

# Human Disturbance and Golden Eagle Populations: Investigating the Effects of Recreation and Eagle Tolerance Using Individual-Based Models

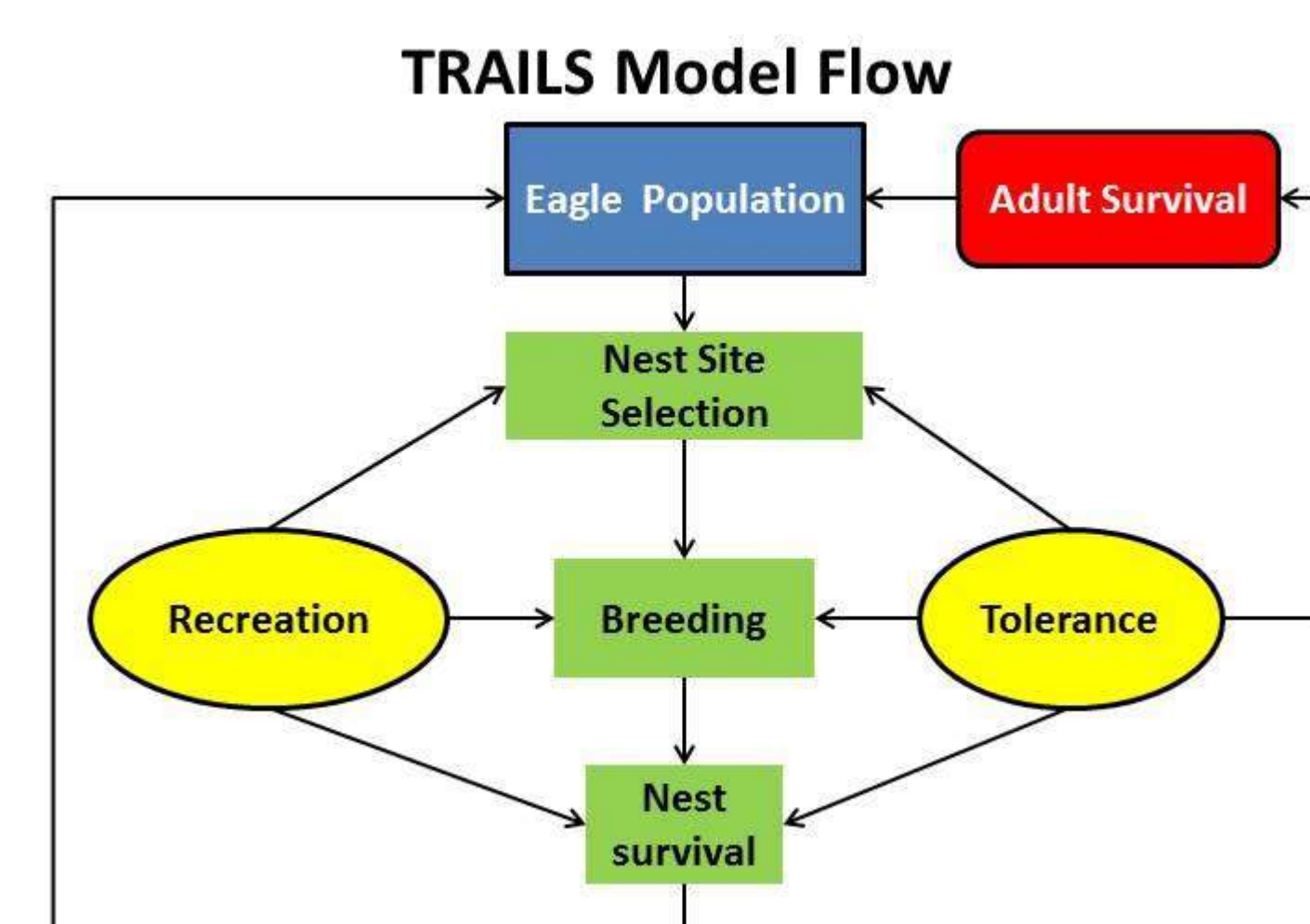
Benjamin P. Pauli, Robert J. Spaul and Julie A. Heath  
Department of Biological Sciences



BOISE STATE UNIVERSITY

## Background

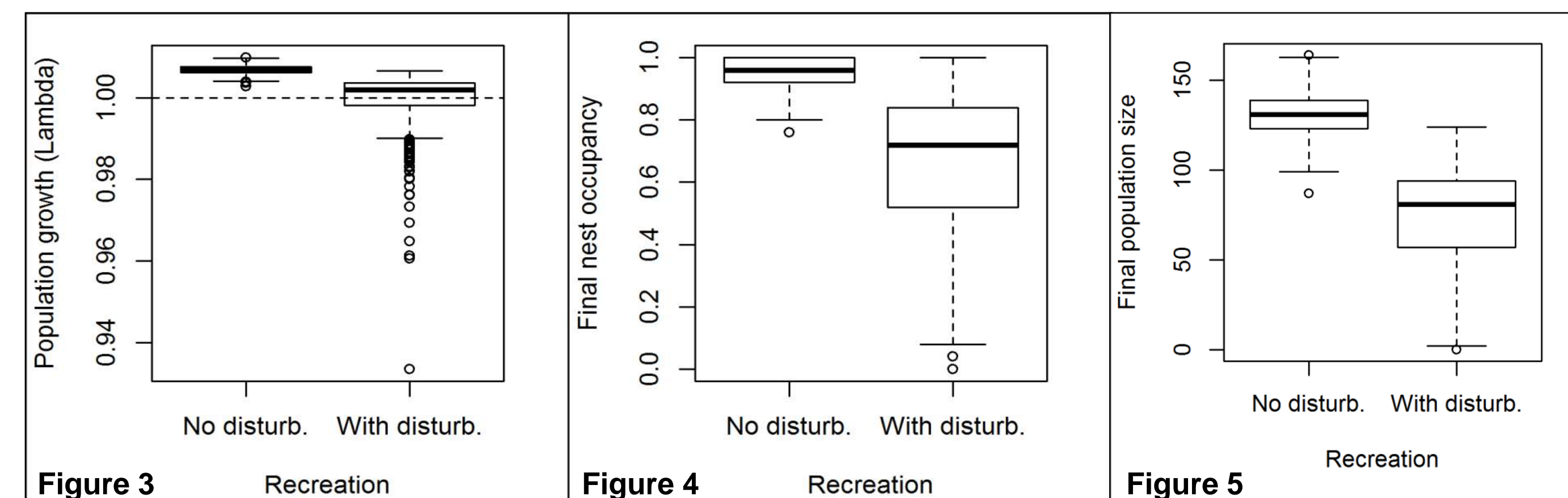
- Human disturbance affects wildlife by increasing stress hormones, changing habitat use and energy budgets, and reducing reproductive output, but understanding long-term population consequences is difficult.
- Wildlife may become tolerant of human disturbance through 1) individual habituation, 2) population selection for genetically tolerant individuals, or 3) habitat imprinting, whereby offspring select habitat similar to their natal site.
- Individual-based models (IBMs) are simulation tools that utilize empirical data on individual animal behaviors (e.g. movements, mortality and reproduction) to simulate the interactions of individuals with one another and their environment. Population level patterns emerge and allow researchers to examine scenarios that are difficult or impossible to study in a field setting.
- We created an IBM to study how motorized (off-highway vehicle) and non-motorized (pedestrian) recreation would affect golden eagle (*Aquila chrysaetos*) populations over a 100 year time-scale.
- Model was parameterized based on empirical work of golden eagle responses to recreation in southwestern Idaho, and from published literature.
- We tested mechanisms of developing tolerance to recreation, and assessed how each mechanism may offset the consequences of disturbance.



**Figure 1. Flow diagram for TRAILS**  
The TRAILS (Tolerance in Raptors and the Associated Impacts of Leisure Sports) model aimed to test and evaluate the role of recreation changes and eagle tolerance to recreational disturbance, and assess its influence on population dynamics over a long timescale.

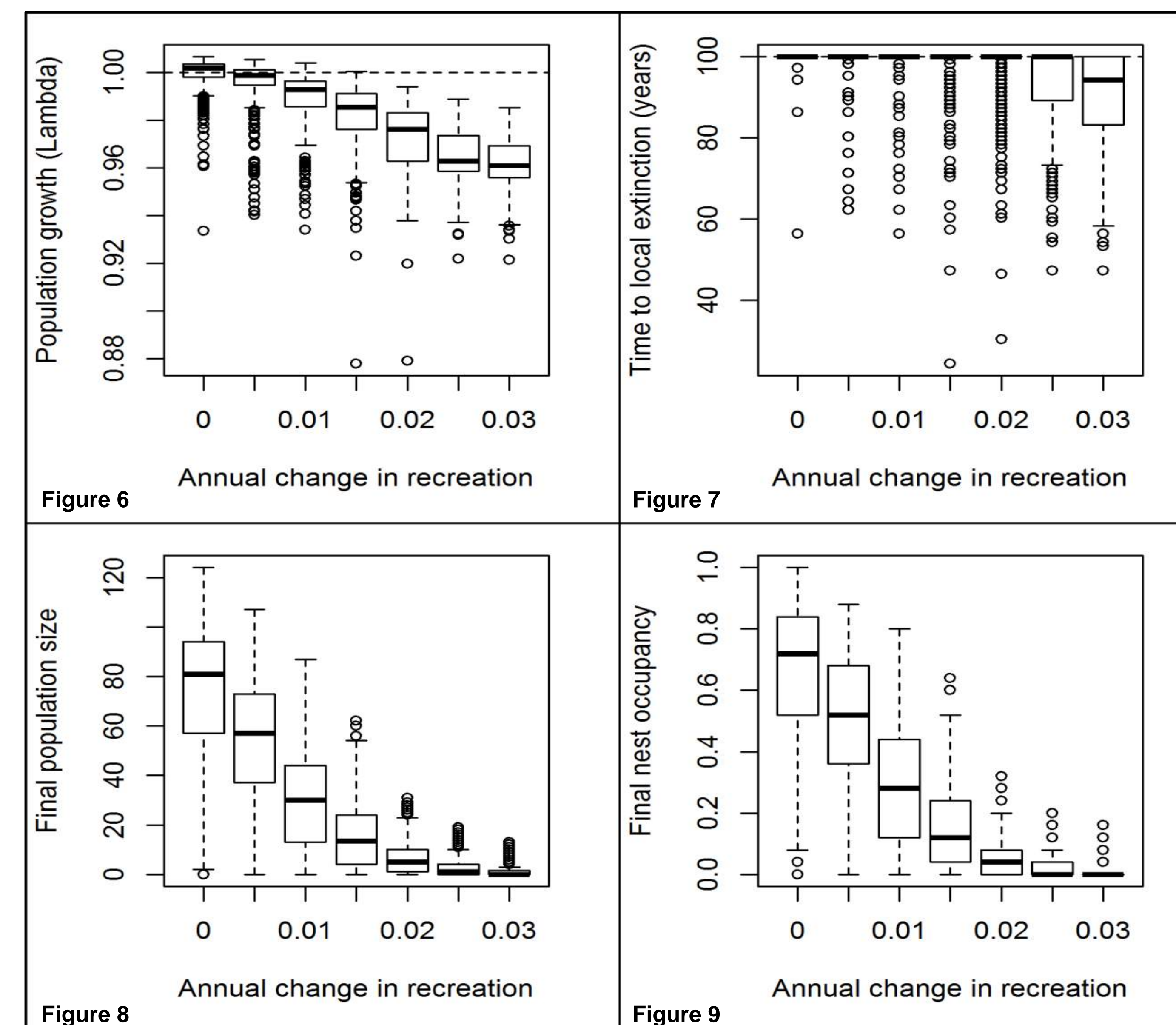


**Figure 2. IBM Screenshot.** Simulated eagles have mates, establish territories at nest sites, lay eggs, and rear nestlings, which are negatively influenced by recreation. Young eagles are subject to juvenile mortality, but may become breeders in the simulated population. Tolerance to recreation reduces adult and juvenile survival though, as birds incur stress and make riskier life choices.



## Do existing levels of recreational disturbance influence the population dynamics of golden eagles in Idaho?

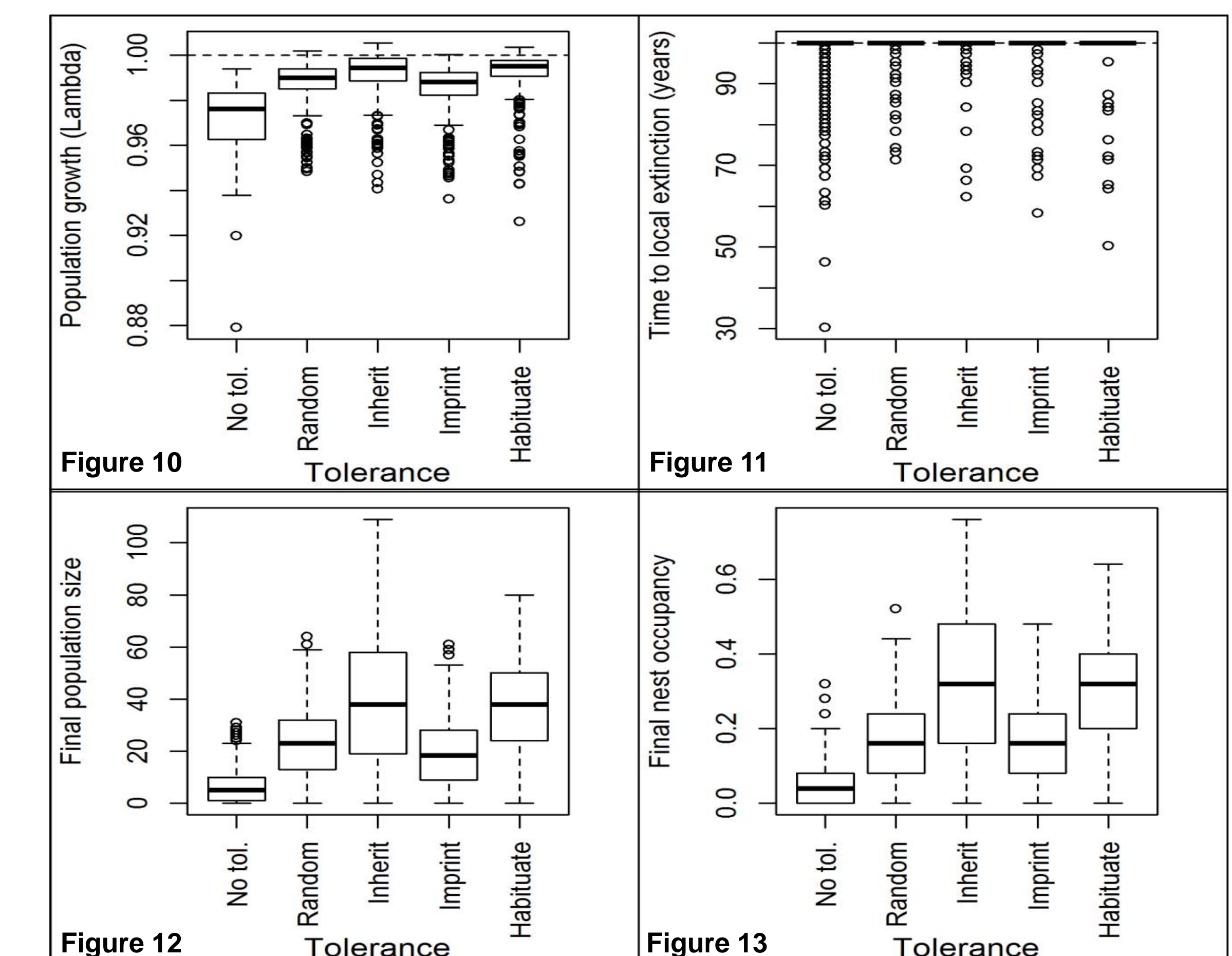
- Simulations without recreation had dramatically higher population growth rates (Figure 3), higher final nest occupancy (Figure 4) and higher population size (Figure 5) than simulations with recreational disturbance present.
- For simulations without recreational disturbance, the average population growth was always positive; when current recreational activities were present, populations often declined (Figure 3).
- Without recreation, populations always persisted for 100 years, but under current recreational pressure simulated populations occasionally went extinct.



## What affect does recreation have on eagle populations?

When recreational pressure increased annually (+ 0.5 - 3.0%)

- Population growth rates of eagles became increasingly negative (Figure 6)
- Local extinction within 100 years became more common (Figure 7)
- Population sizes decreased (Figure 8)
- Occupancy of nest sites decreased (Figure 9)



## Can tolerance to recreational disturbance, derived through individual habituation over time, genetic inheritance, habitat imprinting, or randomly, influence population dynamics and offset the effect of recreational disturbance?

- When tolerance, in any form, was included in simulations, populations showed higher growth rates (Figure 10), fewer extinction events (Figure 11), greater population size (Figure 12) and more occupied nests (Figure 13).
- The mitigating effects of tolerance were more pronounced for genetic inheritance or habituation over habitat imprinting or random assignment.
- The population effects of inherited tolerance and habituation were similar at moderate levels of recreational increase (e.g., 2%), but habituation resulted in less tolerant overall populations compared to the inheritance mechanism.

## Conclusions

- Recreational disturbance can have long lasting effects on eagle populations.
- If recreational activity increases without significant management action to control disturbance, eagle populations likely decline.
- While tolerance, particularly acquired via inheritance or habituation, can be of net benefit to eagles in disturbed landscapes, no mechanism for tolerance allowed eagle populations to withstand moderate recreational increases.

## Where We Are Going Next?

- Incorporating humans with variable decision making into modeling efforts

## Acknowledgements

We would like to thank the Managing Idaho's Landscapes for Ecosystem Services (MILES) EPSCoR project, the Boise State University Vice President of Research-Strategic Research Development Institute grant to the Raptor Research Center, the Bureau of Land Management (BLM), the USFWS Western Golden Eagle Team, and the Boise State Dept. of Biological Sciences for funding this research.

