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Industrial Hemp as a Resource for Birds in Agroecosystems: Human-Wildlife Conflict or Conservation Opportunity?

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Abstract: Industrial hemp (*Cannabis sativa* L.; hemp) is an emerging crop in the United States with little known about bird use or the potential for birds to become an agricultural pest. We identified birds associated with hemp fields, using repeated visits to oilseed plots in North Dakota, USA (n = 6) and cannabinoid (CBD) plots in Florida, USA (n = 4) from August to November 2020. We did not control for plot area or density; our observations were descriptive only. We observed 10 species in hemp, 12 species flying over hemp, and 11 species both foraging in and flying over hemp fields in North Dakota. In Florida, we observed 4 species in hemp, 5 species flying over hemp, and 4 species exhibiting both behaviors. When we observed birds in hemp, we found them perched in the canopy or foraging on the ground. Counts were highest in oilseed and lowest in CBD varieties. The Florida sites were mainly CBD varieties, which explains lower species diversity and raw counts of birds given the lack of seeds produced. Maximum raw counts of the most common birds (mourning doves [*Zenaida macroura*] = 116; house finches [*Haemorhous mexicanus*] = 53; and American goldfinches [*Spinus tristis*] = 40) using very small fields (116–324 m^2) in North Dakota suggest oilseed hemp could suffer yield losses but potentially benefit farmland bird conservation and act as a decoy crop to protect other commodities (e.g., sunflower [*Helianthus annuus* L.]).

Key words: agroecosystem, avian conservation, cannabinoids (CBD), crop damage, ecosystem disservices, granivorous birds, human–wildlife conflict, oilseed hemp, survey, vertebrate pest

North American bird populations are declining, especially species inhabiting farmlands (Stanton et al. 2018, Rosenberg et al. 2019). Many studies have determined grassland bird populations are declining at broad scales due to the degradation, loss, and fragmentation of grasslands resulting from agricultural intensification (Herkert 1994, Vickery et al. 1999, Murphy 2003). Emphasis has also been placed on understanding the bird conservation values of marginal grasslands (i.e., small linear grassland habitat) compared to conservation reserves (Best et al. 1995, Klug et al. 2009, Cox et al. 2014), the influence of rangeland and hayfield management (Blackwell and Dolbeer 2001, Klug et al. 2010, Faria et al. 2016), and grassland plantings for biomass production (Conkling et al. 2018). Despite the prevalence of row-crops, limited research has evaluated direct use of monoculture cropland by birds (Best et al. 1990; Hagy et al. 2007, 2010; Iglay et al. 2017).

When bird communities are evaluated in areas of intensive agriculture, objectives often focus on the impact of agricultural practices that add plant diversity, such as organic farming (Freemark and Kirk 2001), no-till soil management (VanBeek et al. 2014), or cover crops (Wilcoxen et al. 2018). Thus, the importance of habitat within crop fields (i.e., additional plant structure influencing abundance of insects, seeds, and refugia) is often a greater focus than the value of the crop itself to bird communities. Some crops can provide high-energy food or refugia for migratory and resident wildlife (Vance 1971, Blackwell and Dolbeer 2001, Peer et al. 2003). Given monocultures of only a few crop species occupy 60% of the agricultural landscape in the United States, knowing which crops or varieties are beneficial to birds is imperative given agricultural lands dominate the landscape and are capable of being used by birds (Stanton et al. 2018, Crossley et al. 2021). Along with crop species, the diversity of crops across landscapes and the seasonal timing of crop maturation also impacts bird communities (Benton et al. 2003, Krapu et al. 2004). For example, sunflowers (*Helianthus annuus* L.) provide conservation value as evidenced by the diversity of birds using the crop and a later harvest that allows bird use during their molt and migration (Hagy et al. 2010), albeit at levels that create human–wildlfie conflicts.

Industrial hemp (*Cannabis sativa* L.; hemp) is a nationally relevant emerging crop because of the passage of the Agricultural Improvement Act of 2018 (Fike 2016). Concomitantly, increased hemp production may also benefit avian conservation as a food source in highly modified agroecosystems. Hemp is grown for fiber, oilseed, and extraction of cannabinoids (e.g., CBD; Fike 2016). Hemp seeds are rich in essential fatty oils and proteins (Lan et al. 2019). Therefore, hemp was a historically important part of bird seed mixes (Baicich et al. 2015) and a seed type used in ecological studies evaluating feeding preferences of avian granivores (Díaz 1990, 1996). Hemp fields may be attractive to farmland birds as a food resource but also as roosting habitat or refugia for ground dwelling birds, especially in fiber plantings with a high plant density (Fike 2016). Additionally, CBD hemp fields may attract fewer birds because the plants do not produce seeds (i.e., female clones harvested at flowering; Adesina et al. 2020). Natural history notes indicate birds historically used hemp that had escaped from cultivation for foraging seeds and sprouts (Stephens 1920, Errington 1935, Gigstead 1937), including provisioning nestlings (McClure 1943). Birds also used feral hemp for roosting habitat (Errington 1935) and as nesting material (Bendire 1890, Henderson 1907). McClure (1943) also observed northern harriers (*Circus hudsonius*) hunting mourning doves (*Zenaida macroura*) over wild hemp. Because hemp is a relatively new commodity with cultivation strategies differing from historical plantings in the United States, current bird use is unknown.

Our objectives were to identify and quantify bird species found in and flying over hemp and highlight the potential ecological and economic outcomes that may accompany widespread adoption of hemp in a changing agricultural landscape. We did not estimate corrected species relative abundance or density estimates due to the hemp not being widely adopted on the landscape resulting in differences in cultivars, small field areas, and surrounding landscape that could not be controlled with our sample size (Table 1). Our aim was to describe the bird species directly or indirectly using hemp fields in multiple landscape and crop contexts (North Dakota, USA = oilseed hemp; Florida, USA = CBD hemp).

With information gleaned from a recent literature review (Blackwell et al. 2022), we hypothesized that oilseed hemp would be used primarily by granivorous species and, to a lesser extent, insectivorous and carnivorous species foraging on prey provided by the hemp (McPartland 1996). We also hypothesized that bird richness and raw counts would be lower in CBD fields given the feminized plants are harvested prior to pollination and seed production. If oilseed hemp is used heavily by granivorous birds, future work will require estimates of crop damage where visual methods may prove difficult due to vegetative growth patterns.

Study area

We conducted bird surveys from August 13 to September 11, 2020, at the North Dakota State University Research Extension Centers in North Dakota and from September 1 to November 20, 2020, at the University of Florida at Gainesville, Institute of Food and Agricultural Sciences, Plant Science Research and Education Unit (Citra, Florida) and on private farms in Florida

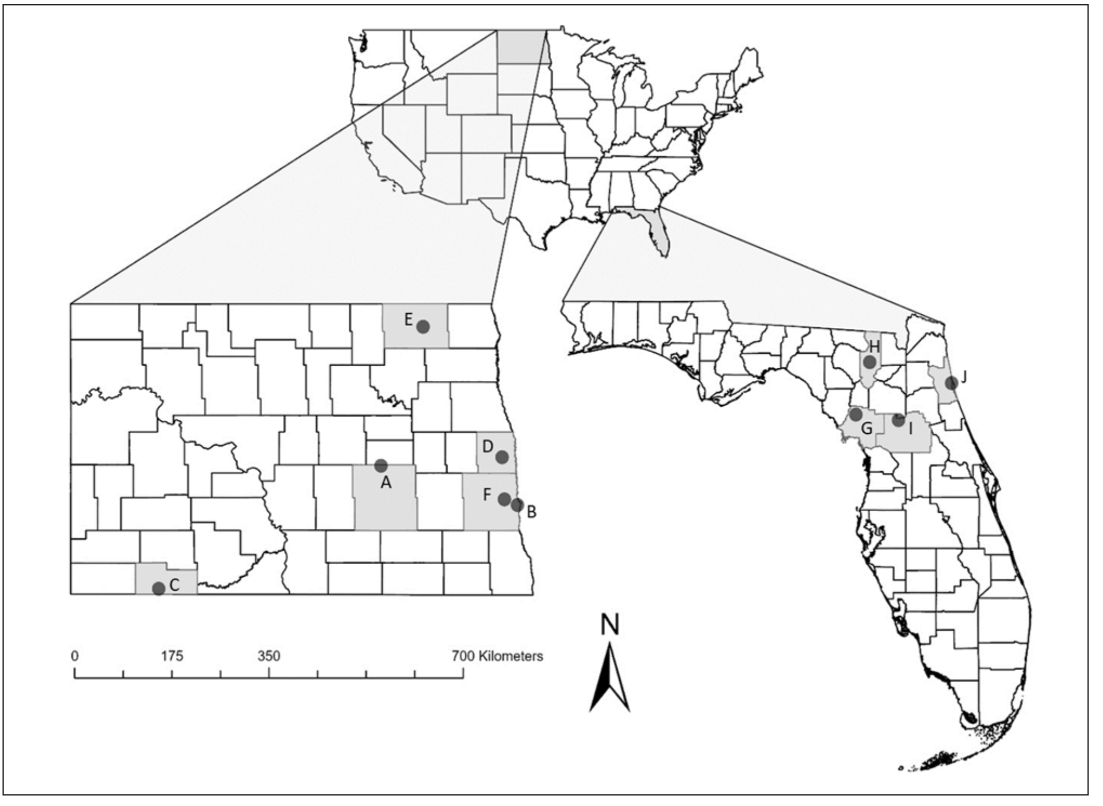

Figure 1. A map of the United States highlighting the location of hemp (*Cannabis sativa* L.) fields where we monitored birds (presence and raw number) from August to October 2020 near Carrington (A), Fargo (B), Hettinger (C), Hillsboro (D), Langdon (E), and Prosper (F), North Dakota, USA, and near Chiefland (G), Lake City (H), Citra (I), and St. Augustine (J), Florida, USA.

(Figure 1; Table 1). The land cover surrounding the study sites was a mosaic of agriculture, peri-urban human development, and natural areas. The North Dakota hemp fields (274–820 m above sea level [ASL]) were within the Lake Agassiz Plain, Northern Glaciated Plains, and Northwestern Great Plains Level III Ecoregions with a continental climate and annual precipitation ranging from 33–51 cm, increasing from west to east. The Florida hemp fields (8–52 m ASL) were within the Southern Coastal Plain Level III Ecoregion with a humid, subtropical climate and annual precipitation of 136 cm, increasing during the warmer months of June to September.

Methods

We conducted surveys between 0730 and 1805 hours (local time) to overlap daytime foraging activity, with 3 surveys per site during crop maturity. We recorded bird species, uncorrected counts, and behavior (i.e., position = canopy or ground; activity = perched in or flying in, out, or over the crop). Surveys were conducted by experienced ornithologists. We recorded date, time, temperature (C), and wind speed (m s^{-1}) prior to each survey. Due to the overarching goal of identifying birds using hemp and the nature of the hemp fields (e.g., small variety trials at research centers; Table 1), we did not standardize by transect length but spent the same amount of time observing birds in each plot.

With such small plots, we thought that we may scare most birds with our initial approach and our presence would deter their return. Thus, we approached the field on foot and recorded birds flushing prior to sampling with point counts and walking transects. Stationary point counts would not include the birds that would flush after disturbance or birds that were silent due to the nonbreeding season, whereas walking transects would obscure individual birds when large flocks

Table 1. We conducted bird surveys in hemp (*Cannabis sativa* L.) fields from August 13 to September 11, 2020, at the North Dakota State University Research Extension Centers in North Dakota, USA, and from September 1 to November 20, 2020, at the University of Florida at Gainesville, Institute of Food and Agricultural Sciences, Plant Science Research and Education Unit (Citra, Florida) and private farms in Florida, USA.

Location	Latitude, longitude	Crop type	Field size (m^2)	Planting date	Harvest date‡	Yield‡ (kg ha^{-1})	Varieties
North Dakota							
Carrington	47.318042, -99.024133	Oilseed CBD*	285†	May 26	Sept 8	1,453	Altair, Bialobrzeskie, Canda, CFX-1, CRS-1, CFX-2, Grandi, Henola, Joey, Katani, NWG-Abound, NWG-Elite, Vega, X-59
Fargo	46.902104, -96.816075	Oilseed	324	May 27	Sept 8	1,861	X-59
Hettinger	46.003222, -102.621769	Oilseed	116	May 27	Sept 17	78§	CRS-1, CFX-2, Grandi, Katani, NWG-Abound, NWG-Elite, X-59
Hillsboro	47.407823, -97.064250	Oilseed	324	May 27	Sept 2	1,743	X-59
Langdon	48.765160, -98.343151	Oilseed	140†	May 29	Sept 14	1,666	Bialobrzeskie, Canda, Joey, Katani, NWG-Abound, NWG-Elite CRS-1, CFX-2, Grandi, Henola, X-59
Prosper	46.962118, -97.026631	Oilseed	324	May 27	Sept 3	1,921	X-59
Florida							
Chiefland	29.47504, -82.860561	CBD	20,787	Sept 18	-	-	Cherry Wine, Imperial
Lake City	30.1841160, -82.637224	CBD	1,875	Aug 18	-	-	Cherry Wine, Golden Sun
Citra	29.400505, -82.171486	Oilseed	132	Jul 10	Oct 1	-	Han-NE, Helena, CFX-1
St. Augustine	29.901200, -81.312400	CBD	8,161	Jul 20–27	-	-	MK Auto, MK Spectrum, Cat Daddy, Cherry Wine, Maverick, Southern Luck, Early Abacus, CBG Hepius, Matterhorn, Sunset, Janet G

* 2 oilseed plots and 1 cannabinoid (CBD; confidential variety) plot
† Each of 3 adjacent plots at Carrington was 95.0 m^2; each of 3 adjacent plots at Langdon was 46.5 m^2
‡ Yield and harvest date not provided for CBD fields due to lack of seed load
§ Low yield due to severe bird damage

of doves and finches were circling the airspace (i.e., these birds would lift off the crop and immediately return a few meters from the observers). Thus, we included both stationary counts and walking transects throughout the entire field to account for all birds present. We also detonated a propane cannon to disperse and count any birds remaining in the field at the end of the survey.

After our initial approach, we alternated between 3 5-minute point counts and 2 10-minute transects (a total of 35 minutes for each visit or survey). The point counts were placed equidistant from each other with all 3 points allowing observation of the entire site due to small field sizes. For the walking transects, we used open rows between variety trial plots inherent in variety trials to cover the entire area planted to hemp.

Because of differences in cultivars, field area, surrounding landscape, and sample size, we did not estimate corrected species relative abundance (Thompson 2002). We did not recount birds moving in and out of the hemp plots within individual sampling periods (i.e., approach, point counts, transects, or propane blast). We considered each sampling period during 1 site visit a separate count (e.g., birds counted in the approach were counted in the subsequent point count if they returned to the plot). We reported the maximum number of birds per species counted in a single sampling period during a site visit for both in-field and flyovers. That is, we took the high count out of all sampling periods during 1 visit to obtain maximum species' counts for that date.

We also recorded birds in flight directly over the field at any altitude (i.e., birds in transit or hunting over the hemp) that never directly entered the crop canopy. Most overhead flights were directional; therefore, birds may not have been responding directly to hemp. In some cases, species' diets and natural histories lend evidence to indirect attraction to hemp fields (i.e., insectivores, carnivores, and granivores).

We recorded planting and harvest date, plot size (m^2), crop type (i.e., fiber, oilseed, or CBD), grain yield (kg ha^{-1}), and crop variety (Table 1). The research farms provided the yield estimates after harvesting with small plot combines. The sites were research farms with a diversity of crops grown nearby, often bordered by shrubs and trees. In North Dakota, Carrington, Fargo, Hettinger, and Langdon were in an exurban landscape (e.g., residential, industrial, agricultural, and natural areas), whereas Prosper and Hillsboro (adjacent to treed wind break) were in open agricultural land. Aside from Citra, the Florida sites were private farms within exurban landscapes. Prosper, North Dakota, had volunteer sunflowers and Chiefland, Florida, had volunteer watermelons (*Citrullus lanatus*) within the fields. Insects (e.g., bees [Apidae], grasshoppers [Acrididae], and aerial insects) were evident in and near the hemp plots, although not identified or quantified. We did not observe mammals (e.g., deer [Cervidae] or small mammals [Rodentia]) in the hemp, but surveys designed to observe nocturnal or secretive animals could show additional taxa using hemp.

To gain perspective on potential food resources and inform strategies for estimating bird damage, we collected 33 mature female inflorescences at Fargo, North Dakota (X-59) and recorded inflorescence length (cm) and buds $plant^{-1}$. We separated and dried seeds in a drying oven (Isotemp™ Thermo Fisher Scientific, Pittsburgh, Pennsylvania, USA) at 37°C for 24 hours and recorded mass per inflorescence length (g cm^{-1}).

Results

We observed higher avian richness in the hemp plots of North Dakota (n = 21 species), where oilseed hemp was prevalent, compared to Florida (n = 8 species; Table 2), where CBD hemp was prevalent. We observed 22 and 9 species flying over hemp in North Dakota and Florida, respectively. We observed species from 5 habitats, 7 foraging guilds, and both migrants and residents (Table 2). In both states, we recorded mourning doves and chipping sparrows (*Spizella passerine*) in-field, whereas barn swallows (*Hirundo rustica*), turkey vultures (*Cathartes aura*), and American crows (*Corvus brachyrhynchos*) were only flying over in both states.

In North Dakota, mourning doves had the highest numbers followed by American goldfinches (*Spinus tristis*) or house finches (*Haemorhous mexicanus*), and various sparrow species (Figure 2; Table 2). We observed mourning doves feeding on the ground, finches (Fringillidae) feeding in the canopy, and sparrows (Passerellidae) performing both behaviors. We recorded fewer birds in Florida with the most common species including eastern bluebirds (*Sialia sialis*), common yellowthroats (*Geothlypis trichas*), and chipping sparrows. In Florida, avian richness came from species flying over, including cattle egrets (*Bubulcus ibis*; n = 350 birds), American crows, and barn swallows.

Grain yields in North Dakota were greater than Florida given CBD varieties do not produce seed (i.e., female clones are harvested at flower-

Table 2. The 41 bird species (North Dakota, USA = 32, Florida, USA = 14) and 22 families (North Dakota = 18, Florida = 13) in or flying over hemp (*Cannabis sativa* L.) from August to September in North Dakota and September to October 2020 in Florida. The presence or raw count of a species may not have been due to hemp if it was only observed flying over, although species diets and natural histories lend evidence to potential indirect attraction to hemp fields (i.e., insectivores, carnivores, and granivores).

Species	Scientific name	Habitat†	Diet‡	Migratory or resident∞	Flyover max§	Field max§
North Dakota						
Anatidae						
Canada goose	*Branta canadensis*	G^F	H	R	39	0
Phasianidae						
Ring-necked pheasant	*Phasianus colchicus*	G^F	O	R	0	6
Columbidae						
Rock pigeon	*Columba livia*	U	O	R	22	0
Mourning dove (MODO)*	*Zenaida macroura*	G^F	G	M	80	116
Trochilidae						
Ruby-throated hummingbird	*Archilochus colubris*	W	O	M	1	1
Laridae						
Franklin's gull	*Leucophaeus pipixcan*	G^F	I	M	36	0
Ardeidae						
American bittern	*Botaurus lentiginosus*	G^F	C	M	1	1
Cathartidae						
Turkey vulture	*Cathartes aura*	G^F	C	M	1	0
Falconidae						
Merlin	*Falco columbarius*	G^F	C	R	1	0
Corvidae						
American crow (AMCR)	*Corvus brachyrhynchos*	W	O	R	53	0
Alaudidae						
Horned lark	*Eremophila alpestris*	G^O	O, G	R	4	0
Hirundinidae						
Bank swallow	*Riparia riparia*	G^F	I	M	2	0
Barn swallow	*Hirundo rustica*	G^F	I	M	16	0
Troglodytidae						
Marsh wren	*Cistothorus palustris*	M	I	M	0	1
Turdidae						
American robin	*Turdus migratorius*	W	O	R	18	8
Mimidae						
Gray catbird	*Dumetella carolinensis*	W	O	M	0	1
Fringillidae						

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House finch (HOFI)*	*Haemorhous mexicanus*	U	F, G	R	12	53
Common redpoll	*Acanthis flammea*	W	O, G	M	0	1
American goldfinch (AMGO)*	*Spinus tristis*	W	O, G	R	16	40
Passerellidae						
Chipping sparrow (CHSP)*	*Spizella passerine*	W	O, G	M	1	7
Clay-colored sparrow (CLSP)*	*Spizella pallida*	G[F]	O, G	M	0	6
Lark sparrow	*Chondestes grammacus*	G[F]	O, G	M	0	1
Vesper sparrow (VESP)*	*Pooecetes gramineus*	G[O]	O, G	M	0	5
Savannah sparrow (SASP)*	*Passerculus sandwichensis*	G[O]	O, G	M	0	3
Song sparrow	*Melospiza melodia*	W	O, G	M	0	1
Cardinalidae						
Dickcissel	*Spiza americana*	G[O]	O, G	M	0	1
Black-headed grosbeak	*Pheucticus melanocephalus*	F	O	M	2	0
Icteridae						
Bobolink	*Dolichonyx oryzivorus*	G[O]	O	M	3	2
Red-winged blackbird	*Agelaius phoeniceus*	G[F]	O, G	R	52	1
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*	M	O	M	14	0
Common grackle	*Quiscalus quiscula*	W	O	R	35	0
Brown-headed cowbird	*Molothrus ater*	G[F]	O, G	M	2	3
Florida						
Columbidae						
Mourning dove (MODO)*	*Zenaida macroura*	G[F]	G	R	14	2
Ardeidae						
Cattle egret	*Bubulcus ibis*	G[F]	I	R	350	0
Threskiornithidae						
White ibis	*Eudocimus albus*	M	R	R	8	0
Cathartidae						
Turkey vulture	*Cathartes aura*	G[F]	C	R	1	0
Accipitridae						
Cooper's hawk (COHA)	*Accipiter cooperii*	W	C	R	0	1
Falconidae						
American kestrel (AMKE)	*Falco sparverius*	G[F]	C	R	4	1
Tyrannidae						
Eastern phoebe	*Sayornis phoebe*	W	I, F	R	1	0
Corvidae						

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American crow (AMCR)	*Corvus brachyrhynchos*	W	O	R	60	1
Hirundinidae						
Barn swallow	*Hirundo rustica*	G^F	I	M	37	0
Turdidae						
Eastern bluebird (EABL)	*Sialia sialis*	G^F	I, O	R	0	6
Parulidae						
Common yellowthroat (COYE)	*Geothlypis trichas*	G^F	I	R	20	7
Passerellidae						
Eastern towhee††	*Pipilo erythrophthalmus*	S	O	R	0	0
Chipping sparrow (CHSP)*	*Spizella passerine*	W	O, G	M	0	5
Icteridae						
Eastern meadowlark	*Sturnella magna*	G^O	I, O	R	0	4

* Most abundant species observed in hemp fields (not including flyovers; see Figure 2).
†† Auditory identification only
† M = marsh, W = woodland, S = scrub, U = urban, G = grassland, O = obligate, F = facultative (Vickery et al. 1999).
‡ C = carnivore, F = frugivore, G = granivore, H = herbivore, I = insectivore, O = omnivore, R = crustaceovore (De Graaf et al. 1985); 1st = breeding season, 2nd = nonbreeding season.
∞ Migratory (M) or resident (R) status for North Dakota and Florida, USA
§ Highest count per single site visit for in-field and flyovers.

ing; Adesina et al. 2020). The oilseed plot in Florida had poor stand quality (no yield data), and thus seed set was not available to attract foraging birds. Oilseed plots in Hettinger, North Dakota suffered severe bird damage from mourning doves and house finches resulting in poor yields (78 kg ha^{-1}; Table 1). The inflorescence lengths (X-59 variety at Fargo, North Dakota) ranged from 14.5–61.5 cm (mean = 36.2±2.4) with range of 11–70 buds $inflorescence^{-1}$ (mean = 26.9±2.2). Dried seed mass ranged from 7.2–75.3 g $plant^{-1}$ (mean = 35.1±3.8) with range of 0.3–1.6 g cm^{-1} (mean = 0.9±0.06). These preliminary findings on seed load inform the available food resources and future protocols for estimating bird damage.

Discussion

We identified a rich bird community with some overlap between states despite less activity in Florida, due to lack of seed load in CBD varieties or potentially the differential timing of migration for the 2 regions. Generalist species adaptable to changing landscapes often remain abundant in highly modified agricultural systems (Linz et al. 2017) and were among the most frequently observed species in North Dakota (e.g., doves and finches). We observed grassland facultative species at lower raw counts (e.g., blackbirds) along with woodland (e.g., chipping sparrow), marsh (e.g., American bittern [*Botaurus lentiginosus*]), and urban species (e.g., house finch). While these species were found using hemp directly for foraging or cover, they were likely present due to movement between suitable habitats in the surrounding landscape (e.g., trees, shrubs, and water features; Dunning et al. 1992). Nongranivorous species, such as birds of prey (Cathartidae, Falconidae), herons (Ardeidae), gulls (Laridae), swallows (Hirundinidae), and hummingbirds (Trochilidae), may have been attracted to other food (e.g., small mammals and birds, insects, and nectar) or vegetative cover provided by hemp (Franklin et al. 2018, Cranshaw et al. 2019). We observed nonnative dove species using adjacent human development (i.e., Eurasian collared doves [*Streptopelia decaocto*] and rock pigeons [*Columba livia*]), but never in

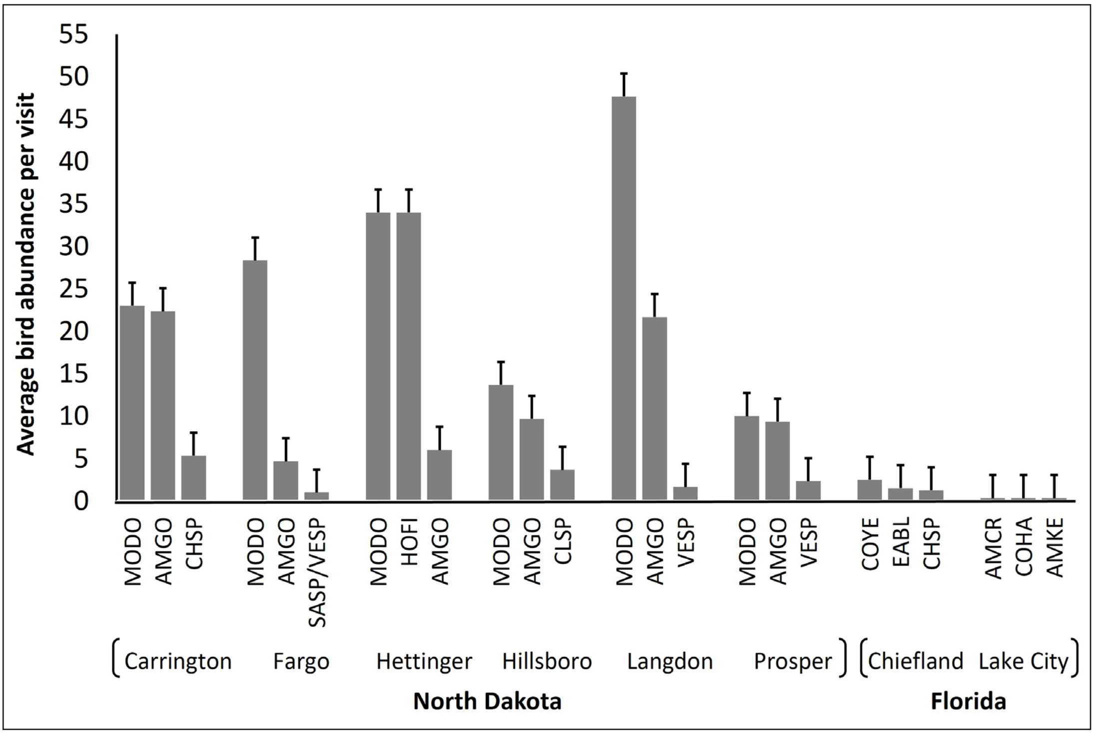

Figure 2. Average maximum raw count (± SE) for the top 3 species found in hemp (*Cannabis sativa* L.) in North Dakota, USA, from August to September 2020 and in Florida, USA, from September to October 2020 (see Table 2 for 4-letter species code). Total species count in hemp was higher for North Dakota (Carrington = 5, Fargo = 10, Hettinger = 6, Hillsboro = 5, Langdon = 6, Prosper = 10) than Florida (Chiefland = 5, Lake City = 3, Citra = 0, St. Augustine = 0). North Dakota sites were planted to oilseed, except for 1 cannabinoid (CBD) planting in Carrington, where only a few chipping sparrows were observed despite high numbers of species and raw counts of granivorous birds in the oilseed plots located <50 m away. Florida sites were all planted to CBD, except for Citra, which was an oilseed planting but harbored a low seed load due to poor stand quality.

hemp, possibly due to their behavior of keeping close to farmsteads (Camacho-Cervantes and Schondube 2018). In North Dakota, we detected grassland obligate species with declining populations that may benefit from hemp's high oil and nutrient content during migration (e.g., vesper sparrow [*Pooecetes gramineus*], savannah sparrow [*Passerculus sandwichensis*], dickcissel [*Spiza americana*], and bobolink [*Dolichonyx oryzivorus*]; Stanton et al. 2018).

In North Dakota, we observed birds that primarily consume seeds year-round or in the nonbreeding season. These granivores (e.g., mourning doves, American goldfinches, and house finches) often forage individually or in small flocks (Badyaev et al. 2020, McGraw and Middleton 2020, Otis et al. 2020), but we observed them in flocks of approximately 40–116 birds in small oilseed hemp fields (116–324 m^2). The doves and finches were particularly tied to the fields and would immediately return to the small plots after being disturbed by the observers. While migrating in the nonbreeding season, sparrows also travel in small, mixed flocks in search of insects and seeds (Jones and Cornely 2020, Middleton 2020, Wheelwright and Rising 2020), but did not reach unusually large flock sizes in hemp (observed flocks were ≤10 birds).

The availability of seeds and insects within hemp may allow for a bridging of diets between breeding and nonbreeding seasons. The current lack of registered agrochemicals for hemp may allow for increased weeds and insects, especially in grain varieties that are less management intensive than CBD (Adesina et al. 2020). Volunteer crops (i.e., sunflower in Prosper, North Dakota; watermelon in Chiefland, Florida) within hemp increased vegetation structure and diversity, and therefore potential attractiveness to birds. With the lack of seed in Florida (CBD), the birds observed in hemp (i.e., American crows and eastern meadowlarks [*Sturnella magna*]) sought refugia or incidental food (i.e., insects and arthropods). In North Dakota, we observed aerial insects, bees, and grasshoppers, which may have attracted avian insectivores and omnivores.

Bird use of oilseed hemp suggests its potential as a monoculture that may benefit farmland birds, but this commodity may suffer significant yield losses, creating a human–wildlife conflict. In Canada, where large-scale hemp grain production is in practice, producers have documented bird damage and instances of losing entire crops to birds (Barker 2016, Harper et. al. 2018, Baxter 2022). In oilseed hemp we observed ground-foragers (e.g., mourning doves, ring-necked pheasants [*Phasianus colchicus*], and sparrows) feeding on waste seed (i.e., seed shatter), suggesting consumption compensatory to other yield loss. For example, when larger-bodied birds moved through the field, their bodies collided with plants, potentially causing damage because oilseed hemp is vulnerable to lodging and shatter due to inconsistent inflorescence maturity (Schluttenhofer and Yuan 2017). We observed songbirds perched on the crop causing damage directly from consumption and indirectly through seed shatter and messy foraging. Effective damage appraisal methods are needed to measure and manage bird damage (DeHaven 1974). Visual assessment of damage is difficult in hemp due to growth structure; therefore, ascertaining seed mass may prove better than visual estimates (DeHaven 1974).

Along with its value as a food resource for resident and migratory birds, hemp may have indirect conservation value when used in wildlife conservation plots (i.e., lure, decoy crop). The purpose of wildlife conservation plots is to divert nuisance birds into safe havens and away from high-value crops by providing alternative forage near the protected field or on flight lines between bird roosts and the higher-value commodity (e.g., sunflower; Hagy et al. 2008). Given ~75% of blackbird damage occurs in August to mid-September (Cummings et al. 1989), coinciding with hemp maturity (Kraenzel et al. 1998), early damage in sunflower might be averted by providing hemp as alternative forage if preferred by blackbirds. Oilseed hemp could continue as a decoy when blackbird flocks reach peak numbers in October if left unharvested (Clark et al. 2020), and waste hemp seeds remaining after harvest could continue to provide a food source, although caution should be taken to avoid hemp seed escaping from cultivation (i.e., feral hemp). Additional studies would be needed to evaluate blackbird preferences for hemp compared to the crop to be protected along with an economic evaluation (Klug 2017).

High-energy food and habitat are essential across the annual cycle, and hemp may provide these vital resources (e.g., roosting or nesting) for resident or migrating birds given the high oil content relative to other crops. Many birds in North America breed from May to August, after which autumn migration begins for transient populations (September to December; Cooke 1915, Lincoln 1935). Along with differing crop types, biogeographic zones, and species pools, the timing of regional bird migrations may explain why bird communities differed between states, given North Dakota was at the peak of fall migration and Florida was just beginning to receive overwintering migrants. Land managers growing hemp should consider regional overlap with bird phenology, while recognizing the growing season of hemp varies by region and birds can shift migration timing, winter ranges, and regional abundance with changing land cover and climate (Blackwell and Dolbeer 2001, Van Buskirk et al. 2009, Curley et al. 2020).

While we provide initial evidence as to avian species using hemp, or indirectly so, further research is needed to determine densities that may occur with broadscale adoption and large commercial fields (e.g., bird diversity in sunflower; Hagy et al. 2010). For example, we observed 116 mourning doves in a 0.01-ha plot, which would not likely translate to 5,800 birds ha^{-1} in larger fields (up to 230 ha). Additionally, small fields tend to suffer more damage than large fields, partly due to edge effects (Canavelli et al. 2014). Larger hemp fields may experience less damage overall but may be discovered by birds with increasing area and become more suitable for birds capable of attaining large flocks (>10,000 birds; e.g., mixed blackbird flocks). Although we observed blackbird species, most were flyovers and were not inflicting crop damage. We have shown hemp is attractive to a variety of birds, but which species may become pests may only be evident after broad-scale adoption of the crop at landscape scales.

Management implications

The presence, richness, and raw numbers of birds using hemp in our study suggest that the future proliferation of hemp on the agricultural landscape may benefit wildlife in agroecosystems by providing an additional food resource. Land managers looking for a monoculture crop to enhance wildlife habitat should consider oilseed hemp varieties. Farmers may choose CBD varieties to avoid conflicts, which may be of particular interest surrounding airports where guidance limits grain crops attractive to wildlife. Aside from anecdotal, we are the first to report the bird species using hemp and the potential for birds to reduce crop yield. Although there is potential for problematic bird damage in oilseed hemp, these varieties could potentially be used in decoy plots to draw nuisance birds away from high-value crops suffering from bird damage. Further examination of diversity and relative abundance of birds in hemp after a full-scale adoption of the crop on the landscape is needed to enable more rigorous assessment of the attractiveness of hemp to birds.

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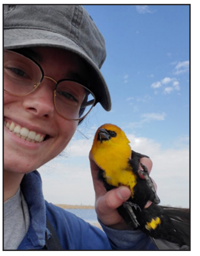

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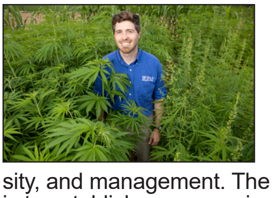

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