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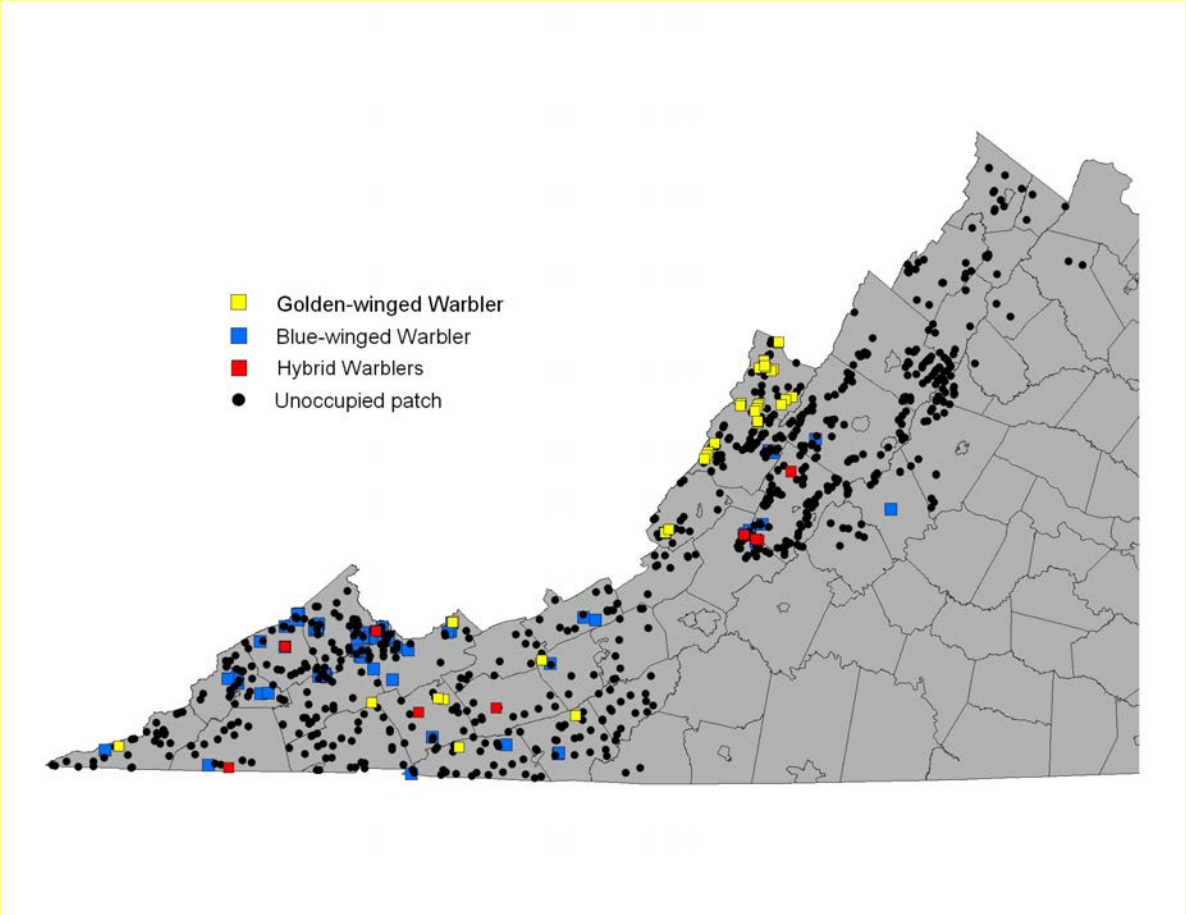

Center for Conservation Biology
College of William and Mary

This project was funded by the State Wildlife Grants Program administered by the Virginia Department of Game and Inland Fisheries (VDGIF) Wildlife Diversity Division. Views expressed herein are those of the authors and do not necessarily reflect the views of VDGIF.

Status Assessment of Golden-winged Warblers and Bewick's Wrens in Virginia

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Executive Summary

The Appalachian Mountains of Virginia have long been considered population strongholds for Golden-winged Warblers (*Vermivora chrysoptera*) and Appalachian Bewick's Wrens (*Thryomanes bewickii altus*). However, both of these species have undergone dramatic population declines in Virginia and throughout the greater Appalachian region including the general belief that Bewick's Wrens are extirpated from this state. Reasons for the decline of these species may be many, but the most common explanations point to the loss and degradation of early successional breeding habitat. Golden-winged Warblers and Bewick's Wrens use shrubby, early successional habitats for breeding such as idle vegetated areas, forest clear-cuts, alder swamps, utility right-of-ways (ROWs), and others. Several forces have worked together to cause the recent decline in early successional shrublands including direct losses caused by human development, re-forestation of farmland, fire suppression, and changes in agricultural and forestry practices. In addition, Golden-winged Warblers may be declining because of competition for breeding habitat and hybridization with Blue-winged Warblers. Blue-winged Warblers have been expanding their range eastward and into higher elevations that were once occupied exclusively by Golden-winged Warblers.

There has been no systematic study on the overall distribution and population status of these species in Virginia. The objectives of this study were to assess the relative distribution and basic habitat use for Golden-winged Warblers and Bewick's Wrens and to determine the amount of geographic and habitat overlap between Golden-winged and Blue-winged Warblers.

We systematically surveyed for the presence of these three species across 40 counties in Virginia's Appalachian Plateau, Ridge and Valley, and Blue Ridge physiographic provinces. Surveys consisted of 11-minute point counts aided by the use of recorded species playback. This effort resulted in the survey of 932 points at 863 different shrub patches. We detected 56 Golden-winged Warblers within 37 patches across only 11 counties. Highland county supported the overwhelmingly greatest number of Golden-winged Warblers with 28 birds observed in 18 patches. A total of 92 Blue-winged Warblers were detected in 62 different habitat patches across 18 counties. Blue-winged Warblers were detected in all but one county where Golden-winged Warblers occurred. The two species distributions overlapped in elevation but differed somewhat in habitat use. Golden-winged Warbler used idle farm/pastureland and forest clear-cuts at a greater rate than expected by chance and used utility ROWs, shrubby wetlands, and other shrub patches less frequently than expected. Blue-winged Warblers showed the opposite pattern for most of these habitat types. Hybrid warblers were detected infrequently but found within 7 counties. We did not detect any Bewick's Wrens during surveys.

Comparing our data with historical records indicates that Golden-winged Warblers are continuing to decline in Virginia and are being replaced by Blue-winged Warblers in order of abundance. The overall low number of Golden-winged Warbler detections may provide justification for regulatory protection and highlights the importance for their conservation. Geographical and habitat use patterns of Golden-winged Warblers from this study provide guidance for proactive management.

Introduction

Concern for the status of many North American bird species that depend on early successional habitats has increased within the scientific and conservation community. The species assemblages associated with the gradient of habitats between grasslands and shrublands are generally less diverse and represent a smaller segment of the overall species compared to forested habitats. However, grassland and shrubland birds have experienced population declines that are in many cases equal or greater than those experienced by forest-dwelling birds (Askins 1993). Results for the annual USGS Breeding Bird Survey indicate that, between 1966 and 2005, nearly two-thirds of all shrubland bird species show negative population trends (Sauer et al. 2005).

The reasons for the decline of shrubland birds may be many but the most pervasive explanation is a decline in the availability of shrubland habitats. Shrublands exist in many forms but in the eastern United States this habitat is only present a short time between the period of forest disturbance and regrowth following natural succession. Prior to human influences on the landscape, most early successional habitats were created by natural forest disturbances such as fire, windthrow, flooding, or insect mortality. Today, most shrublands are created by anthropogenic land uses such as forest clear-cutting and regrowth, idle agriculture and pasture fields, utility right-of ways (ROW), and barren areas.

Several forces have worked together to cause the recent declines in early successional habitats. One significant force is the direct development of natural lands for human uses. Other losses have resulted from the natural succession of farmland following the wave of farm abandonment, re-colonization of these lands by second growth forests, and a dramatic shift back to forested land. In Virginia, open farmland had declined from 9.5 million acres in 1945 to 6.5 million acres by 1978 (U.S. Dept. of Commerce 1981). In addition, only 61% of farmlands were in cropland in 1945 compared to 74 % in 1978. Most of the land converted from farmland to other uses over this period was lost from pasture, wild hayfields, and idle areas.

Aside from direct conversion, shifts in agriculture, forestry practices, and fire suppression have reduced the amount of habitat once available to shrubland birds. For instance, modern agricultural practices use land more efficiently than ever before, leaving little or no land in idle shrub or weedy cover. In the late 1970s, the forest products industry radically shifted the forest landscape with the advent of tree plantations. Most of these plantations are stocked with high densities of fast growing pines. Shrub and herbaceous cover in these plantations quickly decline as a stand matures and the canopy closes. Without thinning, these stands remain unusable for early successional birds for the majority of the rotation length until final harvest. In addition, herbicides are now widely used to suppress shrubby growth in plantations that compete with standing tree crops. Finally, three centuries of fire suppression has greatly reduced the disturbances that yield early successional conditions. For example, fire-dependent habitats of the Appalachians, such as oak savannas, have been almost entirely eliminated.

The Appalachian Mountains are population strongholds for the Golden-winged Warbler (*Vermivora chrysoptera*) and the Appalachian Bewick's Wren (*Thryomanes bewikii altus*). Both of these species depend on early successional habitats and have undergone dramatic population declines throughout this region. Results of the USGS

BBS indicate that Golden-winged Warblers have declined annually by 15 % in Virginia during the past 40 years. Although there may be several reasons cited for population declines, the most prevailing explanations have been attributed to habitat loss and displacement by Blue-winged Warblers (*Vermivora pinus*). Blue-winged Warblers have been expanding their range for over 150 years into many areas that were once used exclusively by Golden-winged Warblers (Gill 1980, Confer 1992). Blue-winged Warblers are believed to directly compete for breeding habitat and hybridize with Golden-winged Warblers. The breeding range of both species and their hybrids overlap in the Virginia mountains where they nest in early successional habitats such as alder swamps, beaver meadows, abandoned farmland, utility ROWs, and young pine plantations.

The current status of the Appalachian Bewick's Wren in Virginia is unknown but the species is believed to have been extirpated. Bewick's Wren began expanding its range throughout the Northeastern U. S. in the late 1800s following a broad wave of land clearing. By the mid-1900s this species range began rapidly contracting from the northeast and has declined or has become extirpated from most areas. Most of the current information regarding its distribution and population size in Virginia has been limited to anecdotal reports of a few birds. There has been no consistent record in Virginia for nearly 20 years leading to the belief that Bewick's Wren has become extirpated.

The purpose of this report is to provide a rapid assessment of Golden-winged Warblers and Bewick's Wren in Virginia. Specifically we determined 1) species' distributions, 2) habitat use and requirements, and 3) the amount of geographic and habitat overlap between Golden-winged and Blue-winged Warblers.

Methods

Surveys were conducted within selected portions of 40 counties in the Appalachian Plateau, Ridge and Valley, and Blue Ridge physiographic provinces of Virginia (Figure 1). This generally includes the region between 39°05´00´´ and 36°30´00´´ North latitude and between 83° 40´00´´ and 78° 35´00´´ West longitude. We divided this area into 33, 7.5 min by 7.5 min blocks according to the Delorme Virginia Gazetteer pages. We began surveys by systematically covering high priority blocks that were higher in elevation and known or suspected to support Golden-winged Warblers and Bewick's Wrens. After these were completed, we surveyed a set of secondary blocks that were at lower elevations and not as likely to support these two species but expected to support Blue-winged Warblers.

Surveys were conducted by driving improved roadways and searching for patches of suitable habitat for Golden-winged Warblers, Blue-winged Warblers, and Bewick's Wren. Suitable habitat included any general shrubby field that was at least 0.10 ha or larger. We classified patches for descriptive purposes into the following categories; 1) idle farm/pastureland, 2) reclaimed strip mines, 3) forest clear-cuts and pine plantings, 4) successional forest (includes open canopy mid-successional forests), 5) utility right-of-ways (ROW), 6) shrubby wetlands (includes alder swamps, beaver wetlands, open forested wetlands, and other shrubby wet areas), and 7) other shrubby fields (includes all other patches that don't fit into other categories). All patches were surveyed one time between 5 May 2006 and 1 July 2006. This range of dates encloses the period when

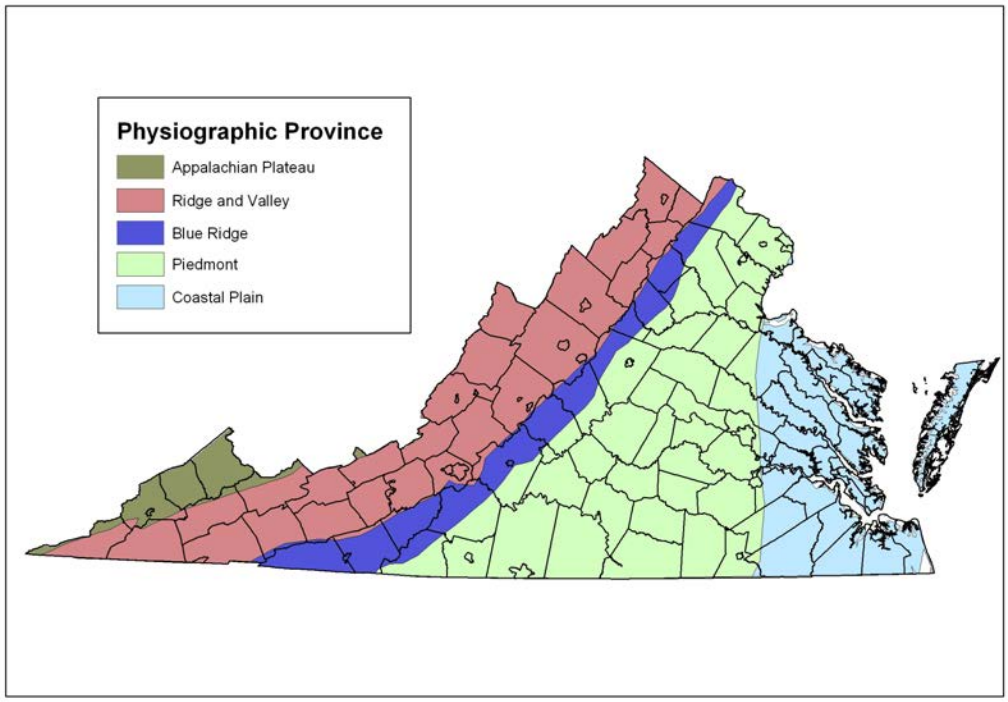

Figure 1. Physiographic provinces of Virginia. County borders are included for spatial reference.

Golden-winged Warblers and Blue-winged Warblers are considered to be most vocally active. Golden-winged Warblers begin breeding in Virginia from mid to late May (Clapp 1997). It is believed that territorial males begin arriving in late April while individuals of more northerly populations are still passing through this area during migration. It is possible that birds observed during earlier portions of the survey were transient individuals. However, it was not possible to re-survey locations where birds were detected early in the survey period because of time constraints. We placed emphasis on searching for and surveying new areas in lieu of revisiting individual habitat patches. Bewick's wren begins breeding in Virginia in mid-April. It is likely that if any Bewick's wrens were detected that they were local breeders.

Appropriate habitat patches were surveyed from the roadside edge using standardized 11-min point counts with species playback. At each point, the survey period began with 30 seconds of silence followed by a seven part sequence that included 60 s of a species song and 30 s of silence for each of the following; 1) Golden-winged Warbler type I song (Highsmith 1989, Confer 1992), 2) Blue-winged Warbler type I song (Kroodsma 1988), 3) Blue-winged Warbler type II song (Kroodsma 1988), 4) Golden-winged Warbler type I song, 5) Blue-winged Warbler type I song, 6) Blue-winged Warbler type II song, and 7) Bewick's Wren song. Playbacks were broadcast using a portable compact disc players and 0.5 watt amplified speakers.

Point counts were positioned along the road in order to provide maximum coverage of a patch. Most small patches were sampled with one point. Larger patches

had points positioned at 200-m intervals along the roadside with points specifically placed to survey any forest-shrub edge running perpendicular to the road. This technique was used because Golden-winged Warblers primarily use the forest-shrub edge (French and Confer 1987, Confer and Knapp 1981). We acknowledge that roadside points does not allow for coverage of interior habitat. However, due to the large number of patches and extensive geographic are covered, it was not feasible to seek landowner permission for access.

Daily surveys were conducted from sunrise until 1300 h. This period extends 3 hrs beyond what is typically recommended for most songbirds. Time constraints reflect the well-known decline in singing rate in late morning to early afternoon. Since the protocol included the use of playbacks which serves to increase detectability, we feel that the expanded survey window was justified (Kubel and Yahner 2007). This suggestion was supported by the fact that 47 % of all detections of Golden-winged and Blue-winged Warblers were made between 1000 and 1300 h. The use of playbacks also appeared to have a significant effect on drawing Golden-winged Warblers and Blue-winged Warblers to the observer. Most initial detections of these species were made within 50 m of the observer and were quickly followed by males approaching to within 10-15 m. Golden-winged Warblers were even seen flying from > 50 m away to land within 15 m of the observer. Because of this, we feel that any attempt to generate density estimates based on detection distance would be biased by the playback method so we used the frequency of occupied patches and unoccupied patches for all analyses.

A cursory measurement of habitat conditions was collected from the roadside at each point sampled. Habitat data included elevation determined by GPS, and visual estimation of; 1) patch area, 2) average vegetation height, 3) percent of patch covered by woody vegetation, 4) predominant habitat surrounding the patch (landscape matrix), 5) dominant plant species, and 6) general hydrologic source for wetland habitats (e.g., stream-fed, basin). We estimated the width of utility ROWs rather than area since these patches often extend for kilometers. A summary of patch metrics are indicative of the characteristics of patches surveyed and do not necessarily represent the general characteristics of the western Virginia landscape. There were many shrubby patches that were not accessed for survey.

Results

We surveyed 932 points within 863 different habitat patches (Table 1). Upland habitats accounted for 96 % of all patches and the remaining 4 % were wetlands. There were large differences in the number of patches surveyed between each county. Most of these differences were due to low coverage counties that barely overlapped the study areas rather than absolute differences in habitat availability.

Surveyed patches ranged in elevation from 121 to 1208 m (approx. 397 ft to 3,963 ft) with a mean of 561.3 m ± 188.59 (SD) (Figure 2). Patch area ranged from 0.08 ha to 45 ha ($\overline{x}$ = 1.7 ± 4.05 [SD]) with 90 % of the patches being 3 ha or smaller. Patch area varied between habitat types with reclaimed strip mines and clear-cuts being larger than other habitat types (Table 2). Average vegetation height was similar between most shrubby habitats but greater in successional forests and wetland habitats. Shrub cover

was the most consistent characteristic between patches with all habitats having 60% or greater average shrub cover.

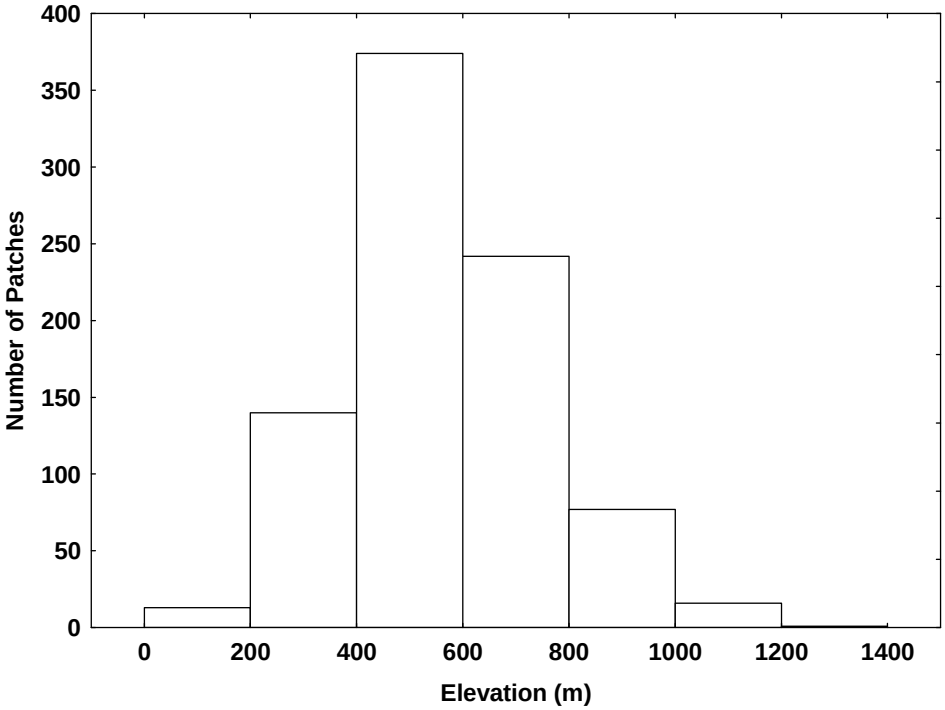

Figure 2. Frequency distribution for the elevation of patches selected for survey.

Golden-winged Warbler

Geographical Patterns. We detected Golden-winged Warblers in only 11 of the 40 counties surveyed (Figure 3, Appendix I). These detections included 56 individual Golden-winged Warblers within 37 different habitat patches. The number of birds detected per occupied patch ranged from 1-2 ($\overline{x}$ = 1.1 ± 0.24 [SD]). At the county level, the overall abundance of Golden-winged Warblers and the number of occupied patches were not correlated with either the total number of points surveyed or the total number of patches surveyed (i.e., all Spearman ranked correlations < 0.48, all *P* values > 0.5) (Appendix I). This suggests that detection rates were independent of sampling effort and that Golden-winged Warblers were un-evenly distributed among the 11 counties where they were detected for some reason other than sampling effort.

Table 1. Number of patches surveyed by county and habitat type.

County	Utility ROW	Strip mine	Succes-sional forest	Idle farmland	Clear-cut	Shrub Wetland	other shrub	Row Totals
Albemarle	5	0	2	4	2	1	5	19
Alleghany	1	0	0	1	10	0	4	16
Amherst	4	0	1	0	0	0	5	10
Augusta	0	0	31	17	5	8	0	61
Bath	2	0	31	33	1	6	3	76
Bland	8	0	1	0	0	0	3	12
Botetourt	3	0	16	3	13	0	1	36
Bristol	1	0	0	0	0	0	1	2
Buchanan	37	6	3	0	0	0	11	57
Carroll	7	0	2	0	1	0	13	23
Clarke	0	0	0	0	0	0	2	2
Craig	2	0	0	0	2	2	3	9
Dickenson	14	0	0	0	0	0	7	21
Fauquier	1	0	0	0	0	0	1	2
Floyd	6	0	1	1	0	0	9	17
Frederick	2	0	0	0	2	0	6	10
Giles	3	1	0	0	0	0	14	18
Grayson	9	0	5	1	1	1	13	30
Green	0	0	5	3	0	0	0	8
Highland	0	0	11	32	1	1	1	46
Lee	17	0	3	0	0	0	11	31
Loudoun	1	0	0	0	0	0	0	1
Madison	0	0	0	0	0	0	1	1
Montgomery	5	0	0	0	0	0	4	9
Nelson	0	0	1	3	0	1	2	7
Page	4	0	3	1	0	0	1	9
Patrick	1	0	0	0	0	0	1	2
Pulaski	6	0	0	0	0	0	0	6
Rappahannock	1	0	0	0	0	1	0	2
Rockbridge	10	0	32	12	6	2	1	63
Rockingham	1	0	40	12	3	4	3	63
Russell	16	0	2	0	0	1	10	29
Scott	10	0	2	0	0	0	5	17
Shenandoah	6	0	0	0	6	2	2	16
Smyth	8	0	1	7	0	0	2	18
Tazewell	25	0	1	1	0	1	4	32
Warren	0	0	0	1	5	1	0	7
Washington	18	0	3	1	0	0	6	28
Wise	21	3	0	0	0	0	11	35
Wythe	5	0	0	2	0	0	5	12
Total	**260**	**10**	**197**	**135**	**58**	**32**	**171**	**863**

Table 2. Characteristics of patches surveyed by habitat type. All values are mean ± SD.

Habitat Type	N	Elevation (m)	Area (ha)*	Vegetation Height (m)	Percent Shrub Cover
Utility ROW	260	585.3 ± 178.16	41.9 ± 15.16	2.8 ± 1.00	71.9 ± 15.74
Strip-mine	10	629.4 ± 78.60	5.7 ± 9.18	2.6 ± 0.69	87.5 ± 7.17
Successional forest	197	503.8 ± 158.31	0.8 ± 1.08	6.5 ± 2.87	71.1 ± 16.44
Idle farmland	135	595.4 ± 204.56	0.9 ± 1.36	4.4 ± 2.55	64.1 ± 18.60
Shrubby wetland	32	511.3 ± 181.30	1.2 ± 1.83	4.9 ± 3.16	69.2 ± 16.17
Clear-cut	58	516.3 ± 197.30	7.0 ± 10.28	4.0 ± 1.74	75.8 ± 14.69
Other shrubby field	171	585.2 ± 207.57	1.6 ± 1.64	2.8 ± 0.96	69.3 ± 15.59

*values for Utility ROWs are based on width (m) rather than area

Highland County supported the overwhelmingly largest concentration of birds in the entire study area with 28 Golden-winged Warblers within 18 different patches. These detections accounted for 50 % of the total number of Golden-winged Warblers over the entire study and 47 % of all the occupied patches. Highland County also had the greatest patch occupation rate (39 %) among all counties surveyed (Figure 4). Bath County supported the second largest concentration of Golden-winged Warblers with 7 detections. Although detections in Bath County were low, they accounted for 12.5 % of all Golden-winged Warblers observed and 18 % of all occupied patches. However, Golden-winged Warblers only occupied 4 of 73 (5 %) patches surveyed in Bath County. The remaining 9 counties where Golden-winged Warblers were observed had only 1 or 2 total detections in each.

Habitat patches where Golden-winged Warblers were observed ranged in elevation from 464 m to 1078 m (approx. 1,500 ft to 3,500 ft) with a mean elevation of 748.9 m ± 167.32 (SD). Occupied patches were not evenly distributed across the range of elevations surveyed ($\chi^2_6 = 37.87$, $P < 0.001$) (Figure 5). Patches > 700 m were used with greater frequency than expected based on the number of patches surveyed and patches < 700 m in elevation were used less frequently than expected based on the number surveyed. Sixty-five percent of occupied patches occurred at elevations 700 m or higher. Seven of the counties surveyed did not contain patches $\geq$ 400 m in elevation. Consequently, Golden-winged Warblers were unlikely to be detected in these seven counties based on habitat availability at the proper elevation. These included Clarke, Faquier, Frederick, Loudon, Madison, Rappahannock, and Warren counties. However, this also demonstrates that Golden-winged Warblers were not detected in 22 counties that contained patches $\geq$ 400 m elevation.

Habitat Use Patterns. Golden-winged Warblers were detected in all upland habitat types except for reclaimed strip mines and were also not detected in wetlands. When patches only > 400 m elevation were examined (N = 710), the frequency with which habitats were occupied was significantly different from the number of patches of each habitat surveyed ($\chi^2_{6Yates} = 29.53$, $P < 0.001$) (Figure 6). Golden-winged Warblers were detected in idle farm/pastureland and clear-cuts at a greater rate than expected based on

the number surveyed. By comparison, detection rates in utility ROWs, other shrub patches, wetlands and successional forest were less than expected based on the number surveyed.

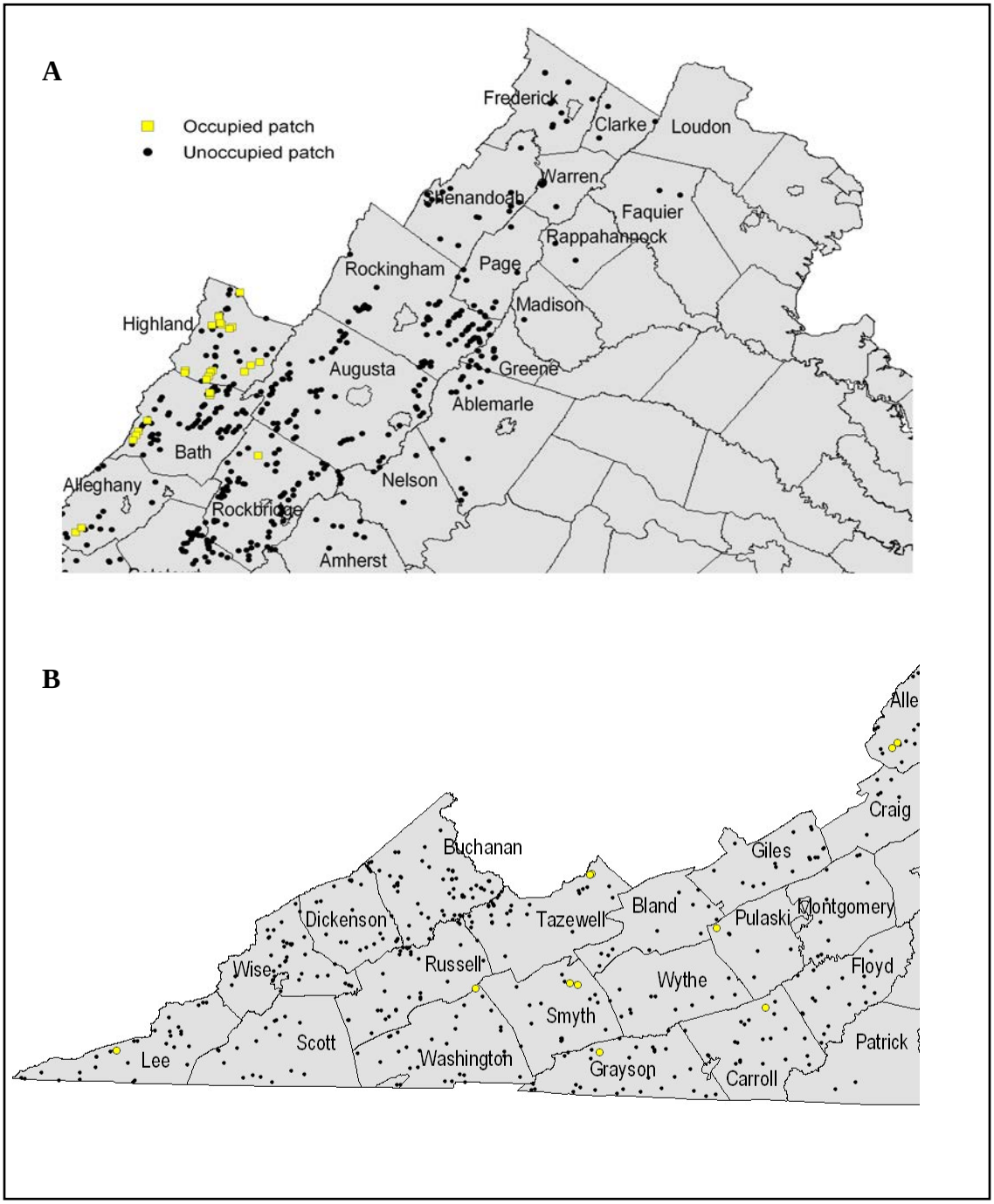

Figure 3. Distribution of Golden-winged Warblers within A) northern portion of study area, and B) southern portion of study area. County names are only labeled for those included in the survey.

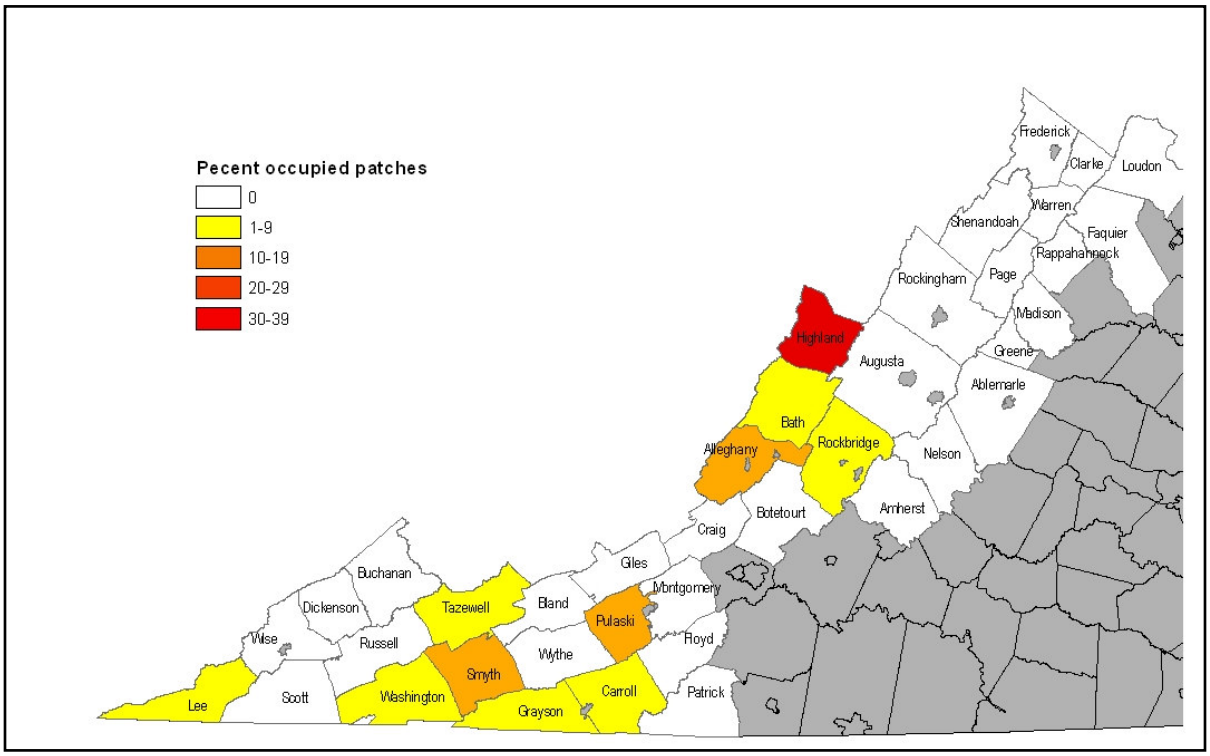

Figure 4. Percent of patches occupied by Golden-winged Warblers in each county. Counties and city boundaries in gray were not surveyed.

Habitat use patterns indicate that idle farm/pastureland was overutilized by more than one order of magnitude compared to other habitat types. Fifty-three percent of all occupied patches were idle farm/pastureland. Further inspection of the data indicate that this result is largely due to the higher numbers of Golden-winged Warblers in Highland and Bath counties, combined with a relatively higher number of idle farm/pasturelands surveyed in Highland and Bath compared to other counties. Highland and Bath counties accounted for 53 % of all idle farm/pastureland patches surveyed. Moreover, idle farm/pastureland was the dominant habitat type of these counties and accounted for 70 % and 43 % of all patches surveyed in Highland and Bath counties, respectively. When habitat patterns within these two counties were investigated alone, Golden-winged Warblers were detected evenly across all habitats in relation to the number of habitat patches surveyed ($\chi^2_5 = 4.2$, $P > 0.5$). However, there were no warblers detected in ROWs in either Highland or Bath counties (N = 2 surveyed). Golden-winged Warbler observations in counties other than Highland and Bath were too low to permit a probability-based analysis but, in general, were detected somewhat evenly across habitat patches; utility ROWs (N = 6), idle farm/pastureland (N = 2), clear-cut (N = 1),

successional forest (N = 1) and other shrubby fields (N = 2). There were no detections within wetlands or reclaimed strip mines.

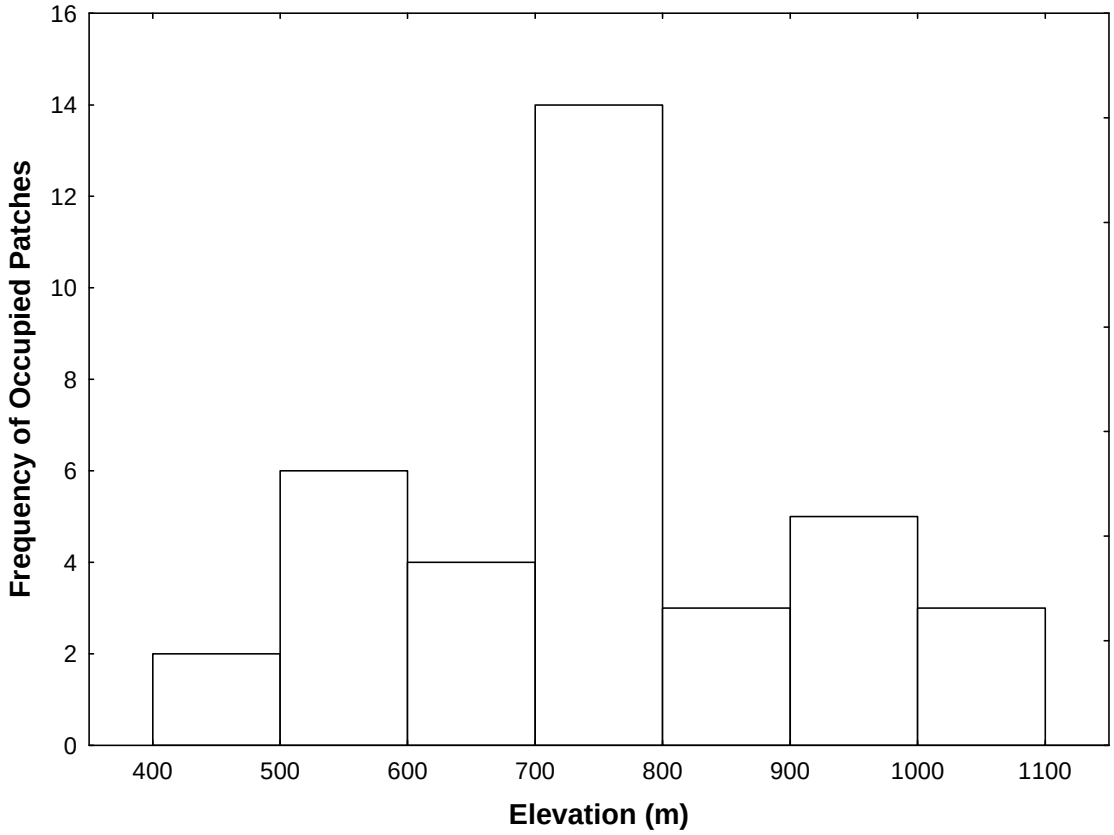

Figure 5. Frequency distribution of elevation for patches occupied by Golden-winged Warblers.

Statistical comparisons of patches > 400 m elevation indicated that there were no significant differences between values of habitat variables between occupied and non-occupied sites (Table 3). These results remained consistent when habitat variables were compared between occupied and non-occupied patches within any one individual habitat category (all *P* values > 0.10) and when habitat variables were examined only for sites in Highland County (all *P* values > 0.10). Overall, Golden-winged Warblers were detected in patches ranging from 0.2 - 30 ha. Forty-four percent of all detections were in patches < 1ha.

Patches occupied by Golden-winged Warblers were predominantly surrounded by deciduous forest, active agricultural/pastureland, or mixed pine-deciduous forest (47 %, 29 %, and 24 % of all occupied patches, respectively) (Table 4). Golden-winged Warblers did not appear to use any one of these combinations over another because the detection rate across the combination of habitat and landscape matrix were proportional to the number of each surveyed ($\chi^2_6 = 10.1$, $P > 0.10$). However, patches surrounded by

residential, commercial, and industrial land, and patches surrounded by pine forest were never occupied.

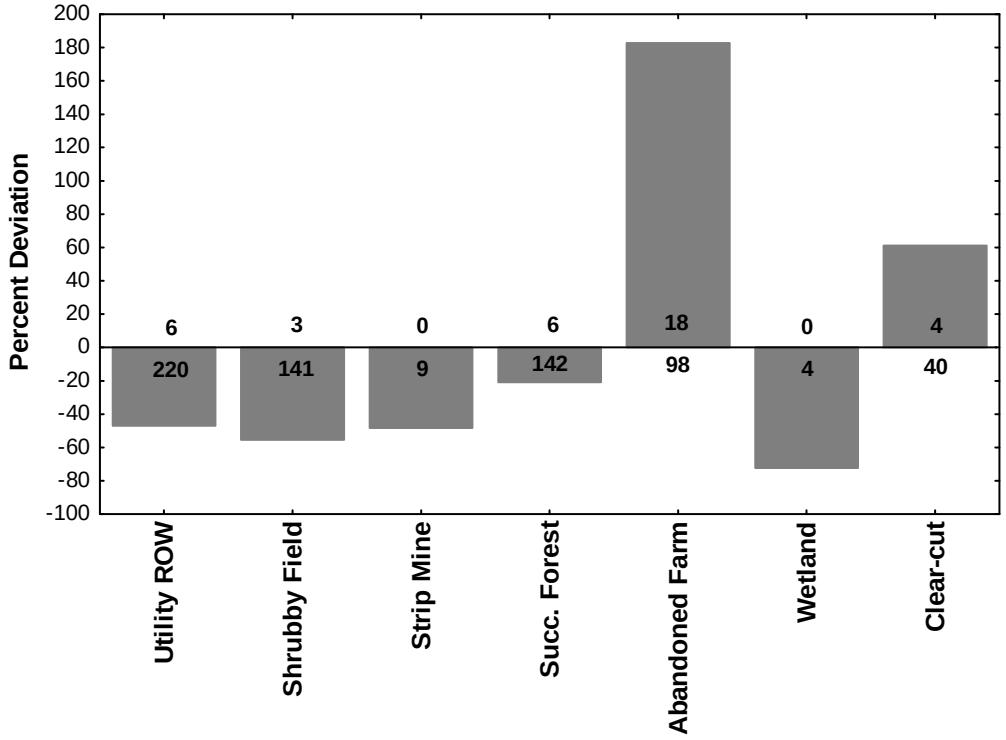

Figure 6. Percent deviation in observed habitat use by Golden-winged Warblers from expected even distribution. Positive values indicate habitats that were used with greater frequency than expected by chance whereas negative values indicate habitats that were used with lower frequency than expected by chance. Values above the neutral line indicate the number of patches where Golden-winged Warblers were detected and values below the line indicate the total number of patches surveyed.

Table 3. Comparison of habitat use variables for Golden-winged Warblers between occupied and non-occupied patches.

Variable	Occupied Patch ($\bar{x}$ ± SD)	Non-occupied Patch ($\bar{x}$ ± SD)	Kolmogorov-Smirnov test result *P*
ROW width (m)	40.9 ± 15.09	40.0 ± 8.16	> 0.10
Patch Area (ha)	3.1 ± 6.11	1.7 ± 2.76	> 0.10
Vegetation Height (m)	3.5 ± 1.97	4.0 ± 2.59	>0.10
Shrub Cover (%)	67.4 ± 16.82	70.1 ± 16.12	> 0.05

Table 4. Habitat matrix conditions for patches occupied by Golden-winged Warblers.

	Patch Matrix		
Occupied Patch Type	**Deciduous Forest**	**Mixed Pine-Deciduous Forest**	**Active Farmland**
Utility ROW	6	0	0
Shrubby Field	0	3	0
Abandoned Farm	7	2	9
Clear-cut	3	1	0

Blue-winged Warbler

Geographical Patterns. Blue-winged Warblers were detected in 18 of 40 counties surveyed (Figure 7, Appendix I). These detections included 92 individuals in 62 different habitat patches. The number of birds per occupied point ranged from 1-4 ($\bar{x}$ = 1.3 ± 0.67 [SD]). However, 92 % of all occupied patches were composed of single bird detections. Both the overall abundance of Blue-winged Warblers and the number of patches they occupied within these 18 counties were independent of the number of points or patches sampled (i.e., all Spearman ranked correlations < 0.46, all *P* values > 0.10). This suggests that Blue-winged Warblers were un-evenly distributed among the counties where they were detected.

Buchanan County contained the greatest number of individual Blue-winged Warblers detected (28 % of all Blue-winged Warblers), the greatest number of patches occupied (29 % of all occupied), and the greatest patch occupation rate (33 % of patches occupied within that county) (Figure 8). Tazewell County ranked second in abundance, number of occupied patches, and patch occupation rate. These two counties were followed closely in rank by Russell County in all three categories. The remaining 15 counties had 1-5 occupied patches with 1-2 individual Blue-winged Warblers detected from each occupied patch.

Blue-winged Warblers were detected at elevations from 232 m to 1044 m (approx. 760 ft to 3,425 ft) with a mean elevation of 607.7 m ± 146.12 (SD). Ninety percent of all occupied patches occurred between 400 m and 800 m elevation (Figure 9). The frequency with which patches were occupied between 400 and 1044m elevation was not significantly different from the frequency of patches surveyed (χ^2_6 = 3.43, *P* > 0.50). Blue-winged Warblers were not detected within 16 counties that contained patches > 400 m elevation. Blue-winged Warblers were also not detected in any county where all the patches surveyed were < 400 m although 5 of 7 of such counties only had 1-2 patches surveyed in each. The elevational distribution of patches occupied by Blue-winged Warblers was not significantly different than patch occupation rates for Golden-winged Warblers (χ^2_6 = 11.3, *P* > 0.5). Blue-winged Warblers were detected in only two patches where Golden-winged Warblers occurred.

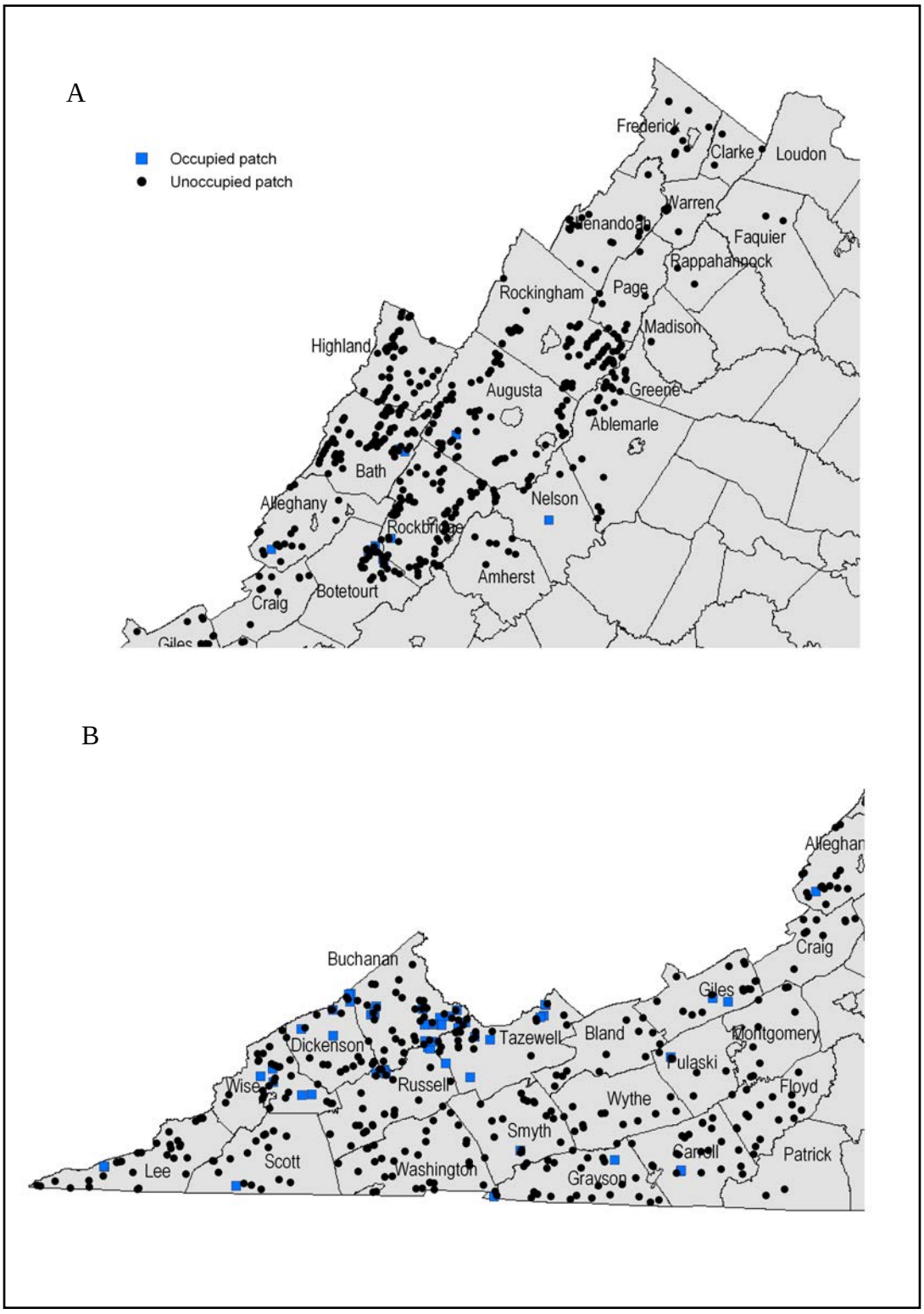

Figure 7. Distribution of Blue-winged Warblers in A) northern portion of the study area and B) southern portion of the study area. County names are only labeled for those included in the survey.

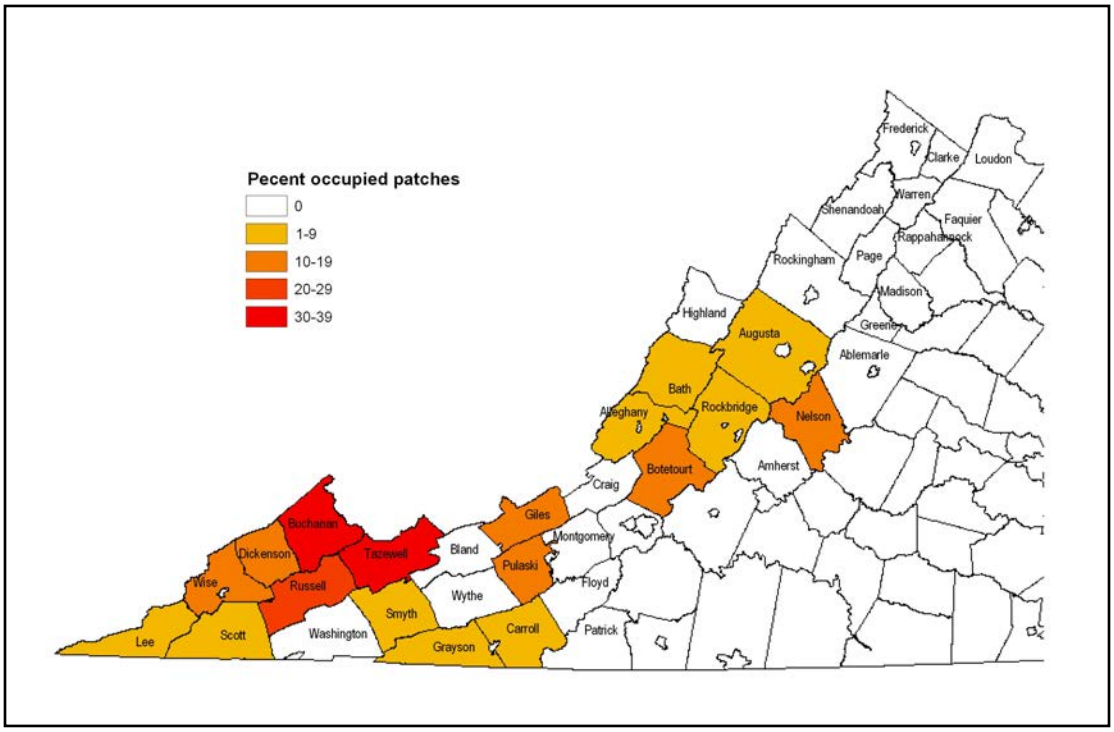

Figure 8. Percent of surveyed patches occupied by Blue-winged Warblers in each county. County names are only labeled if included in the survey.

Habitat Use Patterns. Blue-winged Warblers were observed in all habitat categories. When patches > 400 m were examined (N = 710), occupancy varied according to habitat type ($\chi^2_6 = 21.0$, $P < 0.005$) (Figure 10). Blue-winged Warblers were detected in utility ROWs, reclaimed strip mines, wetlands, and clear-cuts at a greater rate than expected based on the number surveyed, and were detected in successional forests and abandoned farm/pasturelands less than expected.

Utility ROW was the dominant habitat used with 49 % of the patch-level detections. This was followed second in rank by other shrubby fields (25 %). Remaining Blue-winged Warblers were detected in utility ROWs and shrubby fields in nine counties each. Occupied ROWs within Buchanan and Tazwell counties (N = 11 and 7, respectively) accounted for 60% of all occupied ROWs over the entire study area and 30 % of all occupied patches among all habitat types. The remaining habitat types each accounted for $\leq$ 8 % of all occupied patches.

Statistical comparisons for patches > 400 m in elevation indicated that there were no significant differences in average ROW width, vegetation height, or shrub cover (all *P* values > 0.10) between occupied and non-occupied patches (Table 5). However, patch area was significantly larger for occupied patches compared to unoccupied patches. This result may have limited biological value since patch area was visually estimated and the difference was < 1ha.

Detection frequency within each habitat/matrix combination was significantly different from expected based on the number of each surveyed ($\chi^2_5 = 18.7$, $P < 0.005$). Patches surrounded by deciduous forest and pine forest were occupied at a rate greater than expected whereas patches surrounded by mixed forest, idle farm/pastureland were occupied at a rate less than expected. Patches surrounded by industrial, commercial, or residential land were never occupied. Deciduous forest surrounded 75 % of all occupied patches (Table 6). This was followed in rank by mixed forest, active farm/pastureland, and pine forest with 21 %, 2 %, and 2 % of occupied combinations, respectively.

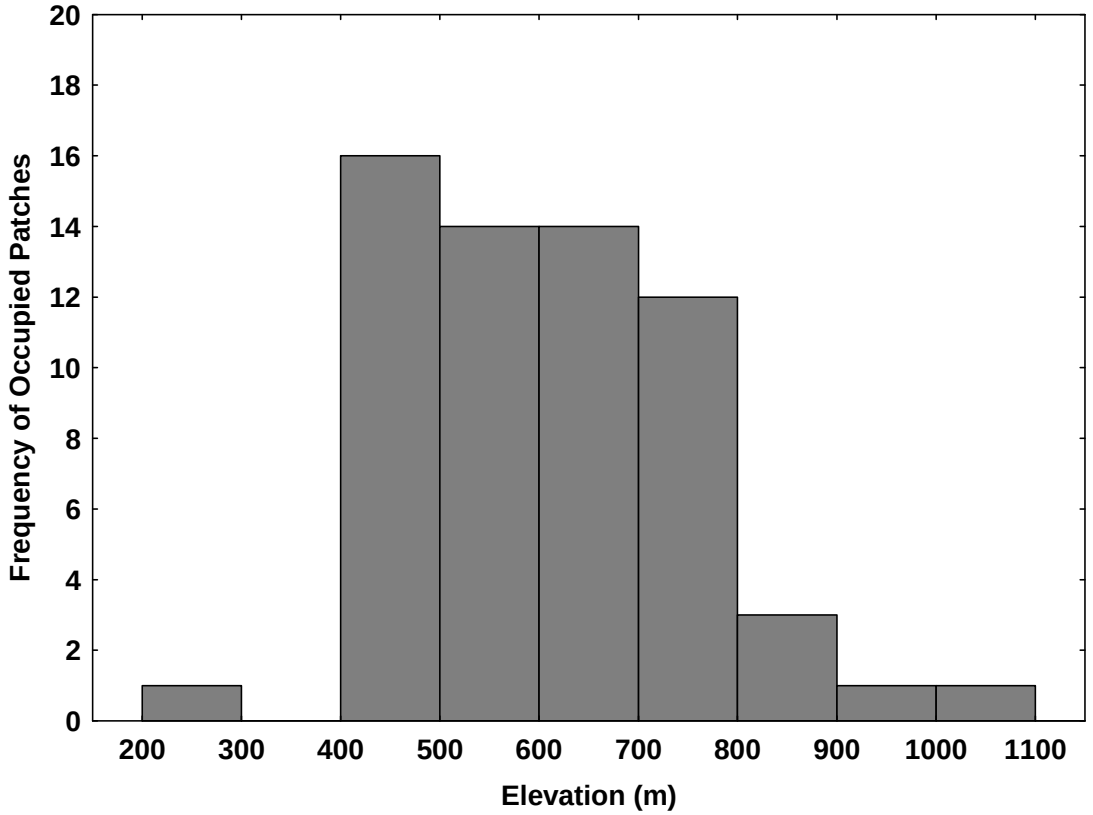

Figure 9. Frequency distribution for the elevation of patches occupied by Blue-winged Warblers.

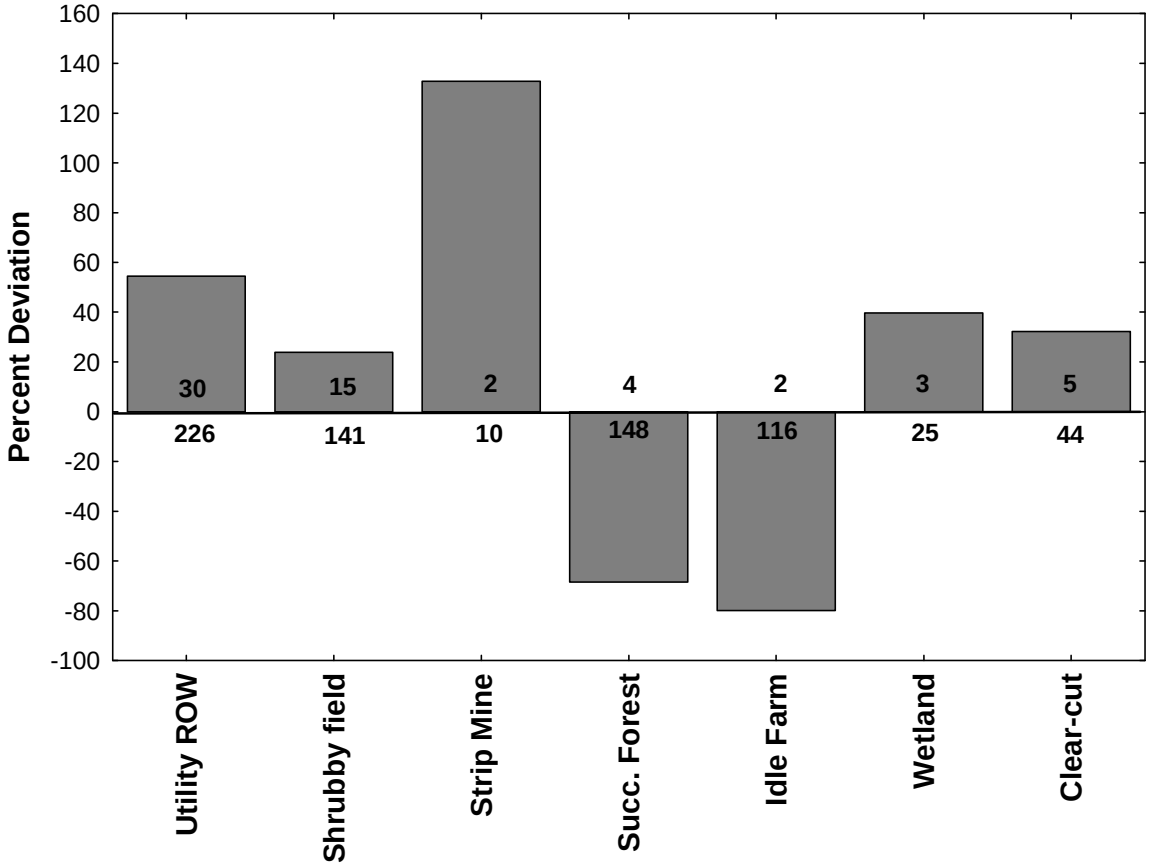

Figure 10. Percent deviation in observed habitat use by Blue-winged Warblers from an expected even distribution. Positive deviations indicate habitats that were used with greater frequency than expected by chance whereas negative deviations indicate habitats that were used less frequently than expected by chance. Values above the neutral line indicate the total number of patches where Blue-winged Warblers were detected and values below the line indicate the total number of patches surveyed.

Table 5. Comparison of habitat use variables for Blue-winged Warblers between occupied and non-occupied patches.

Variable	Occupied Patch ($\bar{x}$ ± SD)	Non-occupied Patch ($\bar{x}$ ± SD)	Kolmogorov-Smirnov test result *P*
ROW width (m)	40.3 ± 14.26	40.9 ± 15.13	> 0.10
Patch Area (ha)	2.4 ± 2.53	1.7 ± 4.03	< 0.05
Vegetation Height (m)	3.1 ± 1.47	4.1 ± 2.63	>0.10
Shrub Cover (%)	70.1 ± 15.69	69.8.1 ± 16.24	> 0.10

Table 6. Habitat matrix conditions for patches occupied by Blue-winged Warblers.

	Patch Matrix			
Occupied Patch Type	**Deciduous Forest**	**Mixed Pine-Deciduous Forest**	**Pine Forest**	**Active Farmland**
Utility ROW	27	2	0	1
Shrubby Field	11	3	1	0
Strip-mine	2	0	0	0
Successional Forest	2	2	0	0
Abandoned Farm	0	2	0	0
Forested Wetland	2	1	0	0
Clear-cut	2	3	0	0

Hybrid Warblers

Geographical and Habitat Patterns. Nine hybrid warblers were detected across seven counties (Figure 11). Three of these hybrids were detected in Botetourt County and one hybrid was detected in each of Buchanan, Dickenson, Rockbridge, Scott, Smyth, and Wythe counties. Two hybrids in Botetourt County and one hybrid in each of Buchanan, and Rockbridge counties were identified as Brewster's Warblers (see Confer 1992 for description of hybrids). One other hybrid in Botetourt County and the five remaining hybrids in Dickenson, Scott, Smyth, and Wythe counties were identified as Lawrence's Warblers.

Hybrid warblers were sympatric with Golden-winged Warblers in Buchanan, Rockbridge, and Smyth counties. One hybrid warbler detected in Rockbridge County was in the same patch as a Golden-winged Warbler. Hybrids were sympatric with Blue-winged Warblers in all counties where hybrids occurred except for Wythe County. Hybrid warblers were detected in the same patch as Blue-winged Warblers in Buchanan and Dickenson counties.

Hybrid Warblers were detected at elevations from 377 m to 741 m (approx. 1,230 ft to 2,430 ft) with a mean elevation of 547.2 m ± 126.50 (SD). Hybrids were detected in utility ROWs (N = 4), shrubby fields (N = 2), abandoned farm/pastureland (N = 1), and a clear cut (N = 1). The surrounding landcover of patches occupied by hybrids included deciduous forest (N = 7), mixed pine/deciduous forest (N = 1), and pine forest (N = 1).

Bewick's Wren

There were no detections of Bewick's Wren during surveys. We surveyed one site in Highland County that supported a breeding pair reported in 1985 (Tueber 1985) and areas surrounding other historic sites as well.

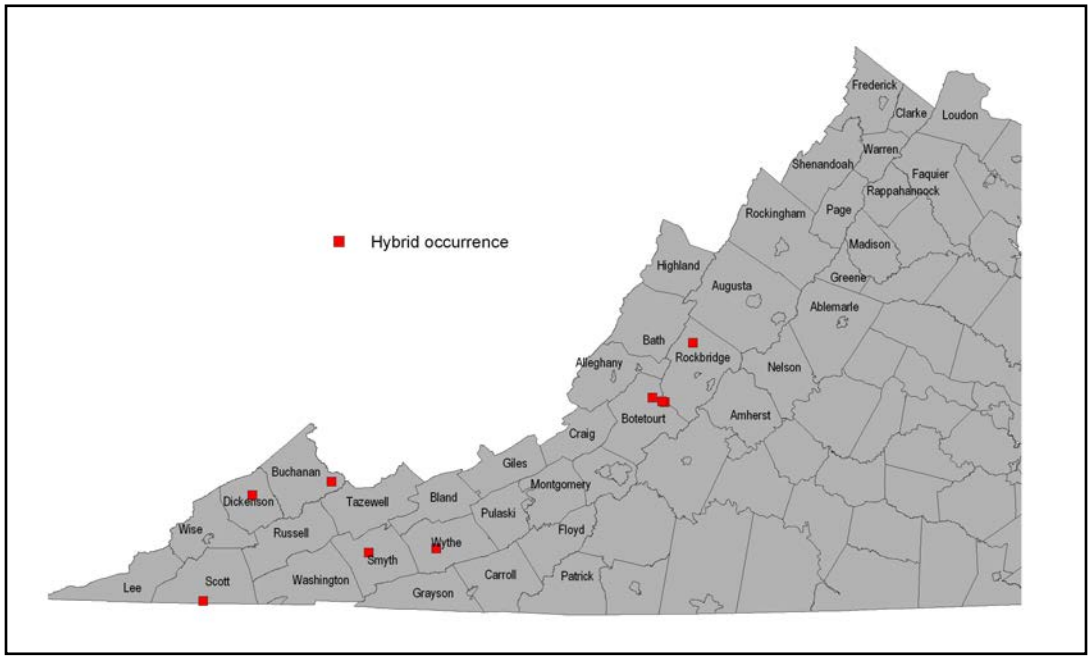

Figure 11. Distribution of individual hybrid warblers (Golden-winged x Blue-winged warblers) in the study area. County names are only labeled if included in the survey.

Discussion

The Appalachian Mountains have long been considered a population stronghold for Golden-winged Warblers. In Virginia, Golden-winged Warblers currently breed in low densities throughout the Appalachian Plateau, Ridge and Valley, and Southern Blue Ridge provinces with the largest population center located in Highland County. Golden-winged Warblers were not detected in the Northern Blue Ridge province (generally north of the town of Roanoke and east of Shenandoah Valley). However, there are breeding season records from the northern Ridge and Valley area from the 1985-1989 Virginia Breeding Bird Atlas project (Trollinger and Reay 2001) in Rockingham and Page counties and unpublished sightings in Shenandoah County in 2004 (personal observation, MGS).

Elevation is a significant modifier on Golden-winged Warbler distribution. Golden-winged Warblers were only detected in patches 464 m elevation and higher with the majority of observations > 700 m. This is consistent with reports throughout the greater Appalachians. Golden-winged Warblers are typically not found at elevations below 600 m in the Cumberland Mountains of Tennessee and Kentucky, or in the Blue Ridge Mountains of Georgia, North Carolina, and Tennessee (Welton 2003, Buehler et al. 2004). Our results are also consistent with historical reports in Virginia that have shown

this species to be concentrated at elevations > 900 m but detected infrequently as low as 480 m (Stevens 1960, Scott 1966, 1974, Peake 1987).

Golden-winged Warblers used an array of upland, early successional habitats but were most prevalent in idle farm/pasturelands in Highland and Bath counties, and general shrubby areas and clear-cuts elsewhere. These results are generally consistent with habitat use patterns throughout the Appalachians (Klaus and Buehler 2001, Welton 2003, Barker unpublished data, Bulluck and Buehler, unpublished data). When considered among all counties, Golden-winged Warblers used utility ROWs less than expected based on the number surveyed. This result is also consistent with what Welton (2003) reports in Tennessee. Reasons for the low use of utility ROWs are not completely known. One possible reason is that ROWs in Virginia do not contain an appropriate vegetation structure. In general, Golden-winged Warbler habitat consists of woody plants with herbaceous openings (Frech and Confer 1987, Confer 1992). Klaus and Buehler (2001) highlighted this importance with their report that Golden-winged Warblers only used ROWs if they had sufficient herbaceous openings. We did not conduct fine level vegetation surveys in our study but most ROWs appeared to contain very dense, continuous cover of shrubs that lacked herbaceous openings. One other reason for the low ROW use could be that Golden-winged Warblers may be more difficult to detect in linear habitats (Kubel and Yahner 2007). All ROWs in this study were surveyed at openings created by roads. The effect of roads on the distribution of Golden-winged Warblers in ROWs is not known.

Golden-winged Warblers were not detected in wetland habitats. This result is surprising because high elevation wetlands are typically used by Golden-winged Warblers in North Carolina (Bulluck and Buehler, unpublished data) and West Virginia (Cantebury, unpublished data) and are typically associated with this habitat as possible reasons for their historical distribution in the Appalachians. The reason for our contrast with those reports is not known. However, Welton (2003) reported that Golden-winged Warblers used wetlands less than expected based on availability in Tennessee. Our result, together with Welton (2003), may suggest that wetlands have limited value for Golden-winged Warblers. It may be that the wetland patches we surveyed did not meet the basic vegetation requirements of this species. One other suggestion could simply be that we did not survey enough high elevation wetland patches to provide an adequate sample. We were only able to survey three roadside wetland patches that were higher than the average elevation of all Golden-winged Warbler detections. Additional surveys would be needed to target high elevation wetlands in off-road areas before any final conclusions on the use of wetland habitats by Golden-winged Warblers are drawn.

The land type immediately surrounding a shrub patch was also an important modifier of use by Golden-winged Warblers suggesting their distribution may be mediated by habitats in the broader landscape. Patches occupied by Golden-winged Warblers were often bordered by deciduous and mixed pine-deciduous forest whereas patches surrounded by residential or industrial land were never occupied. These results imply that Golden-winged Warblers may be associated with disturbed forested landscapes but limited by human development. Golden-winged Warblers also used a number of patches surrounded by farmland. Most of these were idle pastureland in Highland and Bath counties that were also embedded within a predominantly forested landscape. Overall, these results underline the importance of both shrubby and forested

habitat for this species. Thogmartin et al. (unpublished data) have shown that Golden-winged Warbler abundance within early successional habitats in the upper Midwest was positively associated with forest cover across the landscape. Golden-winged Warlblers use a complex of habitats where forest edge is also often included as an important habitat feature in combination with herbaceous cover, shrubs, and scattered trees (Frech and Confer 1987, Confer 1992). In Tennessee, Klaus and Buehler (2001) found that Golden-winged Warblers used the edge of young (< 15 yr) northern hardwood, cove forest, and oak-hickory forest only when spatially associated with an herbaceous opening.

Explanations for the relatively greater number of Golden-winged Warblers in Highland and Bath counties compared with other areas include a combination of history, elevation, and habitat availability. Highland County has the highest average elevation and the smallest human population of all counties in Virginia. Nearly half of Highland County is > 900 m elevation and the landcover has remained relatively unchanged for decades. Forest land covers approximately 80 % of Highland County and the remaining area is used for livestock grazing (Vogelman et al., 2001). Bath County lies directly south of Highland County and is similar in character with nearly 95 % forest cover and very little human development. The combination of small-scale forest management and idle pasturelands within these counties likely create a highly viable landscape for Golden-winged Warblers by providing sustained yields of high elevation, early successional patches over long periods of time. Comparing our results with counts from historical forays indicate that Highland and Bath counties have been a population center for over 30 years (Peake 1978, Larner and Scott 1982, Spahr 2003).

Regional densities of Golden-winged Warblers in Virginia have probably always been low but clustered around areas of appropriate habitat. We had very low or even no detections in counties that were also determined to be low during earlier published accounts (e.g., Washington, Grayson, and Lee counties) (Scott 1966, 1970, Dalmas 1993, 1999). Counties other than Highland and Bath may likely have abundant levels of shrubby habitat but only a small number of these patches are available at higher elevations.

Golden-winged Warbler populations in the Appalachians have declined dramatically over the last several decades. Data from the USGS Breeding Bird Survey indicate that between 1966 and 2006, Golden-winged Warblers have declined annually at a rate of 6.3 %, 7.9 %, and 13.7 % in the Ridge and Valley, Blue Ridge Mountains, and statewide in Virginia, respectively (Sauer et al. 2007). Reports based on county-level breeding bird forays conducted in Virginia suggest the same pattern. Prominent declines are evident in Dickenson, Buchanan, and Tazewell counties when forays conducted in the early 1970s are compared to those from the mid-1980s (Scott 1973, Peake 1986, 1987). More recently, Spahr (2003) shows a dramatic decline in Bath County from a high of 125 birds counted during a 1982 foray (Larner and Scott 1982) to a low count of only 17 birds in 2003. Our observations are similar to Spahr's recent report (2003); we only detected 7 birds within 76 patches in Bath County. Scott (1981) reported Golden-winged Warblers to be fairly common in Craig County with 37 birds detected from all elevations during foray in 1979. We did not detect any birds in Craig County although only nine patches were surveyed.

Reasons for the decline of Golden-winged Warblers may be many but the most likely explanations include the loss of early successional habitats and displacement by

Blue-winged Warblers. Historically, Blue-winged Warblers were distributed primarily west of the Appalachians but have been expanding their range eastward (Gill 1980) and into higher elevations (Canterbury et al. 1993) over the last 150 years. Early breeding records for Blue-winged Warblers in the eastern U.S. date back to the late 1800's (Richmond 1888, Bailey 1913) but regular occurrence in the Appalachians is estimated to have taken place sometime in the 1950's (Gill 1980). Blue-winged Warblers now breed in many places where Golden-winged Warblers populations were formerly isolated. For instance, Dalmas (1995) reported the colonization of northwestern Virginia by Blue-winged Warblers when comparing results between forays in 1994 to those conducted in 1967 (Scott 1967). In areas where they now overlap, Blue-winged Warblers can behaviorally dominate Golden-winged Warblers and force them out of habitat patches (Will 1986, Canterbury, unpublished data) or interbreed with them to form hybrids. Hybridization between Golden-winged and Blue-winged warblers in areas of sympatry is considered infrequent and the effect of hybridization on conservation of Golden-winged Warblers is not entirely known (Confer 1992). Gill (1980) proposed that at current rates of hybridization observed in populations in the Northeast, hybrids will replace Golden-winged Warbler populations within 50 yr after initial contact.

Blue-winged Warblers were detected in the Appalachian Plateau, Ridge and Valley, and Northern and Southern Blue Ridge provinces as well as in the Piedmont. Blue-winged Warblers can also be found throughout areas of the Piedmont that we did not survey (Trollinger and Reay 2001). We detected Blue-winged Warblers in all but one of the counties where Golden-winged Warblers occurred. Highland County was this only exception. However, older records suggest that Blue-winged Warblers nest in Highland County as well (Peake 1978, Bath-Highland Bird Club 1984).

Blue-winged and Golden-winged Warblers overlapped significantly in elevation. We found Blue-winged Warblers at all of the same elevations where Golden-winged Warblers occurred and found hybrid warblers at elevations equal to the average elevation of all Golden-winged Warbler detections. Elevation was previously believed to segregate these two species. However, there are a growing number of observations of Blue-winged Warblers at higher elevations in Virginia and the greater Appalachians. For instance, Blue-winged Warblers were detected in Bath County in 2003 (Spahr 2003) but not during earlier forays in 1982 (Larner and Scott 1983) or during the Virginia Breeding Bird Atlas project from 1985-1989 (Trollinger and Reay 2001). Cantebury (2003) reported that Blue-winged Warblers began rapidly expanding into higher elevation areas in West Virginia in the late 1980s.

Blue-winged Warblers also appear to be replacing Golden-winged Warblers in order of abundance in the Appalachian portion of Virginia. Historically, Golden-winged Warblers were the numerically dominant of these two species in this region. We detected nearly two Blue-winged Warblers for every one Golden-winged Warbler. Peake (1986) provided early indications of this change in Buchanan, Wise, and Dickenson counties by reporting a general decline of Golden-winged Warblers coinciding with an increase in Blue-winged Warblers and hybrid warblers by 1982. Unpublished records from Buchanan County Bird Club indicate a very similar pattern with a recent and rapid turnover in rank abundance from this area (R. Mayhorn, personal comm.). We detected an overwhelmingly greater number of Blue-winged Warblers over Golden-winged Warblers in these three counties. In fact, these counties along with adjoining Tazewell

and Russell counties supported the greatest concentration of Blue-winged Warblers in the state, suggesting their expansion into this area has continued.

Golden-winged and Blue-winged Warblers only co-occurred in the same patch at two locations and used habitats in slightly different proportions. Among these differences were that Blue-winged Warblers were found in ROWs and wetlands more often than expected and found in idle farm/pastureland less than expected. Golden-winged Warblers showed the opposite pattern for these habitat types. The greater use of ROWs by Blue-winged Warbler is consistent with what is known on general habitat use. Blue-winged Warblers tend to use habitats in later succession and greater shrub cover than Golden-winged Warblers (Confer and Knapp 1981). Most ROWs surveyed fit the general profile of later succession favored by Blue-winged over Golden-winged warblers. The use of wetland habitats by Blue-winged Warblers is consistent with reports throughout the Appalachians and elsewhere (Gill et al. 2001). Reasons for the greater use of wetlands by Blue-winged than Golden-winged warblers from our study are not known. Two possible explanations could be that the habitat structure of wetlands was more suitable to Blue-winged Warblers or that the majority of wetlands surveyed were at lower elevations. Similarly, reasons for lower use of idle farm/pastureland by Blue-winged than Golden-winged warblers are not well understood. The result could be attributed to differences in the species affinities for these habitats but could also be biased since most of idle farm/pastureland patches were surveyed in Highland and Bath counties where Blue-winged Warblers were observed in low numbers.

Our study may support the general belief that Bewick's wren has become extirpated from Virginia. We searched one historical location in Highland County (Tueber 1985) and a number of possible sites in Dickenson County near another breeding location cited from 1989 (Ridd 1990) and found none. However, surveys of off-road areas are needed before a final determination on the status of Bewick's wren is made.

There are very few contemporary records for Bewick's Wren in Virginia. The most recent nesting record for Bewick's Wren was collected from Dickenson County in 1989 (Ridd 1990). Other recent nesting records were collected from Highland County in 1982 (Teuber 1985) and Montgomery County in 1974 (Conner 1975) and 1976 (Adkisson 1991). Unpublished breeding season observations were being reported throughout the 1980s and into the 1990s. Most of these were of single birds. The last known breeding season observations are from Highland County in 1998 (S. Thornhill, unpublished data – David Shoch, personal comm.) and 1991 (D. Schwab and T. Gwynn, personal comm.), and in Dickenson County in 1990 (Sauer et al. 2007).

The overall decline of Bewick's Wren in this region appears to be nearly as rapid as its expansion. Bewick's Wren expanded rapidly throughout the northeastern U.S. in the early 1800's coinciding with a large wave of forest clearing that occurred from the mountains to the coast. This land clearing provided a wealth of early successional habitats in areas previously not available. Breeding records rapidly increased in the mountains and piedmont of Virginia during this time (Smyth 1912, Bailey 1913). By the early 1900s, Bewick's Wren had expanded its range as far north as New York. Then by the mid-1900s, these recently expanded populations began to sharply decline. In Virginia, descriptions of Bewick's Wren changed from being common in places such as Montgomery County (Smyth 1912) to uncommon statewide (Murray 1952) within 40 years. By the mid 1970s, Bewick's Wren was considered rare throughout Virginia and

already extirpated from New York and Pennsylvania. So, the period of expansion and withdrawal in Virginia would have spanned less than 100 yrs.

The decline of the Bewick's Wren has also been associated with being outcompeted and displaced by expanding populations of House Wrens (Troglodytes aedon). This phenomenon has been speculated for many years based on the coincidental timing of Bewick's Wren population declines in areas where House Wrens were rapidly expanding. House Wrens began expanding their range into the southeastern United States in the 1940s (Odum and Johnston 1951). Reasons for the expansion may be many but have been attributed, in part, to an increase in habitat availability. Land clearing has probably benefited both species. Both House Wrens and Bewick's Wrens use anthropogenic habitats and often nest near human habitation. House Wrens are believed to compete with Bewick's Wrens for nesting sites and have been reported to directly destroy the eggs, nests, and nestlings of Bewick's Wrens (Kennedy and White 1996). This would help explain why House Wrens continued to expand while Bewick's Wrens have declined despite similar habitat opportunities. Stevens reported two occurrences in Albemarle County, VA where he believed House Wrens displaced Bewick's Wrens during the breeding season (Gray and Stevens 1949). Although still speculative, the prospect that the decline of Bewick's Wren could be attributed to losing a competitive battle with House Wrens appears to have some similarity with the negative interactions of Golden-winged and Blue-winged warblers. The history of each species pair seems to be tied to broad scale changes in habitat over time. There are perhaps lessons that can be learned from the decline of Bewick's Wren that can be used to inform management decisions for Golden-winged Warblers faced with an expanding Blue-winged Warbler population.

There is still debate over the exact origin of Bewick's Wren population expansion in the northeast. The center of this debate is based on whether the Appalachian Bewick's Wren is truly a distinct Appalachian endemic (Phillips 1986, James and Green 2006). This taxonomic discrepancy influences interpretation on the history of the species population origins in the eastern U.S. and has important implications regarding its protection and relative importance as a conservation priority. The principal claim for separation of Bewick's wren into an Appalachian subspecies, ***A. b. altus***, and a western subspecies, ***A. b. bewickii***, is based on differences in plumage color. James and Green (2006) questioned the validity of the ***A. b. altus*** subspecies based on this single criterion by contending that the darker plumage patterns of specimens collected in the Appalachians and typed as ***A. b. altus*** are actually ***A. b. bewickii*** specimens dirty from soot and in need of restoration. If ***A. b. altus*** is not a distinct subspecies endemic to the Appalachians, then expansion into the eastern U.S. during the early to mid-1800's were a result of ***A. b. bewickii*** populations from as far west as Kansas. Alternatively, if ***A. b. altus*** is truly an Appalachian endemic, it could have been the source for new populations in the Northeast that expanded at the same time that ***A. b. bewickii*** was moving into the Appalachians from the Midwest. For Virginia, the distinction of a true Appalachian endemic suggests that populations of the Bewick's Wren resided here at a time earlier than the late 1800's expansion.

Management Conclusions for Golden-winged Warblers

Based on the overall low frequency of observations and the evidence of continued decline, the Golden-winged Warbler appears to be of extremely high conservation concern in Virginia and a possible candidate for regulatory protection. Special attention should be made to maintain appropriate habitats in Highland, Bath, Allegheny counties and the western portion of Rockbridge County. Landowner incentives for habitat management and improvement, such as the USDA-NRCS Wildlife Habitat Incentive Program (WHIP), and targeted landowner education are important tools to create objective-oriented landscapes for Golden-winged Warblers in these and other counties. State technical committees responsible for WHIP planning should consider the geography and habitats required by Golden-winged Warblers as a primary focus in the development of funding criteria for this program. Private companies that own and maintain utility ROWs should be made aware of the conservation concerns for Golden-winged Warblers since these areas have the potential for sustained, long-term management.

Best management practices for Golden-winged Warbler include maintaining early successional habitat in close association with forest edge. In general, Golden-winged Warblers require three fundamental habitat elements; 1) forest edge or scattered small deciduous trees, 2) a layer of shrub vegetation, and 3) herbaceous openings. Conservation and management should focus on creating and sustaining these habitats at elevations of 500m and greater. Patches targeted for management should be at least 0.5 ha. Larger patches are recommended so that multiple breeding pairs may be supported at the same site. Habitat for Golden-winged Warblers should be placed within forested landscapes and away from residential or industrial development. It appears that patches bordered by deciduous and mixed pine deciduous forests are better suited than patches bordered by pine dominated forests. Placing shrubby habitat adjacent to active agriculture or pastureland also appears to support Golden-winged Warblers. We recommend patches with agricultural contexts be located in local landscapes dominated by forest. Because early successsional habitats are not stable through time, landowners need to orchestrate management activities to halt succession of maturing patches or rotate the availability of habitat between several patches. The exact management of an individual patch varies with size and management resources. Small patches (< 1ha) that can be managed regularly should be consistently maintained in an early successional state through selective removal of large trees and creation of herbaceous openings. Larger patches that cannot be managed regularly should be subdivided into equal parcels and managed in a rotational sequence. Patches should be allowed to mature for 5-10 yrs before disturbance. Commercial forestry operations can improve habitat for Golden-winged Warblers by delaying the period of canopy closure for newly planted stands. This can be achieved by stocking crop trees at low levels and eliminating the use of herbicides. In addition, thinning of mid-rotation stands soon after canopy closure or even to eliminate canopy closure will allow regrowth of shrubby vegetation and permit Golden-winged Warblers greater use of the overall plantation cycle. Specific recommendations on stocking and thinning levels are still in need of development.

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Appendix I. County-level summary of survey effort and results for Golden-winged and Blue-winged Warblers and their hybrids.

COUNTY	Effort		Golden-winged Warbler			Blue-winged Warbler			Hybrid warblers		
	# patches surveyed	# points surveyed	Total # of birds	# patches occupied	# points occupied	Total # of birds	# patches occupied	# points occupied	# of Hybrids	# patches occupied	# points occupied
Albemarle	19	19	0	0	0	0	0	0	0	0	0
Alleghany	16	16	3	2	2	1	1	1	0	0	0
Amherst	10	10	0	0	0	0	0	0	0	0	0
Augusta	61	63	0	0	0	1	1	1	0	0	0
Bath	76	84	7	7	7	2	2	2	0	0	0
Bland	12	12	0	0	0	0	0	0	0	0	0
Botetourt	36	36	0	0	0	5	5	5	3	3	3
Bristol	2	2	0	0	0	0	0	0	0	0	0
Buchanan	57	63	0	0	0	23	18	20	1	1	1
Carroll	23	26	1	1	1	4	2	3	0	0	0
Clark	2	2	0	0	0	0	0	0	0	0	0
Craig	9	9	0	0	0	0	0	0	0	0	0
Dickenson	21	22	0	0	0	6	2	3	0	1	1
Fauquier	2	2	0	0	0	0	0	0	0	0	0
Floyd	17	21	0	0	0	0	0	0	0	0	0
Frederick	10	10	0	0	0	0	0	0	0	0	0
Giles	18	19	0	0	0	2	2	2	0	0	0
Grayson	30	32	2	1	2	3	2	3	0	0	0
Green	8	8	0	0	0	0	0	0	0	0	0
Highland	46	52	28	18	24	0	0	0	0	0	0
Lee	31	35	6	1	2	5	2	2	0	0	0
Loudoun	1	1	0	0	0	0	0	0	0	0	0
Madison	1	1	0	0	0	0	0	0	0	0	0
Montgomery	9	9	0	0	0	0	0	0	0	0	0
Nelson	7	7	0	0	0	1	1	1	0	0	0
Page	9	10	0	0	0	0	0	0	0	0	0
Patrick	2	3	0	0	0	0	0	0	0	0	0
Pulaski	6	6	1	1	1	1	1	1	0	0	0

COUNTY	Effort		Golden-winged Warbler			Blue-winged Warbler			Hybrid warblers		
	# patches surveyed	# points surveyed	Total # of birds	# patches occupied	# points occupied	Total # of birds	# patches occupied	# points occupied	# of Hybrids	# patches occupied	# points occupied
Rappahannock	2	2	0	0	0	0	0	0	0	0	0
Rockbridge	63	67	1	1	1	2	1	1	1	1	1
Rockingham	63	64	0	0	0	0	0	0	0	0	0
Russell	29	29	0	0	0	11	6	6	0	0	0
Scott	17	19	0	0	0	1	1	1	1	1	1
Shenandoah	16	25	0	0	0	0	0	0	0	0	0
Smyth	18	19	3	2	2	1	1	1	1	1	1
Tazewell	32	42	2	1	2	15	9	13	0	0	0
Warren	7	8	0	0	0	0	0	0	0	0	0
Washington	28	30	2	1	1	0	0	0	0	0	0
Wise	35	35	0	0	0	8	5	5	0	0	0
Wythe	12	12	0	0	0	0	0	0	1	1	1

Appendix I continued.