individuals in Highland County in 2005 and 8 individuals in Bath County in 2006. A 2006 systematic breeding survey across the majority of the historical range of the species in Virginia found that Golden-winged Warbler continues to decline in the state and is being replaced in order of abundance by Blue-winged Warbler (Wilson et al. 2007). Fifty territorial Golden-winged Warbler males and six females were detected in 11 of 40 counties surveyed (including Bath, Highland, Alleghany, Rockbridge, Pulaski, Carroll, Tazewell, Smyth, Grayson, Washington, and Lee counties); the majority of observations were in Bath and Highland counties (Wilson et al. 2007). Golden-winged Warbler has been nearly extirpated from the Blacksburg area (Montgomery County) coincident with increases of Blue-winged Warbler and extensive development (R. Canterbury, unpubl. data).

BBS. Golden-winged Warbler has been recorded on two BBS routes in the last 10 years (2001–2010; Sauer et al. 2011). Figure 1–38 shows the population trend (-7.7%/year; 95% CI: -11.2, -4.0; *n* = 9 routes) derived from hierarchical analyses of long-term BBS data (1966–2010; Sauer et al. 2012). Low abundance along BBS routes preclude confident conclusions regarding the Virginia trend based on BBS data alone.

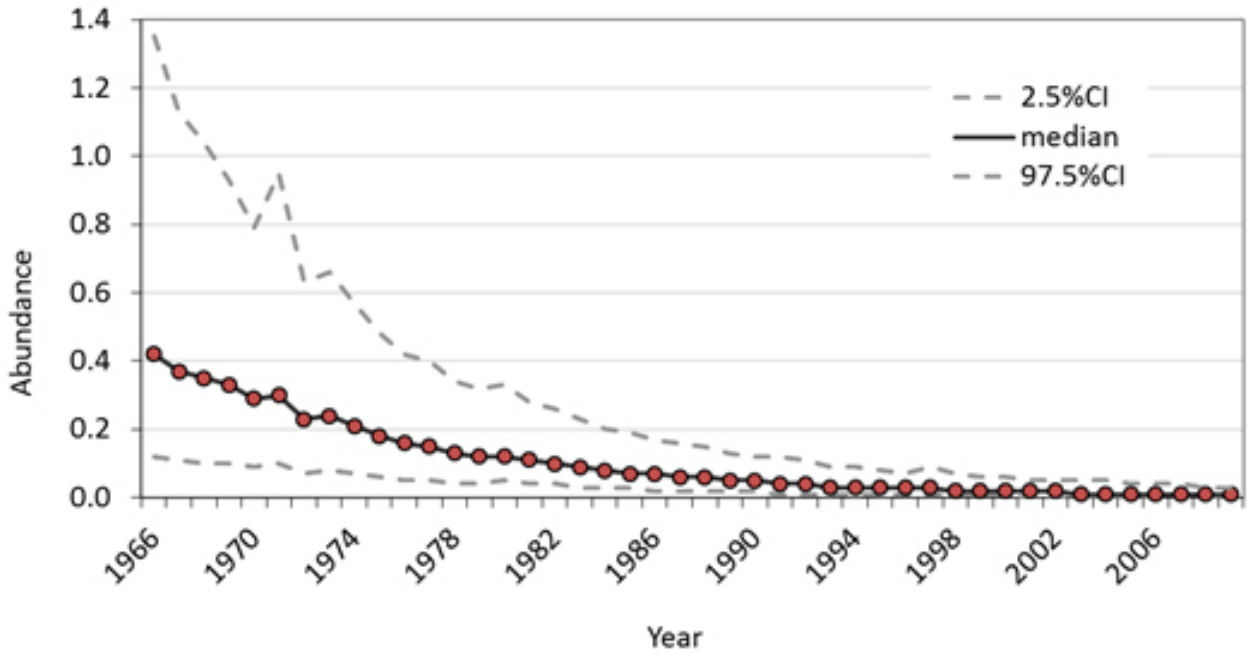

Figure 1–38. Changes in relative abundance of Golden-winged Warbler in Virginia based on hierarchical Bayesian analyses of BBS data (1966–2009).

BBA. The Virginia Breeding Bird Atlas project was conducted from 1985 to 1989 (Trollinger and Reay 2001). Golden-winged Warbler was reported from 53 (34 priority) blocks, and breeding was confirmed in nine (six priority) blocks (USGS BBEA 2012). Blue-winged Warbler was reported from 41 (28 priority) blocks with confirmed breeding in seven (four priority) blocks (USGS BBEA 2012).

BBC. Golden-winged Warbler has not been recorded recently on Virginia Breeding Bird Census plots, although few have been conducted in suitable habitat during the past 30 years.

Habitat Use. Golden-winged Warbler has been documented in old fields and clearcuts at elevations ranging from 580 to 760 m on the George Washington-Jefferson National Forest (J. Overcash, pers. comm., Conner and Adkisson 1975). In a recent systematic roadside breeding survey, Golden-winged Warbler was detected in idle farm/pastureland and forest clearcuts more frequently than expected (based on the number of such habitats surveyed) and in open-canopy mid-successional forest, powerline rights-of-way, and other shrub patches less frequently than expected (Wilson et al. 2007). There were no detections in shrubby wetlands or strip mines, although the species has previously been reported from mineland sites in southwestern Virginia (C. Croy, pers.

comm.). Golden-winged Warbler was only detected at elevations >460 m with the majority of observations occurring at >700 m (Wilson et al. 2007). A 2010 Virginia Department of Game and Inland Fisheries (VDGIF) status assessment of Golden-winged Warbler in wildlife openings, regenerating clearcuts, successional forests, utility rights-of-way, and beaver wetlands on four Wildlife Management Areas (WMAs) documented the species within only two habitat patches on two WMAs (VDGIF, unpubl. data).

In an intensive 2010 breeding season survey in the Golden-winged Warbler population stronghold in Bath and Highland counties, Bulluck and Harding (2010) did find Golden-winged Warbler in shrubby wetlands, but the species was not more likely to occupy such sites than sites lacking water features. Idle farm/pastureland comprised the predominant early successional habitat type within the two counties. In general, Golden-winged Warbler was associated with sites with moderately to highly clumped vegetation where ≥50% of saplings and shrubs were arranged in a contiguous patch; in addition, the species preferred sites with more mid-stature (1–2 m) shrubs (~29% in occupied vs. 18% in unoccupied sites). Landscape-level occupancy modeling suggested that suitable habitat on the landscape was unoccupied and that occupied sites were somewhat spatially clustered on the landscape (Bulluck and Harding 2010).

Current Research and Monitoring. As noted above, Bullock and Harding (2010) completed an intensive survey and analysis of Golden-winged Warbler habitat characteristics, detection probability, and occupancy at both local and landscape scales in Bath and Highland counties. The species has been monitored through county-level breeding bird forays conducted by the Virginia Society of Ornithology since 1966. Monitoring begun in 2004 by USFS biologists on George Washington and Jefferson National Forests, particularly in burned areas, is continuing (C. Croy, pers. comm.). The 2005–2006 surveys by USFS and VA IBAP were repeated in 2009 by the IBA program. Virginia, like other states in the region, is also participating in the spatially balanced monitoring program being coordinated by the Cornell Lab of Ornithology and implemented throughout the Appalachians.

Threats. Potential displacement by Blue-winged Warbler is evidenced by its eastward expansion to geographic areas and elevations formerly occupied only by Golden-winged Warbler and by a reversal in Golden-winged Warbler's historical status as numerically dominant over Blue-winged Warbler (Wilson et al. 2007). Blue-winged Warbler has been documented in all counties in which Wilson et al. (2007) found Golden-winged Warbler (Wilson et al. 2007; M. Elfner, unpubl. data; A. Weldon, unpubl. data). On the other hand, the low number of hybrids detected by Wilson et al. (2007) suggests that the impact of hybridization and genetic introgression may be minimal to moderate. The greatest concentrations of Blue-winged Warbler occurred in southwestern Virginia in Buchanan, Dickinson, Wise, Russell, and Tazewell counties; only Tazewell had Golden-winged Warbler detections (Wilson et al. 2007). Co-occurrence of the two species in the same habitat patches was documented in only two locations. Blue-winged Warbler was found in utility rights-of-way and shrubby wetlands more often than expected, while Golden-winged Warbler showed the opposite pattern for these two habitat types (Wilson et al. 2007).

The same factors affecting loss of early successional habitat rangewide (see pages 1–27-30) are also at work in Virginia, including reforestation, fire suppression, reduced timber harvest, urban development, and reduced acreage of abandoned farmland (S. Harding, pers. comm.). However, the landscape in Bath and Highland counties, which harbor most of the state's Golden-winged Warblers, is 80-95% forested with suitable moderate- to high- elevation early successional habitat being maintained as pasture and idle farms. Both counties have low human populations and current habitat conditions are not expected to change drastically in the coming decades (S. Harding, pers. comm.). Furthermore, both Wilson et al. (2007) and Bulluck and Harding (2010) documented the presence of suitable habitat unoccupied by Golden-winged Warbler, suggesting that habitat may not be a limiting factor in Virginia.

USFWS Southeast Region 4 Summary

Kentucky, Tennessee, North Carolina, Georgia, South Carolina

Region 4 supports an estimated 1.2% of the total global population of breeding Golden-winged Warbler, with five states harboring historical or present breeding populations. Current breeding records for the species are almost completely restricted to the Southern Blue Ridge and Cumberland Mountains of the Southern Appalachians. Golden-winged Warbler has been extirpated as a breeding species from South Carolina, and it breeds only in small numbers in northern Georgia and southeastern Kentucky. According to a population viability analysis (cf. Figure 1–7), the species is also at risk of extinction in North Carolina and Tennessee over the next century. Although the breeding elevation range for Golden-winged Warbler is from 300 to 1500 m, recent observations suggest that the species is increasingly restricted to elevations above 600 m (Klaus and Buehler 2001, Welton 2003). As measured by the BBS from 1966 to 2010, Golden-winged Warbler in Region 4 has experienced the steepest decline of any USFWS Region, a decline of -8.74% per year (95% CI: -12.35, -5.62; n = 15 routes) (Sauer et al. 2012). With the possible exception of Kentucky, there is virtually no evidence that interactions with Blue-winged Warbler have been responsible for this regional decline. Although Blue-winged Warbler has expanded into some areas formerly occupied by Golden-winged Warbler, this close-

ly-related species remains uncommon at best in the Southern Appalachians.

Of 219 sites with Golden-winged Warbler detections surveyed by GOWAP (Barker Swarthout et al. 2009) in the Cumberland Mountains Region (eastern Tennessee and Kentucky, southern West Virginia), 59% were in reclaimed strip mines and 18% were in upland shrub habitats (Figure 1–39). A majority of the birds on reclaimed strip mines were found on older, contour-type mines which are currently passing into more advanced seral stages and becoming less favorable for Golden-winged Warbler. The larger mountain top removal mines and new reclamation techniques do not favor the species (R. Canterbury, pers. comm.). Golden-winged Warbler has responded positively to prescribed burning at sites in Tennessee (D. Buehler, pers. comm.).

Of 197 GOWAP sites in the Southern Blue Ridge region (southern Virginia to Georgia), the majority of birds were in upland shrub (67%) and other upland habitats (10%) such as abandoned farm fields at high elevations (Figure 1–40). Birds were also found infrequently in utility rights-of-way (9%) and successional forest (8%) habitats. Only a small number were found in clearcuts, but these may have been under-represented in the sample.

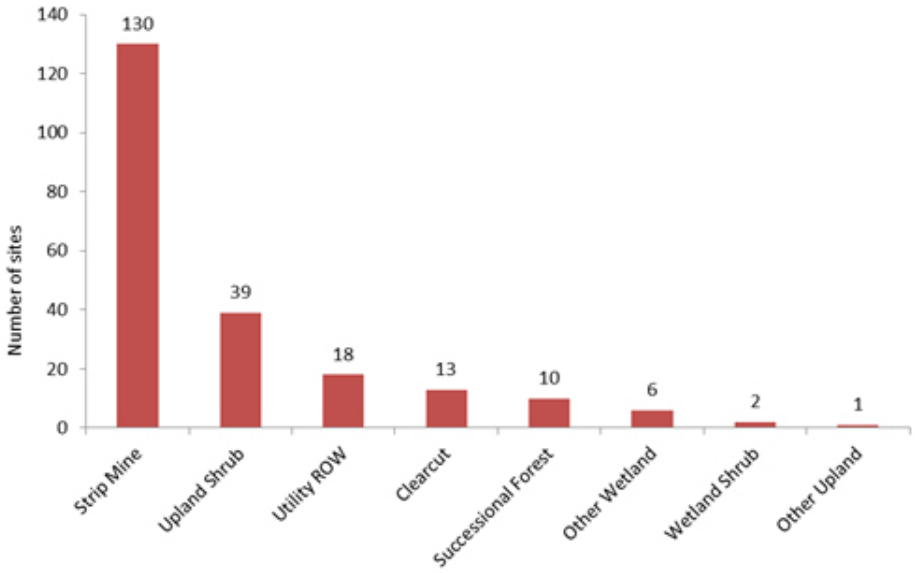

Figure 1–39. Distribution of habitat types at sites in the Cumberland region where Golden-winged Warbler was detected. Since sampling was non-random, these data represent only habitats where the species was detected and therefore do not characterize use versus availability of habitat. See Appendix F for habitat definitions. In this figure, Upland Shrub = upland shrubby field + upland abandoned farm and Wetland Shrub = alder swamp + beaver wetland + shrub wetland.

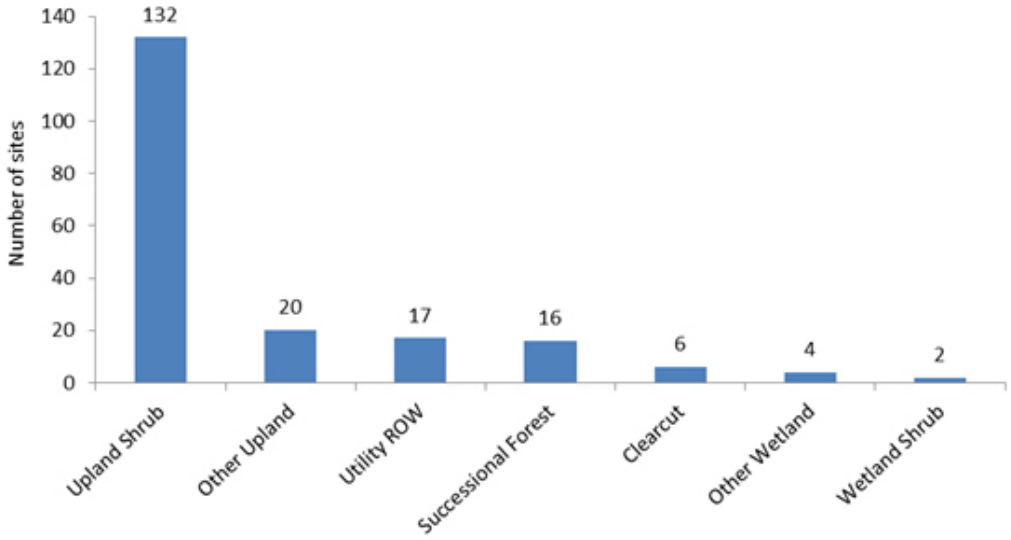

Figure 1–40. Distribution of habitat types at sites in the Southern Blue Ridge region where Golden-winged Warbler was detected. Since sampling was non-random, these data represent only habitats where the species was detected and therefore do not characterize use versus availability of habitat. See Appendix F for habitat definitions. In this figure, Upland Shrub = upland shrubby field + upland abandoned farm and Wetland Shrub = alder swamp + beaver wetland + shrub wetland.

Kentucky

State Legal Status: Threatened
Natural Heritage Rank (see Table 1–6 for definitions): S2

Summary: Mengel (1965) listed Golden-winged Warbler as a very rare summer resident in Kentucky, confined to parts of the Cumberland Mountains and possibly the Cumberland Plateau. Prior to European settlement, breeding populations in Kentucky were likely limited to scattered summits higher than 850 m. Though still confined to the southeastern portion of the state, Golden-winged Warbler breeding populations likely expanded as forested ridgetops were converted to early successional habitat as a result of strip mine reclamation and logging operations. Following a similar pattern, Blue-winged Warbler has recently expanded into southeastern Kentucky, including some high elevation areas where pure Golden-winged Warbler populations have most consistently been found. Hybrids and phenotypes evidencing genetic introgression are now commonly observed in these mixed populations.

BBS: Golden-winged Warbler has been recorded on three BBS routes in southeastern Kentucky, with six individuals recorded from 1973–1979. There have been no detections on BBS routes since 1979 (Sauer et al. 2012). Blue-winged Warbler is now recorded on all three of the routes that formerly listed Golden-winged Warbler. BBS data are insufficient to estimate population trends.

BBA: A Breeding Bird Atlas was conducted in Kentucky from 1985 to 1991. Only four breeding pairs of Golden-winged Warbler were documented from southeastern Kentucky (Palmer-Ball 1996). Two of these were July records of adult females accompanied by freshly molted immatures and thus may have represented migrant rather than breeding birds.

BBC: Golden-winged Warbler has not been recorded on Kentucky Breeding Bird Census plots, although few have been conducted in suitable habitat during the past 30 years.

Habitat Use: Golden-winged Warbler inhabits overgrown old fields and areas that have been recently cleared, including clearcuts, reclaimed coal surface mines, and utility corridors (Palmer-Ball 1996). Sixteen 2003 GOWAP records in nine quadrants ranged in elevation from 390 to 780 m, with most observations above 600 m (Barker Swarthout et al. 2009; S. Vorisek, Kentucky Department of Fish and Wildlife Resources [KDFWR], pers. comm.). Patton (2007) found that 2004–2005 Golden-winged Warbler territories at sites with only Golden-winged Warbler (n = 25) tended to be found at higher elevations (775–925 m), on flatter slopes, and with more grass cover than Blue-winged Warbler territories at locations where both species were present (n =22). Typically Golden-winged Warbler is found on drier slopes that support a well-developed forb cover of goldenrod and sericea lespedeza (*Lespedeza cuneata*) with patchy clusters of black locust and blackberry (Patton et al. 2010).

Current Research and Monitoring: Research in 2006–2008 examined productivity, habitat choice, and reproductive behavior in mixed populations of Golden-winged and Blue-winged warblers in Bell and Whitley counties (P. Hartman and D. Westneat, University of Kentucky). KDFWR will continue monitoring Golden-winged Warbler populations on various state point count surveys and, like other states in the region, will participate in the spatially balanced monitoring program being coordinated by the Cornell Lab of Ornithology and implemented throughout the Appalachians.

Threats: Ecological interactions and hybridization with Blue-winged Warbler likely comprise a significant threat to the persistence of Golden-winged Warbler in Kentucky. Monitoring efforts (2003–2008) indicate that declines of Golden-winged Warbler in southeastern Kentucky coincide with the arrival of Blue-winged Warbler. Populations of both species in eastern Kentucky occur on abandoned and reclaimed coal surface mines that may be vulnerable to re-mining activities. Modern reclamation practices generally do not produce suitable habitat for Golden-winged Warbler. Future viability of the species is also threatened by loss of open oak woodlands and savannas resulting from limitation of forest management on public lands.

Tennessee

State Legal Status: In need of management
Natural Heritage Rank (see Table 1–6 for definitions): S3

Summary: Golden-winged Warbler was considered a rare species by early ornithologists in Tennessee; it was reported from the Southern Blue Ridge Mountains and eastern Cumberland escarpment in the late 1800s (Nicholson 1997). With intensive forest clearing in the early 1900s, Golden-winged Warbler abundance likely increased. Stupka (1963) reported Golden-winged Warbler as fairly common at low and middle elevations in Great Smoky Mountains National Park into the 1950s, although those populations have since disappeared as forests have matured (Nicholson 1997). A small population was reported from clearcut areas within the Cherokee National Forest during the 1990s; that population has also disappeared in recent years as forests matured (Klaus 1999). Golden-winged Warbler occurred in

abandoned farmlands and young pine plantations along the eastern Cumberland escarpment until the late 1990s. Most of these habitats have since succeeded and no longer support the species. Today, sizeable populations (>100 breeding pairs) persist only on public lands, including Royal Blue and Sundquist wildlife management areas in the Cumberland Mountains of Tennessee. Most birds occur on old, narrow surface-mine benches and more modern reclaimed sites (Yahner and Howell 1975, Nicholson 1997, M. Welton, pers. comm.). Blue-winged Warbler is still relatively rare in most areas occupied by Golden-winged Warbler. There is no indication that declines of Golden-winged Warbler are related to competition or genetic swamping from Blue-winged Warbler.

BBS: Golden-winged Warbler has been recorded on seven BBS routes in Tennessee, primarily within the Cumberland Plateau and Cumberland Mountains. In the past 10 years (2001–2010), the species has been detected on only three routes. Analyses of long-term BBS data (1966–2010) suggest that Golden-winged Warbler in Tennessee has experienced steep declines of -7.7% per year (95% CI: -11.5, -4.4; n = 7 routes; Figure 1–41; Sauer et al. 2012). However, low abundance along BBS routes confounds confident conclusions regarding trends in Tennessee based on BBS data alone.

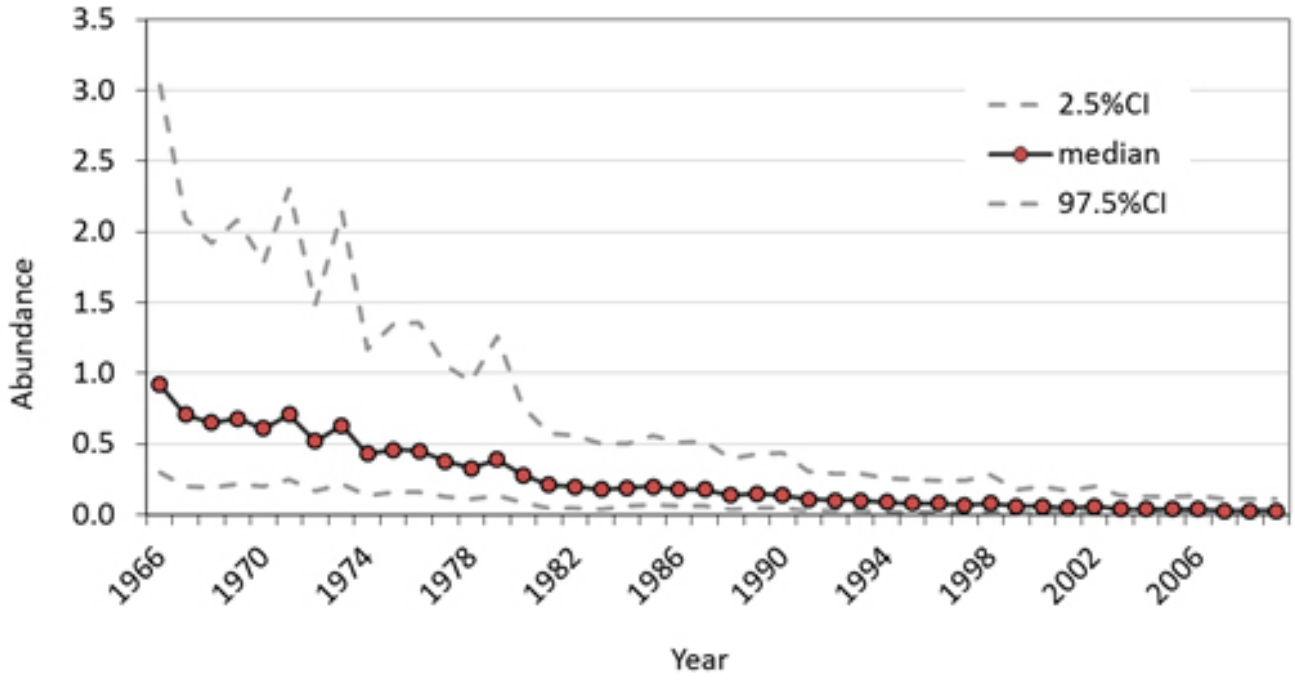

Figure 1–41. Changes in relative abundance of Golden-winged Warbler in Tennessee based on hierarchical Bayesian analyses of BBS data (1966–2009).

By 2100, if trends and variability in trends persist as they have for the last 40 years, Golden-winged Warbler has a 100% (95% credible level: 100%, 100%) risk of a further 90% population loss in Tennessee (Figure 1–42).

BBA: A Breeding Bird Atlas project was conducted from 1986 to 1991. Golden-winged Warbler was recorded in 20 priority and 19 supplemental blocks, primarily on the Cumberland Plateau and in the Cumberland Mountains (Nicholson 1997). GOWAP monitoring in 2001–2002 (Barker Swarthout et al. 2009) documented Golden-winged Warbler on 59 sites across two disjunct physiographic areas—the northern Cumberland Plateau and Mountains, especially on coal surface mines, and in the southern Blue Ridge Mountains in northeastern Tennessee (Welton 2003).

BBC: Golden-winged Warbler has been recorded on several Breeding Bird Census plots: Great Smoky Mountains National Park, 30 pairs per 100 ha (1947–1948; Kendeigh and

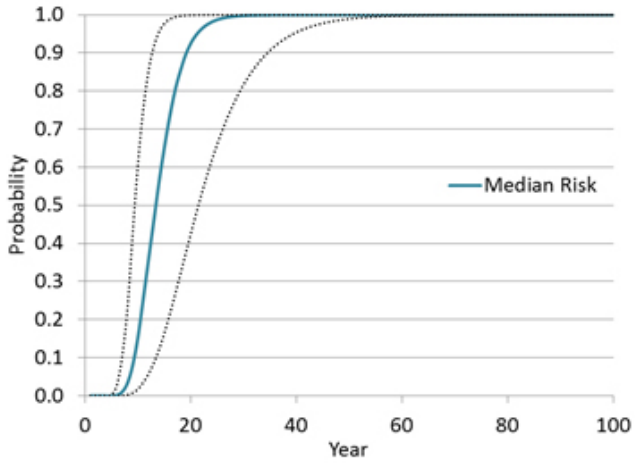

Figure 1–42. Risk of quasi-extinction for Golden-winged Warbler in Tennessee as determined by a 90% decline from the year 2000 population by year 2100. Dashed lines represent the 95% credible interval. See Appendix C for methods.

Fawver 1981); surface mines in the Cumberland Mountains, 3.9–7.7 pairs per 100 ha (1972–1973; Yahner 1972, 1973); and surface mines in the Cumberland Mountains, 4.3–8.5 pairs per 100 ha (1979–1980; Nicholson 1979, 1980). No census plots in similar surface mine habitat in the Cumberland Mountains have been monitored since 1980.

Habitat Use: Habitats used in the Cumberland Mountains include abandoned farms, surface mines with fescue (*Festuca* spp.) and scattered black locust, and rarely young pine plantations in the grass stage (Nicholson 1997). Elsewhere, regenerating clearcut areas have been used when suitable herbaceous cover is present (Klaus 1999).

Current Research and Monitoring: North Cumberland Wildlife Management Area in northeastern Tennessee (Scott, Campbell, and Anderson counties) was one of the eight study sites involved in the 2008–2010 collaborative research project of the Golden-winged Warbler Rangewide Conservation Initiative (Appendix D). Research at this site began in 2003 and is ongoing (D. Buehler, University of Tennessee). Bulluck (2007) and Bulluck and Buehler (2008) reported the results of recent research on Golden-winged Warbler in the Cumberland Mountains, including nesting habitat and ecology, territory size, demography, and effects of land use on long-term population trends. Golden-winged Warbler is tracked in the state's Natural Heritage database. In addition, Tennessee is participating in the spatially-balanced monitoring program being coordinated by the Cornell Lab of Ornithology and implemented throughout the Appalachian region.

Threats: Limited forest management on public lands since 1990 has reduced the availability of early successional habitat to the extent that the future viability of Golden-winged Warbler is threatened—at least in the Southern Blue Ridge portions of Tennessee. Populations have been virtually extirpated from the southern districts of the Cherokee National Forest (Klaus et al. 2005). Modern surface mining reclamation practices generally do not produce suitable habitat for Golden-winged Warbler, and existing populations on abandoned and reclaimed coal surface mines may be vulnerable to re-mining activities. Interactions with Blue-winged Warbler are not perceived to comprise a threat to Golden-winged Warbler in Tennessee.

North Carolina

State Legal Status: Unlisted
Natural Heritage Rank (see Table 1–6 for definitions): S3

Summary: Brewster (1885, 1886) reported Golden-winged Warbler to be abundant in the second-growth forests and open oak woodlands of western North Carolina (elevations between 600 and 1200 m). Pearson et al. (1942) described a 1906 nest with four young located in a pasture near Waynesville (approx. 900 m elevation). Today, Golden-winged Warbler remains a locally common summer resident at middle and high elevations (600–1600 m) across western North Carolina. GOWAP surveys in 2001 located approximately 100 Golden-winged Warbler pairs across western North Carolina (Barker Swarthout et al. 2009). Recent surveys by Audubon North Carolina (Smalling pers. comm.) have detected Golden-winged Warbler in 15 of the 20 western counties in the state concentrated in five key population centers: near the Amphibolite peaks in the northwest; the New River Corridor (especially the north fork); Roan Mountain; the Max Patch mountain area; and the Nantahala National Forest (from Franklin to Robbinsville and the Fontana area). Historical records exist for four additional counties (mostly at lower elevations). Blue-winged Warbler is still rare in the state, occurring in only four counties in extreme southwestern and northwestern North Carolina (Smalling pers. comm.). Although a few hybrids have been detected within areas occupied predominately by Golden-winged Warbler in western North Carolina, there is no evidence of extensive hybridization. Hybrid territories typically comprise only about 7–12% of occupied territories, depending on the area of the state (Smalling pers. comm.).

BBS: Golden-winged Warbler has been recorded on four BBS routes in the last 10 years (2001–2010). Analyses of long-term BBS data (1968–2010) suggest that Golden-winged Warbler has experienced relatively steep declines of -10.1% per year in North Carolina (95% CI: -15.7, -4.3; n = 8 routes; Figure 1–43; Sauer et al. 2012). However, there are insufficient data to confidently draw conclusions regarding trends in North Carolina based on BBS data alone.

BBA: A Breeding Bird Atlas was conducted from 1988 to 1993. Golden-winged Warbler was detected in 20 survey blocks across western North Carolina (North Carolina Museum of Natural Science, unpubl. data).

BBC: Golden-winged Warbler has not been recorded on North Carolina Breeding Bird Census plots, although few have been conducted in suitable habitat during the past 30 years.

Habitat Use: During the breeding season Golden-winged Warbler uses old fields, lightly to moderately grazed agricultural lands, woodland edges, and early successional mixed mesophytic forests (NC Natural Heritage database, C. Smalling, pers. comm.). It has been reported from recently harvested (<15 years old) northern hardwood and oak-hick-

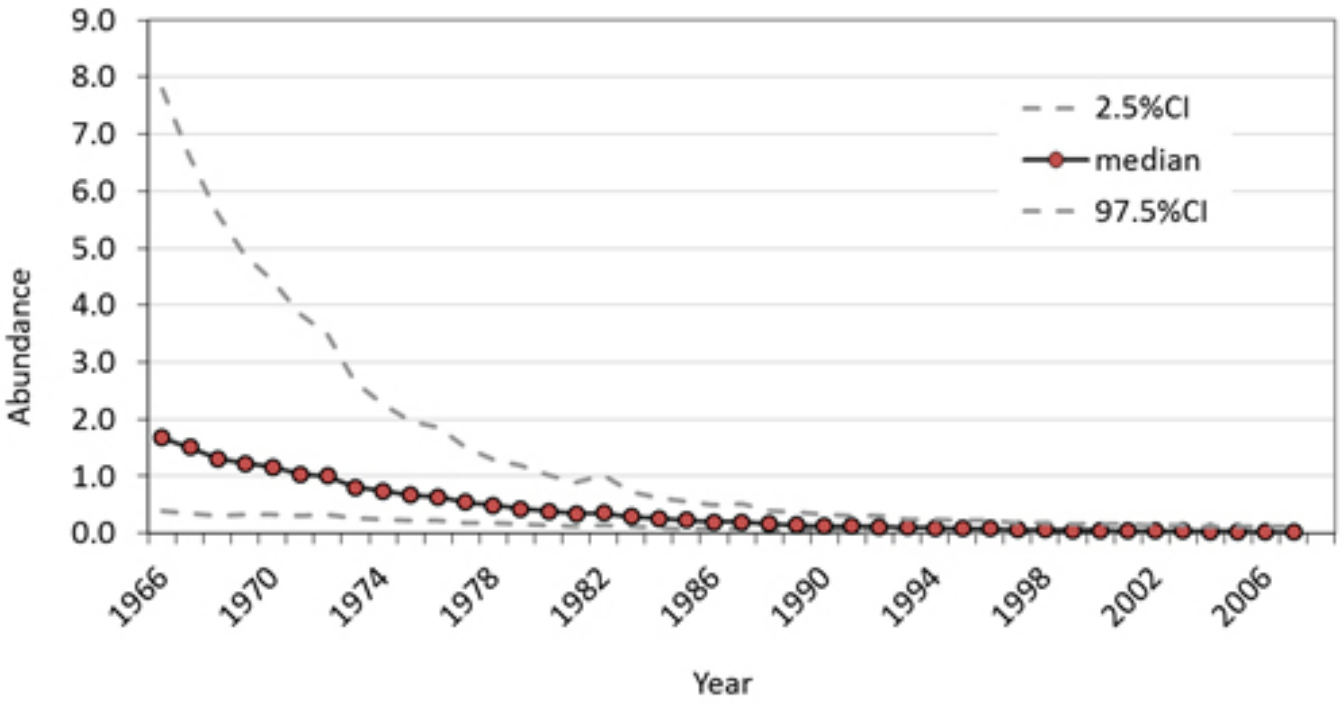

Figure 1–43. Changes in relative abundance of Golden-winged Warbler in North Carolina based on hierarchical Bayesian analyses of BBS data (1966–2009).

ory forests with logging roads and log landings with grass/forb cover in Nantahala National Forest (Klaus 1999, Klaus and Buehler 2001), from floodplain wetlands and associated early successional uplands in southwestern North Carolina (Rossell 2001, Rossell et al. 2003), and from Christmas tree plantations, either newly planted fields or fields abandoned after harvest. A predictive model for western North Carolina (Brown 2007) reinforced the importance of a contiguous forest landscape despite the species affinity for early successional habitat.

Current Research and Monitoring: Watauga County in northwestern North Carolina comprised one of the eight study sites involved in the 2008–2010 collaborative research project of the Golden-winged Warbler Rangewide Conservation Initiative (Appendix D). Research on these Watauga County successional forests at mid- to high elevations (>1000m) is continuing (C. Smalling, Audubon North Carolina). Over 100 locations in the Amphibolite peaks, New River corridor, and Roan Mountain areas of northwestern North Carolina are surveyed annually as part of a long-term monitoring effort. North Carolina is also continuing to refine a habitat suitability model (Brown 2007) to aid in evaluating the efficacy of warbler management techniques and has been a leader in fostering cooperative efforts to sustain Golden-winged Warbler non-breeding populations in Nicaragua. The state is also participating in the spatially-balanced monitoring program being coordinated by the Cornell Lab of Ornithology and implemented throughout the Appalachian region.

Threats: Principal threats to Golden-winged Warbler in North Carolina include continued residential development at elevations suitable for the species (600–1200 m), greatly reduced forest management on the Pisgah and Nantahala National Forests, and unmanaged forest regeneration following agricultural abandonment (resulting in a very transient early successional phase).

Georgia

State Legal Status: Endangered
Natural Heritage Rank (see Table 1–6 for definitions): S1

Summary: Golden-winged Warbler is now a rare summer resident in the mountains of northern Georgia. After five years (1999–2003) of surveying potential habitat on public and private lands within the historic Georgia range, Klaus (2004) found fewer than 20 occupied territories. The species was formerly reported as a fairly common summer resident in northern Georgia (Burleigh 1958). Breeding was first recorded in Whitfield County in 1859 (Baird et al. 1874). Other historical breeding records include Dade County in 1885 and Towns, Union, Dawson, and Fannin counties during the first half of the 20th century (Burleigh 1958). Blue-winged Warbler was first reported nesting in Georgia in the early 1920s

and was considered rare at best, occurring mostly in areas not known to historically support Golden-winged Warbler (Burleigh 1958). In northern Georgia, most areas formerly occupied by Golden-winged Warbler have succeeded to middle-aged or mature hardwoods. With decreased commercial timber harvest and increased fire suppression, no replacement habitat has been created at suitable elevations. Blue-winged Warbler populations have also declined steeply, and the few individuals encountered in recent years have all occurred at lower elevations than Golden-winged Warbler (N. Klaus, Georgia DNR, pers. comm.).

BBS: Golden-winged Warbler was recorded on two BBS routes in northeastern Georgia from 1975–1988, but there have been no detections since 1988. BBS data are insufficient to estimate population trends.

BBA: A Breeding Bird Atlas project was conducted from 1994 to 2001 (Schneider et al. 2010). Golden-winged Warbler was recorded only at a few previously known sites in extreme northern Georgia. These included overgrown pastures in Union County north of Suches and several Hurricane Opal salvage logging cuts at Ledford Gap, Fannin County. In 2000, several pairs were seen engaged in courtship and territorial behavior in the population north of Suches. During the first week of June 2002, the year after BBA surveys were completed, a male Golden-winged Warbler was seen feeding recently fledged young at the Ledford Gap site. Several hybrids were also seen at this site the same year, including an adult female Lawrence's Warbler carrying food (Klaus 2004). A third site in northwest Rabun County was occupied only in 2002 after an intense fire destroyed hundreds of hectares of forest.

BBC: Golden-winged Warbler has not been recorded on Georgia Breeding Bird Census plots, although few have been conducted in suitable habitat during the past 30 years.

Habitat Use: Golden-winged Warbler uses forest clearings and old fields overgrown with scrubby underbrush; it also occupies clearcuts less than 13 years old (Klaus and Buehler 2001).

Current Research and Monitoring: A multi-agency research project is monitoring potential breeding habitat in montane areas of northern Georgia. Although Golden-winged Warbler is tracked through the Natural Heritage database, there are currently no records of this species.

Threats: Interactions with Blue-winged Warbler do not appear to comprise a threat to Golden-winged Warbler in Georgia. However, limited forest management on public land has resulted in minimal availability of early successional habitat to the extent that the future viability of Golden-winged Warbler in Georgia is threatened. The only significant Golden-winged Warbler population in the state is on Brawley Mountain within the Chattahoochee National Forest (Fannin County). This population, which consisted of about three territorial pairs in 2003, has since grown to 12–15 pairs. Suitable habitat exists here as a result of Hurricane Opal in 1995 and subsequent salvage logging, prescribed burns, and one wildfire. Management authorities are proposing that an additional 160 hectares of early successional habitat be created on Brawley Mountain through timber harvest, prescribed burning, and the use of herbicides. These treatments will be monitored to determine their effectiveness.

South Carolina

State Legal Status: Unlisted

Natural Heritage Rank (see Table 1–6 for definitions): SNA

Summary: In the late 1800s, Golden-winged Warbler was reported from Pickens, Greeneville, and Oconee counties in the mountains of northwestern South Carolina (Loomis 1890, 1891; Sprunt and Chamberlain 1949; Post and Gauthreaux 1989). Although large-scale timber harvesting during this period created abundant habitat, Golden-winged Warbler still was presumed to be restricted to higher elevations (750–1050 m). Today these areas are heavily forested and contain very little suitable habitat with the exception of a few small scattered clearcuts and powerline rights-of-way. There are no nesting records for Golden-winged Warbler from the 20th century (J. Cely, pers. comm.). Blue-winged Warbler has not yet been documented as nesting in South Carolina (Dunn and Garrett 1997, J. Cely, pers. comm.) and thus has played no role in the extirpation of Golden-winged Warbler from the state.

BBS: No Golden-winged Warblers have been recorded on South Carolina BBS routes.

BBA: A Breeding Bird Atlas was conducted from 1988 to 1995, but no Golden-winged Warblers were recorded.

BBC: Golden-winged Warbler has not been recorded on South Carolina Breeding Bird Census plots, although none have been conducted in suitable habitat during the past 30 years.

Habitat Use: Golden-winged Warbler formerly frequented open, brushy hillsides and pastures where low bushes and vines grew profusely (Sprunt and Chamberlain 1949).

Current Research and Monitoring: No research or monitoring specific to Golden-winged Warbler is known to be occurring in South Carolina.

Threats: No specific data.

Canada

Saskatchewan, Manitoba, Ontario, Quebec

Canada supports an estimated 16.4% of the global population of breeding Golden-winged Warbler in three provinces, with possible expansion into a fourth (Table 1–7). Ontario contains the core breeding population, approximately 15.3% of the global population. The Canadian population of Golden-winged Warbler has appeared to be relatively stationary or increasing (+1.7% per year; 95% CI: -1.6, 5.0; *n* = 36 routes; Sauer et al. 2012) over the long-term (1967–2010).

A range-wide analysis of genetic introgression between Golden-winged and Blue-winged warblers suggests that Manitoba may be home to the only remaining genetically pure populations of Golden-winged Warbler throughout the breeding range (Vallender et al. 2009). These pure populations appear to exist only in the area around Riding Mountain National Park and the Duck Mountains, with the first cryptic hybrids being discovered in southeastern Manitoba in 2009 (Vallender, unpubl. data).

Saskatchewan

Provincial legal status: Unlisted
Natural Heritage Rank (see Table 1–6 for definitions): SNA

Summary: The Natural Heritage Inventory has not mapped Golden-winged Warbler records because currently the species is considered accidental in the province (J. Keith, SA Conservation Data Center, pers. comm.). There is one confirmed breeding record, and there are reports of probable and possible breeding in the eastern mountains (Smith 1996).

BBS: No Golden-winged Warblers have been reported on BBS routes (1966–2010).

BBA: There are 11 atlas records for Saskatchewan; several, within a reasonable distance of a breeding population at Riding Mountain National Park, involve breeding behavior. Most of the records, however, are spring and fall migrant observations (Smith 1996).

BBC: No known records from censuses.

Habitat Use: No specific data.

Current Research and Monitoring: As part of a Northwest Golden-winged Warbler Working Group project, monitoring has been conducted in the southeastern portion of the province near the Duck Mountains and Porcupine Hills since 2008. To date, no Golden-winged Warbler genetic samples have been collected; however, the close proximity of Saskatchewan to the genetically pure populations in Riding Mountain National Park and the Duck Mountains in Manitoba suggest that Golden-winged Warblers in the province are likely unaffected by hybridization at this point in time.

Threats: No specific data.

Manitoba

Provincial legal status: Unlisted
Natural Heritage Rank (see Table 1–6 for definitions): S3B

Summary: Golden-winged Warbler was first observed near Winnipeg in 1887. Five additional sightings were reported from 1905–1928, and a small breeding population was discovered east of Winnipeg in 1932. The species was rediscovered in the same general area in 1978 and still occurs there regularly today (Koes 2003). In 2008, over 200 individuals were recorded in this region (Artuso 2008). A second population, centered near Riding Mountain National Park in western Manitoba, was first detected in 1967. Monitoring efforts and Golden-winged Warbler sightings have increased in recent years across the province, with over 395 territorial birds recorded in 2008 and 2009 combined (C. Artuso, Bird Studies Canada, pers. comm.)

BBS: Golden-winged Warbler has been recorded on six BBS routes in southeastern Manitoba during the past 10 years (2001–2010; Sauer et al. 2011). This species was not detected on BBS routes prior to 1995. Thus long-term analysis of BBS data (1968–2010) suggests that Golden-winged Warbler has experienced an astronomical increase of +32.6% per year (95% CI: +9.1, +80.6; *n* = 7 routes; Sauer et al. 2012).

BBA: No Breeding Bird Atlas has been completed in Manitoba (BBEA 2008), although one is currently in progress

(2010–2014), with preliminary results available on the web (**http://www.birdatlas.mb.ca**).

BBC: No data.

Habitat Use: The recently discovered and possibly expanding population of Golden-winged Warbler in Manitoba occurs in trembling aspen (*Populus tremuloides*) or mixed deciduous forest stands, especially those with open areas with soft edges created by tree-fall gaps or occasionally with harder edges such as those produced by agriculture. Specific habitat types include upland bur oak (*Quercus macrocarpa*) scrub mixed with trembling aspen; stands dominated by over-mature trembling aspen with standing snags and canopy gaps promoting a dense shrub layer; regenerating deciduous stands or mixed deciduous and conifer stands after fire or logging; alder swales in boreal (mixed) forest or bogs; marshland /trembling aspen ecotones, including beaver-modified ponds and stream edges, marsh edges, and grassland edges; and along rights-of-way in various habitat including tamarack bogs and the habitats mentioned above (Artuso 2008; S. VanWilgenburg, Environment Canada, pers. comm.; W. Vanderschuit, Parks Canada, Riding Mountain National Park, pers. comm.).

Current Research and Monitoring: In 2008, an *ad hoc* multi-agency committee was established to coordinate Golden-winged Warbler monitoring and research in Manitoba and neighboring areas of Saskatchewan and northwestern Ontario. The Canadian *Species at Risk Act* requires the preparation of a Golden-winged Warbler recovery strategy for which the multi-agency committee plans to contribute enhanced distribution and habitat data. By 2010, researchers collected both genetic and stable isotope samples from 355 birds; collection of this information will continue through the next several years (W. Vanderschuit, pers. comm.; Vallender et al. 2009). From 2008–2010, Bird Studies Canada mapped the distribution and broad habitat associations of Golden-winged Warbler in Manitoba and adjacent Saskatchewan using playback surveys; this survey work is complete and is now transitioning into more intensive nest monitoring. Distribution mapping will continue under the auspices of the atlas project. LP Canada Ltd. also began conducting playback surveys for Golden-winged Warbler in 2008 (C. Artuso, pers. comm.).

Threats: Although Manitoba is believed to host the only pure genetic populations of Golden-winged Warbler throughout the breeding range (Vallender et al. 2009), several phenotypic Brewster's Warblers have been detected in Manitoba in recent years, including one male captured near Riding Mountain National Park (C. Artuso and S. Van Wilgenburg, pers. comm.). In addition, a Blue-winged Warbler was captured at Delta Marsh Bird Observatory in the spring of 2010. These discoveries suggest that introgression of Blue-winged Warbler DNA into the pure Golden-winged Warbler population may be imminent.

Ontario

Provincial legal status: Special Concern
Natural Heritage Rank (see Table 1–6 for definitions): S4

Summary: Golden-winged Warbler arrived in Ontario in the early 1900s but was only observed in the extreme southwestern portions of the province (McCracken 1994). They expanded to the western counties near Lake Erie by 1909 (Speirs 1985, McCracken 1994) and then northeastward throughout the southwestern peninsula toward Toronto in the 1930s (Peck and James 1983). Golden-winged Warbler was considered fairly common throughout the Bruce Peninsula and northward to Sudbury by the 1970s (Speirs 1985, McCracken 1994). Currently the species occurs in greatest abundance along the southern edge of the Canadian Shield. In some areas of southern Ontario, a substantial decline in Golden-winged Warbler populations correlates with the arrival and expansion of Blue-winged Warbler in the region (Mills 1987). Except for areas in Norfolk County (e.g., Long Point), Golden-winged Warbler has now all but vanished from extreme southwestern Ontario as a breeding species.

BBS: Golden-winged Warbler has been recorded on 30 BBS routes in Ontario in the last 10 years (2001–2010), primarily in the southeast. Analyses of long-term BBS data (1967–2010) suggest a relatively stationary population throughout Ontario (+0.9% per year; 95% CI: -2.5, +4.1; n = 49 routes; Figure 1–44); the present-day median population estimate is, however, roughly twice that of the 1966 population estimate (Sauer et al. 2012).

BBA: The first Ontario Breeding Bird Atlas project was conducted from 1981–1985 (Cadman et al. 1987). Golden-winged Warbler was reported from 469 priority squares, and breeding was confirmed in 23% of those squares (BBEA 2008). The second atlas project was conducted from 2001–2005 (Cadman et al. 2007). Golden-winged Warbler showed significant declines of up to 65% in its previous strongholds in the province. For example, the probability of occurrence dropped from 26% to 19% in the Southern Shield. Breeding was confirmed in only 15% of squares that reported the species, and nests were only located in two squares (highlighting the difficulty in finding Golden-winged Warbler nests).

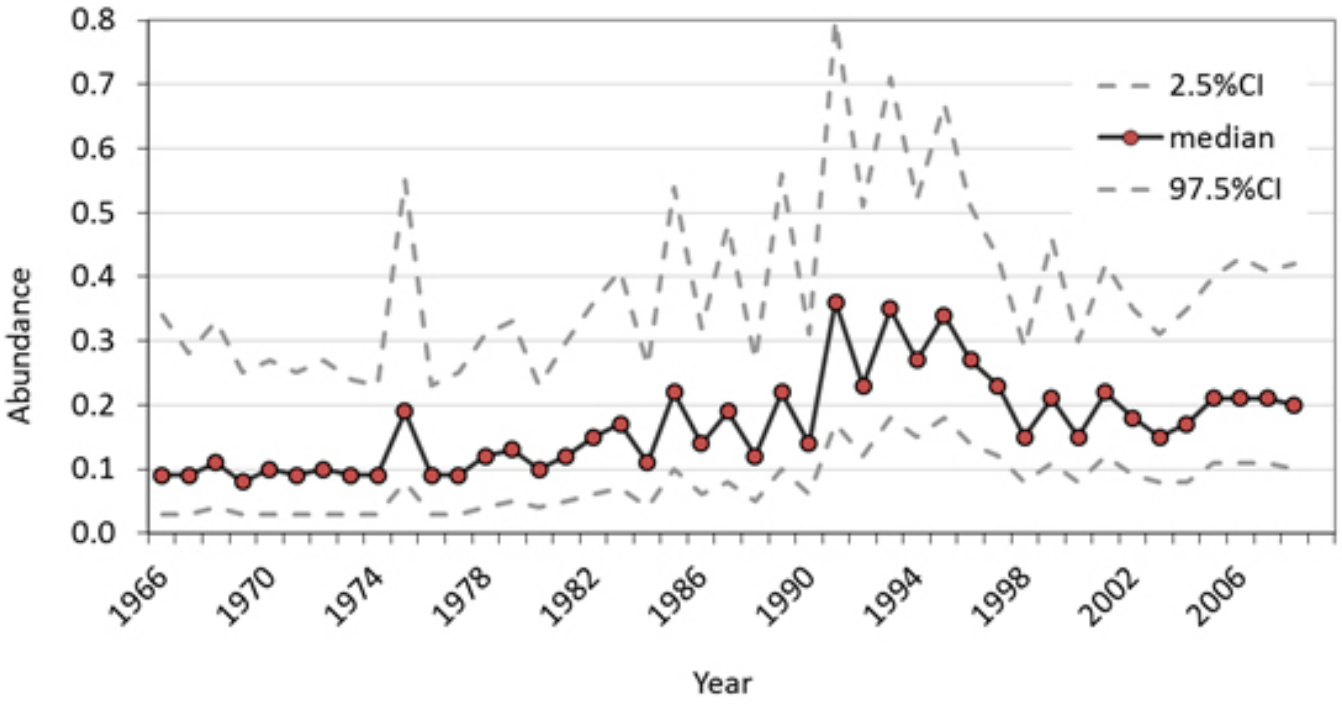

Figure 1–44. Changes in relative abundance of Golden-winged Warbler in Ontario based on hierarchical Bayesian analyses of BBS data (1966–2009).

BBC: Golden-winged Warbler was reported from old field habitat in 1994 (one pair per 5.8 ha) and 1995 (two pairs per 5.8 ha).

Habitat Use: Studies from Queen's University suggest that Golden-winged Warbler in Ontario prefers scrubby upland vegetation over wetland habitats.

Current Research and Monitoring: Research on Golden-winged Warbler has been conducted under the direction of R. J. Robertson at Queen's University Kingston since 1997. Individual projects include studies on song variation (Harper et al. 2010), nest-site selection and predation (Demmons 2000), genetic architecture in a newly formed hybrid zone (Vallender et al. 2007a,b; 2009), nestling sex ratios (Neville et al. 2008), parental feeding habitats (Reed et al. 2007), and population monitoring protocols (King et al. 2009). Many of the later projects (Reed et al. 200; Vallender et al. 2007a,b; Neville et al. 2008; Vallender 2009; Harper 2010) have addressed effects of hybridization as the numbers of Blue-winged Warbler and hybrids increase in the region. Genetic analyses conducted in the mid-2000s indicated that up to 30% of phenotypic Golden-winged Warblers sampled as breeders in southern Ontario were actually cryptic hybrids (Vallender et al. 2007b). Subsequent analysis suggested that an additional population near Barrie, Ontario (N 44° 22′ 770″, W 79° 42′ 130″) also had been affected by hybridization, although to a minimal degree, with 7% of phenotypic Golden-winged Warblers showing Blue-winged Warbler-specific DNA (Vallender, unpubl. data). A Canada-wide study which included Ontario birds (Vallender et al. 2012) found no difference in blood parasite infection probability between pure and hybrid Golden-winged Warblers, adding to the evidence that hybrids in the *Vermivora* system do not face postzygotic selection (cf. pages 1–20-22).

Long Point Bird Observatory's long-term banding studies showed an increase in the number of Golden-winged Warblers captured over the period 1960–2000 (Bird Studies Canada 2001). However, Blue-winged Warbler captures also increased during this time period such that the capture ratio of Golden-winged Warbler to Blue-winged Warbler decreased from 2.6:1 (1960–1969) to 0.25:1 (1990–1999).

Threats: The primary threat in Ontario is the potential genetic replacement of Golden-winged Warbler by expanding populations of Blue-winged Warbler.

Quebec

Provincial legal status: Likely to be designated Threatened or Vulnerable
Natural Heritage Rank (see Table 1–6 for definitions): S3

Summary: Golden-winged Warbler was first detected in Quebec in 1957, and its abundance and range increased until the mid-1980s. The breeding range appears to have contracted since then and is now limited to the southwestern corner of the province. Golden-winged Warbler is considered a rare breeding bird in Quebec (Gauthier and Aubry 1996).

BBS: Golden-winged Warbler has been recorded on only a single BBS route in southern Quebec in the last 10 years (2001–2010 Sauer et al. 2011). Figure 1–45 shows the population trend (-2.1%/year, 95% CI: -11.1, +7.6) derived from hierarchical Bayesian analyses of long-term BBS data (1967–2010; Sauer et al. 2012). Insufficient data due to low abundance along BBS routes, however, preclude confidently drawing conclusions regarding the Quebec trend based on BBS data alone.

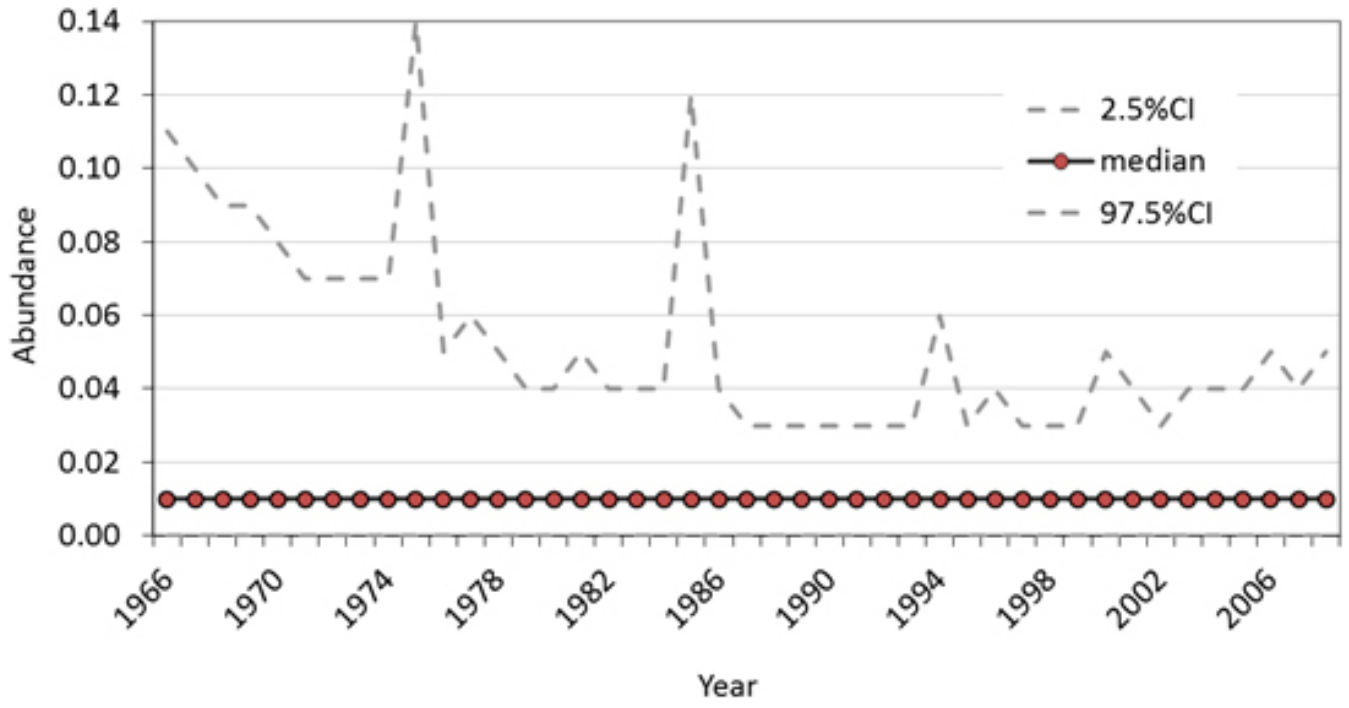

Figure 1–45. Changes in relative abundance of Golden-winged Warbler in Quebec based on hierarchical Bayesian analyses of BBS data (1966–2009).

BBA: The Quebec Breeding Bird Atlas project was conducted from 1984 to 1989 (Gauthier and Aubry 1996). Golden-winged Warbler was reported from 31 (1.3%) of 2,464 atlas blocks.

BBC: No Quebec census plots have been conducted in suitable habitat.

Habitat Use: Golden-winged Warbler inhabits old fields and abandoned pastures, often near a forest edge. Many of these fields occur on poor soils, and thus regrowth is quite slow. Vegetation often consists of deciduous shrubs that are several meters in height along with scattered deciduous trees.

Current Research and Monitoring: Since 1994, Canadian Wildlife Service (CWS) Québec region and Regroupement Québec Oiseaux (RQO) have conducted a species-at-risk monitoring program. This effort has recorded 124 potential breeding sites for Golden-winged Warbler, and breeding was confirmed at 12 of those sites. Genetic monitoring of the small Quebec population has been taking place since 2007. The first cryptic hybrid Golden-winged Warblers were detected in 2008 (Vallender et al. 2009) but remain at low levels as of 2010 (Vallender, unpubl. data).

Threats: Primary threats include the destruction and ecological succession of suitable habitat.

CHAPTER 2.

GOLDEN-WINGED WARBLER FULL LIFE CYCLE CONSERVATION STRATEGY

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www.gwwa.org/committees

Illustration by Bartels Science Illustrator
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CHAPTER 2 SUMMARY

Golden-winged Warbler (*Vermivora chrysoptera*) populations have declined significantly across their breeding range for the past 45 years, based on analysis of North American Breeding Bird Survey (BBS) data. The eastern portion of the breeding population, primarily in the Appalachian Mountains Bird Conservation Region, has declined precipitously and is now largely disjunct from the Midwestern (Great Lakes) populations. Midwestern populations, which now comprise the vast majority of breeding pairs, are now starting to decline as well. Much of the decline of this species can be explained by habitat loss, while hybridization with Blue-winged Warbler (*Vermivora cyanoptera*) has exacerbated the declines and added complexity to the development of effective conservation strategies. These themes related to Golden-winged Warbler biology, ecology, and population status are further explored in Chapter 1 of this Status Review and Conservation Plan.

The Golden-winged Warbler Working Group was established in 2003 to provide a coordinated response to the declining Golden-winged Warbler populations. The Working Group has developed this full life cycle conservation strategy for this species based on contemporary knowledge about its breeding, migration, and wintering ecology. The strategy is based on the presumption that limiting factors on the breeding grounds, during migration, and on the wintering grounds need to be addressed to effectively counteract the factors currently responsible for population declines. On the breeding grounds, this strategy is based on delineation of focal conservation areas where maintenance of breeding populations is being promoted through implementation of habitat management guidelines. These guidelines (Chapter 3) have been developed based on a cooperative research project documenting habitat characteristics and relationships with successful nesting (see sidebar, page 2–9). The Working Group will conduct training workshops for public and private land managers to get knowledge about Golden-winged Warbler habitat prescriptions into the hands of people that can affect habitat management. Additional work is needed to delineate the migration pathways for Golden-winged Warbler to allow for the development of specific conservation strategies to protect migration stopover areas. The Working Group is also working on the wintering grounds to document distribution and habitat associations, and develop proactive conservation strategies to protect and restore quality wintering habitat that will ensure successful over-winter survival (Chapter 4). Success of the conservation strategy will be assessed through a coordinated monitoring program. This monitoring program will track the key components of the conservation strategy, including acres managed for Golden-winged Warbler, population response at multiple spatial scales, and changes in levels of genetic introgression within populations.

This conservation strategy has been developed with the needs of other priority species in mind. The species associated with Golden-winged Warbler have been identified in this document. We have also forged a working relationship with the regional Young Forest Initiatives (**www.youngforest.org**) coordinated by the Wildlife Management Institute, among others, to avoid duplication of effort and benefit from synergistic activities.

For your reference, a glossary of commonly used terms is provided in Appendix A. Other useful sources of information about Golden-winged Warbler are listed in Appendix B.

Understanding a species' ecology and demography throughout its life cycle is the key to identifying the factors leading to population decline or limiting population growth (see sidebar). Until we have definitive evidence identifying specific limiting factor(s); however, we advocate a full life cycle strategy to conservation that includes addressing several identified threats:

1. Increasing quality and quantity of breeding, stopover, and wintering habitats.
2. Minimizing hybridization with the closely related Blue-winged Warbler.
3. Promoting research into refining our understanding of the factor(s) leading to population decline and recovery.

The primary premise behind this conservation strategy is that reproductive output may be increased by increasing the amount of habitat and by improving the quality of existing habitat. This straightforward notion; however, is complicated by the Golden-winged Warbler's interactions with the closely related Blue-winged Warbler. In some areas, therefore, suitable habitat might not be occupied by Golden-winged Warblers if Blue-winged Warblers are present. For this reason, land managers should seek to create habitat in locations and configurations that promote persistence of Golden-winged Warbler populations and minimizes interactions with Blue-winged Warblers.

Example of Factors Limiting Population Growth

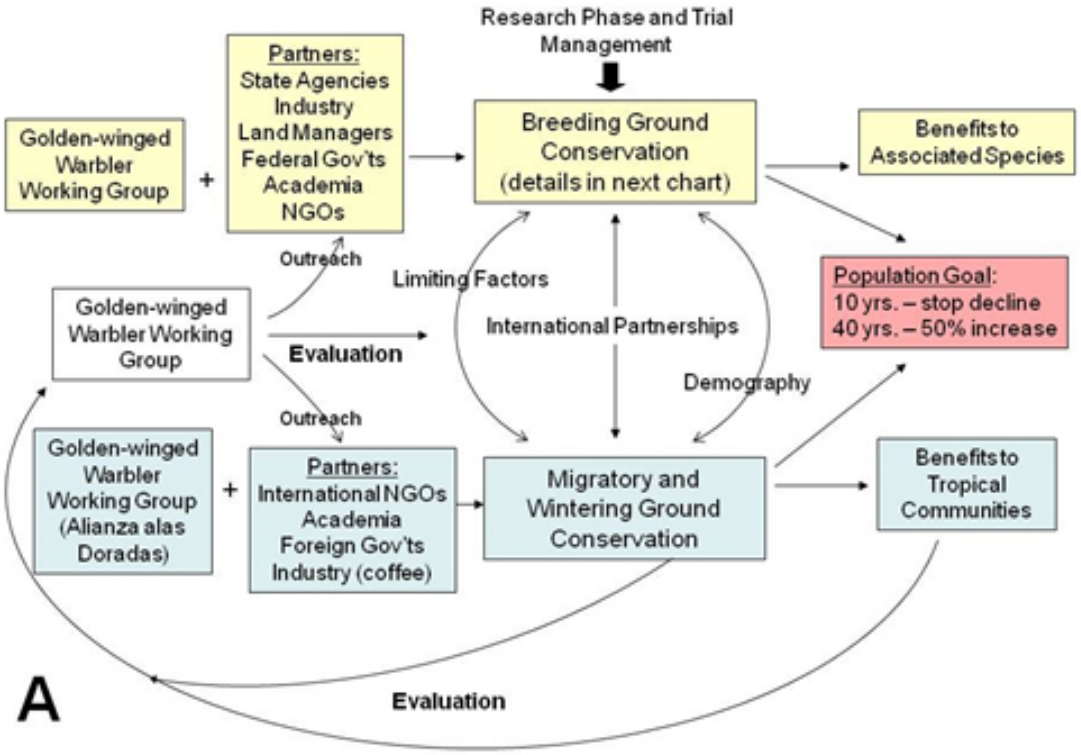
Imagine that a population is like water in a leaky bucket. Because there are holes in the bucket, the water is continually draining out; this represents mortality in a population. To maintain the water level in the bucket, more water must be added periodically; this represents reproduction and recruitment into a population. If the rate of the water leaking from the bucket is equal to the water entering the bucket, then a population is stable. If the rate of the water leaking from the bucket exceeds the rate of the water entering the bucket, then a population is declining, as is the case for the Golden-winged Warbler. To increase population size, there are two options: 1) increase reproductive output (i.e. increase the rate of adding water to the bucket), and/or 2) increase annual survival and recruitment to the population. By increasing reproductive output, we can potentially increase a population, but this will be limited by the breeding ecology of the species. Golden-winged Warblers are single-brooded and produce at most 5–6 young per brood. If the rate of mortality exceeds the maximum reproductive potential of the species, then other conservation actions will be necessary for population recovery.

The conceptual model in Figure 2–1A describes the strategic plan for Golden-winged Warbler conservation. This logic framework was originally developed as part of the National Fish and Wildlife Foundation's Early Successional Habitat (ESH) Initiative business plan. Included are the key components needed for successful implementation to meet the stated population goals with an emphasis on a full life cycle conservation approach. Figure 2–1B and C details the process being implemented by the Golden-winged Warbler Working Group to address conservation during the breeding and nonbreeding seasons. Though this document addresses rangewide and regional planning needs, additional meetings and planning may be needed at the state and local level to assist agencies with implementation. The next phase of implementation will require collaboration between a broad range of partners to protect and manage breeding habitat. The Golden-winged Warbler Working Group will play a fundamental role in providing technical assistance and outreach tools to assist partners in this next phase. Though baseline information on breeding habitat management has been collected, ongoing evaluation of management tools and guidelines will be necessary to improve our effect on populations.

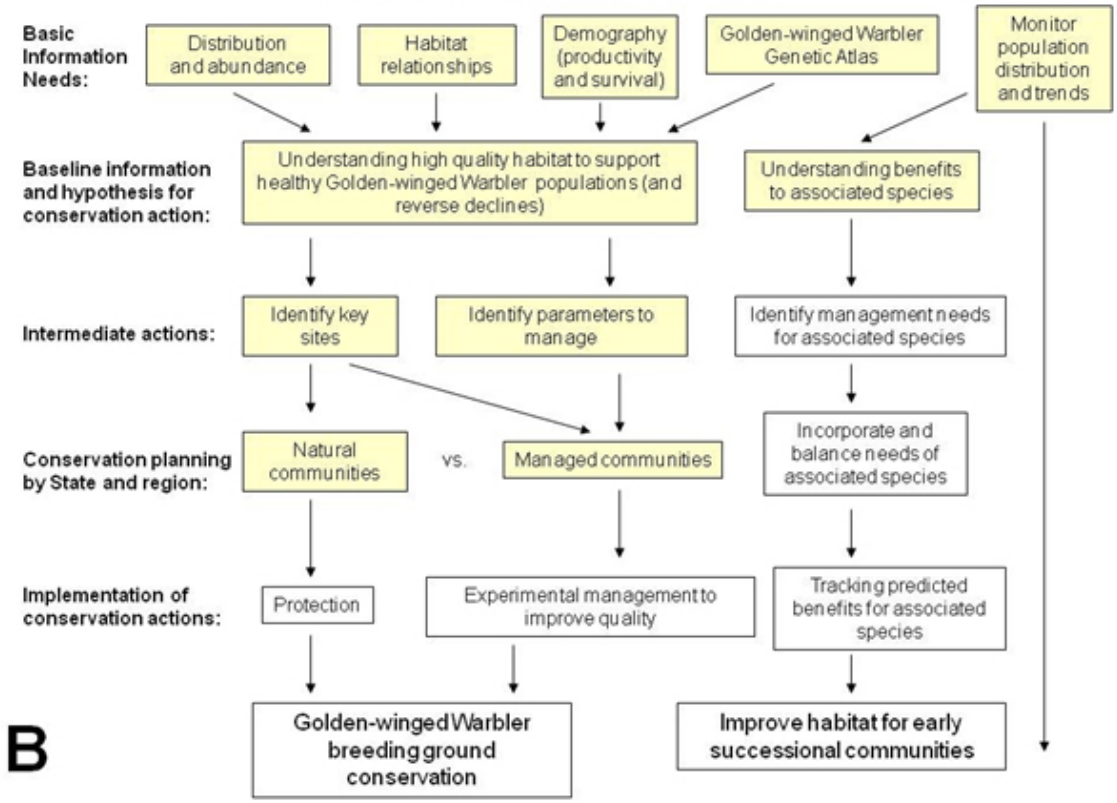
The primary strategy for increasing Golden-winged Warbler populations on the breeding range is through creation, restoration, and maintenance of high quality habitat on a landscape scale. The progression of management phases toward population recovery will follow a conceptual model similar to that developed by the Royal Society for the Protection of Birds (Figure 2–2). The current focus for the Golden-winged Warbler Working Group and partners is to implement large-scale, adaptive management aimed at population recovery in places where further experimentation is either unnecessary or where there are locations and habitat types that have received little previous research. It will be important to evaluate population response at all phases of management to track progress toward population goals. Continued research will be needed to fill gaps in our knowledge about habitat suitability and to evaluate new management techniques and strategies. Given that ESHs can quickly succeed out of suitability for Golden-winged Warbler, all strategies will need to consider that the amount of available habitat may change over time. The rate of habitat turnover will vary depending on habitat type. For example, given poor site conditions and slow succession, reclaimed surface mines might remain suitable for decades, while an aspen clearcut might become unsuitable in as few as ten years. Long-term conservation plans should include provisions for habitat creation (e.g., timber harvesting), restoration (e.g., removing some trees and shrubs in old fields), and maintenance (e.g., periodic use of fire, brush-hogging, or grazing to slow succession). New research following survival of Golden-winged Warbler through fledging (Streby and Andersen, pers. comm.) suggests that the Golden-winged Warbler is a bird of forested landscapes that depends on multiple seral

stages at different stages of the breeding season. Thus, while ESH might be critical to nesting success, the overall forest landscape, including proximity to mature forest, may be important to long-term reproductive success (and hence population growth) of the species. Breeding season success calls for a dynamic forested landscape conservation approach.

GOLDEN-WINGED WARBLER CONSERVATION STRATEGIC PLAN



BREEDING GROUND CONSERVATION



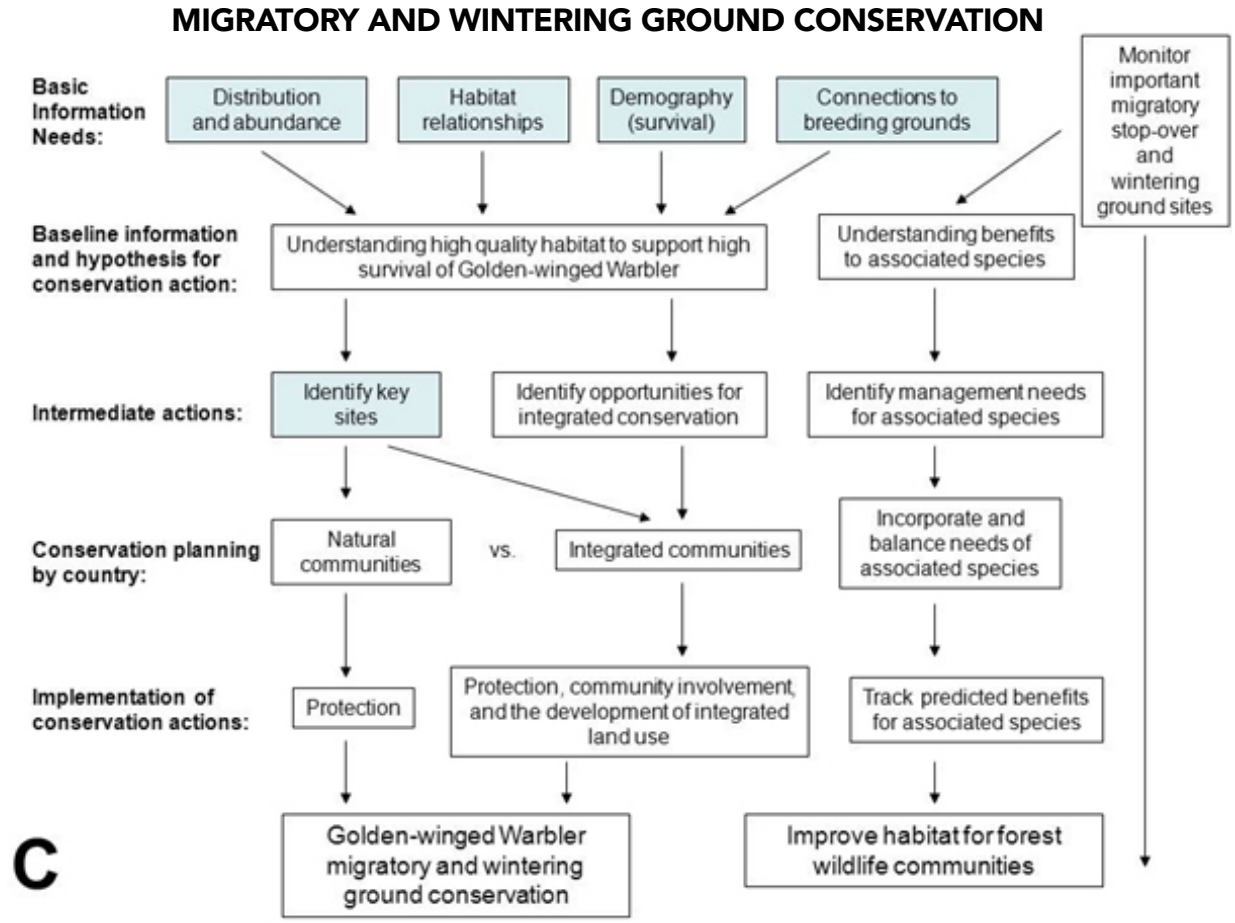


Figure 2–1. (A) Logic framework describing the overall strategy for Golden-winged Warbler conservation with (B) additional details on the breeding ground component and (C) wintering ground component. Note: in (B) and (C) shaded boxes indicate steps that are completed or underway.

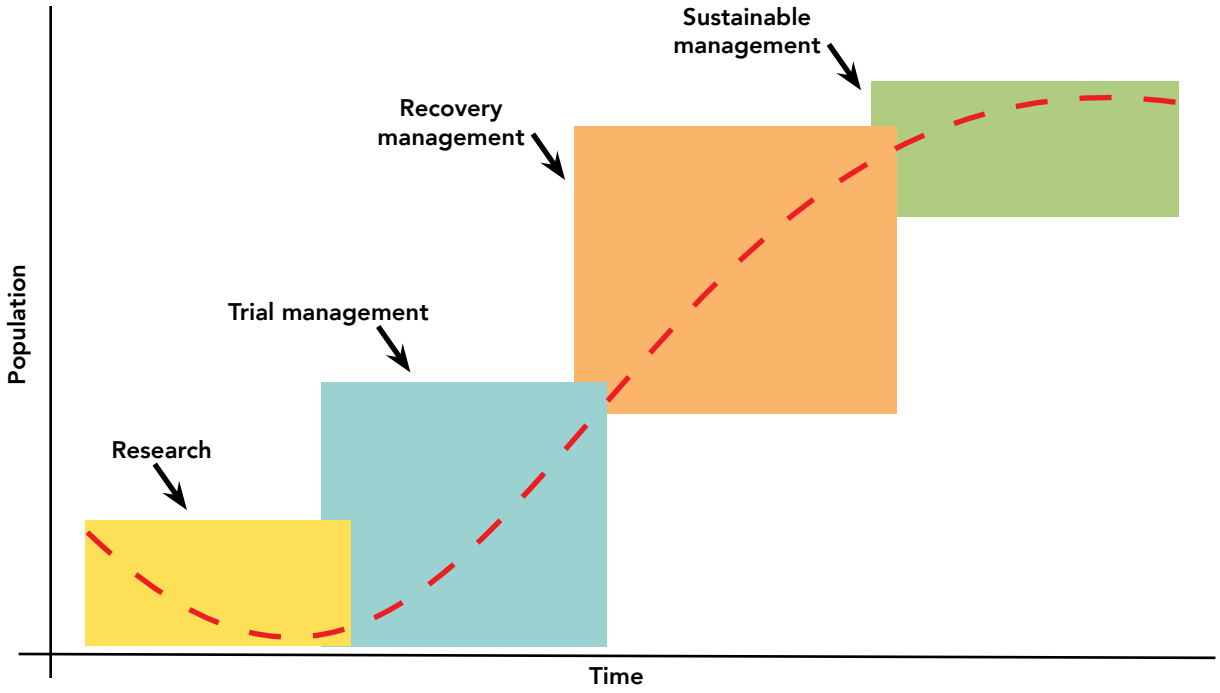


Figure 2–2. A conceptual model showing a progression of recommended habitat management actions based on different population levels (from the Royal Society for the Protection of Birds, reproduced from the US Fish & Wildlife Service's Henslow's Sparrow Conservation Action Plan, 2010).

Given that the breeding range of Golden-winged Warbler includes significant area in both the United States and Canada, working with partners on both sides of the border will be key to the successful recovery of the Golden-winged Warbler across its range. Coordination of efforts among all agencies and organizations working to conserve Golden-winged Warbler populations will benefit rangewide conservation of the species. Key Canadian researchers and policy-makers have participated in the Golden-winged Warbler Working Group and in collaborative research and monitoring efforts that form the basis of this conservation plan.

In Canada, the Golden-winged Warbler is listed as Threatened on Schedule 1 of the *Species at Risk Act* (SARA), which necessitates the preparation of a recovery strategy and action plan. The recovery strategy was completed in 2016 and can be found here: **http://www.sararegistry.gc.ca/default.asp?lang=En&n=35BF48A1-1**. The broad strategies and general approaches to recovery of the Golden-winged Warbler in Canada are presented in Table 2–1. Progress towards meeting the population objective will be measured by realizing no declines in abundance in Canada five years after initiating implementation of the recovery plan. We acknowledge that hybridization with Blue-winged Warblers is now occurring across Canada. The two species are even more closely related than previously believed (Toews et al. 2016) and hybridization cannot be halted by human intervention, so we suggest focusing conservation efforts on the creation and maintenance of high quality habitat for Golden-winged Warblers. This goal of stabilizing Canadian populations covers a shorter time period (5 years) than the time period stated elsewhere in the rangewide conservation plan for stable populations (10 years). We assume that stabilization of the global population will take more time because of the extensive geographic range being addressed. SARA requires that the recovery plan is revisited every five years and that the species' status be reassessed by COSEWIC every 10 years.

Critical Habitat Identification in Canada

Under SARA, Critical Habitat, defined as the specific habitat necessary for the survival or recovery of a listed wildlife

Table 2–1. Broad strategies to recovery and associated general descriptions of research and management approaches to address the main threats and limitations to Golden-winged Warbler populations in Canada.

Threat or Limitation	Priority	Broad Strategy to Recovery	General Description of Research and Management Approaches
Population growth and productivity information gaps	High	Inventory and monitoring	• Implement standard protocol to monitor Golden-winged Warbler populations (Golden-winged Warbler Working Group, **www.gwwa.org/**).
Wide-scale maturation of young forest and old fields; reduction of shrub layer; Loss of habitat through development and other activities in Canada and elsewhere	High	Habitat assessment, management and protection	• Determine suitable nesting and fledgling habitat requirements and availability at the regional level (i.e., provincial scale, Bird Conservation Region scale). • Incorporate techniques and implement guidelines and forestry practices to maintain suitable habitat through commercial forestry and management of old fields and rights-of-way. • Determine land succession and habitat dynamics following farmland abandonment and forest clearing. • Continue to establish stewardship agreements, working relationships, and investigate opportunities for habitat securement.
Nest parasitism by Brown-headed Cowbirds (*Molothrus ater*)	Medium	Research and monitoring	• Determine levels of cowbird parasitism and effects on Golden-winged Warbler nesting and fledgling success. In Manitoba, BHCO were found to significantly decrease number of young fledged per nest (Moulton 2018) and further research is needed.
Knowledge gaps concerning wintering range; wintering habitat requirements; threats to wintering areas	Medium	Collaborate and build partnerships with international agencies	• Collaborate with the United States and Central and South American counterparts to quantitatively describe wintering habitat characteristics and requirements to define important wintering and migration areas. • Collaborate with the United States and Central and South American counterparts to determine breeding subpopulations and subsequent wintering ground associations through stable isotope analysis and other methods.
Hybridization and competition with Blue-winged Warbler	Low	Assess the significance of hybridization	• Continue to monitor levels of hybridization with Blue-winged Warblers and effects on Golden-winged Warbler populations across the Canadian range (Vallender et al. 2009, Moulton et al. 2017).

species, is identified in the recovery strategy or in the action plan for a species. Critical habitat for Golden-winged Warblers has been identified in the recovery strategy and shown to be accurate in subsequent ground-truthing surveys. Given the level of threats and the broad distribution of the species, the current proposal is to use a coarse landscape-level approach to identify the amount of available suitable habitat within high density areas of Golden-winged Warbler abundance (e.g., in Ontario, along the southern edge of the Canadian Shield including the transition zone between the Boreal Shield and Mixedwood Plains ecozones; for a map go to: **http://atlas.nrcan.gc.ca/auth/english/maps/environment/forest/forestcanada/terrestrialecozones/1**). This amount, determined by selecting suitable habitat types and considering the configuration of these habitat types, is based on the needs of the species and its known habitat associations. Preliminary results for Ontario identified the total amount of critical habitat required to meet the population and distribution objectives for the species across its range in Ontario, and a similar approach to the identification of critical habitat will be applied for the remainder of the species' Canadian range (i.e., Manitoba and Québec). Golden-winged Warbler habitat is dynamic, so the bounds placed on the configuration of necessary suitable habitat should be minimal.

Golden-winged Warbler Conservation Initiative's Population and Habitat Study

Over the three years of the National Fish and Wildlife Foundation's (NFWF) Golden-winged Warbler Conservation Initiative, basic demographic data (nest success, annual reproductive output, clutch size, young produced per successful nest, parasitism rates, hybridization rates, and return rates) were collected at seven study sites in MN, NC, NY, PA, TN, WI, and WV (see Appendix D for description of study sites and principal investigators). These data helped develop population models to determine where and under what habitat conditions source/sink populations exist. Baseline data collected in the first year of the study were used to develop habitat manipulative experiments in some locations in years two and three that ultimately lead to the development of these management prescriptions across the Golden-winged Warbler breeding range. Other priority species that co-occur with the Golden-winged Warbler were monitored to extend the inference of this work to the entire early-successional bird community.

ASSOCIATED SPECIES AND PLANS

As a group, bird species associated with shrubland and early successional forest communities in eastern North America have declined since the launch of the USGS BBS in 1966 (Hunter et al. 2001). Although there is still debate about historic baselines for these species within the eastern forest biomes, declining shrubland species have been identified as priorities for conservation based on several bird conservation plan sources. At a continental level, Partners in Flight (PIF) Watchlist species include Golden-winged Warbler, Blue-winged Warbler, and Prairie Warbler (*Setophaga discolor*), and Continental Stewardship species include Alder Flycatcher (*Empidonax alnorum*), Nashville Warbler (*Oreothlypis ruficapilla*), Chestnut-sided Warbler (*Setophaga pensylvanica*), Mourning Warbler (*Geothlypis philadelphia*), Eastern Towhee (*Pipilo erythrophthalmus*), White-throated Sparrow (*Zonotrichia albicollis*), and Indigo Bunting (*Passerina cyanea*). American Woodcock (*Scolopax minor*) is a U.S. Fish and Wildlife Service (USFWS) focal species and game bird with considerable habitat and breeding range overlap with the Golden-winged Warbler. Many other shrubland and young forest-dependent species are identified in regional PIF Plans and in State Wildlife Action Plans (Gilbart 2011). All of these species are identified as relatively high priority for conservation action due to long-term declining population trends due in part to loss or degradation of shrubland and young forest habitat.

At least 38 shrubland and young forest bird species of conservation concern are frequently or potentially associated with Golden-winged Warblers and their habitat, and thus will likely benefit from increasing the acreage of habitat and improving the quality of degraded sites proposed in this plan (Table 2–2). This list is based on overlapping range and habitat with Golden-winged Warbler within the states in which these species are listed as Species of Greatest Conservation Need (Gilbart 2011). A subset of these species were monitored at some of the long-term Golden-winged Warbler research study sites in five states (NC, PA, TN, WI, WV; see sidebar; Appendix D) to measure their degree of association; these are ranked as High Association (H), Medium Association (M), and Low Association (L). Species that were not found at these study sites, but are found within the range of Golden-winged Warbler and have known association based on expert knowledge and *Birds of North America* species accounts, are also listed. Finally, we list several additional species that are considered forest-interior birds, but are associated with shrubby understory or disturbance within the forest – these species also had Medium or High association with Golden-winged Warbler at the long-term study plots and can be considered indicators of healthy forested landscapes within which management for Golden-winged Warblers may be most successful.

Some species such as Eastern Towhee and Field Sparrow (*Spizella pusilla*) have high association with Golden-winged Warbler in many parts of the range and are frequently listed as species of conservation concern in regional plans. Other species such as Ruffed Grouse (*Bonasa umbellus*), Yel-

low-bellied Sapsucker (*Sphyrapicus varius*), and Mourning Warbler are potential associates, but the landscape matrix in which the management is occurring will be important for them to benefit. Still others such as Canada Warbler (*Cardellina canadensis*) will take advantage of shrubland and young forest habitat when it succeeds to a stage when it becomes unsuitable for Golden-winged Warbler. American Woodcock and Eastern Whip-poor-will (*Caprimulgus vociferous*) are known to have high association, but are infrequently detected on diurnal surveys.

Clearly there is opportunity to address the needs of a suite of declining species through implementation of the Golden-winged Warbler conservation plan. We recognize the importance of integrating with other wildlife and habitat plans including the American Woodcock Conservation Plan, Ruffed Grouse Conservation Plan, PIF North American Landbird Conservation Plan, State Wildlife Action Plans, state bird conservation initiative plans, state and federal forest plans, Joint Venture implementation plans, and others. Where there are important points of overlap with these plans, we inserted sidebars to describe the opportunities for integration (see Chapter 3). Some federally and state listed species such as bog turtle (*Glyptemys muhlenbergii*) also have overlapping habitat requirements. In the future, an integrated plan and management guidelines are needed for addressing the full suite of species associated with shrublands and young forest habitats.

REVISED 2019 *Table 2–2. Shrubland and young forest birds associated with Golden-winged Warbler or its breeding habitat. An **X** under the state/province name indicates the species is a Species of Greatest Conservation Need (SGCN,USA)[a] or Species at Risk (SAR, Canada)[b] that is associated with Golden-winged Warbler in that state or province. The Association (GL/AP) column summarizes results from point count surveys conducted at a subset of NFWF population and habitat sites in five states (WI, PA, WV, TN, NC)[c]. These summaries are presented by region. GL=Great Lakes (1 site) and AP=Appalachians (4 sites). The quantitative assessment of association with Golden-winged Warbler is designated as High **(H)**, Moderate **(M)**, or Low **(L)**. Species are included if they are listed as SGCN or SAR in at least one state or province within the Golden-winged Warbler range and if they overlap in geography and habitat. Adapted with permission from Gilbart (2011).*

Species	Association (GL/AP)[c]	CT	GA	KY	MD	MI	MN	NC	NJ	NY	PA	TN	VA	VT	WI	WV	MB	ON	QC
Golden-winged Warbler *Vermivora chrysoptera*		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Species associated with Golden-winged Warbler at 5 study sites																			
Northern Bobwhite *Colinus virginianus*	L (AP)		X	X	X			X	X	X		X	X			X		X	
Yellow-billed Cuckoo *Coccyzus americanus*	L-H (AP)	X					X		X				X						
Black-billed Cuckoo *Coccyzus erythropthalmus*	L (GL) M-H (AP)	X					X		X	X			X	X		X			
Northern Flicker *Colaptes auratus*	H (GL) M-H (AP)	X							X				X						
Eastern Kingbird *Tyrannus tyrannus*	L (GL) L (AP)	X							X				X						
Alder Flycatcher *Empidonax alnorum*	H (GL) L-M (AP)	X			X			X				X				X			
Willow Flycatcher *Empidonax traillii*	L-M (AP)	X		X	X				X		X	X							
White-eyed Vireo *Vireo griseus*	L-H (AP)	X																	
Black-capped Chickadee *Poecile atricapillus*	H (GL) H (AP)											X							
Veery *Catharus fuscescens*	H (GL) M-H (AP)	X			X		X	X	X							X			
Brown Thrasher *Toxostoma rufum*	M (GL) M-H (AP)	X			X		X		X	X			X	X					
Eastern Towhee *Pipilo erythrophthalmus*	H (GL) H (AP)	X					X		X		X		X	X					
Field Sparrow *Spizella pusilla*	M-H (AP)	X					X		X		X		X	X		X			
White-throated Sparrow *Zonotrichia albicollis*	H (GL) L (AP)								X		X								
Yellow-breasted Chat *Icteria virens*	L-H (AP)	X			X				X	X	X	X	X		X	X		X	

Table 2–2. Continued.

Species	Association (GL/AP)[c]	CT	GA	KY	MD	MI	MN	NC	NJ	NY	PA	TN	VA	VT	WI	WV	MB	ON	QC
Ovenbird *Seiurus aurocapilla*	H (GL) M-H (AP)	X			X														
Blue-winged Warbler *Vermivora cyanoptera*	L (AP)*	X		X	X		X		X	X	X	X		X		X			
Nashville Warbler *Oreothlypis ruficapilla*	H (GL) L (AP)				X			X	X		X					X			
Mourning Warbler *Geothlypis philadelphia*	H (GL) L-M (AP)				X														
Magnolia Warbler *Setophaga magnolia*	L (AP)				X														
Chestnut-sided Warbler *Setophaga pensylvanica*	H (GL) M-H (AP)	X												X					
Prairie Warbler *Setophaga discolor*	M (AP)	X		X	X	X		X	X	X	X	X		X		X			
Canada Warbler *Cardellina canadensis*	L-M (AP)	X		X	X				X	X	X	X	X	X		X		X	X
Rose-breasted Grosbeak *Pheucticus ludovicianus*	H (GL) L-H (AP)	X		X					X										
Indigo Bunting *Passerina cyanea*	H (GL) M-H (AP)	X																	
Additional shrubland and young forest species known to use Golden-winged Warbler habitat																			
Ruffed Grouse *Bonasa umbellus*		X		X	X			X	X	X	X	X	X	X		X			
Spruce Grouse *Falcipennis canadensis*						X	X			X				X	X				
Sharp-tailed Grouse *Tympanuchus phasianellus*						X	X								X				
Eastern Whip-poor-will *Caprimulgus vociferus*		X		X	X	X	X		X	X	X	X	X	X	X	X	X	X	X
American Woodcock *Scolopax minor*		X		X	X	X	X		X	X	X	X	X	X	X	X			
Olive-sided Flycatcher *Contopus cooperi*					X		X	X	X	X	X	X		X	X	X		X	X
Loggerhead Shrike *Lanius Indovicianus*			X	X	X	X	X	X	X	X	X	X	X		X	X		X	X
Bewick's Wren *Thryomanes bewickii*				X								X							
Hermit Thrush *Catharus guttatus*						X													
Gray Catbird *Dumetella carolinensis*									X		X		X						
Dark-eyed Junco *Junco hyemalis*					X														
Rusty Blackbird (winter) *Euphagus carolinus*			X	X	X			X	X	X	X	X	X	X		X		X	X
Black-and-white Warbler *Mniotilta varia*		X			X				X		X		X						
American Redstart *Setophaga ruticilla*					X														
Kirtland's Warbler *Setophaga kirtlandii*			X			X									X			X	

Table 2–2. Continued.

Species	Association (GL/AP)[c]	CT	GA	KY	MD	MI	MN	NC	NJ	NY	PA	TN	VA	VT	WI	WV	MB	ON	QC
Additional forest species associated with Golden-winged Warbler habitat at landscape level																			
Yellow-bellied Sapsucker *Sphyrapicus varius*	L (AP)		X		X							X				X			
Wood Thrush *Hylocichla mustelina*	M-H (AP)	X		X	X		X		X	X	X	X	X	X	X	X		X	X
Hooded Warbler *Setophaga citrina*	L-H (AP)				X	X	X		X		X				X				
Cerulean Warbler *Setophaga cerulea*	M-H (AP)	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X	X
Black-throated Blue Warbler *Setophaga caerulescens*	H (AP)	X			X		X		X	X	X	X		X		X			
Scarlet Tanager *Piranga olivacea*	M (GL) M-H (AP)	X			X				X	X	X								

[a] *Sources for Species of Greatest Conservation Need: individual State Wildlife Action Plans* (**https://www1.usgs.gov/csas/swap**).
[b] *Source for Canadian Species at Risk: Species at Risk Public Registry website* (**www.sararegistry.gc.ca/default_e.cfm**).
[c] *Association results are delineated by the probability of observing (visual, aural) the respective species based on point count surveys conducted in five states (WI, PA, WV, TN, NC). Probabilities are high (H) = >30%, moderate (M) = 15–30%, and low (L) = <15%. Some species (e.g. American Woodcock, Eastern Whip-poor-will, Ruffed Grouse) may be underrepresented based on the survey methodology.*
* *Surveys were in Golden-winged Warbler only sites.*

REVISED 2019 CONSERVATION ACTIONS

The following strategic conservation actions were developed by Golden-winged Warbler Working Group members in a series of discussions and workshops beginning in 2005 and were revised in 2018 to reflect new conservation needs. The format for this strategy is similar to that for other Focal Species under the USFWS Focal Species Program. These represent the prioritized goals, objectives, and actions necessary to conserve Golden-winged Warbler throughout their range and annual life cycle. Specific goals and objectives will be addressed in the following chapters that provide management guidelines for the breeding season (Chapter 3) and non-breeding season (Chapter 4).

Goal 1: Understand the full lifecycle of the Golden-winged Warbler to identify factors most likely limiting regional and global populations.

Highlights

- Light-level geolocator research has afforded a much clearer picture of migratory connectivity for Golden-winged Warbler, Blue-winged Warbler, and hybrids. Most Great Lakes subpopulation Golden-winged Warblers overwinter in Central America, and most Appalachian subpopulation individuals overwinter in northern South America (Bennett et al 2017, Larkin et al 2017, Kramer et al 2018). Blue-winged Warblers overwinter from Mexico through Central America, overlapping with Golden-winged Warbler in the southern portion of their winter range (Bennett et al 2017, Kramer et al 2018). Hybrids overwinter throughout the winter ranges of both parental species (Bennett et al 2017, Kramer et al 2018).
- The Midwest Migration Network (**midwestmigrationnetwork.org**) has developed a multi-tiered protocol for bird banding stations and other banders, along with a training program launched in 2018, to standardize landbird monitoring efforts during the migratory periods. The banding protocol includes collection of banding effort, point count surveys, habitat characteristics, and daily bird lists. A data storage and management system is being developed through the Midwest Avian Data Center, a regional node of the Avian Knowledge Network.
- Several studies have been completed (and others are ongoing) to improve understanding of fledgling survival rates (e.g., Streby et al. 2016, Peterson et al. 2016, Lehman 2017, and Fiss 2018). Collectively, these studies emphasize that Golden-winged Warbler fledglings, like the fledglings of other songbird species, have very low survival to independence (often < 50%). In some systems, survival of fledglings may also vary with multi-scale habitat features.

Objective 1.1: Understand connectivity between breeding and non-breeding areas in order to more closely link demographic parameters and establish linkages.

Conservation Action 1.1.1: Summarize Golden-winged Warbler migration connectivity patterns and gaps in knowledge once all regional geolocators papers have been published.

Conservation Action 1.1.2: Use emerging technologies and methods (e.g. geolocators, stable isotopes) to establish linkages between breeding and wintering populations.

Objective 1.2: Develop a sex- and age-explicit full lifecycle population model to identify the demographic parameter(s) driving population sizes regionally and globally.

Conservation Action 1.2.1: Develop a sex- and age-explicit full lifecycle population model.

Conservation Action 1.2.2: Utilize large-scale coordinated banding initiatives (e.g. MAPS, MoSI, new Landbird Migration Banding Initiative in the Midwest) to provide demographic parameters for development of the regional and global full lifecycle population models.

Conservation Action 1.2.3: Evaluate potential carry-over effects of overwinter body condition (fitness) on reproductive output.

Goal 2: Reduce threats to Golden-winged Warbler populations during the breeding stationary period.

Highlights

- Beginning in 2012, the Golden-winged Warbler was added as one of only seven focal species for a widespread NRCS habitat management program: Working Lands for Wildlife (WLFW). This incentive-based program facilitates early-successional habitat management on private lands across the Appalachian Mountains. Moreover, analogous efforts are being implemented by NRCS across Great Lakes states through programs like Regional Conservation Partnership Program (RCPP).
- A large collaboration between Indiana University of Pennsylvania, Cornell Lab of Ornithology, University of Maine, and many others was initiated in 2012 to evaluate Golden-winged Warbler occurrence on habitats created through programs like WLFW and RCPP. This group has focused on species response to habitat management across large spatial extents and has collected data across six Appalachian states (NC, TN, WV, MD, PA, and NJ) and two Great Lakes states (WI and MN).
- Several studies have been completed (and others are ongoing) to improve understanding of habitat needs during the post-fledging period (e.g., Streby et al. 2016, Peterson et al. 2016, Lehman 2017, and Fiss 2018). Collectively, these studies clearly demonstrate that Golden-winged Warbler fledglings use habitat types different from those typically used for nesting.
- Regional partnerships such as the Wisconsin Young Forest Partnership (see youngforest.org/wi) have successfully provided opportunities for partners to pool limited resources to generate young forest habitat for Golden-winged Warbler and other focal wildlife species. Partnership staff can assist landowners with creating management plans, hiring foresters, and navigating agency habitat incentive programs. Additionally, partners can work to support rural communities dependent on forest products and wildlife-based tourism to support local economies.
- A group at Cornell University (Toews et al. 2016) sequenced complete nuclear genomes of a spectrum of *Vermivora* phenotypes from across eastern North America. Their analysis found that Golden-winged and Blue-winged Warblers differed in only six regions of the genome, most of which are previously identified be related to plumage characteristics (*i.e.*, color).

MANAGEMENT AND CONSERVATION STRATEGIES

Objective 2.1: Conserve appropriate forested landscapes at geographic scales needed to maintain core Golden-winged Warbler populations, especially in focal areas.

Conservation Action 2.1.1: Protect large shrub wetland (e.g., shrub swamp, alder thicket, tamarack bog) complexes and communities threatened with development. This includes protecting and restoring ecological processes that maintain and create these areas.

Conservation Action 2.1.2: Protect and manage forest landscapes, including public, private, and tribal lands, for diver-

sity of forest types and stand ages on a large scale by mimicking natural disturbance regimes.

Conservation Action 2.1.3: Incorporate results of climate change modeling to adjust conservation strategies for Golden-winged Warbler at large landscape scales.

Objective 2.2: Better integrate Golden-winged Warbler conservation and management with similar actions for other disturbance-dependent species using the same forested landscapes.

Conservation Action 2.2.1: Integrate management plans and Best Management Practices to focus on suites of species associated with early successional forest, shrub habitats, and surrounding managed forests used by Golden-winged Warblers.

Objective 2.3: Implement best management practices for improving and increasing breeding habitat for Golden-winged Warbler and associated ESH species.

Conservation Action 2.3.1: Develop projects to implement best management practices, with an emphasis in focal areas and on growing populations into adjacent areas. Management guidelines and descriptions of focal areas are provided in Chapter 3.

Conservation Action 2.3.2: Create breeding habitat by coordinating with landowner incentive and cost-share programs and the agencies that implement them (e.g., Natural Resources Conservation Service).

Conservation Action 2.3.3: Implement an adaptive management strategy to revise best management practices that are informed by new research on Golden-winged Warbler habitat response, demographics, and genetic interactions.

Objective 2.4: Develop and implement an evaluation plan that tracks progress towards meeting Golden-winged Warbler population and habitat goals to inform management decisions at all relevant scales.

Conservation Action 2.4.1: Implement a spatially balanced monitoring program to more accurately track population trends (see Wood 2017).

Conservation Action 2.4.2: Develop and implement a habitat monitoring strategy to track acreage created/improved by management activities to evaluate progress toward regional and global habitat goals.

Conservation Action 2.4.3: Develop and implement a monitoring strategy that evaluates site-level response to nesting habitat management, especially best management practices.

INFORMATION NEEDS

Objective 2.5: Identify optimal current and future breeding stationary period habitat characteristics.

Conservation Action 2.5.1: Develop models and experimental approaches to understand sex and age-specific site-scale habitat use, and identify quality habitat (e.g. ecological traps) at different life stages of the breeding stationary period to refine best management practices.

Conservation Action 2.5.2: Evaluate potential survey protocols for assessing site-scale habitat quality using Golden-winged Warbler demographic metrics, such as confirmed breeding evidence.

Conservation Action 2.5.3: Improve land cover (ESH in particular) classification and habitat metrics using remotely sensed data, like LiDAR or other new techniques for identifying appropriate habitat, to predict Golden-winged Warbler occurrence and abundance.

Conservation Action 2.5.4: Apply climate models to predict population and habitat changes to guide future planning and management.

Objective 2.6: Clarify effects of Golden-winged Warbler and Blue-winged Warbler interactions and how these affect use of available habitat.

Conservation Action 2.6.1: Continue to develop techniques to identify genetically pure Golden-winged Warblers and hybrids using markers from nuclear DNA (i.e., identifying single-nucleotide polymorphisms).

Conservation Action 2.6.2: Continue to study population-scale effects of Blue-winged Warbler and Golden-winged Warbler interaction and mate choice; determine if hybridization is adaptive or maladaptive; differentiate habitat use by each species (as well as by their hybrids); and identify management techniques that will promote allopatry.

Conservation Action 2.6.3: Identify and mitigate factors, potentially acting at multiple spatial scales, that influence Blue-winged Warbler distributional replacement of Golden-winged Warblers.

COMMUNICATIONS AND CAPACITY BUILDING

Objective 2.7: Promote management actions for Golden-winged Warbler conservation and habitat management to stakeholders.

Conservation Action 2.7.1: Develop and implement a communication strategy to best deliver conservation messages about Golden-winged Warbler and ESH to diverse audiences.

Conservation Action 2.7.2: Evaluate delivery of information to target audiences.

Conservation Action 2.7.3: Develop partnerships, particularly with state, federal, and tribal land management/agencies, industry, military installations, and non-governmental organizations, to create, manage, and restore habitat on properties they own and manage.

Conservation Action 2.7.4: Deliver breeding habitat management guidelines to land managers and landowners using a variety of tools (such as demonstration areas, printed materials, websites, workshops), particularly those working in or near focal areas.

Conservation Action 2.7.5: Maintain an up-to-date website for the Golden-winged Warbler Conservation Initiative. Provide conservation assessment and plan documents, as well as tools for determining appropriate management and for tracking and evaluating conservation actions.

Objective 2.8: Work with partner agencies and organizations to develop and prioritize policy recommendations to support Golden-winged Warbler management and conservation activities.

Conservation Action 2.8.1: Support current state and federal wildlife habitat incentive programs for landowners (state forest tax law, NRCS's RCCP, Working Lands for Wildlife, Department of Defense, Canada's Ecological Gifts Program, Forest Stewardship Program, etc.), and develop new opportunities for habitat management for Golden-winged Warbler and associated species.

Conservation Action 2.8.2: Work with agencies and organizations to make protection and management of Golden-winged Warbler and ESH a priority at the planning and policy-making levels of administration.

Conservation Action 2.8.3: Develop and sustain regional partnerships to more efficiently direct and use limited resources for habitat management (e.g., Joint Ventures, WI Young Forest Partnership, NY ESH Initiative).

Conservation Action 2.8.4: Inform practices and policies of energy industries with the potential to degrade or create quality Golden-winged Warbler habitat.

Objective 2.9: Coordinate management and policy activities across countries within Golden-winged Warbler breeding distribution.

Conservation Action 2.9.1: Work strategically with Canadian Golden-winged Warbler Recovery Team to identify synergies, management activities, and recovery efforts on the breeding grounds.

Goal 3: Reduce threats to Golden-winged Warbler populations during the migratory and non-breeding stationary periods.

Highlights

- Between 2013-2015, the Alianza Alas Doradas, the Cornell Lab of Ornithology, and the American Bird Conservancy collaborated to delineate non-breeding focal areas, assess threats to habitat within focal areas, and develop conservation strategies and actions to address those threats. This effort is reflected in the recently completed Chapter 4: Golden-winged Warbler Non-breeding Season Conservation Plan, now available in English and Spanish.
- Several new studies have analyzed migration stopover regions with geolocator data (e.g. Kramer et al. 2018, Bennett et al. 2017, Larkin et al. 2017). These studies reveal a majority of male Golden-winged Warblers utilize extended refueling stopovers within Central America and southern Mexico.
- New research describes the patterns, mechanisms, and consequences of sexual segregation of habitats and landscapes within Central America (Bennett 2018).
- Colombian NGO SELVA and the Cornell Lab of Ornithology are in year three of the 10-year Neotropical Flyways Project, which maps spatial and temporal changes in occupancy and abundance of long distance migratory species, including Golden-winged Warbler, at key spring and fall migration stopover sites throughout Central and South America.
- Costa Rica Bird Observatory achieved funding and government support to start a Payment for Ecosystems Services within Costa Rican focal areas.
- The Mesoamerican Development Institute has achieved the sale of carbon credits for trees on coffee farms within the Pico Pijol focal area in Honduras.

MANAGEMENT AND CONSERVATION STRATEGIES

Objective 3.1: Retain and create forest habitat within non-breeding focal areas.

Conservation Action 3.1.1: Create new protected areas around threatened habitat with no legal protection.

Conservation Action 3.1.2: Develop and support Payment for Ecosystem Services (PES) programs in privately owned non-breeding habitat.

Conservation Action 3.1.3: Link land owners and users with financial or other opportunities to retain and create habitat (i.e. Smithsonian Bird Friendly certification, Rainforest Alliance certification, carbon credits, etc.)

Conservation Action 3.1.4: Develop a partnership program with local NGOs and government agencies geared towards effective management and enforcement of protected areas that overlap focal areas.

Objective 3.2: Reduce the loss and degradation of nonbreeding habitat through implementation of best management actions and targeted programs.

Conservation Action 3.2.1: Implement best management practices for Golden-winged Warbler habitat retention in coffee farms, silvopastoral systems, and subsistence farms within non-breeding focal areas.

Conservation Action 3.2.2: Support the transition from wood stoves to gas stoves and expand improved wood-burning stove projects in appropriate countries (see Chapter 4) in conjunction with community managed fuelwood parcels.

INFORMATION NEEDS

Objective 3.3: Identify and address information gaps in the distribution, habitat use, and threats during the non-breeding stationary period and migratory periods.

Conservation Action 3.3.1: Develop best management practices for Golden-winged Warbler habitat retention in coffee farms, silvopastoral systems, and subsistence farms within non-breeding focal areas.

Conservation Action 3.3.2: Within focal areas identify 1) areas experiencing habitat loss, 2) areas vulnerable to habitat loss, and 3) areas appropriate for habitat restoration.

Conservation Action 3.3.3: Examine intra- and inter-seasonal survival and fitness indicators for all age and sex classes. Relate these to frequently used habitat types and their characteristics for the stationary migration period.

Conservation Action 3.3.4: Initiate new research and summarizing existing research on stopover habitat and quality in the migration stopover regions used by large Golden-winged Warbler populations, as identified through geolocator analyses.

Conservation Action 3.3.5: Evaluate effect of migratory obstacles (wind turbines, communication towers, and buildings) on annual survival and assess potential risk from development of these structures in migration corridors.

Conservation Action 3.3.6: Conduct standardized surveys within wintering-ground countries (Colombia, Venezuela, Panama, Costa Rica, Nicaragua, Honduras, Guatemala, Mexico) where new occurrence data are needed to decrease model uncertainty about non-breeding distribution, especially for females.

COMMUNICATIONS AND CAPACITY BUILDING

Objective 3.4: Build local capacity to adopt best management practices and retain existing habitat.

Conservation Action 3.4.1: Work with existing (or create new) adult community education programs focused on understanding ecosystem services and human impacts on the environment.

Conservation Action 3.4.2: Work with existing (or create new) a youth environmental education programs focused on appreciating ecosystem services and natural history.

Conservation Action 3.4.3: Increase local community involvement in energy and transportation development decision-making processes within non-breeding focal areas.

Objective 3.5: Promote management actions for non-breeding Golden-winged Warbler conservation and habitat management to stakeholders at three scales: focal area, country, and range.

Conservation Action 3.5.1: Establish model coffee and livestock farms to promote the best management practices developed in Conservation Action 3.2.1.

Conservation Action 3.5.2: Develop communication and outreach strategy for implementation of wintering ground conservation actions.

Conservation Action 3.5.3: Work with partner organizations to disseminate, promote, and achieve institutional adoption of the non-breeding season conservation plan by Latin American stakeholders.

Conservation Action 3.5.4: Review and update the threats, conservation strategies, and habitat goals identified in Chapter 4 with regular Alianza Alas Doradas meetings that includes partners from all countries in the non-breeding range.

Objective 3.6: Coordinate management and policy activities across countries within Golden-winged Warbler distribution.

Conservation Action 3.6.1: Provide regional coordination for the fundraising and implementation of conservation activities.

Conservation Action 3.6.2: Promote conservation integration and communication with partners across the full range of the species.

Conservation Action 3.6.3: Support stakeholder collaboration and engagement through regular Alianza Alas Doradas meetings.

Photo by Ashley Jensen

CHAPTER 3.

GOLDEN-WINGED WARBLER BREEDING SEASON CONSERVATION PLAN

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RECOMMENDED CITATION

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CHAPTER 3. TABLE OF CONTENTS

CHAPTER 3 SUMMARY

This plan (Chapter 3 of the overall Conservation Plan) outlines goals, objectives, and actions needed for the effective conservation of Golden-winged Warbler (*Vermivora chrysoptera*) on its breeding grounds. The plan is written primarily for conservation planners and land managers, but will also be useful to policy makers, scientists, and representatives from agencies and industry. The basis for the breeding grounds conservation strategy is the delineation of focal areas where stabilizing and ultimately restoring Golden-winged Warbler populations will occur. These focal areas are delineated based on current and historic distribution, hybridization risk, and current and future management potential. Habitat and population goals are stepped down from the region to the focal area to provide managers with conservation targets at a local scale. Land ownership and potential partners for each focal area are also identified.

Management for Golden-winged Warbler habitat must occur at multiple spatial scales from the landscape to the patch, to intra-patch scale because Golden-winged Warblers respond to the structure and composition of available habitat at each scale. Golden-winged Warblers occur largely in forested landscapes, within which varying conditions can occur that support breeding populations, including habitats derived from forest management, wetland habitats, and habitats in a variety of upland settings undergoing succession after grazing, strip mining, or field abandonment. At the patch scale, Golden-winged Warbler habitat is comprised of a dynamic combination of herbaceous elements (grasses and forbs), woody shrubs/saplings, and open mature hardwood trees. Within a territory, the habitat elements are distributed in fine-scale clumps. Nest sites typically occur in a variety of grasses and forbs that form clumps for secure nest placement on the ground. This plan contains habitat guidelines that outline the range of conditions, leading to desired habitat structure and composition. Techniques to maintain, create, or restore these conditions are also described, including the use of forest management, prescribed fire, mowing and brush-hogging, and grazing.

Success of the conservation strategy will be assessed through a coordinated monitoring program. This monitoring program will track the key components of the conservation strategy, including acres managed for Golden-winged Warbler, population response at multiple spatial scales, and changes in levels of genetic introgression within populations.

Additionally, Chapter 1 of the Golden-winged Warbler Status Review and Conservation Plan contains detailed information on the biology and ecology of the species and an overall review of its population status at multiple scales. Chapter 2 provides rationale and explicit goals and objectives of the Golden-winged Warbler Working Group's full life cycle conservation strategy for the species. A glossary of commonly used terminology appears in Appendix A, while Appendix B provides a list of supplementary resources.

REVISED 2019 INTRODUCTION

The Golden-winged Warbler is a high-priority, rapidly declining songbird dependent on early successional and other shrubby habitats for successful breeding. It is listed as *Threatened* in Canada and is considered a *Focal Species* by the U.S. Fish and Wildlife Service (USFWS). In 2010, the species was petitioned to be listed under the U.S. Endangered Species Act; however, a final ruling has yet to be made. The Golden-winged Warbler is also a Keystone Species, along with American Woodcock (*Scolopax minor*), under the National Fish and Wildlife Foundation's Early Successional Habitat (ESH) Initiative and associated business plan. The goal of this Conservation Plan, in accordance with the ESH business plan, is to reverse declines of Golden-winged Warblers and restore populations to recent historical levels by improving habitat for this and other associated ESH species throughout their breeding range in eastern and central North America.

This plan outlines goals, objectives, and actions needed for the effective conservation of the Golden-winged Warbler on the breeding grounds. The plan is written primarily for conservation planners and land managers, but will also be useful to policy makers, scientists, and representatives from agencies and industry. Conservation and habitat management during the non-breeding season will be important components to a successful conservation strategy and will be addressed in the Non-breeding Season Conservation Plan (Chapter 4).

This plan for the breeding grounds assumes knowledge about Golden-winged Warbler distribution, breeding ecology, behavior, general habitat requirements, hybridization with Blue-winged Warbler (*Vermivora cyanoptera*), and threats to populations. If not familiar with these topics, please review the Golden-winged Warbler Status Review (Chapter 1), the Golden-winged Warbler Working Group website **www.gwwa.org/**, and The Birds of North America account **http://bna.birds.cornell.edu/bna** before implementing the following conservation actions and habitat management guidelines. In addition, we encourage conservation planners and land managers to consider this plan in the context of all-bird and community-based conservation, particularly for species associated with shrubland and young forest communities in forested landscapes. This plan

identifies at least 38 bird species of conservation concern associated with Golden-winged Warbler during the breeding season (see Table 2–2).

The primary sources of information used in developing this plan were taken from the Golden-winged Warbler Working Group's Rangewide Golden-winged Warbler Conservation Initiative. From 1999–2005, the Golden-winged Warbler Atlas Project delineated present-day range and concentration areas, mapped an index of Golden-winged Warbler X Blue-winged Warbler hybridization, and assessed rangewide habitat use. In 2008–2010, a collaborative research project, involving eight primary study areas in seven states (Appendix D), provided a better understanding of the Golden-winged Warbler's breeding ecology, habitat associations, genetic introgression with Blue-winged Warbler, and associated bird communities (see sidebar, page 2–11). This project produced important information needed to generate habitat management guidelines, a conservation strategy, and to identify the necessary actions for conservation of this species that are the basis of this plan.

Note that hybridization between Golden-winged Warbler and Blue-winged Warbler likely threatens the genetic integrity and distinctiveness of both species. Both species are identified as high conservation priorities by many states and organizations and their conservation may be indelibly intertwined. Although the goal of this plan is to promote healthy Golden-winged Warbler populations, our recommendations may not prevent establishment by Blue-winged Warbler. In areas outside the current range of Golden-winged Warbler, promotion of healthy Blue-winged Warbler populations may be desirable.

Our overall approach to developing a breeding grounds conservation strategy, reflected in the outline of this plan, is as follows:

1. Define conservation regions and focal areas for targeted conservation action.
2. Set population and habitat goals at rangewide, conservation region, and focal area scales.
3. Develop regional and habitat specific management guidelines for improving breeding habitat for Golden-winged Warblers and associated species.

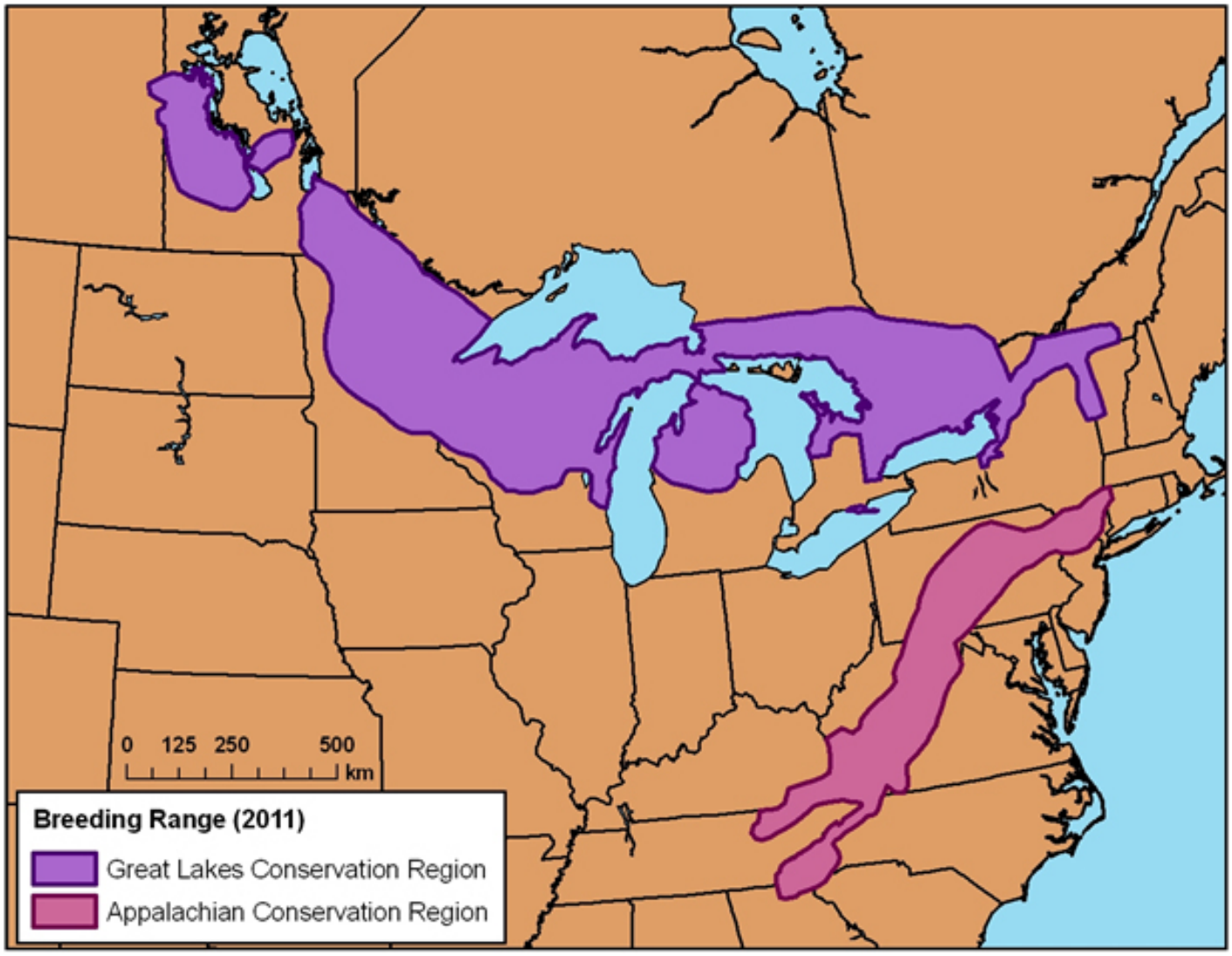

Figure 3–1. Golden-winged Warbler conservation regions based on 2011 breeding range and disjunct population segments.

DEFINITION OF REGIONS AND FOCAL AREAS

Conservation Regions

Each conservation region represents a subset of the current breeding range that is ecologically similar with respect to broad habitat characteristics deemed important to Golden-winged Warbler, and populations with similar demographics and spatial (continuous versus patchy) characteristics. The geographic extents of these two regions represent the Golden-winged Warbler's core breeding population. That is, breeding pairs can be consistently found in these regions from year to year. It is likely that sporadic breeding in other areas, such as central New York State, occurs, but does not measurably contribute to maintenance of the global population.

The Golden-winged Warbler breeding range is segmented into two populations that have considerable overlap with several Bird Conservation Regions ((BCR); Figures 3–1 and 3–2):

1. **Great Lakes** is within BCR 6 (Boreal Taiga Plains–southeast), 12 (Boreal Hardwood Transition–south), 13 (Lower Great Lakes/St. Lawrence Plains–north), and 23 (Prairie Hardwood Transition–north)
2. **Appalachian Mountains** is primarily in BCR 28 (Appalachian Mountains)

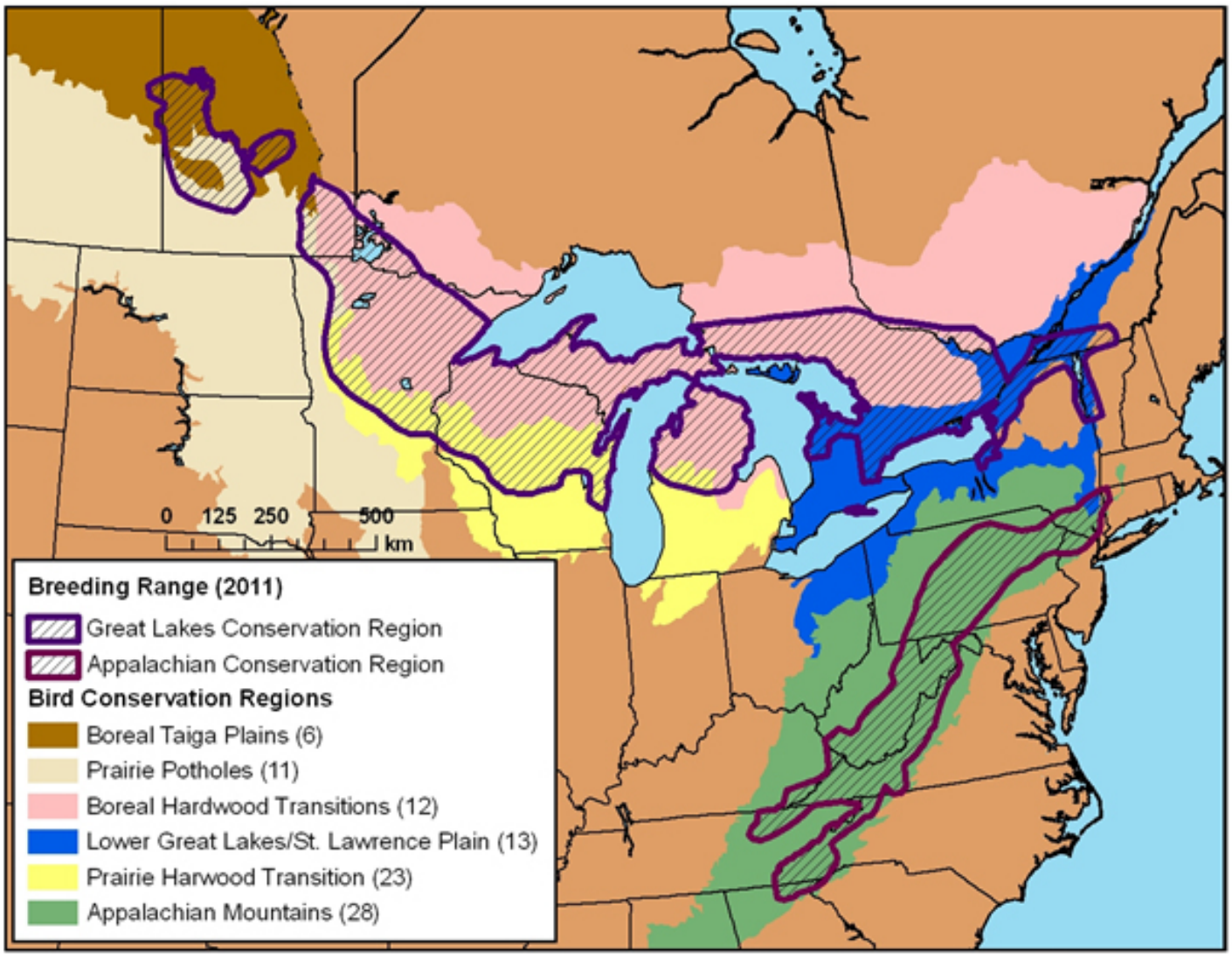

Figure 3–2. Golden-winged Warbler breeding range and boundaries of Bird Conservation Regions

Focal Areas and Priorities

Geographic focal areas, as defined by the Golden-winged Warbler Working Group, are places where the maintenance of core populations will be important for sustaining and growing the current distribution (Figure 3–3). Further, focal areas with greater than 20 breeding pairs will be particularly important for expanding the population into adjacent areas. Eight of the 34 total focal areas contain 20 or fewer pairs and the goal of these areas is to increase the population to sustain the current breeding season distribution.

Not all parts of a focal area are appropriate for habitat management. Places within focal areas where applying the management guidelines from this plan should be **avoided** include: 1) places where management and protection of other rare or imperiled resources are higher priority (e.g., national forest wilderness areas) or have conflicting management needs, and 2) places where Blue-winged Warbler populations co-occur and management for Golden-winged Warbler might hasten Blue-winged Warbler invasion of Golden-winged Warbler territories, increasing the probability for hybridization.

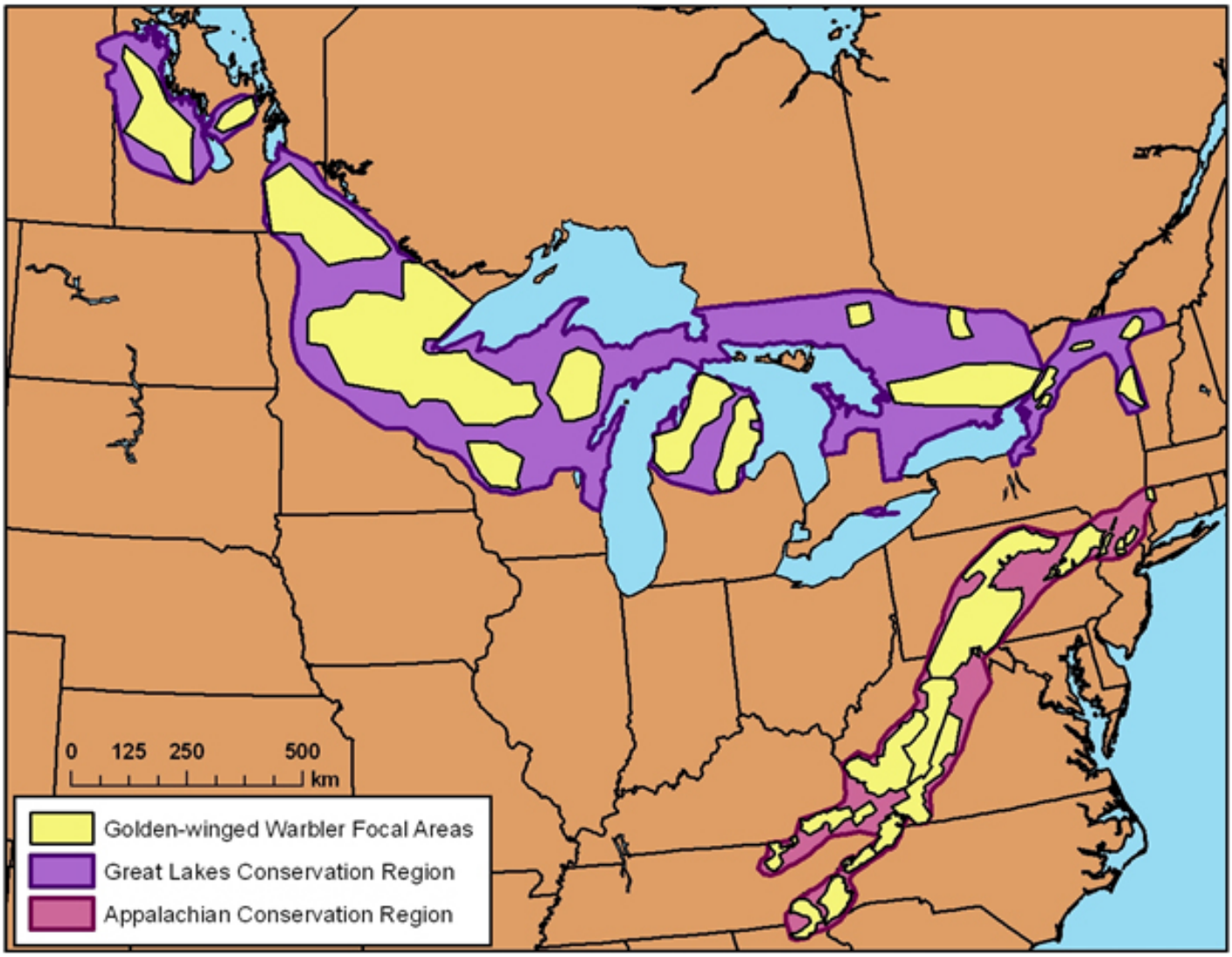

Figure 3–3. Geographic extent of the Appalachian Mountains and Great Lakes conservation regions containing defined Golden-winged Warbler focal areas (yellow).

POPULATION AND HABITAT GOALS

The original rangewide population goal for Golden-winged Warbler, established by the Golden-winged Warbler Working Group at a June 2011 workshop, was to restore the 2010 estimated population of approximately 414,000 breeding individuals to approximately 632,000 birds (similar to population in 1980s), through habitat management and conservation at locations used by Golden-winged Warblers during their annual life cycle (Table 3–1) (see Part II Focal Area Reference Guide, page 3–38). The timeline for achieving this goal was to stabilize the global population (stop present declines) within

10 years (2020 goal) and then increasing the population by ~50% in the following 30 years. The 2020 goal was based on an assumed increase of 12.5% in the Great Lakes region and a 25% increase in the Appalachian region. The 2050 goal was based on an assume 50% increase in the Great Lakes region and a 100% increase in the Appalachian region.

Estimating the population size of any widely dispersed bird species is extremely difficult and requires a set of clearly articulated assumptions. Our Golden-winged Warbler population estimates are based on a procedure developed by Partners in Flight, which uses extrapolation of North American Breeding Bird Survey (BBS) data (Rich et al. 2004, Rosenberg and Blancher 2005). The most recently available population estimates (PIF Landbird Populations Estimation Database **http://rmbo.org/pif_db/laped/**) represent an update from Rich et al. (2004), based on newer BBS data (1999–2008) and revised correction factors agreed to by the Golden-winged Warbler Working Group (June 2011 workshop). The 2018 population estimates were generated by extrapolating the 2010 focal area estimates with state by BCR population trends generated from BBS data for the 2007-2017 period (J. Sauer, USGS, unpubl. data; Table 3–1). When summed, the focal area estimates are less than the PIF rangewide estimates because focal areas do not cover all potential Golden-winged Warbler populations but represent a subset of the total.

These estimates should not be viewed as absolute; rather they present an order-of-magnitude estimate of abundance relative to other bird species in North America, and for comparison among regions. Golden-winged Warbler has one of the lowest estimated population sizes for any species not protected under the Endangered Species Act; most other migratory songbird species have populations in the millions or tens of millions.

Based on BCR-wide analysis, the Appalachian population continues to decline steeply (7.36%/yr), such that the 2018 population estimate is only about 12,000 individuals, down from 22,000 in 2010. The Great Lakes population, in contrast, has remained relatively stable from 2010-2018, because of apparent increase in Canadian populations in Manitoba (BCR 6) offsetting declines in Wisconsin and Michigan, and stable populations in Minnesota where the majority of the Golden-winged Warbler breeding population resides.

The relative population stability in the Great Lakes region from 2010-2018 falls short of the goal of increasing the population by 12.5% by 2020, whereas the Appalachian 2018 population estimate falls far short of the 2020 goal of increasing the population by 25%. The widening gap between population goals and population estimates, especially in the Appalachian region, suggest that current conservation efforts are insufficient to achieve the original goals. There are several possible reasons for this result. Either the amount and/or quality of the breeding habitat restoration in the Appalachian region is insufficient to offset habitat loss from natural succession or human development, or else the population is still being limited by non-breeding season events, during migration or during the non-breeding, stationary period in South America.

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"We already have a lot of early successional habitat so why do we need more?"

Not all early successional habitats are suitable for Golden-winged Warblers. High quality breeding habitat provides optimal conditions for reproduction and survival. For example in the Great Lakes region, where aspen forest and shrub wetlands are abundant, high quality breeding habitat can be identified by:

- Landscapes with 50–70% deciduous forest and less than 20% coniferous forest.
- Aspen clearcuts that are 2–10 years old with 10–15 residual live trees/ac (25–40 trees/ha).
- Shrub wetlands with appropriate habitat components. NOTE: many shrub wetlands are unoccupied for unknown reasons, perhaps because they lack an important habitat component such as the proper ratio of herbaceous to woody vegetation, scattered trees, adjacent forest for foraging, or dry nest sites.
- Close proximity to other breeding populations; isolated patches have higher likelihood of being unoccupied.

Closer examination of existing ESH may reveal that there is not as much high quality Golden-winged Warbler habitat as initially thought. Where ESH does not meet these guidelines, there is an opportunity to convert low quality into high quality habitat. Even where ESH acreage in general is trending downward, by enhancing the quality of ESH for Golden-winged Warbler, we can increase the acreage of high quality habitat.

Restoring Appalachian populations of Golden-winged Warbler is important for two reasons: 1) these represent historic strongholds for the species that until recently supported a much larger proportion of the global population; and 2) these populations have a longer history of interactions with hybridizing Blue-winged Warblers, and therefore the potential to establish long-term co-existence, which is still uncertain in the larger Great Lakes population.

Breeding habitat goals are based on current estimates of available habitat area at the landscape-scale within focal areas and conservation regions. To estimate breeding habitat acreage, a habitat multiplier (1 territorial pair/5 ac [2 ha]) was estimated based on mean territory densities at eight study areas across the breeding range, representing a broad range of community types and management regimes. In addition, the habitat occupancy rate needs to be incorporated into the habitat goals. We have assumed that ~50% of the restored/created habitat will be occupied, based on monitoring of restoration efforts to date. Thus, given the assumed territory density and the occupancy rate, 1 nesting pair may be supported for 10 acres (4 ha) of potential habitat. We further assumed that future creation, maintenance, and restoration of breeding habitat will produce high quality sites based on implementation of the habitat management guidelines in this plan, with the result of producing a roughly average ter-

ritory density. Habitat goals may include habitat generated or maintained through natural disturbance processes, not necessarily solely attained by active management. Note that an explicit assumption, based on current knowledge, is that establishment of high quality breeding habitat will favor genetically pure Golden-winged Warbler in areas where Blue-winged Warbler co-occur; specific management guidelines may need to be adjusted as this assumption is continually tested and evaluated. Finally there is the implicit assumption that habitat that is created or restored will indeed be occupied by breeding Golden-winged Warblers; however, this might not be the case in some areas.

Regional and focal area population and habitat goals need to be stepped down to the state and management site scales, as well. Land managers should assess current and potential habitat management options and estimate acreages. A site-level plan should be developed that includes goals, management practices, and a monitoring schedule. See the Example Management Plan (page 3–15) for how to set goals at the site level.

Table 3–1. Golden-winged Warbler population estimates and breeding habitat area estimates for 2010 and goals for 2020 and 2050. The annual or decadal net gain in suitable breeding habitat that is needed to attain a goal is shown in parentheses.

	Great Lakes Conservation Region	Appalachian Conservation Region	Rangewide
Population (individuals)			
PIF Estimated Population (2010)	392,000	22,000	414,000
Estimated Popn (2010) – Focal Areas	271,000	15,000	286,000
Estimated Popn (2018) – Focal Areas	259,000	8,000	267,000
Population Goal (2020)	441,000	27,000	466,000
Population Goal (2050)	588,000	44,000	632,000
Breeding Habitat			
Estimated Breeding Habitat (2010)	1,960,000 ac (793,000 ha)	110,000 ac (45,000 ha)	2,070,000 ac (838,000 ha)
Breeding Habitat Goal (2020)	2,205,000 ac (+25,000 ac/yr) 892,000 ha (+10,000 ha/yr)	137,000 ac (+3000 ac/yr) 55,000 ha (+1200 ha/yr)	2,330,000 ac (+26,000 ac/yr) 943,000 ha (+11,000 ha/yr)
Breeding Habitat Goal (2050)	2,940,000 ac (+245,000 ac/decade) 1,190,000 ha (+99,000 ha/decade)	220,000 ac (+27,000 ac/decade) 89,000 ha (+11,000 ha/decade)	3,105,000 ac (+259,000 ac/decade) 1,257,000 ha (+105,000 ha/decade)

REVISED 2019 MANAGEMENT GUIDELINES

The management guidelines portion of this plan is divided into three parts. The first is a **Quick Start Guide for Land Managers**. The Quick Start Guide is meant to get land managers started quickly without having to wade through a prohibitive amount of background information. It is a summary of information presented in Part I: Comprehensive Management Guide for Creating and Maintaining Breeding Habitat and contains only the basic knowledge required for understanding the Golden-winged Warbler's landscape-scale habitat requirements and manipulating habitat at the scales of the management site and patch.

Information presented in the Quick Start Guide is repeated in other parts of this plan. For ease of use and to set the Quick Start Guide apart from the remainder of the plan, it is set in a box with a green background on multiple pages.

Part I: Comprehensive Management Guide for Creating and Maintaining Breeding Habitat provides additional technical detail for managing Golden-winged Warbler habitat at the site scale, and discusses management techniques that can be used to achieve the desired habitat conditions.

Part II: Focal Area Reference Guide provides spatially explicit overviews of habitat-use patterns within each of the plan's 34 focal areas, and gives population and habitat goals for each focal area.

With their high level of detail and georeferencing, Parts I and II can be used to answer conceptual questions about habitat management and guide large-scale conservation planning.

REVISED 2019 Quick Start Guide for Land Managers

Golden-winged Warbler require a mosaic of mature and early successional habitats for successful breeding. Nesting habitat often results from disturbances, such as timber harvesting (Figure 3–4) or fire, and more permanent ecological conditions, such as alder swamps and oak barrens. Regardless of the habitat's origin or degree of permanency, the basic conditions required by nesting Golden-winged Warbler are approximately the same:

Shrubby, young forest with limited canopy cover that is frequently interspersed with herbaceous areas of grasses and forbs, and includes widely spaced overstory trees for song perches (Figures 3–4 and 3–5). This basic patch-level configuration often borders more mature forest and is usually set within a landscape matrix of deciduous forest (Figure 3–5).

Figure 3–4. This newly harvested aspen forest has a moderate density of residual canopy trees with a high proportion that are hardwoods (northern red oaks) dispersed throughout the stand. In a couple of years, when the understory has regrown, this site should provide excellent nesting habitat for Golden-winged Warbler. Photo by Laurie Smaglick Johnson.

We highly recommend working within the focal areas for your region. See Part II (page 3–38) for maps and detailed descriptions of each focal area.

We use four guiding principles to describe habitat associations and provide management guidelines:

1. **Context**—what is the landscape-scale context of the management site?
2. **Configuration**—how are the major habitat components configured at the scales of the management site and patch?
3. **Content**—what are the major habitat components within a patch or stand?
4. **Composition**—what are the key species or plant community associations within the region and habitat type?

Context is discussed at the landscape scale, while Configuration, Content, and Composition are considered at the scales of the management site and patch or stand.

Determining Appropriate Landscape Context

Below we describe the landscape-scale conditions necessary when considering the most productive places to establish Golden-winged Warbler management sites. With the exception of elevation, these metrics apply to both the Appalachian and Great Lakes Conservation regions. Parts I and II provide more detail on landscape-scale habitat associations.

Figure 3–5. Sketch of early successional habitat patch as viewed from overhead. Illustration by Ann-Kathrin Wirth.

Macro Landscape Context (within 1.5 mi (2.5 km) of management site):

- **Elevation:**
  Southern Appalachians (GA, KY, NC, TN, VA, WV)—generally above 1,800 ft (560 m), varies with site-specific context. Note: In some areas of this region, Golden-winged Warblers may only be found at elevations well above 1,800 ft and should be assessed for each site in consultation with a regional expert.
- Northern Appalachians (NJ, PA, MD, WV)—generally above 1,000 ft (300 m), lower in heavily forested areas
  Great Lakes—no association with elevation
- **Forest Cover:** ≥50%
- **Forest Type:** primarily deciduous; limited Golden-winged Warbler occurrence in landscapes containing greater than 25% coniferous forest as mixed deciduous/coniferous or pure coniferous stands.
- **Tree Communities:** yellow poplar-red oak; sugar maple-beech-yellow birch; aspen-paper birch; mixed-oak
- **Distance Association:** when feasible target habitat within 15 miles of known breeding Golden-winged Warbler aggregations. Note: the maximum distance likely to attract Golden-winged Warblers to unoccupied habitat is dependent upon the distance to the nearest occupied breeding habitat, the density of Golden-winged Warblers in those areas, and the amount of breeding habitat in the matrix. Please see the Appalachian Mountains or Great Lakes Best Management Practice guides for more information on your region.

Micro Landscape Context (within 800 ft (250 m) of management site):

- **Positive Land Cover Associations:** 60–80% forest, 15–55% shrub-herbaceous, shrub-forest wetlands, and abandoned farmland/pasture
- **Negative Land Cover Associations:** human development and cropland
- **Forest Composition:** deciduous trees, no more than 20% coniferous trees

Developing Habitat at Management Sites and Patches

Within appropriate landscape contexts, identify management sites to create, maintain, or restore nesting habitat. The management site (see sidebar to right) includes the local area that is receiving active habitat management and will ultimately provide primary habitat for breeding territories and nest sites, and the contextual habitat that will potentially receive management action in the future. Management sites can range in size from a few acres or hectares to hundreds of acres or hectares. In some cases, management sites might be part of a larger habitat complex that is collectively being managed for Golden-winged Warbler and other associated species. In large, heavily forested areas, try to maintain 10–20% of forestland in early successional stages appropriate for Golden-winged Warbler nesting.

The management site can further be divided into smaller, more logistically manageable units. These units are often referred to as patches or stands. In this plan, we use the term patch (see sidebar to right) to refer to the smaller units residing within a management site. If there is no other nesting habitat within 1 mi (1.5 km) of the proposed management site, then a minimum of 25 ac (10 ha) should be created as one or more patches of nesting habitat. If other nesting habitat is adjacent (within approximately 1000 ft (300 m)) to the proposed area, then a patch of new habitat can be as small as 5 ac (2 ha).

Habitat Configuration

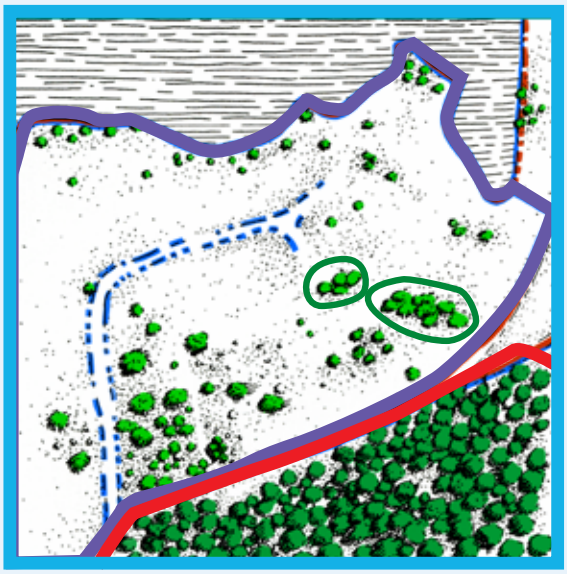


Illustration by Ann-Kathrin Wirth

Decreasing spatial scale

Management Site — area where management prescriptions are focused as defined by a management plan.

Patch — an area of uniform habitat type or successional stage and defined by a habitat edge.

Habitat Edge — distinct boundary between different habitat types or the same habitat but in distinctly different successional stages.

Clump — area of similar vegetation type and height defined by a microedge.

Microedge — readily perceived change in vegetation type or height, such as where grasses change to sedge at the border of a wet area or where a herbaceous opening is bordered by dogwood or *Rubus* shrubs. ***Note: Due to scale, microedges are not shown.***

Appalachian Region

Most common habitat types used:

- Upland shrub communities (abandoned farmland, shrubby fields, lightly grazed pastures)
- Young forest (regenerating forest resulting from forest management or other disturbance)
- Forest-shrub wetland (alder wetland, beaver wetland, hardwood swamp)
- Reclaimed surface mine
- Utility right-of-way

Configuration within Management Sites:

- Patches of young forest or other ESH with feathered or stepped edges (see sidebar, page 3–12) leading up to mature forest boundary.
- Patches ≤ 1000 ft (300 m) from existing, suitable habitat should be ≥ 5 ac (2 ha), while those ≥ 1000 ft (300 m) from existing habitat should be ≥ 25 ac (10 ha).
- Within large management complexes, at any given time, 15–20% of area should be maintained in early successional or young forest habitat.

Content within Patches:

- Overstory trees (>9 in (>23 cm) DBH), saplings, shrubs, herbaceous openings, bare ground, and sometimes surface water.

Configuration within Patches:

- Tall shrubs and saplings 3–13 ft (1–4 m) unevenly distributed as clumps (see sidebar, page 3–12) should make up 30–70% of patch.
- Shrub and sapling clumps, less than 30 ft in diameter, should be interspersed with herbaceous openings, less than 30 ft in diameter, that are primarily composed of forbs with lesser proportions of grasses.
- Scattered, low woody vegetation (< 3 ft (1 m)), leaf litter, and bare ground can occur in openings but should occupy less than 25% of the opening's space.
- Overstory trees should be infrequent (5–15/ac (10–40/ha)) and widely spaced (or retained in clusters) resulting in 10–30% canopy cover throughout the patch. At least 75% of overstory trees should be deciduous.
- Average distance to microedge (see sidebar, page 3–12) should be less than 20 ft (6 m) from any point within the patch.

Composition within Patches – common plant species include:

Note: Below we list numerous species that are commonly found within Golden-winged Warbler territories; however, it's likely that many species not contained in this list will provide the structure that Golden-winged Warblers need. Additionally, several plant species listed are exotic and/or invasive and should not be planted or encouraged to disperse. We list them here only to show possible habitat associations as derived from analyses of empirical data. They potentially can be substituted with native species that provide the same structural attributes.

- ***Forbs:*** goldenrod (*Solidago* spp.), bracken fern (*Pteridium aquilinium*), wild strawberry (*Fragaria virginiana*), large-leaved aster (*Eurybia macrophyllus*), stinging nettle (*Urtica dioica*), milkweed (*Asclepias* spp.), asters (multiple genera), common cinquefoil (*Potentilla simplex*), sericea lespedeza (*Lespedeza cuneata*), mountain mint (*Pycnanthemum* spp.), yarrow (*Achillea millefolium*)
- ***Grasses/Sedges:*** timothy (*Phleum* spp.), sweet vernalgrass (*Anthoxanthum odoratum*), grove bluegrass (*Poa alsodes*), Pennsylvania sedge (*Carex pensylvanica*), wild rye (*Elymus* spp.), smooth brome (*Bromus inermis*), velvet grass (*Holcus lanatus*), orchard grass (*Dactylis glomerata*), panicgrass (*Panicum* spp.)
- ***Shrubs:*** raspberry/blackberry (*Rubus* spp.), blueberry (*Vaccinium* spp.), beaked hazelnut (*Corylus cornuta*), American hazelnut (*Corylus americana*), hawthorn (*Crataegus* spp.), multiflora rose (*Rosa multiflora*), sweetfern (*Comptonia peregrina*), autumn olive (*Elaeagnus umbellata*), maple (*Acer* spp.), honeysuckle (*Lonicera* spp.)
- ***Trees:*** black cherry (*Prunus serotina*), white ash (*Fraxinus americana*), black locust (*Robinia pseudoacacia*), pin cherry (*Prunus pensylvanica*), white oak (*Qurecus alba*), eastern white pine (*Pinus strobus*), American elm (*Ulmus americana*), black walnut (*Juglans nigra*), apple (*Malus* spp.), sugar maple (*Acer saccharum*), tulip poplar (*Liriodendron tulipifera*), American beech (*Fagus grandifolia*), paulownia (*Paulownia tomentosa*), hickories (*Carya* spp), maples (*Acer* spp.)

Great Lakes Region

Most common habitat types used:

- Forest or shrub wetlands (alder/willow wetland, beaver wetland)
- Aspen clearcut
- Successional forest (regenerating young forest from forest management or other disturbance)
- Tamarack bog
- Upland shrub communities (abandoned farmland, shrubby fields)

Configuration within Management Sites:

- Patches of young forest or other ESH with feathered or stepped edges (see sidebar, page 3–12) leading up to mature forest boundary.
- Patches ≤ 1000 ft (300 m) from existing, suitable habitat should be ≥ 5 ac (2 ha), while those > 1000 ft (300 m) from existing habitat should be > 25 ac (10 ha).
- Within large management complexes, at any given time, 10–15% of area should be maintained in early successional or young forest habitat.

Content within Patches:

- Overstory trees (> 9 in or > 23 cm dbh), saplings, shrubs, herbaceous openings, bare ground, and sometimes surface water.

Configuration within Patches:

- Tall shrubs and saplings 3–13 ft (1–4 m) unevenly distributed as clumps (see sidebar, page 3–12) should make up 30–70% of patch.
- Shrub and sapling clumps, less than 30 ft in diameter, should be interspersed with herbaceous openings, less than 30 ft in diameter, that are primarily composed of forbs with lesser proportions of grasses.
- Scattered, low woody vegetation (< 3 ft (1 m)), leaf litter, and bare ground can occur in openings but should occupy less than 25% of the opening's space.
- Overstory trees should be infrequent (5–15/ac (10–40/ha)) and widely spaced (or clustered), resulting in 10–30% canopy cover. Up to 50% of trees can be coniferous as long as 5 trees/acre are deciduous.
- Average distance to microedge (see sidebar, page 3–12) should be less than 20 ft (6 m) from any point within the patch.

Composition within Patches – common plant species include:

Note: Below we list numerous species that are commonly found within Golden-winged Warbler territories; however, it's likely that many species not contained in this list will provide the structure that Golden-winged Warblers need. Additionally, several plant species listed are exotic and/or invasive and should not be planted or encouraged to disperse. We list them here only to show possible habitat associations as derived from analyses of empirical data. They potentially can be substituted with native species that provide the same structural attributes.

- ***Forbs:*** goldenrod, bracken fern, wild strawberry, large-leaved aster, stinging nettle, milkweed, asters
- ***Grasses/Sedges:*** timothy, sweet vernalgrass, grove bluegrass, Pennsylvania sedge, wild rye, smooth brome, orchard grass, panicgrass, fescue (*Festuca* spp.)
- ***Shrubs:*** raspberry/blackberry, blueberry, beaked hazelnut, American hazelnut, hawthorn, multiflora rose, sweetfern, autumn olive, serviceberry (*Amelanchier* spp.)
- ***Trees:*** quaking aspen (*Populus tremuloides*), big-tooth aspen (*Populus grandidentata*), balsam poplar (*Populus balsamifera*), paper birch (*Betula papyrifera*), red maple (*Acer rubrum*), northern red oak (*Quercus rubra*), bur oak (*Quercus macrocarpa*), black cherry, tamarack (*Larix laricina*), balsam fir (*Abies balsamea*), eastern white Pine (*Pinus strobus*), red pine (*Pinus resinosa*), jack pine (*Pinus banksiana*), white spruce (*Picea alba*)

Example Management Plan

A land manager in the Great Lakes has a small population of Golden-winged Warbler with at least five breeding pairs in a forested landscape dominated by deciduous forest. This site falls in an existing forest management site that is 1000 ac (400 ha) and within one of the defined Golden-winged Warbler focal areas (see Part II, page 3–38). The manager assesses the plant composition and structure at the management site and determines that the following distribution of habitat types currently exists (see table below).

The manager wants to generate suitable nesting habitat on 20% of the area, or 200 ac (80 ha), and sets this as the long-term goal for the management site. Currently 12% of the area, or 120 ac (48 ha), is suitable nesting habitat so the manager needs to add 80 ac (32 ha). The manager consults with the local forester and determines that 50 ac (20 ha) of aspen forest can be harvested in the next two years to generate young forest and that 100 ac (40 ha) could be harvested about every 10 years. In addition, there is suitable habitat around the edge of two openings and pairs are nesting in an area of young aspen forest that grades into an alder wetland.

Habitat Type	Current Distribution in acres (ha)	Current Suitable in acres (ha)
Aspen Forest (50%)	500 (200)	50 (20)
Non-aspen Deciduous or Mixed Forest (20%)	200 (80)	0
Conifer Forest (10%)	100 (40)	0
Alder Wetland (15%)	150 (60)	50 (20)
Abandoned Field (5%)	50 (20)	20 (8)
Total (100%)	1000 (400)	120 (48)

Based on current management opportunities, the manager develops the following plan:

Habitat Type	Current Distribution in acres (ha)	Current Suitable in acres (ha)	Two-year Habitat Goal in acres (ha)	Long-term Planned Action
Aspen Forest (50%)	500 (200)	50 (20)	100 (40)	Harvest 100 ac (40 ha) every 10 years.
Non-aspen Deciduous or Mixed Forest (20%)	200 (80)	0	0	Continue uneven-aged management but remove more volume along boundaries adjacent to shrubby or sapling dominated patches.
Conifer Forest (10%)	100 (40)	0	0	No change.
Alder Wetland (15%)	150 (60)	50 (20)	50 (20)	Maintain; experimental enhancement harvest of 5 ac (2 ha) in an area of upland alder to increase patchiness of herbaceous cover.
Abandoned Field (5%)	50 (20)	20 (8)	50 (20)	Mow herbaceous areas less frequently to encourage more small woody cover; remove pine regeneration from openings and mow periodically to control new invasions.
Total (100%)	1000 (400)	120 (48)	200 (80)	

The plan uses timber harvests to increase the acreage of young aspen forest and increase use of edges of other deciduous forest types adjacent to existing suitable habitat. For old fields, the mowing schedule is changed to encourage small-diameter woody cover and to remove pine regeneration from openings. An experimental harvest in upland alder is scheduled to try to improve habitat quality as indicated by an increase in territory density and use of this community type by increasing the patchiness of the mature alder and encouraging regeneration of herbaceous vegetation and young alder. The result is that 20% of the management site is suitable nesting habitat, an increase from 12%. The managed areas will be monitored before and after treatment to evaluate Golden-winged Warbler response.

REVISED 2019 Part 1: Comprehensive Management Guide for Creating and Maintaining Breeding Habitat

Most bird species use just one habitat type, such as forest or prairie. However, the habitat conditions that Golden-winged Warblers rely on can be met within numerous habitat types, ranging from forests to abandoned fields to wetlands. Fortunately, the basic requirements—a patchy mixture of shrubs, saplings, herbaceous openings, and widely spaced tall trees within a primarily forested landscape—are similar regardless of habitat type. The difference lies in the management techniques used to create and maintain these conditions across habitat types. Under natural disturbance regimes, the Golden-winged Warbler was likely restricted to wetland areas impacted by periodic flooding, such as beaver meadows, edges of tamarack bogs, hardwood swamp forests, alder and willow swamps; or upland areas that were frequently disturbed by fire, insect outbreaks, and wind. Periodic wind events creating medium to large-scale forest openings were likely important in some areas. After European settlement, early-successional habitat was created as forests were cleared for settlement and agriculture. Habitat availability probably peaked as farms were abandoned and forests regenerated during the first half of the 20th century.

Given the Golden-winged Warbler's consistent population decline during the past 45 years, it is likely that contemporary land-use patterns are not generating adequate amounts of habitat to sustain stable populations. This trend appears to be especially true in the Appalachian Region where populations are declining most rapidly. Furthermore, these land-use patterns might promote contact between Golden-winged Warbler and Blue-winged Warbler, which is a contributing factor of the Golden-winged Warbler's precipitous decline. Suppression of natural disturbance regimes such as wildfires and flooding has further contributed to the loss of suitable habitat. Without a proactive effort to manage for ESH, continuing declines will likely cause Golden-winged Warbler extirpations at local and regional scales. Reversing population declines will require restoring natural disturbance regimes in appropriate habitats and implementing broad-scale forest management and other management strategies that mimic natural disturbances elsewhere.

The following sections provide detailed information on how to identify and manage Golden-winged Warbler habitat.

Incidental Take and Timing of Habitat Management Activities

Because of its threatened status in Canada and threatened or endangered status in selected U.S. states, the Golden-winged Warbler is afforded certain legal protections. These protections can sometimes complicate the timing of management activities. Whenever possible, habitat management should be conducted during the non-breeding season (mid-August to mid-April), as disturbance during the nesting season potentially can result in "incidental take" of nests, eggs, and young birds.

In cases where habitat objectives can only be achieved during the nesting season, we recommend following guidelines for your agency or organization that address potential take of protected bird nests, eggs, and young as a result of habitat management practices. Please note that these recommendations are solely intended to avoid significant adverse impacts on migratory birds and do not provide any authorization for incidental take of birds and their eggs or for the disturbance, destruction or taking of nests.

The content is organized by geographic scale, starting at the landscape level and drilling down to the breeding territory and nest scales. The raw data and synthesized results used to develop these guidelines were derived from the following sources:

- Golden-winged Warbler Atlas Project (1999–2005)
- Golden-winged Warbler Conservation Initiative (2007–2011)
- Golden-winged Warbler Conservation Workshop (Ithaca, NY August 2010)
- Golden-winged Warbler Habitat Best Management Practices for Forestlands in Maryland and Pennsylvania (Bakermans et al. 2011)
- The primary scientific literature.

Landscape Scale—Selecting Management Sites

Below we discuss landscape-scale habitat requirements of breeding Golden-winged Warblers in the context of selecting management sites that have the greatest probability of attracting breeding pairs and contributing to population level recovery through adequate reproductive success. In some cases, we provide information that, to the extent possible, may reduce the probability of contact and introgression with Blue-winged Warblers.

In general, the management site includes the local area that is receiving active management and will ultimately provide primary habitat for breeding territories and nest sites. Management sites can range in size from a few acres/hectares to hundreds of acres/hectares. Not all habitat within the management site will receive active manipulation. Management sites might be part of a larger habitat complex that is collectively being managed for Golden-winged Warbler, other as-

sociated young forest species, and species that rely on more mature forest.

In most cases, management sites should be selected from within defined focal areas (see Part II, page 3–38) to maintain and grow existing populations. However, management outside of focal areas should be considered if the proposed site is within 1 mi (1.5 km) of a known breeding population. In future years, management outside of focal areas will become increasingly important to grow the numerical size and geographic extent of regional populations as focal-area populations increase and young birds disperse to new habitat outside of focal area boundaries.

Generally, the Golden-winged Warbler is associated with landscapes (within 1.5 mi (2.5 km)) that include 50–75% forest cover that is composed of 75% deciduous forest types, such as mixed hardwoods, mixed oak, northern hardwoods, oak-hickory, and aspen. Golden-winged Warbler is very rarely found in landscapes with more than 25% coniferous forest. Management sites should be placed where there is limited co-occurrence with Blue-winged Warblers to minimize the probability for introgression between the species (Figure 3–6). Where Golden-winged Warbler does not co-occur with Blue-winged Warbler, there is less risk of attracting Blue-winged Warbler to newly managed sites. However, to achieve rangewide population recovery, it is likely that some management will need to take place in areas where the two species co-occur. In these areas, landscape-scale site selection must be undertaken carefully to minimize the attraction of Blue-winged Warbler to newly managed sites.

The probability of finding a genetically pure Golden-winged Warbler, Blue-winged Warbler, or a hybrid varies with geographic location and habitat conditions. It is important to understand this variation when making decisions about where to invest in Golden-winged Warbler conservation. In general, the greatest investments should be made in those places with the lowest probability of facilitating further hybridization. Figures 3–7 to 3–10 display the predicted proba-

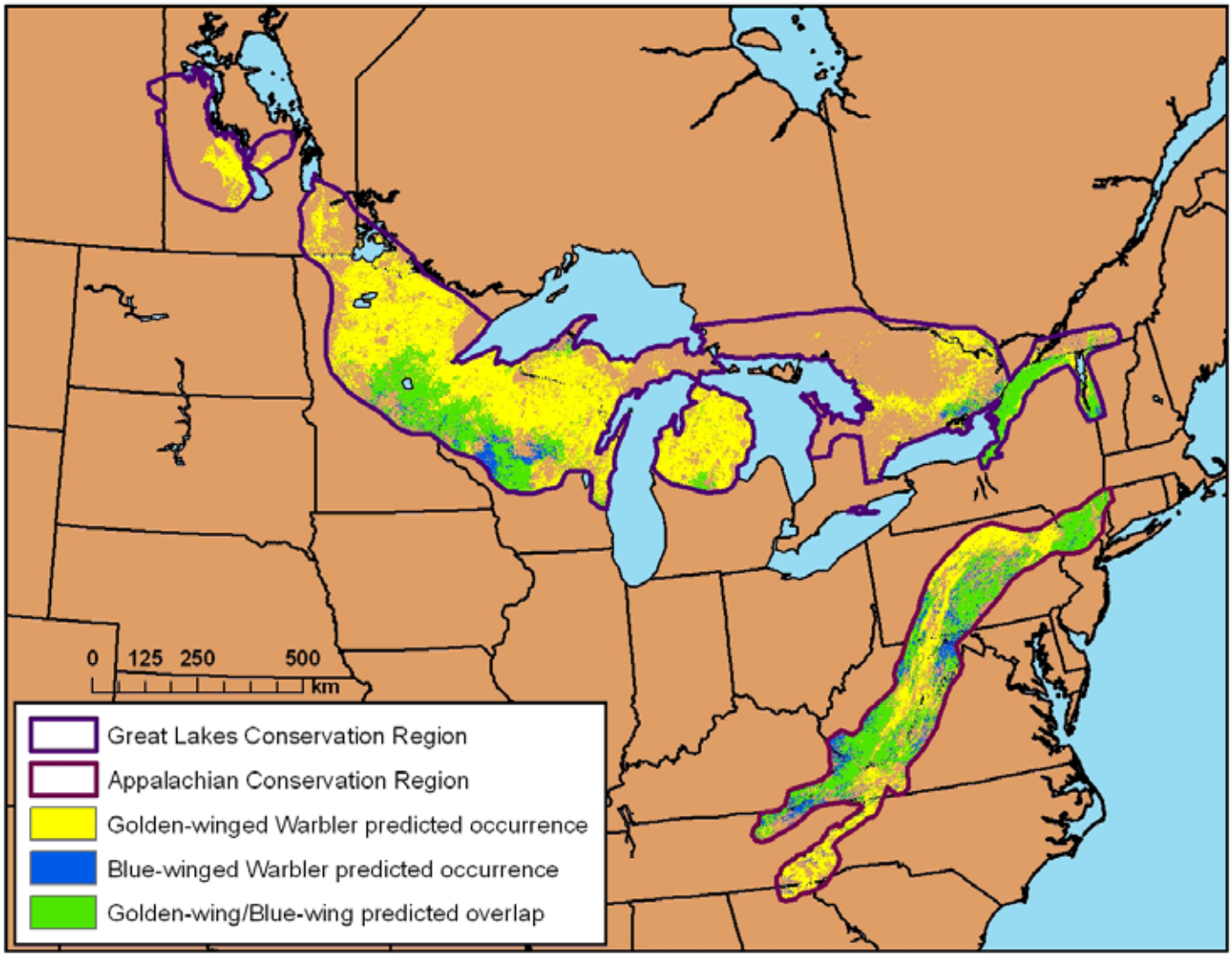


Figure 3–6. Model results showing the current predicted distribution of Golden-winged and Blue-winged warblers with areas of overlap. A smaller number of ecological variables were available to model the estimated warbler distribution in Canada, and thus estimates for some areas within the Great Lakes Conservation region are preliminary. Blue-winged Warbler occurrence may be lesser or greater than depicted in some areas, as predicted by the model.

bility of a given focal area to support hybrid Golden-winged Warblers based on habitat and climatic conditions. These maps can be used to help guide initial, large-scale decisions about where to work. **However, they are not substitutes for empirical knowledge about the presence and distribution of Blue-winged Warblers and hybrids in your local area.** For example, we know there are differences between where Blue-winged Warblers are predicted to occur and where they are known to occur based on a variety of survey data sources. In these circumstances, empirical knowledge should be used to help select and prioritize management sites. When a choice of management sites is available from within a focal area, and field-based data on Blue-winged Warblers and hybrids are unavailable or unreliable, we recommend using the maps to first select areas with < 25% probability of supporting hybrids (gray and yellow shaded areas) and then follow elevation and habitat recommendations for your region to select specific management sites.

When there are few management site options or when all locations within your focal area have > 25% probability of supporting hybrids (green and pink shaded areas), we recommend learning as much as possible about the local presence and distribution of Blue-winged Warblers and hybrids, and following elevation and habitat recommendations for your region to select specific management sites with the greatest chance of supporting pure Golden-winged Warbler populations.

In the Appalachian Region, the probability for hybridization to occur is greater than 25% at elevations below 1500 ft (460 m). We recommend selecting management sites at elevations above the "Blue-winged Warbler zone" (i.e., above 1300 ft (400 m) in the northern Appalachians (NJ, PA, MD, WV) and above

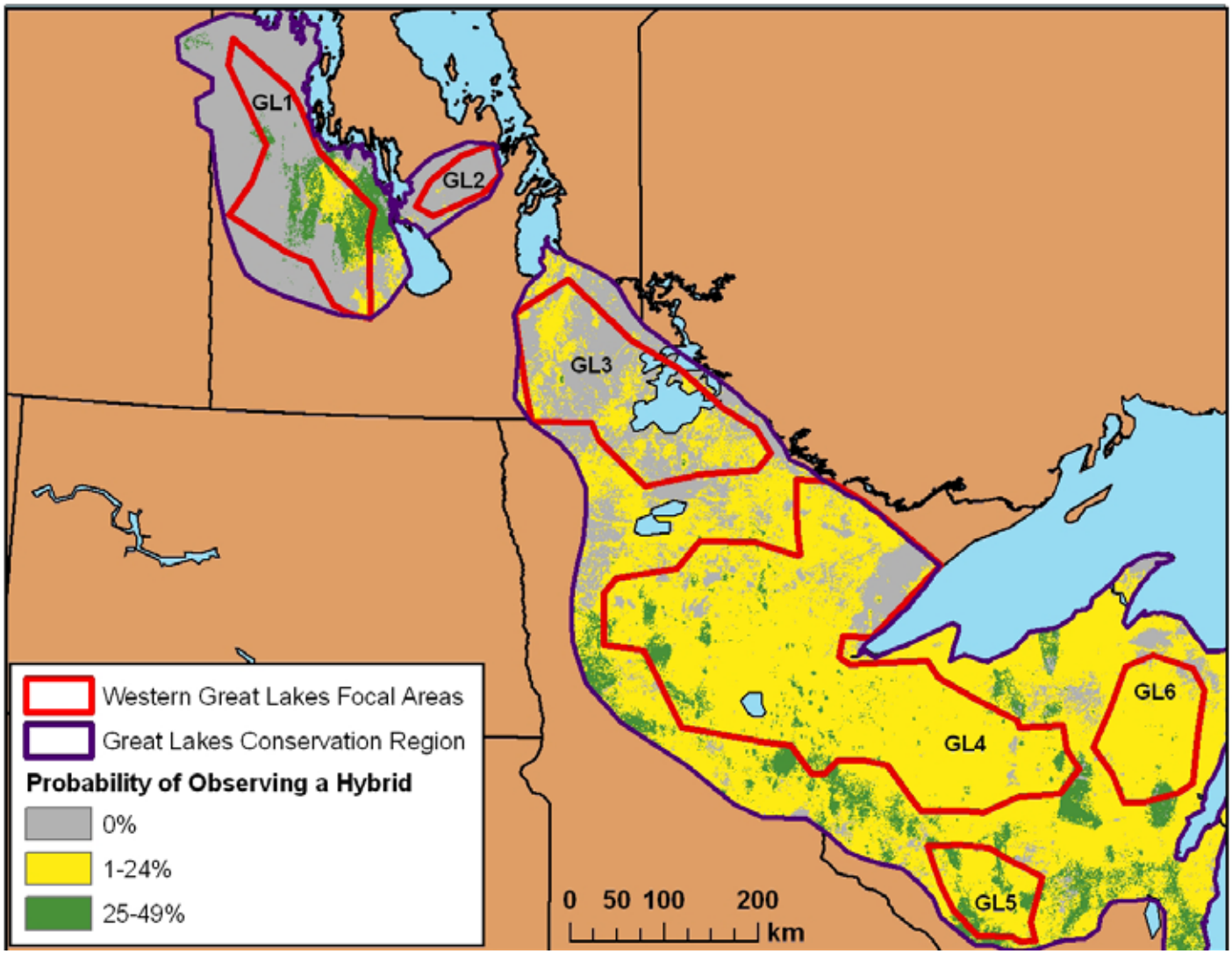


Figure 3–7. Model results showing the current probability of detecting a phenotypic or genotypic hybrid Golden-winged Warbler x Blue-winged Warbler in the western Great Lakes Region based on elevation, forest type, and climate being suitable for Golden-winged Warbler nesting success, and the co-occupation of the same areas by Blue-winged Warbler. Areas defined as having 0% hybrid probability lacked the appropriate environmental conditions to support both species, thus pushing the likelihood of hybridization to near zero. While no hybrid or Blue-winged Warbler individuals have yet been documented in GL1, the model predicts that environmental conditions are suitable for hybridization to occur. Future monitoring in this focal area should emphasize detection and documentation of Blue-winged Warbler and hybrids to help shape management decisions.

2000 ft (610 m) in the southern Appalachians (GA, KY, NC, TN, VA, WV). However, elevation should not be used exclusively in deciding where to work. Heavily forested areas at lower elevations throughout the Appalachian Region can provide excellent Golden-winged Warbler habitat, as other landscape scale factors can mitigate hybridization. The probability of hybridization between Golden-winged and Blue-winged warbler is positively correlated with the percent coniferous forest in the macro landscape (within 1.5 mi (2.5 km) of management site). This is especially true in the Great Lakes Region where there was a 25% greater chance of detecting a hybrid in landscapes with more than 30% coniferous forest. This result is consistent with the habitat affinities we observed for Golden-winged and Blue-winged warbler, where Golden-winged Warbler rarely occurs in landscapes with more than 25% coniferous forest, while Blue-winged Warbler does not appear to show a negative relationship with conifers. This suggests that landscapes with 25% or more coniferous cover might represent marginal habitat for Golden-winged Warblers. If so, these marginal conditions might serve to facilitate hybridization.

It is important to know whether breeding Golden-winged Warbler populations occur within or are nearby to a proposed management site (Figure 3–11). Though little is known about how juveniles disperse or how new habitat is colonized, we recommend creating habitat within 1 mi (1.5 km) of known breeding populations. Small, isolated patches of new habitat that are disassociated with existing breeding populations may have lower likelihood of being occupied. The minimum habitat area required to attract and support a functional sub-population of Golden-winged Warblers is unknown and likely highly correlated with the landscape context. However, in the interest of providing basic information to inform spatially explicit conservation designs, we make the following recommendations. In extensively forested management sites, we recommend maintaining 15–20% of the area in suitable Golden-winged Warbler habitat. This can be done by creating single patches of at least 5 ac (2 ha) or clusters of smaller patches that are no more than 300 yards (275 m) apart and add up to at least 10 ac (4 ha).

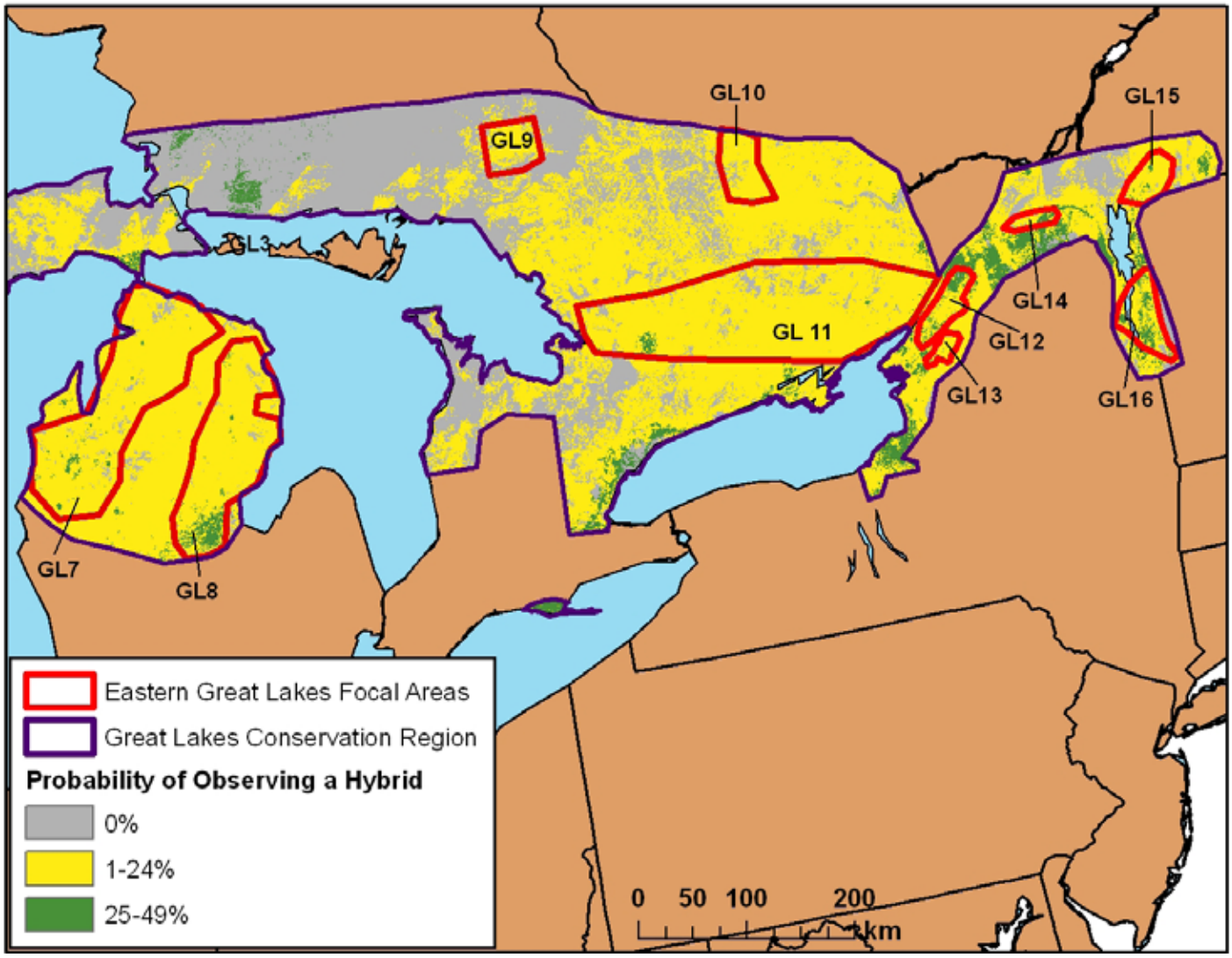


Figure 3–8. Model results showing the current probability of detecting a phenotypic or genotypic hybrid Golden-winged Warbler x Blue-winged Warbler in the eastern Great Lakes Region based on the probability of both Golden-winged and Blue-winged warbler being present, elevation, forest type, and climate. Areas defined as having 0% hybrid probability lacked the appropriate environmental conditions to support both species, thus pushing the likelihood of hybridization to near zero.

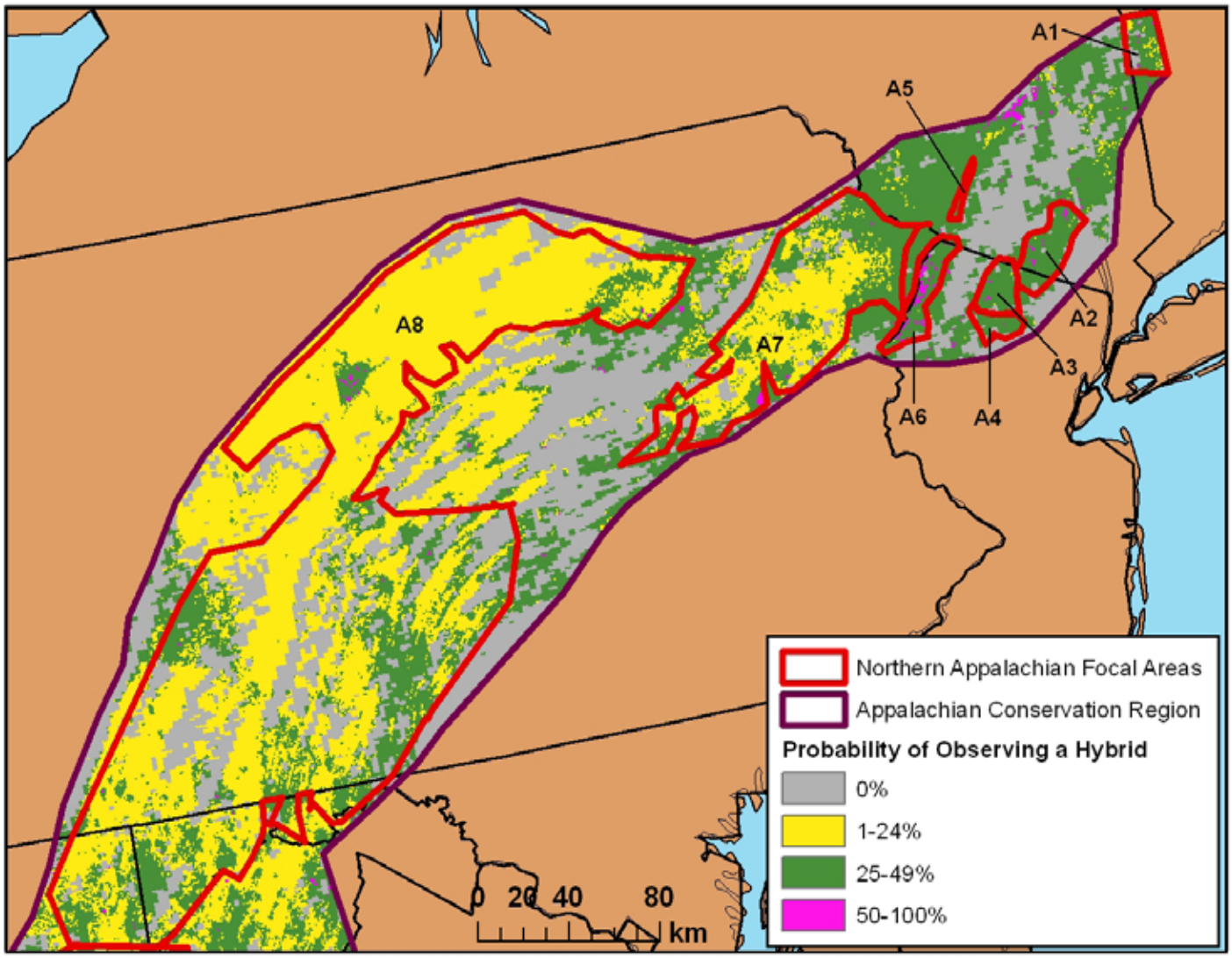


Figure 3–9. Model results showing the current probability of detecting a phenotypic or genotypic hybrid Golden-winged Warbler x Blue-winged Warbler in the northern Appalachian Region based on the probability of both Golden-winged and Blue-winged warbler being present, elevation, forest type, and climate. Areas defined as having 0% hybrid probability lacked the appropriate environmental conditions to support both species, thus pushing the likelihood of hybridization to near zero.

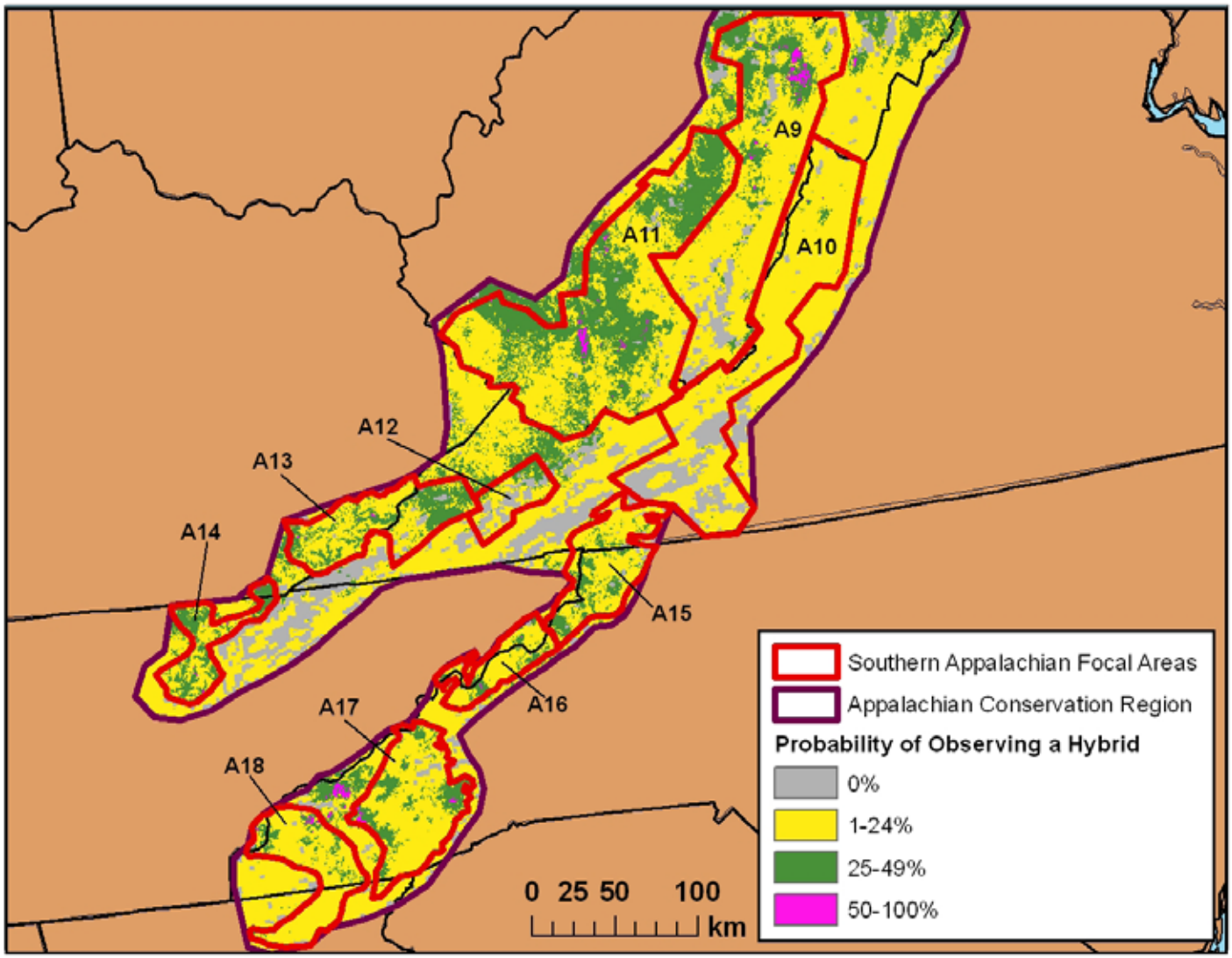


Figure 3–10. Model results showing the current probability of detecting a phenotypic or genotypic hybrid Golden-winged Warbler x Blue-winged Warbler in the southern Appalachian Region based on the probability of both Golden-winged and Blue-winged warbler being present, elevation, forest type, and climate. Areas defined as having 0% hybrid probability lacked the appropriate environmental conditions to support both species, thus pushing the likelihood of hybridization to near zero.

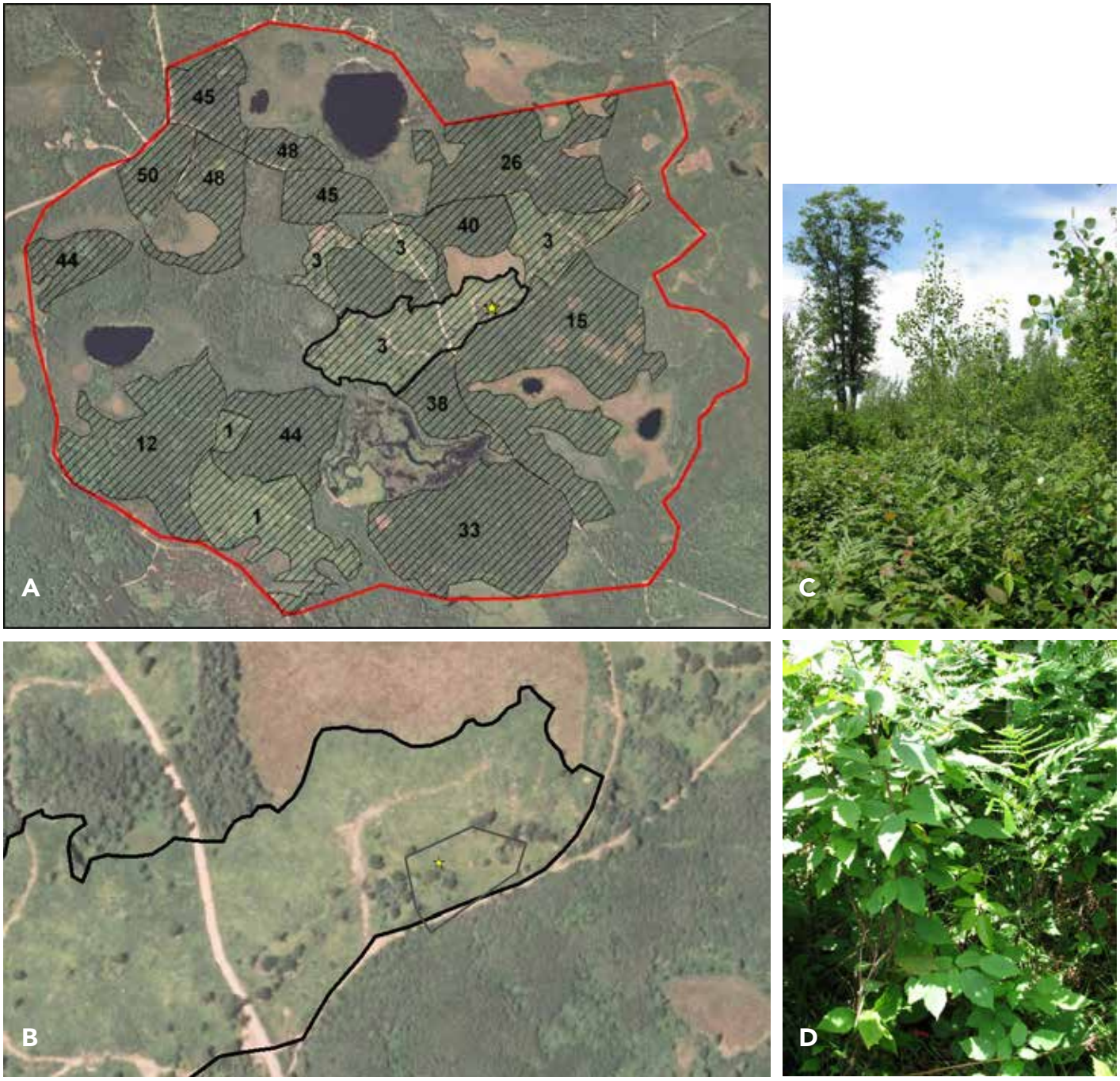


Figure 3–11. Golden-winged Warbler habitat in northern Wisconsin. (A) The yellow star indicates a Golden-winged Warbler nest site within a young aspen forest stand (heavy black boundary line). The management site outlined in red represents 1,100 acres (445 ha) of forest and wetlands. Hatched aspen patchs are labeled with their age since they were clearcut. Aspen is rotationally clearcut on a 50 year cycle such that several aspen stands are harvested approximately every five years to maintain some 1–10 year old aspen in this management area at all times. (B–C) The breeding territory (narrow gray boundary line) contains numerous residual canopy oak trees that are important for song perches. (D) The nest site (orange arrow points to the nest location) is along an over-grown logging trail with a cluster of residual oak trees in the background (C). Photo by Amber Roth.

Management Site Scale

Creating and Maintaining Habitat within Management Sites

After management sites have been selected from within the larger landscape, it is time to develop site level plans and begin creating and maintaining ESH. The management site can be further divided into smaller, more logistically manageable units (Figure 3–11). These units are often referred to as patches or stands. In this plan, we use the term patch to refer to the smaller units residing within a management site.

Golden-winged Warbler habitat occurs across a variety of habitat types that are either naturally disturbed or managed. Though we don't provide management guidelines for how to restore natural disturbance regimes, especially those that historically created ESH (e.g. flooding and lightning-ignited fire), the role of natural disturbances should be considered when developing management plans.

For the sake of discussion, we can divide managed, patch-level Golden-winged Warbler habitat into two categories:

1. Silviculturally-derived habitats: forests that will be managed through timber harvesting to produce habitat where none previously existed.
2. Non-forested habitats: abandoned fields, lightly grazed pastures, surface mines, and pre-existing wetlands that will be improved through non-commercial management and restoration techniques.

Silviculturally-derived habitats, such as clearcuts, shelterwood harvests, or other even-aged harvest prescriptions, will typically be generated proactively by defining a management site, delineating patches within the site, and then prescribing appropriate timber management within those patches.

In non-forested habitats, management is likely to be more opportunistic and focused on discrete, pre-existing habitat patches that are being improved through management. For example, overgrown abandoned fields and surface mines can be brush-hogged, burned, or grazed to promote herbaceous openings and set back succession. Wetland habitats can be improved by creating new habitat in adjacent upland areas or restored by removing deleterious conditions, such as high densities of invasive Phragmites (*Phragmites australis*).

It is important to keep these differences in habitat type and starting point (creating new habitat versus managing existing habitat) in mind as you consider patch-level management.

Some Associated Species Require Large Management Sites

Sharp-tailed Grouse is an area-sensitive species that requires large areas (1000 ac (400 ha) or more) of very young vegetation in open forested and brushland landscapes that are harvested regularly or managed with a combination of timber harvesting, prescribed burning, and mowing to control succession.

Management sites for American Woodcock should be at least 500 ac (200 ha) to support a viable population and to encompass the diverse habitat components needed during the course of the breeding season, including young forest for nesting and brood-rearing, shrub wetlands for foraging, and roosting fields.

Golden-winged Warbler, and other associated songbirds with relatively small territories, may occupy patches within woodcock and grouse management sites. The creative land manager will envision new ways to create Golden-winged Warbler habitat within the context of management for other species.

Patch Area and Configuration

The required patch area for adequate Golden-winged Warbler reproduction is context dependent and will be dictated by the habitat within and around the management site. The following guidelines should be treated as general recommendations and not hard and fast rules. If there is no other suitable habitat within 1 mi (1.5 km) of the proposed patch, then a minimum of 25 ac (10 ha) should be created as one or more patches of habitat. If there is suitable breeding habitat adjacent to the proposed patch (within 300 yards (275 m)), then a patch of new habitat can be as small as 5 ac (2 ha) and might be thought of as an enhancement or expansion of existing suitable habitat especially if already occupied by Golden-winged Warblers.

Patch shape will influence the amount of edge by altering the perimeter to area ratio. Long narrow patches or patches with wandering boundaries create a higher edge to perimeter area ratio than square or round patches. When scattered residual trees are not available for retention, or where this practice is not preferred, then the edge where ESH meets more mature forest will influence Golden-winged Warbler territory placement and the amount of edge will determine the number of pairs supported within the patch. In this case, more edge generally equals more territories per patch. The majority of territories will be found along the edge of the patch and, for large patches, the middle of the patch might not be used. Primary edges should be "feathered" so they transition from younger or more open habitat to older or more closed canopy forest. Even when clearcutting a stand, useable habitat can be enhanced by thinning or conducting a selection harvest along the edge of the stand in adjacent forest.

Configuration of habitat patches within a management site is important, as it helps provide connectivity for young birds dispersing from a nest and for returning adult birds that will be breeding for the first time. Furthermore, ESHs by definition are temporary. Depending on site conditions and habitat type, any given habitat patch will age out of suitability in a relatively short period of time. Generally speaking, suitable habitat can persist from 2–20 years depending on the rate of natural succession. Reestablishing a population is more difficult (and may not happen if a persistent population isn't nearby) than maintaining an existing one. For this reason, management plans for large, heavily forested areas should strive to create a shifting mosaic of habitat ages that consistently maintains 15–20% of the area in ESH while still allowing the full spectrum of age classes to occur across the management site. In most cases, site conditions will dictate the configuration of management activities. When possible, we suggest interspersing the 15–20% of managed habitat across the management site to create a shifting mosaic of young and more mature forest habitats.

This approach will promote regular colonization and abandonment of patches within a management site, as habitat suitability shifts from patch to patch. Similar strategies have been successfully applied on the Nantahala National Forest in North Carolina (Klaus and Buehler 2001) and commercially-managed aspen forests in the Upper Midwest (Roth and Lutz 2004). The Pennsylvania Game Commission is currently managing their State Game Lands in this fashion by using the Golden-winged Warbler Habitat Best Management Practices for Forestlands in Maryland and Pennsylvania (Bakermans et al. 2011) to guide interspersion of young forest stands on State Game Lands within Golden-winged Warbler Focal Areas.

Management sites on the Cherokee National Forest in Tennessee retained suitable habitat conditions for approximately 10 years (Klaus 1999) after harvest, but were not suitable for commercial harvest for another 50–60 years. Given a 1235-acre (500-ha) management site, if 15% of the area is harvested every 10 years (a 70-year rotation), 185 ac (75 ha) of habitat will be available for Golden-winged Warbler use at any point in time. This same strategy can be applied to non-commercial areas such as surface mines or scrub oak barrens, where fire takes the place of timber harvest and serves to set back succession. Fire frequency within a patch will be dependent on site quality (typically 4–10 years), but the goal of 15–20% habitat availability at any given time is still the same.

Suitable habitat may be created as single patch (Figure 3–11) or multiple clustered patches. For example, if overstory trees cannot be retained, multiple small patches that maximize edge might be preferred over one or two very large patches. Providing habitat in clusters allows for contact of individuals among patches (i.e., conspecific attraction) and increases patch occupancy and densities in the management site. Ultimately, patch size and shape will be driven by context dependent silvicultural needs and topographic constraints, particularly in the rugged terrain of the Appalachian Region.

Managing Habitat within Patches

The following sections provide detailed information on within patch habitat requirements of Golden-winged Warbler and basic guidance on how to create these conditions. At the patch scale there are two units of measure that are important for nesting pairs: the **breeding territory** and the **nest site**. The breeding territory is generally defined as the defended area containing the nest site and should not be confused with home range, which also includes undefended areas used for foraging or post-fledging activities. Territory size varies with habitat quality and type, but a good frame of reference for management purposes is 2–5 ac (1–2 ha). The nest site can be thought of as the area immediately around the nest itself (within a 33 ft (10 m) radius). Because nests are naturally located within territories, in many cases the differences in habitat composition and configuration between the two are subtle.

The general idea is to manage habitat in large patches (> 5 ac (2 ha)) in a way that will meet the overall ecological needs of nesting pairs, including providing territories that contain secure nest-site locations. While the patch remains the primary management unit, we present guidelines for both the territory and nest site, as some habitat conditions can effect nest survival.

Do I Need to Micro-manage for Territories and Nest Sites?

The simple answer is probably not. Commercial timber management and other management techniques should be implemented to produce heterogeneity in the regenerating vegetation. Before creating an elaborate management prescription, evaluate the current prescription to determine if Golden-winged Warblers are responding as desired. If they are not responding to your satisfaction, then the prescription might need to be modified to better produce the desired ratio of habitat components. An adaptive management strategy should be employed to work toward a more effective prescription but also one that remains relatively simple to apply.

Breeding Territories

Proportion of Habitat Components —

The primary habitat components found within Golden-winged Warbler territories include:

1. Tall woody cover (shrubs, saplings [<4 in (10 cm) DBH]), up to 13 ft (4 m) tall.
2. Short woody cover (shrubs, seedlings) less than 3 ft (1 m) tall.
3. Herbaceous cover composed of forbs, grasses, and sedges generally less than 3 ft (1 m) tall.
4. Ground cover, including leaf litter, surface water, and exposed soil/rock.
5. Tree canopy cover.
6. Canopy tree density.

The key to creating suitable Golden-winged Warbler habitat is to produce the appropriate proportion of habitat components that are patchily distributed throughout the patch. Depending on habitat type, there are some variations to the targets provided in Table 3–2. For instance, *Rubus* (considered short woody cover) seems to be tolerated at greater proportions in eastern deciduous forest of Pennsylvania than in other habitat types. In aspen forests, eastern deciduous forest, and surface mines, suitable habitat is characterized by greater amounts of grass cover, whereas forb cover tends to be greater in abandoned farmland.

In many places, the suitability of a site is limited by the abundance and distribution of the scarcest habitat element. For example, in aspen clearcuts, grass and sedge cover may be the scarcest element as opposed to an old field where it may be woody cover (shrubs and saplings). Increasing the scarcest element can increase suitability of a larger proportion of a patch.

Table 3–2. Recommended habitat management targets for Golden-winged Warbler territories in silviculturally derived and non-forested habitat types.

Primary Habitat Component	**Management Target**	
	Silviculturally Derived Habitats	Non-forested Habitats
Tall Woody Cover > 3 ft (1 m)	5–35%, definitely < 50%	5–25%, definitely < 40%
Short Woody Cover < 3 ft (1 m)	10–30%	5–15%, definitely < 25%
Herbaceous Cover	5–25%	10–30%
Ground Cover	10–15%	10–15%
Tree Canopy Cover	10–30%, definitely > 10%	10–30%, definitely > 10%
Canopy Tree Density (or Basal Area)	*5–15/ac (10–40/ha); basal area = 10–40 ft^2/ac (2.3–9.2 m^2/ha); definitely < 50 ft^2/ac (11.5 m^2/ha)*	*5–15/ac (10–40/ha); basal area = 10–40 ft^2/ac (2.3–9.2 m^2/ha); definitely < 50 ft^2/ac (11.5 m^2/ha)*

Habitat Interspersion —

A high degree of within-patch habitat interspersion and heterogeneity is important for Golden-winged Warblers. To get a sense of this, as a rule of thumb, one should be able to stand anywhere within an appropriately managed patch and be within 20 ft (6 m) of a microedge (see sidebar, page 3–12 and Figure 3–12). A microedge is any readily perceived change in vegetation type or height, such as where grasses change to sedge at the border of a wet area or where an herbaceous opening is bordered by dogwood or *Rubus* shrubs. Shrubs should be scattered and clumped, with herbaceous openings and ground cover separating the clumps.

Bulluck and Harding 2010 developed a "clumpiness index" for sites in Virginia to describe the spatial configuration of woody vegetation (shrubs and saplings) and the relationship to Golden-winged Warbler habitat use. Shrubs that were spaced < 7 ft (2 m) apart were classified as clumped and shrubs spaced > 7 ft (2 m) apart were classified as scattered (Figure 3–12). The majority of sites occupied by Golden-winged Warblers had 50% or more of their shrubs and saplings in a contiguous clump.

Figure 3–12. The left photo shows a site with a high clumpiness index value (i.e., contiguous patches of shrubs),and presence of adequate microedge indicating high quality habitat for Golden-winged Warblers, and the right shows a site with a low clumpiness index value (i.e., scattered shrubs) and limited microedge that indicates low quality habitat for Golden-winged Warblers (from Bulluck and Harding (2010)).

Plant composition –

Providing the appropriate vegetation structure is likely more important than providing specific plant species. Certain species; however, may more likely produce the structure that Golden-winged Warblers finds attractive. For example, a combination of *Rubus* and goldenrod might serve as indicators of Golden-winged Warbler habitat in the eastern Great Lakes and the Appalachians as these plants are almost universally found on Golden-winged Warbler territories in these areas.

Some other species or species groups that are frequently found within Golden-winged Warbler territories include, but aren't limited to the following:

Note: Below we list numerous species that are commonly found within Golden-winged Warbler territories; however, it's likely that many species not contained in this list will provide the structure that Golden-winged Warblers need. Additionally, several plant species listed are exotic and/or invasive and should not be planted or encouraged to disperse. We list them here only to show possible habitat associations as derived from analyses of empirical data. They potentially can be substituted with native species that provide the same structural attributes.

- *Forbs:* goldenrod, bracken fern, wild strawberry, large-leaved aster, stinging nettle, milkweed, asters, common cinquefoil, sericea lespedeza, mountain mint, yarrow
- *Grasses/Sedges:* timothy, sweet vernalgrass, grove bluegrass, Pennsylvania sedge, wild rye, smooth brome, velvet grass, orchard grass, panicgrass, fescue
- *Shrubs:* raspberry/blackberry, blueberry, beaked hazelnut, American hazelnut, hawthorn, multiflora rose, sweetfern, autumn olive, maple, honeysuckle, serviceberry
- *Trees: (Appalachian Region)* black cherry, white ash, black locust, pin cherry, white oak, eastern white pine, American elm, black walnut, apple, sugar maple, tulip poplar, American beech, paulownia, hickories, maples; *(Great Lakes Region)* quaking aspen, big-tooth aspen, balsam poplar, paper birch, red maple, northern red oak, bur oak, black cherry, tamarack, balsam fir, eastern white pine, red pine, jack pine, white spruce

Nest Sites

Nest-site Selection –

The area within 33 ft (10 m) of nest sites is typically composed of 50% herbaceous cover, 30% woody vegetation, 13% open ground, and 7% scattered canopy trees (Table 3–3). These are approximate percentages and some suitable habitats might have different proportions such that one category could become the limiting element. In our analyses, woody cover was a primary driver of nest-site selection. All nest sites included some wood component, but rarely did woody cover exceed 70%. While herbaceous cover at the nest site is clearly important, the response to forbs versus grasses is somewhat different and dependent on habitat type (Figure 3–13). In silviculturally-derived management sites, most nest sites contain > 50% forbs, while non-forested sites, such as abandoned fields generally contain < 50% forb cover. In all habitat types; however, there seems to be a general selection pressure against high amounts of grass cover, as few sites contain > 45% grass cover. Given this, we recommend using woody cover and grass cover as indicators of when sites are becoming too shrubby versus too open. Where it occurs, relatively small amounts of *Rubus* spp. can be an important indicator of high quality nest sites, but it should not exceed 40% cover.

Table 3–3. Recommended habitat management targets for Golden-winged Warbler nest sites.

Habitat Component	Desired Habitat Component
Woody Cover	5–50%, definitely < 70%
Forb Cover (silviculturally derived sites)	45–100%
Forb Cover (non-forest sites)	5–45%
Rubus Cover (where it occurs)	5–40%
Grass/Sedge Cover	5–25%, definitely < 45%
Vegetation Density (as viewed horizontally)	10–30%, definitely < 40%

Nest Survival –

Vegetation Density and Woody Cover: Golden-winged Warbler nest survival is lowest where vegetation density is scant and optimal where vegetation density is in the moderate to dense range (10–40% as viewed horizontally from 33 ft (10 m) away). As the proportion of woody cover exceeds 50%, the effect on nest survival is negative. This relationship is also reflected in nest-site selection by Golden-winged Warblers where it has an affinity for small-to-moderate amounts of woody cover but avoid sites with excessive cover. Therefore, when vegetation density and woody cover approach these high proportions, management should set back succession to favor forbs and grasses. This can be accomplished by a variety of means such as prescribed burning, brush hogging, or grazing (Table 3–4).

Grass Cover: Nest survival is consistently high when grass cover is < 40%, but as the percentage of grass cover within 33 ft (10 m) of the nest exceeds this amount survival begins to decrease. This result is consistent with nest-site selection where breeding pairs avoided sites with > 45% grass cover. Given its importance to nest site selection and survival, the overall proportion of grass cover within patches should be monitored carefully and used as an indicator of suitable Golden-winged Warbler habitat. When grass becomes too extensive (> 40% cover), management is needed to reduce its proportion relative to other cover types. Typical management of grasses includes mechanical and/or chemical treatments. Dormant season burns or dormant season soil disturbance (disking) promote forbs and reduce grasses. Likewise, high frequency (annual) burns may promote grasses where less frequent burning will yield more shrub-dominated habitats.

Figure 3–13. Golden-winged Warbler nest (orange arrow) in an aspen clearcut in northern Wisconsin. Live and dead grasses, sedges, and bracken fern are important components at nest locations on these sites. Photo by Amber Roth.

Management Techniques

A variety of management techniques are available to create and maintain suitable habitat for Golden-winged Warblers. These techniques can be used to influence the proportion of each habitat component relative to the others. This can include substantially retarding or advancing succession, or making smaller manipulations to favor or disfavor a given set of conditions (Table 3–4).

Table 3–4. Suggested management techniques to manipulate habitat conditions.

Symptom	Timber Management	Mechanical Treatment	Prescribed Burning or Grazing	Restore Natural Disturbances	Plant Desired Species
Excessive canopy cover	Commercial or non-commercial harvest to remove canopy trees and promote shrub growth		Periodic burning can kill fire intolerant trees and reduce canopy cover	Restore hydrology on wetland sites to kill non-wetland adapted canopy trees	
Shrubs too evenly distributed		Mow in patches to create large shrub clumps interspersed with herbaceous openings	Conduct micro-burns to selectively remove shrubs; graze cattle to reduce shrub density	Restore hydrology on wetland sites to kill shrubs and retard re-growth	
Too little herbaceous cover	Harvest canopy trees to create gaps and allow greater sun penetration	Cut or mow to remove woody cover, such as shrubs and saplings; apply herbicide to prevent re-growth	Use late, growing season burns to promote grass and forb growth. Frequent (annual) burning will reduce shrub cover		
Too little edge (when residual canopy trees not present)	Create irregular patch margin through timber harvesting	Mowing can be used to feather edges by cutting some shrubs and small trees			
Too few canopy trees	Create feathered edge through thinning operation; retain select saplings and poles of desirable species as future residual trees				Plant fast growing deciduous trees
High herbaceous cover but low woody cover		Reduce frequency and/or intensity of mowing	Reduce frequency and/or intensity of burning/grazing		Plant appropriate shrub species

Promote natural disturbance regimes

Suppression of fire, beaver activity, flooding, and native insect/disease outbreaks have increased the necessity for active management to provide habitat for Golden-winged Warblers and other ESH associates. Where and when possible, natural disturbance regimes that create habitat should be promoted or restored (Figure 3–14). Careful consideration should be given to the timing of the activities and to possible effects on human habitation and safety, commercially valuable resources (e.g. trees), cold-water fisheries, and other issues that could result in conflicting management needs and priorities.

Figure 3–14. This sedge meadow occupied by Golden-winged Warblers in New York is maintained by beaver activity. Photo by John Confer.

Reclamation and Restoration of Degraded Sites

To reclaim or restore heavily disturbed sites such as surface mines and gravel pits, plant native warm and cool season grasses with forbs and a woody shrub component (Figure 3–15). Plant hardwood tree species known to be important as song perches and forage trees and allow these to reach maturity; these should be retained as scattered, residual trees in future disturbance treatments. The shrubs and trees should be planted in clumps, rather than dispersed evenly across the site. Important residual tree species include red oaks (*Quercus rubra*) in the Upper Great Lakes (Roth et al. unpubl. data), black locust (*Robinia pseudoacacia*) in the Appalachians (Patton et al. 2010), and apple (*Malus sylvestris*), black cherry (*Prunus serotina*), and hawthorn (*Crataegus* spp.) in New York (Ficken and Ficken 1968), though specific species may be less important than having deciduous species that provide critical structure.

Figure 3–15. Not all reclaimed mine areas have appropriate nesting habitat for Golden-winged Warblers, as illustrated at these sites in the Cumberland Mountains, Tennessee. The site in the left photo does not contain the necessary woody structure, while the site in the right photo does. Photo by Katie Percy.

Utility Rights-of-Way (ROW)

Utility ROWs occur extensively throughout the range of the Golden-winged Warbler and are often cited as a potential source of habitat. Kubel and Yahner (2008) compared Golden-winged Warbler density and nest success along ROWs in Pennsylvania to 2.5 ac (1 ha) patch clearcuts. Use of wide ROWs (200 ft (60 m) wide) for nesting was similar to use of clearcuts, although nest success was much lower and narrow ROWs (66 ft (20 m) wide) received no Golden-winged Warbler use. Thus, the suitability of utility ROWs as Golden-winged Warbler habitat is likely to vary extensively depending on width and habitat management. When woody vegetation is controlled aggressively, ROWs are generally unsuitable as Golden-winged Warbler habitat. ROWs that are at least 160 ft (50 m) wide with the potential to manage adjacent vegetation as habitat provide the greatest management opportunities for the species. In forested areas, for example, ROWs often lack a transition zone (soft edge) from adjacent woodlands because utility managers actively control woody growth. Incorporating timber harvests in forest stands adjacent to utility ROW is being used in Pennsylvania and New Jersey to create Golden-winged Warbler breeding habitat.

Figure 3–16. A managed utility ROW in Sterling Forest State Park, New York. This habitat has supported Golden-winged Warbler, Blue-winged Warbler, and various hybrid pairings. With the loss of genetic purity for both species and high nest predation due to eastern chipmunks (Tamias striatus) and black rat snakes (Elaphe obsolete obsolete), the habitat at this location is likely a genetic and population sink. Photo by John Confer.

Managing areas for nesting habitat adjacent to the corridors may be one way to reduce the linearity of the habitat and to provide missing structural components such as saplings, scattered canopy trees, and dense shrubs. The ROW itself then provides the herbaceous and shrub cover needed for nesting. In this way, where possible, two adjacent areas can be managed with different prescriptions that provide habitat characteristics that are complementary. This type of management strategy has not been evaluated for effects on

annual reproduction, especially in relation to traditional, linear corridors. In general, source/sink dynamics are not well understood under different corridor management scenarios thus caution is advised when including utility ROWs as part of a local or regional conservation strategy (Figure 3–16).

Timber Management

Even-aged and two-aged silviculture treatments, such as clearcutting, seed tree harvests, green-tree retention, and shelterwood harvests, can provide the proper structural conditions that Golden-winged Warblers prefer. Group and single-tree selection characteristic of uneven-aged harvest prescriptions produce small gaps that are infrequently occupied by Golden-winged Warblers. **Rotate management between adjacent sites such that at least 15–20% of a management area is available as breeding habitat in any one year.** Refer to the Golden-winged Warbler Forestland Best Management Practices in Pennsylvania and Maryland (Bakermans et al. 2011) for a complete set of guidelines for creating and maintaining Golden-winged Warbler breeding habitat via timber harvests.

Retention of residual canopy trees is an important characteristic of aspen clearcuts supporting breeding pairs of Golden-winged Warblers in northern Wisconsin (Roth et al. unpubl. data, Figure 3–17). Retention of these healthy canopy trees (and snags) provides foraging opportunities and song perches for territorial males (Figure 3–19). Absence of residual trees is correlated with low male densities and poor mating success. **A minimum of five to six large residual canopy trees should be retained per acre (12–14 trees/ha) with at least four (10 trees/ha) of these being hardwood species (Figure 3–18).** This equates roughly to a minimum of 5 ft^2/ac (1 m^2/ha) basal area of residual trees with at least 3 ft^2/ac (0.6 m^2/ha) as hardwoods. Mean diameter at breast height (DBH) for residual trees varied between 8–13 in (20–33 cm), and a maximum of 38 in (97 cm) was recorded. Residual basal areas up to 47 ft^2/ac (10.8m^2/ha) attracted high densities of males. In Minnesota, Huffman et al. (1997) recommended a residual basal area of 20 ft^2/ac (4.6 m^2/ha) or approximately 20% residual canopy cover in aspen forest; at around 40 ft^2/ac (9.2 m^2/ha) or approximately 40% residual canopy cover.

Similarly, in Pennsylvania, Golden-winged Warblers were detected in stands with a residual basal area of 10–50 ft^2/ac (2.3–11.5 m^2/ha); hence Bakermans et al. (2011) recommended retaining 10–15 residual trees per acre (25–37/ha). Large-diameter residual trees (> 9 in (23 cm) DBH) are preferred over smaller trees. Timber stands in Pennsylvania with Golden-winged Warblers had the following size class distribution of residuals: 42% were > 15 in (38 cm) DBH, 39% and 19% were 4–9 in (10–23 cm) DBH. If no large-diameter trees are present, retain trees that have the potential to become large-diameter in future rotations or retain

Ruffed Grouse Habitat is Golden-winged Warbler Habitat

For species that depend on young forests and shrublands, most timber management practices that create ESH for one species will benefit a broad suite of associated species. Ruffed Grouse management is a good example. From the Ruffed Grouse Conservation Plan, recommendations that are compatible with Golden-winged Warbler habitat needs include:

- Maintain a mosaic of young forest (< 20 years old) interspersed with mature stands (> 40 years old).
- Target management along upland-lowland forest ecotones where topography is relatively flat.
- Within a management site, create 2.5–10 ac (1–4 ha) clearcut patches.
- In aspen clearcuts, retain up to 15 ft^2/ac (3.4 m^2/ha) of basal area for residual trees.
- In oak or maple clearcuts, retain up to 25 ft^2/ac (5.7 m^2/ha) of basal area for residual trees.

To see the Ruffed Grouse Conservation Plan, visit **www.ruffedgrousesociety.org/**

Figure 3–17. This newly harvested aspen forest has a moderate density of residual canopy trees with a high proportion of hardwoods (northern red oaks) dispersed throughout the stand. In a couple years, when the understory has regrown, this site should provide excellent nesting habitat for Golden-winged Warblers. Photo by Laurie Smaglick Johnson.

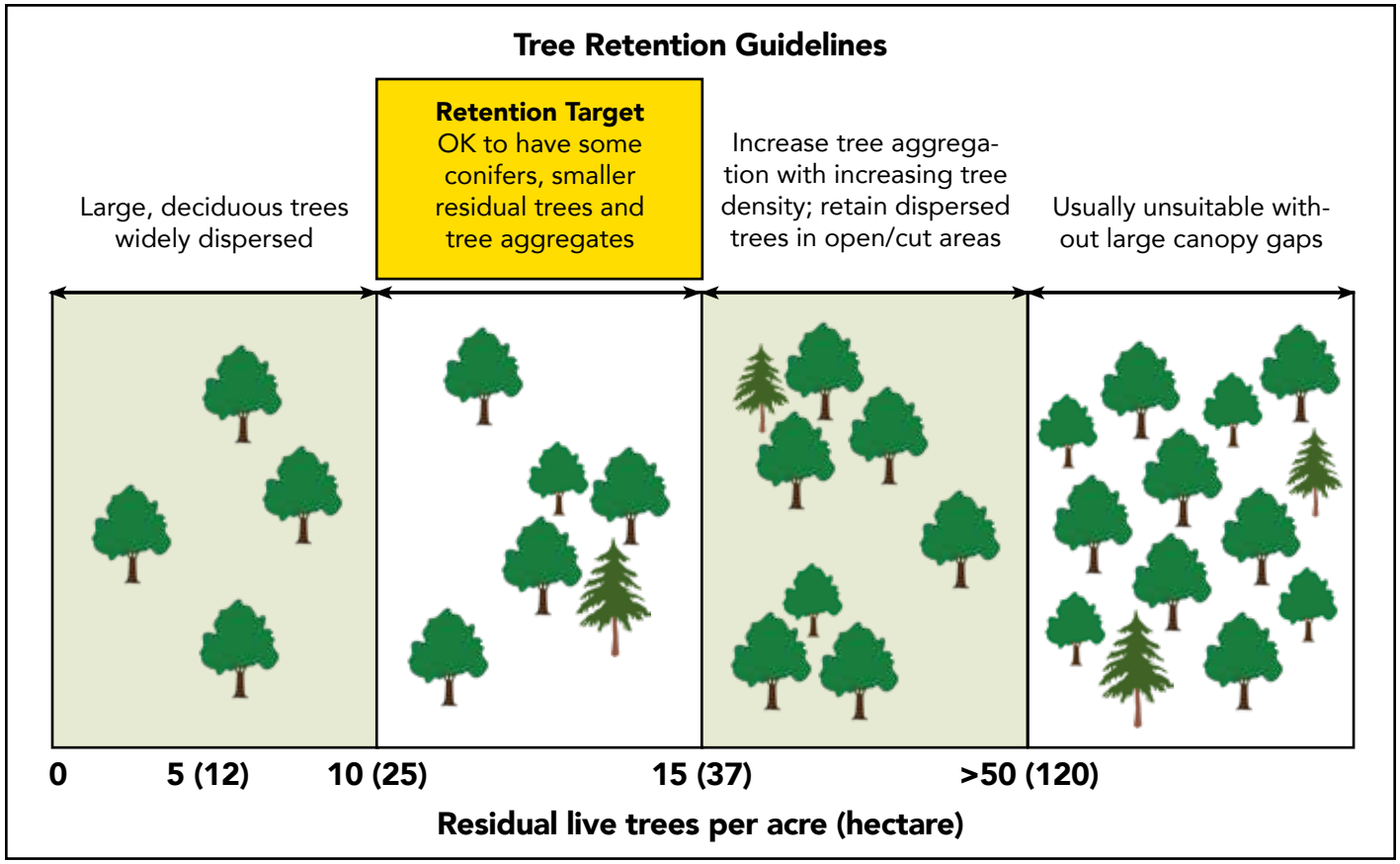


Figure 3–18. Harvest of a forest stand to generate Golden-winged Warbler breeding habitat must take into consideration the size and shape of the harvest area and canopy tree retention options. If retention is not desirable or when there are no canopy trees to retain, then harvest areas should be relatively small (5–10 ac (2–4 ha)) with irregular edges. Adjacent older forest will be used as song perches and to define territory boundaries. If retention is possible, the recommended target is 10–15 trees/ac (25–37 trees/ha). At low retention levels (<10 trees/ac (<25 trees/ha)), a dispersed pattern of retention is important. At or above the retention target level, harvest areas should be relatively large (>25 ac (>10 ha)) and minimize edge; retained trees should be increasingly aggregated as retained tree density increases. At all retention densities, at least 4 trees/ac (10 trees/ha) should be large deciduous trees.

clusters of small trees to provide some structural diversity. For basal areas less than 10 ft^2/ac (2.3 m^2/ha), residual trees should be dispersed throughout the stand or retained in clumps embedded within the harvest. At basal areas >35 ft^2/ac (8.0 m^2/ha), up to half of the residual trees should be spatially aggregated in patches and the remainder dispersed throughout the stand.

In the Appalachians, use of timber harvesting followed by burning extends the habitat availability of forest stands for Golden-winged Warblers by sustaining herbaceous cover (Brose and Van Lear 1998). This practice has been used in the Midwest to promote Sharp-tailed Grouse habitat, particularly in diverse barrens (a combination of herbaceous prairie and brush prairie with 30–60% woody cover) that attract low densities of Golden-winged Warbler (Mossman et al. 1991). When these areas are burned on longer rotations, succession leads to more woody vegetation dominated by aspen, oak, and jack pine and an associated increase in Golden-winged Warbler abundance.

Figure 3–19. Silvicultural practices such as clearcutting with retention of snags and live cavity trees in clearcuts will benefit high priority cavity nesters such as Northern Flicker (Colaptes auratus) *and Yellow-bellied Sapsucker* (Sphyrapicus varius). *Golden-winged Warbler will also use snags for song perches. Photo by Laurie Smaglick Johnson.*

Mechanical Clearing

Mowing and brush-hogging during the non-breeding period is another method to reduce woody growth to maintain Golden-winged Warbler habitat. Cutting of woody brush stems; however, tends to stimulate woody re-growth from the established roots, which may limit the subsequent period of habitat availability. Following the cutting with a selective herbicide application will often be necessary to re-

duce re-sprouting. Cutting should be conducted in patches to maintain the patchy woody structure that Golden-winged Warblers prefer. Cuttings in Minnesota brushlands may reduce quality of breeding habitat for at least three years relative to unmanaged areas though no mention was made about the size and configuration of the cut areas (Hanowski et al. 1999). Thus, where the effect of mechanical cutting is not well understood, it is advised to incrementally increase the ratio of brush cleared and to evaluate Golden-winged Warbler response at each cutting interval. Residual canopy trees or clusters of shrubs and saplings should be retained when present (Figure 3–20). On wet sites and sensitive soils, heavy equipment should be used only when the ground is frozen.

Mechanical cutting is generally a non-commercial treatment though the number of bioenergy and biofuel plants capable of utilizing woody biomass is increasing such that this may be a commercially viable option in some regions. Mowing may also be necessary to reduce vegetation height in shrubland habitats where fire has been excluded (Figure 3–21). Mechanically lowering this vegetative fuel load may allow managers to reintroduce fire as a disturbance factor in Golden-winged Warbler habitats.

Figure 3–20. This area was mechanically treated in Bald Eagle State Park, Pennsylvania to create breeding habitat for Golden-winged Warbler and American Woodcock. Note residual canopy trees and clumpiness of saplings and shrubs. Photo by Darin James McNeil.

Figure 3–21. Mechanical clearing or "brush-hogging" can diversify structure, as shown just following management in the top photo and after two growing seasons in the bottom photo. Golden-winged Warbler often don't respond positively to this type of management for two to three growing years until the vegetation has recovered. Top photo by Cathy Johnson, Bottom photo by Kyle Aldinger.

Prescribed Burning

Fire has played an important role in creating and maintaining habitat for Golden-winged Warbler across many parts of its range. Over the past five decades; however, fire suppression has resulted in widespread forest succession and loss of early-successional habitats. In the absence of wildfires, prescribed burns are the likely management tool for both creating and maintaining Golden-winged Warbler habitat today, particularly in upland sites. For example, experimental burns conducted in 2003 appear to have created and maintained suitable habitat that has enabled a population of Golden-winged Warblers to persist and expand in Georgia. The breeding population increased from three territories in 2002 to 12 territories in 2003 (N. Klaus, GA DNR, pers. comm.). Prescribed burning in Tennessee on reclaimed surface mine sites demonstrated that fire is an effective management tool for restoring Golden-winged Warbler habitat on overgrown mine sites, with breeding pairs increasing from 5 to 25 pairs with repeated burns over 5 years (Figure 3–22 and 3–23, David Buehler, unpubl. data).

Figure 3–22. Prescribed burn on a reclaimed mine site in Tennessee. Photo by Kelly Caruso.

The frequency of burning required to maintain Golden-winged Warbler habitat varies by community type and location. Based on research in the southern Appalachians, an initial burn cycle of two to four years is necessary for restoring herbaceous cover and suppressing woody growth. Once the desired herbaceous cover is in place, a less frequent burn cycle (five to ten years) may be sufficient to maintain Golden-winged habitat (N. Klaus, GA DNR, pers. comm.). In areas where woody growth and development are slower, longer burn cycles may be used from the onset. In Minnesota brushlands, Golden-winged Warblers preferred to nest in unmanaged areas than in zero to three-year-old burned areas, thus longer burn cycles are likely needed in this vegetation community and location (Hanowski et al. 1999).

Burn intensity and timing will depend on whether you need to promote or suppress woody vegetation growth.

Importance of Burns

Allowing natural disturbance or mimicking the natural disturbance regime can increase suitable ephemeral sites for a host of species. For example, forested sites burned by wildfires or prescribed burning have attracted Kirtland's Warbler (*Setophaga kirtlandii*), Spruce Grouse (*Falcipennis Canadensis*), Black-backed Woodpecker (*Picoides arcticus*), and Golden-winged Warbler. Fire-created structures such as "stringers", or lines of unburned live residual trees, may be important for attracting species dependent on residual trees in regenerating forests such as Golden-winged Warbler (Kashian et. al 2012). Fire-killed trees will attract nesting and foraging woodpeckers, most notably Black-backed Woodpecker in the northern Great Lakes.

Late-summer (late August-September) or fall burns may be more intense and most effective at suppressing woody growth, thus prolonging suitability of Golden-winged Warbler habitat, while having the least effect on annual reproduction (Brose and Van Lear 1998). However, if herbaceous cover is abundant and woody vegetation is scarce but you need to control invasive plants, a spring burn prior to the nesting season might be preferred. Some habitat objectives can only be met with prescribed burns that occur during the spring growing season (i.e., invasive plants control, promoting oak regeneration) (see Sidebar on Incidental Take, page 3–16). Spring burning; however, will likely reduce nesting in the burned area for that breeding season (K. Percy and D. Buehler, unpubl. data).

Frequency of burning should be dictated by desired vegetation response, and fire intensity should be used to control vegetation as desired. Fire return interval (i.e. burning regime) will determine the composition and structure of the subsequent plant community. Annual prescribed fire has a tendency to shift the plant community to a more grass-forb-dominated composition, whereas a two- to three-year burning regime generally will yield an herbaceous community with scattered shrubs and saplings. A three- to four-year burning regime will create a mixed grass and forb community with a substantial shrub-sapling component; burning regimes beyond a four year interval typically allow an area to quickly become encroached by mid- and over-story canopy trees. Though Frost (1995) recommended a return interval of 7–25 years, in many cases, an intermediate return interval (7–12 year) may provide the appropriate mix of structural characteristics for nesting habitat. The optimal return interval will ultimately depend on the vegetation response and the rate of woody plant invasion and growth that will need to be evaluated on a site-by-site basis.

Figure 3–23. This reclaimed mine site in Tennessee was previously burned resulting in maintenance of Golden-winged Warbler nesting habitat. Photo by Katie Percy.

Grazing

Grazing can maintain pastures and old fields, in an early-successional condition suitable for Golden-winged Warblers by reducing growth of woody vegetation (Figure 3–24). In the Appalachians, graze one animal unit/5–10 ac (2–4 ha) during the growing season. Greater intensity grazing (up to one animal unit per acre) is acceptable during the summer for short periods of time (i.e., less than two months). On high elevation sites, winter and early spring grazing can help set-back woody vegetation.

Figure 3–25. American Woodcock are frequently associated with Golden-winged Warbler breeding habitat. Photo by Eric Dresser.

Figure 3–24. As this West Virginia site demonstrates, moderate to light cattle grazing can help maintain Golden-winged Warbler habitat. Photo by Kyle Aldinger.

Herbicide Application

Herbicides that selectively target woody plant growth can be used effectively, especially in combination with other management tools, such as fire, grazing, or mowing to retard plant succession and prolong the period of habitat suitability for Golden-winged Warblers. Chemicals should be target specific and applied by a certified applicator (where required). When working in or near surface water or wetlands, use only chemicals appropriate for aquatic systems.

Other Habitat Management Considerations

Invasive plant prevention and management

Anytime habitat is manipulated, especially when using heavy machinery, there is a risk of introducing and spreading exotic, invasive plant species. Prior to management action, target sites should be surveyed for problematic species. When working in an area where invasive species are present, special actions may be necessary and clearly outlined in a management plan. Consultation with an invasive species control expert is advised. Targeted removal of invasive plants by mechanical and/or chemical means may be necessary immediately before and/or after management actions are implemented. Equipment should be cleaned before moving it from one site to another. Winter cutting can reduce spread of these species and the likelihood of mud and seeds sticking to the equipment. In highly degraded sites infested with Phragmites or other invasive plants, we recommend following the guidelines that have been developed for restoration of bog turtle (*Glyptemys muhlenbergii*) habitat by conservation organizations and state agencies. In the northeastern US, Golden-winged Warbler and bog turtles sometimes co-occur in swamp and shrubland habitats, thus these guidelines may also be useful for Golden-winged Warbler habitat restoration though they have not been evaluated specifically for this application (Figure 3–26). The guidelines provide sound information on using grazing to manage habitat in wetland situations.

A stocking density of 0.75 animal units per acre of open habitat is recommended, though 1 animal unit can be used for control of woody invasive species (Tesauro 2006). This equates to 5–10 mature sheep or goats per acre. Duration of grazing should not exceed 5 consecutive months for 1–5 years (Tesauro 2006). Given that this is a higher rate of grazing pressure than we recommend for upland habitat maintenance, care should be taken to monitor effects of grazers on

Managing Shrub Wetlands

Harvesting wetland or upland shrubs as patches perpendicular to open water is commonly used to improve feeding habitat for American Woodcock (Figure 3–25). Strips should be 50–100 ft (15–30 m) wide and cross a moisture gradient when possible; this is important for providing good woodcock foraging conditions through wet and dry weather cycles. Strips or patches should be cut every 20 years with 25% of the area rotationally harvested every five years.

Modifications for Golden-winged Warbler – If strip mowing is used, periodic clumps of shrubs and scattered trees should be retained in each strip. In all cases, edges should be irregular.

For more information on American Woodcock ecology and habitat management guidelines, visit **www.timberdoodle.org/**

Figure 3–26. Goats (left photo) are one option for controlling Phragmites or other invasive plants in Golden-winged Warbler habitat. Though this technique is untested in Golden-winged Warbler habitat, it has been effective for bog turtle habitat restoration as pictured before (top right) and after (bottom right) grazing on this transmission line right-of-way in New Jersey. The bottom right photo depicts the habitat improvement after two years of grazing treatments. Photos by Jason Tesauro.

vegetation such that suitable habitat is generated for Golden-winged Warblers. If the goal is herbaceous plant control with minimal effect on shrubs, then sheep are preferred. If shrub control is also needed, then goats or a mix of sheep and goats is preferred. Guidelines for other restoration techniques such as chemical application, mechanical removal, and prescribed burning are also available. Information on these techniques as applied to bog turtle habitat restoration can be obtained by contacting the US Fish & Wildlife Service Northeastern Regional Office in Hadley, Massachusetts, **www.fws.gov/northeast/ma/ro.html**.

Cowbird parasitism

Landscape context is important to consider when planning and performing habitat management for Golden-winged Warblers. Cowbird parasitism is likely to be a problem in agricultural landscapes or where forested sites are within 5 km of agricultural areas (Figure 3–27). Cowbird parasitism tends to not have a population effect in forested landscapes.

Figure 3–27. This Golden-winged Warbler nest in Wisconsin contains two Golden-winged Warbler eggs and one Brown-headed Cowbird (Molothrus ater) egg (the largest of the three). The female Golden-winged Warbler abandoned this nest after the cowbird egg was laid. Photo by Amber Roth.

Part II: Reference Guide to Focal Areas

This section provides detailed information on each of the 34 focal areas in the two conservation regions. For ecological relevance and ease of discussion, similar focal areas were grouped by using a principal components analysis to form subregions (see Appendix C).

A set of 12 independent variables was initially identified as significant predictors of Golden-winged Warbler habitat selection at the 0.6 mi (1 km) scale. A principal components analysis was conducted to examine how variation among the independent variables was distributed among focal areas. Results demonstrated that > 92% of the variation was explained by elevation, percent forest cover, forest height, and forest type (deciduous versus coniferous). The principal components analysis reduced the 34 focal areas to 11 ecologically distinct subregions (Figures 3–28 and 3–39).

The Appalachian Mountains Conservation Region

The Appalachian Mountains Conservation Region is divided into five subregions, containing one or more focal areas each.

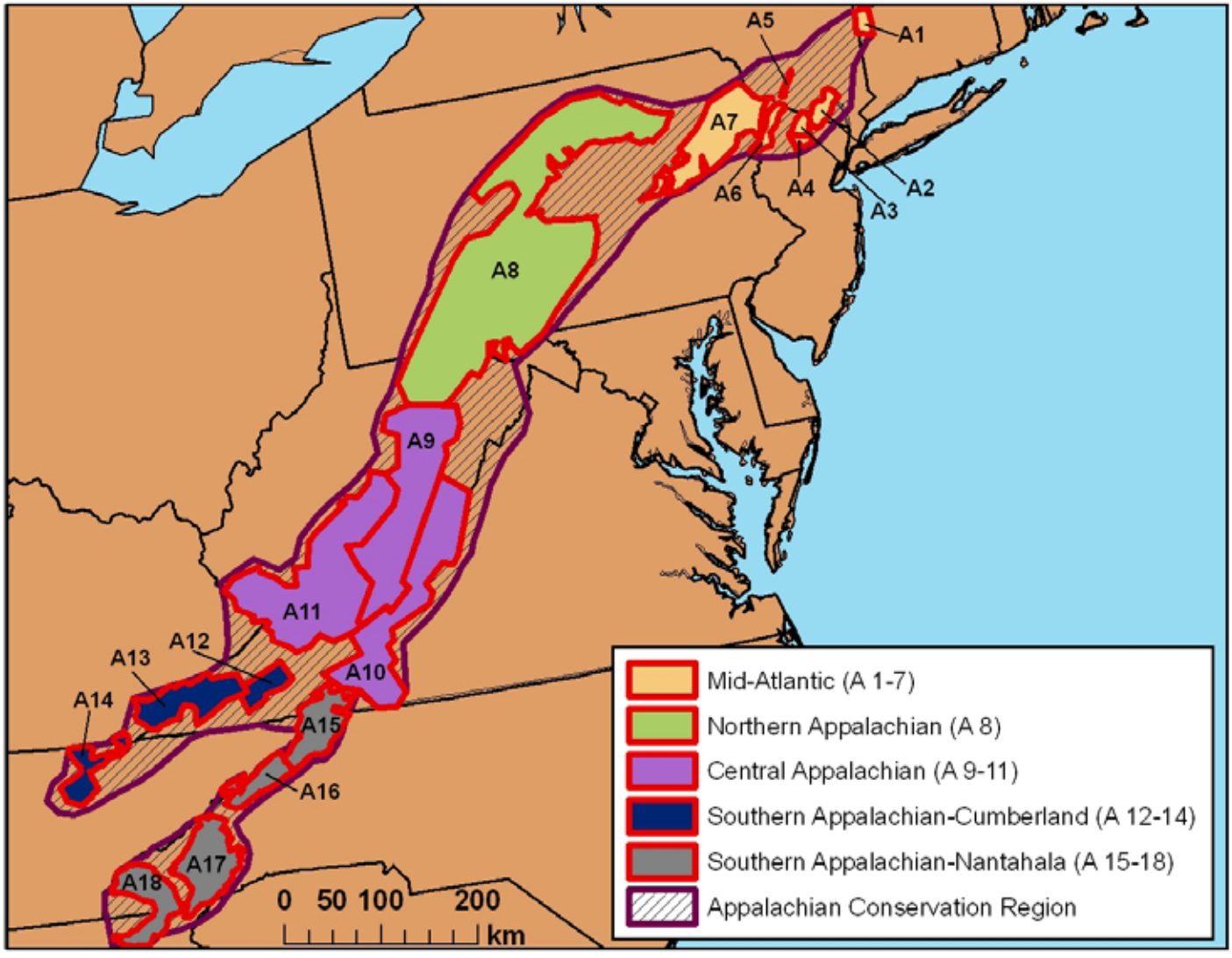


Figure 3–28. Golden-winged Warbler subregions and focal areas in the Appalachian Mountains Conservation Region.

Mid-Atlantic Subregion (Focal areas A1–A7; Figures 3–29 and 3–30; Table 3–5)

General Description

The focal areas in this subregion support approximately 13% of the region's (and 0.7% of the world's) Golden-winged Warblers. This subregion has a couple of large populations and several small, remnant populations. Managed successional forests and scrub barrens are the primary habitats in the Poconos where 51% of surveyed timber harvests had Golden-winged Warbler present. The largest, estimated Golden-winged Warbler population occurs in the Hudson Highlands, which supports mixed populations of Golden-winged and Blue-winged warblers in abandoned fields and shrub-swamp, and nearly pure Golden-winged Warbler populations in hardwood swamp forests where reproductive success is particularly high and elevations relatively low. The hardwood swamp forests of the Hudson Highlands provide habitat segregation between Golden-winged Warblers and Blue-winged Warblers at elevations below 1300 ft (400 m). The swamp forests that support Golden-winged Warblers have 30–70% canopy cover with extensive understory. Control of the invasive plant Phragmites is necessary to sustain Golden-winged Warbler populations in the hardwood swamps (Confer et al. 2010).

Macro Landscape Context (within 1.5 mi (2.5 km) of management site)

Golden-winged Warblers are generally associated with landscapes containing:

- Elevations that range from 750–1180 ft (230–360 m), but habitat management in uplands should be above 1300 ft (400 m) to exclude Blue-winged Warblers. Presence of Golden-winged Warbler in hardwood swamp forests of Hudson Highlands seems to be unrelated to elevation.
- Forests that are 33–82 ft (10–25 m) in height (i.e. large sapling to small sawtimber sized trees).
- A relatively open forest canopy, more so than in other subregions (except in Hudson Highlands).
- Relatively high coniferous forest cover (14–25%) with a ratio of 70:30 deciduous:coniferous trees in the landscape (expect nearly pure deciduous forest in Hudson Highlands).

Micro Landscape Context (within 0.15 mi (0.25 km) of management site)

Sites where Golden-winged Warblers are found generally:

- Have a lower ratio of deciduous:coniferous trees (85:15) relative to the central and southern Appalachians (expect hardwood swamps of Hudson Highlands, which are 100% deciduous).
- Have less herbaceous cover (32%) than elsewhere in region (40%).
- Contain the following primary land cover types: deciduous forest (45%); woody wetlands (11%); mixed forest (5%). Blue-winged Warblers have similar occurrence in all land cover types except hardwood swamps of Hudson Highlands.

*Table 3–5. Population and habitat goals for focal areas in the Mid-Atlantic subregion.**

Focal Area ID	Focal Area Name	2010 Popn Estimate	2010 Habitat (ha)	Popn Trend 2007-17	2018 Popn Estimate	2020 Popn Goal	2020 Habitat Goal (ha)	2050 Popn Goal	2050 Habitat Goal (ha)
A1	Northwest Connecticut	8	40	-18.05	2	10	50	16	80
A2	Hudson Highlands	1500	7500	-7.65	794	1875	9375	3000	15000
A3	Newark Watershed/Wawayanda	40	200	-8.11	20	50	250	80	400
A4	Picatinny/Sparta/Wildcat	8	40	-8.11	4	10	50	16	80
A5	Bashakill	14	70	-8.11	7	18	88	28	140
A6	Delaware Water Gap	26	130	-8.11	13	33	163	52	260
A7	Pennsylvania Poconos	1250	6250	-7.11	693	1563	7813	2500	12500

**2010 Population estimates are based on expert knowledge and Golden-winged Warbler Atlas Project data; 2018 population estimates are extrapolated from 2010 estimates based on BBS trends 2007-17.*

Potential Partners and Priority Sites

National/Regional – Appalachian Mountains Joint Venture, Atlantic Coast Joint Venture, National Park Service (Delaware Water Gap National Recreational Area), Natural Resources Conservation Service, Palisades Interstate Park Commission, US Department of Defense (Picatinny Arsenal, West Point), US Fish and Wildlife Service (Migratory Bird Program, Partners for Fish and Wildlife, Wallkill River National Wildlife Refuge)

State – Connecticut Department of Energy and Environmental Protection, Morris County Park Commission (NJ), New Jersey Department of Environmental Protection-Division of Fish and Wildlife (Bureau of Land Management), New Jersey Department of Environmental Protection-Division of Parks and Forestry (High Point State Park, Stokes State Forest), New Jersey Highlands Council, New York Natural Heritage Program, New York State Office of Parks, Recreation and Historic Preservation (Sterling Forest State Park), Newark Watershed Conservation and Development Corporation (NJ), Pennsylvania Department of Conservation and Natural Resources-Bureau of Forestry (Delaware State Forest), Pennsylvania Game Commission, East Stroudsburg University, Indiana University of Pennsylvania, Cornell Cooperative Extension, University of Connecticut Cooperative Extension System, Penn State Cooperative Extension, Rutgers Cooperative Extension, county conservation districts

NGOs – Appalachian Fire Learning Network, Audubon, Audubon New York, Audubon Pennsylvania, Black Rock Forest Consortium, Conserve Wildlife Foundation of New Jersey, Cornell Lab of Ornithology, Hawk Mountain Sanctuary, Highlands Environmental Research Institute, land trusts (Orange County Land Trust, Ridge and Valley Conservancy), native plant societies, local forest owners associations (contact extension service for information), The Nature Conservancy, New Jersey Audubon, New Jersey

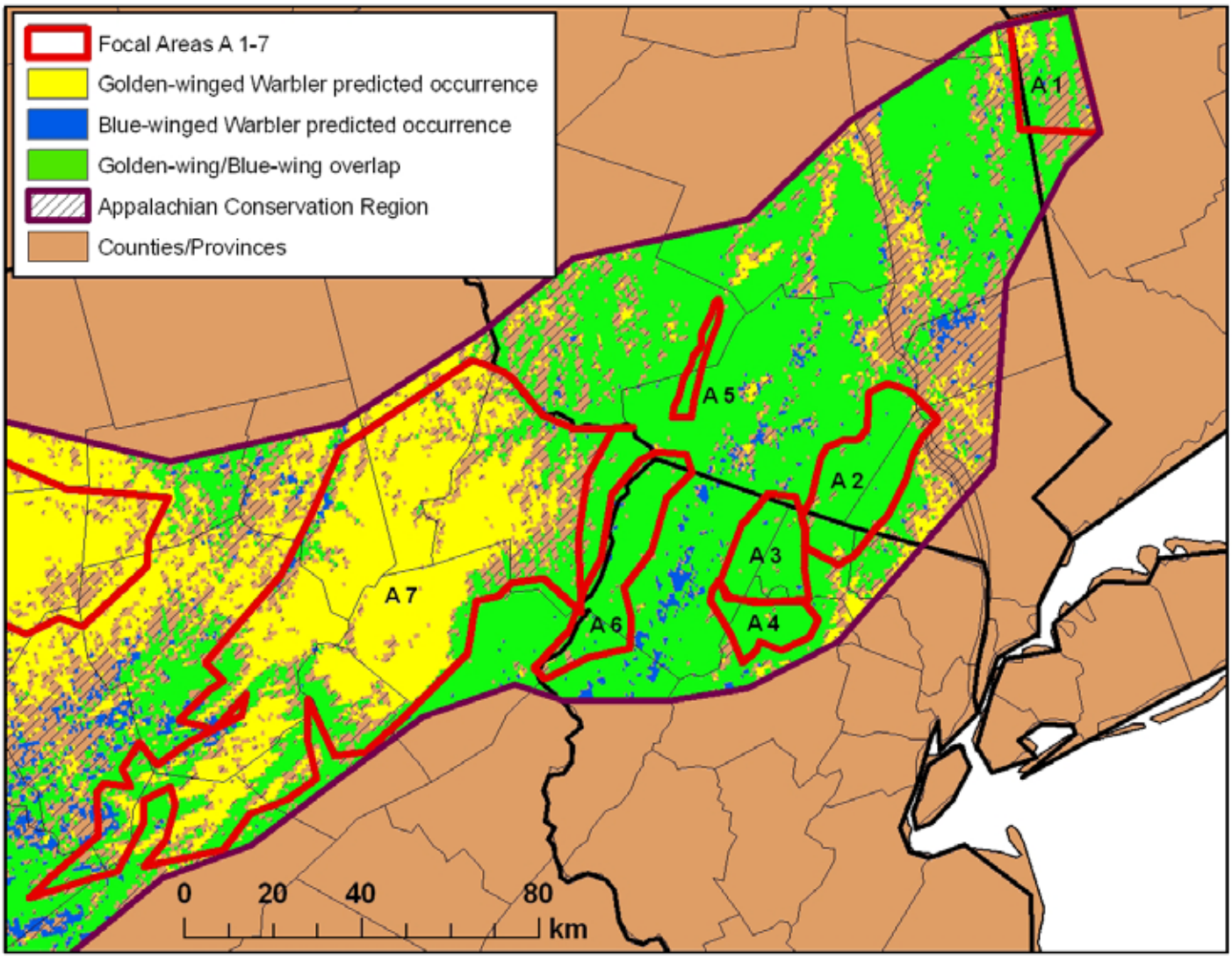


Figure 3–29. Model results showing the current predicted distribution of Golden-winged and Blue-winged warbler in Mid-Atlantic. Locations inside focal areas and without Blue-winged Warbler should receive highest priority for conservation and management actions.

Conservation Foundation, The New York-New Jersey Trail Conference, Pennsylvania Forestry Association, Pennsylvania Society for Ornithology, Sterling Forest Partnership, Wildlife Management Institute, Quality Deer Management Association, Ruffed Grouse Society, Wild Turkey Federation, Woodcock Limited of Pennsylvania

Industry – Jersey Central Power & Light, Public Service Electric & Gas, The Wagner Companies, Pike County Light & Power Company, Pennsylvania Power & Light, UGI Utilities Inc.

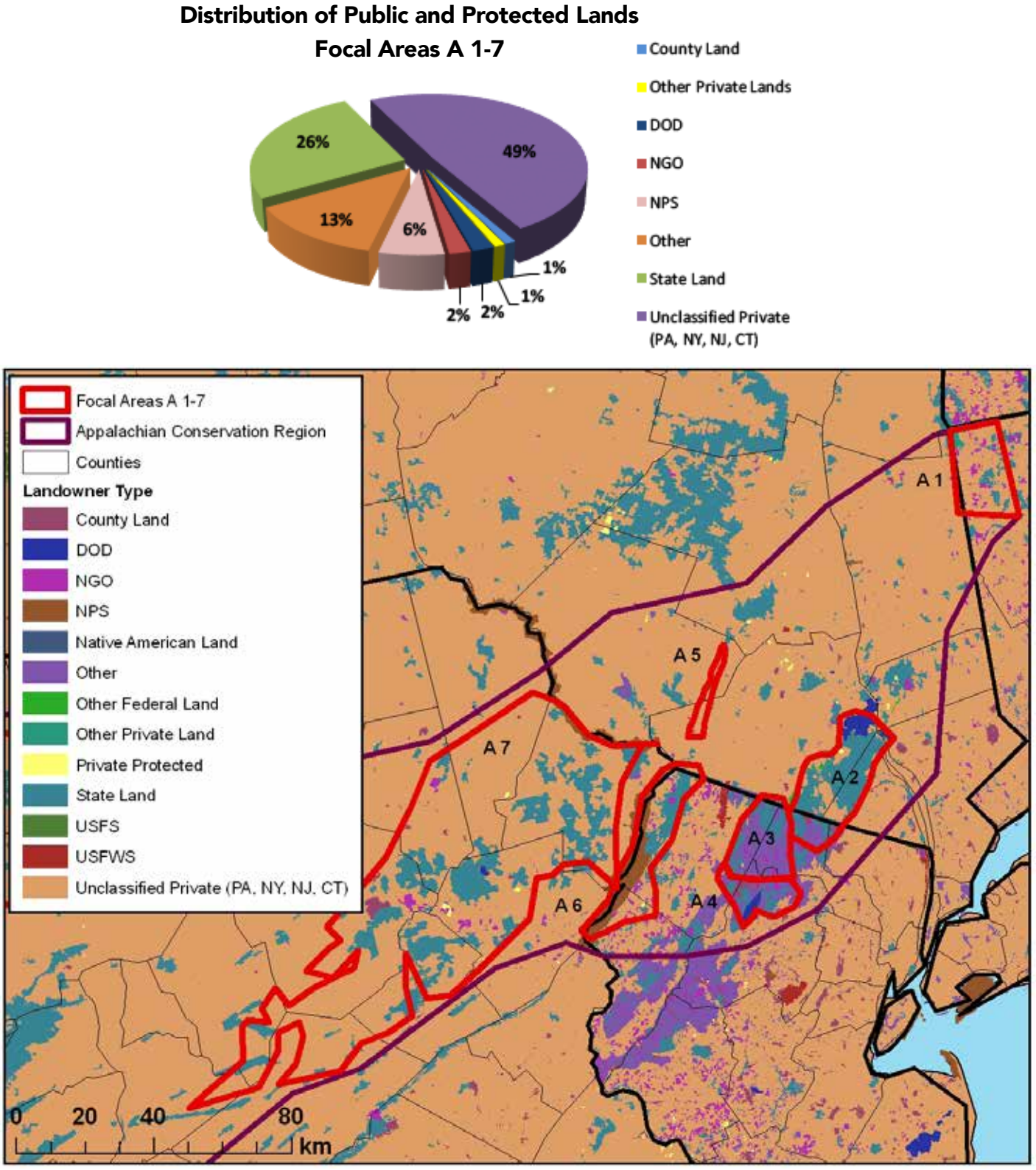


Figure 3–30. Percentage of landowner types and spatial layout of public and protected areas in the Mid-Atlantic focal areas (USGS Protected Areas Database of the USA, version 1.2, **www.protectedlands.net/padus/***).*

Northern Appalachian Subregion (Focal Area A8; Figures 3–31 and 3–32; Table 3–6)

General Description

This subregion supports approximately 27% of the region's (and 1% of the world's) Golden-winged Warblers. The primary habitats in this area are managed successional forest, abandoned farmland, scrub barrens, utility rights-of-way, and reclaimed surface mines. Major threats in this area are lack of active timber harvesting, energy extraction, and Blue-winged Warbler encroachment. With appropriate site-scale reclamation, energy extraction may also create additional Golden-winged Warbler habitat.

Macro Landscape Context (within 1.5 mi (2.5 km) of management site):

Golden-winged Warblers are generally associated with landscapes containing:

- Elevations ranging from 1200–2300 ft (370–700 m) but habitat management to exclude Blue-winged Warblers should be above 1575 ft (480 m).
- 60–95% forest cover that is widely dispersed and more open than in the southern Appalachians.
- Forests that are 33–82 ft (10–25 m) in height (i.e. large sapling to small sawtimber sized trees).
- The following land cover types: mixed deciduous-coniferous forests and open woodlands (e.g. savannah, pine and oak barrens, forest-grassland ecotones). Some Golden-winged Warblers are associated with upland red maple forests, an association not found elsewhere in the region.

Micro Landscape Context (within 0.15 mi (0.25 km) of management site)

Sites where Golden-winged Warblers are found generally:

- Have a slightly higher herbaceous cover (mean of 45%) than region-wide (mean of 40%).
- Have a lower ratio of deciduous:coniferous trees (85:15) relative to farther south.
- Contain the following primary land cover types: deciduous forest (46%); pasture-hay (12%); and evergreen and mixed forests (6%). Very few Golden-winged Warblers are associated with shrub-scrub or wetland habitats at this scale. Compared to Golden-winged Warblers, Blue-winged Warblers were more frequently associated with urban landscapes (11%, compared with 3% for Golden-winged Warbler).

*Table 3–6. Population and habitat goals for focal areas in the Northern Appalachian subregion.**

Focal Area ID	Focal Area Name	2010 Popn Estimate	2010 Habitat (ha)	Popn Trend 2007-17	2018 Popn Estimate	2020 Popn Goal	2020 Habitat Goal (ha)	2050 Popn Goal	2050 Habitat Goal (ha)
A8	Northern Appalachians	6000	30000	-7.11	3326	7500	37500	12000	60000

**2010 Population estimates are based on expert knowledge and Golden-winged Warbler Atlas Project data; 2018 population estimates are extrapolated from 2010 estimates based on BBS trends 2007-17.*

Potential Partners and Priority Sites

National/Regional – Appalachian Mountains Joint Venture, US Army Corps of Engineers, USDA Forest Service (Northern Forest Research Station)

State – Maryland Department of Natural Resources, Pennsylvania Department of Conservation and Natural Resources: Bureau of Forestry (Buchanan, Elk, Forbes, Gallitzin, Loyalsock, Moshannon, Rothrock, Sproul, and Tiadaghton State Forests) and State Parks (Bald Eagle, Canoe Creek, and Ohiopyle State Parks), Pennsylvania Department of Environmental Protection (Ebensburg), Pennsylvania Game Commission, West Virginia Division of Natural Resources, Garrett College, University of Maryland Extension, Indiana University of Pennsylvania, Penn State Cooperative Extension, West Virginia University Extension Service, county conservation districts

NGOs – Appalachian Fire Learning Network, Audubon Pennsylvania, local bird clubs (State College and Three Rivers Birding Clubs), Maryland Ornithological Society, Mountaineer Audubon Society, The Nature Conservancy, Pennsylvania Society for Ornithology, Powdermill Avian Research Center, Western Pennsylvania Conservancy, Quality Deer Management Association, local forest owners associations (contact extension service for information), Ruffed Grouse Society, Woodcock Limited of Pennsylvania, Appalachian Mountain Young Forest Initiative (Wildlife Management Institute)

Industry – The Wagner Companies, Pennsylvania Power & Light, Peoples Natural Gas, Dominion, Equitable Gas, Columbia Gas of Pennsylvania, UGI Utilities Inc.

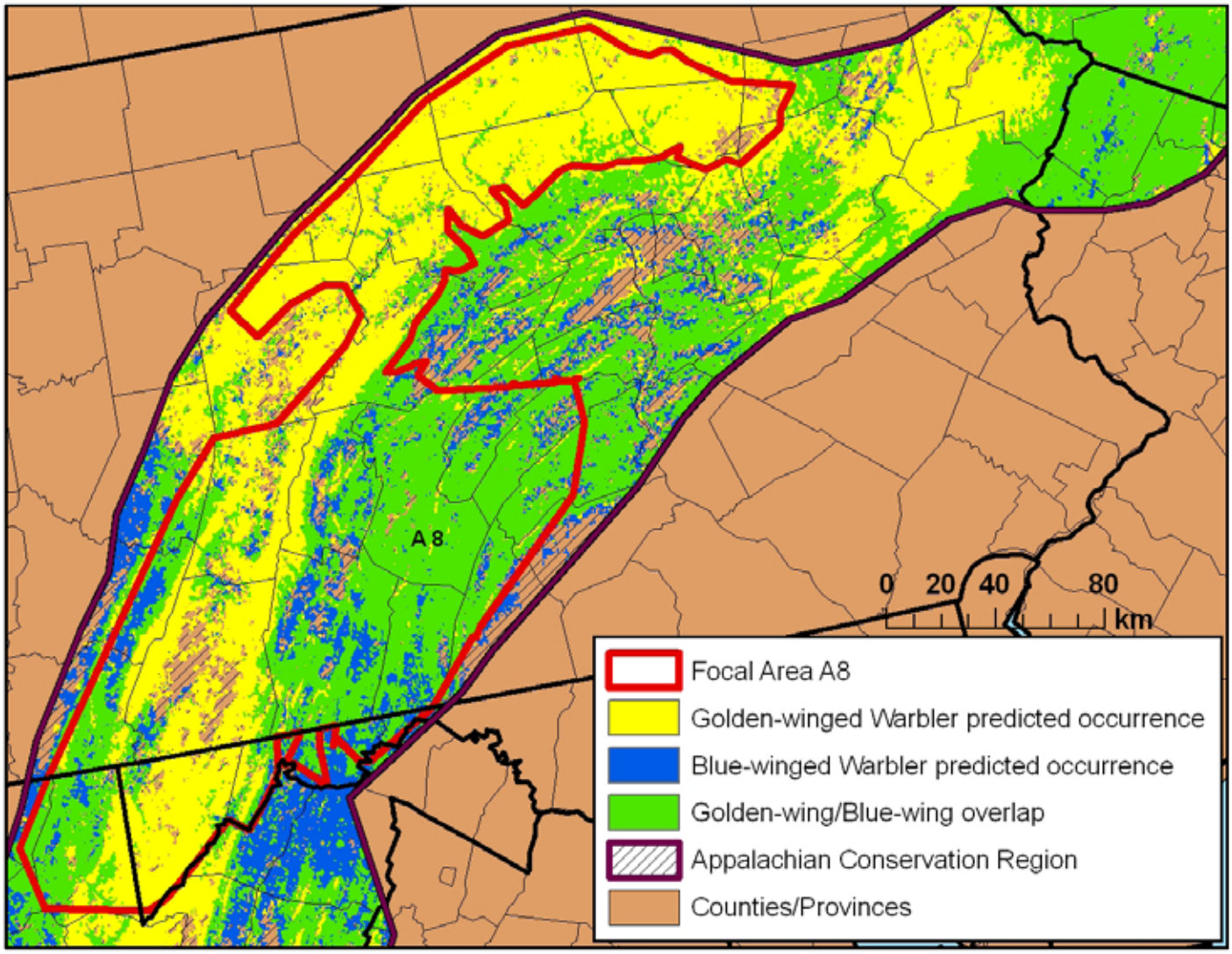
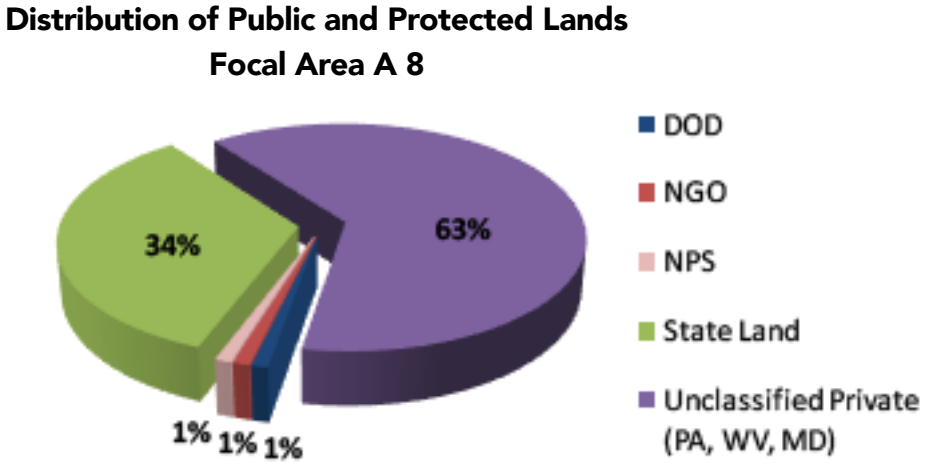


Figure 3–31. Model results showing the current predicted distribution of Golden-winged and Blue-winged warbler in Northern Appalachians. Locations inside focal areas and without Blue-winged Warbler should receive highest priority for conservation and management actions.



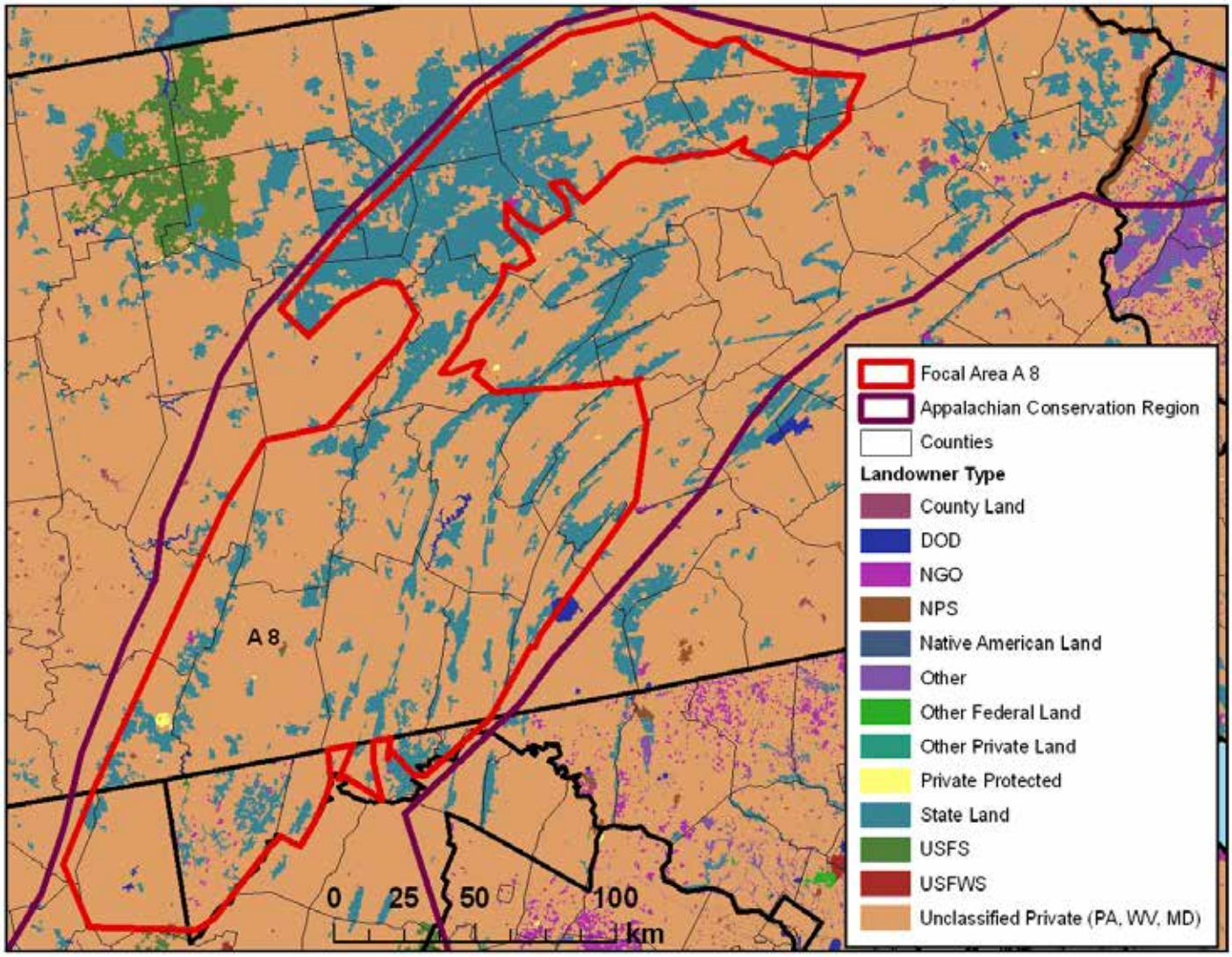


Figure 3–32. Percentage of landowner types and spatial layout of public and protected areas in the Northern Appalachian focal area (USGS Protected Areas Database of the USA, version 1.2, **www.protectedlands.net/padus/***).*

Central Appalachian Subregion (Focal Areas A9–A11; Figures 3–33 and 3–34; Table 3–7)

General Description

The focal areas in this subregion support approximately 21% of the region's (and 1% of the world's) Golden-winged Warblers. The primary habitats for Golden-winged Warblers in these areas are abandoned contour mines and pasturelands in West Virginia, and abandoned farmland and pasturelands in Virginia. There is ample opportunity in this subregion to create Golden-winged Warbler habitat through forest management, management of pasturelands, and reforestation of minelands. Major threats in these areas are restricted access for monitoring, lack of timber management to create new habitat, Blue-winged Warbler encroachment, and succession and mountaintop mining of contour mines.

Macro Landscape Context (within 1.5 mi (2.5 km) of management site)

Golden-winged Warblers are generally associated with landscapes containing:

- Elevations ranging from 1975–2650 ft (600–800 m) but habitat management to exclude Blue-winged Warblers should be above 2035 ft (620 m).
- A higher ratio of deciduous trees in the landscape (90:10; deciduous:coniferous trees) than in the rest of the region.
- Forests that are 33–82 ft (10–25 m) in height (i.e. large sapling to small sawtimber sized trees).
- Sugar maple-beech-yellow birch and yellow poplar (sometimes with red oak) forests.

Micro Landscape Context (within 0.15 mi (0.25 km) of management site)

Sites where Golden-winged Warblers are found generally:

- Contain the following primary land cover types: deciduous forest (47%); pasture/hay (8%); and grassland/herbaceous (4%). Very few Golden-winged Warblers are in emergent wetlands and none are in woody wetlands. Blue-winged Warbler are more frequently associated grassland-herbaceous and evergreen and mixed forests and less in pasture-hay.

*Table 3–7. Population and habitat goals for focal areas in the Central Appalachian subregion.**

Focal Area ID	Focal Area Name	2010 Popn Estimate	2010 Habitat (ha)	Popn Trend 2007-17	2018 Popn Estimate	2020 Popn Goal	2020 Habitat Goal (ha)	2050 Popn Goal	2050 Habitat Goal (ha)
A9	Eastern West Virginia	2500	12500	-8.41	1238	3125	15625	5000	25000
A10	Virginian Appalachians	600	3000	-7.94	310	750	3750	1200	6000

**2010 Population estimates are based on expert knowledge and Golden-winged Warbler Atlas Project data; 2018 population estimates are extrapolated from 2010 estimates based on BBS trends 2007-17.*

Potential Partners and Priority Sites

National/Regional – Appalachian Mountains Joint Venture, Appalachian Regional Reforestation Initiative, National Park Service, Natural Resources Conservation Service, USDA Forest Service (George Washington and Jefferson National Forests, Monongahela National Forest), US Office of Surface Mining Reclamation and Enforcement

State – Virginia Department of Game and Inland Fisheries, , Virginia Department of Forestry, Virginia Department of Conservation and Recreation, West Virginia Division of Forestry, West Virginia Division of Natural Resources, Virginia Commonwealth University, Virginia Cooperative Extension, West Virginia University Extension Service

NGOs – Appalachian Fire Learning Network, local bird clubs (Bath-Highland Bird Club, Brooks Bird Club, New River Valley Bird Club), Canaan Valley Institute, local watershed groups, The Mountain Institute, The Nature Conservancy, private landowners, Virginia Important Bird Areas Program, Virginia Society of Ornithology, Ruffed Grouse Society, Wild Turkey Federation, Appalachian Mountain Young Forest Initiative (Wildlife Management Institute), local forest owners associations (contact extension service for information)

Industry – Equitable Gas, Nicholas Energy, Trinity Coal, Raw Coal Mining Inc., Columbia Gas of Virginia, Bluefield Gas Company, Appalachian Natural Gas Distribution Company

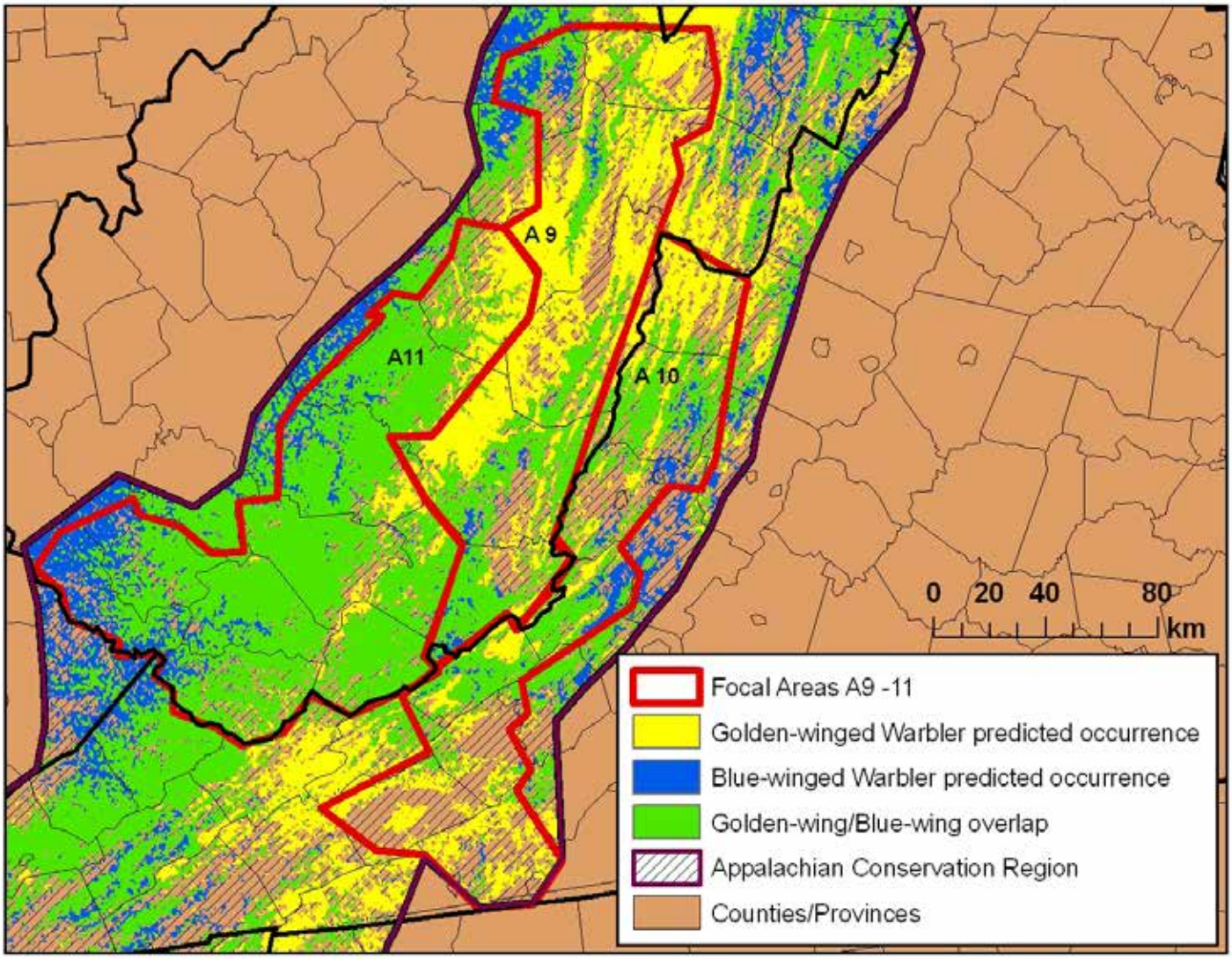
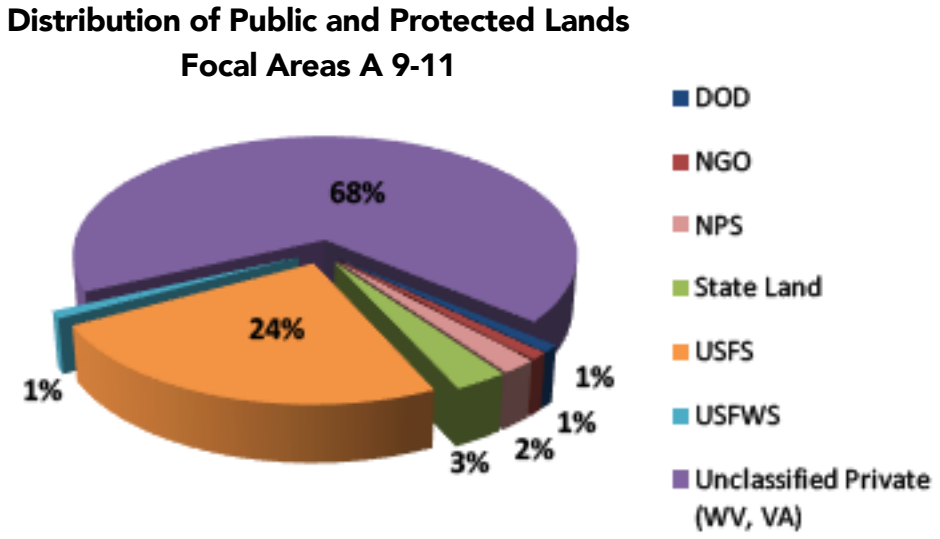


Figure 3–33. Model results showing the current predicted distribution of Golden-winged and Blue-winged warbler in Central Appalachians. Locations inside focal areas and without Blue-winged Warbler should receive highest priority for conservation and management actions.



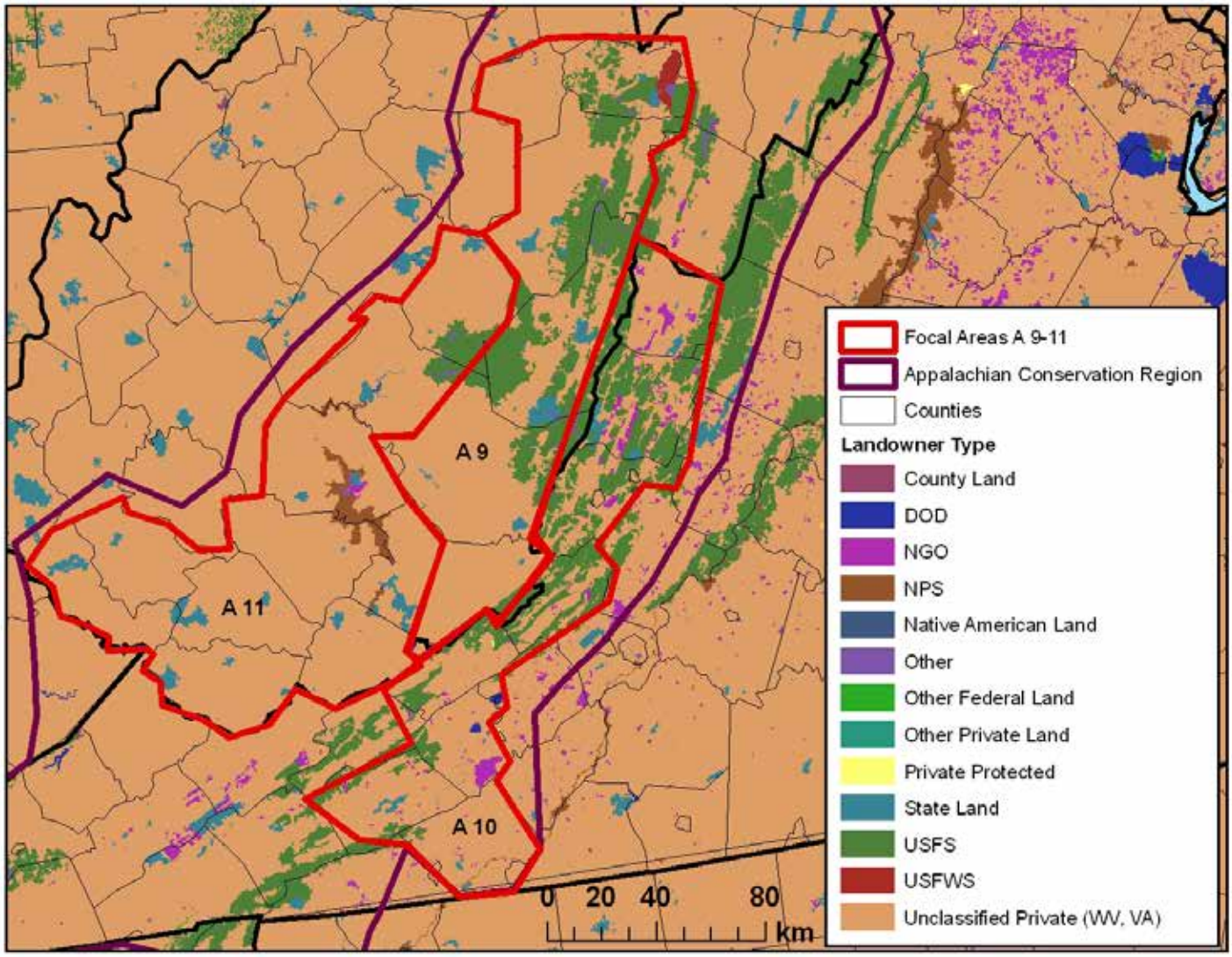


Figure 3–34. Percentage of landowner types and spatial layout of public and protected areas in the Central Appalachian focal areas (USGS Protected Areas Database of the USA, version 1.2, **www.protectedlands.net/padus/***).*

Southern Appalachian-Cumberland Subregion (Focal Areas A12–A14; Figures 3–35 and 3–36; Table 3–8)

General Description

This subregion supports approximately 3% of the region's (and 0.1% of the world's) Golden-winged Warblers. The areas are characterized by small but often high-density local populations primarily on reclaimed surface mine sites. Significant management opportunities exist with forest management but require additional post-harvest treatments of prescribed burning and use of herbicides to control woody growth. Major threats in these areas are succession and the re-mining of previously-mined and abandoned surface mines.

Macro Landscape Context (within 1.5 mi (2.5 km) of management site)

Golden-winged Warblers are generally associated with landscapes containing:

- Elevations ranging from 1975–3000 ft (600–800 m) but habitat management to exclude Blue-winged Warblers should be above 2000 ft (620 m).
- A high proportion of contiguous forest (100% forest cover) which is unique to the southern Appalachians. In contrast, around 25% of Golden-winged Warblers are found in landscapes where herbaceous cover is between 70–90%.

Micro Landscape Context (within 0.15 mi (0.25 km) of management site)

Sites where Golden-winged Warblers are found generally:

- Contain the following primary land cover types: deciduous forest (48%), grassland-herbaceous cover (14%), and barren cover (8%). Barren cover is uniquely important in this subregion and may include glacial debris, surface mines, and gravel pits. Also the absence of wetland cover types is a notable difference for Golden-winged Warbler sites in this subregion as compared to elsewhere in the range.

*Table 3–8. Population and habitat goals for focal areas in the Southern Appalachian-Cumberland subregion.**

Focal Area ID	Focal Area Name	2010 Popn Estimate	2010 Habitat (ha)	Popn Trend 2007-17	2018 Popn Estimate	2020 Popn Goal	2020 Habitat Goal (ha)	2050 Popn Goal	2050 Habitat Goal (ha)
A12	Virginia Clinch Valley	100	500	-7.94	52	125	625	200	1000
A13	Black & Little Black Mts	120	600	-7.94	62	150	750	240	1200
A14	Cumberland Mountains	370	1850	-7.73	194	463	2313	740	3700
A15	Northern Peaks	300	1500	-7.27	164	375	1875	600	3000

**2010 Population estimates are based on expert knowledge and Golden-winged Warbler Atlas Project data; 2018 population estimates are extrapolated from 2010 estimates based on BBS trends 2007-17.*

Potential Partners and Priority Sites

National/Regional – Appalachian Mountains Joint Venture, Natural Resources Conservation Service, USDA Forest Service (Jefferson National Forests: Clinch Ranger District), US Office of Surface Mining Reclamation and Enforcement

State – Kentucky Department of Fish and Wildlife Resources, Tennessee State Parks, Tennessee Wildlife Resources Agency, Virginia Department of Conservation and Recreation-Natural Heritage Program, Virginia Department of Game and Inland Fisheries, University of Kentucky, Kentucky Cooperative Extension Service, University of Tennessee, University of Tennessee Extension, Virginia Cooperative Extension, Virginia Commonwealth University, Virginia Tech, Indiana University of Pennsylvania

NGOs – Appalachian Fire Learning Network, local bird clubs (e.g. Russell County Bird Club), The Nature Conservancy, private landowners, Virginia Society of Ornithology, Tennessee Ornithological Society, Ruffed Grouse Society, Wild Turkey Federation, local forest owners associations (contact extension service for information), Wildlife Management Institute, The Nature Conservancy, Bristol Bird Club, New River Valley Bird Club, Virginia Audubon Important Bird Areas Program

Industry – coal companies, Lyme Timber Company, Fountain Forestry, state surface mining (KY)

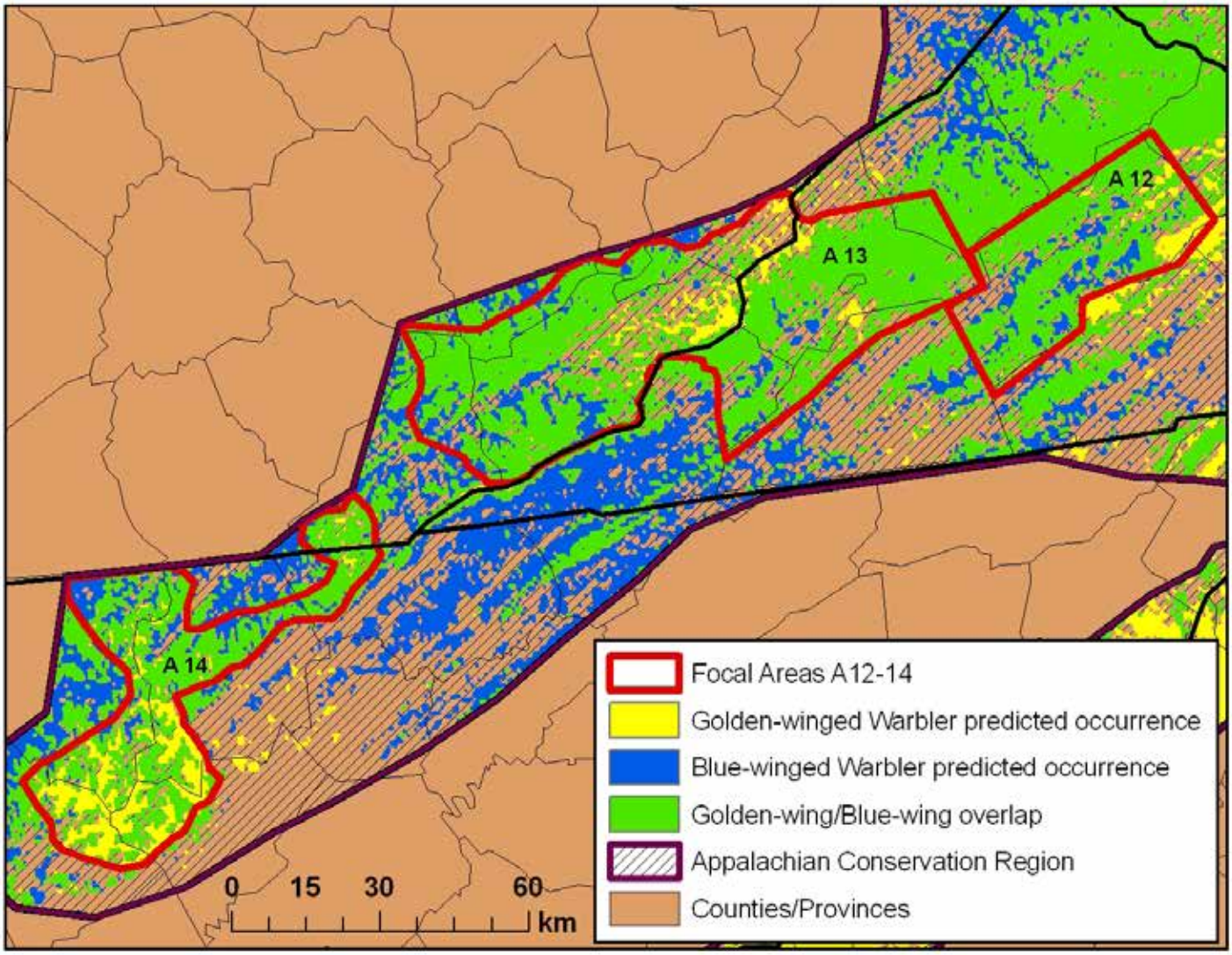
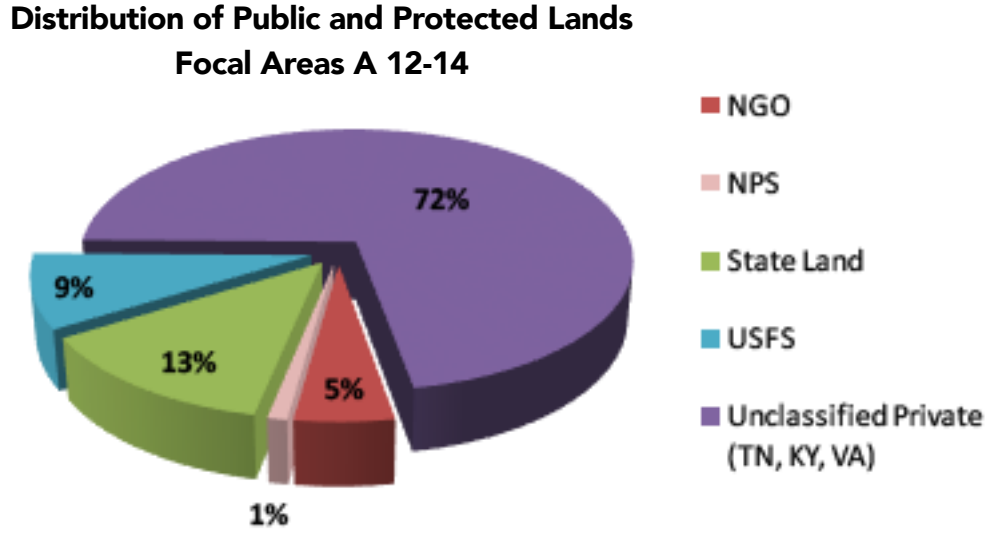


Figure 3–35. Model results showing the current predicted distribution of Golden-winged and Blue-winged warbler in Southern Appalachians–Cumberlands. Locations inside focal areas and without Blue-winged Warbler should receive highest priority for conservation and management actions.



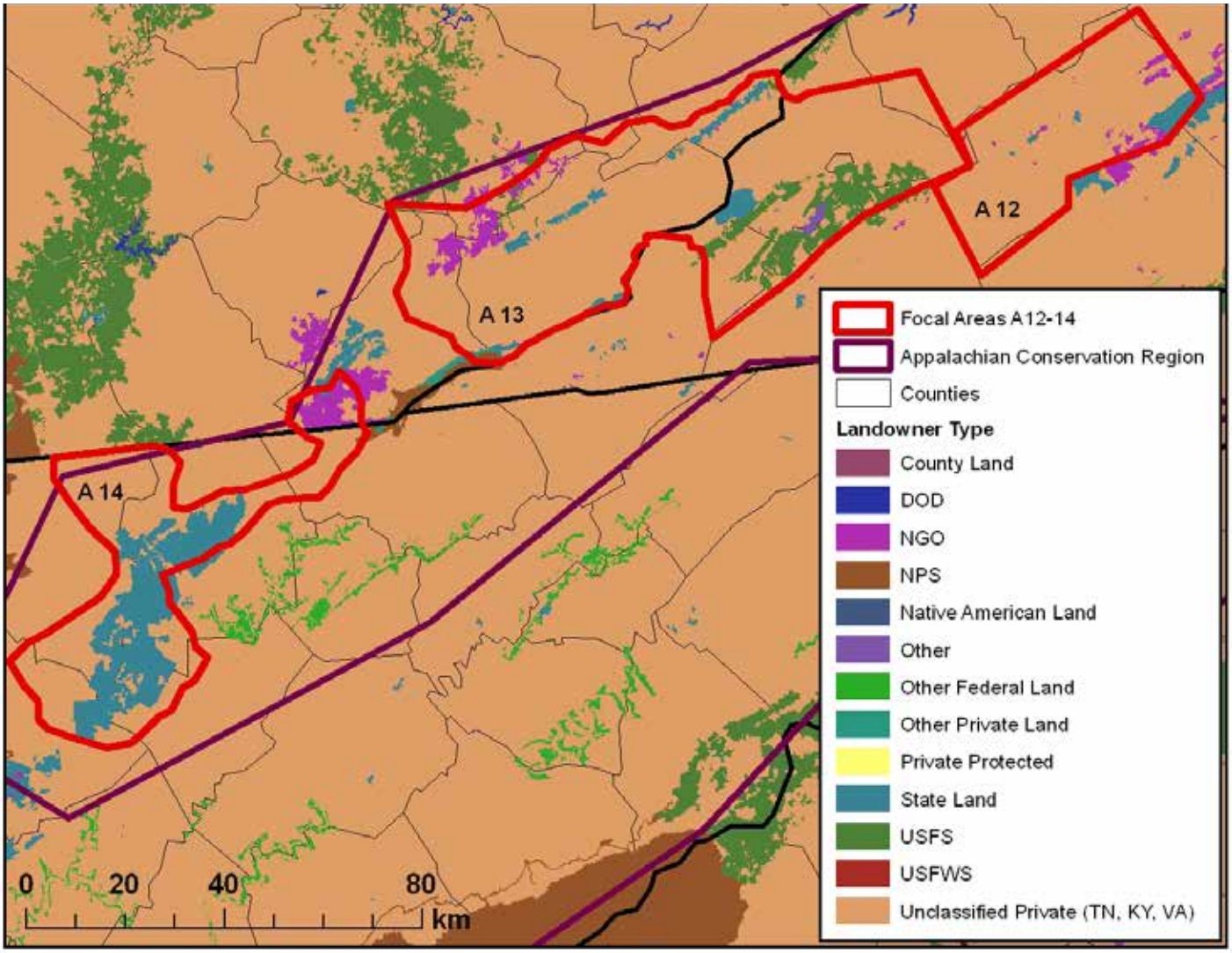


Figure 3–36. Percentage of landowner types and spatial layout of public and protected areas in the Southern Appalachian-Cumberland focal areas (USGS Protected Areas Database of the USA, version 1.2, **www.protectedlands.net/padus/***).*

Southern Appalachian-Nantahala Subregion (Focal Areas A15–A18; Figures 3–37 and 3–38; Table 3–9)

General Description

This subregion supports approximately 5% of the region's (and 0.2% of the world's) Golden-winged Warblers. The focal areas are characterized by small but often high-density local populations frequently found in upland successional forests and on grazing lands. Major threats in these areas are succession, development, and reduced cutting of timber.

Macro Landscape Context (within 1.5 mi (2.5 km) of management site)

Golden-winged Warblers are generally associated with landscapes containing:

- Elevations ranging from 2800–4600 ft (850–1100 m) and habitat management at these elevations should exclude Blue-winged Warblers.
- A high proportion of contiguous forest (100% forest cover), which is unique to the southern Appalachians.

Micro Landscape Context (within 0.15 mi (0.25 km) of management site)

Sites where Golden-winged Warblers are found generally:

- Contain the following primary land cover types: deciduous forest (48%); pasture/hay (14%); and coniferous and mixed forests (2%). Very few Golden-winged Warblers are associated with shrub-scrub or wetland habitats.

*Table 3–9. Population and habitat goals for focal areas in the Southern Appalachian-Nantahala subregion.**

Focal Area ID	Focal Area Name	2010 Popn Estimate	2010 Habitat (ha)	Popn Trend 2007-17	2018 Popn Estimate	2020 Popn Goal	2020 Habitat Goal (ha)	2050 Popn Goal	2050 Habitat Goal (ha)
A16	Roan-Unaka	200	1000	-7.27	109	250	1250	400	2000
A17	Nantahala North	200	1000	-7.27	109	250	1250	400	2000
A18	Nantahala South	300	1500	-7.27	164	375	1875	600	3000

**2010 Population estimates are based on expert knowledge and Golden-winged Warbler Atlas Project data; 2018 population estimates are extrapolated from 2010 estimates based on BBS trends 2007-17.*

Potential Partners and Priority Sites

National/Regional – Appalachian Mountains Joint Venture, Natural Resources Conservation Service, USDA Forest Service (Nantahala National Forest, Pisgah National Forest), Cherokee National Forest, Chattahoochee National Forest, George Washington National Forest, and Jefferson National Forest)

State – North Carolina Forestry, North Carolina Wildlife Resources Commission (Division of Wildlife Management), University of Georgia Cooperative Extension, North Carolina Cooperative Extension, North Carolina State University, University of Tennessee Extension, Virginia Cooperative Extension, Tennessee Wildlife Resources Agency, Tennessee Department of Environment and Conservation, University of Tennessee, Georgia Department of Natural Resources, Virginia Department of Conservation and Recreation, Grayson Highlands State Park, Virginia Department of Game and Inland Fisheries

NGOs – Audubon North Carolina, Blue Ridge Conservancy, Southern Appalachian Highlands Conservancy, Wildlife Management Institute, Bristol Bird Club, Virginia Audubon Important Bird Areas

Industry – Dunaway Timber Company, Heartland Timber Company

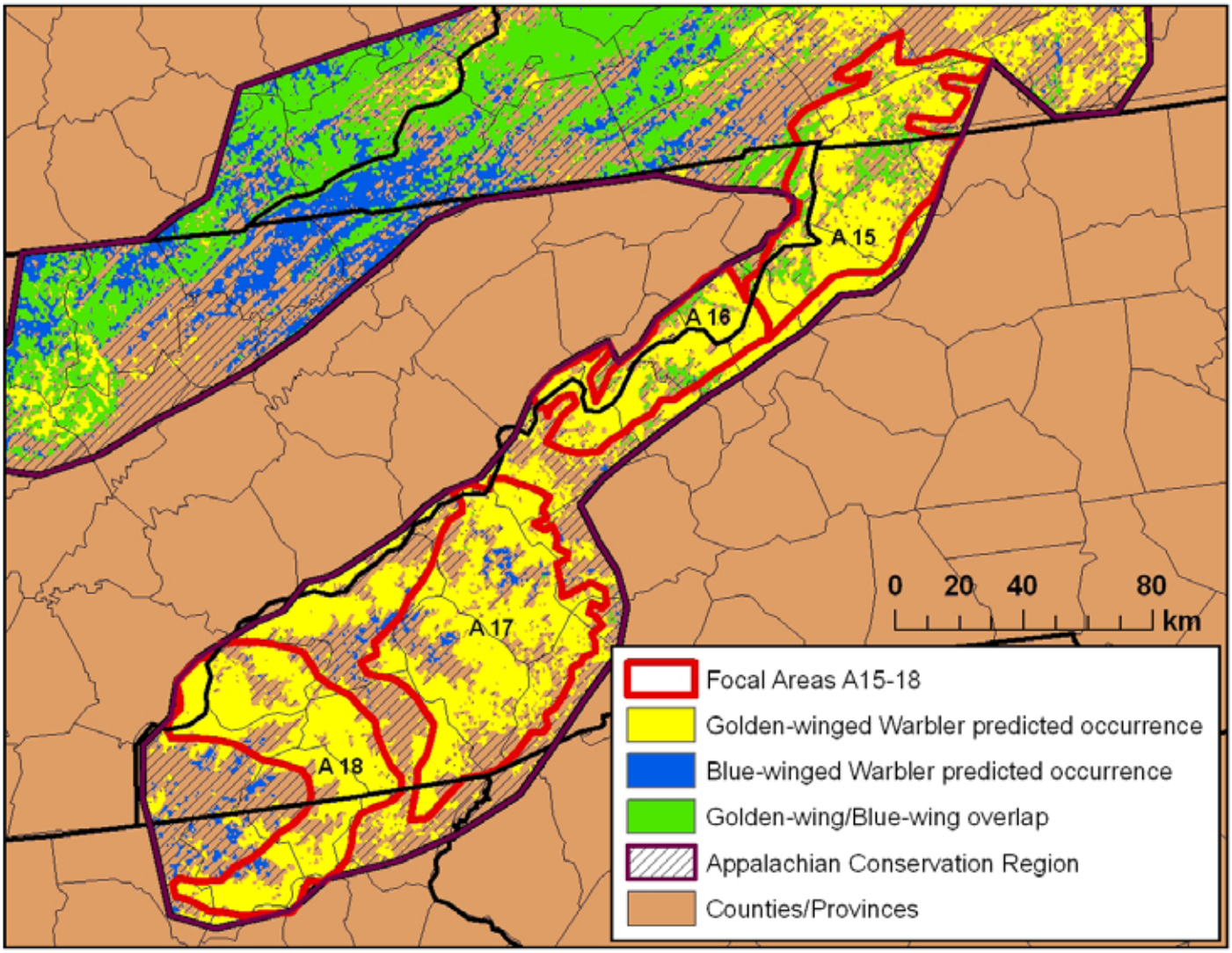
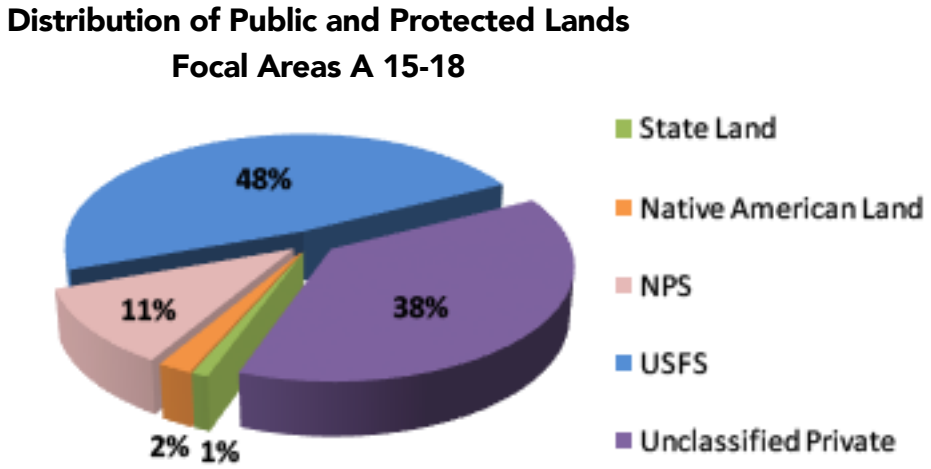


Figure 3–37. Model results showing the current predicted distribution of Golden-winged and Blue-winged warbler in Southern Appalachian-Nantahala. Locations inside focal areas and without Blue-winged Warbler should receive highest priority for conservation and management actions.



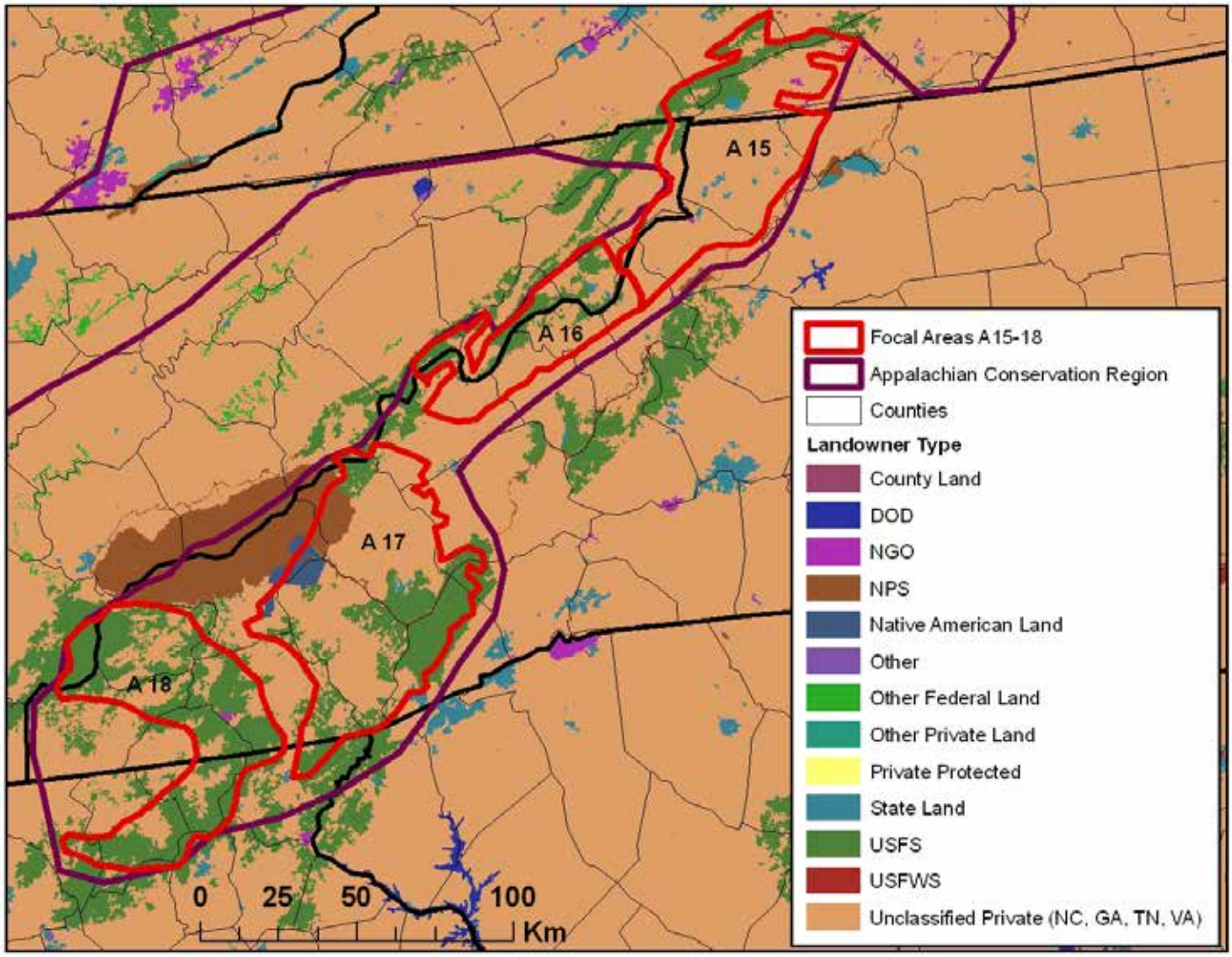


Figure 3–38. Percentage of landowner types and spatial layout of public and protected areas in the Southern Appalachian-Nantahala focal areas (USGS Protected Areas Database of the USA, version 1.2, **www.protectedlands.net/padus/***).*

The Great Lakes Conservation Region

The Great Lakes Conservation Region is divided into six subregions containing one or more focal areas each (Figure 3–39). The following accounts give detailed information specific to those focal areas and subregions.

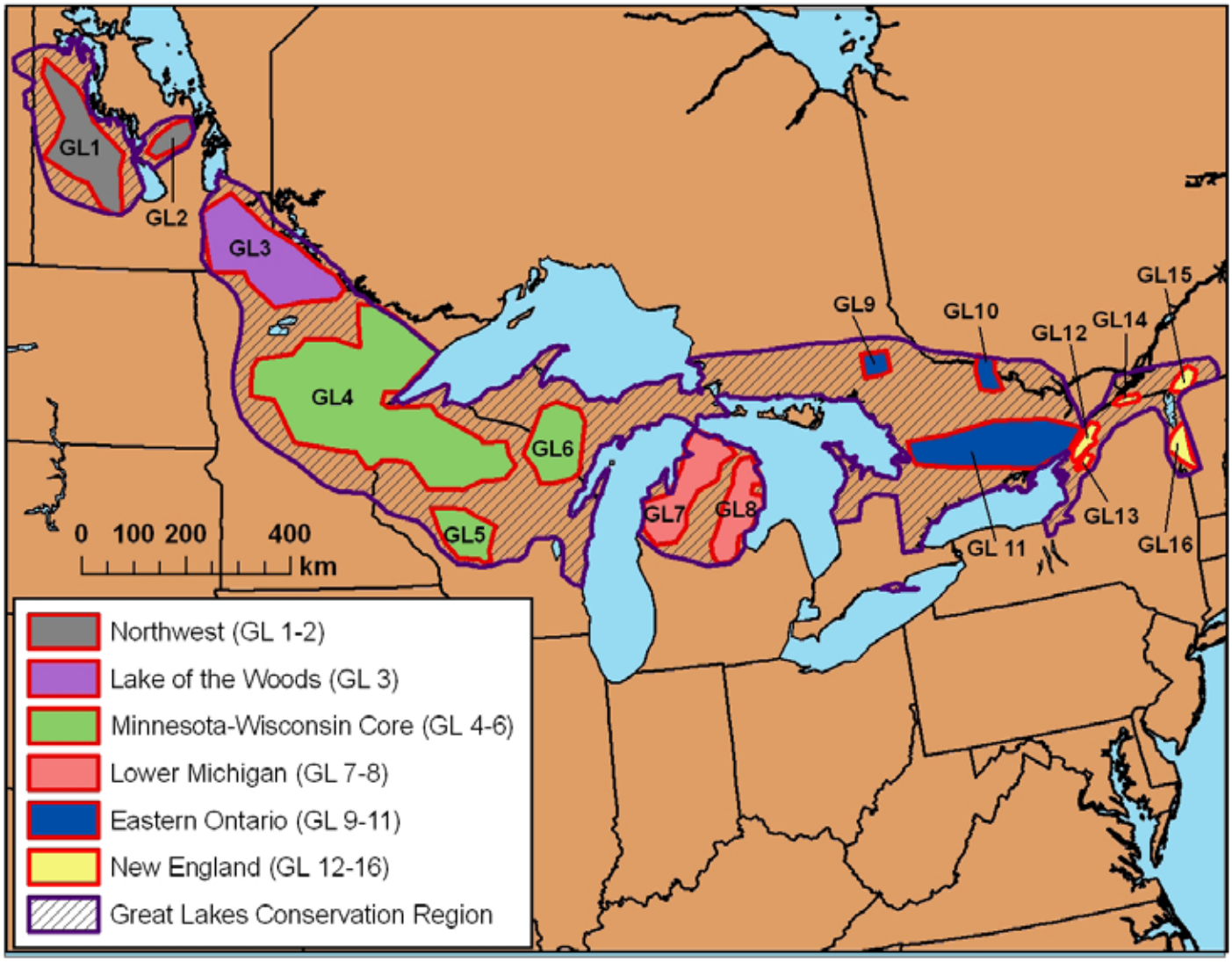


Figure 3–39. Golden-winged Warbler subregions and focal areas in the Great Lakes Conservation Region.

Northwest Subregion (Focal Areas GL1–GL2; Figures 3–40 and 3–41; Table 3–10)

General Description

This subregion supports approximately 1% of the region's and world's Golden-winged Warblers. The primary habitats for Golden-winged Warblers in these focal areas are young aspen forests, aspen parkland, and open oak/shrub savannah. It is notable that Golden-winged Warblers occupy mature aspen forests where gap dynamics provide suitable nesting habitat (i.e. aspen parkland). This ecology is unique to this subregion because aspen forest is the climax community unlike in other parts of the range where it is succeeded by hardwood forest or other forest types. Blue-winged Warblers have not been observed here and no Golden-winged Warbler cryptic hybrids have been detected, so this is one of the last strongholds for pure Golden-winged Warblers. There is high potential for creating suitable habitat via aspen harvesting and prescribed burning.

Note: there was insufficient remotely sensed data to model Golden-winged Warbler habitat associations in this subregion.

*Table 3–10. Population and habitat goals for focal areas in the Northwest subregion.**

Focal Area ID	Focal Area Name	2010 Popn Estimate	2010 Habitat (ha)	Popn Trend 2007-17	2018 Popn Estimate	2020 Popn Goal	2020 Habitat Goal (ha)	2050 Popn Goal	2050 Habitat Goal (ha)
GL1	Manitoba Escarpment	2500	12500	3.98	3417	2813	14063	3750	18750
GL2	Manitoba Interlakes	500	2500	3.98	683	563	2813	750	3750

**2010 Population estimates are based on expert knowledge and Golden-winged Warbler Atlas Project data; 2018 population estimates are extrapolated from 2010 estimates based on BBS trends 2007-17.*

Potential Partners and Priority Sties

National/Regional – Environment Canada (Golden-winged Warbler Recovery Team), Riding Mountain National Park, Riding Mountain Biosphere Reserve

Provincial – Manitoba Conservation

NGOs – Bird Studies Canada, The Nature Conservancy Canada, Nature Manitoba (Manitoba Naturalists Society), local forest owners associations (contact extension service for information)

Industry – Louisiana-Pacific Canada

Tribal – First Nations in Manitoba

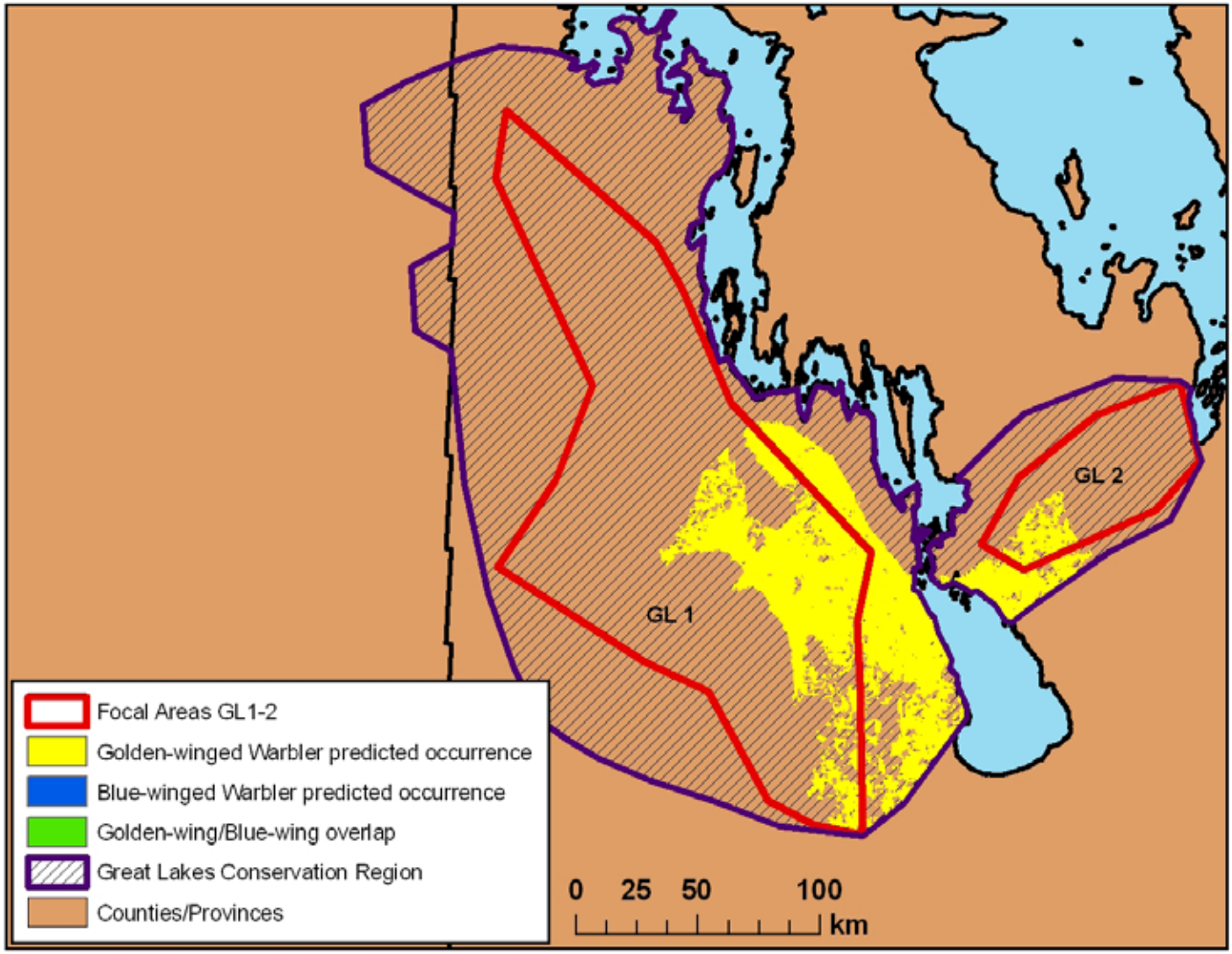


Figure 3–40. Model results showing the current predicted distribution of Golden-winged and Blue-winged warblers the Northwest. Locations inside focal areas and without Blue-winged Warbler should receive highest priority for conservation and management actions. A smaller number of ecological variables were available to model the estimated warbler distribution in Canada, and thus estimates for some areas within the Great Lakes Conservation region are preliminary. However, model predictions for these focal areas demonstrated relatively good support.

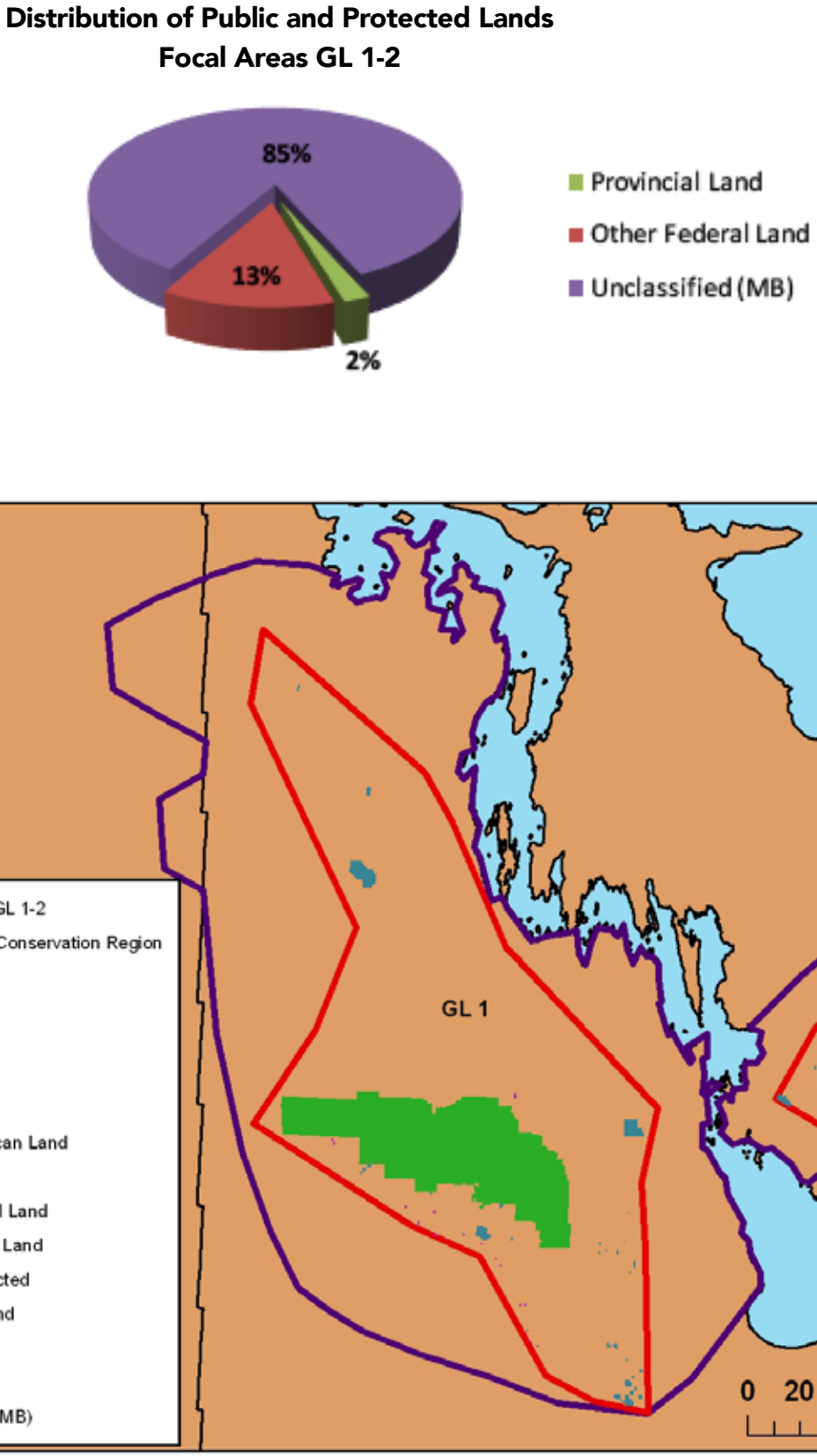


Figure 3–41. Percentage of landowner types and spatial layout of public and protected areas in the Northwest focal areas (Conservation Areas Reporting and Tracking System (CARTS) and Atlas of Canada 1,000,000 National Frameworks Data, Protected Areas, http://geogratis.cgdi.gc.ca/geogratis/en/option/select.do?id=BA8D1149-7714-EC04-343B-6AFEC3BDA84A). Some protected areas are not mapped due to incomplete land ownership datasets.

Lake of the Woods Subregion (Focal Area GL3; Figures 3–42 and 3–43; Table 3–11)

General Description

This focal area supports approximately 2% of the region's and world's Golden-winged Warblers. The primary habitats in this area are young aspen forest, aspen parkland, and oak/pine barrens. Blue-winged Warblers and hybrids are rare here, so this is one of the last strongholds for pure Golden-winged Warblers. Populations appear to be increasing naturally in this area.

Note: there was insufficient remotely sensed data to model Golden-winged Warbler habitat associations in this subregion.

*Table 3–11. Population and habitat goals for focal areas in the Lake of the Woods subregion.**

Focal Area ID	Focal Area Name	2010 Popn Estimate	2010 Habitat (ha)	Popn Trend 2007-17	2018 Popn Estimate	2020 Popn Goal	2020 Habitat Goal (ha)	2050 Popn Goal	2050 Habitat Goal (ha)
GL3	Lake of the Woods	7000	35000	-1.39	6261	7875	39375	10500	52500

**2010 Population estimates are based on expert knowledge and Golden-winged Warbler Atlas Project data; 2018 population estimates are extrapolated from 2010 estimates based on BBS trends 2007-17.*

Potential Partners and Priority Sites

National/Regional – Environment Canada (Golden-winged Warbler Recovery Team), Upper Mississippi River and Great Lakes Region Joint Venture

State/Provincial – Manitoba Conservation, Ontario Ministry of Natural Resources (provincial reserves), Minnesota Department of Natural Resources (state forests, state parks, wildlife management areas), University of Minnesota Extension

NGOs – Bird Studies Canada, The Nature Conservancy Canada, Nature Manitoba (Manitoba Naturalists Society), Audubon Minnesota, local forest owners associations (contact extension service for information)

Industry – Minnesota Forest Industries

Tribal – First Nations in Manitoba, First Nations in Ontario

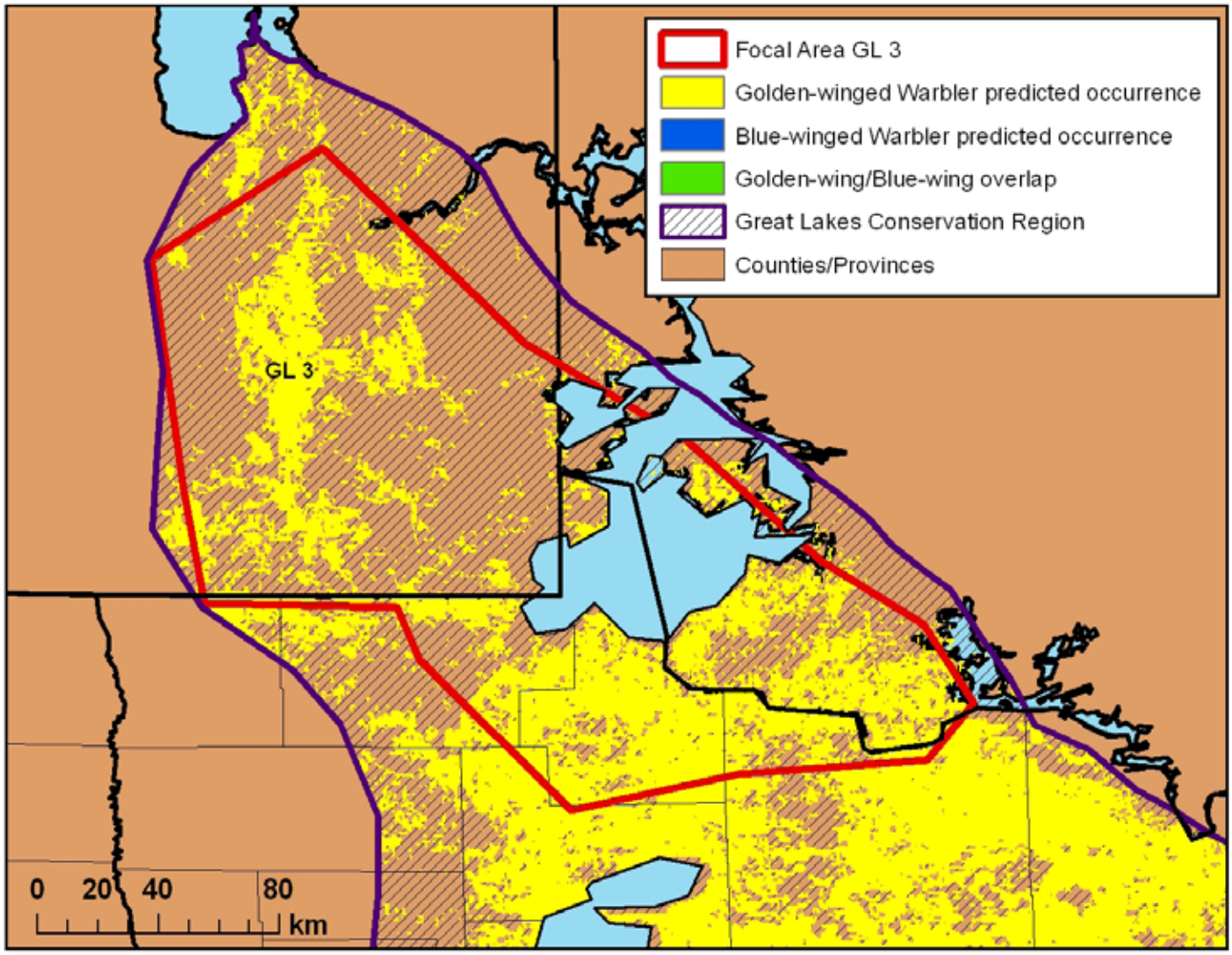
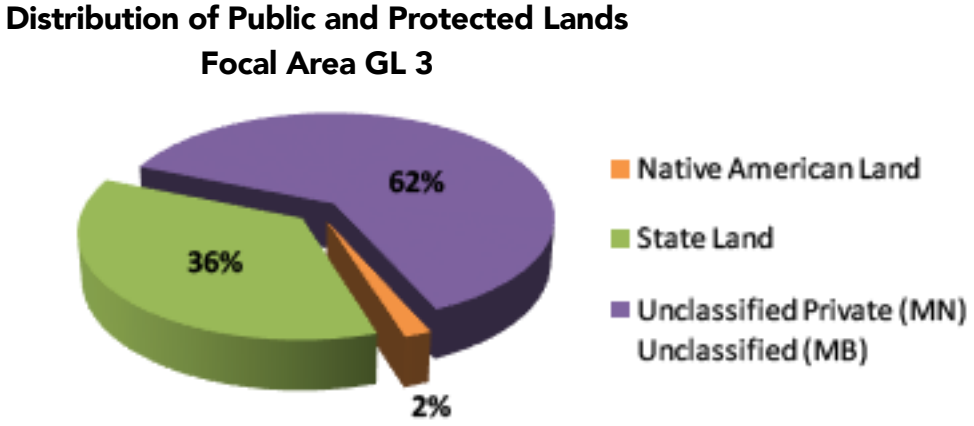


Figure 3–42. Model results showing the current predicted distribution of Golden-winged and Blue-winged warblers in Lake of the Woods. Locations inside focal areas and without Blue-winged Warbler should receive highest priority for conservation and management actions. A smaller number of ecological variables were available to model the estimated warbler distribution in Canada, and thus estimates for some areas within the Great Lakes Conservation region are preliminary. However, model predictions for this focal area demonstrated relatively good support.



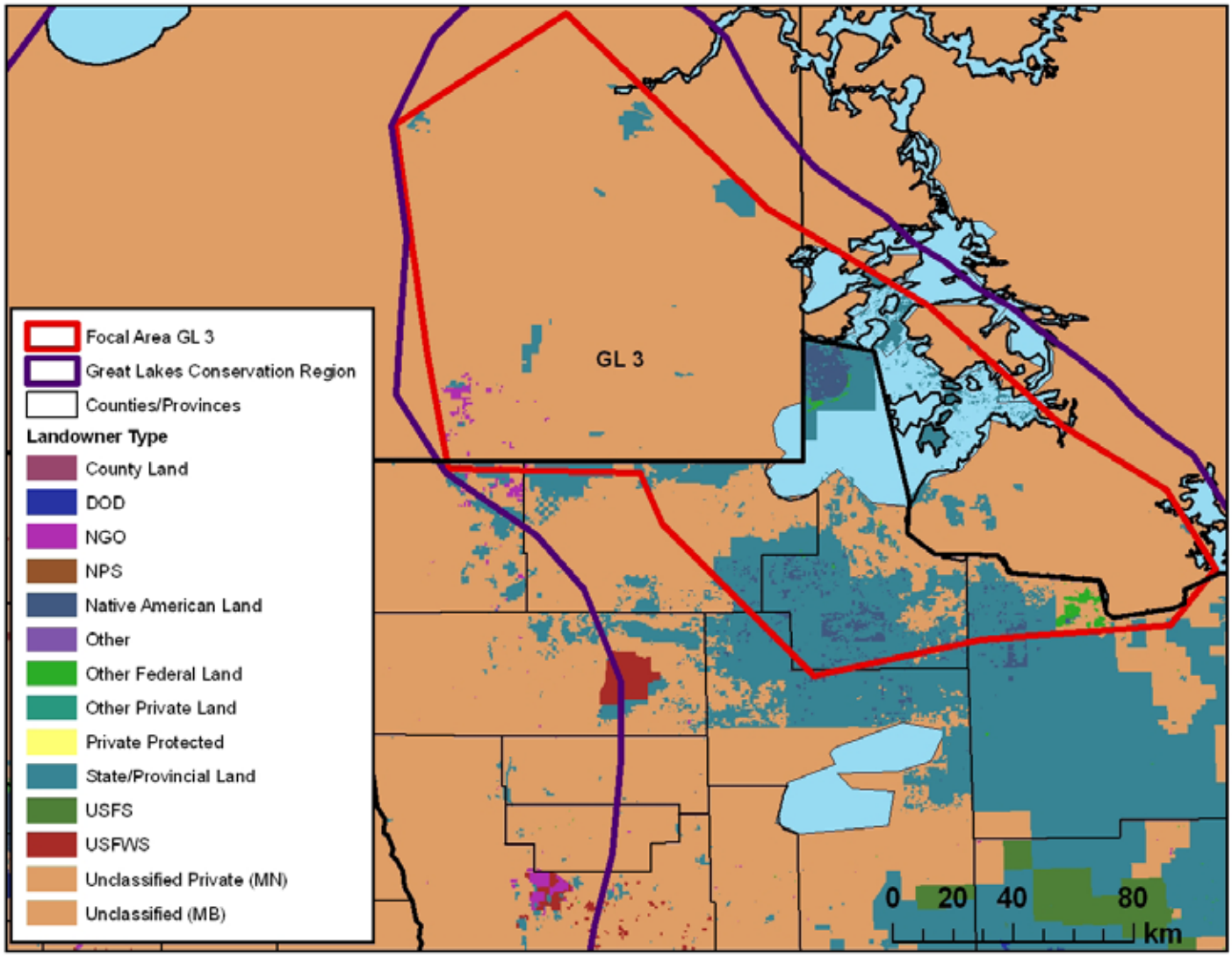


Figure 3–43. Landowner types and spatial layout of public and protected areas in the Lake of the Woods focal area (USGS Protected Areas Database of the USA, version 1.2, **www.protectedlands.net/padus/***; Conservation Areas Reporting and Tracking System (CARTS); and Atlas of Canada 1,000,000 National Frameworks Data, Protected Areas,* **http://geogratis.cgdi.gc.ca/geogratis/en/option/select.do?id=BA8D1149-7714-EC04-343B-6AFEC3BDA84A***). Some protected areas are not mapped due to incomplete land ownership datasets.*

Minnesota-Wisconsin Core Subregon (Focal Areas GL4–GL6; Figures 3–44 and 3–45; Table 3–12)

General Description

This subregion supports approximately 61% of the region's (and 58% of the world's) Golden-winged Warblers. The primary habitats for Golden-winged Warblers in these focal areas are shrub wetlands and young aspen forest. Major threats in these areas are the decline of even-aged forest management (conversion to northern hardwood forest and agencies falling short of aspen harvest goals), forest fragmentation by second-home development, and Blue-winged Warbler encroachment (especially in the Central Forest of Wisconsin). There is a high potential for creating young forest and for protecting shrub wetland communities, and enhancing these communities through active management. Additionally, there is potential for overlapping management with Sharp-tailed Grouse within this subregion.

Macro Landscape Context (within 1.5 mi (2.5 km) of management site)

Golden-winged Warblers are generally associated with landscapes containing:

- The following primary land cover types: 22% herbaceous and 70% forest cover that is predominantly 33–82 ft (10–25 m) in height (large sapling to small sawtimber sized trees).
- A ratio of 70:30 deciduous:coniferous trees with low or no Golden-winged Warbler occurrence in forested landscapes containing greater than 35% coniferous forest.
- Tree communities dominated by balsam poplar, aspen, or paper birch with trees that are 16–33 ft (5–10 m) tall (sapling-sized trees).

Micro Landscape Context (within 0.15 mi (0.25 km) of management site):

Sites where Golden-winged Warblers are found generally contain:

- The following primary land cover types: deciduous forest (44%); woody wetlands (20%); emergent herbaceous wetlands (6%), shrub-scrub (6%). Blue-winged Warblers used very similar habitats (only ±2–3% different in each category).

*Table 3–12. Population and habitat goals for focal areas in the Minnesota-Wisconsin Core subregion.**

Focal Area ID	Focal Area Name	2010 Popn Estimate	2010 Habitat (ha)	Popn Trend 2007-17	2018 Popn Estimate	2020 Popn Goal	2020 Habitat Goal (ha)	2050 Popn Goal	2050 Habitat Goal (ha)
GL4	N. Minn. & Wisc.	226,000	1130000	-0.25	221434	254250	1271250	339000	1695000
GL5	Wisconsin Central Forest	5000	25000	-4.45	3473	5625	28125	7500	37500
GL6	N. WI and Up. Penin. MI	8000	40000	-0.18	7886	9000	45000	12000	60000

**2010 Population estimates are based on expert knowledge and Golden-winged Warbler Atlas Project data; 2018 population estimates are extrapolated from 2010 estimates based on BBS trends 2007-17.*

Potential Partners and Priority Sites

National/Regional – Natural Resources Conservation Service, US Fish and Wildlife Service (Necedah and Tamarac National Wildlife Refuges, Partners for Fish and Wildlife), USDA Forest Service (Chequamegon-Nicolet, Chippewa, and Superior National Forests), Upper Mississippi River and Great Lakes Region Joint Venture

State – Michigan Department of Natural Resources (Landowner Incentive Program), Minnesota Department of Natural Resources, Wisconsin Department of Natural Resources, Michigan State University Extension, University of Minnesota Duluth (Natural Resources Research Institute), University of Minnesota Extension, University of Wisconsin-Extension, University of Wisconsin-Green Bay, county forests, Legislative-Citizen Commission on Minnesota Resources (Environment and Natural Resources Trust Fund)

NGOs – Audubon Minnesota, Bird Conservation Minnesota, Minnesota Ornithologists' Union, Friends of Sandhill, Michigan Audubon, Michigan Bird Conservation Initiative, private landowners, Wild Rivers Interpretive Center, The Wildlife Society (University of Wisconsin-Stevens Point,

University of Wisconsin-Madison), Wisconsin Audubon, Wisconsin Bird Conservation Initiative, Wolf Ridge Environmental Learning Center, Ruffed Grouse Society, Wisconsin Woodland Owners Association, local forest owners associations (contact extension service for information), local bird clubs and nature centers

Industry – Plum Creek Timber Company, Potlatch Corporation, UPM Blandin Forestry, RMK

Tribal – Leech Lake, White Earth, Fond du Lac, Lac Court Oreilles, Lac du Flambeau, St. Croix, Mole Lake, and Potawatomi Tribal Nations.

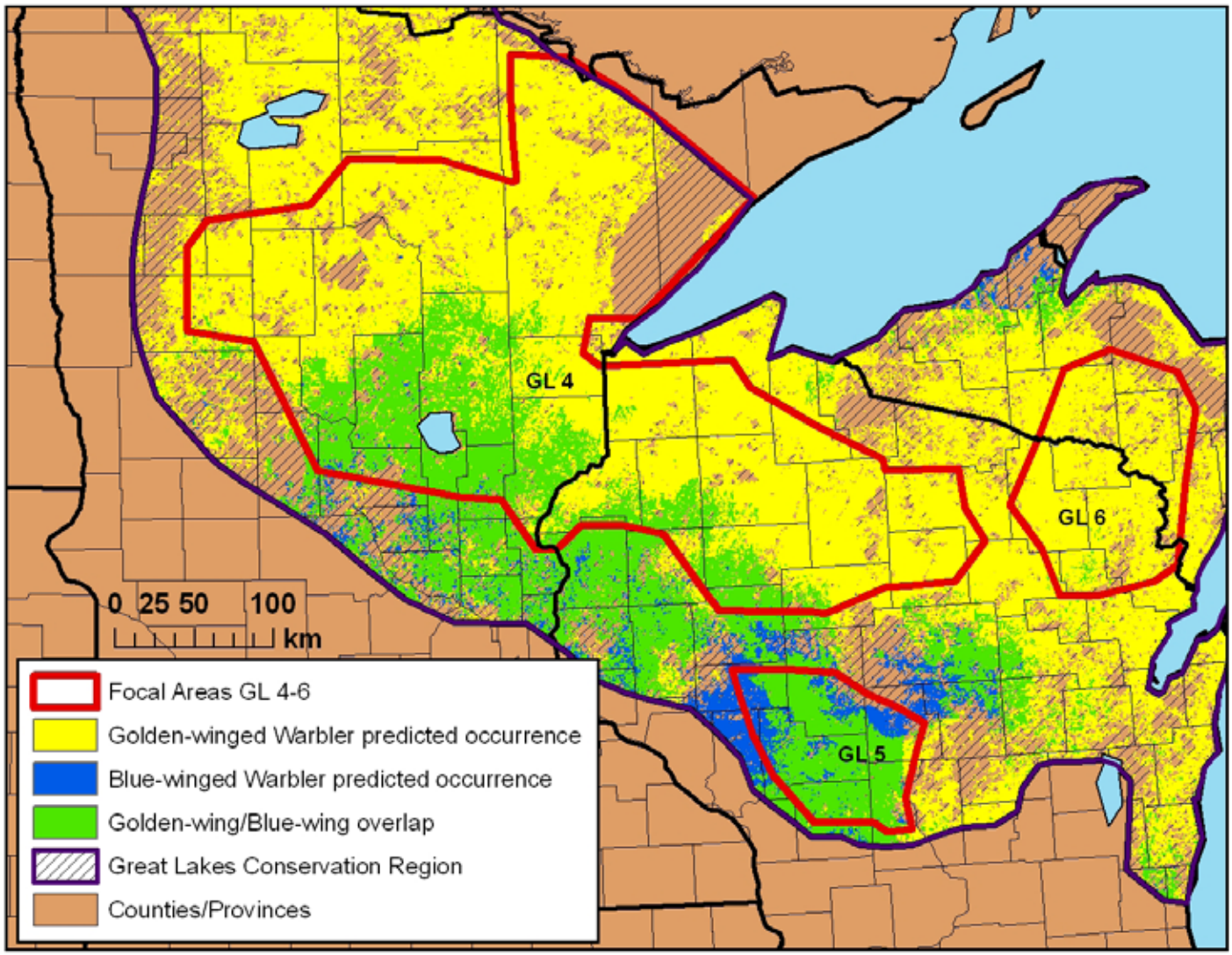


Figure 3–44. Model results showing the current predicted distribution of Golden-winged and Blue-winged warblers in Minnesota-Wisconsin Core. Locations inside focal areas and without Blue-winged Warbler should receive highest priority for conservation and management actions. Blue-winged Warbler occurrence may be lesser than depicted in some areas and includes areas lacking regular breeding activity in east-central Minnesota and the western Upper Peninsula of Michigan. A smaller number of ecological variables were available to model the estimated warbler distribution in Canada, and thus estimates for some areas within the Great Lakes Conservation region are preliminary. The model may over-estimate the distribution of the Blue-winged Warbler in GL4.

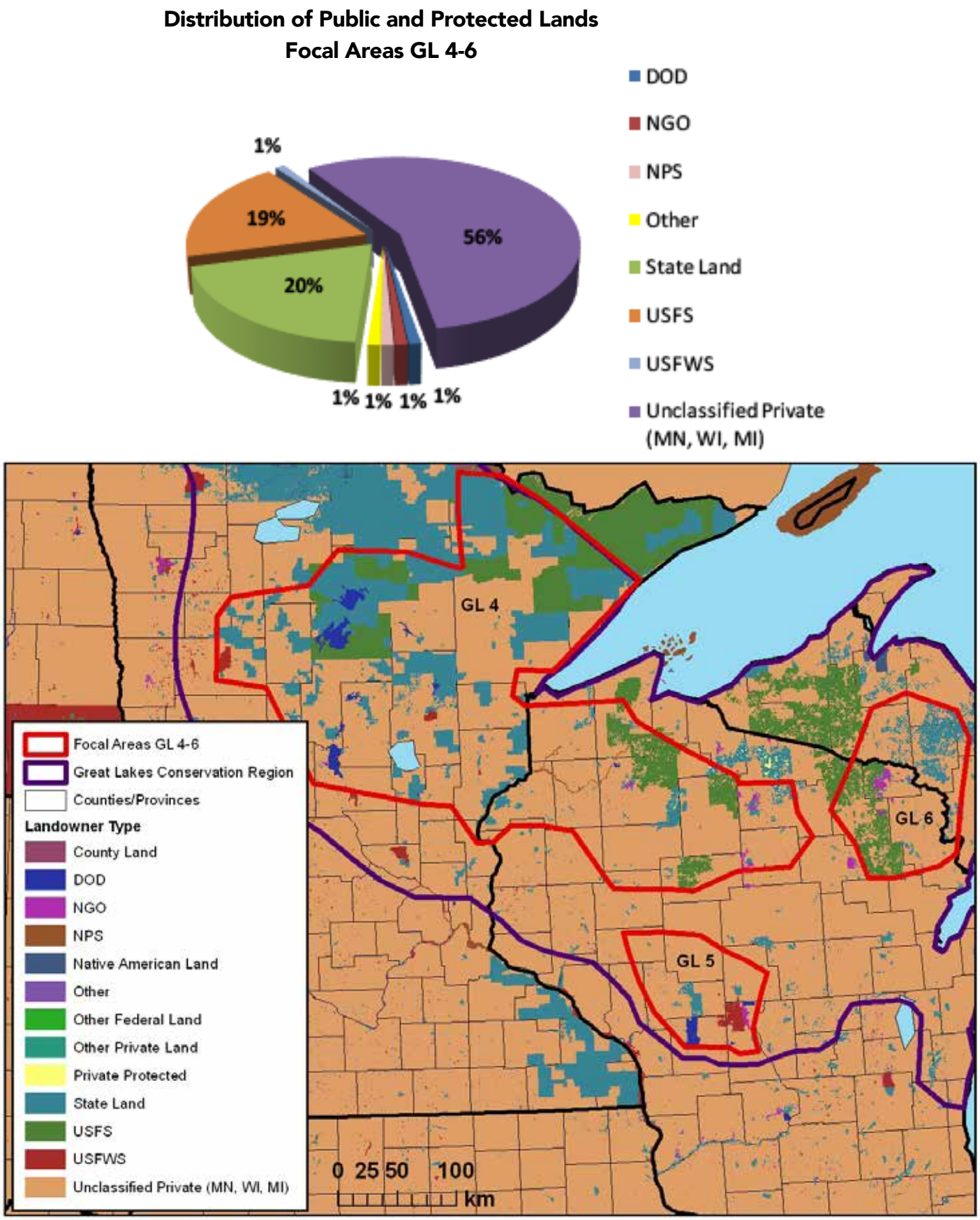


Figure 3–45. Percentage of landowner types and spatial layout of public and protected areas in the Minnesota-Wisconsin Core focal areas (USGS Protected Areas Database of the USA, version 1.2, **www.protectedlands.net/padus/***). NOTE: Wisconsin and Michigan county forests and many tribal lands, and potentially other protected areas that were not intentionally excluded, are missing from this map and pie chart.*

Lower Michigan Subregion (Focal Areas GL7–GL8; Figures 3–46 and 3–47; Table 3–13)

General Description

This subregion supports approximately 3% of the region's (and 2% of the world's) Golden-winged Warblers. The primary habitats for Golden-winged Warbler in these focal areas are young aspen forest and shrub wetlands. Major threats in these areas are the lack of even-aged forest management and Blue-winged Warbler encroachment (especially in the south). There is a high potential for creating young forest here, but private lands are crucial.

Macro Landscape Context (within 1.5 mi (2.5 km) of management site)

Golden-winged Warblers are generally associated with landscapes containing:

- The following land cover types: 22% herbaceous and 70% forest that is predominantly 33–82 ft (10–25 m) in height (large sapling to small sawtimber sized trees).
- A ratio of 70:30; deciduous:coniferous trees with low or no Golden-winged Warbler occurrence in forested landscapes containing greater than 35% coniferous forest.
- Tree communities dominated by balsam poplar, aspen, or paper birch with trees that are 16–33 ft (5–10 m) tall (sapling-sized trees).

Micro Landscape Context (within 0.15 mi (0.25 km) of management site)

Sites where Golden-winged Warblers are found generally contain:

- The following land cover types: deciduous forest (44%); woody wetlands (20%); emergent herbaceous wetlands (6%), shrub-scrub (6%). Blue-winged Warblers used very similar habitats (only ±2–3% different in each category).

*Table 3–13. Population and habitat goals for focal areas in the Lower Michigan subregion.**

Focal Area ID	Focal Area Name	2010 Popn Estimate	2010 Habitat (ha)	Popn Trend 2007-17	2018 Popn Estimate	2020 Popn Goal	2020 Habitat Goal (ha)	2050 Popn Goal	2050 Habitat Goal (ha)
GL7	MI NW Lower Peninsula	5000	25000	-5.75	3113	5625	28125	7500	37500
GL8	MI Gladwin Lake Plain IBA	5000	25000	-5.75	3113	5625	28125	7500	37500

**2010 Population estimates are based on expert knowledge and Golden-winged Warbler Atlas Project data; 2018 population estimates are extrapolated from 2010 estimates based on BBS trends 2007-17.*

Potential Partners and Priority Sites

National/Regional – Natural Resources Conservation Service, US Fish and Wildlife Service (Partners for Fish and Wildlife), USDA Forest Service (Huron-Manistee National Forest), Upper Mississippi River and Great Lakes Region Joint Venture

State – Michigan Department of Natural Resources (Landowner Incentive Program), Michigan State University Extension

NGOs – local bird clubs, Michigan Audubon, Michigan Bird Conservation Initiative, private big game refuges and hunting clubs, private landowners, Ruffed Grouse Society, local forest owners associations (contact extension service for information)

Industry – Northland Timber Company, Pike Lumber Company

Tribal – Little River Band of Ottawa Indians, Little Traverse Bay Band of Odawa Indians, Saginaw Chippewa Tribal Nation

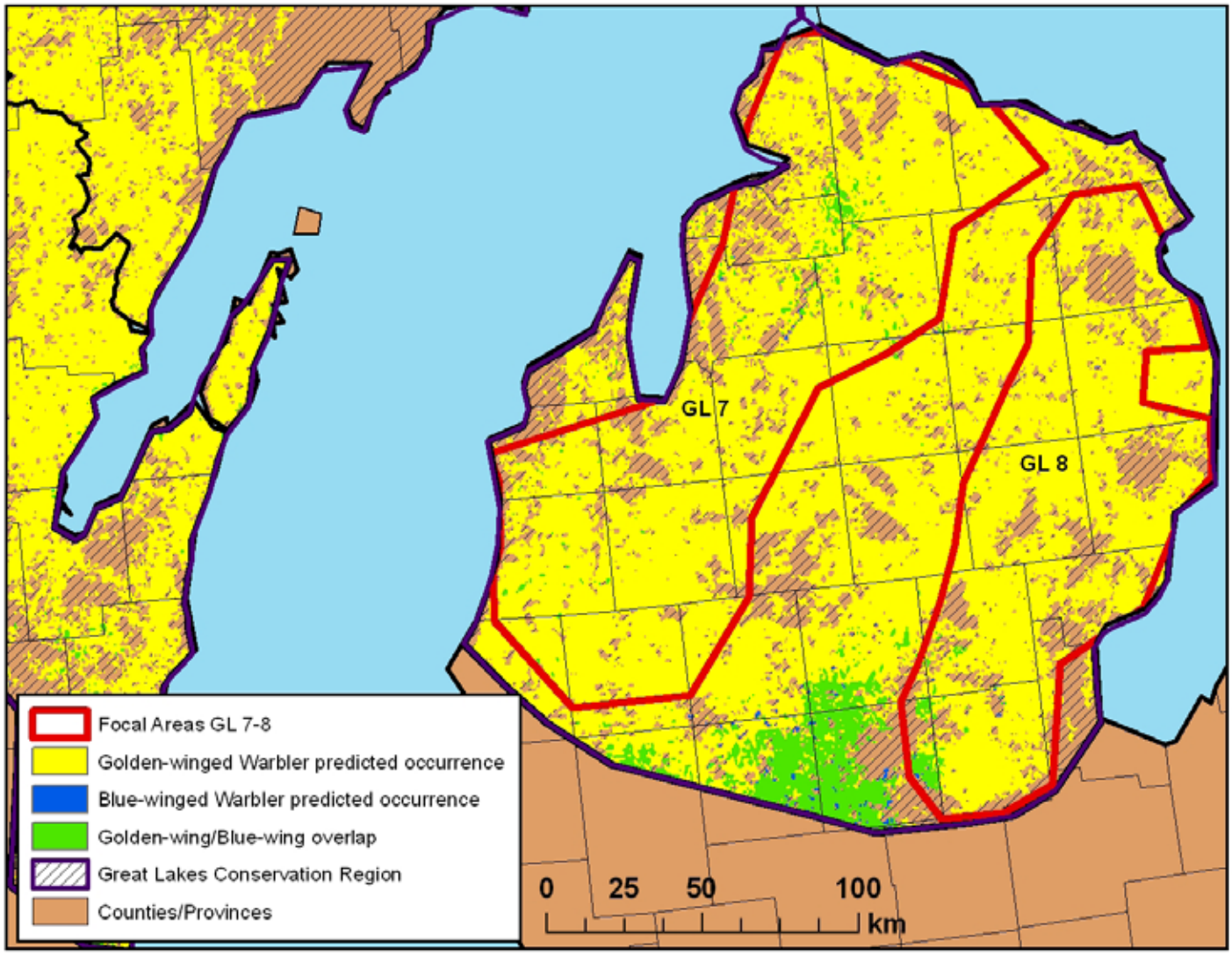
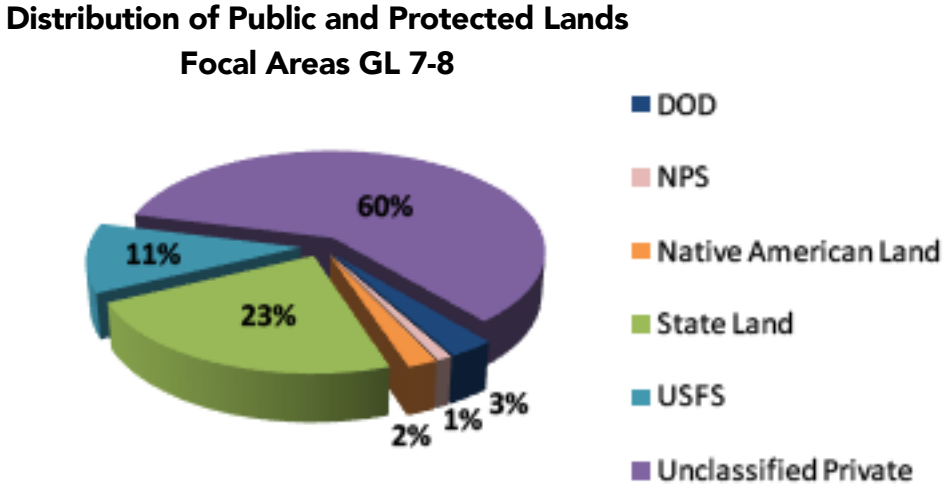


Figure 3–46. Model results showing the current predicted distribution of Golden-winged and Blue-winged warbler in Lower Michigan. Locations without Blue-winged Warbler and inside focal areas should receive highest priority for conservation and management actions. A smaller number of ecological variables were available to model the estimated warbler distribution in Canada, and thus estimates for some areas within the Great Lakes Conservation region are preliminary. The model for these focal areas may under-predict the presence of Blue-winged Warbler, particularly in southern GL7 and GL8, and this should be considered in management planning on a site-by-site basis.



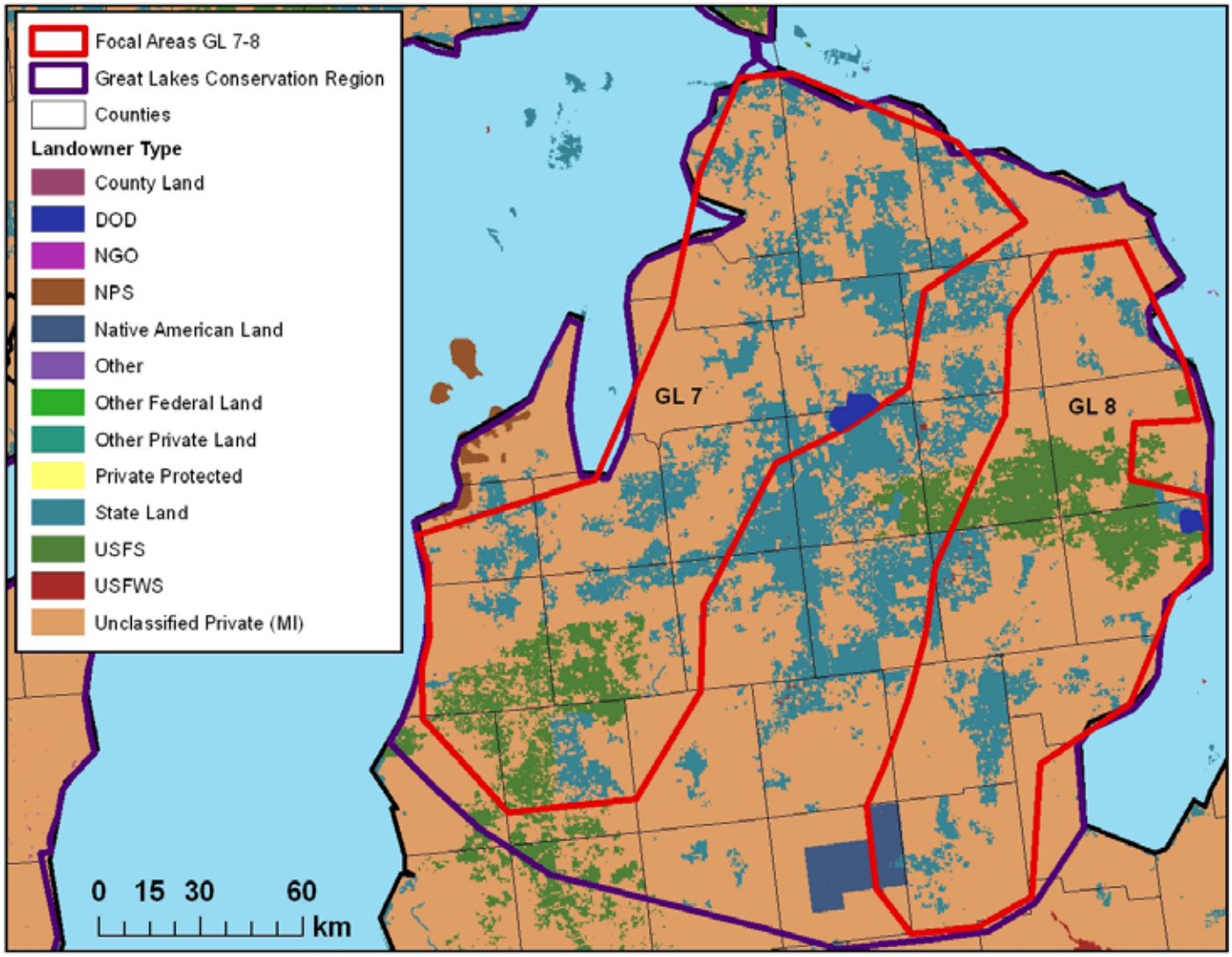


Figure 3–47. Percentage of landowner types and spatial layout of public and protected areas in the Lower Michigan focal areas (USGS Protected Areas Database of the USA, version 1.2, www.protectedlands.net/padus/). Some protected areas are not mapped due to incomplete land ownership datasets.

Eastern Ontario Subregion (Focal Areas GL9–GL11; Figures 3–48 and 3–49; Table 3–14)

General Description

The focal areas in this subregion support approximately 3% of the region's and world's Golden-winged Warblers. They are most commonly found where the landscape is a mosaic of abandoned and marginal farmland, rock barrens, wetlands, and forest (Vallender 2007). Major threats in these areas are natural succession and Blue-winged Warbler encroachment.

Note: there was insufficient remotely sensed data to model Golden-winged Warbler habitat associations in this subregion.

*Table 3–14. Population and habitat goals for focal areas in the Eastern Ontario subregion.**

Focal Area ID	Focal Area Name	2010 Popn Estimate	2010 Habitat (ha)	Popn Trend 2007-17	2018 Popn Estimate	2020 Popn Goal	2020 Habitat Goal (ha)	2050 Popn Goal	2050 Habitat Goal (ha)
GL9	Ontario Lake Nipissing	1000	5000	-2.88	792	1125	5625	1500	7500
GL10	Pembroke-Ottawa River	200	1000	-2.88	158	225	1125	300	1500
GL11	S. Canadian Shield	10000	50000	-2.88	7917	11250	56250	15000	75000

**2010 Population estimates are based on expert knowledge and Golden-winged Warbler Atlas Project data; 2018 population estimates are extrapolated from 2010 estimates based on BBS trends 2007-17.*

Potential Partners and Priority Sites

National/Regional – Environment Canada (Golden-winged Warbler Recovery Team)

Provincial – Ontario Ministry of Natural Resources, Queen's University Biological Station

NGOs – Bird Studies Canada, The Nature Conservancy Canada, local forest owners associations (contact extension service for information)

Industry – unknown

Tribal – First Nations in Ontario

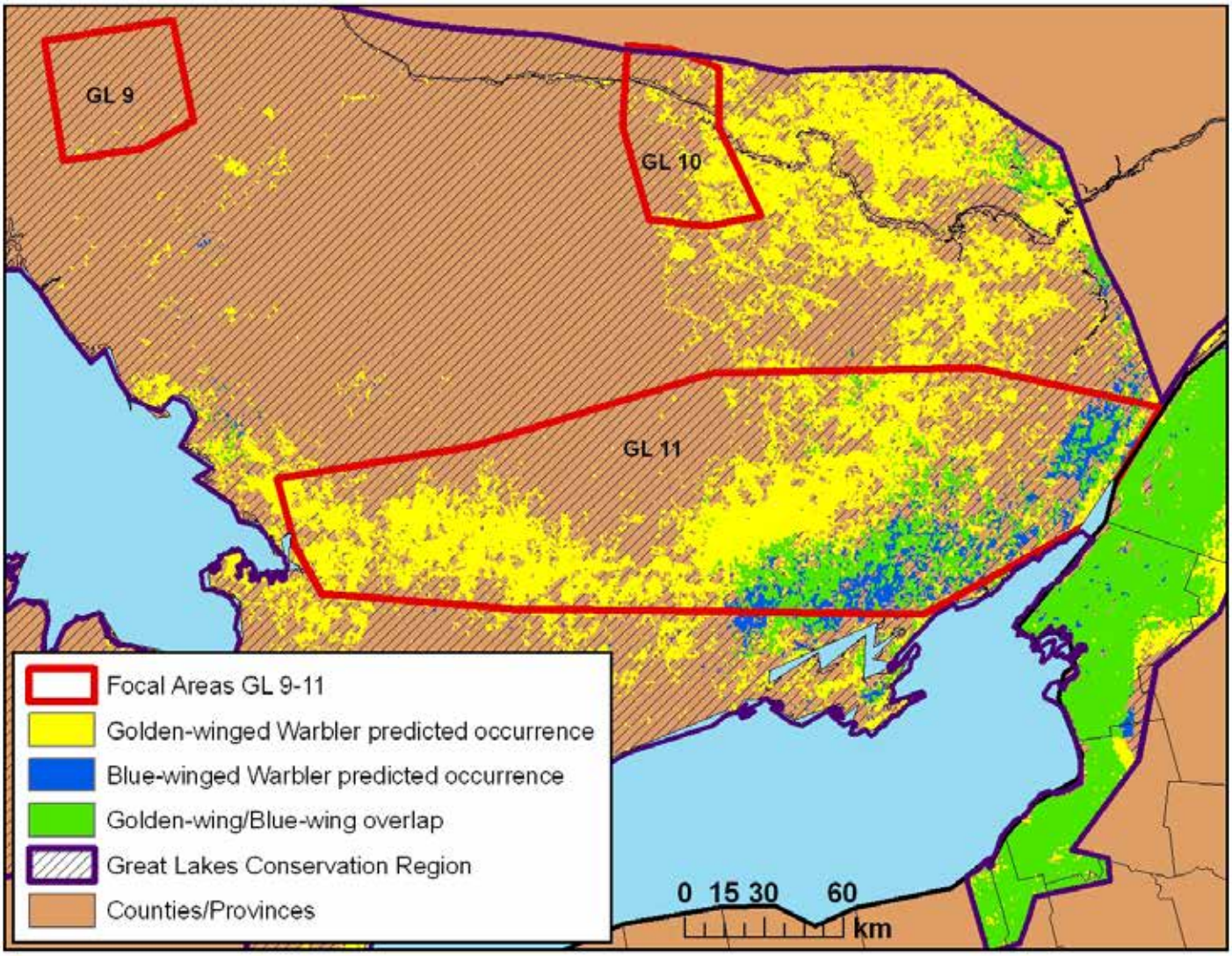


Figure 3–48. Model results showing the current predicted distribution of Golden-winged and Blue-winged warblers in Eastern Ontario. Locations inside focal areas and without Blue-winged Warbler should receive highest priority for conservation and management actions. A smaller number of ecological variables were available to model the warbler distribution in Canada. As a result, the distribution of the Golden-winged Warbler may be greater than predicted for these focal areas.

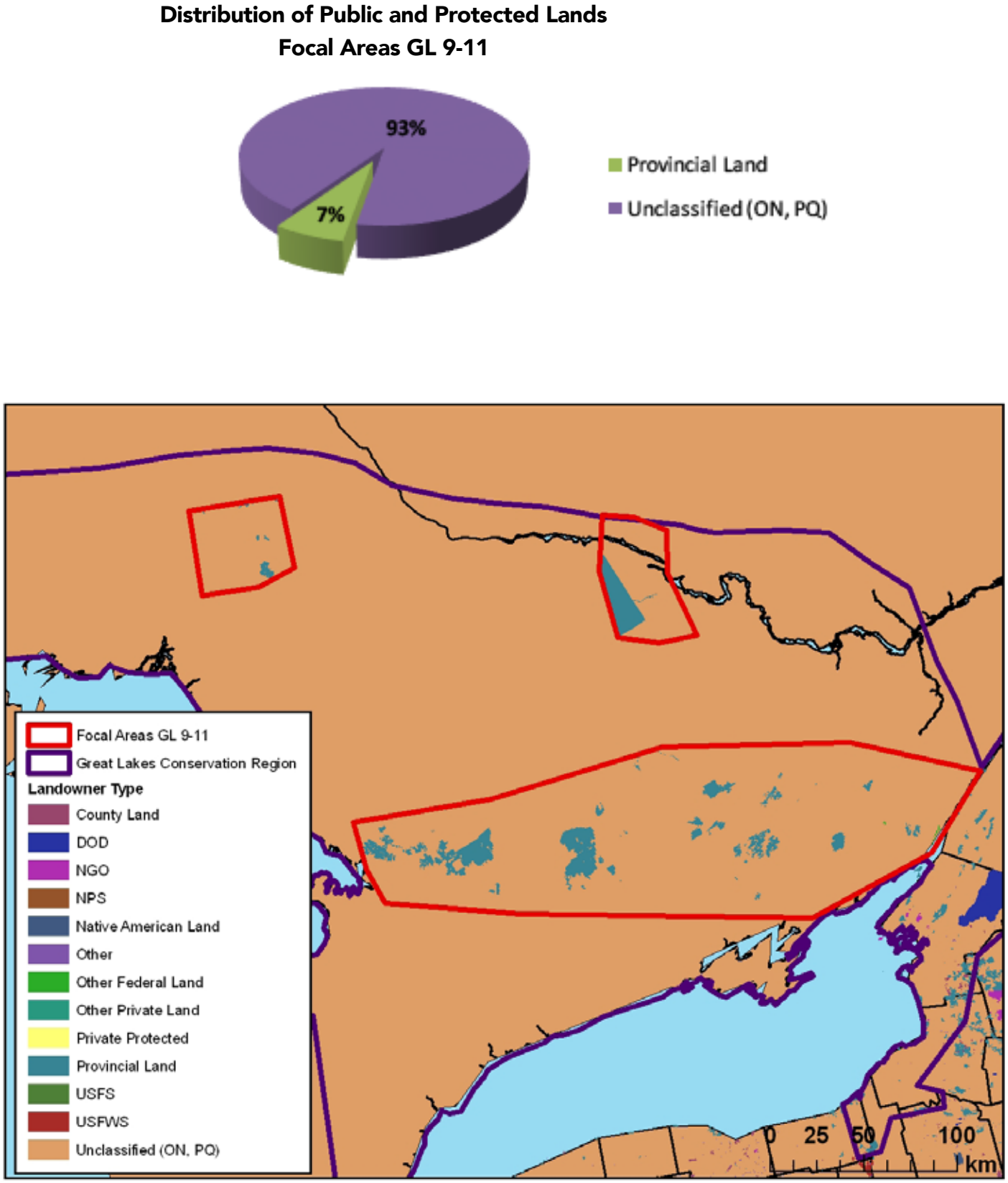


Figure 3–49. Landowner types and spatial layout of public and protected areas in the Eastern Ontario focal areas (Conservation Areas Reporting and Tracking System (CARTS) and Atlas of Canada 1,000,000 National Frameworks Data, Protected Areas, **http://geogratis.cgdi.gc.ca/geogratis/en/option/select.do?id=BA8D1149-7714-EC04-343B-6AFEC3BDA84A**). *Some protected areas are not mapped due to incomplete land ownership datasets.*

New England Subregion (Focal Areas GL12–GL16; Figures 3–50 and 3–51, Table 3–15)

General Description

This subregion contains the St. Lawrence Valley, Lake Champlain, and Quebec and supports approximately 0.4% of the region's and world's Golden-winged Warblers. The primary habitats for Golden-winged Warblers in these areas are upland shrubs, shrub wetlands, and successional forest. Major threats to the small populations found here are succession, conversion to agricultural land use, and Blue-winged Warbler encroachment.

Macro Landscape Context (within 1.5 mi (2.5 km) of management site)

Golden-winged Warblers are generally associated with landscapes containing:

- The following types of primary land cover: 10% herbaceous cover, 15–40% shrub cover, and 58% forest cover with the latter comprised of trees that are 16–33 ft (5–10 m) tall (5%), 33–82 ft (10–25 m) tall (60%), and 82–160 ft (25–50 m) tall (10%).

Micro Landscape Context (within 0.15 mi (0.25 km) of management site)

Sites where Golden-winged Warblers are found generally contain:

- The following primary land cover types: deciduous forest (44%); pasture/hay (8%); woody wetlands (9%). More Golden-winged Warblers were associated with woody and emergent wetlands, shrub-scrub and grassland-herbaceous meadows than Blue-winged Warblers. More Blue-winged Warblers are associated with pasture-hay, cultivated cropland, and coniferous and mixed forests than Golden-winged Warblers.

*Table 3–15. Population and habitat goals for focal areas in the New England subregion.**

Focal Area ID	Focal Area Name	2010 Popn Estimate	2010 Habitat (ha)	Popn Trend 2007-17	2018 Popn Estimate	2020 Popn Goal	2020 Habitat Goal (ha)	2050 Popn Goal	2050 Habitat Goal (ha)
GL12	St. Lawrence Valley	1000	5000	-2.51	816	1125	5625	1500	7500
GL13	Fort Drum	400	2000	-2.51	327	450	2250	600	3000
GL14	New York/Quebec border	30	150	-2.51	24	34	169	45	225
GL15	Quebec: Iron Hill	20	100	-5.08	13	23	113	30	150
GL16	Lake Champlain/VT	20	100	-4.27	14	23	113	30	150

**2010 Population estimates are based on expert knowledge and Golden-winged Warbler Atlas Project data; 2018 population estimates are extrapolated from 2010 estimates based on BBS trends 2007-17.*

Potential Partners and Priority Sites

National/Regional – Atlantic Coast Joint Venture, Environment Canada (Golden-winged Warbler Recovery Team), Natural Resources Conservation Service, St. Regis Mohawk Tribe, US Department of Defense (Fort Drum), US Environmental Protection Agency (Great Lakes Initiative), US Fish and Wildlife Service (Migratory Bird Program, Partners for Fish and Wildlife)

State/Provincial – New York Natural Heritage Program, New York State Department of Environmental Conservation (private lands foresters), Partnerships for Regional Invasive Species Management, Clarkson University, Cornell Cooperative Extension (Master Forest Owners), Middlebury College, SUNY College of Environmental Science and Forestry, SUNY Plattsburgh, The University of Vermont Extension, Quebec Ministry of Natural Resources and Wildlife (aka Ministère des Ressources naturelles et de la Faune)

NGOs – National Audubon Society, Audubon New York, Audubon Vermont, Cornell Lab of Ornithology, land trusts (Indian River Lakes Conservancy), local/regional hunting clubs, native plant societies, The Nature Conservancy, New York Farm Bureau, New York Forest Owner's Association, New York Sea Grant, New York Society of American Foresters, Northern New York Audubon, Onondaga Audubon, Vermont Center For Ecostudies, Wildlife Management Institute, Quality Deer Management Association, Ruffed Grouse Society, Wild Turkey Federation, Bird Studies Canada

Industry – Hydro Quebec

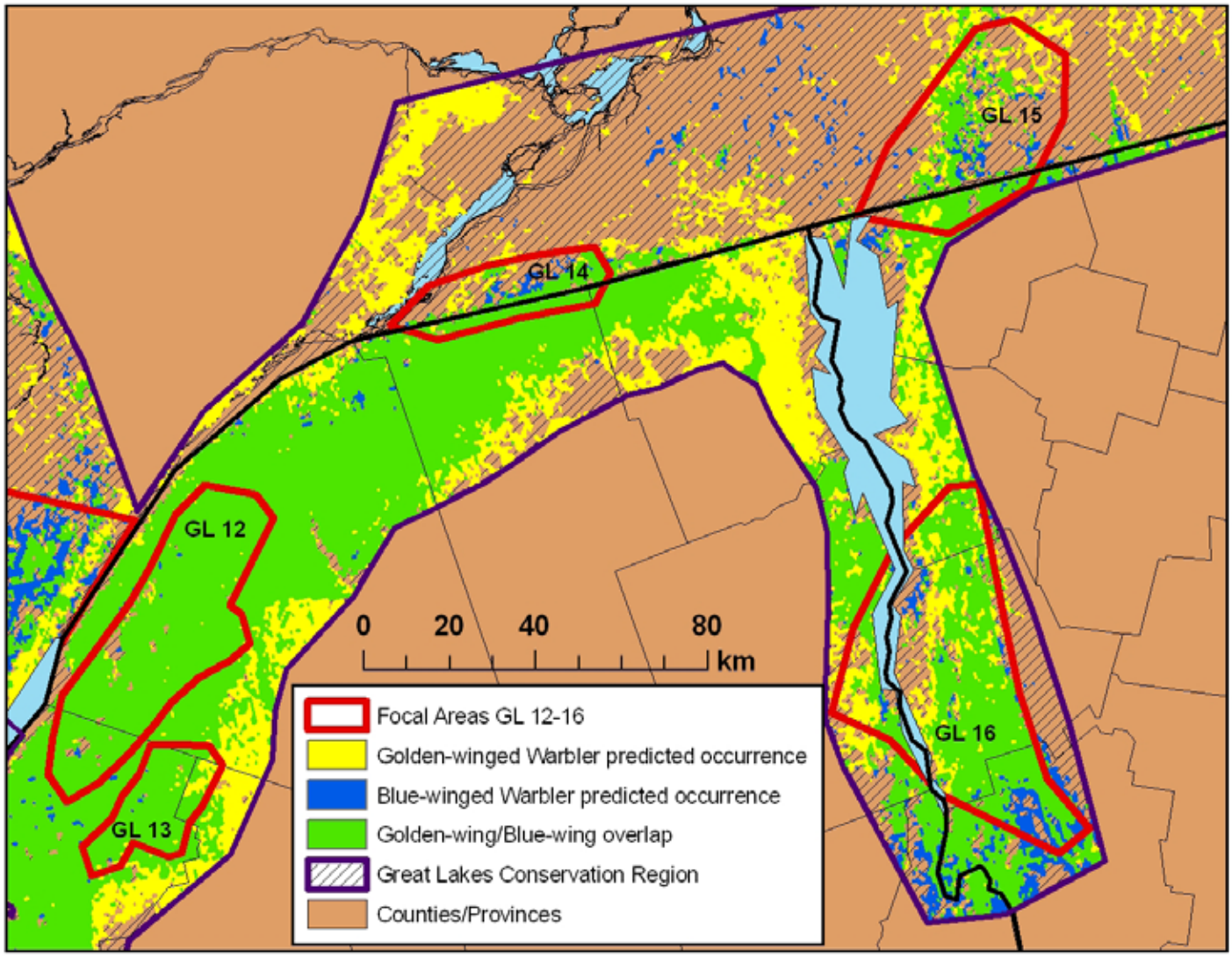
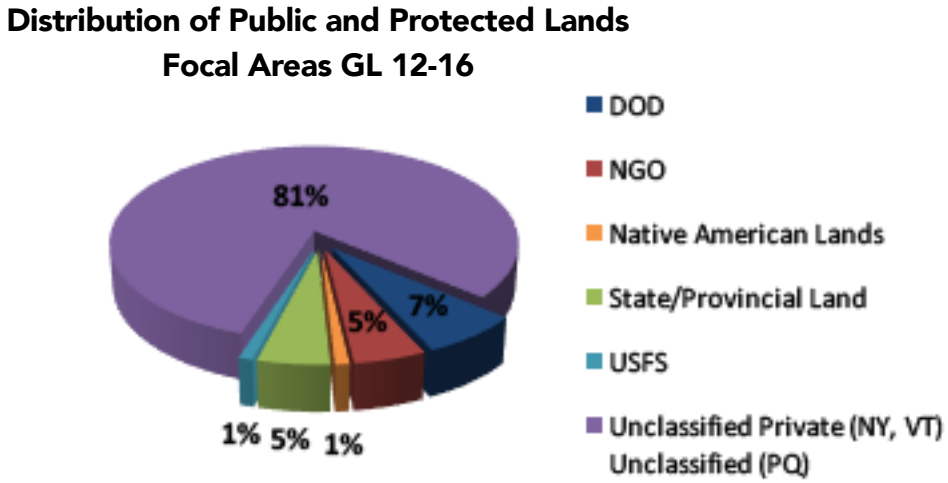


Figure 3–50. Model results showing the current predicted distribution of Golden-winged and Blue-winged warblers in New England subregion. Locations inside focal areas and without Blue-winged Warbler should receive highest priority for conservation and management actions. A smaller number of ecological variables were available to model the estimated warbler distribution in Canada. As a result, the model for the Great Lakes Conservation Region may over-predict the degree of overlap between warbler distributions for these focal areas.



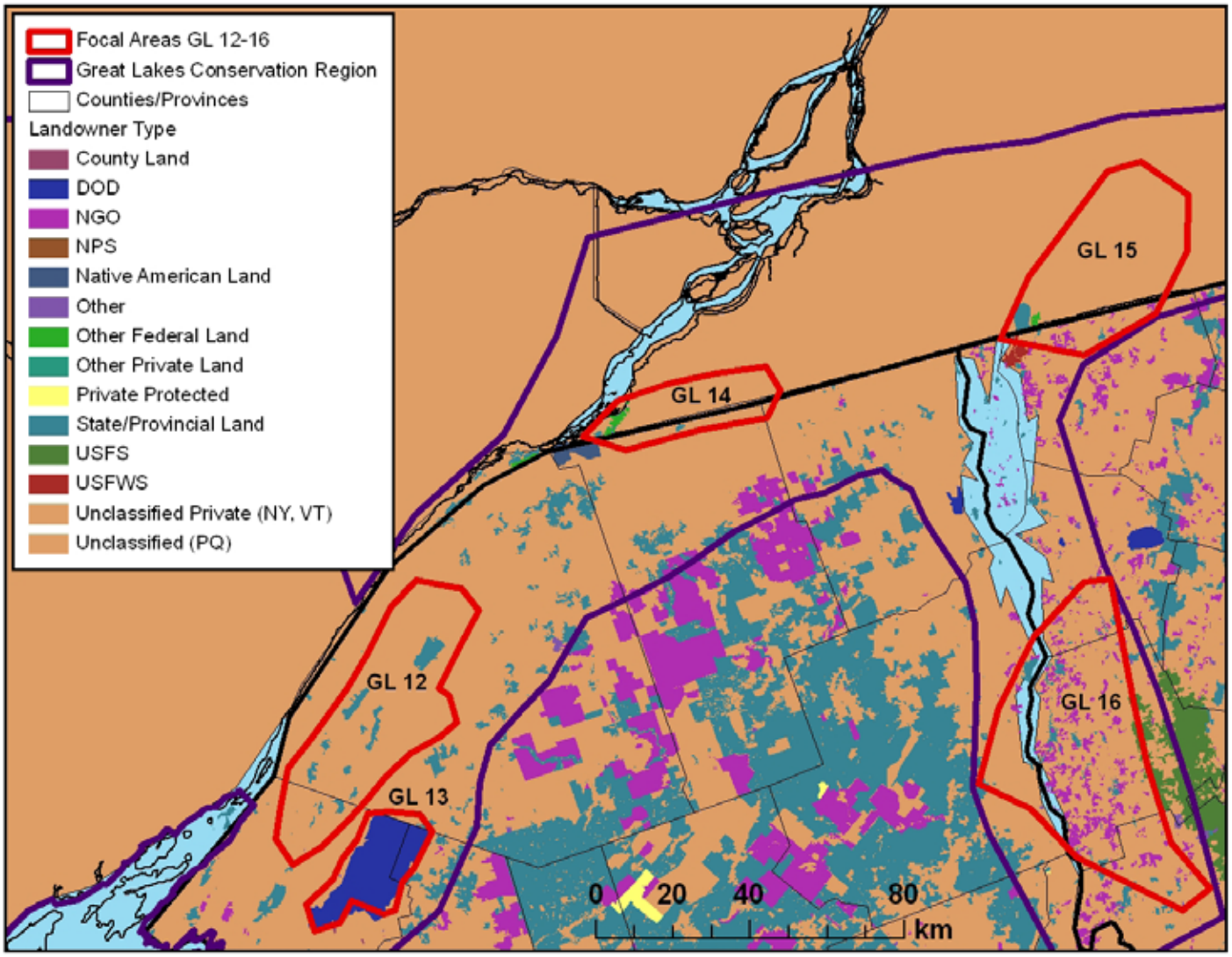


Figure 3–51. Percentage of landowner types and spatial layout of public and protected areas in the New England subregion (USGS Protected Areas Database of the USA, version 1.2, **www.protectedlands.net/padus/***; Conservation Areas Reporting and Tracking System (CARTS); and Atlas of Canada 1,000,000 National Frameworks Data, Protected Areas,* **http://geogratis.cgdi.gc.ca/geogratis/en/option/select.do?id=BA8D1149-7714-EC04-343B-6AFEC3BDA84A***). Some protected areas are not mapped due to incomplete land ownership datasets.*

Golden-winged Warbler Working Group

The Golden-winged Warbler Working Group was founded in 2003 and is comprised of over 133 United States, Canadian, and Latin American ornithologists, conservationists, and managers from academia, federal and state agencies, international non-governmental organizations, and industry. Their mission is to ensure the conservation of Golden-winged Warbler populations through sound science, education, and management.

The Golden-winged Warbler Working Group members will play a pivotal role in continuing to conduct research, leading monitoring efforts, and implementing the following conservation actions. Working Group activities can be followed at **www.gwwa.org/**.

In Canada, the Golden-winged Warbler is listed as Threatened on Schedule 1 of the Canadian *Species at Risk Act* (SARA), which necessitates the preparation of a recovery strategy and action plan. Thus, the Canadian members of the Working Group have a separate mandate necessitated by Canadian law, which presents additional opportunities for collaboration and integration with this plan.

Golden-winged Warbler Working Group Objectives

1. Increase awareness of Golden-winged Warbler conservation status throughout its range.
2. Identify gaps in knowledge and develop priorities for coordinated Golden-winged Warbler research and management.
3. Develop and implement a conservation plan for Golden-winged Warbler that includes research, education, management, regional coordination, and monitoring.
4. Develop a mechanism for information sharing and conservation action follow-through.

Canadian Recovery Team

The Canadian Golden-winged Warbler Recovery Team was founded in 2009 and is comprised of representatives from the federal and provincial governments, and non-governmental organizations. The main objectives of the team are to produce a recovery strategy, guide the implementation of the strategy, report on progress and success of recovery efforts, and establish project priorities by providing biological advice on how to best recover the Golden-winged Warbler as guided by SARA. The team estimates to have a draft strategy ready for public review mid-2012.

The recovery team uses information gathered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) to begin developing a recovery strategy. The recovery strategy sets out the population and distribution objectives, identifies threats to the survival of the species and the broad approaches to address these threats, identifies the species' critical habitat, if possible, and sets time lines for the preparation of an action plan.

The recovery strategy is currently in draft form and will be posted as a final document to the Species at Risk Public Registry upon completion. The draft population and distribution objective is to maintain the Golden-winged Warbler population at its current range of abundance (approximately 19,000 to 50,000 pairs (COSEWIC 2006)) in Canada and to maintain the areas where minimal overlap occurs with Blue-winged Warblers within the Canadian range, while allowing continuing range expansion and contraction; and genetically pure populations where they occur within this range.

Next Steps

Development of this conservation plan does not guarantee implementation. Many conservation actions need to be stepped down into specific tasks so as to implement each action. Specific partners need to be identified to be accountable for the implementation of these tasks and other components of this plan.

At a minimum, the Golden-winged Warbler Working Group, Wildlife Management Institute, and other key partners should work together under the objectives of the National Fish and Wildlife Foundation's Early Successional Business Plan to make habitat recommendations compatible and consistent across all focal areas, and ensure, when appropriate, that implementation strategies and management activities consider all associated species.

Further, given the strong interest in ESH by a large number of potential researchers and land managers, an organized effort should be made to update National Fish and Wildlife Foundation's Early Successional Business Plan to help guide future work and funding. The need to step down the plan by identifying management sites and conservation strategies in each state is an important agency process that the Golden-winged Warbler Working Group should assist with in the future.

This plan is a dynamic document that will require periodic reviews and updates. We propose an initial national review and associated workshop in 2015. Keeping the conservation planning process fluid will allow for incorporation of new science and provide information useful to the U.S. Fish and Wildlife Service in making decisions about listing the species under the Endangered Species Act. Further, we suggest that periodic reviews be coordinated with the 5-year Canadian recovery plan review process as required by SARA.

REVISED 2019 EVALUATING ACCOMPLISHMENTS

2019 PLAN REVISION: Though this section is focused on evaluation of Golden-winged Warbler populations and habitat in response to management and conservation activities, evaluation of the response of other *Vermivora* genus phenotypes and associated species (see Table 2-2) are important components to a comprehensive management plan. A consistently changing ratio of Golden-winged Warblers, Blue-winged Warblers, and hybrids within a sympatric population can be an important pattern to track depending on local and regional management goals and objectives. A ratio that changes in a consistent way through time can be an indicator of distribution shifts of one or more phenotypes, differential response of phenotypes to management activities, or a response to other processes. Understanding these patterns are important for long-range planning and evaluation of conservation activities that can be achieved through monitoring phenotypes. Thus, at this time, we are no longer recommending rangewide genetics monitoring for *Vermivora* species using a systematic sample collection protocol due to extensive rangewide genetic introgression between Golden-winged Warbler and Blue-winged Warbler. We support the decision of researchers and managers who undertake genetics monitoring or testing to address other scientific questions.

Strategy for Evaluating Population and Habitat Goals

Adaptive habitat management that results in successfully stabilizing or reversing declining bird populations requires evaluation and monitoring programs that track population trends and measure species-level responses at multiple relevant scales. Evaluation programs are necessary to assess management practices, identify limiting factors, and document population change and recovery at the local, regional, and rangewide scales. Because ESHs that support breeding Golden-winged Warbler are ephemeral and dependent on regular disturbance, evaluation strategies must also help guide the timing and frequency of land-management actions. In addition, because Golden-winged Warbler is a long-distance Neotropical migrant, evaluation of breeding-season conservation actions must be tied to year-round demographic parameters, using protocols yet to be developed. Finally, the unique biology of Golden-winged Warbler, and threats from hybridization with closely related Blue-winged Warblers, requires that evaluation programs include a component for measuring genetic purity of established populations and tracking the dynamics of hybridization. In this section, we describe an overall strategy to track the success of our conservation efforts in terms of 1) numbers of acres established or enhanced, and 2) the response by Golden-winged Warbler and associated species at several spatial scales. Evaluating this response will be necessary to inform future conservation actions in an adaptive management framework.

Habitat Tracking

The most immediate measure of conservation action will be the number of acres of ESH suitable for breeding Golden-winged Warblers established, enhanced, or protected within each focal area identified in this Plan.

Tracking the number of acres of new ESH established under this Plan must be evaluated in the context of overall landscape-scale trends in available ESH. Conservation of Golden-winged Warbler and associated species will not be successful if new habitat is established at rates that do not exceed rates of regional habitat loss, or if new habitat is established in areas that can no longer support regional populations of Golden-winged Warbler (i.e., become population sinks). At present, identification and tracking of ESH using remote sensing data and GIS technology is extremely difficult. Existing data layers and modeling tools are inadequate for evaluating habitat availability for Golden-winged Warbler and other ESH specialists. Developing new tools and models for interpreting ESH from remotely sensed data is a critical research, conservation, and evaluation need.

The Wildlife Management Institute (WMI) is developing a web-based tool to track ESH created through American Woodcock management. Rather than duplicate the effort, we will work with WMI to help support and use this tool for tracking Golden-winged Warbler habitat. WMI has agreed to facilitate this effort (S. Williamson, pers. comm.).

Tracking acres of ESH on the landscape is just the first step; however, in evaluating success of the Golden-winged Warbler Conservation Plan. Not all acres of ESH within a region will be suitable for Golden-winged Warbler, and not all suitable acres of Golden-winged Warbler habitat will be occupied. In addition, the appearance of male Golden-winged Warbler, especially in the years immediately following habitat manipulations, may not ensure successful breeding, or that a breeding population of Golden-winged Warbler is established. Tracking the population-level response to habitat change, including fecundity and genetic purity of newly established Golden-winged Warbler populations, is essential for meeting the population goals in this conservation plan.

Population Response by Golden-winged Warbler

Continued monitoring of Golden-winged Warbler populations is critical to: 1) track rangewide trends in the context of meeting population goals and understanding the pace and status of overall population recovery, and 2) measure local response to habitat establishment and manipulation, helping to determine if newly created habitats are being occupied and if reproductive performance is adequate to create source populations. Monitoring must inform knowledge of population dynamics and management decisions at all relevant scales – rangewide, regional, focal area, and local management sites. The population sampling that occurs at these different scales should be hierarchical and coordinated in such a way as to produce outputs that are comparable across spatial scales. We recommend using protocols (see Appendix G) established under the Golden-winged Warbler Conservation Initiative to measure local response of Golden-winged Warbler to habitat manipulations, and then relate these to regional and rangewide population goals established under the Golden-winged Warbler Conservation Plan and the ESH Business Plan developed for the National Fish and Wildlife Foundation.

The patchy nature of present-day Golden-winged Warbler distribution prevents effective surveying with traditional methods, such as the North American BBS. This makes estimates of regional population size and trend difficult. At present, BBS data give us a general measure of long-term trends over the entire range, but low detection rates, especially in the Appalachian Region (BCR 28), preclude estimation of trends over smaller areas (regions/states/provinces) and potentially erodes confidence in rangewide trends. To overcome these problems, the Golden-winged Warbler Working Group developed and tested a spatially balanced sampling methodology (see Appendix F) aimed at establishing a monitoring strategy that is effective for patchily distributed species, but not overly cumbersome or costly to implement.

Under the NFWF-funded Golden-winged Warbler Conservation Initiative, this spatially balanced monitoring design was pilot-tested in Pennsylvania in 2008 and throughout the Appalachian Region in 2009, and implemented successfully during the 2010 and 2011 breeding seasons. Partners in nine states, with supplemental support from USFWS, carried out Golden-winged Warbler sampling at roughly 520 points each year, giving us the ability to detect significant regional population changes. The flexibility of the spatially balanced monitoring design allows for additional sampling within states, provinces, and focal areas to provide inferences at finer spatial scales and to track the fate of local populations. Wildlife agencies in eight states (KY, MD, NC, NJ, PA, TN, VA, WV) have committed to future monitoring of sampling points within their states. Centralized coordination of monitoring and data management and analysis, as well as coordination of field personnel to complete the sampling design, will be necessary to fully implement this evaluation program.

Presently, spatially balanced monitoring is only being implemented in the Appalachian region where populations have been declining for decades. However, given that Golden-winged Warblers are now declining in the upper Midwest and Canada, and the BBS program has route-level data deficiencies for Michigan, Wisconsin, Minnesota, Quebec, and Manitoba, we recommend that spatially balanced monitoring be used in both the Appalachian and Great Lakes regions, as well as in Canada where the density of BBS routes is inadequate to develop robust population trends (**www.mbr-pwrc.usgs.gov/bbs/reglist07.html**). Expanding the spatially balanced monitoring design to these new regions will require further coordination and commitments by new partners.

Ideally each management site should become a case history with documentation of habitat quality before and after management, and the response of Golden-winged Warbler, American Woodcock, and other associated species should be tracked before and after management activities. At a minimum, evaluation protocols must document the occurrence of Golden-winged Warbler at managed sites; ideally evaluation would document the reproductive performance of Golden-winged Warbler population response in the context of focal-area and regional population goals, presence of Blue-winged Warbler and other associated species, and measures of genetic purity or introgression. Evaluation protocols implemented at managed sites should be compatible with regional and rangewide protocols established by the Golden-winged Warbler Conservation Initiative to track population response over larger areas.

Past experience with other Neotropical migrant species tells us that measuring occurrence or density of Golden-winged Warbler at managed sites will be insufficient for documenting population response to conservation actions. Specifically, careful attention must be paid to how our management is influencing fecundity. Because efficient, inexpensive protocols to measure fecundity do not currently exist, we recommend developing several experimental protocols, possibly including brood counts and the collection of Breeding Bird Atlas type data in different habitats, to create an index of demography across sites and correlated across habitat types. Research is necessary to determine the effectiveness of simple protocols and to see if they yield the type of results useful to managers. Intensive research should continue within long-term study sites to calibrate any new demographic index.

Because of the real and imminent threat of genetic swamping and competition from the Blue-winged Warbler, populations targeted for management should be monitored to assess genetic integrity, to discourage management that may favor introgression by Blue-winged Warbler, and to measure the genetic health of Golden-winged Warbler populations throughout their range. Even with a demographic index in place, there is still the question of how much introgression exists at each site and how this is influencing fecundity in Golden-winged Warbler populations. Monitoring introgression is straightforward, using simple blood and feather sampling protocols developed under the Golden-winged

Warbler Conservation Initiative (Appendix H). Newly developed DNA-assay techniques are then performed at qualified labs; these include existing mitochondrial DNA assays, and the addition of nuclear DNA sampling as future techniques improve. Biologists working at managed and experimental sites should collect blood as often as possible. We recommend periodic (i.e., every 5 years) blood sampling at permanent locations to track introgression across the Golden-winged Warbler's range starting in 2016 and then again in 2021. After the first sampling period in five years, sampling could continue in five year increments; however, this time period should remain flexible to adjust to new findings. Sampling and analysis of blood samples for genetic purity can be carried out by the Golden-winged Warbler Working Group partners and assayed via a molecular systematics laboratory such as the Fuller Evolutionary Biology Program at the Cornell Lab of Ornithology.

Response of Associated Species

We recommend that future Golden-winged Warbler survey protocols at all relevant scales record the presence or relative abundance of selected associated species (Figure 3—52) listed in Table 2—2. For response of American Woodcock, the Wildlife Management Institute has a survey protocol available for use in documenting response to habitat management (**www.timberdoodle.org/**). Additional species may be surveyed using other protocols to evaluate the response of birds not well detected by the above point count protocols (e.g. owls, nightjars, grouse, winter birds) or other non-bird species (e.g. imperiled herptiles or mammals). Moreover, supplemental observation of Golden-winged Warbler associated species will help guide management for a broader suite of species. Conversely, where other species are the focus of monitoring and research in ESH within the Golden-winged Warbler range, Golden-winged Warbler should be a high priority for monitoring as an associated species.

Figure 3–52. Eastern Towhee is a species frequently associated with Golden-winged Warbler. Photo by Laurie Smaglick-Johnson.

Photo by Auriel Van Der Laar

Coordination of Evaluation Strategy

A centrally coordinated database and monitoring system with consistent effort across years would be ideal for successful evaluation and monitoring of Golden-winged Warbler population response at relevant scales. A single Evaluation Coordinator could implement the evaluation strategy for tracking progress toward meeting the project's goals, tracking activities (land manager and landowner contacts, training workshops conducted and their outputs, awareness, etc.), recording project outputs (acres created or restored, population responses, etc.), and providing continuity with coordination of all previous aspects of the Golden-winged Warbler Conservation Initiative. This Coordinator would rely on the support of state, provincial, and federal agencies and non-governmental organizations to contribute to range-wide and regional surveys, possibly employing monitoring teams consisting of qualified volunteers and technicians to keep it sustainable, and would help research teams and land managers establish monitoring points within the focal areas and management sites. Without this centrally coordinated, long-term monitoring program of Golden-winged Warbler populations, associated species, and key sites, it will be very difficult to effectively evaluate and track the overall effectiveness of the Conservation Plan's management prescriptions to increase Golden-winged Warbler populations and improve the overall integrity of early successional communities as they begin to be implemented by land managers.

Evaluating Response at Management Site

Until a centrally coordinated monitoring system is in place, we recommend that biologists working with land managers address the following question:

Are Golden-winged Warblers present and if so, is there a breeding population?

Research has shown that documenting the presence of territorial males alone does not indicate a breeding population. Additional evidence must be gathered before you can be confident that males are acquiring mates and actually breeding. The following are two methods to help you document these two responses to management:

1. Follow the field protocol described in Appendix F to determine if Golden-winged Warblers are present.
2. If Golden-winged Warblers are located on-site, then attempt to confirm breeding activity. Probable breeding activity includes one of the following: Presence of a female Golden-winged Warbler or presence of at least 4 territorial males within singing distance of one another. Confirmed breeding activity includes observation of one of the following: copulation behavior, female carrying nest material, nest with eggs or nestlings, female or male carrying food or fecal sac, or fledglings. If your state or province is conducting a Breeding Bird Atlas, we encourage you to submit breeding evidence data to them.

Evaluating Progress toward Conservation Objectives

The two goals of this plan can only be realized by measuring the progress towards meeting each of the objectives and specific conservation actions identified for each objective above. The actions for each objective are numerous and progress will hinge on cooperation among many organizations and agencies. We have identified specific metrics and targets for evaluating success toward meeting this plan's conservation goals and related objectives (Table 3–16).

REVISED 2019 *Table 3–16. Summary of conservation, research, and monitoring objectives and suggested metrics to evaluate success of each objective.*

Conservation Objectives	Evaluation Metrics and Targets
Goal 1: Understand the full lifecycle of the Golden-winged Warbler to identify factors most likely limiting regional and global populations.	
Objective 1.1: Understand connectivity between breeding and non-breeding areas in order to more closely link demographic parameters and establish linkages.	• Map and measure geographic changes in natural range relative to historic range. • Deploy adequate numbers of light-level geolocators, nanotags, or other technologies to have high confidence in understanding migration connectivity for all breeding populations.
Objective 1.2: Develop a sex- and age-explicit full lifecycle population model to identify the demographic parameter(s) driving population sizes regionally and globally.	• Creation of a well-parameterized model that successfully identifies factors limiting populations.
Goal 2: Reduce threats to Golden-winged Warbler populations during the breeding stationary period.	
Objective 2.1: Conserve appropriate forested landscapes at geographic scales needed to maintain core Golden-winged Warbler populations, especially in focal areas.	• Number of wetland and forest acres protected from land use conversion, especially in focal areas, as tracked through USGS Protected Areas Dataset, state/provincial/federal agencies, wetland inventories, etc. • Creation of a model to track spatial and temporal characteristics of forested landscapes to evaluate fragmentation and other forest trends. • Creation of a model to forecast landscapes for future habitat conservation based on climate model predictions.
Objective 2.2: Better integrate Golden-winged Warbler conservation and management with similar actions for other disturbance-dependent species using the same forested landscapes.	• Golden-winged Warbler and its habitat components are incorporated into plans, during development or revision, for associated species and forests within the warbler's range, particularly in focal areas.
Objective 2.3: Implement best management practices for improving and increasing breeding habitat for Golden-winged Warbler and associated ESH species.	• Acreage of demonstration areas in and adjacent to focal areas. • Acres and enrollees in state/provincial/federal habitat incentive programs. • Every five years revisit the BMPs to determine if revisions are needed based on new information.
Objective 2.4: Develop and implement an evaluation plan that tracks progress towards meeting Golden-winged Warbler population and habitat goals to inform management decisions at all relevant scales.	• Establish and fund a centrally coordinated population monitoring program. • Number of individuals and breeding pairs as estimated through coordinated monitoring, BBS, and PIF population estimates, and measured against stated population goals. • Establish and fund a centrally coordinated habitat monitoring program. • Acres of habitat created using USFS FIA, WMI web tracker, and state/provincial/federal agency databases.
Objective 2.5: Identify optimal current and future breeding stationary period habitat characteristics.	• Creation of a survey protocol to assess site-scale habitat quality. • Predictive distribution map of Golden-winged Warbler in response to climate model predictions.

Table 3–16. Continued.

Objective 2.6: Clarify effects of Golden-winged Warbler and Blue-winged Warbler interactions and how these affect use of available habitat.	• Map and measure hybridization periodically.
Objective 2.7: Promote management actions for Golden-winged Warbler conservation and habitat management to stakeholders.	• Creation of a communication plan. • Creation of a new up-to-date website for the Golden-winged Warbler Working Group. • Number of Golden-winged Warbler Working Group website visits by new and returning users. • Number of stakeholders reached with BMP resources. • Number of stakeholders implementing BMPs. • Number of outreach events (workshops, webinars, etc.) led by Working Group members and partners, as well as attendees. • Number of outreach tools available for Working Group member and partner use. • Number of demonstration areas in a well-distributed network across the range. • Number of Working Group members based on listserv membership. • Number of partner groups implementing Golden-winged Warbler conservation activities.
Objective 2.8: Work with partner agencies and organizations to develop and prioritize policy recommendations to support Golden-winged Warbler management and conservation activities.	• Number of policy meetings attended by Golden-winged Warbler Working Group members on topics of climate, bird collisions with structures, and energy. • Number of habitat and species plans incorporating Golden-winged Warbler conservation activities. • Number of habitat incentive programs that have adopted Golden-winged Warbler conservation actions. • Number of regional partnerships focused on ESH management relevant to Golden-winged Warbler.
Objective 2.9: Coordinate management and policy activities across countries within Golden-winged Warbler breeding distribution.	• Number of shared monitoring and conservation activities as facilitated through regular joint meetings (every 1–2 years) between U.S. Golden-winged Warbler Working Group members and Canadian Recovery Team.
Goal 3: Reduce threats to Golden-winged Warbler populations during the migratory and non-breeding stationary periods.	
Objective 3.1: Retain and create forest habitat within non-breeding focal areas by developing and promoting economic incentives to keep forest on working lands and by supporting the creation and enforcement of protected areas.	• Number of new protected areas overlapping focal areas • Number of hectares of habitat with legal protection in focal areas • At least one new Payment for Ecosystem Services scheme implemented in one non-breeding focal area by 2020. • Legal protection of forest surrounding community watersheds, rivers, and streams obtained in collaboration with legal watershed protection mechanisms in at least one focal area per country. • By 2026, 30% of the habitat lost since the year 2000 (approximately 45,000 ha) has been restored within non-breeding focal areas.
Objective 3.2: Reduce the loss and degradation of nonbreeding habitat through outreach and education of landowners and land users in focal areas.	• By 2026, the net loss of Golden-winged Warbler winter habitat is reduced by 50% within non-breeding focal areas.
Objective 3.3: Identify and address information gaps in the distribution, habitat use, and threats during the non-breeding stationary period and migratory periods.	• Maps and assessment of areas of critical importance to non-breeding GWWA vulnerable to habitat loss or appropriate for habitat restoration have been identified in a document accessible to the working group • Best management practices for non-breeding habitat creation and retention in coffee, silvopastoral, and small-scale farming systems published in English and Spanish. • Golden-winged Warbler migration ecology review published that highlights bottlenecks, vulnerable periods, and conservation strategies appropriate for spring and fall migration. • Analysis completed on the effect of migratory obstacles on annual survival. • Overwinter survival of males and females in at least two habitat types and two regions analyzed and included as metrics in full-annual population model.
Objective 3.4: Build local capacity to adopt best management practices and retain existing habitat.	• Number of adults and youth reached through capacity building programs • Average amount of time spent in training per program participant • At least one advocacy and community decision-making program established in non-breeding range to assess and contribute to infrastructure and mining decisions within focal areas. • Number of teachers trained in Bird Sleuth curriculum • Number of schools implementing Bird Sleuth (Detectivas de Aves) curriculum

Table 3–16. Continued.

Objective 3.5: Promote management actions for non-breeding Golden-winged Warbler conservation and habitat management to stakeholders at the focal area, country, and range level for the non-breeding period.	• At least one model farm that embodies best management practices established in each country by 2017 and in each focal area by 2021 • Alianza Alas Doradas meets and reassesses/updates non-breeding conservation strategy and plan in 2020 and every five years thereafter. • All national governments and governing authorities at the focal area level approve and adopt conservation recommendations in Ch 4: Non-breeding Season Conservation Plan.
Objective 3.6: Coordinate management and policy activities across countries within Golden-winged Warbler non-breeding distribution.	• Improved protected area protocol created in collaboration with communities and local and national governments and disseminated for at least one protected area in each country by 2020 • Regional coordinator contracted to manage and implement projects in the Golden-winged Warbler non-breeding range. • Regional coordinator develops yearly and five-year working plans. • Communication strategy evaluated and revised at Alianza Alas Doradas meeting in 2020.

Illustration by Bartels Science Illustrator Reyn Ojiri

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Appendices

APPENDIX A. GLOSSARY OF TERMS

Adaptive Management: An iterative conservation strategy where management recommendations are modified over time based on monitoring and other new information that becomes available.

Anthropogenic: An effect or object resulting from human activity.

Associated Species: Different species that are found in the same area during the same time of year. For Table 2–2 in this plan, association results are delineated by the probability of detecting the respective species based on point count surveys (high = > 30%, moderate = 15–30%, and low = < 15%).

Basal Area: The area of a breast-high cross section of a tree or of all the trees in a stand.

Biome: A major habitat type such as tundra, boreal forest, temperate broadleaf forest, etc.

Bird Conservation Regions: Ecologically distinct regions in North America with similar bird communities, habitats, and resource management issues. Bird Conservation Regions facilitate domestic and international cooperation in bird conservation, because they traverse state, provincial, and national borders. (**www.nabci-us.org/bcrs.htm**)

Breeding Bird Atlas (BBA): A comprehensive, systematic field survey of the occurrence and breeding status of breeding birds, conducted by citizen scientists during a limited time period. A state Breeding Bird Atlas includes information on all species and survey areas throughout the entire state. It is considered systematic because critical survey areas, referred to as Priority Blocks, are randomly selected based on a geographic grid system. All Priority Blocks are about the same size (8-10 mi^2) and are chosen independent of the habitat present within the block or any other characteristic that could bias the results. Different grid systems have been used by states to define their blocks including DeLorme map pages, U.S.G.S. topographic maps, or the U.S. Public Land Survey System.

Breeding Bird Survey (BBS): A cooperative program of the U.S. Geological Survey and the Canadian Wildlife Service for monitoring population changes in North American breeding birds by using point counts along roads. Three-minute counts are done at 0.5-mi (0.8-km) intervals along a 24.5-mi (39.4-km) route. (**www.pwrc.usgs.gov/bbs/**)

Breeding Grounds: The specific geographic locations within the breeding range where habitat and community characteristics are such that breeding occurs.

Breeding Range: The geographic area over which breeding is carried on by individual pairs or breeding populations of a particular species.

Brood: A group of young birds hatched or cared for at the same time.

Clump: A group of plants clustered together rather than dispersed evenly. Bulluck and Harding (2010) defined shrubs that were spaced < 7 ft (2 m) apart as clumped and shrubs spaced > 7 ft (2 m) apart as scattered.

Conservation Region: A subset of the current breeding range that is ecologically similar from the perspective of regional ecological patterns, broad habitat characteristics deemed important to Golden-winged Warbler, and populations with similar demographics and spatial (continuous versus patchy) characteristics. See page 3–5 for map.

Critical Habitat: In the Canadian Species at Risk Act (SARA), critical habitat is defined as the specific habitat necessary for the survival or recovery of a listed wildlife species and is identified in the recovery strategy or in an action plan for the species.

Cryptic Hybrid: An individual that is phenotypically a normal Golden-winged or Blue-winged warbler but has mixed ancestry in its genotype.

DBH: Diameter at breast height. A common tree measurement used by foresters.

Demography: The study of group life-history patterns. Specifically, things like annual survival rates and fecundity which can then be used to estimate population change over time. In birds, for example, clutch size and survival rate during migration are important demographic factors.

DOD: U.S. Department of Defense. (**www.defense.gov/**)

Early Successional Habitat: Habitats such as grassland, old field, shrubland, and young forest. It can develop naturally through succession or it can be created and maintained by using various land management techniques. Some early successional habitats, such as alder swamps, may be relatively permanent, but most are constantly changing and need some sort of disturbance to be maintained.

Ecotone: A transitional area between two adjacent but different land cover types, such as forest and grassland.

Ecozones: Broad ecological zones that cover a large range of ecosystems such as temperate forest, grassland, extensive river systems, and farmlands. Each ecozone has its own climate, relief, soil, fauna, flora, and distinct human activities. (**http://atlas.nrcan.gc.ca/auth/english/maps/environment/forest/forestcanada/terrestrialecozones/1**)

Feathered Edge: A border between habitat types that is not narrow and sharp but rather wide and more gradual (one habitat blending into another).

Fecundity: Birth rate, or in the case of birds, the number of young that are fledged.

Focal Area: As defined by the Golden-winged Warbler Working Group, is a place where the maintenance of a core population will be important for sustaining and growing the current distribution of Golden-winged Warblers.

Focal Species: In this plan, focal species refers to a species listed in the USFWS Focal Species strategy. The USFWS selected species that need investment because they: 1) have high conservation need, 2) are representative of a broader group of species sharing the same or similar conservation needs, 3) act as a potential unifier for partnerships, and/or 4) have a high likelihood that factors affecting status can be realistically addressed. (**www.fws.gov/migratorybirds/CurrentBirdIssues/Management/FocalSpecies.html**)

Forb: An herbaceous plant that is not a grass, especially one growing in a field, prairie, or meadow.

Genotype: The inherited instructions an organism carries within its genetic code. Not all genes are expressed in the phenotype, however. The cryptic hybrids discussed in this plan are a good example. An individual can look like a Golden-winged Warbler, but it may have some Blue-winged Warbler genetic material in its genotype.

Geolocator: A lightweight electronic tracking device usually used in bird migration research. It records changes in light levels at different latitudes and longitudes. It uses low power technology and data compression, so it is able to record data for long periods of time. Geolocator data are not as accurate as GPS data, but the devices are lighter and cheaper.

Habitat Edge: The distinct boundary between different habitat types or between distinctly different successional stages of the same habitat.

Habitat Interspersion: The intermixing of patches of different habitat types.

Habitat Turnover: Changing from one seral stage to another (succession). In this document, habitat turnover refers to suitable habitat changing to unsuitable habitat.

Herbaceous Cover: Plant cover that includes grasses, sedges, and forbs (non-woody plants).

Hybridization: Breeding that occurs between two individuals of different, but usually closely-related, species.

Incidental Take: The accidental harm to an individual or species caused by management activities.

Introgression: The movement of genes from one species into another closely related species. It results from successful hybridization and subsequent backcrossing of the hybrids with one of the parental populations.

Joint Venture: A partnership of state and federal agencies, non-governmental organizations, and industries who work together to ensure the long-term sustainability of native bird populations. There are many habitat and regional Joint Venture partnerships in the U.S.

Keystone Species: In this plan, keystone species refers to one of a set of species identified by the National Fish and Wildlife Foundation. They are imperiled species that are a high priority for state or federal agencies and for which NFWF believes its investment can make a measureable impact.

Land Cover: As offered by the Multi-Resolution Land Characteristics Consortium (**www.mrlc.gov/**) where land cover classes are defined into 21 different classes using the Anderson Level I and Level II (Anderson 1976; Cowardin et al. 1979).

Land cover classification definitions as follows:

Barren land – Barren areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, sand dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.

Coniferous (Evergreen) Forest – Areas dominated by trees where 75% or more of the tree species maintain their leaves all year. Canopy is never without green foliage. At the site scale, this generally includes trees greater than 16 ft (5 m) tall and greater than 20% of the vegetation cover. At the landscape scale, these values are unknown.

Cultivated crops – Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation, this class also includes all land being actively tilled.

Deciduous Forest – Areas dominated by trees where 75% or more of the tree species shed foliage simultaneously in response to seasonal change. At the site scale, this generally includes trees greater than 16 ft (5 m) tall and greater than 20% of the vegetation cover. At the landscape scale, these values are unknown.

Emergent Herbaceous Wetlands – Areas where perennial herbaceous vegetation accounts for 75–100% of the cover and the soil or substrate is periodically saturated with or covered with water.

Mixed Forest – Areas dominated by trees where neither deciduous nor evergreen species represent more than 75% of the cover present. At the site scale, this generally includes trees greater than 16 ft (5 m) tall and greater than 20% of the vegetation cover. At the landscape scale, these values are unknown.

Pasture/Hay – Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops.

Shrub/scrub – Areas dominated by shrubs; less than 16 ft (5 m) tall with shrub canopy typically greater than 20% of the total vegetation. This class includes true shrubs, young trees in an early successional stage or trees stunted from environmental conditions that tend to be drier than woody wetlands.

Woody Wetlands – Areas where forest or shrubland vegetation accounts for 25–100% of the cover and the soil or substrate is periodically saturated with or covered with water.

Landscape: A large area surrounding a Golden-winged Warbler observation or management site. In this plan, we often refer to macro landscape (within 1.5 mi (2.5 km)) and micro landscape (within 0.15 mi (0.25 km)).

Management Site: The area that is receiving active habitat management, and the contextual habitat that will potentially receive management action in the future. Management sites can range in size from a few acres or hectares to hundreds of acres or hectares.

Micro-edge: As used in this plan, a micro-edge is any readily perceived change in vegetation type or height, such as where grasses change to sedge at the border of a wet area or where an herbaceous opening is bordered by dogwood or *Rubus* shrubs.

Model (Modeling): A description of a system that uses mathematical concepts and language. To use a mathematical formula to describe the behavior of a system.

Neotropical Migrant: A bird species that winters in the Neotropics (Central America, South America, and West Indies) and breeds in the Nearctic (North America).

Nest Site: The area immediately around the nest itself (within a 33-ft (10-m) radius).

NFWF: National Fish and Wildlife Foundation (**www.nfwf.org/AM/Template.cfm?Section=Home**)

NGO: Non-governmental Organization. Generally, they are non-profit citizens' groups which are organized and run by people with a common interest.

NPS: U.S. National Park Service (**www.nps.gov/index.htm**)

Occurrence: The presence of a particular species at a given place.

Partners in Flight Watchlist: Bird species that have multiple reasons for conservation concern across their entire ranges. They were identified in the PIF North American Landbird Conservation Plan (Rich et al. 2004). (**www.partnersinflight.org/watchlistneeds/Research%20Crosswalk%20Taxon.htm**)

Patch: In this plan, we use the term patch to refer to a smaller unit residing within a management site that is the focus of current or future activities.

Phenotype: The observable characteristics of an organism that are produced by a combination of genotype and the influence of environmental factors (appearance). Not all genes are expressed in the phenotype, however. The cryptic hybrids discussed in this plan are a good example. An individual can look like a Golden-winged Warbler, but it may have some Blue-winged Warbler genetic material in its genotype.

Population: All the individuals of the same species that live in the same geographic area.

Remotely Sensed Data: Information used to detect and classify objects on the Earth that is collected by using aerial sensors or cameras mounted on aircraft or satellites.

Sapling: In general use, a young tree. In forestry terms, a tree that is taller than 4.5 ft (1.4 m) and is 0.4–4 in (1–10 cm) DBH.

Sawtimber: A log or tree that is large enough to be sawn into lumber (usually at least 10–12 in (25–30 cm) in diameter and a minimum of 8 ft (2.4 m) in length).

Seral Stages: The series of plant communities that develop during ecological succession as an area moves towards its climax community. Annual plants, perennials and grasses, shrubs, softwood trees, hardwood trees, for example.

Shelterwood Harvest: The removing of trees in a series of two or more cuttings so that new seedlings can grow from the seed of older trees (leave trees). This method ultimately produces an even-aged forest. The new stand is established under the shelter of the leave trees, and then the leave trees are removed when the new even-aged stand is well developed.

Shrub: A low, usually several-stemmed woody plant.

Silviculture: The practice of controlling the establishment, growth, composition, and quality of forest vegetation to meet landowner objectives. In other words, the agriculture of forest trees.

Single-brooded: Normally raise one brood per breeding season. Single-brooded species may renest, however, if the first nest fails for some reason.

Site: The specific area where something has happened or is happening. See management site and nest site.

Source-sink Demographics: An ecological theory describing how variation in habitat quality may affect population levels of organisms. The source is an area of high quality habitat that allows the population to increase. The sink is an area of low quality habitat that cannot support a population by itself. If the excess individuals from the source area frequently move to the sink area, however, the sink population can survive.

Spatially Balanced Monitoring: A type of monitoring where the sample sites are more or less evenly dispersed over the extent of the resource that is being monitored. This is opposed to the commonly used random sampling.

Species of Greatest Conservation Need: High-priority species as identified by individual State Wildlife Action Plans.

Stable Isotope Research: In ornithology, a technique used to identify the general area where a feather was grown. The food that birds eat while growing feathers contains isotopes of hydrogen, carbon, and nitrogen, and these isotopes vary in known patterns across the landscape. The isotopic content of a feather reflects the bird's diet when the feather was grown, and, thus the area where the feather developed.

State Wildlife Action Plans: Plans (technically known as comprehensive wildlife conservation strategies) developed by each state and territory. Congress ordered the plans to make the best use of the federal funds provided through the Wildlife Conservation and Restoration Program and the State Wildlife Grants Program.

Subregion: A smaller spatial extent of a Conservation Region containing one or more ecologically similar focal areas. See pages 3–38 and 3–54 for maps.

Succession: The process of more or less orderly and predictable changes in the species composition and structure of an ecological community over time. It can follow either disturbance or the initial colonization of bare land.

Territory: The defended area in which the male and female spend the bulk of their time during the breeding period. Territory size varies with habitat quality and type, but a good frame of reference for Golden-winged Warbler is 2–5 ac (1–2 ha).

USFS: U.S. Forest Service (**http://www.fs.fed.us/**)

USFWS: U.S. Fish & Wildlife Service (**www.fws.gov/**)

WMI: Wildlife Management Institute (**www.wildlifemanagementinstitute.org/**)

APPENDIX B. ADDITIONAL INFORMATION AND RESOURCES

- Golden-winged Warbler Conservation Initiative website (contains a webpage with resources and a list of published literature): **www.gwwa.org/**

- Golden-winged Warbler Habitat Best Management Practices for Forestlands in Maryland and Pennsylvania (Bakermans et al. 2011) : **http://amjv.org/wp-content/uploads/2018/09/GWWA_bmp_Final.pdf**

- Natural Resources Conservation Service Golden-winged Warbler programs and services: **www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/programs/?&cid=stelprdb1046990**

- U.S. Fish & Wildlife Service Golden-winged Warbler information: **https://www.fws.gov/midwest/es/soc/birds/GoldenWingedWarbler/GWWA90DayFinding.html**

- Birds of North America account (requires a subscription or institutional access): **bna.birds.cornell.edu/bna/species/020/articles/introduction**

- Ontario's Forest Management Guides, including topics on landscape-scale management, conserving biodiversity at the stand and site scale, and natural disturbance pattern emulation, are available at: **www.mnr.gov.on.ca/en/Business/Forests/2ColumnSubPage/STEL02_164533.html**

APPENDIX C. ESTIMATING THE RISK OF QUASI-EXTINCTION

To estimate extinction risk for Golden-winged Warbler, we used a count-based population viability analysis first developed for estimating extinction risk of Pacific salmonid stocks (McClure et al. 2003, Holmes et al. 2007). This approach has been used for estimating extinction risk in other rare species of concern, namely Cerulean Warbler (*Setophaga cerulea*) (Thogmartin et al. 2006) and shortjaw cisco (*Coregonus zenithicus*) (Bronte et al. 2010). The approach estimates extinction risk by way of a diffusion approximation from data that contain environmental noise in year-to-year transitions in population indices ("process error"), random errors in sampling, and possible biases in the samples; these latter two sources of error are described as "non-process error" (Holmes 2004, Holmes et al. 2007). A Bayesian sampling-importance-resampling (SIR) algorithm addressed uncertainty in the parameter estimates given the data. Thus, rather than developing a single function describing the probability of population extinction, the methodology employs uncertainty in the parameter estimates to estimate the uncertainty surrounding the probability of extinction through time. These probabilities of probabilities were derived from a large number of candidate vectors chosen at random from prior distributions and their importance (i.e., their contribution to the likelihood). Samples of these vectors were drawn—with replacement and in proportion to their importance—to generate a sample from the posterior distribution. A state-space Kalman filter, evaluating likelihoods from a running-sums method (Holmes 2004), was used to discriminate process error from non-process error.

Population viability was predicted at levels above which demographic stochasticity and Allee effects may become important (Lande et al. 2003, Fagan and Holmes 2006). As such, we did not estimate absolute risk of extinction per se, but rather the potential for *quasi-extinction*—a drop in the population below some subjective level. Both the World Conservation Union's International Union for the Conservation of Nature (IUCN) risk criteria (Mace and Lande 1991) and the proposed quantitative criteria for the U.S. Endangered Species Act (DeMaster et al. 2004) rely on quasi-extinction probabilities for inference.

Setting a quasi-extinction level is not necessarily straight-forward, as it can be subjective and value-laden. Ordinarily, a minimum detection level is selected in accordance with the survey method used to assess population trend for the species in question. However, in the trend analyses for Breeding Bird Survey counts, it is not clear what minimum detection level exists. Thus, to overcome this uncertain minimum detection issue, quasi-extinction was calculated for a relative abundance index of 10% of the year 2000 estimate. This, in effect, calculates the probability of obtaining an additional 90% decline from the year 2000 population.

APPENDIX D. COLLABORATIVE RESEARCH STUDY SITES

The study sites listed below collaborated during the 2008–2010 Golden-winged Warbler Rangewide Conservation Initiative to provide the nest monitoring and detailed habitat measurements that resulted in the analysis and consequent management guidelines presented in Chapter 3. Coordination of research objectives and shared protocols across the entire Golden-winged Warbler breeding range (and including seven states) provides an excellent example of the kind of focused research activity possible under the broad umbrella of an active Golden-winged Warbler Working Group. Funding for the 2008–2010 study was provided by the National Fish and Wildlife Foundation and partner match. Several of the sites had been involved in Golden-winged Warbler monitoring, research, and management prior to the period of the collaboration, as indicated below.

Tamarac National Wildlife Refuge. Becker County, west-central Minnesota. 2008–2010. *Site Description:* Mixed hardwood and conifer forest with successional habitats, usually associated with harvest. *Principal Investigator and co-PIs:* J. Loegering (University of Minnesota), H. Streby, D. Andersen.

Northern Highlands State Forest. Vilas, Oneida, and Iron counties, north-central Wisconsin. 2007–2010. *Site Description:* Aspen forests in three age classes (2–10, 10–20, 20+ years) and three retention types (oak, conifer, none). *Principal Investigator and co-PIs:* A. Roth (Michigan Tech University), D. Flaspohler, C. Webster.

Central Sand Plains Ecological Landscape. Wood, Clark, Jackson, and Juneau counties, central Wisconsin. 2008–2009. *Site Description:* Six sites each in young aspen stands, young hardwood stands, and swamp edges. *Principal Investigator and co-PIs:* M. Fowlds (University of Wisconsin), S. Lutz, K. Martin (Wisconsin Department of Natural Resources).

Watauga County, North Carolina. Northwestern North Carolina. 2007–2012. *Site Description:* Successional forests at mid to high elevations (>1000 m). *Principal Investigator:* C. Smalling (Audubon North Carolina).

North Cumberland Wildlife Management Area. Scott, Campbell, and Anderson counties,northeastern Tennessee. 2003–2012. *Site Description:* Reclaimed coal mines at elevations >600 m. *Principal Investigator and co-PIs:* D. Buehler (University of Tennessee), L. Bulluck, K. Percy, K. Caruso.

Monongahela National Forest. West Virginia. 2008–2012. *Site Description:* Grazing allotments. *Principal Investigator and co-PIs:* P. Wood (USGS West Virginia Cooperative Fish and Wildlife Research Unit), K. Aldinger (West Virginia University).

Sproul State Forest (SSF) and Bald Eagle State Park (BESP). Clinton and Centre counties, central Pennsylvania. 2008–2012. *Site Description:* SSF— successional habitat associated with 10,000 ac (4,046 ha) burn within a forested matrix; BESP— barrens, state park lands managed for shrub habitat. *Principal Investigator:* J. Larkin (Indiana University of Pennsylvania).

Sterling Forest State Park. Orange County, southeastern New York. 2000–2011. *Site Description:* Restoration footprint— herbs and shrubs, especially coppice growth; adjacent swamp forests— tussock sedge and <70% canopy closure; marsh— < 30% canopy closure with tussock sedge and marsh fern. *Principal Investigator:* J. Confer (Ithaca College).

APPENDIX E. ANALYSIS METHODS FOR HABITAT ASSOCIATIONS AND PREDICTIVE SPATIAL MODELING ACROSS MULTIPLE SPATIAL SCALES

Analysis of Rangewide Habitat Characteristics

A dataset of 31,555 "modern" (1998–2010) occurrence points for the Golden-winged Warbler and Blue-winged Warbler were collected from 5 primary sources: 1) Golden-winged Warbler Project data managed by the Cornell Lab of Ornithology (n = 8281), 2) Summer eBird records (n = 17,644; Sullivan et al. 2009), 3) Warbler data collected by collaborators (n = 1693), 4) Breeding Bird Atlas (n = 1128), and 5) BBS (n = 2809).

We examined the distributions of Golden-winged Warbler and Blue-winged Warbler as a function of climatic and ecological variables using an ensemble forecasting approach. This method mitigates for inter-model variation by employing several models within a single framework and the resulting projections analyzed (Araujo and New 2006). The ensemble is composed of several simulations, each of which permutes the initial conditions, model class parameters and boundary conditions. The final projection is evaluated through a measure of the central tendency across all model output.

The distribution of the Golden-winged Warbler, Blue-winged Warbler, and hybrids was modeled with 16 variables related to temperature and precipitation (Hijimans et al. 2005; **www.worldclim.org**), land cover characteristics, and elevation at 0.6 mi (1 km) and 3 mi (5 km) spatial scales. A third set of analyses at the 500m scale excluded climatic variables (unavailable at this scale). To examine how ecological variation influences warbler distribution at different spatial scales, analyses were conducted at the rangewide scale, the Conservation Regions scale (Great Lakes and Appalachian Conservation Region) and at the focal sub-regional scale (See Chapter 3, Part II, page 3–38). We chose environmental variables that characterized early-successional habitat. Studies of early successional habitat landscapes demonstrate that these landscapes are characterized by a high degree of spatial heterogeneity, with relatively open canopy, dense and a well-developed sub-story community of shrub and perennial herbaceous species (Swanson et al. 2011).

Environmental parameters indicating Golden-winged Warbler distribution were modeled using an ensemble approach, where the consensus or median model is calculated from among the models with the highest levels of support (Thuiller et al. 2009; Angelo-Marini et al. 2010). The predictive performance of each model was evaluated by selecting 80% of the data to train the model, and the remaining 20% used for model testing. To ascertain the central tendency across the model simulations and to calculate the final projection, we selected the 4 models with the highest AUC and kappa criteria, and then calculated the un-weighted average probability distribution across all pixels. This mean model was then used to project the species distribution. In the Appalachian region, elevation was the most important predictor of distribution with Golden-winged Warbler occupying higher elevations compared to Blue-winged Warbler. Elevation was followed in importance by the percent of deciduous forest present within the study area, vegetation height, and maximum summer temperature. In general, we found Golden-winged Warblers tend to occupy habitat that is cool, dry, at moderate to high elevation (range approximately 1000–2500 ft (~330–762 m) and composed of approximately 50% deciduous tree species that were between approximately 16–65 ft (5–20 m) in height. These results inform suggested management prescriptions at the landscape and regional scales (See Chapter 3).

Focal Area Group Identification

A set of 12 independent variables was preliminarily identified as significant to Golden-winged Warbler habitat selection at the 0.6 mi (1 km) scale (see Chapter 3, Part II, page 3–38). A principal components analysis was conducted to examine how variation among the independent variables was distributed among focal areas. Results demonstrated that more than 92% of the variation was explained by the first three principal components. High eigenvalues on the first component represent a trend from high to low elevation. The second principal component is associated with large values for % vegetative cover and vegetation height. The third principal component represents variation in the type of tree community present within the study area, with large positive values associated with deciduous trees such as aspen, maple and birch, and low values associated with coniferous species. The principal components analysis reduced the 34 focal areas to 11 ecologically distinct focal subregions (Figure AP–E1).

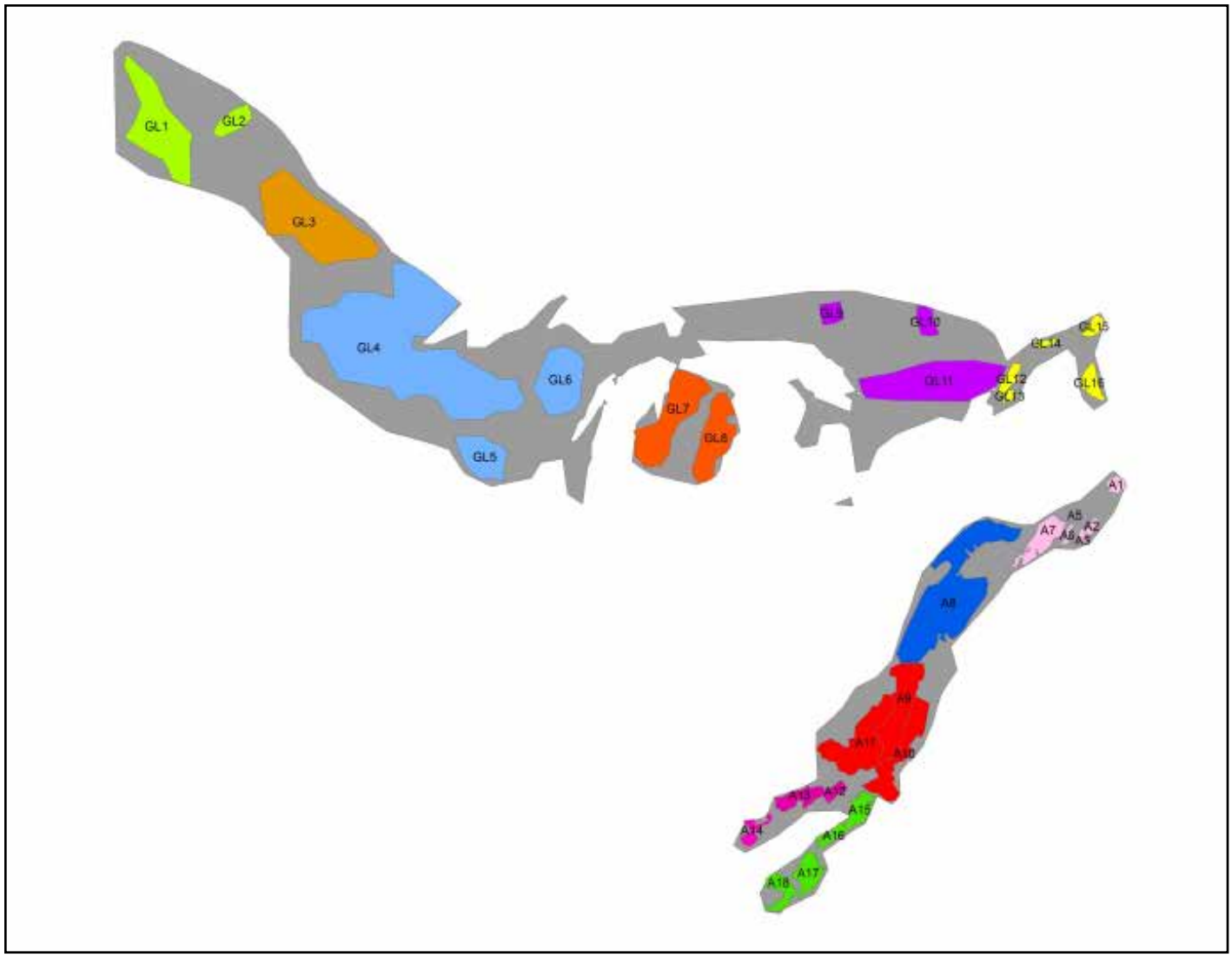


Figure AP–E1. Focal Area groups identified from analysis of environmental data. Each focal area group is indicated as a distinct color.

Predictive Habitat Modeling

Locality data and habitat characteristics indicative of Golden-winged Warbler habitat identified from previous analyses were used to parameterize models that indicate where the species was likely to occur, given habitat preferences. Data for the Blue-winged Warbler was included to examine the degree of overlap between the predicted distributions of the two species. The predictive models were calculated using a multi-model inference approach in R v.2.12. This approach constructs a set of candidate models, and each model is constructed using different assumptions about the fit of the data (assumptions: 1) data normally distributed; 2) no assumptions). We used an ensemble forecasting approach to project warbler distributions using R v.2.1.2. Predictive distribution models for both species exhibited great levels of support ($AUC_{Golden\text{-}winged\ Warbler}$ = 0.912; $AUC_{Blue\text{-}winged\ Warbler}$ = 0.878). The predicted range for both species was most distinguished at the rangewide scale by differences in elevation and land cover type similar to results from habitat analyses. Despite the degree of overlap in the predicted distribution of the species, models depicted areas in the southern Appalachians and in the upper Midwest where Golden-winged Warbler is expected to occur in the absence of Blue-winged Warbler. Notably, some of these areas occur outside the boundary of current focal areas. These areas of allopatry suggest places where management strategies to promote genotypically pure populations of Golden-winged Warbler may be most effective.

Modeling Hybridization Dynamics

Spatial and temporal extent of study

Recent work on the distribution of the Golden-winged Warbler identified two primary management and conservation regions within the breeding range of the species that delimited relatively stable populations over time; a region across the northern end of the Golden-winged Warbler range (Upper Great Lakes and Canada polygon) and a second region across the Appalachian Mountain region (Appalachian polygon). This current breeding range of the Golden-winged Warbler was set as the spatial extent of the hybridization analysis. The resultant data was partitioned into historical (1935–1997; n = 13,012) and current (1998–2010, n = 27,455) time periods following Crawford et al., 2012 (in prep). Historical data was not considered in this study.

Genotypic Data

A dataset of 2105 records resulted from the NFWF Genetic Atlas Project (1999–2010). This dataset consists of two classes of information: 1) the number of birds identified phenotypically in the field as Golden-winged Warbler, Blue-winged Warbler or hybrid; and 2) the genotypic identification for each bird record based on a blood sample. A genotyping method developed at the Cornell Lab of Ornithology was used in the genotypic analysis (Vallender et al. 2009). The combination of phenotype/genotype combinations helped to identify hybrid birds (Table AP–E1). The data was projected in ArcGIS v.10.0 to classify the data into 50 unique study sites (Figure AP–E2). The number of genotypic Golden-winged Warbler, Blue-winged Warbler, and hybrids were summarized for each study site (subsequently, "species" for analysis purposes).

Table AP–E1. The phenotypic/genotypic combinations assessed in this study.

Phenotype of bird	Genotype of bird	Study Category
Golden-winged Warbler	Golden-winged Warbler	Pure Golden-winged Warbler
Golden-winged Warbler	Blue-winged Warbler	Cryptic hybrid
Blue-winged Warbler	Blue-winged Warbler	Blue-winged Warbler

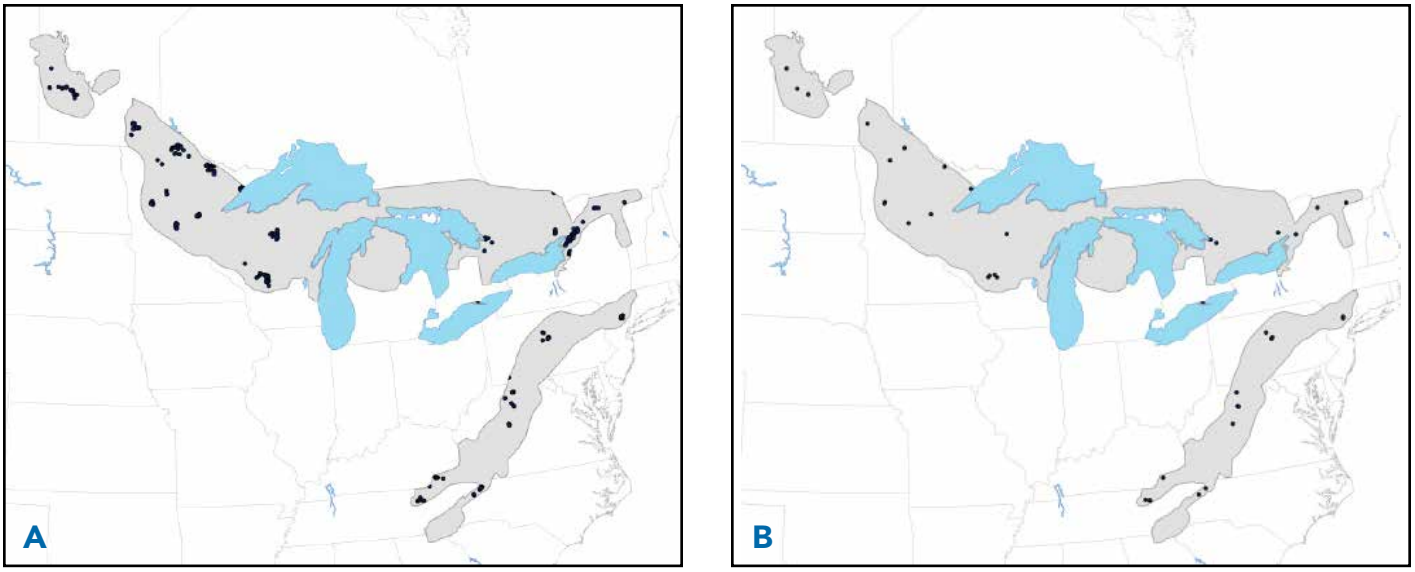


Figure AP– E2. Distribution of genotypic data (A), and the 50 unique sites identified (B).

Genotypic Correction

To correct for variation associated with the identification of cryptic hybrids in the field, a correction factor was developed. Here, the number of cryptic hybrids was divided by the total number of Golden-winged Warblers originally identified for each study site to yield a spatially explicit correction that was subsequently applied to observational data from numerous field surveys.

Predicting hybridization across the breeding range

A model was constructed to estimate the likelihood of hybridization across the current breeding range of the Golden-winged Warbler. The final model used to estimate hybridization was composed of 4 sub-models: 1) an ecological model that described the habitat characteristics of the species; 2) a climate model that estimated suitable habitat given temperature and precipitation; 3) an elevation model; and 4) a model that described the probability that both a Golden-winged and a Blue-winged Warbler co-occurred within the study area (i.e. 0.6 mi (1 km) grid cell). Model performance was evaluated using permutation and evaluation (i.e. comparison of AUC values after multiple runs of each model) so that the most likely sub-model was fed into the final model, which was evaluated in the same manner.

The locality data used in the hybrid model was a phenotypic dataset that included the latitude, longitude and species identification based on appearance. A genotypic correction (see above) was applied to the phenotypic data to correct the number of Golden-winged Warbler reported with the percentage that are likely cryptic hybrids. The phenotypic data included 37,767 occurrence points for Golden-winged Warbler and Blue-winged Warbler. Data were pooled from 5 primary sources: 1) Golden-winged Warbler Project data managed by the Cornell Lab of Ornithology (n = 8137), 2) Breeding Bird Census (n = 397), 3) Breeding Bird Atlas (n = 10,834), 4) Summer eBird records (n = 17,637; Sullivan et al. 2009), and 5) Warbler data collected by collaborators (n = 762).

The same climate, elevation and habitat characteristics identified from previous analyses as influential to the Golden-winged Warbler (Chapter 3, Part II) were examined in this analysis. A model that represented the likelihood that both Golden-winged and Blue-winged warblers were both present within the study area was estimated. The probabilities were modeled with a binomial distribution, pGW and pBW and the joint probability was $p_{GW} \times p_{BW}$.

Nest Habitat Selection

We conducted an analysis of nestsite characteristics to examine habitat selection at a smaller scale (i.e. compared with rangewide or regional analyses). Surveyors collected nest site parameters from paired observed and random locations using a standardized protocol. The following parameters were measured at seven survey locations in five states during 2008–2010:

- % Litter cover
- % Bare cover
- % Woody cover
- % Vine cover
- % *Rubus* cover
- % Other cover
- Edge distance
- Mean vegetation density
- Mean Litter depth
- Sapling height
- Shrub height
- Snag count
- Basal Area

The analysis consisted of a saddlepoint approximation (SSA) and conditional logistic regression analyses. First, an SSA analysis takes advantage of the paired observed versus random sampling scheme, which is suited to an evaluation of habitat use versus availability. Here, SSA was conducted where the upper and lower values for habitat parameters are a proxy for habitat suitability. The cumulative frequency distribution for each variable was modeled using several functions (i.e. Poisson, Gaussian) and evaluated. The model with the highest support was transformed into a probability density function (pdf). The pdf was plotted against the distribution of random points to yield the selection function for each habitat parameter. In this way, a selection function > 1 indicates selection of a habitat characteristic and a function < 1 represents avoidance (Arredondo et al. 2007). Following, a conditional logistic regression was conducted to evaluate the effects of multiple habitat parameters on nest site selection. Through all analyses and across sites, five habitat parameters best explain nest site selection by the Golden-winged Warbler (% woody cover, % forb cover, % grass cover, vegetation density, and % *Rubus* cover).

Nest Success Analysis

We examined the habitat parameters most influential to nest success in the Golden-winged Warbler. Data for Blue-winged Warbler and known hybrids were included for comparison. Nest success was measured primarily through the number of fledglings, clutch size, and mean daily survival. Analyses of clutch size and fledgling number compared to hybrids demonstrated lower overall nesting success of Golden-winged Warblers. Habitat parameters on nest survival were modeled. The explanatory power of each model was evaluated using the Akaike's Criterion including a penalty for extra parameters (AIC_c), for which the performance of a model is measured by how much information is lost (the model with the lowest AIC_c value is considered the best supported). A model of % grass cover and nest height were among the best supported (AIC_c = 945.801) compared to a model with no habitat parameters (AIC = 959.89).

Genetic-Habitat Analyses

We examined the relationship between habitat covariates and presence of the Golden-winged Warbler, Blue-winged Warbler and cryptic hybrids (hereafter, "species") using analysis of variance and regression in R v.2.14.1. Data on the vegetative community for this Genetic-Habitat project was collected from survey sites in New York, West Virginia, Tennessee, North Carolina, Pennsylvania and Wisconsin (Table AP–E2). The nested spatial scale examined plant structure and composition at 3 scales; 1m plots, 5m plots and 11.3m plots (Figure AP–E3). Data was collected during 2009–2010, though not for all sites.

Table AP– E2. Examples of vegetative characteristics examined as a function of Golden-winged Warbler, Blue-winged Warbler and hybrid presence at three scales.

Vegetation characteristic	Scale
% grass cover	1m
% forb cover	1m
% fern cover	1m
% *Rubus* spp.	1m
# shrubs 1–2m in height	5m
# shrubs > 2m in height	5m
# saplings < 10cm dbh	5m
Shrub and tree species	11.3m
Tree species diversity	11.3m
# snags	11.3m

Data was vetted and errors removed, and then aggregated into 3 datasets, one for each of the 3 spatial scales. At the 11.3m scale, we also included the as an additional habitat covariate of tree species diversity to test its effect on warbler presence. The species reported for each record was treated as the dependent variable, with 3 groups. We compared the habitat characteristics to presence as species-pair comparisons: 1) Golden-winged Warbler versus Blue-winged warbler, and 2) Golden-winged Warbler versus hybrid. We tested the hypothesis that groups differ in habitat use using a hierarchical analysis of variance approach. First, we tested the effect of the independent variables on group membership using a multivariate analysis of variance. Independent variables that were not significant to Golden-winged Warbler/Blue-winged Warbler/hybrid membership in the MANOVA were dropped from subsequent analyses. Following, we examined the difference between group means among the independent variables using a post-hoc in a univariate analysis of variance with the LSD test, which minimizes Type I errors. Bar plots were also used to visualize the habitat differences between species pairs. A series of multivariate regression analyses were conducted to identify the independent variables that were the best predictors of group membership.

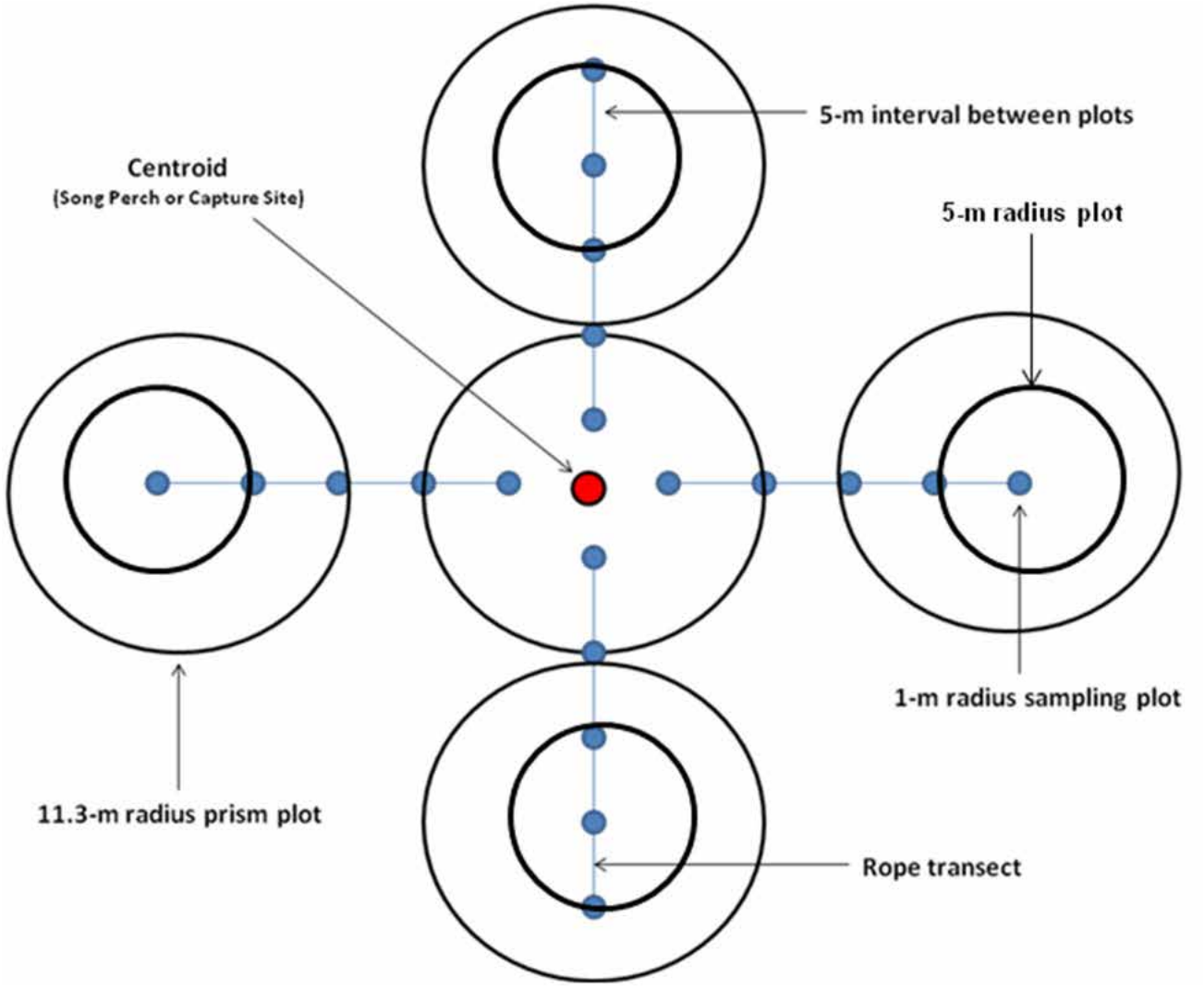


Figure AP– E3. Spatial sampling scheme for the Genetic-Habitat Project.

APPENDIX F. SPATIALLY BALANCED MONITORING PROTOCOL AND DATA FORM

The patchy nature of present-day Golden-winged Warbler distribution prevents effective surveying with traditional methods, such as the North American Breeding Bird Survey (BBS). This makes estimates of regional population size and trend difficult. To overcome these problems, the Golden-winged Warbler Working Group, under the NFWF-funded Golden-winged Warbler Conservation Initiative, developed and tested a spatially balanced sampling methodology (see page 3–75) aimed at establishing a monitoring strategy that is effective for patchily distributed species, but not overly cumbersome or costly to implement.

This spatially balanced monitoring design was pilot-tested in Pennsylvania in 2008 and throughout the Appalachian Region in 2009, and implemented successfully during the 2010 and 2011 breeding seasons. Partners in nine states, with supplemental support from USFWS, carried out Golden-winged Warbler sampling at roughly 520 points each year, giving us the ability to detect significant regional population changes. Wildlife agencies in eight states (KY, MD, NC, NJ, PA, TN, VA, WV) have committed to future monitoring of sampling points within their states.

Note: This protocol was initially developed for only the Appalachian region; however, given the BBS program has route-level data deficiencies for Michigan, Wisconsin, Minnesota, Quebec, and Manitoba, the spatially balanced monitoring protocol is being considered for expansion to the Great Lakes region as well.

Below you will find a snap shot of what was distributed to participants during the project. Included is an example of the protocol instructions and data form from a single year. Participants also received an example data form with fields pre-filled to act as a reference, an MP3 file of the playback sequence, and an excel spreadsheet for data entry that included a data dictionary to explain the various entry fields and the site locations and coordinates from the previous season.

Golden-winged Warbler Monitoring Protocol

In 2009, the Cornell Lab of Ornithology, along with partners in the Appalachian region, will broaden the application of a spatially balanced sampling design to monitor Golden-winged Warblers. In 2008, we pilot tested a similar design in Pennsylvania and now hope to apply a refined version to begin monitoring population trends throughout the Appalachians and portions of New York.

Golden-wings are patchily distributed and poorly sampled by the Breeding Bird Survey and other similar surveys; thus a long-term monitoring methodology is needed to track occupancy, relative abundance, and population trends. The methodology must be able to both monitor known sites without the biases associated with non-random sampling and ameliorate the logistical drawbacks of randomization. At the point level, the design must employ an efficient survey protocol, capable of detecting uncommon species with regularity. The points you visit this year, and in subsequent years, are a subset of 100 monitoring locations from New York to North Carolina that have been established using geo-spatial tessellation algorithms in SPsurvey(http://www.epa.gov/nheerl/arm/analysispages/software.htm). The 100 quarter Delorme pages were selected from a pool of 425 that had positive reports of golden-wings from the Cornell Lab of Ornithology's Golden-winged Warbler Atlas Project (1999-2005). We hope that by monitoring points over time, we will be able to efficiently track golden-wing populations region-wide to help formulate conservation decisions and provide early indications of potential population collapses.

Objectives for the 2009 field season

- Test the feasibility of spatially balanced sampling (monitoring) at a region-wide scale in the Appalachians.
- Determine habitat suitability status of initial 500 monitoring points (5 in each of 100 quads) and identify replacement points where necessary.
- Begin collecting population data to model occupancy, relative abundance, and population trends.
- Complete final year of field testing the passive/playback detection protocol.
- Identify imperiled subpopulations and locations for conservation action.
- Determine presence/absence of early successional indicator species at points with and without golden-wings.

Suggested Dates for Surveys

Central Pennsylvania and southern states:
May 10 to June 15
Central Pennsylvania and northern states:
May 15 to June 20

Please note, repeat visits are unnecessary for implementing the spatially balanced monitoring protocol. However, it is okay if you want to make repeat visits for your own data collection requirements.

Time of Day to Survey

Identification must be based on visual ID of the study species and, therefore, should not begin until there is sufficient light to recognize subtle differences in plumage. We recommend that you start your surveys around sunrise.

Monitoring should end by the following times:
By 11:00 am before May 20/May 25
By 10:30 am between May 20/25 and May 31/June 5
By 10:00 am between May 31/June 5 and June 15/20

Identifying Suitable Habitat

A key to the success of this monitoring protocol is to ensure that points are located in suitable golden-wing habitat. Golden-wings, blue-wings and hybrids frequently nest in dry, upland sites produced by natural succession on abandoned farmland and in openings of forest clear cuts or power-line ROWs. They also occur in alder swamps, beaver meadows, and along the edge of tamarack swamps. In dry areas the herbaceous growth usually includes goldenrod, while the shrubs include dogwood, witchhazel, raspberries, and *Viburnum*. In wetter areas the vegetation includes sedge, alder, willow, and dogwood, and sometimes cattails. They occur in young conifer plantations that still have deciduous vegetation and abundant open areas between the trees.

Golden-wing and blue-wing territories are large, typically 2-5 acres (1-2 hectares). Oblong territories often extend for 600 feet (175 meters). Territories will usually be dominated by herbaceous growth with patches of shrub, including some forested edge. Territories often include some taller trees, especially along edges, which are used as singing perches. Most golden-wing territories have less than 60% herbaceous growth and less than 10% forest cover. Most territories include patches of shrub that are over 10 feet (3 meters) tall and unmowed or ungrazed herbaceous growth. Since golden-wings are found in a wide variety of shrub habitat in natural and manipulated areas, locating suitable habitat may require some preliminary searching on your part.

Selecting New Survey Points

The latitude and longitude for your survey points have been sent to you previously. You will be surveying 5 points within each selected Delorme atlas quarter page or quad.

There are three possible reasons why you may need to select new (additional up to 5) points within a Delorme quad in addition to those that were sent to you; 1) an original point has become unsuitable, 2) there were not 5 points within the original Hybrid Index quad due to its size (small inset instead of full page), or 3) the quad was selected based on Population Survey data and did not have 5 survey points to choose from within the quad boundaries. Select your new survey points in suitable golden-wing habitat types for your region.

- Go to the closest suitable golden-wing habitat to your original point and place a new survey point at this location. Do not select a point based on prior knowledge of a golden-wing territory, however if you get to the closest suitable habitat and a previously unknown golden-wing is present, it's acceptable to use this point.
- Make sure to stay within your quad boundaries when selecting a new point.
- New survey points may be placed within the extent of suitable habitat if accessible or along existing roads, trails, and public rights-of-way (ROW) that border the habitat.
- New survey points should be at least 400 meters (0.25 miles) from any existing points to ensure that you don't count the same birds twice.
- More than one survey point may be established in the same block of habitat as long as all the points are at least 400 meters (0.25 miles) apart.
- Be sure to mark the exact location of each survey point by using a GPS unit and record your coordinates on the data form in decimal degrees.

Field Surveys

The field protocol combines a standard passive point count with audio playback. It is very similar to the Golden-winged Warbler Atlas Project protocol, except that the initial GWWA Type I song sequence has been lengthened to 5 minutes and a mobbing sequence has been added. The total protocol lasts for 17 minutes.

This protocol is being used to test the relative effectiveness of the three components (passive observation, conspecific playback, mobbing playback) at detecting golden-wings. Always use the "GWWA PB first" track for this protocol.

1) Passive Point Count: Begin with a 3-minute point count (silent watch and listen period) divided into 3, 1-minute time bands. All detections should be recorded in the appropriate 1-minute band on the data form. Remember to record early successional indicator species.

2) Conspecific Playback: This 8-minute golden-wing sound file is included with all silent periods built into the track. Record all detections in the appropriate 1-min time band on the data form.

5-min GWWA Type I
1-min silent observation period
1-min GWWA Type II
1-min silent observation period

3) Mobbing Playback: This 6-minute mobbing sequence (Black-capped Chickadee and Eastern Screech-Owl) sound file is included. Record all detections in the appropriate 1-min time band on the data form.

5-min Mobbing Sequence
1-min silent observation period

- When conducting playback, set the volume so it sounds natural to your ear when listening to a golden-wing.
- Golden-wings, blue-wings, and hybrids sing the same Type II song so it is important to get a visual ID of each bird.
- During the playbacks and observation periods, make sure to search in all directions for golden-wings, blue-wings, and hybrids. Individuals may fly in from great distances, may approach silently, or may fly back and forth past the speaker.
- **NOTE: Finish the entire protocol even if a golden-wing is detected before the end of the third sequence.**

Completing the Data Form

Please use one data form per Delorme Atlas Quad and the associated 5 survey points.

All data should be entered into the Excel spreadsheet provided by Cornell and hard copies mailed to the address below at the end of the season. If you have questions, please contact:

Sara Barker
Cornell Lab of Ornithology
159 Sapsucker Woods Rd.
Ithaca, NY 14850
607-254-2465
sb65@cornell.edu

The following instructions refer to the Point Status, Location Data, Habitat Data, and Bird Data sections on the dataform. Please complete the Point Status, Location Data, and Habitat Data sections on the same day as your bird survey if possible. All habitat related data refer to an area within a 150-m radius from the survey point.

Point Status

Stand at the original survey point and evaluate whether or not the habitat surrounding you continues to be suitable for golden-wings. If yes, mark the yes block under the appropriate point number and move to the next section on your data form. If no, please mark the box that most closely describes why the habitat has become unsuitable and describe if necessary. Refer to the *Selecting New Survey Points* section for detailed instructions about how to select a replacement for unsuitable points.

Location Data

Give a very brief location description, such as distance to prominant land marks like roads, bodies of water, towns, etc.

Record county and latitude and longitude in decimal degrees from a GPS unit at the time of your survey. Make sure to record a latitude and longitude for ALL points, not just the newly created points.

Habitat Data

- HABITAT CODE (within 150-m radius)

Please write the one habitat code from the list at the bottom of the form that best applies to your site. If you choose MOSAIC, list all applicable habitat codes in parentheses after MOS. If you choose the 'other' habitat codes (UP or WE) describe in the comments section.

AF (upland abandoned farm) an early stage of succession, over 50% herbaceous cover that was once used for agriculture.

CC (upland clearcut) an area of intentionally managed forest, recently clearcut. The stumps and/or growth of saplings from stumps is visible (Succession=EARLY).

PB (upland pine barren) sandy areas with scattered pine trees.

SHF (upland shrubby field) essentially open, but with patches of dense, woody stems under 20 feet (6 meters) covering much of the survey site. Can have scattered tall trees. (Succession=EARLY) Does not include harvested forest (clearcuts).

SM (upland abandoned strip mine)

SUF (upland successional forest) young forest, other than clearcut, dominated by woody stems greater than 20 feet (6 meters). Includes young conifer plantings. (Succession=MIDDLE or LATE).

UP (other upland habitat) if not covered by the above categories. Make sure this is not MOSAIC.

UT-U (upland utility right-of-way) a gas pipeline or electrical transmission line in an upland or dry area.

BW (beaver wetland) wetlands created or enlarged by beaver activity.

HS (hardwood swamp) dominated by hardwood trees greater than 20 feet (6 meters).

SEM (sedge grass wetland) mostly sedge meadow with small clumps of shrubs and/or small aspen or hardwood islands.

TB (tamarack bog) bog/swamp dominated by tamarack trees (or other conifers).

UT-W (wetland utility right-of-way) a gas pipeline or electrical transmission line in a wetland.

WE (other wetland) if not covered by the above wetland categories. Make sure this is not MOSAIC.

WS (shrub wetland) wetland/swamp, lowland shrub community with deciduous shrubs throughout and/or along the edge (AL habitat descriptor if >60% alder).

MOS (mosaic) if your site is made up of two or more habitat types, use MOS followed by all applicable habitat codes (example: MOS (SHF/WS/SUF)).

- HABITAT DESCRIPTOR (within 150-m radius)

Record the predominant species at your survey point.

AL (alder) dominated (> 70%) primarily by alder shrubs.

AP (aspen) dominated (> 70%) primarily by aspen trees.

CF (conifer forest) pine plantations, black spruce, jack pine, cedar, etc., with > 75% conifers.

MHC (mixed hardwood & conifer) with at least 10% conifers.

NH (northern hardwoods) 90% or more mixed hardwoods--birch, red oak, maple, aspen, etc.

OT (other species) dominated (> 70%) primarily by some other species; name the species.

- ELEVATION

Note the elevation from your GPS unit at your survey point in feet. **Record one number, not a range.**

- EXTENT OF POTENTIAL HABITAT

Estimate the extent of potential Golden-winged Warbler habitat at your survey point in acres. This may be the same for several points that fall within the same habitat patch. If you can't clearly see the extent of the habitat, try to use a map to help determine the size. **Record one number, not a range.**

- SUCCESSION (within 150-m radius)

List the stage of succession based on the age and size of trees.

EARLY seedlings and small saplings; trees < 20 feet tall, about 0-6 years old, or < 1.2 inch DBH on average.

MIDDLE large saplings and pole timber; trees 20-40 feet tall, about 6-20 years old, or 1.2 - 4.7 inches DBH on average.

LATE large pole and saw timber; trees > 40 feet tall, > 20 years old, or > 4.7 inches DBH on average.

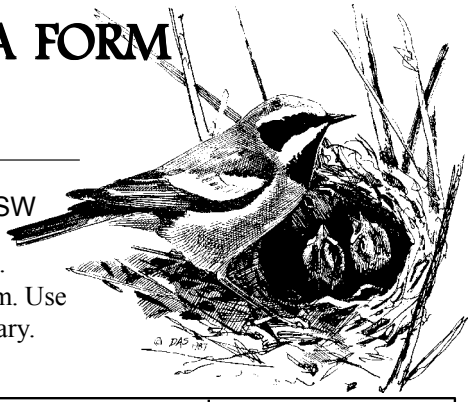
Bird Data

- Record all relevant bird observations in each of the 17-time bands. Use the codes that are provided at the bottom of the Bird Data section of your data form. Make sure to put a zero in the time band if nothing is detected, thus there should be a code or zero in every time band. See scanned example form.
- Circle the species code in the appropriate time band when visual confirmation of each indivdual is made for the first time. Your bird might already be singing. You only need to circle an individual once.
- If a hybrid is detected, please differentiate the hybrid type and record either Brewster's Warbler, Lawrence's Warbler, or introgressed (a weird looking hybrid that does not conform to the stereotyped plumage designations).
- Although we are most interested in the abundance of golden-wings, blue-wings and their hybrids, please also record the presence of other early sucessional indicator species (BRTH, FISP, PRAW, EATO, WIFL) using the codes provided **only during the passive point count period.**
- Provide notes in the comments section if any behavioral or breeding information is observed.
- Keep copies of all data forms and maps for your records.

Thank you for participating!

GOLDEN-WINGED WARBLER DATA FORM

MONITORING PROTOCOL



Observers _____ State _____

Delorme Atlas Page _____ Quad (1/4 Delorme page) ☐ NE ☐ NW ☐ SE ☐ SW

Survey the 5 assigned points in each Delorme Atlas Quad (check appropriate box above). Be sure to record within the correct time band under "Bird Data" on the back of the form. Use the comments section on the back to provide more detail about any section if necessary.

POINT STATUS:

Point No.	1.	2.	3.	4.	5.
Point in suitable GWWA habitat?	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no	☐ yes ☐ no
If not suitable, then why? (check box, then describe in cell as best as possible below other)	☐ succession ☐ development ☐ other (describe)	☐ succession ☐ development ☐ other (describe)	☐ succession ☐ development other (describe)	☐ succession ☐ development ☐ other (describe)	☐ succession ☐ development ☐ other (describe)

NOTE: If original point is unsuitable, make sure to establish a NEW point in the closest suitable GWWA habitat (see protocol instructions for details) and be sure to check the "new point" box beside the appropriate point number below.

LOCATION DATA: Make sure to record a latitude and longitude for EVERY point, even if it's not new.

Point No.	1. ☐ new point	2. ☐ new point	3. ☐ new point	4. ☐ new point	5. ☐ new point
Location (brief description)					
County					
Latitude					
Longitude					

HABITAT DATA: Habitat, Descriptor, and Succession codes are listed below. All variables apply to a 150-m radius circle around the point (see protocol instructions for details). Record a single value, not a range and only one habitat code unless within a mosaic.

Point No.	1.	2.	3.	4.	5.
Habitat code					
Habitat descriptor					
Elevation-ft					
Extent of potential habitat - acres					
Succession					

HABITAT CODES

AF (upland abandoned farm)
CC (upland clear cut)
PB (upland pine barren)
SHF (upland shrubby field)
SM (upland abandoned strip mine)
SUF (upland successional forest)
UP (other upland habitat)
UT-U (upland utility ROW)
BW (beaver wetland)
HS (hardwood swamp)
SEM (sedge wetland)
TB (tamarack bog)
UT-W (wetland ROW)
WE (other wetland)
WS (shrub wetland)
MOS (mix, list all)

HABITAT DESCRIPTOR

AL (alder)
AP (aspen)
CF (conifer forest)
MHC (mixed hardwood/conifer)
NH (northern hardwoods)
OT (list other dominant sp)

SUCCESSION

Early, Middle, or Late

BIRD DATA: Record bird observations in each of the 17-time bands by using the codes at the bottom. Put a zero in the time band if nothing is detected, thus there should be a code or zero in every time band. Circle the species code in the appropriate time band when visual confirmation of each indivdual is made for the first time.

	Point No.	**1.**	**2.**	**3.**	**4.**	**5.**
	Date					
	Time					
TIME BANDS — Passive Pt. Count	1:					
	2:					
	3:					
Conspecific Playback (CPB)	1T1:					
	2T1:					
	3T1:					
	4T1:					
	5T1:					
	6OB:					
	7TII:					
	8OB:					
Mobbing Playback (MPB)	1M:					
	2M:					
	3M:					
	4M:					
	5M:					
	6OB:					
	Total of each spp.					

Use these codes to note study species, # of individuals, and sex in EVERY time band:

Golden-winged Warbler = G **Lawrence's Warbler = L**
Blue-winged Warbler = B **Introgressed = I**
Brewster's Warbler = R **female = f (lower case f next to sps. code)**

Use these codes to note other species, in the 3 PASSIVE POINT COUNT time bands:

Brown Thrasher = T **Prairie Warbler = P** **Willow Flycatcher = W**
Field Sparrow = F **Eastern Towhee = E**

If no birds are detected in a given time band, mark a 0 (zero) in that box.

Circle the species code in the appropriate time band, the FIRST time the bird is seen visually (the bird might already be singing).

COMMENTS

APPENDIX G. GOLDEN-WINGED WARBLER FIELD SURVEY PROTOCOL

This protocol is used by state cooperators and other research partners who are implementing the Appalachian Region spatially balanced sampling design or other monitoring efforts that are aimed at accessing regional long-term trends, relative abundance estimates, or occupancy.

This field protocol combines a standard passive point count with audio playback and can be used within any sampling framework. The complete spatially balanced sampling design methodology, digital audio file for playback, and data forms can be obtained from Sara Barker **sb65@cornell.edu** at the Cornell Lab of Ornithology.

1. **Passive Point Count:** begin with a 3-minute point count (silent watch and listen period) divided into 3, 1-minute time bands. All detections should be recorded in the appropriate 1-minute band on a data form. It is a good idea to record any associated early successional bird species during this period.

2. **Conspecific Playback:** broadcast 8-minute Golden-winged Warbler audio sequences with built in silent periods. Record all detections by 1-minute time bands on a data form.

   5-min Golden-winged Warbler Type I

   1-min silent observation period

   1-min Golden-winged Warbler Type II

   1-min silent observation period

3. **Mobbing Playback:** broadcast 6-minute mobbing sequence (Black-capped Chickadee and Eastern Screech-Owl). Record all detections by 1-minute time band on a data form.

   5-min Mobbing Sequence

   1-min silent observation period

Additional Information:

- When conducting playback, set the volume so it sounds natural to your ear when listening to a Golden-winged Warbler.
- Golden-winged Warblers, Blue-winged Warblers, and hybrids sing the same Type II song so it is important to get a visual ID of each bird.
- During the playback and observation periods, make sure to search in all directions for Golden-winged Warblers, Blue-winged Warblers, and hybrids. Individuals may fly in from great distances, may approach silently, or may fly back and forth past the speaker.
- Finish the entire protocol even if a Golden-winged Warbler is detected partway through the protocol.

APPENDIX H. PROCEDURES FOR EVALUATING GENETIC PURITY OF A GOLDEN-WINGED WARBLER POPULATION

How Many Individuals Do You Need to Sample?

Ideally, we recommend collecting genetic samples from a minimum of 50 adult individuals for each site or group of nearby sites, thus this may take multiple years of collection. This many samples are necessary to adequately estimate the genetic introgression rate, especially where cryptic/genetic hybrids are relatively rare.

Golden-winged Warbler Genetic Atlas

Please submit your genetic results to the Fuller Evolutionary Biology Lab at the Cornell Lab of Ornithology (159 Sapsucker Woods Road, Ithaca, NY 14850 USA) for inclusion in the international Golden-winged Warbler Genetic Atlas. For each sample collected include information on the collector (name, institution, address, email, phone #), GPS coordinates of capture site, name of capture site, and bird specifics (sex, age, USFWS/CWS band#). The Atlas provides a broad picture of genetic introgression across North America and will allow continuity in tracking genetic introgression at specific sites through time by providing a central location for housing these data.

Standard Operating Procedures for Collecting Blood, Feathers and Claws from Birds

Prior to collecting samples, please make sure you have completed the following:

1. Confirmed that you know what you need to do to properly collect, store, and ship the samples to a genetics lab. Ensure that the lab where you will send the samples has the capability to analyze them and that you have communicated in advance regarding the most appropriate storage method for samples (e.g. feather, blood collected on filter paper, blood collected in a lysis buffer). Also, you should know what data from the bird, capture site, and collector need to be supplied before heading to the field.

2. Acquired all necessary capture and collection permits (e.g. USGS Bird Banding Lab Federal Bird Banding permit or Environment Canada Scientific Permit to Capture and Band Migratory Birds, relevant state/provincial agency permits), as well as Institutional Animal Care and Use approvals. If the lab is in another country, then you may need an export permit, the lab may need an import permit, and a zoo sanitary certificate.

3. The collector has received training for proper and safe collection of the samples.

General Instructions

Please be careful and considerate of the birds you sample. No data point is worth causing unnecessary stress or death.

If you have not taken blood samples before, it is very important that you obtain your initial training from someone who has experience with these or similar protocols. Taking blood samples is simple once you have practiced, but no set of instructions can replace hands-on instruction. If birds are handled carefully, bleeding should result in zero mortality and no lowered fitness of sampled birds (Sheldon et al. 2008).

Needles and Glass Hematocrit Tubes (capillary tubes)

Used disposable needles and hematocrit tubes **must not** be bent, sheared, broken, recapped or otherwise manipulated by hand before disposal; rather, they must be carefully placed in a disposal container and disposed of as regulated medical waste in accordance with regulations set out by your academic institution.

For adult warblers, you should be using 27 gauge sterile needles. They can be purchased from Fischer Scientific for $10.45/100 needles. Catalogue number: 14-826-48, Item number: 305109, **www.fishersci.com/ecomm/servlet/cmstatic?href=index.jsp&store=Scientific&segment=scientificStandard&&storeId=10652**

Do not dispose of needles in the regular solid waste stream.

Blood Collection Instructions

1. Once you have a bird in hand, prepare the needle by loosening it from its cap. Remove a hematocrit tube from its container and have it easily available with a piece of cotton and the rubbing alcohol out and ready to grab. Once you pierce the vein, you want to move quickly for all of the following steps.

2. Hold the bird with the wing extended. Find the brachial vein and use a Q-tip dipped in rubbing alcohol to dampen the feathers around the vein. The alcohol will help hold the feathers away from the vein and will also cause the vein to thicken slightly. Be cautious to not apply too much alcohol, especially in cold weather. Some people use Vaseline to dampen the feathers — the choice is up to you. If you do use Vaseline make sure you apply only a very thin layer to the area.

3. Prick the vein with a needle, using a new sterile needle for each bird. Place the used needle in a "sharps" waste container without recapping it. While in the field, a small soda bottle wrapped in duct tape works well as a sharps container.

4. Use a capillary tube to draw up the drop(s) of blood. For our purposes, a single large drop is sufficient. Blood will coagulate in the tube if left there for any length of time, so immediately transfer (see note 1 below) the blood to a lysis-buffer tube and mix well by capping the tube and shaking. Don't simply place the capillary tube into the buffer or the blood will clot. Place the used capillary tube into the sharps waste container.

5. Place a piece of cotton over the site of venipuncture, close the wing, and apply gentle pressure to stop any further bleeding.

6. Label lysis buffer tube (see note 2 below) and fill in the data sheet before processing another bird.

Notes and Suggestions

1. There are two ways to transfer blood from capillary tubes to sample tubes. If you use a capillary tube bulb to hold your capillary tube, you can blow the blood out of the cap tube by squeezing the rubber stopper of the bulb. Practice using some drops of water if you have not tried this method in the past. The alternative method is to blow gently across the top of the capillary tube **without touching your mouth or lips to the tube** (for your own health and safety). Be sure to mix the blood and lysis buffer immediately by inverting or gently shaking the capped tube.

2. When labeling tubes and envelopes, it is critical to label them as you use them, one by one. Sample switches can easily occur if there are multiple, unlabeled tubes in your work area. Label each tube using a sharpie marker with the unique ID number of the bird (preferably the USFWS/CWS band number) and the four-letter alpha code (e.g. GWWA = Golden-winged Warbler, BWWA = Blue-winged Warbler). Please put this information on the top and side of the tube. Also include the date of capture.

3. If you can't get a good bleed please don't release the bird prior to pulling a feather sample. DNA from feathers is not as good, or as plentiful, as DNA from blood, but it's preferable to not getting a sample at all. See the feather collection section below.

Data Sheets

Please create a datasheet like the one below in which to enter every bird that you capture. Note that the datasheet should include information with your contact information and the locations where you obtained samples, in addition to information about the individual birds you sampled. The fields that are important to include on a data sheet:

1. Location of capture (i.e. site name)
2. State/province
3. Name of collector/bander
4. Species (by phenotype)
5. Date
6. FWS/CWS band number
7. Age (HY, SY, ASY)
8. Sex
9. Song type (GWWA or BWWA)
10. LATITUDE of capture site (in decimal degrees, e.g. 36.19442)

11. LONGITUDE of capture site (in decimal degrees, e.g. -84.39111)
12. Notes (e.g. plumage abnormalities)
13. Blood collected? (Y or N)
14. Feather collected? (Y or N)
15. Claw clipping collected? (Y or N)

GWWA, BWWA, & HYBRID BANDING DATA															
	Location of capture	State	Name of bander	Species (phenotype)	Date	FWS band #	Age (HY, SY, AHY)	Sex	Song (GWWA or BWWA)	LATITUDE of capture site (in decimal degrees, e.g. 36.19442)	LONGITUDE of capture site (in decimal degrees, e.g. -84.39111)	Notes (e.g. plumage abnormalities)	Blood taken? (yes or no)	feathers?	clawclips?
1															
2															
3															
4															
5															

Storage of Blood Samples

DNA in blood preserved in the lysis buffer below is stable at room temperature and should not be frozen. If possible, store the samples in a refrigerator, but this is not at all critical. It is important to keep the samples out of direct sunlight or other heat sources.

Lysis Buffer Ingredients: 100 mM TRIS, 100 mM Na_2EDTA, 10 mM NaCl, 0.5 % SDS (2.0% SDS if going to be shipped internationally)

Hallux & Feather Collection (see diagram below if needed)

In order to obtain a claw sample please use small, sharp scissors and cut the very end of the hallux claw (Figure AP–H1). Keep in mind that the claw may bleed if you cut too far and hit the quick. Included below is a diagram that shows approximately where you should cut. It ends up being about a 1.5mm piece in Golden-winged Warbler.

Place the claw sample in an empty sample tube and label as detailed above in note 3. This is a very fiddly process and thus recommend doing the cutting over a blank piece of white paper so that you can see where the claw samples lands.

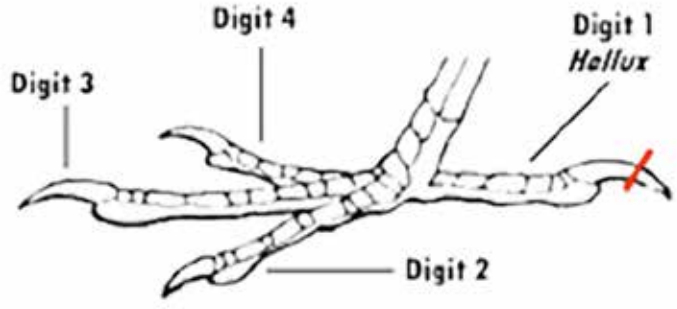


Figure AP– H1. Diagram showing approximately where the hallux should be cut, about a 1.5 mm piece in a Golden-winged Warbler.

Feathers provide a back-up DNA source and can also be used in a stable isotope study that will help us link breeding and wintering grounds of Golden-winged Warblers.

Please pull the following feathers (Figure AP–H2) and place them in a small envelope:

- P1
- R3 or R1 (**Please make a note of which one you pull)
- 3 or 4 black facial mask feathers
- 1 claw sample (hallux)

The best way to obtain a P1 or R feather is to grasp the feather at the base (where it attaches to the body) and pull it out in one quick motion. The facial feathers may be easier to obtain with tweezers.

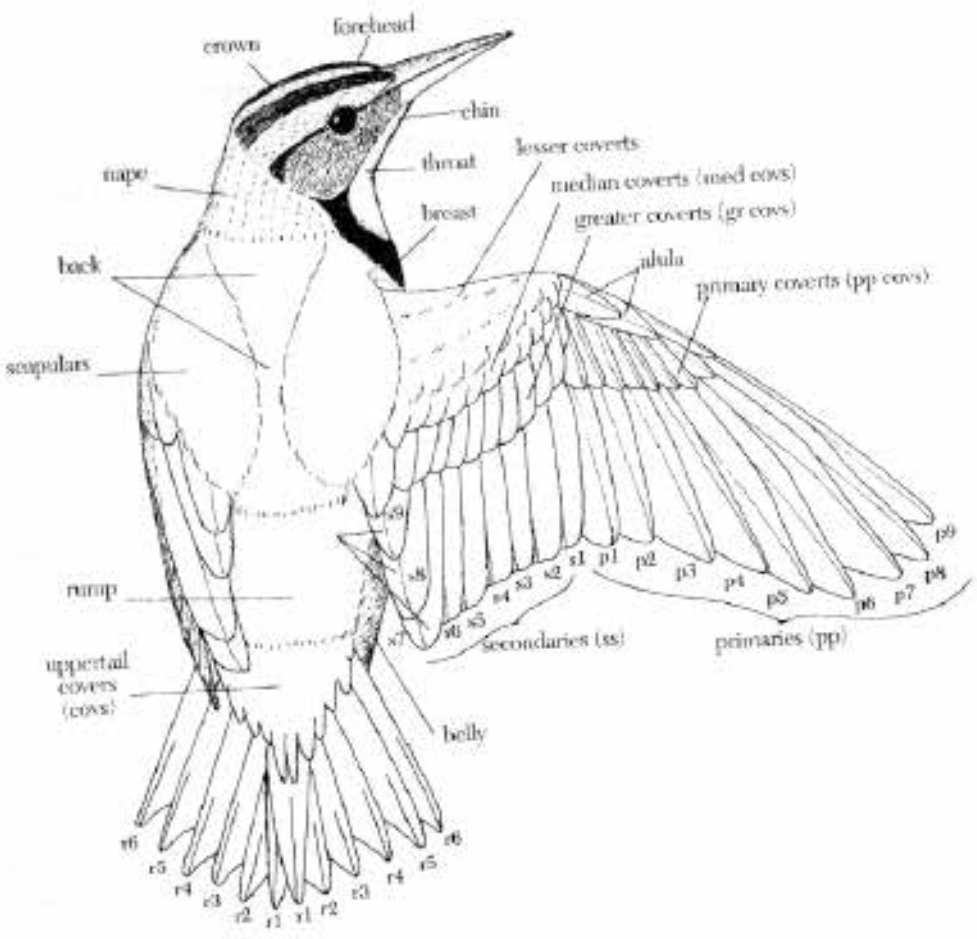


Figure AP-H2. Diagram showing a bird's body and facial feathers.

Photographs and Identification Issues (if possible)

It is helpful to photograph (either using film or a digital camera) the birds from which you obtain genetic samples. Traditionally, all studies of avian systematics were based on vouchered specimens permanently archived in museum collections. In this case, a photograph can serve as a partial voucher in the sense that it preserves an independent record of the bird's phenotype.

Photographs will be particularly useful in studies of hybridizing taxa where the photographs can be used to generate a 'hybrid index' of plumage traits.

Alianza Alas Doradas

American Bird Conservancy

Appalachian Mountains Joint Venture

Audubon North Carolina

Ecosystem Science Center

Environment Canada

Focus on Energy

Forest Resources & Environmental Science
Michigan Tech

Golden-winged Warbler Working Group

Indiana University of Pennsylvania

Ithaca College

National Fish and Wildlife Foundation

Pennsylvania Department of Conservation and Natural Resources

Pennsylvania Game Commission

Ruffed Grouse Society

Tall Timbers
Stewards of Wildlife & Wildlands

The Cornell Lab of Ornithology

The Garden Club of America

University of Maine

University of Minnesota

University of Tennessee

U.S. Fish & Wildlife Service

U.S. Forest Service

West Virginia Division of Natural Resources

West Virginia University

Wisconsin Society for Ornithology

WV CFWRU

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