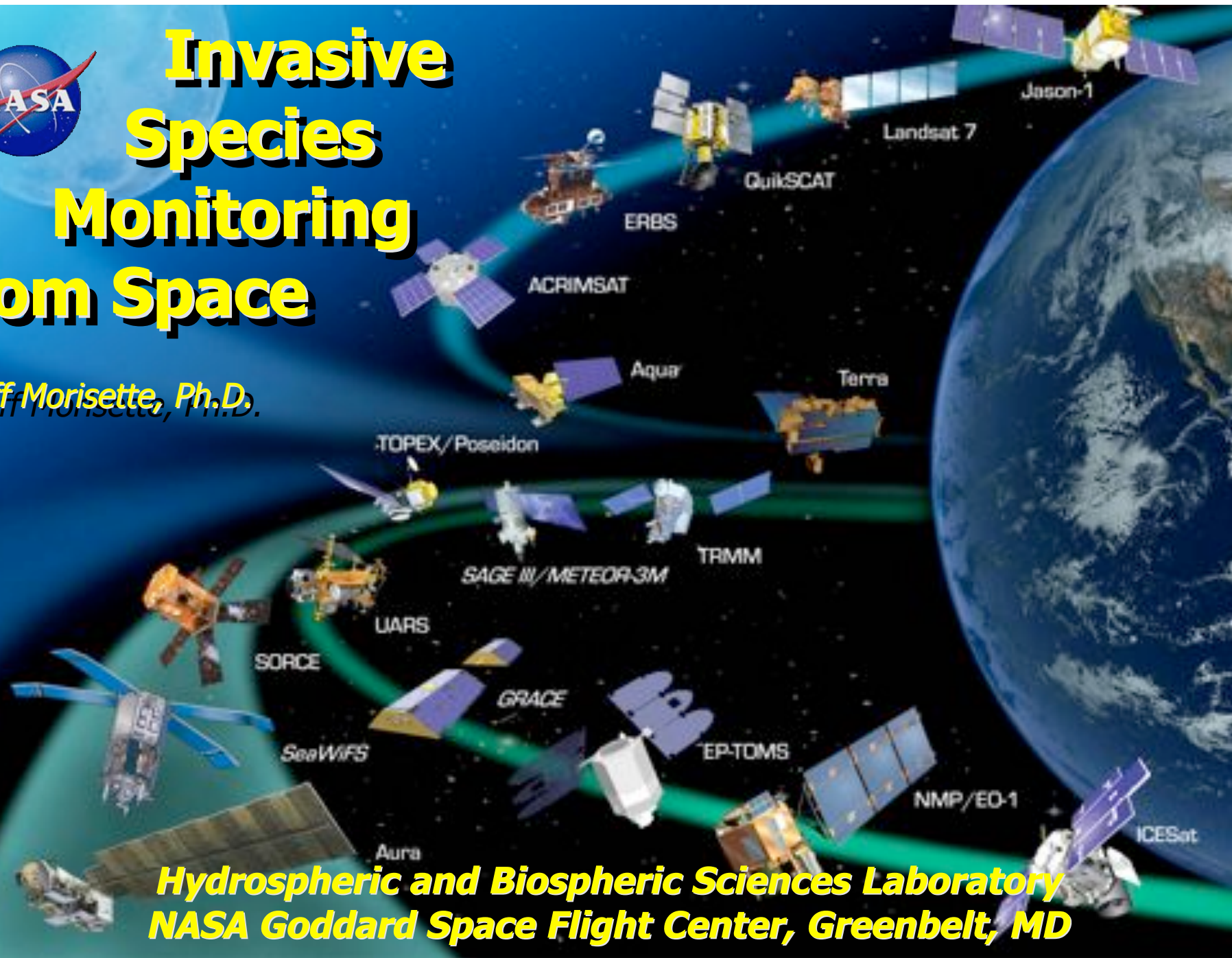


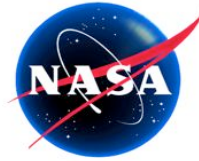


# Invasive Species Monitoring from Space

*Jeff Morisette, Ph.D.*



**Hydrospheric and Biospheric Sciences Laboratory  
NASA Goddard Space Flight Center, Greenbelt, MD**



---

# Weeding our National Garden

## NASA / USGS

### Invasive Species Project

Jeff Morisette<sup>1</sup>, Jeff Pedelty<sup>1</sup>, John Schnase<sup>1</sup>,  
Tom Stohlgren<sup>2</sup>, Catherine S. Jernevich<sup>2</sup>,  
Neal Most<sup>3</sup>, Asad Ullah<sup>4</sup>,  
Weijie Cai<sup>5</sup>, Jim Gentle<sup>5</sup>

<sup>1</sup>NASA Goddard Space Flight Center, Greenbelt, Maryland

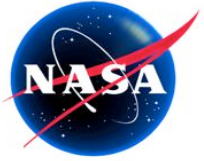
<sup>2</sup>National Institute of Invasive Species Science, USGS, Fort Collins Colorado

<sup>3</sup>Innovim, <sup>4</sup>Science Systems and Applications Inc.

<sup>5</sup>George Mason University

*Animations provided by NASA Goddard Space Flight Center  
Scientific Visualization Study*

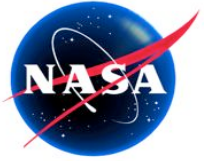
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# Outline

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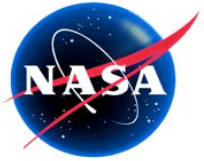
- What are invasive species and why do we care about them.
- National response
- NASA contribution
- Modeling species habitat
- Tamarisk Case study
- Future work



# Outline

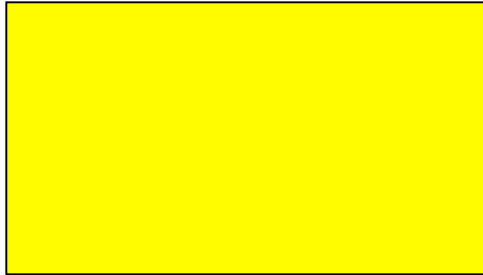
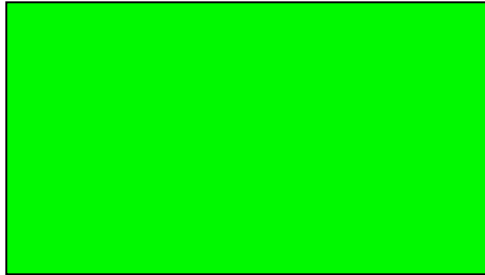

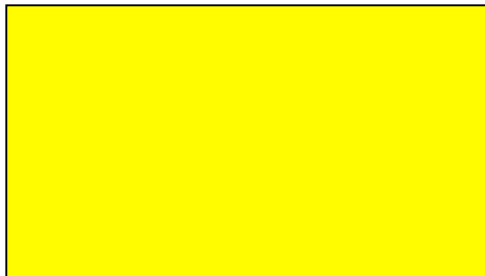
---

- What are invasive species and why do we care about them.
- National response
- NASA contribution
- Modeling species habitat
- Tamarisk Case study
- Future work



# Alien-invasive species

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	Invasive	Non-invasive
Native		
Non-Native		

Magic City Morning Star: "Invasive Species" is Junk Science

http://magic-city-news.com/article\_4371.shtml

Google



**Magic City Morning Star**  
 146 Katahdin Avenue  
 Millinocket, ME 04462  
 207.723.4456

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**OPINION**

**"Invasive Species" is Junk Science**

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By Julie Kay Smithson  
 Aug 7, 2005, 08:35

"Invasive Species" is Junk Science. That's right, and I can prove it.

"Invasive Species" can be almost any plant or animal -- deemed "native" or "non native" -- that "invades" a place it is not welcome. The newly sprouting layer of bureaucracy, regulation, and government graft stems, not from a desire to curb "invasives," but from what is seen as a golden opportunity to tap into many more taxpayer dollars, while further regulating taxpayers and draining property rights.

How can this be, you ask? The media is screaming about "invasive species" from every corner, as though it were a foreign army landing

**OPINION Latest Headlines**

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- [The People's Revolt](#)
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## Firewood Advisory

### Attention! Invasive Beetles found in Firewood Threaten Forests

Before bringing firewood to a Pennsylvania State Park, please read the information below about a very real threat to forests in Pennsylvania and all of North America.

Firewood may contain non-native insects and plant diseases. Bringing firewood into the park from other areas may accidentally spread pest insects and diseases that threaten park resources and the health of our forests. Management of trees infected with these pests involves drastic measures, such as the complete removal of all trees (infested and otherwise) in the immediate and surrounding areas.

The Asian Long Horned Beetle and Emerald Ash Borer are two insects that can be easily spread in firewood. Although the adult beetle may not be present, the firewood may be infested with the immature stage of these insects.

Movement of any/all firewood from infested and/or quarantine areas is prohibited in accordance with the Pennsylvania Plant Pest Act of 1992. All such regulated firewood will be confiscated and destroyed. First time offenders will be issued a warning letter by Pennsylvania Department of Agriculture, with repeat offenders subject to prosecution according to provisions in the Pennsylvania Plant Pest Act. Even if you are not within a quarantine area using local firewood is best. Do not take wood home with you and do not leave firewood - Burn It!

Emerald Ash Borer Beetle Quarantine exists in portions of Michigan, Indiana, and Ohio. For further information go to: [www.sphas.usda.gov/ppq/ep/eab/quarantine.html](http://www.sphas.usda.gov/ppq/ep/eab/quarantine.html)

Invasive Removal this Sunday at Little Paint Branch Park

To protect your privacy, some pictures in this message were not downloaded. [Download pictures](#)

From: The Anacostia Watershed Society <[info@anacostiaws.org](mailto:info@anacostiaws.org)>  
Reply-To: [info@anacostiaws.org](mailto:info@anacostiaws.org)  
Date: Tuesday, September 13, 2005 8:53 AM  
To: [jeff.morisette@gsfc.nasa.gov](mailto:jeff.morisette@gsfc.nasa.gov)  
Subject: Invasive Removal this Sunday at Little Paint Branch Park

## SUNDAY INVASIVE REMOVAL

### Join AWS for an Invasive Plant Removal at Little Paint Branch Park

Beltsville, MD September 18th 10:00am - 3:00pm

There will be a sign-in and safety orientation. Gloves and tools are provided. Our objective is to remove the invasives to allow natives to grow back.

#### DIRECTIONS

Take U.S. 1 North from the beltway. Go about 1 mile, passing the National Agricultural Research Center and turn left at the light on Montgomery Rd. Go 3 blocks and turn left on Sellman Road. Go about 5 blocks and turn right into Little Paint Branch Park at the bottom of the hill.

and

Join us in Magruder Park on September 24th from 9am - 12pm for National Public Lands Day.

Help restore America's public lands by participating in the 12th annual National Public Lands Day - a nationwide hands-on restoration event!

Register to volunteer with the Hyattsville Office of Volunteer Services. For more information contact Volunteer Coordinator Colleen Ahtis at 301.985.5057 or at [cahtis@hyattsville.org](mailto:cahtis@hyattsville.org). The City will supply tools and volunteers should dress for the elements.





**Environmental Costs...**

**Agricultural Costs...**

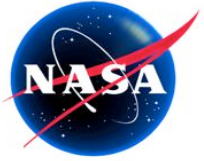
**Human-Health Costs...**

# **invasive Species**

**... plus connections to  
fire activity and climate change**

“Update on the environmental and economic costs associated  
with alien-invasive species in the United States”

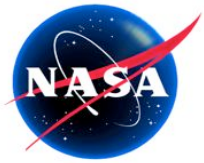
David Pimentel\*, Rodolfo Zuniga, Doug Morrison,  
in *Ecological Economics*



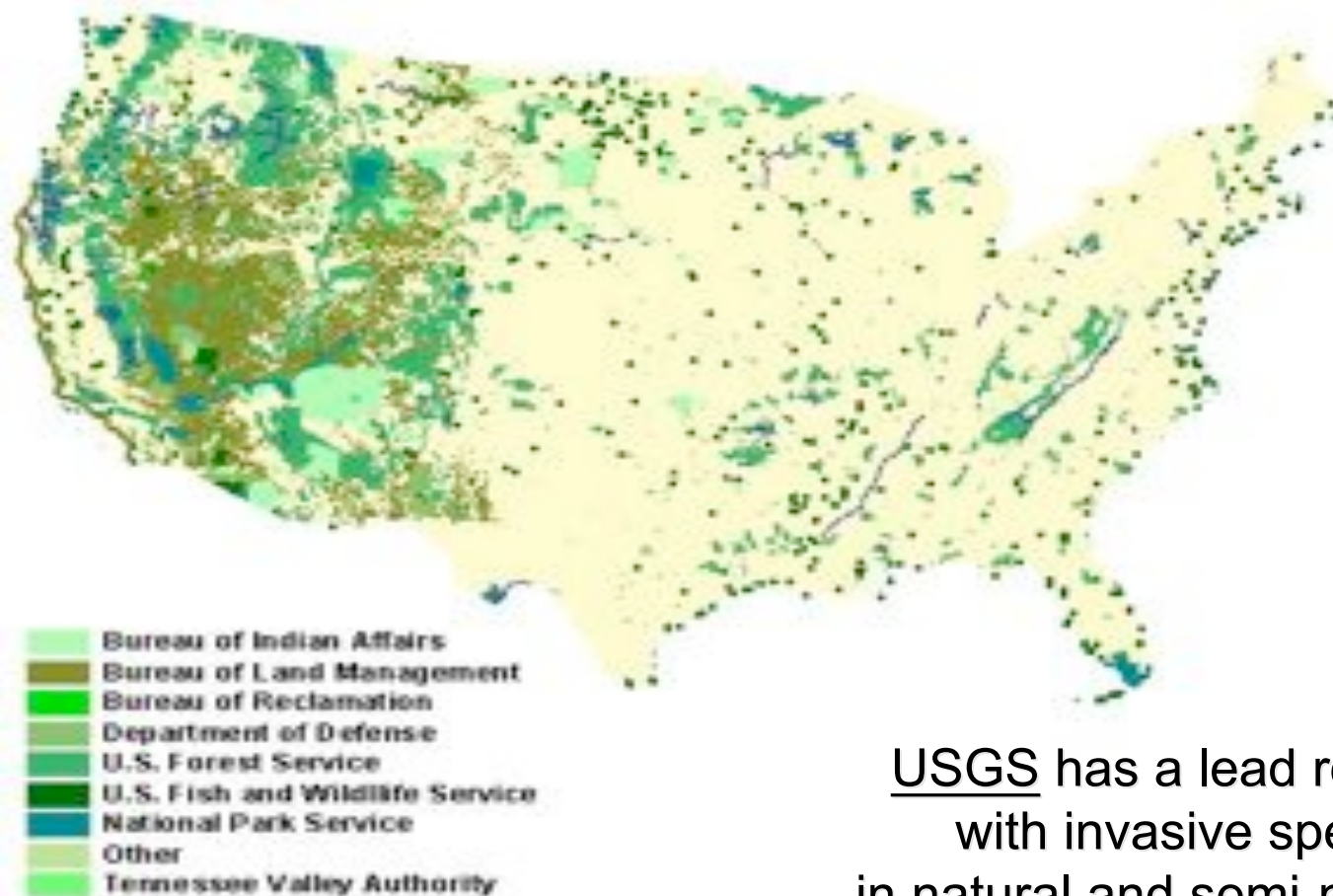
# Outline

---

- What are invasive species and why do we care about them.
- **National response**
- NASA contribution
- Modeling species habitat
- Tamarisk Case study
- Future work



# National Response: National Invasive Species Council



USGS has a lead role in dealing with invasive species science in natural and semi-natural areas.



# NEWS

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## U.S. Department of the Interior

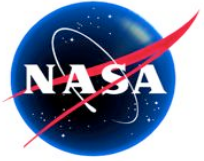
Office of the Secretary  
For Immediate Release: May 13, 2005  
National Council Promotes Strategies for War  
on Invasive Plants, Animals, Pathogens

Secretary Norton Commends Council's Team Tamarisk Initiative

WASHINGTON - Secretary of the Interior Gale Norton today urged leaders of a cabinet-level council to increase their war-planning against an invasion of plant and animal species that costs the nation more than \$120 billion annually in ecological and economic damage.

"No single agency, no one department can do it alone"

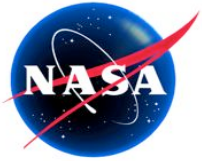
"The potential invaders are many. Their potential impacts are vast. By working together we can continue to win the small victories that mean much in the larger war."



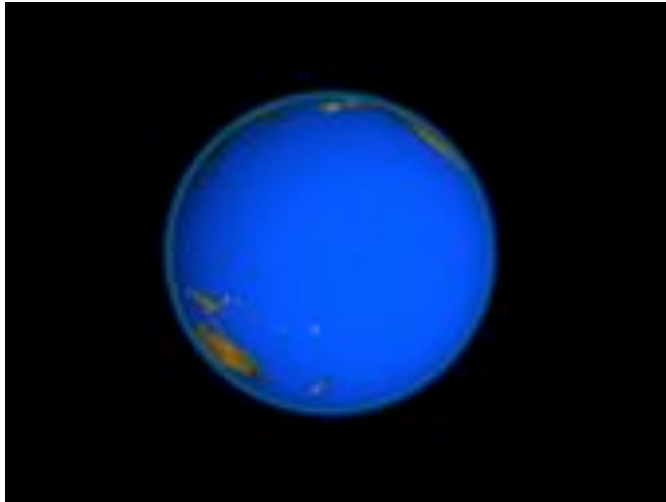
# Outline

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# NASA's Response

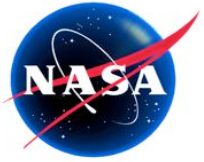


## NASA / USGS “Invasive Species Forecasting System”

NASA brings expertise on:

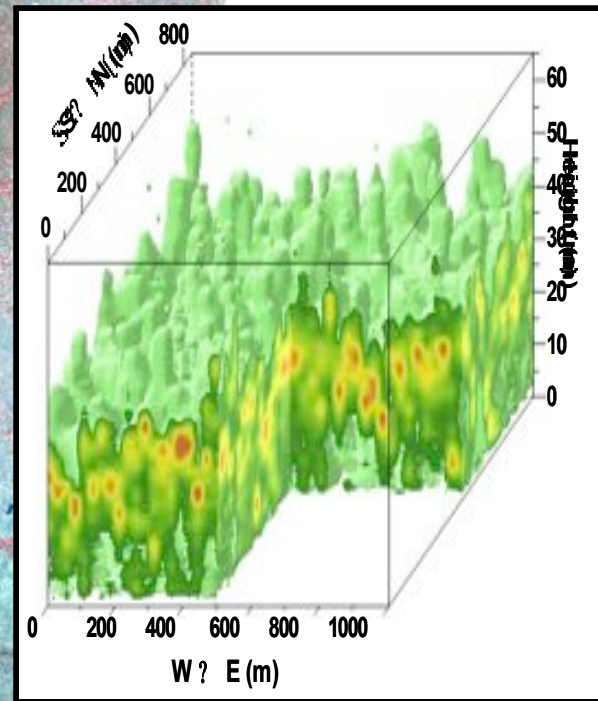
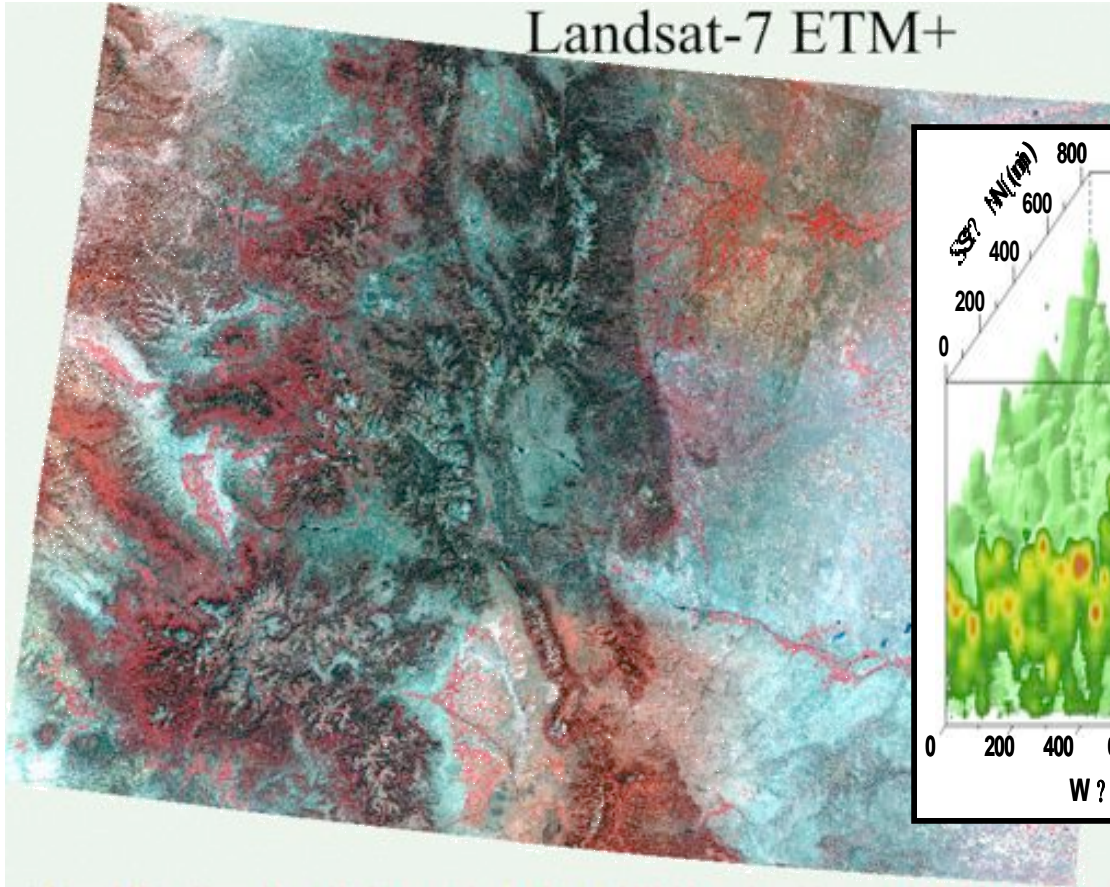
- satellite data and derived products
- computation technologies
- modeling





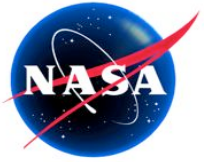
# Input data: Vegetation signal

Landsat-7 ETM+

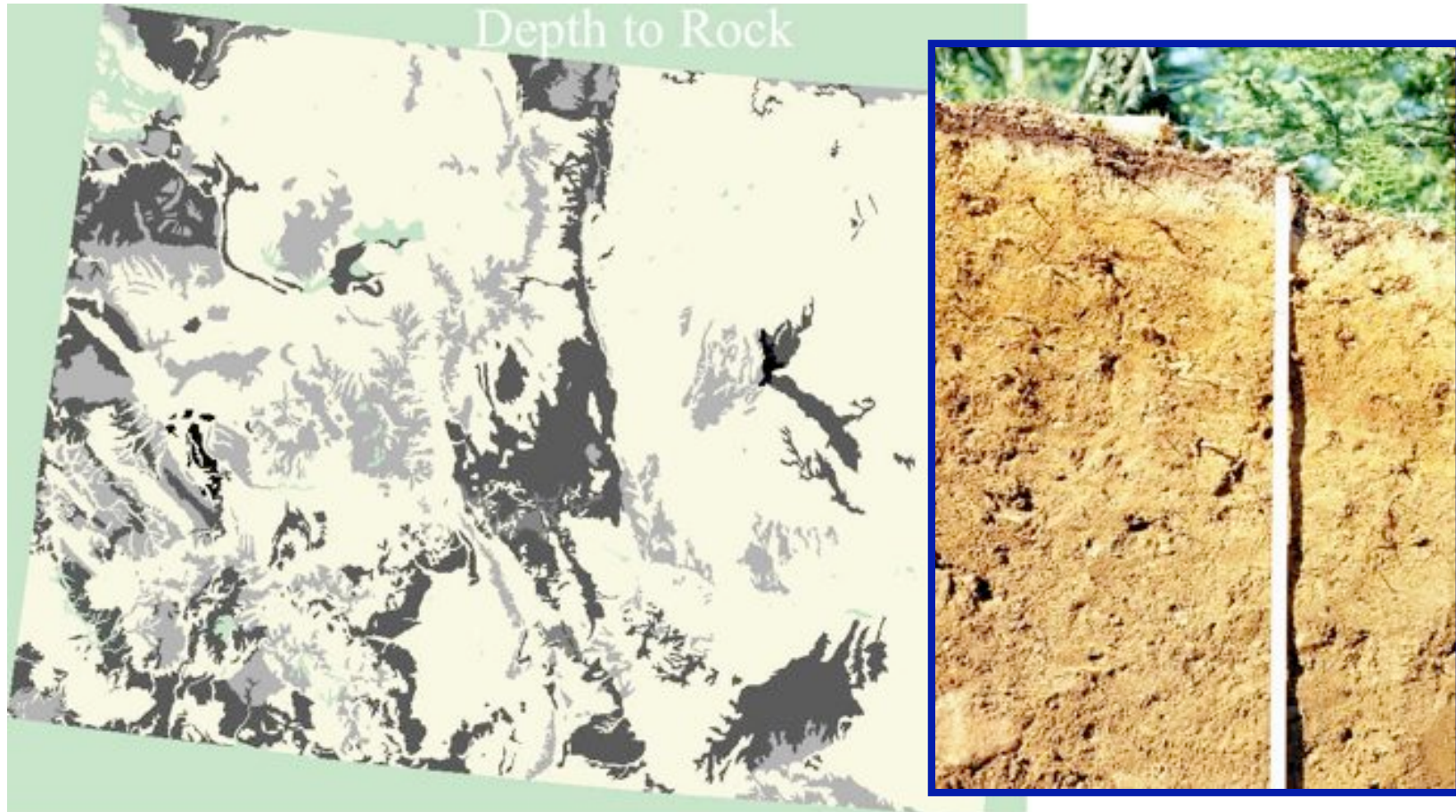


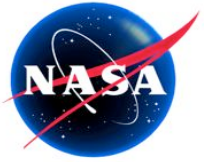
LIDAR





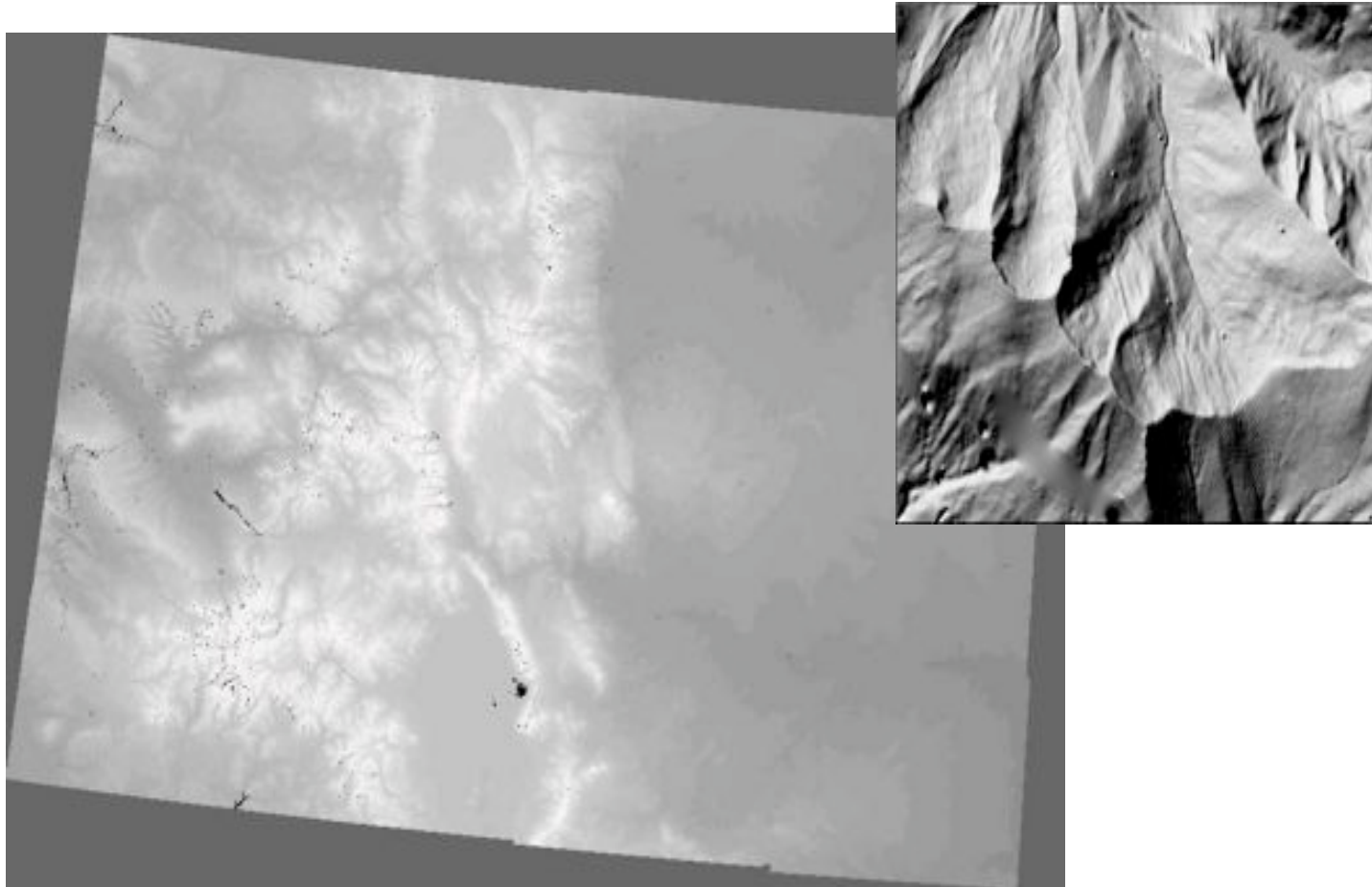
# Input data: Soil properties

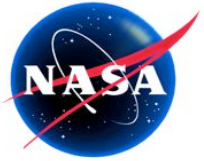




# Input data: Elevation, slope and aspect

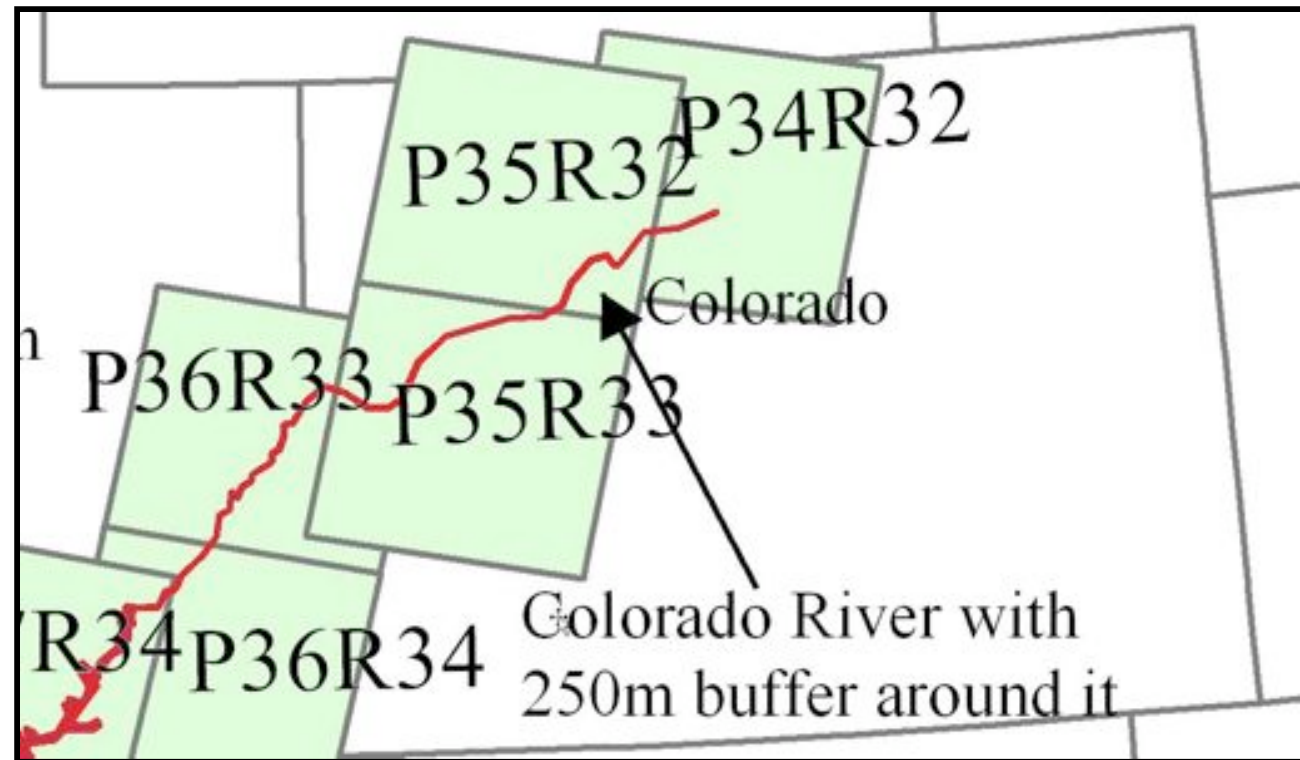
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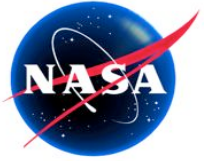




## Input data: Distance to...

- Streams
- Roads

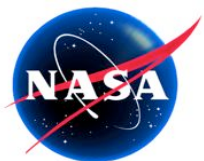




# Outline

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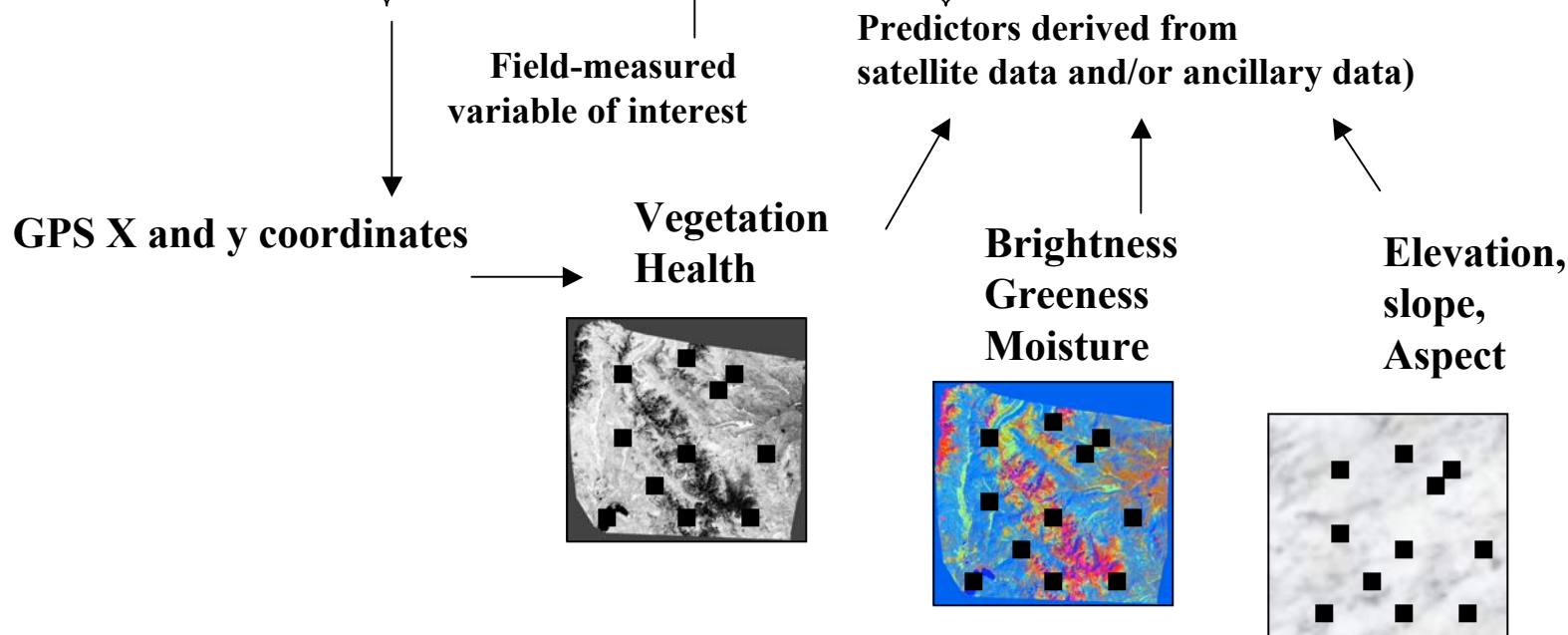
- What are invasive species and why do we care about them.
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- **Modeling species habitat**
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- Future work

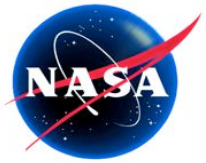


# Base-line Statistical Modeling Array

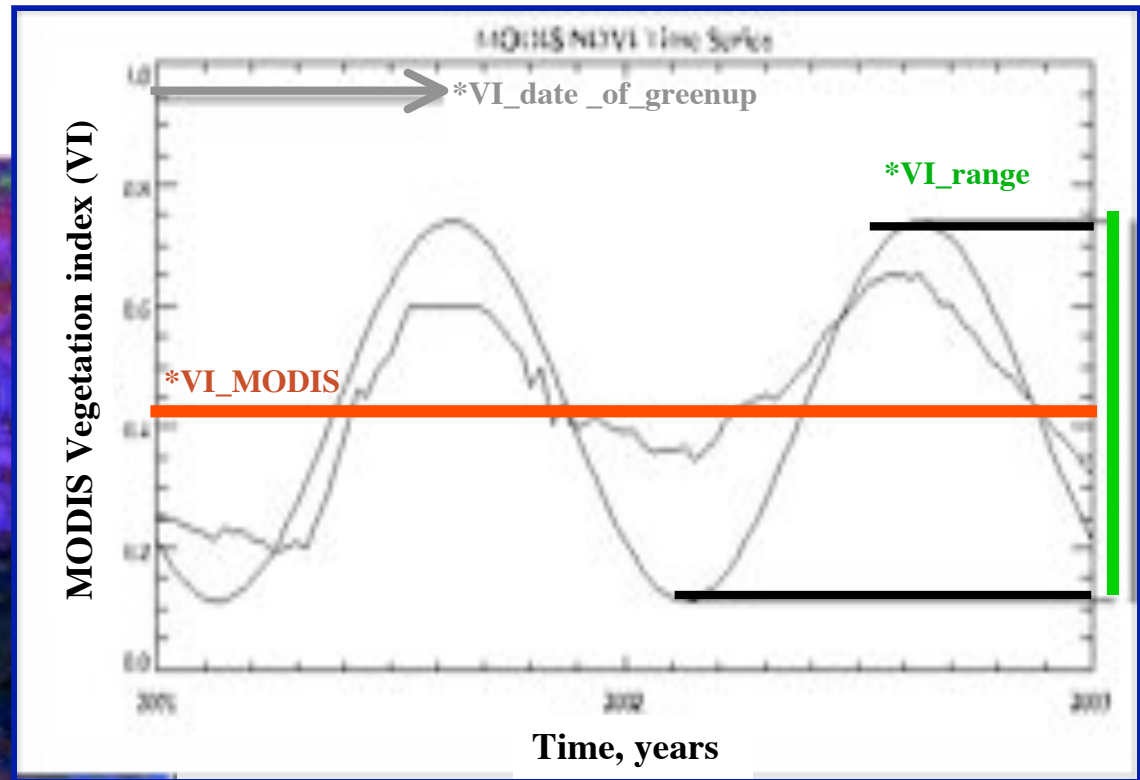
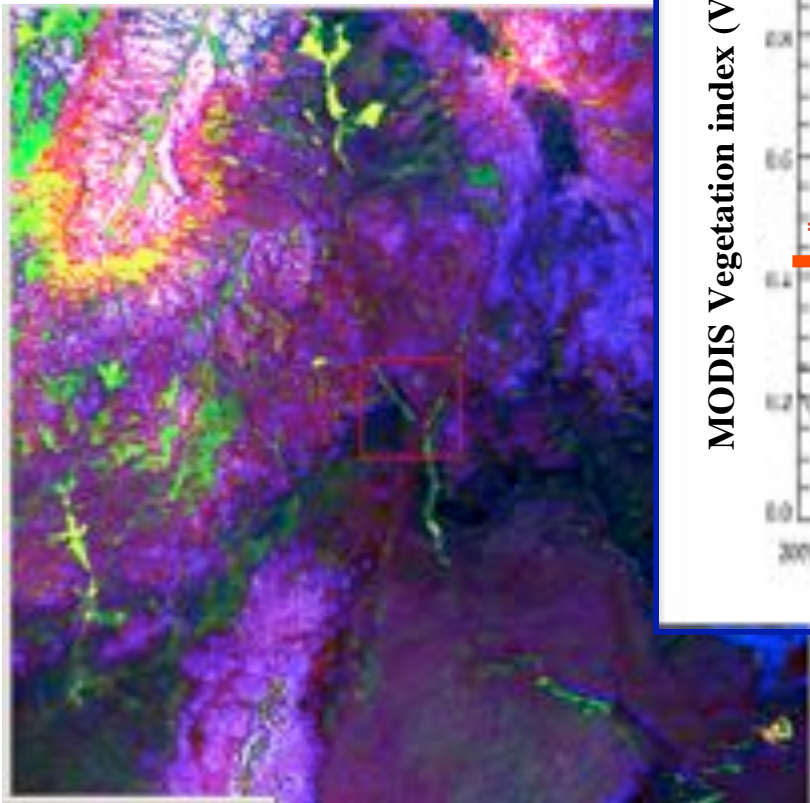
**Example  
Existing Model Array:**

Lat	lon	response	Predictor 1	...	Predictor N
$X_1$	$Y_1$	$R_1$	$X_{11}$	...	$X_{n1}$
$X_2$	$Y_2$	$R_2$	$X_{12}$	...	$X_{n2}$
...	...	...	...	...	...

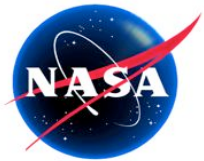




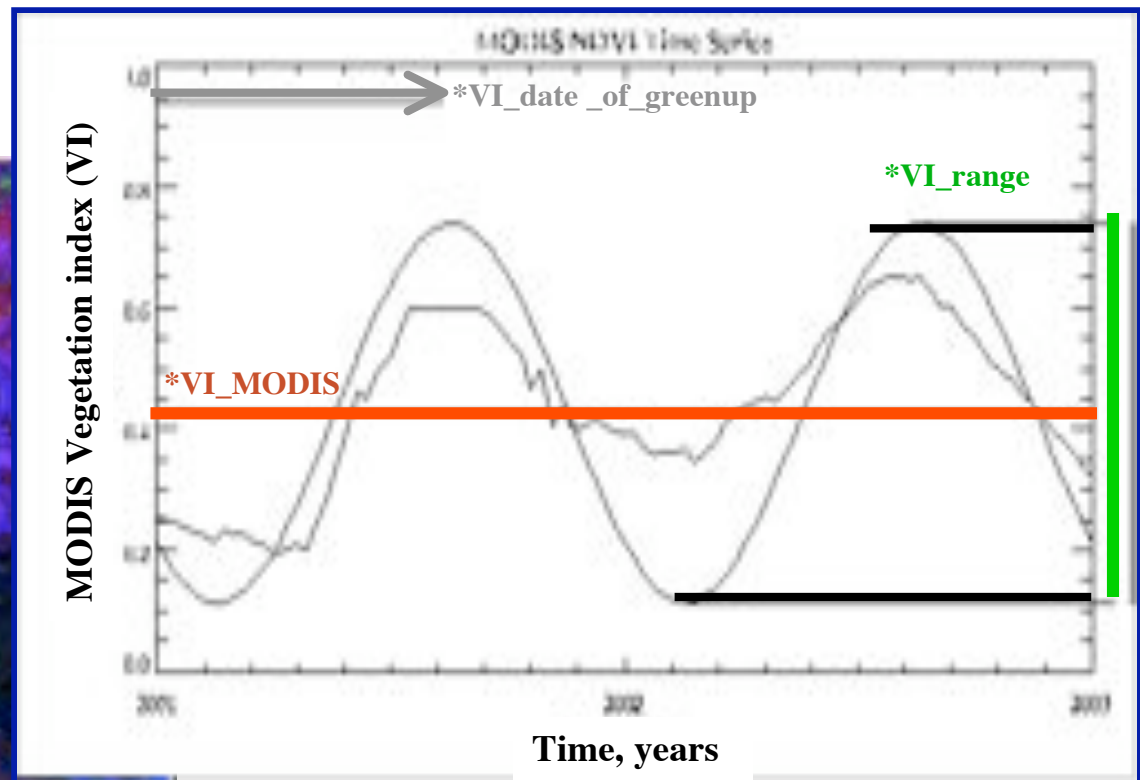
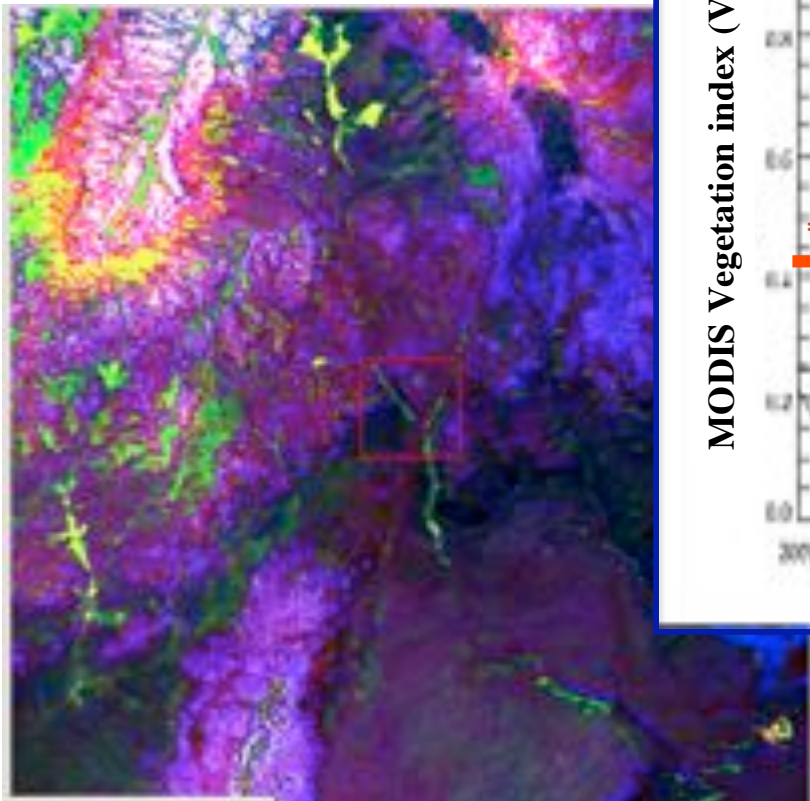
# “Phenology” from time series



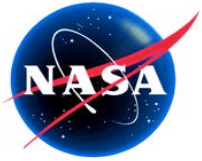
# Mapping Invasive Species Using MODIS Times-Series Data



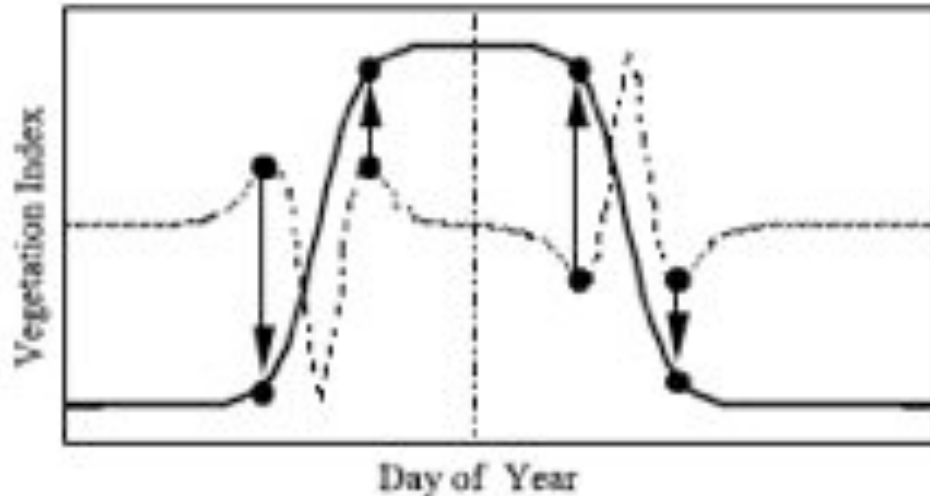
# “Phenology” from time series







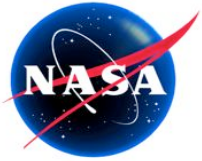
## Parameters extracted from MODIS “phenology” product



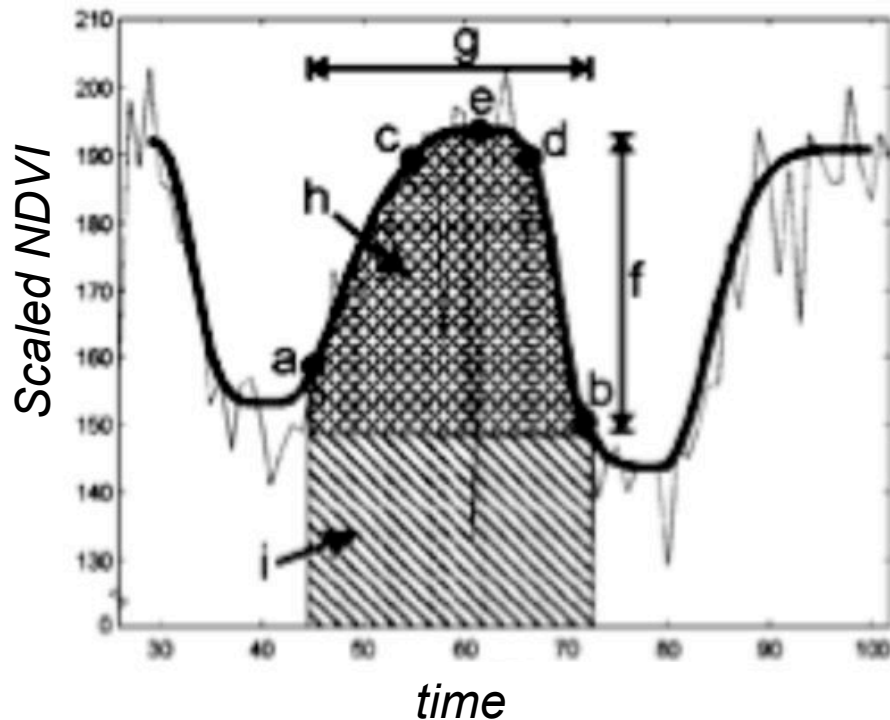
1. Greenup
2. Maturity
3. Senescence
4. Dormancy

Zhang, X., M A Friedl, C.S Schaaf, A H Strahler, JCF Hodges, F. Gao, BC Reed, A Huete, 2003. Monitoring vegetation phenology using MODIS, Remote Sensing of Environment, 84:471-475

(see also, the review article: Reed, B.C., M.A. White, J.F Brown, 2003. Remote sensing phenology. In: Phenology: An Integartive Science, M.D. Shwartz, ed. Kluwer Publishing.)

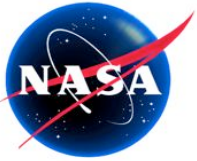


## Parameters extracted from "TIMESAT"

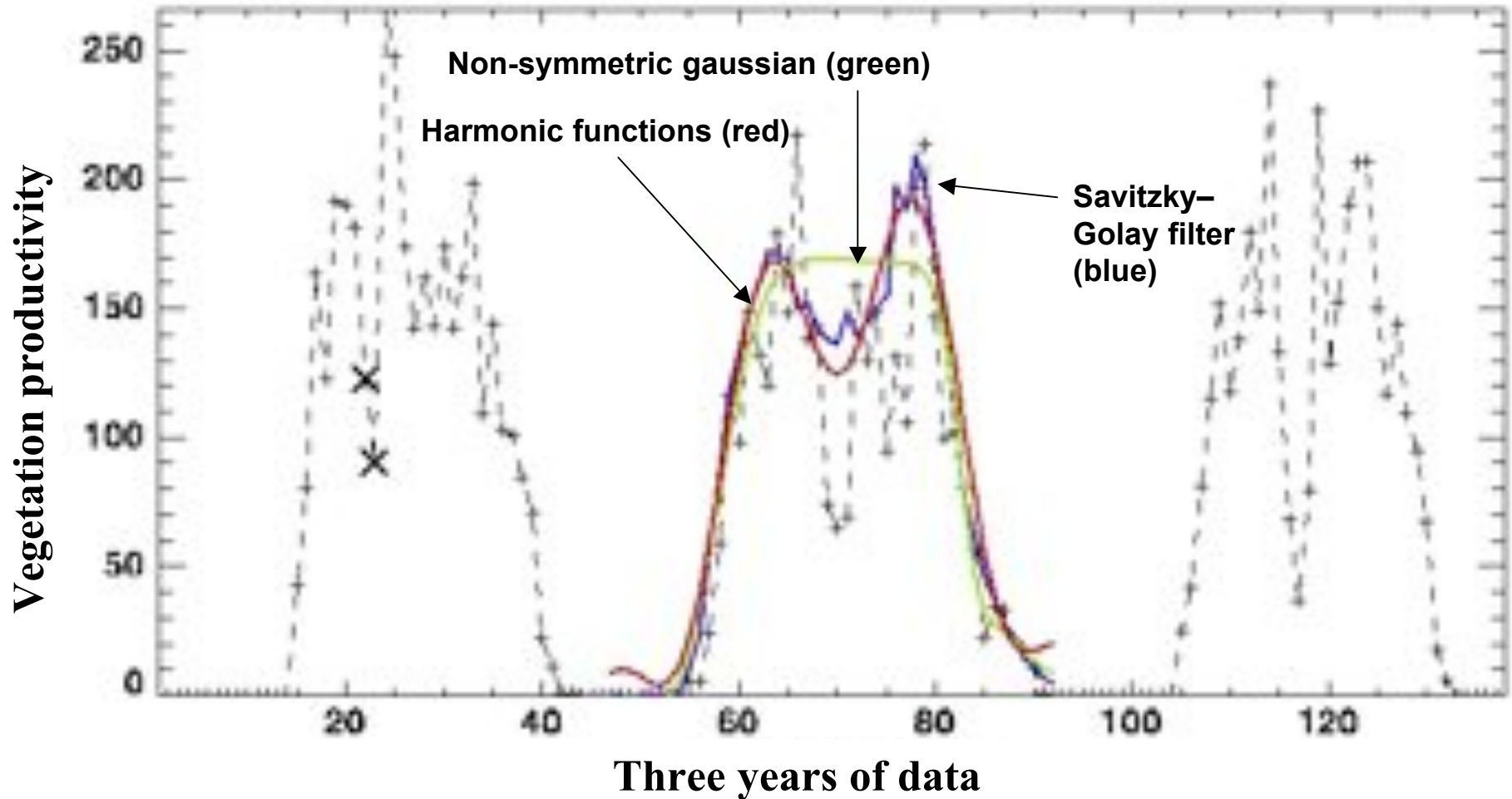


- a) Beginning of season
  - b) End of season
  - c) Left 90% level
  - d) Right 90% level
  - e) Peak
  - f) Amplitude
  - g) Length of season
  - h) Integral over season - scaled
  - i) Integral over season - absolute
- for each of three methods.*

TIMESAT - a program for analyzing time-series of satellite sensor data  
Per Jonsson & Lars Eklund, Computers & Geosciences 30:833-845, 2004.



# MODIS Gross Primary Production time series 2001-2003





# Enhanced Statistical Modeling Array

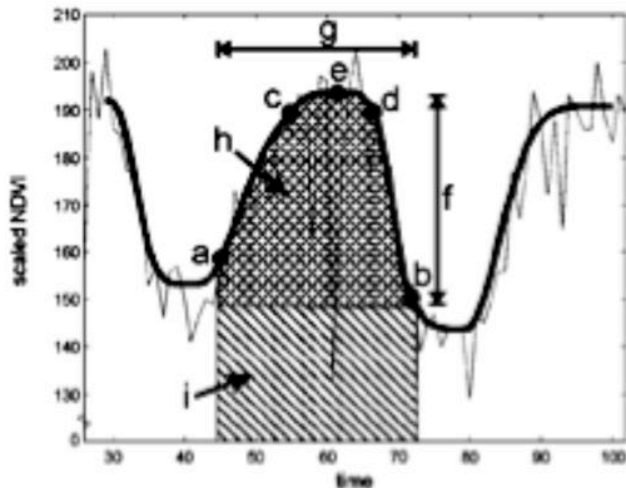
**Example Existing Model Array:**

Lat	lon	response	Predictor 1	...	Predictor N
$X_1$	$Y_1$	$R_1$	$X_{11}$	...	$X_{n1}$
$X_2$	$Y_2$	$R_2$	$X_{12}$	...	$X_{n2}$
...	...	...	...	...	...

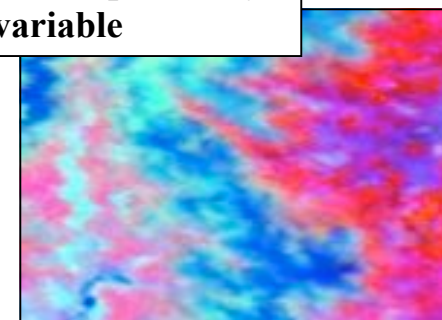
GPS X and y coordinates

Field-measured variable of interest

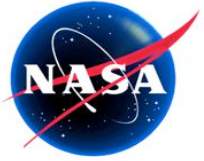
New explanatory variable



- a) Beginning of season
- b) End of season
- c) Left 90% level
- d) Right 90% level
- e) Peak
- f) Amplitude
- g) Length of season
- h) Integral over season - scaled
- i) Integral over season - absolute



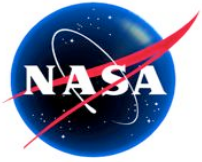
**Phenology Summary Layers**



# Outline

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- What are invasive species and why do we care about them.
- National response
- NASA contribution
- Modeling species habitat
- **Tamarisk Case study**
- Future work

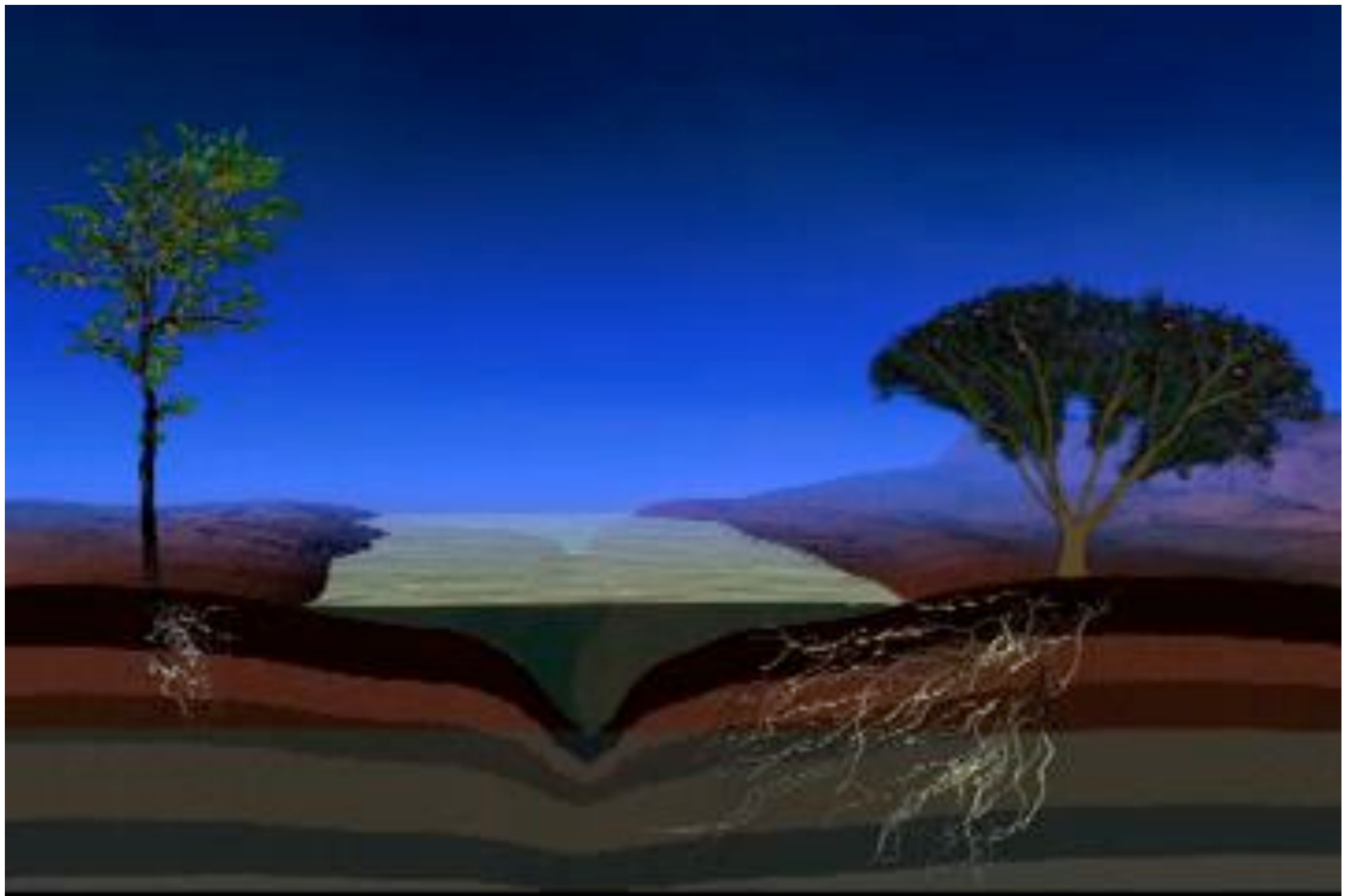


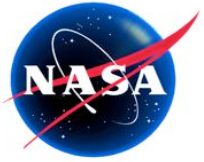
## Case Study: National tamarisk habitat suitability map

---

**Tamarisk (*Tamarix spp.*, salt cedar) was chosen as an initial target species for the Invasive Species Forecasting System work.**



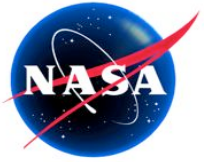




# Tamarisk throughout the year

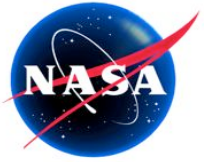






# Tamarisk throughout the year

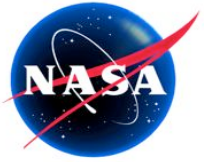




# Tamarisk throughout the year

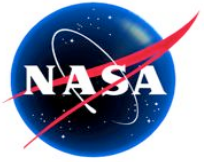


September



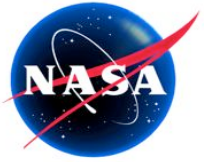
# Tamarisk throughout the year





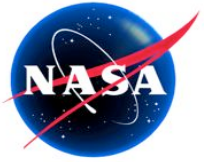
# Tamarisk throughout the year



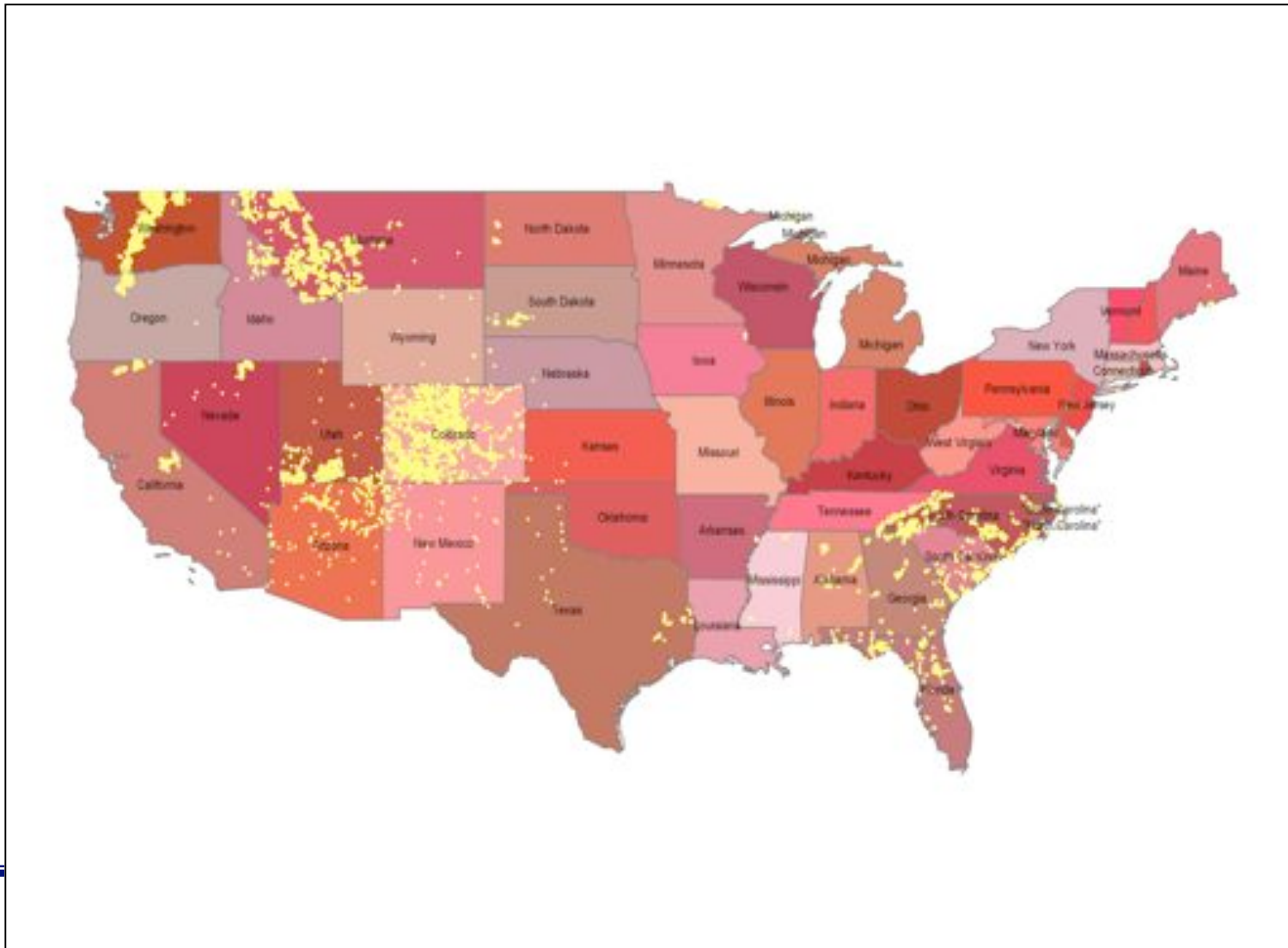


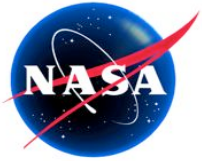
# Tamarisk throughout the year





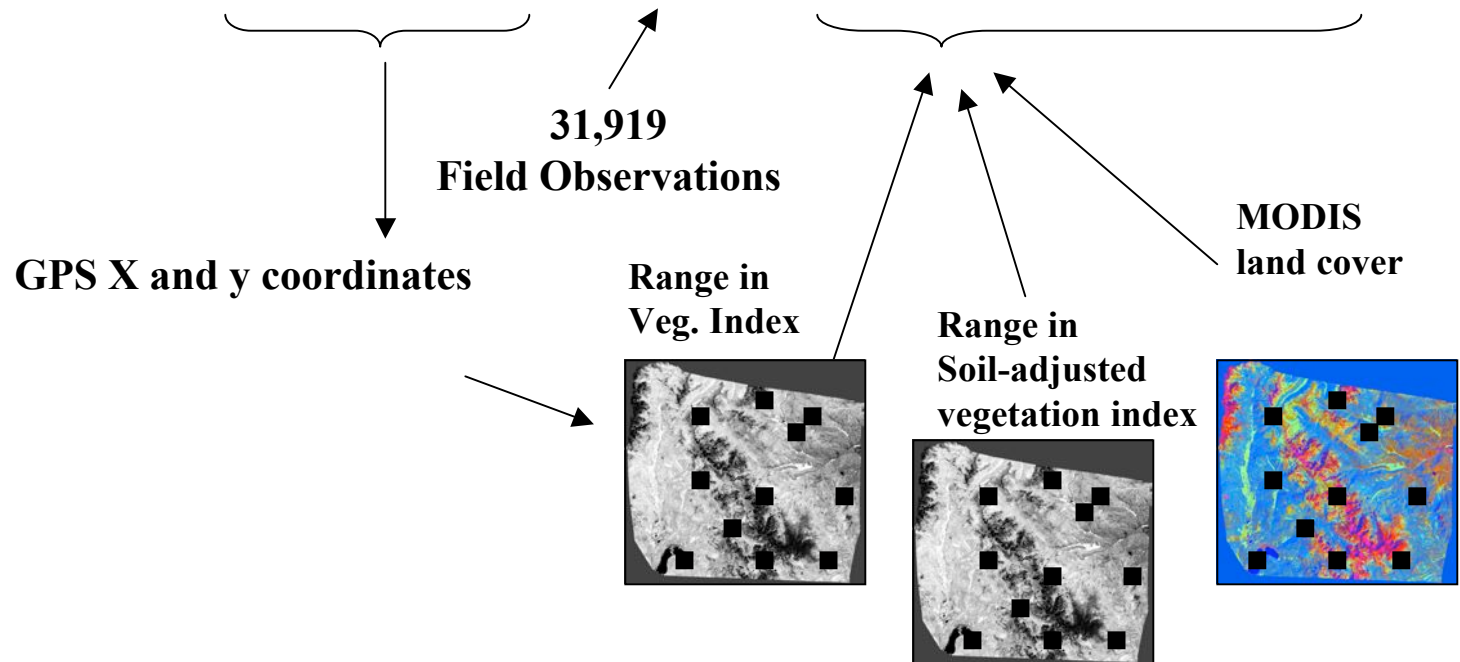
# USGS-supplied tamarisk field observations

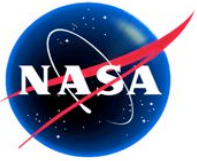




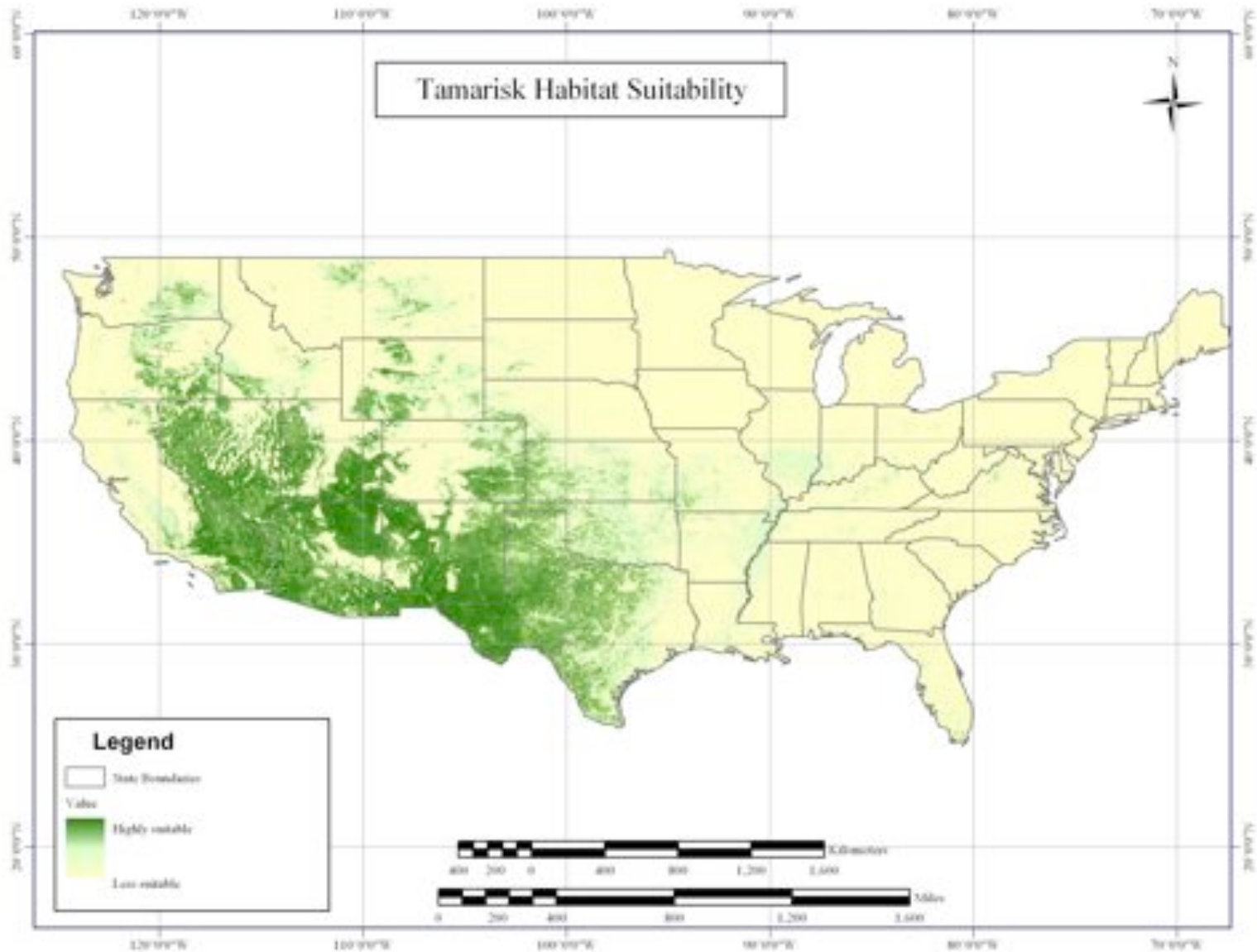
# ISFS Tamarisk Modeling Array

Lat	lon	response	Predictor 1	...	Predictor N
$X_1$	$Y_1$	$R_1$	$X_{11}$	...	$X_{n1}$
$X_2$	$Y_2$	$R_2$	$X_{12}$	...	$X_{n2}$
...	...	...	...	...	...

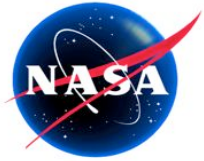




# National map of habitat suitable for tamarisk





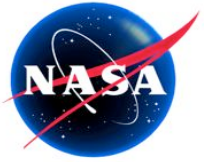


## Applying the map: States with highest percent of “highly suitable” habitat

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State	Percent area with highly suitable habitat
Texas	30.11
New Mexico	13.55
Nevada	12.97
Utah	8.34
Arizona	8.24
California	0.38
Oregon	0.32
Florida	0.19
Ohio	0.18
Colorado	0.16
Wyoming	0.10
Kansas	0.10
Montana	0.10





# Outline

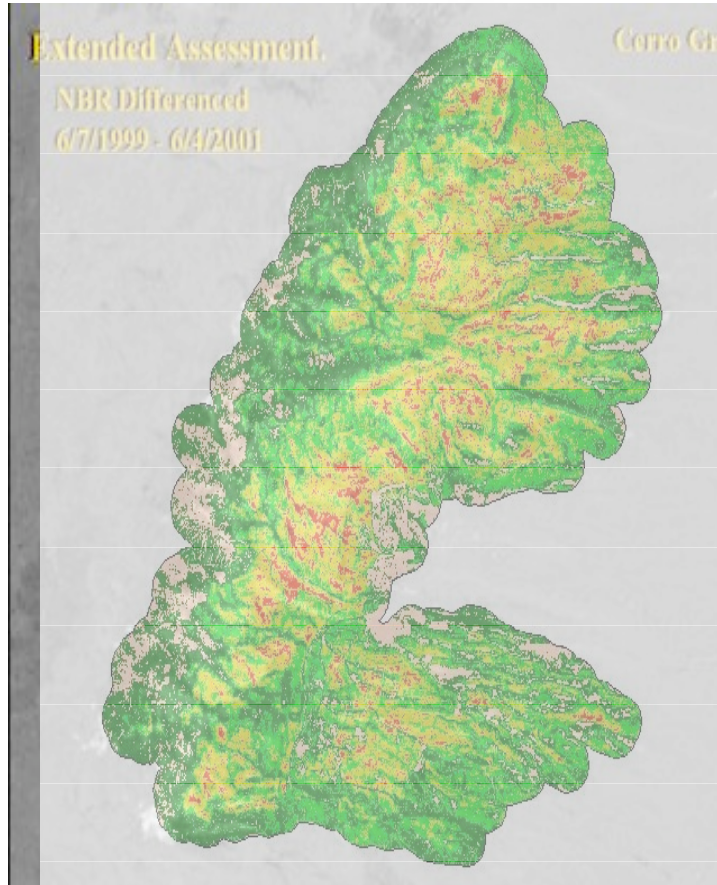
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- What are invasive species and why do we care about them.
- National response
- NASA contribution
- Modeling species habitat
- Tamarisk Case study
- **Future work**



## Future work: Integrating Invasive species habitat map and MODIS burnt area product within NPS

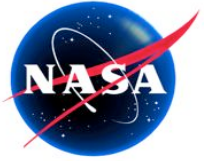
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...inform park managers of critical areas that may need treatment against invasion.

...use invasive species habitat maps to identify areas within candidate prescribed burn units that are likely to be invaded.

...use ISFS to extrapolate post-burn ecological assessment in space and time



# Thank you!

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For more information

please visit

National Institute for Invasive Species Science

<http://www.niiss.org/>

NASA/USGS Invasive Species Forecasting System

<http://isfs.gsfc.nasa.gov/>