Modeling of Wildlife and Habitat: An Overview

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Overview of the Presentation

1. Predictive Modeling
2. Wildlife and Habitat Data
3. Case Study White Stork
4. Policy Context + Outlook

Wildlife Data: Presence/Absence

- Pres.
- Abs.

PS. This works also with abundances

Wildlife Data

Wildlife Surveys
Telemetry (Satellite or Radio)
‘Presence Only’ e.g. Museum Collections, Interviews
Wildlife Data: Survey Data (Land)

Breeding Bird Survey (Sage Grouse)

(available on Internet for free: http://www.mbr-pwrc.usgs.gov/bbs/bbs96t3.htm)

Wildlife Data: Survey Data (Ocean)

1966-1992
R.B. Brown & T. Lock / CWS

10min counts
Index Relative Abundance
Freely available

For more details see:
CWS Metadata, or
Brown et al. 1975
Diamond 1986
Lock et al. 1994
Huettemann 2000

Wildlife Data: Satellite Telemetry

All GPS Bears 1999-2002 by strata

Data:
Alberta Foothills
Model Forest, G. Stenhouse

Geographic Information System (GIS) as the Spatial Modeling Platform

Source
T. Gottschalk
The Techno Geek vs. The Biologist/Conservationist

Habitat Use

The GIS Overlay

Habitat Preference

Pres Abs

Why Predictive Modeling: Prediction

1. Consistent Coverage (and Variance)
2. (Cost Efficient) Survey Effort

Gray Wolves Mladenoff et al. 1996

Modeling is not a competing and/or theoretical exercise, but an integral part of (wildlife) research and management projects.

Before -> During -> After -> Future
Hypothesis  Field Work  Refinement  Policy

When Predictive Modeling

Modeling is not a competing and/or theoretical exercise, but an integral part of (wildlife) research and management projects.

Before  ->  During  ->  After  ->  Future
Hypothesis  Field Work  Refinement  Policy

=> Feedback Loop (Adaptive Management)
1. **Inference**: What predictors determine the wildlife distribution and abundance?

2. **Prediction**: Where do we find animals in the study area?
Concept of Predictive Spatial Modelling

**Wildlife Survey Data**

- Environment 1
- Environment 2
- Environment 3

Predicted Wildlife Presence

between 0 and 1

Use vs. Availability

- Test
- Predict

Wildlife Survey Data

between 0 and 1

Learning Area (⇒Inference) Test/Prediction Area

Concept of Predictive Spatial Modelling

- Animal YES/NO ~ Habitat 1 + Habitat 2 + Habitat 3 ...

Traditional Modeling: GLMs

Generalized Linear Models (GLM)

Animal YES/NO ~ Habitat 1 + Habitat 2 + Habitat 3 ...

Logit (Response P/A) ~ α + β1predictor1 + β2predictor2 + β3predictor3
Traditional Modeling: GLMs

Generalized Linear Models (GLM)

Animal YES/NO $\sim$ Habitat 1 + Habitat 2 + Habitat 3 ...

Logit (Response P/A) $\sim \alpha + \beta_1 predictor1 + \beta_2 predictor2 + \beta_3 predictor3$...

\[
\frac{\alpha + \beta_1 predictor1}{1 + e}
\]

$\Rightarrow$ 'valid' inference and prediction

Traditional Modeling: Spatial

Resource Selection Functions (RSF)


Model Applications


and many others...

‘Progressive’ Modeling

Animal YES/NO $\sim$ Habitat 1 + Habitat 2 + Habitat 3 ...

CART

TreeNet

MARS

NNET

GARP

BioMapper, Mahalanobis...

$\Rightarrow$ 'valid' inference and prediction ?!

Movements of the Short-tailed Albatross

Legend:

- Breeding-Area
- Study-Area
- Suggested Migration

Almost no Short-tailed Albatross Sightings off B.C. (Morgan et al. 1991)
Study-Area and Short-tailed Albatross Sightings (1940-2001)

Legend:
- Sightings
  - July
  - August
  - remaining months

Progressive Modeling: A Multispecies Outlook...
Credit: NCEAS ‘Biodiversity Alternative Modeling’ Working Group: Australian Wet Tropics (Reptiles, Plants, Insects and Birds)

Short-tailed Albatross Predictions: MARS (mean predictions across months)

Legend:
- Index of Presence/Random:
  - -0.05 - 0
  - 0 - 0.01
  - 0.01 – 0.02
  - 0.02 – 0.25

Accuracy Measure

Species

John Elder’s ‘Ensemble Models’
Global Data Sets
...freely available...

PS. Also exist for oceans...

Case Study: White Stork Model
Do habitat preferences and niches stay consistent among individuals (juveniles) when inferred from spatial modeling?

A Satellite Telemetry Study with a removal design

Landcover (SAGE/HYDE)
Data Freely Available
Digital Elevation Model (DEM)

Air Temperature Mean August (CRU)

Precipitation Mean August (CRU)

Hydrology (CSER)

Data Freely Available
Distance to Hydro Features

Via GIS computations

Human world population (SAGE/HYDE)

Data Freely Available

Human footprint (CIESIN)

Data Freely Available

The Animals to Model...
The Animals to Model…

Stork details:
- Origin: Rybachy, (Kaliningrad/Russia)
- Ciconia ciconia ciconia
- juveniles & unknown gender
- individuals from different nests
- taken from nest before fledging
- Rybachy + transported to Samara (by air/boat) and Omsk (air/car)
- released in good/wet habitats

The fieldwork

Dr. N. Chernetsov with Stork
The fieldwork

Satellite Transmitter

Sophisticated Stork Travel Device (Box)

The fieldwork
Storks on the Map
Training Data

(Removed &
Released Birds)

Omsk
n=3

Samara
n=7

Rybachy
n=3

Presence vs. Pseudoabsences (Random)

Presence vs. Pseudoabsences (Random)

Presence

Absence

The Stork Model

Pres/Abs ~ DEM + Air Temp + Prec. + Dist. Hydro + Landuse + Human Population

Buffer diameter 50km
1 random point per km²

=> Training Data
The Stork Model

Pres/Abs \sim \text{DEM} + \text{Air Temp} + \text{Prec.} + \text{Dist. Hydro} + \text{Landuse} + \text{Human Population}

Inference + Predictions

CART
(Breiman et al.
Salford Systems Inc.)

The Stork Model

Pres/Abs \sim \text{DEM} + \text{Air Temp} + \text{Prec.} + \text{Dist. Hydro} + \text{Landuse} + \text{Human Population}

CART
(Breiman et al.
Salford Systems Inc.)

Pruning

Importance Value

correctly predicted absence app. 77%
correctly predicted presence app. 65%
The Stork Model (CART)

Pres/Abs ~ DEM + Air Temp + Prec. + Dist. Hydro + Landuse + Human Population

CART (Breiman et al., Salford Systems Inc.)

Pruning

Importance Value

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PREDICTIONS

Predictions: Rybachy Release (ID14)

Predictions: Rybachy Release (ID14)

Expert Knowledge of Stork Migration Flyways vs ‘Rybachy (ID14) Model

Avian Demography Unit
Capetown

=>Evaluation across months ?!
'Zoom in' of a Control Bird

Control Bird

‘Rybachy (ID 14)’ Model

Evaluation of points across scales and shapes ?!

Predictions: Omsk Release (ID36) Removed Birds

Predictions: Samara Release (ID13) Removed Birds
Comparison across CART Predictions and Release Sites

Rybachy  Omsk  Samara

These pixels these pixels...

=> The model (algorithm) must be wrong...

The Stork Model (TreeNet)

Pres/Abs ~ DEM + Air Temp + Prec. + Dist. Hydro + Landuse + Human Population

TreeNet
(Breiman et al.
Salford Systems Inc.)
The Stork Model (TreeNet)

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Pruning

Comparison across Predictions and Release Sites
Rybachy  Omsk  Samara

Comparison across Predictions and Release Sites
Rybachy  Omsk  Samara
Comparison across Predictions and Release Sites

Rybachy  Omsk  Samara

CART

TreeNet

Expert Knowledge

⇒Dueling Models
(what is truth ?)

‘Truth’ is brought by evaluation data ...

Africa

Global Oceans
Conclusions

Need more stork data...
So far, models are not very strong, yet (this is an extreme modeling exercise with low #presences, though)
General support for known Flyway (=Wintering) Habitat exists
Habitat Preferences seem to be ‘somewhat’ similar among birds
Meaningful model accuracy tests needed
Once established: A potential policy tool…
A Global Policy Context?

A potential policy tool...

Migratory Bird Act

RAMSAR

CMS/Bonn

CEC/NAFTA

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Traditional Modeling: GLM Crux

1. Model/Predictor Selection: p-values vs. AIC (Burnham and Anderson 2001)

2. Model Fit

Wildlife Data: ‘Presence Only’

- Pres.
- e.g. obtained from -sightings -opportunistic surveys -specimens -interviews -telemetry

‘No Confirmed Absence’ => Pseudo absence/random
Traditional Modeling: Spatial

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and many others…

THE PROBLEM

=> DATA and INFORMATION GAPS in field data

> to be overcome by predictions/extrapolations (=modeling)