Evaluating the Costs and Benefits of Alternative Weed Management Strategies for Three Montana Landscapes

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Coming soon to conserveonline.org/workspaces/montanaweedmodel

- Final report
- Executive summaries
- Presentations/ Figures
- Maps
- Data
- Model Package
Weed Management Progression

- Prevention
- Eradication
- Control
- Containment
- Restoration/Management

What Is Best Management Strategy?
What Is Possible?
Modeling Tools:

- State and transition models using the Vegetation Dynamics Development Tool (VDDT).
- Spatial simulations using the Tool for Exploratory Landscape Scenario Analyses (TELSA).

Available from:
ESSA Technologies
essa.com
Modeling Objectives:

- Understand weed spread at the landscape scale
- Compare effectiveness of various management strategies
- Understand economic costs and impacts of various management strategies

Species Modeled:

- Spotted Knapweed
- Leafy Spurge
Overview of How the Model Works

Based on vegetation – divides study area into polygons about 2½ ac in size

Add data and “rules” to model to give it direction

Model runs simulations to predict weed distribution based on data and rules
State and Transition Model

- **Un-invaded**
- **Initial 1**
- **Initial 2**
- **Established**

**Processes:**
- Invasion
- Escape
- Setback or Failure
- Establishment
- Control Failure
- Eradication
- Resurgence
- Dormancy
- Increasing Cover of Invasive Weeds
Time Since Invasion (Years)
Proportion of Polygon Invaded

- Initial 1
- Initial 2
- Established
- Logistic Growth

Proportion of Polygon Invaded

Time Since Invasion (Years)
Model Parameters

• Spread Rates
• Control Effectiveness
• Factors that affect Spread Rates
  – Vegetation Susceptibility
  – Spread Vectors
• Biocontrol Establishment, Spread, and Extinction Rates
Biological Control

Established

Un-invaded

Invasion

Initial 1

Control

Escape

Setback

Initial 2

Establishment

Failure

Escaping

Dormancy

Setback or Failure

SETBACK OR FAILURE

Seedbank/ Monitoring

Resurgence

Establishment

Biological Control

Increasing Cover of Invasive Weeds
Parameter Values From:

- Literature
- Unpublished data from landscapes
- Targeted data collection in landscapes
- Expert Input – 40+ researchers and managers in our landscapes
- For key variables (spread rate, control success) with lots of uncertainty used a range of values
Spatial Inputs

- Weeds
- Biocontrol
- Vegetation Types
- Features that affect spread – roads, ditches, trailheads, etc.
- Tessellation
Riparian
Tamegrass
Tamegrass
Limber Pine
Fescue
Mixed Grass
Conifer
Conifer
No Weeds In:

- Water
- Wetland
- Annual Cropland
- Rock
Reality Check

Not a Magic Black Box!

Data → Truth
Knapweed Calibration
Calibration Results
Actual vs. High Spread vs. Low Spread

Area Invaded (ha)

- Knapweed
- Spurge

1990 2008
First Generation Management Scenarios

- **No management**
- **No constraints** - 100% treatment of all populations
- **Blocked** – 100% treatment in 80% of landscape, no treatment in remaining 20%
- **Small patch** – Ceiling on total treatment, treat small patches first (early detection/control)
- **Large patch** – Ceiling on total treatment, treat large patches first
- **Delay** – no treatment for initial 5-15 years of simulation
Centennial Valley - TELSA Weed Model

Seedbank, Initial & Established Knapweed
-- High Control -- Large Patch Edge Priority --
Year 50
0.05 spread with 200ha ceiling
Centennial Valley - TELSA Weed Model

Seedbank, Initial & Established Knapweed
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Centennial Valley - TELSA Weed Model

Seedbank & Initial Knapweed
-- High Control -- Large Patch Edge Priority --
Year 50
0.05 spread with 400ha ceiling

Potential Vegetation Types
- Sagebrush
- Aspen
- Sandhills
- Riparian
- Water/Wetland
- Conifer
- Wet Meadow
- Unprojectable

Scale: 0 2.5 5 10 Kilometers
          0 2.5 5 10 Miles
Centennial Valley - TELSA Weed Model

Seedbank & Initial Knapweed
-- High Control -- Small Patch Priority --
Year 50
0.05 spread with 400ha ceiling

Potential Vegetation Types
- Sagebrush
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- Water/Wetland
- Conifer
- Wet Meadow
- Unprojectable

Scale: 0 to 10 Miles
Area Invaded and Treated After 50 Years
Centennial Valley
Spotted Knapweed - High Spread/Low Control

<table>
<thead>
<tr>
<th>Strategies</th>
<th>No-MGT</th>
<th>200-LPE</th>
<th>200-SP</th>
<th>400-LPE</th>
<th>400-SP</th>
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<tr>
<td>Hectares</td>
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<tr>
<td>Area Invaded</td>
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<td>25000</td>
<td>10000</td>
<td>15000</td>
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<tr>
<td>Area Treated</td>
<td>15000</td>
<td>15000</td>
<td>10000</td>
<td>15000</td>
<td>10000</td>
</tr>
</tbody>
</table>

Area Invaded

Area Treated (cumulative)
Initial Results - RMF

• Doing nothing = 5-10x more weeds in 40 years
• Treating only small patches and edges of large patches just as effective as treating everything but at less cost
• Highly susceptible habitats are (like gravel riparian) are tough to manage – either already invaded to likely to become so
• Can stay ahead of weeds in other vegetation types
• Waiting to implement management greatly increases long-term costs
• Consistent management across landscape is important (20% non-participation doubles the amount of weeds)
No Management – No Biocontrol
No Management except Biocontrol
HS 70% - Leafy Spurge Cover Type - Year 40

Leafy Spurge Cover
- Initial
- Established
- Biological control
- Seed bank
- Uninvaded
Chemical Management and Biocontrol

HS 70% - Leafy Spurge Cover Type - Year 40

Leafy Spurge Cover
- Initial
- Established
- Biological control
- Seed bank
- Uninvaded

Legend:
- Orange: Initial
- Red: Established
- Black: Biological control
- Light grey: Seed bank
- Dark grey: Uninvaded

Distance Scale:
- 0 miles
- 0.5 miles
- 1 mile
- 2 miles
- 3 miles
Initial Results - Biocontrol

- Biocontrol is a key component of integrated management, especially within landscapes with large infestations where chemical control is not cost effective.

- Integration of biocontrol into management program can reduce area invaded by 1/3 at ½ the cost of chemical only management.
Measures

• **What is most effective strategy?**
  – Total Area Invaded
  – Cumulative area treated

• **Economic analysis**
  – Treatment cost
  – Grazing value
Estimating Economic Benefits and Costs

• Only single direct costs considered: ranching
• No indirect costs or non-use values included
• NPV = Benefits – treatments costs
• Results in 2008 dollars using a 2.7% discount rate
Centennial Valley - TELSA Weed Model
Spotted Knapweed
High Spread - 70 Percent Control Success -
No Management - Year 40

Centennial Valley - TELSA Weed Model
Spotted Knapweed
Low Spread - 70 Percent Control Success -
11 Aware Management - Year 40
Economic Inputs

• **Grazing Value:**
  - Average AUM rate for 2008 - $18.10
  - Carrying Capacity from NRCS county estimates (0.26 AUM/acre)

• **Treatment costs:**
  - Established - $40/acre
  - Initial 2 - $85/acre
  - Initial 1 - $225/acre

• **Discount rate: 2.7%**
Second Generation Management Scenarios

- **Standard** – Small patch priority, 70% treatment success rates
  - Range of treatment ceilings
- **Large patch priority**
- **I1 Aware**
- **95% treatment success**
- **Roaming**
State and Transition Model

- **Un-invaded**
- **Initial 1**
- **Initial 2**
- **Established**

**Key Processes:**
- Invasion
- Control
- Escape
- Setback
- Resurgence
- Setback or Failure
- Establishment
- Extinction

**Key States:**
- Eradication
- Dormancy
- Biological Control

**Increasing Cover of Invasive Weeds**
Second Generation Management Scenarios

• **Standard** – Small patch priority, 70% treatment success rates
  – Range of treatment ceilings

• **Large patch priority**

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Measures

• **What is most effective strategy?**
  – Total Area Invaded
  – Cumulative area treated

• **Economic analysis**
  – Net Present Value
  – Benefit Cost Ratio
RMF Effects of Management on Weed Distribution
RMF Area Invaded and Treated by Treatment Ceiling

[Bar chart showing the comparison of invaded and treated areas for different treatment ceilings: No Management, 100 Ha Ceiling, 575 Ha Ceiling, 1150 Ha Ceiling, 2300 Ha Ceiling, Unlimited. The bars are color-coded with blue for invaded and red for treated.]
RMF Treatment over Time, High Spread Scenarios

Area Treated (ha)

Simulation Year

HS-Unlimited
HS-2300HA
HS-1150HA
HS-575HA
HS-100HA
CVTreatment over Time, High Spread Scenarios

- High Spread 125 ha Polygon Ceiling
- Low Spread 125 Ha Polygon Ceiling
- High Spread 63 Ha Polygon Ceiling
- Low Spread 63 Ha Polygon Ceiling

Mean Area Treated (ha)

Year

1, 3, 5, 7, 9, 11, 13, 15, 17, 19, 21, 23, 25, 27, 29, 31, 33, 35, 37, 39
RMF Treatment over Time, High Spread Scenarios

Area Treated (ha)

Simulation Year
RMF Alternative Strategy Area Treated

Percentage of Landscape Treated Annually

- High
- High
- High
- High
- High
- Low
- Low
- Low
- Low
- Low

- 95% Success
- I1 Aware
- Default
- Large Patch Edges
- Roaming
- 95% Success
- I1 Aware
- Default
- Large Patch Edges
- Roaming
RMF Costs of Delaying Management

Net Present Value

- $1,000,000.00
- $800,000.00
- $600,000.00
- $400,000.00
- $200,000.00
- $0.00
- $-$
- $-$
- $-$
- $-$
- $-$
- $-$
- $-$
- $-$
- $-$

Years Treatment Delayed

0 2 4 6 8 10 12 14 16

High
Low

RMF Costs of Delaying Management

- $1,000,000.00
- $800,000.00
- $600,000.00
- $400,000.00
- $200,000.00
- $0.00
- $-$
- $-$
- $-$
- $-$
- $-$
- $-$
- $-$
- $-$
- $-$

Years Treatment Delayed

0 2 4 6 8 10 12 14 16

High
Low
High Spread 70 - No Management - BC Spread - Spurge - Year 40

Leafy Spurge Cover
- Initial
- Established
- Biological control
- Seed bank
- Uninvaded

0 0.5 1 2 3 Miles
Take home messages

• Prevention important to reduce spread rates
• Prioritize small (satellite) patches, then edges of large patches
• Maximize treatment success rates
• Important to detect and track weed locations, including previously treated patches
• Biocontrol important for treating unmanageable infestations and reducing costs
Take home messages

• Can’t eradicate weeds on RMF, but can keep at manageable level
• Smart management results in net positive economic values
• Don’t delay
• At broad scale prioritize relatively uninvaded areas over heavily invaded areas
Long-term success on RMF is within reach – with consistent, strategic effort and modest increase in current capacity we should be able to keep most of the landscape in good condition

So how do we do this?