NORTH DAKOTA GAME AND FISH DEPARTMENT

Final Report

Breeding Ecology of Ferruginous Hawks, Swainson's Hawks, and Northern Harriers in South-central North Dakota

Project T-36-R

March 1, 2013 – February 28, 2015

Terry Steinwand
Director

Submitted by
Greg Link
Chief, Conservation and Communications Division

June 2015

FINAL REPORT

State: **North Dakota** **Grant Number**: T-36-R; CFDA # 15.634

Project Title: Breeding ecology of ferruginous hawks, Swainson's hawks, and northern harriers in south-central North Dakota

Period Covered: 1 March 2013 to 30 May 2015.

Objectives:

1. Using ground and aerial surveys, record all locations of nesting raptor species of interest (ferruginous hawk, Swainson's hawk, and northern harrier) in the study area.
2. Evaluate nest success, fledging success, and number of active nests for ferruginous hawk, Swainson's hawk, and northern harrier.
3. Quantify food habits associated with nest sites including regurgitated pellets, uneaten prey remains, and food delivered to young for ferruginous hawks, Swainson's hawks, and northern harriers.
4. Estimate mammalian prey species abundance, focusing on prey species documented as major prey items for ferruginous hawks, Swainson's hawks, and northern harriers.
5. Identify landscape characteristics associated with raptor nests by examining habitat characteristics at multiple spatial scales around each nest site, and evaluating how local and landscape-level processes influence nesting patterns and overall reproductive success.
6. Estimate detection probabilities of raptors and nest occupancy through time, and model how land-use changes could influence population viability and sustainability.
7. Provide existing and pre-construction nesting and reproductive information relative to wind energy facilities in south-central North Dakota.

Accomplishments: Ferruginous hawk and northern harriers

Objective 1: We surveyed Logan, McIntosh, and Dickey counties, hereafter south-central North Dakota, for active raptor nests. Once active nests were identified we attempted to obtain land access for monitoring nests. In 2013, we identified 181 active raptor nests in south-central North Dakota (ferruginous hawk [*n* = 16], Swainson's hawk [*n* = 41], red-tailed hawk [*n* = 69], northern harrier [*n* = 12], great-horned owl [*n* = 28], and other *Buteo* [*n* = 17]). In 2014, we identified 281 active raptor nests (ferruginous hawk [*n* = 14], Swainson's hawk [*n* = 83], red-tailed hawk [*n* = 152], northern harrier [*n* = 10], great-horned owl [*n* = 44], Cooper's hawk [*n* = 1], and other *Buteo* [*n* = 22]). Nests belonging to other *Buteo* category were based on paired raptors seen at nests but the species were unconfirmed due to constraints of land access.

Objective 2: **2013 –** Ten of 15 (67%) active ferruginous hawk nests fledged successfully with 2.2 chicks (*n* = 22) per successful nest. One active ferruginous hawk nest was identified post fledging therefore limited information was available. Three of the five failed ferruginous hawk nests were abandoned during the incubation phase; egg fragments were found in and around nests. Two nests failed early in the rearing period; chicks 7 to 15 days old were found near the nests. Primary cause of fledgling mortality was attributed to premature fledging (*n* = 2) and chicks falling out of nests (*n* = 2). Three of 12 (25%) active northern harrier nests fledged successfully with 2.33 chicks/successful nest (*n* = 7). Primary reason for nest failures were predation (*n* = 3) and nest abandonment (*n* = 3). Please refer to Inselman (MS thesis; 2015) for 2013 Swainson's hawk nesting information.

2014 – All 14 (100%) active ferruginous hawk nests fledged successfully with 2.9 chicks (*n* = 40) per successful nest. Post fledging nestling mortality (*n* = 4) were attributed to premature fledging. Seven of 10 (70%) active northern harrier nests fledged successfully with 3.1 chicks (*n* = 22) per successful nest. Primary reason for nest failures were predation (*n* = 1) and nest abandonment (*n* = 2). Please refer to Inselman (2015) for 2014 Swainson's hawk nesting information.

Nest Survival – We used the United States Department of Agriculture (USDA; 2012) Cropland Data Layer (CDL) to evaluate land cover pertaining to FEHA and NOHA nest sites. We generated random points using the Geospatial Modeling Environment (Beyer 2012) to simulate random nest sites for logistic regression analysis. We reclassified the CDL layers into water, development, forested, grasslands, hay/pasture, cultivated, and wetlands. We clipped reclassified CDL layers to 1500-m buffers around each random and actual nest sites using Geospatial Modeling Environment and calculated land cover percentages using FRAGSTATS (McGarigal and Marks, 1994) and ArcGIS 10.1 (ESRI, Inc., Redlands, CA). We used Program Mark to estimate nest survival. Nest survival analysis of ferruginous hawk nests indicated that the constant model, S_{Null} was the top-ranked model (w_i = 0.83, β = 2.31, 95% CI = 0.87–4.34), indicating that land cover had limited effect on survival (Table 1); probability of nest survival for the duration of the study was 0.79 (95% CI = 0.66–0.91). We will gather nest survival data on ferruginous hawks again in 2015 to add to our modelling efforts.

Table 1. Nest survival models of ferruginous hawks during 2013 and 2014 breeding season in south-central North Dakota, USA.

Model	AIC_c [a]	ΔAIC_c [b]	w_i [c]	K [d]	Deviance
S_{Null}	367.33	0.00	**0.83**	1	364.21
$S_{\%Grass+\%Pasture/hay}$	371.98	4.65	0.14	3	365.38
$S_{\%Grass+Year}$	373.18	5.86	0.02	3	367.09
$S_{\%Grass+\%Pasture/hay+Year}$	374.29	6.97	0.01	4	365.03
$S_{\%Grass+\%Cultivated}$	375.71	8.38	0.00	3	367.22
$S_{\%Development}$	376.24	8.91	0.00	2	372.44
$S_{\%Grass+\%Water}$	378.11	10.78	0.00	3	366.92
$S_{Saturated}$	379.88	12.55	0.00	9	363.03

[a] Akaike's Information Criterion corrected for small sample size (Burnham and Anderson 2002).
[b] Difference in AICc relative to min. AIC.
[c] Akaike wt (Burnham and Anderson 2002).
[d] Number of parameters.

Nest survival analysis of northern harrier nests indicated that the year model, S_{Year} was the top-ranked model (w_i = 0.65), indicating that survival varied by year (Table 2). The 95% confidence intervals of the β estimate for the S_{Year} model (0.92, 95% CI = 0.64–1.96) did not encompass zero, indicating significant effect of year. We also considered the $S_{\%Grass+\%Pasture/hay+Year}$ model (w_i = 0.23) as competitive. This model was 1.5 ΔAIC_c from the top-ranked model and the 95%

confidence intervals of the β estimates for %Grass (0.23, 95% CI = 0.06–0.39), %Pasture/hay (0.17, 95% CI = 0.002–0.280), and Year (0.54, 95% CI = 0.03–0.81) did not encompass zero and indicated positive association to higher percentages of both %Grass and %Pasture/hay. Estimated nest survival for northern harriers in 2013 was 0.21 (95% CI = 0.22–0.55), and in 2014 was 0.49 (95% CI = 0.32–0.61).

Table 2. Nest survival models of northern harrier during 2013 and 2014 breeding season in south-central North Dakota, USA.

Model	**AIC_c**	**ΔAIC_c**	**w_i**	**K**	**Deviance**
S_{Year}	298.48	0.00	**0.65**	2	296.64
$S_{\%Grass+\%Pasture/hay+Year}$	299.99	1.51	0.23	4	295.58
$S_{\%Grass+\%Pasture/hay+\%Water}$	301.92	3.43	0.09	4	296.09
S_{Null}	302.23	3.75	0.02	1	295.03
$S_{\%Development+\%Cultivated}$	304.54	6.07	0.01	3	297.31
$S_{\%Development}$	306.94	8.46	0.00	2	295.44
$S_{\%Grass+\%Water}$	307.97	9.49	0.00	3	296.46
$S_{\%Water}$	310.46	11.98	0.00	2	296.13

[a] Akaike's Information Criterion corrected for small sample size (Burnham and Anderson 2002).
[b] Difference in AICc relative to min. AIC.
[c] Akaike wt (Burnham and Anderson 2002).
[d] Number of parameters.

Please refer to Inselman (2015) for 2013–2014 Swainson's nest survival analysis.

Objective 3: A total of 241 pellets and 13 prey remains from ferruginous hawk nests was collected in 2013 and 2014 breeding seasons. Majority of ferruginous hawk diet consisted of mammalian prey (74%), followed by avian prey (11%), and insect matter (0.06%). Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) composed of 76% of identifiable mammalian prey.

A total of 1,663 hours of time-lapse video footage were collected from ferruginous hawk nests ($\bar{x}$ = 277 ± 26 hrs/nest) and 725 prey deliveries were observed. Richardson's ground squirrel (*Urocitellus richardsonii)*, and thirteen-lined ground squirrel together composed 42% of the diet, followed by small mammals (35%), and avian prey (5%). The cameras at the ferruginous hawk nests were smeared with bird excreta after deployment; therefore, approximately 21% of all prey deliveries could not be identified. Cameras will be opportunistically deployed on 10–14 ferruginous hawk nests during the breeding season in 2015.

A total of 2,284 hours of time-lapse video footage were collected from northern harrier nests ($\bar{x}$ = 326 ± 32 hrs/nest) and 996 prey deliveries were observed. Approximately 19% of northern harrier diet consisted of small mammals (voles and mice), 18% consisted of Franklin's ground squirrel (*Poliocitellus franklinii*) and thirteen-lined ground squirrel, and avian prey constituted approximately 13% of their diet. Forty six percent of deliveries could not be identified as feedings occurred away from the field of the camera.

Please refer to Inselman (2015) for 2013–2014 Swainson's hawk time-lapse video footage for prey deliveries and biomass estimation.

Objective 4: To estimate prey abundance we surveyed 20 transects, each 12.8 km long (10 targeted around nests and 10 random) at least twice during the nesting season in 2013 and 2014. We observed 384 prey items (2.7 prey/km) during a total of 80 transect drives. Richardson's ground squirrels were observed to be the most abundant prey ($n = 221$) followed by thirteen-lined ground squirrels ($n = 58$) and Franklin's ground squirrels ($n = 51$). Targeted and random transects did not differ ($P = 0.77$) in prey abundance.

To estimate prey abundance for northern harrier we conducted live-trapping using Sherman traps at 38 sites (19 targeted around northern harrier nests and 19 random). Each trapping session constituted two trap lines 30 m apart that were open for a 48 hour period. Each line had 15 traps, 10 m apart, and was checked three times during the day; morning (7-10 am), afternoon (12:30-3:00 pm) and in the evening (6-9 pm). We marked captured animals with ear tags bearing a unique number in order to assess abundance in a capture-recapture framework. A total of 489 small mammals were trapped and marked from June through August in 2013 and 2014. Prey abundance at targeted trap sites (0.44 mammal/trap [95% CI = 0.32-0.58]) did not differ from random sites (0.42 mammal/trap [95% CI = 0.28-0.60]). Small mammals observed in traps in order of abundance were, deer mouse (*Peromyscus maniculatus* [$n = 223$]), white-footed mouse (*P. leucopus* [$n = 69$]), thirteen-lined ground squirrel ($n = 61$), western harvest mouse (*Reithrodontomys megalotis* [*n* = 19]), meadow vole (*Microtus pennsylvanicus* [*n* = 19]), and prairie vole (*M. ochrogaster* [*n* = 11]).

Objective 5: We used logistic regression and Akaike's Information Criterion (AIC) to determine the effects of intrinsic and extrinsic variables on nest site selection. We generated random nest sites to use as pseudo-absent points. We clipped reclassified CDL layers to 1500-m buffers around each random and actual nest sites (multiple spatial scales of analysis will be used during final analysis of data.) We created a priori models from published literature to estimate the influence of our selected predictor variables on nest sites of ferruginous hawk (Table 3) and northern harrier (Table 4). We considered models as competing models if they differed by ≤4 ΔAIC (Richards 2005) from the top model and used Akaike weights (wi) as an indication of support for each model. Predictive capacities of significant models were tested using receiver operating characteristics (ROC) values. We followed guidelines stated by Hosmer et al. (2013) and considered acceptable discrimination for ROC values between 0.7 and 0.8 and excellent discrimination between 0.8 and 1.0.

Table 3. Logistic regression models estimating nest site selection for ferruginous hawks in south-central North Dakota, USA, 2013–2014.

Model Covariates	**K**	**AIC**	**ΔAIC**	w_i	**ROC**[d]
Grass + Pasture	3	346.44	0.00	0.78	0.91
Grass + Cultivated + Forest	4	349.40	2.96	0.17	0.88
Grass + Pasture+ Forest + Cultivated	5	350.66	4.21	0.04	0.83

Null	1	352.77	6.33	0.01	0.72
Grass + Forest	3	355.63	9.19	0.00	0.81
Cultivated + Hay	3	359.19	12.75	0.00	0.74
Grass + Forest + Water + Development	5	360.58	14.14	0.00	0.69

[a] ROC = receiver operating characteristic curve. Values between 0.7 – 0.8 considered acceptable discrimination and between 0.8 – 1 were considered excellent discrimination (Hosmer and Lemeshow 2000).

Table 4. Logistic regression models estimating nest site selection for northern harriers in south-central North Dakota, USA, 2013–2014.

Model Covariates	K	AIC	ΔAIC	w_i	ROC[d]
Grass + Pasture + Water	4	323.94	0.00	0.87	0.95
Grass + Pasture	3	326.28	2.34	0.11	0.90
Pasture + Water	3	327.85	3.91	0.02	0.84
Water + Grass	3	330.07	6.13	0.00	0.75
Grass + Development + Water	4	333.41	8.66	0.00	0.82
Water	2	334.09	10.15	0.00	0.81
Grass	2	337.08	13.14	0.00	0.72

[a] ROC = receiver operating characteristic curve. Values between 0.7 – 0.8 considered acceptable discrimination and between 0.8 – 1 were considered excellent discrimination (Hosmer and Lemeshow 2000).

Grass and pasture/hay had the highest AIC weights ($w_i = 0.78$) for ferruginous hawk nests; grass, pasture, and water ranked as the top model for northern harrier ($w_i = 0.87$) indicating importance of less altered prairies on nest site selection for these raptor species. Logistic odds-ratio estimates from top-ranked model for ferruginous hawk indicated the odds of nest site selection were 1.31 (95% CI = 1.03–1.42) times greater for every percent increase in grasslands, and 1.19 (95% CI = 1.11–1.27) times greater for every percent increase in pasture. Logistic odds-ratio estimates from top-ranked model for northern harrier indicated the odds of nest site selection were 1.48 (95% CI = 1.27–1.58) times greater for every percent increase in grasslands, and 1.2 (95% CI = 1.06–1.31) times greater for every percent increase in water; logistic odds ratio for percent pasture indicated no effect at 1500-m scale (1.06, 95% CI = 0.98–1.14). Further analysis at multiple spatial scales will be performed to understand nest site selection better after a third year (2015) of nesting information becomes available on ferruginous hawk.

Please refer to Inselman (2015) for 2013–2014 Swainson's hawk nest site selection.

Objective 6: Analysis of detection probability of raptors and nest occupancy modeling will be performed after the breeding season of 2015.

Objective 7: All GIS-based coverage maps indicating raptor nesting in relation to wind-energy pre-construction sites and current wind farms in south-central North Dakota that were developed during the analysis will be provided for reference.

Literature cited

Beyer, H. L. 2012. Geospatial Modelling Environment (Version 0.7.2.1). (software). URL: http://www.spatialecology.com/gme

Burnham, K. P., and D. R. Anderson. 2002. Model selection and multimodel inference: a practical information-theoretic approach. Springer Science & Business Media, New York, USA.

Hosmer Jr, D. W., S. Lemeshow, and R. X. Sturdivant. 2013. Applied logistic regression (Vol. 398). John Wiley & Sons, Mississippi, USA.

Inselman, W. M. 2015. Buteo ecology: An intensive study of Swainson's hawks on the northern Great Plains. M.S. Thesis. South Dakota State University.

McGarigal, K. and B. Marks. 1994. FRAGSTATS: Spatial pattern analysis program for quantifying landscape structure. Reference manual. Forest Science Department, Oregon State University, Corvallis Oregon. 62 pp.#Appendix.

Richards, S. A. 2005. Testing ecological theory using the information-theoretic approach: examples and cautionary results. Ecology 86:2805–2814.

Report prepared by: Shubham Datta

Report submitted by: Troy W. Grovenburg