

CHAPTER TWO

Nonbreeding Golden-winged Warbler Habitat*

STATUS, CONSERVATION, AND NEEDS

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Abstract. Anecdotal reports and more recent quantitative findings suggest Golden-winged Warblers (*Vermivora chrysoptera*) are most abundant in mid-elevation moist forests of Central America during the nonbreeding season. The species appears to be tolerant of moderate levels of disturbance, inhabiting both primary and secondary forest; however, occupation of agricultural cover types such as shade coffee may be contingent on the presence of adjacent forest. Trends in deforestation in Latin America offer discouraging prospects for the future of habitat for Golden-winged Warblers in the region in the short term. Nevertheless, recent innovations in agroforestry practices offer market-based tools for restoring and maintaining forest for nonbreeding warblers. One example is hybrid solar-biomass coffee driers that eliminate the use of fuelwood for drying coffee and lower the costs of coffee drying by over 80%. Currently, the equivalent of 6,500 ha of forest is harvested annually in Latin

America to fuel coffee driers. Another example is Integrated Open Canopy (IOC) coffee, where coffee is grown with sparse or no shade adjacent to forest patches of equivalent or greater size. In addition to promoting the conservation of forest habitat required by Golden-winged Warblers and other species, IOC increases income to farmers by increasing yields. Increased income to farmers is important because alternative agroforestry systems provide a market-based incentive for forest conservation. Future work will be directed at implementing these market-based forest conservation strategies over large areas using co-management agreements as a framework for enhancing communication, cooperation, and policy to decrease rural poverty and the pressure on forest resources for the benefit of both humans and birds alike.

Key Words: agroforestry, coffee, co-management, market-based, renewable energy, *Vermivora chrysoptera*.

* King, D. I., R. B. Chandler, C. Smalling, R. Trubey, R. Raudales, and T. Will. 2016. Nonbreeding Golden-winged Warbler habitat: status, conservation, and needs. Pp. 29–38 in H. M. Streby, D. E. Andersen, and D. A. Buehler (editors). Golden-winged Warbler ecology, conservation, and habitat management. Studies in Avian Biology (no. 49), CRC Press, Boca Raton, FL.

GOLDEN-WINGED WARBLER HABITAT SELECTION

Like many Neotropical migrants, Golden-winged Warblers (*Vermivora chrysoptera*) spend the majority of their annual cycle on their tropical nonbreeding grounds in Central and northern South America, and birds that spend the nonbreeding season in Costa Rica and Nicaragua arrive in late September and stay past the middle of April (Chandler 2011). Anecdotal observations and incidental reports from community-level studies indicate that Golden-winged Warblers may be specialized in their habitat use (Bent 1963, Tramer and Kemp 1980, Blake and Loiselle 2000), apparently restricted to lower- and middle-elevation tropical wet forests (Powell et al. 1992, Robbins et al. 1992, Blake and Loiselle 2000; Chapter 1, this volume), and specializing on invertebrate prey in dead leaf clusters (Morton 1980, Tramer and Kemp 1980, Gradwohl and Greenberg 1982; Chapter 11, this volume).

Habitat specialization could increase the vulnerability of Golden-winged Warblers to habitat destruction or degradation, especially because the wet tropical forests where the species is most abundant have been extensively deforested in recent decades (Sader and Joyce 1988, Myers et al. 2000, Aide 2012). Similarly, dead leaf clusters are patchily distributed, further restricting the habitat available to Golden-winged Warblers (Chandler and King 2011). Until recently, quantitative analyses of habitat selection by Golden-winged Warblers based on systematic surveys across cover-type and land-use gradients on the nonbreeding grounds had not been conducted. Without this information, it is difficult for conservationists to evaluate the current status of habitat availability for this species or develop strategies to preserve or restore appropriate conditions. Here, we briefly review recent findings on habitat selection of Golden-winged Warblers at the nonbreeding grounds, and discuss them relative to current patterns of forest change in the nonbreeding grounds, and review established strategies and new innovations for conserving nonbreeding habitat.

Recent findings in Costa Rica using standardized point-count surveys indicated that Golden-winged Warblers were absent from tropical dry forest, were most abundant in naturally disturbed primary forest and advanced secondary forest, where they were closely associated with intermediate levels of precipitation and canopy

height, and with dead-leaf tangles (Chandler and King 2011). These standardized surveys were complemented with radiotelemetry studies that showed similar results, but also demonstrated birds encountered within shade coffee were individuals in transit between forest patches. Within their home ranges, Golden-winged Warblers select microhabitat features such as vine tangles and hanging dead leaves, which occur in greatest abundance in gaps within forest and along edges. Last, recent analyses of data collected using a standardized protocol with 10-min 100-m-radius point counts by the Alianza Alas Doradas over a six-country area indicated these same general patterns held over the entire nonbreeding distribution, with birds most abundant in mid-elevation moist forests with vine tangles (Bennett 2013, Chandler 2013).

Sexual habitat segregation has been reported for a number of Neotropical migrants (Morton 1990, Rappole et al. 1999, Marra and Holmes 2001, Rappole 2013) and has potentially important implications for conservation. For example, if reserves were established based on records for conspicuous males, but females occurred in other regions or habitats, the habitat needs for both sexes might not be met, potentially hampering conservation efforts. Chandler and King (2011) encountered relatively few females on point-count surveys at their study sites in Costa Rica. However, the data they were able to collect on 22 females sighted incidentally in combination with point-count data indicated that males and females occurred in similar habitats within the study area, and in several instances within the same flock (Chandler 2011). The more recent region-wide analyses by Chandler (2013) confirmed that females use the same general forest cover types as males, but females tended to occur at lower elevations and warmer locations.

TRENDS IN DEFORESTATION

Previous analyses of deforestation rates in Latin America have offered little comfort for conservationists concerned about species dependent on primary forests in the humid tropics (Myers 1994). The net amount of forest cover is a function of forest regeneration and deforestation, however, and the association of Golden-winged Warblers with edges, gaps, and secondary forests suggests

these disturbed and regenerating habitats may provide an opportunity for conservation. Asner et al. (2009) used a combination of data sources to evaluate the impact of deforestation, selective logging, and forest recovery to derive an estimate of net forest change in the humid forests worldwide and concluded 1.4% of Central American humid forests was impacted by deforestation and logging between 2000 and 2005, and >67% of the forest has <50% tree cover. However, a corresponding level of forest growth (1.2%) had offset losses almost entirely in terms of net change in forest cover. Similarly, Aide et al. (2012) reported a net increase in forest cover in Central America, once increases from forest regeneration were taken into account.

Recent studies suggest no dramatic changes recently in the extent of nonbreeding habitat available for Golden-winged Warblers, because the species tolerates intermediate levels of disturbance, and also uses secondary forest (Chavarría and Duriaux 2009, Chandler and King 2011). Furthermore, forest regeneration was documented throughout the core nonbreeding distribution of Golden-winged Warblers; predominantly within hilly or mountainous terrain and intermediate elevations (Sánchez-Azofeifa et al. 2003, Asner et al. 2009, Aide et al. 2012), which is within the intermediate elevations occupied by Golden-winged Warblers. The trends are encouraging; however, total forest cover is still greatly reduced from historical levels, covering only 41% of the nonbreeding distribution of this species (Honduras, Nicaragua, Costa Rica, and Panama; Chapter 1, this volume) on average (FAO and JRC 2012). Golden-winged Warblers require forest during the nonbreeding period and a reduction in forest cover has almost certainly reduced the carrying capacity of the nonbreeding grounds from previous levels. Furthermore, future populations trends are contingent on the assumption that forests will continue to be allowed to regenerate, which is far from certain given increased interest in biofuels, intensification of agriculture, and increased demand for natural resources associated with an increased standard of living for rural communities (Wunder 2001, Asner et al. 2009). As such, a long-term solution that ensures the protection and restoration of forest cover types associated with Golden-winged Warblers remains a conservation priority.

CONTEMPORARY APPROACHES TO CONSERVING FOREST

Protected Areas

A variety of approaches has been taken to address the issue of tropical deforestation. One of the most established methods is the creation of parks and preserves where extractive uses by people are prohibited or regulated. Approximately 57% of forest within the core nonbreeding distribution of Golden-winged Warblers is encompassed within protected areas, and 43.5% of forest within protected areas consists of lands where biodiversity conservation is the primary purpose, with the remainder of lands within protected areas consisting primarily of areas where sustainable use of natural resources is permitted (FAO and JRC 2012).

Tropical protected areas generally slow the rate of deforestation within their administrative boundaries (Brooks et al. 2009), but deforestation can still occur within protected areas despite statutory protection. For example, worldwide, DeFries et al. (2005) analyzed satellite data for a sample of 198 highly protected areas (IUCN status 1 and 2) throughout the tropics for a 20-year period starting in the early 1980s, and reported that 25% experienced forest loss within their administrative boundaries and a far higher percentage (70%) underwent forest loss within designated buffer zones. The remote sensing data are consistent with our observations that extensive deforestation has occurred and continues in the buffer zones of three Central American protected areas where we work; the BOSAWAS (Bocay River, Mount Saslaya, and Waspuk River) reserve in northern Nicaragua, and Pico Pijol and Texiguat National Parks in Honduras. According to the Honduran Ministry responsible for protected areas (Instituto Nacional de Conservación y Desarrollo Forestal, Áreas Protegidas y Vida Silvestre), Pico Pijol, and particularly Texiguat National Park, are experiencing alarming rates of deforestation due primarily to conversion of cloud forest to intensive coffee production in buffer zones. Similarly, Porter-Bolland et al. (2012) summarized protection outcomes for 40 protected areas and reported that the average annual loss of forest cover was 1.47%, with parks sampled in Costa Rica and Honduras exhibiting annual rates of forest loss of 8.7% and 0.76%, respectively. Last, establishment of protected areas can displace human activities,

potentially accelerating deforestation in adjacent areas (Dewi et al. 2013).

Clearly, protected areas have potential to be an effective means of protecting forest, but in practice they appear to be inadequate on their own, judging from studies indicating that forest cover is reduced and continues to be diminished within their boundaries and in adjacent areas. The effectiveness of protected areas may ultimately be contingent on the degree to which the social and economic needs of local inhabitants, and their land tenure rights and local expertise, are recognized (Porter-Bolland et al. 2012). Successful conservation needs to include the development of institutional and administrative frameworks that recognize local governance and seek to promote sustainable livelihoods (Chazdon et al. 2009, Porter-Bolland et al. 2012). If regulatory efforts are responsive to local needs, compliance will be more aligned with self-interest, and enforcement, always the weak link in the top-down paradigm of natural resources conservation, should be less costly and more effective.

Payments for Ecological Services

Payments for ecological services are a strategy by which forest conservation can be accomplished while compensating governments, communities, or individuals for the loss of access to resources extracted from protected forests (Barrett et al. 2013). A well-known example is payment for watershed protection by municipalities (Southgate and Wunder 2009). For example, in Costa Rica, landowners are paid \$50/ha to conserve forest, the valuation based on ecosystem services of carbon sequestration and watershed protection (World Resources Institute 2005). The REDD program (Reducing Emissions from Deforestation and Forest Degradation) seeks to create a financial value for the carbon stored in forests to provide financial incentives for conserving forest. In areas where incentive programs have been implemented, they appear to be successful, at least in the short term. Pagiola (2008) suggested that in Costa Rica, most secondary forests still present are the result of financial incentives and conservation regulations.

Programs providing payments for ecological services depend on ability and willingness of entities to pay, but not all ecologically interesting sites have economic value (Pagiola et al. 2004). In

addition, the viability of these programs depends on political commitments or economic resources that may change with changes in government policies or economic conditions, and an increased uncertainty can present another impediment to farmer participation in these programs (Chandler 2011). Still, in most cases these agreements are contractual with the rights and obligations of interested parties well defined. Furthermore, the legal framework required for enforcement is well developed, and enforcement can be simpler than policing encroachment on protected areas. The flexibility of payment for ecological services approaches to conserving biodiversity has important advantages over strict regulatory arrangements, so they are certain to remain an important tool for conservation of Golden-winged Warblers in cases where forest provides ancillary values for which parties are willing to pay.

Agroforestry

Agroforestry describes practices that incorporate either planted or retained trees or other woody perennial plants into farming systems (Schroth et al. 2004). Agroforestry systems seek to compensate farmers for losses in yield associated with the retention of trees and other features that enhance the conservation of biodiversity with price premiums and access to specialty markets. With these market-based incentives, and costs of enforcement that are borne by the producer, this approach to conservation is less subject to the limitations inherent in strict protection such as lack of political will or costs of enforcement. Shade coffee is a form of agroforestry where trees are retained or planted over coffee to provide suitable conditions for coffee production in areas with abundant sun and as a means of biodiversity conservation. Shade coffee can enhance biodiversity in landscapes where tree cover is reduced and is clearly favorable to sun coffee in terms of its value for conservation. Some migratory birds are more abundant in shade coffee or other agroforestry habitats compared to primary forests and some appear to maintain or even increase their body condition over the course of the nonbreeding season (King et al. 2007, Bakermans et al. 2009). However, the potential for agroforestry to create incentives for converting native forest could offset the habitat value shade that coffee provides (Rappole et al. 2003).

Golden-winged Warblers are regularly encountered in shade-coffee farms and other agroforestry systems (Komar 2006, King et al. 2007); but, telemetry data from Costa Rica indicate these individuals are birds in transit between forest patches (Chandler 2011). Evidence for transience is supported by observations from Honduras that Golden-winged Warblers are seldom encountered in coffee farms without adjacent suitable forest cover (Chavarría and Duriaux 2009; D. King, unpubl. data). The habitat associations are likely explained by the close association between Golden-winged Warblers and vine tangles, a habitat feature that is typically absent from shade-coffee farms (Chandler and King 2011). It seems unlikely that shade-coffee certification programs could effectively mandate the retention of habitat features such as vine tangles and hanging dead leaves that would potentially make shade coffee suitable for Golden-winged Warblers without placing an unrealistic burden on coffee farmers (Chandler 2011). Agroforestry may still increase population connectivity and perhaps the effective size of forest patches; however, the retention of native forest appears to be key to conserving Golden-winged Warblers during the nonbreeding season.

NEW INNOVATIONS

Current work is directed at developing new approaches and refining existing strategies to conserve forest for Golden-winged Warblers and other bird species in Central and South America. One new approach for conserving forest within a market-based framework is the development of a coffee drier that uses renewable energy. Coffee must be dried prior to shipment, and currently most coffee driers use wood as fuel, which results in the harvest of wood equivalent to 6,500 ha of forest across Latin America annually (Arce et al. 2009). Hybrid solar-biomass coffee driers (Figure 2.1) use solar-thermal and biomass energy to dry coffee, which is supplemented with biofuel produced from oil derived from the fruit of a native Neotropical tree *Jatropha curcas*. The hybrid system completely eliminates the use of wood for fuel, while reducing drying costs by 88% on average (Arce et al. 2009).

Integrated Open Canopy (IOC) coffee represents an example of a refinement of an existing approach to biodiversity conservation (Arce et al. 2009). Like other forms of agroforestry, IOC coffee cultivation systems seek to use financial incentives to influence farmer behavior to maintain



Figure 2.1. Solar-hybrid coffee drying facility in Subirana, Honduras. Panels in foreground collect thermal energy, which is circulated through drying towers located in the building behind.

biodiversity; however, IOC conserves native forest and not just shade trees. Forest conservation is accomplished by reserving forest patches of equivalent size to areas planted with coffee (typically 2–3 ha) grown with a level of shade that promotes the highest yield, which in some cases is sparse or no shade. IOC increases income to farmers by increasing yields relative to shade coffee (>4×/ha on average; Arce et al. 2009). IOC is particularly well suited for carbon trading, as the carbon accounting for farms includes crops and their integrated buffer of existing, regenerating, or both existing and regenerating forest cover, thereby providing substantially more carbon sequestration than other typical agricultural-based carbon credit projects. If combined with solar drying and carbon credits, IOC coffee could increase income for farmers by >150% (Figure 2.2), and thus represents a market-based strategy for conserving forest.

Last, IOC coffee conserves forest patches of equal size to the patches planted in coffee, and forest patches this size are known to support Golden-winged Warblers and forest-dependent birds that do not occur in shade coffee in the absence of forest (Chandler et al. 2013). Thus, the IOC system imposes a lower limit on the extent of forest that will remain in mixed-use landscapes; forest that otherwise may have no explicit protection, thus would be vulnerable to degradation and conversion to other land uses.

IMPLEMENTATION

Implementation is key to the success of even the most carefully developed innovation for conserving forest or other natural resources (DeClerk et al. 2006). Efforts to translate pilot projects to on-the-ground conservation initiatives at meaningful scales are most successful when they are collaborative and reflect the needs and interests of rural communities that rely on forest resources (Hayes 2006, Chazdon et al. 2009). In addition, community integration can be a critical determinant of the success of forest conservation initiatives (Tucker et al. 2005). One potential strategy for accomplishing community integration is through co-management agreements, which describe a condition of shared responsibility between the government and private citizens. Co-management agreements are a vehicle for developing participatory, decentralized, democratic, conservation-oriented solutions that complement and multiply the capabilities and benefits for all parties (Horowitz 1998, Reed 2008).

A co-management agreement approach is being applied to conserve Golden-winged Warbler habitat in regions of central Honduras. The region is currently threatened by the rapid development of strictly high-grown coffee, which is recognized as a principal threat to forest in the region, including forest within the Pico Pijol National Park. The park encompasses 122 km² of forest, and supports large

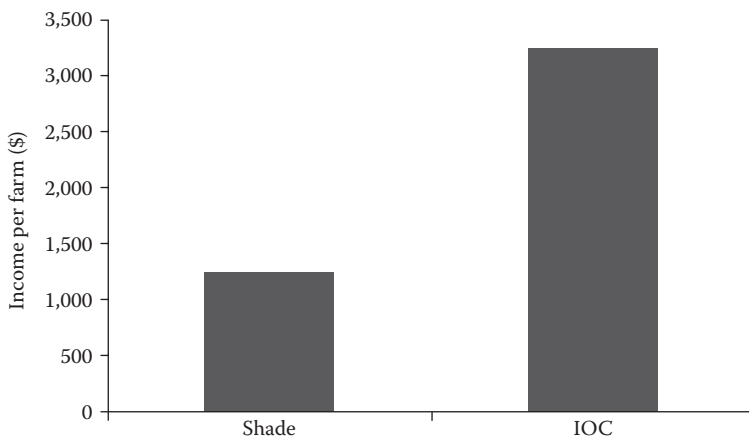


Figure 2.2. Comparison of income for two hypothetical coffee farms, one using shade-coffee cultivation and a conventional wood-fired coffee dryer and the other IOC coffee cultivation and a solar-thermal coffee dryer. On average, coffee yield is 106% higher using IOC, energy costs are reduced by 88% using solar-thermal energy, and sales of carbon credits from forest conservation and solar energy use are 20% of the value of coffee production (Arce et al. 2009).

populations of migrants of heightened conservation concern, including Golden-winged Warblers and Wood Thrushes (*Hylocichla mustelina*). Despite statutory protection, the park is being threatened by extensive degradation of the surrounding buffer zone due to the expansion of commercial production of coffee for export (Figure 2.3). Coffee in this region is typically dried with fuelwood that is harvested locally and can only be grown without shade due to dense cloud cover. The Mesoamerican Development Institute and the COMISUYL (Cooperativa Mixta Subirana Yoro Limitada) Coffee Cooperative have entered into a co-management agreement with the Institute for Forest Conservation (ICF) to manage Pico Pijol National Park using their market-based strategies for conservation and restoration of native forest cover.

A new agreement will serve as a platform for protecting the park through promoting market-based mechanisms for the conservation of native forest biodiversity that serve the common interests of all signatories. For example, ICF has a

statutory obligation to protect forest within the buffer zone of the park. The surrounding municipal governments, Yoro, Victoria, El Negrito, and Morazan, depend on the park for water as does a nearby electrical utility company that operates a 12 MW hydropower station, and maintaining forest cover within the park is paramount for maintaining sustainable water flows. The objective of the co-management agreement is to promote the conservation and sustainable management of Pico Pijol National Park through legal and technical implementation of the shared management of the area. Our expectation is that by providing a platform for communication and cooperation among users with similar or compatible interests, the co-management agreement will complement other conventional policies and practices for forest conservation.

FUTURE NEEDS

Future priorities for research should address key gaps in the understanding of the ecology of



Figure 2.3. High-elevation coffee planted in place of forest in the buffer zone of Pico Pijol National Park, Honduras.

Golden-winged Warblers and refining market-based strategies for forest conservation. One key information need for nonbreeding Golden-winged Warblers, which has an important bearing on developing strategies for their conservation, is habitat-specific survival. Nonbreeding migrants are often reported to use suboptimal habitats where survival is lower due to despotic interactions with conspecifics or other mechanisms (Rappole 2013). Thus, it is important to determine whether the patterns of habitat selection observed in Golden-winged Warblers are reflected in patterns of habitat-specific survival, as reported from other species of migratory songbirds, or whether habitat-specific differences in body condition constrain migration or breeding success. Golden-winged Warblers can be cryptic during the nonbreeding season and have large home ranges (~9 ha; Chandler 2011); thus, ordinary mark-resight studies to estimate habitat-specific survival are not practicable for nonbreeding Golden-winged Warblers. Radiotelemetry can overcome these challenges with monitoring, but radios small enough for Golden-winged Warblers do not have long enough battery life to yield sufficient exposure days, and transmitters appear to reduce survival if birds carry them during migration (Chandler 2011). Hierarchical mixture models are an alternative method for estimating survival rates from repeated point counts of unmarked birds (Chandler and King 2011), and research is ongoing to develop and apply mark-resight surveys for cryptic species with large home ranges (Ritterson 2015).

Another important issue related to Golden-winged Warbler conservation is the susceptibility of the species to climate change on the nonbreeding grounds. In Costa Rica, the distribution of Golden-winged Warblers is closely related to moisture, with birds occurring at maximum abundance in areas with ~2.5 m annual rainfall (King et al. 2012). At a nonbreeding-distribution-wide scale, temperature is also an important predictor of local abundance of nonbreeding Golden-winged Warblers (Chandler 2013). Although there is substantial variation, zones of precipitation and temperature within the nonbreeding distribution are linked with elevation, and studies have documented incursions of lower elevation birds into montane areas in the Neotropics (Pounds et al. 1999). The relationship of abundance with moisture raises the possibility that Golden-winged Warblers could be subjected to impacts from climate change, both directly and from increased

orographic restriction as their optimal climatic conditions increase in elevation as a result of increased global temperatures. Assessing vulnerability of nonbreeding Golden-winged Warblers to predicted climatic shifts and identification of landscape features associated with potential refugia are research priorities.

Planned refinements of market-based incentives for forest conservation include the development of carbon certification guidelines for small land holders to market carbon credits derived from conservation of forest on their IOC farms. Sales of carbon credits will provide added incentive for farmers to conserve forest, and carbon sales could exceed 20% of the value of the coffee produced. Additionally, the Best Management Practices for IOC coffee specifying the area, shape, and configuration of forest patches must be developed to ensure that farms achieve the goal of conserving biodiversity. Work to develop Best Management Practices is underway based on data on bird abundance versus tree height, patch size, and other forest characteristics from IOC farms in Costa Rica and will also form the basis of a bird-friendly certification that may provide additional income to farmers practicing in IOC coffee cultivation. Last, modeling the relative value of agroforestry landscapes managed using renewable energy and IOC coffee cultivation versus using conventional systems, accounting for changes in income to farmers and its influence on deforestation, will (1) contribute to the growing knowledge base on the socioeconomic aspects of deforestation, (2) help quantify the benefits of this system to support its promotion, and (3) provide the data needed to develop guidelines for agroforestry landscapes implementing these alternative coffee processing and cultivation methods.

ACKNOWLEDGMENTS

We thank the members of the Cooperativa Montes de Oro, particularly V. J. Arce Chavez and A. Morales for their assistance with site selection and logistics, and C. Chandler, S. Beaudreault, C. Orlando Delgado, M. Gonzalez, J. Aguero, J. Wolfe, N. Hazlet, A. Anderson, J. Wells, and J. Ritterson for assistance in the field. Our project was funded by the U.S. Fish and Wildlife Service's Neotropical Migratory Bird Conservation Act program and the U.S. Forest Service International Program. We thank J. P. Kelley, C. Lively, and J. Rappole for comments on an earlier version of this manuscript.

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