An Evaluation of Farmer Perceptions and Biological Efficacy of Drones for Avian-Agriculture Conflict

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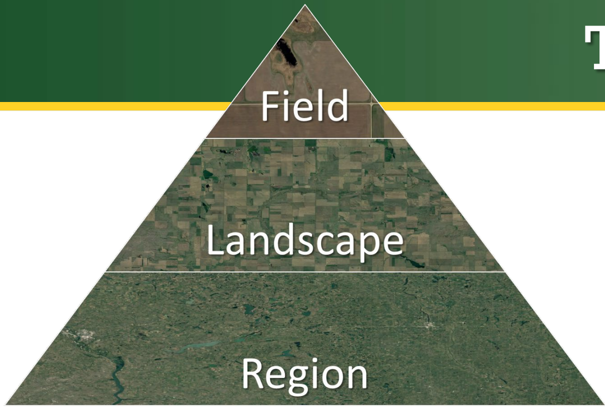
Outline

- Background Information
- Farmer perceptions of current and novel management tools for blackbird crop damage
- Flock characteristics and environmental variables that influence the response of blackbirds to drone approach and hazing
- Summary

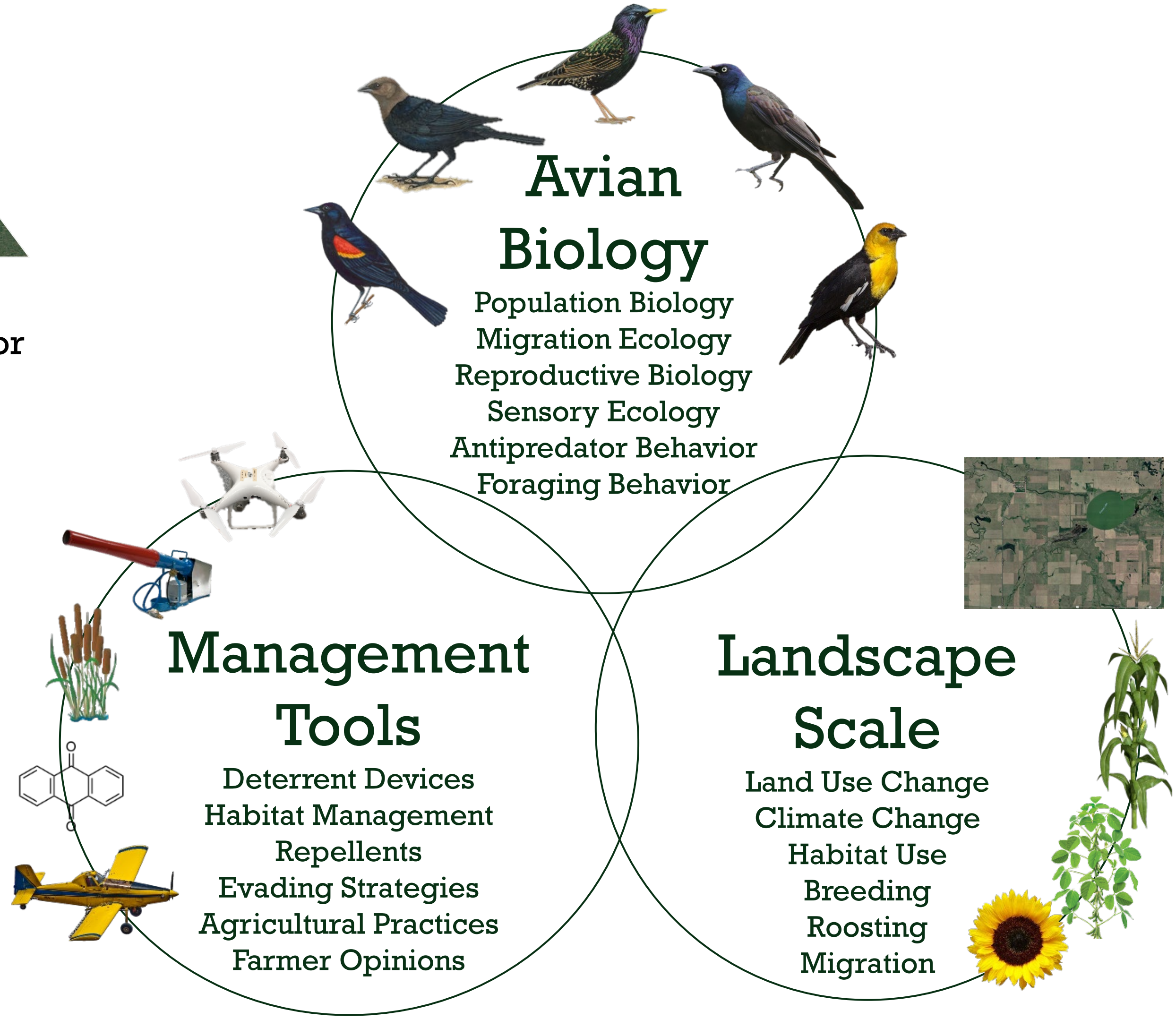
The Research Approach



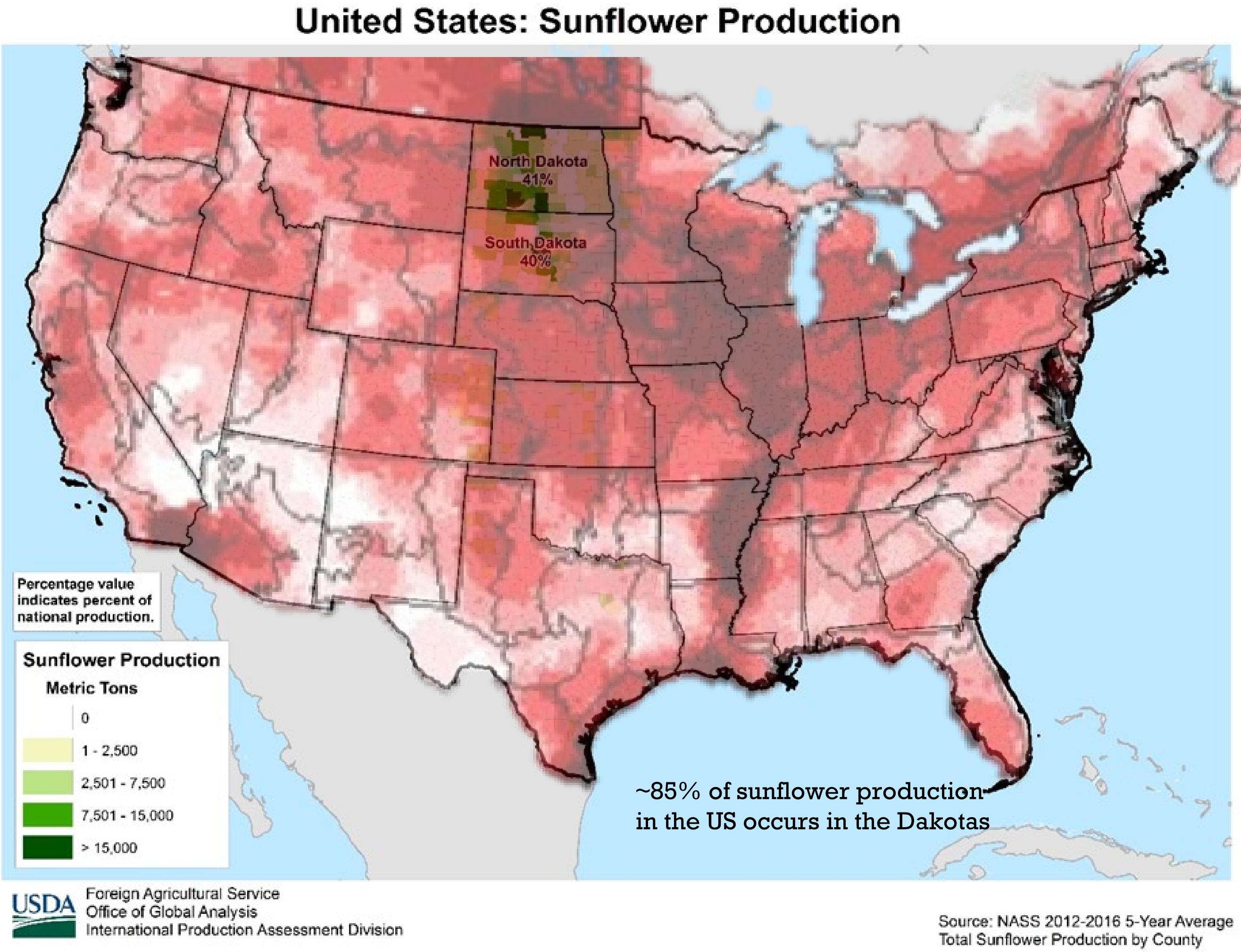
Field scale
Foraging & antipredator behavior

Landscape scale
Habitat & resource selection

Regional scale
Demographic trends



~85% of sunflower production in the US occurs in the Dakotas



+

single roost >1 million blackbirds

Sunflower Damage in Prairie Pothole Region

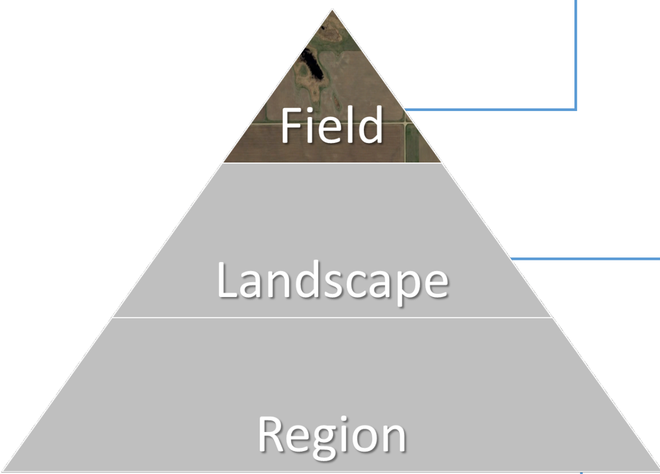
>$3.5 million annually

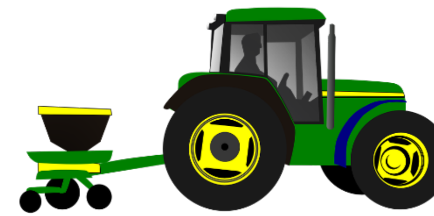
Sunflower Damage in North Dakota

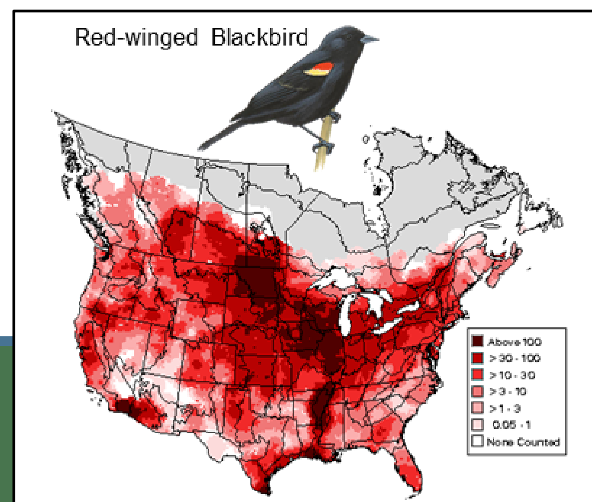
>$10.7 million annually

(regionally 2%, locally >20%)

Scale of Tool Implementation

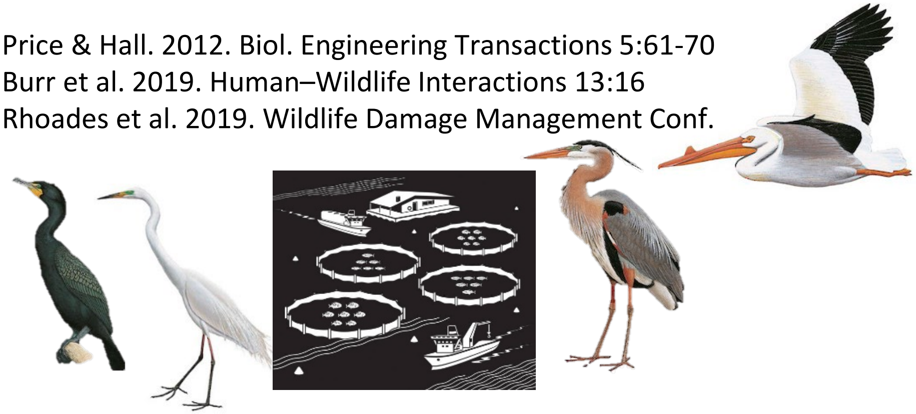






Drones used in various agricultural settings for resource protection

Price & Hall. 2012. Biol. Engineering Transactions 5:61-70
Burr et al. 2019. Human–Wildlife Interactions 13:16
Rhoades et al. 2019. Wildlife Damage Management Conf.



Wandrie et al. Crop Protection 117:15-19
Egan et al. Condor 122:1-15

Dayoub et al. 2020. Advanced Intelligent Systems & Informatics Conf.
Wan Mohamed et al. 2020. Materials Science & Engineering Conf.
Pla et al. 2019. Drones 3: 45.

Wang et al. 2019. Crop Protection 120:163-170
Wang et al. 2020. Crop Protection 137:105260
Bhusal et al. 2018. Intern. Conference Precision Ag.
Goel et al. 2017. ASABE Annual International Mtg.

Farmer Opinions on Current and Novel Tools

Tool efficacy → ? → Tool use

1997 Sunflower Grower Survey

Table 67. Bird species causing sunflower yield loss in 1997.

Bird Species	Kansas	Minnesota	North Dakota	South Dakota
	% of respondents*			
Blackbirds	78.0	86.8	95.7	90.5
Sparrows	15.3	5.7	3.8	5.6
Other	6.8	7.5	0.5	4.0

Table 66. Estimated sunflower yield loss due to bird damage in 1997.

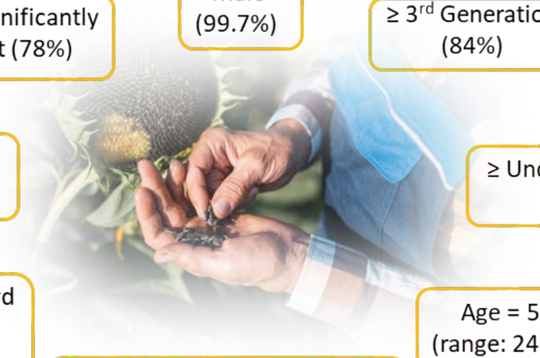
Bird Damage	Kansas	Minnesota	North Dakota	South Dakota
% yield loss	% of respondents			
0-5	68.0	71.2	54.0	60.0
5-10	24.0	20.3	25.5	25.0
10-25	4.0	8.5	14.9	10.7
25-50	4.0	0	4.7	2.1
50-100	0	0	0.9	2.1

Table 69. Bird control costs per respondent in 1997.

Control Method	Kansas	Minnesota	North Dakota	South Dakota
	amount spent per respondent			
Cattails	$0	$0	$515	$0
Exploder	$0	$10	$171	$547
Gasoline	$0	$20	$87	$110
Shells	$48	$162	$134	$104
Hours	3	17	37	111

1. What are producers' perceptions of tools frequency of use?
2. How willing are producers to allow drones on their property?
3. What factors influence their level of willingness?
4. How is their willingness to spend influenced by other factors?

Bird Damage: A Survey of Sunflower Producers



Bird damage significantly impacts profit (78%)

Male (99.7%)

≥ 3rd Generation (84%)

Sunflower acres = 652 (range: 10-6,000)

≥ Undergrad degree (75%)

Annual cost to control bird damage: $1,093 (range: $0-30,000)

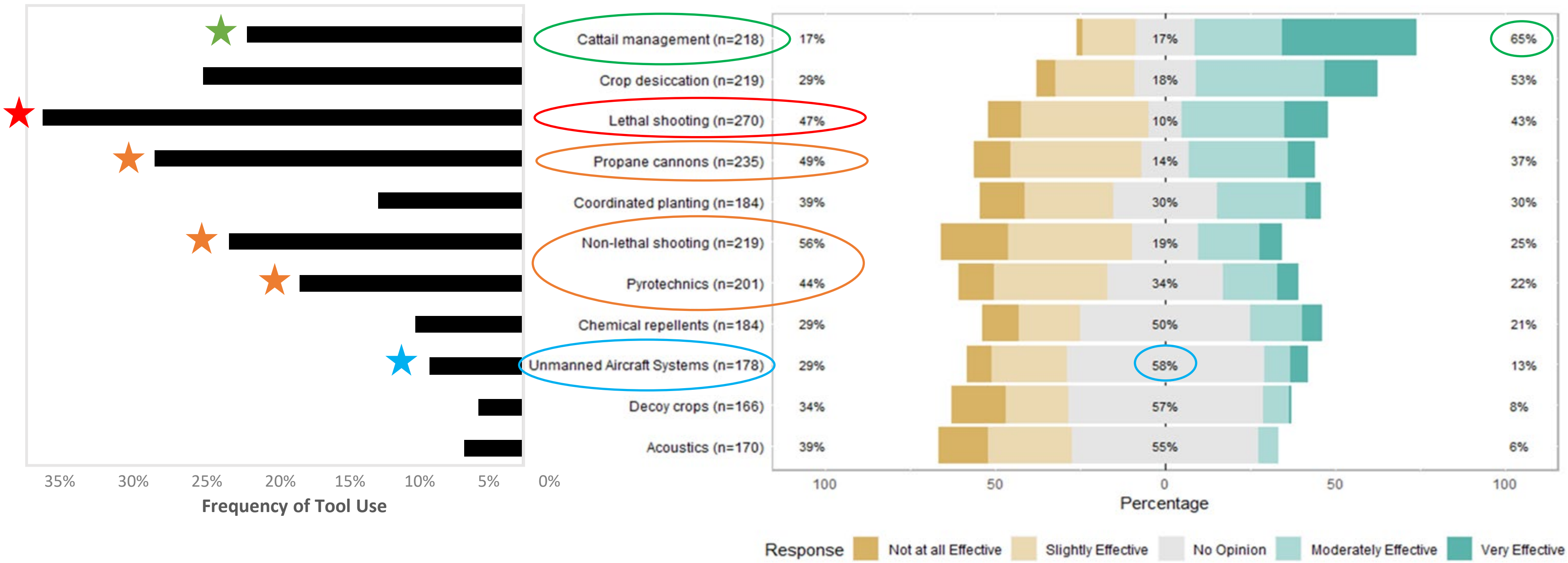
Age = 55 (range: 24-86)

Sunflower experience = 19 yrs. (range: 1-48)

National Sunflower Association list

Surveys Mailed:
ND = 7,346
SD = 2,568

Responses = 1,065
(2020 growers = 343)
11.4% response rate



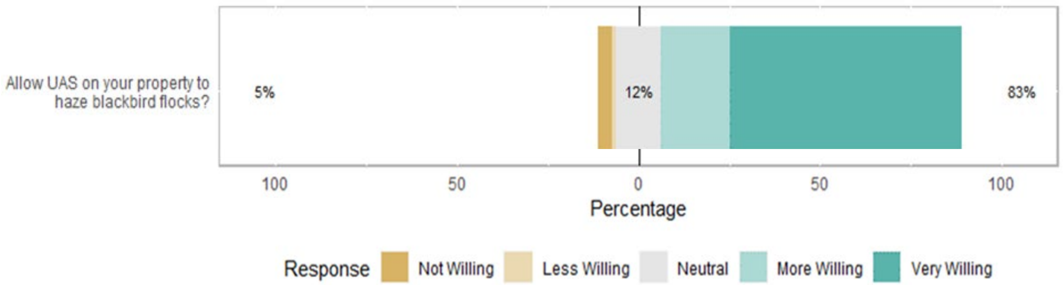
50 CFR § 21.43 - Depredation order for blackbirds, cowbirds, crows, grackles, and magpies.

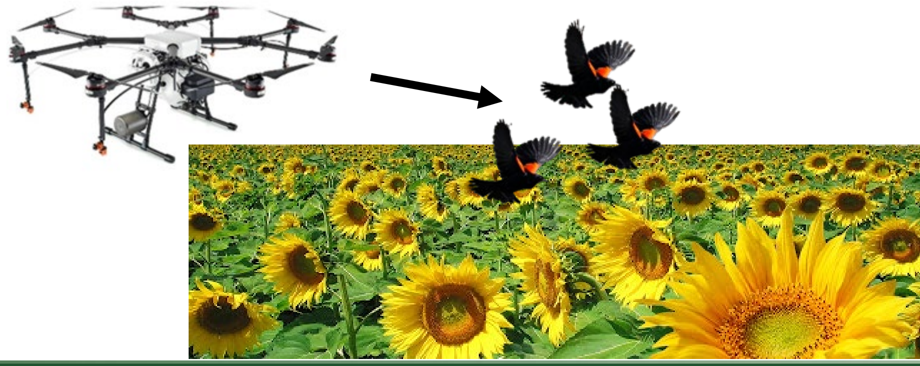
Farmers (83%) open to allowing drones to haze blackbirds

Dependent variable	Allow UAS to haze blackbirds (Q1)	
Independent variable	Coefficient ± SE	OR
- Age	-0.056 ± 0.013***	0.945
Education [a]		
≥ College	0.073 ± 0.453	1.076
Sunflower experience	0.035 ± 0.022	1.036
Impact on profit [b]		
+ Medium	1.012 ± 0.329***	2.750
+ High	0.624 ± 0.204***	1.867
Yield lost to birds (%)	0.016 ± 0.020	1.017
- Generation	-0.843 ± 0.203***	0.430
Sunflower acreage	<-0.001 ± <0.001	0.999
Maximum cost	<0.001 ± <0.001	1.000
Management action taken	0.423 ± 0.393	1.526
+ Prior UAS experience	0.781 ± 0.459*	2.184
McFadden's Pseudo R^2	0.13	
L.R.χ^2	29.91***	
N	208	

***p ≤0.01, **p ≤0.05, *p ≤0.10.

[a] reference category ≤high school, [b] reference category = low





Farmers (71%) open to allowing drones to apply pesticide

	Dependent variable	Allow UAS to apply pesticide (Q2)	
	Independent variable	Coefficient ± SE	OR
	Age	0.004 ± 0.011	1.004
	Education [a]		
+	≥ College	0.656 ± 0.363*	1.928
	Sunflower experience	-0.002 ± 0.018	0.998
	Impact on profit [b]		
+	Medium	0.630 ± 0.261**	1.877
	High	0.235 ± 0.167	1.264
	Yield lost to birds (%)	0.022 ± 0.016	1.022
-	Generation	-0.291 ± 0.163*	0.747
	Sunflower acreage	<-0.001 ± <0.001	0.999
	Maximum cost	<0.001 ± <0.001	1.000
+	Management action taken	0.676 ± 0.318**	1.966
	Prior UAS experience	0.545 ± 0.357	1.724
	McFadden's Pseudo R^2	0.08	
	L.R.χ^2	26.10***	
	N	208	

***p ≤0.01, **p ≤0.05, *p ≤0.10.

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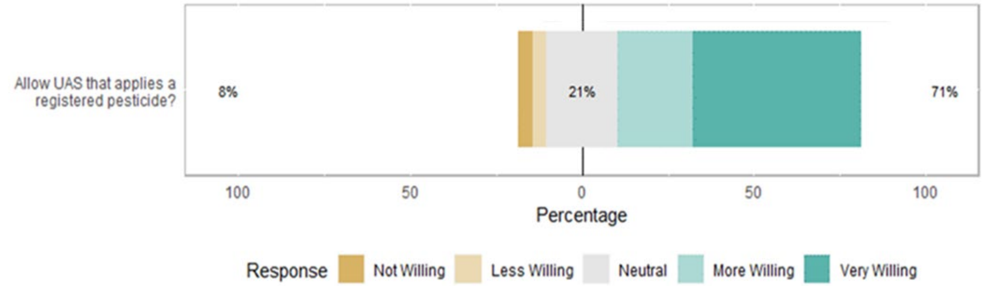
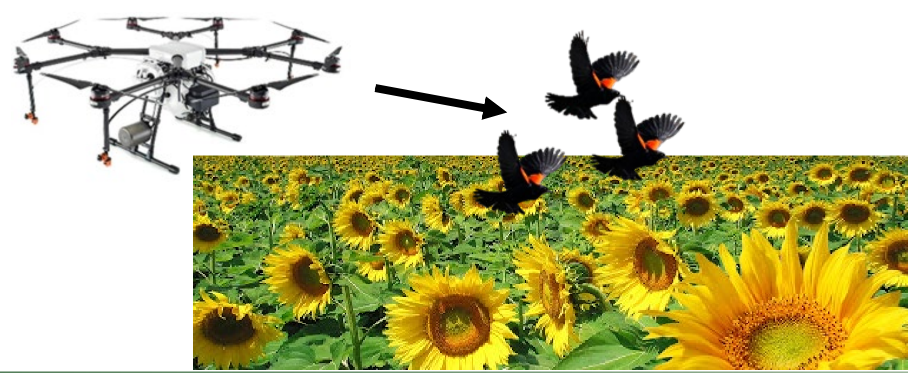


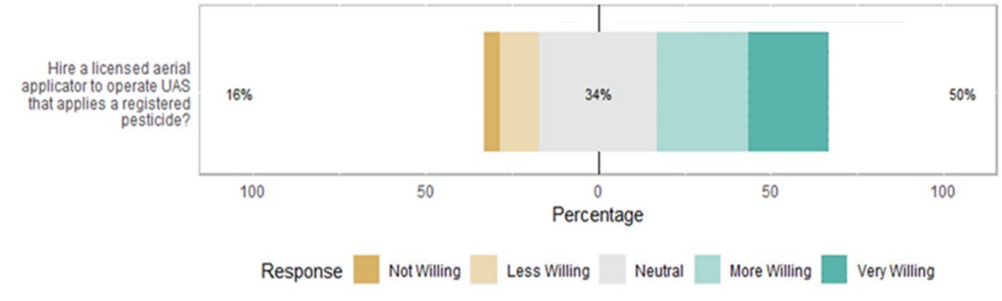


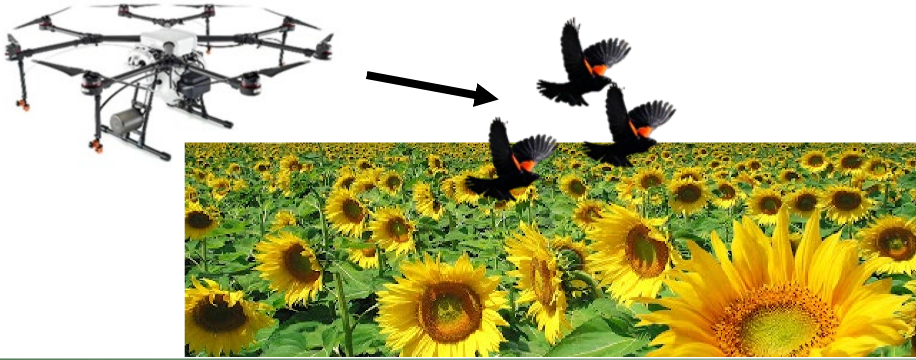
Farmers (50%) open to hiring pilot to apply pesticide by drone

Dependent variable	Hire pilot to operate UAS and apply pesticide (Q4)	
Independent variable	Coefficient ± SE	OR
Age	0.008 ± 0.010	1.008
Education [a]		
≥ College	0.174 ± 0.319	1.190
Sunflower experience	0.002 ± 0.016	1.002
Impact on profit [b]		
Medium	0.107 ± 0.374	1.113
High	0.060 ± 0.523	1.062
Yield lost to birds (%)	0.013 ± 0.015	1.013
Generation	0.224 ± 0.140	1.251
Sunflower acreage	<0.001 ± <0.001	1.000
+ Maximum cost	<0.001 ± <0.001**	1.000
+ Management action taken	0.788 ± 0.319**	2.198
+ Prior UAS experience	0.577 ± 0.297*	1.780
McFadden's Pseudo R^2	0.08	
L.R.χ^2	33.02***	
N	207	

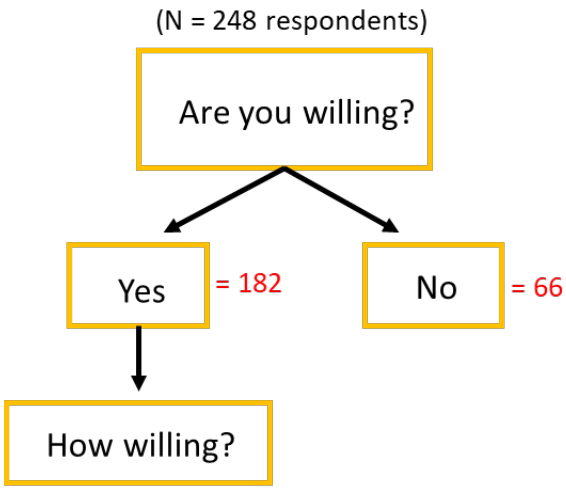
***p ≤0.01, **p ≤0.05, *p ≤0.1

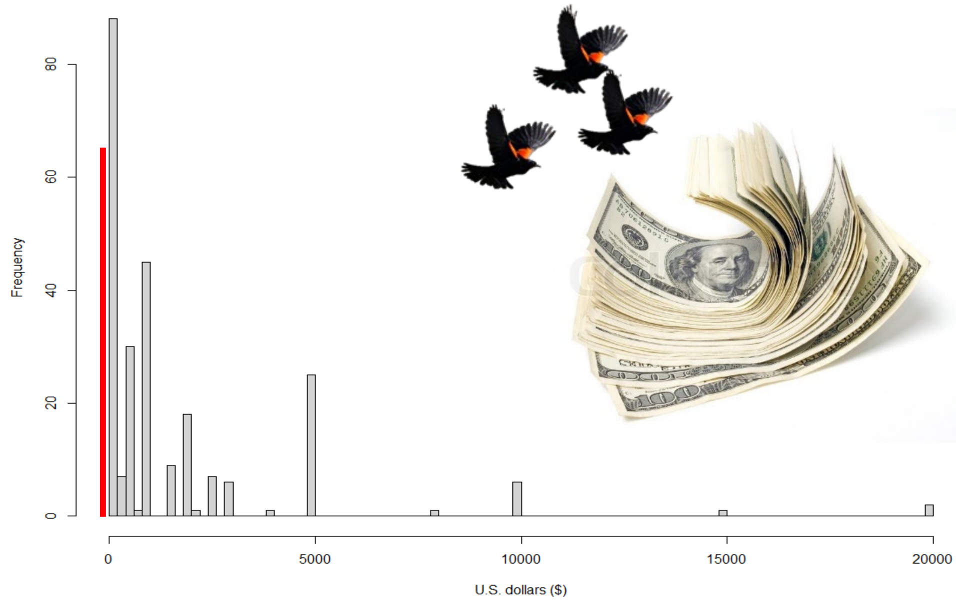
[a] reference category ≤high scho





Willingness-to-pay related to impact on profit, past actions, age, and acreage





	Participation (yes/no)	Willingness-To-Pay ($ - $$$)
Covariates	Coefficient ± S.E.	Coefficient ± S.E.
Age	-0.007 ± 0.018	-0.022 ± 0.010**
Education	0.280 ± 0.367	-0.152 ± 0.191
Sunflower growing experience	0.027 ± 0.019	0.004 ± 0.011
Yield lost to birds (%)	0.022 ± 0.017	0.002 ± 0.008
Impact on profit	0.549 ± 0.333*	0.336 ± 0.175*
Generation	-0.001 ± 0.261	-0.075 ± 0.126
Acreage in sunflower	<-0.001 ± 0.001	<0.001 ± <0.001***
Management action	2.017 ± 0.365***	0.295 ± 0.214
Log psuedolikelihood	-1,436 (df = 19)	
n	215	
Wald χ^2 (df = 7)	68.6***	

***p ≤0.01, **p ≤0.05, *p ≤0.10.

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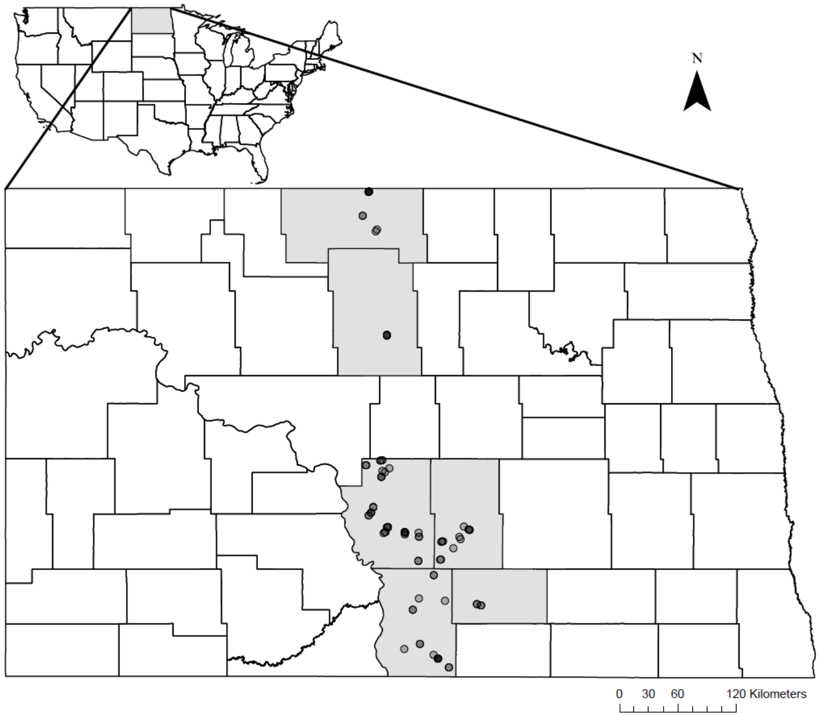
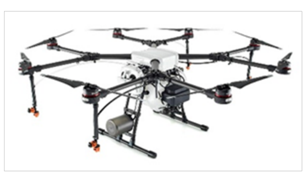
95 UAS trials across ND (Sept to Oct 2019-20)



Time: 7:30 am - 6:40 pm

Avg. Flock size: 898
(range: 25 - 6,000)



Avg. Field size: 187 ac
(range: 11 – 600)

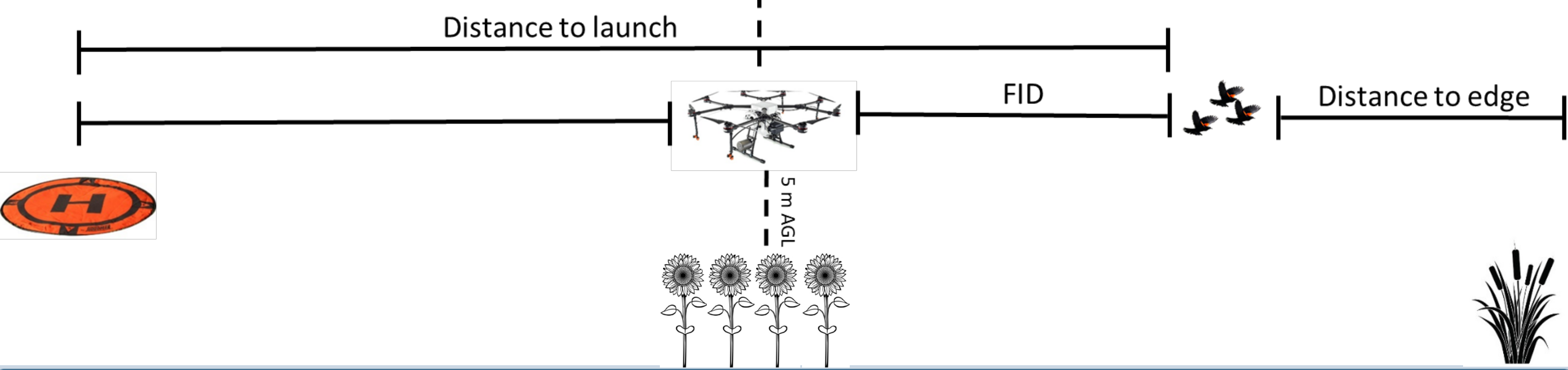
Avg. FID: 39 m
(range: 12 - 76)

Avg. DTL: 245 m
(range: 90 – 665)

Avg. Temperature: 9^{o}C
(range: -3 - 28)

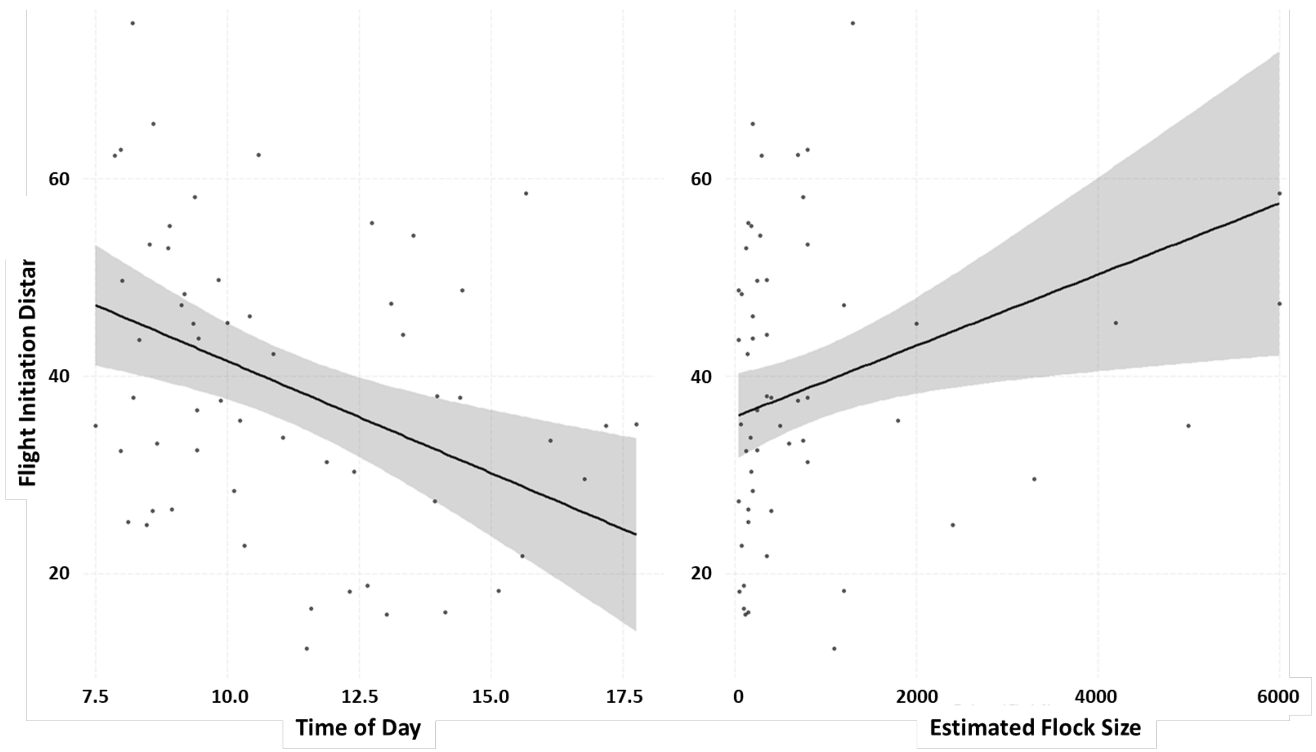
What variables influence the flock's response to UAS approach?

Covariates
Time of Day
Flock Size
Wind
Temperature
Ambient Light
Cattail Area
Sunflower Area
Distance to Launch
Distance to Edge
Habitat (cattail or sunflower)



Time of day & flock size influence flight initiation distance (FID)

Eye-in-the-Sky
60-80 m

Covariates
Time of Day
Flock Size
Wind
Temperature
Ambient Light
Cattail Area
Sunflower Area
Distance to Launch
Distance to Edge
Habitat (cattail or sunflower)

Flight Initiation Distance
40 ± 14 m

Optimal Model:
lm(FID ~ Time + Cattail + Flock Size + Distance to Launch)

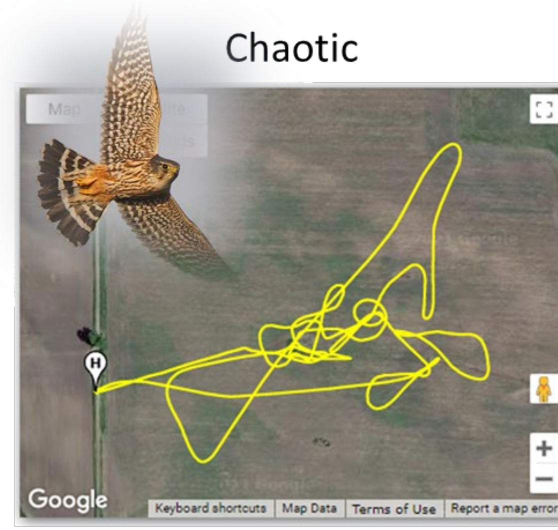
OPTIMAL MODEL	Estimate	95% C.I.
Time	-2.267	-3.638, -0.895
Cattail acreage	-0.147	-0.344, 0.051
Flock size	0.004	0.001, 0.006
Distance to Launch (DTL) (DTL)	-0.025	-0.056, 0.007

What variables influence the flock's response to UAS hazing?

Success = Flock abandoned the habitat they were in prior to UAS approach

Covariates
Julian Day
Cattail Area
Sunflower Area
Wind
Time of Day
Temperature
Flock Size
Total Flight Duration
Flight Path
Habitat

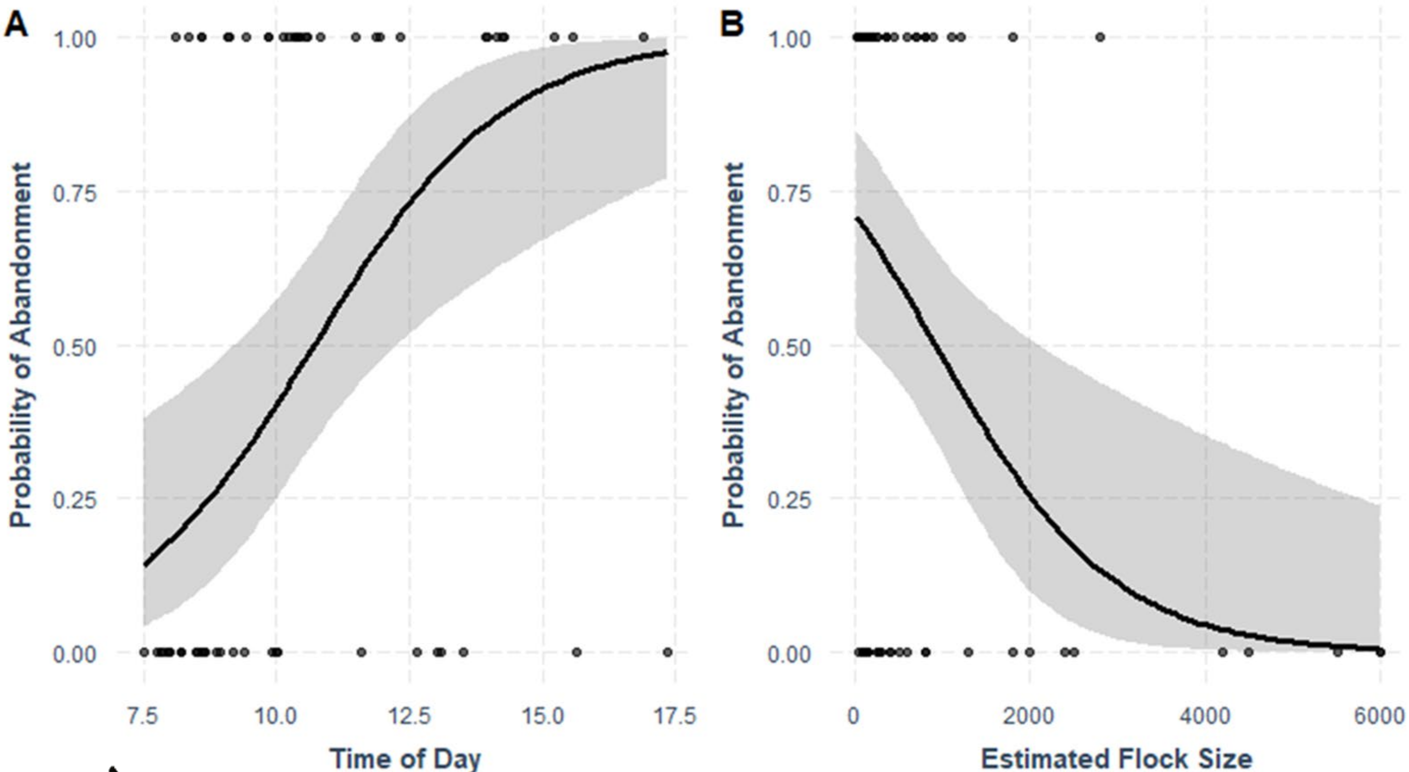
Chaotic



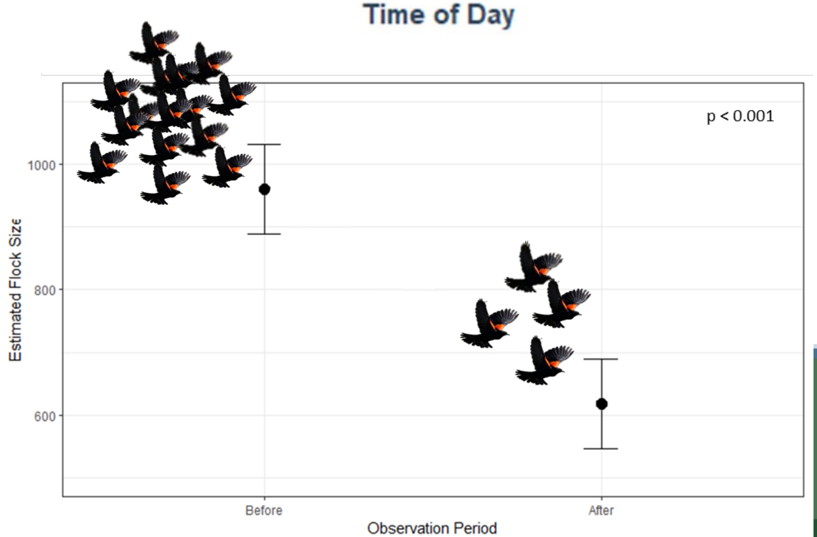
Herding

United States Department of Agriculture
Animal and Plant Health Inspection Service
Wildlife Services – National Wildlife Research Center

Time of day & flock size influence field abandonment (hazing)



Covariates
Julian Day
Cattail Area
Sunflower Area
Wind
Time of Day
Temperature
Flock Size
Total Flight Duration
Flight Path
Habitat



52% of flocks abandoned

Average flock size reduction of 13.4%

81% of flocks returned within 15 min

Optimal Model:
glm(Success ~ Time + Flock Size + Temp)

OPTIMAL MODEL	Estimate	95% C.I.
Time	0.558	0.241, 0.951
Temperature	-0.098	-0.209, 0.002
Flock size	-0.001	-0.002, -0.0004

USDA

Farmers are willing to try UAS, even with low perceived efficacy

Some producers aren't willing to pay anything towards prevention

Identifying early adopters is important for novel tools

Although 52% of flocks abandoned during 10 min of hazing, 90% returned within 15 min with 14% reduction in flock size

Drone hazing in agriculture settings influenced by flock size, time of day, field size

Efficacy of drones may be improved with longer hazing duration, added negative stimuli, or deployment early in the season when flocks are small and establishing feeding areas

Thank You!

National Sunflower Association
John Sandbakken, Board of Directors, and sunflower producers

NDSU Biological Sciences
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North Dakota State University

National Sunflower Association

NDSU North Dakota State University

NDSU Biological Sciences

Environmental & Conservation Sciences, NDSU

United States Department of Agriculture
Animal and Plant Health Inspection Service
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USDA