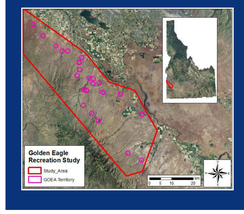
The Effects of Motorized and Non-Motorized Recreation on the Breeding Ecology of a Shrub-steppe Raptor



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Background

- There has been a rapid national and local increase in motorized and non-motorized recreation; wildlife and recreation managers are seeking a better understanding of the implications to birds of prey.
- Recreation activities are generally not regulated around nesting raptors.
- In Southwest Idaho, reduced golden eagle (*Aquila chrysaetos*) nest productivity has been associated with OHV use (Steenhof et al. 2014), but the mechanisms for this are not fully understood.
- An understanding of whether direct disturbance to nesting eagles is occurring, and at what temporal and spatial scales this occurs, is necessary.

Objectives

- Understand how recreation volume, proximity and temporal patterns influence golden eagle territory occupancy, egg laying, nest survival and breeding behavior.
- Assess the effectiveness of existing recreation management efforts, to inform future trail management near eagle territories.

Methods and Analysis

- Monitored recreation, breeding behavior, territory occupancy, egg-laying and nest survival at 23 historical golden eagle territories in the Owyhee Front, southwest Idaho
- Used trail cameras to record recreation on trails within 1200m of eagle nests.
- Recreationists were assigned to four categories:
  1) *Road vehicles* (trucks, SUVs, etc.)
  2) *Non-motorized riders* (equestrian and mountain bikes),
  3) *OHVs* (ATVs, dirt bikes, utility terrain vehicles (UTVs), and rock crawlers)
  4) *Pedestrians*
- Recreation volumes calculated on a per day, per trail basis and tabulated in 3 ways:
  1) Breeding season mean volume (*Rec_AVG_DAY*)
  2) Early season mean volume, i.e. before egg-laying (*Rec_PreLay*)
  3) Short-term mean volume, i.e. taken from each camera survey (*Int_Rec_Day*)
- During 4-hr observations (from a blind or truck) we counted all recreation traffic within 1200m of the focal nest, and assigned eagle behaviors to activity budget.
- Assessed trail and road density (km/km^2) at three spatial scales: within 1) 0.4km, 2) 1km and 3) 3km of the nest, using ArcGIS 10.1.
- Measured distances between recreation sites and the focal nest (Table 1).
- We used generalized linear mixed models (GLMMs) in R 3.1.1 (package "lme4"), to assess recreation predictors on territory occupancy and egg laying.
- Created nest survival models in R 3.1.1 (package "nestsurvival", courtesy of Mark Herzog, USGS) to assess the influence of recreation and nest characteristics on nest survival. Interval specific recreation data were used to account for seasonal fluctuations in traffic volume.
- Created nest survival models to determine the best behavioral predictor nest success
- Used AICc, forward-stepwise model selection to determine best models (package "lme4"), and used model averaging where appropriate.

Connections, Integration and Synergies

- Research is part of an adaptive management plan (in cooperation with the Bureau of Land Management) to sustain eagle populations and continue providing recreation opportunities on public lands
- Results of this project help parameterize simulation models used in other EPSCoR projects, aimed at understanding long-term implications to eagles of varying recreation management strategies

Results

OHV recreation reduces likelihood of territory occupancy

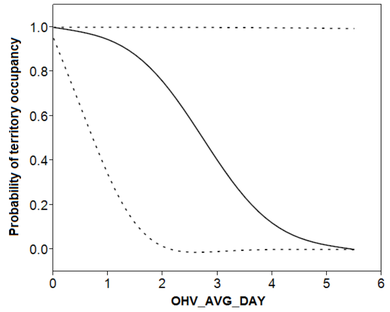

Figure 1. The effect of OHV activity on territory occupancy (n=46).

Pedestrian recreation reduces the likelihood of occupied territories breeding

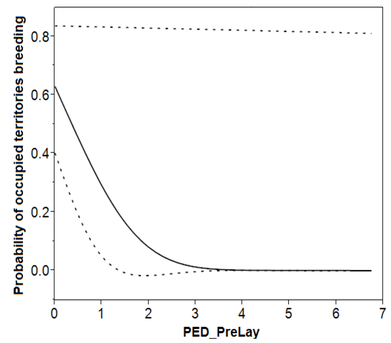

Figure2. The effect of pedestrian activity on whether occupied territories breed (n=41).

OHV recreation decreases Daily Survival Rate of golden eagle nests

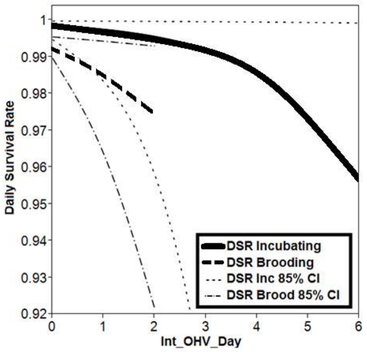

Figure 3. Model averaged daily nest survival rate (DSR) and the short-term volume of OHVs per day for golden eagles.

Linear model of Total Nest Attendance vs. nest age allows prediction of age-corrected nest attendance, a behavioral predictor of nest survival

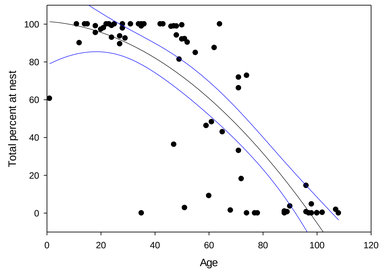

Figure 4. Linear model of Total Nest Attendance vs. nest age

Table 1. List of variables included in analyses; variables were separated by hypothesis model categories. We used AICc model selection to select the variables that best represented each hypothesis. Top models, stronger than the intercept and with ΔAICc < 2.00 went into the final candidate model; no variables correlated ($r \geq .7$) were in the same model. Model abbreviations: Territory Occupancy (TO), Egg-laying (EL), Nest Survival (NS)

Effect Category	Variable	Description	Included in models of
Recreation Volume	OHV_AVG_DAY	Breeding season mean volume of OHVs/day	TO, EL, and NS
	OHV_PreLay	OHVs/day before the Mean Laying Date	TO, EL
	Int_OHV_Day	Short-term volume of OHVs/day	NS
	Ped_AVG_Day	Breeding season mean volume of Pedestrians /day	TO, EL, and NS
	PED_PreLay	Pedestrians/day before Mean Laying Date	TO, EL
	Int_PED_Day	Short-term volume of Pedestrians/day	NS
	TRUCK_AVG_DAY	Breeding season mean volume of Road Vehicles/day	TO, EL, and NS
	TRUCK_PreLay	Road Vehicles/day before Mean Laying Date	TO, EL
	Int_TRUCK_Day	Short-term volume of Road Vehicles/day	NS
	NO_MOTOR_AVG_DAY	Breeding season mean vol. Horseback and Mt Bikes/day	TO, EL, and NS
	NO_MOTOR_PreLay	Horseback and Mountain Bikes/day before Mean Laying Date	TO, EL
	Int_NO_MOTOR_Day	Short-term vol. of Horseback and Mountain Bikes/day	NS
Trail Density	Trail_Density_3k	Trail density at a 3 km buffer around the focal nest	TO, EL, and NS
	Trail_Density_1k	Trail density at a 1 km buffer around the focal nest	TO, EL, and NS
	Trail_Density_400m	Trail density at a 400 m buffer around the focal nest	TO, EL, and NS
Proximity to Recreation Sites	Closest_Trail	Distance (m) to the Closest Trail or Road	TO, EL, and NS
	Closest_Open_Trail	Distance (m) to the Closest Open Trail or Road	TO, EL, and NS
	Closest_Trail_Head	Distance (m) to the Closest Trail Head	TO, EL, and NS
	Closest_Shoot	Distance (m) to the Closest Recreational Shooting Spot	TO, EL, and NS
	Closest_Camp	Distance (m) to the Closest Campsite	TO, EL, and NS
	Nest-trail height	Vertical distance (m) from the nest to the Closest Trail	NS
Nest Specific	Year	Year of Breeding Attempt	NS
	Age	Number of Days since Estimated Laying Date	NS
	Middate	Middle Julian Day of Interval	NS
	Stage	Whether the pair is Incubating or Brooding	NS
	Nest Height	Vertical distance (m) from the nest to the cliff bottom	NS

Pedestrians per hour negatively influences age-corrected nest attendance

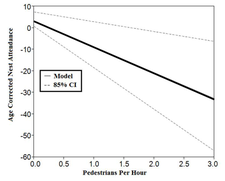

Figure 5. Nest-age corrected nest attendance predicted by Pedestrians Per Hour, during behavioral surveys (n = 68 surveys) of nesting golden eagles.

Most pedestrians arrive at eagle nest sites via motorized vehicles

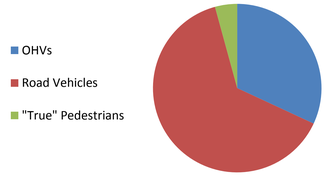

Figure 6. Origin of pedestrians occurring within 1200m of eagle nests during behavioral surveys of incubating or brooding eagles.

Discussion

- Territory occupancy was negatively influenced by OHV use.
- At occupied territories, the volume of pedestrians negatively influenced egg laying.
- For breeding pairs, nest survival was negatively influenced by the volume of OHVs.
- Total nest attendance was the best behavioral predictor of nest survival; pedestrian volume reduced age-corrected nest attendance.
- OHVs facilitate disturbance events leading to nest failure by transporting motorized recreationists, which become pedestrians, to areas near eagle nests.
- Eagle nest sites in steep canyons and large buttes are also attractive sites for people to transition from motorized activities and begin exploring on foot

Application and Recommendations

- Establishing recreation buffer zones around golden eagle nests has the potential to reduce disturbance to eagles.
- By combining seasonal and permanent trail closures, direct disturbance may be alleviated, overall trail density can be reduced, and user conflicts may be minimized.
- Trail management decisions should consider hiker and other non-motorized recreation, in addition to OHV use.
- Research assessing how golden eagle prey species (jackrabbits, ground squirrels, game birds, snakes, etc.) and their habitat are influenced by recreation is necessary.

Where We Are Going Next?

- **Investigate human disturbance effects on predator-prey dynamics**
- **Research implications of wildfire on recreationist behavior and eagle reproduction**
- **Improve understanding of recreationist decision making for simulation modeling**

References

Steenhof, K., J.L. Brown, and M.N. Kochert. 2014. Temporal and Spatial Changes in Golden Eagle Reproduction in Relation to Increased Off Highway Vehicle Activity. Wildlife Society Bulletin 1-7.
Steenhof, K. and I. Newton. 2007. Assessing Nesting Success and Productivity. Pages 181-192. In: Bird, D. M., K. L. Bildstein, D.R. Barber, and A. Zimmerman [eds.] Raptor Research and Management Techniques. Raptor Research Foundation.

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