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

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The Nature Conservancy
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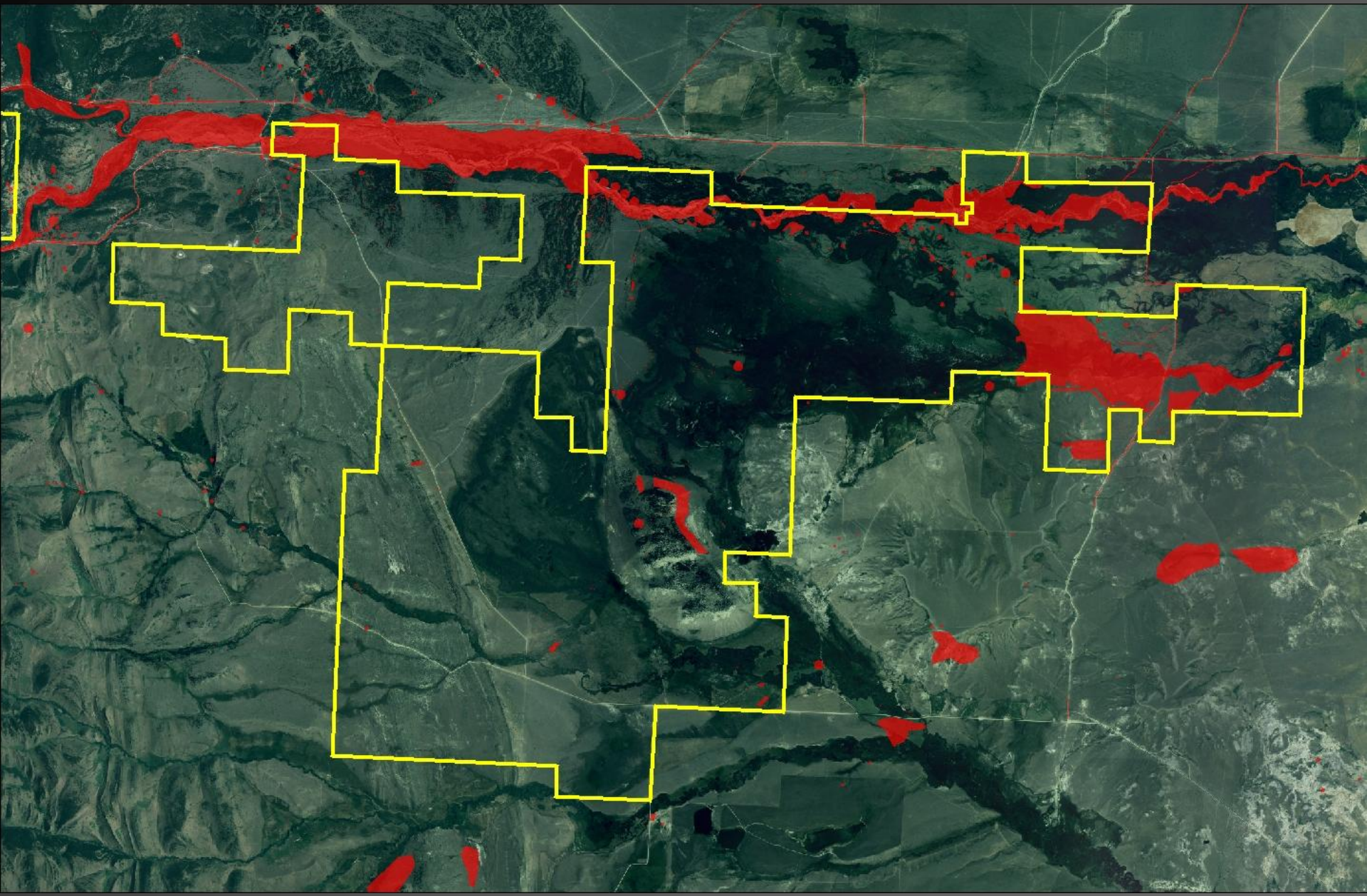
Coming soon to conserveonline.org/workspaces/montanaweedmodel

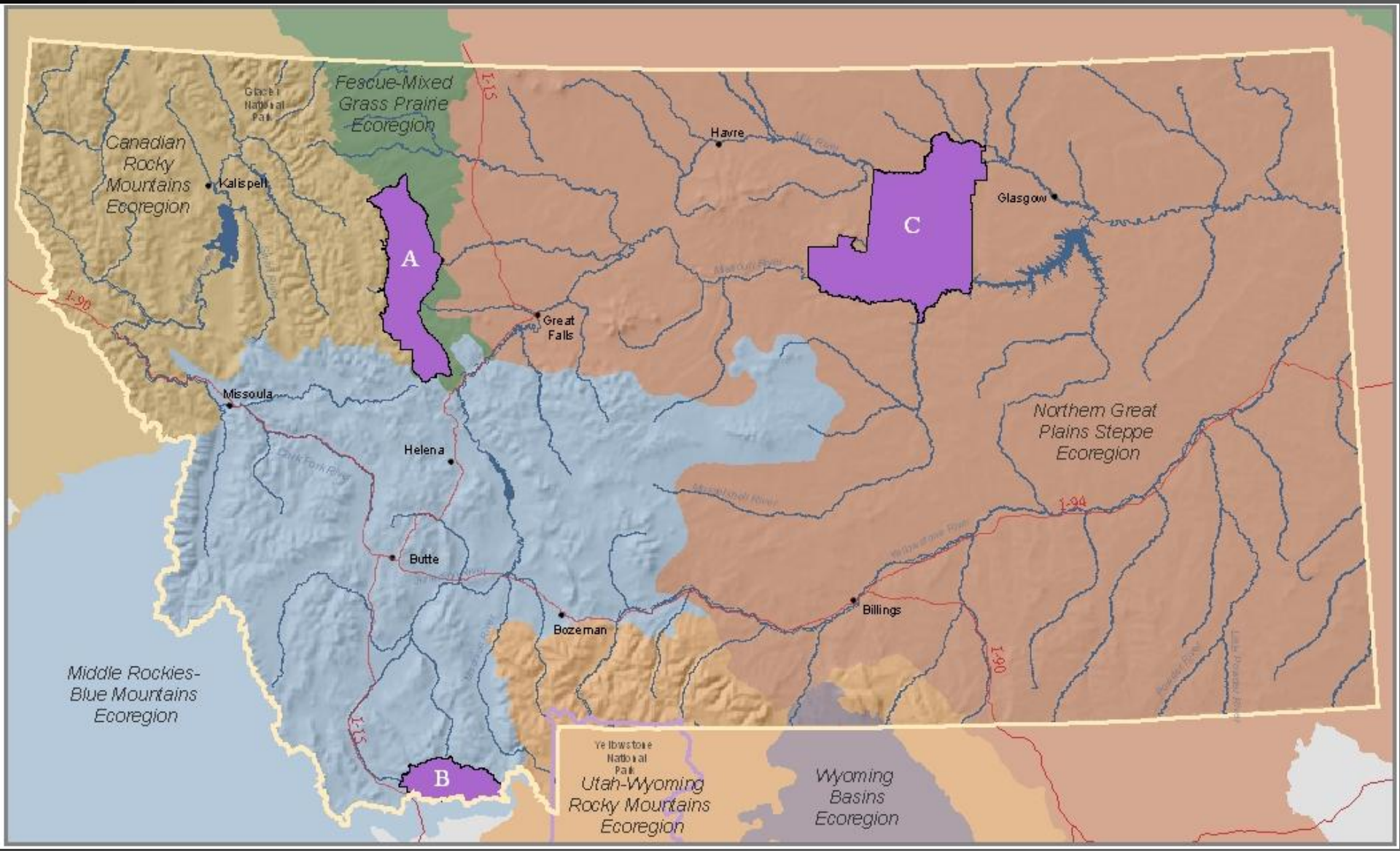
- Final report
- Executive summaries
- Presentations/Figures
- Maps
- Data
- Model Package



Weed Management Progression

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

What Is Best Management Strategy?
What Is Possible?


Fescue-Mixed Grass Prairie Ecoregion
Canadian Rocky Mountains Ecoregion
Glacier National Park
Kalispell
Havre
Glasgow
A
C
Great Falls
Missoula
Helena
Butte
Bozeman
Billings
Northern Great Plains Steppe Ecoregion
Middle Rockies-Blue Mountains Ecoregion
Yellowstone National Park
Utah-Wyoming Rocky Mountains Ecoregion
Wyoming Basins Ecoregion
B
I-15
I-90
I-94

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

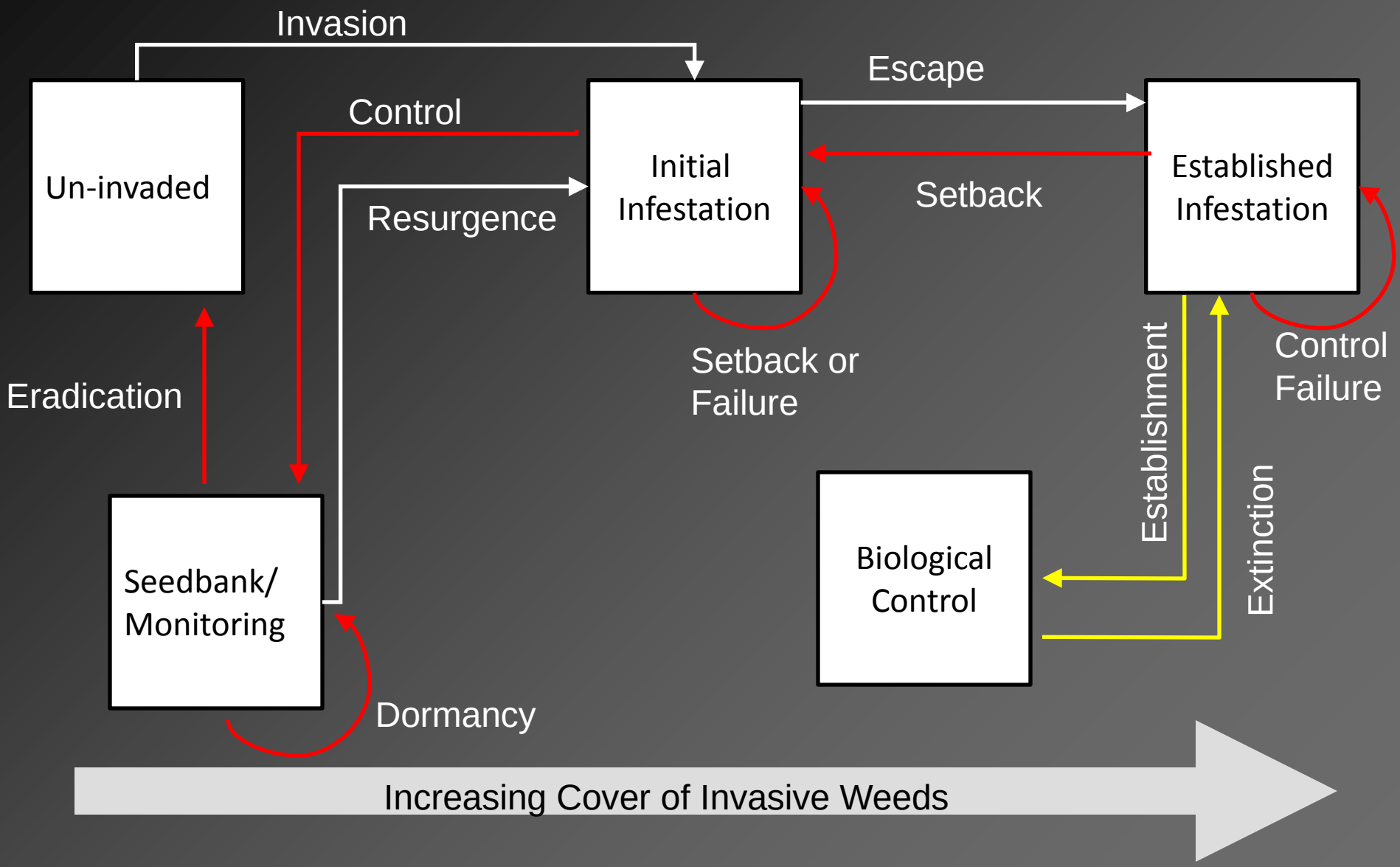
Overview of How the Model Works

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

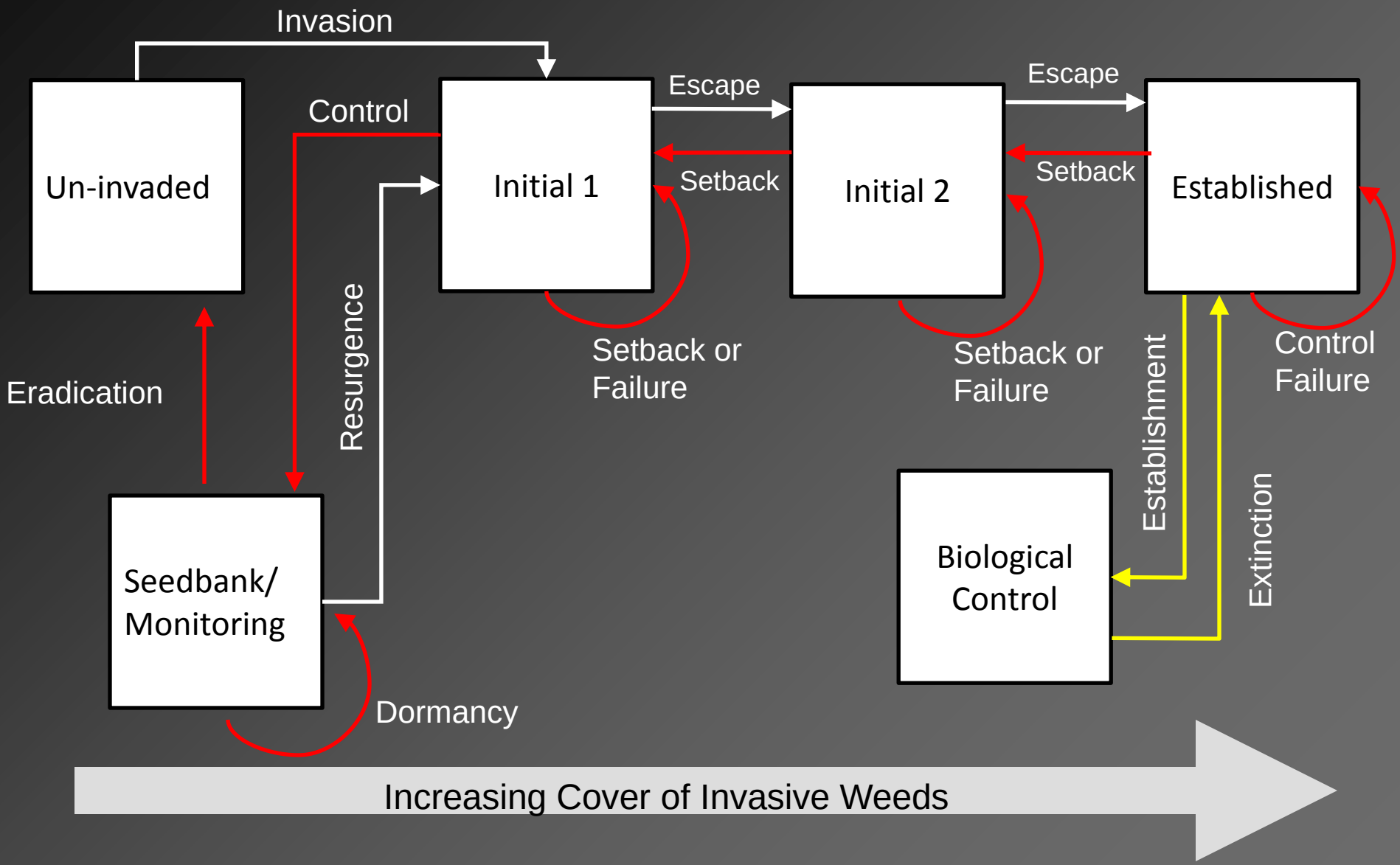
Add data and “rules” to model to give it direction

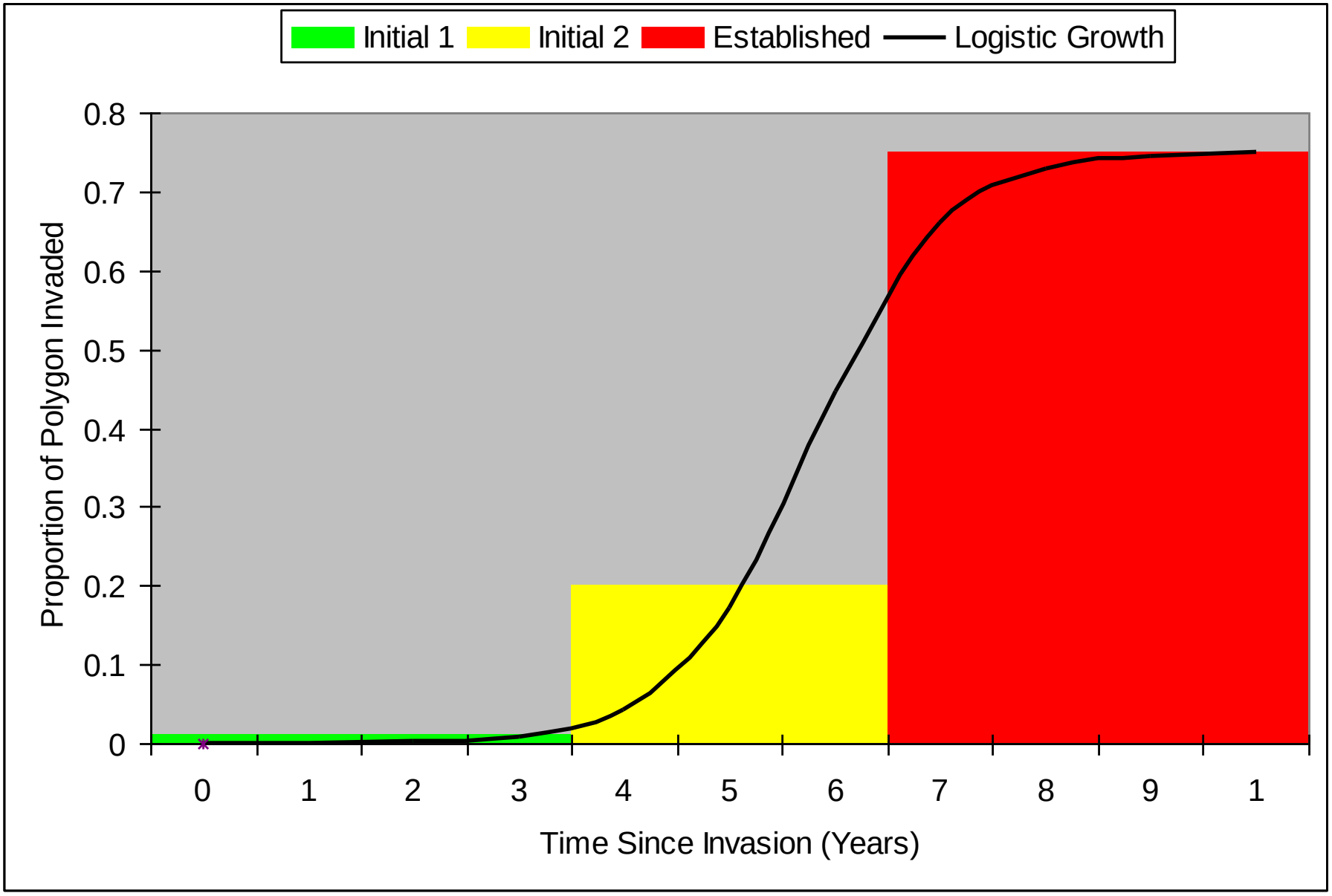
Model runs simulations to predict weed distribution based on data and rules

State and Transition Model



State and Transition Model

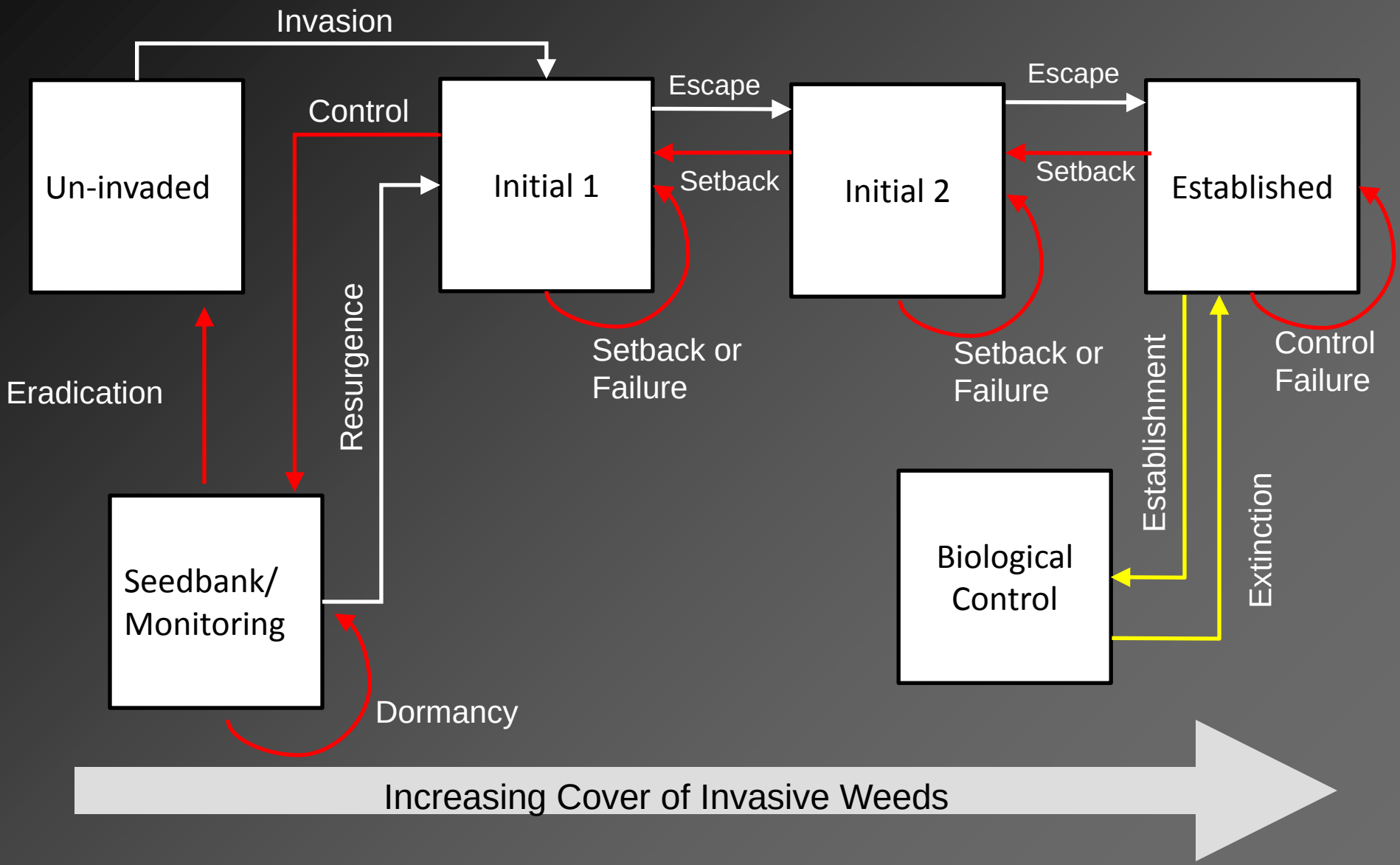



Initial 1
Initial 2
Established
Logistic Growth
Proportion of Polygon Invaded
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9
1
Time Since Invasion (Years)

Model Parameters

- Spread Rates
- Control Effectiveness
- Factors that affect Spread Rates
  - Vegetation Susceptibility
  - Spread Vectors
- Biocontrol Establishment, Spread, and Extinction Rates

State and Transition Model



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

Gravel Riparian

Riparian

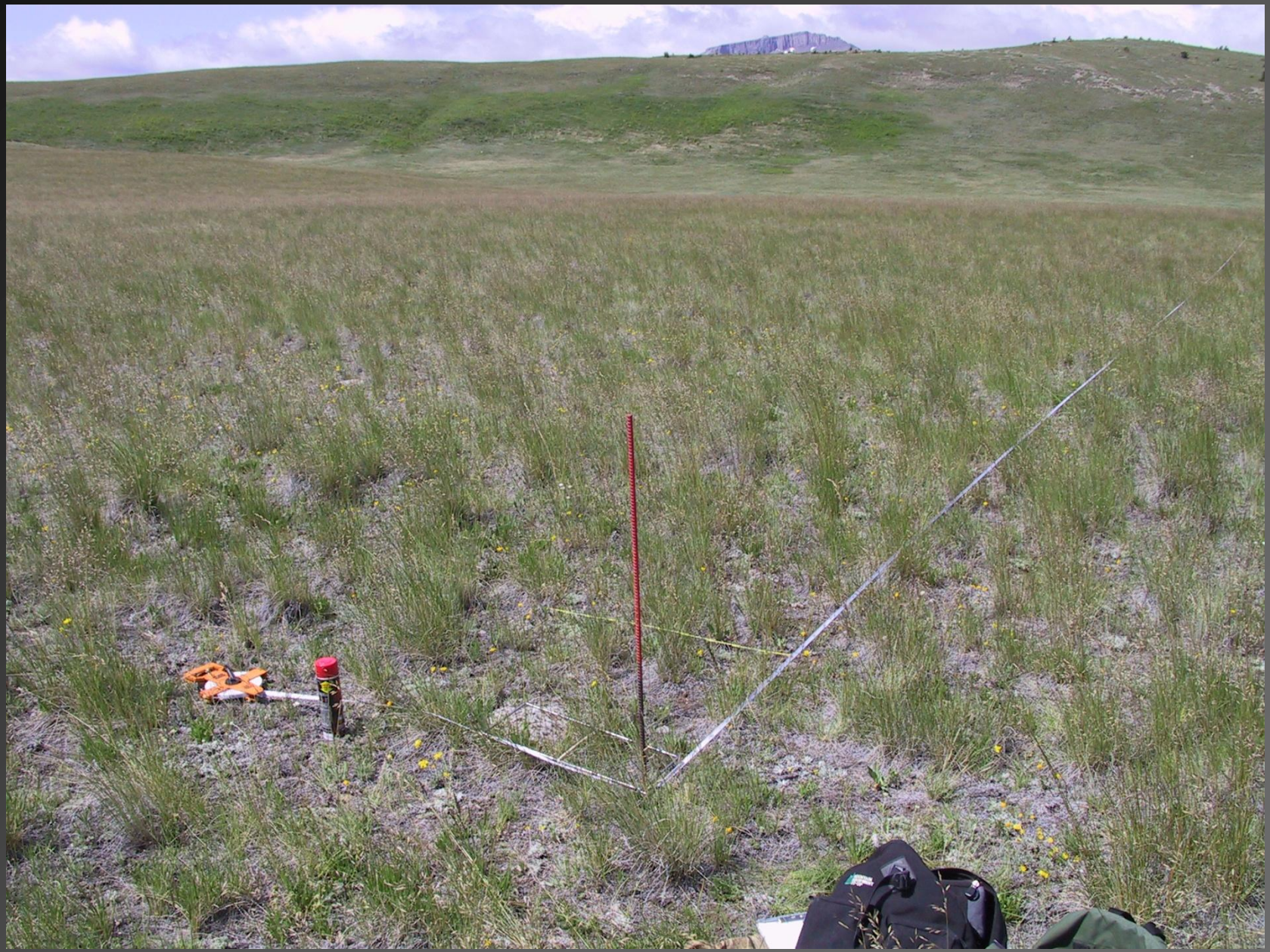
Tamegrass

Tamegrass

Limber Pine

Limber Pine

Fescue



Mixed Grass

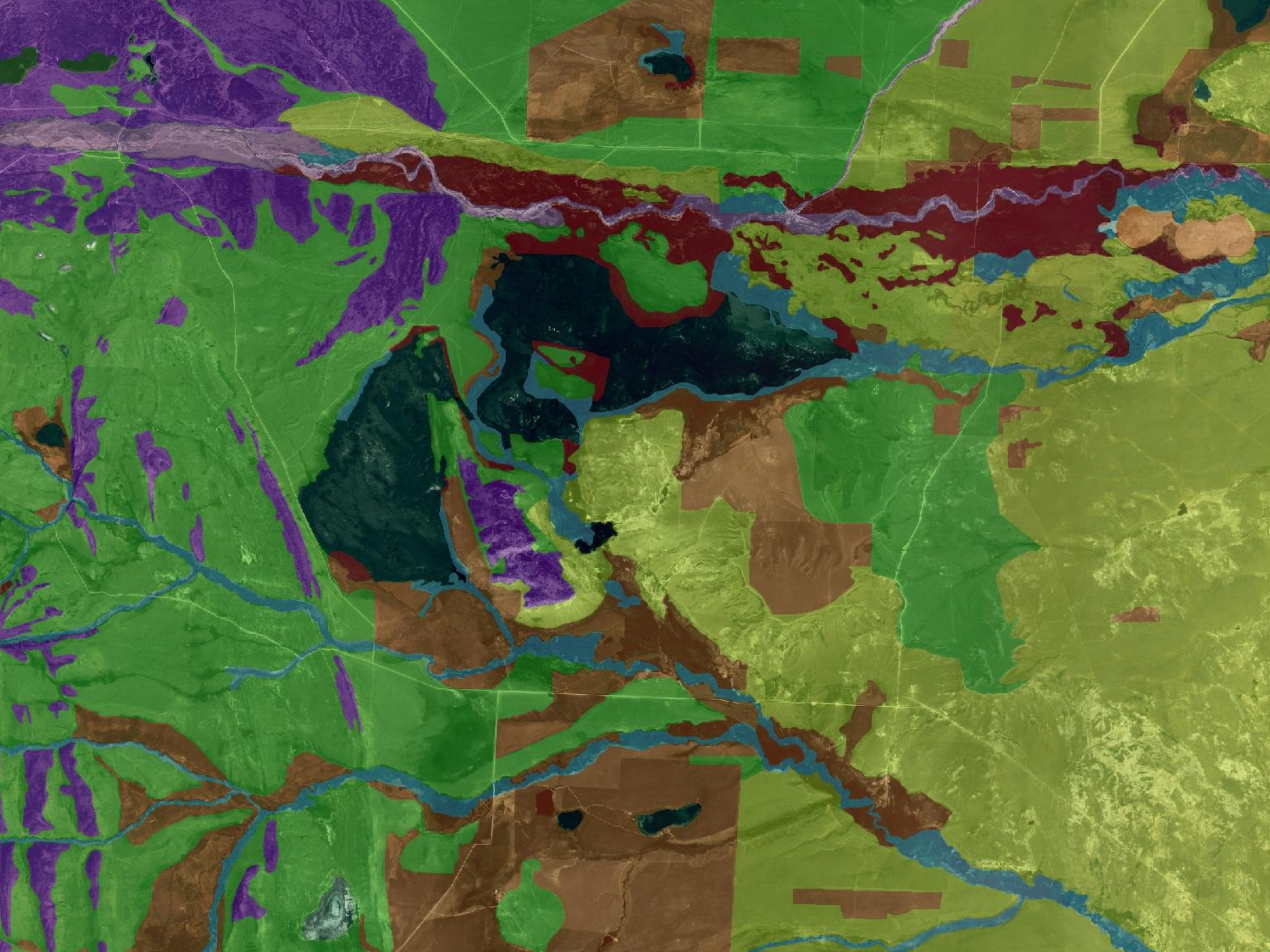
Aspen

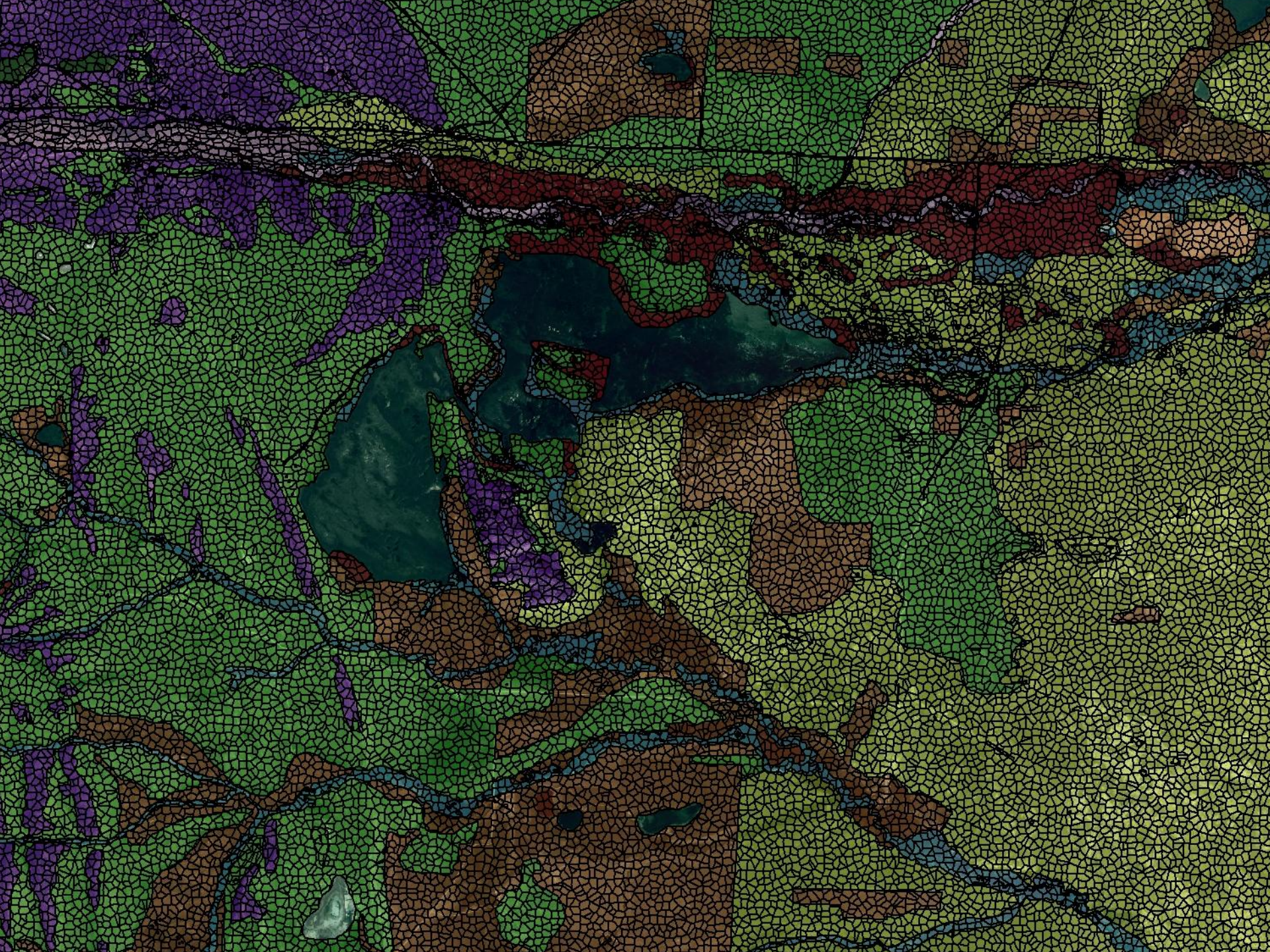
Conifer

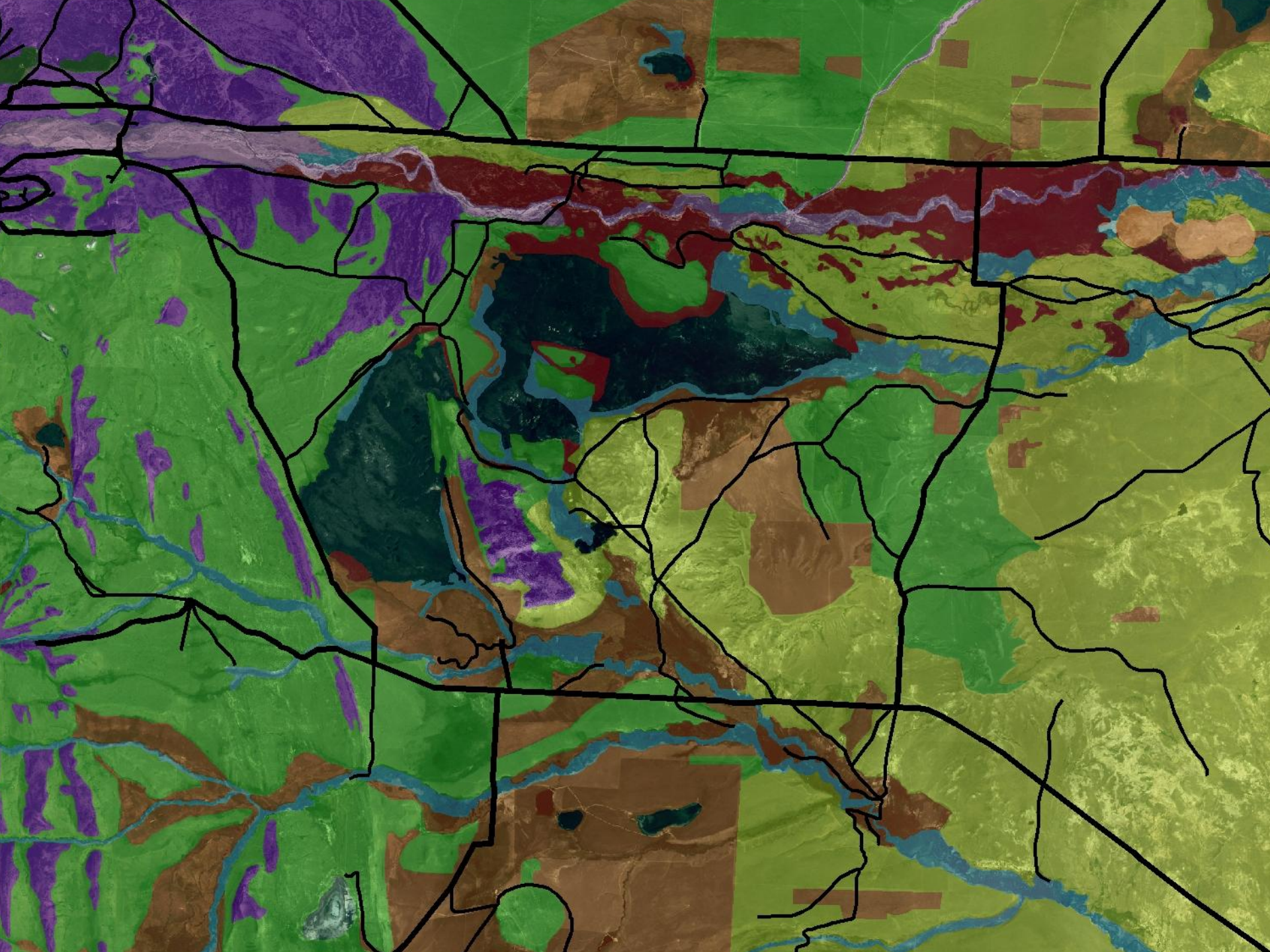
Conifer

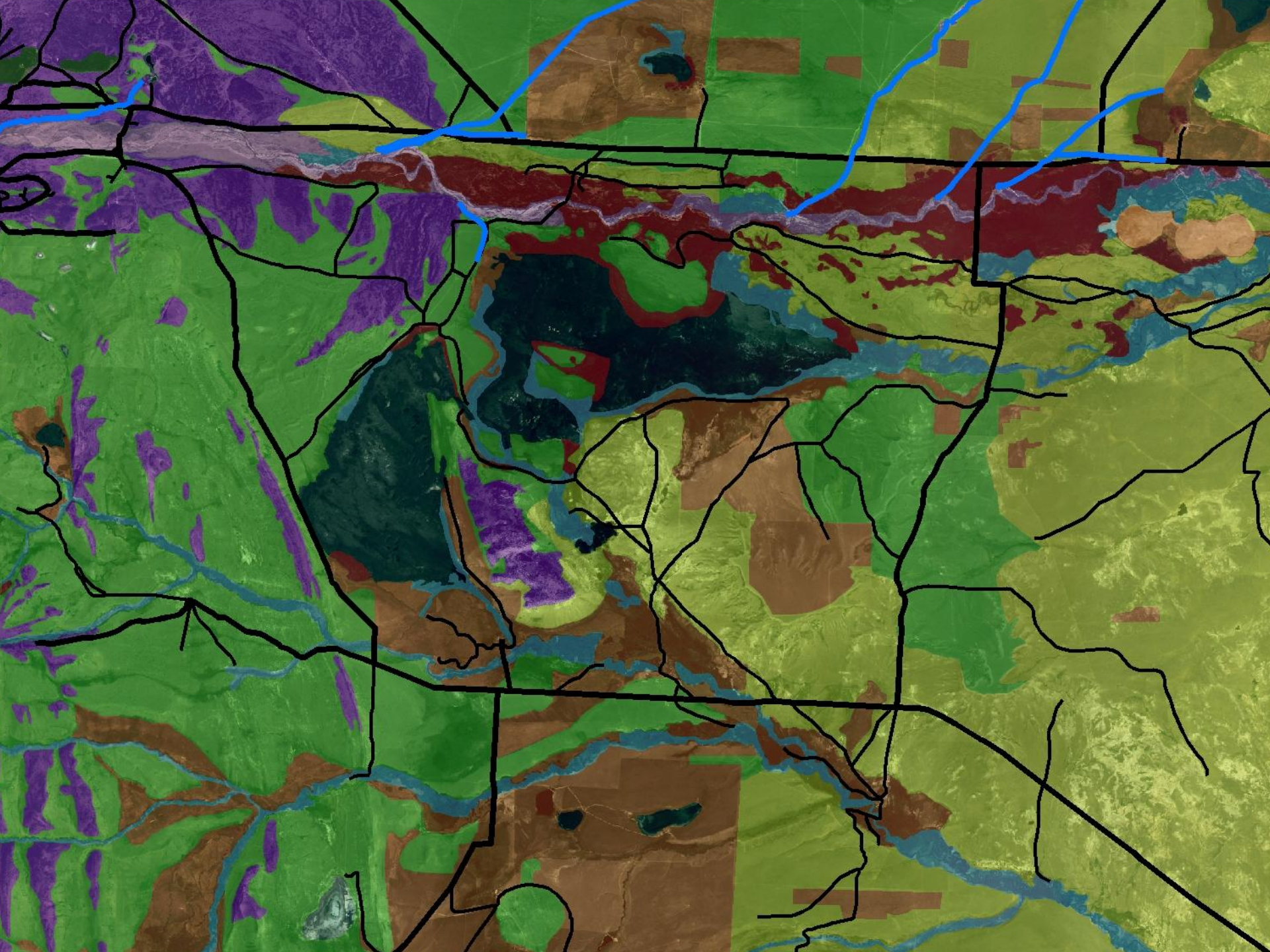
No Weeds In:

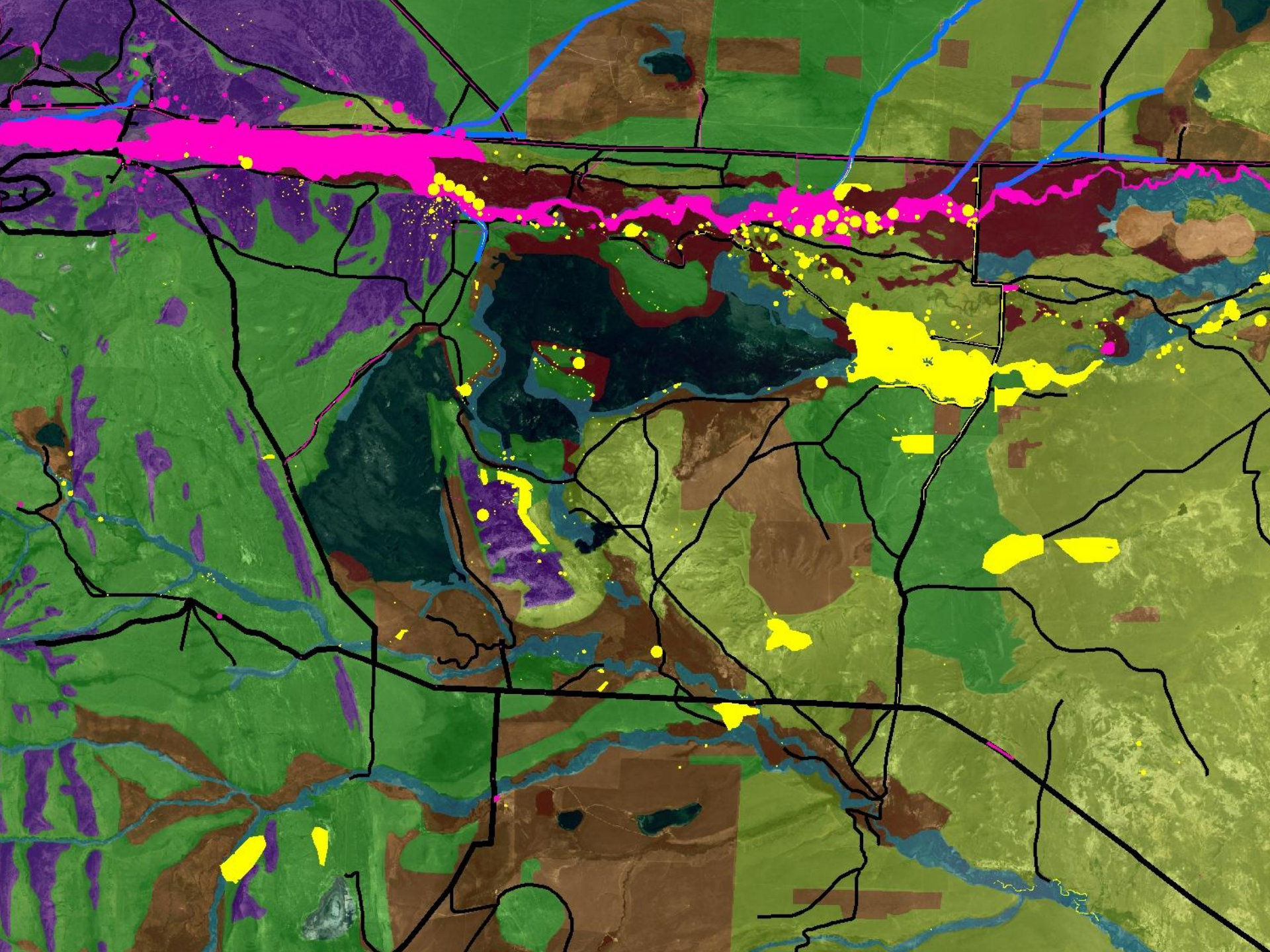
- Water
- Wetland
- Annual Cropland
- Rock

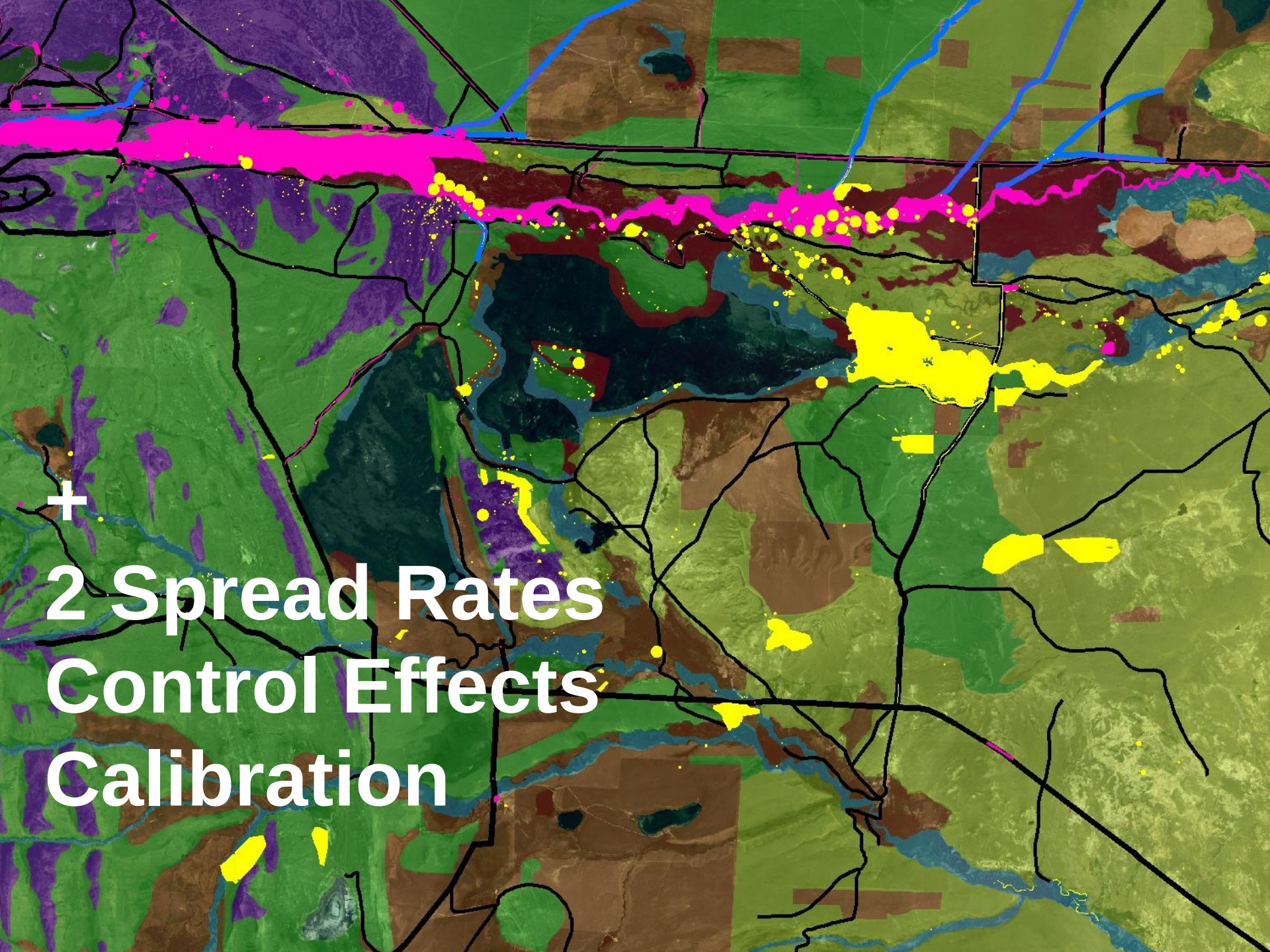


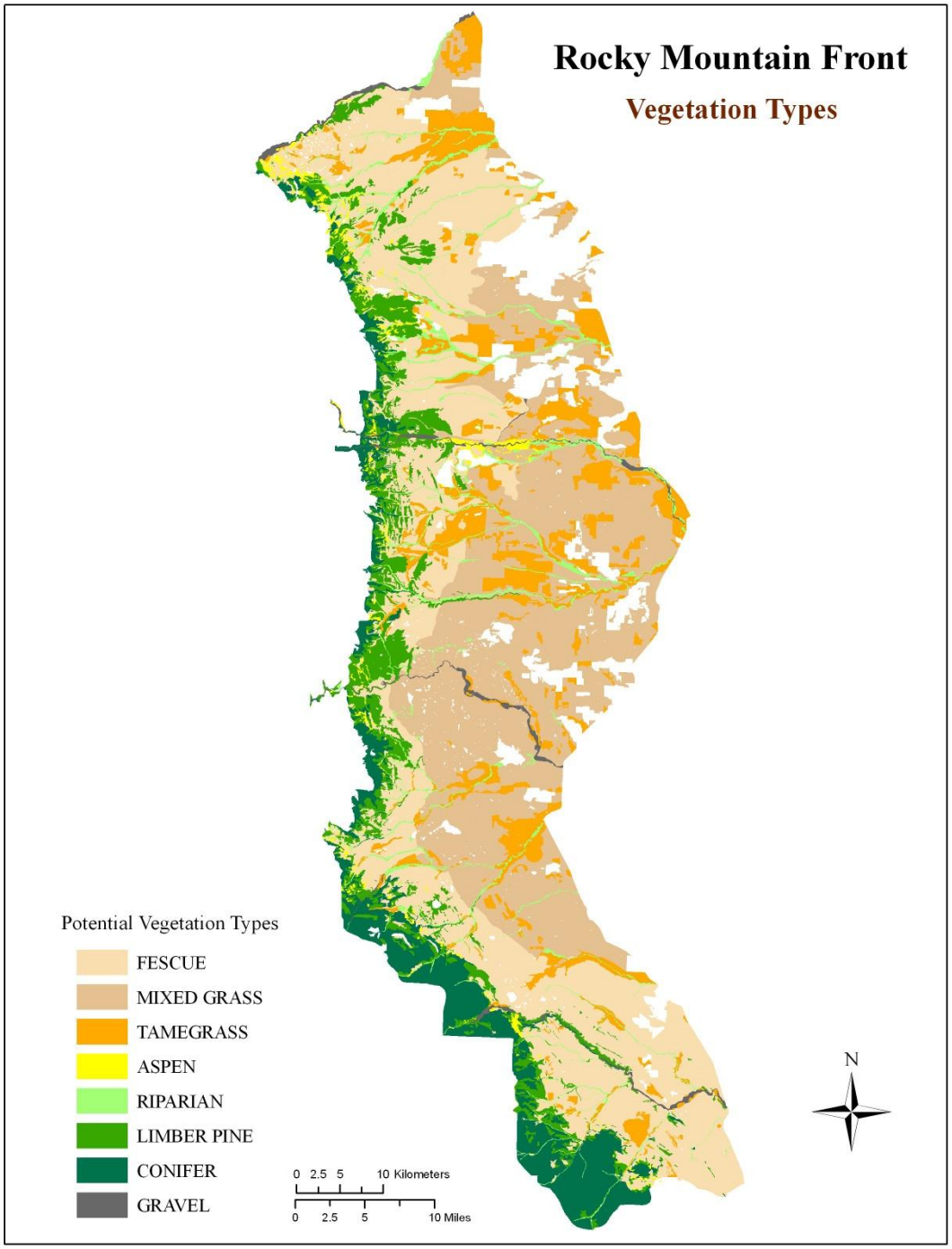






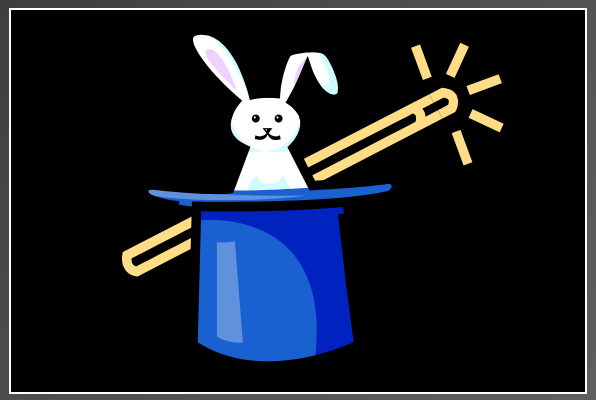


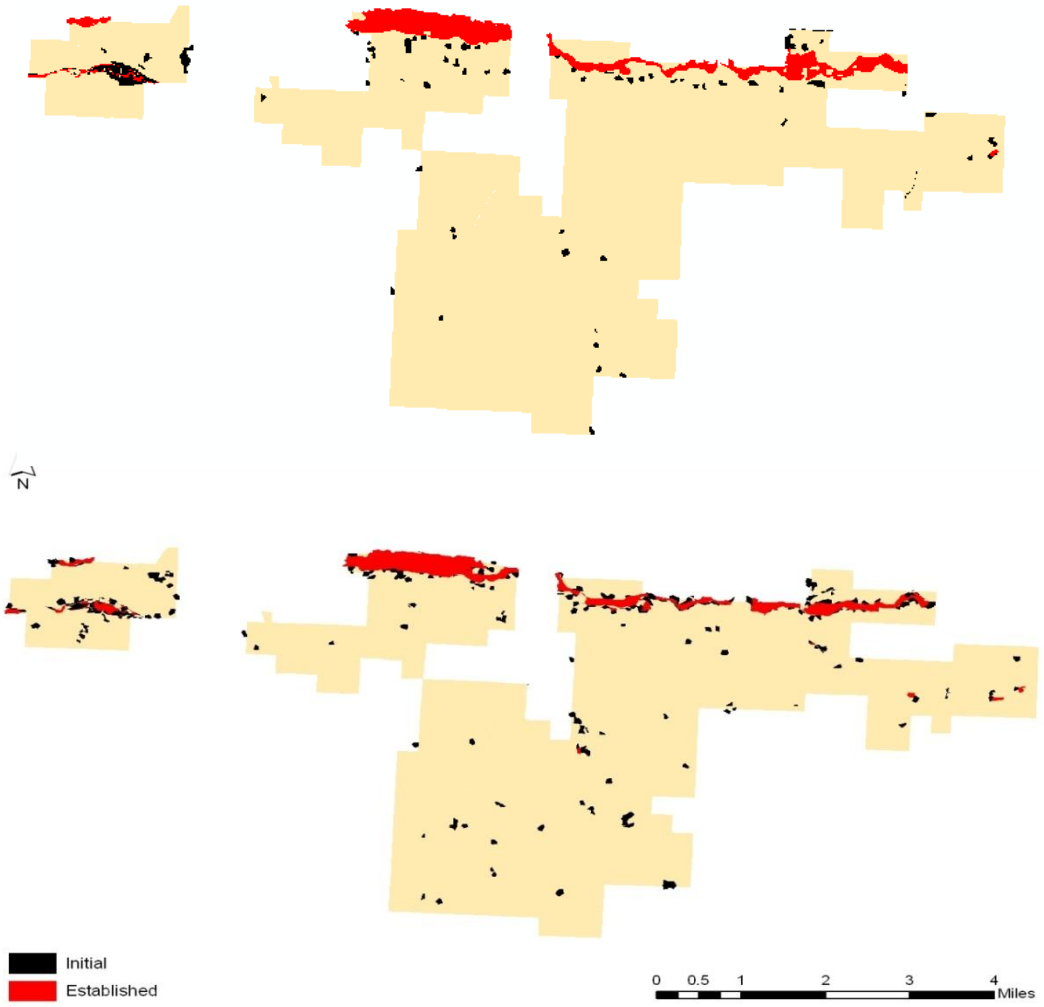

+
2 Spread Rates
Control Effects
Calibration


Rocky Mountain Front
Vegetation Types
Potential Vegetation Types
FESCUE
MIXED GRASS
TAMEGRASS
ASPEN
RIPARIAN
LIMBER PINE
CONIFER
GRAVEL
0 2.5 5 10 Kilometers
0 2.5 5 10 Miles
N

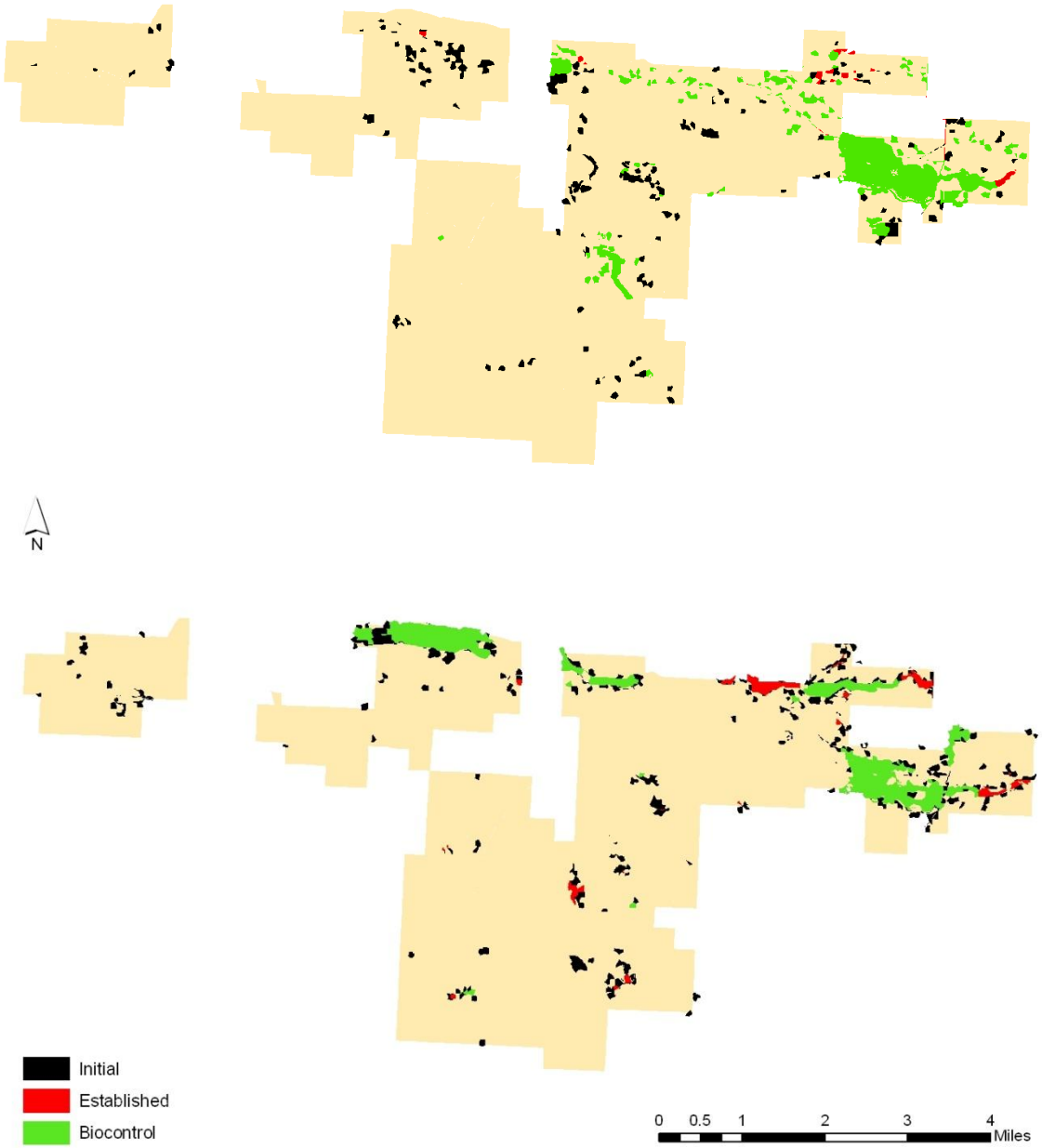
Reality Check

Not a Magic Black Box!

Data →  → **Truth**

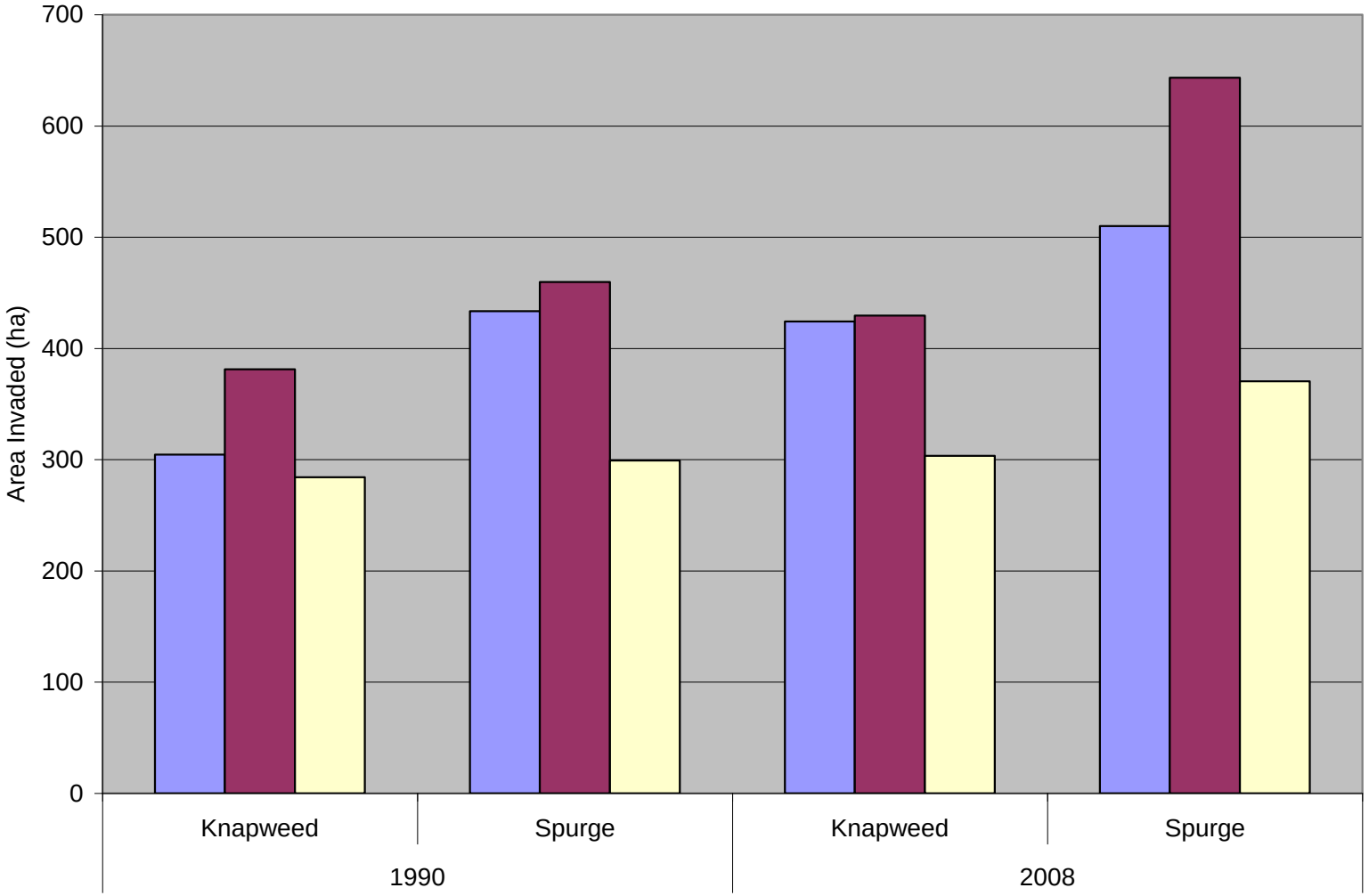


Knapweed Calibration



Spurge Calibration

Calibration Results
Actual vs. High Spread vs. Low Spread

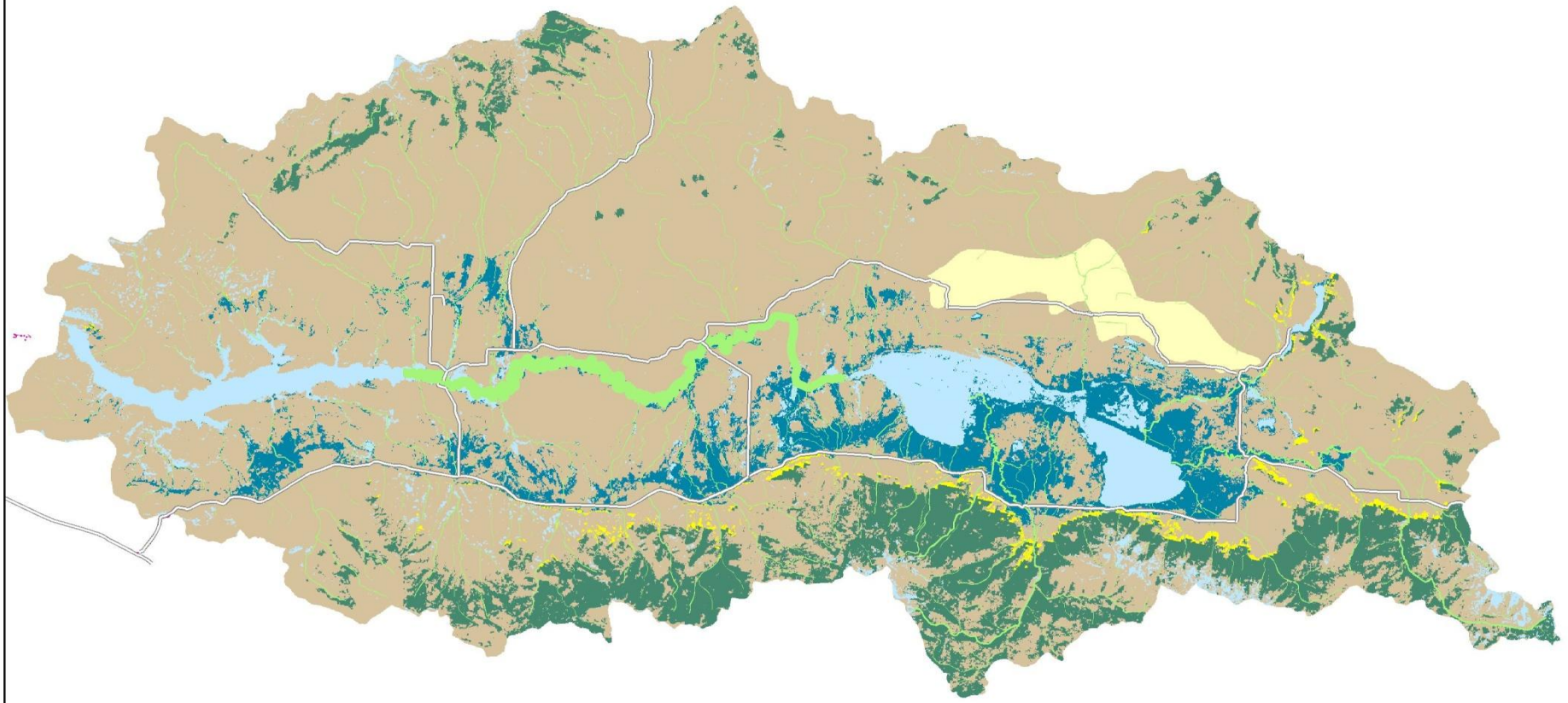


First Generation Management Scenarios

- **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

Vegetation Types



Potential Vegetation Types

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

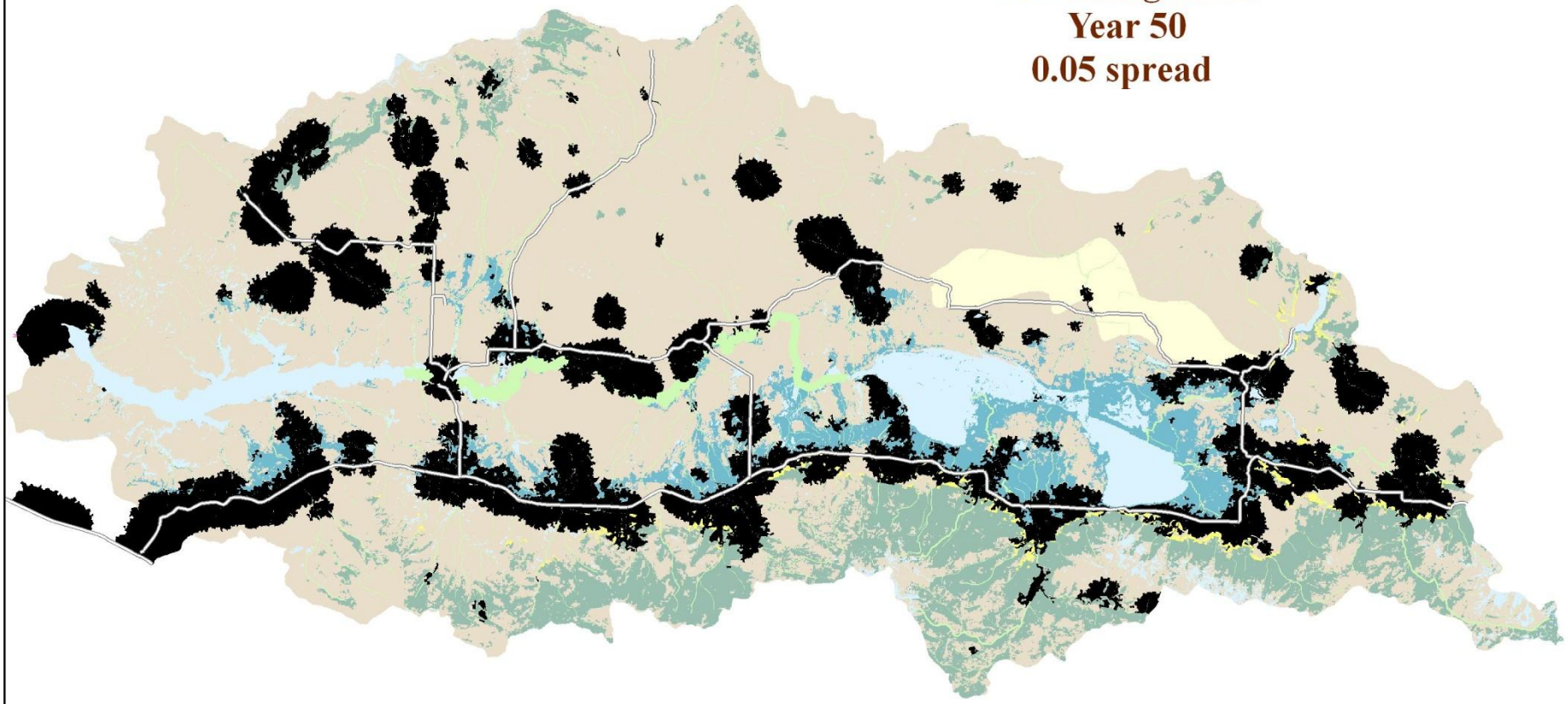
0 2.5 5 10 Kilometers

0 2.5 5 10 Miles

N

Centennial Valley - TELSA Weed Model

Initial & Established Knapweed
-- No Management --
Year 50
0.05 spread



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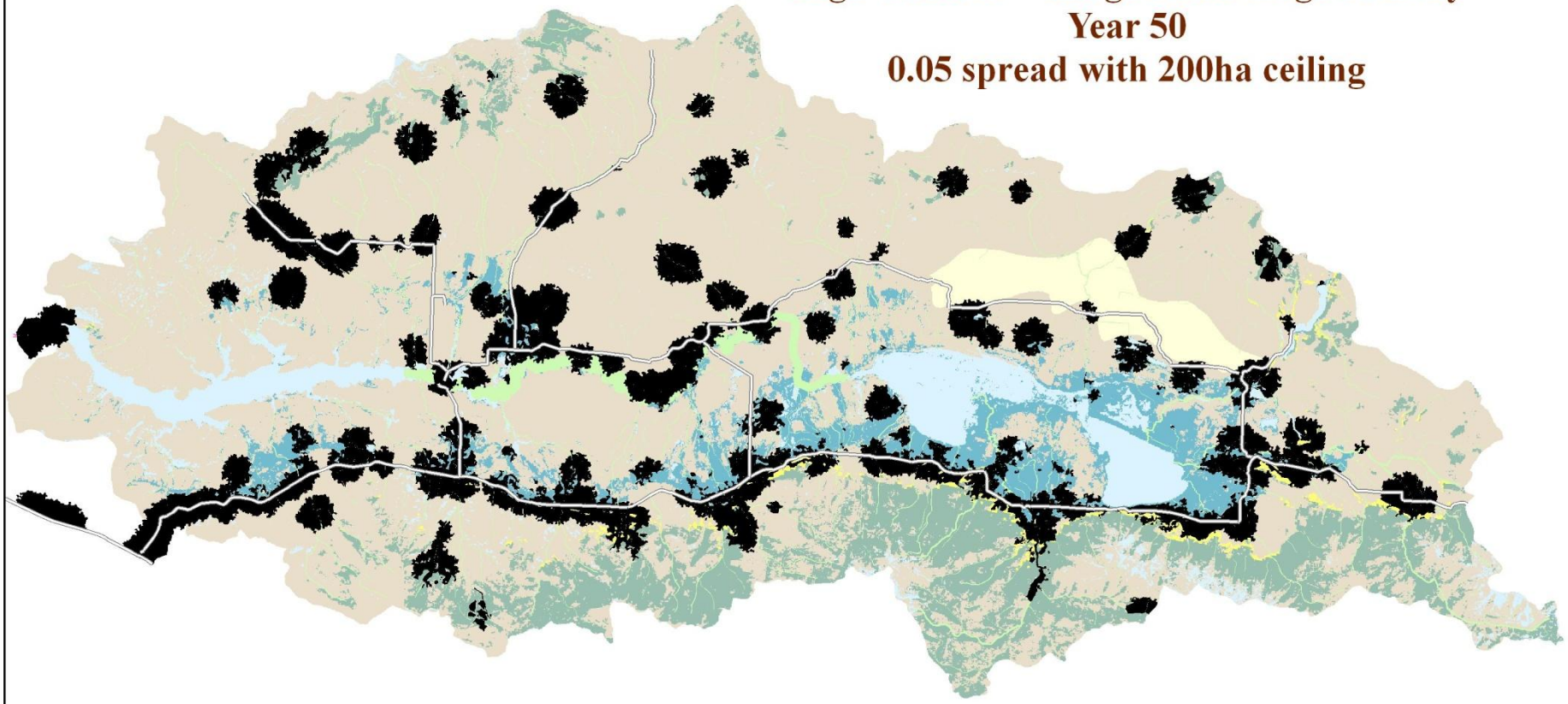
N

Centennial Valley - TELSA Weed Model

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



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- Conifer
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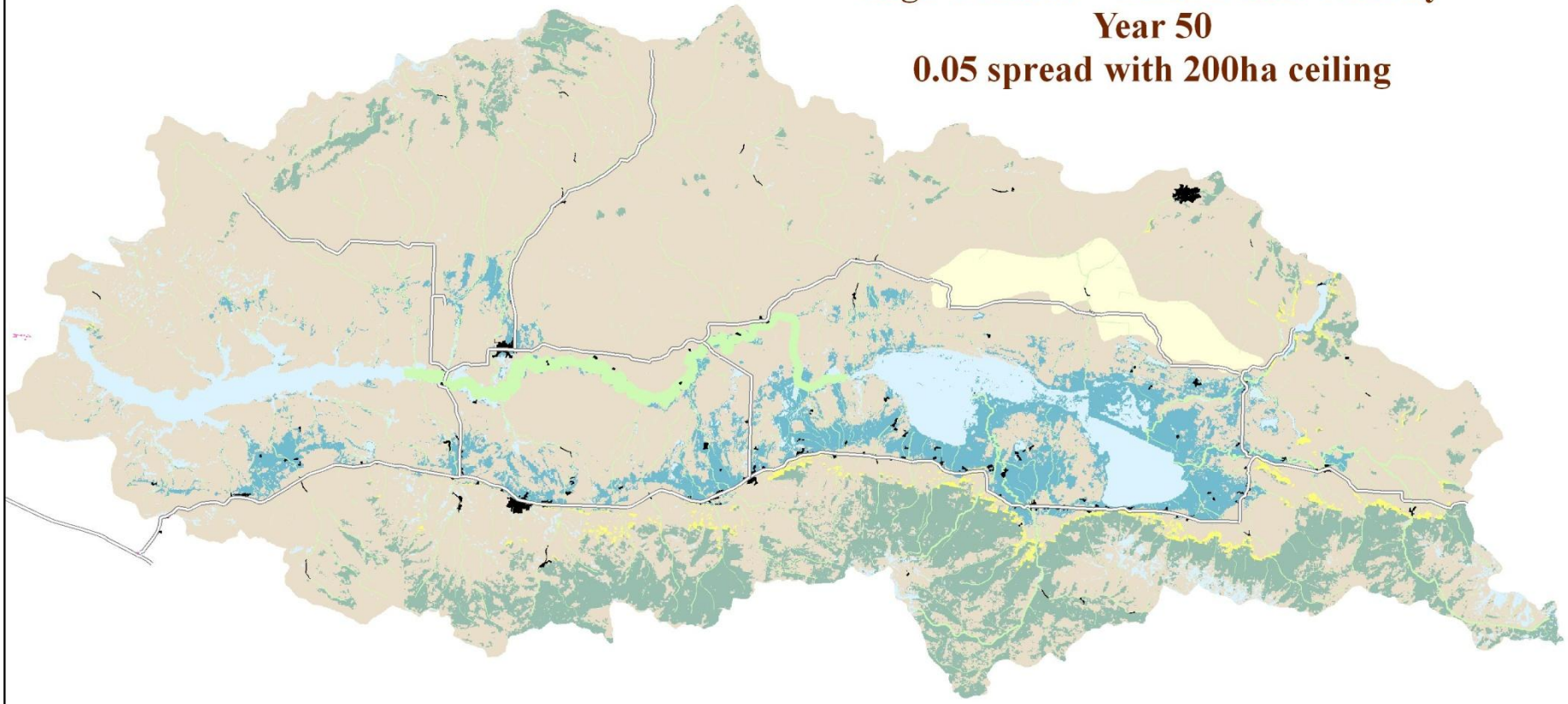
0 2.5 5 10 Kilometers

0 2.5 5 10 Miles

N

Centennial Valley - TELSA Weed Model

Seedbank, Initial & Established Knapweed
-- High Control -- Small Patch Priority --
Year 50
0.05 spread with 200ha ceiling



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- Riparian
- Conifer
- Unprojectable

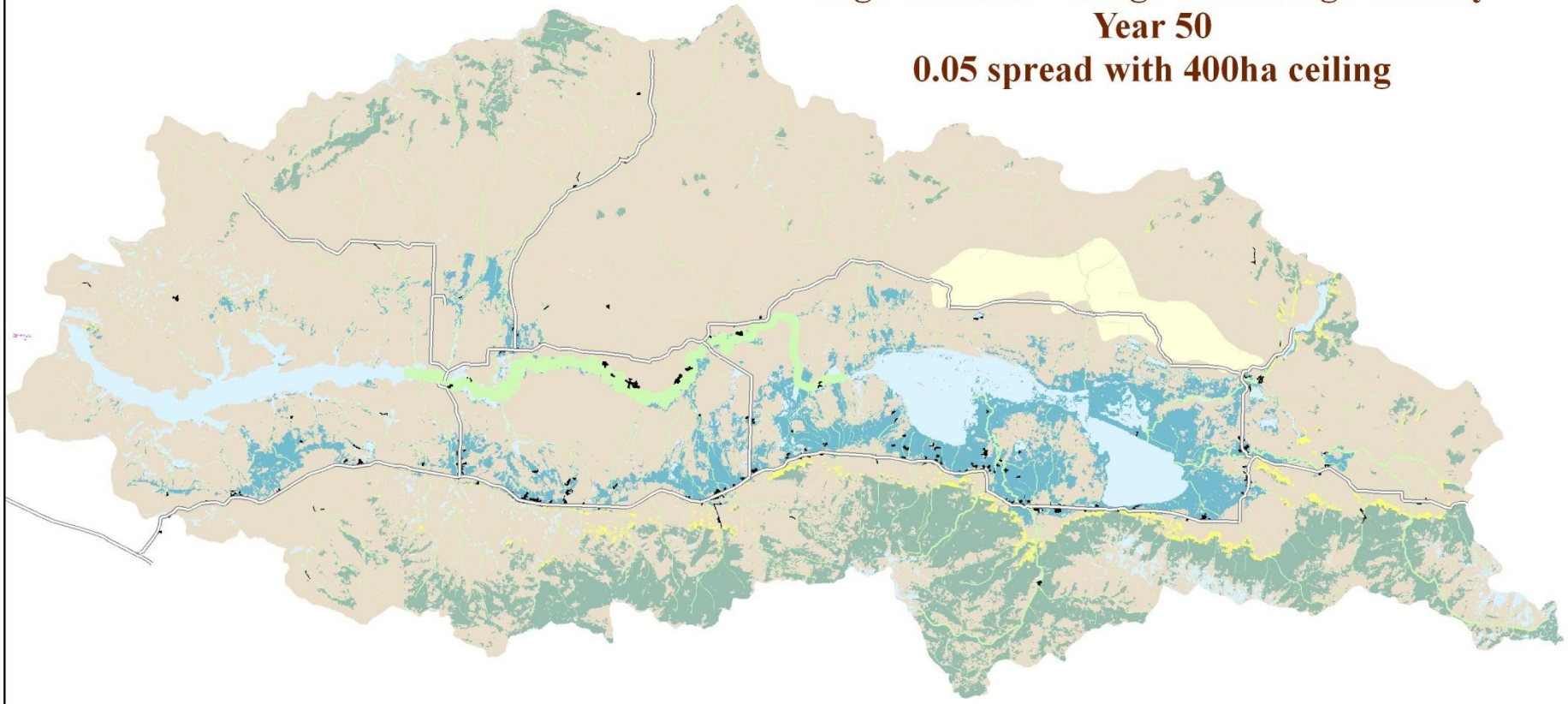
0 2.5 5 10 Kilometers

0 2.5 5 10 Miles

N

Centennial Valley - TELSA Weed Model

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



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0 2.5 5 10 Kilometers

0 2.5 5 10 Miles

N

Centennial Valley - TELSA Weed Model

Seedbank & Initial Knapweed
-- High Control -- Small Patch Priority --
Year 50
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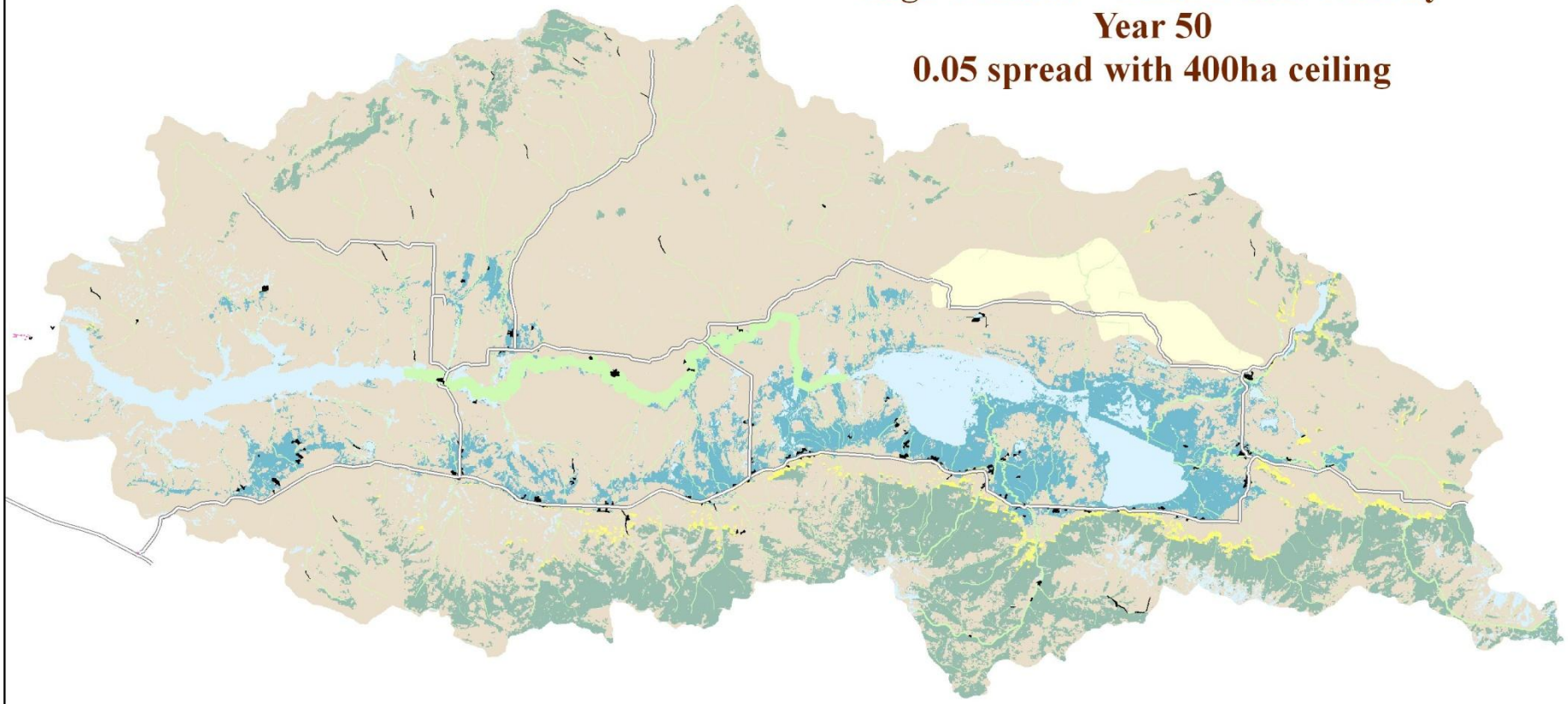

Potential Vegetation Types

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- Aspen
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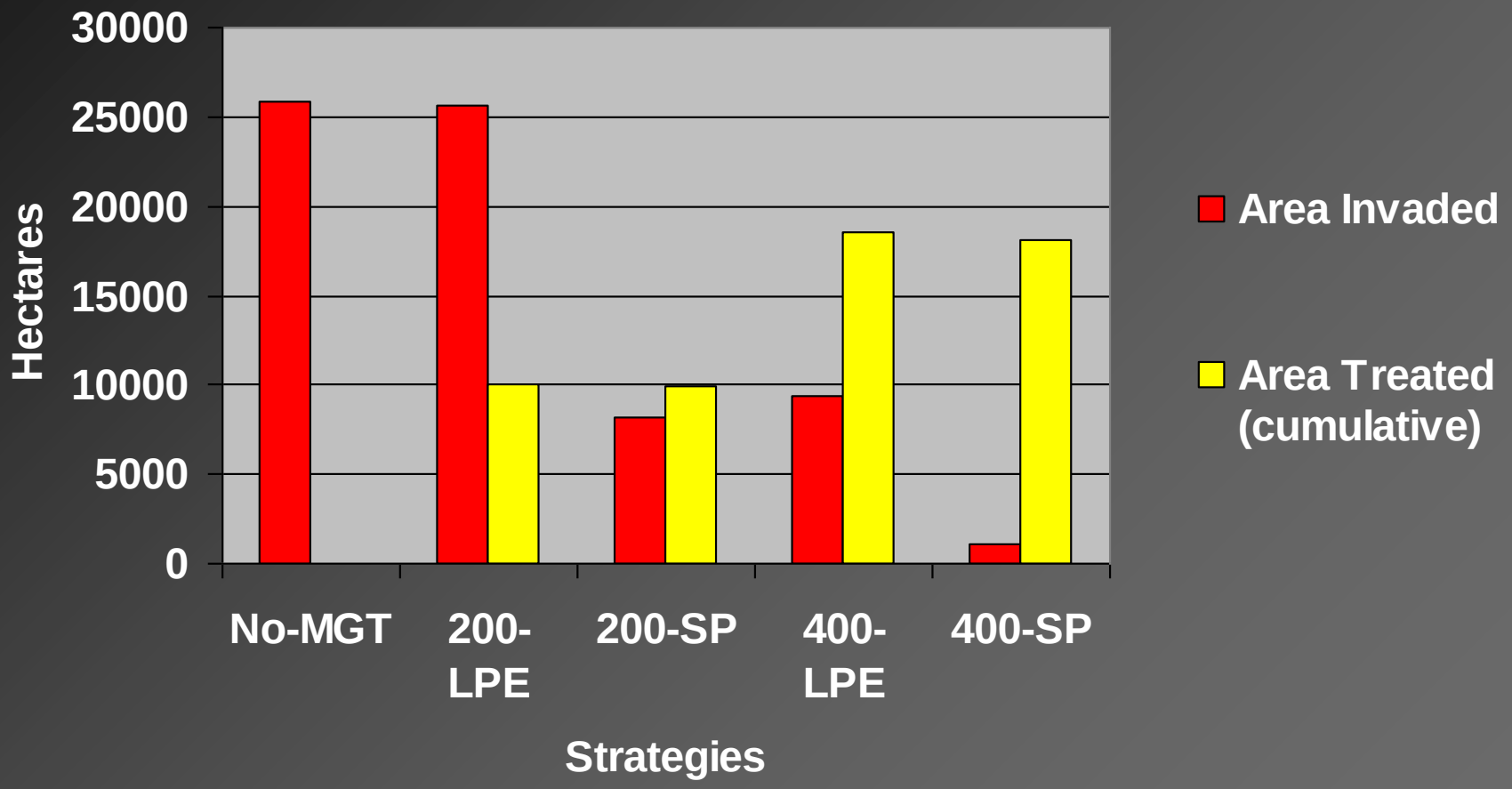
- Unprojectable

0 2.5 5 10 Kilometers

0 2.5 5 10 Miles

N

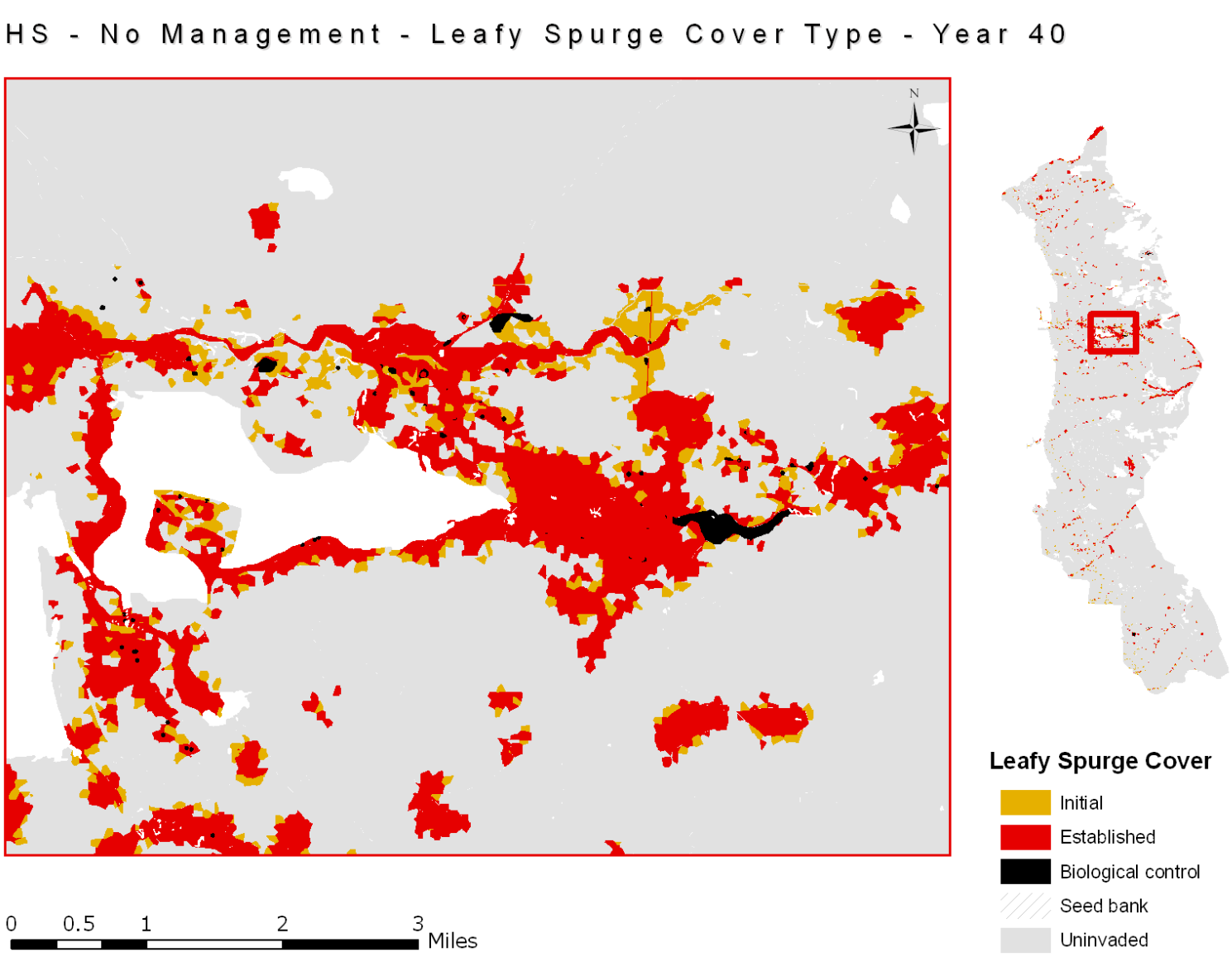
Area Invaded and Treated After 50 Years
Centennial Valley
Spotted Knapweed - High Spread/Low Control



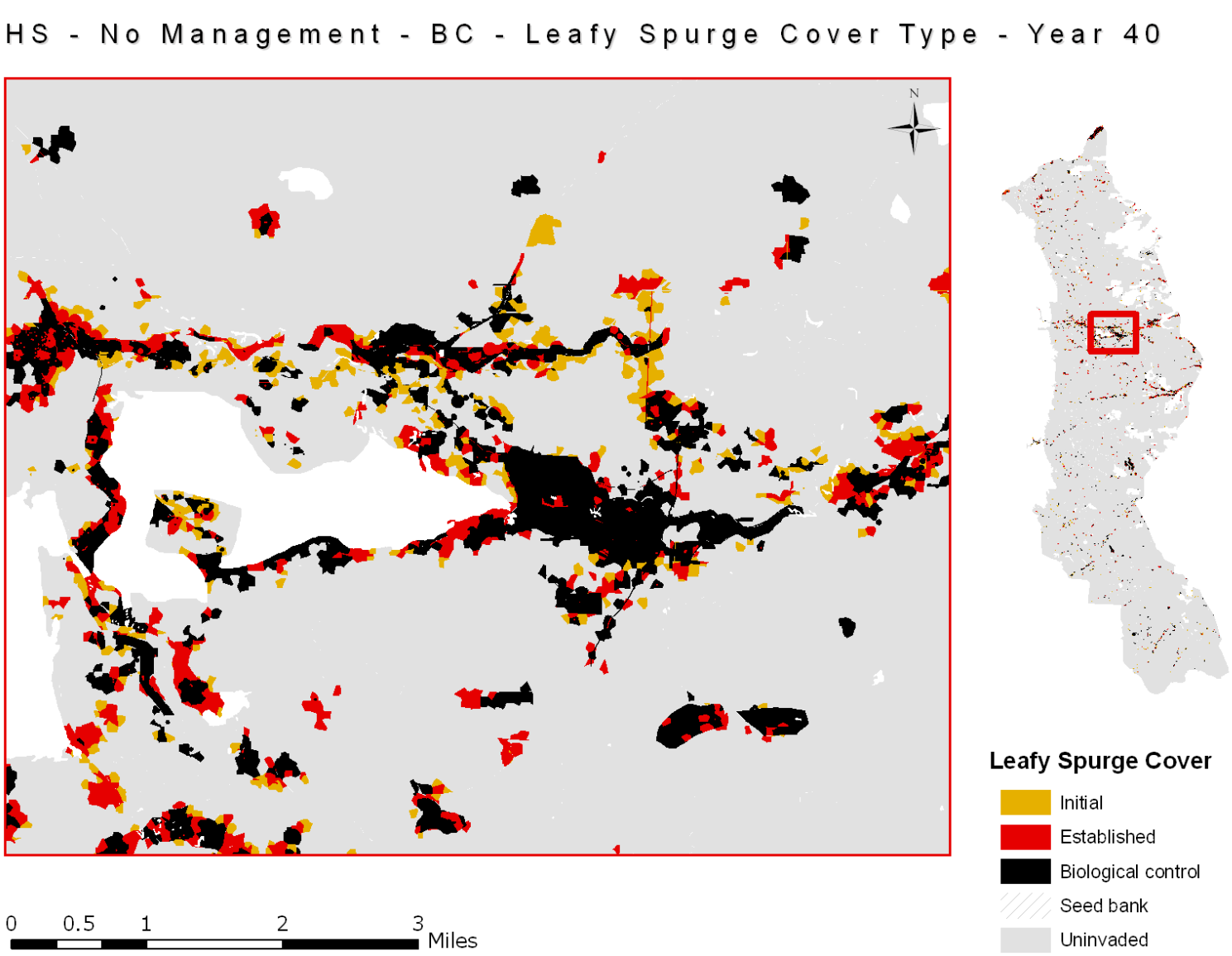
Initial Results - RMF

- 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)

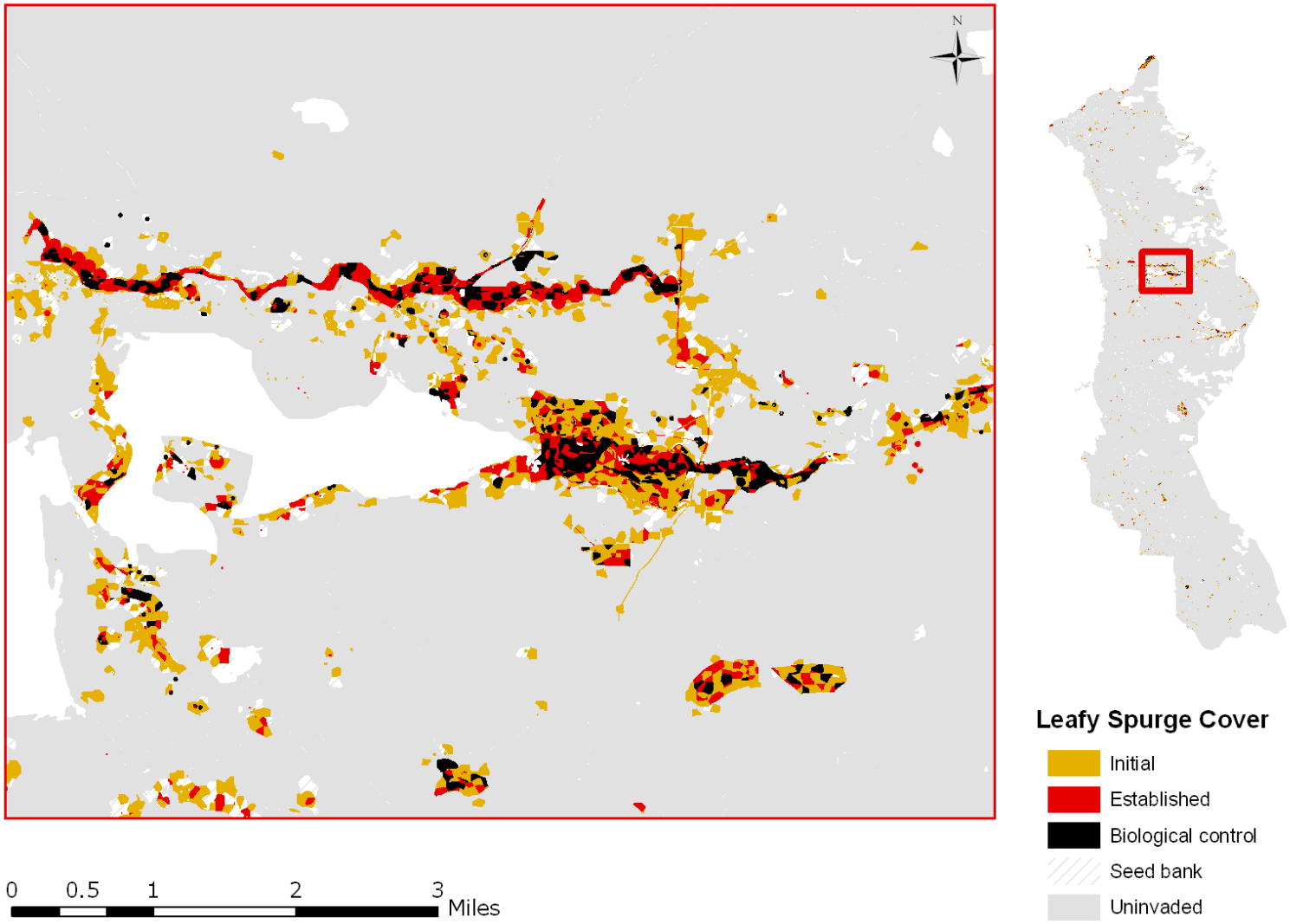
No Management – No Biocontrol



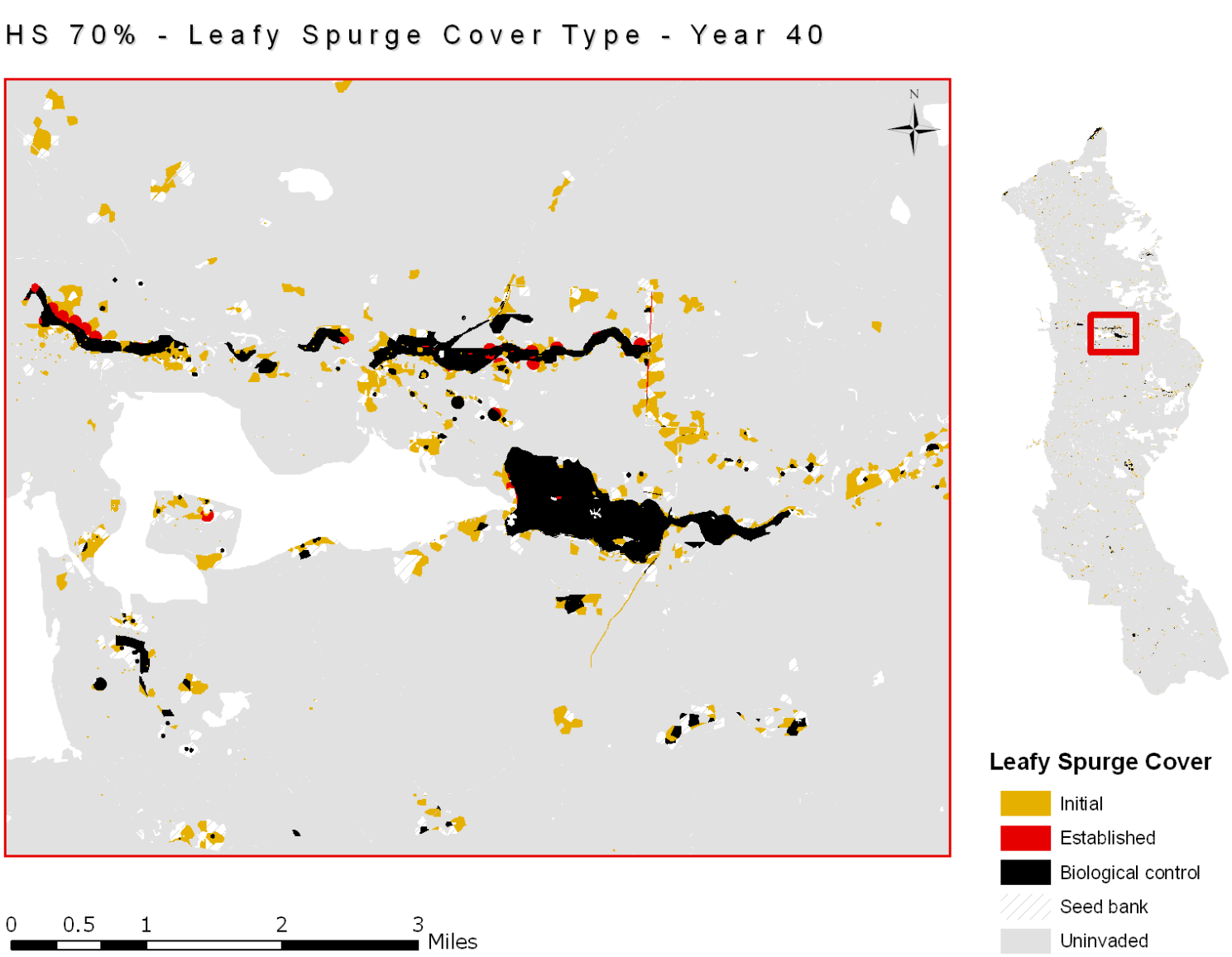
No Management except Biocontrol



Chemical Management – No Biocontrol



Chemical Management and Biocontrol



Initial Results - Biocontrol

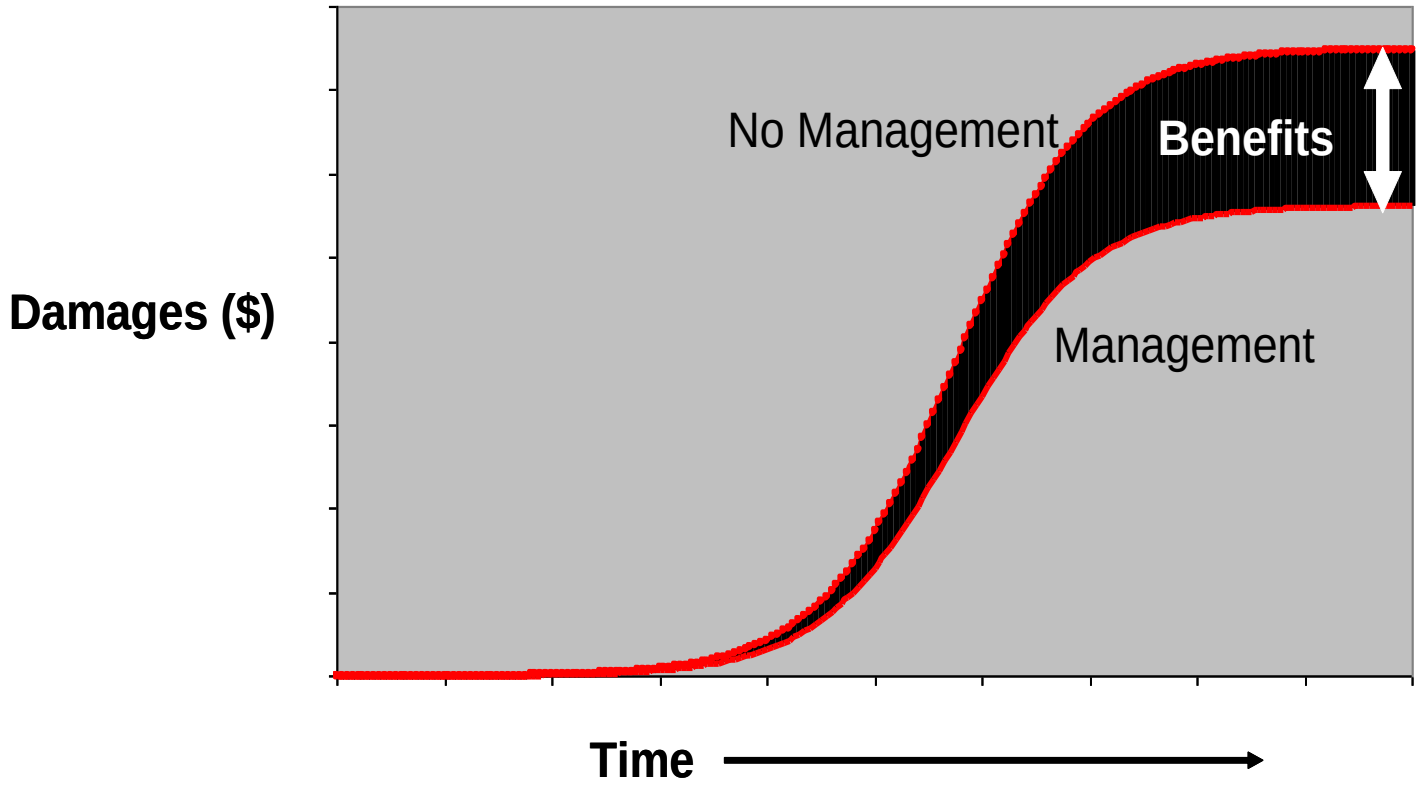
- Biocontrol is a key component of integrated management, especially within landscapes with large infestations where chemical control is not cost effective

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

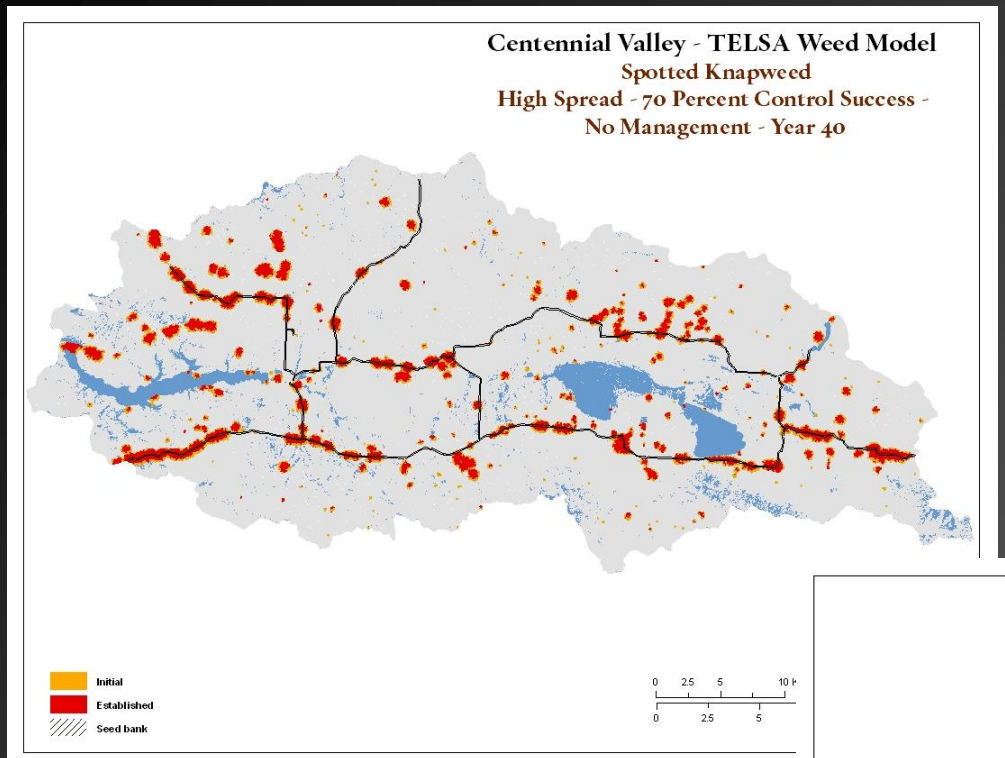
Measures

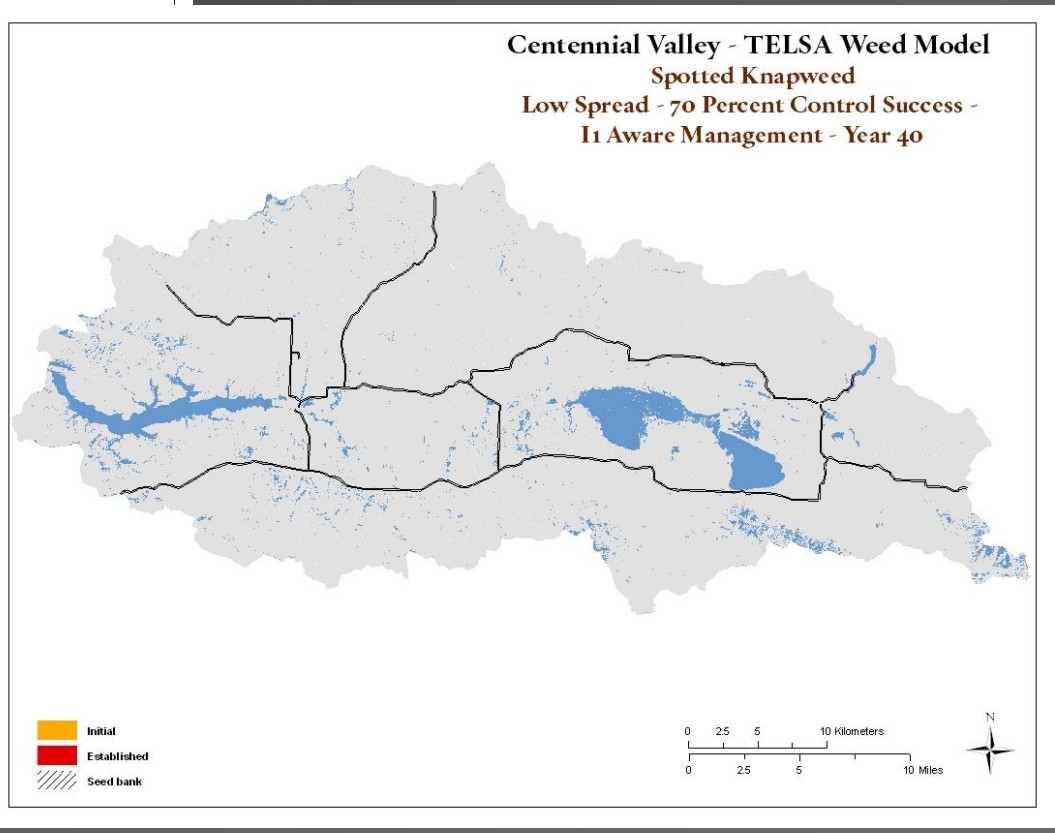
- **What is most effective strategy?**
  - Total Area Invaded
  - Cumulative area treated
- **Economic analysis**
  - Treatment cost
  - Grazing value

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
Initial
Established
Seed bank
0 2.5 5
0 2.5 5


Centennial Valley - TELSA Weed Model
Spotted Knapweed
Low Spread - 70 Percent Control Success -
I1 Aware Management - Year 40
Initial
Established
Seed bank
0 2.5 5 10 Kilometers
0 2.5 5 10 Miles
N

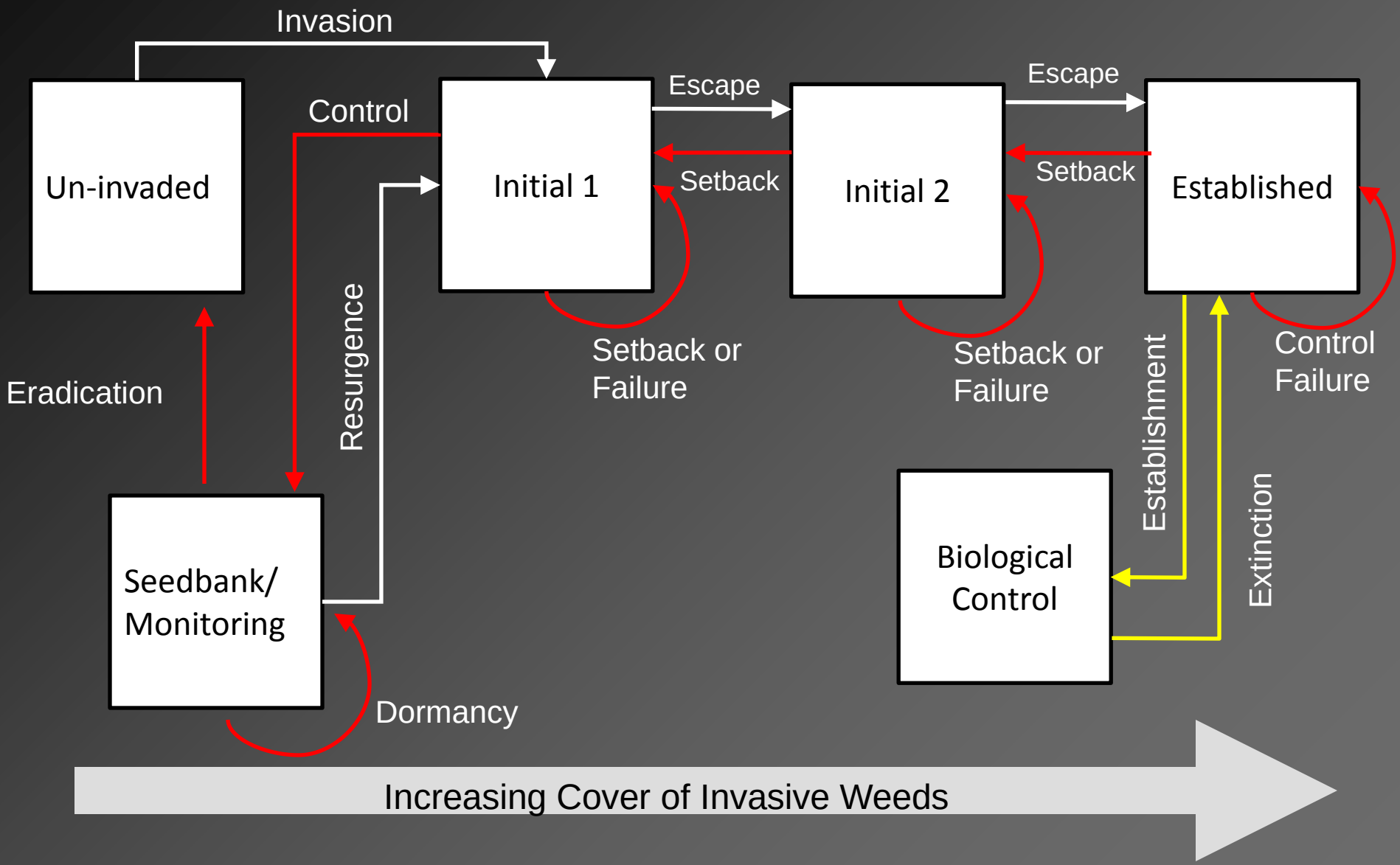
Economic Inputs

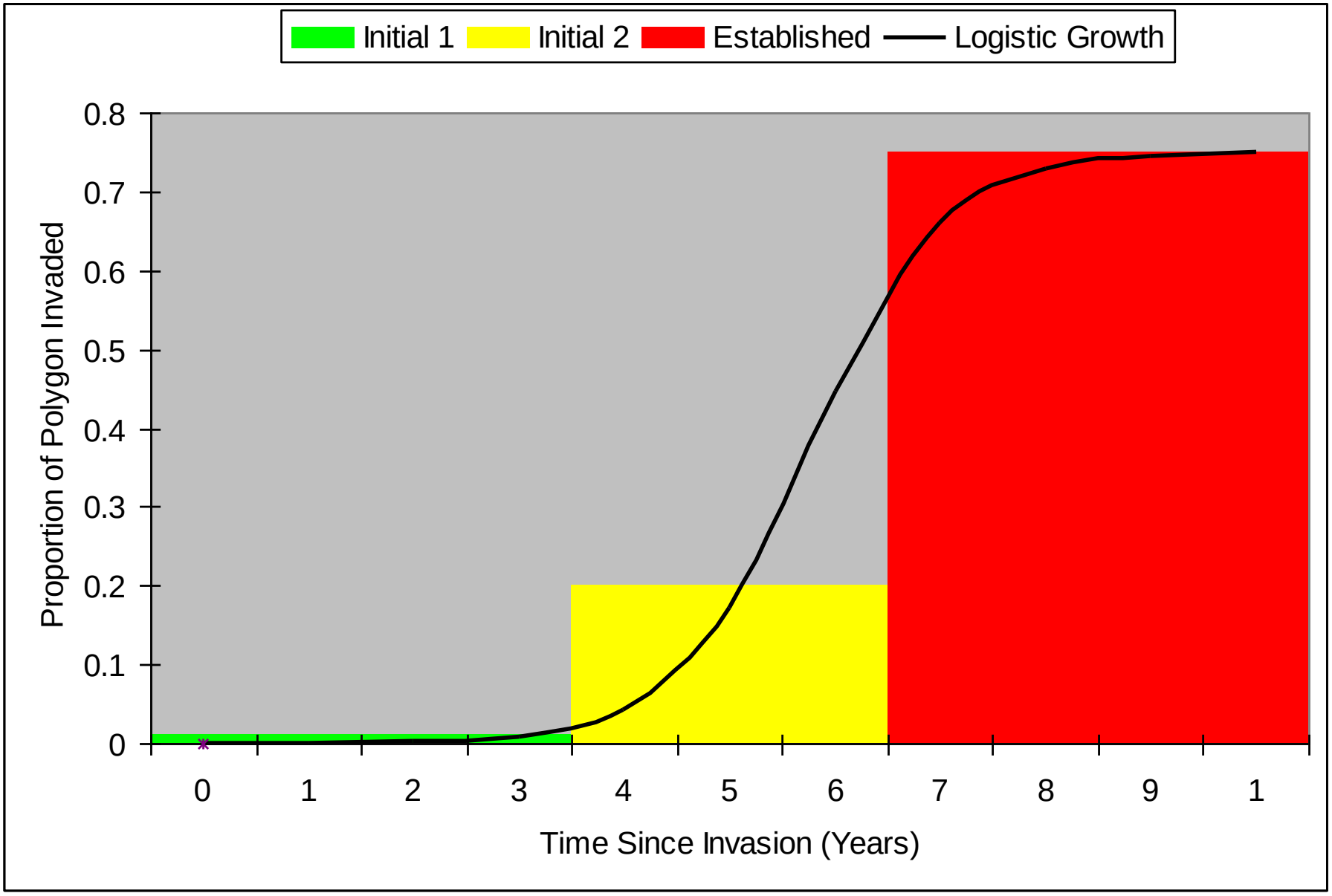
- **Grazing Value:**
  - Average AUM rate for 2008 - $18.10
  - Carrying Capacity from NRCS county estimates (0.26 AUM/acre)
- **Treatment costs:**
  - Established - $40/acre
  - Initial 2 - $85/acre
  - Initial 1 - $225/acre
- **Discount rate: 2.7%**

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




Initial 1
Initial 2
Established
Logistic Growth
Proportion of Polygon Invaded
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
1
2
3
4
5
6
7
8
9
1
Time Since Invasion (Years)

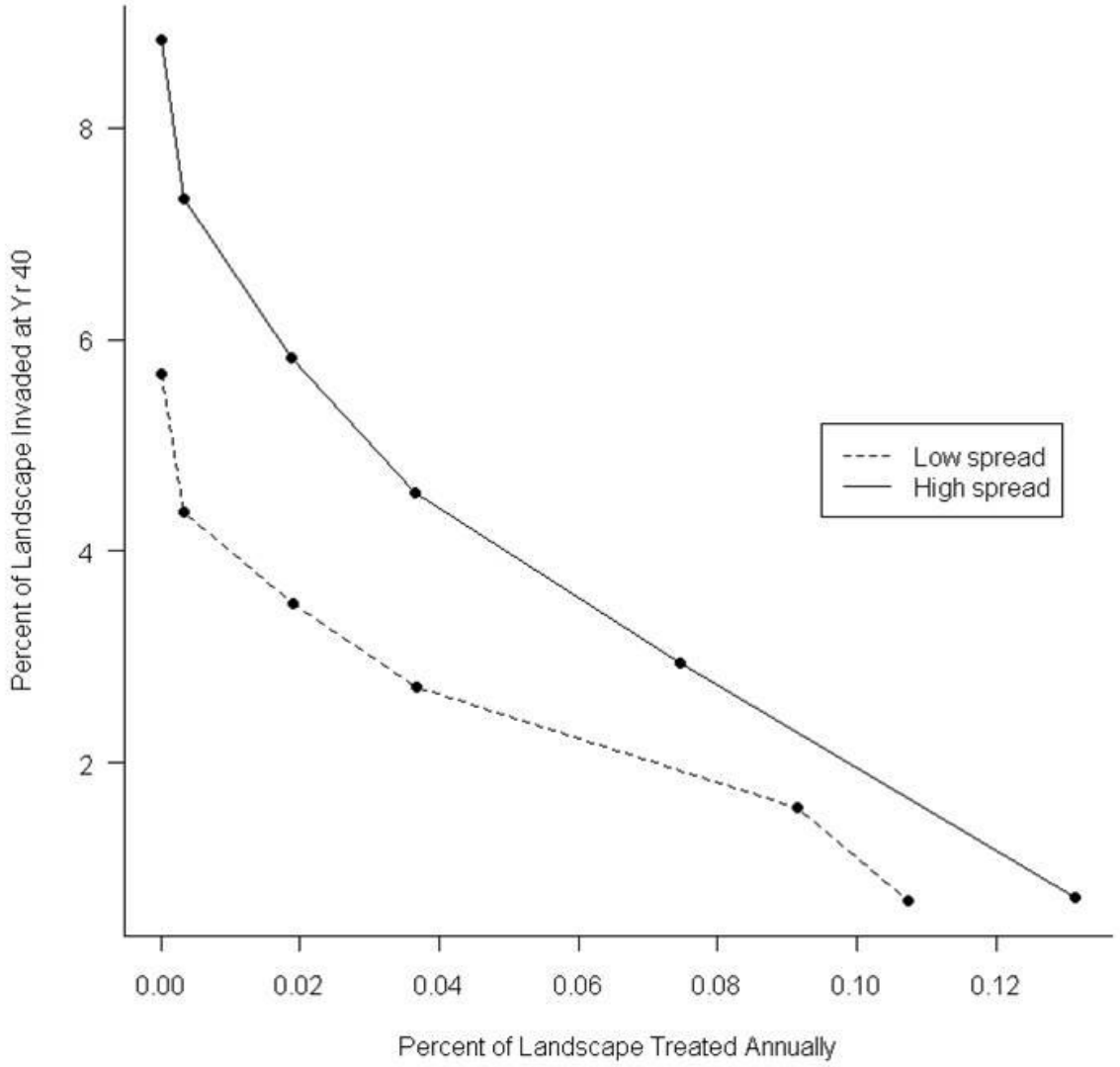
Second Generation Management Scenarios

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

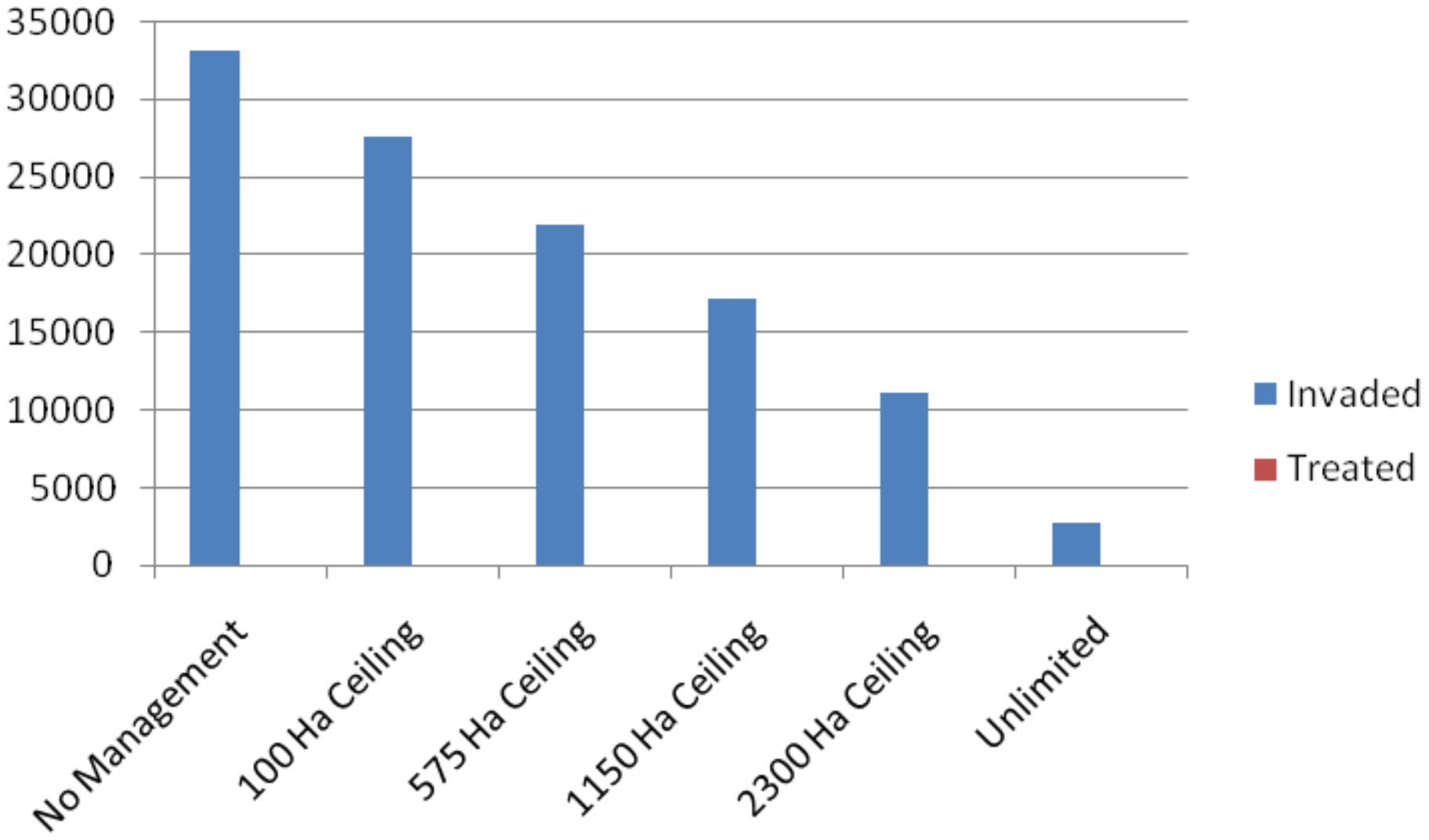
Measures

- What is most effective strategy?
  - Total Area Invaded
  - Cumulative area treated
- Economic analysis
  - Net Present Value
  - Benefit Cost Ratio

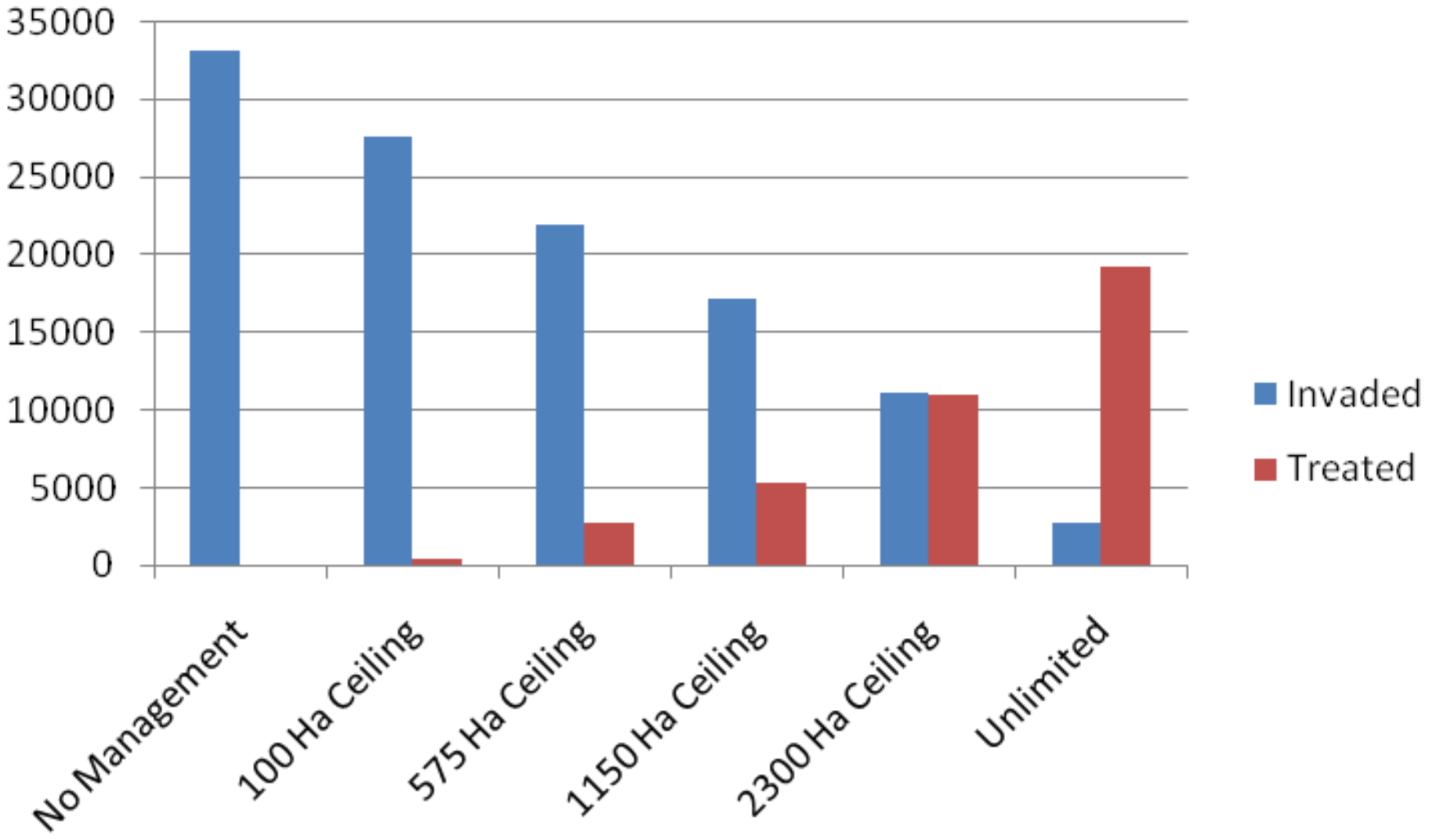
RMF Effects of Management on Weed Distribution



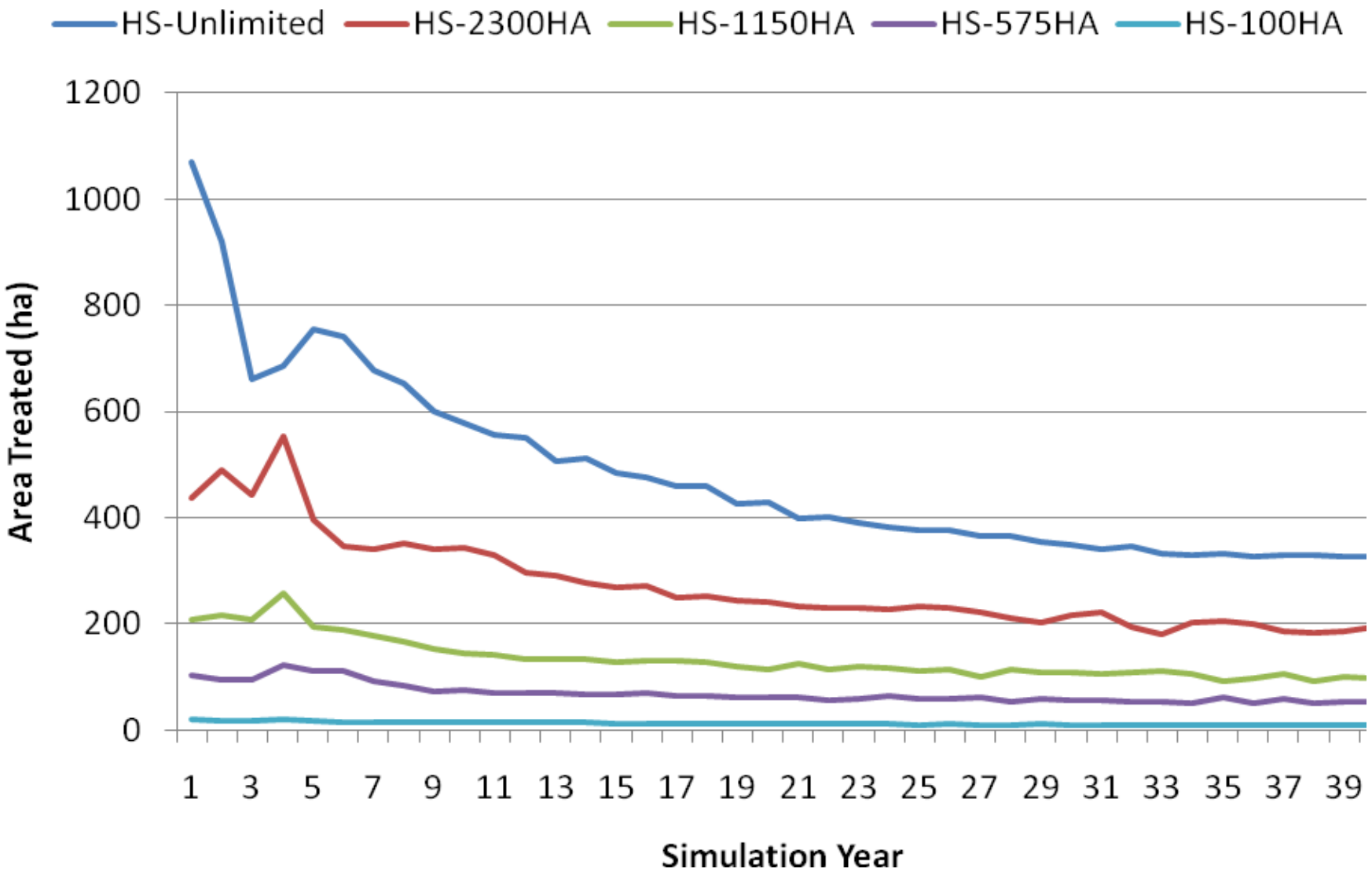
RMF Area Invaded by Treatment Ceiling



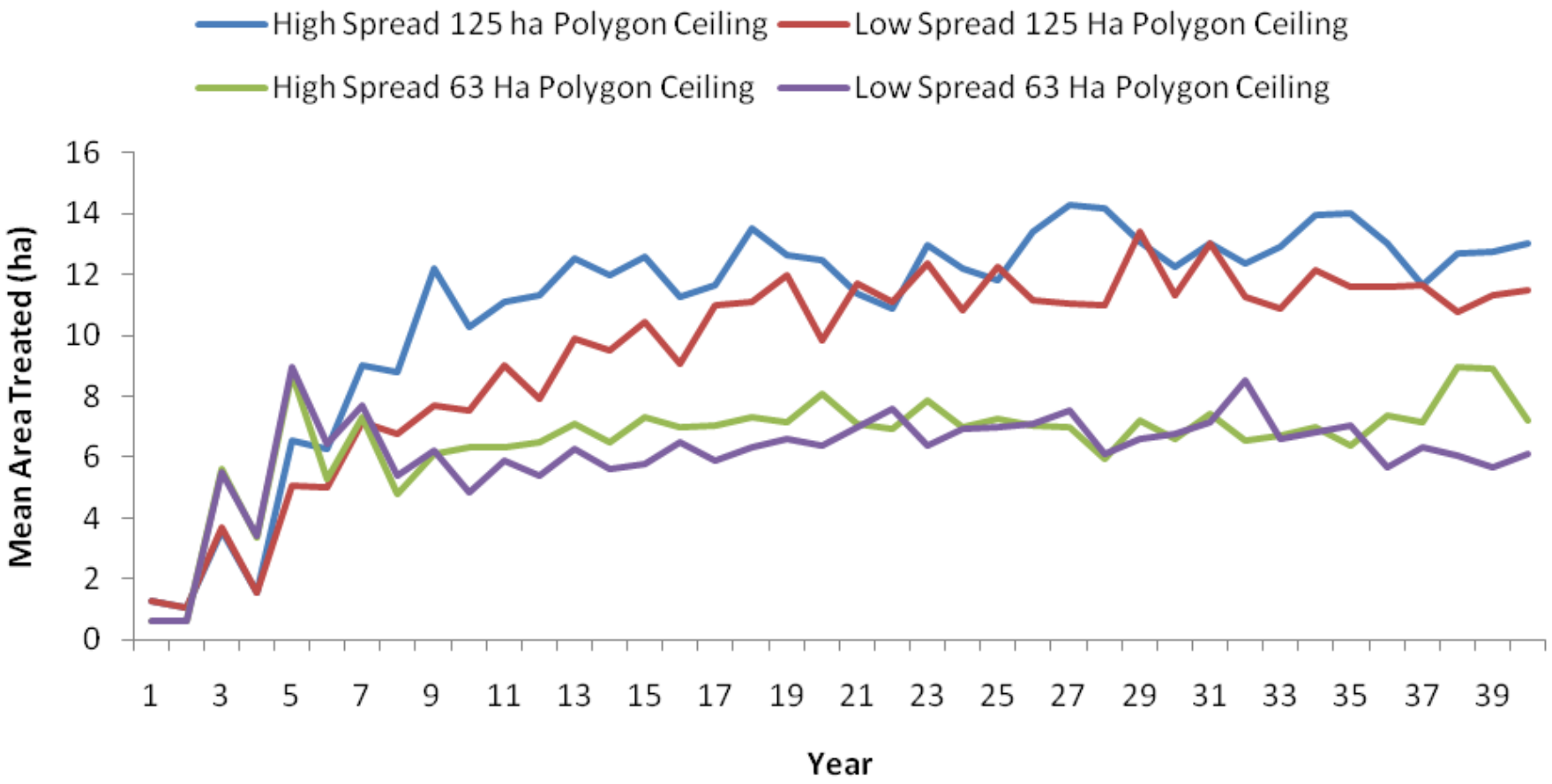
RMF Area Invaded and Treated by Treatment Ceiling



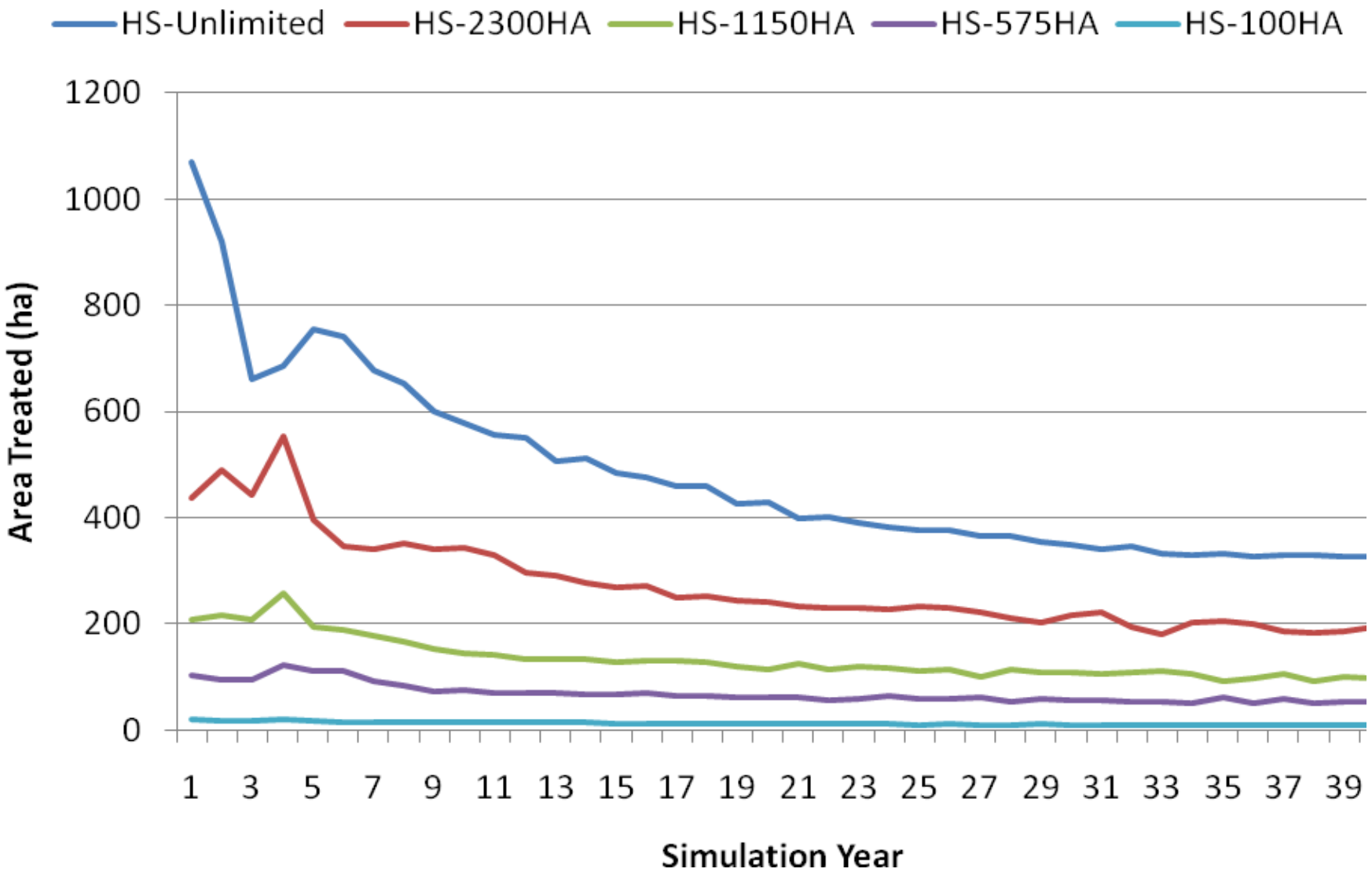
RMF Treatment over Time, High Spread Scenarios



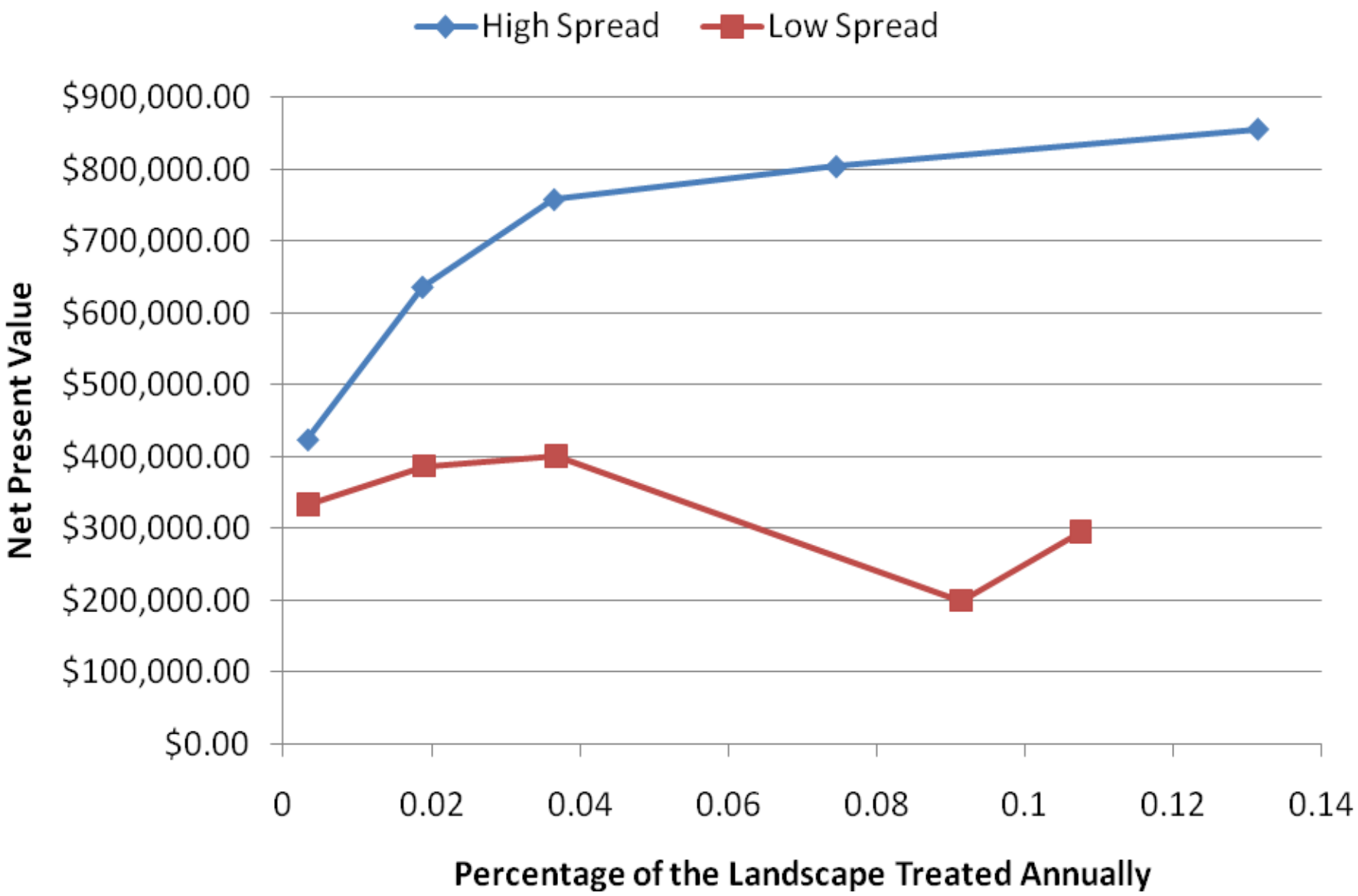
CVTreatment over Time, High Spread Scenarios



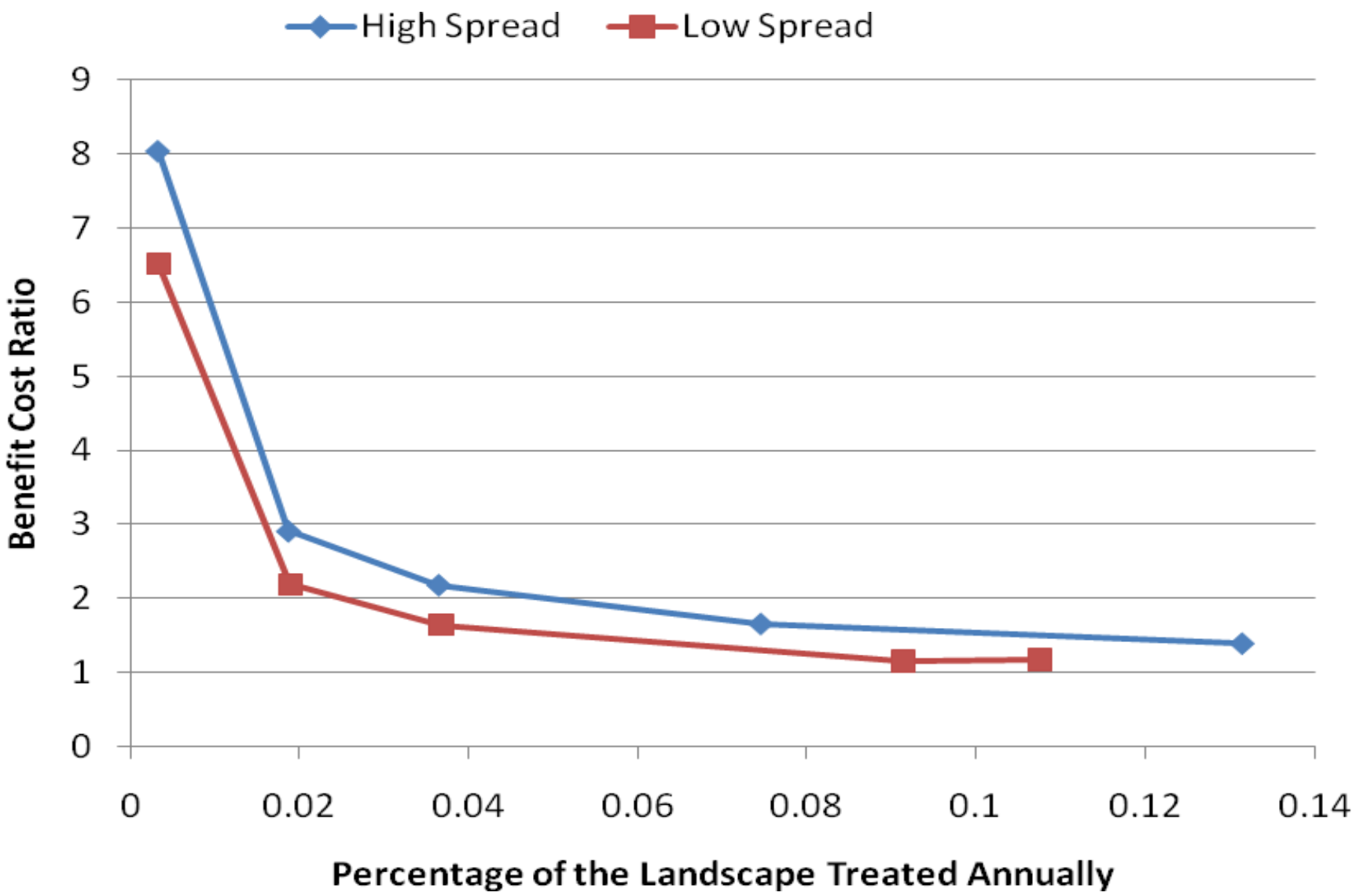
RMF Treatment over Time, High Spread Scenarios

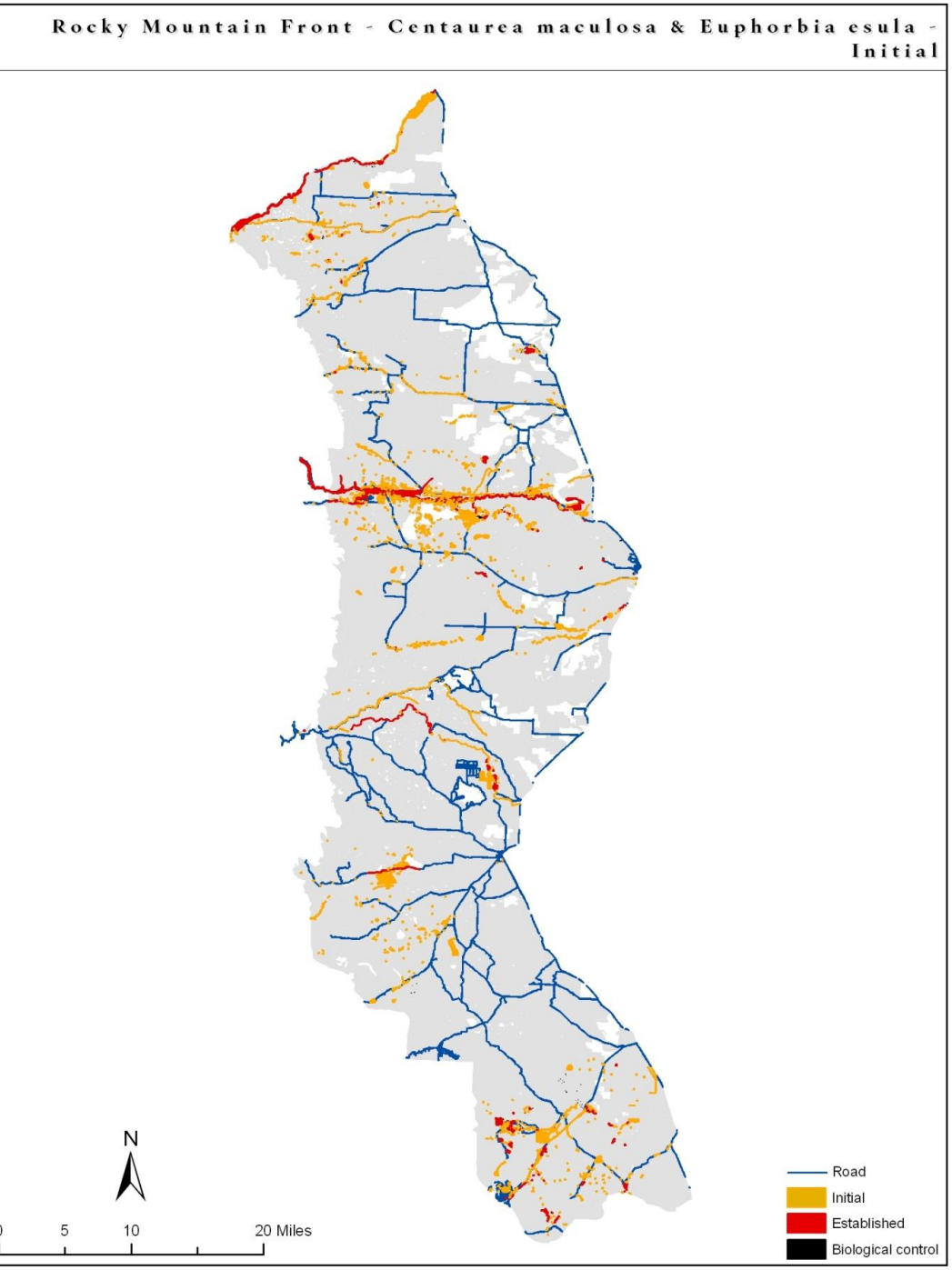


RMF Net Present Value

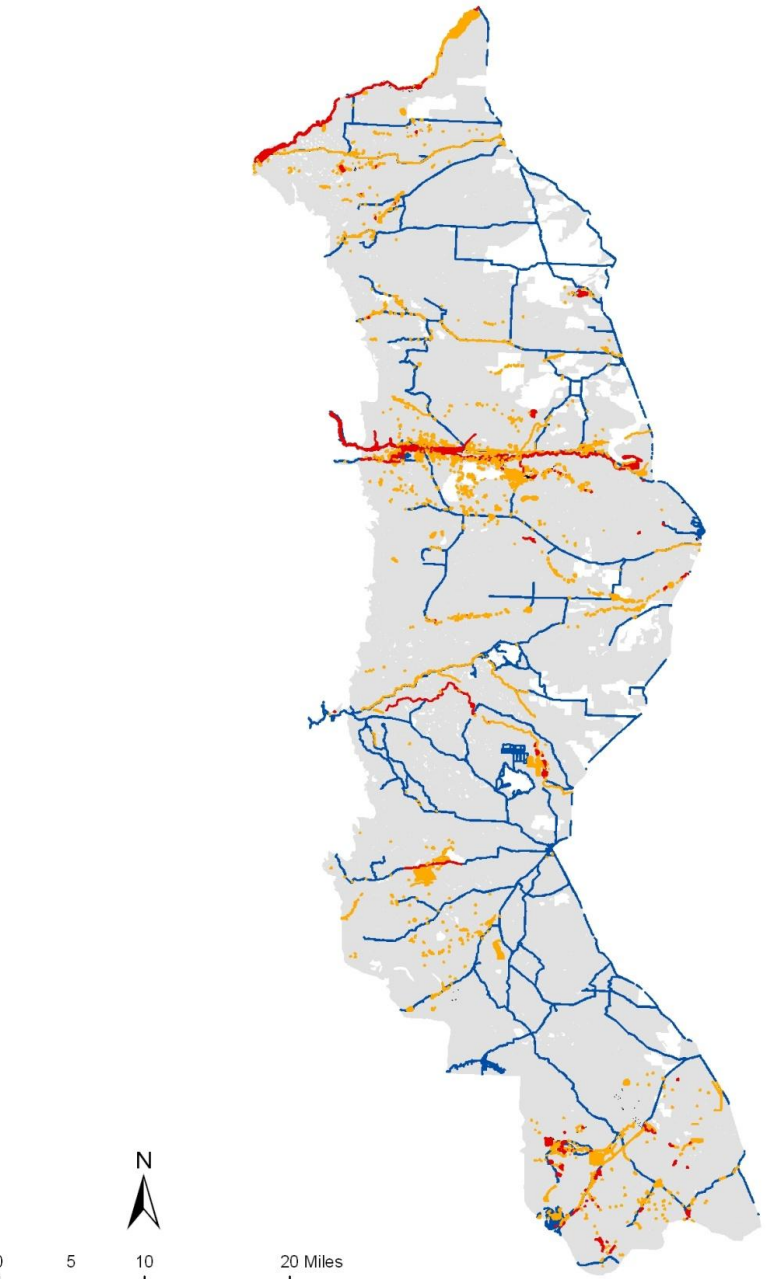


RMF Benefit Cost Ratio

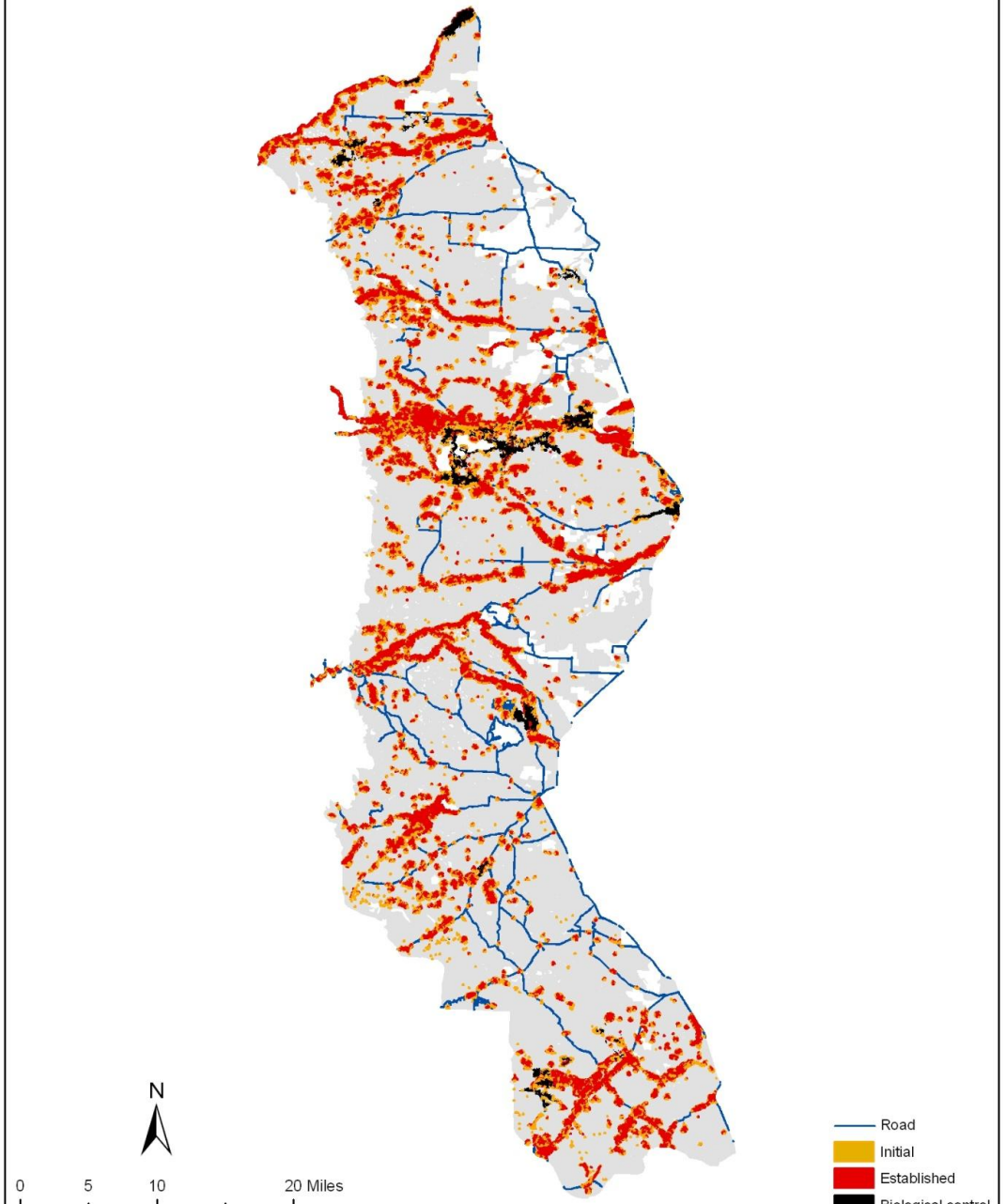



Rocky Mountain Front - Centaurea maculosa & Euphorbia esula - Initial
N
5
10
20 Miles
Road
Initial
Established
Biological control

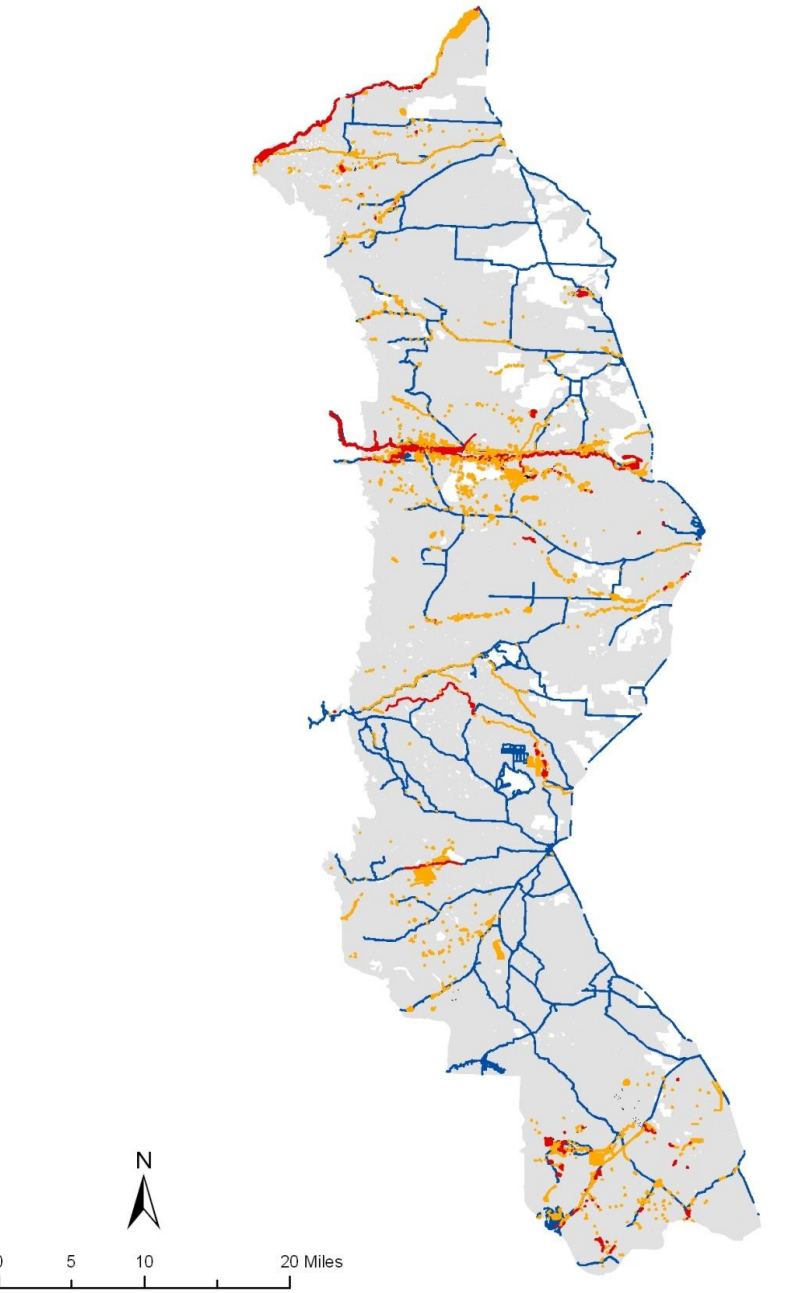
Rocky Mountain Front - Centaurea maculosa & Eu



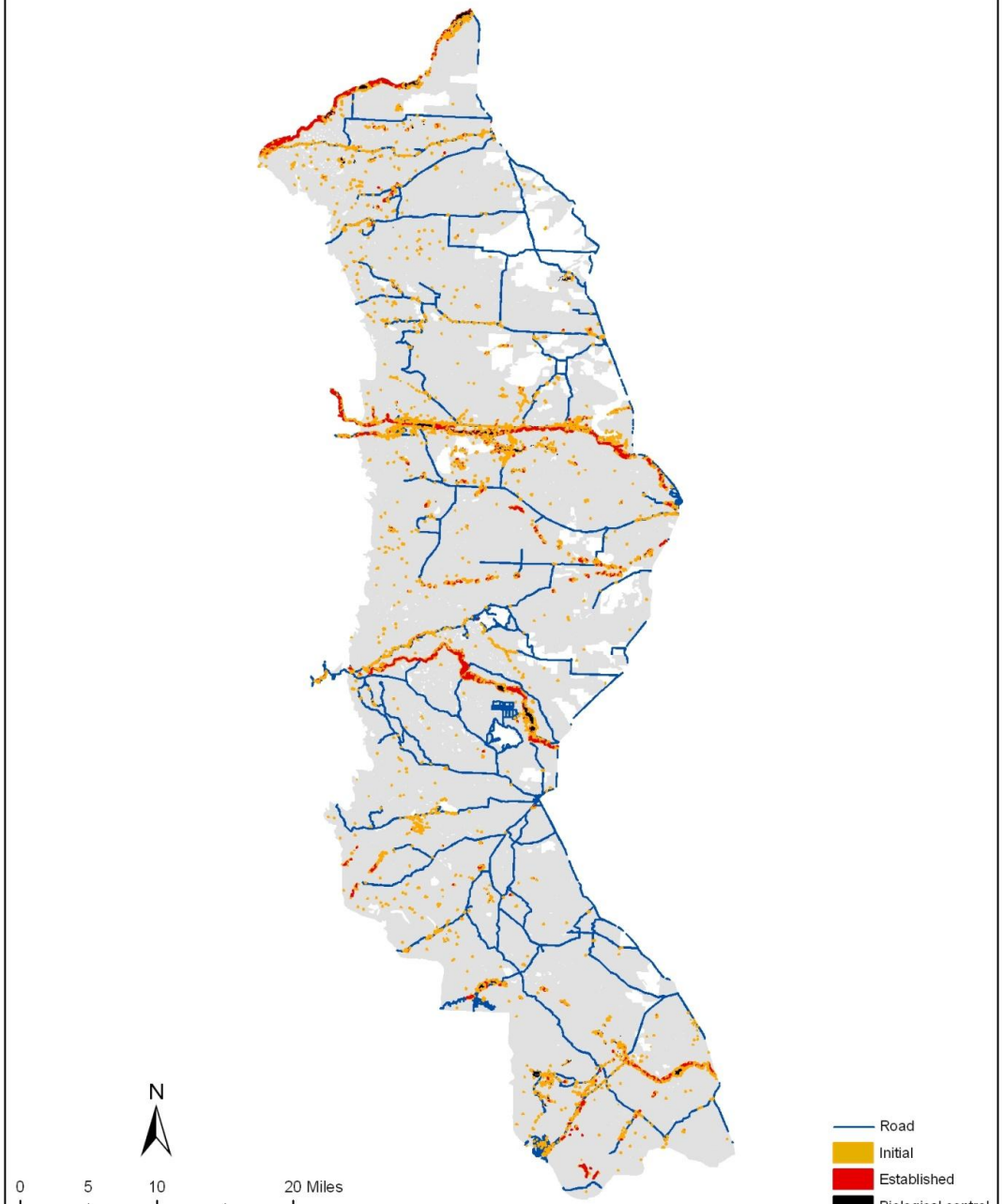
Rocky Mountain Front - Centaurea maculosa & Euphorbia esula -
High Spread - No Management - Year 40



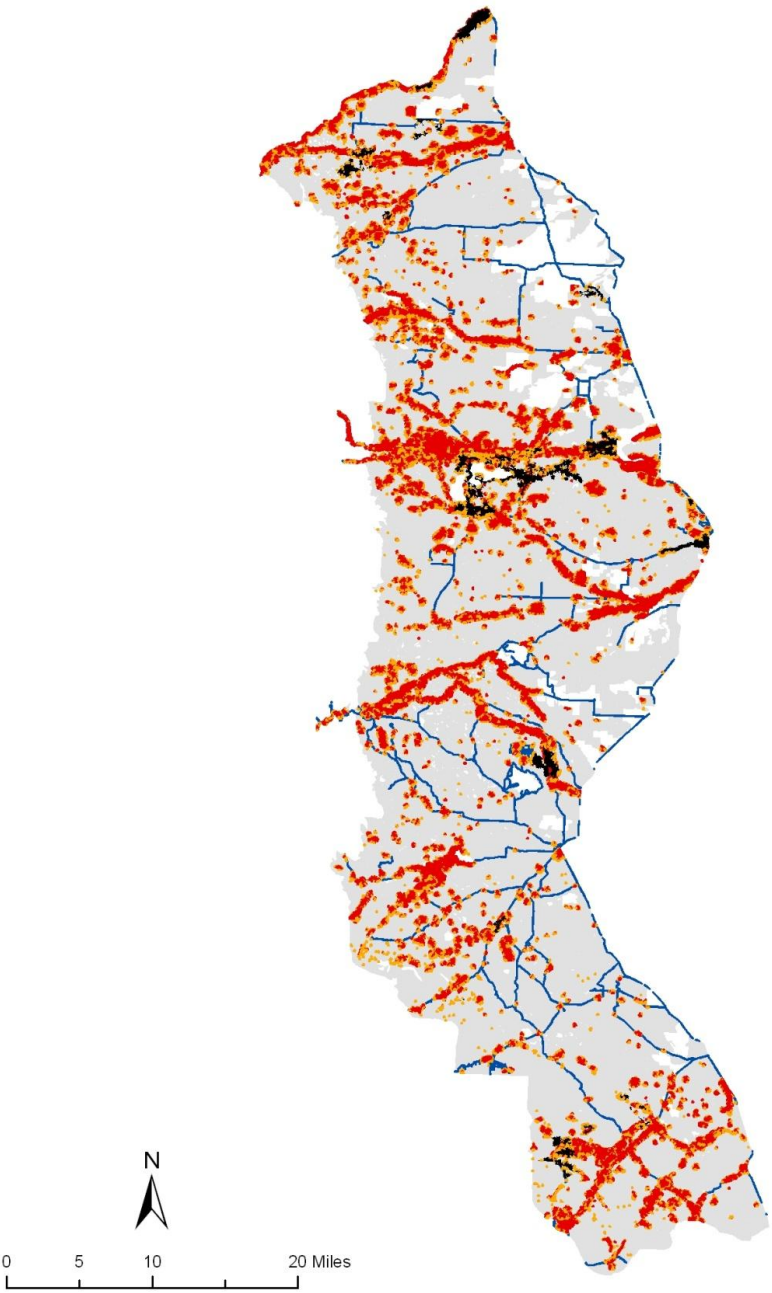
Rocky Mountain Front - Centaurea maculosa & Eu



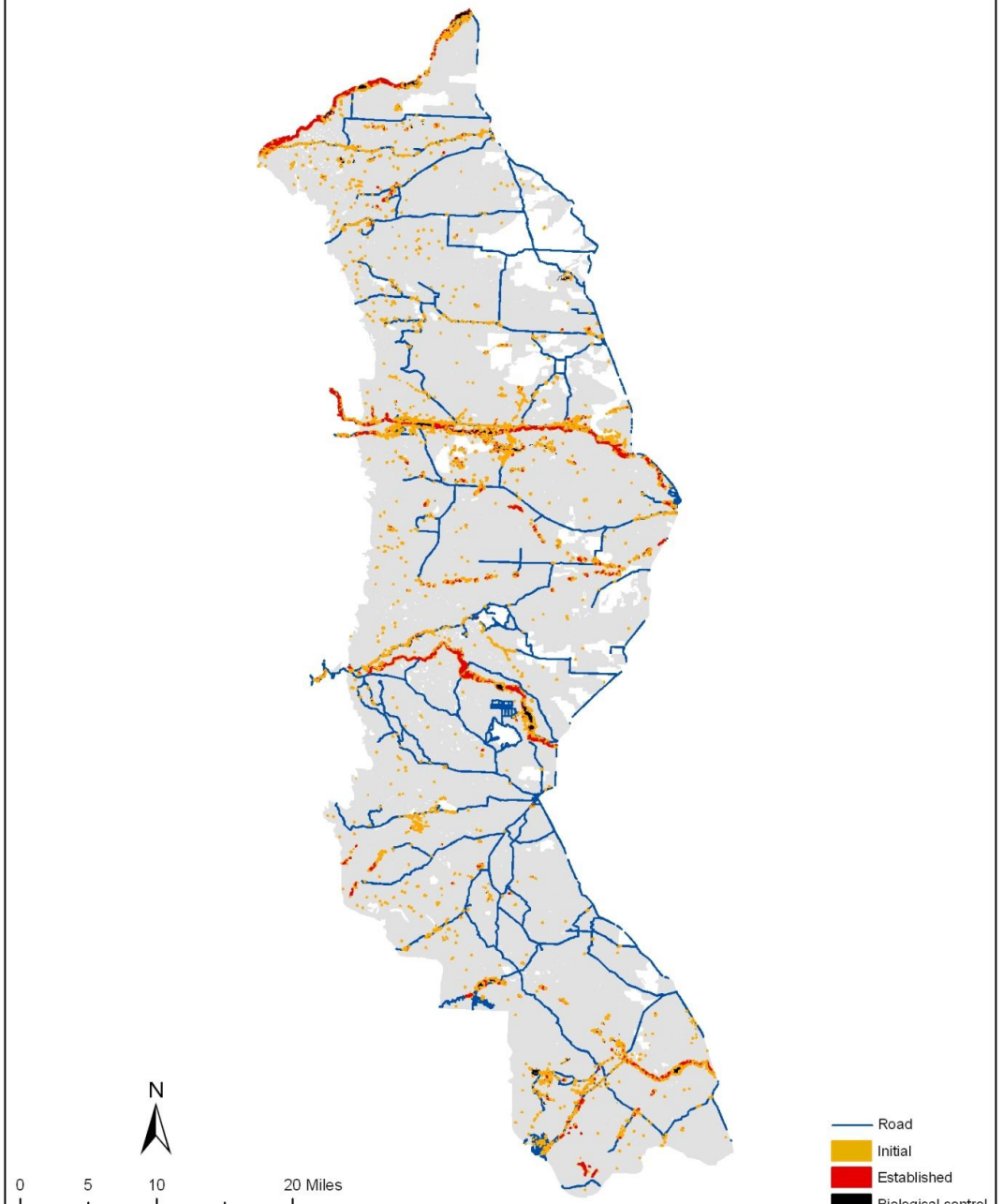
Rocky Mountain Front - Centaurea maculosa & Euphorbia esula - High Spread - Unlimited Management - Year 40



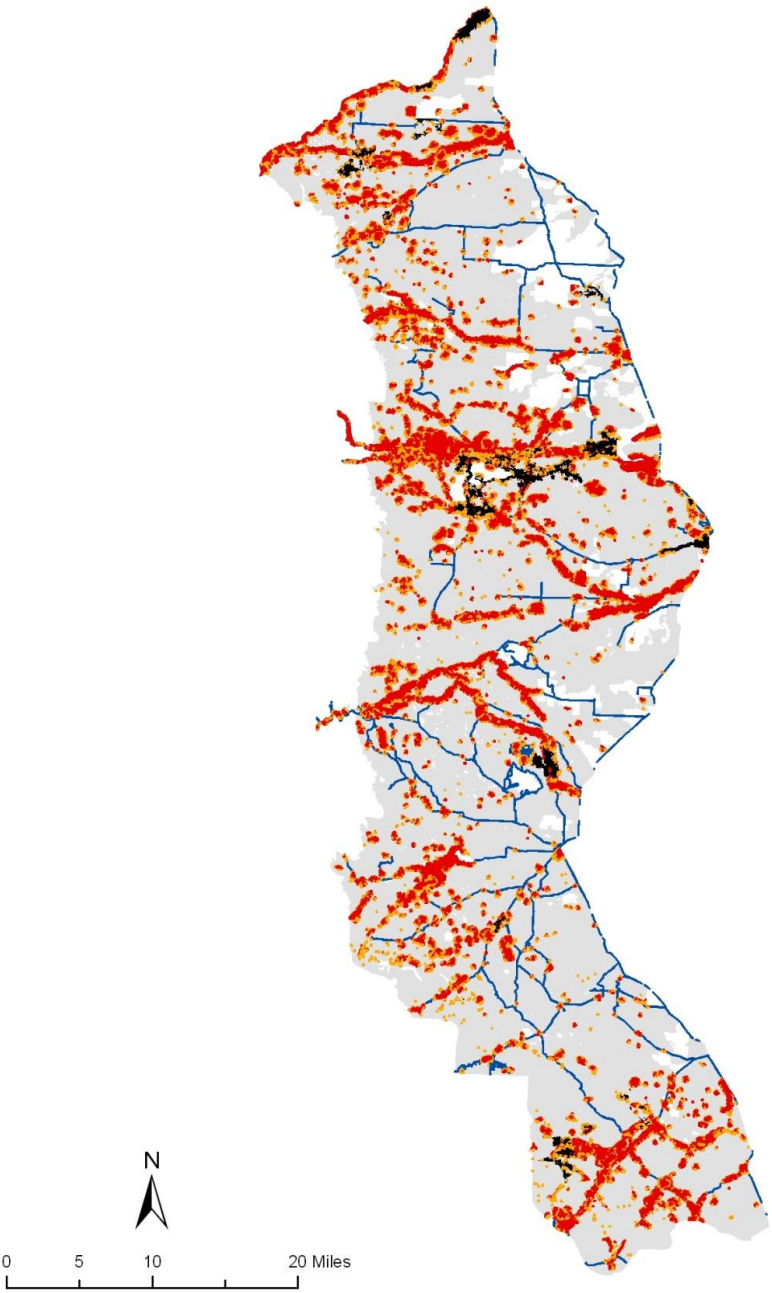
Rocky Mountain Front - Centaurea maculosa & Eu
High Spread - No Manag



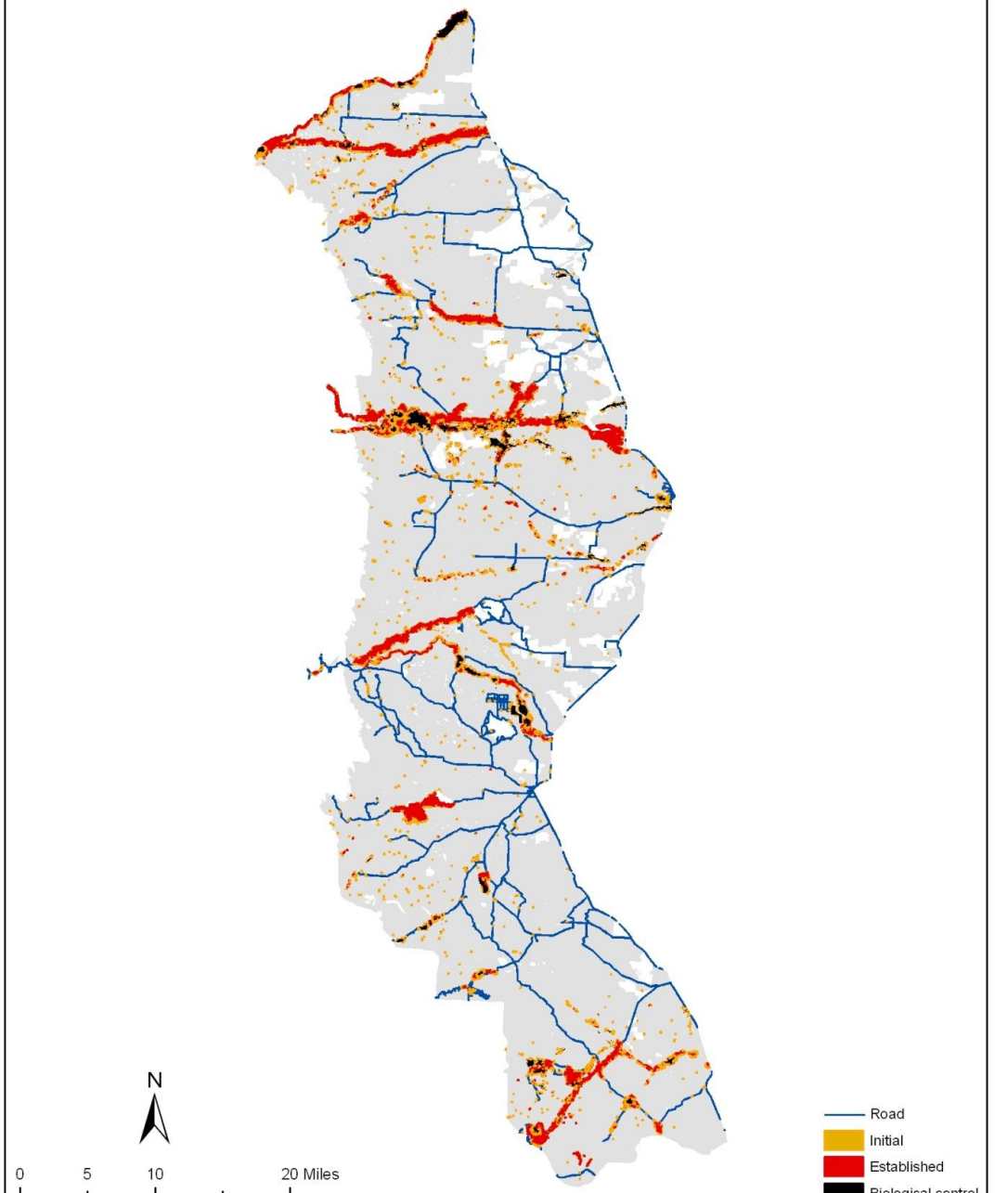
Rocky Mountain Front - Centaurea maculosa & Euphorbia esula -
High Spread - Unlimited Management - Year 40



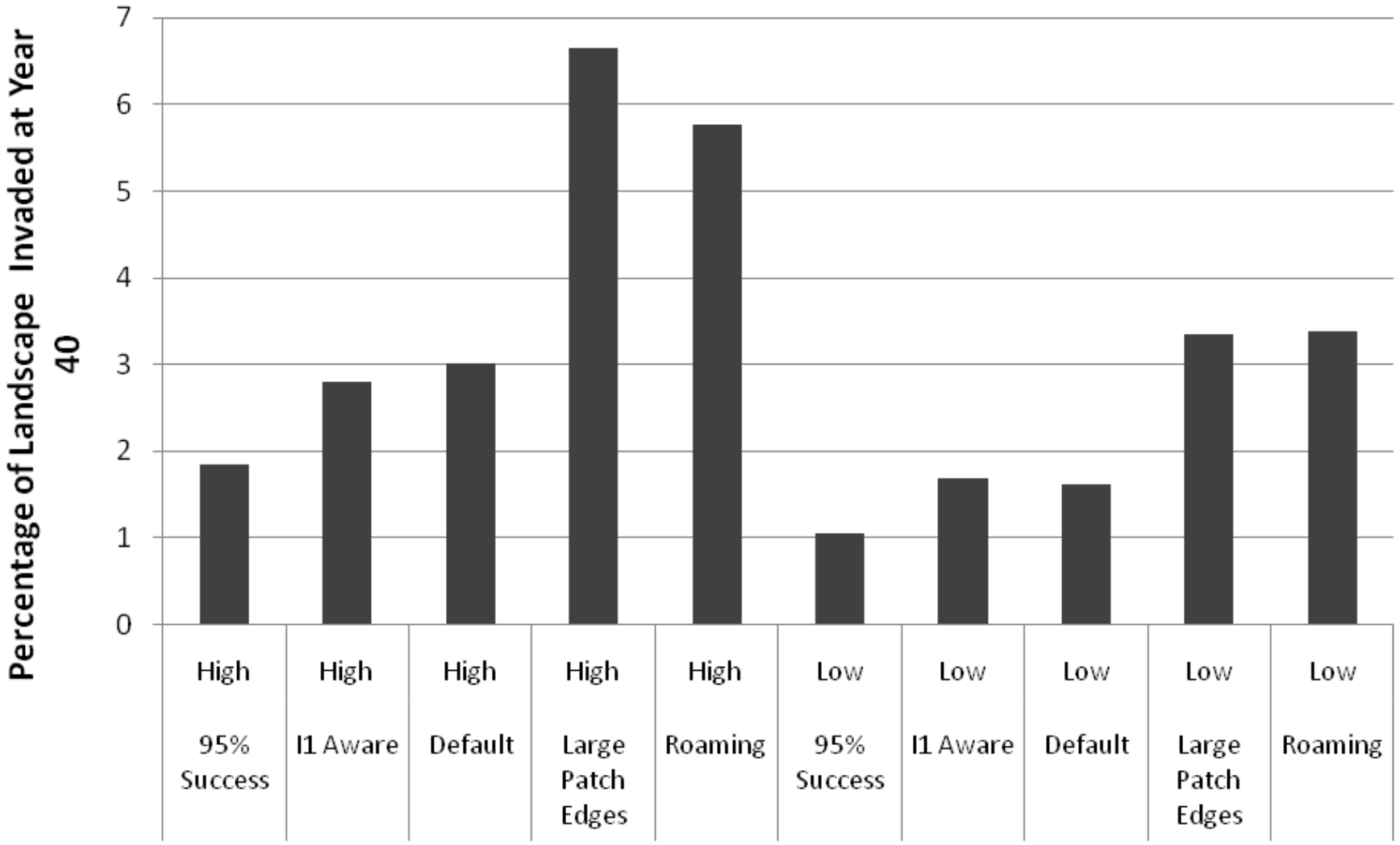
Rocky Mountain Front - Centaurea maculosa & Eu
High Spread - No Manag



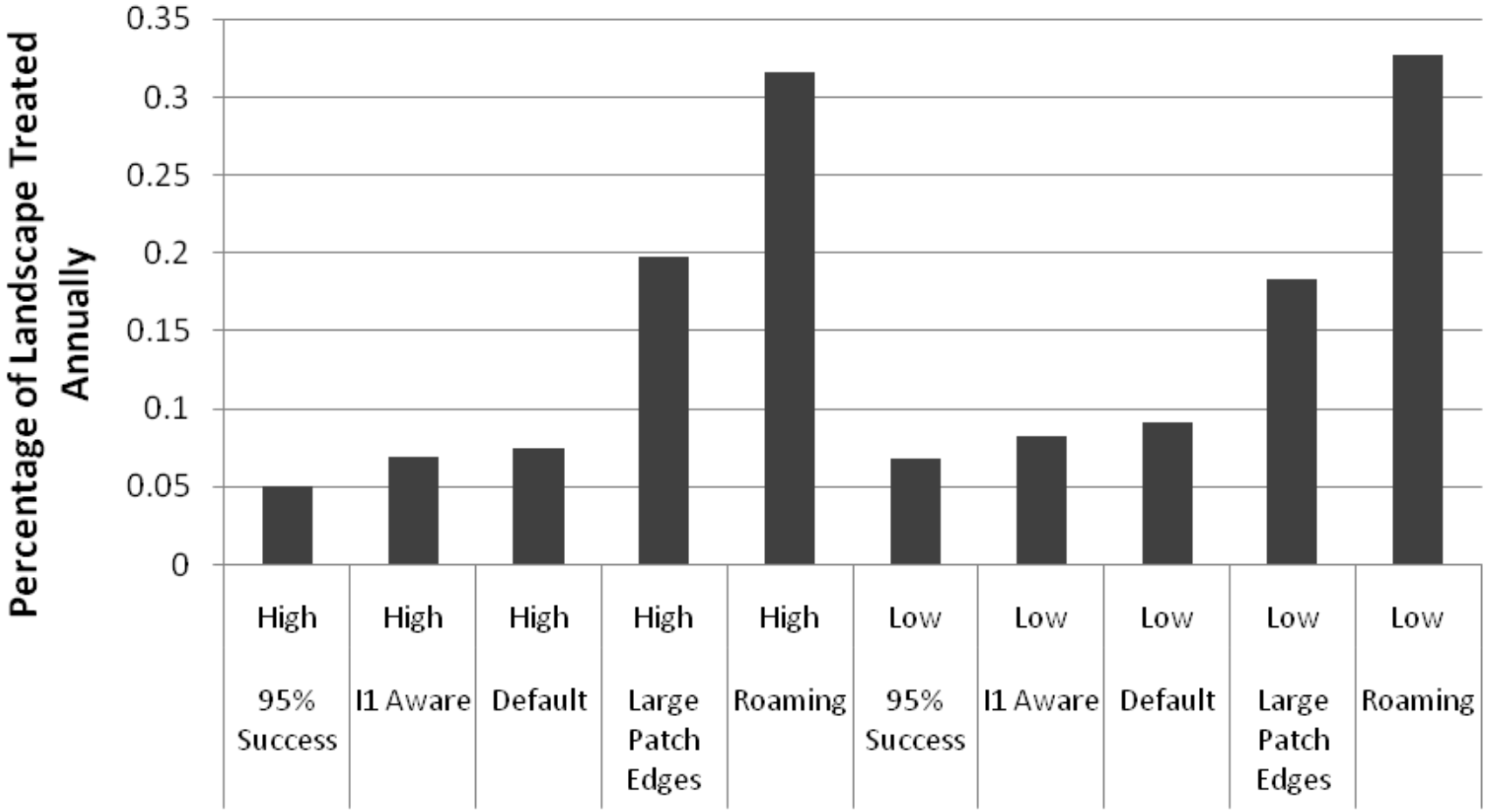
Rocky Mountain Front - Centaurea maculosa & Euphorbia esula -
High Spread - 2300 ha Management Ceiling - Year 40



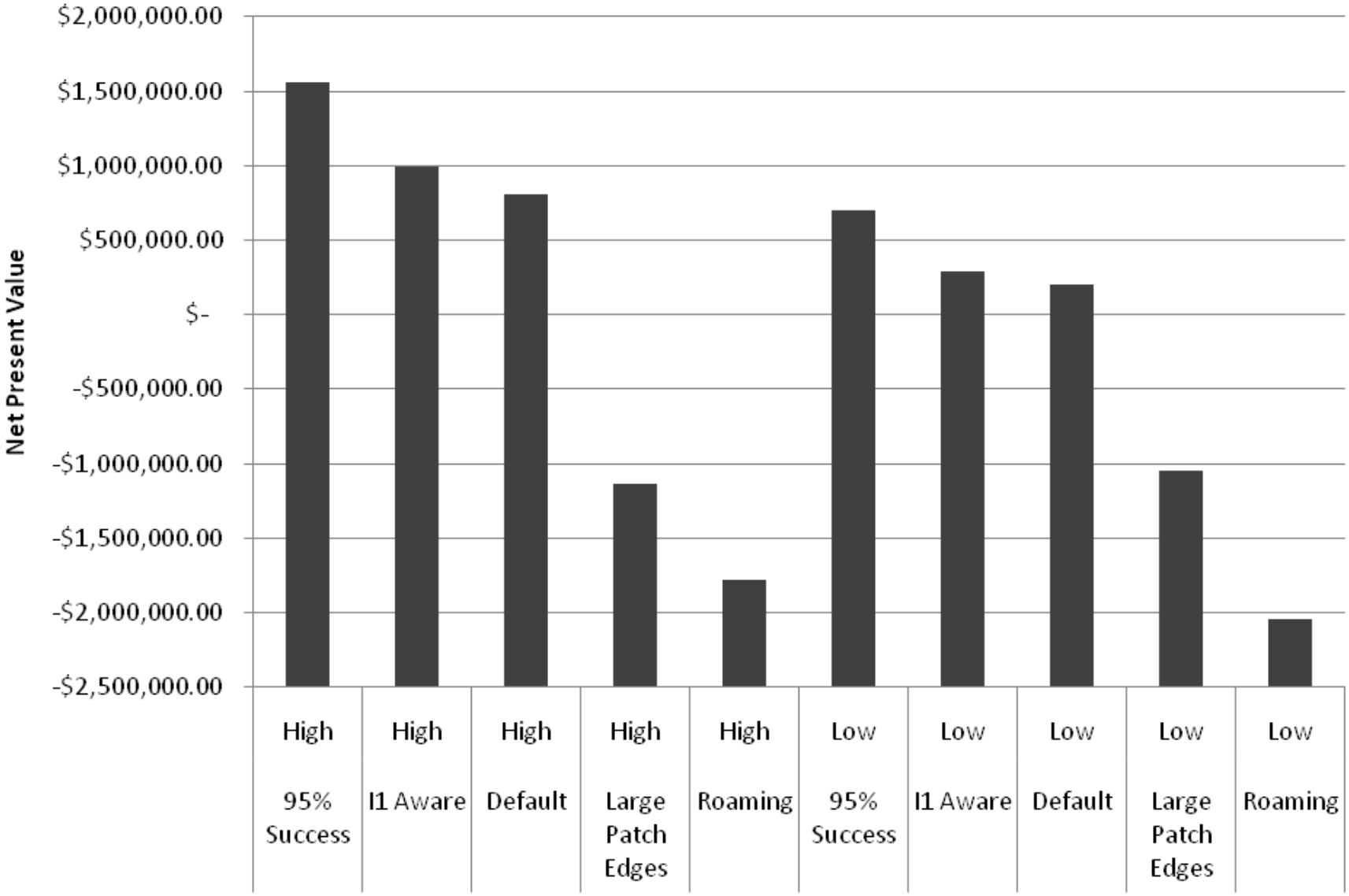
RMF Alternative Strategy Area Invaded



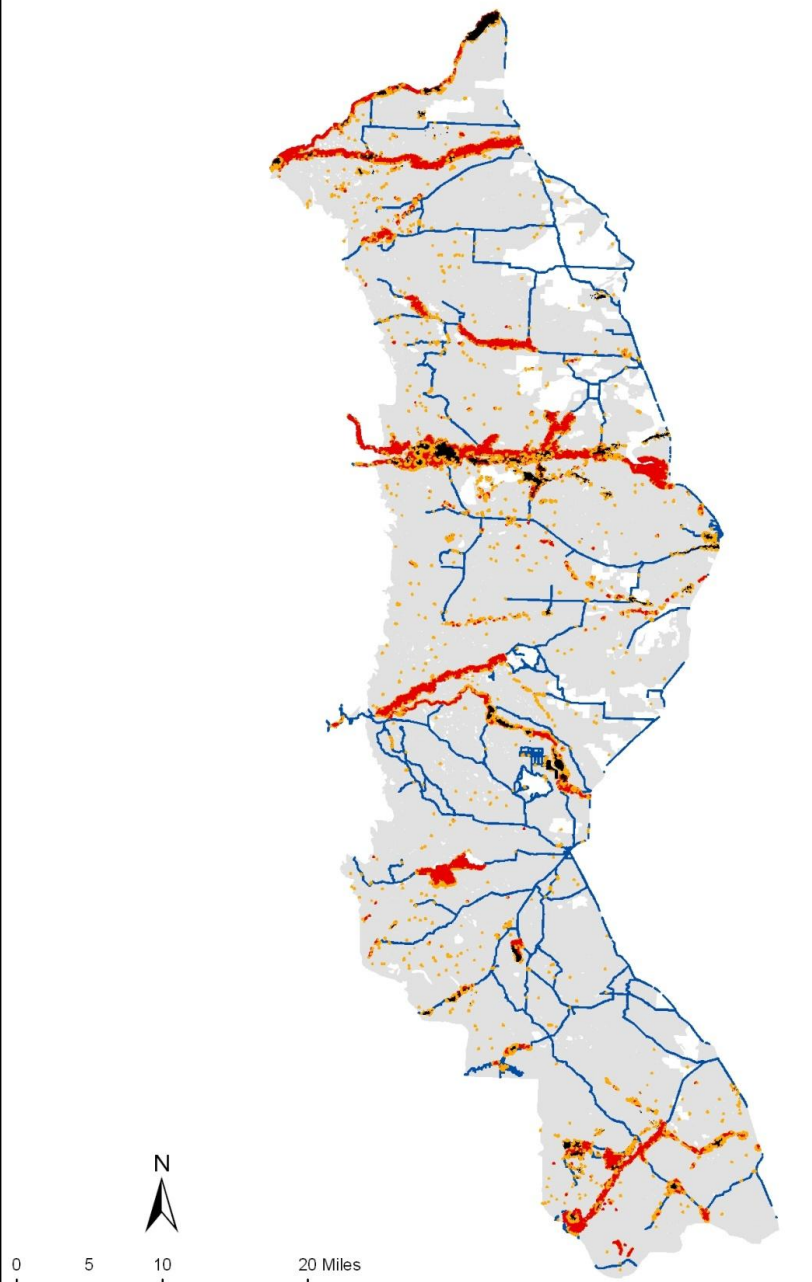
RMF Alternative Strategy Area Treated



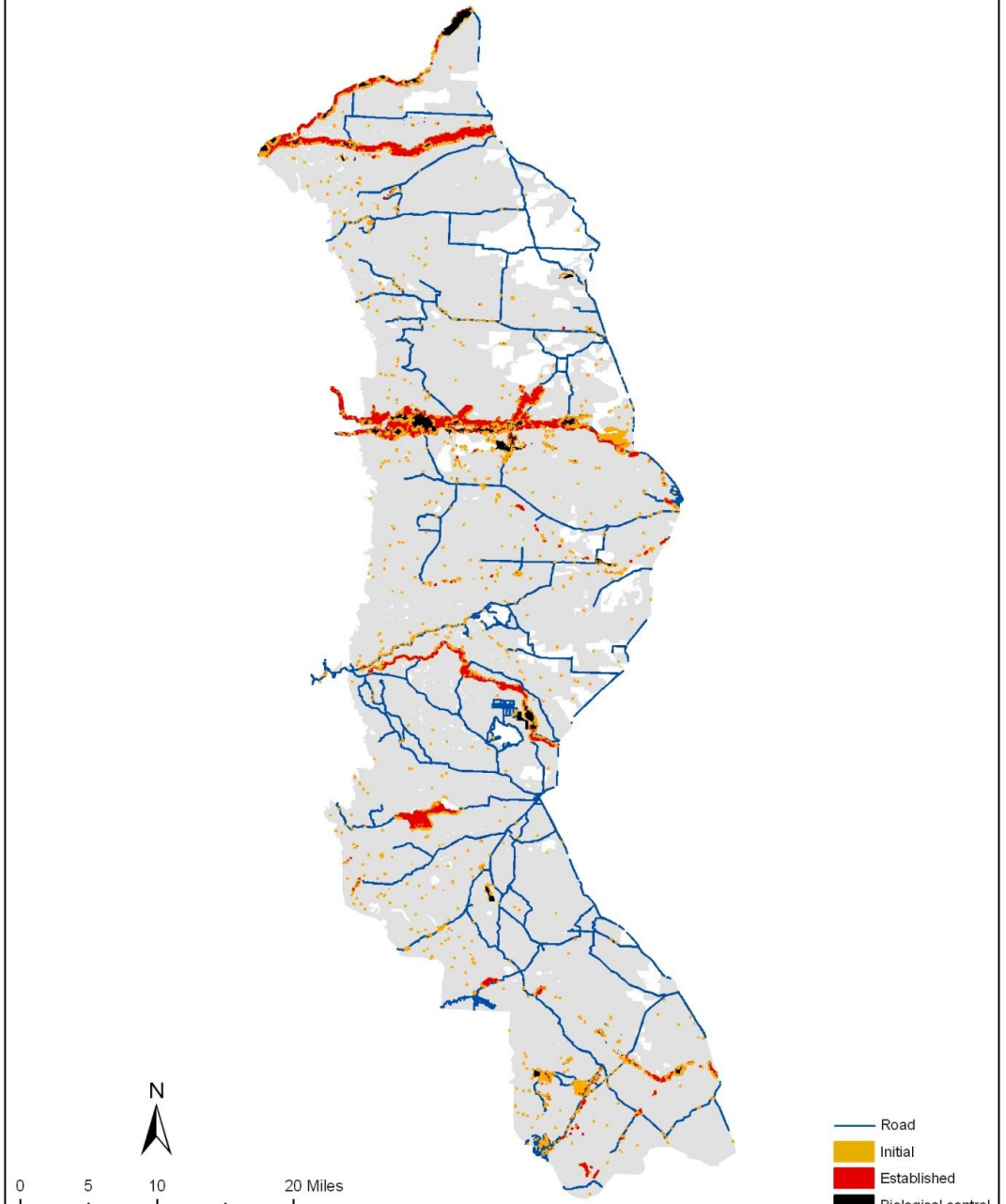
RMF Alternative Strategy NPV



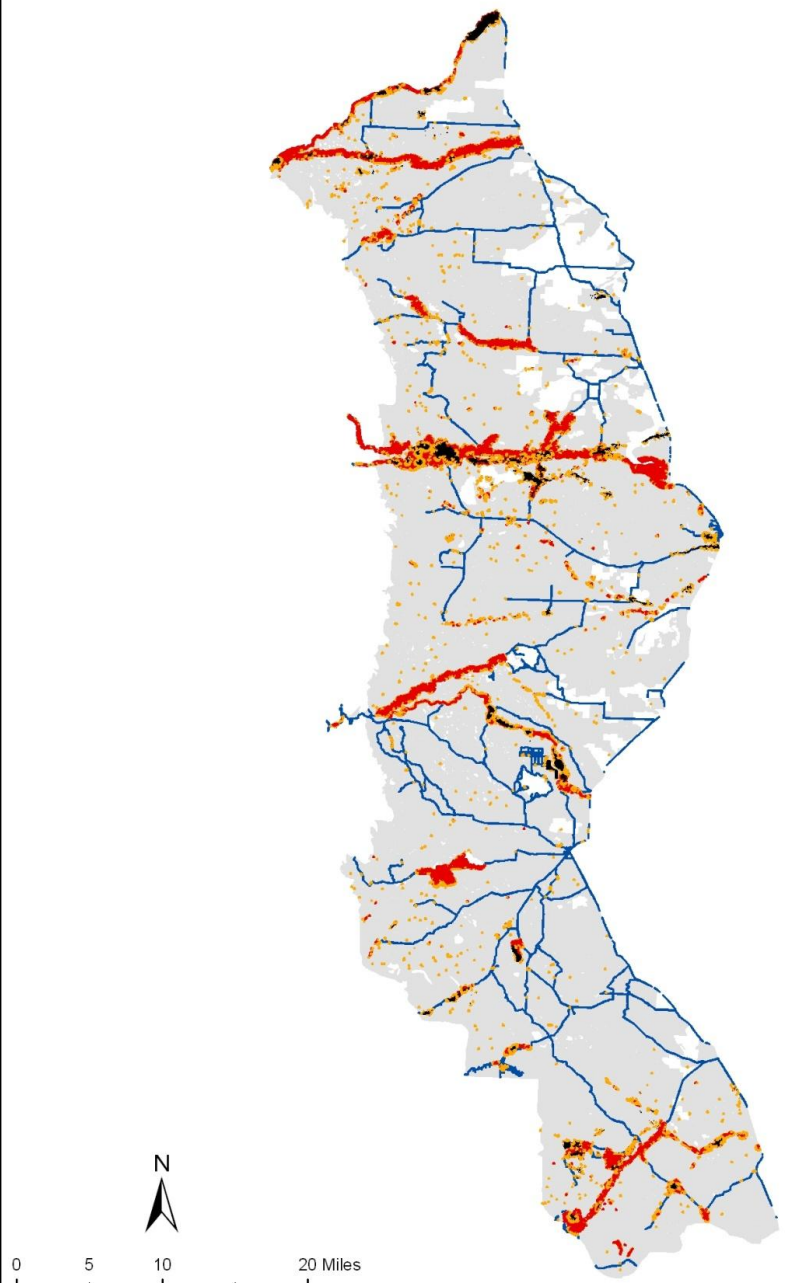
Rocky Mountain Front - Centaurea maculosa & E
High Spread - 2300 ha Management C



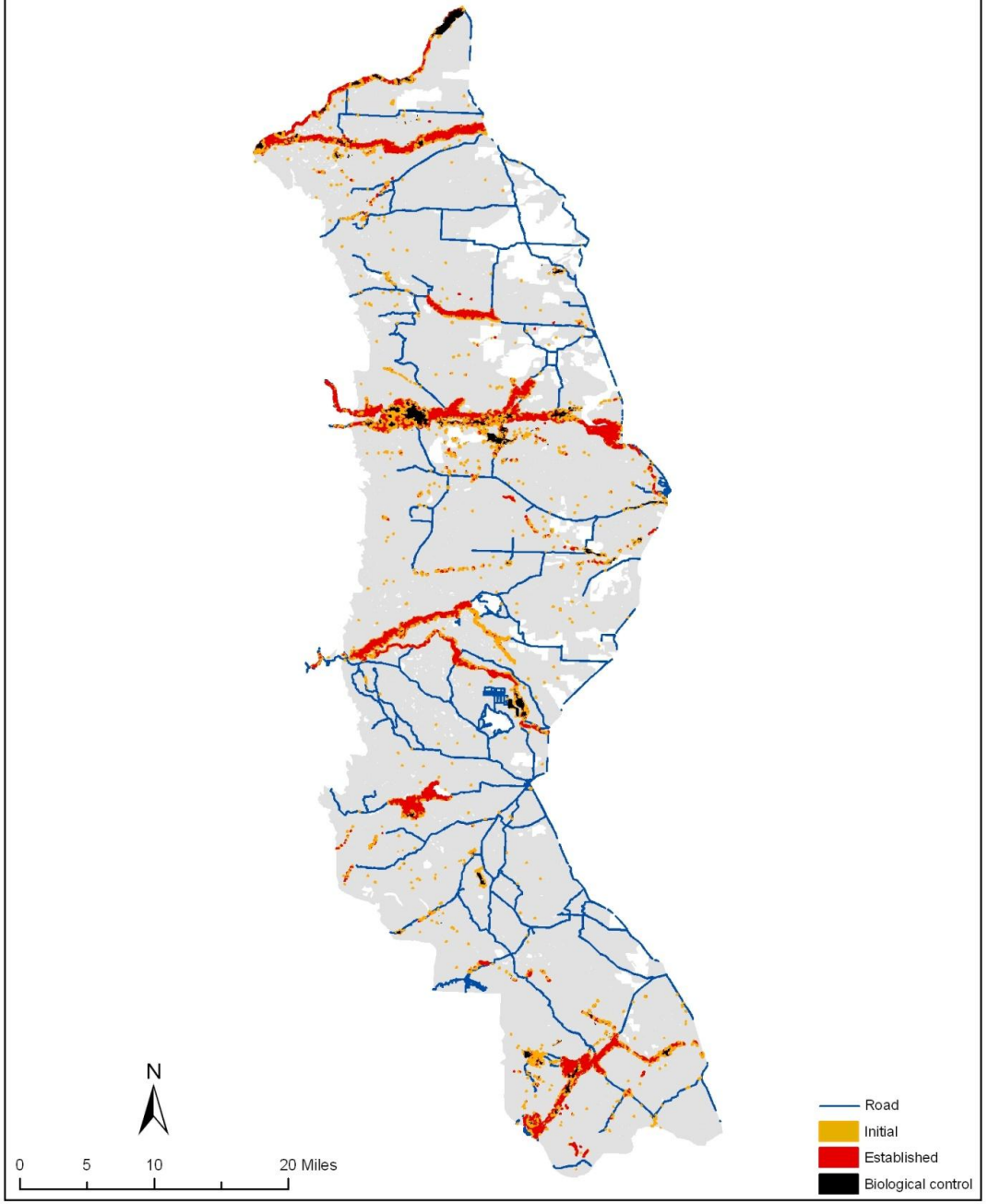
Rocky Mountain Front - Centaurea maculosa & Euphorbia esula -
High Spread - High Control Success - Year 40



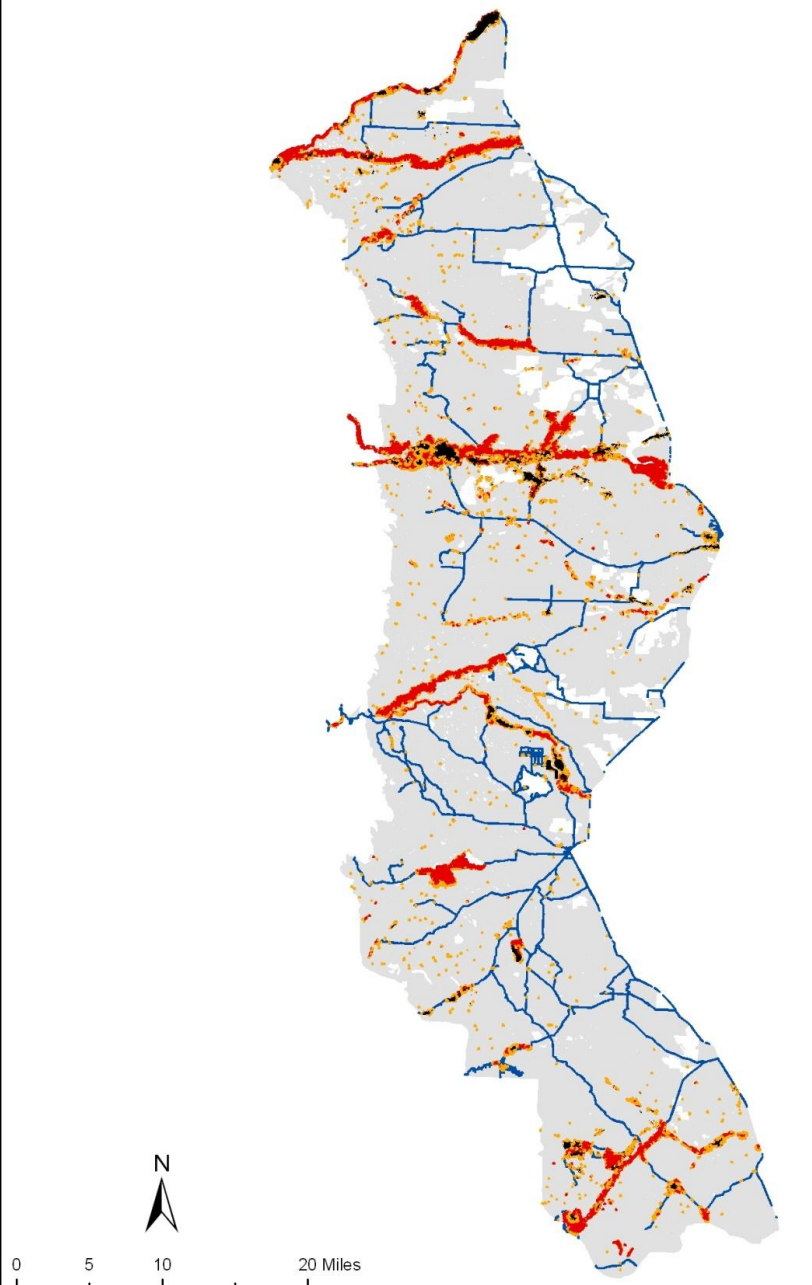
Rocky Mountain Front - Centaurea maculosa & E
High Spread - 2300 ha Management C



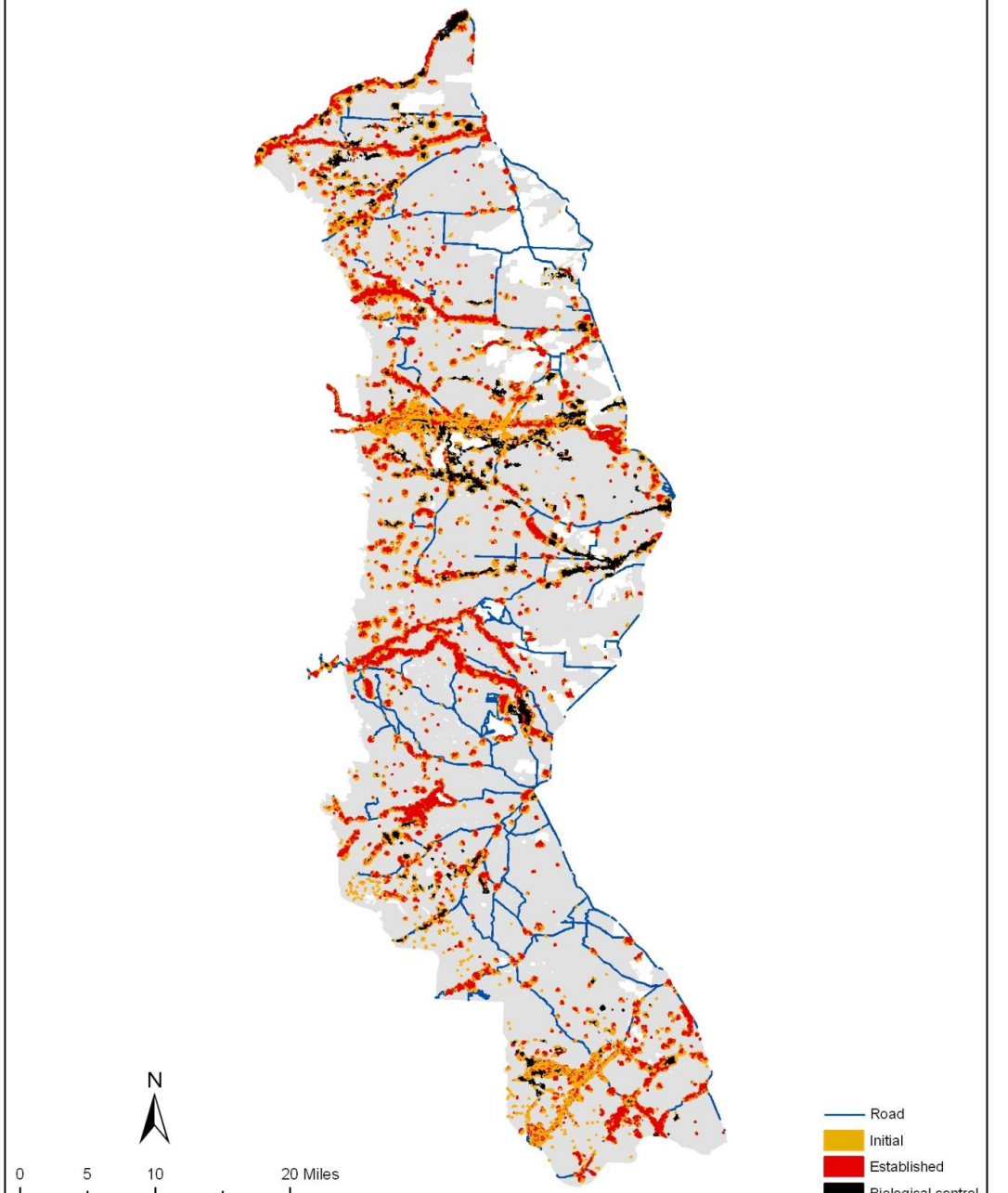
Rocky Mountain Front - Centaurea maculosa & Euphorbia esula -
High Spread - I1 Aware - Year 40



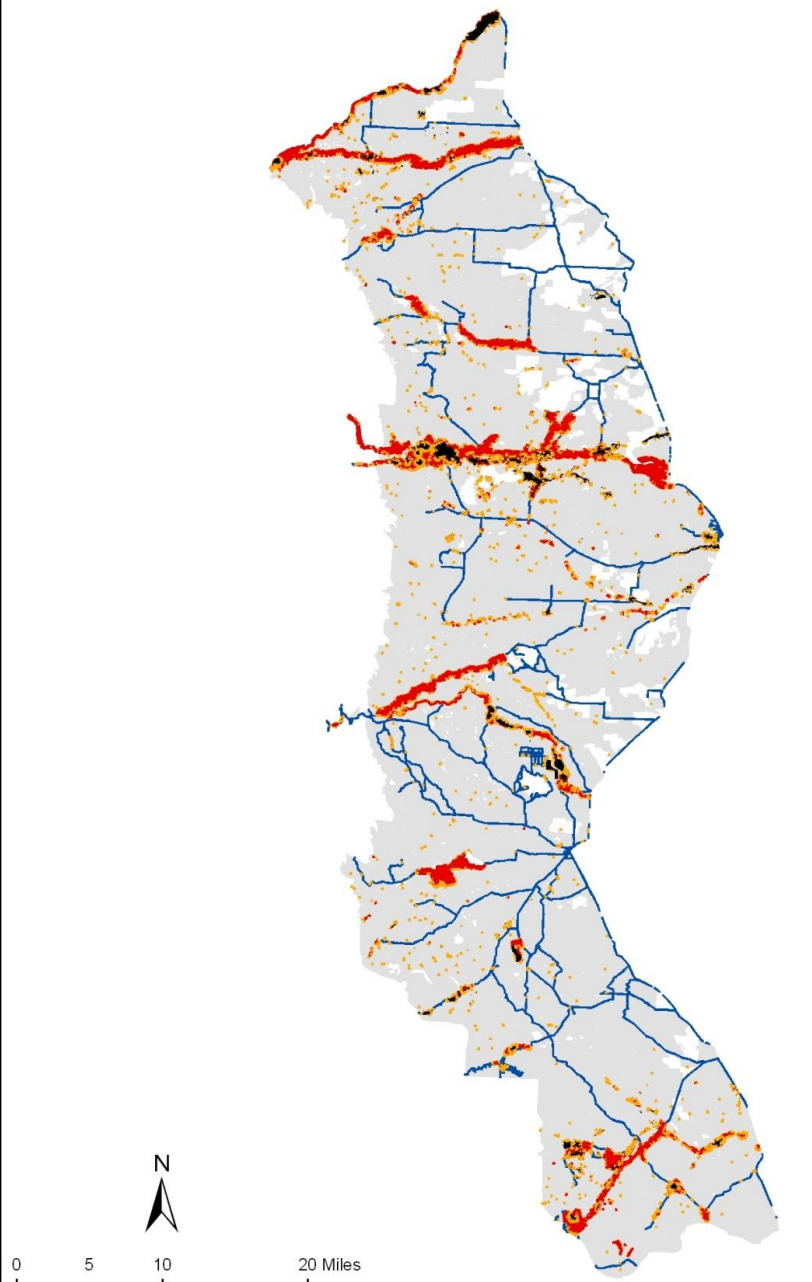
Rocky Mountain Front - Centaurea maculosa & E
High Spread - 2300 ha Management C



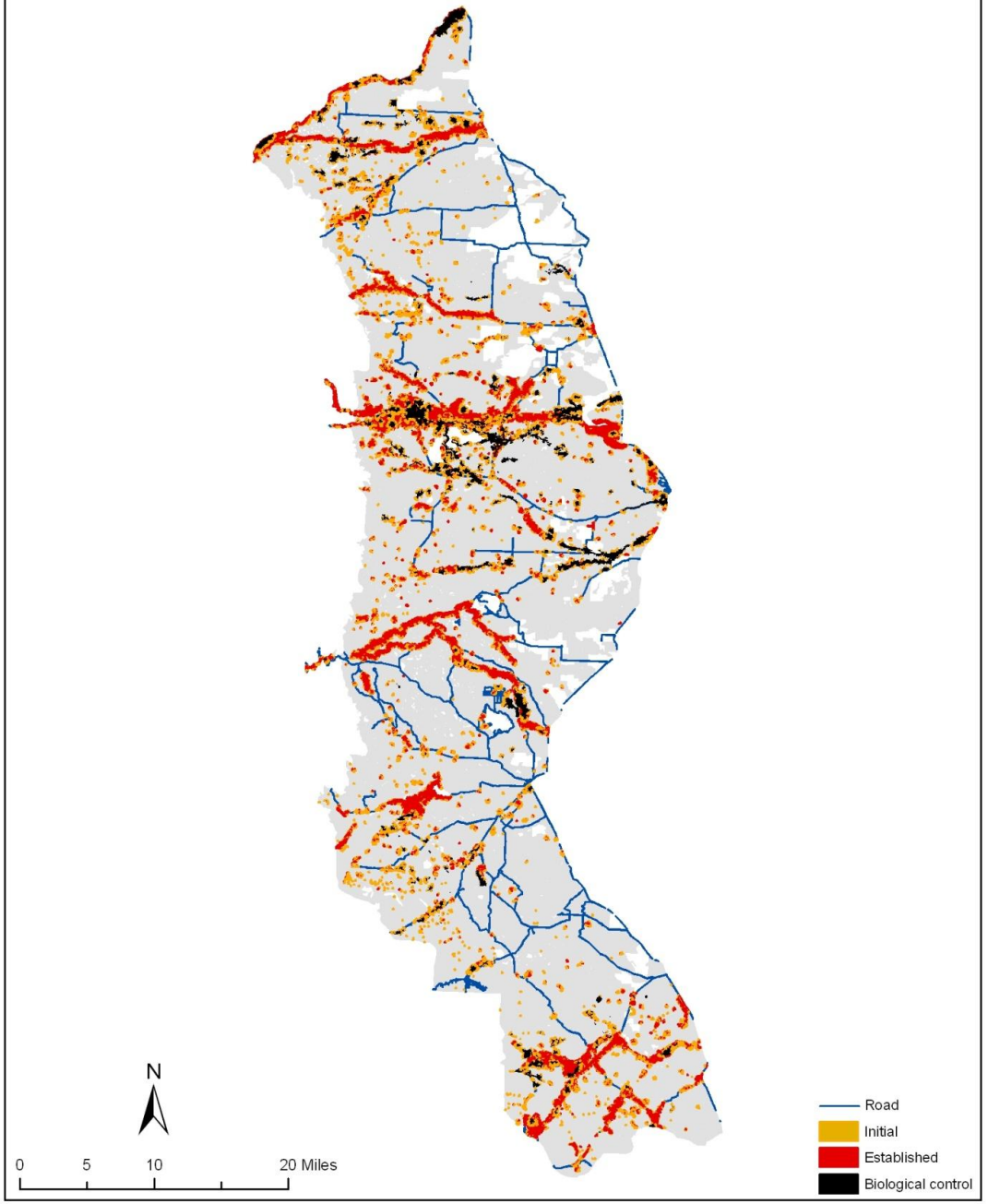
Rocky Mountain Front - Centaurea maculosa & Euphorbia esula -
High Spread - Large Patch Edges - Year 40



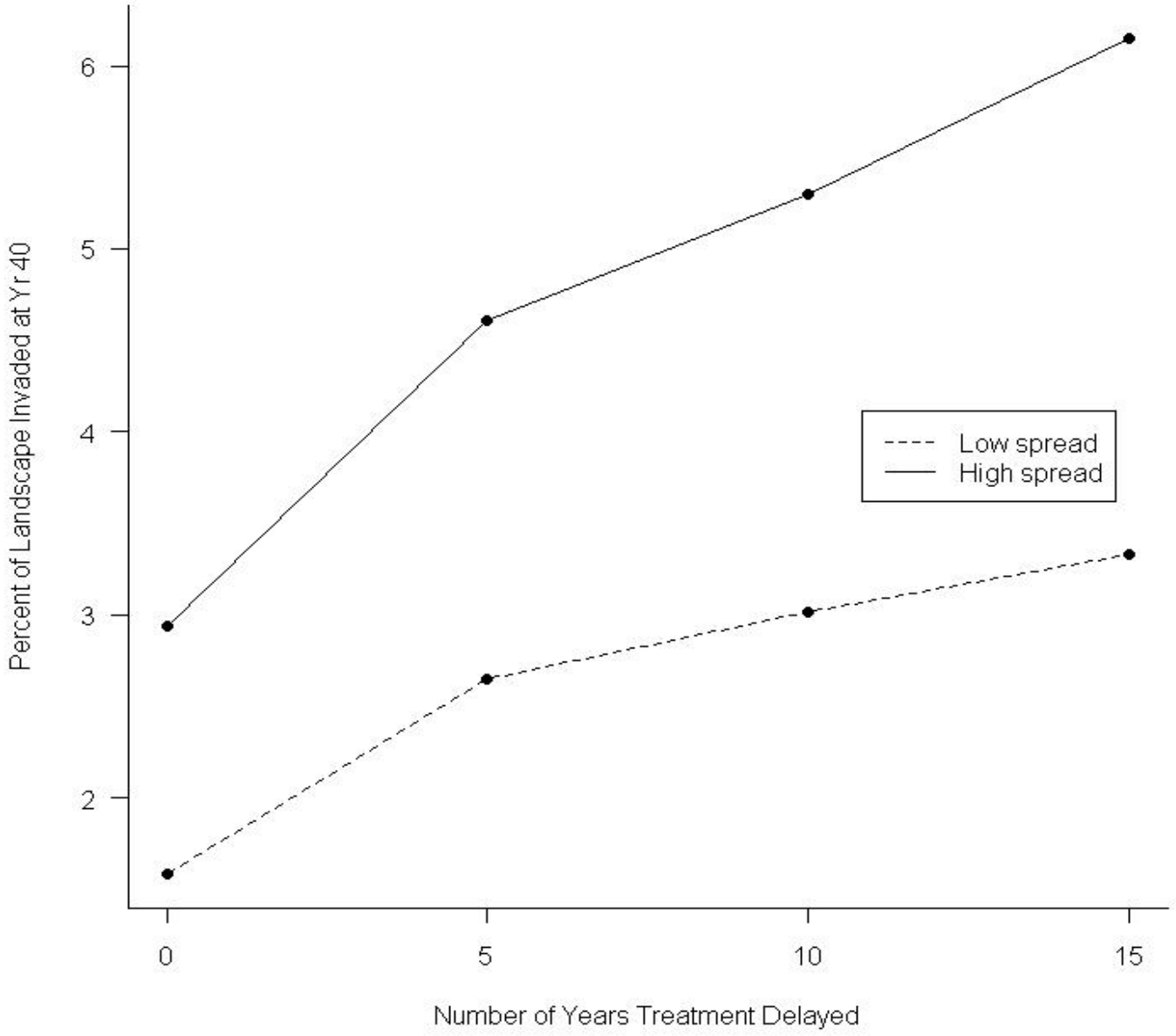
Rocky Mountain Front - Centaurea maculosa & E
High Spread - 2300 ha Management C



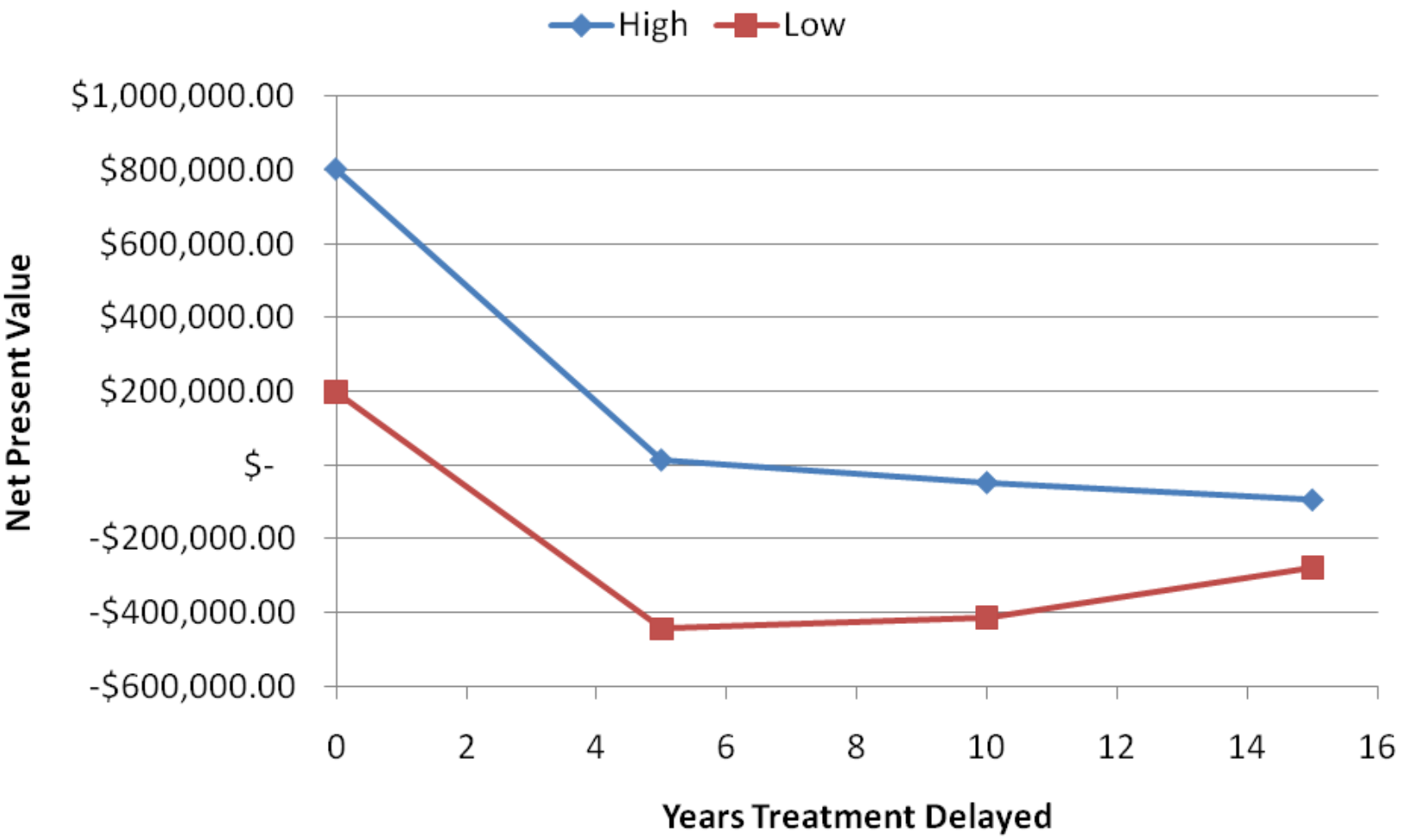
Rocky Mountain Front - Centaurea maculosa & Euphorbia esula -
High Spread - Roaming Treatment - Year 40

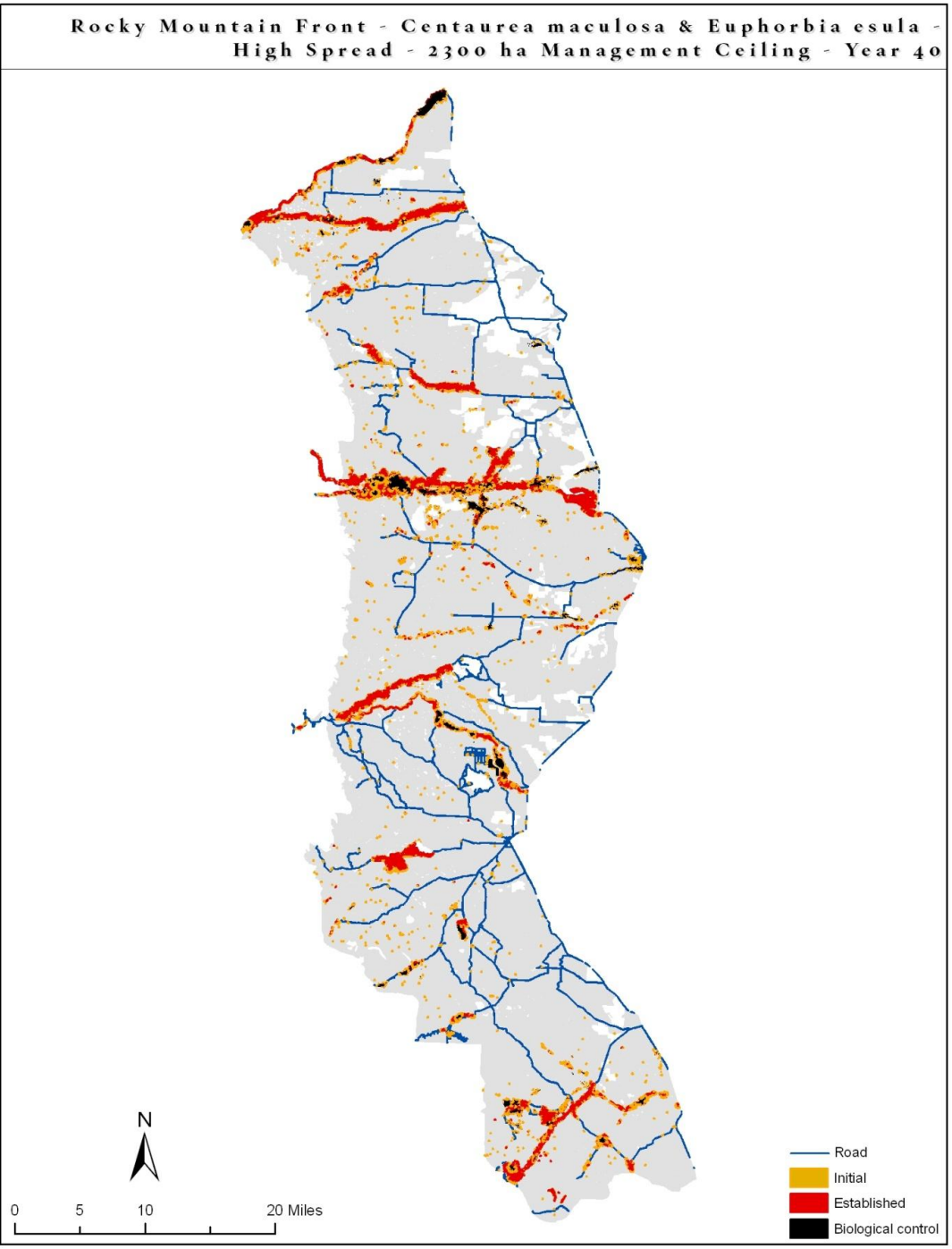


RMF Effects of Delaying Management

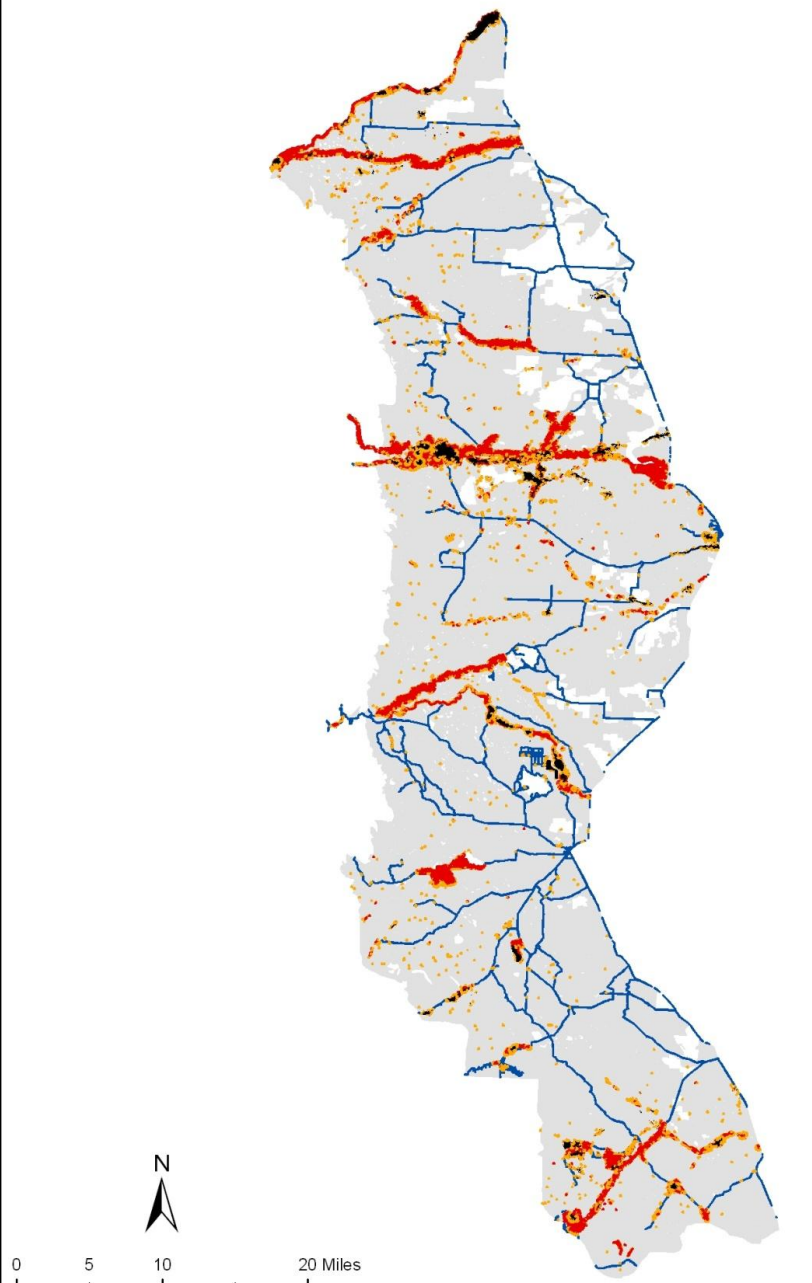


RMF Costs of Delaying Management

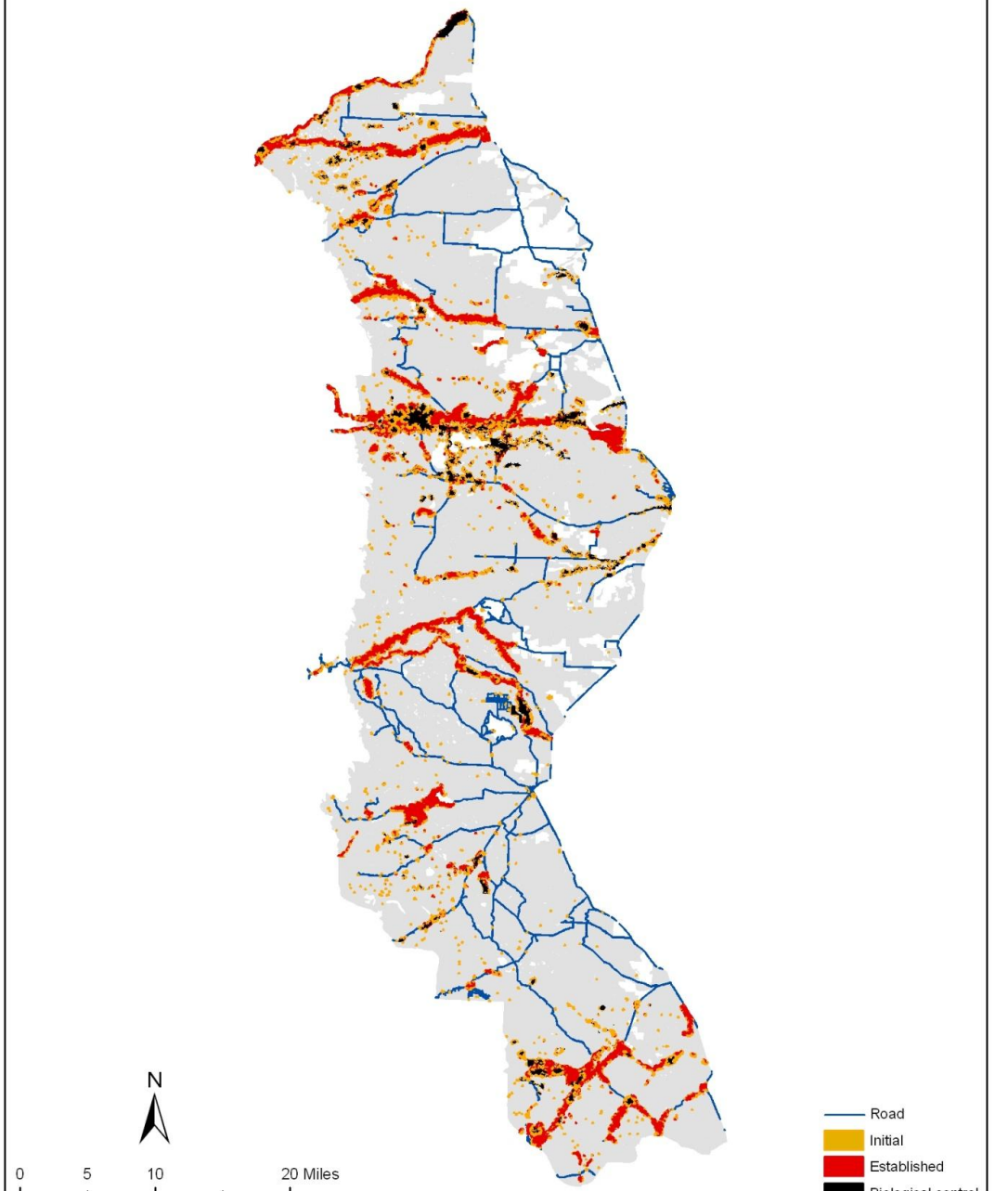



Rocky Mountain Front - Centaurea maculosa & Euphorbia esula - High Spread - 2300 ha Management Ceiling - Year 40
N
0
5
10
20 Miles
Road
Initial
Established
Biological control

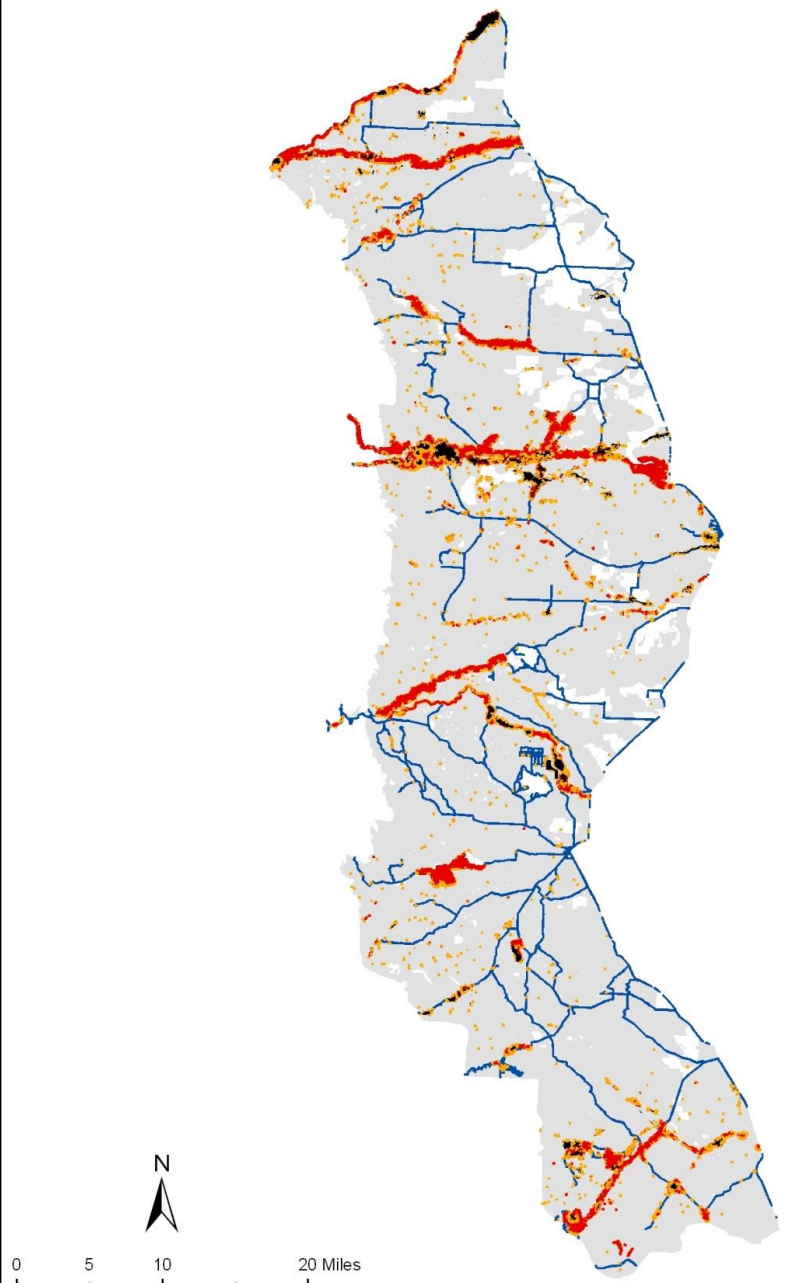
Rocky Mountain Front - Centaurea maculosa & E
High Spread - 2300 ha Management C



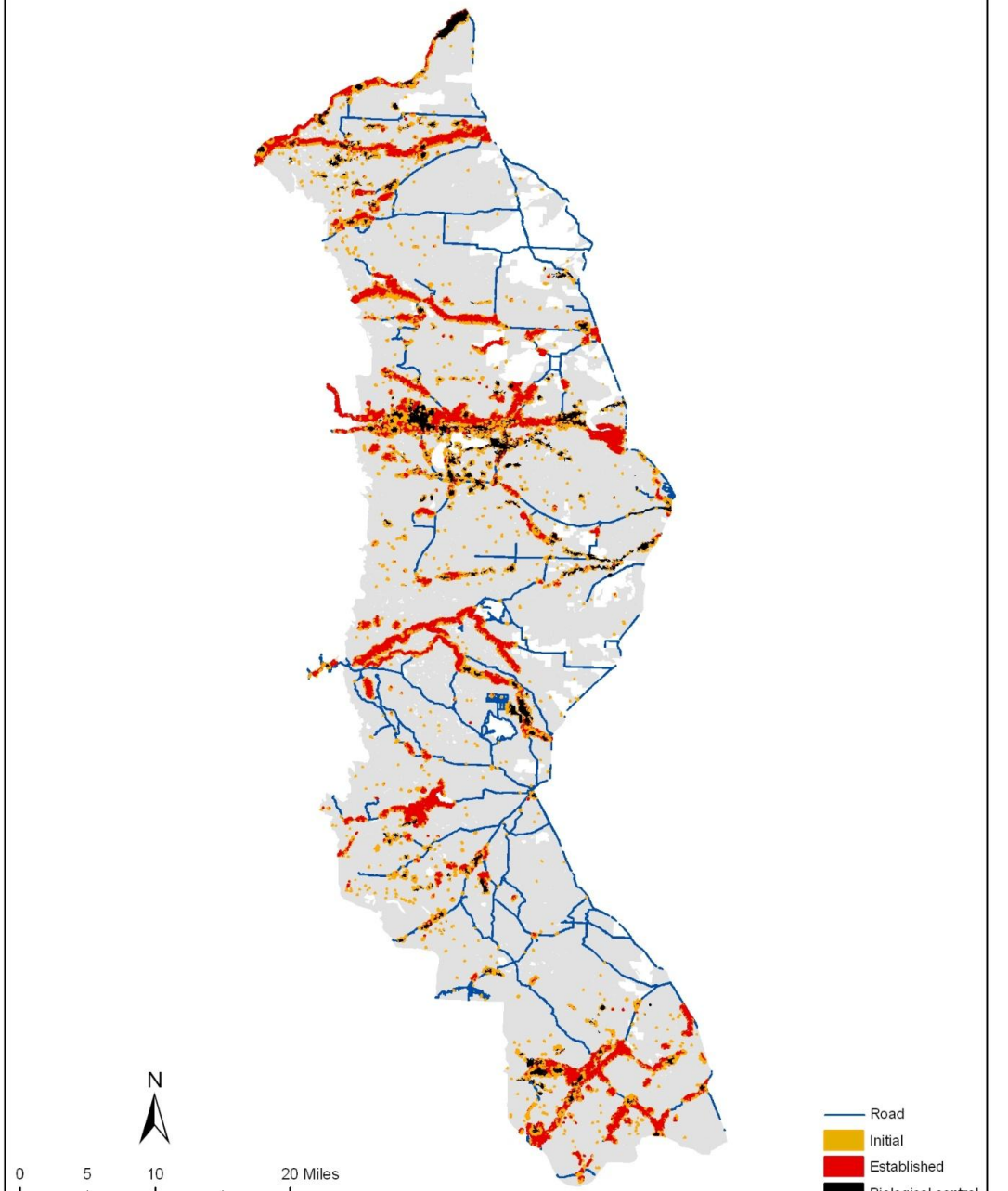
Rocky Mountain Front - Centaurea maculosa & Euphorbia esula -
High Spread - 5 Years Delay Before Treatment Starts - Year 40



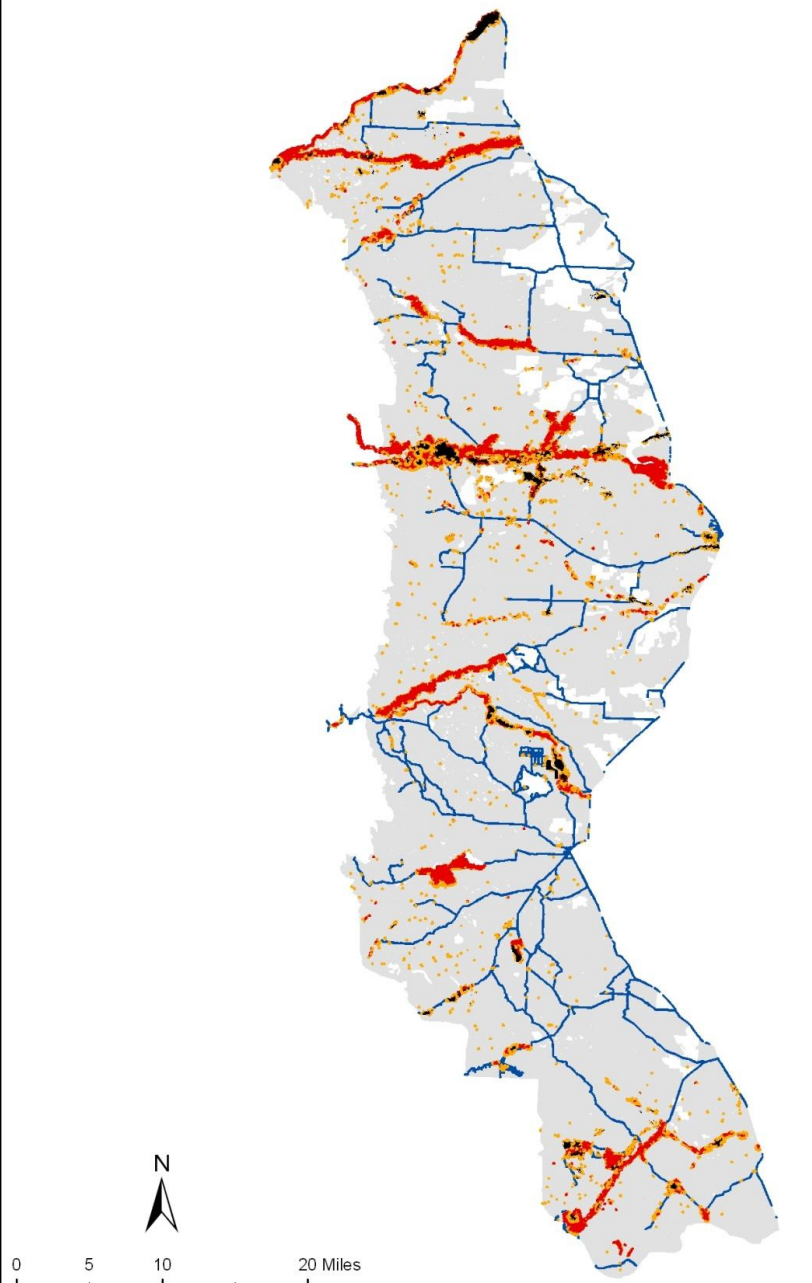
Rocky Mountain Front - Centaurea maculosa & E
High Spread - 2300 ha Management C



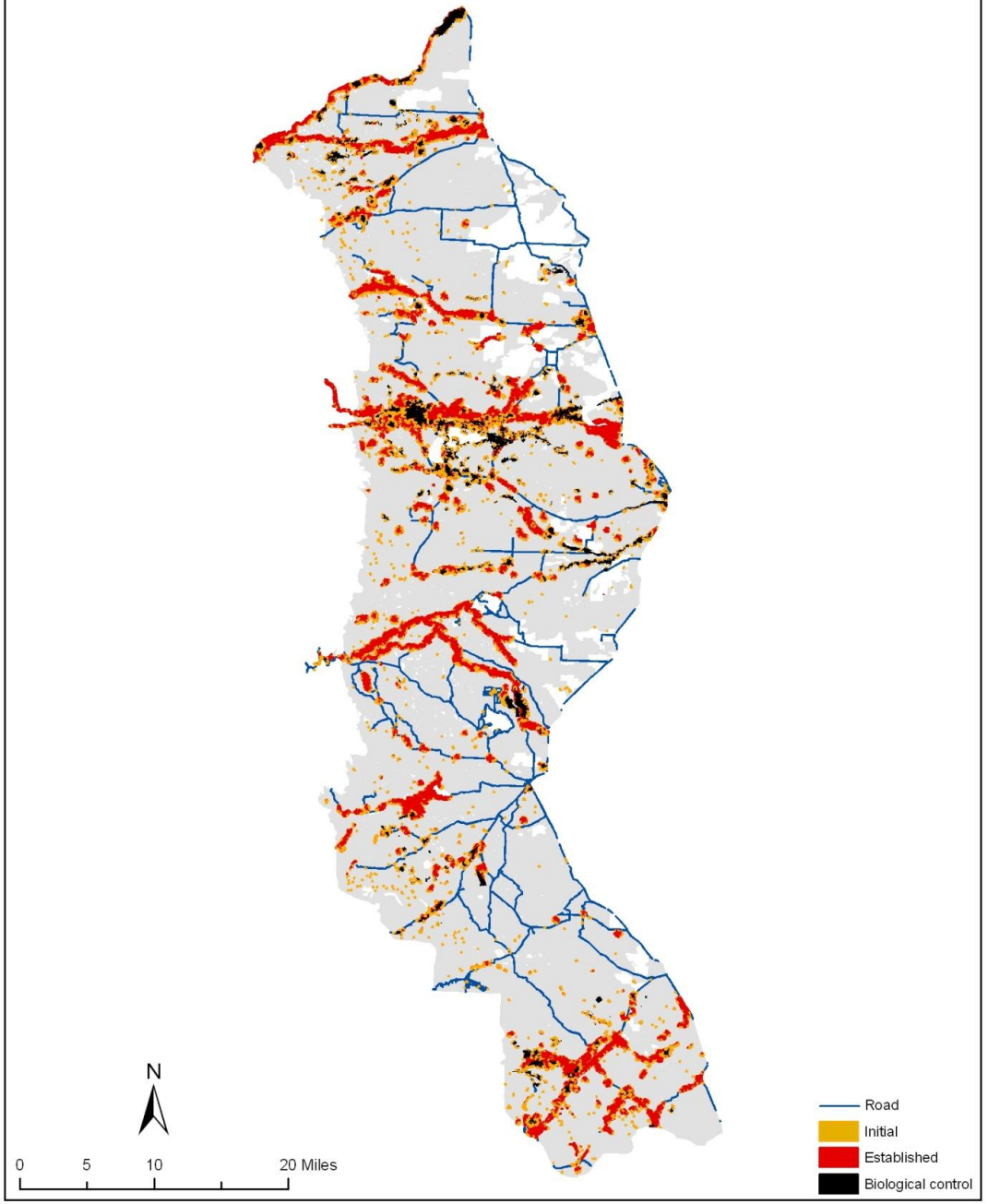
Rocky Mountain Front - Centaurea maculosa & Euphorbia esula -
High Spread - 10 Years Delay Before Treatment Starts - Year 40



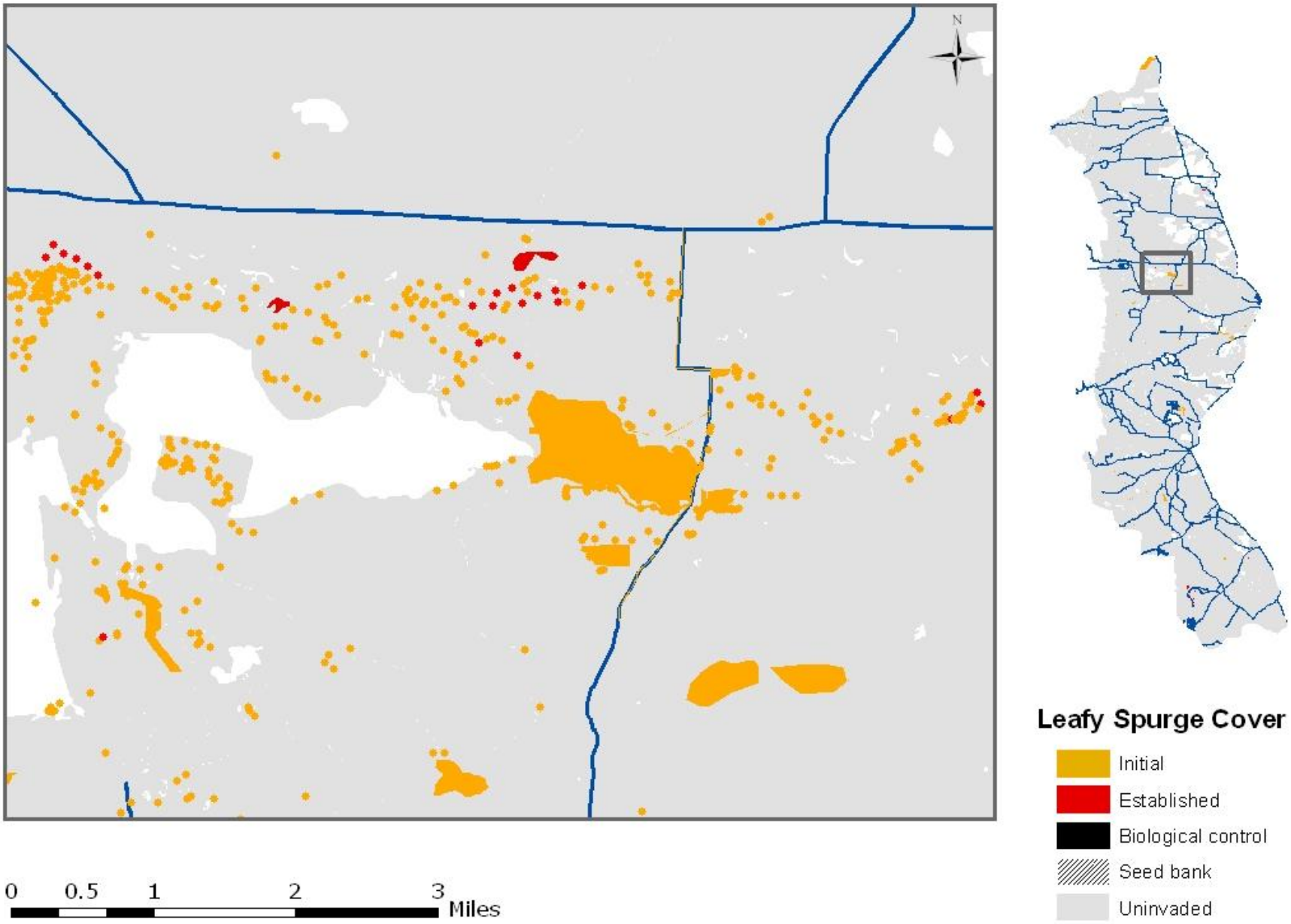
Rocky Mountain Front - Centaurea maculosa & E
High Spread - 2300 ha Management C



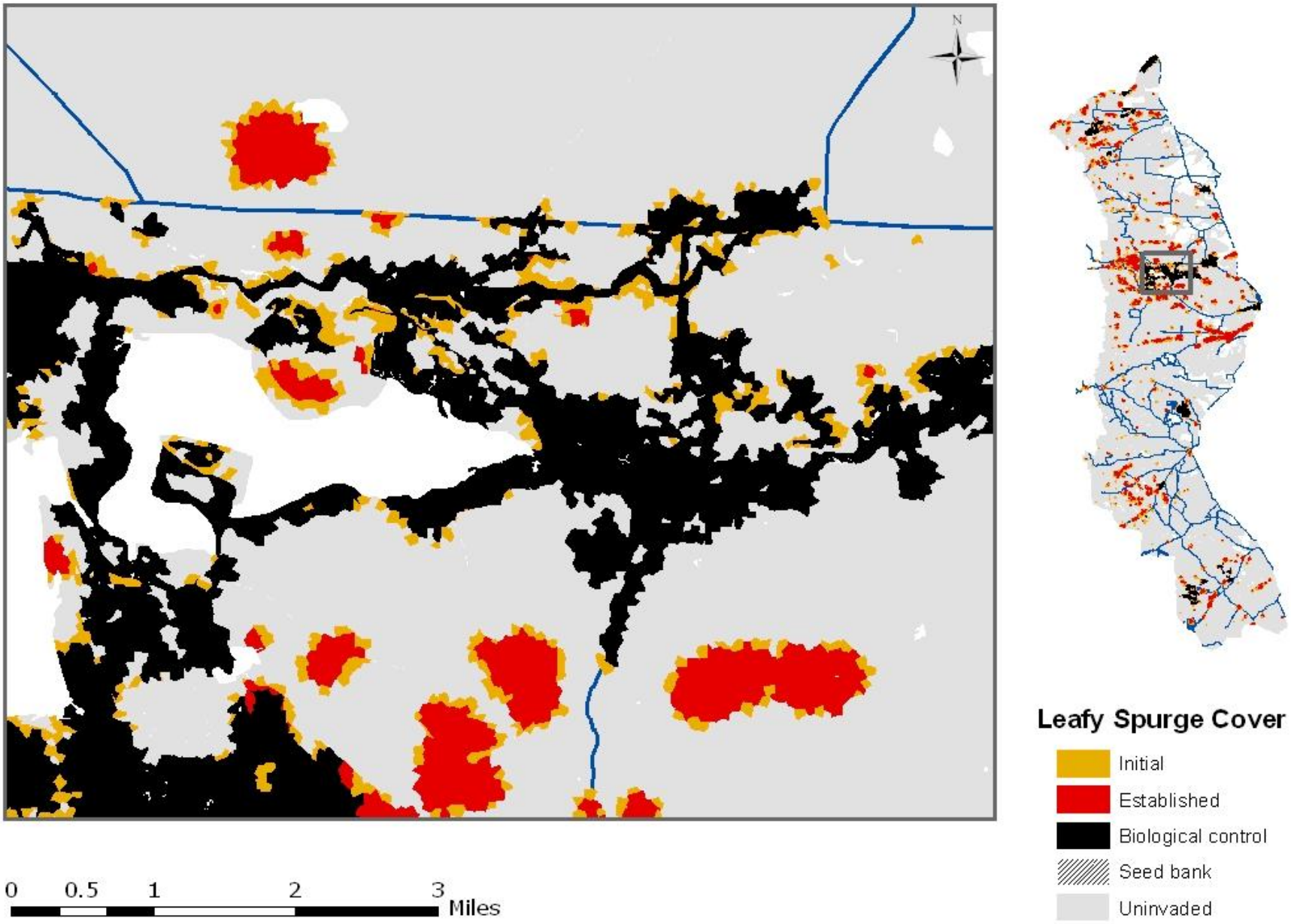
Rocky Mountain Front - Centaurea maculosa & Euphorbia esula -
High Spread - 15 Years Delay Before Treatment Starts - Year 40



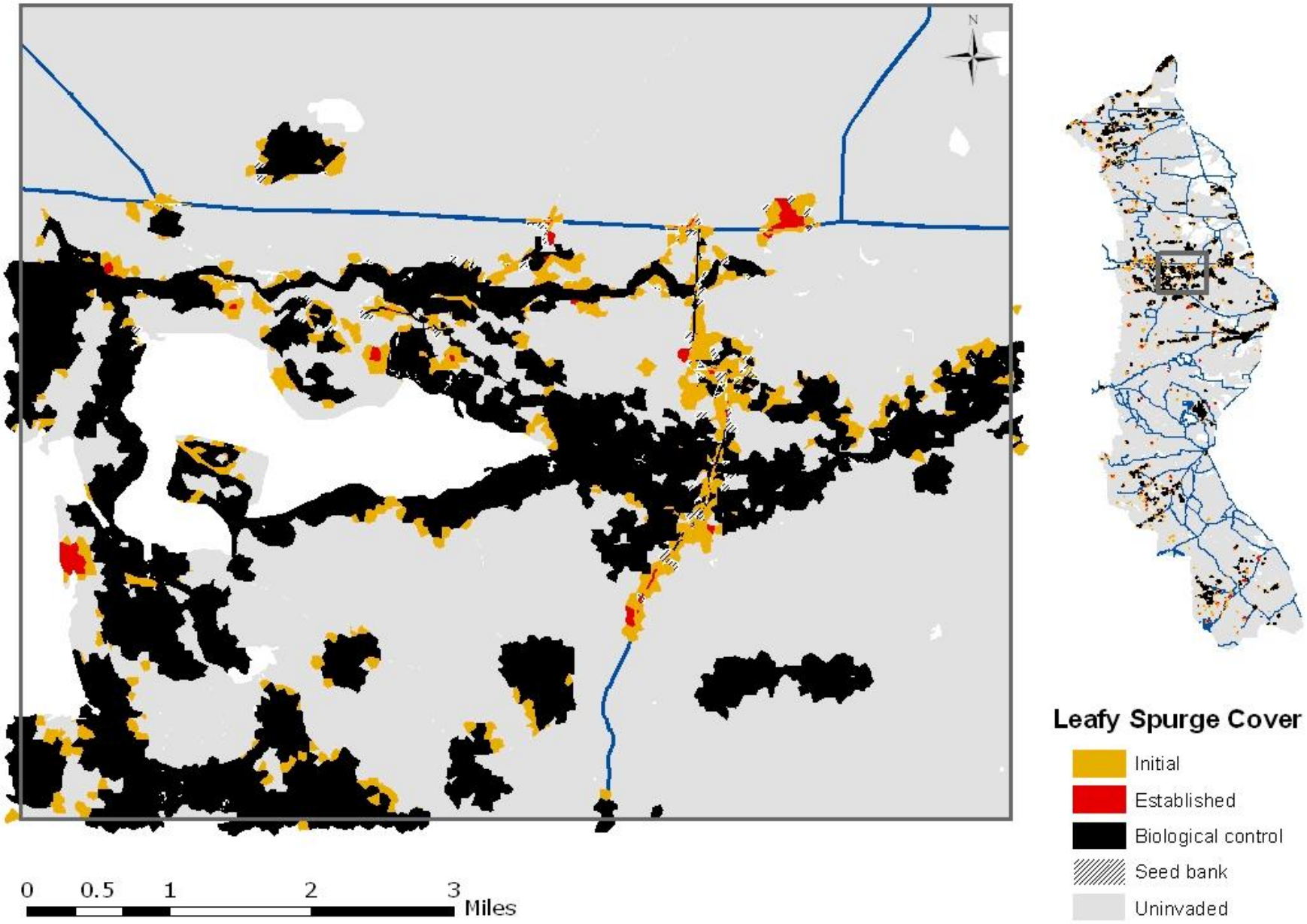
Spurge Initial



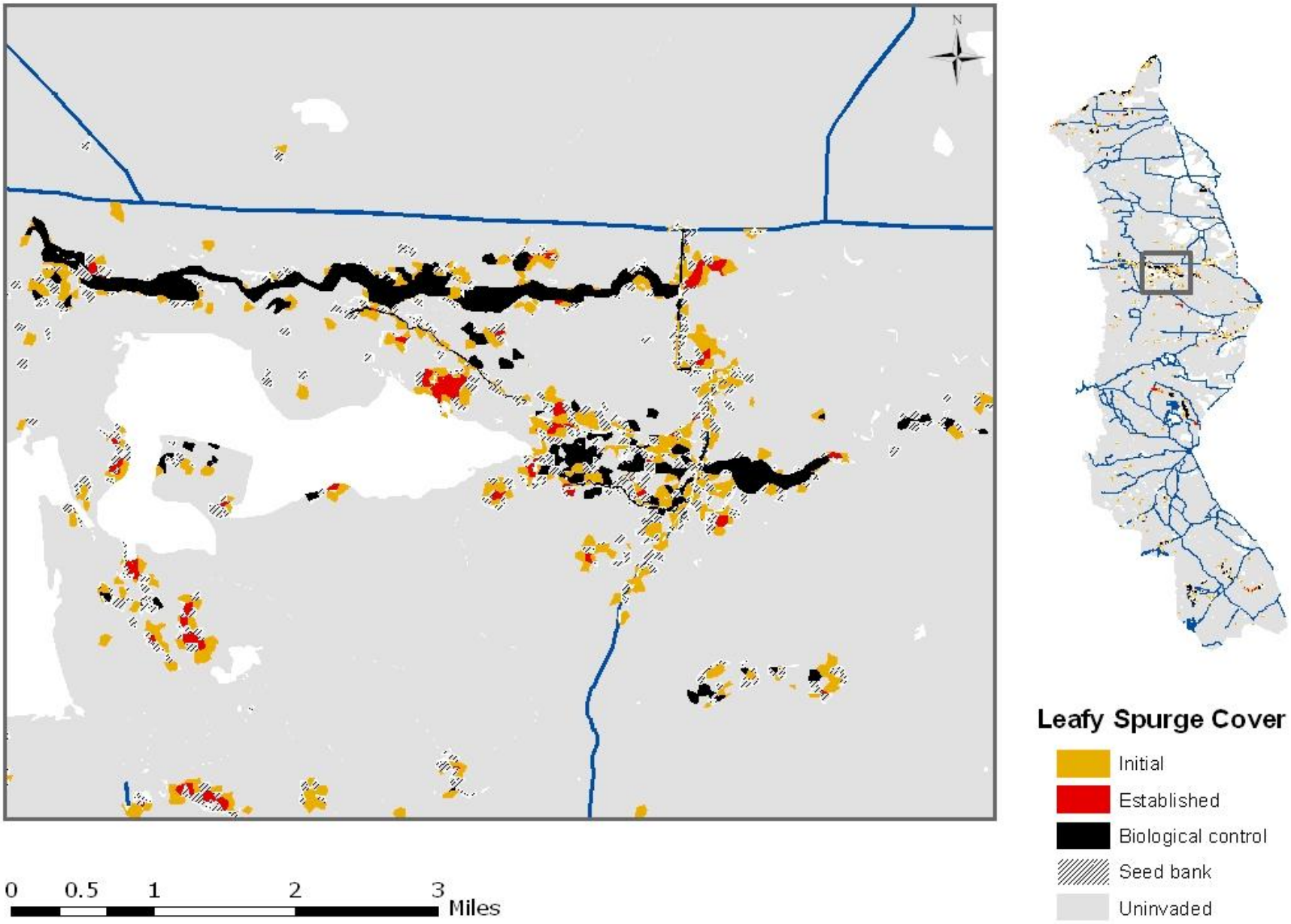
High Spread 70 - No Management - BC Spread - Spurge - Year 40



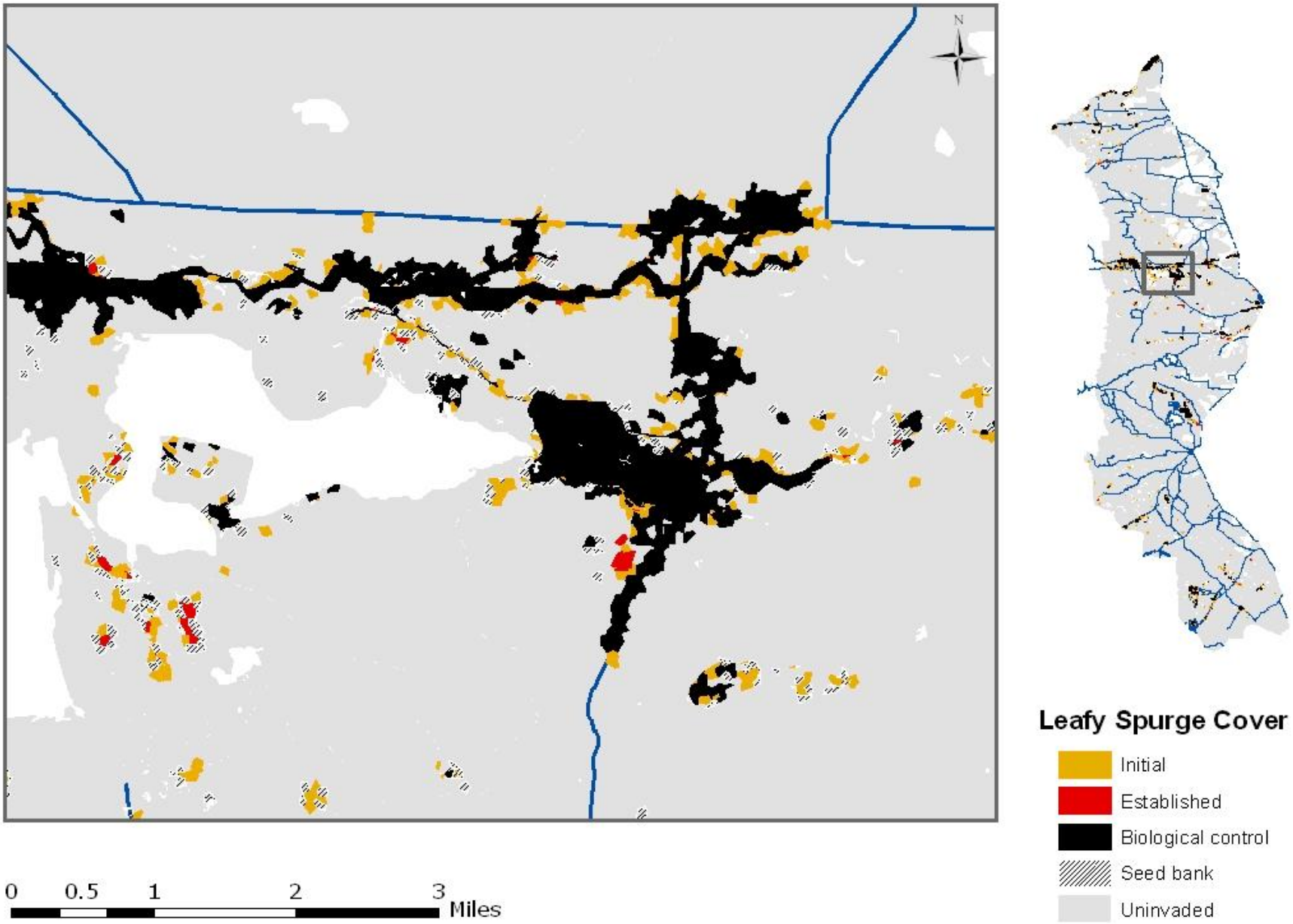
High Spread 70 - 2300 ha ceiling - LPE - Spurge - Year 40



High Spread 70 - Unlimited - Spurge - Year 40



High Spread 70 - 2300 ha ceiling - Spurge - Year 40



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?