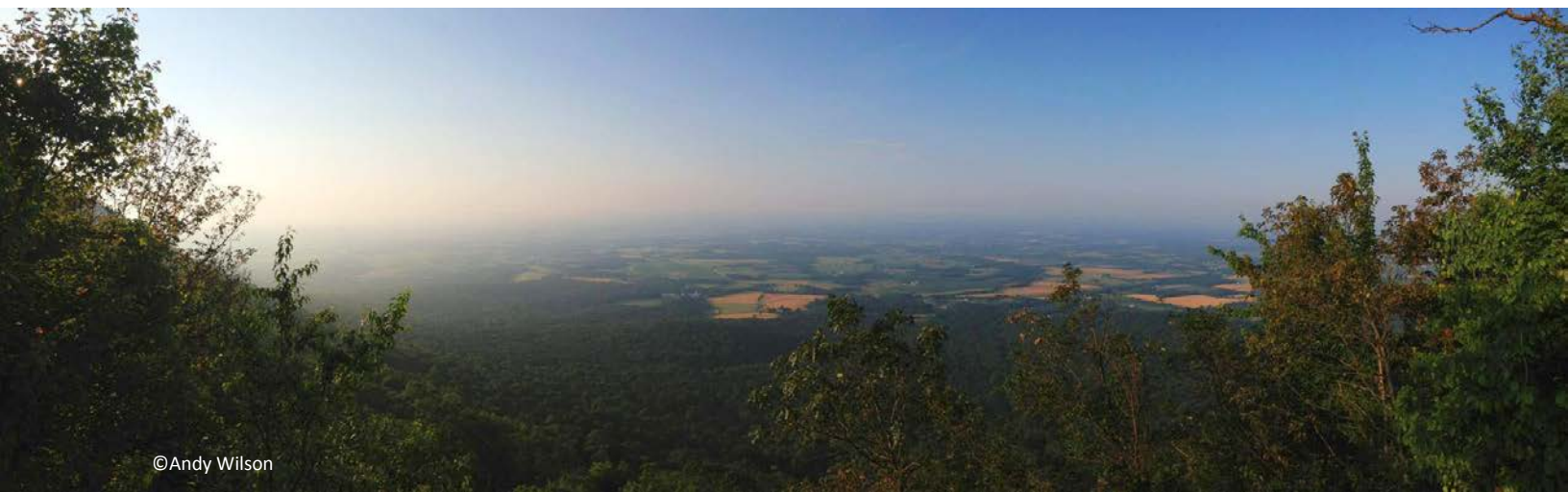


# **A Survey of Cerulean Warblers and other Priority Forest Birds of the Kittatinny Ridge IBA, Pennsylvania, 2013**



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## 1. PURPOSE

The Kittatinny Ridge is a largely forested ridge that extends for 185 miles through southeastern Pennsylvania, from the Delaware Gap to the Mason-Dixon Line. It is one of the primary hawk migration routes in eastern North America and is designated an Important Bird Area (IBA) by the Audubon Society. The ridge is the south/easternmost in the Ridge and Valley Province and includes the largest block of contiguous forest in the southern half of Pennsylvania.

The Kittatinny Ridge is an important breeding area for the Cerulean Warbler *Setophaga cerulea* (Stoleson and Rutt 2012) and other forest interior birds of conservation importance (Audubon Pennsylvania 2006; Wilson, Brauning and Mulvihill 2012). However, population sizes of Cerulean Warblers and other forest songbirds within the Kittatinny Ridge IBA are not well known. Point count data from the 2<sup>nd</sup> Pennsylvania Atlas of Breeding Birds (2<sup>nd</sup> PBBA 2004-2009; Wilson, Brauning and Mulvihill 2012) provide the most comprehensive counts for the area, but due to the roadside bird count protocol used, the 2<sup>nd</sup> PBBA considerably under-sampled forest interior habitat along the Kittatinny Ridge. The aim of this study was to supplement 2<sup>nd</sup> PBBA data for interior forests by conducting bird surveys along off-road trails. Data from both 2<sup>nd</sup> PBBA and 2013 would then be used to assess the abundance of Cerulean Warblers within the Kittatinny Ridge IBA. Population estimates produced by this effort will assist in possible Global IBA nomination for ridge based on Cerulean Warbler population, and will provide a baseline for possible future comparisons.

## 2. METHODS

### 2.1 Survey site selection

Hiking trail survey routes were established on public trails, such as the Appalachian Trail, Tuscarora Trail and other trails, primarily within public lands. Starting locations were identified in ArcMap (ESRI 2011) by identifying intersections of public roads and public parking areas, with trails. Routes were then laid out along the trail, with point counts spaced every 400 m. Lengths of the routes varied, due to the varying distances between trail access points. Routes comprised between 12 and 37 points.

### 2.2 Field methods

To ensure compatibility with 2<sup>nd</sup> PBBA data, point counts were conducted between civil twilight (30 minutes before sunrise) and 10 am. All counts were completed during June 2013. All birds detected were counted, with detection assigned as either singing, non-song cue, or flyover. In

keeping with 2<sup>nd</sup> PBBA, two distance bands were used:  $\leq 75$  m, and  $>75$  m. Count duration was five minutes. 2<sup>nd</sup> PBBA point counts consisted of 5x75 second time bands. When using 2<sup>nd</sup> PBBA data for analysis in this study, only birds detected in the first 4 time-bands (=5 minutes) were included. GPS coordinates were taken for all 2013 point locations, wherever possible. In some instances, GPS readings were not taken, in which case the point location was interpolated from neighboring points. A copy of the field recording form can be found in Appendix 1.

## **2.3 Analytical methods**

### **2.3.1 Assessing point count location bias**

Detection radii for almost all bird species were assumed to be  $<200$  m, as ascertained by 2<sup>nd</sup> PBBA analysis (Wilson, Brauning and Mulvihill 2012). Therefore, we used a radius of 200 m around each point count location as a basis for assessing bias in 2<sup>nd</sup> PBBA and 2013 point count locations. Using ArcMap we overlaid the Kittatinny IBA plus a 5 km buffer with 381 m wide hexagons ( $n=11,944$ ) – which have the same area as circles with radius of 200 m (i.e. 12.57 hectares). We then compared the following landscape metrics for the hexagons with the 200 m buffers around 2<sup>nd</sup> PBBA and 2013 locations:

- Land Cover types (National Land Cover Data 2006)
- Land Form (topography)
- Elevation (mean and range)
- Distance to road

A list of the landscape metrics can be found in Appendix 2.

### **2.3.2 Estimating Cerulean Warbler abundance**

The IBA was divided into 16 sections using major intersecting roads as boundaries (Figure 1). Estimates of Cerulean Warbler densities were calculated for each of 16 sections of the IBA by extrapolating densities estimated from combined 2<sup>nd</sup> PBBA and 2013 point counts. Extrapolations were based on 2<sup>nd</sup> PBBA analysis (Wilson, Brauning and Mulvihill 2012). We estimated a detection radius of 150 m with a spherical detection function; hence, we estimate that 78% of birds are detected within the 150 m count radius, within a five minute count period. It should be noted that this extrapolation deliberately provides conservative estimates. The estimated detection radius used in 2<sup>nd</sup> PBBA analysis was actually 135 m, and models used to estimate statewide densities also including time of day and time of season effects, to account for lack of song output at sub-optimal times. Such detailed models are only possible with large sample sizes ( $>100$  bird detections); hence it was not possible to construct those

models for the data used in this analysis.

### **2.3.3 Bird Community analysis**

Bird counts were used in conjunction with landscape metrics (see 2.3.1) to describe the bird community within the Kittatinny IBA and 5 km buffer. Canonical Correspondence Analysis (CCA) was performed in the Program R package “Vegan” (Oksanen et al. 2013). CCA provides bi-plots showing the relationships between counts of organisms and environmental gradients.

## **3. RESULTS**

### **3.1 Coverage and species totals**

Bird surveys were conducted on 25 hiking routes distributed along the length of the Kittatinny Ridge from the Maryland state line to the New Jersey state line. Routes comprised between 12 and 37 points, with a mean of 23.6 points per route, for a total of 590 points (Figure 2).

Analysis of landscape characteristics around the 2<sup>nd</sup> PBBA and 2013 point count locations demonstrated that 2<sup>nd</sup> PBBA point count locations were biased towards lower elevations, and areas with lower elevational range (Table 1). Not surprisingly, they were highly significantly biased towards roads – the mean distance to road of the 200 m radii around 2<sup>nd</sup> PBBA point was 91 m, whereas the mean distance to road across the Kittatinny Ridge IBA was 419 m (Table 1). In contrast, 2013 points were biased towards higher elevations and greater distances from roads (Table 1).

Two landscape metrics were assessed for bias in point count locations: land cover, and land form (topography – Appendix 2). 2<sup>nd</sup> PBBA point count locations significantly under-represented three major forest types, and significantly over-represented agricultural and developed land cover types (Figure 4). Similarly, there were certain land form types that were under-represented, notably slopes (steep slope and sideslopes; Figure 5), while flatter ground (wet flats and valley/toeslope) were over-represented.

In contrast, 2013 point count locations were strongly dominated by forest cover types, with rather little of other habitats within 200 m of the 590 point count locations (Figure 6). As intended, the 2013 point count data included an over-representation of some of the topographic land forms that were under-represented by 2<sup>nd</sup> PBBA: summits/ridgetops, slope crests (Figure 7).

### **3.2 Species totals**

Eight-eight full species were detected on the 2013 point counts with a total of 7,369 individual birds detected in all (Appendix 3). The 20 most frequently detected species (Table 2) accounted for 81% of detections, with Red-eyed Vireo *Vireo olivaceus*, Ovenbird *Seiurus aurocapilla* and Scarlet Tanager *Piranga olivacea* the most numerous species. Red-eyed Vireos and Ovenbirds were almost ubiquitous, being detected at 96% and 81% of points respectively.

Among the forest interior songbirds that were of prime interest, detections of Black-and-white Warbler *Mniotilta varia* (189) and Hooded Warbler *Setophaga citrina* (166) were surprisingly frequent. Other notable totals of forest songbirds include 79 Worm-eating Warblers *Helmitheros vermivorum*, 57 Yellow-throated Vireos *Vireo flavifrons*, 54 Cerulean Warblers, 27 Black-throated Green Warblers *Setophaga virens* and 24 Louisiana Waterthrushes *Parkesia motacilla* (see Appendix 3 for complete list).

In the case of songbirds, the counts in Table 2 and Appendix 3 are almost all singing males, but include some visual detection and non-song cues. Additionally the percentage of birds detected within 75m distance band ranged from 17% for Pileated Woodpecker to 100% for a few scarce species. Hence, the totals presented in Table 2 and Appendix 3 is not sufficient for comparing abundances across species. Further analysis incorporating detectability and habitat covariates will be necessary to provide robust population estimates across all species.

A comparison of singing males detected per point in 2013 with 2<sup>nd</sup> PBBA data (first 4 time bands = 5 minute count) shows that the forest interior hiking trail point counts in 2013 allowed for much higher rates of detection of forest interior songbirds, including the Cerulean Warbler (Table 3).

### 3.2 Cerulean warbler densities and hotspots

Most Cerulean Warbler (CERW) detections were within distinct clusters (Figure 3) in the central sections of the ridge (3 through 9), i.e., from Northern Franklin east to western Lebanon counties. The estimated population of Cerulean Warblers within the Kittatinny IBA is 1,411 singing males (Table 4). We estimate that populations of Cerulean Warblers exceed 100 singing males in five of the 16 sections, and suggest that these be considered as potential Global IBAs for this species:

IBA Sections	Description	Area (km <sup>2</sup> )	Estimated population of male Cerulean Warblers
3, 4 and 5	State Rd 4004 east to State Rd 74	324	824
7, 8 and 9	State Rd 34 east to Route 81	204	481

Estimates of Cerulean Warbler density exceed 1 male per square kilometer in five of the 16 sections of the ridge, and are as high as 4.18 males/km<sup>2</sup> in section 8 (Dauphin County).

### 3.3 Bird Community Analysis

Multivariate analysis of birds at all 2<sup>nd</sup> PBBA and 2013 point combined reveals that the bird community within the Kittatinny IBA (and inside a 5km buffer) can be well described by two environmental gradients in a canonical correspondence analysis (CCA) bi-plot (Figure 8). Axis 1 (horizontal) is positively correlated with higher elevations, greater distance to road and a higher proportion of Appalachian Hemlock-Hardwood Forest; while it is negatively correlated with farmland land cover types (Appendix 2). Hence, species scores in the bi-plot show a gradient from open country species at the left, to interior forest species on the right (Figure 8 - left, and Figure 9). Interestingly, in this analysis, Cerulean Warbler is at one extreme of this gradient, suggesting that it is among the most forest interior dependent birds in the study area.

Plotting individual survey point on the same CCA bi-plot axis clearly shows that the 2013 surveys greatly improved coverage of the landscape associated with forest-interior songbirds (Figure 8 – right).

## 4. DISCUSSION

Analysis of landscape metrics demonstrates how significantly biased the 2<sup>nd</sup> PBBA roadside point count locations were. Adding hiking trail counts in 2013 greatly improved representativeness of bird data for forest-interiors, away from roads, and on steep slopes and ridge tops.

Because of this coverage of interior forests, the 2013 point counts achieved much higher rates of detections of forest interior songbirds, including the Cerulean Warbler. This, in turn, allowed us to estimate Cerulean Warbler abundance with more confidence. With simple extrapolation techniques, based on conservative measures, we are confident that several sections of the Kittatinny Ridge IBA qualify as global IBAs on the basis of their Cerulean Warbler populations. We suggest two possible approaches to this designation, either designate two areas (sections 3+4+5, & 7+8+9; see Figure 1), or designate all sections 3 through 9 together in one larger area. Either approach would result in areas that hold many times more Cerulean Warblers than would be required to designate these areas a global IBA.

## Acknowledgements

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**Table 1.** Elevation and distance from road of 2<sup>nd</sup> PBBA and 2013 point count locations (sample; 200 m radii of point) and hexagons representing the entire area (actual)

	sample	actual	Z test	
			Z score	p
Mean elevation				
PBBA - within IBA	246	299	10.2	<0.001
PBBA - within 5km	228	249	7.62	<0.001
2013 points	376	299	17.7	<0.001
Elevation range				
PBBA - within IBA	43.6	63.9	13.7	<0.001
PBBA - within 5km	36.5	47.5	14.8	<0.001
2013 points	63.9	63.9	0.042	0.966
Distance from road				
PBBA - within IBA	91	419	60.6	<0.001
PBBA - within 5km	103	359	58.5	<0.001
2013 points	477	419	3.2	0.001

**Table 2.** Twenty most frequently detected species (abundance and ubiquity) on point counts in the Kittatinny Ridge IBA, June 2013

Species	total birds	% of points	Abundance rank	Ubiquity rank
Red-eyed Vireo	1,529	96.3	1	1
Ovenbird	1,089	81.3	2	2
Scarlet Tanager	555	64.9	3	3
Eastern Wood-Pewee	298	40.2	4	4
Wood Thrush	289	32.6	5	6
Eastern Towhee	279	33.3	6	5
Indigo Bunting	205	26.0	7	8
Black-and-white Warbler	189	27.5	8	7
Tufted Titmouse	174	22.9	9	9
Hooded Warbler	166	21.9	10	10
Blue Jay	160	20.7	11	11
American Crow	149	18.0	12	12
American Redstart	148	17.7	13	13
Northern Cardinal	136	17.7	14	14
American Robin	123	11.0	15	20
Acadian Flycatcher	112	12.2	16	17
Cedar Waxwing	107	8.8	17	28
Yellow-billed Cuckoo	104	16.0	18	15
Mourning Dove	99	14.8	19	16
Chipping Sparrow	84	10.2	20	23
Pileated Woodpecker	79	12.1	22	19
Worm-eating Warbler	79	12.2	23	18

**Table 3.** Comparison of bird detection rates on 2013 surveys and PBBA point counts. Species are ranked according to whether they were relatively more frequently detected on 2013 surveys (top) to more frequent on PBBA (bottom).

Species	Singing males/point		ratio 2013/PBBA
	2 <sup>nd</sup> PBBA	2013	
Black-and-white Warbler	0.042	0.308	7.262
<b>Cerulean Warbler</b>	<b>0.027</b>	<b>0.095</b>	<b>3.575</b>
Blackburnian Warbler	0.007	0.024	3.352
Hooded Warbler	0.085	0.276	3.252
Worm-eating Warbler	0.042	0.129	3.032
Scarlet Tanager	0.313	0.902	2.878
Ovenbird	0.627	1.771	2.827
Eastern Towhee	0.158	0.417	2.647
Acadian Flycatcher	0.076	0.188	2.472
Red-eyed Vireo	1.133	2.525	2.229
Rose-breasted Grosbeak	0.028	0.056	1.975
Eastern Wood-Pewee	0.258	0.498	1.928
Chestnut-sided Warbler	0.002	0.003	1.915
Pine Warbler	0.009	0.017	1.915
Yellow-throated Vireo	0.055	0.095	1.730
American Redstart	0.173	0.249	1.436
Black-throated Green Warbler	0.034	0.046	1.361
Yellow-billed Cuckoo	0.129	0.163	1.259
Blue-winged Warbler	0.011	0.012	1.117
Louisiana Waterthrush	0.030	0.031	1.014
Wood Thrush	0.490	0.469	0.958
Tufted Titmouse	0.273	0.224	0.821
Blue-headed Vireo	0.018	0.010	0.575
Common Yellowthroat	0.241	0.134	0.556
Carolina Wren	0.193	0.102	0.527
Indigo Bunting	0.642	0.336	0.522
Prairie Warbler	0.028	0.014	0.479
Northern Parula	0.016	0.007	0.426
Northern Cardinal	0.497	0.205	0.412
Veery	0.037	0.015	0.410
Mourning Dove	0.368	0.146	0.396
American Robin	0.494	0.173	0.350
Bobolink	0.011	0.003	0.319
Yellow-breasted Chat	0.011	0.003	0.319
Field Sparrow	0.170	0.044	0.259
Kentucky Warbler	0.007	0.002	0.239
Eastern Phoebe	0.115	0.027	0.236

Willow Flycatcher	0.019	0.003	0.174
Brown Thrasher	0.050	0.007	0.137
Gray Catbird	0.529	0.064	0.122
Chipping Sparrow	0.719	0.086	0.120
Baltimore Oriole	0.129	0.014	0.105
Yellow Warbler	0.122	0.010	0.083
Orchard Oriole	0.023	0.002	0.074
Eastern Bluebird	0.073	0.005	0.070
Red-winged Blackbird	0.336	0.019	0.055
Song Sparrow	0.604	0.027	0.045
House Wren	0.363	0.010	0.028
Northern Mockingbird	0.191	0.005	0.027
House Finch	0.104	0.002	0.016

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**Table 4.** Cerulean Warbler detections and density estimates from 2<sup>nd</sup> PBBA and 2013 point count surveys for IBA sections.

Section	Area (km <sup>2</sup> )	2 <sup>nd</sup> PBBA			2013			Overall			
		point counts	male CERW	male CERW/km <sup>2</sup>	point counts	male CERW	male CERW/km <sup>2</sup>	point counts	male CERW	male CERW/km <sup>2</sup>	Total male CERW
IBA	1363.7	336	9	0.49	561	54	1.75	897	63	1.28	1,411
1	88.2	17	0	0	50	0	0	67	0	0	0
2	104.4	22	0	0	0	0	NA	22	0	0	0
3	60.8	13	0	0	44	7	2.89	57	7	2.23	136
4	171.6	42	7	3.03	52	3	1.05	94	10	1.93	332
5	91.4	25	0	0	31	12	7.04	56	12	3.90	356
6	49.3	12	0	0	2	0	0	14	0	0	0
7	76.1	32	1	0.57	54	10	3.37	86	11	2.33	177
8	62.0	23	0	0	51	17	6.06	74	17	4.18	259
9	66.3	15	1	1.21	12	0	0	27	1	0.67	45
10	62.8	14	0	0	14	0	0	28	0	0	0
11	49.8	10	0	0	0	0	NA	10	0	0	0
12	81.3	13	0	0	24	0	0	37	0	0	0
13	146.3	29	0	0	93	0	0	122	0	0	0
14	76.6	22	0	0	48	2	0.76	70	2	0.52	40
15	114.3	35	0	0	47	0	0	82	0	0	0
5 km buffer		1,291	22	0.31	587	54	1.67	1,878	76	0.74	NA <sup>a</sup>

a = not computed, too few off road counts

**Figure 1.** Sections of the Kittatinny Ridge IBA, used for estimation of Cerulean Warbler populations.

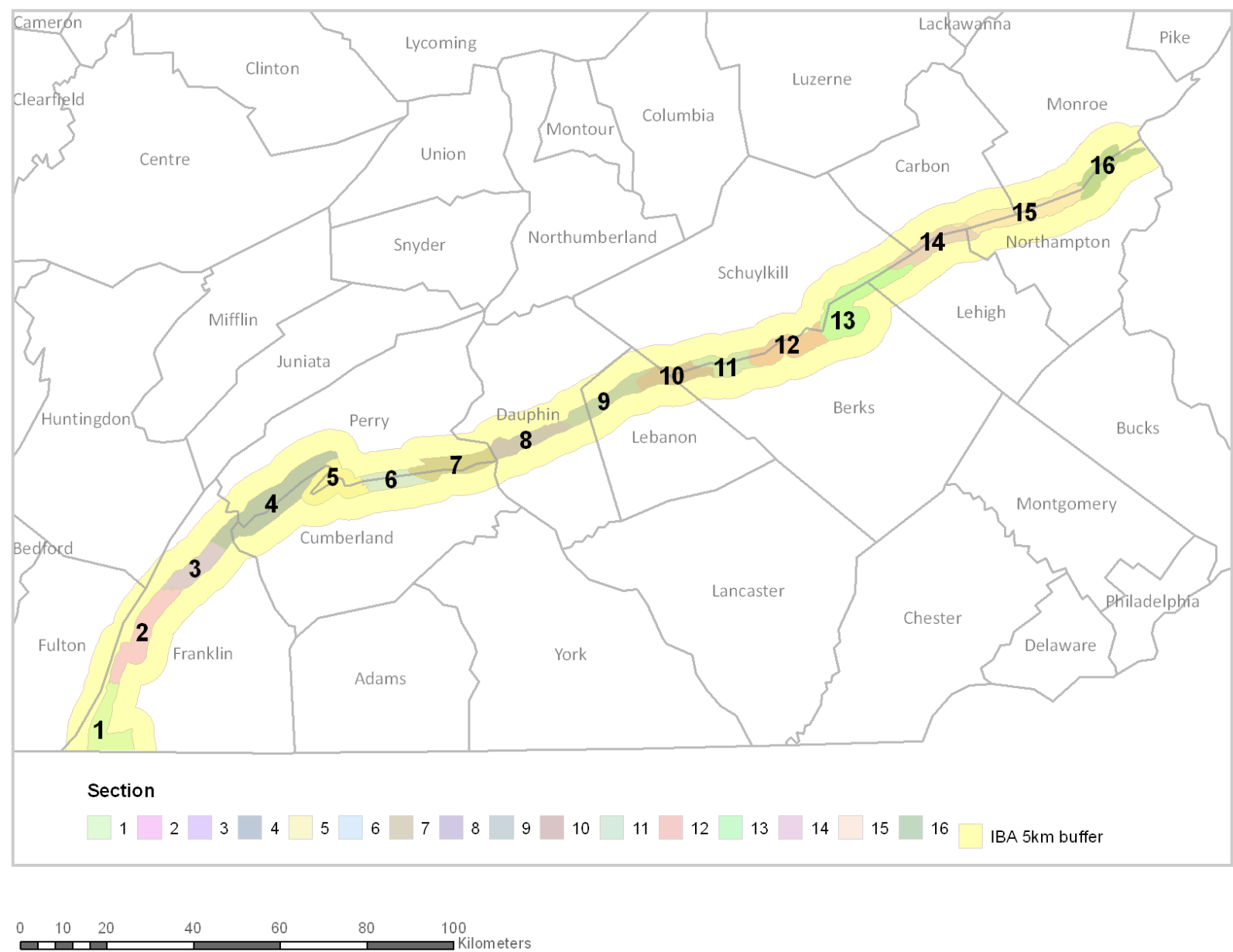


Figure 2. Locations of 2<sup>nd</sup> PBBA and 2013 point counts

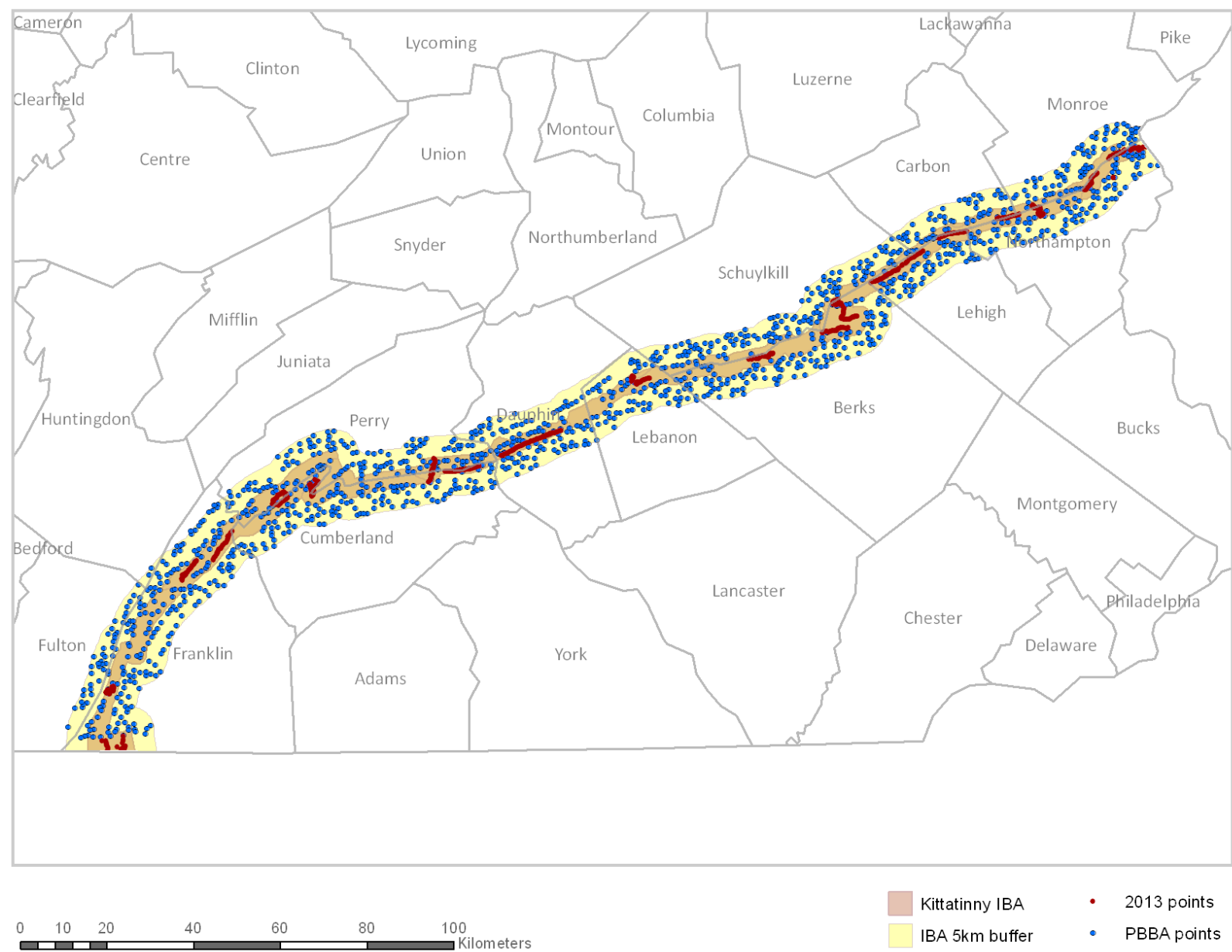
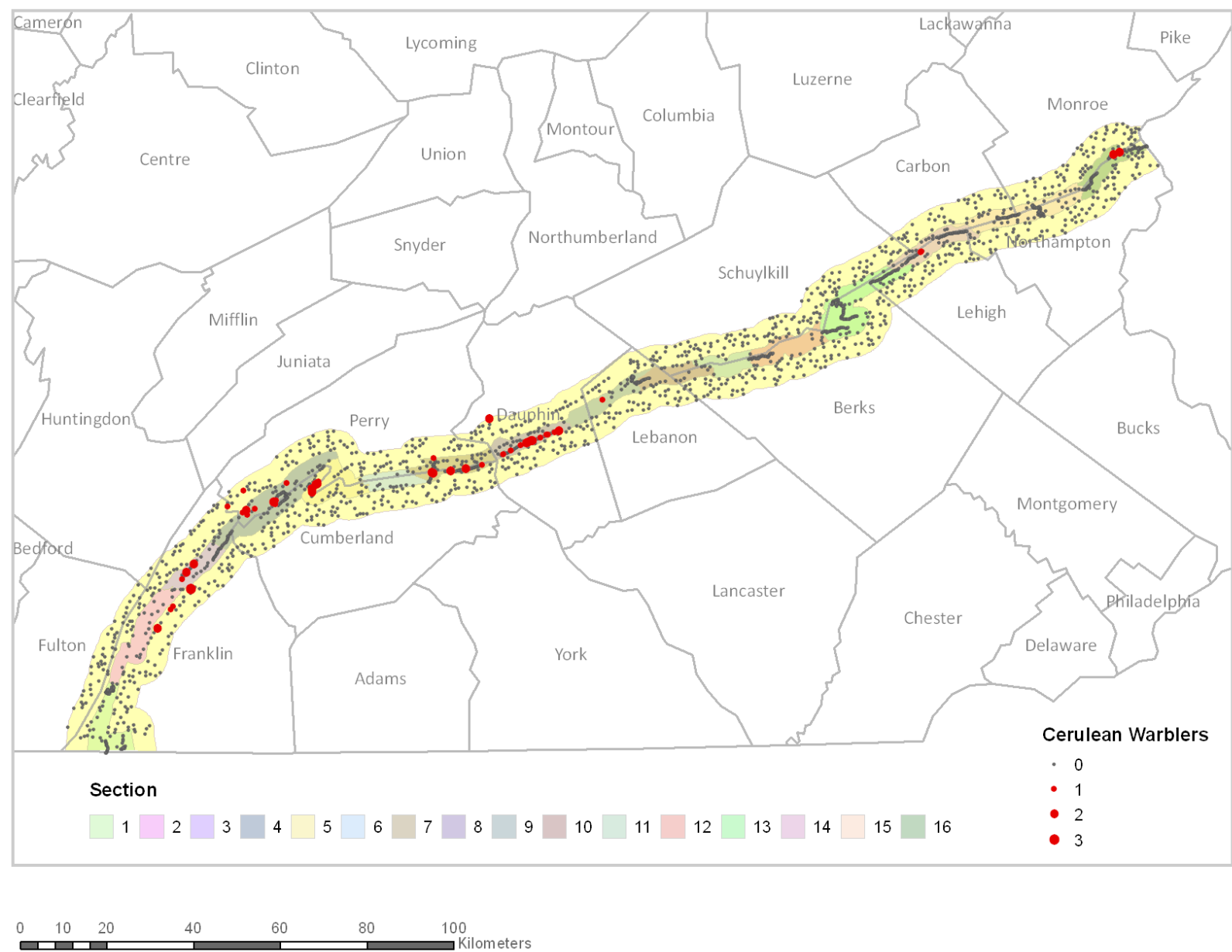
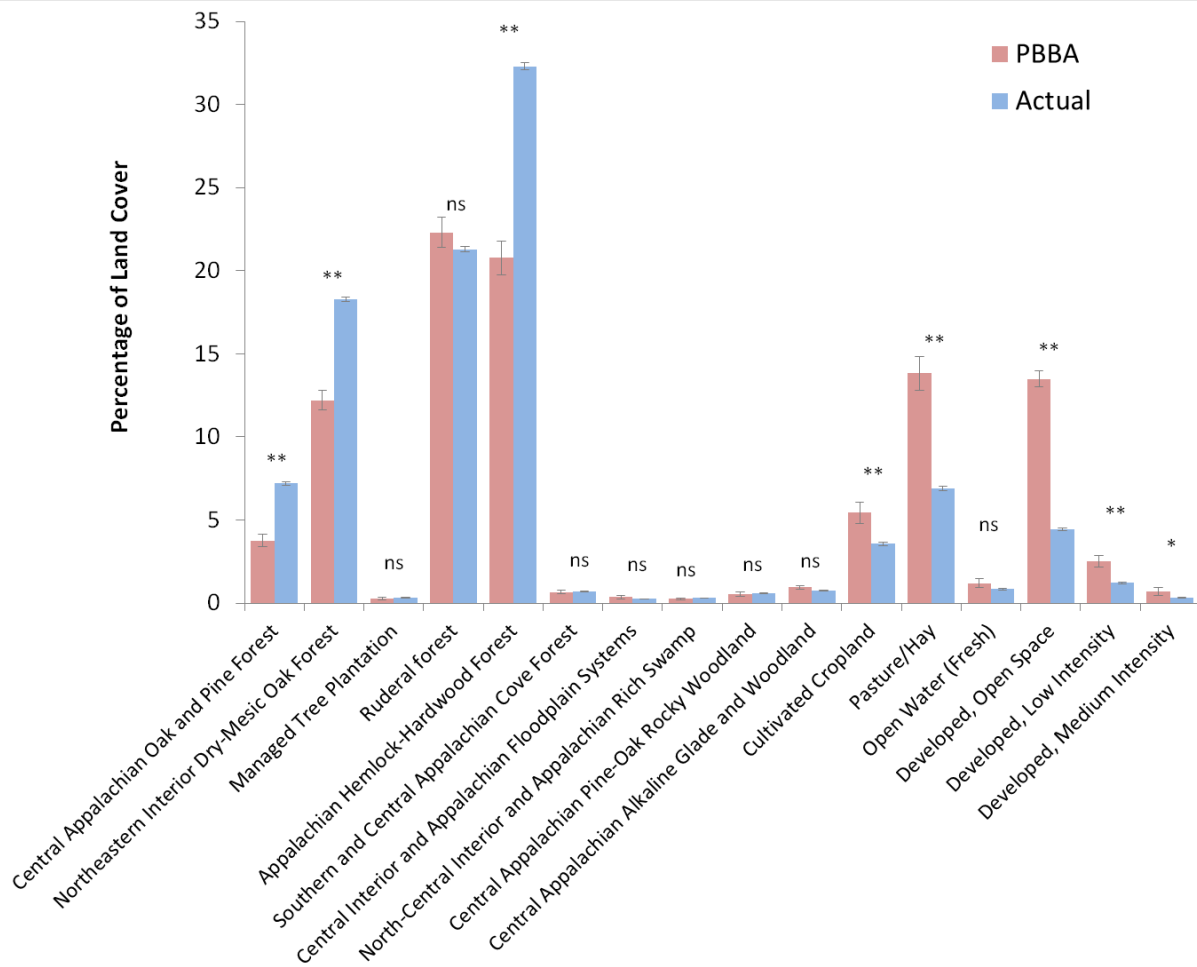


Figure 3. Cerulean Warbler detections

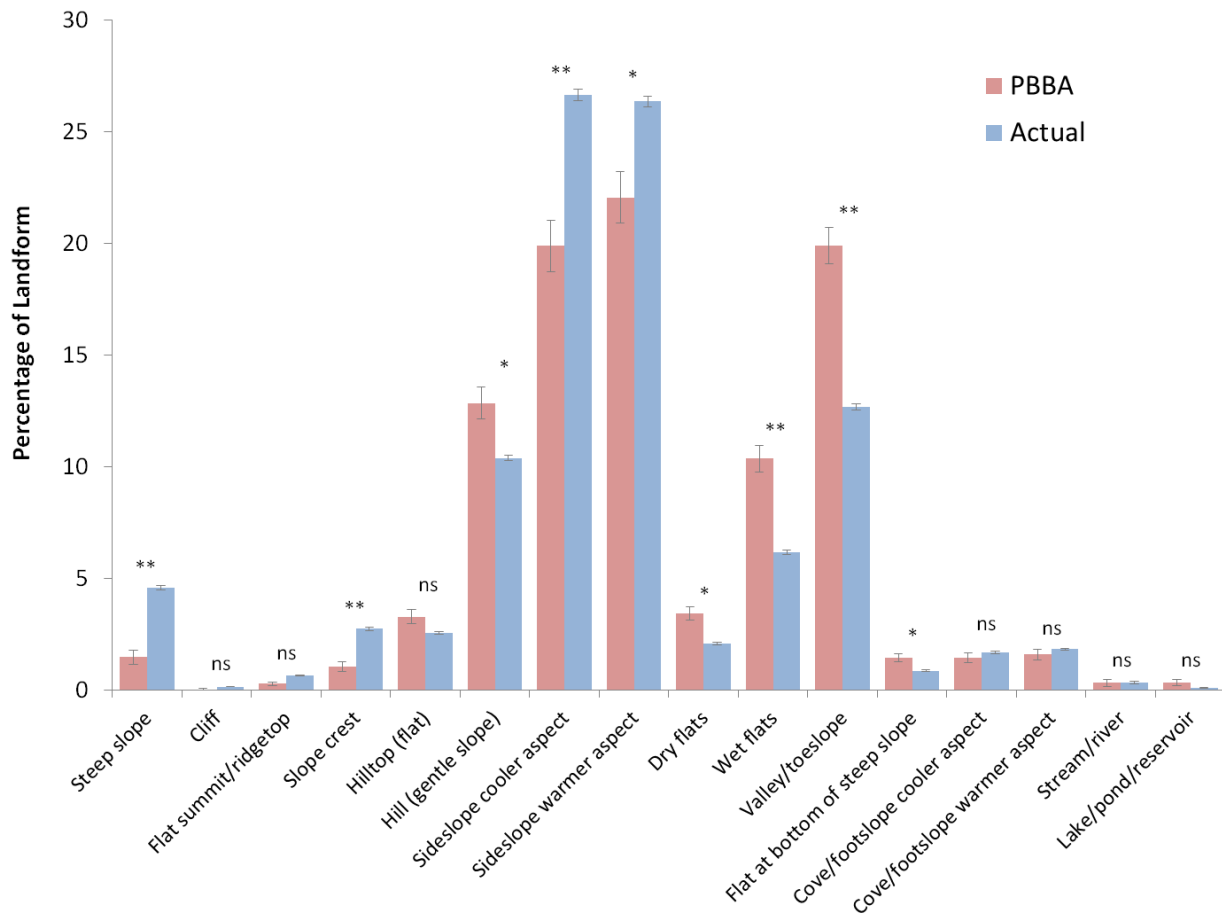




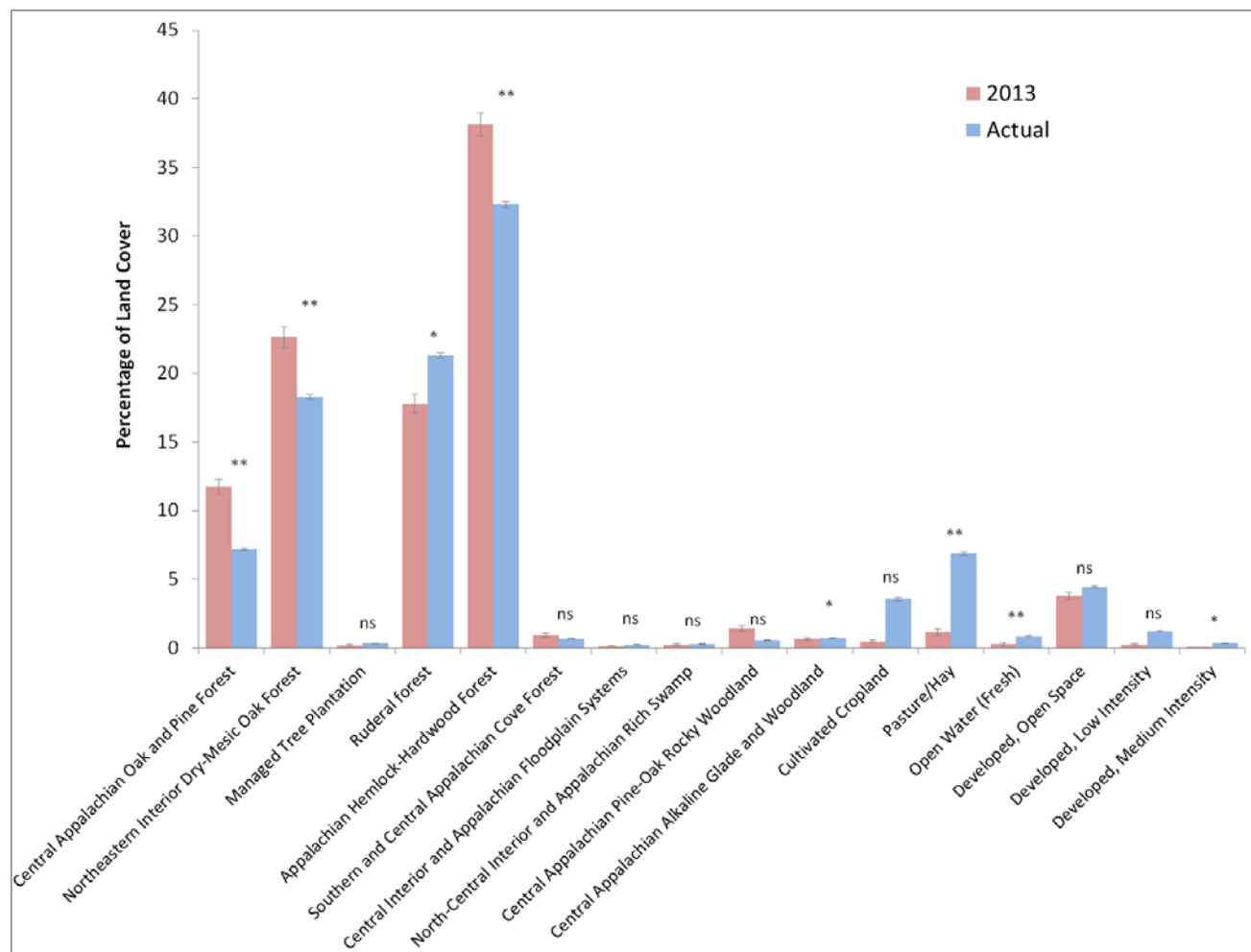
**Figure 4.** Bias in land cover due to the roadside sampling protocol of 2<sup>nd</sup> PBBA point counts. Red columns are land cover within a 200 meter radius of point count locations, and blue columns are the actual percentages of land cover types within the Important Bird Area. Significant bias is indicated as follows: \*P <0.05, \*\*P <0.01 from two-proportion z-tests.



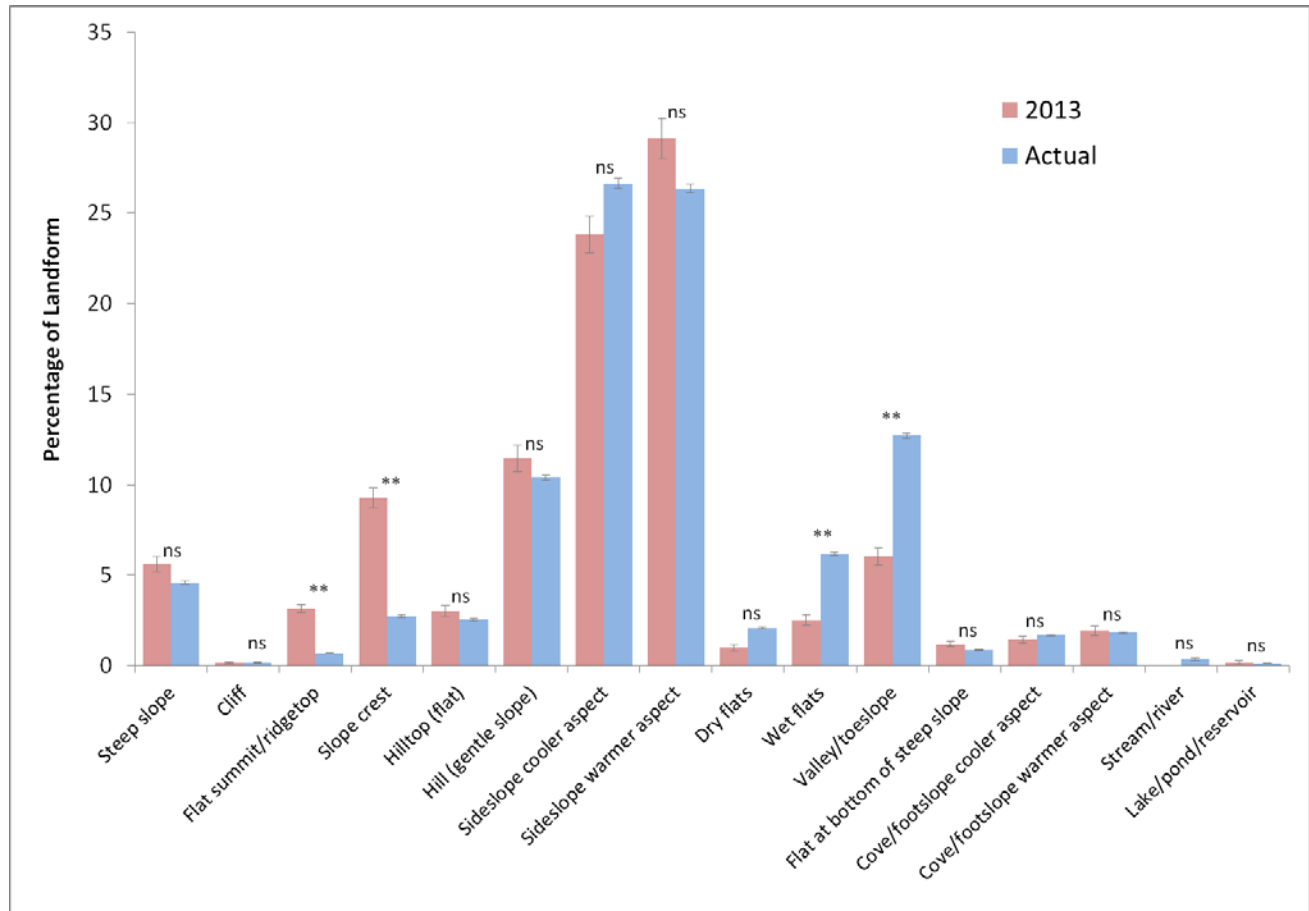
**Figure 5.** Bias in landform due to the roadside sampling protocol of 2<sup>nd</sup> PBBA point counts. Red columns are landform within a 200 meter radius of point count locations, and blue columns are the actual percentages of landform types within the Important Bird Area. Significant bias is indicated as follows: \*P <0.05, \*\*P <0.01 from two-proportion z-tests.



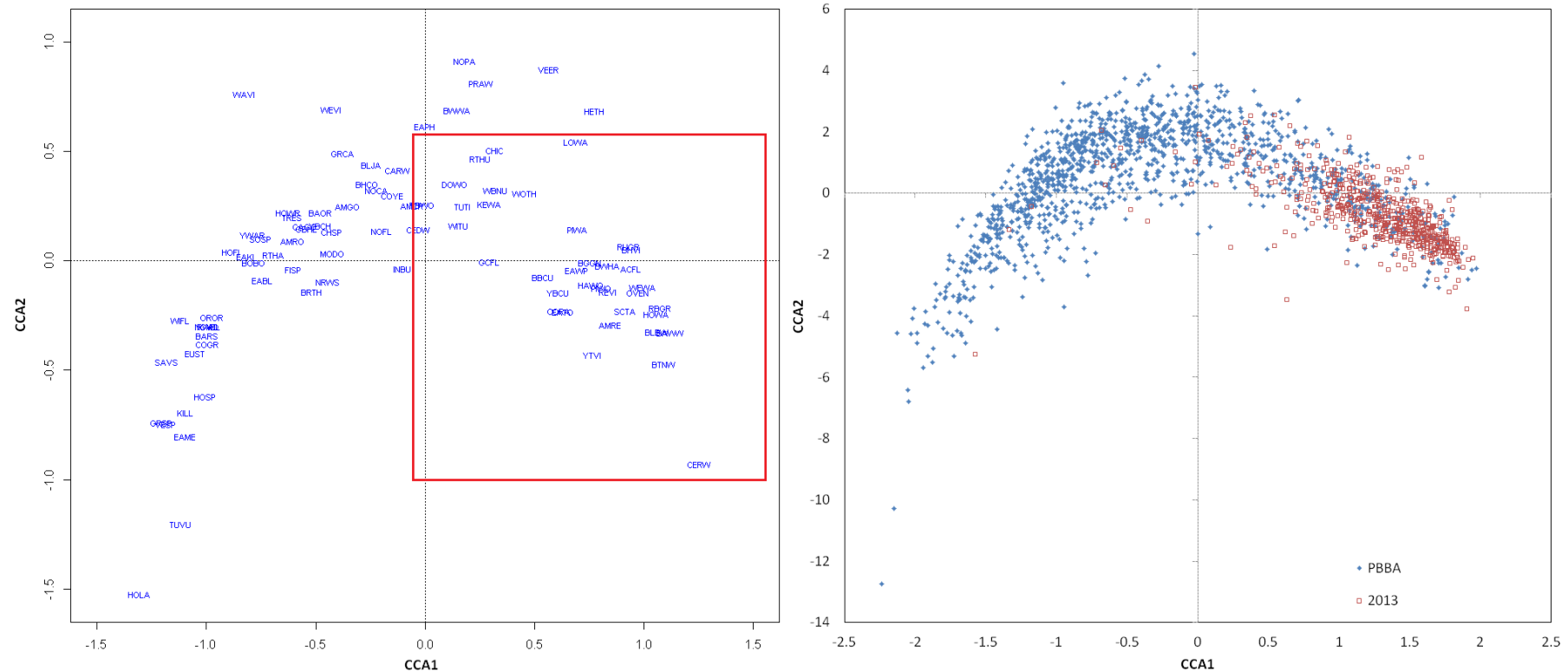
**Figure 6.** Bias in land cover due to the roadside sampling protocol of 2013 point counts. Red columns are land cover within a 200 meter radius of point count locations, and blue columns are the actual percentages of land cover types within the Important Bird Area. Significant bias is indicated as follows: \*P <0.05, \*\*P <0.01 from two-proportion z-tests.



**Figure 7.** Bias in landform due to the roadside sampling protocol of 2013 point counts. Red columns are landform within a 200 meter radius of point count locations, and blue columns are the actual percentages of landform types within the Important Bird Area. Significant bias is indicated as follows: \*P < 0.05, \*\*P < 0.01 from two-proportion z-tests.

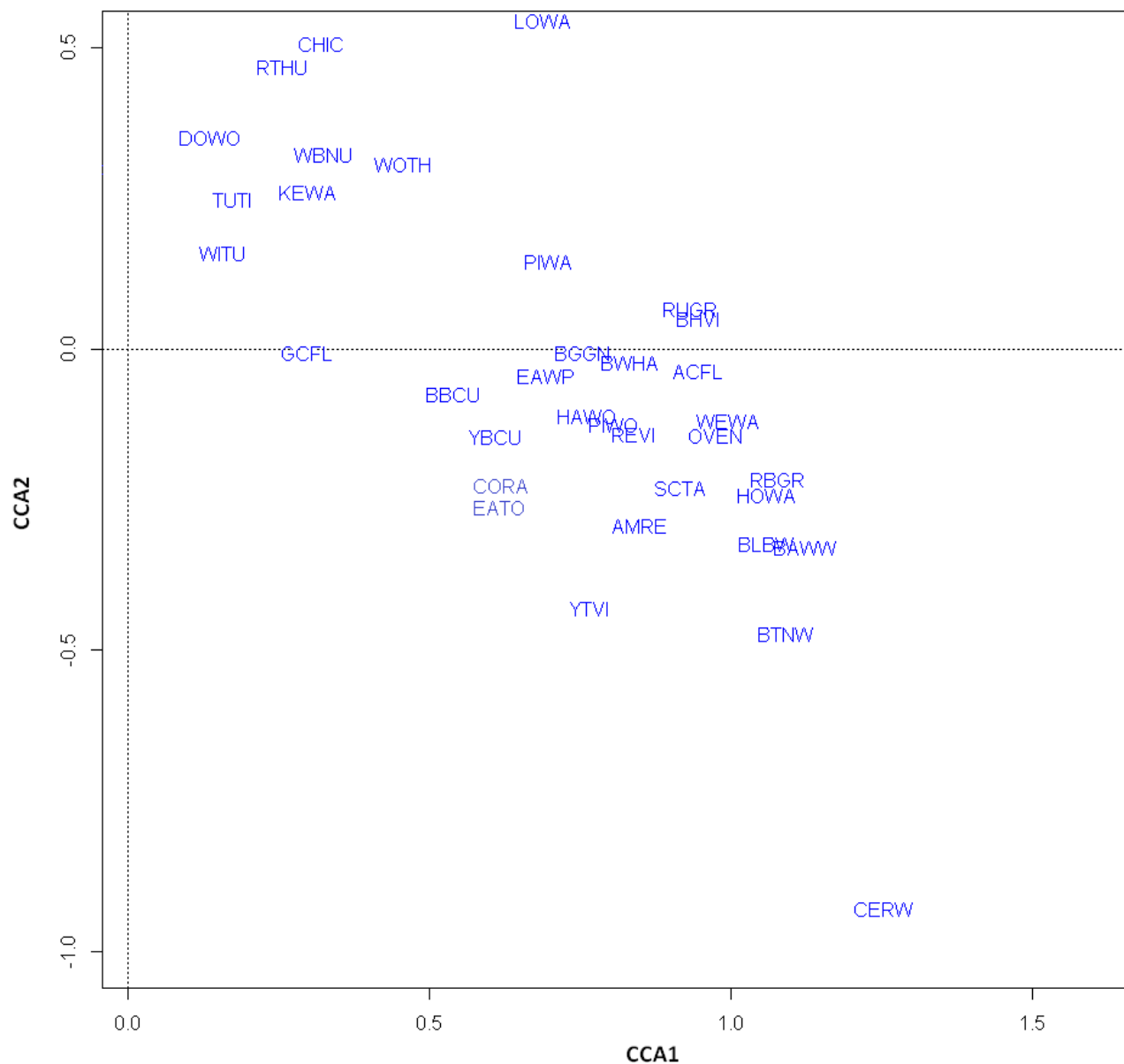


**Figure 8.** Canonical Correspondence Analysis bi-plots showing species scores (left) and point count location scores (right). Axis weightings for the landscape metrics uses in this CCA can be found in Appendix 2. The red box is shown in closer detail in figure 9.



HOLA	Horned lark	YWAR	Yellow Warbler	GRCA	Gray Catbird	RTHU	Ruby-throated Hummingbird	HETH	Hermit Thrush
GRSP	Grasshopper Sparrow	BOBO	Bobolink	AMGO	American Goldfinch	PRAW	Prairie Warbler	PIWO	Pileated Woodpecker
VESP	Vesper Sparrow	SOSP	Song Sparrow	BHCO	Brown-headed Cowbird	KEWA	Kentucky Warbler	BWHA	Broad-winged Hawk
SAVS	Savannah Sparrow	EABL	Eastern Bluebird	BLJA	Blue Jay	GCFL	Great Crested Flycatcher	REVI	Red-eyed Vireo
WIFL	Willow Flycatcher	RTHA	Red-tailed Hawk	NOCA	Northern Cardinal	CHIC	chickadee	AMRE	American Redstart
TUVU	Turkey Vulture	HOWR	House Wren	NOFL	Northern Flicker	WBNU	White-breasted Nuthatch	SCTA	Scarlet Tanager
EAME	Eastern Meadowlark	TRES	Tree Swallow	COYE	Common Yellowthroat	WOTH	Wood Thrush	RUGR	Ruffed Grouse
KILL	Killdeer	AMRO	American Robin	CARW	Carolina Wren	BBCU	Black-billed Cuckoo	ACFL	Acadian Flycatcher
EUST	European Starling	FISP	Field Sparrow	INBU	Indigo Bunting	VEER	Veery	BHVI	Blue-headed Vireo
HOSP	House Sparrow	CAGO	Canada Goose	AMCR	American Crow	YBCU	Yellow-billed Cuckoo	OVEN	Ovenbird
BARS	Barn Swallow	GBHE	Great Blue Heron	CEDW	Cedar Waxwing	CORA	Common Raven	WEWA	Worm-eating Warbler
COGR	Common Grackle	BRTH	Brown Thrasher	RBWO	Red-bellied Woodpecker	EATO	Eastern Towhee	BLBW	Blackburnian Warbler
NOMO	Northern Mockingbird	YBCH	Yellow-breasted Chat	EAPH	Eastern Phoebe	LOWA	Louisiana Waterthrush	HOWA	Hooded Warbler
RWBL	Red-winged Blackbird	BAOR	Baltimore Oriole	DOWO	Downy Woodpecker	EAWP	Eastern Wood-Pewee	RBGR	Rose-breasted Grosbeak
OROR	Orchard Oriole	NRWS	Northern Rough-winged Swallow	BWVA	Blue-winged Warbler	PIWA	Pine Warbler	BTNW	Black-throated Green Warbler
HOFI	House Finch	WEVI	White-eyed Vireo	WITU	Wild Turkey	BGGN	Blue-gray Gnatcatcher	BAWW	Black-and-white Warbler
WAVI	Warbling Vireo	CHSP	Chipping Sparrow	TUTI	Tufted Titmouse	HAWO	Hairy Woodpecker	CERW	Cerulean Warbler
EAKI	Eastern Kingbird	MODO	Mourning Dove	NOPA	Northern Parula	YTVI	Yellow-throated Vireo		

**Figure 9.** CCA bi-plot showing forest interior songbirds, inset from Figure 8.



#### SPECIES CODES

DOWO	Downy Woodpecker
WITU	Wild Turkey
TUTI	Tufted Titmouse
RTHU	Ruby-throated Hummingbird
KEWA	Kentucky Warbler
GCFL	Great Crested Flycatcher
CHIC	chickadee
WBNU	White-breasted Nuthatch
WOTH	Wood Thrush
BBCU	Black-billed Cuckoo
YBCU	Yellow-billed Cuckoo
CORA	Common Raven
EATO	Eastern Towhee
LOWA	Louisiana Waterthrush
EAWP	Eastern Wood-Pewee
PIWA	Pine Warbler
BGGN	Blue-gray Gnatcatcher
HAWO	Hairy Woodpecker
YTVI	Yellow-throated Vireo
HETH	Hermit Thrush
PIWO	Pileated Woodpecker
BWHA	Broad-winged Hawk
REVI	Red-eyed Vireo
AMRE	American Redstart
SCTA	Scarlet Tanager
RUGR	Ruffed Grouse
ACFL	Acadian Flycatcher
BHVI	Blue-headed Vireo
OVEN	Ovenbird
WEWA	Worm-eating Warbler
BLBW	Blackburnian Warbler
HOWA	Hooded Warbler
RBGR	Rose-breasted Grosbeak
BTNW	Black-thrtd Green Warbler
BAWW	Black-and-white Warbler
CERW	Cerulean Warbler

### Kittatinny Ridge Important Bird Area Point Count Surveys – 2013

**AIMS** – to enable estimates of the population sizes of forest interior birds within the IBA. Data will complement 2<sup>nd</sup> PA Bird Atlas point counts, but due to the latter being roadside counts, forest interior areas and ridge-tops were under-sampled.

**METHODS** – point counts along hiking trails

#### Route details

- Note: the maps provided are only a guide – use them as basis for your route and try to space counts every 300m along them. Use the GPS coordinates provided as a reference. It is not essential that your points fall exactly on the given points – you'll likely lose GPS reception in places!
- Point counts should be 300m apart to avoid recording the same individual bird at adjacent points. Some vocalizations can be heard at >150m in forest (e.g. Pileated Woodpecker drum, Scarlet Tanager song) but most other detections will be within 150m.
- Try to get GPS coordinates for as many points as possible (all would be good!), but especially the first and last points of your route. Coordinates should be in decimal degrees. Datum is NAD1983 or WGS1984 (effectively the same). If you do not get GPS reception please record NA in the "Latitude" and "Longitude" boxes on the recording form.
- Aim to do *at least* 20 point counts on each route.
- Note that 25 points 300m apart would make a route of 7.2km (4.5 miles).

#### Dates, times and conditions

- Counts to be undertaken 5/29/13 – 6/30/13.
- Start counts 30 minutes after civil twilight (dawn), no earlier than 05:10 AM.
- Counts continue until 10:00 AM. Counts should be curtailed if song activity is depressed (e.g. due to high temperatures or wind).
- Counts should only be undertaken in suitable weather – calm to light winds, no precipitation (occasional light drizzle is OK), no fog, temperature no higher than 77F (25C).

#### Count methods

- **IMPORTANT:** before going out, practice estimating a 75m (c.80 yard) radius – I can lend a laser range finder to you if that would be useful. Clearly, we cannot expect high precision in your ability to estimate the 75m distance, but we need to be confident that you do not systematically over or underestimate (i.e. bias is worse than lack of precision).
- PLEASE USE THE RECORDING FORM PROVIDED (see example on reverse). There is space for 4 point counts on each side and 20 species/points (should be plenty most of the time!).
- Count for FIVE MINUTES – please use a stopwatch/phone set to timer!
- Focus on singing songbirds but record all other bird detections. Use a tally to record the number of individuals in 4 categories (see example on reverse):
  1. Singing males <or=75m from point count station
  2. Singing males > 75m from point count station
  3. Non-song (calls or visual cues) <or=75m from point count station
  4. Non-song (calls or visual cues) >75m from point count station
- Only record each individual bird **ONCE** – in the distance band in which you first detected it.
- Do not record birds flying well above the canopy (e.g. soaring raptors, vultures, flyover starling and swallows etc.).
- Do not use playback.

*Please keep a photocopy of all your recording forms before mailing them back to Andy Wilson.*

#### Please take all the usual Health and Safety precautions for hiking:

- Tell someone where you are going and when you should be expected back home
- Leave your car in a safe place, remove valuables from view
- Carry fluids to avoid dehydration
- Wear suitable footwear, some of the trails are arduous
- Protect yourself from ticks and sunburn

Example of a completed form (use a tally to note each individual bird in each category)

Route	Franklin 1	Point #	7	Date	6/10/13
Time	06:15	Obs. initials	AW		
Longitude	-77.796539	Latitude	40.008427		
Species	Singing <75m	Singing >75m	Non-song <75m	Non-song >75m	
REVI	II	I			
SCTA	I				
HAWO			I		
CERW	I				
WOTH	I	I			
EATO		I			
CARW		I			
WBNU			I		
AMCR				II	
INBU		I			
TUTI			I		

Four-letter codes of likely species (more complete list at <http://www.birdpop.org/AlphaCodes.htm>)

COHA	Cooper's Hawk	BARS	Barn Swallow	BTBW	Black-throated Blue Warbler
RSHA	Red-shouldered Hawk	CACH	Carolina Chickadee	BTNW	Black-throated Green Warbler
BWHA	Broad-winged Hawk	BCCH	Black-capped Chickadee	PIWA	Pine Warbler
RTHA	Red-tailed Hawk	HYCH	chickadee hybrid/uncertain	BAWW	Black-and-white Warbler
ROPI	Rock Pigeon	TUTI	Tufted Titmouse	AMRE	American Redstart
MODO	Mourning Dove	RBNU	Red-breasted Nuthatch	WEWA	Worm-eating Warbler
BBCU	Black-billed Cuckoo	WBNU	White-breasted Nuthatch	OVEN	Ovenbird
YBCU	Yellow-billed Cuckoo	BRCR	Brown Creeper	LOWA	Louisiana <u>Waterthrush</u>
RTHU	Ruby-throated Hummingbird	HOWR	House Wren	COYE	Common <u>Yellowthroat</u>
BEKI	Belted Kingfisher	CARW	Carolina Wren	CAWA	Canada Warbler
RBWO	Red-bellied Woodpecker	WIWR	Winter Wren	YBCH	Yellow-breasted Chat
YBSA	Yellow-bellied Sapsucker	GCKI	Golden-crowned Kinglet	SCTA	Scarlet Tanager
DOWO	Downy Woodpecker	BGGN	Blue-gray Gnatcatcher	EATO	Eastern Towhee
HAWO	Hairy Woodpecker	EABL	Eastern Bluebird	CHSP	Chipping Sparrow
NOFL	Northern Flicker	HETH	Hermit Thrush	FISP	Field Sparrow
PIWO	Pileated Woodpecker	WOTH	Wood Thrush	SOSP	Song Sparrow
ACFL	Acadian Flycatcher	AMRO	American Robin	DEJU	Dark-eyed Junco
EAWP	Eastern Wood-Pewee	GRCA	Gray Catbird	NOCA	Northern Cardinal
LEFL	Least Flycatcher	BRTH	Brown Thrasher	RBGR	Rose-breasted Grosbeak
EAPH	Eastern Phoebe	NOMO	Northern Mockingbird	BLGR	Blue Grosbeak
GCFL	Great-Crested Flycatcher	EUST	European Starling	INBU	Indigo Bunting
EAKI	Eastern Kingbird	CEDW	Cedar Waxwing	RWBL	Red-winged Blackbird
YTVI	Yellow-throated Vireo	BWWA	Blue-winged Warbler	COGR	Common Grackle
WAVI	Warbling Vireo	GWWA	Golden-winged Warbler	BHCO	Brown-headed Cowbird
BHVI	Blue-headed Vireo	NOPA	Northern <u>Parula</u>	BAOR	Baltimore Oriole
REVI	Red-eyed Vireo	CERW	Cerulean Warbler	OROR	Orchard Oriole
BLJA	Blue Jay	YWAR	Yellow Warbler	HOFI	House Finch
AMCR	American Crow	CSWA	Chestnut-sided Warbler	HOSP	House Sparrow
FICR	Fish Crow	MAWA	Magnolia Warbler	AMGO	American Goldfinch
CORA	Common Raven	BLBW	<u>Blackburnian</u> Warbler		
TRES	Tree Swallow	YRWA	<u>Yellow-rumped</u> Warbler		



## Appendix 2. Landscape metrics and axis scores from Canonical Correspondence Analysis

Landscape covariate	CCA score	
	Axis 1	Axis 2
Longitude (DD)	0.002	0.406
Latitude (DD)	0.030	0.392
Mean elevation (m)	<b>0.730</b>	-0.467
Elevation range (m)	<b>0.688</b>	-0.146
Distance to road (m)	<b>0.482</b>	-0.342
Land cover type (NLCD 2006)		
Central Appalachian Oak and Pine Forest	0.477	-0.126
Northeastern Interior Dry-Mesic Oak Forest	0.645	-0.127
Managed Tree Plantation	0.019	0.069
Ruderal forest	0.318	0.473
<b>Appalachian Hemlock-Hardwood Forest</b>	<b>0.798</b>	-0.082
Laurentian-Acadian Northern Hardwoods Forest	-0.043	0.206
Laurentian-Acadian Pine-Hemlock-Hardwood Forest	-0.027	0.111
Southern and Central Appalachian Cove Forest	0.214	0.000
Appalachian Shale Barrens	-0.072	0.173
Southern Appalachian Montane Pine Forest and Woodland	-0.042	-0.040
Central Interior and Appalachian Floodplain Systems	-0.044	0.222
Central Interior and Appalachian Riparian Systems	-0.048	0.207
Laurentian-Acadian Floodplain Systems	-0.031	0.126
North-Central Interior and Appalachian Rich Swamp	0.052	0.106
Laurentian-Acadian Swamp Systems	0.037	0.052
Central Appalachian Pine-Oak Rocky Woodland	0.122	0.036
Central Appalachian Alkaline Glade and Woodland	0.041	0.281
<b>Cultivated Cropland</b>	<b>-0.600</b>	-0.384
<b>Pasture/Hay</b>	<b>-0.777</b>	-0.121
Introduced Upland Vegetation - Annual Grassland	-0.050	-0.052
Introduced Riparian and Wetland Vegetation	-0.014	0.042
Introduced Upland Vegetation - Treed	0.020	0.043
Disturbed, Non-specific	-0.017	0.025
Harvested Forest - Grass/Forb Regeneration	-0.054	-0.074
Harvested Forest-Shrub Regeneration	-0.028	0.074
Open Water (Fresh)	-0.105	0.206
Developed, Open Space	-0.354	0.390
Developed, Low Intensity	-0.361	0.006
Developed, Medium Intensity	-0.168	-0.008
Developed, High Intensity	-0.098	-0.058
Land form type		
Steep slope	0.349	-0.235
Cliff	0.117	-0.084
Flat summit/ridgetop	0.363	-0.225
Slope crest	0.411	-0.248

Landscape covariate	CCA score	
	Axis 1	Axis 2
Hilltop (flat)	-0.375	-0.158
Hill (gentle slope)	-0.438	-0.080
Sideslope cooler aspect	0.385	0.043
Sideslope warmer aspect	0.424	0.087
Dry flats	-0.412	-0.036
Wet flats	-0.403	0.107
<b>Valley/toeslope</b>	<b>-0.570</b>	0.132
Flat at bottom of steep slope	0.216	0.151
Cove/footslope cooler aspect	0.280	-0.035
Cove/footslope warmer aspect	0.260	0.011
Stream/river	-0.073	0.154
Lake/pond/reservoir	-0.016	0.018
elevx	0.730	-0.467
elevr	0.688	-0.146
road	0.482	-0.342

Appendix 3. Total individual birds detected on 2013 point count surveys (n=590 points)

Species	singing birds	non-song birds	total birds	points detected	% of points
Canada Goose	0	1	1	1	0.2
Great Blue Heron	0	1	1	1	0.2
Killdeer	0	2	2	2	0.3
Ruffed Grouse	1	1	2	2	0.3
Wild Turkey	4	8	12	7	1.2
Mourning Dove	86	13	99	87	14.8
Turkey Vulture	0	2	2	2	0.3
Red-tailed Hawk	0	3	3	3	0.5
Broad-winged Hawk	0	2	2	2	0.3
Yellow-billed Cuckoo	96	8	104	94	16.0
Black-billed Cuckoo	4	2	6	6	1.0
Belted Kingfisher	0	1	1	1	0.2
Hairy Woodpecker	0	28	28	25	4.2
Downy Woodpecker	0	62	62	59	10.0
Pileated Woodpecker	0	79	79	71	12.1
Red-bellied Woodpecker	0	64	64	57	9.7
Northern Flicker	0	26	26	25	4.2
Ruby-throated Hummingbird	0	5	5	5	0.8
Eastern Kingbird	2	3	5	4	0.7
Great Crested Flycatcher	28	43	71	63	10.7
Eastern Phoebe	16	5	21	20	3.4
Eastern Wood-Pewee	294	4	298	237	40.2
Acadian Flycatcher	111	1	112	72	12.2
Willow Flycatcher	2	0	2	2	0.3
Blue Jay	0	160	160	122	20.7
Common Raven	0	4	4	5	0.8
American Crow	0	149	149	106	18.0
European Starling	0	5	5	3	0.5
Bobolink	2	2	4	1	0.2
Brown-headed Cowbird	12	37	49	39	6.6
Red-winged Blackbird	11	10	21	6	1.0
Orchard Oriole	1	0	1	1	0.2
Baltimore Oriole	8	1	9	9	1.5
Common Grackle	0	37	37	12	2.0
House Finch	1	0	1	1	0.2
American Goldfinch	4	27	31	23	3.9
Chipping Sparrow	51	33	84	60	10.2

Species	singing birds	non-song birds	total birds	points detected	% of points
Field Sparrow	26	3	29	21	3.6
Song Sparrow	16	0	16	14	2.4
Eastern Towhee	246	33	279	196	33.3
Northern Cardinal	121	15	136	104	17.7
Rose-breasted Grosbeak	33	7	40	37	6.3
Indigo Bunting	198	7	205	153	26.0
Scarlet Tanager	532	23	555	382	64.9
Barn Swallow	0	6	6	3	0.5
Tree Swallow	0	3	3	1	0.2
Northern Rough-winged Swallow	0	2	2	1	0.2
Cedar Waxwing	0	107	107	52	8.8
Red-eyed Vireo	1490	39	1529	567	96.3
Yellow-throated Vireo	56	1	57	52	8.8
Blue-headed Vireo	6	0	6	6	1.0
Black-and-white Warbler	182	7	189	162	27.5
Worm-eating Warbler	76	3	79	72	12.2
Blue-winged Warbler	7	0	7	6	1.0
Lawrence's Warbler	1	0	1	1	0.2
Northern Parula	4	0	4	4	0.7
Yellow Warbler	6	0	6	4	0.7
Cerulean Warbler	54	0	54	38	6.5
Chestnut-sided Warbler	2	0	2	2	0.3
Blackburnian Warbler	14	0	14	11	1.9
Black-throated Green Warbler	27	0	27	23	3.9
Pine Warbler	10	0	10	8	1.4
Prairie Warbler	8	1	9	7	1.2
Ovenbird	1045	44	1089	479	81.3
Northern Waterthrush	0	1	1	1	0.2
Louisiana Waterthrush	18	6	24	19	3.2
Kentucky Warbler	1	0	1	1	0.2
Common Yellowthroat	79	0	79	64	10.9
Yellow-breasted Chat	2	0	2	2	0.3
Hooded Warbler	163	3	166	129	21.9
American Redstart	147	1	148	104	17.7
House Sparrow	0	15	15	1	0.2
Northern Mockingbird	3	0	3	3	0.5
Gray Catbird	38	5	43	32	5.4
Brown Thrasher	4	2	6	5	0.8
Carolina Wren	60	1	61	55	9.3
House Wren	6	0	6	6	1.0

Species	singing birds	non-song birds	total birds	points detected	% of points
Winter Wren	1	0	1	1	0.2
White-breasted Nuthatch	0	53	53	50	8.5
Tufted Titmouse	132	42	174	135	22.9
Chickadee sp.	42	39	81	59	10.0
Black-capped Chickadee	17	15	32	28	4.8
Hybrid Chickadee	6	15	21	10	1.7
Carolina Chickadee	19	9	28	21	3.6
Blue-gray Gnatcatcher	12	40	52	40	6.8
Wood Thrush	277	12	289	192	32.6
Veery	9	1	10	8	1.4
American Robin	102	21	123	65	11.0
Eastern Bluebird	3	2	5	4	0.7