 +  = ?!

Modeling of Wildlife and Habitat: An Overview

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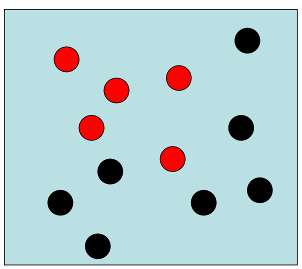
Overview of the Presentation

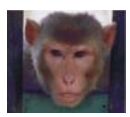
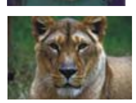

1. Predictive Modeling
2. Wildlife and Habitat Data
3. Case Study White Stork
4. Policy Context + Outlook


Wildlife Data: Presence/Absence

Pres.

Abs.



PS. This works also with abundances

Wildlife Data

Wildlife Surveys

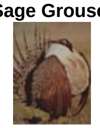
Telemetry (Satellite or Radio)

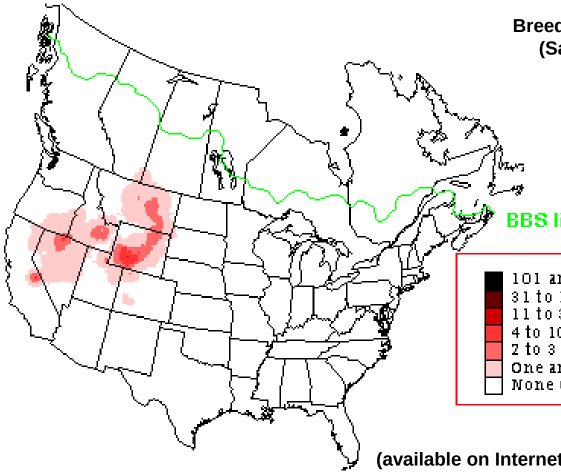
'Presence Only' e.g. Museum Collections, Interviews

1
12
5
10
15

Wildlife Data: Survey Data (Land)

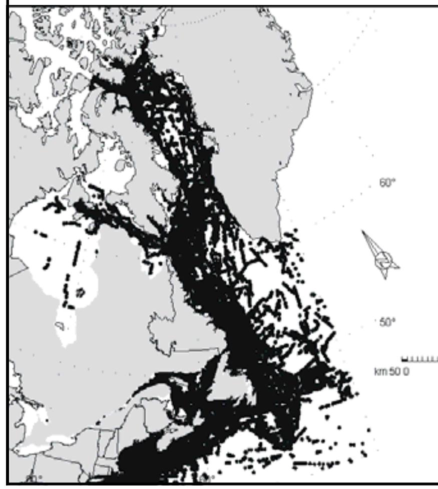
Breeding Bird Survey
(Sage Grouse)





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

Wildlife Data: Survey Data (Ocean)



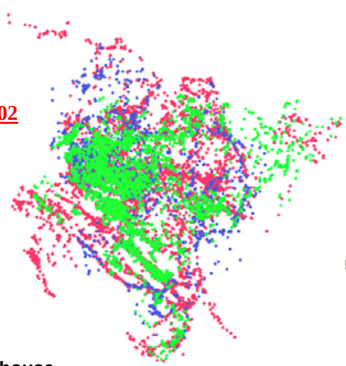
1966-1992
R.B. Brown & T. Lock / CWS

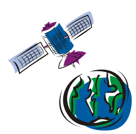
10min counts
Index Relative Abundance
Freely available

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

Wildlife Data: Satellite Telemetry

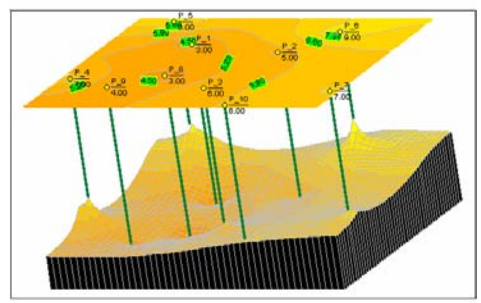
All GPS Bears 1999-2002
by strata





Data:
Alberta Foothills
Model Forest, G. Stenhouse

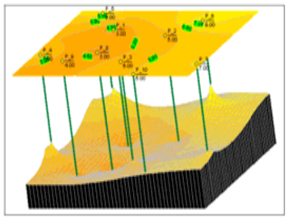
Geographic Information System (GIS) as the Spatial Modeling Platform



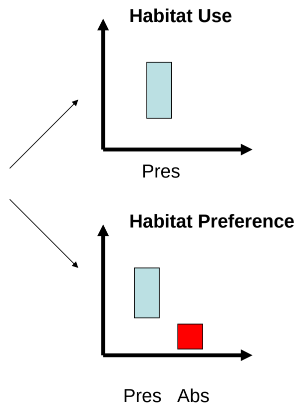
=>GIS
Overlay &
Mapping

Source
T. Gottschalk

The Techno Geek vs.
The Biologist/ Conservationist



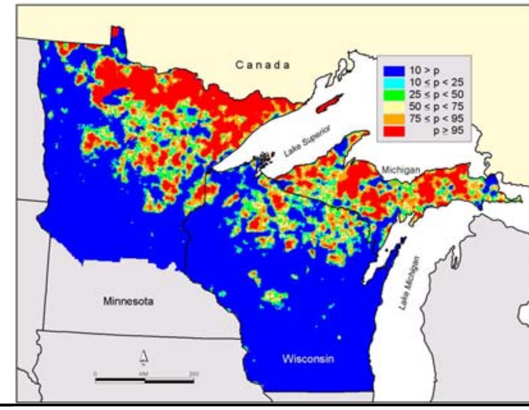
The GIS Overlay



Why Predictive Modeling: Prediction

1. Consistent Coverage (and Variance)

2. (Cost Efficient) Survey Effort



Gray Wolfs
Mladenoff et al.
1996

=> science
=> 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

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

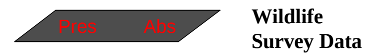
=>Feedback Loop (Adaptive Management)

Why Predictive Modeling for Wildlife/Habitat

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



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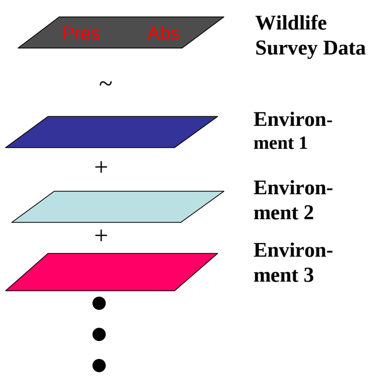
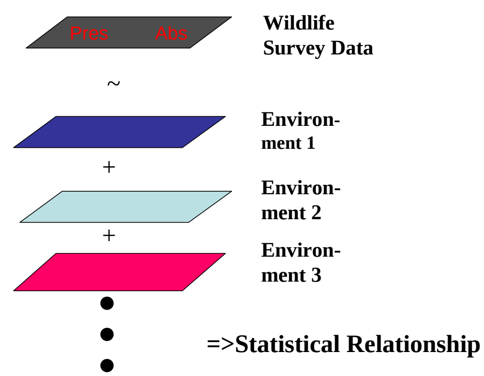


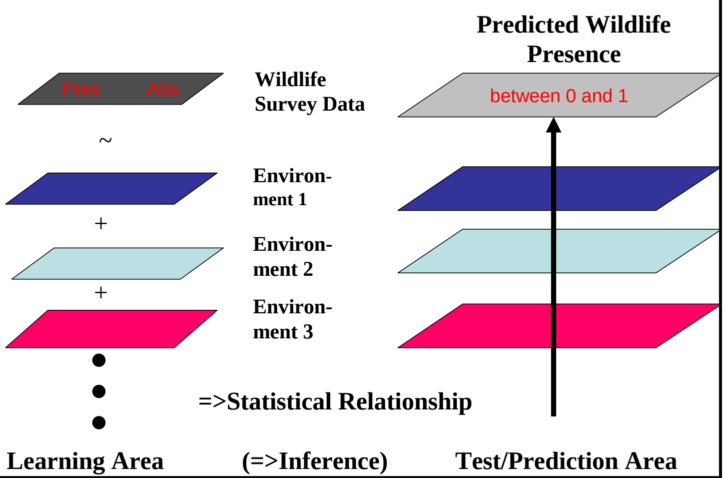
Learning Area

Concept of Predictive Spatial Modelling



Learning Area **(=>Inference)**

Concept of Predictive Spatial Modelling



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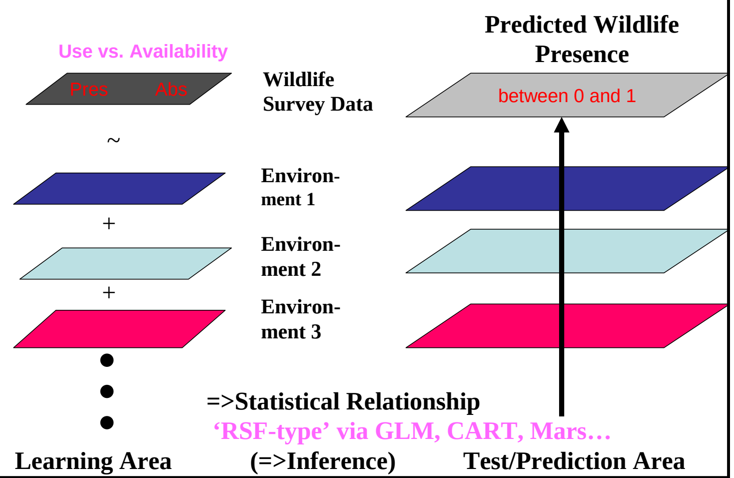

Traditional Modeling: GLMs

Generalized Linear Models (GLM)

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

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Logit (Response P/A) ~ $\alpha + \beta 1$predictor1 + $\beta 2$predictor2 + $\beta 3$predictor3

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Generalized Linear Models (GLM)

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

Logit (Response P/A) ~ $\alpha + \beta 1$predictor1 + $\beta 2$predictor2 + $\beta 3$predictor3..

$$\text{Prob.} = \frac{e^{\alpha + \beta 1 \text{ predictor1} \ldots}}{1 + e^{\alpha + \beta 1 \text{ predictor1} \ldots}}$$

=>'valid' inference and prediction

Traditional Modeling: Spatial

Resource Selection Functions (RSF)

Manly, B., L. McDonald, D. L. Thomas, T. L. McDonald and W. P. Erickson. 2002. Resource Selection by Animals. Kluwer Academic Publishers.

Model Applications

Scott, M.J., P. J. Heglund, M.L. Morrison, J.B. Haufler, M.G. Raphael, W. A, Wall and F.B. Samson. 2002. Predicting Species Occurrences: Issues of Accuracy and Scale. Island Press.

and many others…

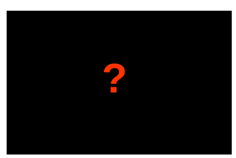
'Progressive' Modeling

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

Non-linear Algorithms

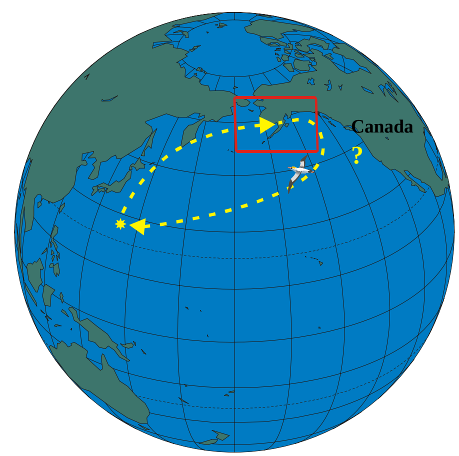
- CART
- TreeNet
- MARS
- NNET
- GARP
- BioMapper, Mahalanobis…

The Black Box



=>'valid' inference and prediction ?!

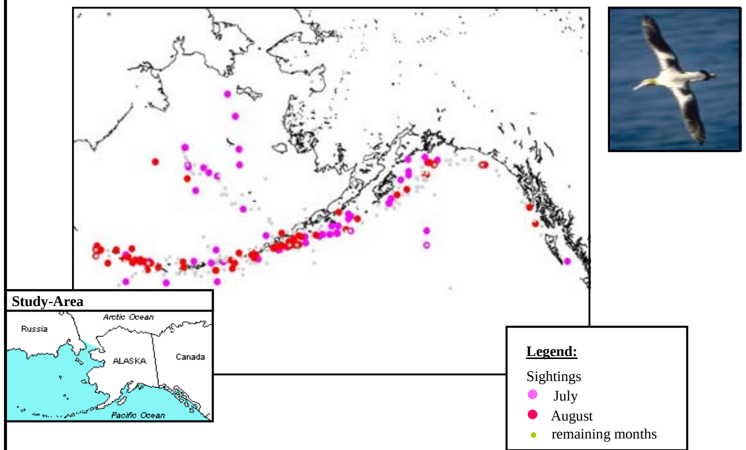
Movements of the Short-tailed Albatross



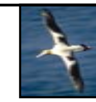
Legend:
- Breeding-Area
- Study-Area
- Suggested Migration

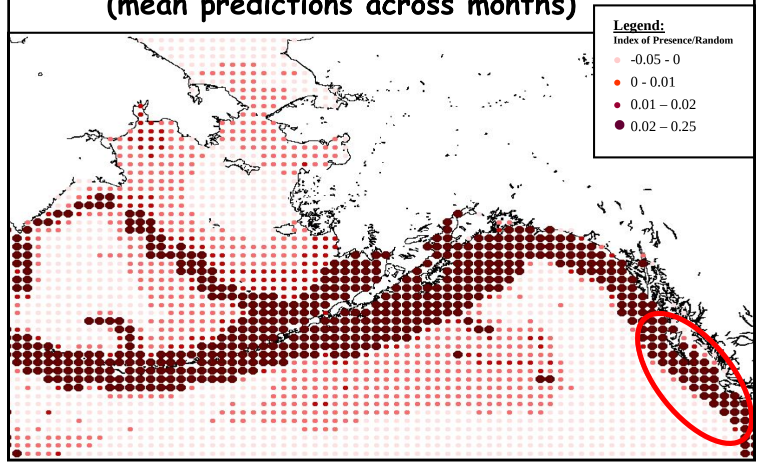
Almost no Short-tailed Albatross Sightings off B.C. (Morgan et al. 1991)

Study-Area and Short-tailed Albatross Sightings (1940-2001)



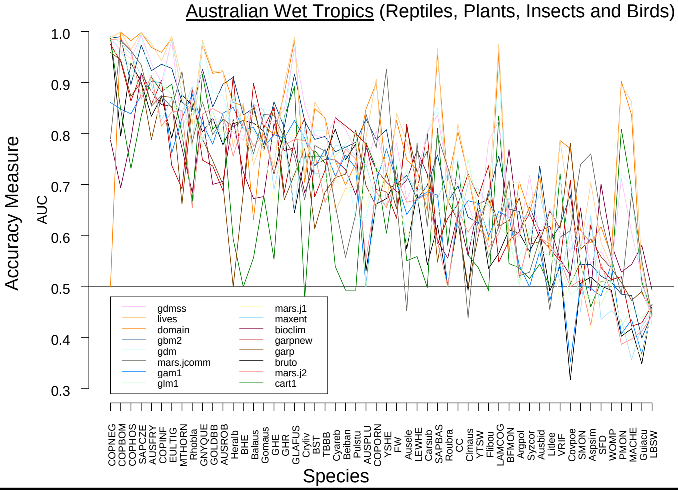
Short-tailed Albatross Predictions: MARS (mean predictions across months)





Progressive Modeling: A Multispecies Outlook…

Credit: **NCEAS** 'Biodiversity Alternative Modeling' Working Group:
Australian Wet Tropics (Reptiles, Plants, Insects and Birds)



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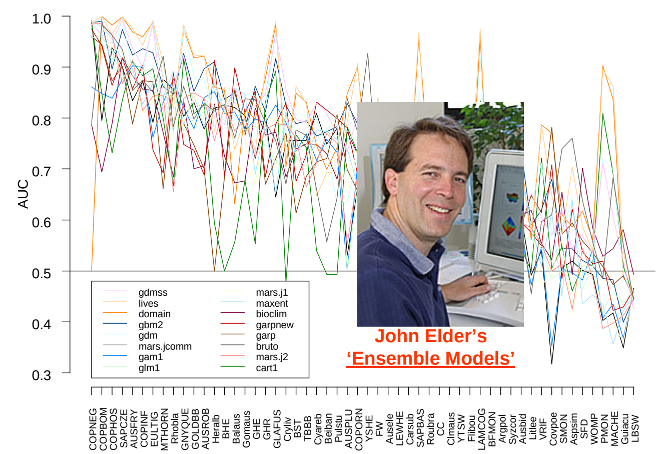
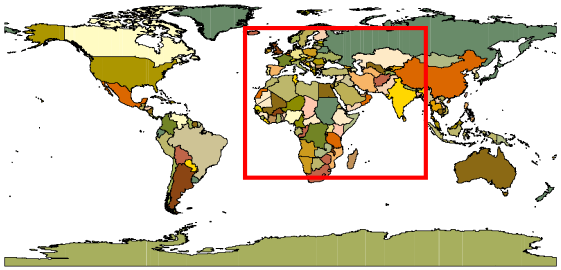


John Elder's
'Ensemble Models'

Global Data Sets ?!

…freely available…



PS. Also exist for oceans…

Case Study: White Stork Model

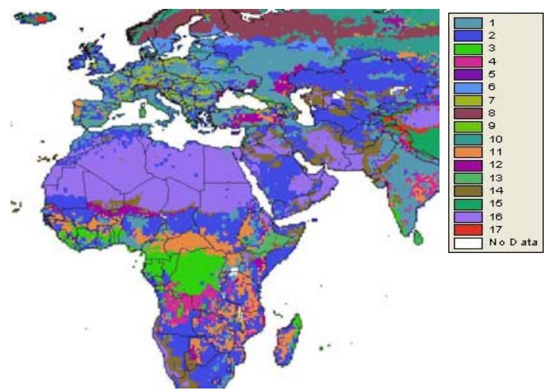
Do habitat preferences and niches stay consistent among individuals (juveniles) when inferred from spatial modeling ?

A Satellite Telemetry Study with a removal design

+

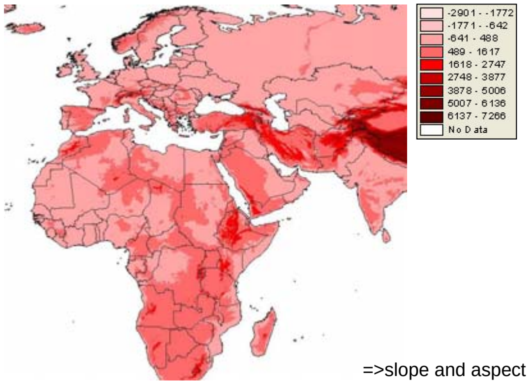
= ?!

Landcover (SAGE/HYDE)



Data Freely Available

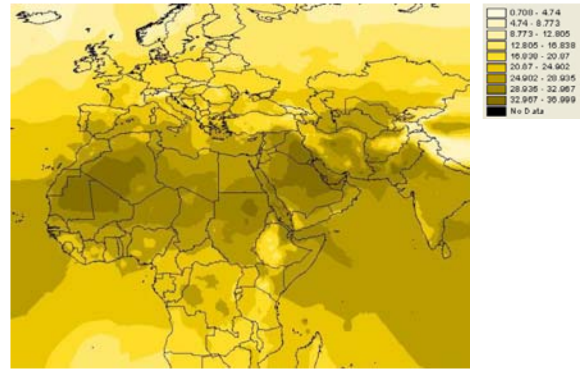
Digital Elevation Model (DEM)



=>slope and aspect

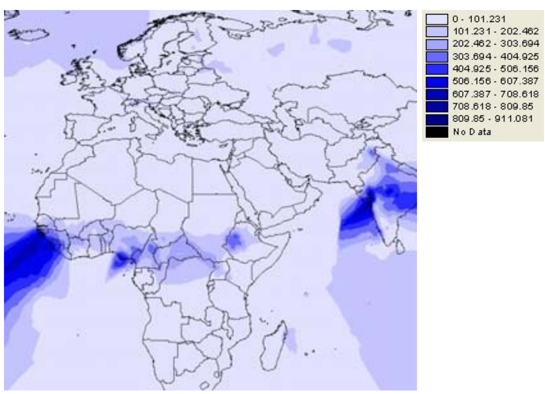
Data Freely Available

Air Temperature Mean August (CRU)



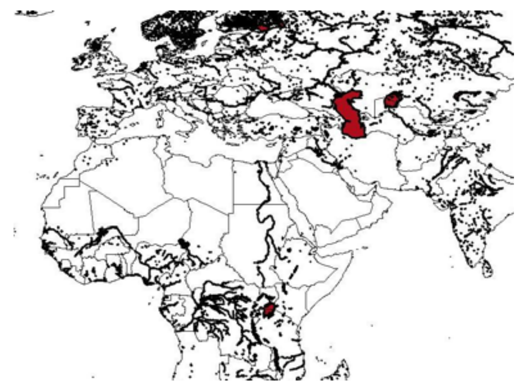
Data Freely Available

Precipitation Mean August (CRU)



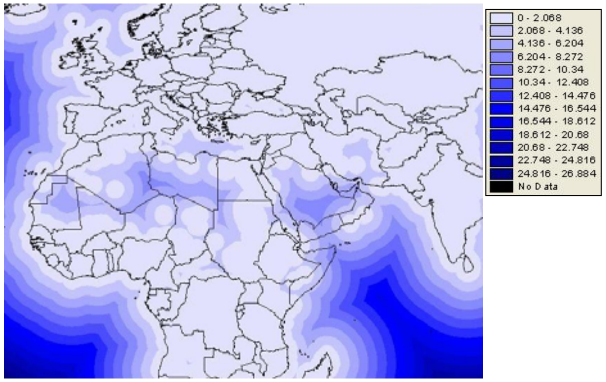
Data Freely Available

Hydrology (CSER)



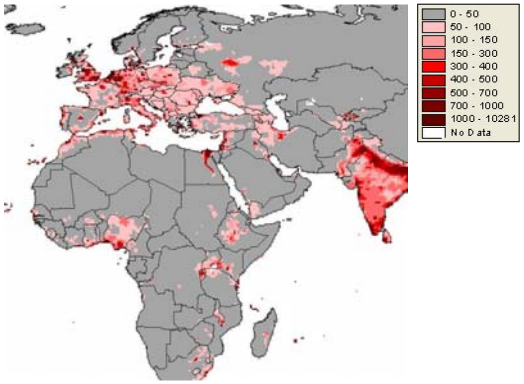
Data Freely Available

Distance to Hydro Features



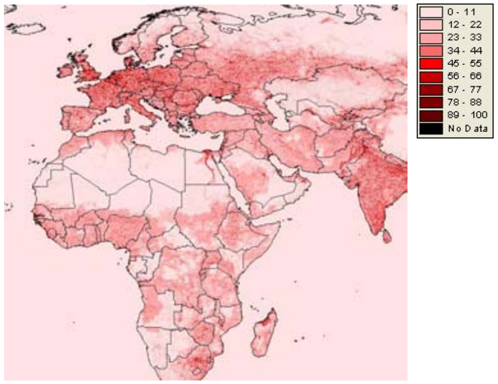
Via GIS computations

Human world population (SAGE/HYDE)



Data Freely Available

Human footprint (CIESIN)



Data Freely Available

The Animals to Model…

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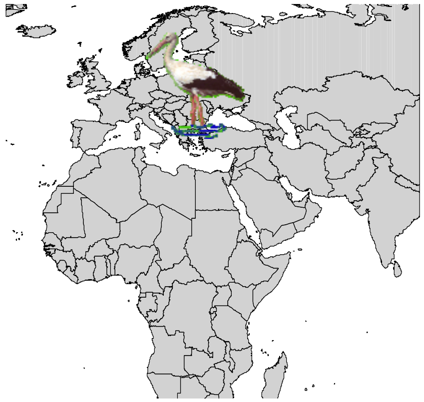


Data Not Freely Available, yet (but FGDC NBII Metadata on UAF & USGS server)

Stork details:

-Origin: Rybachy, (Kaliningrad/Russia)

-Ciconia ciconia ciconia

-juveniles & unknown gender

-individuals from different nests

-taken from nest before fledging

-original study goal: "Clock and Compass Hypothesis"
(Chernetsov et al. 2004. Migratory orientation of first-year white storks: inherited information and social Interactions. J. Exp. Biol. 207(6): 937-943)

-Rybachy + transported to Samara (by air/boat) and Omsk (air/car)

-released in good/wet habitats

The fieldwork

The fieldwork

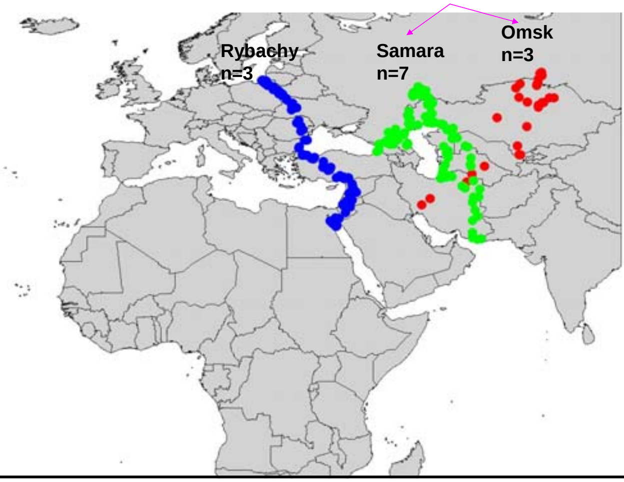
The fieldwork

The fieldwork

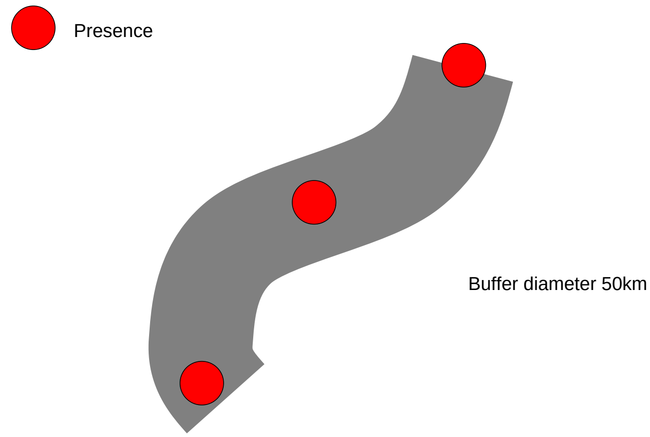

Dr. N. Chernetsov without Stork


beep beep beep…

Storks on the Map
Training Data
(Removed & Released Birds)



Presence vs. Pseudoabsences (Random)



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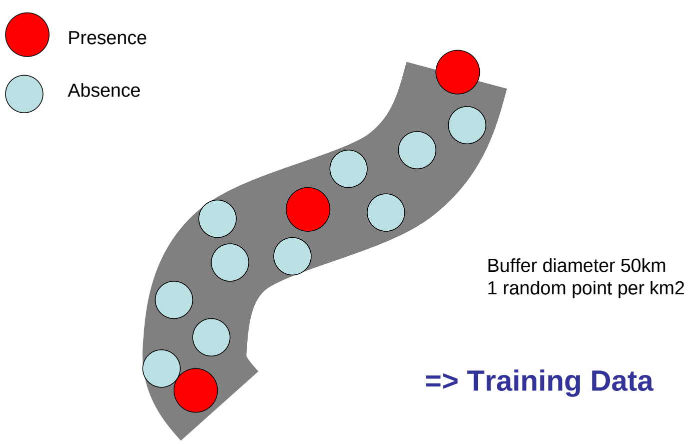


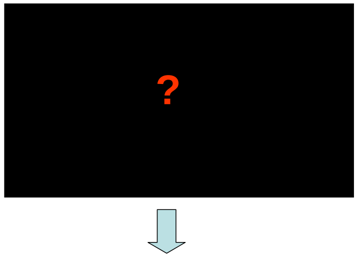
=> Training Data

The Stork Model

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

The Stork Model

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

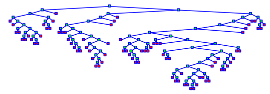


Inference + Predictions

The Stork Model

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

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



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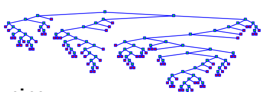
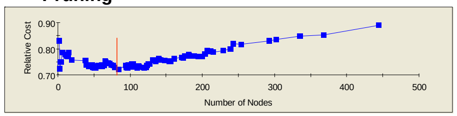


Pruning



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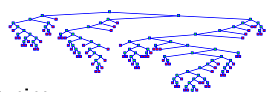

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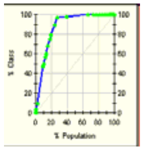
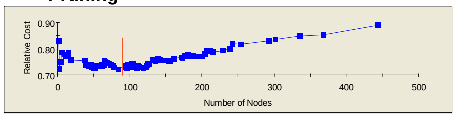




correctly predicted absence app. 77%
correctly predicted presence app. 65%

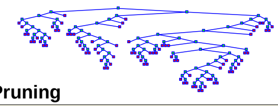
Importance Value

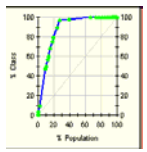
DEM	100.00	|||||||||||||||||||||||||||||||||||||||
TAIR_AUG	77.58	||||||||||||||||||||||||||||||
PREC_AUG	69.46	|||||||||||||||||||||||||||
HYDRO	54.59	|||||||||||||||||||||
POP	47.39	||||||||||||||||||
LDUSE	40.88	||||||||||||||||

The Stork Model (CART)

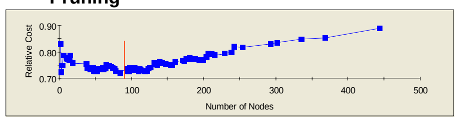
Pres/Abs ~ DEM + Air Temp + Prec. + Dist. Hydro + Landuse + Human Population

CART
(Breiman et al.
Salford Systems Inc.)





Pruning



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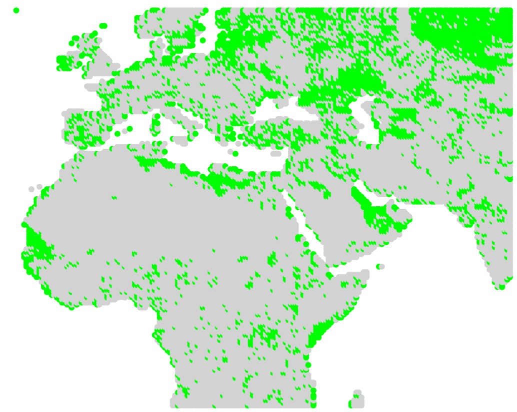
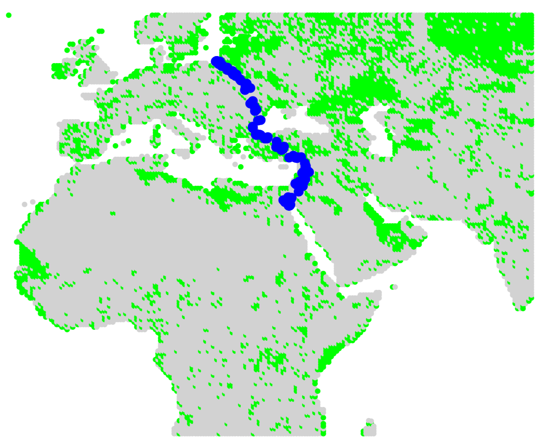
PREDICTIONS

Predictions: Rybachy Release (ID14)



Predictions: Rybachy Release (ID14)

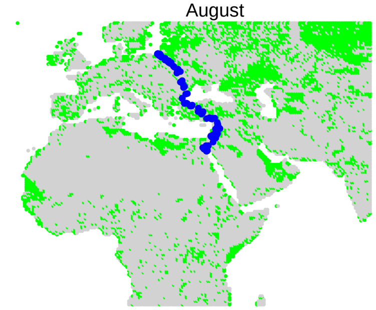


Expert Knowledge of Stork Migration Flyways vs 'Rybachy (ID14) Model

Whole year average

Avian Demography Unit Capetown

August



=>Evaluation across months ?!

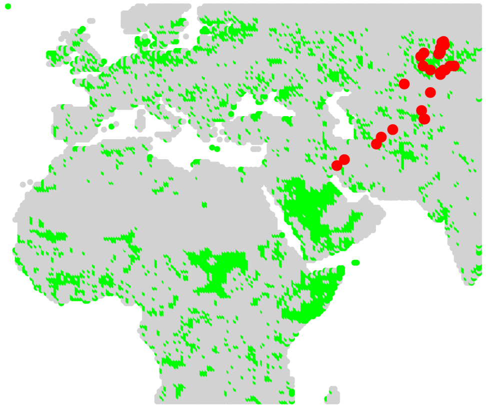
‘Zoom in’ of a Control Bird

Control Bird

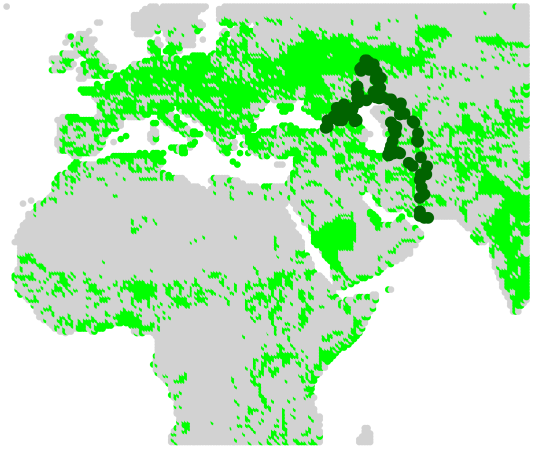
‘Rybachy (ID 14)’ Model

=>Evaluation of points across scales and shapes ?!

Predictions: Omsk Release (ID36) Removed Birds

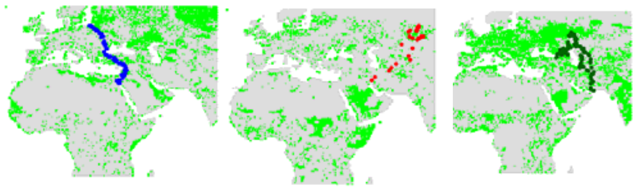


Predictions: Samara Release (ID13) Removed Birds



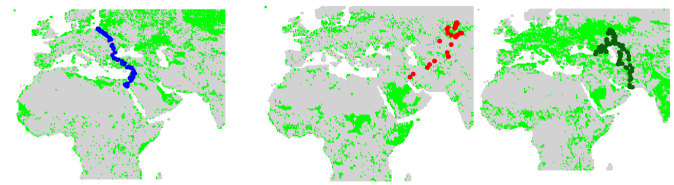
Comparison across CART Predictions and Release Sites

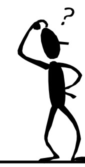
Rybachy Omsk Samara



Comparison across CART Predictions and Release Sites

Rybachy Omsk Samara





These pixels these pixels…

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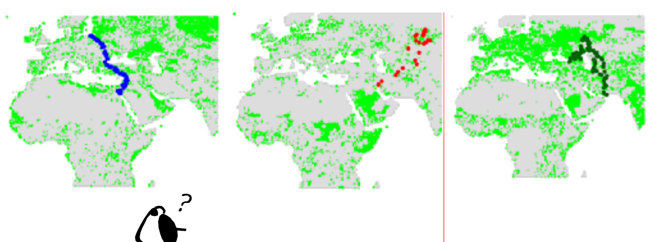
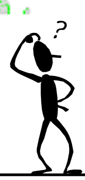




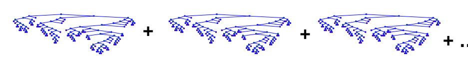
These pixels these pixels…

=> 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.)



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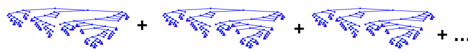
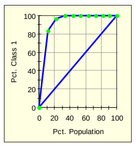
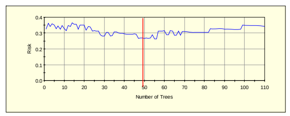




Pruning



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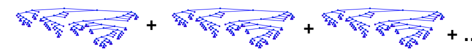
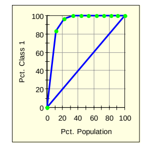
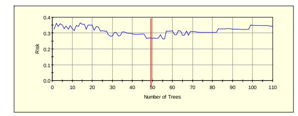




Pruning



Importance Value

Variable	Score
LDUSE 100.00	|||||||||||||||||||||||||||||||||||||
TAIR_AUG 97.62	||||||||||||||||||||||||||||||||||||
HYDRO94.35	|||||||||||||||||||||||||||||||||||
DEM94.01	||||||||||||||||||||||||||||||||||
PREC_AUG 90.17	|||||||||||||||||||||||||||||||||
POP 82.54	||||||||||||||||||||||||||||||
HMFPT81.46	||||||||||||||||||||||||||||||

correctly predicted absence app. 100%
correctly predicted presence app. 85%

PREDICTIONS

Comparison across Predictions and Release Sites

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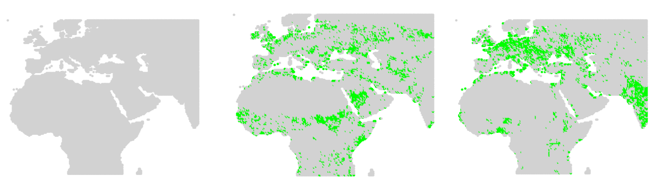
TreeNet



Comparison across Predictions and Release Sites

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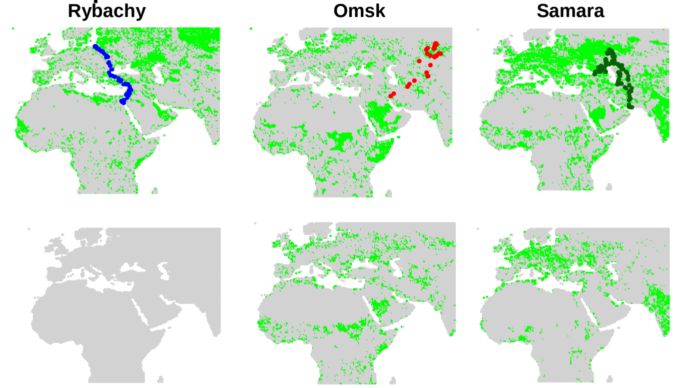
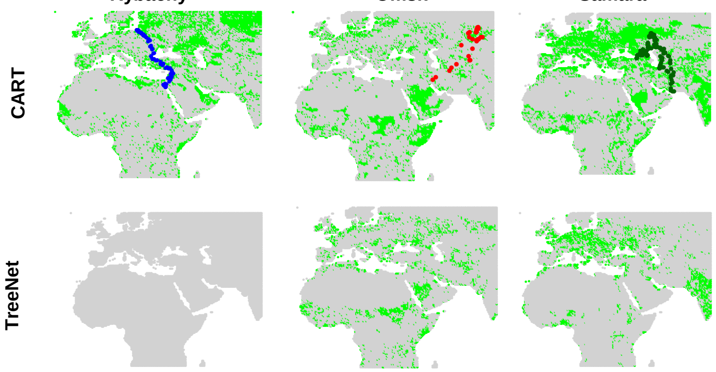
CART

TreeNet

Expert Knowledge



Comparison across Predictions and Release Sites



⇒Dueling Models
(what is truth ?)

‘Truth’ is brought by evaluation data …

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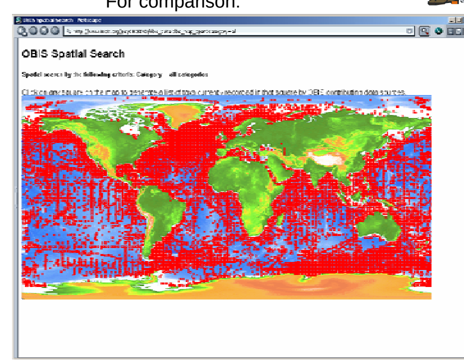
Africa

‘Truth’ is brought by evaluation data …

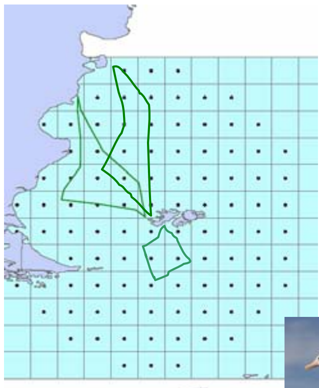
Africa

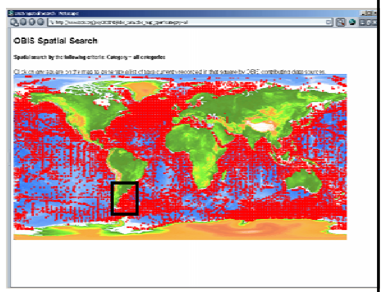
For comparison:



Global Oceans

The Ocean Example





Credit: Jon Syder et al.

Black-browed Albatross
GPS locations foraging

Conclusions

<u>Need more stork data…</u>

So far, models are not very strong, yet
(this is an extreme modeling exercise with low #presences, though)

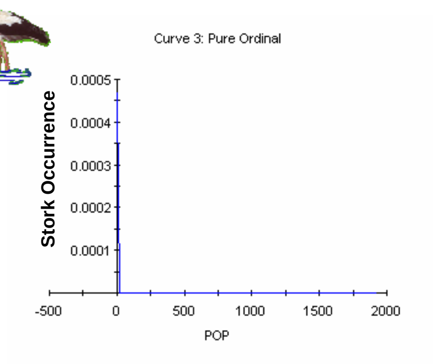
General support for known Flyway (=Wintering) Habitat exists

Habitat Preferences seem to be 'somewhat' similar among birds

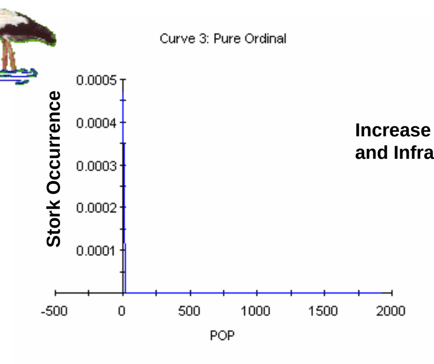
Meaningful model accuracy tests needed

Once established: A potential policy tool…

Inference (taken from MARS Model)



Inference (taken from MARS Model)

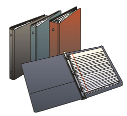


Increase in Human Population and Infrastructure ?

A Global Policy Context ?

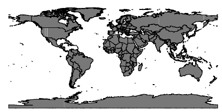
A potential policy tool…

Migratory Bird Act



RAMSAR

CMS/Bonn



CEC/NAFTA

English Español Français
North American Commission for Environmental Cooperation
Three countries working together to protect our shared environment

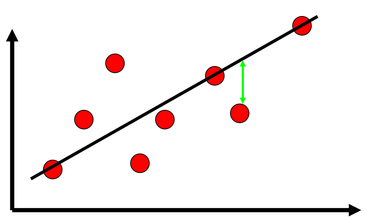
Acknowledgements

Vogelwarte Rybachy, Prof. P. Berthold, Vogelwarte Radolfzell, University of Alaska-Fairbanks, J. & S. Linke, B. Bluhm (OBIS map), L. Strecker, EWHALE lab, and many others

Traditional Modeling: GLM Crux

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

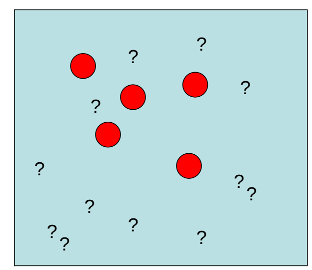
2. Model Fit



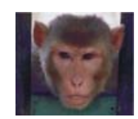
'Mean'
SD

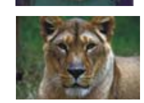
Wildlife Data: 'Presence Only'

Pres.



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





'No Confirmed Absence'

=> Pseudo absence/random

Traditional Modeling: Spatial

Resource Selection Functions (RSF)

Manly, B., L. McDonald, D. L. Thomas, T. L. McDonald and W. P. Erickson. 2002. Resource Selection by Animals. Kluwer Academic Publishers.

Model Applications

Scott, M.J., P. J. Heglund, M.L. Morrison, J.B. Haufler, M.G. Raphael, W. A, Wall and F.B. Samson. 2002. Predicting Species Occurrences: Issues of Accuracy and Scale. Island Press.

and many others…

THE PROBLEM

=> DATA and INFORMATION GAPS in field data

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