Visualizing causes of range limits: Landscape as grid

- unsuitable habitat
- suitable habitat
- large population
- range edge
- low genetic var.
- low quality
- low genetic var.; small $N_e$
- small population
- unstable population
Scenario 1: Suitable habitat is absent beyond edge

2006 findings:
- Pollinator distribution? Yes (specialists absent beyond border)?
- Precipitation? Yes (declines beyond border)?
- Soil? No (suitable beyond border)?
- Slope/aspect? No (suitable beyond border)?
- Herbivores?
Scenario 2: Suitable habitat occurs beyond edge; the species just hasn’t reached there yet.

→ 2006 findings: Pollinator distribution? No (absent beyond border)?
Precipitation? No (declines beyond border)?
Soil? Yes (suitable beyond border)?
Slope/aspect? Yes (suitable beyond border)?
Herbivores?
Scenario 3: Environmental quality declines toward edge; gene flow from interior to range edge creates maladaptation

<table>
<thead>
<tr>
<th>Interior (Int.)</th>
<th>Edge (Ed.)</th>
<th>transplant experiment prediction</th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>Fitness at Edge</td>
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</tbody>
</table>

→ 2006 findings:

- Germination
- Survival
- Water stress
- Pollinator density?
- Precipitation?
- Soils?
- Slope/aspect?
- Herbivores?
- Yes (lower near border)?
- No (no decline till beyond border)?
- Yes (harder near border)?
- No (suitable throughout range)?
- No (less abundant near border)?
Scenario 4: Insufficient genetic variation at edge prevents adaptation beyond edge

2006 findings
No? population size, density, area similar across range?
Scenario 5: Greater variability (and higher extinction risk) among border populations

→ 2006 findings must wait for additional years