

Nostradamus, Palantirs, and the Pros and Cons of Predictive Modelling for Invasive Species Management

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A Nod Of Thanks

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- Matt Brooks
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- Jen Gibson
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- John Randall
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- And especially....Emma Underwood

Just What Are These Predictive Model Things?



These models trouble my thoughts. Are they just math? Where is the ecology? How do they work? Do they work?

Goals Of This Talk

1. Simple, largely non-technical overview of predictive models and where they came from
2. Provide a bestiary of types of models
3. Appreciation for their potential usefulness
4. Wariness of their shortcomings
5. Lead-in to Emma's talk

Is Predictive Modeling Equivalent To One Of Nostradamus' Quatrains?

Hmmm...
invasive
species



In the world there
will be star thistle
which will take over
rangelands galore,
followed by pepper
grass cloaking the
creeks shore.



Or Are They Like The Palantir?

(be careful Pippin...)

I bet Cal IPC
could use this
predictive
Palantir!



We will be able to
predict where
cheatgrass and
knapweed and all
sorts of bad
species will be!!



Model Conceptualization

Model Development

Uh Oh. Gotta' Be Careful With Those Things...



GANDALF!!

**Peregrine Took!!
I told you to
beware of CART
and neural nets!**



Model (in)Validation!!



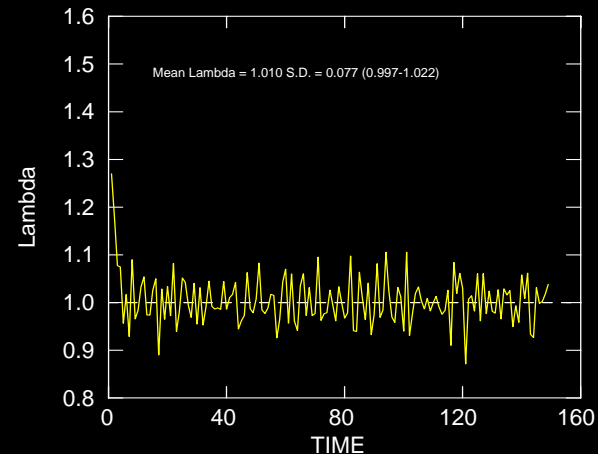
Some Early History

- Predict which species will be invasive
- Predict which communities are most prone to invasion



Some Later History

- Some consistency emerging in characteristics of invaders
- Advances in statistical methods
- Advances in computer technology
- Extensive and often useful application in other fields
 - Wildlife-habitat relationships
 - Population dynamics
 - Climate Modeling



Current Perceptions

- ***Relationship between when a species is invasive and site characteristics***
 - Modeling at appropriate scale relative to predictor variables



Predictive Modeling In Context Of Invasive Plant Management

- Prediction of the distribution (and often abundance) of an invader based on the relationship that species has with particular environmental factors
 - Generally abiotic factors



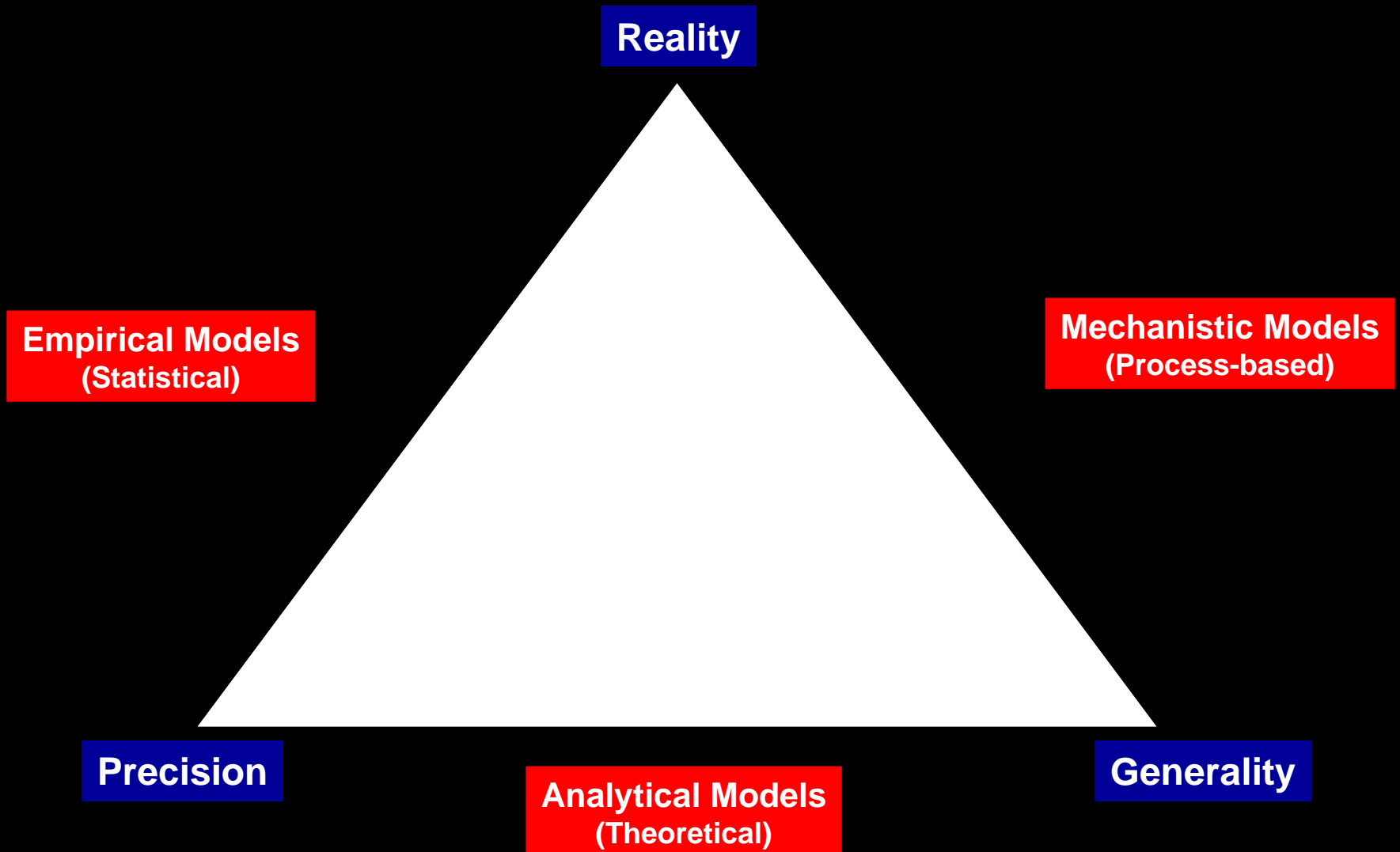
Ecological Basis

- Niche theory
 - Hutchinsonian (Realized)
- Two critical assumptions
 - “Species – environment” relationship
 - Relationship is in pseudo-equilibrium



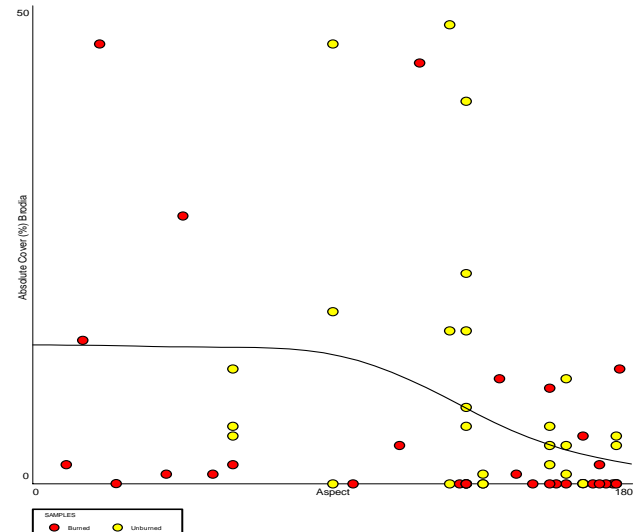
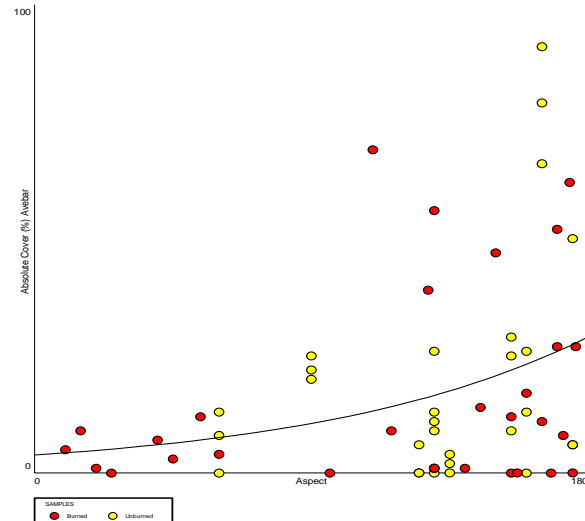
A Useful Classification

(Levins 1966; Sharpe 1990; Guisan & Zimmerman 2000)



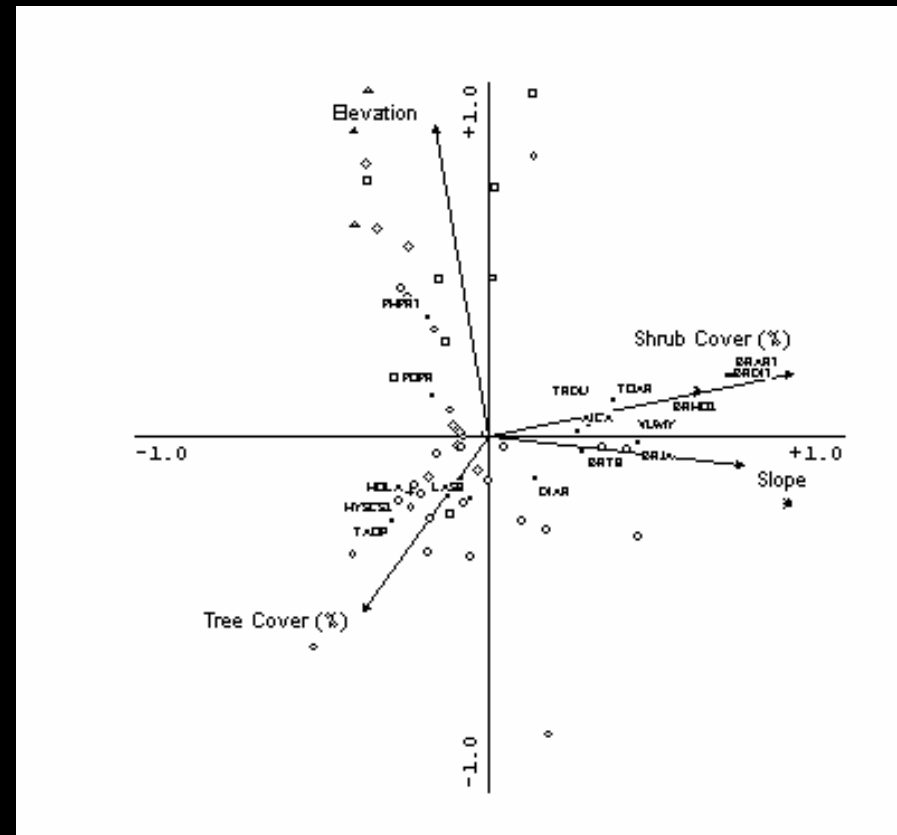
A Bestiary Of Models-Part I

- Regression (parametric/semi and non-parametric)
 - Simple linear (SLR)
 - Multiple linear (MLR)
 - Logistic (LogR)
 - Generalized linear (GLM)
 - Generalized additive (GAM)
 - Classification & Regression Trees (CART)



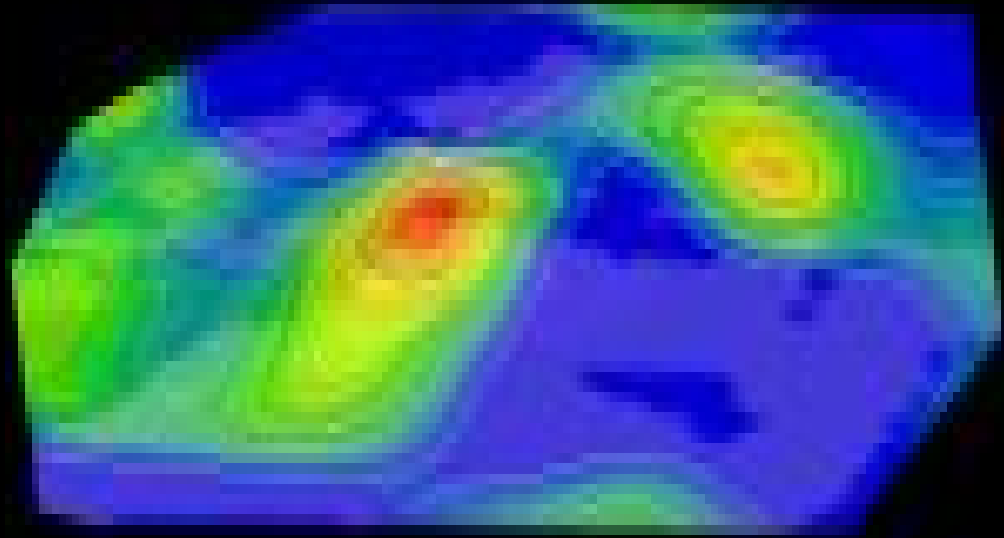
A Bestiary Of Models-Part II

- Ordination
 - Principle Components Analysis (PCA)
 - Detrended Correspondence Analysis (DCA)
 - Canonical Correspondence Analysis (CCA)
 - Non-metric Multidimensional Scaling (NMDS)



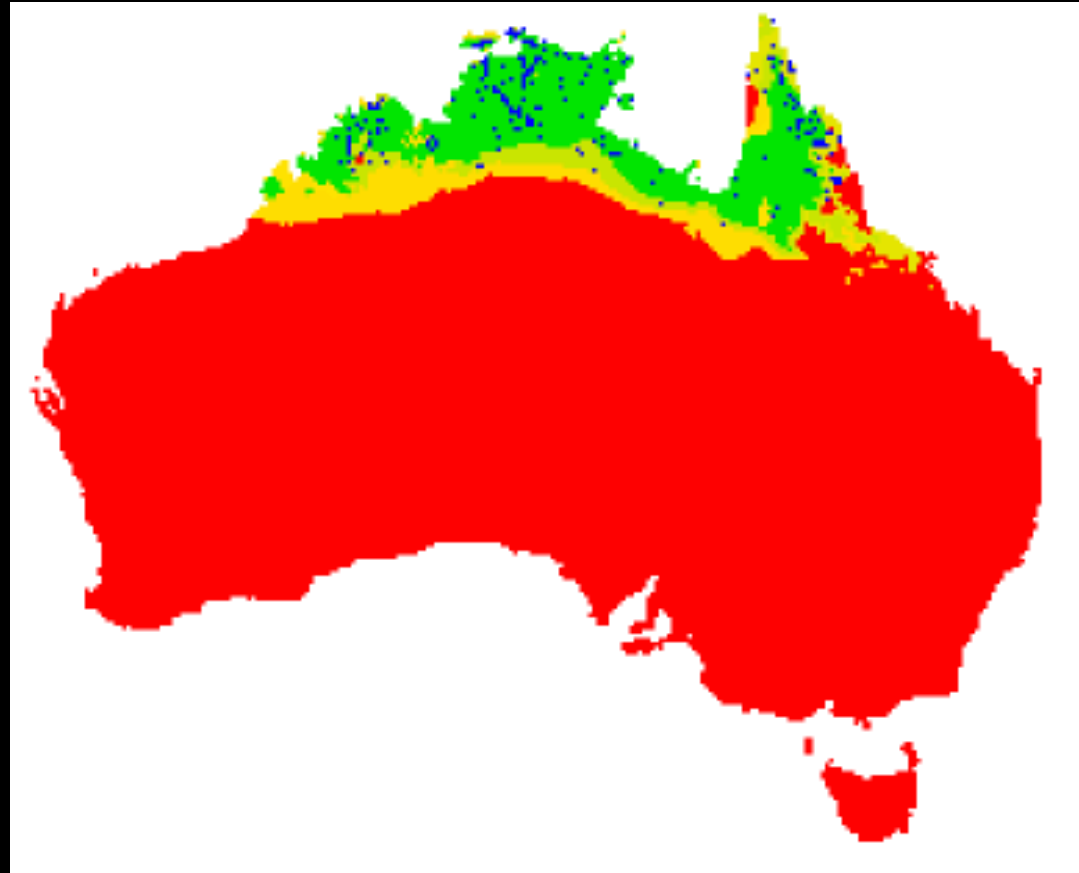
A Bestiary Of Models-Part III

- Spatial & Interpolation
 - Variograms
 - Kriging
 - Co-kriging



A Bestiary Of Models-Part IV

- Environmental Envelopes
 - BIOCLIM
 - CLIMEX
 - DOMAIN



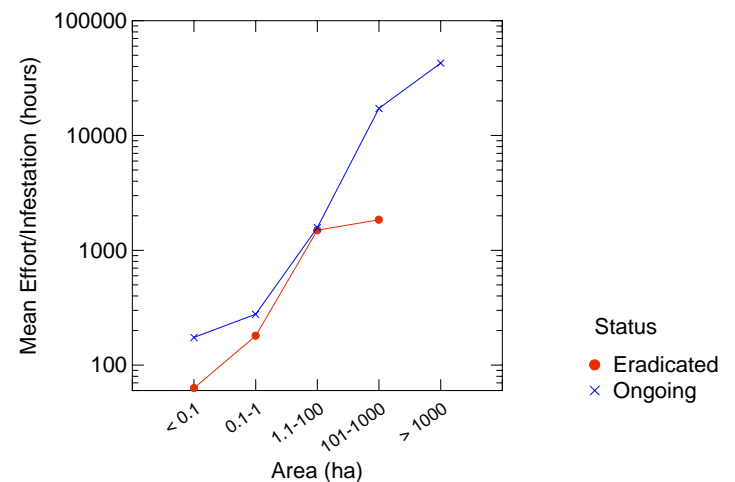
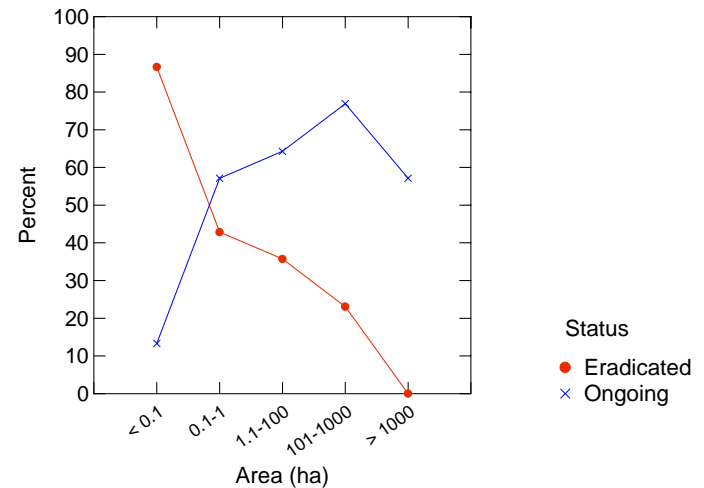
A Bestiary Of Models-Part V

- Black Box (computer intensive, non-parametric, optimal solution convergence)
 - GARP
 - “Genetic” algorithm
 - ANN
 - Neural net algorithm
 - MAXENT



Why Predictive Models Are Useful

- Management
 - Better chance of control/eradication
 - Save resources
 - Target management efforts
 - Justify actions
- Ecological
 - Better understanding of factors limiting/enhancing invasions



Why Predictive Models Can Be Dangerous

- Ecology secondary to statistical/technological components
- Appropriateness and resolution of predictor variables
- Multiple invaders
 - Single vs. multiple species modeling?
- Data from single surveys
 - Appropriate phase of invasion process?
- Validation simplistic or overlooked
- Persistence of ecological context
 - Equilibrium/pseudo-equilibrium?



Early Detection... *Of What?*

- Invasion Process Needed For Context
 - **Colonization Phase**
 - Presence of colonizers
 - **Establishment Phase**
 - Spatial distribution
 - Abundance
 - **Spread Phase**
 - Spatial distribution
 - Abundance
 - Dispersal
 - Impacts



How To Build And Use Effective Predictive Models

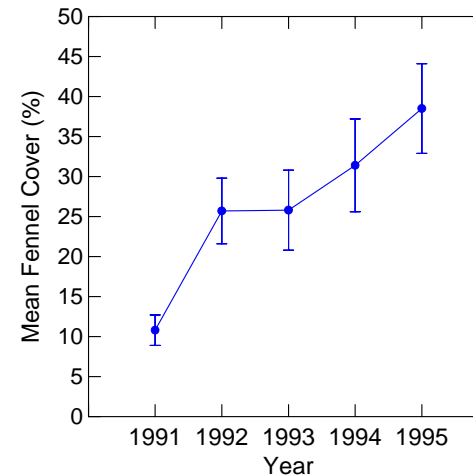
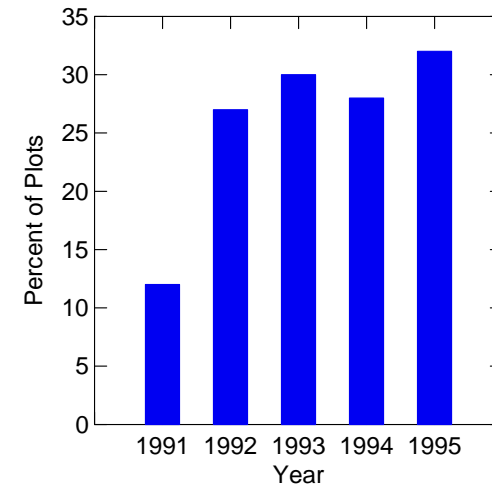
- Model Conceptualization
 - Focus on ecological processes/patterns
 - Define phase of invasion process being modeled
- Model Development
 - Select variables based on ecological relationships
 - Eliminate redundant variables
- Model Evaluation (validation)
 - Use multiple evaluation criteria
 - Evaluate with independent datasets collected in different years



Even Then....



- Lag effects
- Stochastic events



And Most Important...

- It is still all ***CORRELATION***



The Cons of Predictive Modeling

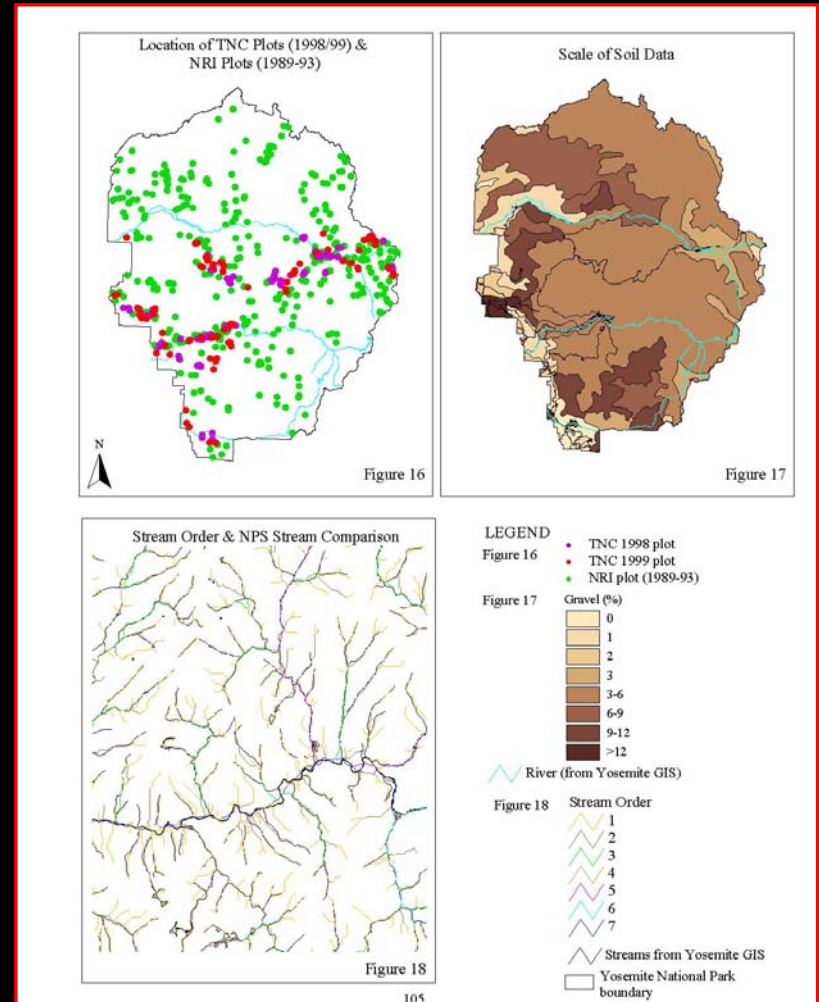
- **Resources**
 - Wasted
 - Misdirected
- **Surveys**
 - Don't survey vulnerable areas
 - Ignore problematic species



Yosemite National Park

(Underwood et al. 2004; Klinger et al. *in press*)

- Goal
 - Develop protocol for sampling of invasive plants in burned areas
- Qualitative Assessment of Predictive Modeling Component
 - Useful for management



But Beyond The Modeling...

- Things we did right
 - **Ecological analysis**
 - Fire not significant influence
 - Species distribution/abundance patterns
 - **Careful, thoughtful approach to model development**
 - Justification for species grouping
 - Variable selection
 - Proper scale
 - Thorough evaluation
- Things that could have been better
 - **Better match in scale (resolution) between soil data and species data**
 - **Inclusion of other variables**
 - Moisture
 - Nutrients
 - Light
 - Fire intensity/severity
 - **Vague specification of phase of invasion process**
 - **Incorporation of biotic interactions**

In Conclusion

Jeane Dixon sees peace in 2000, defines mystic talent as 'God-given'

By [illegible]

WASHINGTON (AP) — Jeane Dixon, the mystic who predicted the end of the world in 1954, said she sees peace in 2000. Dixon, 75, said she has seen the future in her visions, which she has written down. She said she has seen the end of the world in 1954, but she has seen peace in 2000. She said she has seen the end of the world in 1954, but she has seen peace in 2000.

Dixon, a woman who has lived in the same house in Washington, D.C., since 1954, said she has seen the end of the world in 1954, but she has seen peace in 2000. She said she has seen the end of the world in 1954, but she has seen peace in 2000.

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And we will find and eradicate all invasive plants before they spread!