Lower Keys marsh rabbit (a.k.a. LKMR)

... and its place near the sea

... and its neighbor the silver rice rat, even nearer to the sea

Phillip Hughes
Taxonomy

*Sylvilagus palustris hefneri*, (A)

*S. p. paludicola*, (B)

*S. p. palustris*, (C)
BPK subpopulation
Boca Chica subpopulation
Birth...dispersal...survival
Birth...dispersal...survival
Imagery-cover type approach for delineation of potential habitat
Range
The “range”; why is mapping it so important?

- Protections / regulatory reasons
- Monitoring in a probabilistic manner, and adaptive management, including possibilities for optimization
- Quantifying habitat/components
  - The latter 2 both important for sea level considerations as well as fire and IPM assessment / prediction
Corridor? ‘Other’ Habitat?
Two environments
Rabbit Habitat Map - Big Pine Key, FL

Legend
Lower Keys Marsh Rabbit Habitat

Descriptions:
- Salt marsh
- Freshwater marsh
Matrix “surrounding” the 2 environments
Saltwater-freshwater marsh transitions
Mosquito ditches
Mosquito ditches
Mosquito ditches
Population trends
Proportion of patches at which pellets were detected (rangewide)

\[ y = -0.0091x + 18.796 \]

\[ R^2 = 0.2418 \]
Proportion of patches at which pellets were detected, by metapopulation

LKMR frequency of occurrence

BOCHICA  BPK  SUGAR

2 environments

pellet detection (freq.occur.) in patches grouped by coastal/saltwater vs interior/freshwater

C_ST

I_FR
ARM
Decision Problem

- Long-term sustainability of LKMR in its natural range (using sociopolitically acceptable means)
Alternative Actions

- Do nothing
- Burn
- Predator control
- Burn & Predator control
- Mechanical control of overstory
- Brushpiles/artificial structures
- Supplement numbers in occupied habitats
- Reduce road mortality (speed bumps, tunnels, signals)
- Restore habitat (fill in mosquito ditches, plant grasses)
- Translocation to potential suitable habitat
- Land acquisition
Objectives

Fundamental Objective:
Ensure the long-term viability of the Lower Keys marsh rabbit throughout its natural range by implementing ecologically appropriate and socio-politically acceptable action(s).

Means Objectives:

Reduce predation

Improve habitat

Measurable Attribute:
Maximize rabbit patch occupancy rates to within 90% of historically high occurrence across all potential rabbit habitats on federal lands in the National Key Deer Refuge.
Attributes that can be measured effectively, and efficiently (predation, usually less-so)

Predominant factors through which management can be influential
Increase viability

Reduce predation
- Control cats
- IPM

Improve habitat
- Study raccoons
- Increase herb. cover
- Increase patch size
- Increase connectivity

Impart fire
LKMR related concerns

- salinity
- fire
- predators

Population viability
Alternatives

1 - **Do nothing** = Status quo

2 - **Improve habitat** = Conduct prescribed burning and/or mechanical control in poor condition habitats on federal lands to remove or thin overstory and encourage herbaceous plants

*Model Assumption: Only apply treatment to subset of poor patches per year due to operational constraints and only about 70% of burns will likely be “successful” (e.g. consistent vs. patchy fuels, burn conditions, etc.).*

3 - **Reduce predation** = Remove non-native predators (cats) from federal lands

*Model Assumption: Trapping effort is successful in removing large majority of cats.*

4 - **Improve habitat & reduce predation** = Combination of above
State Transition Model

Current State
- Poor Habitat/ Low Occupancy
- Poor Habitat/ High Occupancy
- Good Habitat/ Low Occupancy
- Good Habitat/ Good Occupancy

Action

Predicted State
- Poor Habitat/ Low Occupancy
- Poor Habitat/ High Occupancy
- Good Habitat/ Low Occupancy
- Good Habitat/ Good Occupancy

probabilities
$(a + b + c + d = 1.0)$
Trade-offs (Optimization)

1. Optimal Policy Projection

![Graph showing optimal policy projection over years with different colors for each category: Poor/lo, Poor/hi, Good/lo, Good/hi.]

2. Decision Policy Table

<table>
<thead>
<tr>
<th>Habitat/Occupancy State (t=0)</th>
<th>Optimal Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor/lo 5 13 15</td>
<td>1</td>
</tr>
<tr>
<td>Poor/hi 6 21</td>
<td>3</td>
</tr>
<tr>
<td>Good/lo 3 7 22</td>
<td>1</td>
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<td>9 5 3 23</td>
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</table>
In our case – in our overall framework – *occupancy* modeling and monitoring are essentially synonymous
Occupancy model

- The proportion of sites occupied by LKMR is an appropriate state variable for use in prescribing management actions (i.e., state-dependent decisions) and for monitoring.
Occupancy model

- Occupancy is a central state variable in meta-population studies, where the principal concern is the extinction and colonization of local sites (patches) rather than estimates of abundance or density (Hanski 1991, Komonen et al. 2008).
Occupancy model

- Considerations when using occupancy as opposed to abundance should include possible trade-offs between reduced cost and effort and the strength of the correlation between abundance and area occupied.
Occupancy model

We considered multiple survey plots within each patch as independent spatial replicates and as the basis for estimating $p$. 
The choice of a 12-m diameter plot reflected a compromise between:

1) an area small enough to yield high detection probabilities (given the presence of pellets in the plot) for better precision of occupancy estimates and

2) a large enough area as to have a non-negligible probability of containing pellets (given presence of rabbits in the patch).
Occupancy model

- Thus far our analyses are limited to a priori hypotheses of 2 potential explanatory variables influencing occupancy and detection probability: 1) patch location with respect to coastal or inland vegetation communities and 2) patch area
Predicted probability of Lower Keys marsh rabbit occupancy at coastal sites, conditioned on habitat patch size
Occupancy model

- This approach allows conservation efforts to be more targeted, focusing on those factors and vital rates (e.g., demographic rates of colonization and extinction) having the greatest impact relative to management goals.
Occupancy model

- LKMR is not unique in the sense that ~25% of all rabbits, hares, and pikas are threatened with extinction (and more declining, “of course”) [see Smith 2008].

- The study design and analytical approach used here can allow for quantification of detection probability when estimating distribution or occupancy, and may be appropriate for many lagomorphs and other cryptic species inhabiting diverse or dynamic habitats.
Acknowledgements

Special thanks to
Katherine Perry
Acknowledgements

- U.S.F.W.S. – Anne Morkill, Kristie Killam, Joshua Albritton, Chad Anderson; numerous SFESO staff and previous NKDR staff/associates plus folks at RO and beyond
- U.S.G.S. Patuxent – James Nichols, Mitch Eaton, Allan O’Connell and others
- Naval Air Station Key West – Rod Flemming, Carrie Backlund, Ed Barham and many others
- Elizabeth A. Forys, Eckerd College
- Texas A&M University – Nova Silvy, Roel Lopez; Craig Faulhaber, Jason Schmidt and many other students/interns
- U. Central Florida – Eric Hoffman, Rosanna Tursi, James D. Roth, Matthew Gordon and others
Acknowledgements

- John Litvaitis, U. New Hampshire