Modeling Trophic Relationships Using Agent-Based GIS Simulation

Executive Summary

by

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The natural dispersal of grey wolves (*Canis lupus*) from Idaho to Eastern Oregon in 1999 led to their successful reintroduction across the state. Partially delisted from the Endangered Species Action in 2011, wolves in Eastern Oregon are the target of increasingly aggressive lethal management action under Phase 3 of the Oregon Department of Fish and Wildlife (ODFW) Wolf Management Plan. However, wolves in the Western part of the state continue to fall under Phase 1, which entitles them to limited protection from lethal management action (ODFW, 2019). ODFW reported that by the end of 2020 there would be an estimated 173 wolves in Oregon. A population viability assessment conducted by ODFW indicates wolf populations will continue to increase in distribution and abundance, as habitat in the state could support a maximum population of around 1,450 wolves (Clark, 2015). This population assessment lacks a spatial component that could provide a more realistic representation of wolf population dynamics, habitat use, impact on prey species, and areas of potential human-wolf conflict. The effects of habitat on survival, reproduction, and dispersal are difficult to accurately model, and although wolf habitat suitability maps exist for Oregon, they lack validation (Larsen and Ripple, 2006). Rather than invest in GIS models that require substantial amounts of data to develop, ODFW relies on radio-collar pings, reported sightings, and remote sensing cameras to track wolf activity.

Cascadia Wild, a 501(c)(3) nonprofit, collects and shares remote sensing imagery and ground survey data related to rare carnivore species with trusted conservation organizations and ODFW. Volunteers maintain a network of cameras in the Mt. Hood National Forest and White River Wildlife Area (WRWA). In 2018, they captured some of the first photos of wolves in the area. Cascadia Wild’s team of knowledgeable ecologists and trackers rely on their skill and experience to set cameras where wolves and other species of interest are likely to be. Advanced knowledge where wolves may gravitate could enable organizations like Cascadia Wild and ODFW to economize personnel resources and preemptively work with landowners to monitor wolf activity.

Partial delisting of wolves from the ESA in 2011 prompted ODFW to establish a management plan that includes nonlethal requirements. Implementing nonlethal strategies often relies on subject matter expertise and landowner preferences in lieu of scientific rigor. The accessibility of robust GIS software and increasing computing power allows researchers to design realistic models that simulate the impact of nonlethal requirements, habitat use, and trophic relationships. The ability to manipulate key variables and quickly evaluate outcomes across multiple iterations can inform management decisions intended to minimize wolf predation of livestock. The return of wolves in Oregon offers researchers the opportunity to test an agent-based simulation's ability to predict the impact of nonlethal strategies, habitat use, and trophic cascades and compare the model's predictions against real-world results.

Developing an agent-based GIS model requires accurate land cover data, clear definition of mechanistic variables, and an understanding of specific energy costs associated with species' behaviors as they interact with the landscape, other species, and anthropogenic disturbances. Critical interactions initiated by predators that determine prey survival include stalking, initiation, rushing, and chasing. The outcome of predation attempts are also contingent on many prey-specific behaviors including vigilance and speed. The distance at which prey first identify a predator and begin to move away from the approaching threat, also called flight initiation distance (FID), plays an important role in their ability to evade. My research seeks to identify species-specific behaviors and relate them to energetic costs that interact in a spatially explicit model. Understanding prey vigilance and flight behaviors are prioritized, and the relationship between audible threat indicators and prey vigilance proved statistically significant (Table 1) with higher vigilance correlating with audible canid threat indicators (Figure 1).

Table 1 – Results from one-way ANOVA single factor significance test of distance fled in relation to audible threat indicators.

ANOVA Single Factor Significance Test for Threat Indicator - Distance Fled					
Threat Indicator	**N**	**df**	**F-Value**	**p-value**	**F critical**
Ambient Noise	70	2	3500.2	< 0.05	3.107
Anthropogenic	7				
Predator	9				

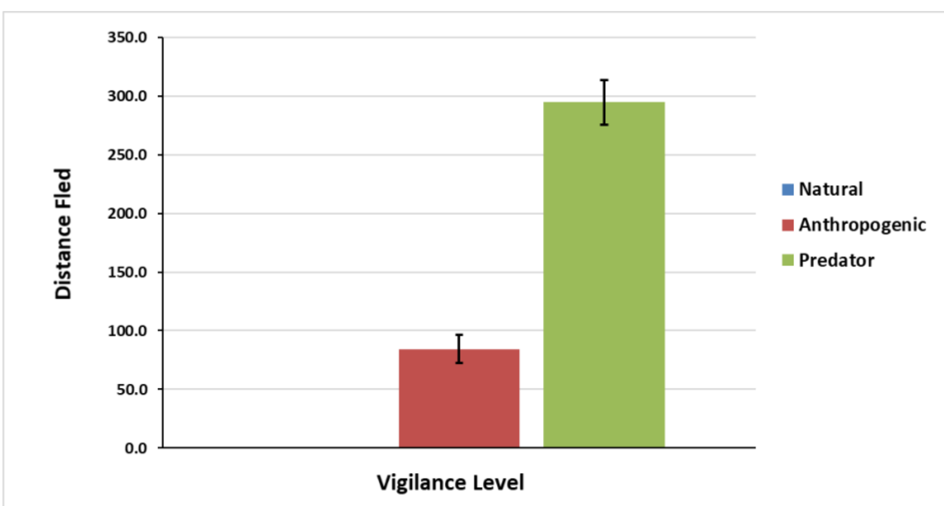

Figure 1 – Distance fled in relation to the audible threat indicators.

My research establishes the foundation for programmatic representation of these interactions based on energetic costs and benefits derived from species interacting with each other and the landscape. Though preliminary, the GIS model serves as a prototype simulating wolf, deer, and livestock relationships that creates a foundation for incorporating additional environmental variables, species, anthropogenic disturbances, and iterative testing of nonlethal management strategies. The resulting experimental model is intended to help manage wildlife and reduce conflict between wolves and humans in areas adjacent to private land.

Keywords: wolf, nonlethal management, antipredator, black-tailed deer, flight initiation distance, vigilance, energetics, harvest, agent-based

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