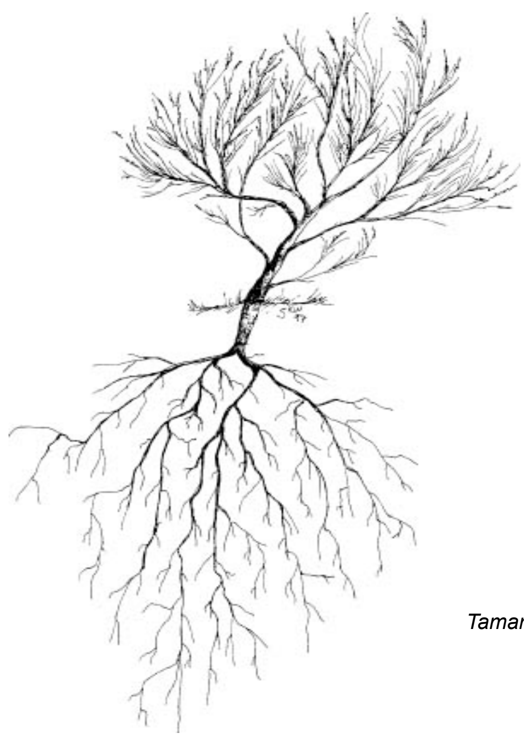
The Invasive Species Forecasting System

A NASA / USGS National Application Project



Tamarisk

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Greenbelt, MD 20771

Invasive Species

An "invasive species" is a species that is non-native to the ecosystem under consideration …

… and whose introduction causes or is likely to cause economic or environmental harm or harm to human health.

- *National Invasive Species Council*

Invasive Species

A Top Environmental Issue of the 21st Century …

- Economic Costs:
  - *$137+ Billion / Yr*
    (Pimentel, et al. 1999; NISC Management Plan, 2001)
- Environmental Costs:
  - *Decreased biodiversity, ecological services, etc.*
- Human-Health Costs:
  - *West Nile Virus, Malaria, etc.*
- Agricultural Costs:
  - *Crop pathogens, hoof-and-mouth, mad cow disease*

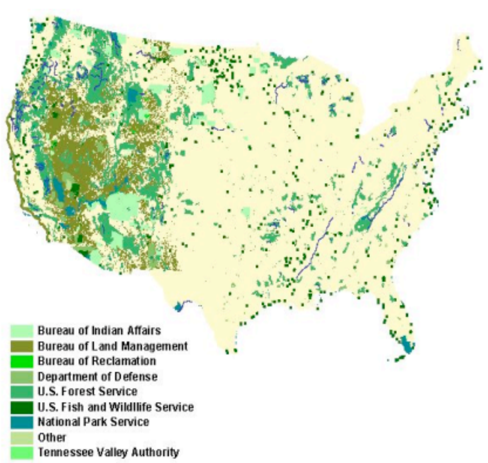
Notorious examples include:

Dutch elm disease, chestnut blight, and purple loosestrife in the northeast; kudzu, Brazilian peppertree, water hyacinth, nutria, and fire ants in the southeast; zebra mussels, leafy spurge, and Asian long-horn beetles in the Midwest; salt cedar, Russian olive, and Africanized bees in the southwest; yellow star thistle, European wild oats, oak wilt disease, Asian clams, and white pine blister rust in California; cheatgrass, various knapweeds and thistles in the Great Basin; whirling disease of salmonids in the northwest; hundreds of invasive species from microbes to mammals in Hawaii; and the brown tree snake in Guam.

As many as 50,000 now, hundreds new each year …

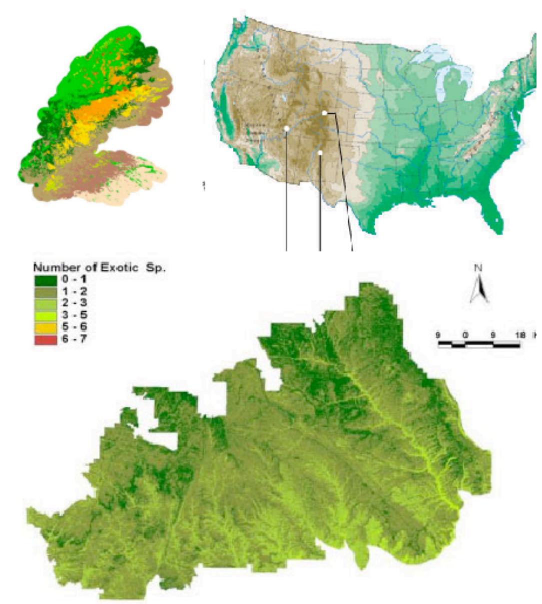
Federal Government Response

- National Invasive Species Council (EO 13122 - 1999)
- Chaired by USDA, DOI, DOC
- USGS has a lead role in dealing with invasive species science in natural and semi-natural areas



USGS Science / Client Needs

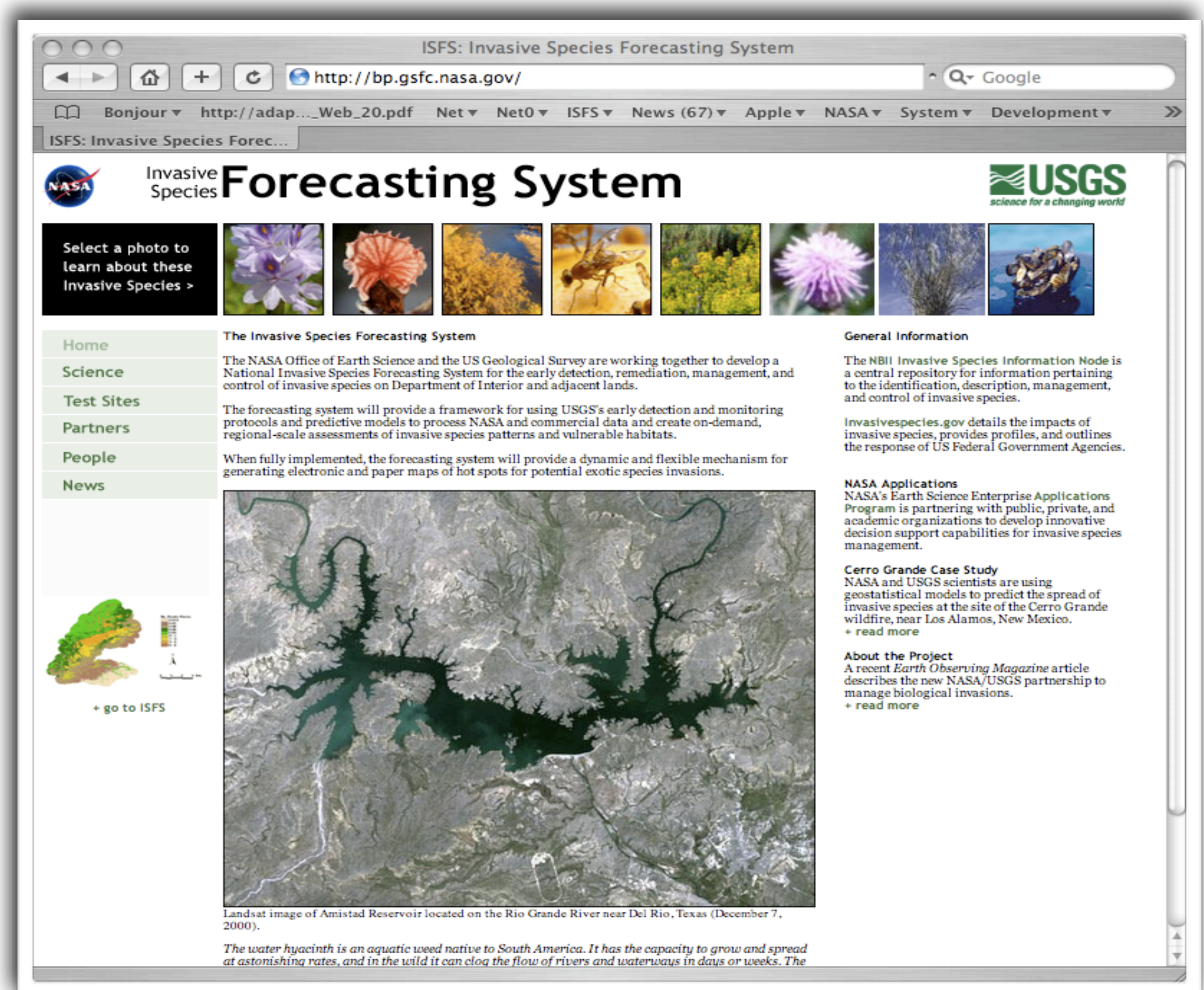
- On-demand, predictive landscape- and regional-scale models and maps for biological invasions
- Low-cost, high-performance computer modeling
- Integrated access to biological field data & NASA Earth Science data



Invasive Species Forecasting System

The ISFS Project ...

- Partnership between NASA and the US Geological Survey
- Goal to improve the invasive species management decision processes by improving efficiency, effectiveness, and access to tools tailored to the needs of the invasive species management communities.
- Based on USGS's early detection and monitoring protocols.
- Targets DOI operational agencies and DOI lands.



Technology Accomplishments

Scalable processing improvements with Cerro Grande Fire Site (CGFS) data

Re-engineered original S-plus code into a Fortran routine

- Reduced processing from 18 days to 61 mins

Parallelized Fortran code

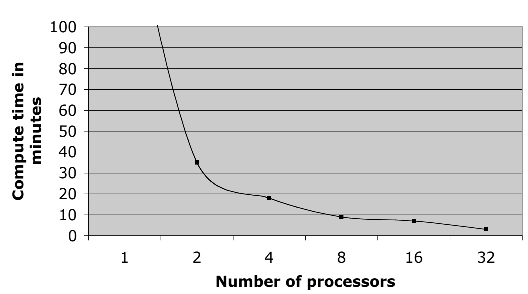
- Reduced processing from 61 mins to 2.47 mins

18 days 2.5 min changes the science!

Performance of "Adaptive Kriging" for the CGFS study site exceeded goals

- 1x Area: goal of 2.47 min, achieved 33 seconds. Exceeded goal by 4.5x
- 10x Area: goal is 24.7 min, achieved 4 min 2 sec. Exceeded goal by 6x

Multiprocessor Scaling Curve
Cerro Grande Fire Site (nn-18)



Dramatically improved both the quality and capacity of science results for our USGS clients through code optimization and cluster computing

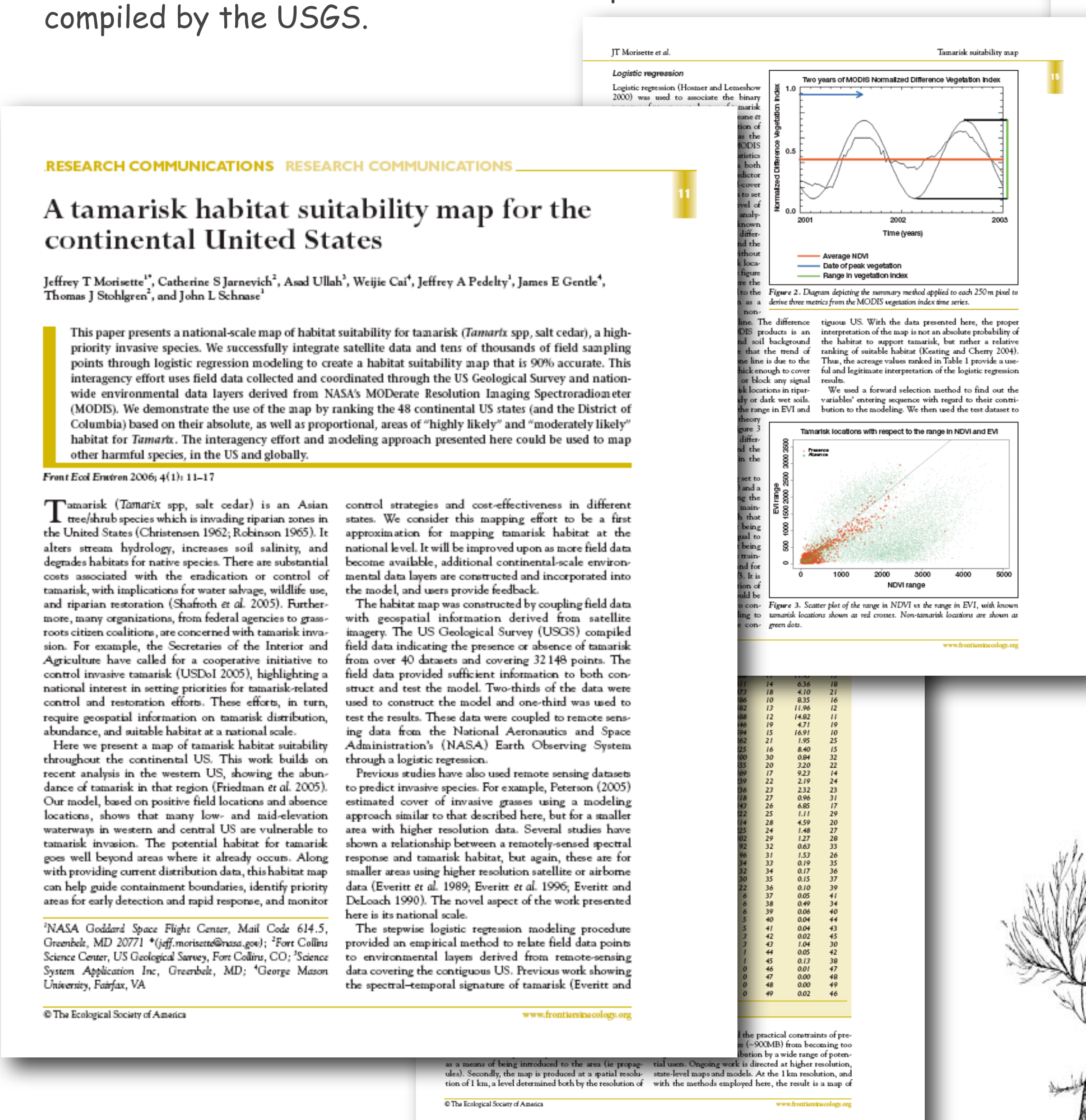
"Constraints in computational time often forced us to substitute simple models for complex, more realistic and accurate models. We needed to greatly reduce computational time to allow us to evaluate larger areas more quickly."

- Dr. Tom Stohlgren, Director National Institute of Invasive Species Science, USGS

Invasive Species Forecasting System

Science Accomplishments ...

- National habitat suitability map for tamarisk ...
- A function of MODIS Land Cover and vegetation seasonality.
- Model based on over 30,000 field data points compiled by the USGS.



RESEARCH COMMUNICATIONS

A tamarisk habitat suitability map for the continental United States

Jeffrey T Morisette[1*], Catherine S Jarnevich[2], Asad Ullah[3], Weijie Cai[4], Jeffrey A Pedelty[1], James E Gentle[4], Thomas J Stohlgren[2], and John L Schnase[1]

This paper presents a national-scale map of habitat suitability for tamarisk (*Tamarix* spp, salt cedar), a high-priority invasive species. We successfully integrate satellite data and tens of thousands of field sampling points through logistic regression modeling to create a habitat suitability map that is 90% accurate. This interagency effort uses field data collected and coordinated through the US Geological Survey and nation-wide environmental data layers derived from NASA's MODerate Resolution Imaging Spectroradiometer (MODIS). We demonstrate the use of the map by ranking the 48 continental US states (and the District of Columbia) based on their absolute, as well as proportional, areas of "highly likely" and "moderately likely" habitat for *Tamarix*. The interagency effort and modeling approach presented here could be used to map other harmful species, in the US and globally.

Front Ecol Environ 2006; 4(1): 11–17

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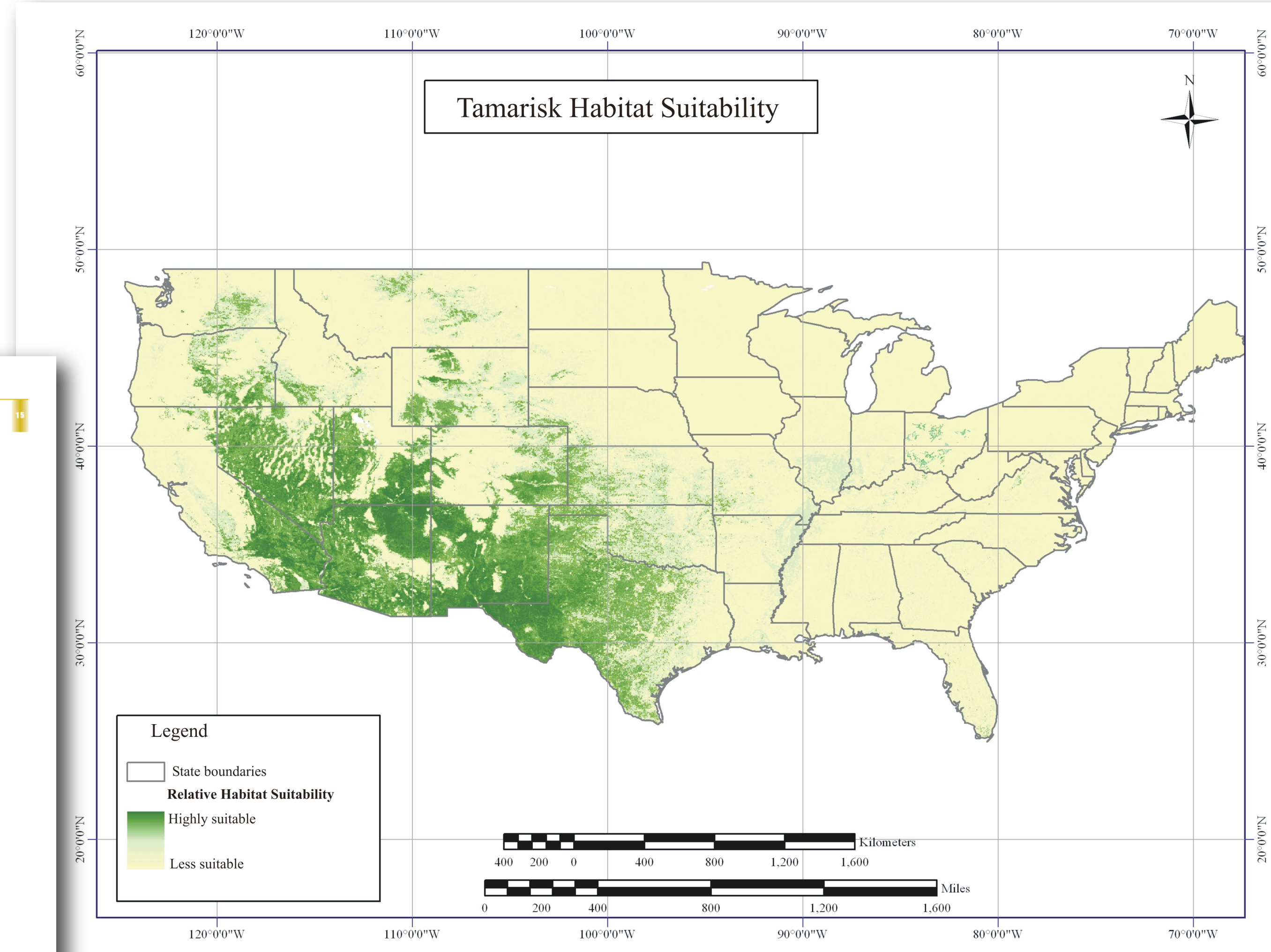
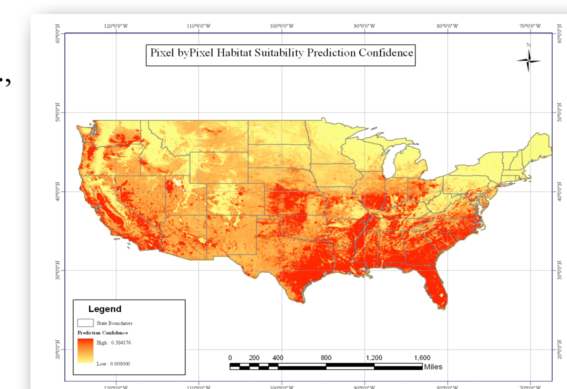
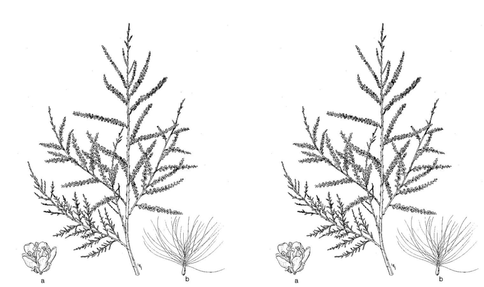


Morisette, J.T., C. S. Jernevich, A. Ullah, W. Cai, J.A. Pedelty, J. Gentle, T.J.Stohlgren, J.L. Schnase, A tamarisk habitat suitability map for the continental US., *Frontiers in Ecology*, February 2006.





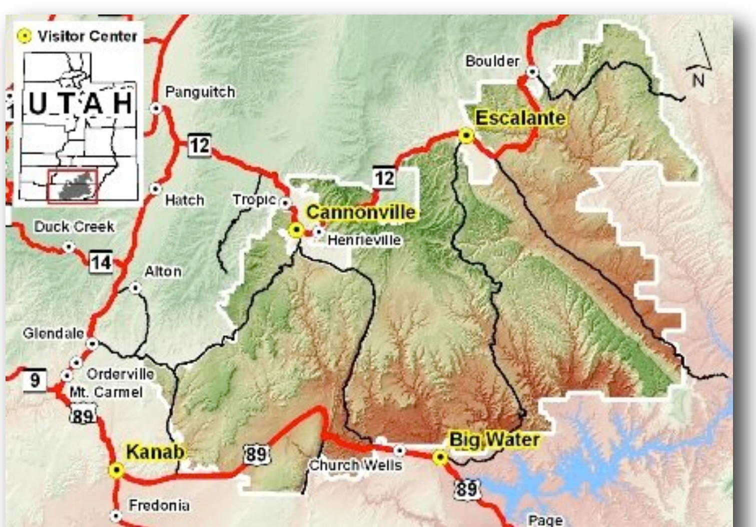
Operational deployment ...

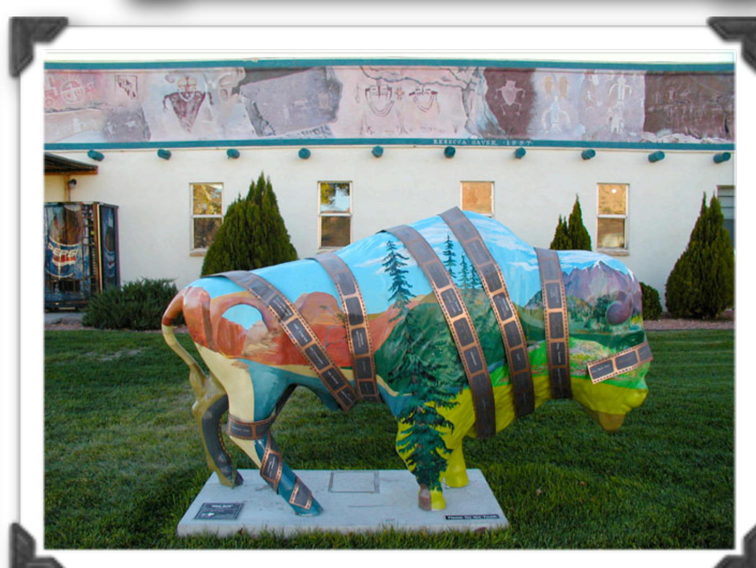
1. Classic Web Services / USGS Fort Collins Science Center
2. WebDAV-enabled Runtime Service / BLM Grand Staircase - Escalante National Monument ...

Both based on a simple, adaptable, componentized "ISFS Framework" that implements our notion of a canonical modeling workflow ...

Option 2 - Turning out to be the winner

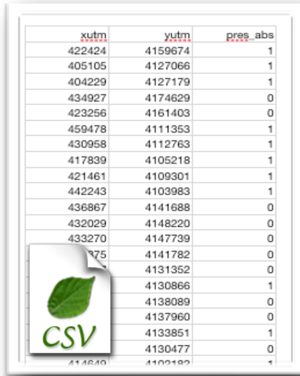
Light-weight application, assumes only intermittant / asynchronous internet connectivity, personalized / private data management, iTunes U / RSS / peer-to-peer sharing and communication ...



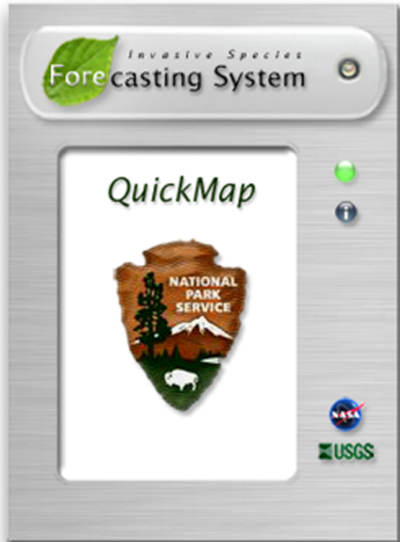


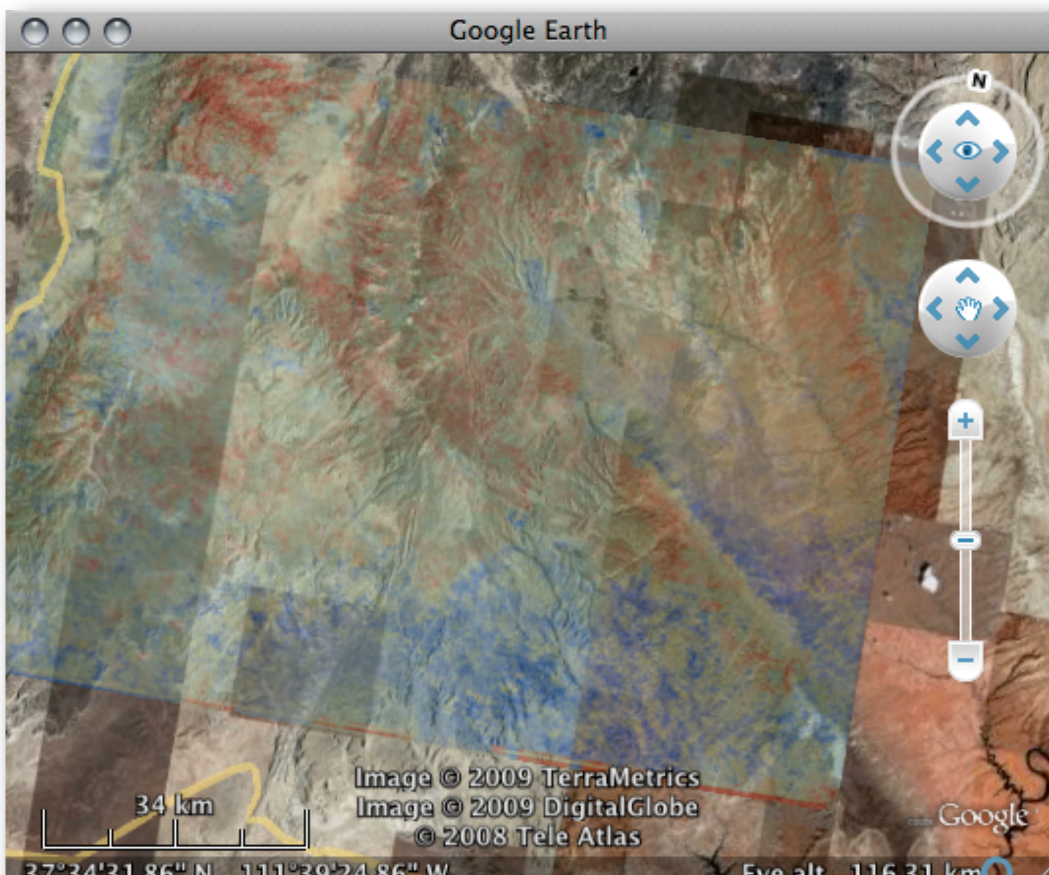
ISFS-G100-Console
ISFS-G101-Moqui
ISFS-G102-Cayote
ISFS-G103-Peregrine
ISFS-G104-Pareah
ISFS-G105-Wolverine

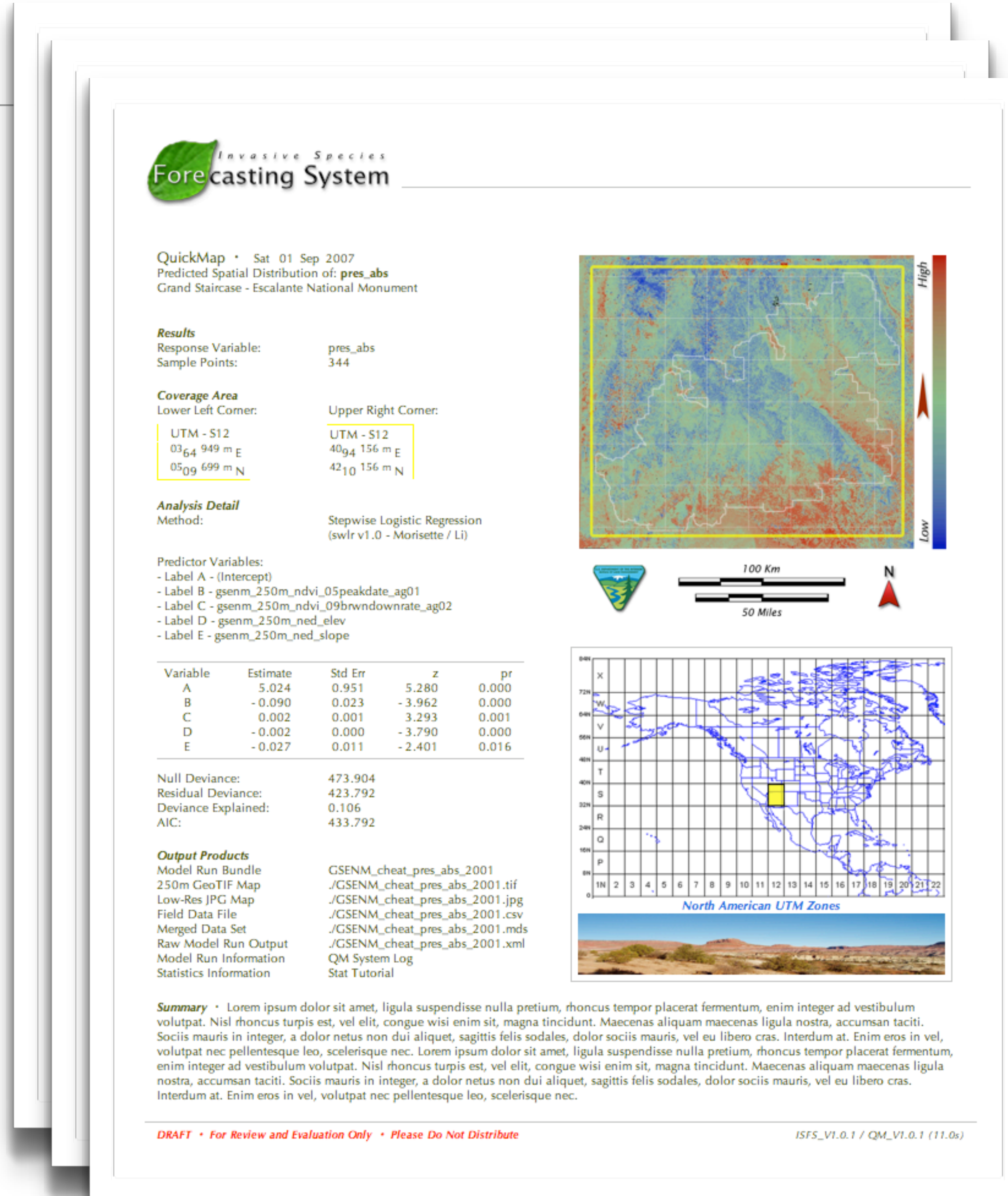
Invasive Species Forecasting System



Field Data Input







Invasive Species Forecasting System

QuickMap · Sat 01 Sep 2007
Predicted Spatial Distribution of: **pres_abs**
Grand Staircase - Escalante National Monument

Results
Response Variable: pres_abs
Sample Points: 344

Coverage Area

Lower Left Corner:	Upper Right Corner:
UTM - S12	UTM - S12
0364 949 m E	4094 156 m E
0509 699 m N	4210 156 m N

Analysis Detail
Method: Stepwise Logistic Regression (swlr v1.0 - Morisette / Li)

Predictor Variables:
- Label A - (Intercept)
- Label B - gsenm_250m_ndvi_05peakdate_ag01
- Label C - gsenm_250m_ndvi_09brwndownrate_ag02
- Label D - gsenm_250m_ned_elev
- Label E - gsenm_250m_ned_slope

Variable	Estimate	Std Err	z	pr
A	5.024	0.951	5.280	0.000
B	- 0.090	0.023	- 3.962	0.000
C	0.002	0.001	3.293	0.001
D	- 0.002	0.000	- 3.790	0.000
E	- 0.027	0.011	- 2.401	0.016

Null Deviance: 473.904
Residual Deviance: 423.792
Deviance Explained: 0.106
AIC: 433.792

Output Products

Model Run Bundle	GSENM_cheat_pres_abs_2001
250m GeoTIF Map	./GSENM_cheat_pres_abs_2001.tif
Low-Res JPG Map	./GSENM_cheat_pres_abs_2001.jpg
Field Data File	./GSENM_cheat_pres_abs_2001.csv
Merged Data Set	./GSENM_cheat_pres_abs_2001.mds
Raw Model Run Output	./GSENM_cheat_pres_abs_2001.xml
Model Run Information	QM System Log
Statistics Information	Stat Tutorial

Summary · Lorem ipsum dolor sit amet, ligula suspendisse nulla pretium, rhoncus tempor placerat fermentum, enim integer ad vestibulum volutpat. Nisl rhoncus turpis est, vel elit, congue wisi enim sit, magna tincidunt. Maecenas aliquam maecenas ligula nostra, accumsan taciti. Sociis mauris in integer, a dolor netus non dui aliquet, sagittis felis sodales, dolor sociis mauris, vel eu libero cras. Interdum at. Enim eros in vel, volutpat nec pellentesque leo, scelerisque nec. Lorem ipsum dolor sit amet, ligula suspendisse nulla pretium, rhoncus tempor placerat fermentum, enim integer ad vestibulum volutpat. Nisl rhoncus turpis est, vel elit, congue wisi enim sit, magna tincidunt. Maecenas aliquam maecenas ligula nostra, accumsan taciti. Sociis mauris in integer, a dolor netus non dui aliquet, sagittis felis sodales, dolor sociis mauris, vel eu libero cras. Interdum at. Enim eros in vel, volutpat nec pellentesque leo, scelerisque nec.

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ISFS_V1.0.1 / QM_V1.0.1 (11.0s)

Lessons learned ...

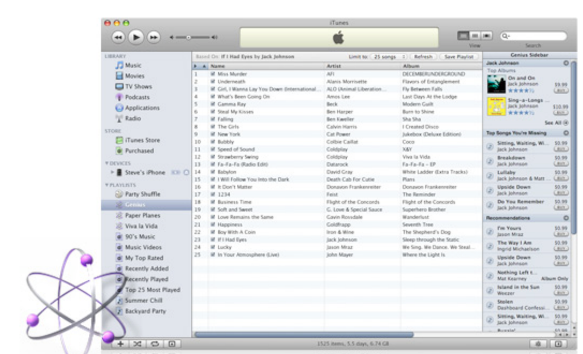
- **Major successes**
  Habitat-suitability modeling important to many people and many types of decision processes. And "pretty close" is often good enough ...

- **Major failures**
  Traditional, enterprise-scale, government-based information services difficult to implement these days. Points to expanded role for private-sector infrastrucures and alternative deployment strategies ...

- **What's missing**
  A coherent approach to regionalized data and application construction and delivery. Problems, solutions, responses, budgets, and management scopes are regional. For example, the National Interagency Fire Center is very interested run-time ISFS (BAER Teams especially). Important implications for a globe-centric NASA ...

- **What's next**
  R&D that moves us toward a generative ecology for Earth science modeling: Lightweight (microkernel) modeling architectures, agile regionalized delivery, multi-appliance accommodative, data/model syndication, podcasting/catching, client-side tailorability, mashups, iconographic interfaces, private-sector infrastructures, etc. ...

Google™



USGS science for a changing world

Invasive Species Forecasting System

GRAND STAIRCASE - ESCALANTE

NATIONAL MONUMENT