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CEAP-Wildlife Conservation Insight

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Conservation Practices Benefit Golden-winged Warblers in Appalachia

Summary of Findings

The golden-winged warbler has experienced significant population declines throughout its Appalachian breeding range. Loss of breeding habitat is thought to be a significant driver of these declines.

An assessment was conducted to evaluate golden-winged warbler response to habitat management using conservation practices suggested by the Natural Resources Conservation Service's (NRCS) *Working Lands For Wildlife (WLFW)* in the southern and central Appalachian states. Key findings include:

- Most golden-winged warbler demographics (e.g., territory density, adult survival, and nest survival) did not differ among the five management systems evaluated, thus indicating similar capabilities to support breeding populations of this species.

- Although some of the management systems failed to achieve nest-site vegetation characteristics in the ranges recommended by the *Golden-winged Warbler Conservation Plan* (Roth et al. 2012), they still supported high nesting success.

- Juvenile and adult golden-winged warblers used multiple stages of forest succession (i.e., early, mid, and late successional forest) during the breeding and post-breeding periods, thus stressing the need for managing local landscapes to create a mosaic of forest age classes.

- The post-fledging period, particularly the first 4 days out of the nest, results in significant fledgling mortality and could be a focal point for habitat management to increase reproductive output.

- Quantifying differences in post-fledgling survival among management systems is critical for comparing and evaluating each system's potential for successfully contributing to golden-winged warbler population recovery.

- Ultimately, it is necessary that both the nesting and post-fledging habitat needs of the golden-winged warbler are considered when developing conservation plans for private landowners.

Background

The golden-winged warbler *(Vermivora chrysoptera)* is a neotropical migrant songbird that winters in portions of Central and South America and breeds in the northern Great Lakes regions of the United States and Canada, and at higher elevations of the central and southern Appalachian Mountains (Confer et al. 2011). The species is experiencing steep population declines throughout its Appalachian Mountains breeding range (8.5% per year, Sauer et al. 2014) and has thus become rare and patchily distributed throughout this region. Several factors are thought to be driving population declines of this songbird, including habitat loss in both the breeding and wintering range, hybridization with the blue-winged warbler, and nest parasitism by brown-headed cowbirds (Buehler et al. 2007). Of these factors, loss of quality breeding habitat—young forests and shrublands embedded in extensively forested landscapes—is thought to be the most significant (Roth et al. 2012).

The Golden-winged Wabler Working Group (gwwa.org) identified implementation of management prescriptions that create or maintain golden-winged warbler breeding habitat as a conservation priority (Roth et al. 2012). Recently, science-based guidelines for creating golden-winged warbler breeding habitat were developed (Bakermans et al. 2011, Roth et al. 2012). Conservationists are now faced with the challenge of large-scale implementation of these habitat management guidelines to stabilize and reverse golden-winged warbler population declines. Habitat management targeting golden-winged warblers will also likely benefit other at-risk birds that rely on young forest and shrubland including eastern whip-poor-will, prairie warbler, eastern towhee, field sparrow, and American woodcock (North American Bird Conservation Initiative 2009, Roth et al. 2012). Additionally, many mature forest nesting songbirds and their offspring use young forest and shrubland habitat during post-fledging and migration (King et al. 2006, Vitz and Rodewald 2006, Labbe and King 2014).

While efforts to create and enhance golden-winged warbler breeding habitat on public lands in the Appalachian Mountains are underway, the fate of this species will likely depend on the consistent availability of high quality habitat on private forestlands. In 2012, the USDA Natural Resources Conservation Service (NRCS) launched the *Working Lands for Wildlife (WLFW)* effort to create habitat on private lands for seven imperiled wildlife species including the golden-winged warbler. Through cost-share assistance associated with WLFW, landowners are using conservation practices such as Early Successional Habitat Development & Management (NRCS Practice Code 647) to create early successional or young forest patches within the forested landscapes of Appalachia that provide critical nesting habitat for this imperiled songbird.

Due to significant landscape heterogeneity across the Appalachian Mountains portion of the golden-winged warbler's range, there are numerous ways in which young forest nesting habitat can be created or maintained for the species. These treatments can be categorized into five primary management systems (Fig. 1).

A. Timber Harvest: This management system creates new golden-winged warbler nesting habitat via stands of young, regenerating forest with adequate residual trees. Timber Harvest involves removing overstory and results in a regenerating forest with abundant saplings, shrubs, and forbs. Live residual trees are usually the largest and healthiest of the deciduous hardwoods in the stand, and snags are also retained.

B. Grazing Management: This method of maintaining existing golden-winged warbler habitat uses domestic livestock to limit natural succession. In areas where golden-winged warblers are known to breed, low-intensity grazing (1 animal unit/2–4 ha) may be used during May-October or even year-round if overgrazing is not occurring. High-intensity grazing (up to 1 animal unit/0.4 ha) may be used during non-nesting periods to limit natural succession in overgrown areas (i.e., those with >60% shrub cover).

C. Prescribed Fire - Young Forest: This management system creates new and maintains existing golden-winged warbler nesting habitat using prescribed fire as preparatory treatment for a timber harvest or as a method of maintaining early successional habitat after a harvest. Maintaining the area in early succession with prescribed fire may mimic natural disturbance events that historically created breeding habitat for golden-winged warblers.

D. Old Field Management: This management system can be used to maintain golden-winged warbler habitat through the use of the NRCS conservation practice Brush Management and associated practices. This management practice sets back the succession of shrubs and other woody plants primarily by using mechanical methods to remove some woody vegetation. The goal is to restrict the growth of woody vegetation and revert late successional shrublands to earlier stages of succession having 30–60% shrub and sapling cover within the targeted area. A shrub and sapling cover closer to 60% allows immediate nesting by golden-winged warblers, while a cover closer to 30% may result in delayed nesting until woody vegetation recovers.

E. Prescribed Fire - Old Field: This management system maintains existing shrubland habitat as old fields, including abandoned agricultural areas and reclaimed surface mines, primarily through the use of prescribed burning. The result of this management system is an early successional shrubland with herbaceous cover and slowed growth of woody plants such as shrubs and saplings. Prescribed fire on Appalachian surface mines can be used to set back vegetative growth, but it must be used regularly to maintain the area in an early successional state.

Assessment Partnership

Monitoring the response of golden-winged warblers to habitat established via NRCS conservation practices is necessary in order to 1) evaluate the effectiveness of primary management systems, 2) quantify WLFW's relative contribution to the species' recovery, and 3) provide data necessary to

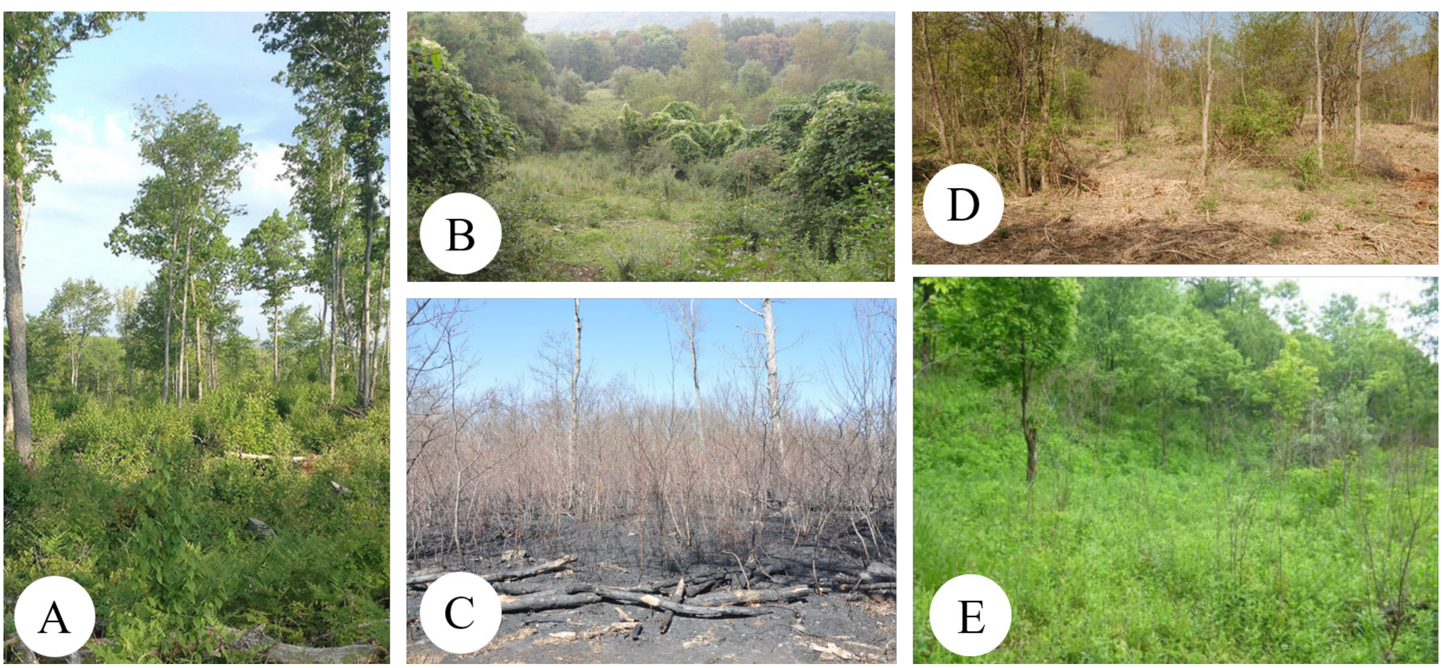

Figure 1. Five primary management systems used to provide early successional breeding habitat for golden-winged warblers: (A) timber harvest, (B) grazing management, (C) prescribed fire - young forest, (D) old field management, (E) prescribed fire - old field.

modify existing practice guidelines via adaptive management to improve WLFW program effectiveness.

In 2012, NRCS formed a Conservation Effects Assessment Project (CEAP) partnership with the Indiana University of Pennsylvania Research Institute to lead a team of scientists representing several universities, state and federal agencies, and non-governmental conservation organizations to assess golden-winged warbler response to NRCS WLFW activities. The assessment used multiple sites in four Appalachian states to represent the scope of habitats and WLFW practices across the species' Appalachian Mountains breeding range. The study approach and findings of the first three years of this assessment are presented in detail by Aldinger et al. (2015). Highlights of the assessment are presented in this Conservation Insight. Additional work is underway to fine-tune initial findings and to assess benefits to other birds associated with early successional habitats.

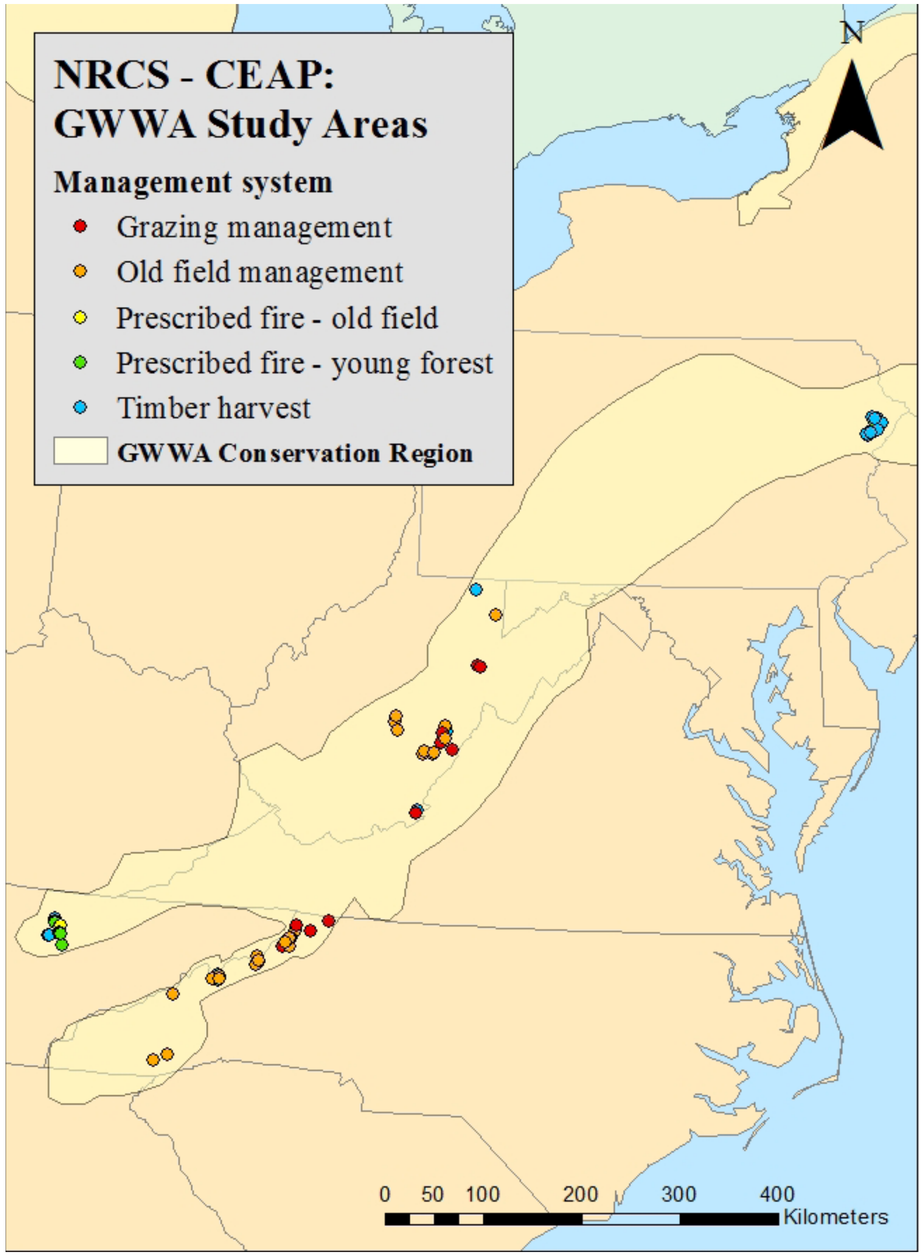

Figure 2. Assessment study sites were located throughout the Appalachian Mountains and within the golden-winged warbler breeding range.

Assessment Approach

The assessment focused on evaluating the demographic response of golden-winged warblers to habitat management guided by NRCS conservation practices at 70 sites located across portions of the species' Appalachian Mountains breeding range (Fig. 2). For each of the five management systems, assessments were made for (1) golden-winged warbler minimum annual survival, territory size, and density derived from territory mapping; (2) territory density derived from point counts; (3) nest survival and fledgling productivity; (4) attainment of recommended nesting vegetation; (5) space use by radio-tagged adult males; (6) fledgling survival, movements, and habitat use; and (7) implications drawn from these analyses on golden-winged warbler demographic response to USDA conservation practices.

Annual survival, territory size, and territory density

Male golden-winged warblers were captured with mist nets and banded annually to estimate minimum survival rates and to aid in the identification of individual males during territory mapping. The number of sites studied for each management system were: timber harvest (n=26), grazing management (n=12), old field management (n=17), prescribed fire - old field (n=2), and prescribed fire - young forest (n=13). Captured males were fitted with a standard USGS aluminum leg band and a unique combination of 1–3 additional color leg bands (Fig. 3). Minimum annual survival was estimated using re-sighting data and the program MARK (version 7.1, Colorado State University, Ft. Collins, Colorado, USA). Field technicians visited each study site every 1–3 days to visually locate marked territorial males and record associated geographic coor-

Figure 3. A male golden-winged warbler fitted with an aluminum USGS leg band and a unique combination of plastic color bands for identification purposes.

dinates. Approximately 30 locations per individual male were recorded on at least eight separate days during the breeding season. Locations for each male (within a single breeding season) were used to delineate territory boundaries. Territory size was estimated for each male during each breeding season from 2012–2014. Estimates of territory density (males/ha) for each study site and for each management system as a whole were also made to enable comparisons among management systems.

Golden-winged warbler territory density was also estimated using data collected during 10-minute point count surveys (n=95 sites). Each point count survey location was visited 1–3 times annually during the peak of the breeding season (May 10–June 25). Over a 10-minute period, a laser range finder was used to record the exact distance from the point count location to all golden-winged warblers detected. To characterize habitat conditions, a detailed vegetation survey was also collected at each point count location. Two model suites exploring warbler density were evaluated: model suite 1 (elevation, latitude, and management system effects) and model suite 2 (vegetation effects).

Nest survival and fledgling productivity

During 2012–2014, nests of golden-winged warblers were located and monitored on 46 sites. Sites were searched multiple times weekly to locate nests using behavioral cues of adults. Once a nest was found, it was monitored to determine nest fate. A nest was classified as "successful" if at least one golden-winged warbler nestling fledged.

Vegetation characteristics were measured at nests after nest fate was determined. A nested plot design (1-m, 5-m, and 11.3-m radius) was used to survey vegetation centered at nest sites. Percent cover for leaf litter, bare ground, grasses, forbs, vines, blackberry/raspberry (*Rubus* spp.), and woody plant species within a 1-m radius of plot centers were recorded. Within 5 m of plot centers, 1–2 m tall shrubs ("short shrubs"), >2 m tall shrubs ("tall shrubs"), and saplings (1–10 cm diameter at breast height—dbh, >0.5 m tall) were tallied by species. Within 11.3 m of each plot's center, the species and dbh of all trees (>10 cm dbh), number of snags (>10 cm dbh), average shrub height, and average sapling height were also recorded.

Nest survival: All golden-winged warbler nests that reached at least the egg-laying stage (i.e., active nests) were included in nest-survival analyses. Two groups of models were developed for golden-winged warbler nest daily survival rate (DSR). Model suite I featured management system, study area, time within season, vegetation community type, and year covariates. Model suite 2 included models with vegetation covariates within each management system. Nest survival for each management system was analyzed separately. Prescribed fire - young forest was excluded due to small sample size.

Fledgling productivity: Golden-winged warbler fledgling productivity (number of fledglings produced/ha) was estimated for each management system. Fledgling productivity was the product of four components: 1) probability of nest success given three nesting attempts, 2) number of fledglings produced per successful nest, 3) territory density, and 4) male pairing rate. Territory density for each management system was the mean of the across-year territory mapped densities for sites within each management system. A constant pairing rate (0.8) was used among management systems based on a compilation of pairing rates from golden-winged warbler populations across the Appalachian Mountains region (Confer et al., unpubl. data).

Attainment of recommended nesting vegetation

The same vegetation protocol used to survey nest sites was also used at plots distributed randomly (1 plot/ha) throughout each study site (hereafter, "stand-level plots"). Stand-level plots quantified the vegetation characteristics available across each site. One primary management target for golden-winged warbler nesting habitat was the nesting vegetation recommended in the *Golden-winged Warbler Conservation Plan* (Roth et al. 2012). Recommended nesting vegetation "attainment" was associated with the proportion of stand-level plots having vegetation characteristics that fell within ranges recommended by Roth et al. (2012). Recommended values for vegetation within 1-m of nest sites include 0-10% bare ground, 5-25% grass cover, 4-45% forb cover in herbaceous-dominated sites (grazing management, old field management, and prescribed fire - old field), 45-100% forb cover in silviculturally-derived sites (prescribed fire - young forest and timber harvest), 5-40% *Rubus* cover, and 5-50% woody cover.

Space use by adult male golden-winged warblers

Between May and June 2012 and 2013, adult male golden-winged warblers were captured at 16 sites in Pennsylvania and West Virginia. Study sites were categorized as old field management (n=7), prescribed fire - young forest (n=3), and grazing management (n=6). Nineteen (n=19) males that weighed ≥9 g were each equipped with radio transmitters and fitted with a metal U.S. Geological Survey leg band and a unique combination of color bands for visual identification purposes. Visually mapped territories and telemetry-based home ranges for each male were delineated using 100% and 50% minimum convex polygons (MCPs) in ArcMap. The amount of overlap between each radio-tagged male's visually mapped territory and telemetry-based home range was measured using the intersect tool in ArcMap. Vegetation data were collected within each visually mapped territory and at all telemetry locations that were ≥12 m outside the visually mapped territory (to prevent potential overlap of sampling areas).

Fledgling survival, movements, and habitat use

Study sites in Pennsylvania (timber harvest sites, n=8) and Tennessee (prescribed fire - old field sites, n=2) were searched multiple times weekly to locate nests during 2013–2014. When nestlings were 7–8 days old (1–2 days prior to the anticipated fledge date), 1–3 birds were briefly removed from their nest and weighed, and then a leg band was attached. A radio transmitter was also attached to each bird using a figure-eight harness. The combined mass of radio transmitter, harness, and leg band was < 5% of each nestling's weight. Radio-tagged individuals that successfully fledged were tracked daily to record each fledgling's exact location and survival status. Two groups (TN and PA) were used to model fledgling survival, and days 1–4 and days 5–25 were analyzed separately because survival was noticeably lower in the first 4 days.

Assessment Findings

Minimum annual survival: Over 3 field seasons, 290 male golden-winged warblers were captured and banded across all five management systems: timber harvest, n=88; old field management, n=107; prescribed fire - young forest, n=13; prescribed fire - old field n=22; and prescribed grazing, n=60. Adult male annual survival by management system ranged widely from 0.40 to 0.81 (Fig. 4). When combining birds from all management systems, the average survival rate was 0.58, which falls near the rate (0.62) found in Bulluck et al. (2013) in Tennessee and Ontario.

Territory size: Over 3 field seasons, 526 golden-winged warbler territories were mapped within 70 study sites. Of these, 474 territories met the criteria for inclusion in territory size comparisons among the 5 management systems. Average territory size was largest for those in grazing management sites (1.77 ha, n = 98) and smallest for timber harvest (0.82 ha, n = 172) (Fig. 5).

Territory density derived from territory mapping: Golden-winged warbler territory densities across the 70 sites that were territory mapped ranged from 0.0–4.61 males/10 ha. Mean golden-winged warbler density estimates by management system ranged from 1.05–3.37 males/10 ha with a mean density of 1.5 males/10 ha across all five management systems (Table 1).

Territory density derived from point counts: A total of 864 point count surveys were completed at 191 unique locations across 70 sites during 2012–2014. The best-supported golden-winged warbler density model in model suite I (elevation, latitude, and management system effects) included linear elevation and latitude effects and an interaction between these two variables. At southern latitudes density increased with elevation, and at northern latitudes density decreased with elevation. Models with management system had essentially no support (ΔAIC > 10, Burnham and Anderson 2002), suggesting that golden-winged warbler density overall was consistent among management systems. The best-supported density model in model suite II (vegetation covariates) included a sapling count effect whereby density increased with sapling count. This finding is consistent with previous management recommendations to achieve average sapling densities that range between 3,000–8,400 stems/ha (1,300–3,300 stems/acre).

Nest survival: Across 46 sites, the survival of 288 golden-winged warbler nests was monitored during 2012–2014. Of these nests, 79, 86, 61, 48, and 14 nests were found in timber harvest, old field management, grazing management, prescribed fire - old field, and prescribed fire - young forest sites, respectively. Overall DSR for all golden-winged warbler nests was 0.963 ± 0.003, which equates to a probability of 0.767 ± 0.035 of producing a successful nest, given three attempts. Successful golden-winged warbler

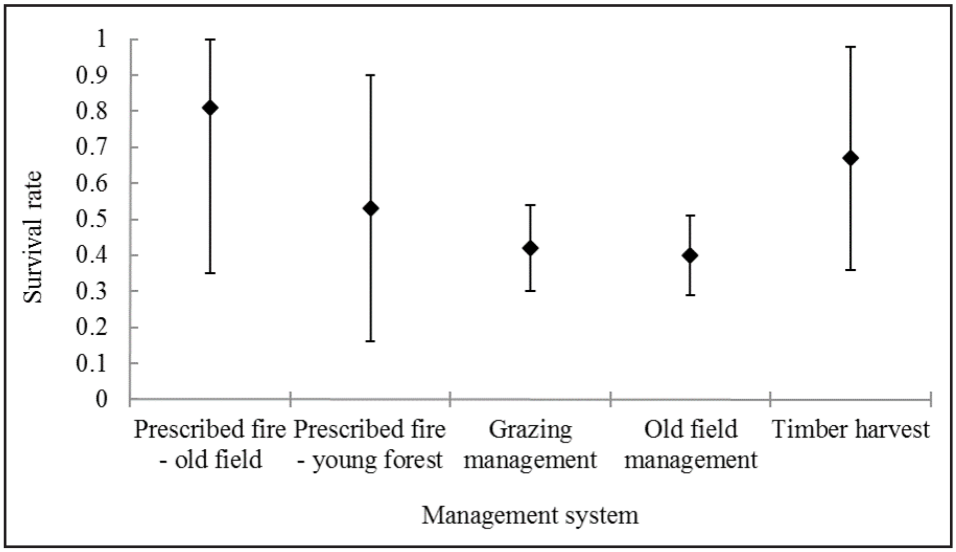

Figure 4. Minimum annual survival rate estimates (± SE) for adult male golden-winged warblers.

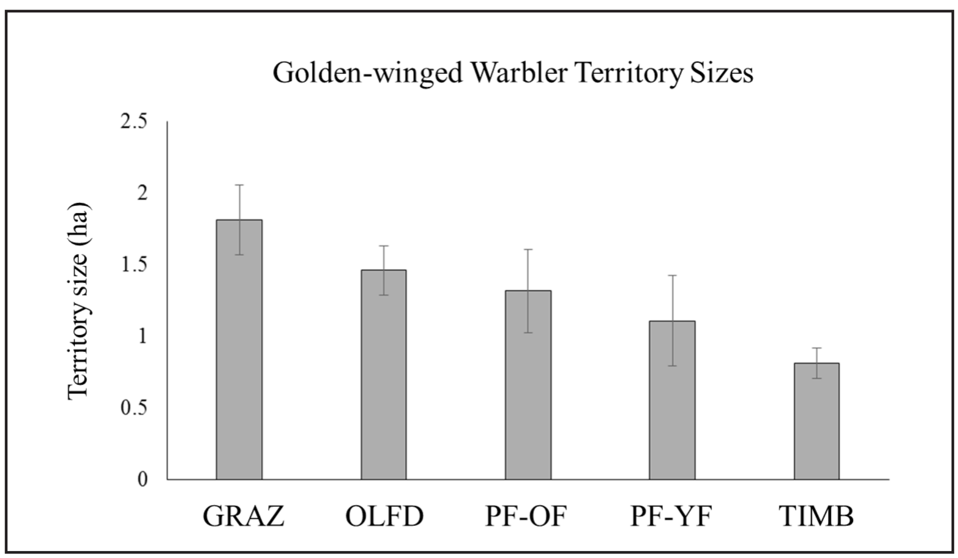

Figure 5. Territory sizes of golden-winged warblers mapped in 2012-2014. Error bars represent 95% confidence intervals. Sample sizes were: grazing magagement (GRAZ) = 86, old field mangagement (OLFD) = 159, prescribed fire - old field (PF-OF) = 45, prescribed fire - young forest (PF-YF) = 22, and timber harvest (TIMB) = 162.

nests (n = 143) produced on average 4.0 ± 0.1 fledglings. For model suite I (management system, study area, time within season, vegetation community type, and year covariates), DSR decreased as the season progressed (Fig. 6). For models that included management system, DSR was similar among management systems. However, the probability of producing a successful nest given three attempts (a common number of attempts among study areas according to Aldinger et al. 2015) showed more differentiation among management systems and was lowest for prescribed fire - young forest (Fig. 7).

The effects of vegetation (model suite II) on nest success was evaluated within each management system. Prescribed fire - young forest was not analyzed due to small sample size (n=13 nests). Modelling revealed that, for timber harvest and prescribed fire - old field, nest survival was not well explained by vegetation variables. It is inferred from these results that timber harvest and prescribed fire - old field consistently produced vegetation characteristics associated with average nesting success. There were significant effects of vegetation variables on nesting survival for grazing management and old field management. Intermediate levels of *Rubus* were best for nest survival on grazing management sites, whereas tall shrub (>2m) count was negatively associated with nest survival on Old Field Management sites (Fig. 8).

Fledgling Productivity: Mean golden-winged warbler fledgling productivity across all five management systems was 0.56 (± 0.10) fledglings/ha. Fledgling productivity among the management systems ranged from 0.21 ± 0.16 fledglings/ha for prescribed fire - young forest sites to 0.87 ± 0.23 fledglings/ha for prescribed fire - old field sites (Fig. 9). However, these two management systems also had the widest variation in two of the productivity components: 1) probability of nest success given three attempts and 2) number of young fledged per successful nest.

Attainment of recommended nesting vegetation: Vegetation was quantified at 2,719 random plots across 45 managed sites over the course of our study (746 in grazing management, 627 in old field management, 146 in prescribed fire - old field, 335 in prescribed fire - young forest, and 865 in timber harvest). The attainment of recommended levels for all five nest vegetation variables occurred in 39 of 2,719 (1.4%) random plots. The average number of variables that attained recommended levels simultaneously within a single random plot ranged from 1.9 (SE: 0.12) in timber harvests to 2.5 (SE: 0.08) in grazing management sites.

Table 1. Mean territory density (males/10 ha) across each of five management systems.

Management system	Number of sites territory mapped	Golden-winged warbler mean (±SE) density
Grazing management	12	1.26 (0.30)
Old field management	17	1.39 (0.31)
Prescribed fire - old field	2	3.37 (0.82)
Prescribed fire - young forest	13	1.05 (0.41)
Timber harvest	26	1.69 (0.30)

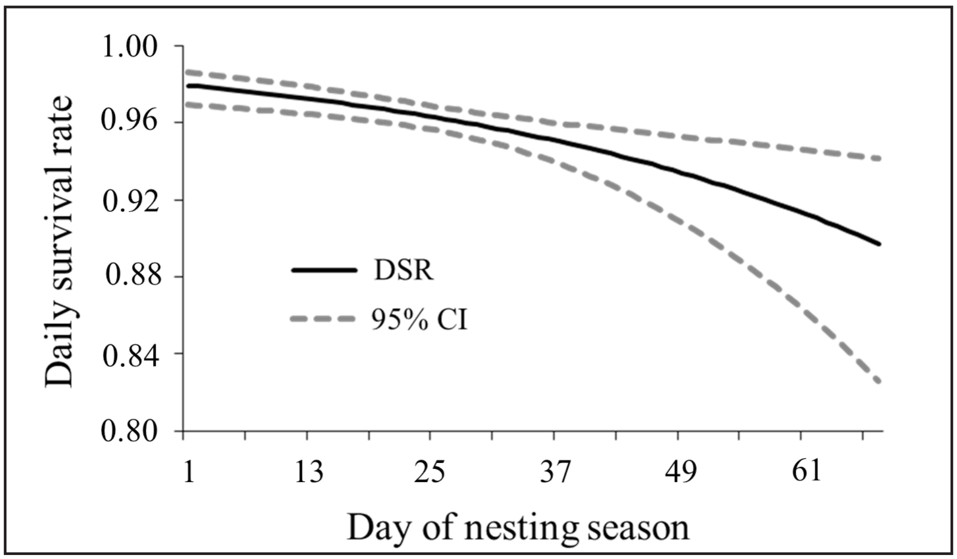

Figure 6. Daily survival rate (DSR) of golden-winged warbler nests decreased as the 69-day nesting season progressed.

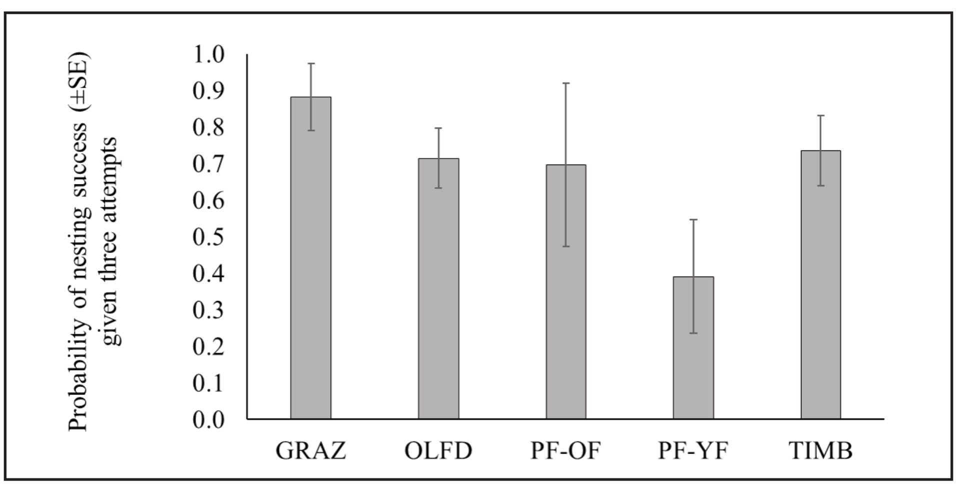

Figure 7. Probability of golden-winged warbler nest success (± SE) given three attempts among management systems: grazing management (GRAZ), old field mangagement (OLFD), prescribed fire - old field (PF-OF), prescribed fire - young forest (PF-YF), and timber harvest (TIMB).

Golden-winged warbler territories are structurally diverse and must support activities other than nesting (e.g., singing, foraging, and fledgling-rearing). Thus, while it is important that managed sites provide multiple options for nest placement, the attainment of recommended levels of nest site vegetation should not be expected to approach 100% across an entire site.

Space use of radio-tagged adult males: A total of 524 telemetry and 439 visually mapped locations among 12 male golden-winged warblers in Pennsylvania and 488 telemetry and 616 visually mapped locations among 7 males in West Virginia were recorded. Telemetry-delineated home ranges were 2–4 times larger than visually mapped territories (Table 2, Fig. 10) (Frantz et al. 2016).

Forty percent of radio telemetry locations were outside of visually mapped territories. Sapling abundance was greater in home ranges (mean 20.7 saplings/5-m radius plot ± 2.9 SE) than in visually mapped territories (11.5 ± 2.9) in Pennsylvania. In managed pastures of West Virginia, tree abundance was greater in home ranges (7.3 trees/11.3-m radius plot ± 0.8) than in visually mapped territories (1.9 ± 0.6) and telemetry locations were closer (14.3 m ± 8.0) to intact forested edges than were visually mapped locations (44.8 m ± 6.7). More telemetry locations than visually mapped locations occurred in forest in both states. On several occasions, radio-marked individuals were observed >200 m (maximum of 1.5 km) from their visually mapped territory boundaries. Why golden-winged warblers left their visually mapped territories is unknown, but observations suggest foraging, extra-pair copulation, and reconnaissance for post-breeding movement as possible motives (Frantz et al. 2016).

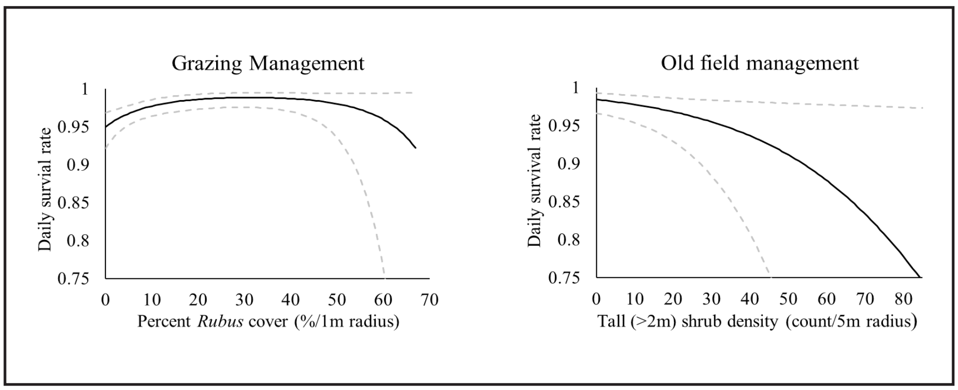

Figure 8. Vegetation features associated with nest survival as described by best-supported models of golden-winged warbler nest survival. Grazing management showed nest survival related to percent *Rubus* cover within 1 m in a manner where intermediate levels were best. The model for Old field Management revealed that tall shrub (>2m) count within 5 m of the nest was negatively associated with nest survival.

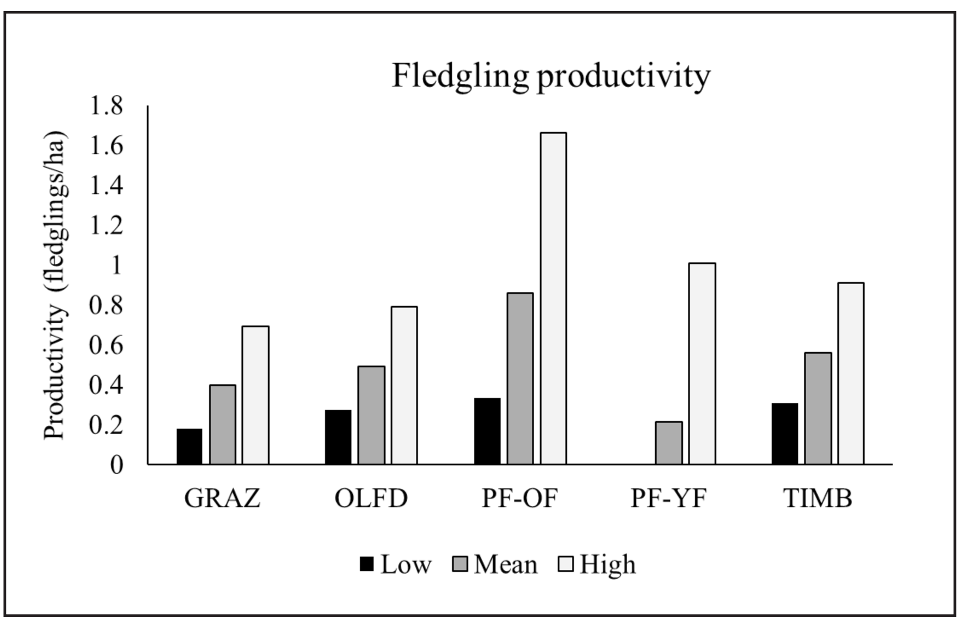

Figure 9. Fledgling productivity among management systems. Fledgling productivity was the product of four components: (1) probability of nest success given three nesting attempts, (2) number of fledglings produced per successful nest, (3) territory density, and (4) pairing rates. Low and high estimates were calculated using lower and upper 95% confidence intervals.

Fledgling survival: A total of 76 fledglings were radio-tracked during the 2-year post-fledging study (TN 2013, n = 10; TN 2014, n = 31; and PA 2014, n = 35). Depredation was greatest during the first four days after fledging, with 81% (34/42) of the mortalities occurring within this period. Daily survival increased considerably thereafter (5+ days post-fledging). Daily survival for the 5–25 day interval was 98.7 ± 0.8% in Tennessee and 98.2 ± 0.8% in Pennsylvania. Fledgling survival for the entire 25-day post-fledging period was 25.3 ± 8.2% in Tennessee and 45.5 ± 13.3% in Pennsylvania. Average shrub height at each fledgling location was the most important habitat feature associated with daily survival, as fledgling survival was negatively related to average shrub height during the first four days after fledging.

Fledgling habitat use and movement: Habitat use changed considerably as the fledglings aged over their first 30 days post-fledging. Very young fledglings (<5 days out of the nest) used primarily early-successional habitat on the first day post-fledging but gradually used other cover types as they aged (Figs. 11 and 12). By Day-12 post-fledging, early-successional habitat made up less than half of total cover types used by fledglings in Pennsylvania and Tennessee. Fledglings studied in Tennessee used proportionally more pole-staged stands than fledglings in

Table 2. Size comparisons of radio-marked golden-winged warbler visually mapped territories and telemetry-delineated home ranges using 50% and 100% minimum convex polygons (MCPs).

			Visually mapped territory (ha)			Telemetry-delineated home range (ha)		
Metric	State	n	Mean	± SE	Range	Mean	± SE	Range
Territory Size (ha):								
100% MCP	PA	12	1.7	0.2	0.65–3.69	6.3	1.7	1.40–19.76
	WV	7	2.4	0.5	0.79–4.77	11.8	6.2	2.27–47.99
50% MCP	PA	12	0.3	0.1	0.12–0.69	0.5	0.1	0.13–1.03
	WV	7	0.3	0.1	0.13–0.63	0.6	0.1	0.20–1.28

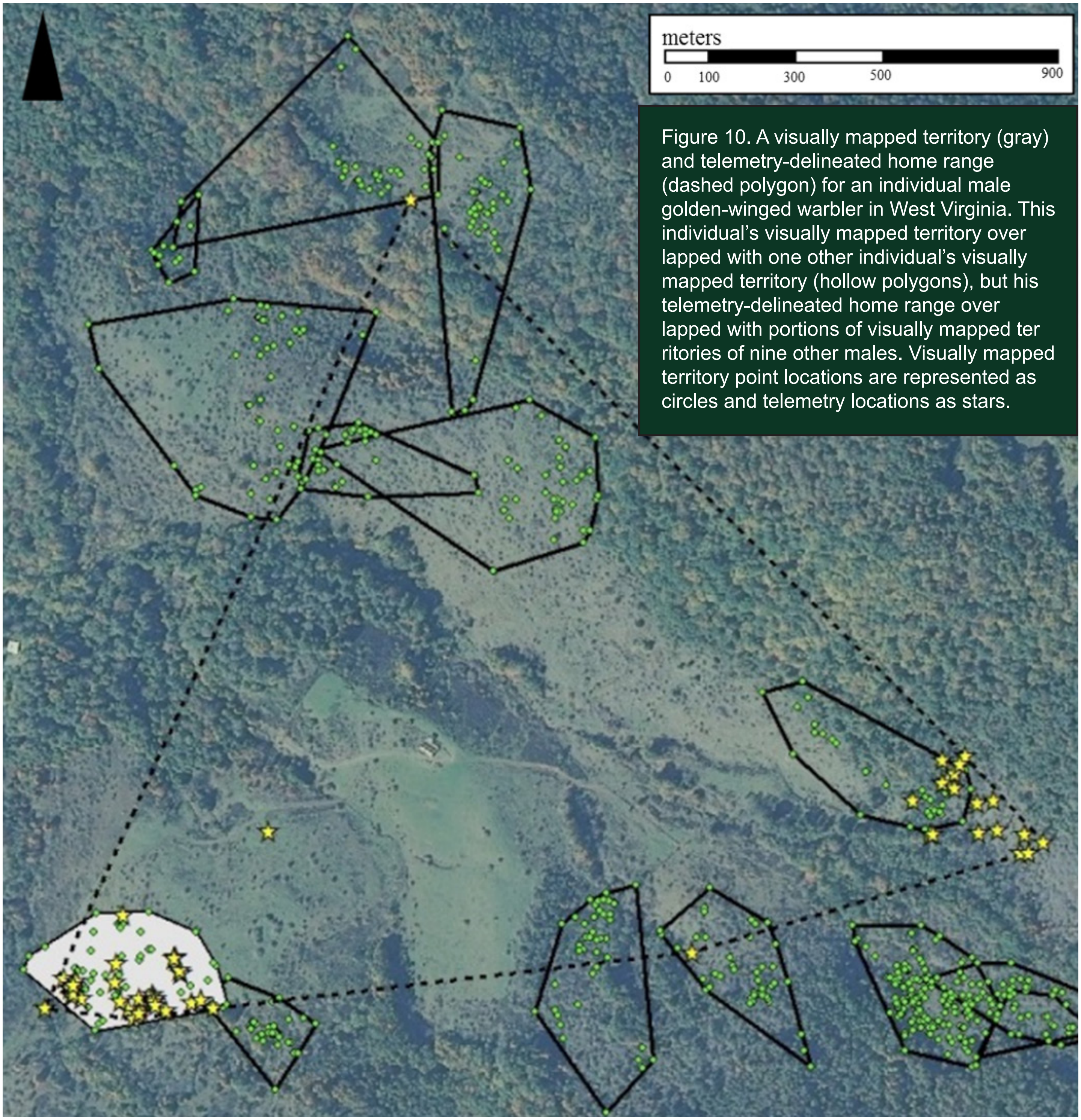

Figure 10. A visually mapped territory (gray) and telemetry-delineated home range (dashed polygon) for an individual male golden-winged warbler in West Virginia. This individual's visually mapped territory over lapped with one other individual's visually mapped territory (hollow polygons), but his telemetry-delineated home range over lapped with portions of visually mapped ter ritories of nine other males. Visually mapped territory point locations are represented as circles and telemetry locations as stars.

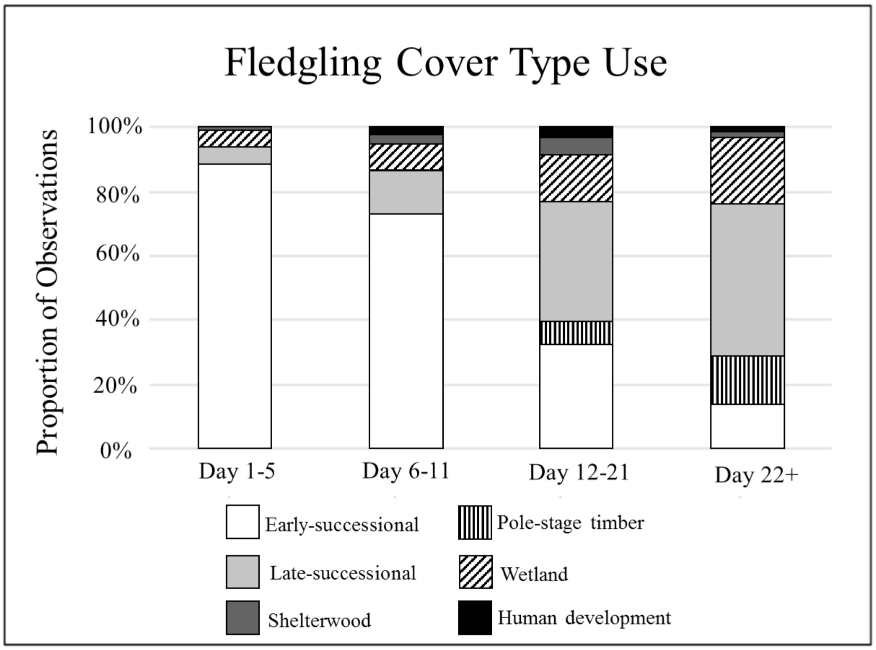

Figure 11. The use of five different cover types by golden-winged warbler fledglings during four time intervals across the first 30 days post-fledging. (Note: Wetlands and shelterwoods were not present in the Tennessee study area.)

Figure 12. An example of mid-successional habitat used by older golden-winged warbler fledglings in Pennsylvania—often a patch of moderately dense regeneration within canopy gaps created by individual tree falls or gypsy moth mortality.

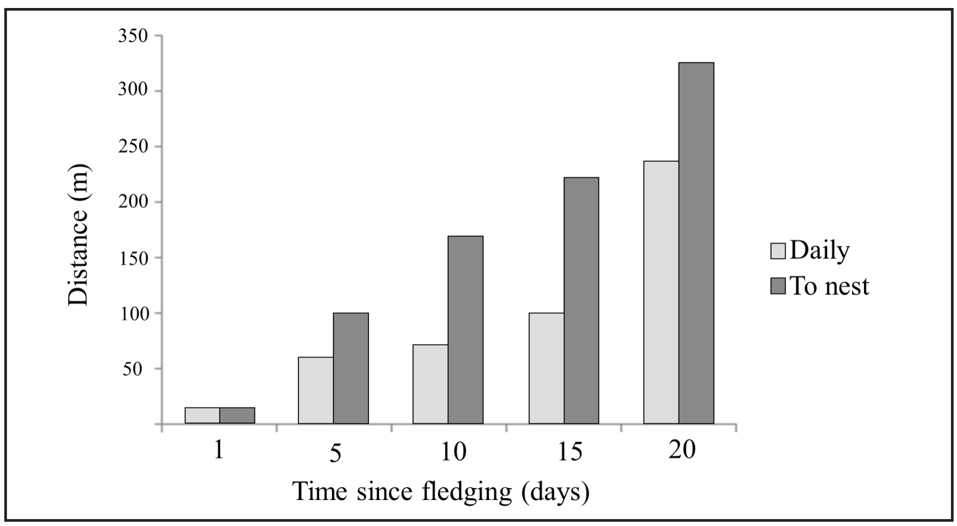

Figure 13. Daily movement patterns of fledgling golden-winged warblers in Tennessee and Pennsylvania over the first 20 days post-fledging. Movement is measured as day-to-day movements and distance to nest.

Pennsylvania over all time intervals. Pennsylvania birds used wetlands and shelterwoods (which were not available in Tennessee) more frequently as they aged. Day-to-day movements and total distance from the nest increased during each of five time steps examined for all radio-marked individuals (Fig. 13). Figure 14 shows the daily movements of a fledgling golden-winged warbler in Pennsylvania.

Putting Findings into Practice

The purpose of this assessment was to evaluate golden-winged warbler response to active habitat management using conservation practices suggested by NRCS's *Working Lands for Wildlife* in the southern and central Appalachian states. Golden-winged warbler populations, and those of many other wildlife species that require forested landscapes with a mix of young and old successional communities, have declined drastically. To reverse these population declines, many government natural resource agencies and their partners are using active management (e.g., timber harvest, brush mowing, and prescribed fire) to increase the availability of early successional communities in forested landscapes. The financial and human resource costs associated with these efforts are often considerably high. As such, evaluating which conservation systems are effective and identifying potential ways to improve management

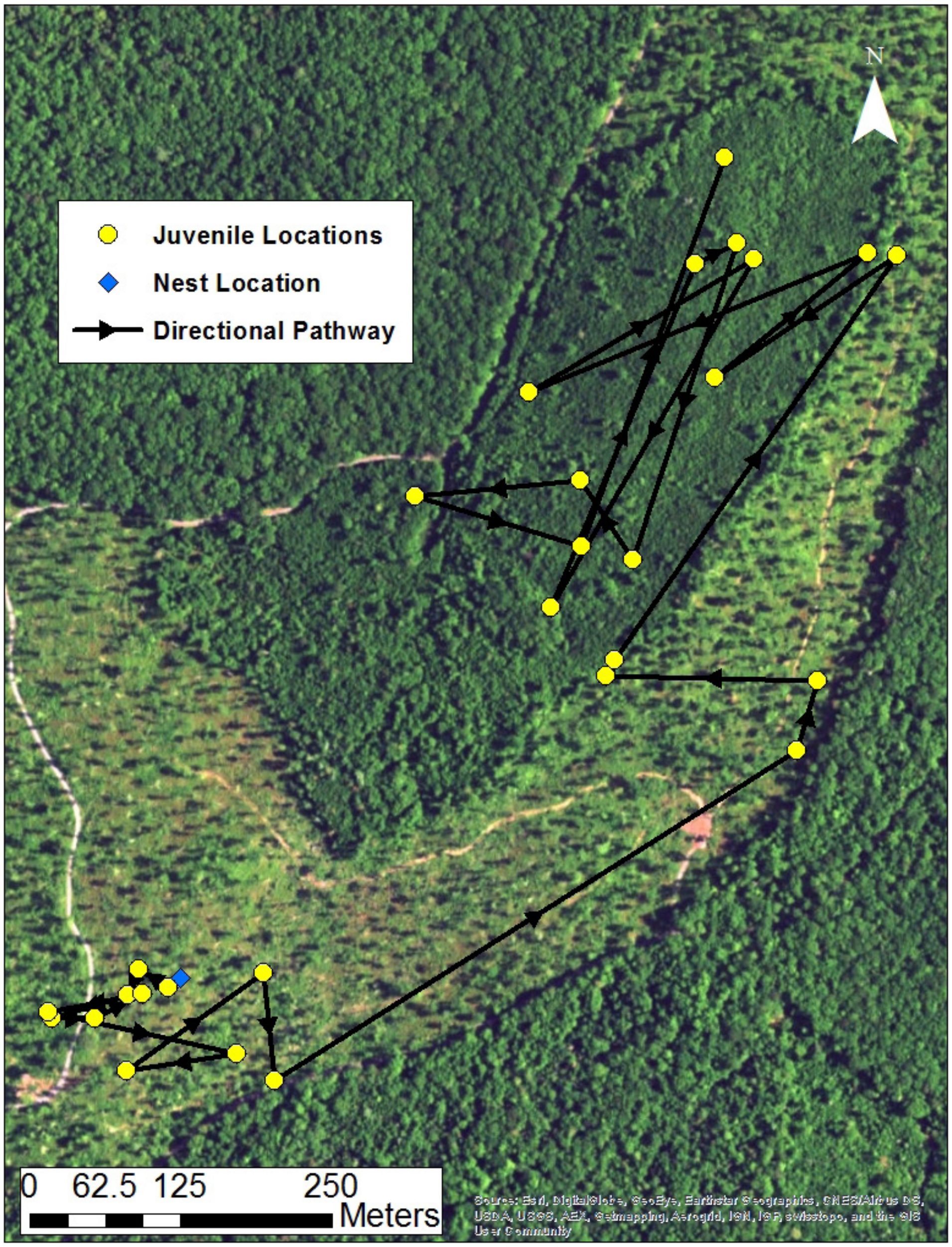

Figure 14. An example of a 27-day movement pathway of a fledgling golden-winged warbler within a timber harvest management system site in Pennsylvania.

effectiveness is important. Assessment findings can be used to maximize the contribution of NRCS's *Working Lands for Wildlife* to reversing the decline of this imperiled songbird.

• Many of the golden-winged warbler demographic metrics assessed (e.g., annual adult survival, territory density, and nest survival) did not differ among the five management systems (timber harvest, prescribed fire - young forest, prescribed fire - old field, grazing management, and old field management), thus indicating that each was effective at supporting breeding populations of this species in the landscapes where it was applied.

• Golden-winged warbler territories were relatively small with most (>90%, n = 463) defended territories being <3 ha (7.5 acres) in size. Average territory size was greatest for grazing sites (1.77 ha) and least for timber harvests (0.82 ha). Across all sites, regardless of management system, territory size averaged 1.36 ha (3.5 acres).

• On average, managed sites supported 1.5 males/10 ha (0.6 males/10 acres).

•Across all management systems, adult males had a minimum annual survival probability of 0.58 (± 0.04, n = 290 males).

• Golden-winged warbler density increased linearly with sapling count. Management should result in average sapling densities that range between 3,000–8,400 stems/ha (1,200–3,300 stems/acre).

• Although the simultaneous attainment of recommended levels of the five nest site vegetation characteristics presented in the *Golden-winged Warbler Conservation Plan* (Roth et al. 2012) was rare for all five management systems, they still maintained the capacity to produce high-quality nesting habitat.

• While WLFW sites were used by golden-winged warblers, there are a few aspects of vegetation that managers need to pay close attention to in order to improve attainment of recommended levels outlined in the *Golden-winged Warbler Conservation Plan.* Specifically, woody-dominated sites (timber harvest and prescribed fire - young forest) generally needed more grass cover (observed 2–6% vs. the recommended 5–25%) and herbaceous-dominated sites (old field management, grazing, and prescribed fire) needed to reduce grass cover (observed 30–35% vs. the recommended 5–25%). The recommended values for these particular vegetation components can be achieved by incorporating the appropriate facilitating practices into NRCS conservation plans.

• This assessment represents one of the single largest efforts to relate golden-winged warbler nesting success to a suite of specific land management systems. Two hundred eighty-eight golden-winged warbler nests across all study areas were found and monitored. Management system itself was not associated with survival of golden-winged warbler nests.

• Individual management systems supported different vegetation relationships with respect to nest survival. Timber harvest and prescribed fire - old field had no apparent relationships with microhabitat characteristics while old field management and grazing management nests survived as a function of >2-m tall shrubs and *Rubus,* respectively.

- Average fledgling productivity across management systems was 0.56 fledglings/ha (1.38 fledglings/acre).

- Radio telemetry revealed that adult males often (in 40% of locations) move beyond their defended territories. These frequent, and sometimes long-distance (1 km), movements into areas with different vegetation structure than found in typical nesting habitat indicates the importance of managing for a diversity of forest age classes at the local landscape scale.

- The concept of providing young forest nesting habitat within a mosaic of other forest age classes is also important for the post-fledging period. The 76 fledglings monitored used a combination of early-, mid-, and late-successional communities within the first 25 days post-fledging.

- Fledgling survival was examined in two management systems (old field-prescribed fire and timber harvest) and was found to be significantly higher in timber harvest.

- Reduced shrub height (<0.5m) may increase juvenile survival during the first 4 days post-fledging—the period when mobility of juveniles was limited and most mortality occurred.

- Future research should attempt to quantify post-fledging survival in habitats created by other management systems not investigated here.

- This assessment reinforces that the availability of multiple age-class forests within highly (>70%) forested landscapes is important for breeding and post-breeding golden-winged warblers.

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Conservation Effects Assessment Project: Translating Science into Practice

The Conservation Effects Assessment Project (CEAP) is a multiagency effort to build the science base for conservation. Project findings will help to guide USDA conservation policy and program development and help farmers and ranchers make informed conservation choices.

One of CEAP's objectives is to quantify the environmental benefits of conservation practices for reporting at the national and regional levels. Because wildlife is affected by conservation actions taken on a variety of landscapes, the CEAP-Wildlife National Component complements the CEAP national assessments for cropland, wetlands, and grazing lands. The Wildlife National Assessment works through numerous partnerships to support relevant assessments and focuses on regional scientific priorities.

This assessment was conducted through a partnership among NRCS, Indiana University of Pennsylvania (IUP), American Bird Conservancy, West Virginia University, USGS West Virginia Cooperative Research Unit, North Carolina Audubon, Worcester Polytechnic Institute, University of Tennessee, and Appalachian State University. The primary investigator on this project was Jeff Larkin (IUP).

For more information: www.nrcs.usda.gov/technical/NRI/ceap/, or contact Charlie Rewa at charles.rewa@wdc.usda.gov.