BIOSECURITY AND INVASIVE SPECIES INITIATIVE

WESTERN GOVERNORS' ASSOCIATION

WEBINAR SERIES

WEDNESDAY, MAY 1, 2019

Species Distribution Modeling and Scenario Planning

MODERATOR:

- **Jeff Morisette**, Chief Scientist, National Invasive Species Council Secretariat

PANELISTS:

- **Terri Hogan**, Invasive Plant Program Manager, National Park Service
- **Catherine Jarnevich**, Ecologist, U.S. Geological Survey
- **Greg Haubrich**, Noxious Weed Coordinator, Washington Department of Agriculture
- **Brian Miller**, Research Ecologist, U.S. Geological Survey

MaxEnt

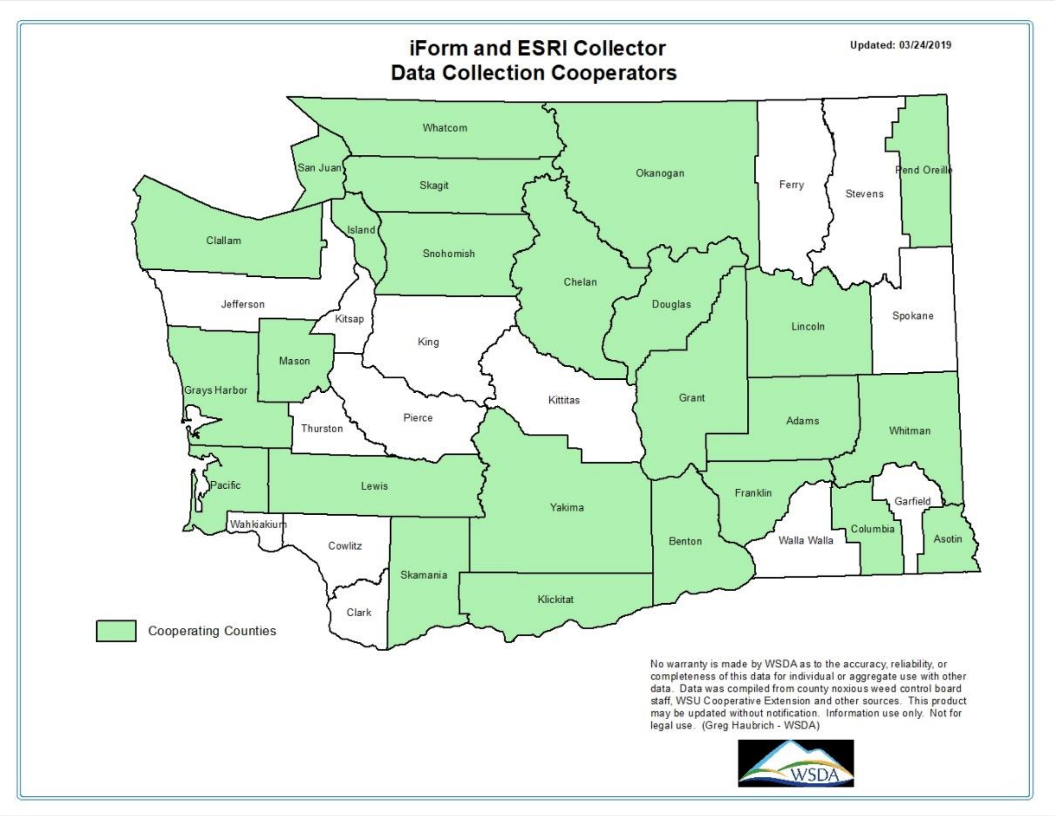
- MaxEnt (Phillips et al. 2006) short for Maximum Entropy modeling is a relatively common Presence Only (PO) tool used for predicting the potential distribution of a species based on a set of records and environmental predictors
- Fairly easy to use, performs well, free
- Perfect?
- Requires georeferenced species presence locations

WSDA Data Collection Tools

- iForm/Collector
- iPhones/iPads
- Licensing
- Data plan
- Technical support
- Collector licenses
- AGOL licenses

WSDA Cooperators

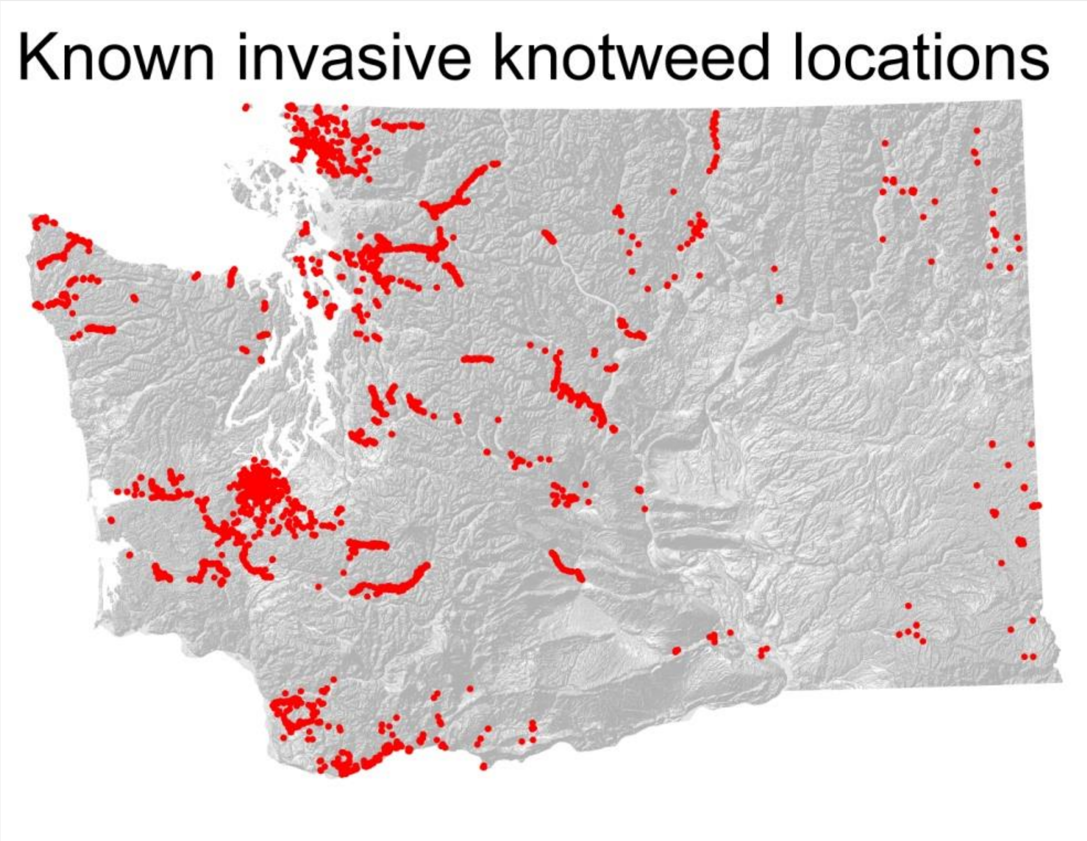
- Adams County NWCB
- Asotin County NWCB
- Benton County NWCB
- Chelan County NWCB
- Clallam County NWCB
- Columbia County NWCB
- Douglas County NW Task Force
- Franklin County NWCB
- Grant County NWCB
- Grays Harbor County NWCB
- Island County NWCB
- Klickitat County NWCB
- Lewis County NWCB
- Lincoln County NWCB
- Mason County NWCB
- Okanogan County NWCB
- Pacific County NWCB
- Pend Oreille NWCB
- San Juan County NWCB
- Skagit County NWCB
- Skamania County NWCB
- Snohomish Count NWCB
- Whatcom County NWCB
- Whitman County NWCB
- Yakima County NWCB
- Washington State University IWCP
- WDFW Spartina Program
- WDNR Spartina Program
- WSNWCB
- WSDA Pest Program – Noxious Weeds, Gypsy Moth, Apple Maggot, Plant Pathology
- WSDA F&V and Seed Programs



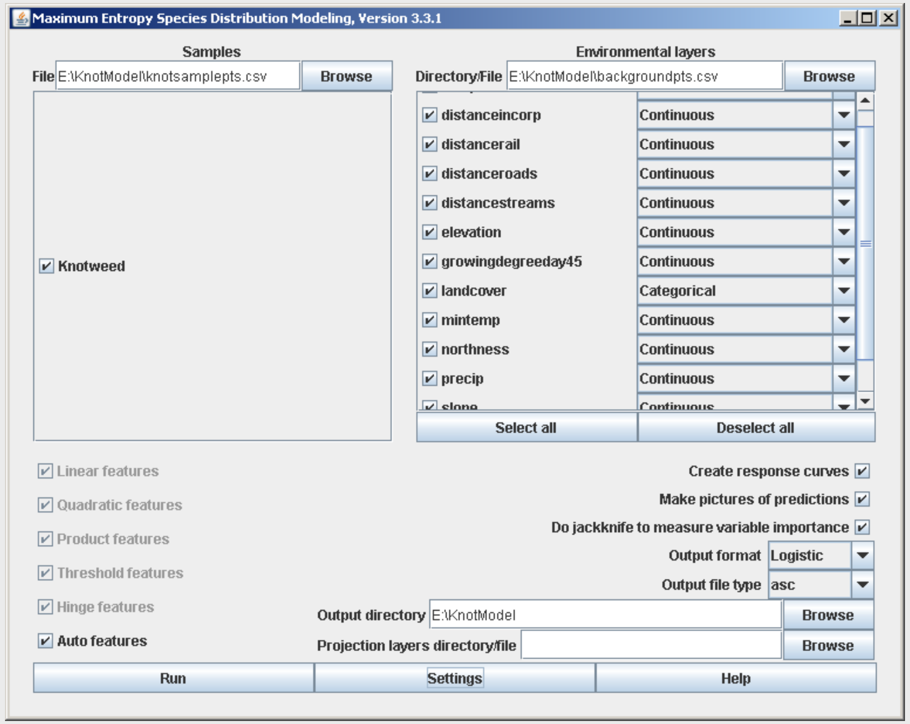
Other Sources of Data

- County, state and federal agencies, tribes, NGO's, farmers and ranchers, private citizens
- Washington Invasive Species Council App
- EDDMapS
- Pacific Northwest Invasive Plant Council, Citizen Scientist App
- Herbarium records and museum specimens - often not georeferenced.

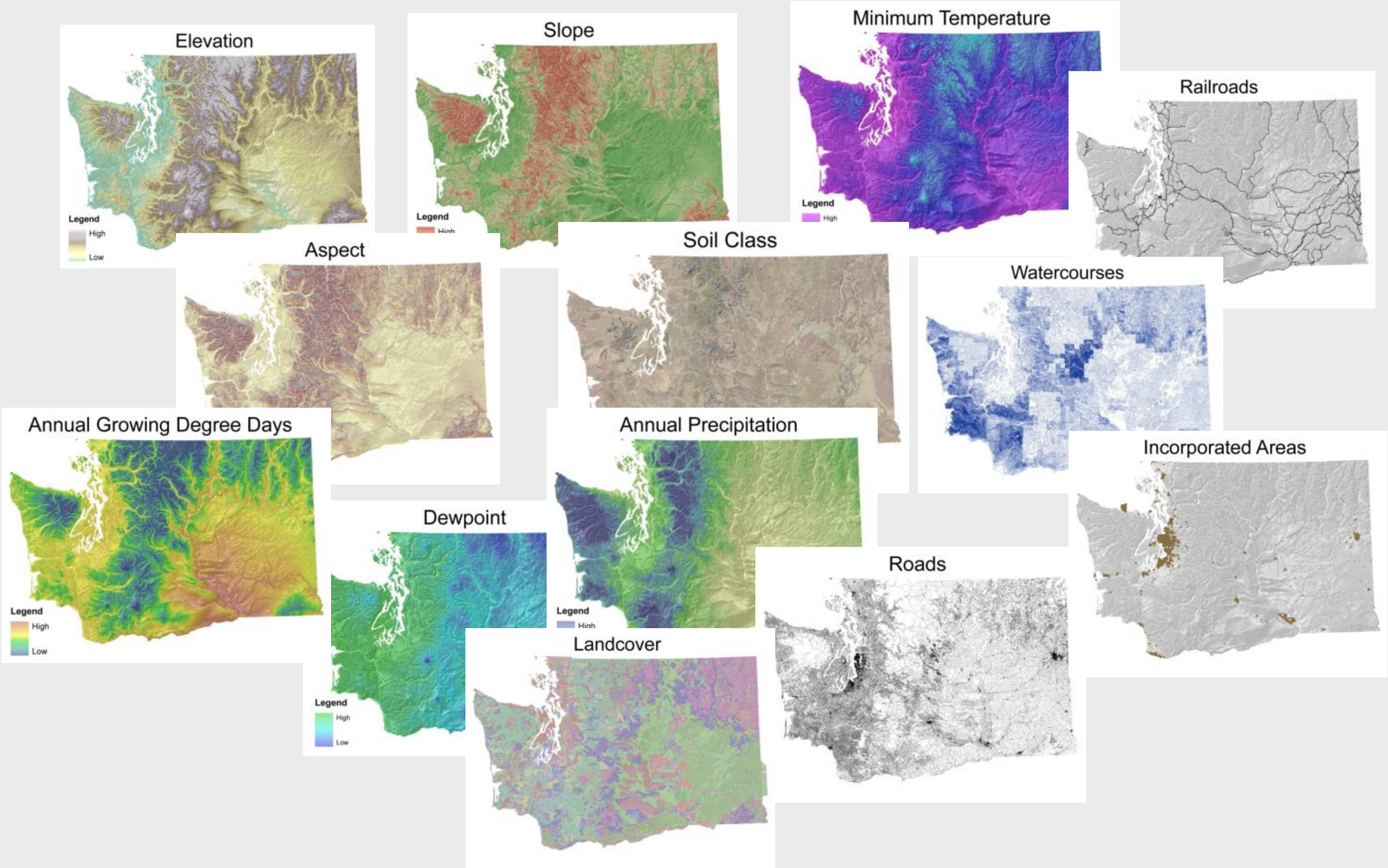
Model Input



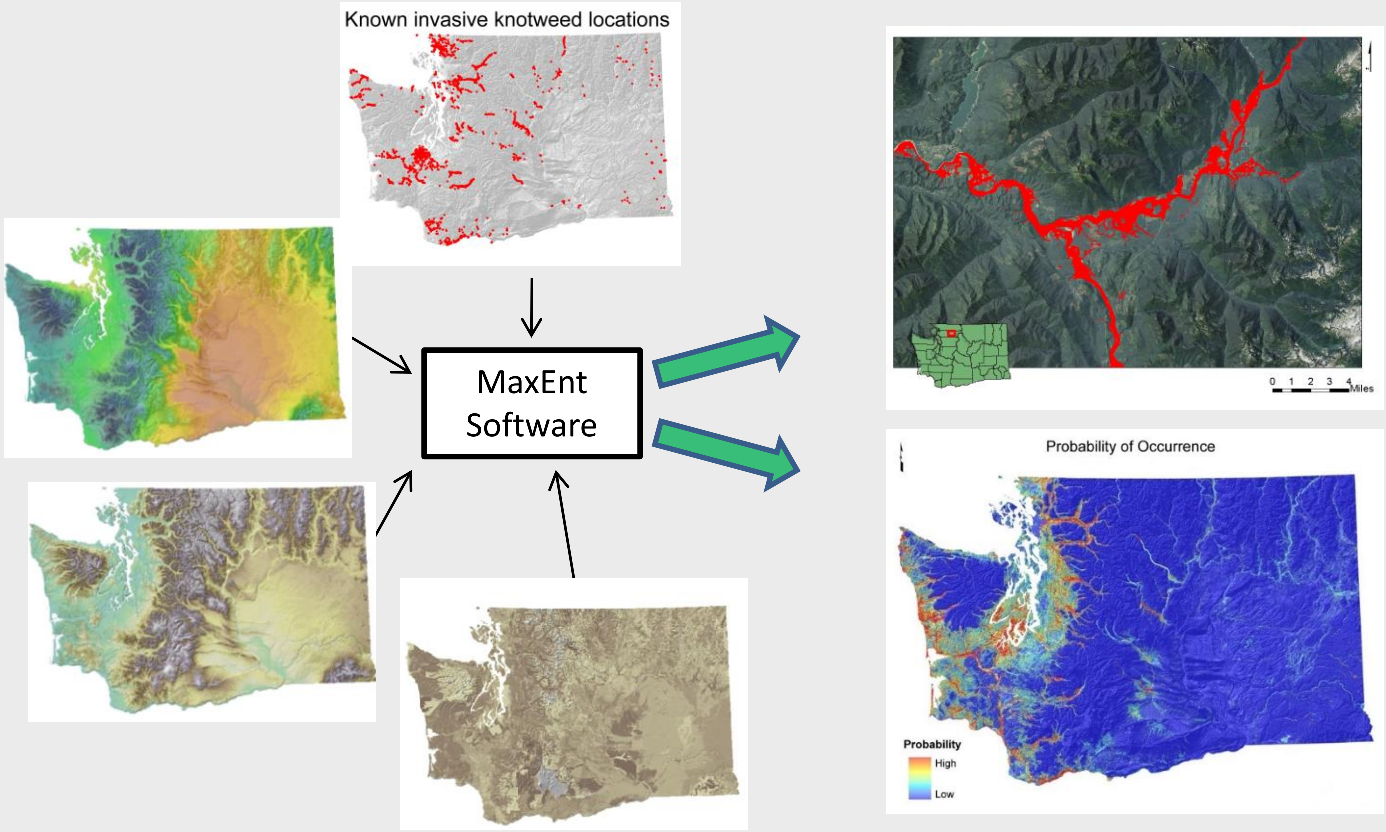
MaxEnt Interface



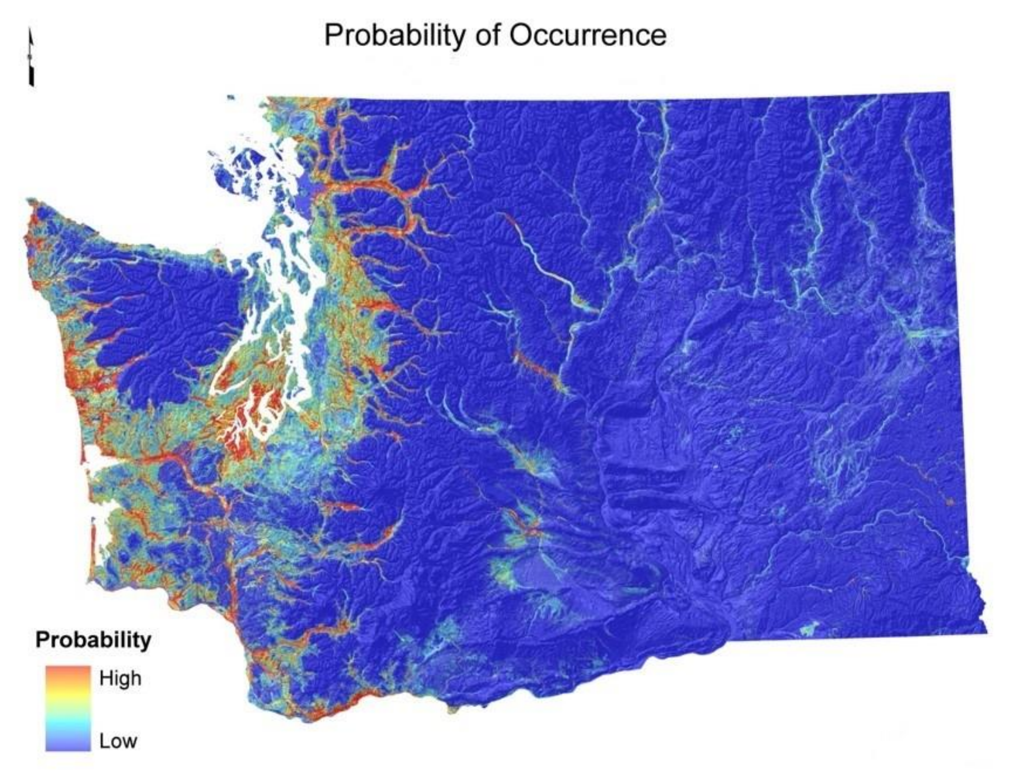
Model Input


Elevation
Slope
Minimum Temperature
Railroads
Aspect
Soil Class
Watercourses
Annual Growing Degree Days
Annual Precipitation
Incorporated Areas
Dewpoint
Roads
Landcover

Input and Visualization

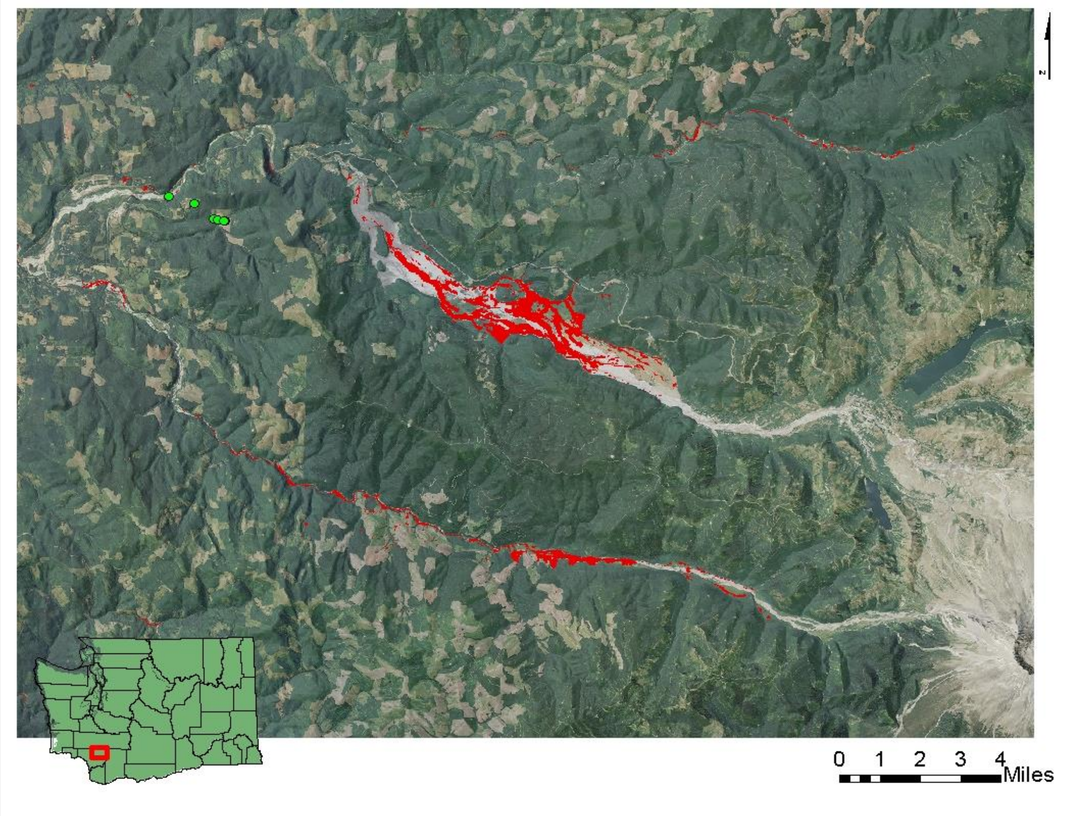


Model Output



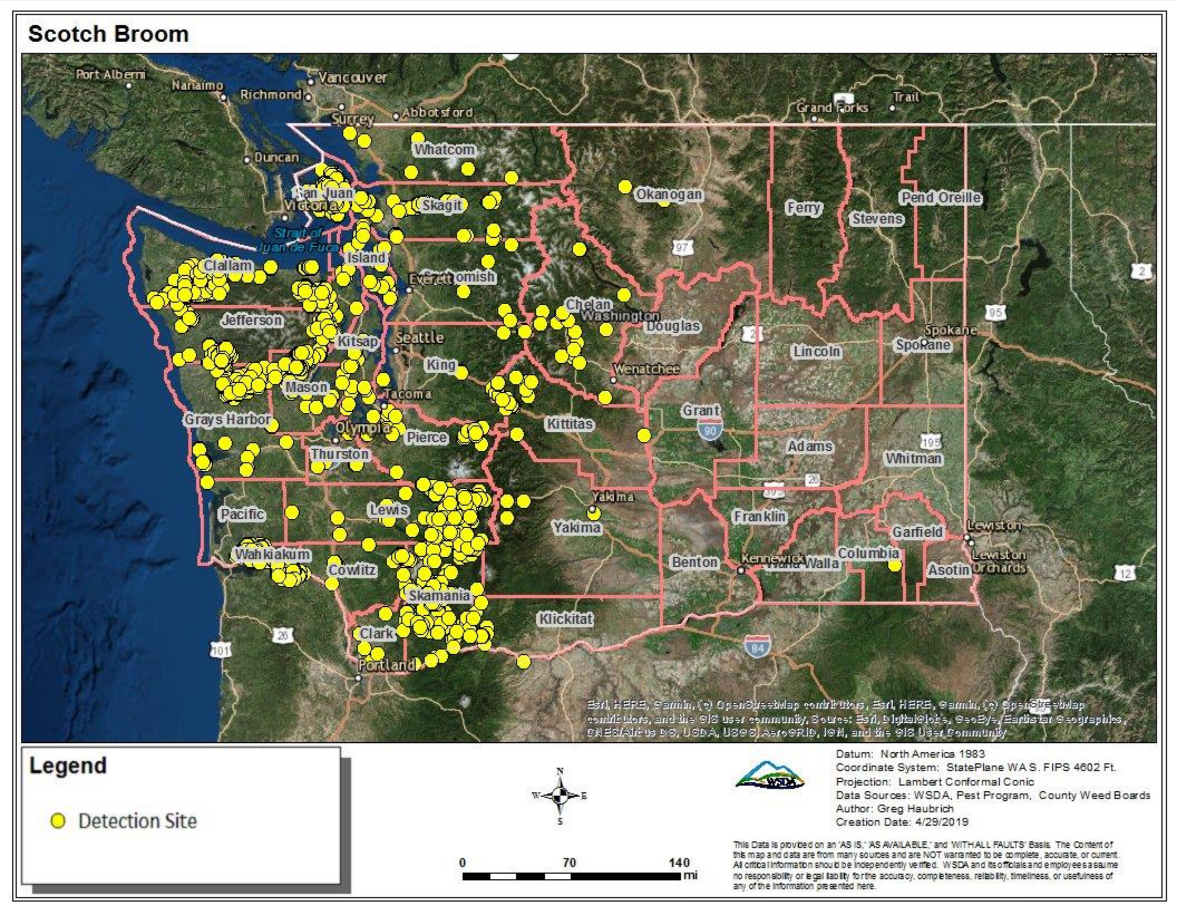
Expansion Modeling

(Current vs. Future Cost)

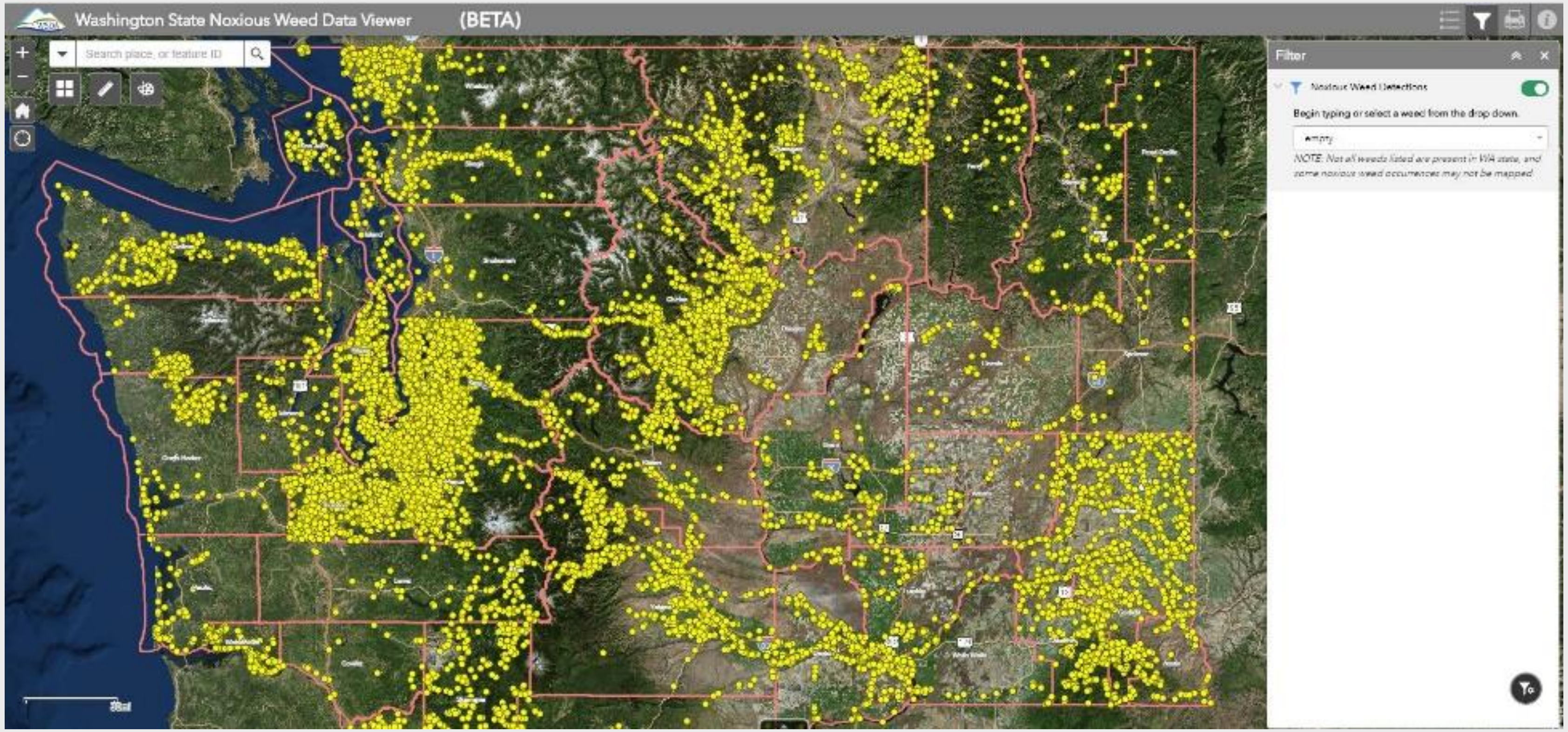


- Toutle River Watershed
- Current knotweed locations vs. predicted
- Current cost of control to WSDA $3,400, compared to $150,000 in the future

Scotch Broom Distribution



Public Noxious Weed Data Viewer





Economic Impact of Selected Invasive Species

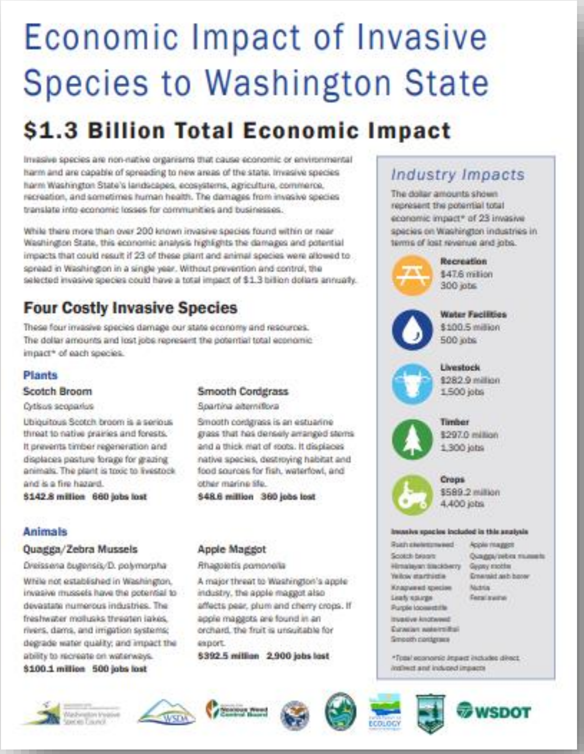
Direct Costs Estimates and Economic Impacts for Washington State



Economic Impacts of Invasive Species

- Environmental and Economic Costs of Nonindigenous Species in the United States, Pimentel et al. (2000, 2005)
- Oregon Noxious Weed Strategic Plan & Economic Analysis, ODA (2000)
- Economic Impact from Selected Noxious Weeds in Oregon, ODA (2014)

Washington State Report


Economic Impact of Invasive Species to Washington State

$1.3 Billion Total Economic Impact

Invasive species are non-native organisms that cause economic or environmental harm and are capable of spreading to new areas of the state. Invasive species harm Washington State's landscapes, ecosystems, agriculture, commerce, recreation, and sometimes human health. The damages from invasive species translate into economic losses for communities and businesses.

While there more than over 200 known invasive species found within or near Washington State, this economic analysis highlights the damages and potential impacts that could result if 23 of these plant and animal species were allowed to spread in Washington in a single year. Without prevention and control, the selected invasive species could have a total impact of $1.3 billion dollars annually.

Four Costly Invasive Species

These four invasive species damage our state economy and resources. The dollar amounts and lost jobs represent the potential total economic impact* of each species.

Plants

Scotch Broom

Cytisus scoparius

Ubiquitous Scotch broom is a serious threat to native prairies and forests. It prevents timber regeneration and displaces pasture forage for grazing animals. The plant is toxic to livestock and is a fire hazard.

$142.8 million 660 jobs lost

Smooth Cordgrass

Spartina alterniflora

Smooth cordgrass is an estuarine grass that has densely arranged stems and a thick mat of roots. It displaces native species, destroying habitat and food sources for fish, waterfowl, and other marine life.

$48.6 million 360 jobs lost

Animals

Quagga/Zebra Mussels

Dreissena bugensis/D. polymorpha

While not established in Washington, invasive mussels have the potential to devastate numerous industries. The freshwater mollusks threaten lakes, rivers, dams, and irrigation systems; degrade water quality; and impact the ability to recreate on waterways.

$100.1 million 500 jobs lost

Apple Maggot

Rhagoletis pomonella

A major threat to Washington's apple industry, the apple maggot also affects pear, plum and cherry crops. If apple maggots are found in an orchard, the fruit is unsuitable for export.

$392.5 million 2,900 jobs lost

Industry Impacts

The dollar amounts shown represent the potential total economic impact* of 23 invasive species on Washington industries in terms of lost revenue and jobs.

Recreation
$47.6 million
300 jobs

Water Facilities
$100.5 million
500 jobs

Livestock
$282.9 million
1,500 jobs

Timber
$297.0 million
1,300 jobs

Crops
$589.2 million
4,400 jobs

Invasive species included in this analysis

Rush skeletonweed, Scotch broom, Himalayan blackberry, Yellow starthistle, Knapweed species, Leafy spurge, Purple loosestrife, Invasive knotweed, Eurasian watermilfoil, Smooth cordgrass, Apple maggot, Quagga/zebra mussels, Gypsy moths, Emerald ash borer, Nutria, Feral swine

*Total economic impact includes direct, indirect and induced impacts

While there are more than 200 known invasive species found in or near Washington state, the economic analysis highlights the damages and potential impacts that could result if 23 of these species were allowed to spread in Washington in a single year without prevention or control measures…

Without prevention and control, the selected invasive species could cost Washington $1.3 billion annually.

Economic Impacts of Invasive Species: Direct Cost Estimates and Economic Impacts for Washington State. A report prepared by Washington Invasive Species Council, Washington State Department of Agriculture, Washington State Noxious Weed Control Board, Washington State Department of Fish and Wildlife, Washington State Department of Ecology, Washington State Parks, and Washington State Department of Natural Resources. 2017.

Invasive Species Selected

Invasive Plants (15)

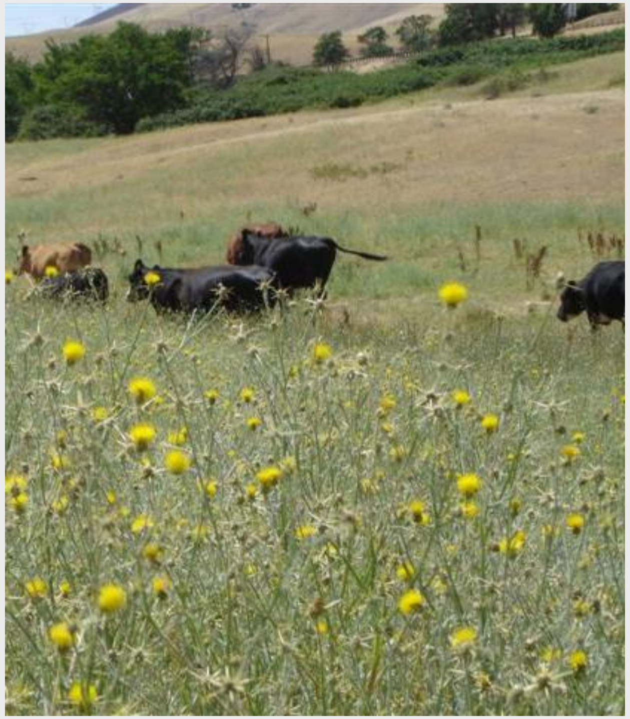
- Eurasian watermilfoil
- Himalayan blackberry
- Knapweeds (diffuse, meadow, spotted
- Knotweeds (Bohemian, giant, Himalayan, Japanese)
- Leafy spurge
- Purple loosestrife
- Rush skeletonweed
- Scotch broom
- Smooth cordgrass
- Yellow starthistle

Invasive Animals (8)

- Apple maggot
- Asian and European gypsy moths
- Emerald ash borer
- Feral swine
- Nutria
- Quagga and zebra mussels

Summaries of Individual Species

- Description of Species
- Distribution in Washington (2016)
- Impacts Considered
- Other Considerations
- Direct Economic Impact of Species
- Total Economic Activity at Risk



Results

- Washington – $1.3 billion per year without any prevention and control and the loss of up to 8,000 jobs
- Oregon between $1.5 billion and $2.4 billion personal income if infestation moved into all of the susceptible areas and up to 40,800 jobs lost

Most Costly Invasive Species

Invasive Plants

- Rush Skeletonweed
  - $149.2 million dollars
  - 1,080 jobs
- Scotch Broom
  - $142.7 million dollars
  - 660 jobs

Invasive Animals

- Apple Maggot
  - $392.5 million dollars
  - 2,900 jobs
- Quagga/Zebra Mussels
  - $100.1 million dollars
  - 500 jobs

Knotweed Impacts by County

	Acres Impacted			Direct Revenue Impacts				Total Economic Impacts		
County	Rangeland	Hunting	Fishing	Livestock	Recreational Hunting	Recreational Fishing	Total	Lost Revenues	Lost Jobs	Lost Labor Income
Adams	-	-	-	-	-	-	-	$5,131	-	$0
Asotin	-	-	12,670	-	-	2,650	2,650	$6,029	-	$1,762
Benton	-	-	7,820	-	-	1,640	1,640	$31,641	-	$1,106
Chelan	-	-	64,190	-	-	13,440	13,440	$39,109	-	$8,641
Clallam	1,570	1,570	59,460	103,640	2,720	12,450	118,810	$213,494	1	$76,233
Clark	560	560	21,890	36,820	970	4,590	42,380	$124,487	1	$29,347
Columbia	-	-	17,180	-	-	3,600	3,600	$6,616	-	$2,399
Cowlitz	1,780	1,780	35,850	117,740	3,090	7,510	128,340	$259,107	3	$86,637
Douglas	-	-	10,460	-	-	2,190	2,190	$8,640	-	$1,439
Ferry	-	-	24,840	-	-	5,200	5,200	$8,616	-	$3,370
Franklin	-	-	5,930	-	-	1,240	1,240	$20,390	-	$838
Garfield	-	-	12,750	-	-	2,670	2,670	$4,214	-	$1,636
Grant	-	-	15,870	-	-	3,320	3,320	$30,721	-	$2,152
Grays Harbor	2,600	2,600	78,110	172,000	4,520	16,360	192,880	$369,976	3	$129,901
Island	40	40	90	2,320	60	20	2,400	$8,196	-	$1,515
Jefferson	1,230	1,230	43,380	81,590	2,140	9,080	92,810	$172,145	1	$61,065
King	1,460	1,460	57,420	96,590	2,540	12,020	111,150	$556,255	1	$75,610
Kitsap	140	140	7,010	9,230	240	1,470	10,940	$35,904	-	$6,732
Kittitas	-	-	53,410	-	-	11,190	11,190	$23,150	-	$7,359
Klickitat	-	-	32,900	-	-	6,890	6,890	$14,118	-	$4,431
Lewis	2,610	2,610	75,310	172,660	4,530	15,770	192,960	$378,340	3	$131,257
Lincoln	-	-	14,530	-	-	3,040	3,040	$6,034	-	$2,031
Mason	1,250	1,250	29,960	82,500	2,170	6,270	90,940	$165,962	1	$57,774
Okanogan	-	-	80,770	-	-	16,920	16,920	$34,363	-	$10,496
Pacific	1,370	1,370	36,690	90,570	2,380	7,680	100,630	$185,644	1	$65,434
Pend Oreille	-	-	41,650	-	-	8,720	8,720	$13,814	-	$5,383
Pierce	1,530	1,530	34,740	101,150	2,660	7,270	111,080	$325,120	1	$75,311
San Juan	40	40	450	2,370	60	90	2,520	$6,523	-	$1,646
Skagit	1,460	1,460	42,000	96,440	2,530	8,790	107,760	$258,118	1	$77,368
Skamania	1,760	1,760	40,510	116,170	3,050	8,480	127,700	$230,133	3	$83,244
Snohomish	1,350	1,350	58,580	89,120	2,340	12,270	103,730	$256,280	1	$68,019
Spokane	-	-	17,100	-	-	3,580	3,580	$69,423	-	$2,559
Stevens	-	-	36,160	-	-	7,570	7,570	$14,800	-	$4,959
Thurston	620	620	21,210	41,260	1,080	4,440	46,780	$112,767	1	$31,040
Wahkiakum	330	330	13,880	22,020	580	2,910	25,510	$45,271	-	$16,247
Walla Walla	-	-	17,890	-	-	3,750	3,750	$17,033	-	$2,422
Whatcom	1,980	1,980	49,900	131,140	3,440	10,450	145,030	$375,627	3	$105,789
Whitman	-	-	14,500	-	-	3,040	3,040	$13,590	-	$1,899
Yakima	-	-	79,550	-	-	16,660	16,660	$85,221	-	$10,949

Economic Impact of Invasive Knotweed

$4.5 Million Total Economic Impact to Washington State

Invasive knotweed grows in many different habitats in Washington State, but can primarily be found along waterways. The tall, bamboo-like plants are robust perennials that form dense thickets and spread by long creeping rhizomes.

Invasive knotweed includes giant knotweed (*Polygonum sachalinense*), Himalayan knotweed (*Polygonum polystachyum*), the hybrid bohemian knotweed (*Polygonumx bohemicum*), and Japanese knotweed (*Polygonum cuspidatum*). The plants can be difficult to tell apart, and share similar habitat, impacts and control methods.

If invasive knotweed is not controlled or prevented and increases at a mere **1 percent a year, $4.5 million in business sales could be lost** across the state, along with 25 jobs and $1.2 million in lost income.

Top 5 At-Risk Counties

Invasive knotweed disproportionately affects different areas in the state. The counties listed here could incur the following total economic impact* from invasive knotweed spread.

	Economic Impact
King County	$556,000
Lewis County	$378,000
Whatcom County	$376,000
Grays Harbor County	$370,000
Pierce County	$325,000
All Other Counties	$2.5 million

*The total economic impact includes direct and secondary impacts.

Invasive Knotweed Distribution, 2016

Management & Restoration Investment

Many different agencies, Native American tribes, and non-governmental organizations have worked cooperatively to stop invasive knotweed and improve habitat damaged by the plant. The spread of invasive knotweed threatens this investment.

From 2004 to 2016, the Washington State Recreation and Conservation Office and the Washington State Department of Agriculture have invested **$30.4 million** (2017 dollars) to control invasive knotweed and restore shoreline areas for salmon recovery. If invasive knotweed is allowed to spread and impact these areas, these significant investments in mitigation and habitat restoration may be lost.

Direct Impacts by Industry

Invasive knotweed can out-compete native plants and crops, lowering the amount of crops farmers can harvest and reducing the diversity of plants in the state. Knotweed can dominate riverbanks, replacing the trees that normally would grow there. Without tree roots to hold the soil on the bank, more erosion occurs and water quality is degraded, harming wildlife, including salmon. The direct economic impact to several of Washington's industries include:

Rangeland $1.57 million in direct costs

Fishing $265,000 in direct costs

Hunting $41,000 in direct costs

Noxious Weed Control Board

cai community attributes inc

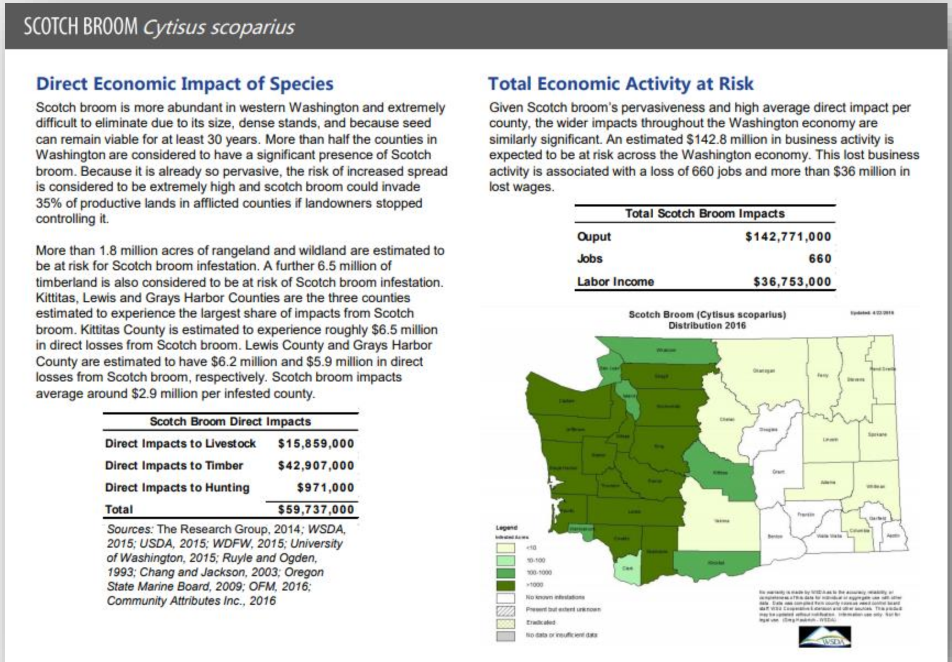
Washington State Report

The Daily Chronicle
County Will Consider Tax to Fund Noxious Weed Board
INVASIVE: Proposed Tax Would Cost $8 Per Parcel

According to a study conducted by the Washington State Department of Agriculture, Lewis County stands to sustain $6.2 million in losses as Scotch broom invades rangeland and wildland areas.

- Bill Wamsley, Lewis County Noxious Weed Control Coordinator

The Daily Chronicle
October 22, 2018
County Approves New Tax to Fund Noxious Weed Board



SCOTCH BROOM *Cytisus scoparius*

Direct Economic Impact of Species

Scotch broom is more abundant in western Washington and extremely difficult to eliminate due to its size, dense stands, and because seed can remain viable for at least 30 years. More than half the counties in Washington are considered to have a significant presence of Scotch broom. Because it is already so pervasive, the risk of increased spread is considered to be extremely high and scotch broom could invade 35% of productive lands in afflicted counties if landowners stopped controlling it.

More than 1.8 million acres of rangeland and wildland are estimated to be at risk for Scotch broom infestation. A further 6.5 million of timberland is also considered to be at risk of Scotch broom infestation. Kittitas, Lewis and Grays Harbor Counties are the three counties estimated to experience the largest share of impacts from Scotch broom. Kittitas County is estimated to experience roughly $6.5 million in direct losses from Scotch broom. Lewis County and Grays Harbor County are estimated to have $6.2 million and $5.9 million in direct losses from Scotch broom, respectively. Scotch broom impacts average around $2.9 million per infested county.

Scotch Broom Direct Impacts	
Direct Impacts to Livestock	$15,859,000
Direct Impacts to Timber	$42,907,000
Direct Impacts to Hunting	$971,000
Total	$59,737,000

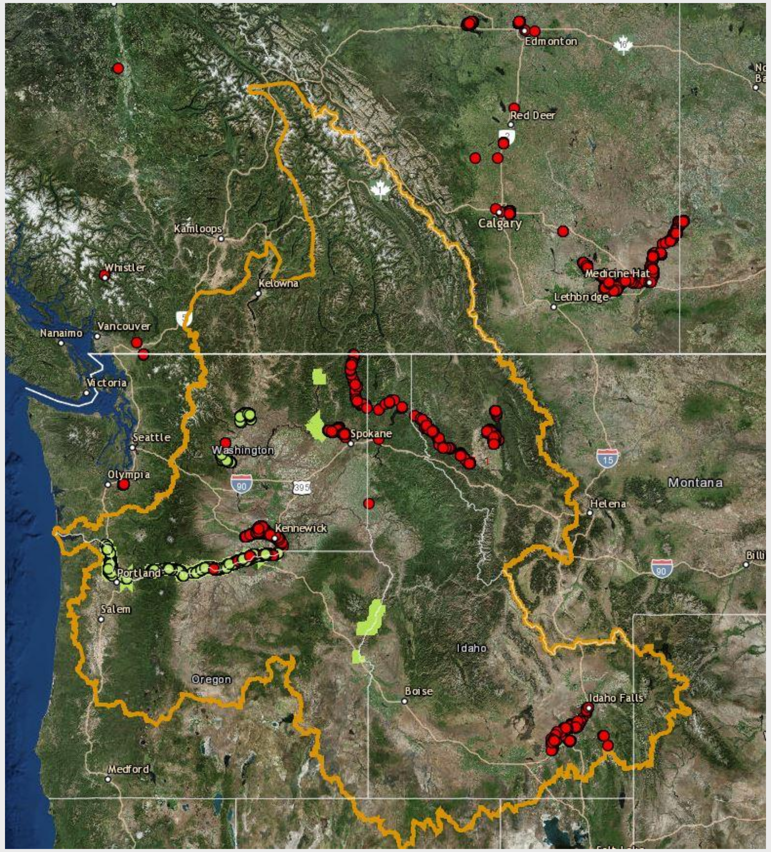
Sources: The Research Group, 2014; *WSDA, 2015; USDA, 2015; WDFW, 2015; University of Washington, 2015; Ruyle and Ogden, 1993; Chang and Jackson, 2003; Oregon State Marine Board, 2009; OFM, 2016; Community Attributes Inc., 2016*

Total Economic Activity at Risk

Given Scotch broom's pervasiveness and high average direct impact per county, the wider impacts throughout the Washington economy are similarly significant. An estimated $142.8 million in business activity is expected to be at risk across the Washington economy. This lost business activity is associated with a loss of 660 jobs and more than $36 million in lost wages.

Total Scotch Broom Impacts	
Ouput	$142,771,000
Jobs	660
Labor Income	$36,753,000

Flowering Rush Distribution
Columbia River Basin Watershed



WISC applied for and received NFWF PTI grant $65,000

3 main components:

- Form the Columbia Basin CWMA
  - First plant of focus = flowering rush
- Summit
- Develop Basin-wide plan
- Use the plan to seek implementation funding
- Develop potential distribution model

Visualizing predicted distributions to inform search and control of priority invasive plants

Catherine Jarnevich
Research Ecologist
USGS Fort Collins Science Center

Terri Hogan
Invasive Plant Program Lead
National Park Service

With help from: Peder Engelstad, Ian Pearse, Jennifer Sieracki, Helen Sofaer, Julia Sullivan, Nicholas Young

Invasive Species Threaten Resources

- Invasive species pose a significant threat to natural resources, cultural resources, and facilities within the NPS.
- Invasive species degrade habitat for both native plant and animal species, alter ecosystem regulators like fire, and directly compete with native plant species for necessary resources.

Grand Portage Band of Lake Superior Chippewa ceremony (ca.1955) in the east village meadow. NPS photo.

The same meadow in 2016 where vetch is impacting wild caraway and sweetgrass, Great Lakes EPMT. NPS photo.

USGS

Invasive Species Threaten Resources

- Land managers need tools to help make strategic decisions about where to focus limited resources to best address invasive plant control.
- This work provides a tool to support informed decision making and improve the effective management of resources.

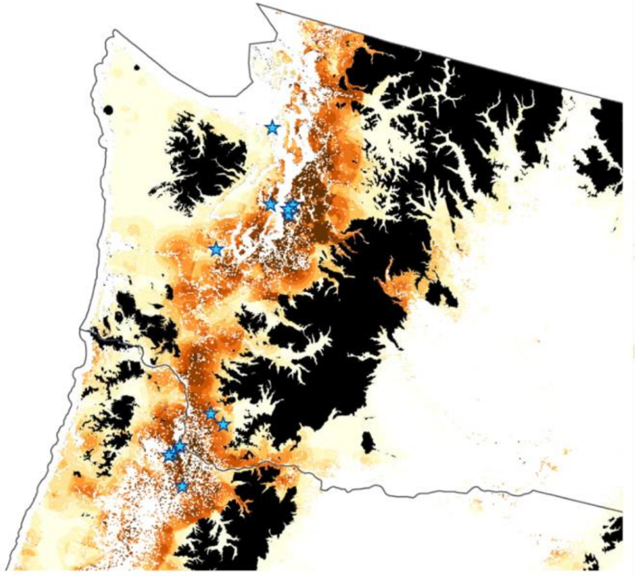
Reed canarygrass (*Phalaris arundicacea*) treatment at Ross Lake National Recreation Area. NPS photo.

What can species distribution models be used for?

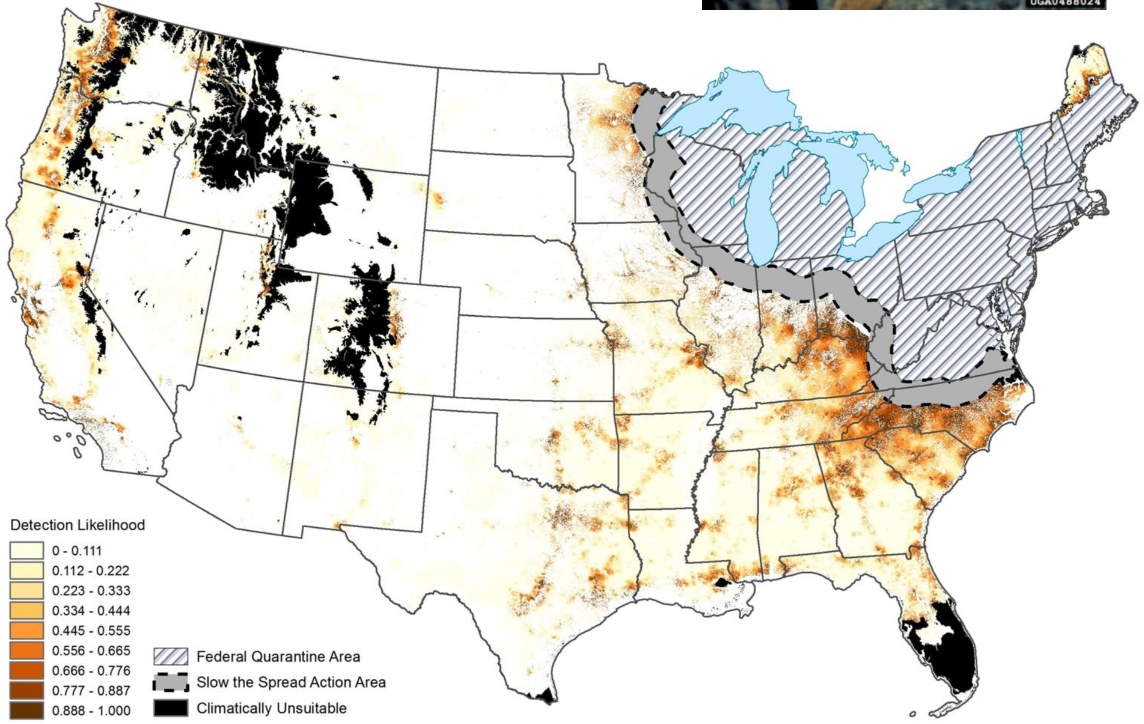
- Regional risk assessment
  - What might be in the region that I am unaware of?
  - Watch lists: What EDRR species should I focus on?
  - Potential habitat for a species across a large region

- Local targeting
  - Where am I most likely to find patches to treat?
  - Where should I search for satellite populations?

Invasive species EDRR

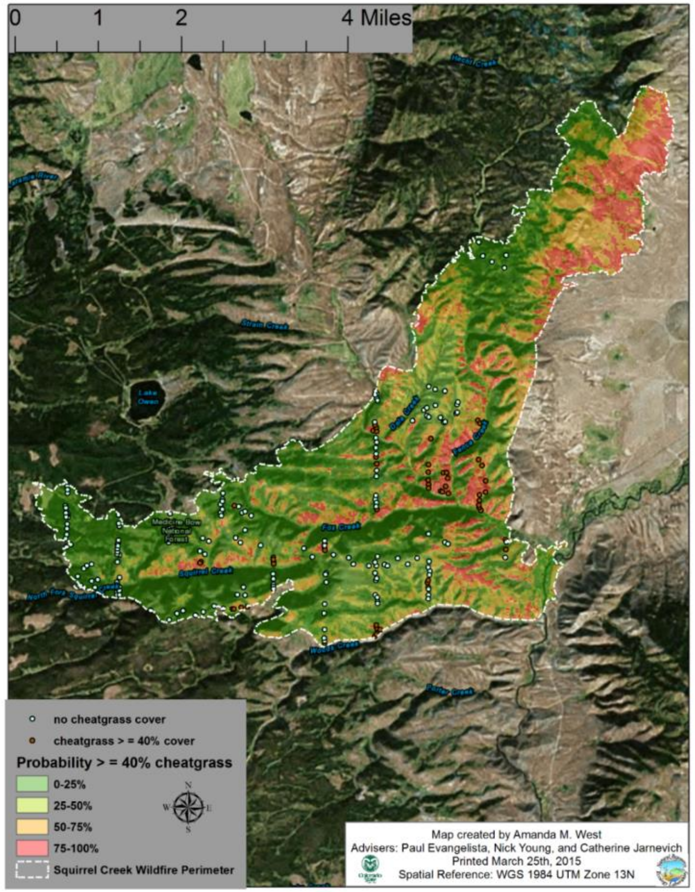


Cook et al. 2019, Forests



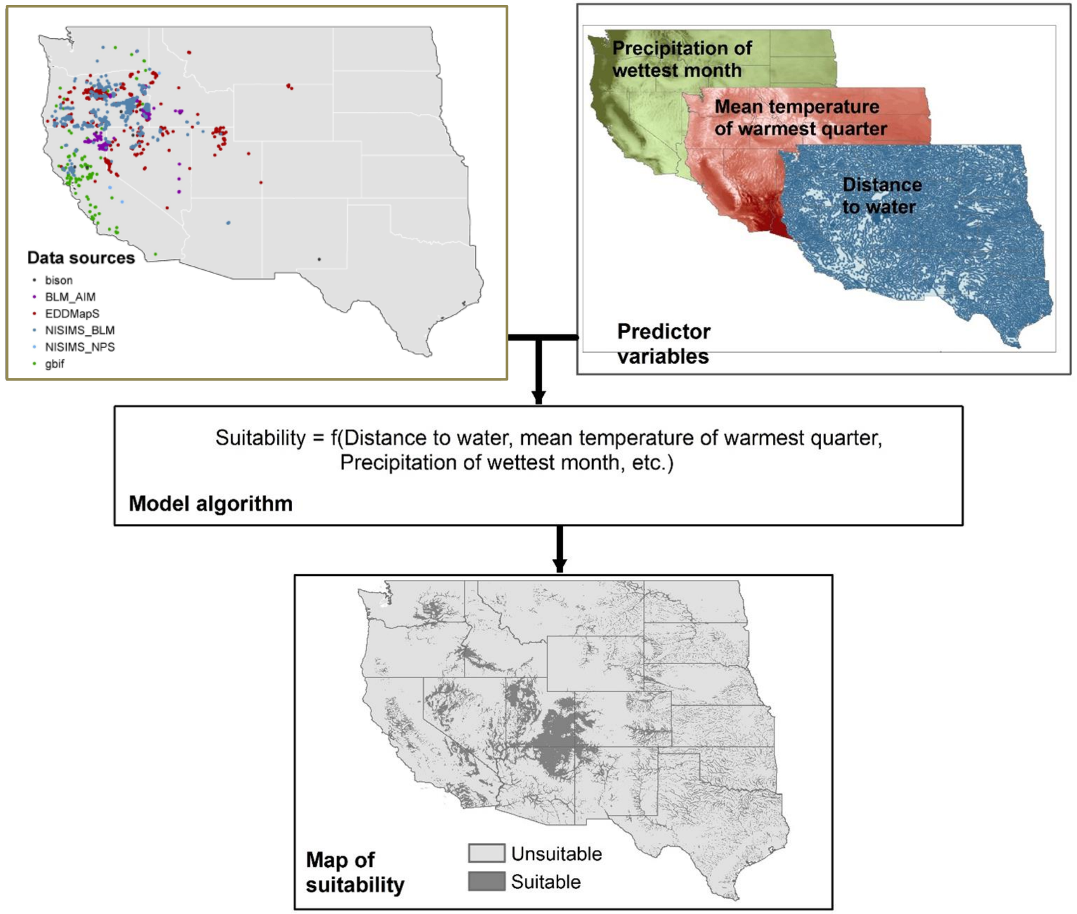
Invasive species control

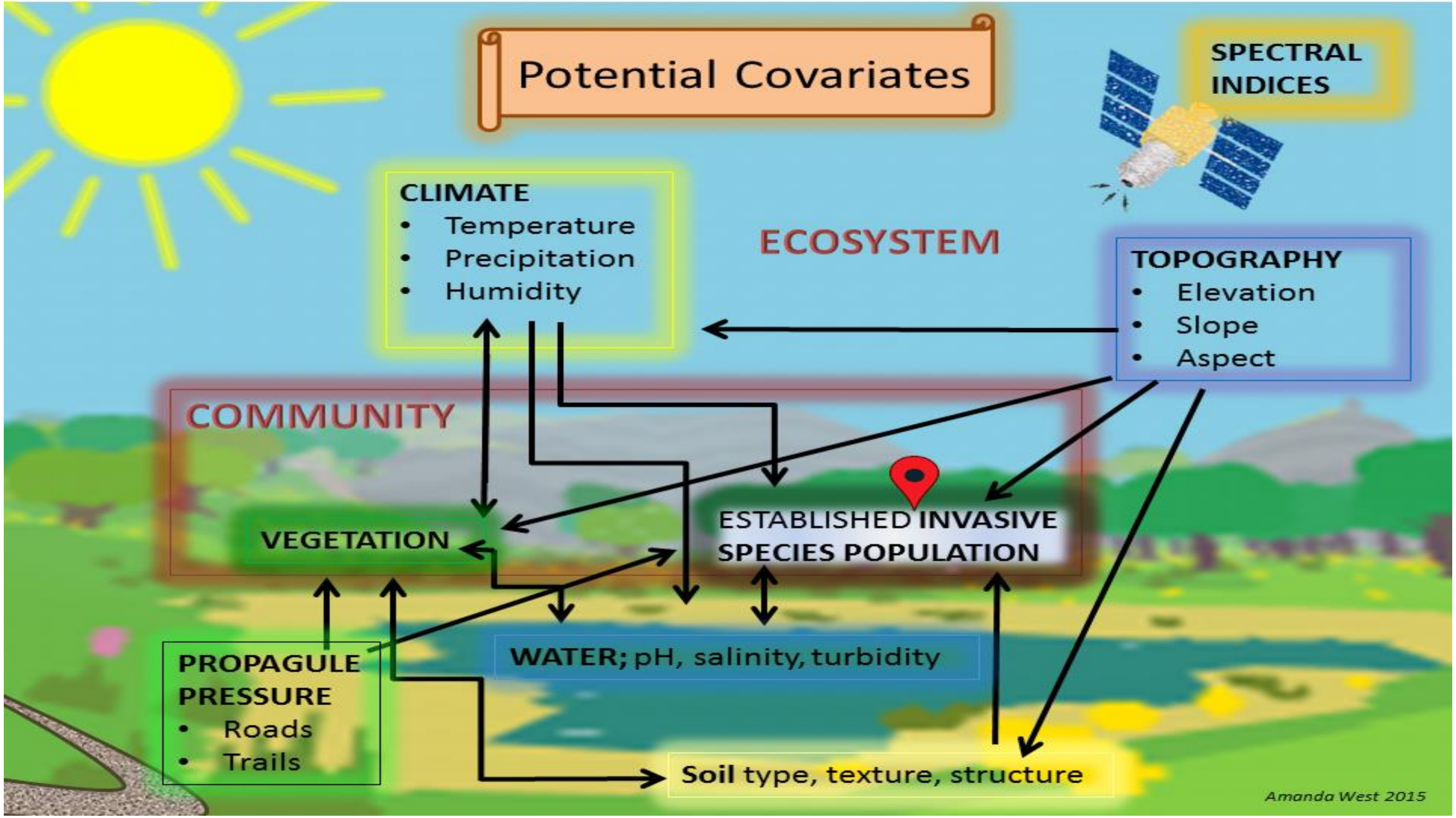
West et al. 2017, International Journal of Applied Earth Observation and Geoinformation



Model development and delivery

Model development

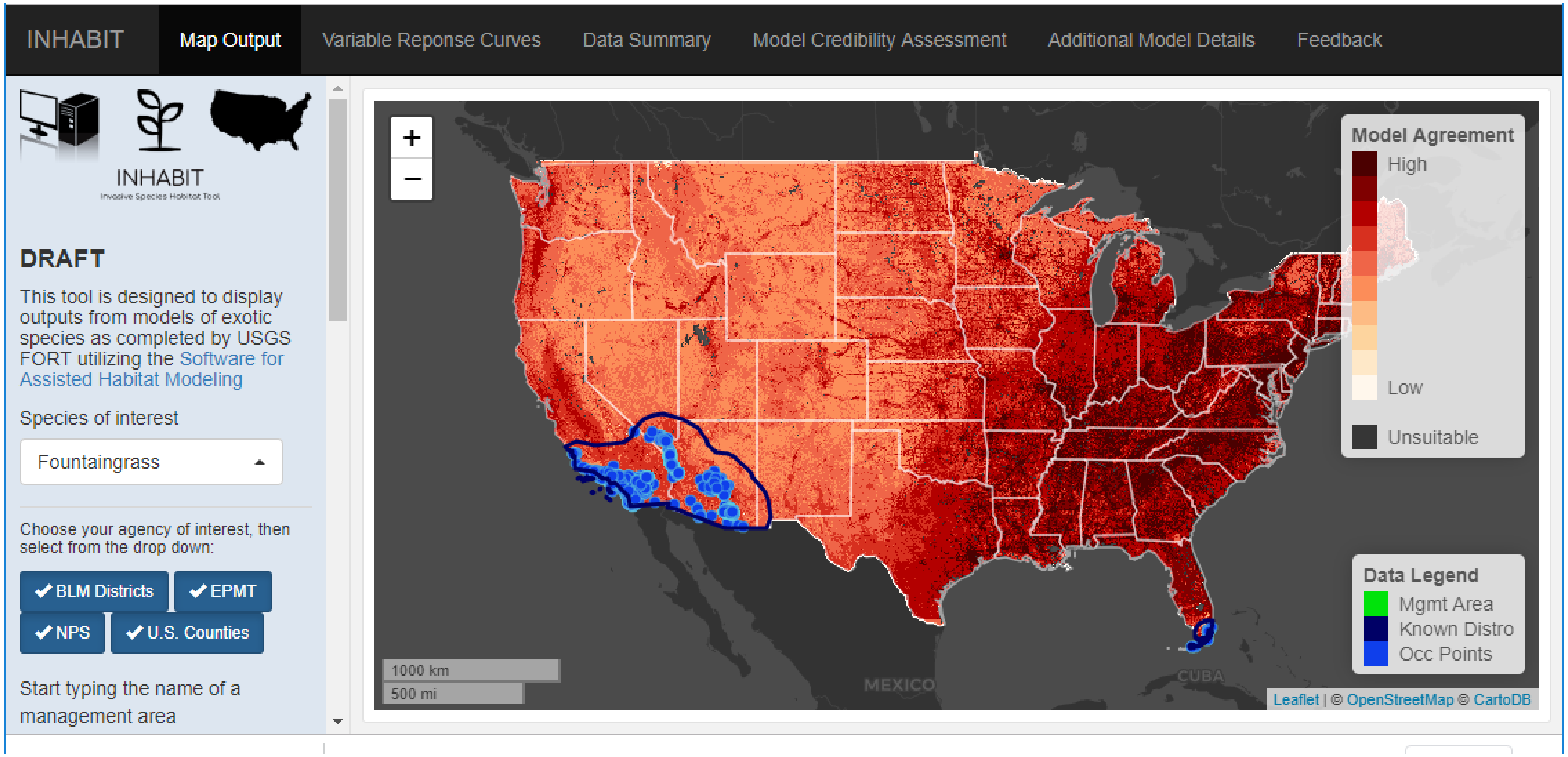




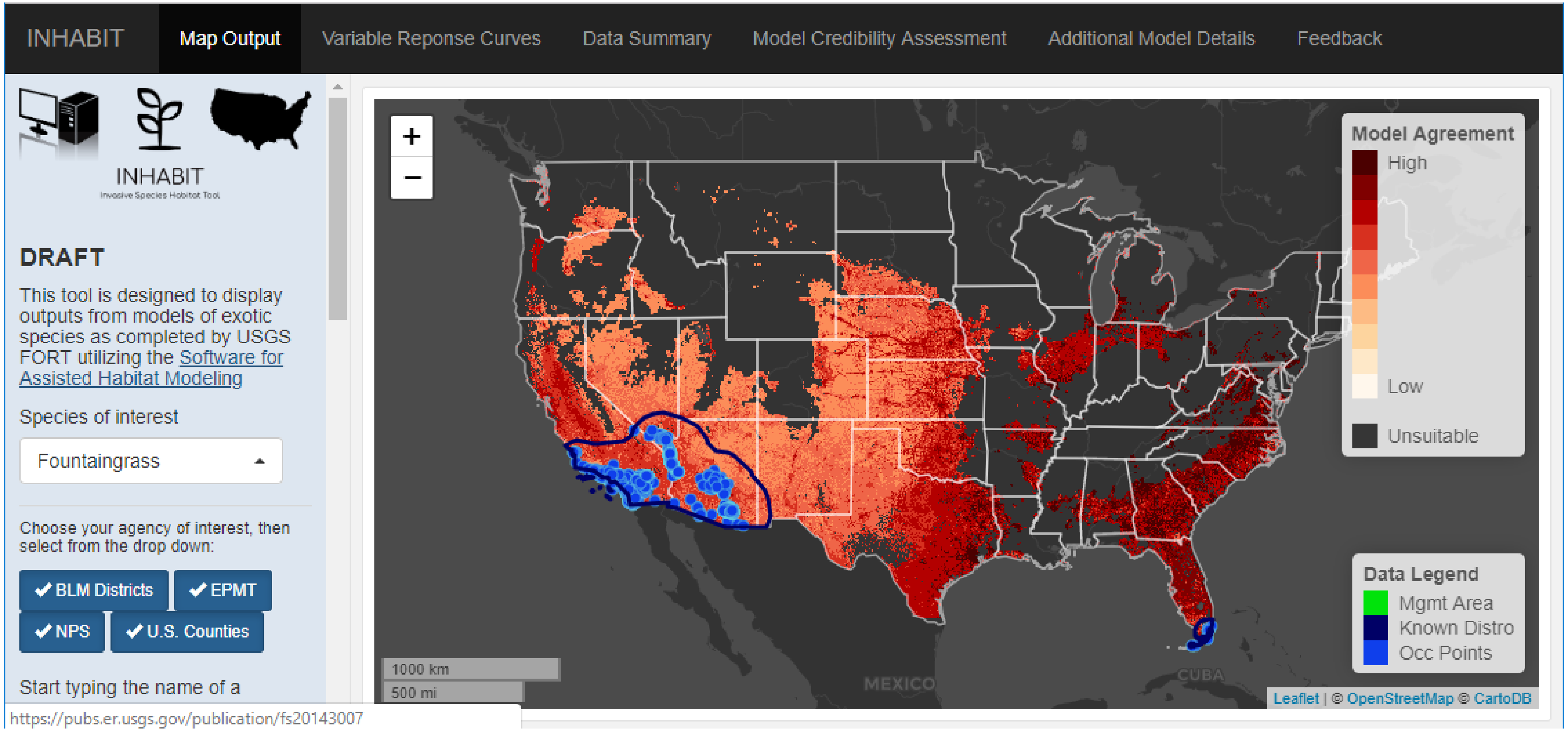
Potential Covariates
SPECTRAL INDICES
CLIMATE
• Temperature
• Precipitation
• Humidity
ECOSYSTEM
TOPOGRAPHY
• Elevation
• Slope
• Aspect
COMMUNITY
VEGETATION
ESTABLISHED INVASIVE SPECIES POPULATION
PROPAGULE PRESSURE
• Roads
• Trails
WATER; pH, salinity, turbidity
Soil type, texture, structure
Amanda West 2015

Model delivery

- INHABIT (Invasive Species Habitat Tool)
  - On-line tool to delivery models to managers
  - Compatible across device types
- Requesting feedback on features and utility


INHABIT
Map Output
Variable Reponse Curves
Data Summary
Model Credibility Assessment
Additional Model Details
Feedback
INHABIT
Invasive Species Habitat Tool
DRAFT
This tool is designed to display outputs from models of exotic species as completed by USGS FORT utilizing the Software for Assisted Habitat Modeling
Species of interest
Fountaingrass
Choose your agency of interest, then select from the drop down:
BLM Districts
EPMT
NPS
U.S. Counties
Start typing the name of a management area
Model Agreement
High
Low
Unsuitable
Data Legend
Mgmt Area
Known Distro
Occ Points
MEXICO
CUBA
1000 km
500 mi
Leaflet | © OpenStreetMap © CartoDB

USGS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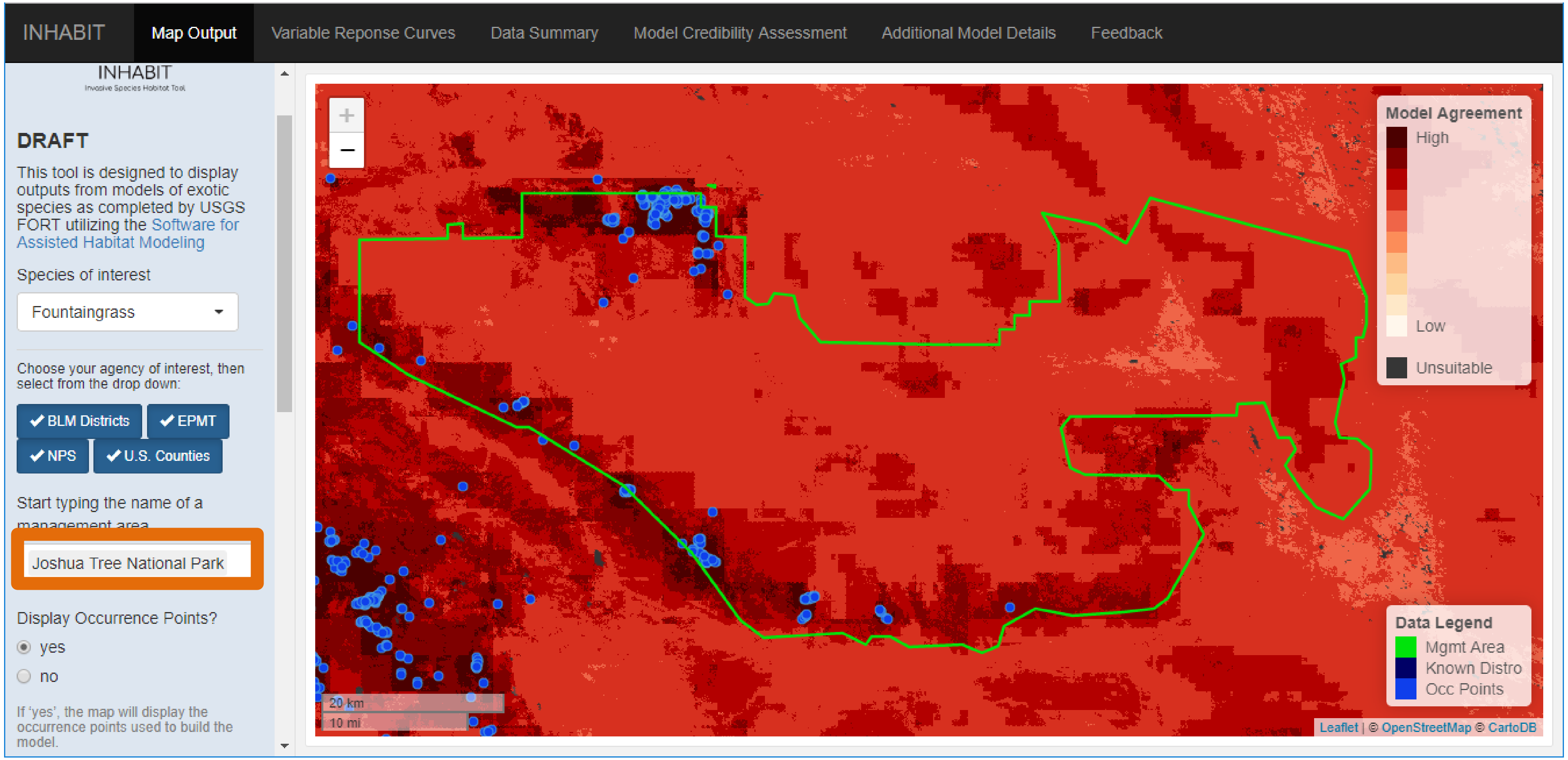
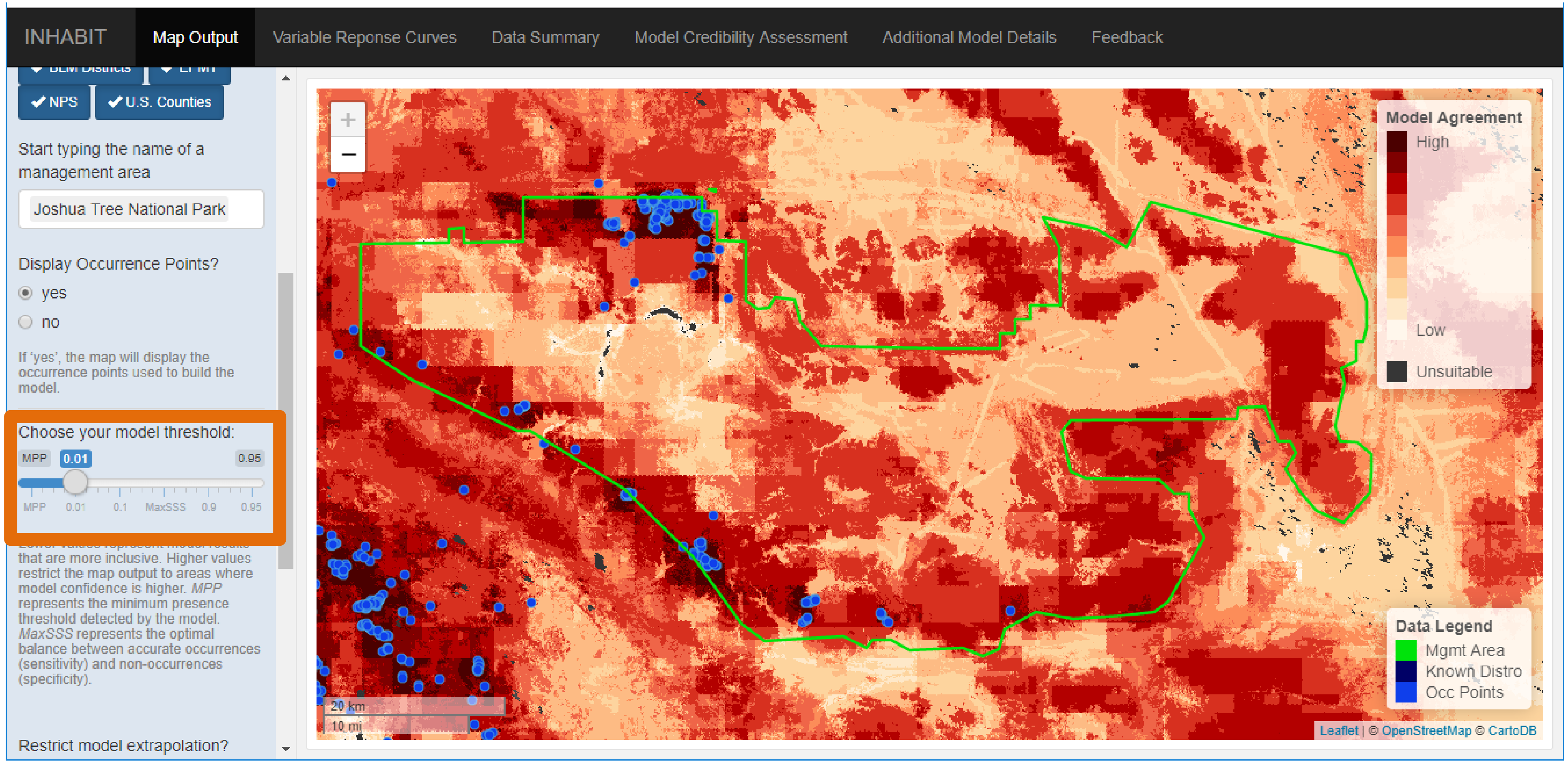
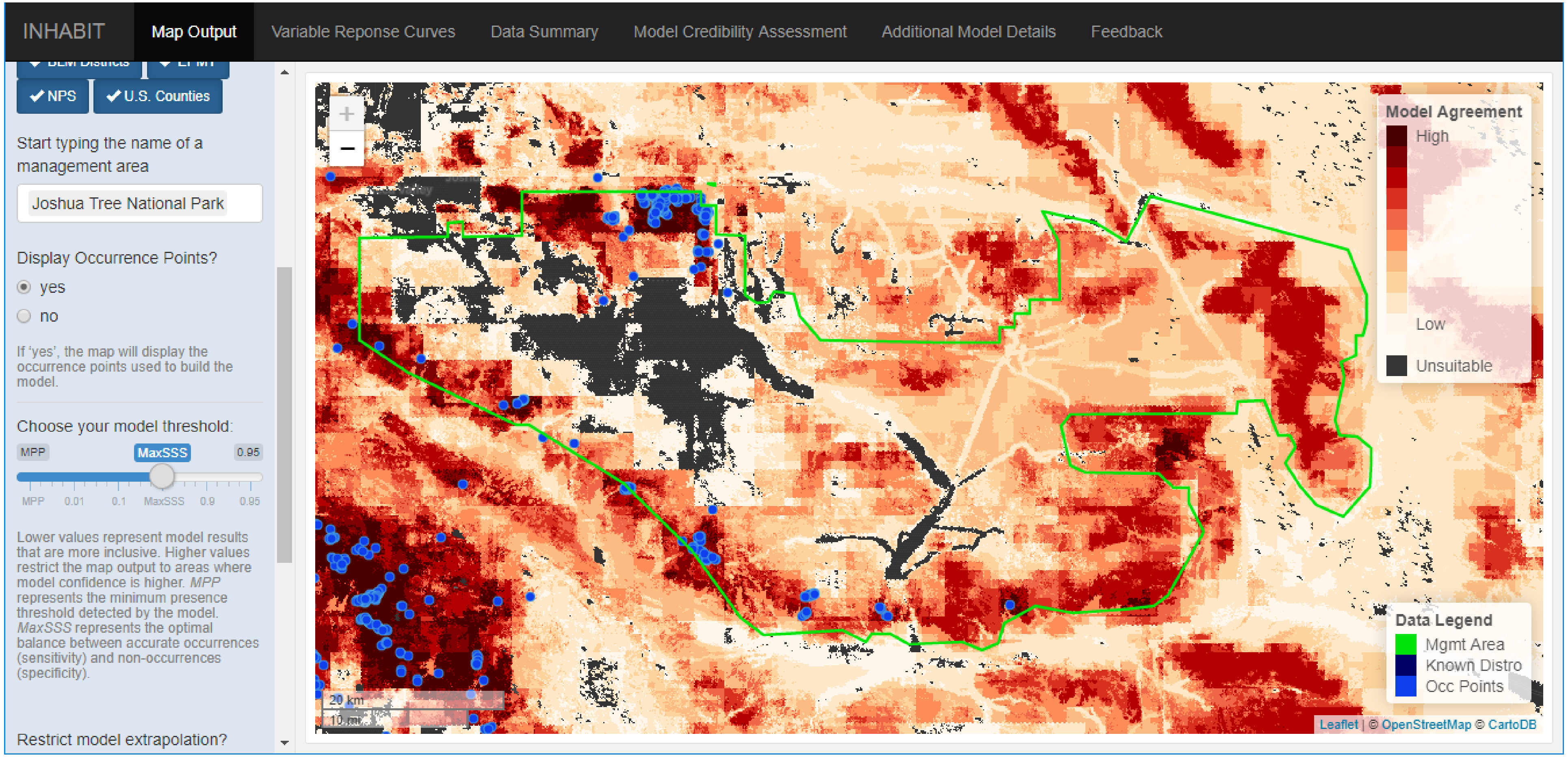
Fountaingrass
Choose your agency of interest, then select from the drop down:
BLM Districts
EPMT
NPS
U.S. Counties
Start typing the name of a
https://pubs.er.usgs.gov/publication/fs20143007
+
−
Model Agreement
High
Low
Unsuitable
Data Legend
Mgmt Area
Known Distro
Occ Points
MEXICO
CUBA
1000 km
500 mi
Leaflet | © OpenStreetMap © CartoDB


INHABIT
Map Output
Variable Reponse Curves
Data Summary
Model Credibility Assessment
Additional Model Details
Feedback
INHABIT
Invasive Species Habitat Tool
DRAFT
This tool is designed to display outputs from models of exotic species as completed by USGS FORT utilizing the Software for Assisted Habitat Modeling
Species of interest
Fountaingrass
Choose your agency of interest, then select from the drop down:
BLM Districts
EPMT
NPS
U.S. Counties
Start typing the name of a management area
Joshua Tree National Park
Display Occurrence Points?
yes
no
If 'yes', the map will display the occurrence points used to build the model.
Model Agreement
High
Low
Unsuitable
Data Legend
Mgmt Area
Known Distro
Occ Points
20 km
10 mi
Leaflet | © OpenStreetMap © CartoDB


INHABIT
Map Output
Variable Reponse Curves
Data Summary
Model Credibility Assessment
Additional Model Details
Feedback
NPS
U.S. Counties
Start typing the name of a management area
Joshua Tree National Park
Display Occurrence Points?
yes
no
If 'yes', the map will display the occurrence points used to build the model.
Choose your model threshold:
MPP 0.01 0.95
MPP 0.01 0.1 MaxSSS 0.9 0.95
that are more inclusive. Higher values restrict the map output to areas where model confidence is higher. MPP represents the minimum presence threshold detected by the model. MaxSSS represents the optimal balance between accurate occurrences (sensitivity) and non-occurrences (specificity).
Restrict model extrapolation?
Model Agreement
High
Low
Unsuitable
Data Legend
Mgmt Area
Known Distro
Occ Points
20 km
10 mi
Leaflet | © OpenStreetMap © CartoDB


INHABIT
Map Output
Variable Reponse Curves
Data Summary
Model Credibility Assessment
Additional Model Details
Feedback
NPS
U.S. Counties
Start typing the name of a management area
Joshua Tree National Park
Display Occurrence Points?
yes
no
If 'yes', the map will display the occurrence points used to build the model.
Choose your model threshold:
MPP
MaxSSS
0.95
MPP 0.01 0.1 MaxSSS 0.9 0.95
Lower values represent model results that are more inclusive. Higher values restrict the map output to areas where model confidence is higher. MPP represents the minimum presence threshold detected by the model. MaxSSS represents the optimal balance between accurate occurrences (sensitivity) and non-occurrences (specificity).
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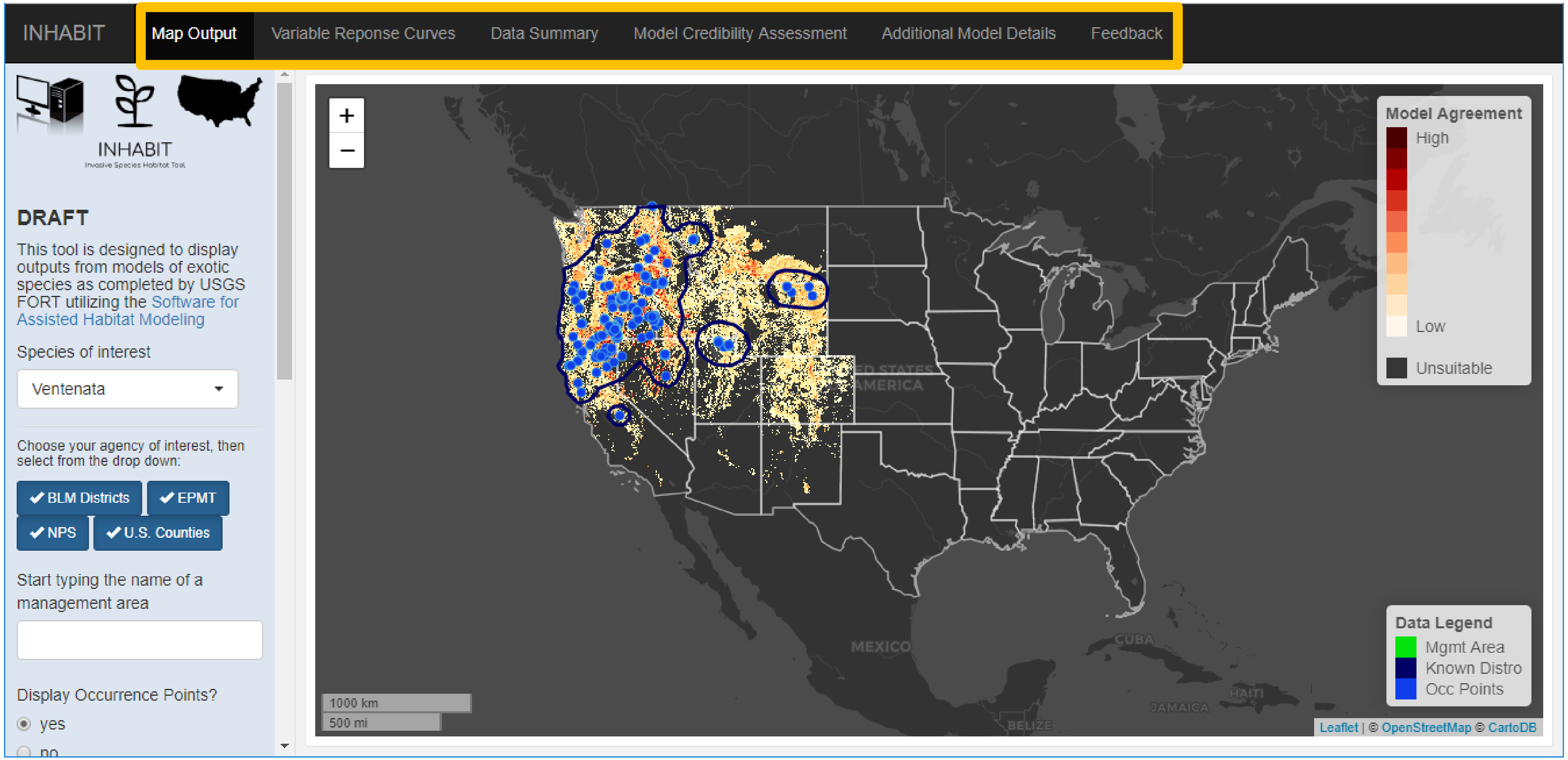
Model Agreement
High
Low
Unsuitable
Data Legend
Mgmt Area
Known Distro
Occ Points
20 km
10 mi
Leaflet | © OpenStreetMap © CartoDB


INHABIT
Map Output
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Additional Model Details
Feedback
INHABIT
DRAFT
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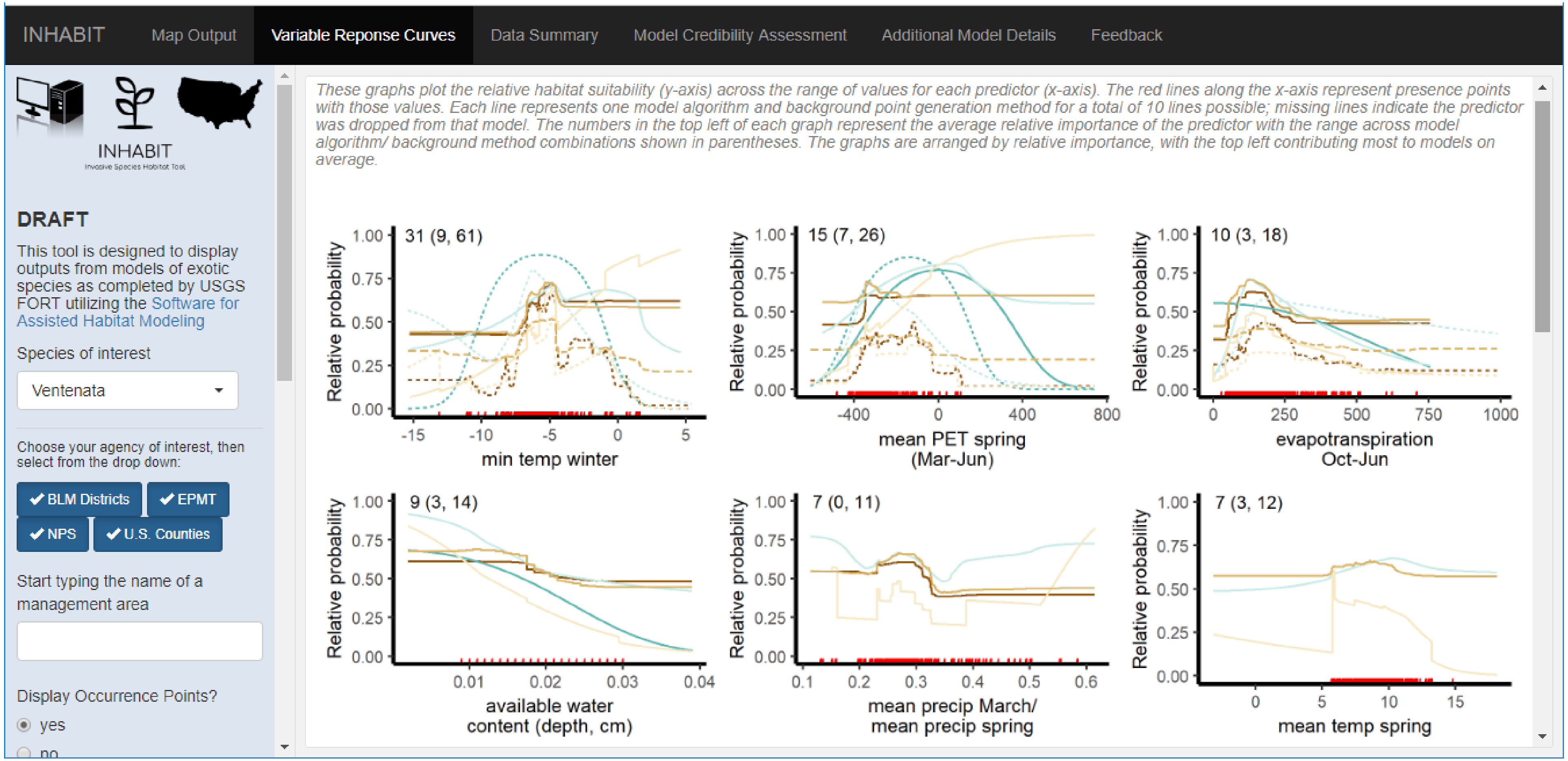
Species of interest
Ventenata
Choose your agency of interest, then select from the drop down:
BLM Districts
EPMT
NPS
U.S. Counties
Start typing the name of a management area
Display Occurrence Points?
yes
no
Model Agreement
High
Low
Unsuitable
Data Legend
Mgmt Area
Known Distro
Occ Points
MEXICO
CUBA
HAITI
JAMAICA
BELIZE
1000 km
500 mi
Leaflet | © OpenStreetMap © CartoDB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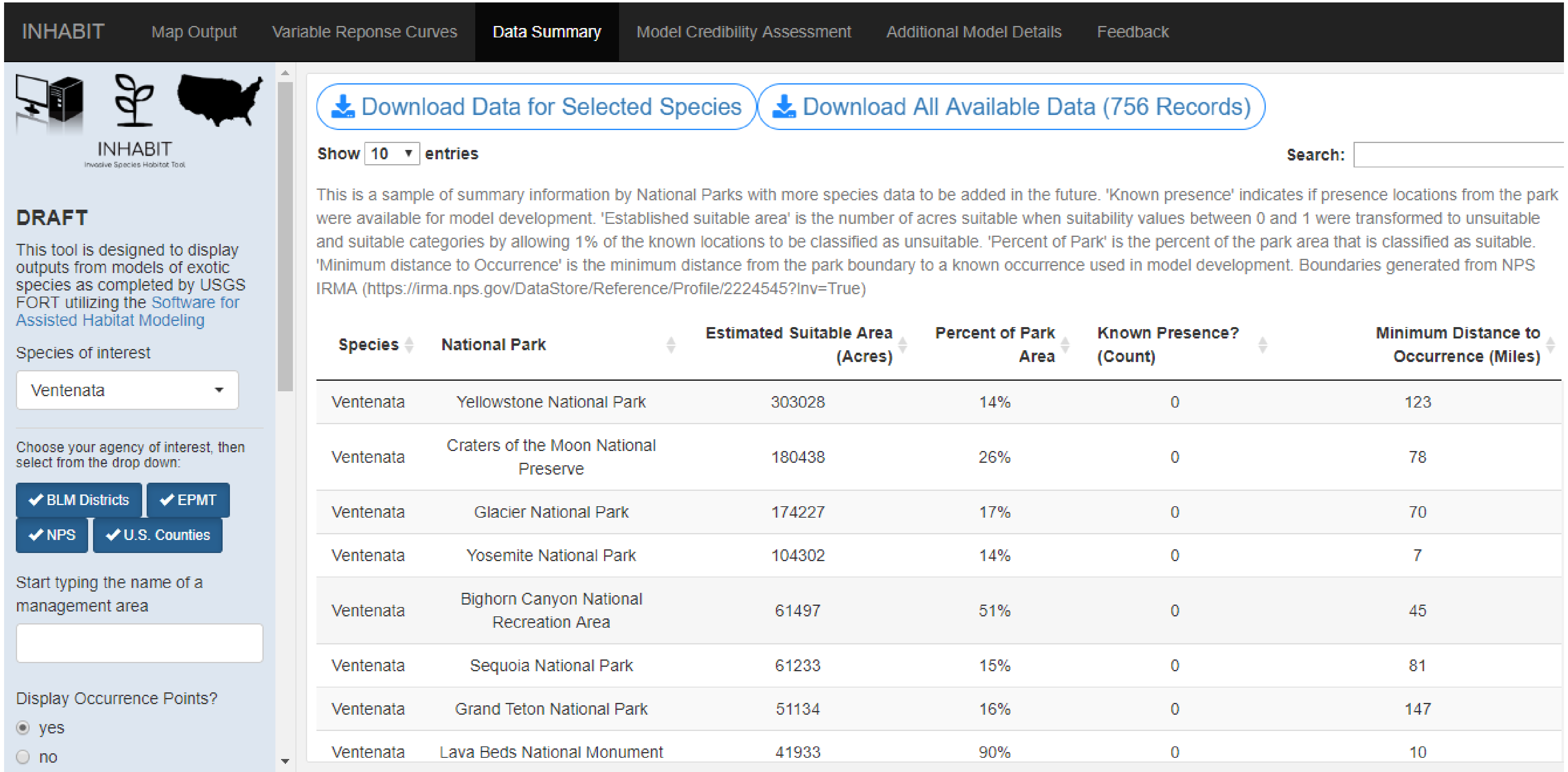
Choose your agency of interest, then select from the drop down:
BLM Districts
EPMT
NPS
U.S. Counties
Start typing the name of a management area
Display Occurrence Points?
yes
no
These graphs plot the relative habitat suitability (y-axis) across the range of values for each predictor (x-axis). The red lines along the x-axis represent presence points with those values. Each line represents one model algorithm and background point generation method for a total of 10 lines possible; missing lines indicate the predictor was dropped from that model. The numbers in the top left of each graph represent the average relative importance of the predictor with the range across model algorithm/ background method combinations shown in parentheses. The graphs are arranged by relative importance, with the top left contributing most to models on average.
Relative probability
31 (9, 61)
min temp winter
15 (7, 26)
mean PET spring (Mar-Jun)
10 (3, 18)
evapotranspiration Oct-Jun
9 (3, 14)
available water content (depth, cm)
7 (0, 11)
mean precip March/ mean precip spring
7 (3, 12)
mean temp spring



INHABIT | Map Output | Variable Reponse Curves | Data Summary | Model Credibility Assessment | Additional Model Details | Feedback

INHABIT
Invasive Species Habitat Tool

DRAFT

This tool is designed to display outputs from models of exotic species as completed by USGS FORT utilizing the Software for Assisted Habitat Modeling

Species of interest

Ventenata

Choose your agency of interest, then select from the drop down:

✔ BLM Districts ✔ EPMT ✔ NPS ✔ U.S. Counties

Start typing the name of a management area

Display Occurrence Points?

yes

no

Download Data for Selected Species | Download All Available Data (756 Records)

Show 10 entries   Search:

This is a sample of summary information by National Parks with more species data to be added in the future. 'Known presence' indicates if presence locations from the park were available for model development. 'Established suitable area' is the number of acres suitable when suitability values between 0 and 1 were transformed to unsuitable and suitable categories by allowing 1% of the known locations to be classified as unsuitable. 'Percent of Park' is the percent of the park area that is classified as suitable. 'Minimum distance to Occurrence' is the minimum distance from the park boundary to a known occurrence used in model development. Boundaries generated from NPS IRMA (https://irma.nps.gov/DataStore/Reference/Profile/2224545?Inv=True)

Species	National Park	Estimated Suitable Area (Acres)	Percent of Park Area	Known Presence? (Count)	Minimum Distance to Occurrence (Miles)
Ventenata	Yellowstone National Park	303028	14%	0	123
Ventenata	Craters of the Moon National Preserve	180438	26%	0	78
Ventenata	Glacier National Park	174227	17%	0	70
Ventenata	Yosemite National Park	104302	14%	0	7
Ventenata	Bighorn Canyon National Recreation Area	61497	51%	0	45
Ventenata	Sequoia National Park	61233	15%	0	81
Ventenata	Grand Teton National Park	51134	16%	0	147
Ventenata	Lava Beds National Monument	41933	90%	0	10

Questions for you

- How might you use the tool for planning and in the field?
  - Established versus new invaders?
  - Regional versus local assessment?
- Who are key partners to involve in feedback?
- What are top priority tool features?
  - What should be downloadable? What format?
- Opportunity to suggest future priority species to add
- What would make you view this tool as a success?

http://bit.ly/inhabitdata

jarnevichc@usgs.gov

USGS

Science for Stewarding Resources into an Uncertain Future: Combining Scenario Planning & Simulation Modeling to Inform Resource Management

Brian W. Miller – U.S. Geological Survey & North Central Climate Adaptation Science Center
Amy Symstad – U.S. Geological Survey, Northern Prairie Wildlife Research Center
Gregor W. Schuurman – National Park Service, Climate Change Response Program

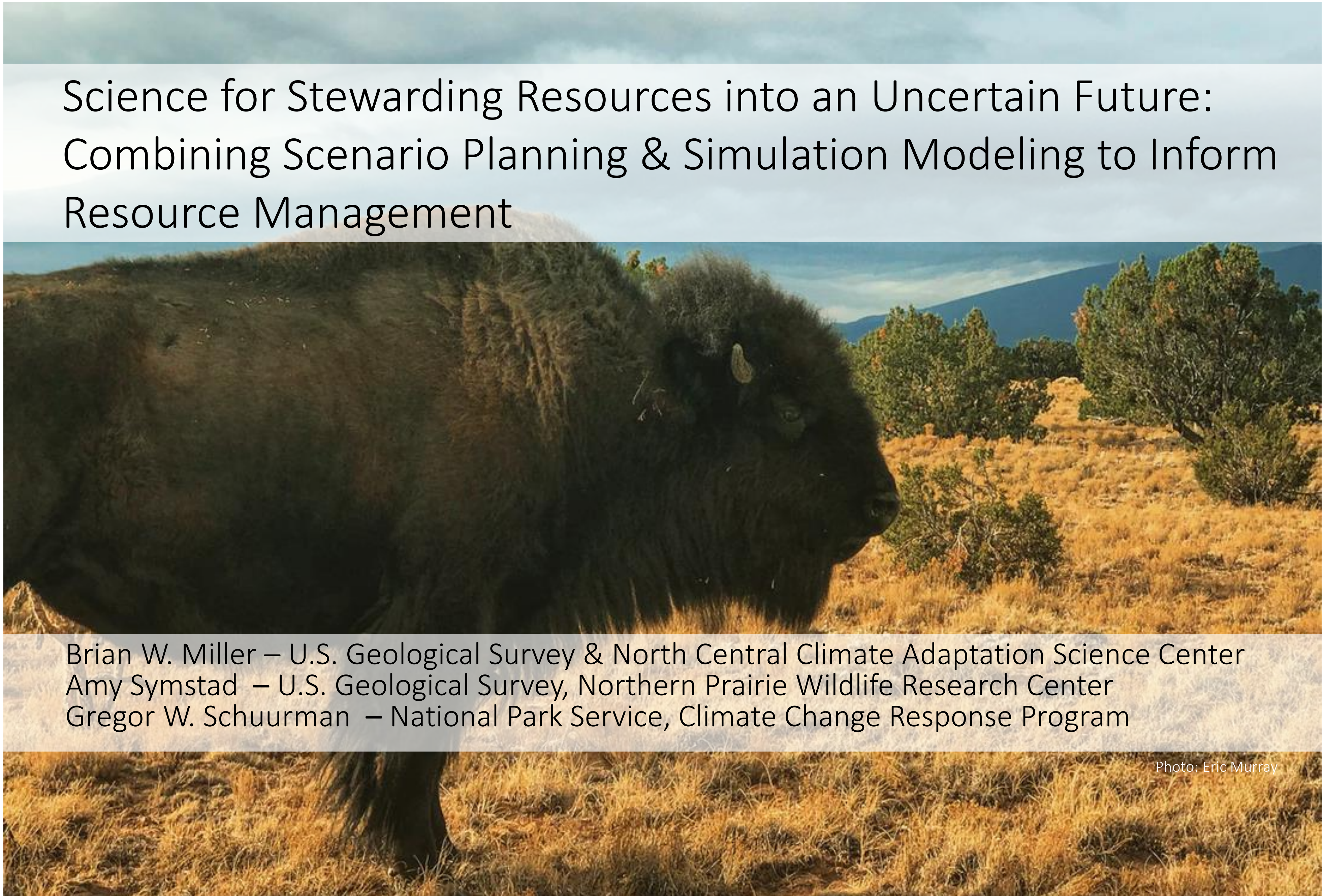


Photo: Eric Murray

Overview

- Climate Adaptation Science Centers (CASCs)
- Scenario planning
- Case study from southwest South Dakota
  - Scenario planning
  - Ecological modeling
- Closing thoughts on science & management

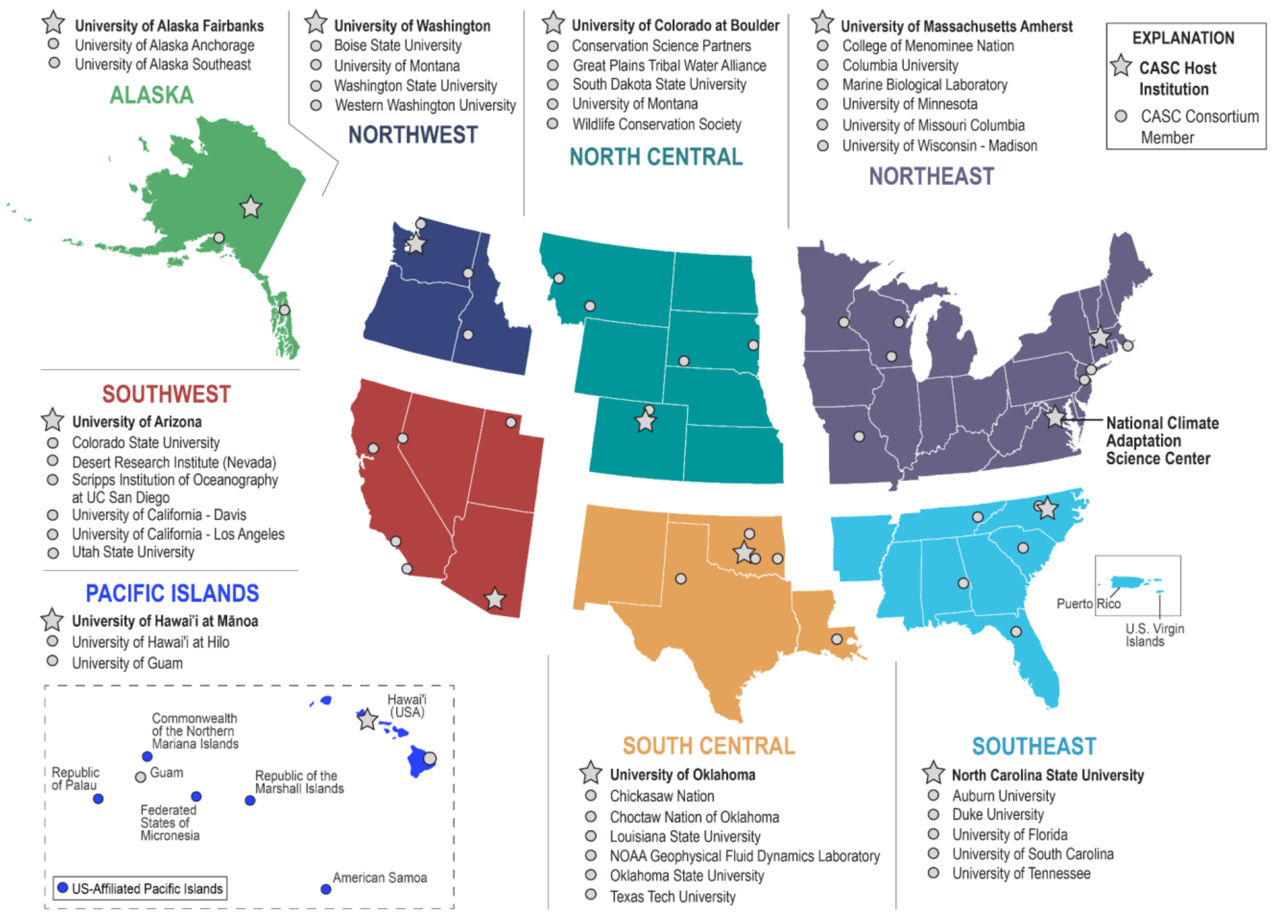
Introduction to CASCs

- Network comprised of eight Regional CASCs, managed by the National CASC located at USGS headquarters in Reston, VA.

- Mission: *deliver science to help fish, wildlife, water, land, and people adapt to a changing climate*

Climate Adaptation Science Center (CASC) Regions

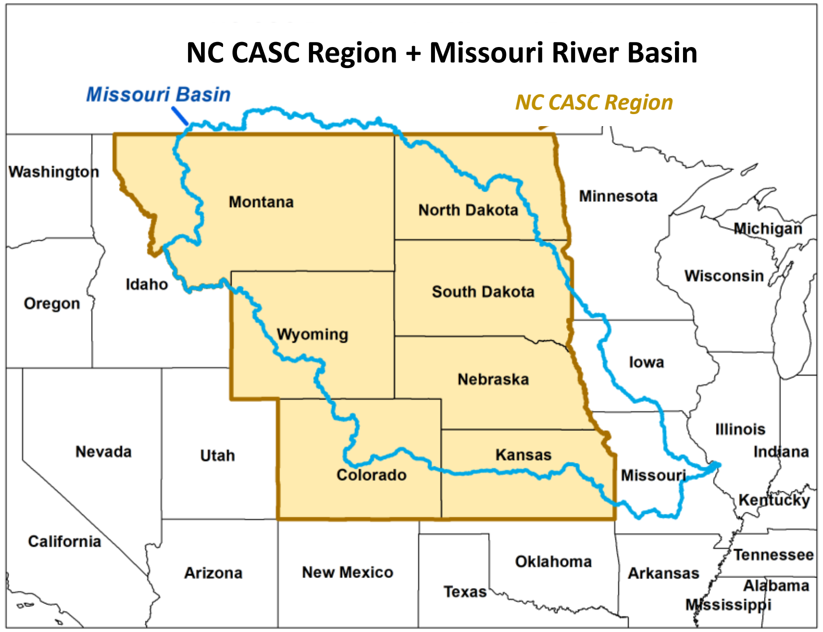
The CASCs collaborate across boundaries to address shared ecosystems, watersheds, and landscapes



Introduction to CASCs

North Central CASC

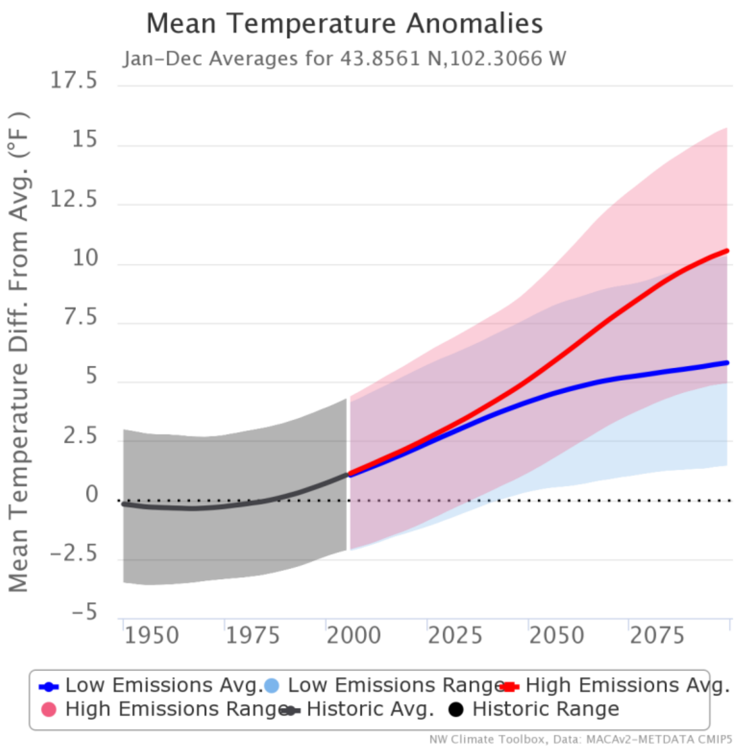
- Federal + university consortium
- Established 2011; relocated to CU-Boulder in 2018
- Small staff, deep bench
- State fish and game, DOI agencies, tribal nations
- “Actionable science”

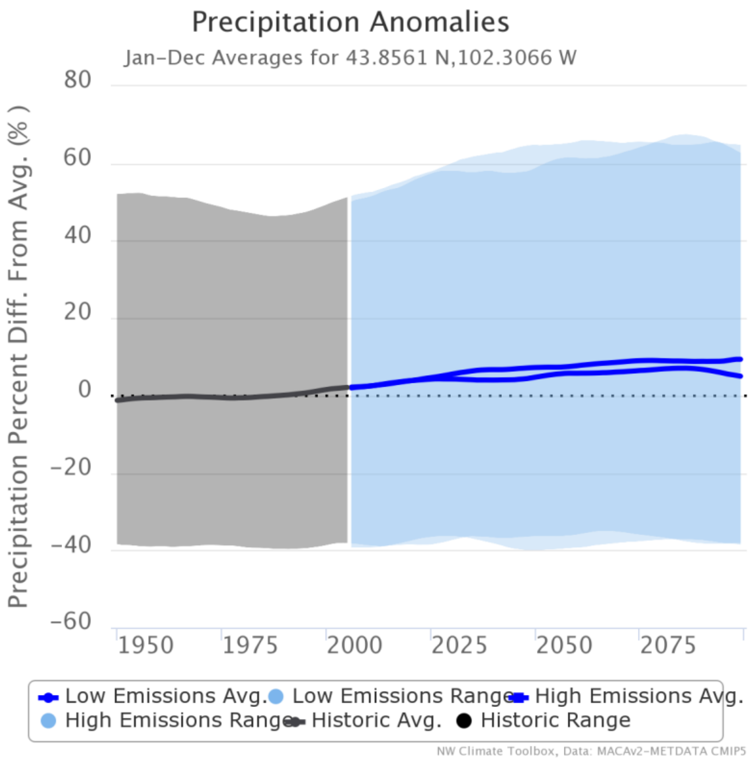


University of Colorado - Boulder

Conservation Science Partners
Great Plains Tribal Water Alliance
South Dakota State University
University of Montana
Wildlife Conservation Society

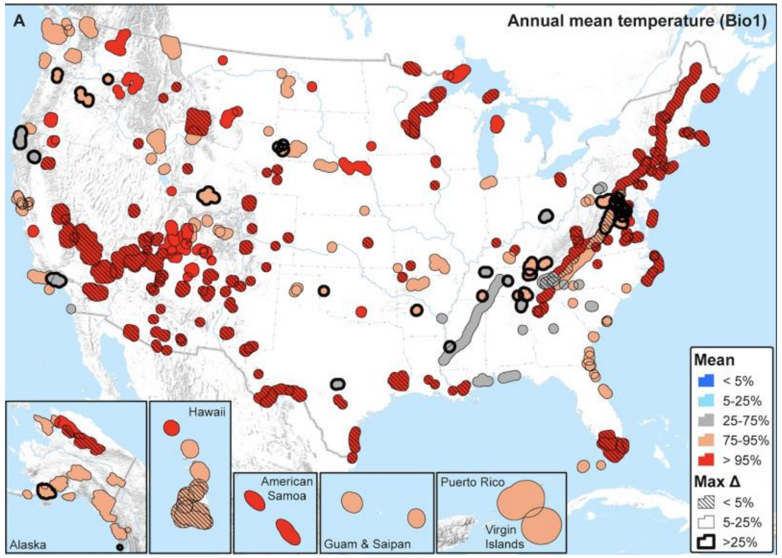
Scenario Planning





Scenario Planning

- Changes are already happening
- More changes are expected, with potentially dire consequences



<u>81% (235 of 289) National Parks already extreme warm</u>

(past 10-30 years warmer than 95% of historical range of conditions)

Monahan, W.B. and Fisichelli, N.A., 2014. Climate exposure of US national parks in a new era of change. PLoS One, 9(7), p.e101302.

Scenario Planning

Despite this uncertainty, resource managers need to make decisions and act to meet goals.

How can they know what to do?

"C'mon, c'mon—it's either one or the other."

Image: Gary Larson
http://allyduncan.blogspot.com/2009/09/daily-lol-far-side-damned-if-you-do.html

Scenario Planning

Scenario Planning

- Framework to support decisions under conditions that are uncertain & uncontrollable
- Scenarios offer a range of plausible futures – not predictions

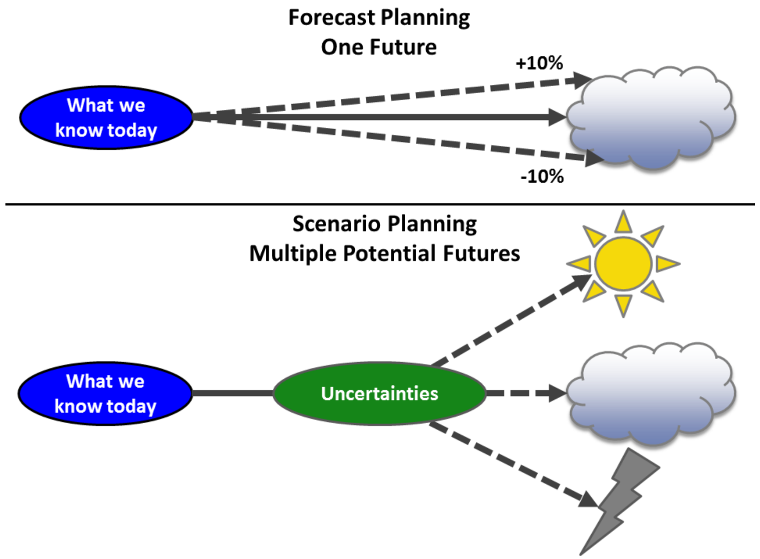


Image adapted from Global Business Network

"Scenarios are stories about the ways that the world might turn out tomorrow…that can help us recognize and adapt to changing aspects of our current environment."

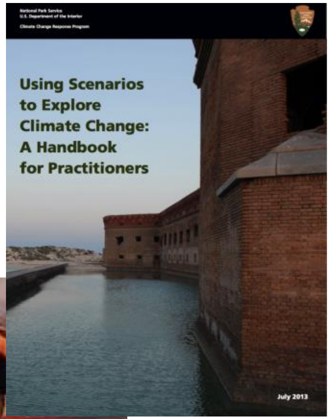
--Peter Schwartz (*The Art of the Long View*, p. 3)

Scenario Planning

- Has been applied in a variety of contexts, and in many forms

By Konstantin Von Wedelstaedt [GFDL 1.2]


By Sai Saketh [CC-BY-SA-4.0]



Images via Wikimedia Commons

Scenario Planning

There's increasing interest in using scenario planning for climate adaptation…

Scenario Planning

There's increasing interest in using scenario planning for climate adaptation…

BUT…

Scenario Planning

There's increasing interest in using scenario planning for climate adaptation…

BUT…

…managers often need or want quantitative info

Scenario Planning

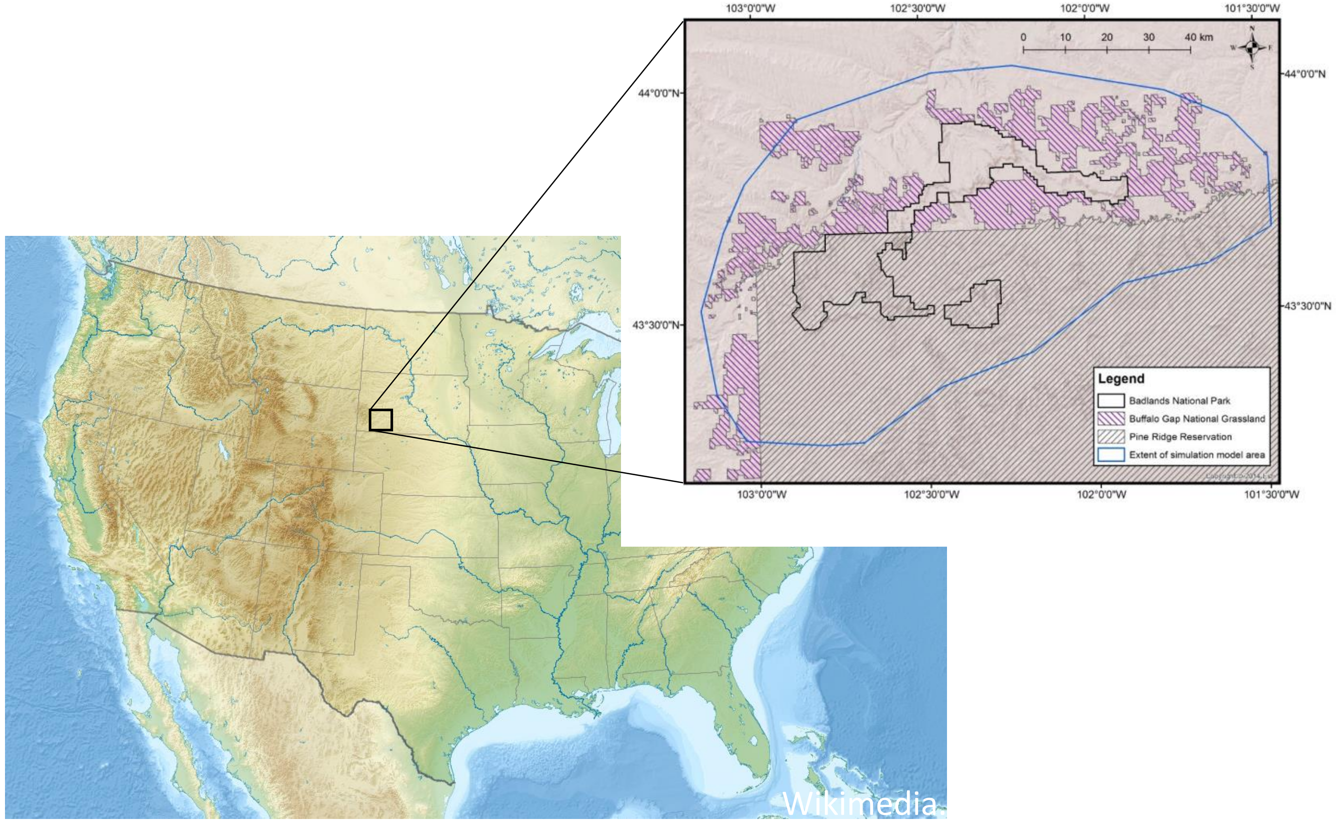
There's increasing interest in using scenario planning for climate adaptation…

BUT…

…managers often need or want quantitative info

…and there are complex interactions between system components, climate, and management

Case Study – Study Area



Case Study

Key Management Issues

- Grasslands & grazing
- Infrastructure
- Paleo & archaeological resources
- T&E Species



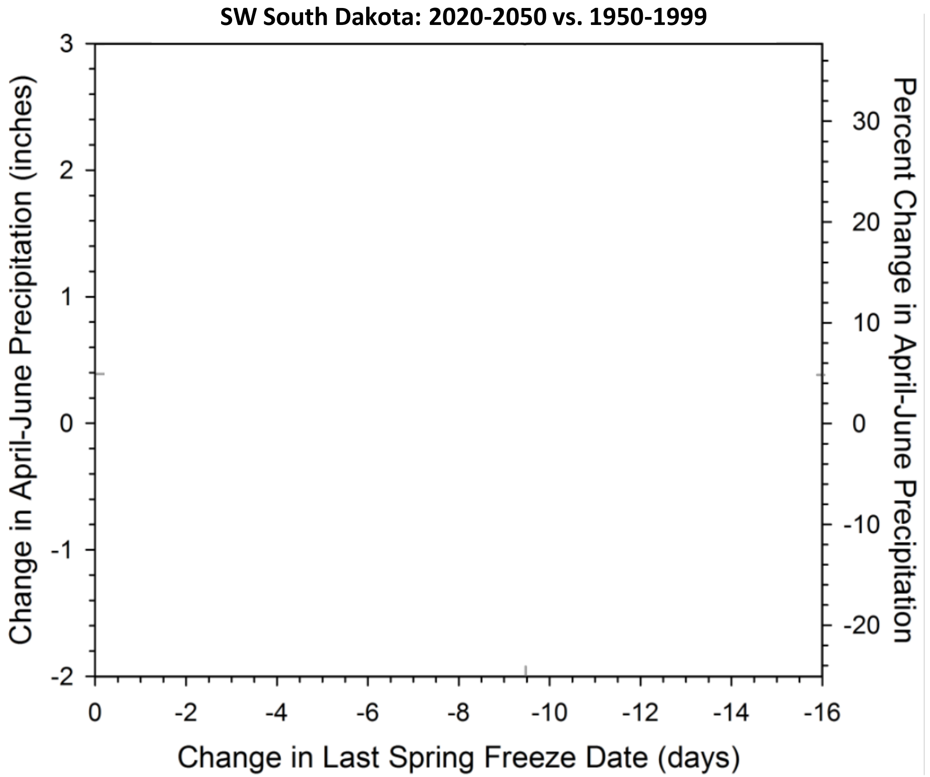



Case Study

Climate drivers for key resources

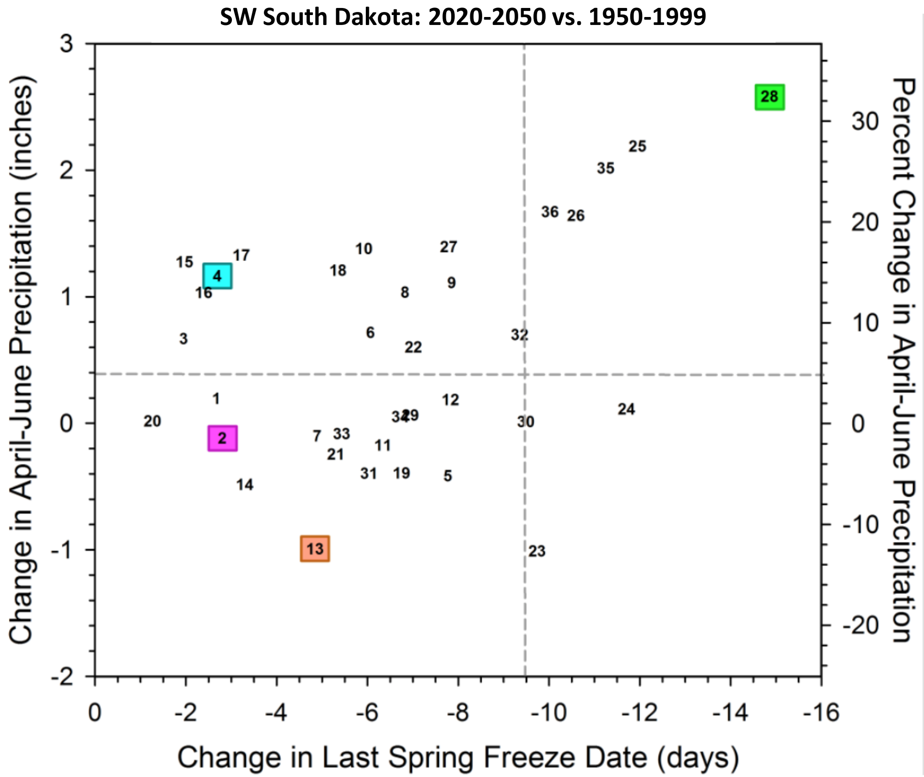
- Temperature
- Spring precipitation amounts
- Heavy precipitation events
- Growing season onset (last spring frost date) and length
- Soil moisture

Case Study



Fisichelli, N.A., Schuurman, G.W., Symstad, A., Ray, A., Miller, B., Cross, M., Rowland, E., 2016. Resource management and operations in southwest South Dakota: Climate change scenario planning workshop summary January 20-21, 2016, Rapid City, SD. Natural Resource Report. Report No. NPS/NRSS/NRR—2016/1289

Case Study



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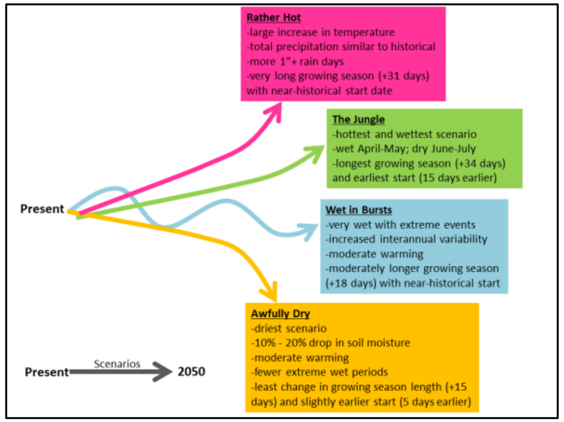
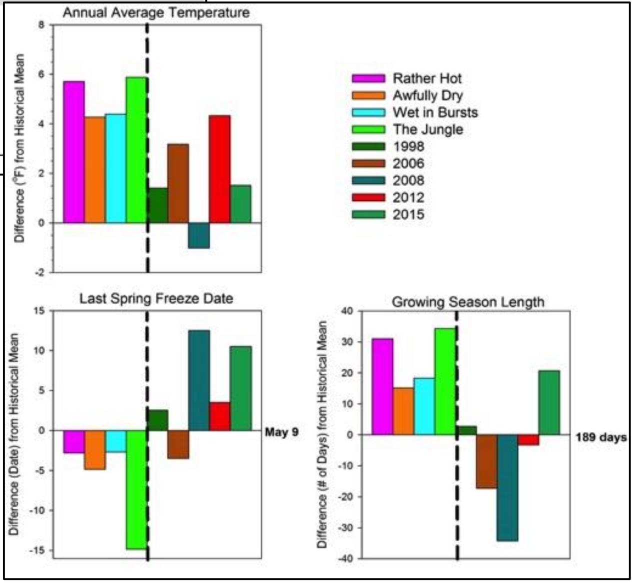
Driver	Rather Hot	Awfully Dry	Wet in Bursts	The Jungle
Annual temperature	+5.7 °F	+4.8 °F	+4.4 °F	+5.9 °F
Seasonal temperature	W: +7.2 °F Sp:+4.0 °F Su: +6.4 °F Fa:+5.2 °F	W: +3.9 °F Sp:+6.2 °F Su: +5.0 °F Fa:+4.2 °F	W: +5.3 °F Sp:+2.4 °F Su: +5.0 °F Fa:+4.8 °F	W: +6.7 °F Sp:+6.5 °F Su: +5.6 °F Fa:+4.7 °F
Growing season length	+31 days/yr	+15 days/yr	+18 days/yr	+34 days/year
Last freeze date	3 days earlier	5 days earlier	3 days earlier	15 days earlier
Annual precipitation	-0.4" (-2%)	-2.1" (-13%)	+2.2" (+13%)	+2.5" (+15%)
Seasonal precipitation	W: +0.5" (+41%) Sp:+0.7" (+13%) Su: -1.3" (-20%) Fa: -0.3" (-8%)	W: +0.2" (+21%) Sp: +0.1" (+1%) Su: -2.1" (-32%) Fa: -0.3" (-10%)	W: +0.1" (+10%) Sp: +1.2" (+21%) Su: +0.1" (+2%) Fa: +0.7" (+25%)	W: +0.3" (+31%) Sp: +2.9" (+51%) Su: -0.8" (-12%) Fa: +0.03" (+1%)
April-June precipitation	-0.1" (-2)%	-1.0" (-13)%	+1.2" (+15)%	+2.6" (+33%)
Frequency of days with >1" precipitation	+88%	-3%	+68%	+65%
Freq. of 5-day periods with >2.5" precipitation	-5%	-39%	+146%	+116%
Spring (Mar, Apr, May) soil moisture	+3%	-7%	+8%	[illegible]
Spring soil moisture (% of years > historical mean)	45%	19%	52%	[illegible]
Summer soil moisture (Jun, Jul, Aug)	-7%	-13%	+6%	[illegible]
Summer soil moisture (% of years > historical mean)	23%	10%	45%	[illegible]





Climate Driver	Rather Hot	Awfully Dry	Wet in Bursts	The Jungle
Temperature	↑	↑	↑	↑
Last spring freeze date	↔	↑	↔	↑
April-June precipitation	↔	↓	↑	↑
Spring-Summer soil moisture	↔	↓	↑	↑
One-day heavy rain events	↑	↔	↑	↑
Five-day heavy rain events	↔	↓	↑	↑

Case Study – Scenario Planning

- Effects to resources, facilities, and infrastructure
- Management responses

Photos: G. Schuurman

Case Study – Scenario Planning

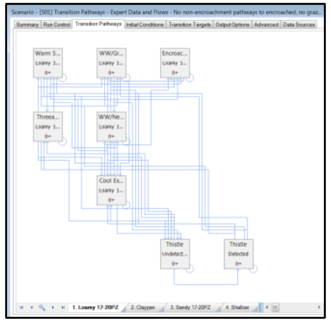
- Findings
  - Facilitated open-minded thinking about a set of divergent and challenging, yet relevant and plausible, climate scenarios and management alternatives for a wide range of resources

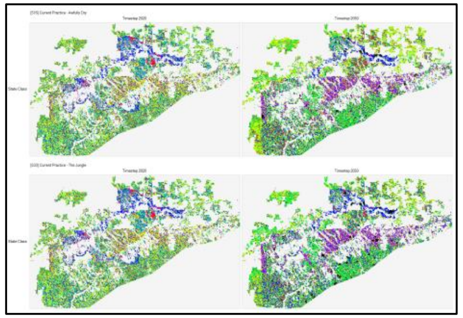
Case Study – Scenario Planning

- Findings
  - Facilitated open-minded thinking about a set of divergent and challenging, yet relevant and plausible, climate scenarios and management alternatives for a wide range of resources
  - Helped ensure that the most important variables and scenarios related to resource management were being addressed in simulation

Case Study – Ecological Modeling

- Track veg. biomass & composition, costs
- 4 climate futures
  - Rather Hot
  - Awfully Dry
  - Wet in Bursts
  - The Jungle





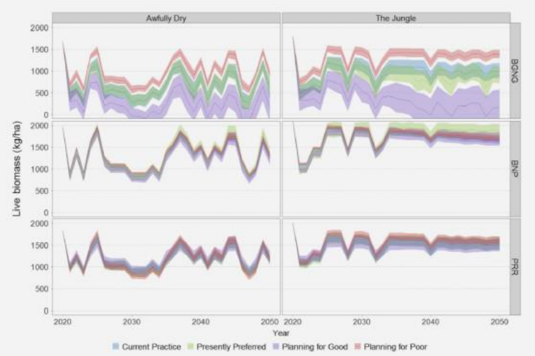
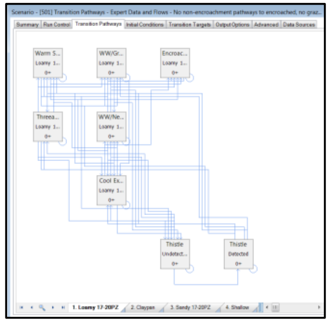


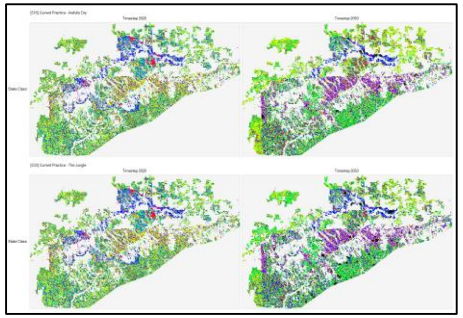
Fig. 5. Peak live biomass (kg/ha) for each management jurisdiction (rows) under two climate scenarios (Awfully Dry [left] and The Jungle [right]) and four management alternatives (colored lines). Lines represent the means of 100 Monte Carlo simulations, and shaded regions represent the 95th percentile range.

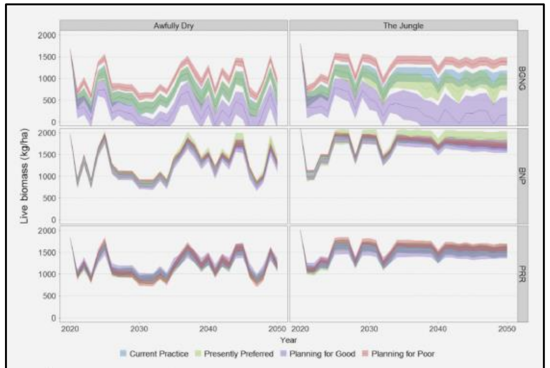
Miller, BW, AJ Symstad, L Frid, NA Fisichelli, GW Schuurman. 2017. Co-producing simulation models to inform resource management: a case study from southwest South Dakota. *Ecosphere* 8(12).

Case Study – Ecological Modeling

- Track veg. biomass & composition, costs
- 4 climate futures
  - Rather Hot
  - Awfully Dry
  - Wet in Bursts
  - The Jungle
- 4 management alternatives (vary grazing rates/seasons, Rx fire, invasive inventory & treatment) by jurisdiction
  - Current Practice
  - Presently Preferred
  - Planning for Good
  - Planning for Poor







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Case Study – Ecological Modeling

- Tradeoffs
  - More conservative livestock/bison management (i.e., lower densities of grazers) may provide buffer in forage for dry years, but more cool-season exotic grass

Case Study – Ecological Modeling

- Tradeoffs
  - More conservative livestock/bison management (i.e., lower densities of grazers) may provide buffer in forage for dry years, but more cool-season exotic grass
- Cost-effective solutions
  - Larger initial investment in eliminating Canada thistle could pay off
    - But without a cross-jurisdictional coordination, will be continued cost for treating thistle that spreads from adjacent public or private lands
  - Lower cost options for achieving similar results (woody encroachment)

Case Study – Conclusions

- Managers and scientists learned from “looking over the fence” at mgmt. strategies of each jurisdiction and how they play out under different climate scenarios

Case Study – Conclusions

- Managers and scientists learned from “looking over the fence” at mgmt. strategies of each jurisdiction and how they play out under different climate scenarios

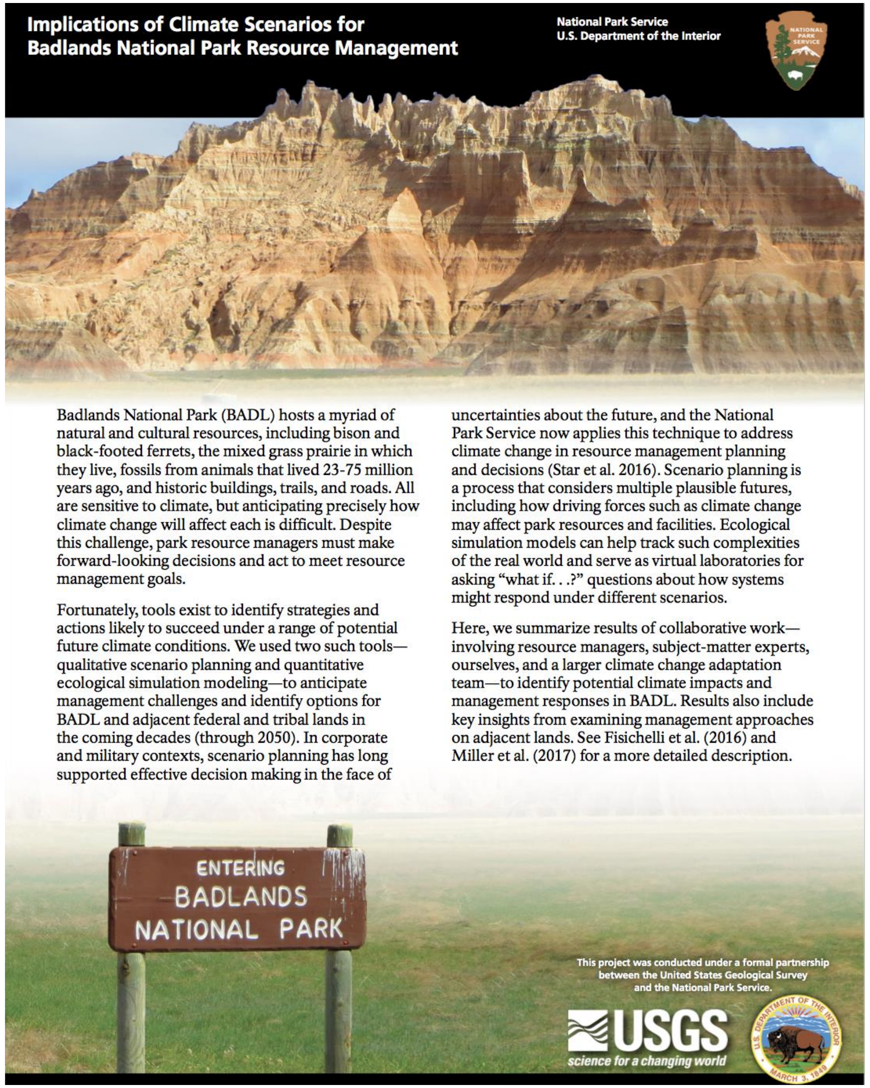
- Qualitative and quantitative approaches provided complementary information

Case Study – Conclusions

- Managers and scientists learned from “looking over the fence” at mgmt. strategies of each jurisdiction and how they play out under different climate scenarios

- Qualitative and quantitative approaches provided complementary information

- Combined approach led to discovery of counter-intuitive and surprising findings, and resulted in a more tractable set of possible futures to plan for



Implications of Climate Scenarios for Badlands National Park Resource Management

National Park Service
U.S. Department of the Interior

Badlands National Park (BADL) hosts a myriad of natural and cultural resources, including bison and black-footed ferrets, the mixed grass prairie in which they live, fossils from animals that lived 23-75 million years ago, and historic buildings, trails, and roads. All are sensitive to climate, but anticipating precisely how climate change will affect each is difficult. Despite this challenge, park resource managers must make forward-looking decisions and act to meet resource management goals.

Fortunately, tools exist to identify strategies and actions likely to succeed under a range of potential future climate conditions. We used two such tools—qualitative scenario planning and quantitative ecological simulation modeling—to anticipate management challenges and identify options for BADL and adjacent federal and tribal lands in the coming decades (through 2050). In corporate and military contexts, scenario planning has long supported effective decision making in the face of uncertainties about the future, and the National Park Service now applies this technique to address climate change in resource management planning and decisions (Star et al. 2016). Scenario planning is a process that considers multiple plausible futures, including how driving forces such as climate change may affect park resources and facilities. Ecological simulation models can help track such complexities of the real world and serve as virtual laboratories for asking “what if. . .?” questions about how systems might respond under different scenarios.

Here, we summarize results of collaborative work—involving resource managers, subject-matter experts, ourselves, and a larger climate change adaptation team—to identify potential climate impacts and management responses in BADL. Results also include key insights from examining management approaches on adjacent lands. See Fischelli et al. (2016) and Miller et al. (2017) for a more detailed description.

This project was conducted under a formal partnership between the United States Geological Survey and the National Park Service.

USGS
science for a changing world

NPS “Scenario Showcase”:
https://www.nps.gov/subjects/climatechange/scenarioplanning.htm

Badlands National Park provides the largest area for bison to range freely in the Great Plains. NPS Image by Brad Barker.

WHAT CLIMATE CONDITIONS MIGHT WE FACE?

Climate scientists use complex models to understand how Earth's climate works and, in turn, project climate trends into the future. Because our understanding of Earth's climate is incomplete, each model is unique in the way it represents the physical and biological forces that influence climate patterns. Consequently, each climate model produces a different—and plausible—view of future climates. For instance, models consistently project warming temperatures in the Northern Great Plains, but they differ as to whether precipitation will increase or decrease. Moreover, the magnitude of climatic changes also depends on societal decisions that affect the emissions of gases that influence climate—principally carbon dioxide and methane. Climate scientists have thus developed projections for multiple greenhouse gas emissions pathways. It is tempting to reduce the range of potential future conditions resulting from both different models and different emissions pathways to a single future—for example, an average of all the projections—but doing so puts managers at risk of planning for an outcome that doesn't materialize and failing to anticipate one that does. Potential consequences include mis-investment and lost opportunities. Scenario planning is highly appropriate in this situation.

Scenario planning and ecological simulation modeling for BADL began with selection of four climate projections from a set of 36. Each projection describes coherent, scientifically plausible climatic conditions for the coming decades (through 2050). We selected four projections relevant to major park resources and sufficiently divergent to bracket the range of potential future conditions, and thereby facilitate planning for the spectrum of possibilities and challenge conventional assumptions. Then, for each climate projection, we compiled information on how the aspects of climate most important to major park resources would differ from recent history. We summarized this information with graphs, tables, and narratives, then gave each climate future a memorable name (Table 1). We used these climate futures in qualitative scenario planning and quantitative ecological simulation modeling.

Table 1. Changes in key aspects of BADL climate through 2050 for four climate futures. Arrow size and direction denote trends compared to conditions of the recent past (1950-1999). Down arrows denote decreasing values or earlier dates, up arrows increasing values, and sideways arrows no change. Larger arrows indicate greater change.

Climate Feature	Rather Hot	Awfully Dry	Wet in Bursts	The Jungle
Temperature	↑ (large)	↑ (small)	↑ (small)	↑ (large)
Spring Precipitation	↔	↓ (large)	↑ (small)	↑ (large)
Start of Spring	↔	↓ (small)	↔	↓ (large)
Heavy Precipitation Events	↑ (large)	↔	↑ (small)	↑ (small)

Table 2. Resource implications, achievability of current goals, and potential management responses for four climate futures by mid-century, for five resources and management concerns. Conclusions for native vegetation are based largely on simulation modeling; for all other resources and concerns, they are based on qualitative scenario planning assessments, with some modifications or notes based on simulation modeling.

Resource or Concern	Current Goals	Rather Hot Impacts	Awfully Dry Impacts	Wet in Bursts Impacts	The Jungle Impacts	Achievability of Current Goals & Scenario-Dependent Responses	Additional Management Implications & Robust Responses
Native Vegetation 	• 30-60% of BADL vegetation in "historical climax plant community" (grassland with large component of grazing-sensitive species), 10-20% in each of late-intermediate and early-intermediate stages of succession, and 10% in early successional stage (composed largely of species highly tolerant of multiple disturbances)* • Exotic species comprise a small component	• Lowest vegetation production of all scenarios	• Lower vegetation production • Strongest expansion of shortgrass species of all scenarios	• Higher vegetation production • Tends toward greatest increase in Canada thistle of all scenarios	• Higher vegetation production • Tends toward greatest woody encroachment into grasslands of all scenarios under current management**	Regardless of future climate, current goals are not achievable with current actions. Increasing fire frequency from every ~100 years (the current frequency) to every 10 years, expanding bison grazing to the whole park, and an aggressive invasive species treatment program would bring the park closer to, but still not achieve, current goals by the year 2050. Higher grazing rates achieved through higher bison herd sizes, or directing bison grazing to certain locations through water developments, mineral licks, or prescribed fire, may be tools for achieving vegetation goals under all climate scenarios. However, grazing pressure as high as in adjacent national grasslands may be too high, especially in the drier scenarios.	• **No-gainer**: Continue the current combination of infrequent fire, conservative bison herd size, and insufficient weed inventory and treatment. • **No-regrets**: Develop a Vegetation Management Plan incorporating (1) park-determined vegetation goals; (2) increased prescribed fire frequency and extent; (3) increased invasive monitoring and treatment; (4) adoption of appropriate and vetted biocontrol methods as they become available; and (5) integration with bison and prairie dog management. • **No-brainer**: Continue vegetation monitoring by outside programs.
Bison 	• Maintain herd health, promote genetic diversity, protect vegetation, and work with Tribes and the Intertribal Buffalo Council to establish and maintain tribal herds for sustenance and cultural use	• Reduced forage and water	• Similar to Rather Hot, but also increase in wildlife disease with concentration around water sources	• Larger bison populations may be supportable • Increase in ticks and mosquitos and associated pathogens and diseases	• Similar to Wet in Bursts	Likely achievable for all climate futures, but may require new or modified actions that are dependent on the climate future: **Rather Hot** and **Awfully Dry**: • Stronger fencing and additional water sources to keep bison from escaping the park in search of water • Supplemental feeding (but simulation modeling suggests this would not be necessary) **Wet in Bursts** and **The Jungle**: • Round-up approaches relying on something other than water scarcity in autumn to attract bison • Enhanced monitoring for pathogens and diseases carried by ticks and mosquitoes	• **No-brainer**: Continue participating in the development of a regional bison management strategy that (1) includes best practices or guidelines for bison genetics, breeding, and culling strategies based on recent science and modern tools, and (2) ensures strong relationships with Tribes and the Intertribal Buffalo Council. • **No-regrets**: monitor for new diseases in bison and cattle on adjacent lands.
Black-Footed Ferret 	• Expand the area occupied by prairie dog (the ferret's primary prey)	• Dry conditions favor expansion of prairie dog towns because shorter vegetation reduces predation risk	• Similar implications as Rather Hot	• Increase in unsuitable habitat (taller vegetation and potentially greater woody encroachment)	• Similar implications as the Wet in Bursts scenario, but impacts may be more severe due to persistently wetter conditions	**Rather Hot** and **Awfully Dry**: current goal is likely achievable with current actions **Wet in Bursts**: may require more intensive grazing **The Jungle**: may require revision of overall goal from expanding to simply maintaining prairie dog area	• **No-brainer**: Continue to (1) monitor prairie dog and ferret population sizes and disease rates; and (2) research methods to immunize both against plague.
Archeological & Paleontological 	• Preservation and protection	• Exposure of resources to weather and looting due to greater erosion from extreme precipitation events and reduced vegetation cover	• Exposure of resources to weather and looting due to reduced vegetation cover	• Loss of some sites due to vegetation growth • Exposure of resources in other sites to weather and looting due to greater erosion from extreme precipitation events and flooding	• Similar implications as Wet in Bursts	**Awfully Dry**: achievable with current actions **Rather Hot** may require revised actions, including: • Increased salvage collection and the funds and personnel to do so • Additional cooperative agreements for storing additional specimens • Increased visitor education and outreach regarding fossil poaching • Enhanced modeling to identify potential sites **Wet in Bursts** and **The Jungle** may require revised goals, including: • Prioritize archeological sites for stabilization and data recovery • Target fossil rich areas for protection and preservation • Access to priority sites may need to be restricted	• **No-regrets**: Increase capacity for collecting and storing specimens.
Infrastructure & Geohazards 	• Maintain infrastructure safety and usability and minimize geohazards	• More erosion, flooding, mass wasting • Damage to road infrastructure	• Increased soil instability due to decreased vegetation	• Similar implications as Rather Hot, plus increased flood- and erosion-related geohazards	• Similar implications as Wet in Bursts	**Rather Hot**: in the long term, revised goals for usability of existing infrastructure are likely required. In the short term, the current goal may be achievable with revised actions: • Installation of additional culverts • Switching investment from contracts to park-owned equipment **Awfully Dry**: achievable with current actions **Wet in Bursts** and **The Jungle**: similar to Rather Hot, but may require new actions, including: • Updating current drainage systems • Re-aligning and re-engineering current roads, many of which have cultural resource status	• **No-regrets**: compare the cost-effectiveness of contracting infrastructure repair to purchasing equipment so that the park can implement repairs on its own.

*Badlands National Park does not have an established goal for vegetation composition. The goal listed here is an approximation of the current goal for the adjoining Buffalo Gap National Grassland, and it was used as the BADL vegetation goal in the qualitative scenario planning discussions.

**Workshop participants expected greater woody encroachment under this scenario, whereas the simulation model projected relatively stable or slightly decreased woody encroachment for all climate futures under current management practices.

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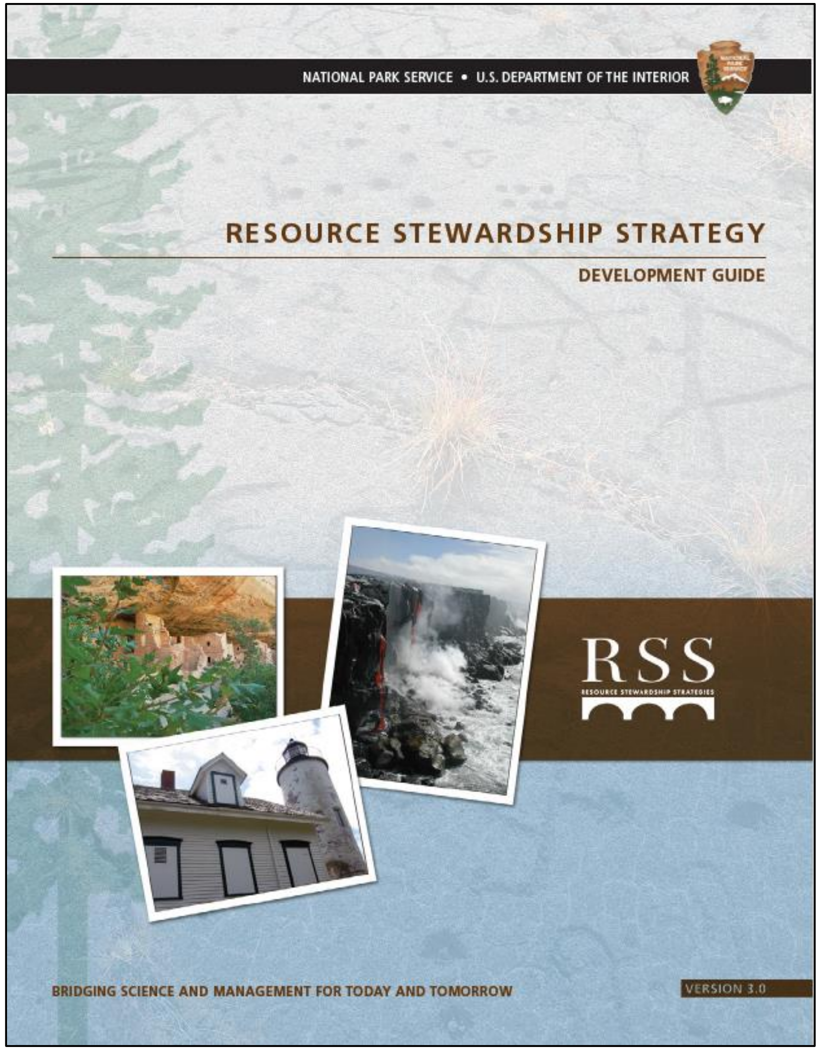
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RESOURCE STEWARDSHIP STRATEGY
DEVELOPMENT GUIDE
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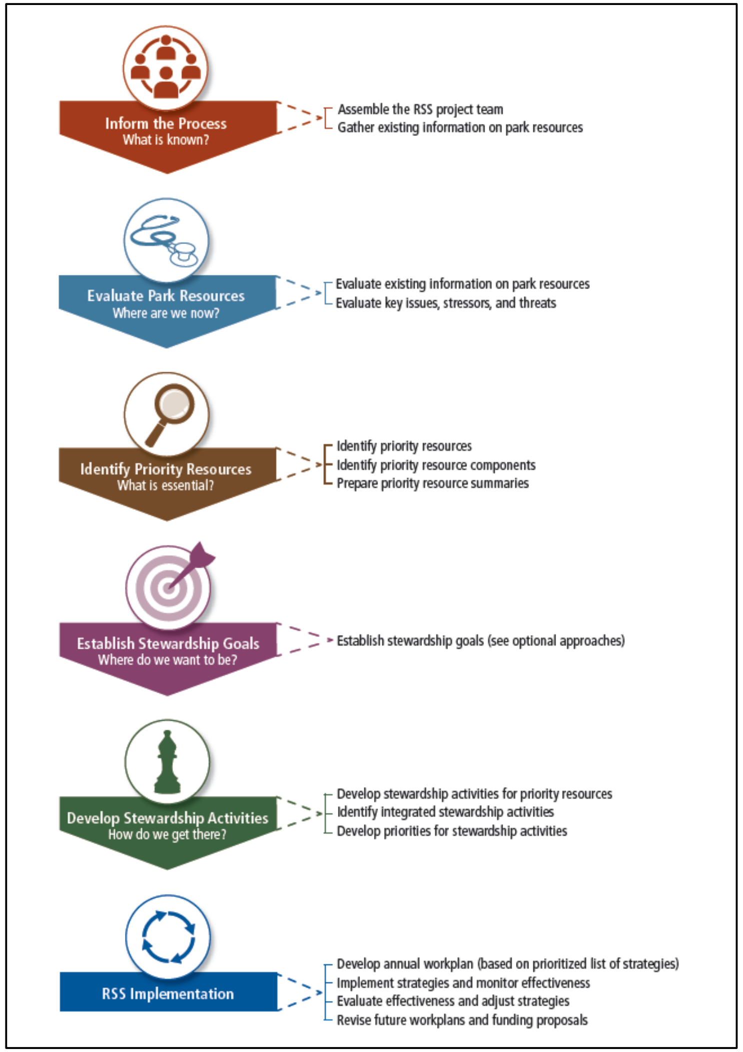
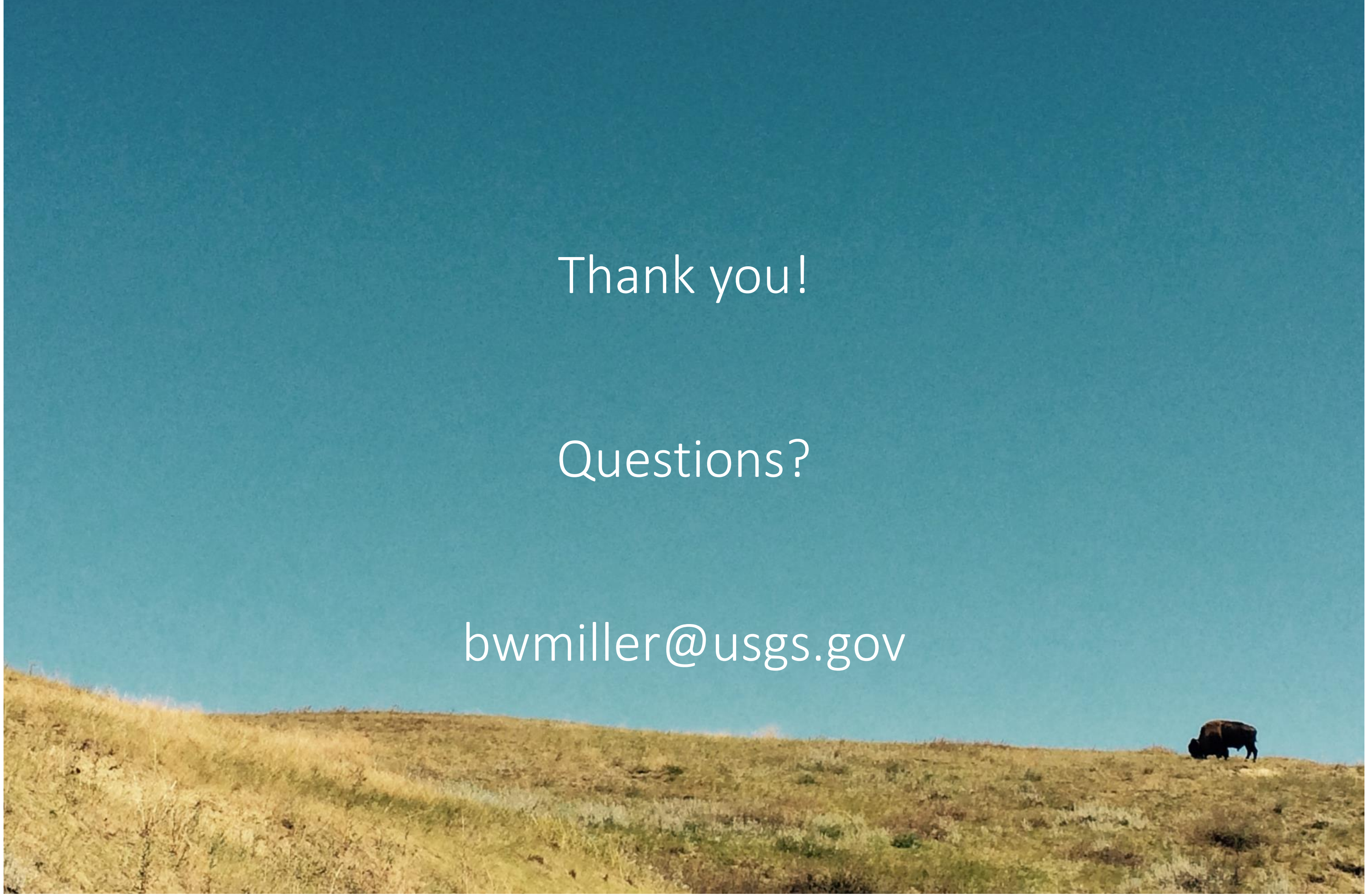
BRIDGING SCIENCE AND MANAGEMENT FOR TODAY AND TOMORROW
VERSION 3.0


Inform the Process
What is known?
Assemble the RSS project team
Gather existing information on park resources
Evaluate Park Resources
Where are we now?
Evaluate existing information on park resources
Evaluate key issues, stressors, and threats
Identify Priority Resources
What is essential?
Identify priority resources
Identify priority resource components
Prepare priority resource summaries
Establish Stewardship Goals
Where do we want to be?
Establish stewardship goals (see optional approaches)
Develop Stewardship Activities
How do we get there?
Develop stewardship activities for priority resources
Identify integrated stewardship activities
Develop priorities for stewardship activities
RSS Implementation
Develop annual workplan (based on prioritized list of strategies)
Implement strategies and monitor effectiveness
Evaluate effectiveness and adjust strategies
Revise future workplans and funding proposals

Closing Thoughts

- Start with management concerns
- Co-produce knowledge
- Link science to management decisions and processes
- Embrace uncertainty


Thank you!
Questions?
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BIOSECURITY AND INVASIVE SPECIES INITIATIVE

WESTERN GOVERNORS' ASSOCIATION

WEBINAR SERIES

WEDNESDAY, MAY 1, 2019

Species Distribution Modeling and Scenario Planning

MODERATOR:

- **Jeff Morisette**, Chief Scientist, National Invasive Species Council Secretariat

PANELISTS:

- **Terri Hogan**, Invasive Plant Program Manager, National Park Service
- **Catherine Jarnevich**, Ecologist, U.S. Geological Survey
- **Greg Haubrich**, Noxious Weed Coordinator, Washington Department of Agriculture
- **Brian Miller**, Research Ecologist, U.S. Geological Survey