Optimum Land Allocation for Species Protection and Military Training on DoD Installations

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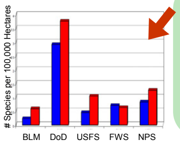
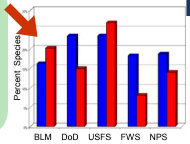
1. Introduction



Density of Species

Suitable habitats for many endangered species are located on DoD lands



Distribution of Species

Why?

Conservation and the Military

- The DoD prevents urban and agricultural development within military installations
- The DoD spends more per acre to manage species than any other federal land management agency

In 2006, the DoD spent $1.6 billion for restoration and conservation

But

Increasing military needs require more land

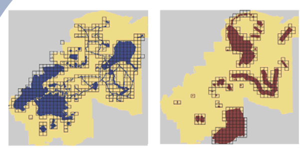
Therefore

- Need effective utilization of land for **both military and conservation** goals
- Need to **relocate species** affected by expanding military training needs

How?

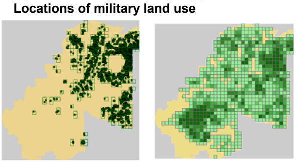
Mathematical programming models can design an optimum landscape for conservation and military needs

An Example: Ft. Benning, GA



(a) Current (b) Future
Locations of military land use

- Covers 182,000 acres
- US Army Armor Center and School will be relocated
- New firing ranges and maneuver areas are being built on lands **that have large Gopher Tortoise populations**



(a) Observed GT (b) GT suitability
Observed GT and habitat suitability

Gopher Tortoise (GT)

- Species at Risk
- Essential for survival of more than 200 species
- Social species, community integrity must be maintained

Need to identify training areas and habitat areas to relocate GTs

2. The Research Problem

Identify conservation managements areas (CMAs) to manage endangered and threatened species given the military training needs

Spatial Considerations

- ❖ Compact CMAs - GTs are a ground-bound species
- ❖ Movement distances - Minimize relocation distances
- ❖ Meta-clustering - Multiple populations can interact
- ❖ Cluster distances - Locate military areas and CMAs apart

Joint Management Considerations

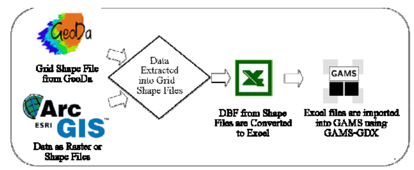
- ❖ Joint management is more efficient,
- ❖ GFs rely on burrows and need ponds
- ❖ Simultaneously identify military areas and CMAs

3. Methods

We develop six linear mixed-integer multi-objective programming models

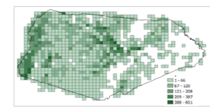
1. Base relocation model for Ft. Benning
2. Minimum distance relocation model for Ft. Benning
3. Meta-clustering relocation model for Ft. Benning
4. Clustered habitat selection model for Ft. Stewart
5. Multiple species habitat selection model for Ft. Stewart
6. Multiple land use model for Ft. Benning

The models are solved using GAMS/CPLEX

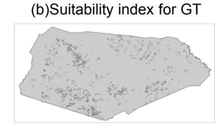


An Example: Ft. Stewart, GA

(a) Military ranges



(b)Suitability index for GT



(c)Location of ponds

- Covers 280,000 acres
- Largest military installation in the Eastern US
- Ft. Stewart has a significant population of GTs

Gopher Frog

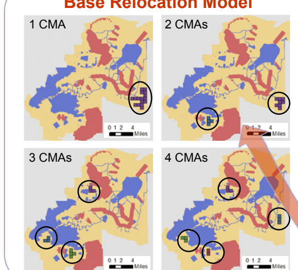
Ft. Stewart has a significant population of Gopher Frogs (GF)

- Near Threatened Species
- Rely on GT burrows for shelter
- Breed in ponds and require ponds within 2 miles of burrows

Need to identify management areas for the management of GT and GF

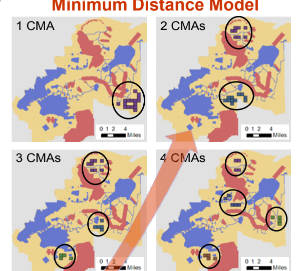
4. Results

Base Relocation Model



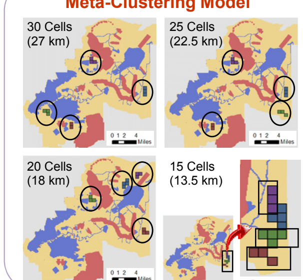
Current military area
Future/planned military area
Installation area
The CMAs are shown in dark colors within black circles

Minimum Distance Model



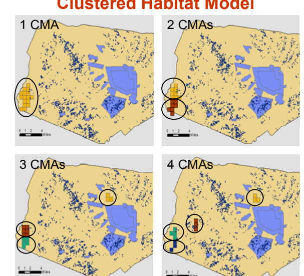
❖The minimum distance relocation model places the CMAs closer to original habitat sites (in red) compared to the base model

Meta-Clustering Model



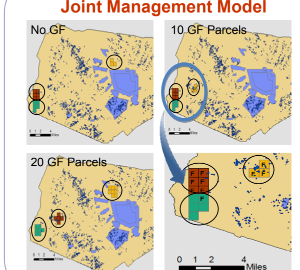
❖Selected CMAs are meta-clustered
❖Smaller meta-cluster distances result in one cluster

Clustered Habitat Model



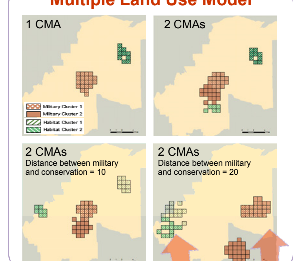
❖The model selects clustered CMAs

Joint Management Model



❖The model selects GT CMAs that are also close to ponds (The ponds are shown in dark blue)

Multiple Land Use Model



- ❖ Row-1: Clustered military and CMAs
- ❖ Row-2: Training areas and CMAs are located away from each other

5. Conclusions

❖Optimization models can be used to identify land for conservation given military land use
❖Spatial and ecological criteria can be incorporated into integer programming models
❖Multiple land uses, both conservation and military, can be solved simultaneously

❖ Adding spatial requirements can lead to

- ❖ CMAs made up from less suitable parcels
- ❖ Less compact or contiguous CMAs
- ❖ Larger CMAs to meet the minimum population
- ❖ Complex models that are computationally harder to solve

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