Demographic Analysis of the Endangered Plant *Sanicula mariversa*

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### Background

*Sanicula mariversa* is an endangered perennial herb in the Parsley family (Apiaceae) that occurs on exposed, seric ridges in rocky soil in the Waianae Mountains of Oahu. This species is deciduous, dying back to a fleshy tap root in the dry summer months. It takes several years to flower and is monocarpic. All of these factors make it difficult to determine population dynamics from year to year. Two years of demographic data were taken at two of the four known populations.

### Methods

Measurements of vegetative individuals included: radius of largest leaf, length of the longest petiole, and number of leaves. The number of fruit produced by each reproductive individual was also noted. Some of the plants observed at the four populations were on cliffs thus requiring the use of ropes and rappel work.

*Assumptions*

- If a plant did not emerge in the next season it was considered dead. Therefore, we did not allow for the possibility of plants skipping growing seasons.
- No seed bank. This means that every seedling observed was assumed to be from the previous year’s seed set. This is almost certainly not the case but we did not have data for seed bank persistence.
- Each plant has an equal chance of reaching maturity. There was no differential treatment of individuals located in more or less favorable growing sites.
- The tagging scheme we used was adequate to track an individual between seasons and to identify the same individual in the next season.

### Life cycle Transition Model

Life cycle transition models and stage structured transition matrix models were created based on two years of data. The Stage class transition probabilities shown below are from the Kamaileunu population.

![Life cycle Transition Model Diagram](image)

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Seed bank

Seedling stage: with cotyledons or one leaf

Immature small: 2-6 leaves

Immature large: 5+ leaves, non-reproductive

Mature: with infructescence
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<table>
<thead>
<tr>
<th>State</th>
<th>Transition Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed bank</td>
<td>.02</td>
</tr>
<tr>
<td>Seedling stage</td>
<td>.36</td>
</tr>
<tr>
<td>Immature small</td>
<td>.14</td>
</tr>
<tr>
<td>Immature large</td>
<td>.62</td>
</tr>
</tbody>
</table>

**Est. 11.6**

Habitat at Kamaileunu Population

Habitat at Ohikilolo Population

Leaf diameter

Petiole length

Seedling count

Fruit count

Leaf diameter

Petiole length

Seedling count

Fruit count

# of leaves

11

22

33

44

55

66

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Analysis

A matrix model was used to estimate the growth rate (λ) and can be used to predict the number of individuals likely to mature in the next season. Probabilities of transitioning between life stages were used as the vital rates to create the matrix. Lambda values (λ) can be calculated by Mathematica, and R (r-project.com).

Selected Bibliography:

Kamaileunu Population

<table>
<thead>
<tr>
<th>Seedlings and 1 leaf</th>
<th>Small Immature 2-4 leaves</th>
<th>Large Immature 5+ leaves</th>
<th>Mature</th>
</tr>
</thead>
<tbody>
<tr>
<td>02</td>
<td>.04</td>
<td>.03</td>
<td>11.6*2</td>
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</table>

Keaau Population

<table>
<thead>
<tr>
<th>Seedlings and 1 leaf</th>
<th>Small Immature 2-4 leaves</th>
<th>Large Immature 5+ leaves</th>
<th>Mature</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>.34</td>
<td>0</td>
<td>3.72</td>
</tr>
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</table>

Reproductive probability (est. # of seedlings resulting from each mature)

Transition from seedlings + 1 leafs to small immature (2-4 leaves)

Kamaileunu Population

6% (3 of 51) actual value calculated from # of seedlings found in yr 1 that transitioned into the small immature size class

20% (10.2 of 51) increased # of seedlings transitioning

Keaau Population

52 seedlings observed/(132 seeds per mature*14mature previous yr) = 3.7 (2.8% germ.)

100 seedlings observed/(132 seeds per mature*14mature previous yr) = 7.1 (5.4% germ.)

Results and Discussion

Kamaileunu Population

- With the current assumptions, λ = 0.91 (i.e. declining by 19% per year)
- Elasticity matrix values indicate the three vital rates with the highest effect on λ are:
  1) the transition of seedlings and plants with 1 leaf into the small immature size class;
  2) the number of seedlings generated from each mature individual (It is possible that some seedlings were missed during monitoring because of the difficulty of detection); and
  3) the survivorship of the small immature size class.
- Manipulation of these 3 parameters shows how λ is affected.
  Example: Increasing the numbers of individuals moving from the seedling-1 leaf stage to the small immature size class from 6% to 20% results in a positive growth rate, λ = 1.07 (could be increased in situ via outplanting of small immatures and/or by mitigate fencing and weed control).
- In 2007 approximately 18% of the small immature size class and about 62% of the large size class became mature. Assuming all factors influencing maturity are constant from year to year (a big assumption!) we might expect ~ 17 individuals (of those monitored last year) may be mature in the next growing season (a prediction cannot be made for the 30% of individuals not monitored for both years).
- This population had a larger number of seeds produced per mature individual than Keaau, 269 seeds/mature versus 132 seeds/mature.

Keaau Population

- With the current assumptions, the model indicates λ = 0.87 (i.e. declining by 13% per year).
- The elasticity matrix values indicated the same three vital rates as the Kamaileunu population would have the most effect on λ if manipulated (although in different order).
  Example: Increasing the reproductive potential of mature individuals from the observed 2.8% to 5% the growth rate becomes positive, λ = 1.0002. In other words, the number of observed seedlings would need to increase from 52 to 100 to observe this change in λ.
- One reason why the survivorship of the small immature size class would have a large influence on λ, based on this data set is that not all of the live individuals in any size class might have above-ground vegetation during the monitoring trip (one trip only in April 2008). More frequent monitoring trips may be necessary to observe all individuals above ground.

Conclusions and Lessons Learned

- These data suggest that increasing any of the three vital rates with the highest elasticity values can change the population growth rate to be positive. These data therefore support an active management program for this species, including a reintroduction plan and unglutate control efforts.
- Demographic investigations can be useful in guiding conservation management, models are only as good as the data fed into them and the longevity of the study.
- Develop clear assumptions in demographic investigations.
- Consider the potential negative impacts to the resources you are monitoring.
- Before field monitoring is conducted, sketch out a transition matrix model for your taxa to determine the knowns and unknowns. Intensive field monitoring required for conducting these investigations require significant labor input. Consider the duration and time investment required to obtain the information you seek.
- The intensive monitoring associated with demographic investigations provides excellent baseline data for future comparison.
- The methodology will always require refinement after the first field excursion because there are unique situations that you do not expect.

Future Plans

- In the next year a buried seed and germination study will help to determine the longevity of the soil seed bank.
- Following further study, the Army Natural Resources Program may utilize this type of analysis to determine restoration needs in order to meet population stabilization goals for this species.