Fingerprinting Native and Non-Native Biodiversity in the U.S.: Phase I

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³NASA Goddard Space Flight Center
Challenges with Fingerprinting Biodiversity

- Quantifying patterns of biodiversity has been hampered by poor taxonomic knowledge of small and uncommon organisms, woefully incomplete surveys over large areas (in the US and elsewhere), inadequate coupled models of field data and high-resolution remote sensing data, and little systematic monitoring to detect the status and trends of all but the most common or charismatic species.
Challenges with Fingerprinting Biodiversity

- Fingerprinting biodiversity in the US is facilitated by more complete taxonomic information for many taxa and long-term systematic monitoring of some taxa (e.g., birds, fishes, native and non-native vascular plants, mammals, amphibians) that jointly may provide some insights on the patterns of other biological groups. Adequate data are at least available to test this basic assumption.
Background Justification for the Project

• Because there currently exists no coherent scientific or technological framework for biodiversity assessments (especially at continental scales), we embarked on a multidisciplinary research study to advance the science and technology of mapping and modeling patterns of biodiversity (i.e., biological fingerprinting).

• We also sought to document the patterns of the invasion of harmful non-native plants, fishes, and birds in the U.S.
Research Objectives: Based on Interdisciplinary Research Incorporating

• Data from several remote sensing satellites;
• Synthesis of biodiversity field data sets from Department of Interior (USGS, BLM, NPS, BOR), Department of Agriculture (USFS, APHIS, ARS), non-government organizations (The Nature Conservancy, NatureServe), and universities;
• New Multi-scale Geospatial Modeling-Mapping Algorithms (Web Internet Tools); and
• High-Performance Computing Capabilities (HPCC-NASA-USGS) to document, map, and forecast the distributions and abundances of selected native and non-native plants and animals in the United States.
Research Objectives: Based on Interdisciplinary Research Incorporating

- Our state of the art research approach is proving successful at local and landscape scales.
- We focused on Tamarix spp. (tamarisk, salt cedar) and Bromus tectorum (cheatgrass) as test species for high-resolution mapping and modeling of harmful invasive species; however, our study has expanded well beyond these two species examining other invasive plant species, wildlife and pathogens.
- In addition, we tested a new field pixel nested plot (PNP- Kalkhan et. al., 2007a,b) sampling design with link to geospatial information data for using geostatistical modeling and thematic mapping applications into forecasting biodiversity, environmental, and ecological parameters.
Geospatial Modeling - Thematic Mapping
Web Internet Tools
Through Multiple - Collaborative Teams:

NREL-CSU, USGS-FORT, & NASA-GFSC
A Global Organism Detection and Monitoring (GODM) System for Plants, Animals, and Pathogens

Core Database Design

Who & When

Where

What

Organizations

Projects

Taxon Units

Area
(Name, Code)

Visit
(Date)

Organism Data
(TSN)

Treatments

Attributes

Spatial Data
(X, Y)

Pathways

Cultural Change

IT Infrastructure

Expertise

### Various Data Types & GIS: Helping Resource Management Activities

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Continue

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Includes real-world predictor variables (e.g., distance to sea, elevation).
The National Institute of Invasive Species Science

Analysis Results

Results of Multiple Logistic Regression:

Response Variable: Present

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Null Deviance: 2787.353
Residual Deviance: 1012.422
Deviance explained: 0.637
AIC (Akaike's Information Criterion): 1026.422
AICc (AIC corrected for small sample size): 1026.473

Graphs of residuals versus fitted

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The Maxent Model was Tested on the Predicting White Pine Blister Rust Across Western USA Forests, Kumar et al. In Progress
Diddymo, an invasive diatom infesting streams throughout the U.S., was modeled using GARP Model (Kumar et al. In Review).
At Hart Mountain Wildlife Refuge Oregon, we tested logistic regression analyses to model areas at risk for white top infestation (Barnett *et al.* Work in Progress).
CART models statistically partition the dependent data into two homogenous groups, repeating the procedure for each group in a continuing process that forms a hierarchal tree based on the predictive strength of each environmental variable (Evangelista et al. In Press).
Tamarisk habitat suitability for the continental U.S. by Morisette et al. 2006.
Tamarisk Habitat Suitability for the Continental U.S. by Evangelista et al. Work in Progress.
Using the Envelope model, the number of non-native species was tracked over time in selected counties in Washington (Jarniviche et al. In Review).
The Geographic Setting

- Understanding the geography and topography of the continental U.S. helped set the stage for evaluating patterns of species diversity.
- Data from the 3,004 county centroids showed that as latitude increased from Mexico to Canada, mean annual temperature sharply declined ($r = -0.91$), and mean annual precipitation declined ($r = -0.42$) with exceptions no doubt in mountainous areas.
- Due to the shape and topography of the US, increasing latitudes coincided with increasing distance to coastlines ($r = 0.54$) and increasing mean elevation ($r = 0.48$)
Conclusions and Future Directions

- We are not yet satisfied that we achieved our objectives. Each of our data sets could be improved, as could the ancillary data layers used in geospatial modeling and the models themselves.
Conclusions and Future Directions

- This is the first attempt to evaluate patterns of native and non-indigenous vascular plants, birds, and fishes at multiple spatial scales relative to environmental factors, human population, and cross-correlations among the biological groups. Additional data on plant species richness are needed for many counties in the US (i.e., those with less than a few hundred native plant species seem suspiciously low).
Conclusions and Future Directions

- Non-indigenous fish data have not all been refined to the 8-HUC (Hydologic Unit Code) drainage scale. Additional data at higher resolutions will be helpful in refining spatially predictive models of species richness and density.
Conclusions and Future Directions

- Need to more closely link richness and density to abundance, cover, and dominance, and to link species-level data to habitat quantity, quality, and connectedness by roads and waterways (i.e., corridors of invasion) and barriers to invasion.
Caveats aside, we are gaining a much more robust general geospatial model – thematic maps of successful invasions by multiple biological groups. The general patterns observed here provide insights into changes needed for prevention, early detection and rapid response, research, control, and monitoring.
Questions,
Comments,
!!!!!!!!!!!!!!

Thank you