PART FOUR

Synthesis and Future Directions

CHAPTER THIRTEEN

Conservation Perspectives*

REVIEW OF NEW SCIENCE AND PRIMARY THREATS TO GOLDEN-WINGED WARBLERS

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Abstract. In this penultimate chapter, we examine new perspectives on ecology of Golden-winged Warblers (*Vermivora chrysoptera*), review primary population-level threats, and offer conservation recommendations. Adequate forest cover and patch-level habitat configuration are important for successful reproduction and to buffer against negative interactions with Blue-winged Warblers (*V. cyanoptera*). We recommend landscape-scale forest cover of 50%–100% and meso-scale (500-m radius) habitat designs that provide nesting habitat bounded by a mosaic of structurally diverse, multiple age-class forest or connected to such forest by dispersal corridors <200 m in length. The primary threat to breeding and nonbreeding Golden-winged Warbler populations is land-use change, resulting in forest conversion to human development and agriculture. In the Great Lakes breeding-distribution segment, which holds 95% of the global breeding population, we recommend protection and improvement of existing habitat, whereas we recommend critically needed habitat creation in the Appalachian Mountains breeding-population segment. At the nonbreeding grounds, we recommend protection of humid forest at 700–1,400 m elevation, establishment of a system of national forest reserves, and promotion of agroforestry, such as Integrated Open Canopy Coffee. Given that Golden-winged Warblers likely use a migration pathway across the Gulf of Mexico, which is similar to many other Neotropical migrants, we recommend a general strategy of protecting coastal Gulf of Mexico stopover locations. Last, protection of inland migration pathways such as ridge tops and riparian forests along major river systems could also confer benefits to Golden-winged Warblers.

INTRODUCTION

Devising conservation strategies for Neotropical migrant landbirds, such as Golden-winged Warblers (*Vermivora chrysoptera*), is complicated by a remarkable life cycle that includes a latitudinal migration covering thousands of kilometers and separate breeding and nonbreeding distributions with different ecological conditions and threats. The diverse science presented in this Studies in

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Avian Biology volume, ranging from regional studies of postfledgling survival to broad inquiries about migratory connections that potentially stretch from Manitoba to Colombia, underscores the complexities of understanding Golden-winged Warbler ecology and conservation, not only at one point in space or time, but across all stages of the annual life cycle—breeding, migrating, and nonbreeding.

During the 1990s and early 2000s, Golden-winged Warbler conservation efforts were opportunistic, site-specific, and largely focused on the Appalachian Mountains. Researchers and managers, often working at local scales, protected and maintained human-modified (e.g., utility rights-of-way and surface mines) and natural (e.g., forested wetlands) habitats occupied by breeding Golden-winged Warblers (Canterbury and Stover 1999, Confer and Pascoe 2003, Kubel and Yahner 2008). Recently, the first guide to Best Management Practices (Bakermans et al. 2011) and comprehensive conservation plan (A. M. Roth et al., unpubl. plan) have taken a more systematic, distribution-wide approach to Golden-winged Warbler conservation. A. M. Roth et al. (unpubl. plan) provided a strategic, spatially explicit approach to setting population and habitat goals, identifying threats, delineating high-priority focal areas, and making habitat management recommendations. Guidance provided by these publications has been used across the breeding distribution to improve and create habitat. For example, the Golden-winged Warbler is one of seven species targeted for conservation via the U.S. Department of Agriculture, Natural Resource Conservation Service's Working Lands for Wildlife program. In the Appalachian Mountains during 2012–2015, the working lands program created 3,700 ha of Golden-winged Warbler habitat on private lands by using science-based habitat management prescriptions based on Bakermans et al. (2011, 2015) and A. M. Roth et al. (unpubl. plan).

The new science in this volume provides fresh viewpoints on the challenges facing Golden-winged Warbler populations and the strategies required to implement effective conservation practices. Continued steep population declines in the Appalachian Mountains breeding-distribution segment and broadening declines in the Great Lakes breeding-distribution segment emphasize the urgency in addressing known threats. In this chapter, we (1) examine results from this volume that yield new perspectives on Golden-winged Warbler conservation needs, including suggestions for updating current management prescriptions, and (2) review primary population-level threats and offer strategies for ameliorating these in the context of full life-cycle conservation planning. There is growing need to better understand the connectivity among different life-cycle phases. We have organized this chapter around the breeding, nonbreeding, and migrating stages, and identify potential linkages where possible. We conclude with a discussion of the need for quantitative, full life-cycle models to identify spatiotemporal population constraints and more efficiently direct conservation resources for the greatest positive impact on the global Golden-winged Warbler population.

BREEDING

New Conservation Perspectives

Status and Distribution

Effective conservation planning requires detailed knowledge about the distribution and abundance of target organisms on the landscape, especially as populations rapidly decline or undergo geographic shifts in response to environmental changes (Faaborg et al. 2010). Rosenberg et al. (Chapter 1, this volume) point out the inadequacy of available monitoring programs to track current population trends and distribution shifts in patchily distributed Golden-winged Warbler populations. The North American Breeding Bird Survey is now ineffective at monitoring Golden-winged Warbler population trends and distribution in the Appalachian Mountains breeding-distribution segment because birds are detected on too few survey routes. The same issue is a concern in portions of the Great Lakes breeding-distribution segment, and the problem will likely become more systemic in coming years as fewer Golden-winged Warblers are available to be detected on each route. A related issue is the lack of knowledge about what is driving population dynamics and shifts in distribution of Blue-winged Warblers (*V. cyanoptera*). Hybridization and competitive exclusion by Blue-winged Warblers may be drivers of Golden-winged Warbler population declines (Buehler et al. 2007). However, few research projects and no targeted monitoring projects for Blue-winged Warblers have been undertaken in the past decade.

This basic lack of data is an obstacle to understanding Golden-winged Warbler ecology and population dynamics at a distribution-wide scale where it is difficult to compare the relative influence of habitat loss, nonbreeding-season survival, and climate change against the influence of interactions with Blue-winged Warblers.

Rohrbaugh et al. (2011) developed a spatially balanced, occupancy-based monitoring program for Golden-winged Warblers in the Appalachian Mountains breeding-distribution segment. We recommend establishment of a similar standardized, distribution-wide program capable of tracking Golden-winged and Blue-winged Warbler breeding populations at multiple spatial scales. A standardized protocol will allow biologists, managers, and ultimately policy makers to measure population response to management actions and refine conservation strategies.

Habitat Requirements and Reproduction

Emerging science documents the importance of adequate forest cover at all spatial scales for successful Golden-winged Warbler reproduction and possibly as a buffer against negative interactions with Blue-winged Warblers (Streby et al. 2014; Chapters 3, 5, 8, and 9, this volume). Crawford et al. (Chapter 3, this volume) reported that landscape-scale settlement patterns of Golden-winged Warblers were positively associated with increasing forest cover and higher elevations but negatively associated with increasing agriculture and human development. In contrast, Blue-winged Warblers showed the opposite relationship with the same covariates and were more commonly associated with agriculture. These new findings are important in understanding and mitigating for land-use patterns at landscape scales, which are driving interspecific spatial interactions and may facilitate competitive exclusion or hybridization. For example, in the absence of a strong elevational gradient, does an increase in agricultural cover in the landscape facilitate co-occurrence or increased frequency of hybridization between Golden-winged and Blue-winged Warblers?

A. M. Roth et al. (unpubl. plan) recommended focusing Golden-winged Warbler breeding habitat management on sites with 50%–75% forest cover within 2.5 km. Although this recommendation is consistent with results in Crawford et al. (Chapter 3, this volume), we see no reason to cap the range at 75%, as occupancy has not been shown to decline above this percentage (Thogmartin 2010; Chapter 3, this volume). Moreover, a recent study that examined Golden-winged Warbler habitat use in New York and Pennsylvania suggests working in landscapes with >70% forest cover (Wood et al. 2016). Also, in light of a positive correlation between Blue-winged Warblers and agricultural and human-developed landscapes, conservation projects in landscapes (2.5-km scale) with >25% combined agricultural and urban cover should be considered lower priority relative to those in landscapes with <25% of these cover types. One exception to this recommendation would be projects focused on reforesting large portions of open land-use types, such as reclaimed surface mines that are widespread in some portions of the Appalachian Mountains breeding-distribution segment.

Forest that is more mature than that used for primary nesting sites is essential, not only in the larger landscape, but also adjacent to Golden-winged Warbler breeding territories, where it has been shown to be used by adults and is important for fledgling survival (Streby et al. 2014; Chapters 5, 8, and 9, this volume). The results underscore the importance of considering not only cover-type composition, but also configuration within and among Golden-winged Warbler management sites. To better incorporate adult and postfledging habitat requirements, mesoscale habitat designs (e.g., within 500-m radius) should provide potential nesting habitat in shrubland or young forest that is bounded by structurally diverse, multiple age-class forest (at least one home-range size or ≥6 ha, see Chapter 5, this volume) or connected to such forests by dispersal corridors no longer than 200 m (Chapters 5 and 10, this volume). Functionally, conservation plans should maintain dynamic forested landscapes with a shifting mosaic of forest-patch sizes and ages, where the interior of clustered young forest patches is <200 m from the edge of surrounding older age-class forest.

Primary Threats and Conservation Actions

The primary threat to Golden-winged Warbler breeding populations is land-use change through conversion of forest to agriculture or other human development, resulting in habitat loss and reduction in habitat quality by creating inappropriate landscape and patch-level configurations. These landscape changes facilitate negative interactions with Blue-winged Warblers (Chapters 3 and 4, this volume) and impair reproduction and fledgling survival (Chapters 8 and 9, this volume). Compounding the problem of land-use change, an overall maturing of forest within significant parts of the Golden-winged Warbler's breeding distribution, combined with lack of natural disturbances and forest management, has reduced regeneration of early successional habitats used by Golden-winged Warblers for nesting.

A. M. Roth et al. (unpubl. plan) set a goal of restoring the global Golden-winged Warbler population from the current estimate of 414,000 to 621,000 individuals by 2050. Currently, the Great Lakes breeding-distribution segment is estimated to hold 95% of the global breeding population, with only 5% in the Appalachian Mountains breeding-distribution segment (Chapter 1, this volume). The imbalance is increasing as populations are declining more rapidly in the Appalachian Mountains breeding-distribution segment than in the Great Lakes segment. Data from the U.S. Forest Service's Forest Inventory Analysis indicate that opportunities to create new habitat are greater in the Appalachian Mountains segment, where presently only about 7% of forest is suitable for Golden-winged Warblers compared with 19% suitable forest in the Great Lakes segment (A. M. Roth et al., unpubl. data). A. M. Roth et al. (unpubl. plan) suggested that landscape-scale forest management should strive to perpetually keep 15%–20% of forest in an early successional stage for Golden-winged Warblers and associated bird species. Following this guidance, the proportion of early successional forest in the Appalachian Mountains breeding-distribution segment could be more than doubled before the 15%–20% threshold is met, whereas the Great Lakes segment is already near the recommended maximum. Given the imbalance in initial population size and opportunities for habitat and population growth, different conservation strategies are required to address the threat of land-use change in each breeding-distribution segment.

The most important conservation actions for Golden-winged Warblers in the Great Lakes breeding-distribution segment are to:

1. Improve the quality of existing habitat by altering forest configuration and structure, following recommendations in Roth et al. (2014, unpubl. plan) and the new science presented in this volume.
2. Prevent a net loss of habitat, especially on private lands, which support about 70% of the current breeding distribution (North American Bird Conservation Initiative 2013).
3. Protect significant populations on public land, particularly in places where surrounding unprotected land is likely to undergo extensive land-use change.
4. Increase cooperation among conservation groups to ensure management for associated species, such as American Woodcock (*Scolopax minor*) also benefits Golden-winged Warblers (Bakermans et al. 2015).
5. Work collaboratively with Canadian officials to facilitate population expansion in northern latitudes where genetic purity of subpopulations is still high (Vallender et al. 2009; Chapter 4, this volume).

Conservation actions in the Appalachian Mountains breeding-distribution segment are necessary to maintain the species within portions of its historical breeding distribution (Chapter 1, this volume). Nonbreeding season loss of individuals from the vanishingly small Appalachian Mountains breeding-distribution segment to rapid habitat loss or stochastic events could hasten local extirpations and hinder population recovery. The most important immediate actions in the Appalachian Mountains breeding-distribution segment are to:

1. Protect key, high-elevation populations that have historically withstood co-occurrence with Blue-winged Warblers and that remain largely unaffected by hybridization (Dabrowski et al. 2005, Vallender et al. 2009).
2. Increase subpopulations by creating and maintaining biologically meaningful amounts of habitat within Golden-winged Warbler focal areas (A. M. Roth et al., unpubl. plan) where Blue-winged Warbler co-occurrence is unlikely.
3. Act on new knowledge about linkages between breeding and nonbreeding populations to enhance nonbreeding survival and condition of the Appalachian Mountains breeding-distribution segment where it occurs during the nonbreeding season (Chapters 12 and 14, this volume).

NONBREEDING

New Conservation Perspectives

Findings from this volume inform conservation of Golden-winged Warblers at nonbreeding areas in a number of important ways. Rosenberg et al. (Chapter 1, this volume) provided the first detailed description of the nonbreeding distribution, including areas where the species is most concentrated during the nonbreeding season; these results are being used to identify focal areas as part of the ongoing development of a nonbreeding grounds conservation plan. King et al. (Chapter 2, this volume) reported that Golden-winged Warblers in Costa Rica, Honduras, and Nicaragua occupied both regenerating and primary forest within a suitable range of elevation and moisture conditions, bounded by dry forests at lower elevations and cloud forest at upper elevations. Edges and canopy gaps with abundant dead leaves and vine tangles for foraging were important determinants of Golden-winged Warbler presence within their nonbreeding distribution (Chapter 2, this volume).

Observations concerning other aspects of Golden-winged Warbler nonbreeding ecology have conservation implications. Chandler et al. (Chapter 11, this volume) reported that Golden-winged Warblers spent most of their time within mixed-species flocks, within which they defended territories from conspecifics. Because individual flocks use large areas (~9 ha), and each flock may only support a single Golden-winged Warbler, nonbreeding densities are necessarily low, and thus a large area is required to support their nonbreeding populations.

Development of a comprehensive conservation strategy for the nonbreeding grounds is a daunting task because of the number of countries involved (Chapter 2, this volume). Landscape-scale conservation on the nonbreeding grounds will require partnering with governments, industries, and nongovernmental organizations throughout the Golden-winged Warbler's nonbreeding distribution. There is urgent need to involve the "Protected Areas Management" departments of Latin American governments. With partnerships, government officials can incorporate conservation recommendations into their protected areas management plans and train their field biologists to recognize and manage for Golden-winged Warbler habitat.

In addition to working within protected areas, it is important to provide Golden-winged Warbler habitat in working lands. Shade coffee represents a potential strategy for accomplishing conservation on working lands because it involves the retention of trees within areas of coffee production, which support more biodiversity than other forms of agriculture. Golden-winged Warblers are reported from shade-coffee farms, but these farms may provide suboptimal habitat because microhabitat features required by Golden-winged Warblers are seldom present in coffee farms. Moreover, the cohesion of the mixed species flocks on which Golden-winged Warblers depend is not maintained in these farms (Pomara et al. 2007; Chapter 11, this volume). Perhaps a more effective option is Integrated Open Canopy (IOC) Coffee, where coffee is grown with sparse or no shade adjacent to forest patches of equivalent or greater size that provide habitat for Golden-winged Warblers (Chapter 2, this volume). In addition to promoting the conservation of forest habitat required by Golden-winged Warblers and other species, IOC coffee increases income to farmers by increasing yields and providing a market-based incentive for forest conservation.

Primary Threats and Conservation Actions

Quantitative data on Golden-winged Warbler population limiting factors during the nonbreeding season are lacking, but we presume that the primary threat is loss of forested habitat from conversion to agriculture and other land uses, similar to known limiting factors for better studied Neotropical migrant species (Johnson et al. 2006). In the middle-elevation humid forest zones occupied throughout the nonbreeding distribution of Golden-winged Warblers (Chapter 1, this volume), forest conversion for commodity production is particularly acute, with rapid recent loss of forest occurring in Guatemala, Honduras, and Nicaragua (Cherrington et al. 2011). In Colombia and Venezuela, most forest conversion occurred in the 1980s and 1990s; thus, reduction in nonbreeding Golden-winged Warblers populations in South America may reflect past loss of forest and may be linked to population declines in the Appalachian Mountains breeding-distribution segment (Chapter 1, this volume). In Costa Rica, forest loss has slowed in the past decade and forested corridors are being regenerated in an attempt to reconnect a system of isolated national parks and preserves (Cherrington et al. 2011). Clearly, any assessment of threats to nonbreeding populations must account for regional variation in land-use change. As part of developing a nonbreeding grounds conservation strategy for Golden-winged Warblers, a country-by-country threats analysis was recently completed within the focal areas identified in Rosenberg et al. (Chapter 1, this volume).

Even with limited knowledge, strategies for mitigating threats and increasing survival of nonbreeding Golden-winged Warblers can be derived from recent studies of nonbreeding distribution, ecology, and habitat use (Chapters 1, 2, and 11, this volume). These actions fall into four broad areas:

1. Protect remaining primary and secondary humid forests between 700 and 1,400 m in the Central American highlands and northern Andes by establishing national reserves, municipal watershed protection, and conservation easements. Protected areas should be large enough to support cohesive mixed-species flocks within which Golden-winged Warblers can maintain nonbreeding territories (Chapter 11, this volume).
2. Restore and regenerate forest patches and corridors within focal areas of the nonbreeding grounds, especially near occupied Golden-winged Warbler nonbreeding sites.
3. Promote agroforestry practices and other land uses that are compatible with nonbreeding Golden-winged Warblers, especially IOC coffee, which encourages retention of intact forest patches in the landscape (Chapter 2, this volume).

MIGRATING

New Conservation Perspectives

Of the three life-cycle stages for Golden-winged Warblers, migration is the least studied and consequently has the largest number of knowledge gaps (Chapter 14, this volume). Given that the migration period may be when mortality for migratory birds is greatest (Sillett and Holmes 2002), comprehensive full life-cycle conservation planning for Golden-winged Warblers will be hampered until knowledge gaps during this stage are addressed.

Stable isotope analysis has provided the first look at migratory connectivity for Golden-winged Warblers (Chapter 12, this volume). The geographic resolution of the connections is broad, owing to small sample sizes and the uncertainty inherent in interpreting isotope data. Nevertheless, these results provide the first chance to link regional Golden-winged Warbler population declines with not only breeding ground attributes, but also specific locations and corresponding habitat conditions at nonbreeding areas. Understanding connectivity is a critical step in making linkages among life cycle stages and discerning the interdependence of each stage.

New technologies, such as light-level and GPS-enabled geolocators, provide great promise for developing fine-scale maps of migratory connectivity and stopover sites. These devices have been used to successfully map migratory connectivity of Neotropical migrants such as Wood Thrushes (*Hylocichla mustelina*) and Purple Martins (*Progne subis*) (Fraser et al. 2012, McKinnon et al. 2013). Current research with geolocators provides promising results that may soon generate meaningful insights into connectivity patterns in Golden-winged Warbler populations (Chapter 14, this volume).

Primary Threats and Conservation Actions

Two potential threats to migrating Golden-winged Warblers are loss and degradation of migratory stopover habitats and fatal collisions with anthropogenic structures (Arnold and Zink 2011, Loss et al. 2014). Rosenberg et al. (Chapter 1, this volume) and Hobson et al. (Chapter 12, this volume) speculated that Golden-winged Warblers mainly use a migration pathway across the Gulf of Mexico during spring and fall. A large number of Neotropical migrant species use a similar pathway (La Sorte et al. 2014). Thus, a general strategy of protecting coastal stopover sites that have been identified as being critical for other Neotropical migrants along the Gulf Coast of the U.S., Mexico, and Central America, and known inland migration pathways such as ridge tops and riparian forests along major river systems, could enable Golden-winged Warbler migration. For Golden-winged Warblers and other migrants that spend the nonbreeding season in South America, stopover areas and corridors on the north coast of Colombia also might be critical for successful long-distance migration (Bayly et al. 2012).

Collision mortality might pose a significant threat during migration for Golden-winged Warblers. Arnold and Zink (2011) identified Golden-winged Warblers as having a greater than expected incidence of collision at communications towers, and Loss et al. (2014) estimated that Golden-winged Warblers had a collision risk with buildings (windows) that was 35.3 times greater than a migrant species with average risk. Moreover, Loss et al. (2014) suggested that building collisions may contribute to or exacerbate overall Golden-winged Warbler population declines.

Lacking specific information for Golden-winged Warblers, the most straightforward strategy to help ensure safe migration passage is to support existing efforts that are already protecting critically important stopover habitats and influencing policies focused on reducing collision risk with buildings and towers. The most relevant initiatives include the following:

1. The Joint Venture network operated by U.S. Fish and Wildlife Service and American Bird Conservancy, especially the Gulf Coast, East Gulf Coastal Plain, and Appalachian Mountains Joint Ventures
2. The Fatal Light Awareness Program and other similar programs, which focus on reducing collisions with buildings and collecting data on fatal bird strikes
3. The American Bird Conservancy's "Bird Smart" programs aimed at policy reforms to reduce collision risk at wind turbines, buildings, and communications towers
4. The Midwest Landbird Migration Monitoring Network and other regional initiatives focused on improved understanding of migratory landbird ecology and conservation

CONCLUSIONS

Call for Full Life-Cycle Conservation

As evidenced from the extensive field projects conducted by a diversity of research partners in this volume, the Golden-winged Warbler is becoming one of the most studied Neotropical migrant warbler species. Yet, we still lack necessary information about the extent to which the Golden-winged Warbler's population is being limited in each stage of its life-cycle. Conservation biologists have recognized the value in considering all segments of a migratory species' annual cycle to develop full life-cycle population models and conservation strategies (Sherry and Holmes 1995, Faaborg et al. 2010). This full life-cycle approach has illuminated biological and geographical relationships between nonbreeding grounds and breeding grounds. For example, Norris et al. (2004) found that variation in site quality of American Redstart (*Setophaga ruticilla*) nonbreeding locations carried over into the breeding season, causing impacts to reproductive fitness. New understanding about population limitations at various stages throughout the full life cycle opens novel opportunities to create dynamic conservation plans that identify and mitigate for population constraints in both space and time. Traditional conservation strategies for migratory birds have mostly relied on the broad scheme of protecting and creating habitat within the breeding distribution. The traditional approach can increase breeding population density and perhaps fecundity, but source–sink population models (Donovan and Thompson 2001) have shown that passerine populations are most sensitive to adult and juvenile mortality, which is often highest during migration (Sillett and Holmes 2002). Full life-cycle strategies could help resolve this potential conservation disconnect by pinpointing the locations and periods when management action would be most effective, thereby hastening population recovery and maximizing the impact of limited conservation funds (Berlanga et al. 2010).

Recent, large-scale collaborative research on Golden-winged Warblers has generated new demographic and movement data required for developing quantitative, full life-cycle population models. The Golden-winged Warbler research community has collected useful data for such models in both the breeding and nonbreeding periods, and ongoing research (Chapters 12 and 14, this volume) will soon provide data to parameterize the demographics of migration. Given new information, and the urgent need to reverse Golden-winged Warbler population declines, we suggest a collaborative research effort to begin developing quantitative full life-cycle models that can adaptively inform existing conservation plans.

In the meantime, the lack of such models should not preclude immediate conservation action to address known threats in each life-cycle stage. Conservation actions can protect existing populations, reduce mortality, and increase reproduction, while building capacity, infrastructure, and partnerships to more quickly and effectively take additional action when spatiotemporal population limits have been identified through full life-cycle population modeling.

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