An evaluation of bird conservation and ecosystem services on northeastern farms

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Background: Birds that rely on early successional or shrubland habitats have experienced some of the most severe population declines in recent decades of any species within the New England region. A rare and ephemeral habitat type, shrubland only accounts for about 12% of the New England landcover, and the majority is created and actively managed by state and federal land-management agencies and non-governmental conservation organizations. Historically, one of the most important drivers of shrubland habitat in the region was agricultural development and abandonment. Today, farming in New England is becoming increasingly characterized by small-scale, diversified operations, which implement largely sustainable production practices and retain natural habitats such as shrubby hedgerows and herbaceous fields. Little is known about the role these farms play as bird habitat in the region, and whether they are supporting any priority shrubland birds.

Methods: To address this knowledge gap, we conducted avian surveys across 22 small, diversified farms in the Pioneer Valley of Massachusetts. We then compiled avian survey data from previous studies of four other shrubland habitat types in the region (powerline rights-of-way, regenerating clearcuts, wildlife openings, and beaver meadows). We compared the relative bird abundance, community composition, and conservation value across all five habitat types (including farms) using Generalized Linear Models (GLMs), non-metric multidimensional scaling (NMDS) ordination, and by calculating an Avian Conservation Significance (ACS) score for each habitat by weighting species abundances by their Partners in Flight (PIF) conservation scores and summing them over all species for each habitat.

Results: Over the two years of this study, 2017 and 2018, we recorded 2,056 detections and 67 species. As expected, shrubland birds were the most frequently detected species, with 21 species (Schlossberg

and King, 2007) accounting for 52% of the total observations. Forest nesting birds were the most diverse habitat guild, with 29 species (Sauer and Hines, 2017), however they only accounted for 16% of the total observations. Eight grassland species were recorded, accounting for 12% of the total observations (Stanton et al., 2018).

Vegetation structure variables (vegetation height and density) appeared in the top models ($\Delta AIC \leq 2$) for all species, and were only highly significant ($p<0.05$) for three species, gray catbird, song sparrow, and yellow warbler (Table 1). Common yellowthroats demonstrated strong, negative relationships with herbaceous productive cover in all of their top models. Song sparrows were the only species to show a strong, positive relationship with this variable, which included habitats such as vegetable crops, hay, and cover crops. Woody productive landcover, such as orchards and berries, exhibited a positive relationship with American goldfinches and song sparrows, but was negatively associated with indigo buntings. Most species were positively associated with increased vegetation density and/or woody cover, either in the form of productive or nonproductive habitats.

The avian community composition of farms most closely resembled that of wildlife openings (Fig. 1) and harbored more open-habitat and generalist species such as American robin (*Turdus migratorius*), red-winged blackbird (*Agelaius phoeniceus*), and eastern kingbird (*Tyrannus tyrannus*). Several shrubland species were found to have higher relative abundances on farms than any of the other four habitats including song sparrow (*Melospiza melodia*), northern cardinal (*Cardinalis cardinalis*), and willow flycatcher (*Empidonax traillii*). Farms possessed higher ACS scores than powerline rights-of-way and beaver meadows, but were lower than clearcuts and wildlife openings (Fig. 2).

Conclusions: Our results demonstrate that small, diversified farms support a number of priority shrubland bird species, and that these farms have similar bird conservation value, as indicated by species abundances weighted by their Partner's in Flight conservation scores, as Wildlife Management

Areas. Although the similarity of conservation of farms between these farms and sites managed explicitly for wildlife highlights the value of small farms to conservation, key species present on wildlife management areas and other shrubland habitats are scarce or absent on wildlife management areas, and thus farms should be viewed a complimentary habitats that support an important segment of the bird fauna not supported elsewhere. Although some priority species are associated with productive habitats, farmers can enhance habitat on their farms by maintaining hedgerows and fallow areas.

Table 1. Parameter estimates of habitat and detection covariates for N-mixture models of bird abundance with ΔAIC≤2. Habitat covariates include: Height (vegetation height in cm), Density (vegetation density expressed as average % visual obstruction), HP (% cover of herbaceous productive habitat: herbaceous rowcrop, cover crop, and hay), HNP (% cover of herbaceous nonproductive habitat: herbaceous, fallow), WP (% cover of woody productive habitat: orchard, woody rowcrop), WNP (% cover of woody nonproductive habitat: shrubland, woodland, hedgerow, tree), WNP2 (quadratic term of WNP), and Year (2017, 2018). Bold text represents estimates statistically significant to an alpha of 0.1. Bold and italic text represents estimates statistically significant to an alpha of 0.05.

Species	HT	DN	HP	HNP	WP	WNP	WNP2	Year	K	AICc	ΔAICc	Wi	R^2
YEWA		***3.19***		**0.15**				***-0.90***	5	216.27	0	0.20	0.12
		3.04						***-0.90***	4	216.96	0.68	0.14	0.10
		3.34		0.13	-0.20			***-0.89***	6	217.38	1.11	0.12	0.13
		3.30			-0.25			***-0.87***	5	217.4	1.13	0.11	0.11
		2.46		**0.19**		0.13		***-0.95***	6	217.52	1.25	0.11	0.13
		3.43	0.05	0.18				***-0.92***	6	218.1	1.83	0.08	0.13
				0.21		***0.26***		***-1.00***	5	218.13	1.85	0.08	0.11
	0.09	**2.84**		**0.16**				***-0.92***	6	218.13	1.85	0.08	0.13
		2.64	0.19	**0.31**		0.25		***-1.06***	7	218.26	1.99	0.07	0.14
COYE			***-0.21***			***0.28***			4	309.22	0	0.34	0.23
			-0.19	0.03		***0.30***			5	311.11	1.89	0.13	0.23
	-0.05		***-0.21***			***0.29***			5	311.14	1.92	0.13	0.23
		0.35	***-0.20***			***0.26***			5	311.15	1.93	0.13	0.23
			-0.22		-0.03	***0.27***			5	311.16	1.94	0.13	0.23
			-0.21			***0.27***		0.02	5	311.21	1.99	0.13	0.23
INBU		1.92		***-0.23***	-0.33				7	228.13	0	0.09	0.08
				-0.23	-0.28				6	228.29	0.16	0.09	0.06
				-0.20					5	228.93	0.81	0.06	0.04
	0.17			**-0.21**	-0.30				7	229.25	1.12	0.05	0.07
		1.86		***-0.23***	-0.32			-0.32	8	229.44	1.31	0.05	0.09
				-0.23	-0.32			-0.32	8	229.44	1.31	0.05	0.09
		1.52		**-0.19**					6	229.56	1.44	0.05	0.05

			-0.10	***-0.28***	**-0.35**				7	229.58	1.45	0.05	0.07
				-0.21	-0.28	0.09			7	229.62	1.49	0.04	0.07
				-0.20				-0.40	6	229.88	1.75	0.04	0.05
	0.05	1.72		***-0.23***	0.33				8	230.07	1.95	0.04	0.08
		1.82	-0.02	***-0.24***	-0.34				8	230.11	1.98	0.04	0.08
		1.98		***-0.23***	-0.33	-0.01			8	230.12	2	0.03	0.08
AMGO					***0.19***				4	363.04	0	0.12	0.08
		-1.27			***0.11***				5	363.21	0.18	0.11	0.09
		-2.08			***0.23***	0.15			6	363.48	0.44	0.10	0.10
		-2.21			***0.27***	**0.18**			5	363.92	0.89	0.08	0.09
					0.23				3	364.17	1.13	0.07	0.05
	-0.11				***0.20***				5	364.2	1.16	0.07	0.08
	-0.25				***0.22***	0.14			6	364.61	1.58	0.06	0.10
		-1.44	-0.06		**0.19**				6	364.68	1.64	0.05	0.10
		-1.15			***0.26***				4	364.7	1.66	0.05	0.06
	-0.14	-1.65			***0.24***	0.19			7	364.88	1.84	0.05	0.11
					0.19	0.03			5	364.91	1.87	0.05	0.08
									3	364.91	1.88	0.05	0.04
			-0.03		**0.18**				5	364.91	1.88	0.05	0.08
				0.02	***0.20***				5	364.91	1.88	0.05	0.08
		-2.18		0.05	***0.25***	0.17			7	365.01	1.98	0.05	0.11
GRCA	***0.24***					0.01	***-0.06***		5	600.89	0	0.20	0.25
	0.24				0.09	0.01	***-0.06***		6	601.32	0.43	0.16	0.26
	0.24		-0.10	-0.10		-0.08	***-0.07***		7	601.94	1.05	0.12	0.27
	0.23			-0.04		0.00	***-0.06***		6	602.12	1.23	0.11	0.25
	0.25					0.01	***-0.06***	-0.16	6	602.14	1.25	0.11	0.25
	0.22	0.66				-0.02	***-0.06***		6	602.23	1.34	0.10	0.25
	0.25				0.10	0.00	***-0.06***	-0.19	7	602.33	1.44	0.10	0.26
	0.26		-0.04			-0.01	***-0.06***		6	602.44	1.55	0.09	0.25
SOSP		0.70	***0.14***	***0.14***	**0.11**	***0.12***			8	1074.27	0	0.11	0.11

		0.14	***0.14***	***0.13***	***0.15***		7	1074.53	0.26	0.10	0.09
	0.71	***0.14***	***0.14***	**0.11**	**0.11**		7	1075.05	0.78	0.08	0.09
		0.14	***0.14***	***0.12***	***0.15***		6	1075.39	1.12	0.07	0.07
	1.08	0.06	**0.06**				6	1075.39	1.12	0.07	0.07
	0.82	***0.09***	***0.09***		0.07		7	1075.43	1.16	0.06	0.09
	0.80						4	1075.49	1.22	0.06	0.04
	0.72	***0.13***	***0.13***	0.10	0.10	0.10	9	1075.67	1.4	0.06	0.11
	0.81		0.04				5	1075.82	1.55	0.05	0.05
	1.08	0.06	**0.07**				5	1075.9	1.64	0.05	0.05
0.05		***0.14***	***0.14***	**0.12**	***0.13***		8	1075.98	1.71	0.05	0.10
	0.83	***0.09***	***0.09***		0.07		6	1076	1.73	0.05	0.07
		0.13	***0.13***	**0.11**	***0.14***	0.09	8	1076.04	1.78	0.05	0.10
	0.81						3	1076.06	1.79	0.05	0.02
	0.83		0.04				4	1076.21	1.94	0.04	0.03
0.01	0.66	***0.14***	***0.14***	**0.11**	**0.11**		9	1076.23	1.97	0.04	0.11

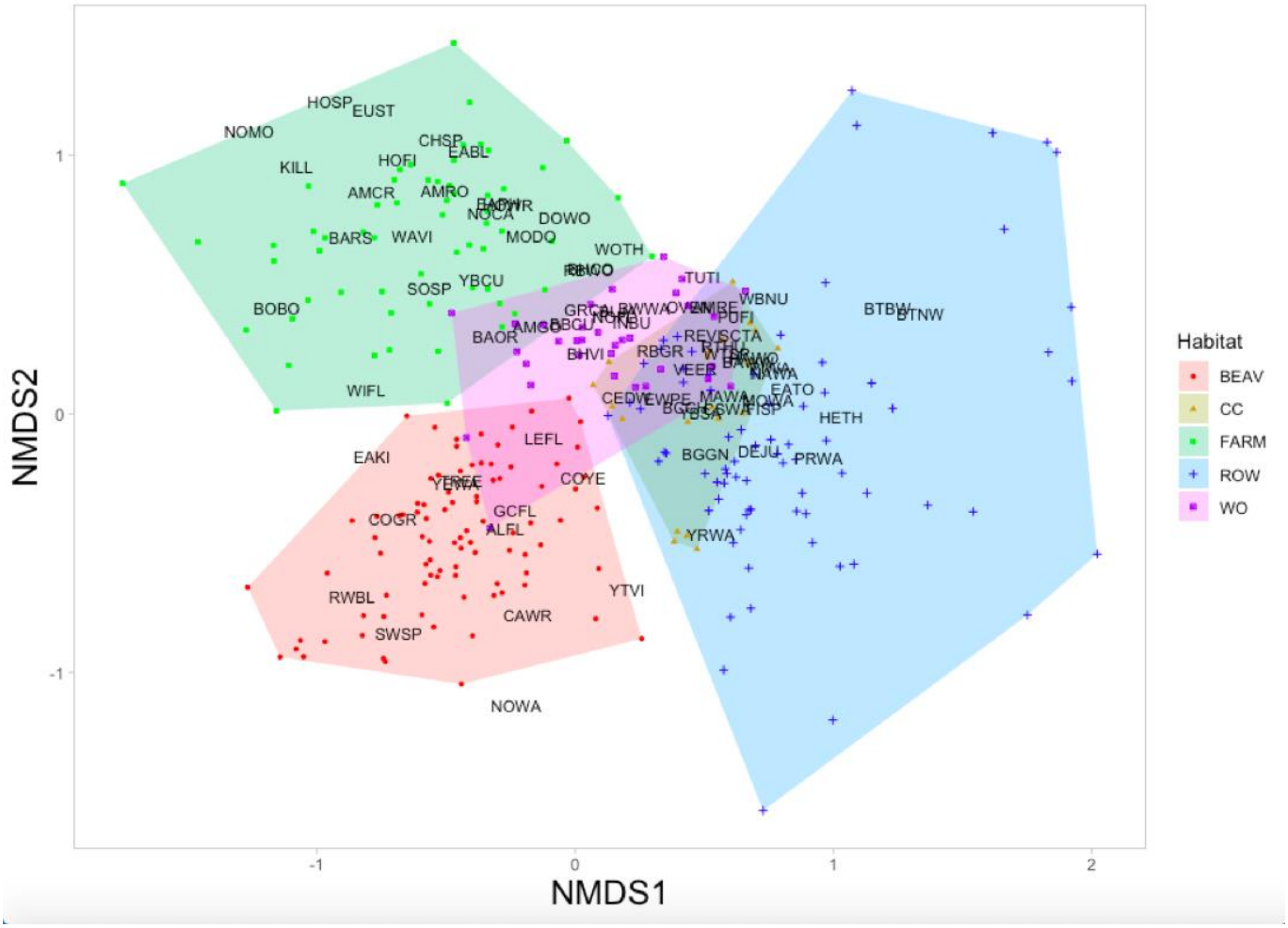

Figure 1 Non-metric multidimensional scaling (NMDS) ordination plot of 75 birds with >5 observations across 5 habitat types from data collected in beaver meadows (BEAV), clearcuts (CC), rights-of-way (ROW), and wildlife openings (WO) between 2002-2006, and on small, diversified farms between 2017-2018. Species that are closer together and located in closer proximity to certain habitat polygons are more closely associated with each other or that habitat type. Species codes are in Table 1.

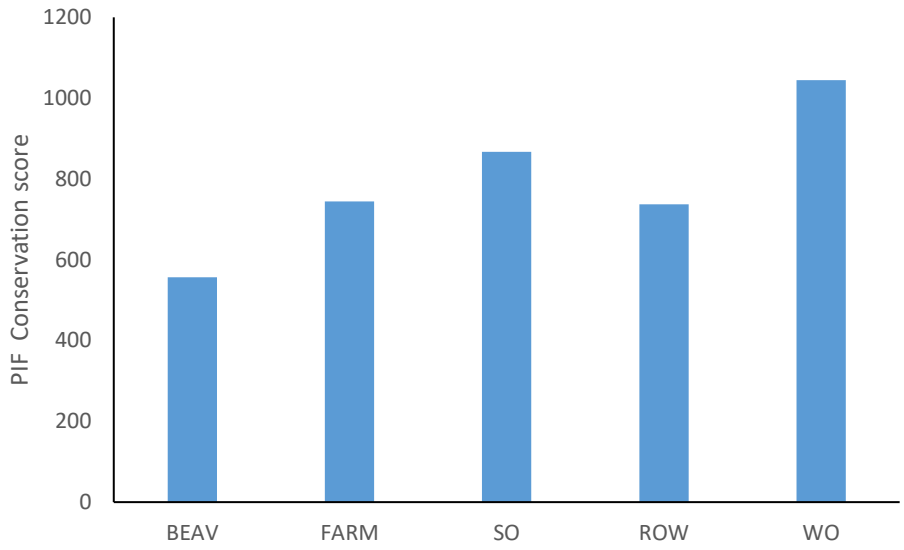

Fig. 2. Conservation concern score for 75 species with >5 observations across 5 habitat types in western Massachusetts. Partners in Flight (PIF) scores are for the New England/Mid-Atlantic coast region. Avian Conservation Significance (ACS) scores for each habitat type are provided as the sum of individual species conservation concern scores.