Introduction to Remote Sensing for Scenario-Based Ecoforecasting

Week 4: Overview of Species Distribution and State-And-Transition Simulation Modeling

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• Qualitative scenario planning has proven useful in a variety of contexts
• Quantitative information often desired or needed
• Quantitative methods include:
  – Species distribution modeling
  – Simulation modeling
Introduction to Species Distribution Modeling
Overview of Species Distribution & State-and-Transition Simulation Modeling

Introduction

Monitoring Strategies
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Introduction

• Invasive species control

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Introduction

- Risk assessment

Vall-llosera et al. 2017, Biological invasions
Species Distribution Models
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Species Distribution Models

Numerical relationships with the environment define where a species may be found

Do:

- identify areas with environmental conditions similar to where a species occurs

Do not:

- necessarily identify where a species actually is
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Species Distribution Models

- **Process** – mechanism; physiological constraints

- **Correlation** – pattern; based on current locations

![Graph showing survival rate vs. winter temperature](image)

![Maps illustrating species distribution models](image)

- **Species Distribution Models**
  - Correlation – pattern; based on current locations

- **Survival**
  - Winter temperature

![MAXENT model](image)

- **MAXENT**
  - Model algorithm
  - Map of suitability

[USGS and NASA logos]

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Species Distribution Models

• Where is it now?
  – mapping

• Where might it be?
  – potential

West et al. 2016, JoVE
Jarnevich et al. 2011, Western North American Naturalist
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Species Distribution Models

- **Model algorithm**
  - Suitability = f(Distance to water, mean temperature of warmest quarter, precipitation of wettest month, etc.)

- **Map of suitability**
  - Unsuitable
  - Suitable
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Species Distribution Models

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Species Distribution Models

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Species Distribution Models

- Soberon and Peterson 2005, Biodiversity Informatics

Realized range

Invadable area

Abiotic

Biotic

Movement

Soberon and Peterson 2005, Biodiversity Informatics
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Species Distribution Models

• Assessment

Arctic species in tropics

• Caveats

Jarnevich et al. 2015, Ecological informatics
VisTrails: SAHM software
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VisTrails: SAHM software

Morisette et al. 2013, Ecography
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VisTrails: SAHM software

Morisette et al. 2013, Ecography
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VisTrails: SAHM software

• Freely available software
• Google group: https://groups.google.com/forum/?fromgroups#!forum/vistrails-sahm
• Ecography paper
• User’s guide and tutorial
• Training materials https://my.usgs.gov/catalog/RAM/SAHM

VisTrails SAHM: visualization and workflow management for species habitat modeling

Jeffrey T. Murisette, Catherine S. Jarnewich, Tracy R. Holcomb, Colin R. Talbert, Drew Ignizio, Marian K. Talbert, Claudio Silva, David Koop, Alan Swanson and Nicholas L. Young

The Software for Animal Habitat Modeling (SAHM) has been created to both expedite habitat modeling and help maintain a record of the various input data, pre- and post-processing steps and modeling options incorporated in the construction of a species distribution model through the established workflow management and visualization VisTrails software. This paper provides an overview of the VisTrails/SAHM software, including a link to the open source code, a table detailing the current SAHM modules, and a single example modeling an invasive weed species in Rocky Mountain National Park, USA.
Species Distribution Modeling Conclusions
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Species distribution modeling conclusions

• No universally correct way!

• Methodology adapted to
  – Ecological and biogeographical situation
  – Meet study goals
  – Available data

• VisTrails: SAHM is one software option
Simulation Models
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Species Distribution Modeling

• Correlative models of abiotic variables & species occurrence
• Common tool for estimating species response to climate
• Does not project species distributions, models project suitable climates
• Does not account for disturbances, competition, or management

Overview of Species Distribution & State-and-Transition Simulation Modeling Simulation Models

• Computer-based prototype of real world
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Simulation Models

• Computer-based prototype of real world
• Many kinds of simulation models:
  – Climate
  – Population
  – Biogeochemistry
  – Dynamic Global Vegetation Models
  – Agent-Based Models
  – State-and-Transition Simulation Models
  – Etc…

Images: B. W. Miller
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Simulation Models

• Why Simulations?
  – Integrate data
  – Identify data gaps and influential uncertainties
  – Reproduce complexity
    • Thresholds, secondary effects, emergence
  – Understand processes
  – Explore “what if...?” scenarios

• What can’t they do?
  – Create scenarios
  – Capture everything
  – Statistical analysis
  – Give you the answer
State-and-Transition Simulation Models
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State-and-Transition Simulation Models

- **States**: any suite of vegetation communities

- **Transitions**: process (natural or management) that can move vegetation between states

Source: Westoby et al. (1989)

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State-and-Transition Simulation Models

- Stochastic simulation models
- Run using software
- Can be spatially explicit
- Model Inputs:
  - Transition probabilities and/or targets
  - Area in each state today
- Model Outputs:
  - Area in each state over time
  - Area transitioned over time
- \( \rightarrow \) Predict vegetation dynamics (w/uncertainty)

Slide credit: modified from L. Frid
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State-and-Transition Simulation Models

Image: L. Frid

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State-and-Transition Simulation Models

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State-and-Transition Simulation Models


Image: L. Frid
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State-and-Transition Simulation Models

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State-and-Transition Simulation Models

→ Monte Carlo simulations provide uncertainty estimates in forecasts

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State-and-Transition Simulation Models

- Optional Model Features
  - Spatial autocorrelation (e.g., clustering)

![Diagram showing state-and-transition models with and without spatial autocorrelation]

$P_{cell,t} = 1 \rightarrow$ spatially-explicit external model

Image: L. Frid
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State-and-Transition Simulation Models

• Optional Model Features
  – Spatial autocorrelation (e.g., clustering)
  – Spatial and/or temporal variability in transitions (e.g., jurisdictions, fire)

Image: L. Frid
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State-and-Transition Simulation Models

• Optional Model Features
  – Spatial autocorrelation (e.g., clustering)
  – Spatial and/or temporal variability in transitions (e.g., jurisdictions, fire)
  – Management targets (e.g., exotic species inventory and treatment)

Image: L. Frid
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State-and-Transition Simulation Models
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ST-Sim Software

- Free software for building and running STSMs: www.apexrms.com
- Released in 2013
- Next generation of TELSA & VDDT
- 15 peer-reviewed publications since 2014
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ST-Sim Software

• Video Tutorials

• “SyncroSim” -> “Getting Started”

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ST-Sim Software
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Conclusions

- State-and-Transition Simulation Models (STSMs)
  - Integrate existing knowledge
  - Identify data gaps & research priorities
  - Explore “what if” climate & management scenarios
- Simulations can leverage the strengths of other methods (e.g. species distribution modeling)
Questions?