Leafy Spurge Biocontrol Fails in Some Habitats
-How to Proceed-

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New age of classical biological control of weeds

• Prioritize targets more effectively
• Understand the effects of invasive species before biocontrol development
  • driver? passenger? does it matter?
• Redefine success. Manage expectations.
• Accept and plan for invasive species replacement
Knowledge required for effective BC

Now we have more research on:

- Invaded environment ecology
- Plasticity
- Cryptic species
- Modeling; demography
- Rapid evolution
- Genomics
  - Genetics of host-specificity/herbivory
- Sensory ecology
- Invasion pathways
- Cost/benefit of bc
- Restoration post-bc
Leafy Spurge

• We have successful agents, but success has been variable.

• New insights will aid in targeting potential for agents to fill management gaps.
Status of leafy spurge

• This weed remains a top concern for western stakeholders despite decades of active management and a widely successful biocontrol program.

• Biological control remains the most cost effective means of long term management (Hyder et al. 2008), but agent success varies.
Why does leafy spurge biocontrol fail at times? 4 hypotheses.

• Ecology
  • soil type, moisture, deep roots, shady areas, riparian areas

• Taxonomy
  • provenance of agents

• Plant genotype x agent
  • some evidence for variation in efficacy on different plant genotypes

• Agent selection
  • not all agents released in all locations
Ecology
What does the literature say?

• Few published experiments
• ND prevalence
• Mixed and varying releases

• ~50 studies with quantitative data
• 22 (45%) Monitored releases
• 15 (30%) Experiments
• 13 (25%) Surveys, models
What next?

• Multi-state survey of:
  • Plant populations
  • Agent communities
  • Leafy spurge cover

In replicated habitat types.

We need DATA.
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1. Characterize habitat variables and the current status of leafy spurge infestations where agents have been released.

   1. Native range pre-release and local scale post-release studies have reported variation in agent establishment and impacts related to factors such as slope, soil type, vegetation characters, and soil moisture (Hansen et al. 1997, Jonsen et al. 2001, Nowierski et al. 2002, Joshi and Olson 2009).

   • Identify long-term release sites (n=60) that cover a range of replicated soil and vegetation types. 3 year study.
     • soil samples (nutrients and texture, moisture)
     • vegetation community and spurge density and slope
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2. Quantify the variance in agent communities and abundance across sites.

• agent presence
• SIMP transect (Weed et al. 2017)
Caveats

• Specific release and management records are unlikely to be available for all sites, and all sites will have variable use histories.

• Associations between site-level habitat conditions, agent presence and spurge infestations will likely vary, because biological control is often combined with chemical or grazing management.

• Sampling a large number of sites will decrease the influence of individual differences on the overall correlational trends being evaluated.

• Further, the objective of this study is to examine the variation in large scale habitat associations, not the local scale mechanisms driving such associations.

• We will run power analysis after Year 1 to assess whether data are too noisy to detect trends; if this is the case, we will add additional sites.
Taxonomy
Taxonomic conclusions (hypotheses) so far

• Fact: Many morphological studies have been done, with varying taxonomic conclusions
• Fact: Many synonyms exist (~60 for the aggregate)
• Common conclusion: We have E. esula
• USDA Plants: We have E. esula var. esula and var. uralensis
• Recent conclusion: We have E. pseudovirgata (= E. esula x E. virgata) (Ebke and McCarty 1983)
• Latest conclusion: We only have E. virgata (Berry et al. FNA)
3. Taxonomy

- Compare DNA sequences (cpDNA and nDNA) from USA and native range
- Include plant DNA from original agent collection sites
- Compare genotypes and morphology
- AFLP data can help with determination of hybrids
Genetics
Genetically based variation in efficacy of herbivory

• Earlier studies (Lym 1996, Lym and Carlson 2002) found variation in agent feeding and emergence on 5 NA spurge genotypes.

• We still don’t know how different genotypes or taxa are distributed, and whether some are more or less correlated with certain agents.

### Table: Aphthona spp. Emergence from Various Leafy Spurge Genotypes Following Adult Free-Choice Feeding in a Field Cage over the Growing Season

<table>
<thead>
<tr>
<th>Genotype</th>
<th><em>A. czwalinae</em>/<em>lactevosa</em></th>
<th><em>A. flava</em></th>
<th><em>A. nigriscutis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>78AS001</td>
<td>27</td>
<td>7</td>
<td>40</td>
</tr>
<tr>
<td>79MB001</td>
<td>20</td>
<td>9</td>
<td>26</td>
</tr>
<tr>
<td>80MT002</td>
<td>22</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>79NE003</td>
<td>72</td>
<td>14</td>
<td>80</td>
</tr>
<tr>
<td>84ND001</td>
<td>11</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>80SD001</td>
<td>32</td>
<td>3</td>
<td>32</td>
</tr>
<tr>
<td>80Wy001</td>
<td>32</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>23</td>
<td>4</td>
<td>26</td>
</tr>
</tbody>
</table>

* Two hundred adults of each species were given free choice of feeding on 12 plants of each genotype in field cages during the growing season. Data are averages of three runs over 2 years at two locations.

* The number of adults emerging from plants of each genotype following a cold period in the lab.

* LSD = 0.10.
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3. Identify the genetic structure and variation within patches across sites.
   • Population level collections (n=20)
   • AFLP analysis for population level
Agents
Status

• *Aphthona* species have been particularly successful; various other agents failed to establish extensively, or had negligible impacts, and have not been actively distributed or studied as intently as *Aphthona* (Progar et al. 2011)
How to proceed

• Approved but not released agents are available
• Other agents are in the pipeline
• New agents, from the correct species or habitat, could be developed
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4. Evaluate potential correlations between habitat conditions, correct plant species, population genetic structure, and agent.

• stepwise discriminant analysis
• partial least squares regression
• glm-based permutation analysis
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What are your needs?

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