Ecological connectivity network maintains genetic diversity and fitness in a flagship wildflower

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Gene Flow Between Subdivided Populations is Essential for Population Persistence

Landscape Fragmentation

Gene Flow

Genetic Diversity & Structure

Fitness

Photo: H. J. Böhmer, 2011
Ecological Networks to Enhance Genetic Diversity and Fitness

Landscape Fragmentation

Gene Flow

Genetic Diversity & Structure

Fitness

http://www.tverc.org/cms/content/ecological-networks
Calcareous Grasslands
Study Area: Southern Franconian Alb, Germany

Is the ecological connectivity network working?

Landscape Fragmentation → Gene Flow → Genetic Diversity → Fitness
Is the ecological connectivity network working?
Is the ecological connectivity network working?

1) Is genetic diversity higher within the ecological network?

2) Do well-connected populations have higher genetic diversity?

3) Are genetic diversity and fitness correlated?
Sampling

Genetic Data:
- Leaf tissue from 57 populations
- Genotyped at 7 microsatellite marker

Fitness Data:
- Seeds from 10 populations
- Counted and weighed
Is genetic diversity higher within the ecological network?

Grazed populations have higher genetic diversity than ungrazed populations.
Do well-connected populations have higher genetic diversity?

Shepherding Network → Gene Flow → Genetic Diversity → Fitness

\[ S_i = \sum_{i \neq j} \exp (-\alpha d_{ij}) \]

Hanski (1994)

<table>
<thead>
<tr>
<th>DISTANCE MEASURE ((D_{ij}))</th>
<th>DESCRIPTION</th>
<th>DISPERSAL HYPOTHESIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euclidean</td>
<td><img src="1" alt="Diagram" /></td>
<td>Simple wind diffusion</td>
</tr>
<tr>
<td>Distance Through Sheep Grazing Routes</td>
<td><img src="2" alt="Diagram" /></td>
<td>Seeds transported by sheep, Distance matters</td>
</tr>
</tbody>
</table>

Slide: Y. Rico
Do well-connected populations have higher genetic diversity?

Genetic Diversity ~ $S_{\text{SHEEP}} + S_{\text{EUCLIDEAN}} + \text{Population Size}$
Do well-connected populations have higher genetic diversity?

Shepherding Network → Gene Flow → Genetic Diversity → Fitness

<table>
<thead>
<tr>
<th>Model</th>
<th>R²</th>
<th>p-value</th>
<th>AIC</th>
<th>ΔAIC</th>
<th>w_i</th>
</tr>
</thead>
<tbody>
<tr>
<td>$S_i_{SHEEP} + S_i_{EUCLIDEAN} + Population Size</td>
<td>0.38</td>
<td>0.0030</td>
<td>25.83</td>
<td>1.83</td>
<td>0.170</td>
</tr>
<tr>
<td>$S_i_{SHEEP} + Population Size</td>
<td>0.40</td>
<td>0.0008</td>
<td>24.00</td>
<td>0</td>
<td>0.420</td>
</tr>
<tr>
<td>$S_i_{EUCLIDEAN} + Population Size</td>
<td>0.11</td>
<td>0.1000</td>
<td>34.90</td>
<td>10.9</td>
<td>0.002</td>
</tr>
<tr>
<td>$S_i_{SHEEP} + S_i_{EUCLIDEAN}</td>
<td>0.35</td>
<td>0.0020</td>
<td>26.32</td>
<td>2.33</td>
<td>0.130</td>
</tr>
<tr>
<td>$S_i_{SHEEP}</td>
<td>0.36</td>
<td>0.0005</td>
<td>24.78</td>
<td>0.78</td>
<td>0.280</td>
</tr>
<tr>
<td>$S_i_{EUCLIDEAN}</td>
<td>0.05</td>
<td>0.1200</td>
<td>35.54</td>
<td>11.5</td>
<td>0.001</td>
</tr>
<tr>
<td>Population Size</td>
<td>0.02</td>
<td>0.2100</td>
<td>36.43</td>
<td>12.4</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Do well-connected populations have higher genetic diversity?

Shepherding Network → Gene Flow → Genetic Diversity → Fitness

Population Size

Variable Importance (Summed w.)

Predictor Variable

Si_{EUCLIDEAN}  Si_{SHEEP}  PopSize
Do well-connected populations have higher genetic diversity?

Shepherding Network → Gene Flow → Genetic Diversity → Fitness

\[ R^2 = 0.05, \ p = 0.13 \]

\[ R^2 = 0.35, \ p < 0.001 \]
Do well-connected populations have higher genetic diversity?
Are genetic diversity and fitness correlated?
Are genetic diversity and fitness correlated?

Gene Flow → Genetic Diversity → Fitness

Shepherding Network

\[ R^2=0.42, \ p<0.001 \]

\[ R^2=0.24, \ p=0.08 \]
Are genetic diversity and fitness correlated?

Shepherding Network → Gene Flow → Genetic Diversity → Fitness

\[ R^2 = 0.44, \ p < 0.001 \]

\[ R^2 = 0.36, \ p < 0.001 \]
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Thank You!

Lab Assistance: Amaneet Lochab, Michael Liu, Qasim Muhammad, Nimesh Patel

Shepherds: Erich Beil, Erich Neulinger, Alfred Grimm

Government of Central Franconia, Bavaria, Germany
Fragmentation Divides Populations
Is the ecological connectivity network working?

Shepherding Network → Gene Flow → Genetic Diversity → Fitness