Weed Treatment Planner (WTP) – A Spatial Decision Support System for Invasive Weed Management

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Greg Jones, ***USDA Forest Service Rocky Mountain Research Station***

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- Concluding Remarks

Project Overview

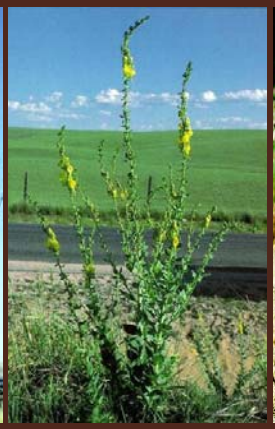
- Project period
  - September 15, 2006 – September 30, 2010

- Research Personnel
  - Project Investigators
    - Woodam Chung, University of Montana
    - Greg Jones, USDA Forest Service
    - Peter Rice, University of Montana
    - Timothy Prather, University of Idaho
  - Other research personnel
    - Pablo Aracena, University of Montana
    - Janet Sullivan, USDA Forest Service
    - Kurt Krueger, USDA Forest Service
    - Larry Lass, University of Idaho
  - Collaborators
    - Gil Gale, Invasive Plants Program Leader, Bitterroot NF, MT
    - Pat Green, Forest Ecologist, Nez Perce NF, ID
    - Carl Crabtree, County Weed Program Leader, Idaho County, ID

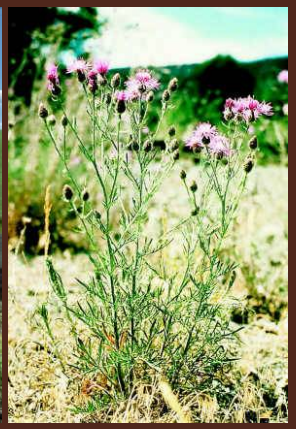
Background

- It is difficult to optimize the use of suppression resources, especially late in the “eradication priority” stage and during most of the “control priority” stage

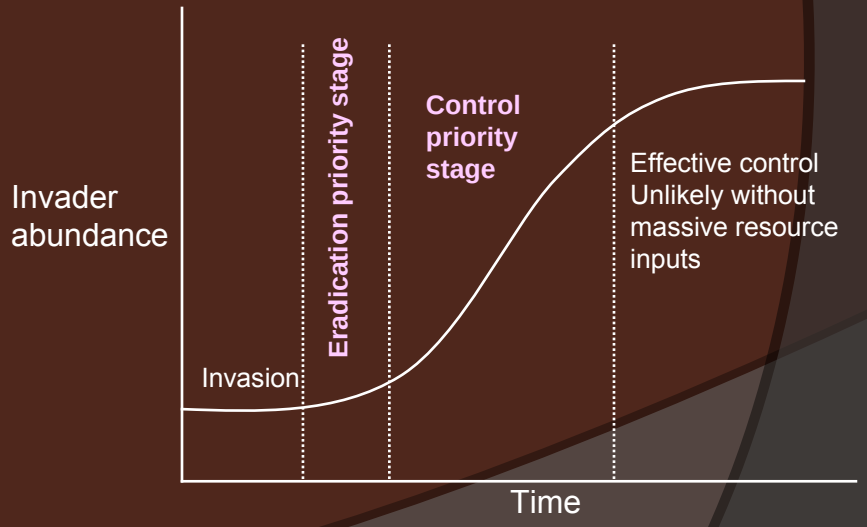
Rush skeletonweed



Dalmatian toadflax



Spotted knapweed



Background

- Lack of the ability to analyze trade-offs between alternative spatial and temporal treatment strategies
- Trade-off analyses are critical to developing cost-effective treatment decisions in the usual case of limiting resources and budgets

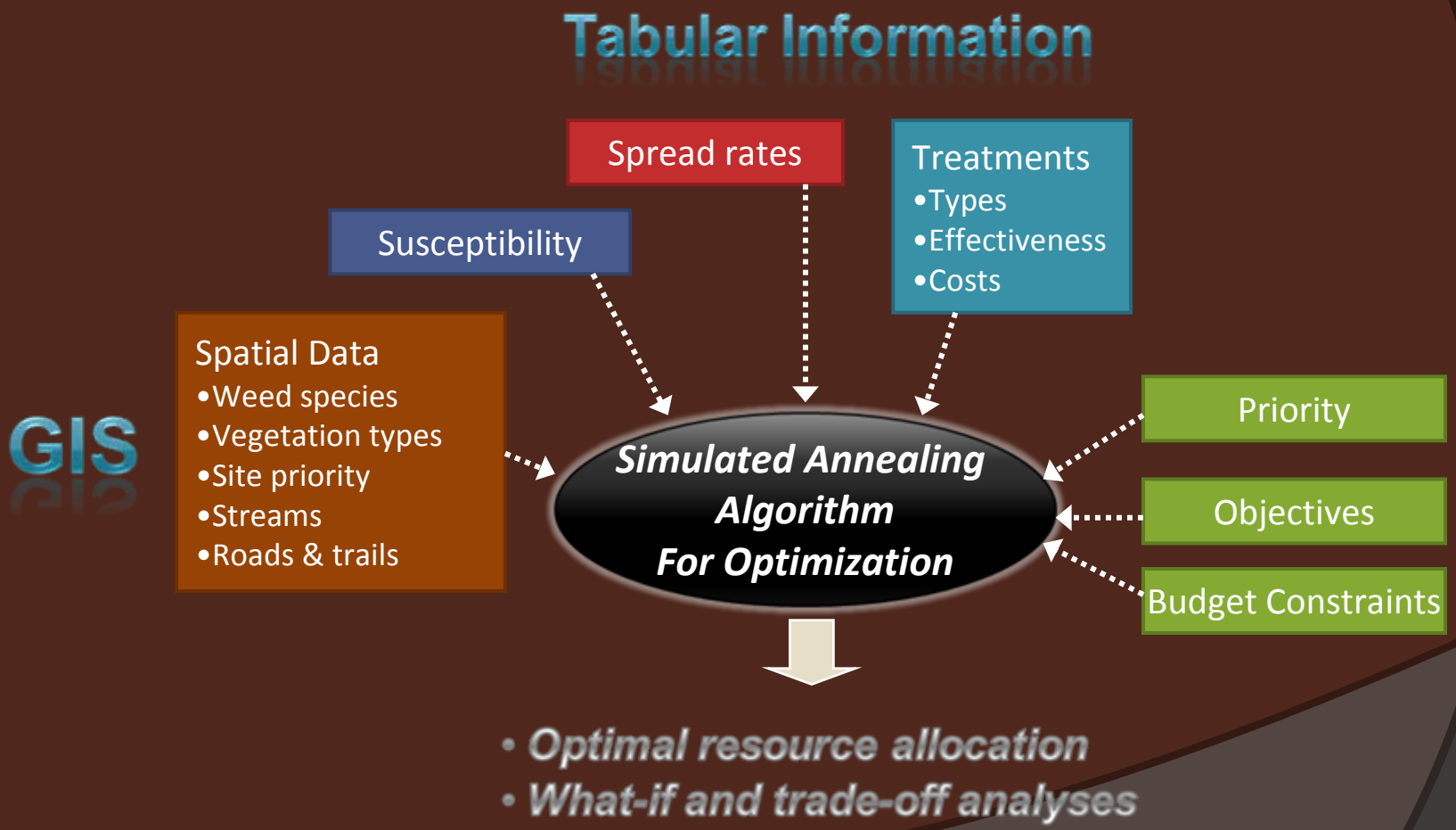
Leafy spurge

Objectives

- Develop a spatially explicit decision support system for invasive weed species management
  - The system will offer the optimization of resource allocation in deciding among treatment alternatives by incorporating species specific spread dynamics
- Test the system on two National Forests: Bitterroot NF in Montana and Nez Perce NF in Idaho

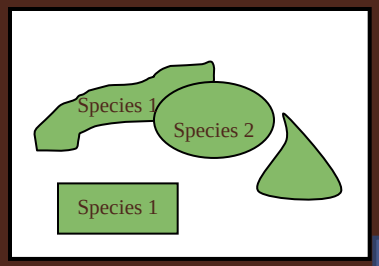
Weed Treatment Planner (WTP)

Conceptual Model



Conceptual Model

"Weed species" layer



Tabular Information

Spread rates

Susceptibility

Treatments
- Types
- Effectiveness
- Costs

GIS

Spatial Data
- Weed species
- Vegetation types
- Site priority
- Streams
- Roads & trails

Simulated Annealing Algorithm For Optimization

Priority

Objectives

Budget Constraints

- ***Optimal resource allocation***
- ***What-if and trade-off analyses***

Conceptual Model

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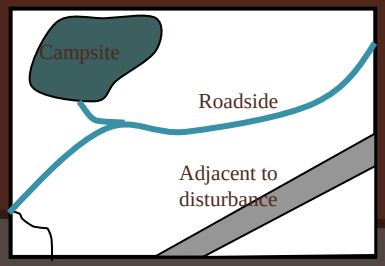
Simulated Annealing Algorithm For Optimization

Priority

Objectives

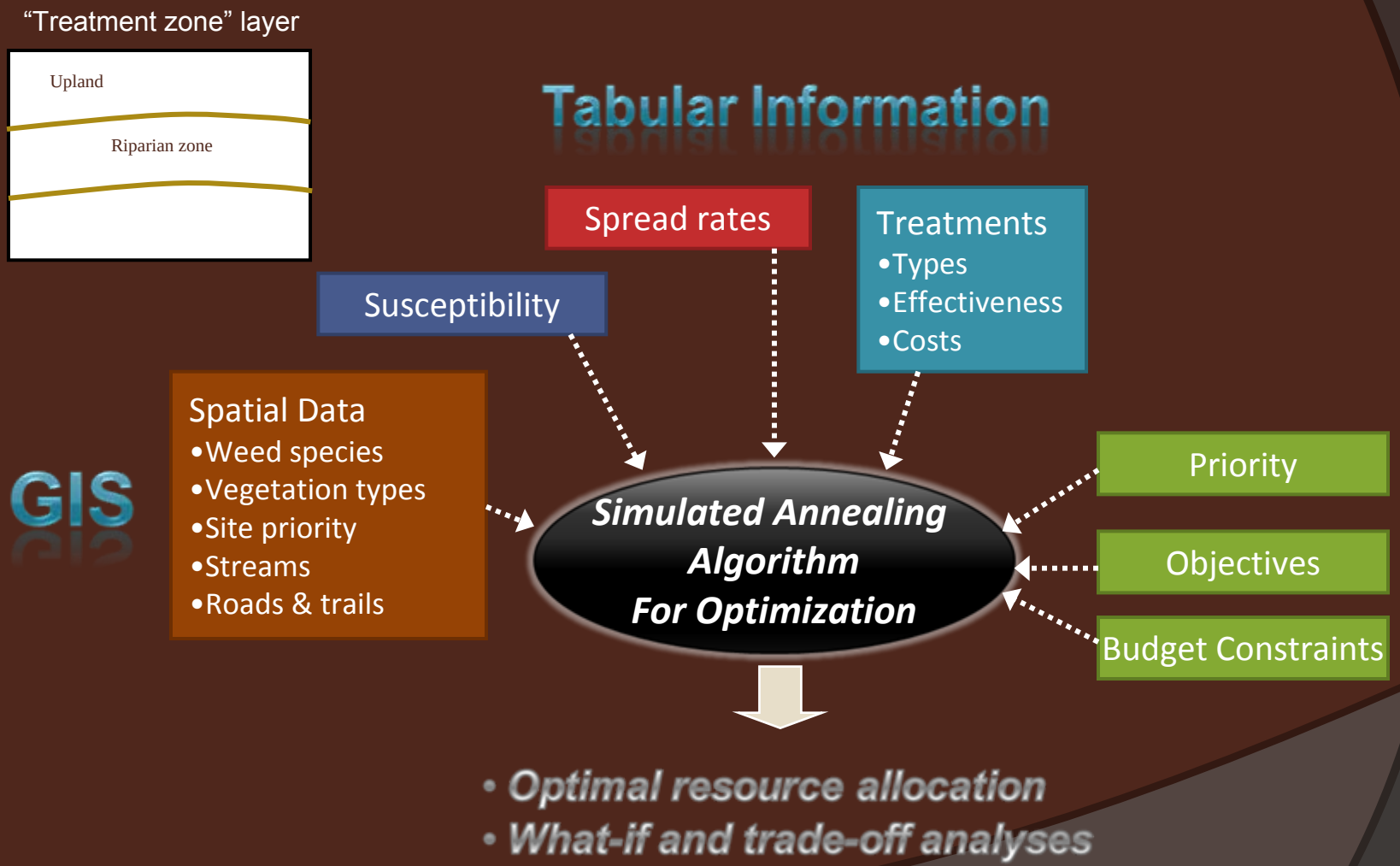
Budget Constraints

"Site priority" layer

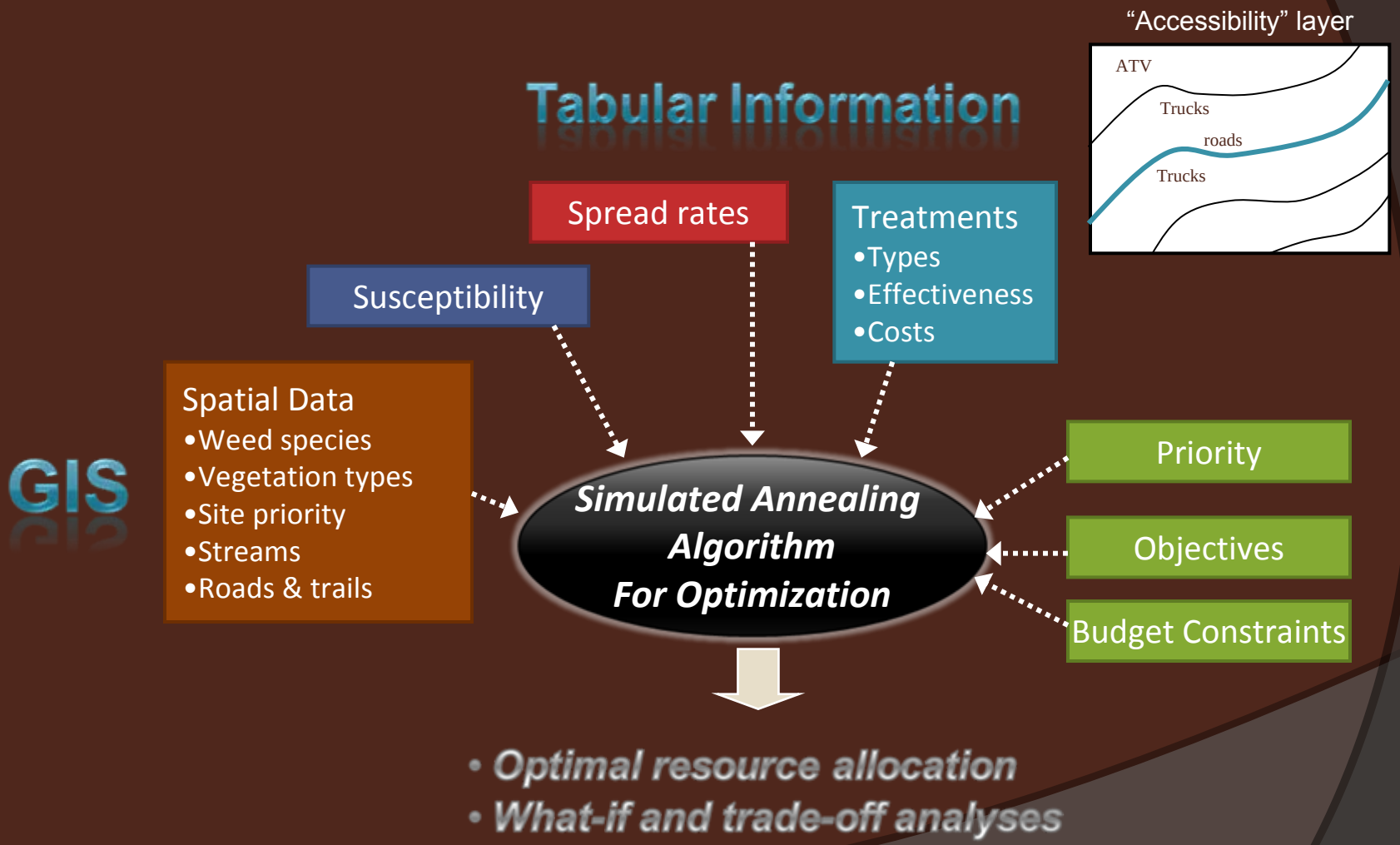


- ***Optimal resource allocation***
- ***What-if and trade-off analyses***

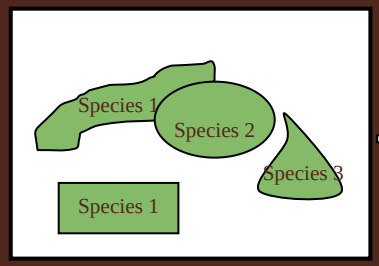
Conceptual Model



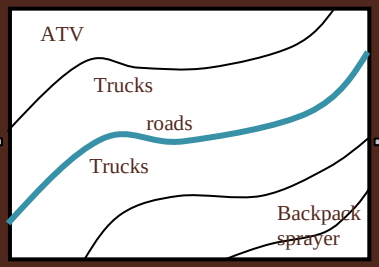
Conceptual Model



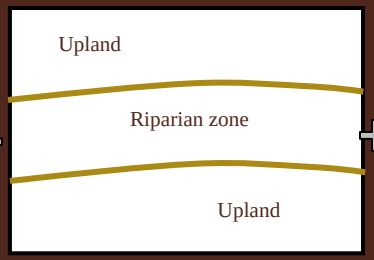
“Weed species” layer



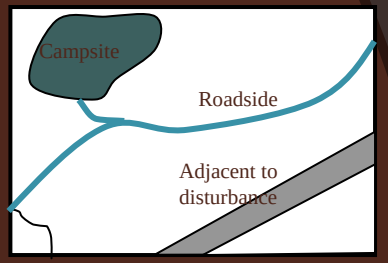
“Accessibility” layer



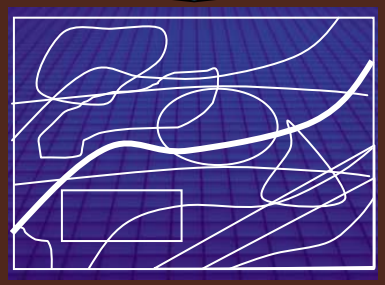
“Treatment zone” layer



“Site priority” layer



Rasterization and Union

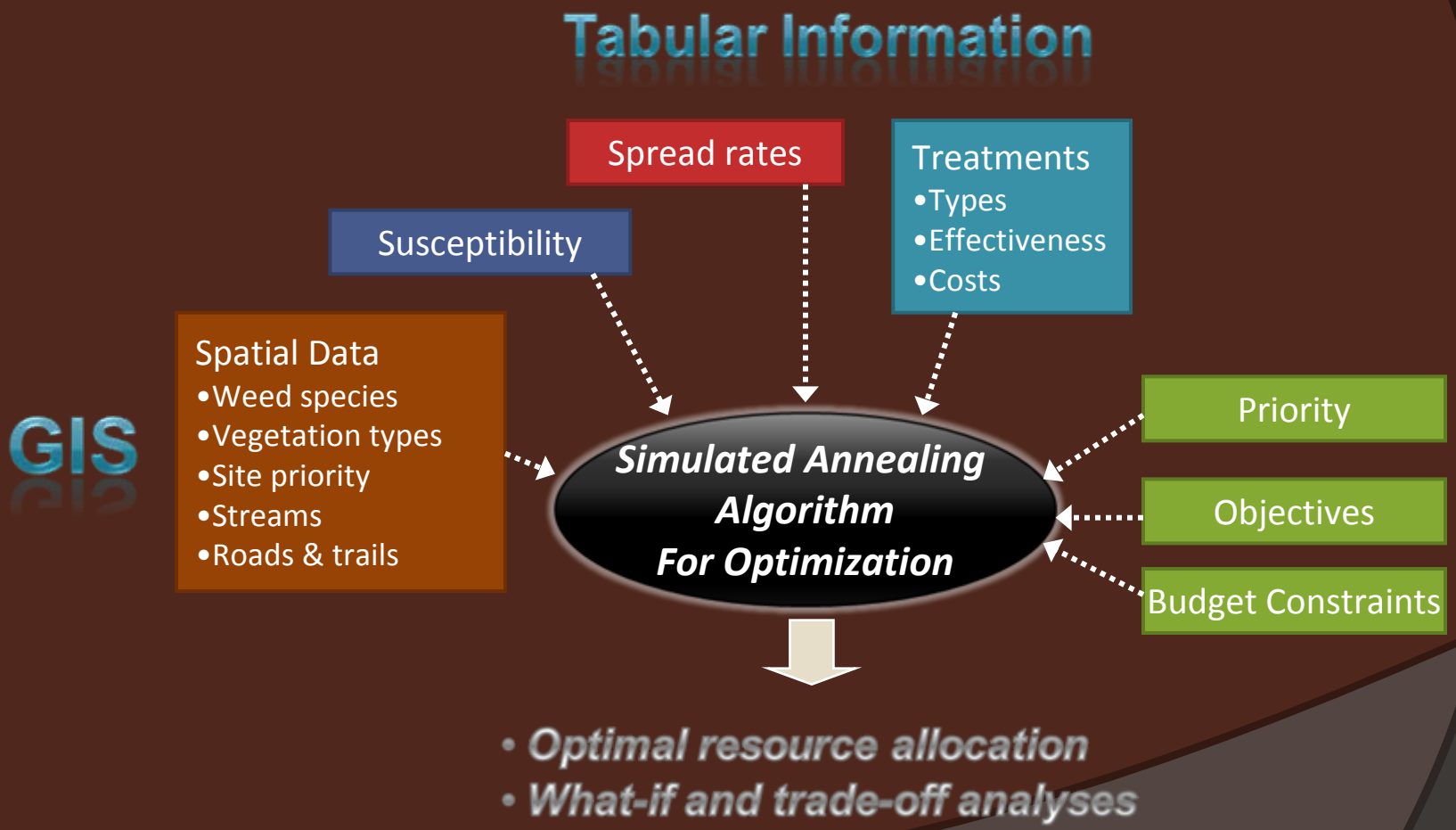


Treatment units with unique attributes

Creating treatment units

Simulated Annealing Algorithm For Optimization

Conceptual Model



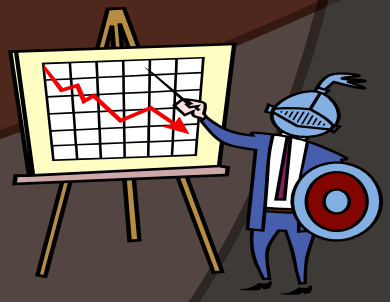
Solution Evaluation

- Temporal consideration
  - The decision support system (DSS) is designed to develop yearly weed treatment plans for up to 5 years, but the effects of treatment plans are analyzed for 10 years

- Objective Function

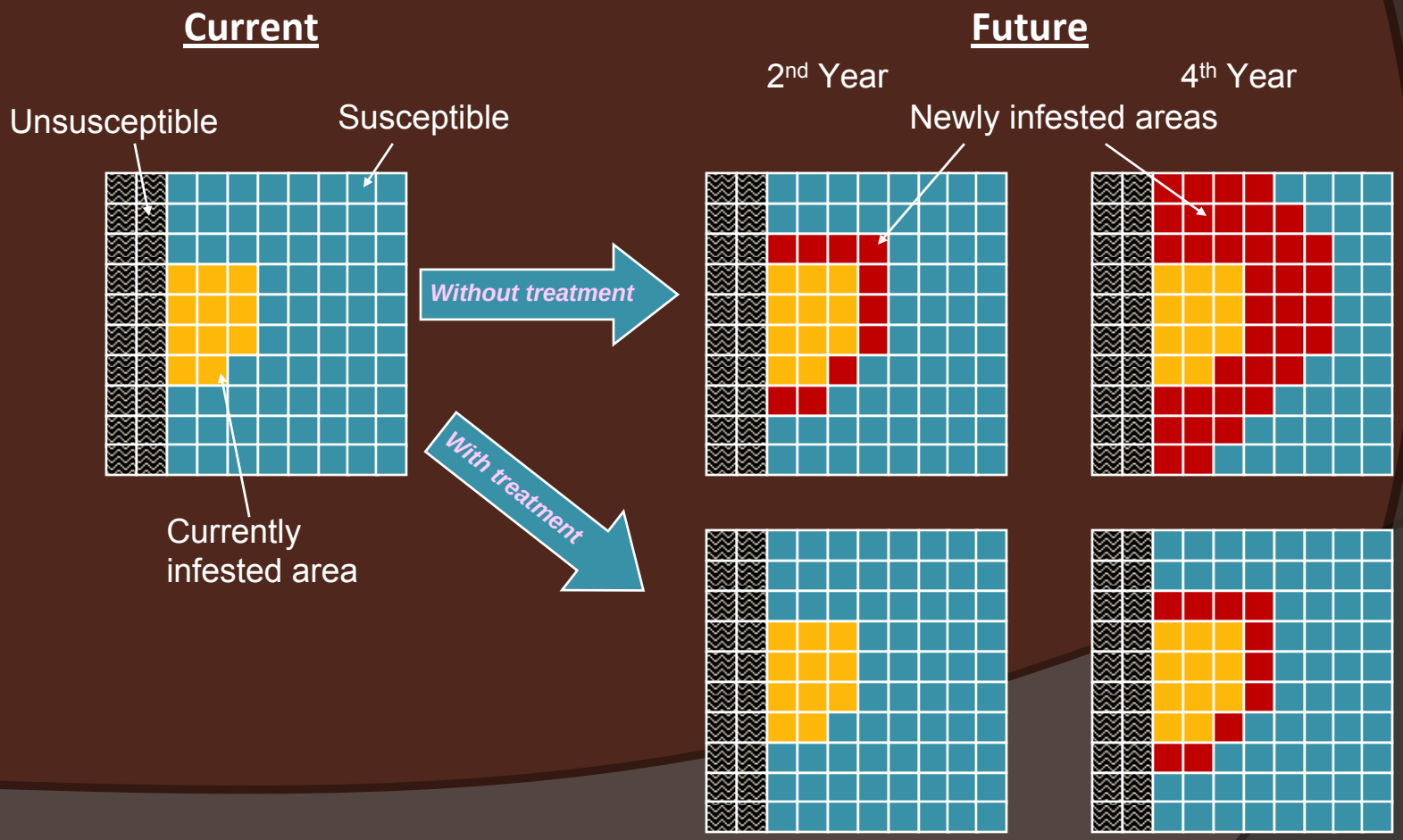
$$\text{Min} \sum_{j=1}^{10} \sum_{i=1}^{I} \left(\text{Infested Area}_{ij} \times \text{Species Priority Index}_{i} \times \text{Site Priority Index}_{i} \right)$$

where *i* represents a grid cell, and *j* is year



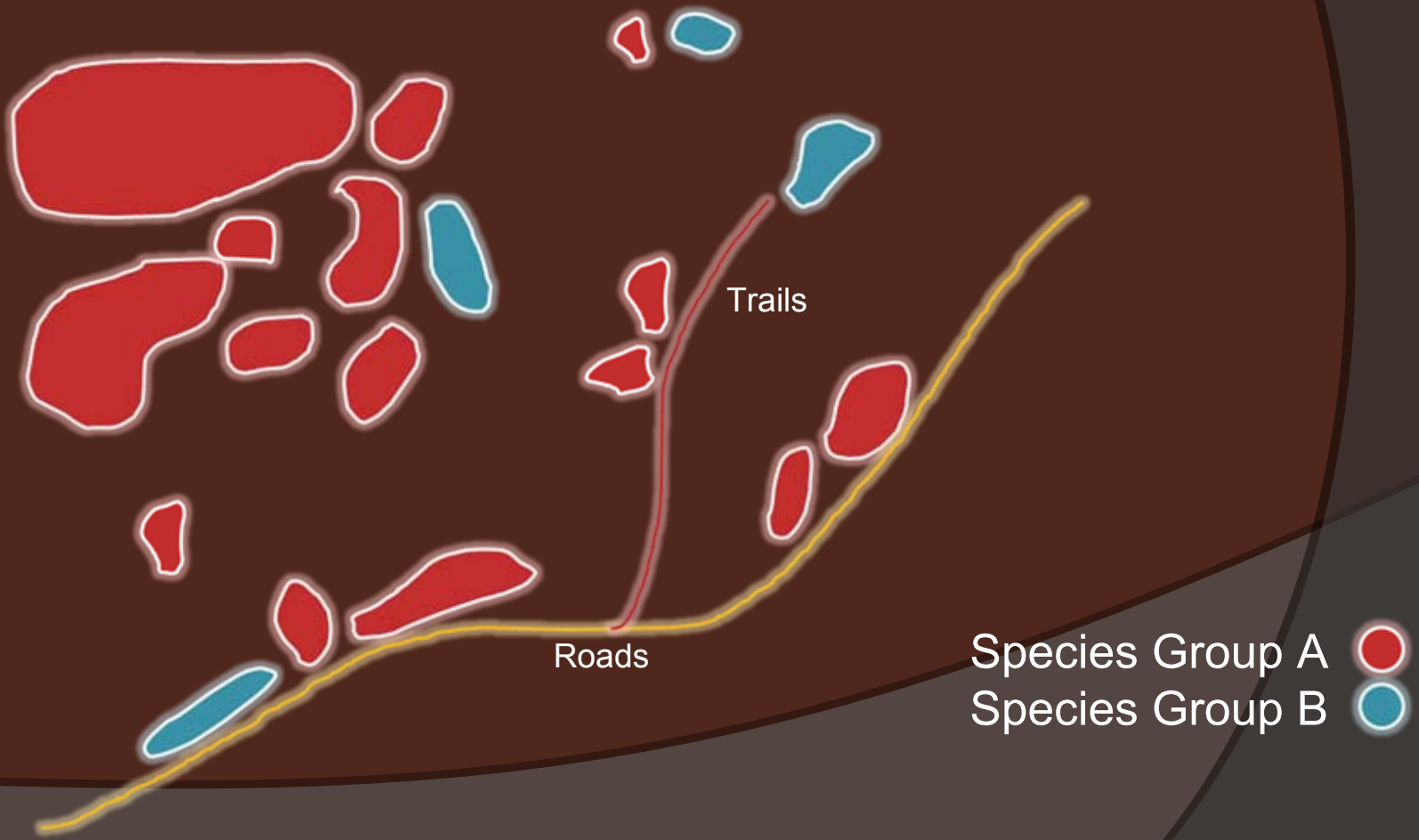
Modeling Weeds Spread

- Modeling weeds spread and treatment effectiveness



Developing Alternative Treatments

- Determining alternative application methods



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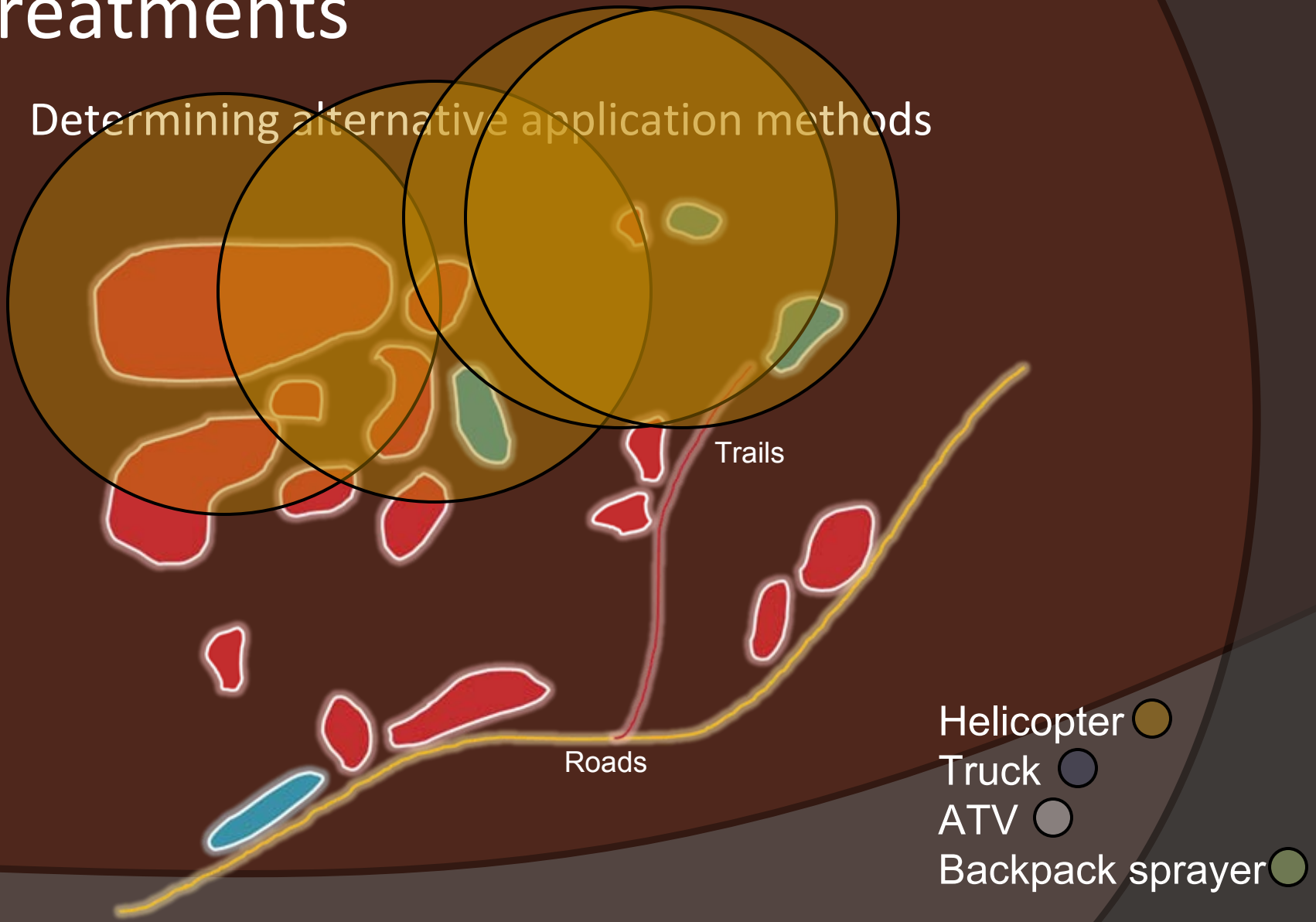
- Determining alternative application methods



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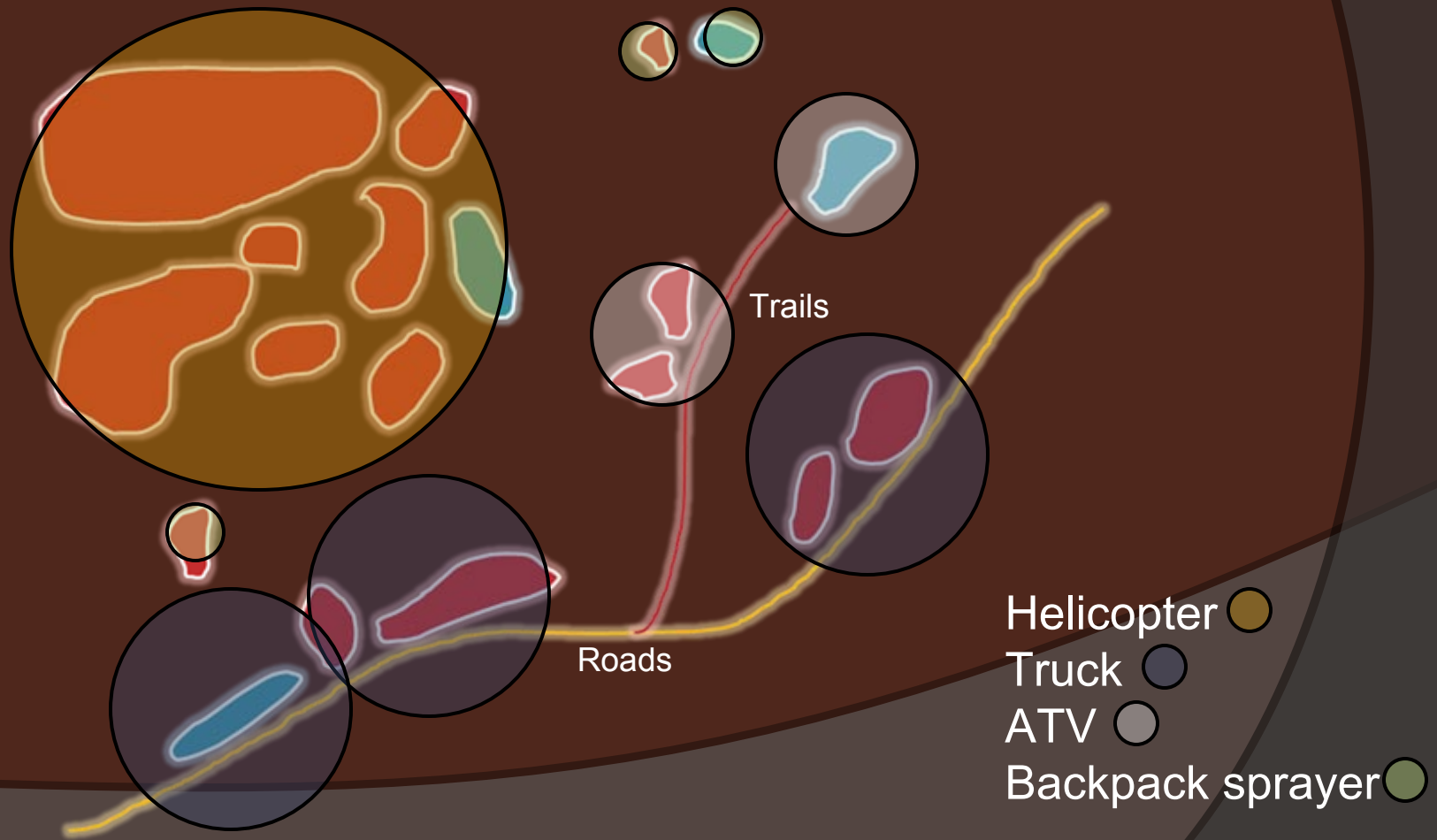
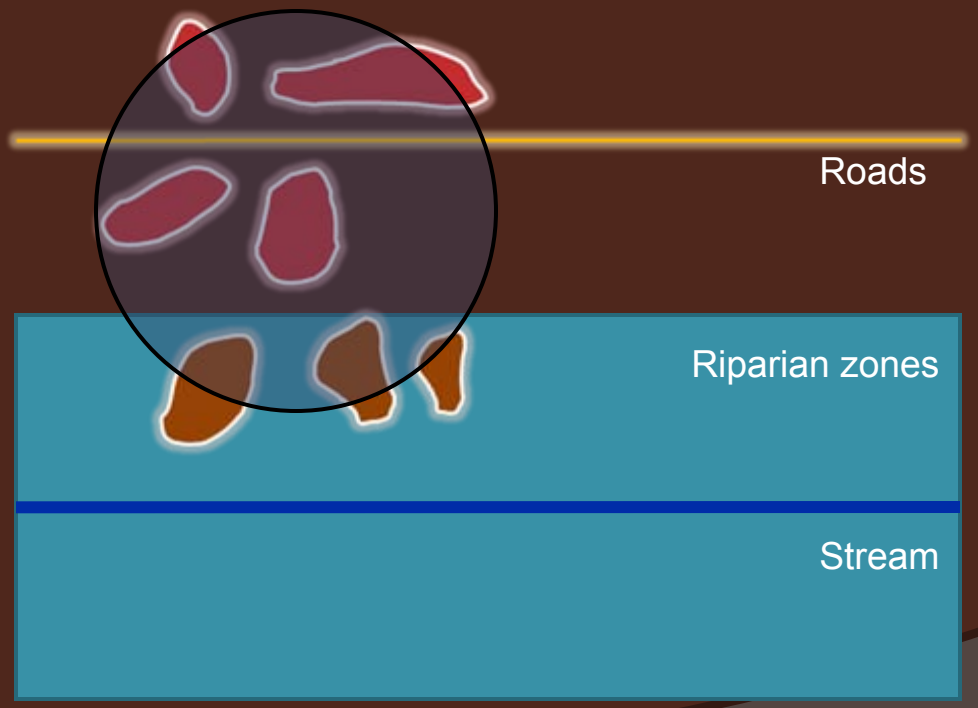
- Determining alternative application methods



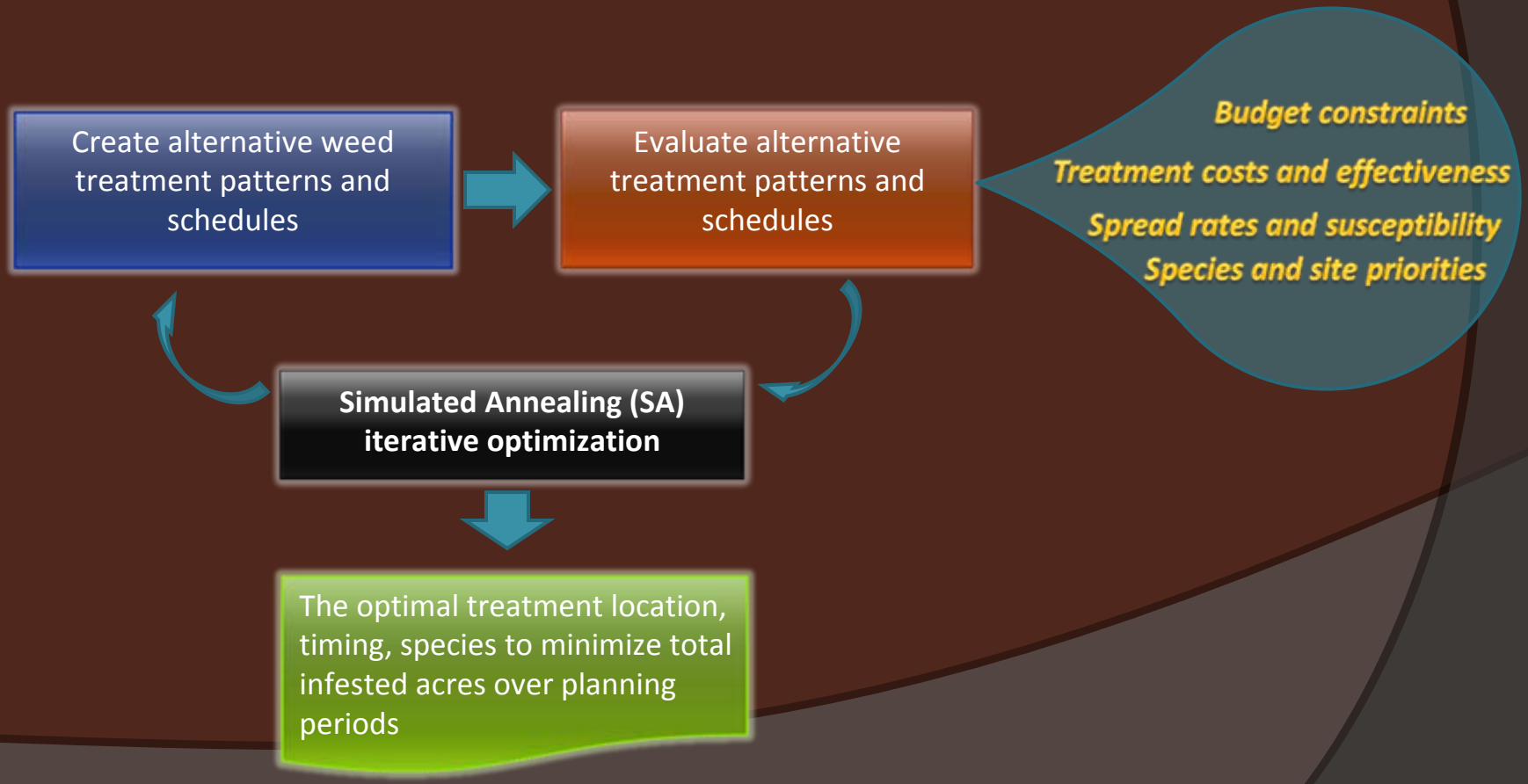
Developing Alternative Treatments

- Determining herbicides and application areas

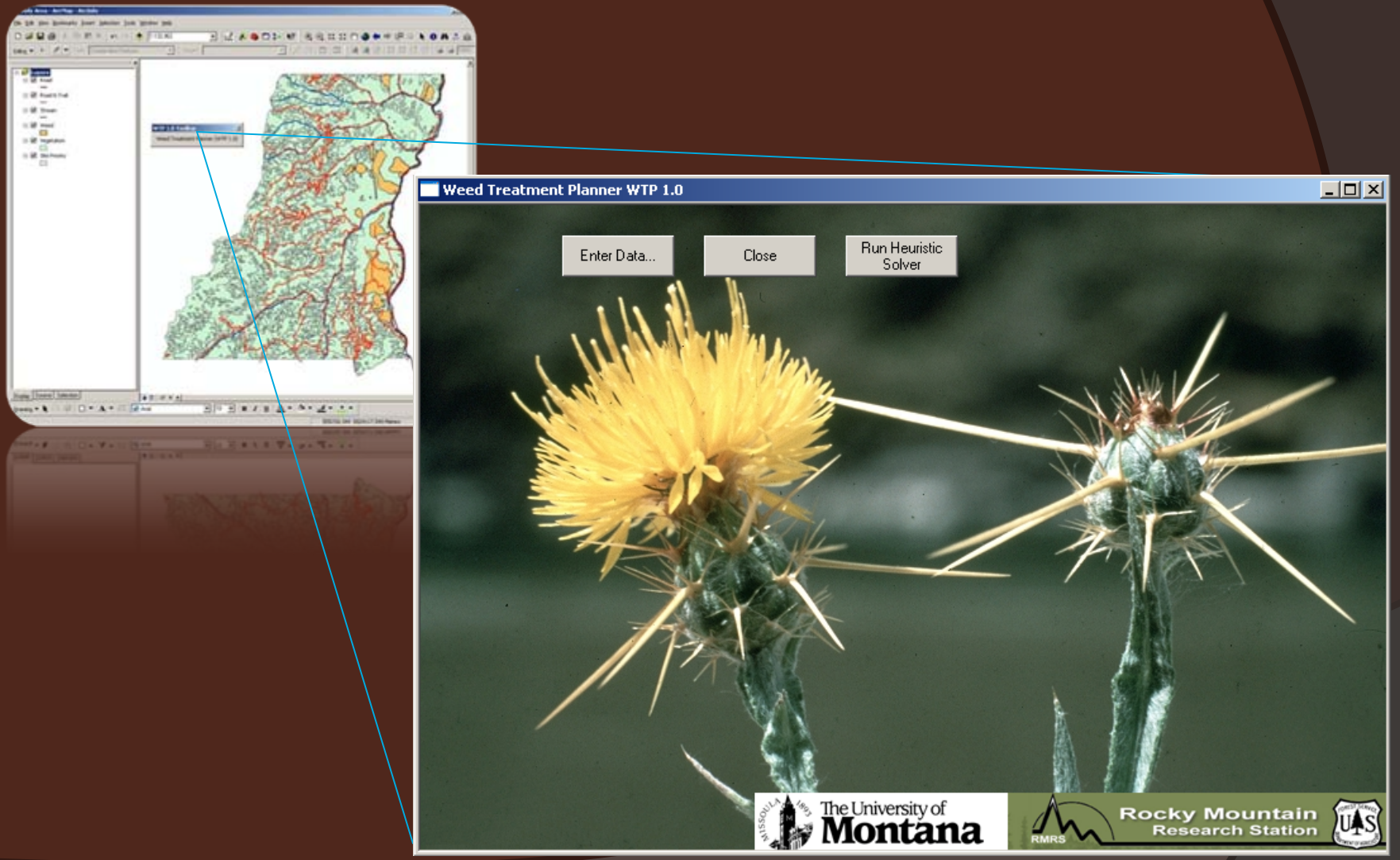


Optimization

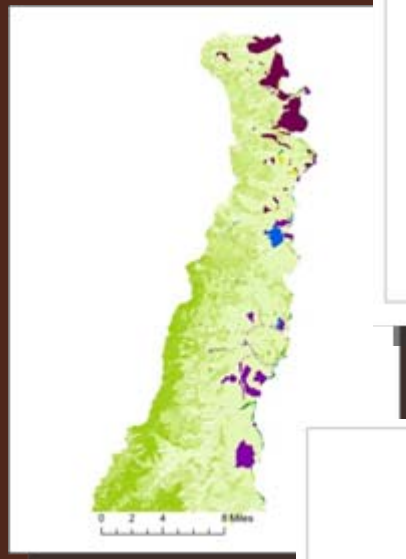
- Selecting best locations, methods, timing of weed treatment

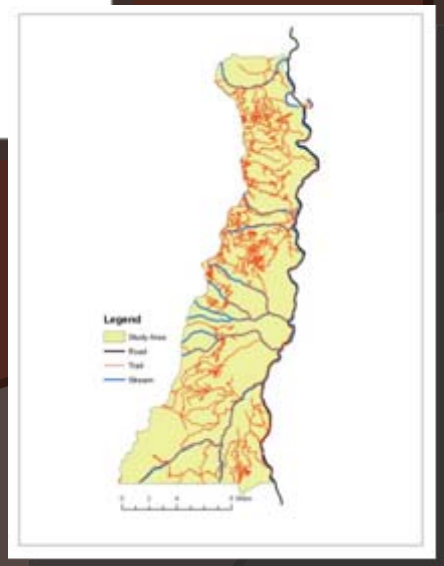


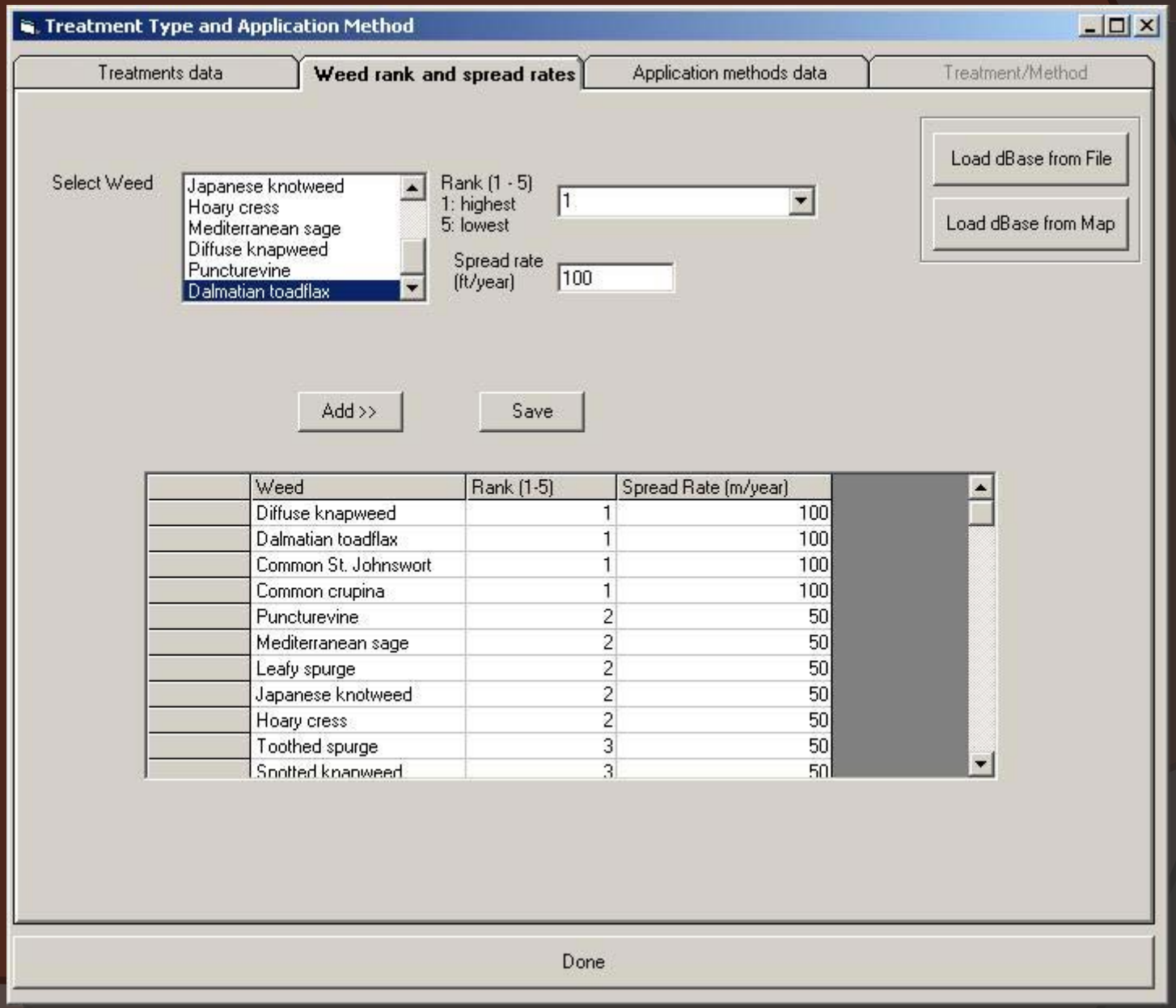
WTP: User Interfaces



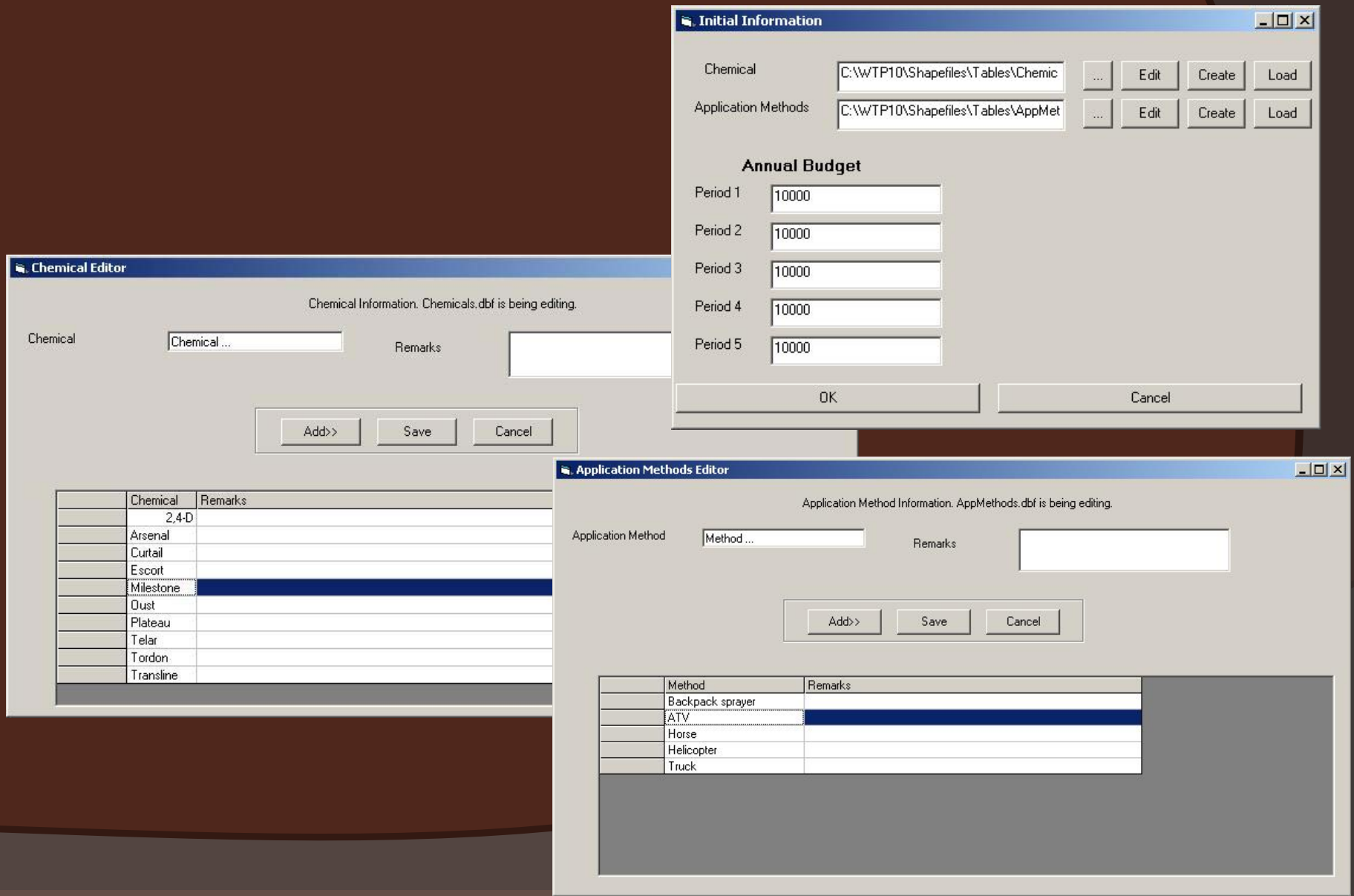
WTP: User Interfaces






Treatment Type and Application Method
Treatments data
Weed rank and spread rates
Application methods data
Treatment/Method
Load dBase from File
Load dBase from Map
Select Weed
Japanese knotweed
Hoary cress
Mediterranean sage
Diffuse knapweed
Puncturevine
Dalmatian toadflax
Rank (1 - 5)
1: highest
5: lowest
1
Spread rate
(ft/year)
100
Add >>
Save
Weed
Rank (1-5)
Spread Rate (m/year)
Diffuse knapweed 1 100
Dalmatian toadflax 1 100
Common St. Johnswort 1 100
Common crupina 1 100
Puncturevine 2 50
Mediterranean sage 2 50
Leafy spurge 2 50
Japanese knotweed 2 50
Hoary cress 2 50
Toothed spurge 3 50
Spotted knapweed 3 50
Done

WTP: User Interfaces



Define Application Mehtods from Roads

Application Method

- Backpack sprayer
- ATV
- Horse
- Helicopter
- Truck

Distance from Road 100 (ft)

Load dBase from File

Load dBase from Map

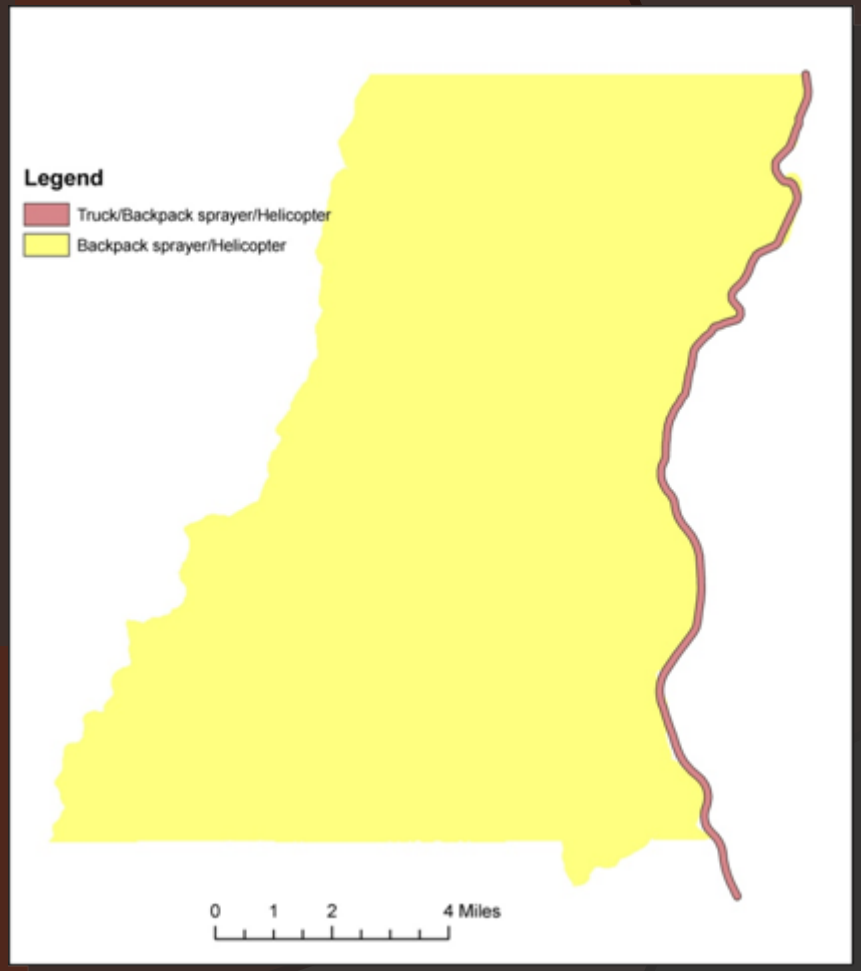
Add >>

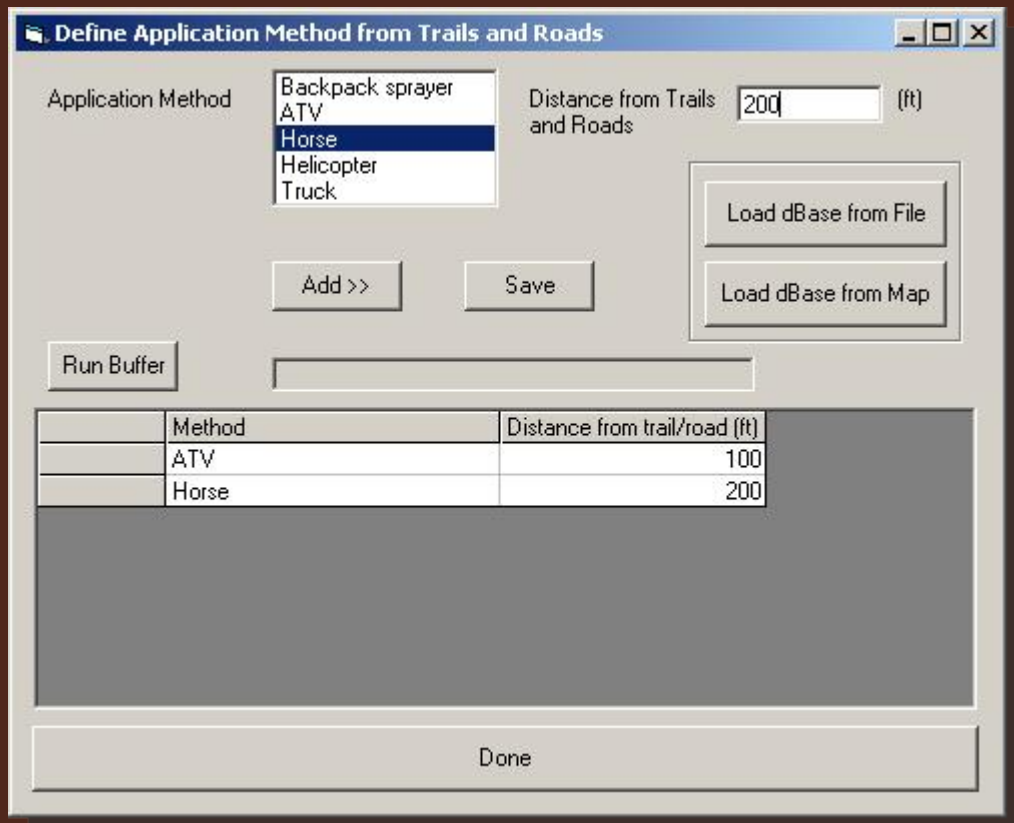
Save

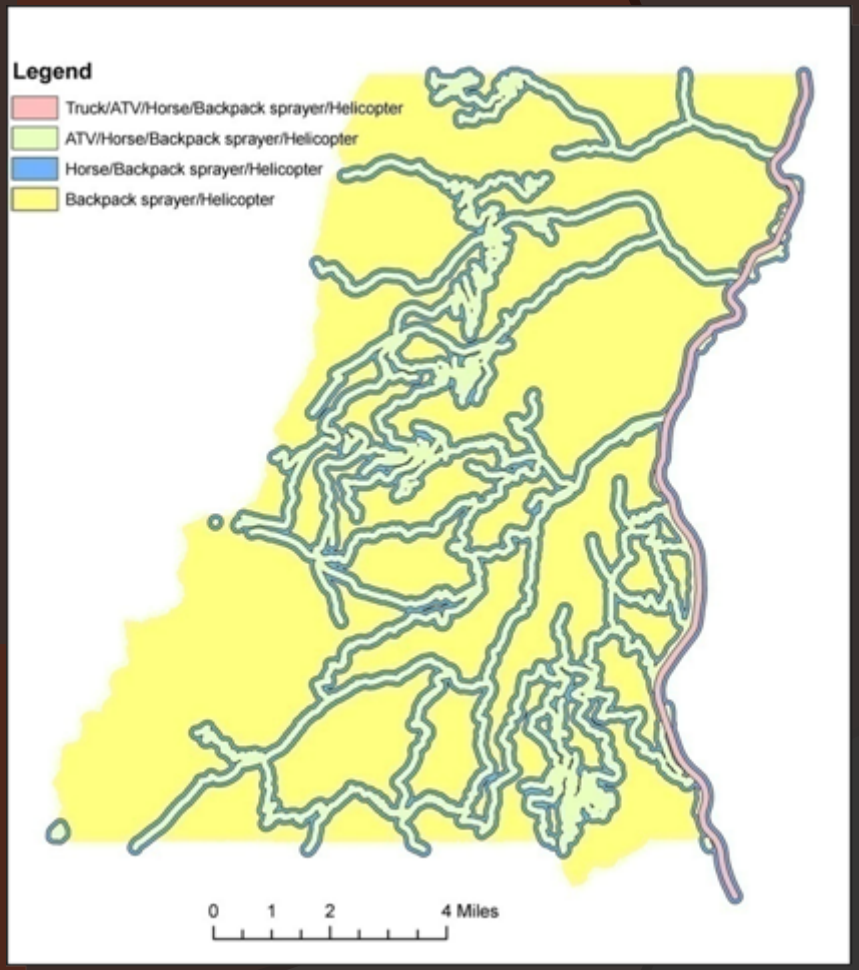
Run Buffer

	Method	Distance from road (ft)
	Truck	100

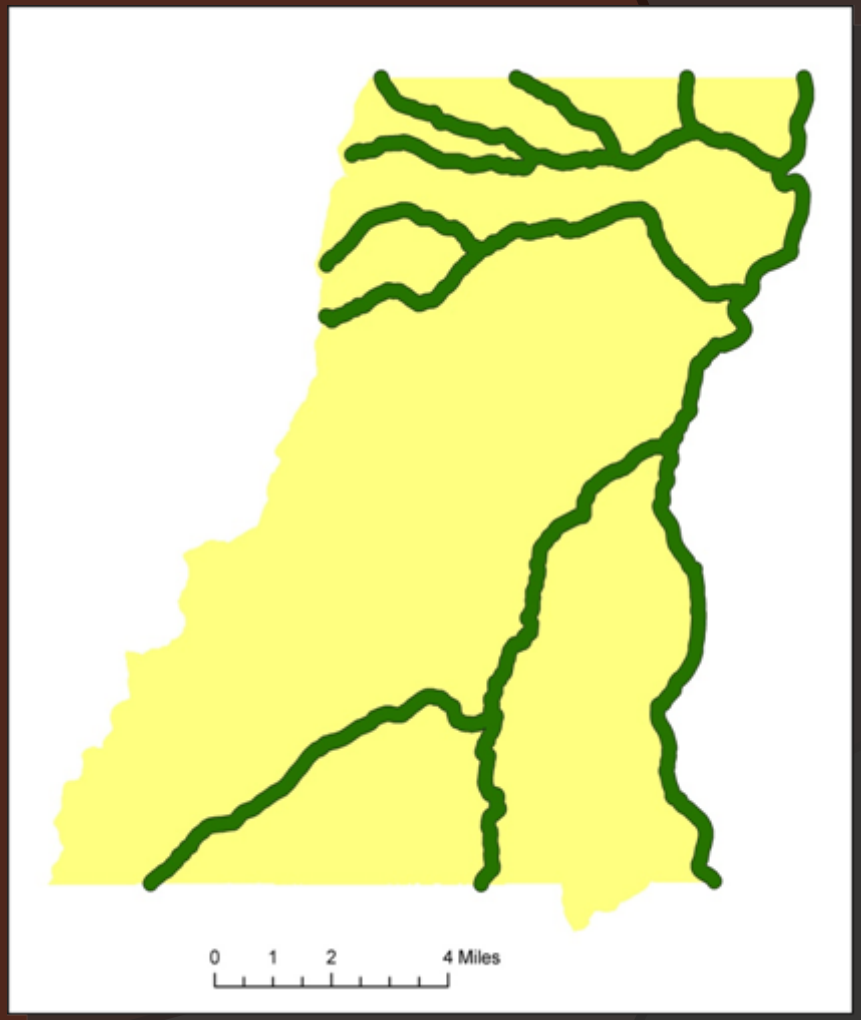
Done

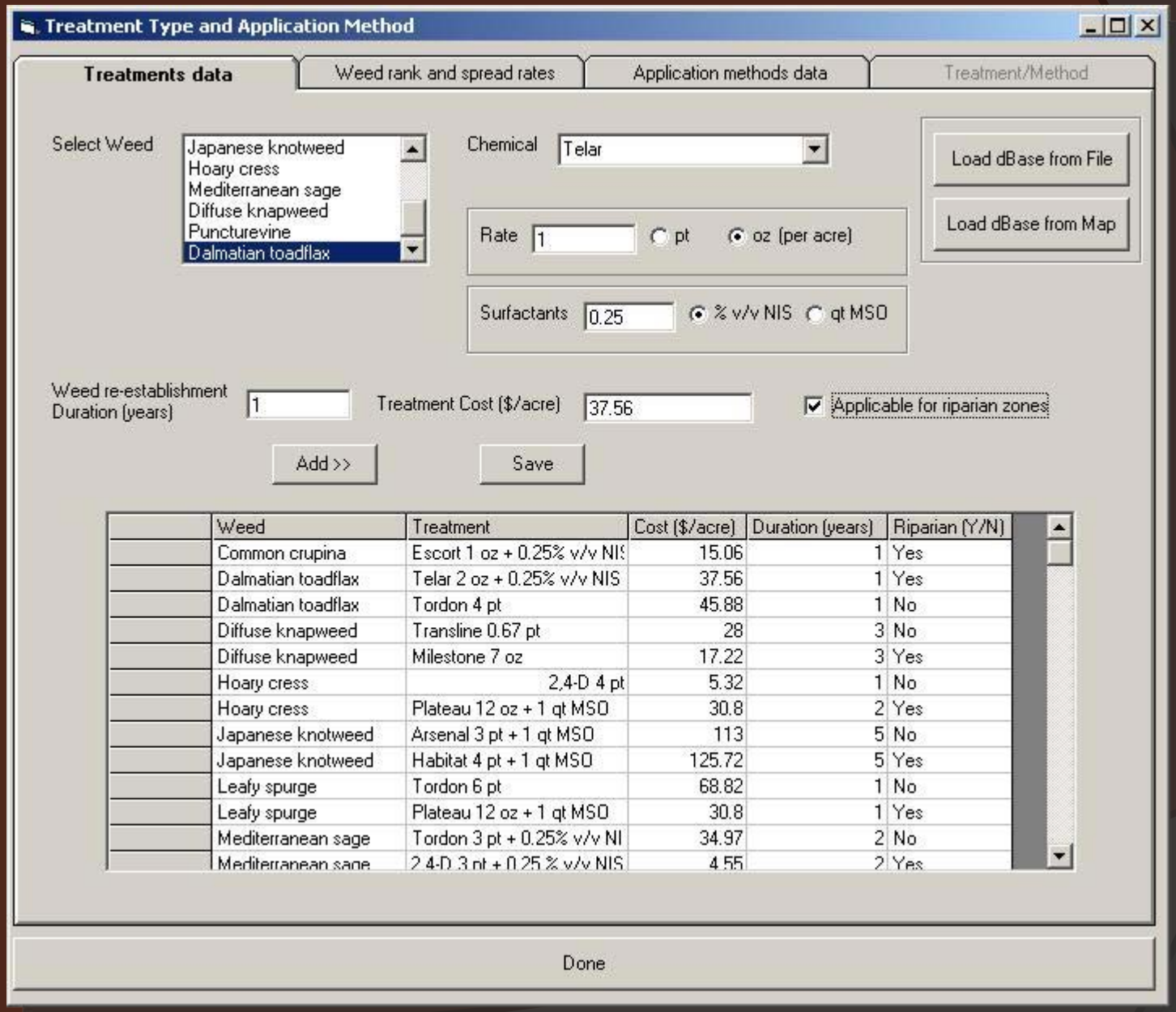


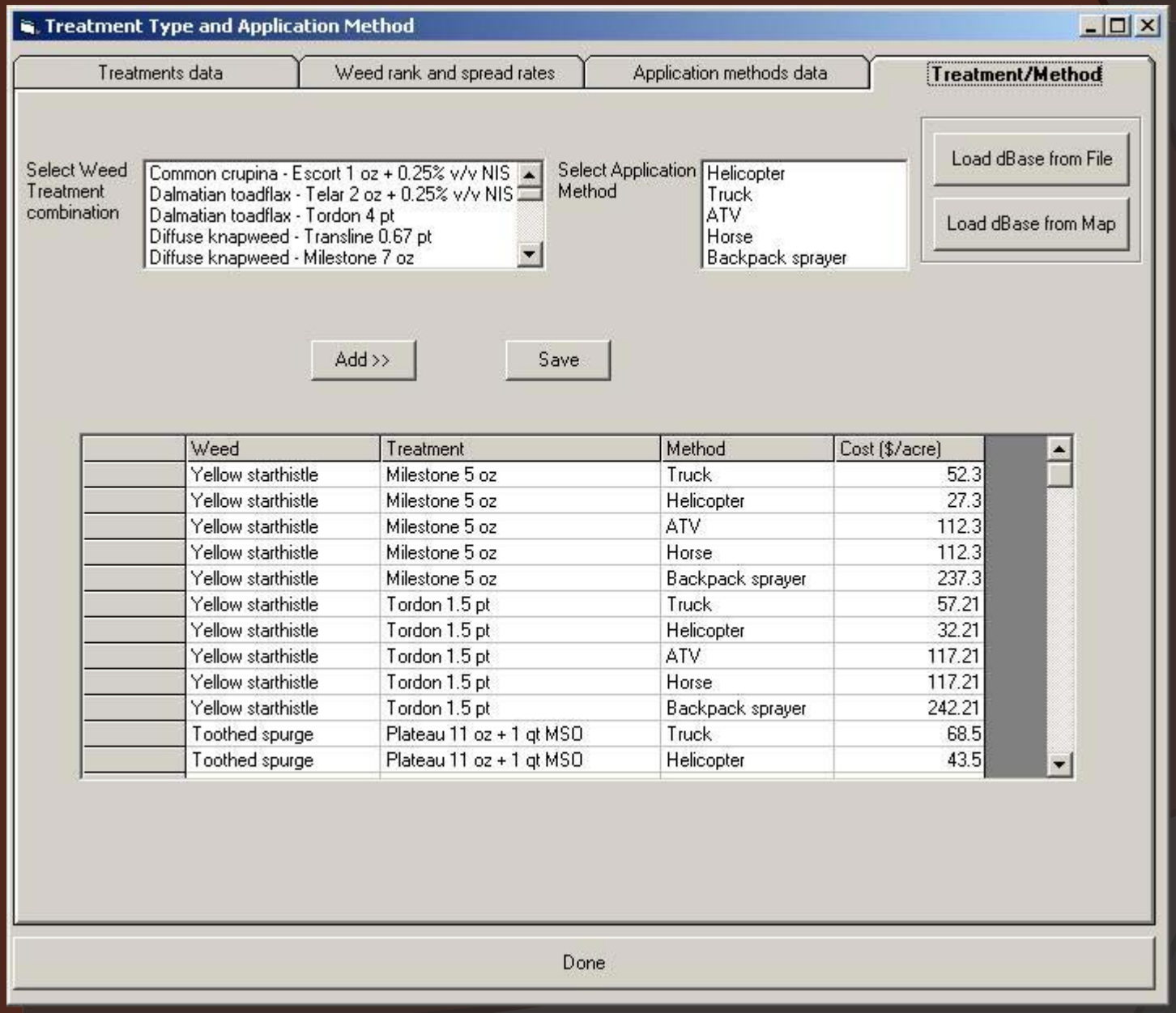

Define Application Method from Trails and Roads
Application Method
Backpack sprayer
ATV
Horse
Helicopter
Truck
Distance from Trails and Roads
200
(ft)
Load dBase from File
Load dBase from Map
Add >>
Save
Run Buffer
Method
Distance from trail/road (ft)
ATV
100
Horse
200
Done

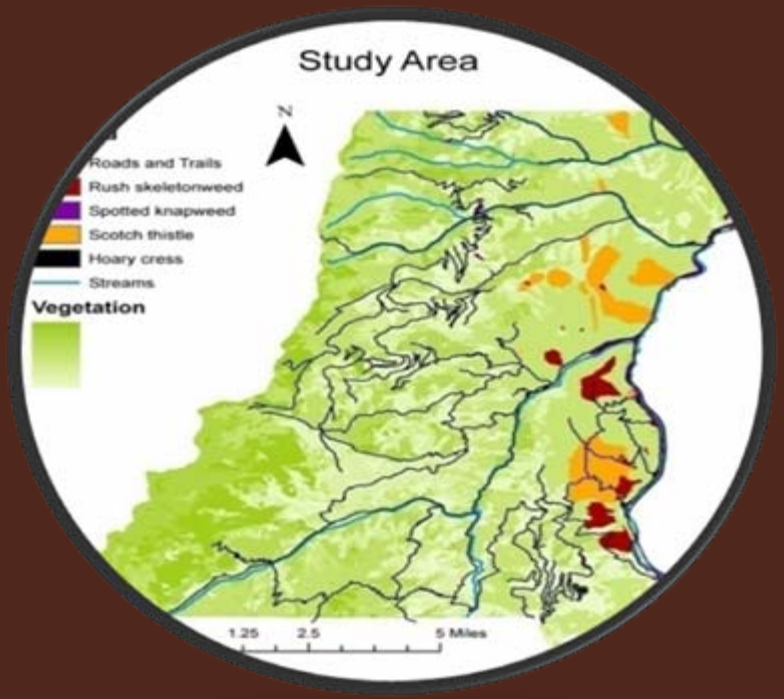

Legend
Truck/ATV/Horse/Backpack sprayer/Helicopter
ATV/Horse/Backpack sprayer/Helicopter
Horse/Backpack sprayer/Helicopter
Backpack sprayer/Helicopter
0
1
2
4 Miles


Riparian Zones
Distance from Stream (ft)
300
Run Buffer
Done


0
1
2
4 Miles


Treatment Type and Application Method
Treatments data
Weed rank and spread rates
Application methods data
Treatment/Method
Select Weed
Japanese knotweed
Hoary cress
Mediterranean sage
Diffuse knapweed
Puncturevine
Dalmatian toadflax
Chemical
Telar
Load dBase from File
Load dBase from Map
Rate
1
pt
oz (per acre)
Surfactants
0.25
% v/v NIS
qt MSO
Weed re-establishment Duration (years)
1
Treatment Cost ($/acre)
37.56
Applicable for riparian zones
Add >>
Save
Weed
Treatment
Cost ($/acre)
Duration (years)
Riparian (Y/N)
Common crupina
Escort 1 oz + 0.25% v/v NIS
15.06
1
Yes
Dalmatian toadflax
Telar 2 oz + 0.25% v/v NIS
37.56
1
Yes
Dalmatian toadflax
Tordon 4 pt
45.88
1
No
Diffuse knapweed
Transline 0.67 pt
28
3
No
Diffuse knapweed
Milestone 7 oz
17.22
3
Yes
Hoary cress
2,4-D 4 pt
5.32
1
No
Hoary cress
Plateau 12 oz + 1 qt MSO
30.8
2
Yes
Japanese knotweed
Arsenal 3 pt + 1 qt MSO
113
5
No
Japanese knotweed
Habitat 4 pt + 1 qt MSO
125.72
5
Yes
Leafy spurge
Tordon 6 pt
68.82
1
No
Leafy spurge
Plateau 12 oz + 1 qt MSO
30.8
1
Yes
Mediterranean sage
Tordon 3 pt + 0.25% v/v NI
34.97
2
No
Mediterranean sage
2,4-D 3 pt + 0.25 % v/v NIS
4.55
2
Yes
Done

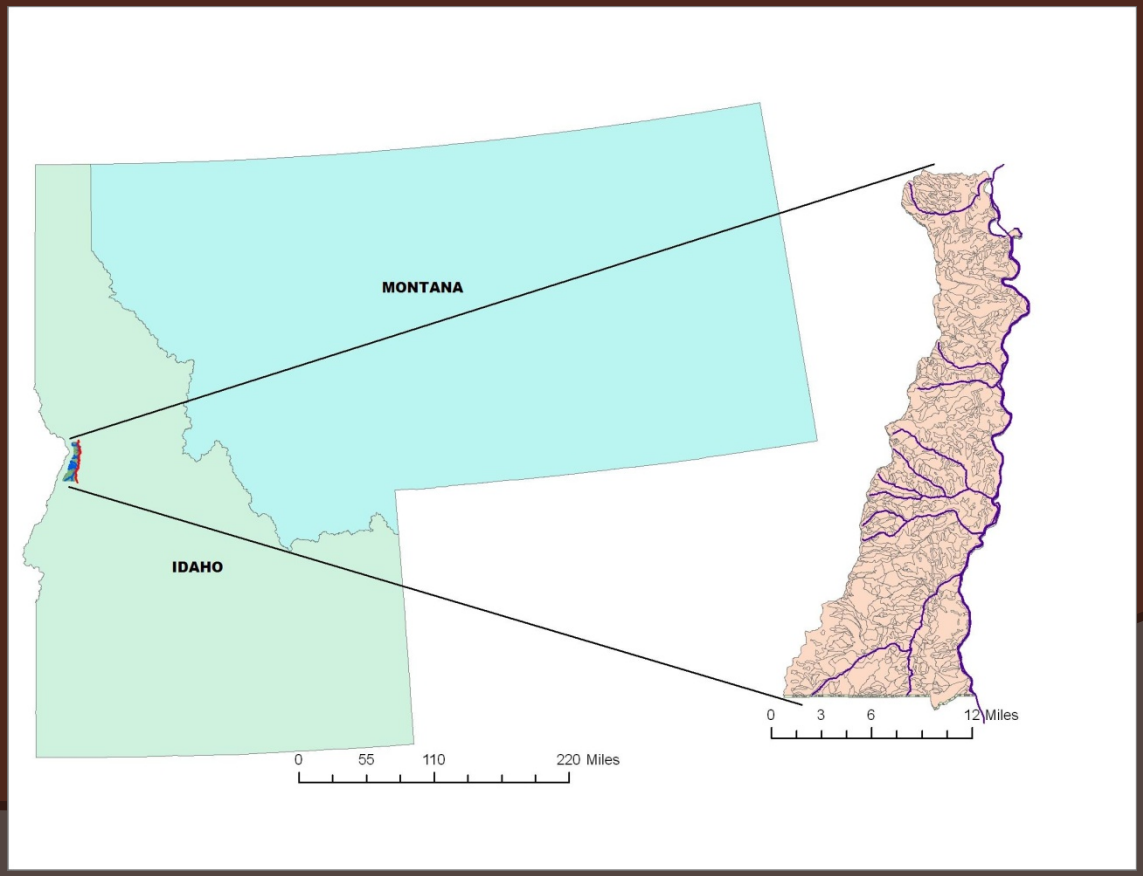

Treatment Type and Application Method
Treatments data
Weed rank and spread rates
Application methods data
Treatment/Method
Select Weed Treatment combination
Common crupina - Escort 1 oz + 0.25% v/v NIS
Dalmatian toadflax - Telar 2 oz + 0.25% v/v NIS
Dalmatian toadflax - Tordon 4 pt
Diffuse knapweed - Transline 0.67 pt
Diffuse knapweed - Milestone 7 oz
Select Application Method
Helicopter
Truck
ATV
Horse
Backpack sprayer
Load dBase from File
Load dBase from Map
Add >>
Save
Weed
Treatment
Method
Cost ($/acre)
Yellow starthistle Milestone 5 oz Truck 52.3
Yellow starthistle Milestone 5 oz Helicopter 27.3
Yellow starthistle Milestone 5 oz ATV 112.3
Yellow starthistle Milestone 5 oz Horse 112.3
Yellow starthistle Milestone 5 oz Backpack sprayer 237.3
Yellow starthistle Tordon 1.5 pt Truck 57.21
Yellow starthistle Tordon 1.5 pt Helicopter 32.21
Yellow starthistle Tordon 1.5 pt ATV 117.21
Yellow starthistle Tordon 1.5 pt Horse 117.21
Yellow starthistle Tordon 1.5 pt Backpack sprayer 242.21
Toothed spurge Plateau 11 oz + 1 qt MSO Truck 68.5
Toothed spurge Plateau 11 oz + 1 qt MSO Helicopter 43.5
Done



System Application

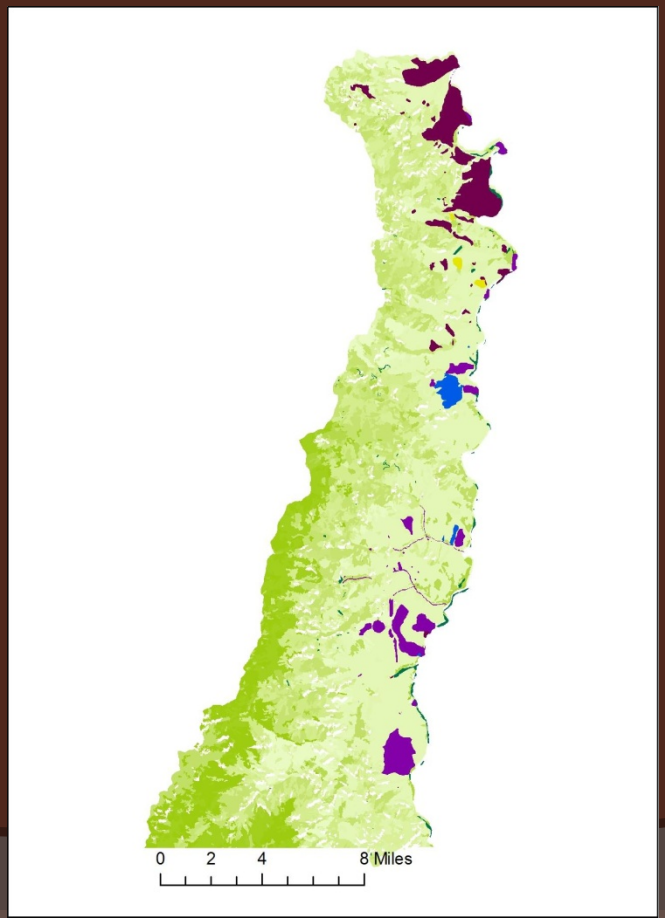
Application Area

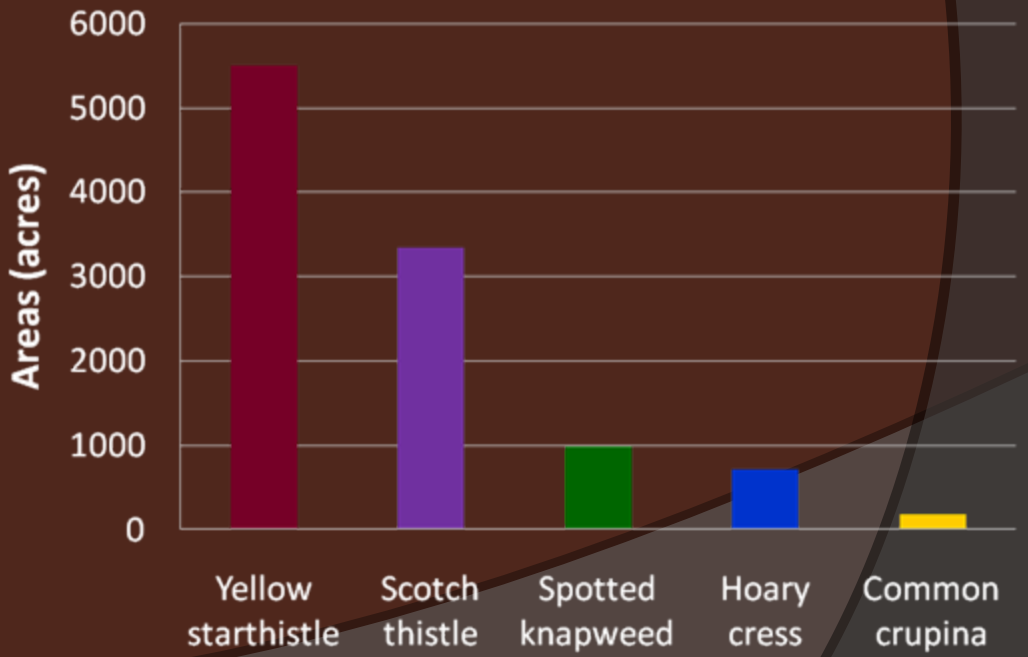
- Spatial Data
  - 130,262 acres (a part of the Nez Perce National Forest, ID)



Input Data

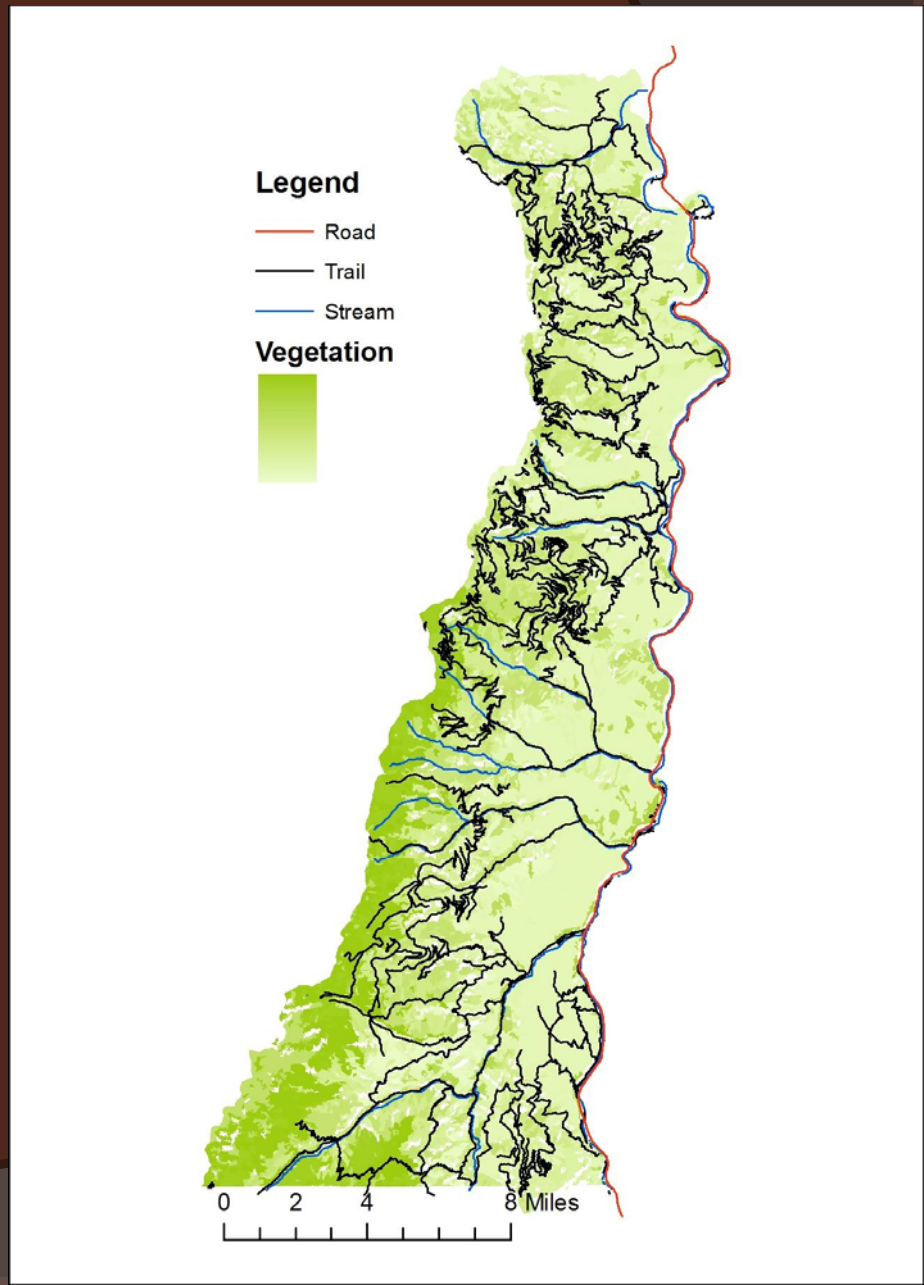
- Spatial Data
  - Infested Areas: 4,216 acres (6% of the study area)





Input Data

- Spatial Data
  - Existing Roads: 41.7 miles
  - Trails: 510.1 miles
  - Streams: 107.2 miles



Input Data

- Tabular Data

Weed species	Ranks
Common crupina	3
Hoary cress	1
Scotch thistle	4
Spotted knapweed	2
Yellow starthistle	5

Weed species	Spread rates
Common crupina	150 ft/year
Hoary cress	150 ft/year
Scotch thistle	500 ft/year
Spotted knapweed	150 ft/year
Yellow starthistle	150 ft/year

Weed species	Treatment type	Applicable for riparian zone (Y/N)	Effectiveness	
			Efficacy (Effects right after treatment)	Duration (Weed re-establishment rates)
Hoary cress	Plateau 12 oz + 1 qt MSO	Yes	Stop spreading	2 years
Hoary cress	2,4-D 4 pt	No	Stop spreading	1 year
Spotted knapweed	Tordon 1pt	No	Stop spreading	3 years
Spotted knapweed	Milestone 7 oz	Yes	Stop spreading	3 years
…	…		…	…

Input Data

- Tabular Data

C: Close to invasion
D: Disturbance allows invasion
I: Invasive without disturbance

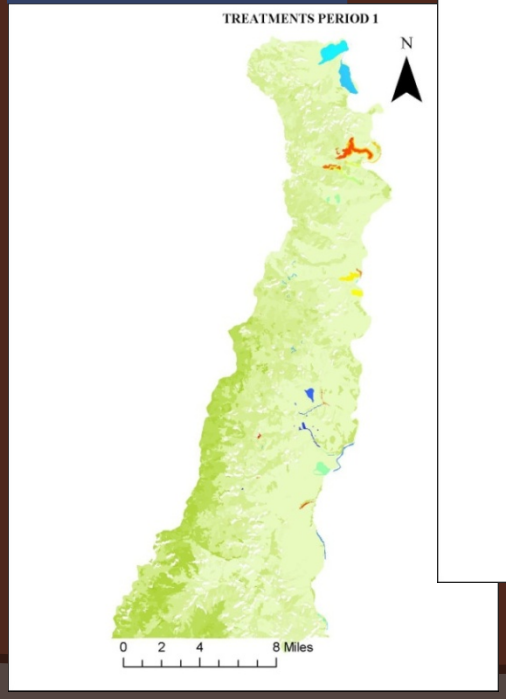
Vegetation Type	Weed species	Susceptibility*
Douglas Fir	Scotch thistle	D
	Common crupina	D
	Spotted knapweed	I
	Hoary cress	D
Ponderosa Pine	Scotch thistle	D
	Common crupina	D
	Spotted knapweed	I
	Hoary cress	D
…	…	…

Weed species	Treatment type	Application method	Cost per acre
Common crupina	Tordon 1 pt	Backpack sprayer	$225/acre + chemical
	Escort 1 oz 0.25% v/v NIS	Backpack sprayer	$225/acre + chemical
		ATV	$100/acre + chemical
		Helicopter	$15/acre + chemical
Spotted knapweed	Tordon 1pt	Backpack sprayer	$225/acre + chemical
		ATV	$100/acre + chemical
Hoary cress	2,4-D 4 pt	Horse	$200/acre + chemical
…	…	…	…

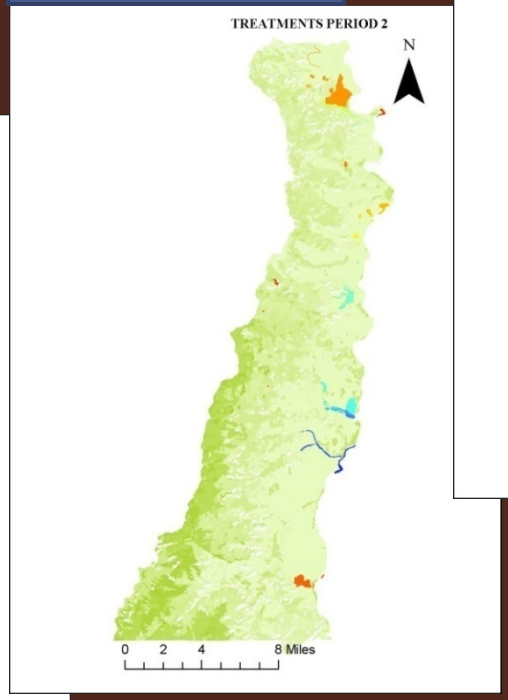
Application Results

- Treatment schedules

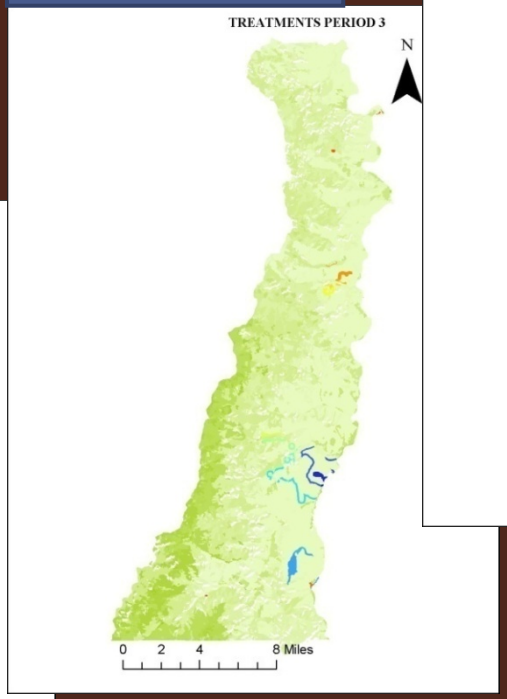
Year 1: 3,109 acres



Year 2: 2,737 acres

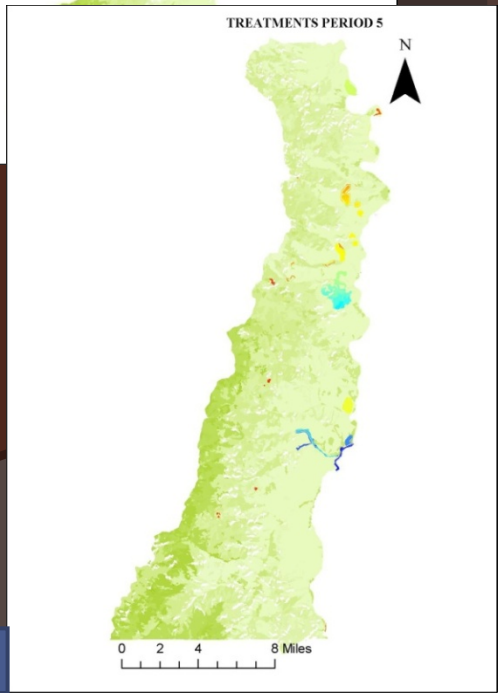


Year 3: 1,746 acres



Year 4: 2,372 acres

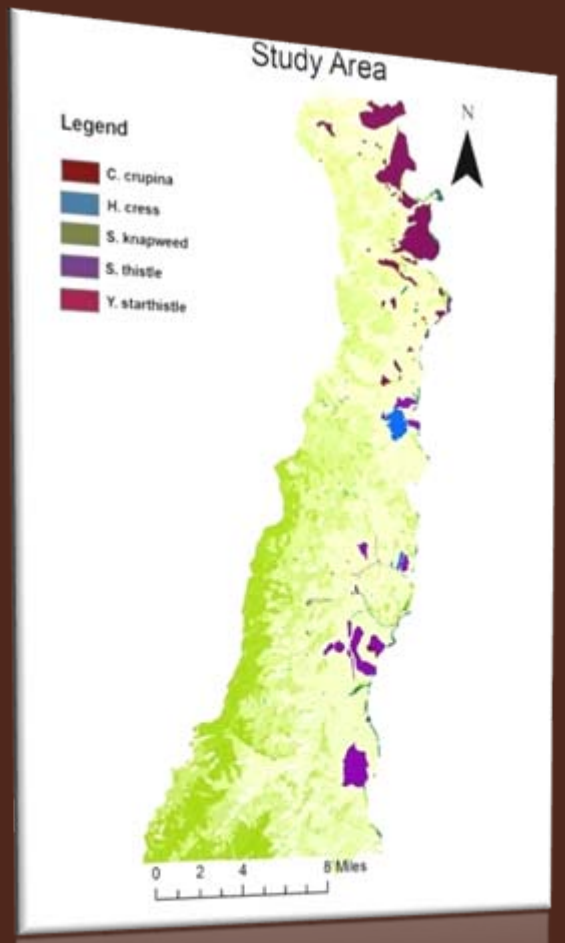
Year 5: 2,541 acres

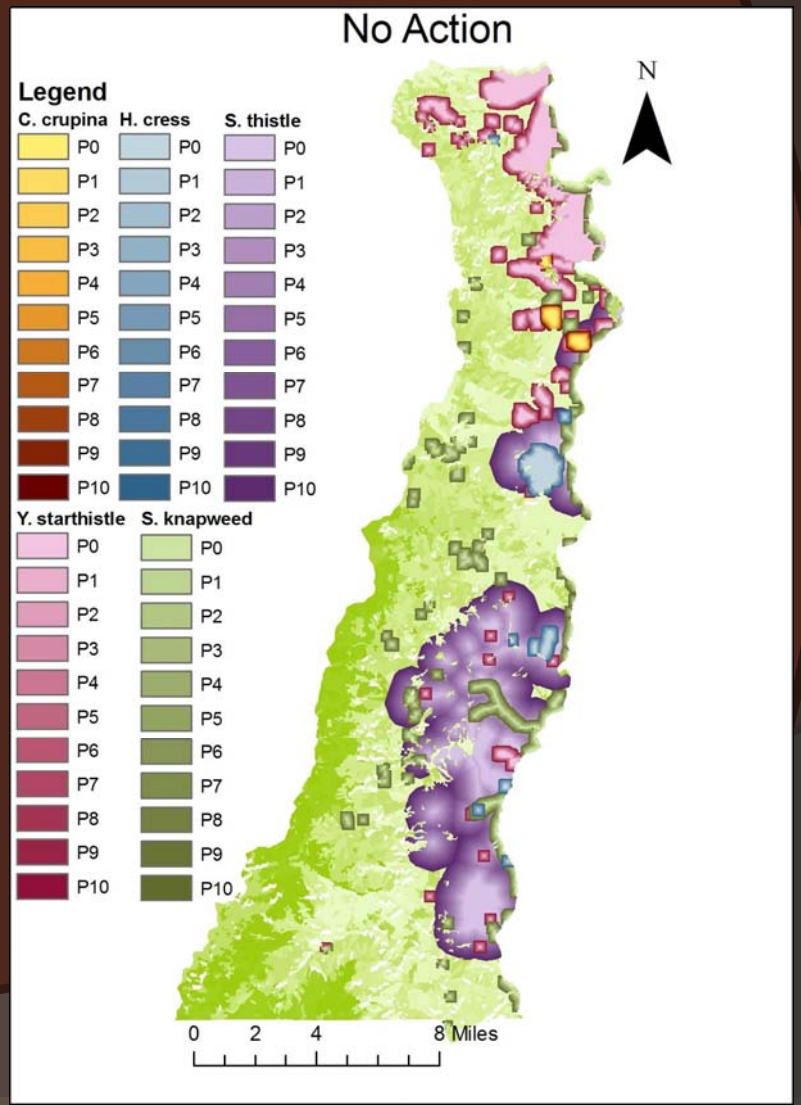


Application Results

Estimated infestation acres in year 10 with no action

	Initial Condition	No Action
Yellow starthistle	5,500	14,539
Scotch thistle	3,350	32,753
Spotted knapweed	987	11,188
Hoary cress	715	2,411
Common crupina	182	819

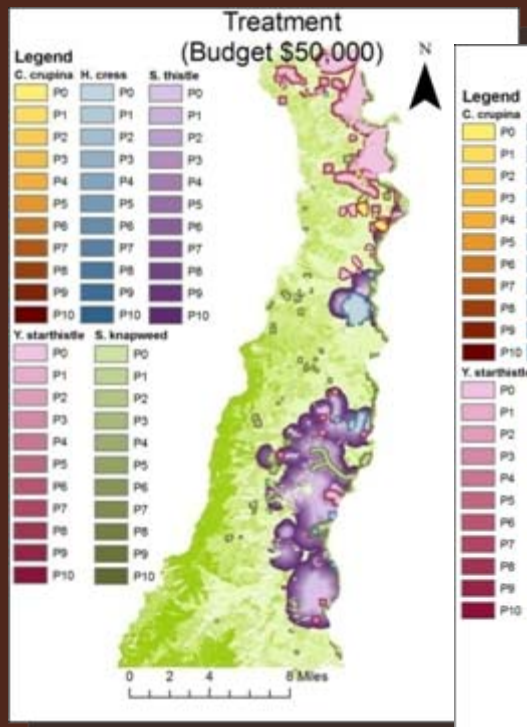


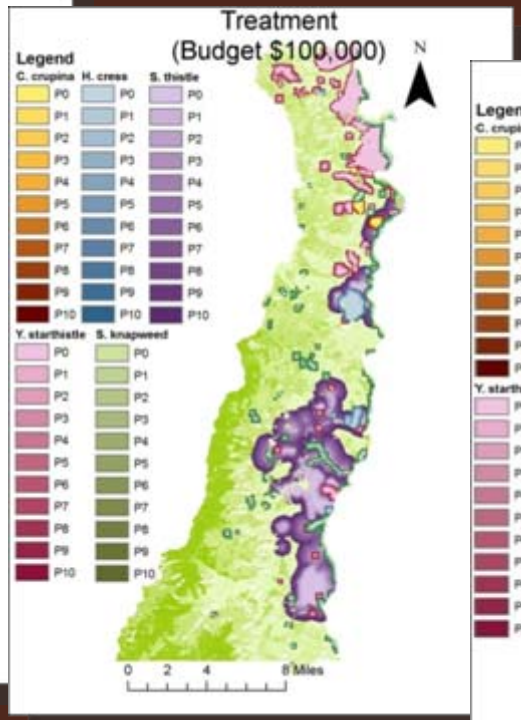


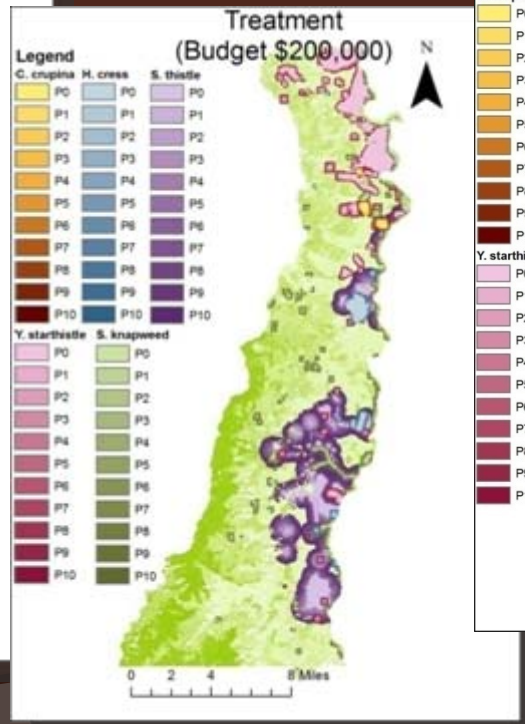
Application Results

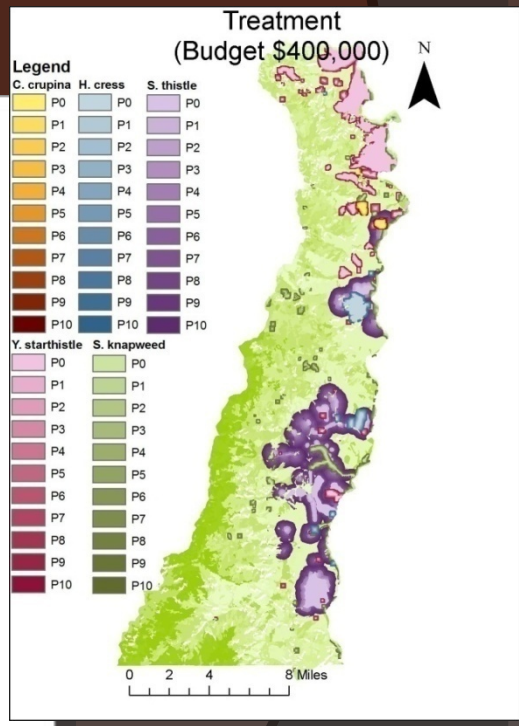
Estimated infestation acres in year 10

	No Action	$50,000	$100,000	$200,000	$400,000
Yellow starthistle	14,539	13,287	12,281	12,094	10,390
Scotch thistle	32,753	27,435	27,063	24,228	22,418
Spotted knapweed	11,188	8,237	8,807	7,670	5,499
Hoary cress	2,411	2,335	2321	1,942	1,880
Common crupina	819	566	666	693	552



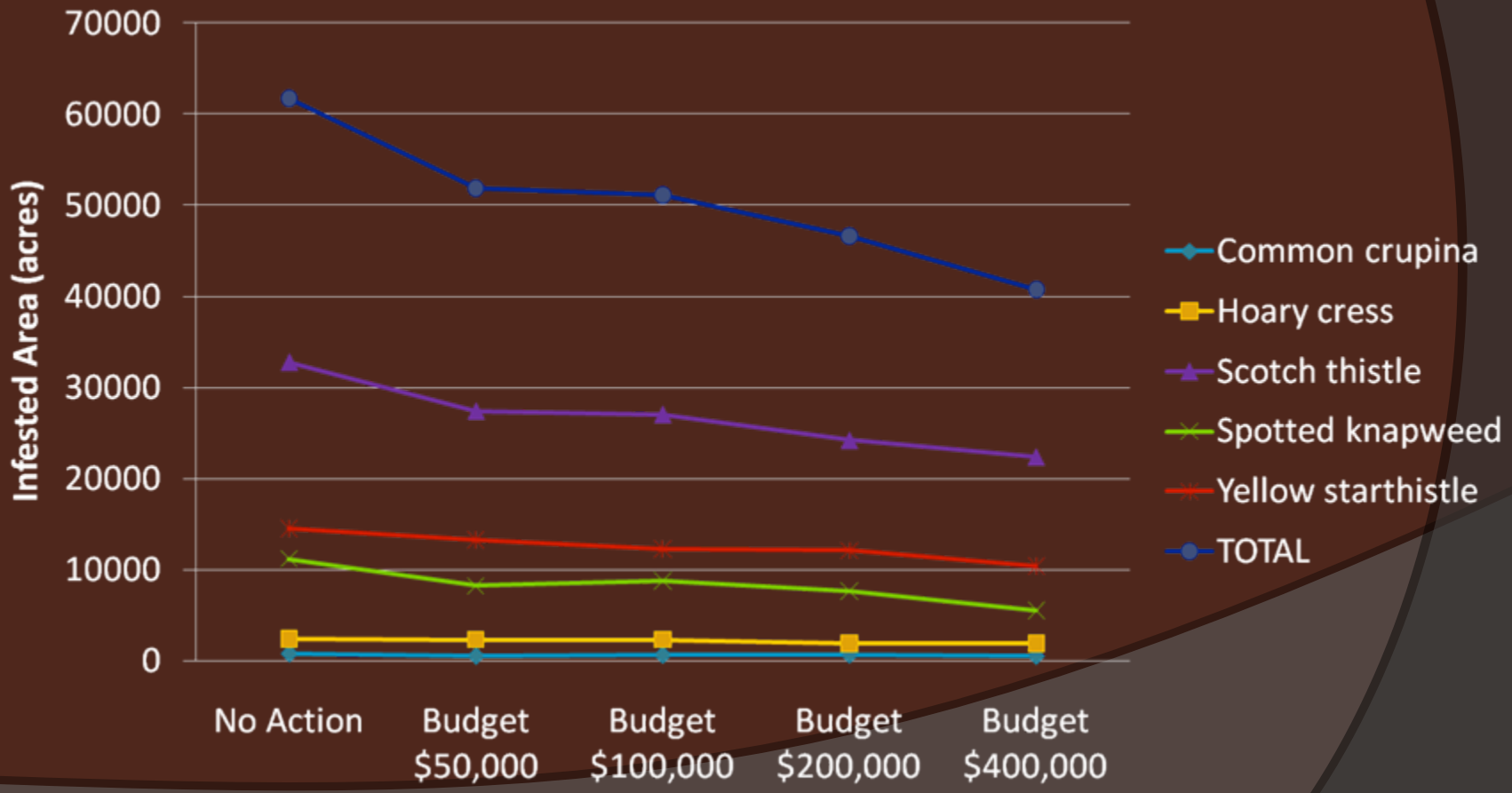






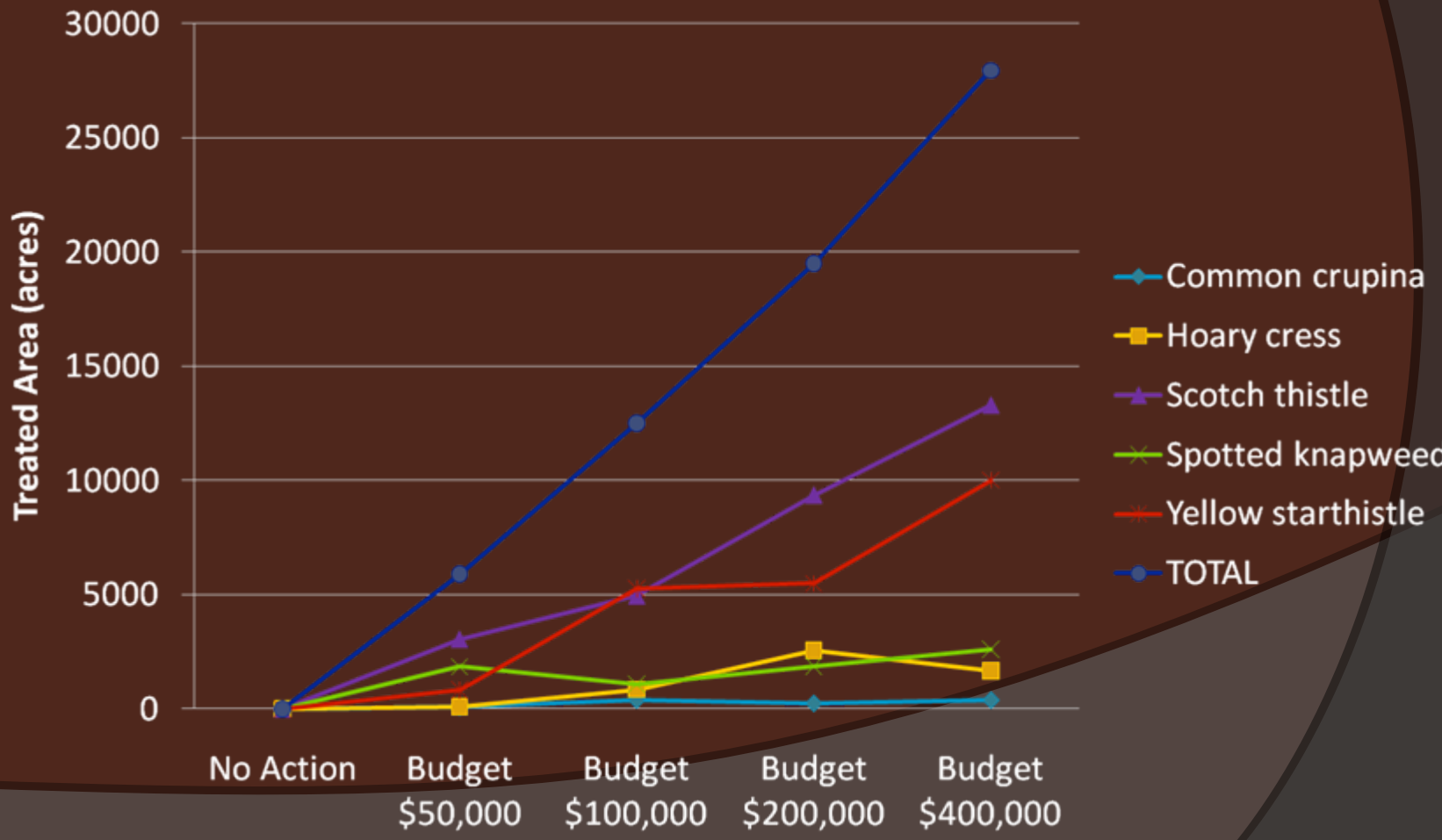
Application Results

- Estimated total infested acres per species



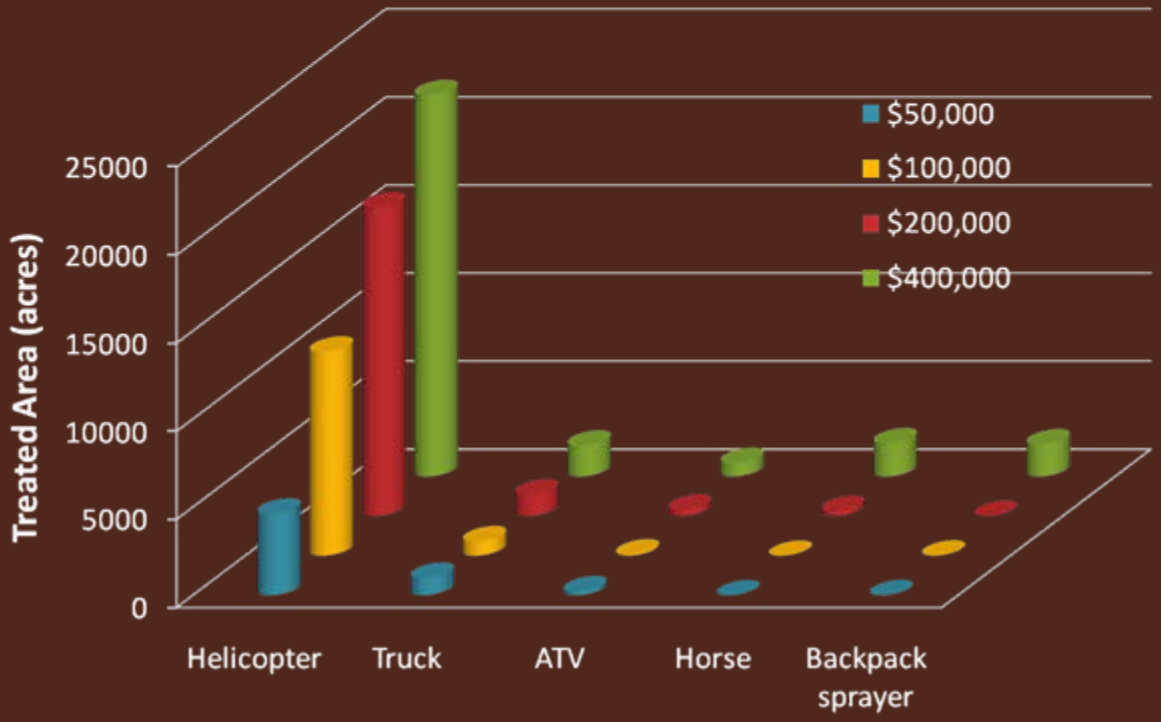
Application Results

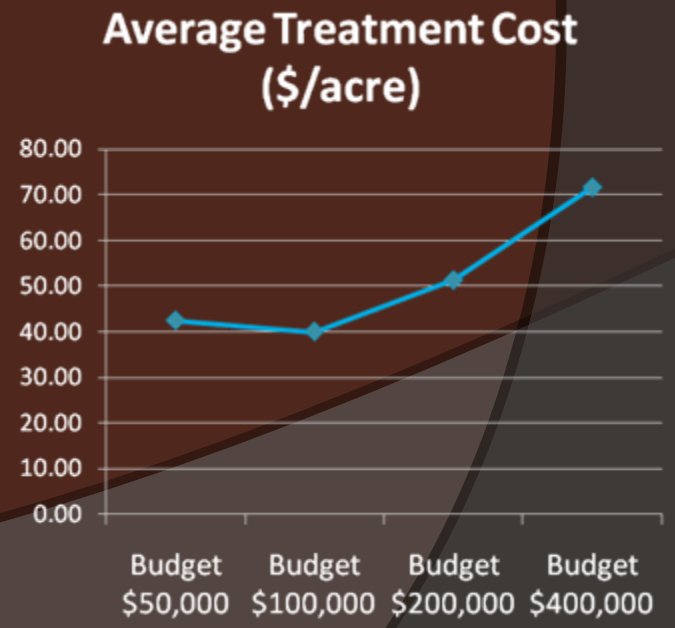
- Acres to be treated per species



Application Results

- Application methods allocated under each budget scenario





Concluding Remarks

- Spatial decision support system for invasive weeds management (WTP) has been developed through the funding support of the USDA ERS's PREISM

- WTP can facilitate trade-off analyses for alternatives
  - Which of multiple invasive species to treat (weed priorities, locations, etc.)
  - How to treat (various treatment methods)
  - Where to treat (site priorities, along road or trail networks, in main infestation areas, in satellite infestations, etc.)

Concluding Remarks

- Helps national forests and other public land management agencies develop efficient management strategies that achieve the maximum amount of weed control for a limited budget
- Helps weed managers justify budget request and use of funds
- Helps weed managers realize the importance of inventory, mapping and monitoring of noxious weeds

Concluding Remarks

- Lack of weed dispersal models and information on efficacy of treatments
- WTP will be improved through another research project funded by the USDA National Research Initiative program (PI: Tim Prather)
  - Developing weed dispersal models
  - Estimating market and non-market damage costs of not treating invaders
  - Incorporating the above outcomes into WTP

Questions or comments?