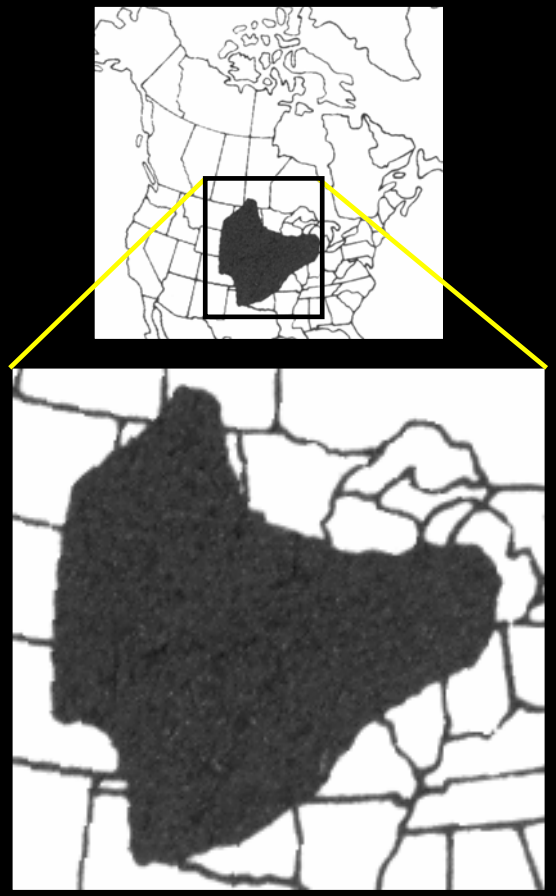
Outline

- *Quick* overview of range models
- Where are we now?
  - Predicting where species are today and where they are going tomorrow.
  - RS needs
- Suggestions on where to go in the future.
  - What tools are indispensable?

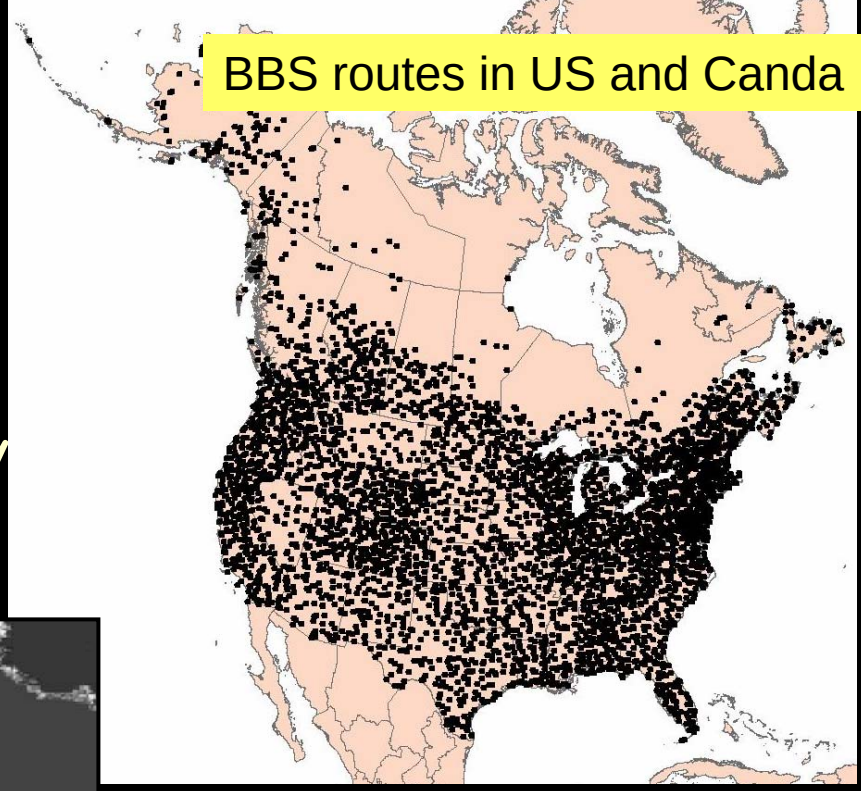
Species range models

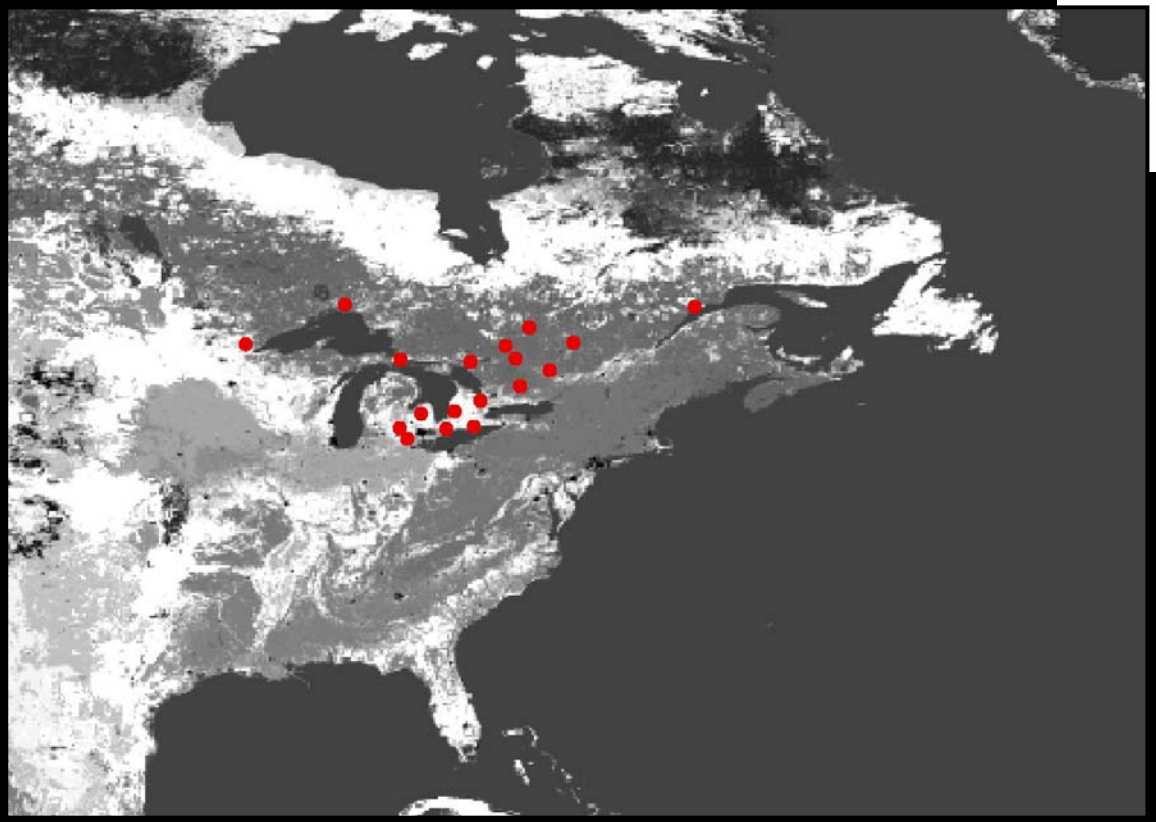
- Knowing where species are found is the first step in conserving them.
- These have come a long way…
- Systematists usually map observations, only sometimes extrapolating to continuous ranges.
- Quantitative accuracy assessments are not part of this process.



Species range models

- Data for some species are readily available.
- Most species are, at best, data deficient, limiting the reliability of further model efforts.





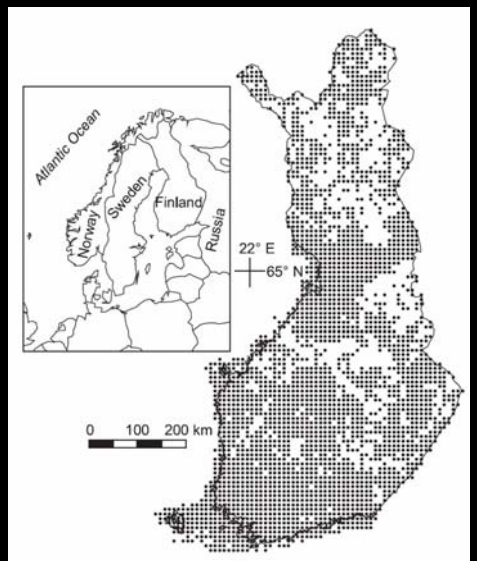
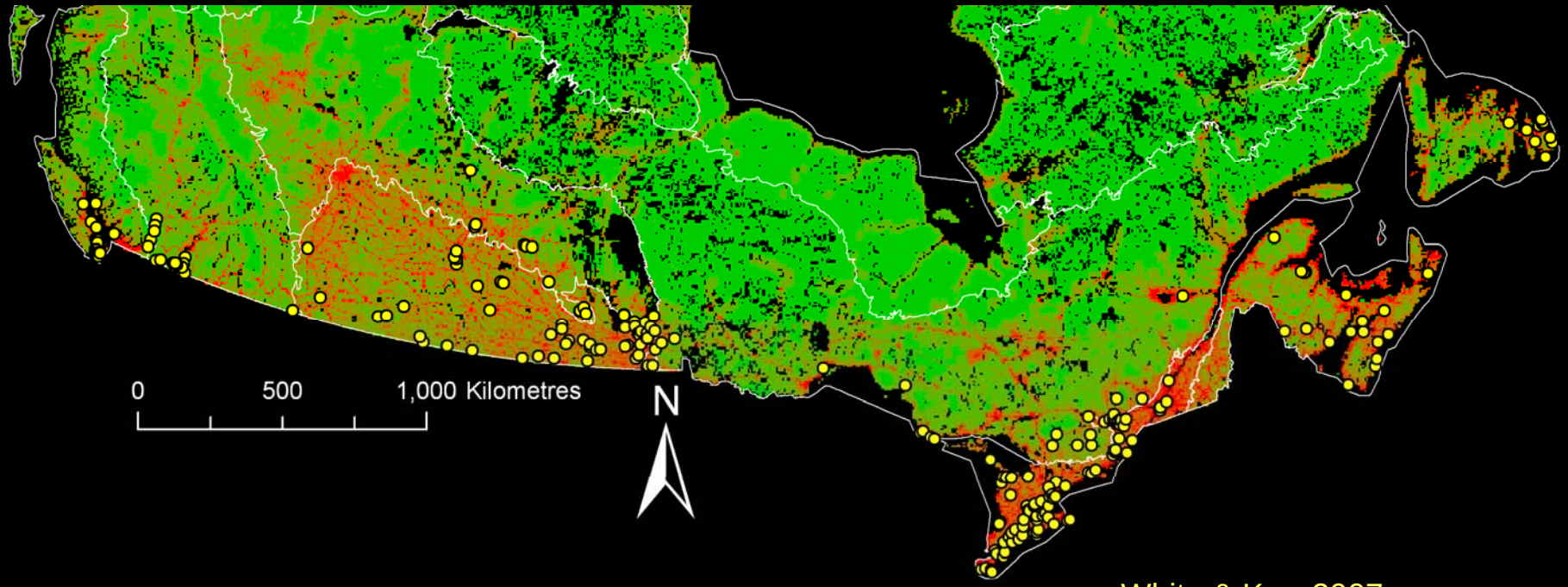


Figure 1 Location of Finland in northern Europe and the distribution of 10 × 10 km squares with good quality bird data available in Finland.

Species range models

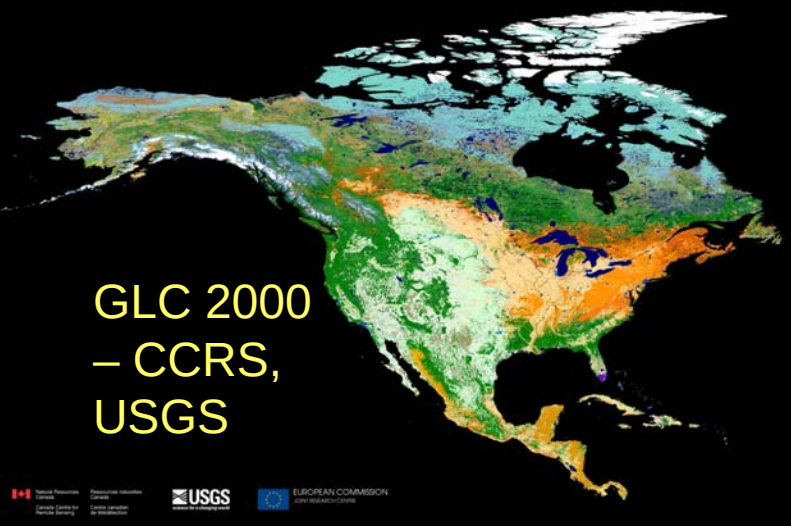
- Many quantitative methods for modeling ranges are now available
  - e.g. bioclimatic models, GAP models, GARP, logistic regression, regression trees, GAMs, Maximum entropy, etc…
  - These methods rely on biophysical data (including RS) to translate a small number of observations into synoptic range models.

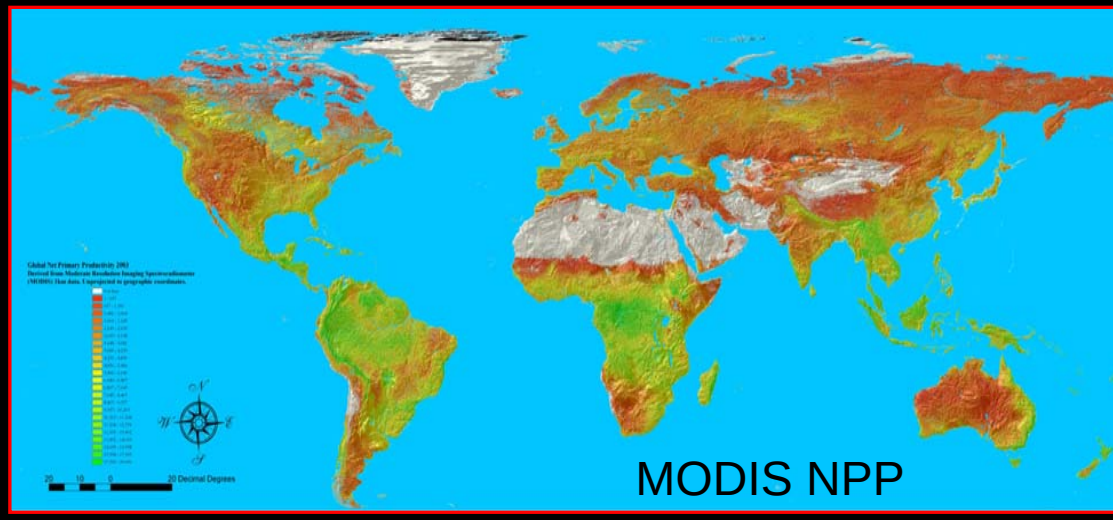


White & Kerr 2007

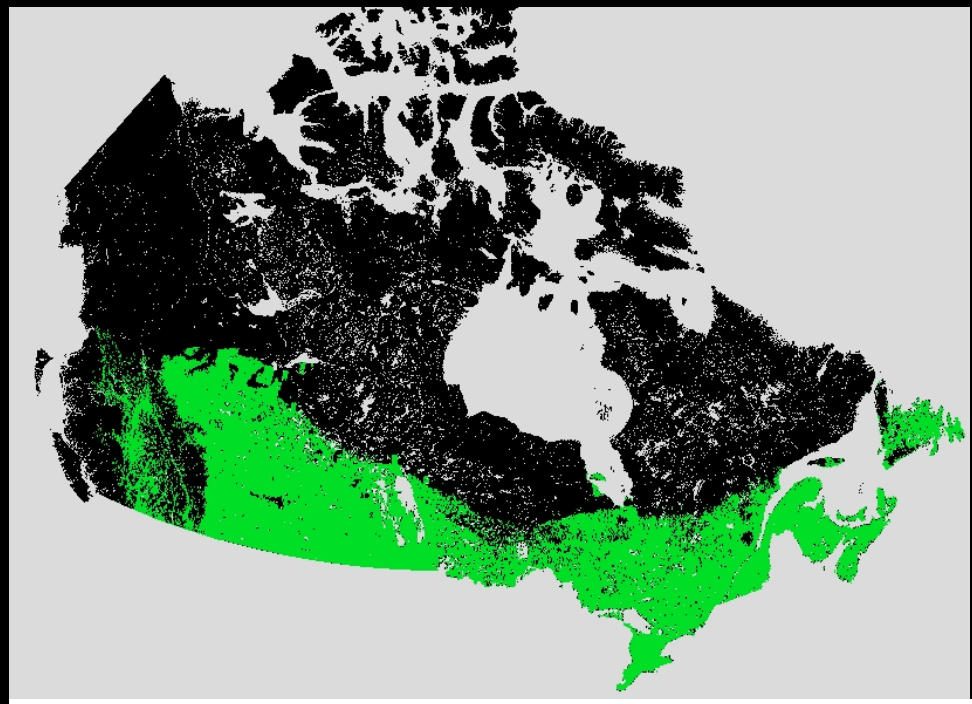
Species range models

- Data requirements cover the major niche dimensions for the species in question.
  - e.g. climatic data are commonly used, NDVI composites from moderate-coarse res sensors, land cover data, food plant distributions, etc…

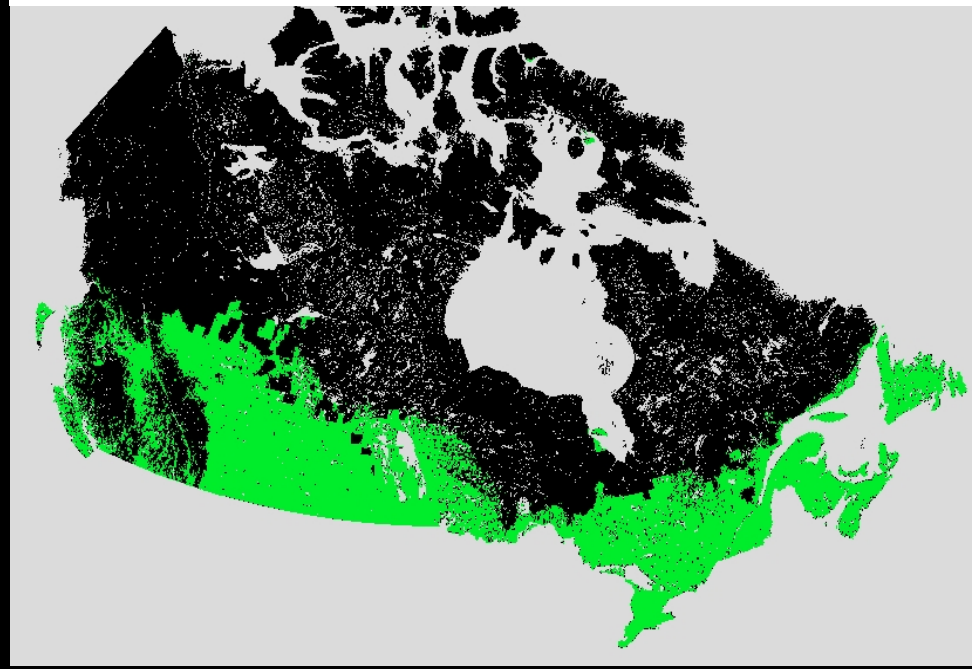




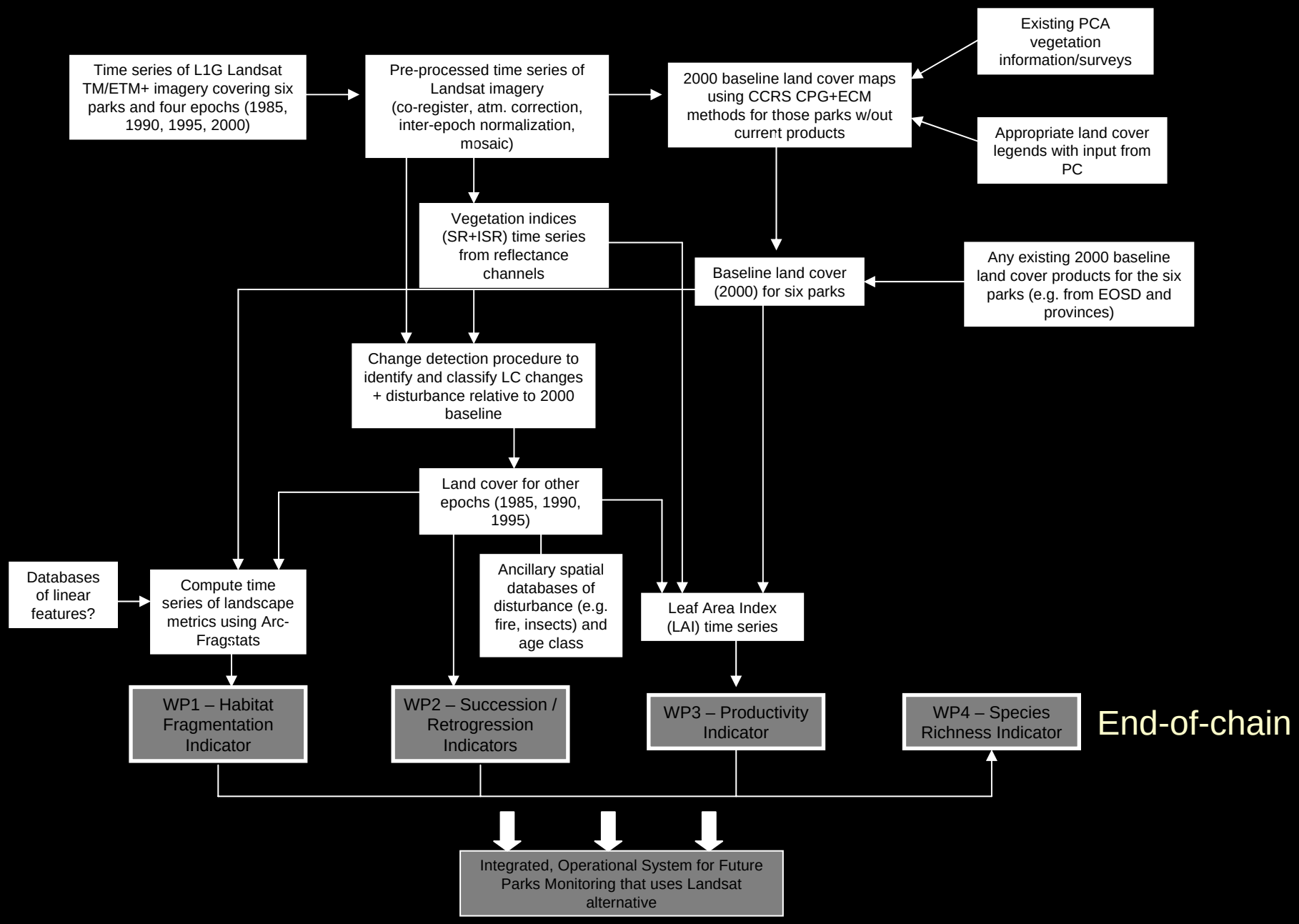
- Example of product of species model for one of those species at risk.
- Modeling method: GARP
- From Year 1 of GRIP project.



e.g. Monarch, Nymphalidae, *Danaus plexippus*

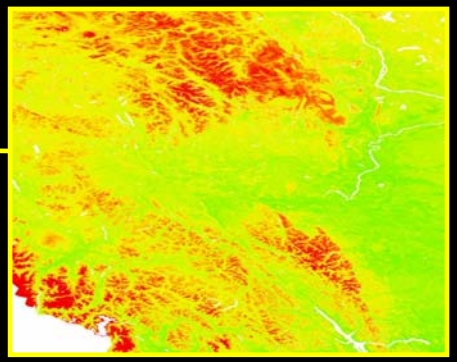


EO Components of Work Packages #1-4 for CSA/GRIP Parks Project



Environmental data layers

- Climate (Worldclim 1.4)
  - Minimum temperature, seasonality, precipitation, etc.
- Land cover (TM from CCRS)
- Fragmentation (TM from CCRS)
- Digital elevation (Sawada, uOttawa; SRTM elevation)
- Other data sets as necessary
  - (e.g. Carte Écoforestière for LMNP)



Validation

- Test quality of output with independent species observations

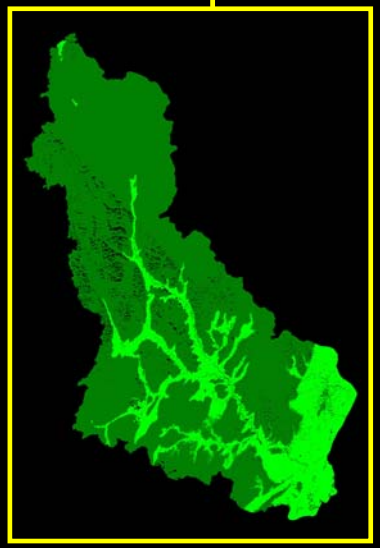
Modelling system

- Combines environmental layers to build species' distributions from individual observations.
- Conceptually similar to bioclimatic modelling.

DesktopGarp

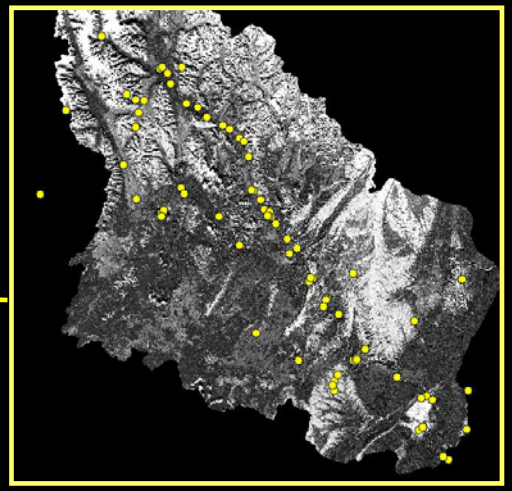
Output

- Estimates of species' ranges



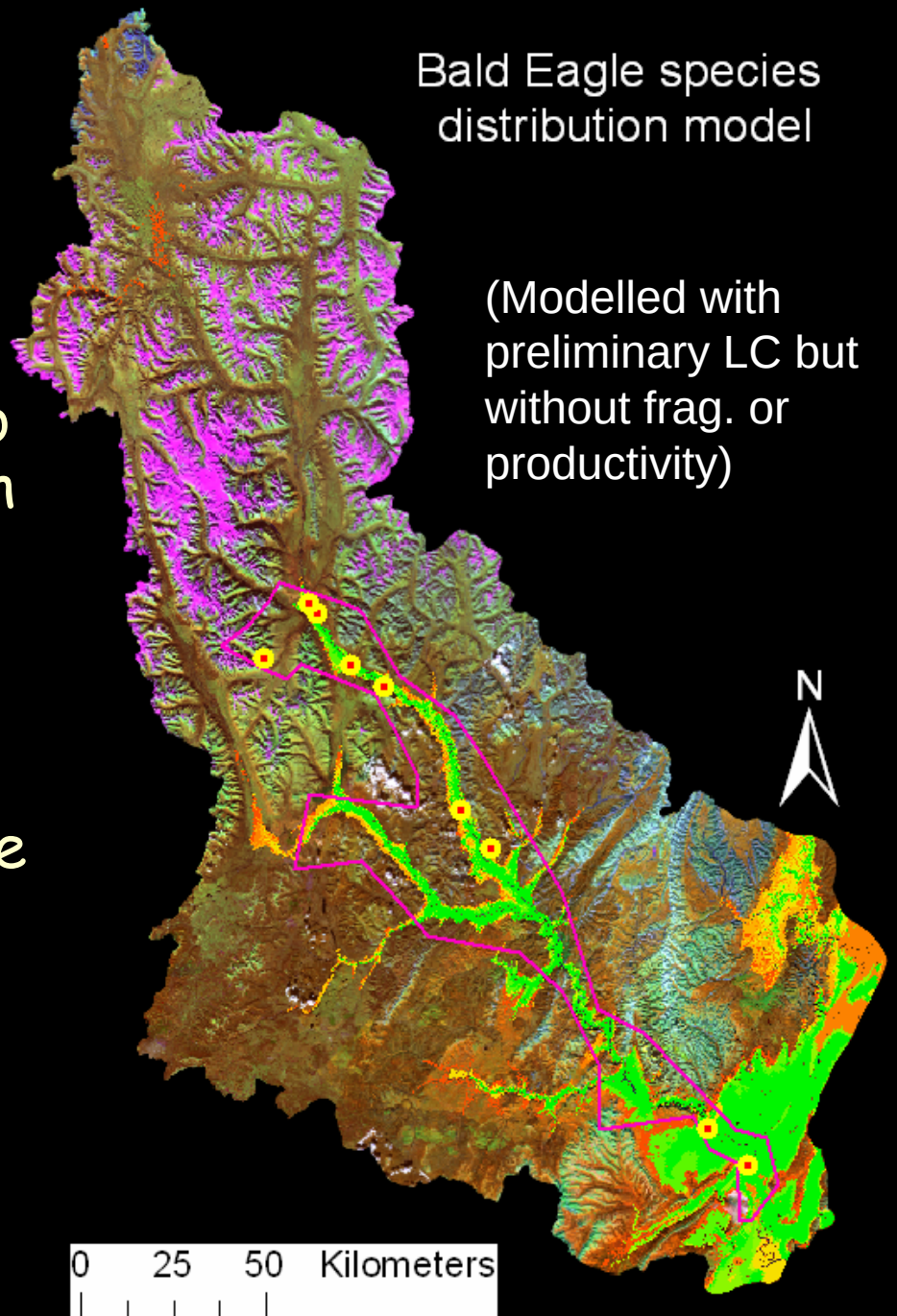
Species data layers

- Absolute requirement
- Consist of, minimally, point locales where focal species has been observed. Absence points are not required but are beneficial (but unavailable to us now).
- *Derived from*:
  - Existing PCA data
  - Field work
  - Other sources (AAFC, CWS, etc.)



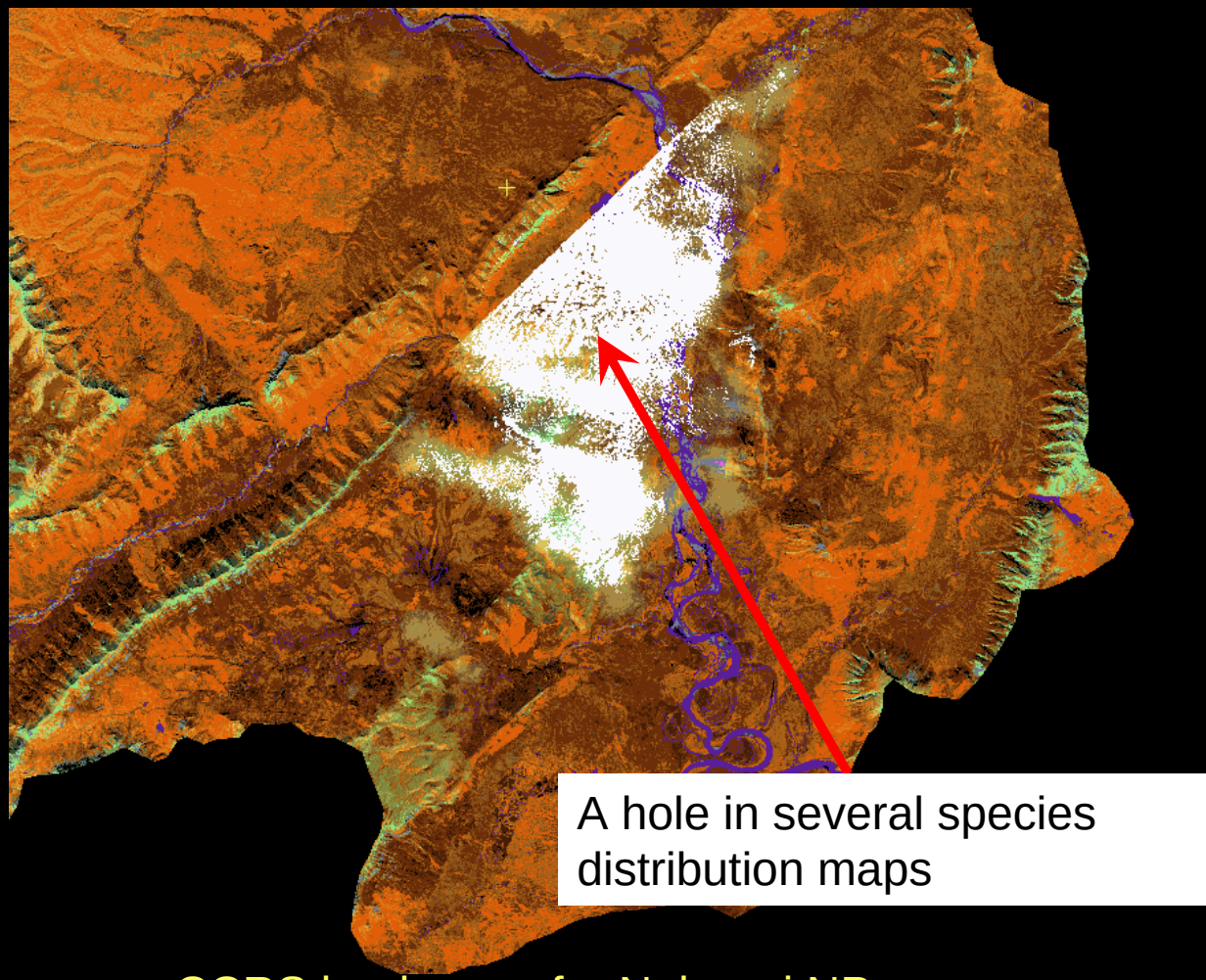
Start → Finish

- Nahanni NP: large bird observation database.
  - However, not a large number of <u>spatially unique</u> observations.
  - These observations also do not span the breadth of the GPE.
- Training and testing data.
- In this case, hundreds of models were generated, best 10 are retained, these are overlaid to provide index of modelling certainty.



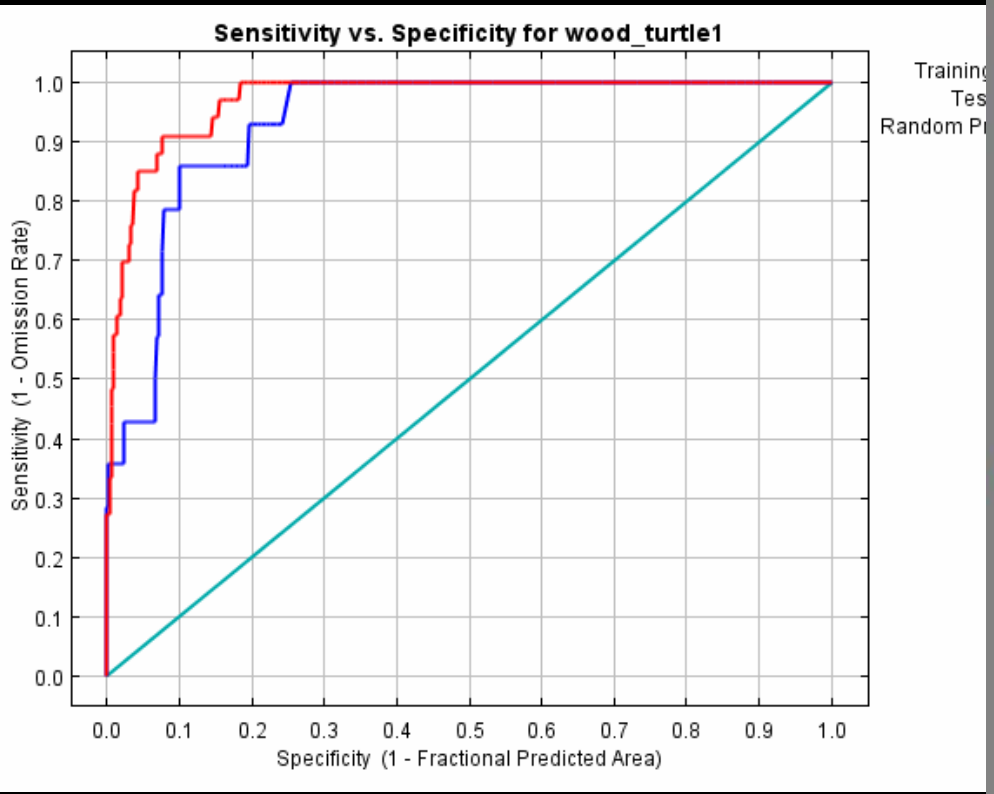
- Niche models are strongly affected by irregularities in the environmental data.

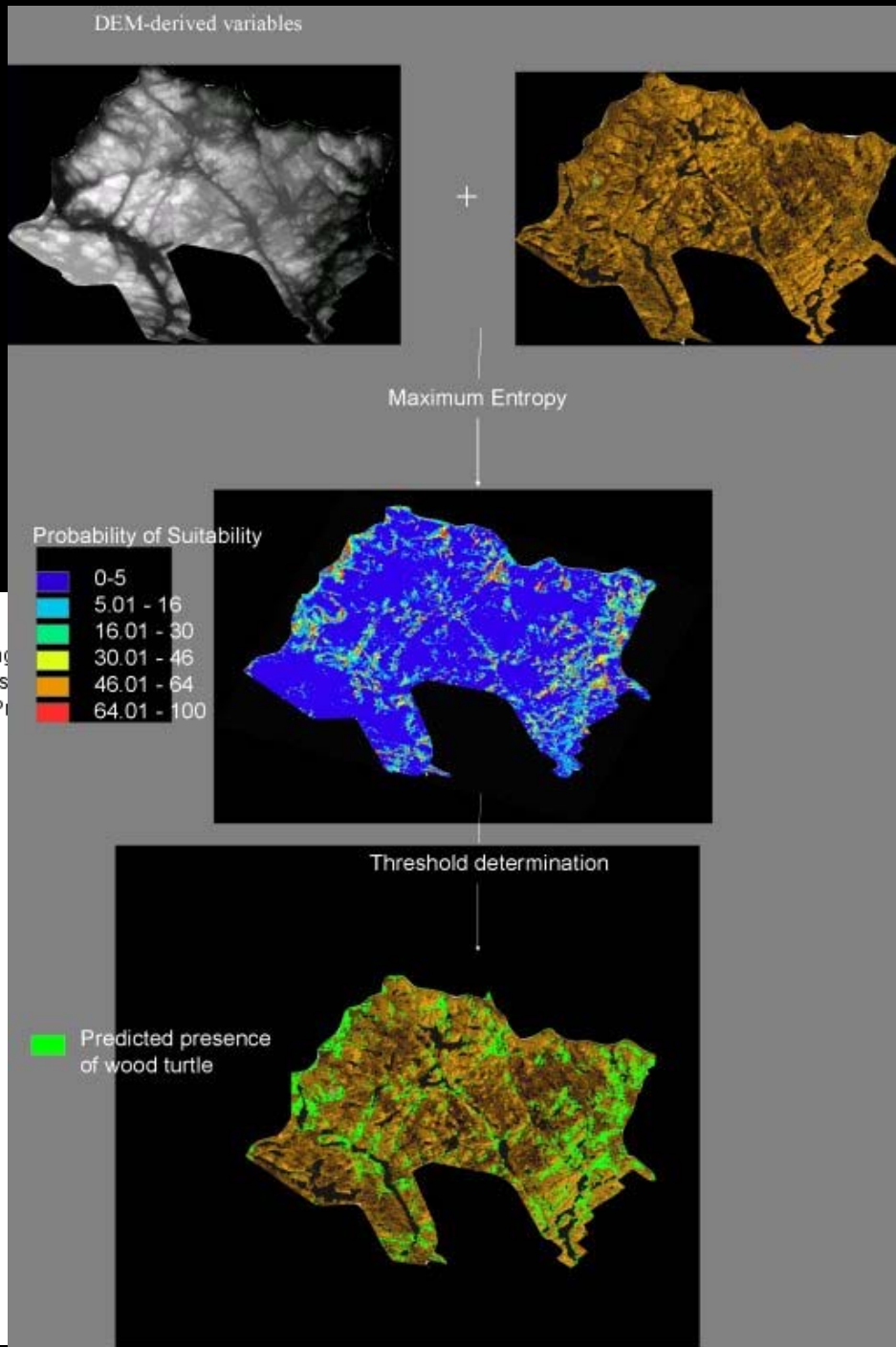
- Mosaicking process here is excellent but cannot compensate for cloud cover.



CCRS land cover for Nahanni NP – courtesy R. Fraser, D. Pouliot, I. Olthof

- Wood turtle distribution model for La Mauricie NP, based on CCRS land cover, processed DEM, and Maximum Entropy distribution model.





Species range models

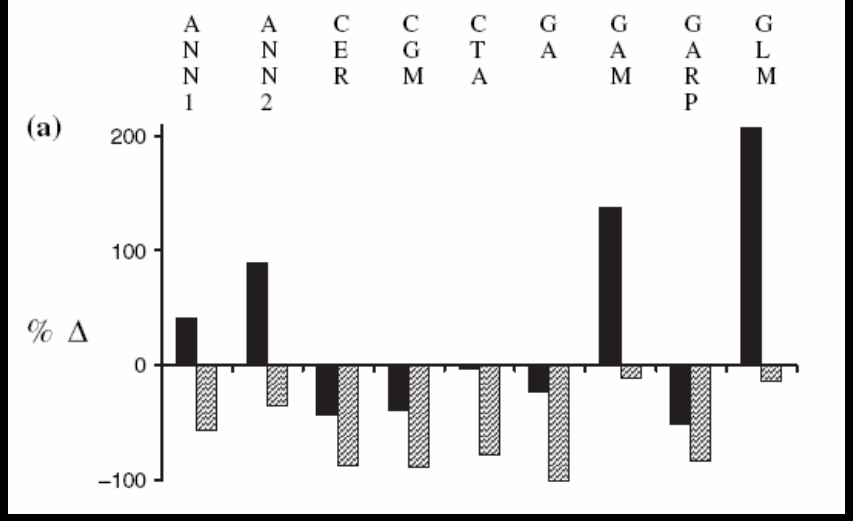
- Niche models differ in their accuracy.
  - Elith et al. 2006 Ecography suggests GAMS, Maxent, MARS, etc. are most accurate.

- Accuracy assessments for niche models can be misleading.
  - Comparisons with randomized data.
  - Data is commonly limiting: only a few records available over century time periods.
  - Models may fit well but still be wrong.

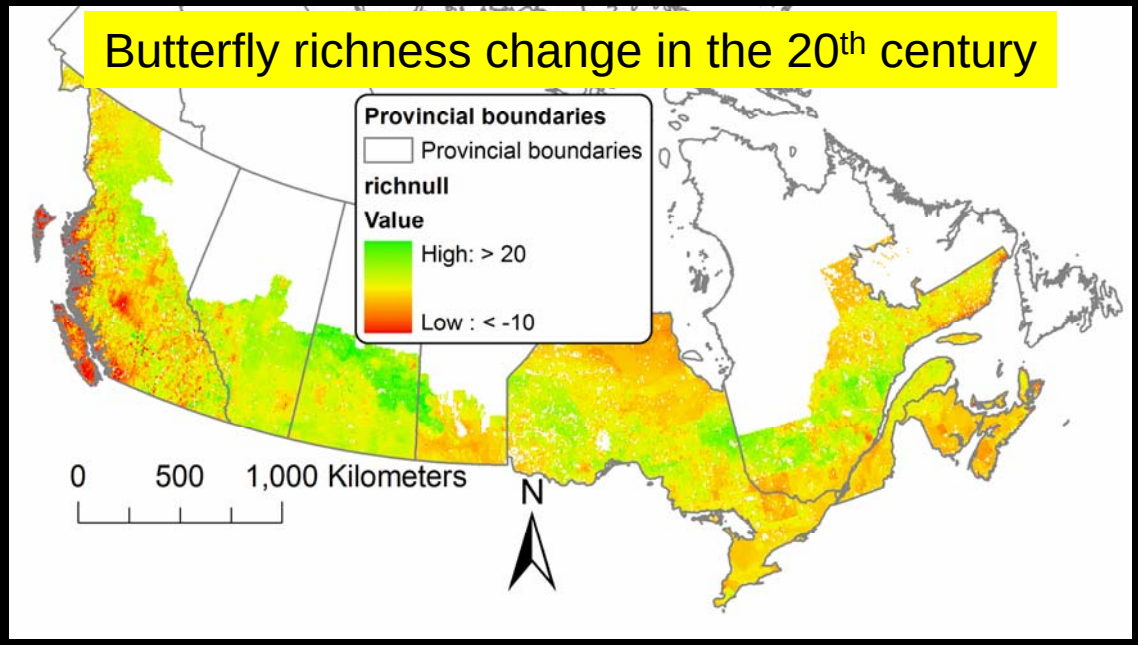
Species range models

- Space substitutes poorly for time!
- Pearson & Araujo 2006: Ranges predictions: -90% to +300% change… <u>for the same species!</u>
- White & Kerr 2006: positive *spatial* correlates of diversity can be *negative* temporal correlates.
- These problems are analagous to those confronted by the RS community when comparing LC maps from two epochs.
  - Past change is the best indicator for the future.

AUC for each model ~0.93 or higher.

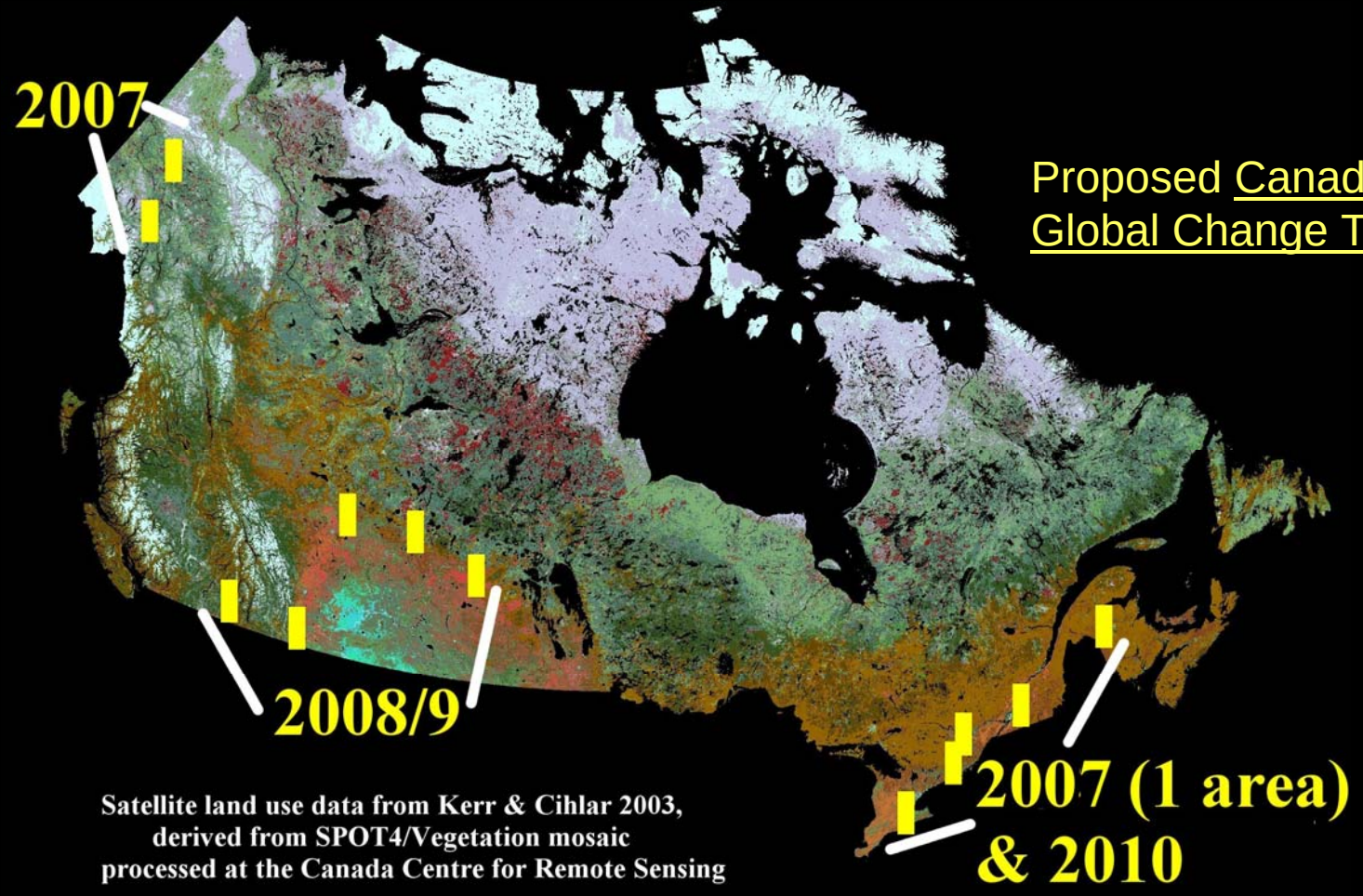


Butterfly richness change in the 20th century



Species range models

- There is hope: Hijmans and Graham (2006 GCB) compare niche models with "known" range and find correspondence can be reasonable.
- Ensemble forecasting (Araujo and New, 2007)
- Models need to be validated with additional or set aside data.



Proposed Canada Global Change Transect

Species range models

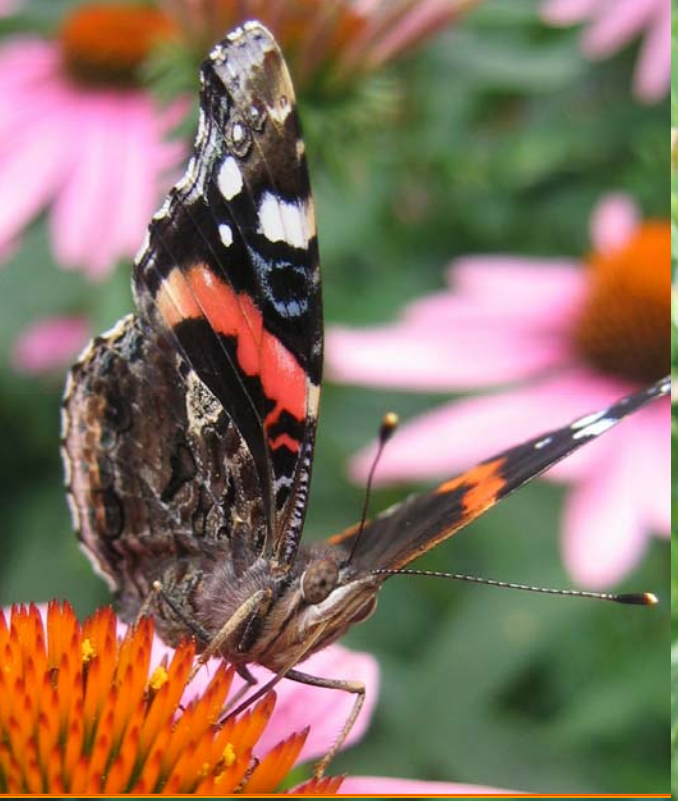
- Today's yardstick might only measure 4 inches by tomorrow's standard… or maybe 9 feet.

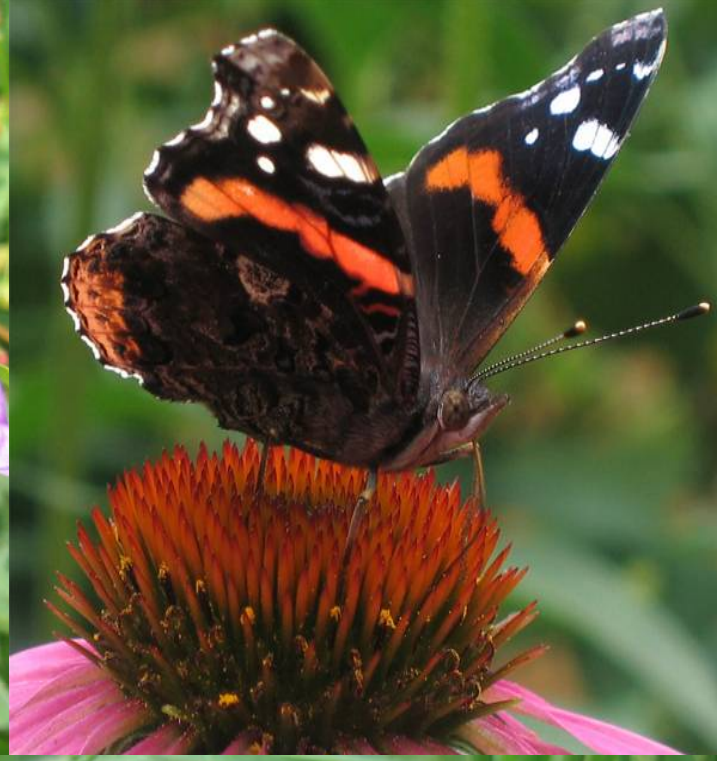
- Monitoring works better when it is based on consistent measurement/models.

- Contributions from theoretical ecology can guide models.
  - e.g. countryside SAR – accurate land cover required to detect species' true habitat use.
  - e.g. factors affecting species ranges depend on range size (small-ranged species = habitat heterogeneity, broad-ranged = climate).

Species range models

- Accuracy of species' models will <u>not</u> exceed the accuracy of inputs.
- RS data must be excellent and consistent over broad areas (or models for adjacent parks might rely on different data sources for the same species).
  - North American land cover change initiative!
  - Reference conditions are valuable for biodiversity monitoring.
- Only RS data are likely to detect changes of biotic significance in time.





Introduction

- Our task
  - Detect changes that will affect the status of focal species.

- Our tools
  - Species range models
  - Broad-scale environmental gradients
  - RS data measuring fine-grained difference

Introduction

- First problem:
  - What species to pick?
  - What species range models to select?
  - What biophysical data to include
  - What RS data to collect

Introduction

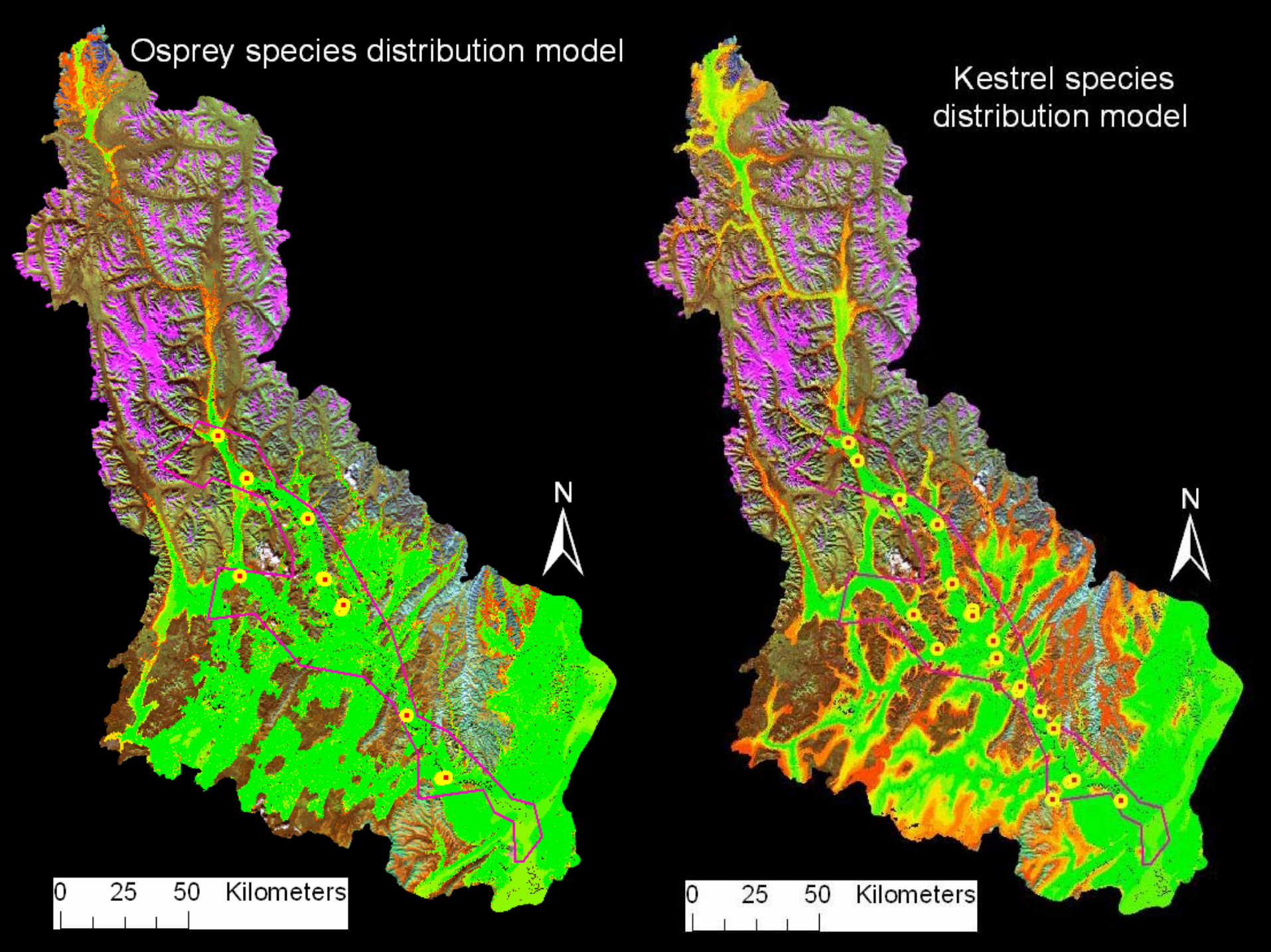
- In the best of worlds, model and data selections are scientifically justifiable.
- In the real world (i.e. outside the UK), you more commonly work with what you can get.

- A key problem to recognize up front:
  - Today's yardstick might not measure a yard tomorrow.
  - Monitoring works better when it is based on consistent measurement/models.

Structure of indicator

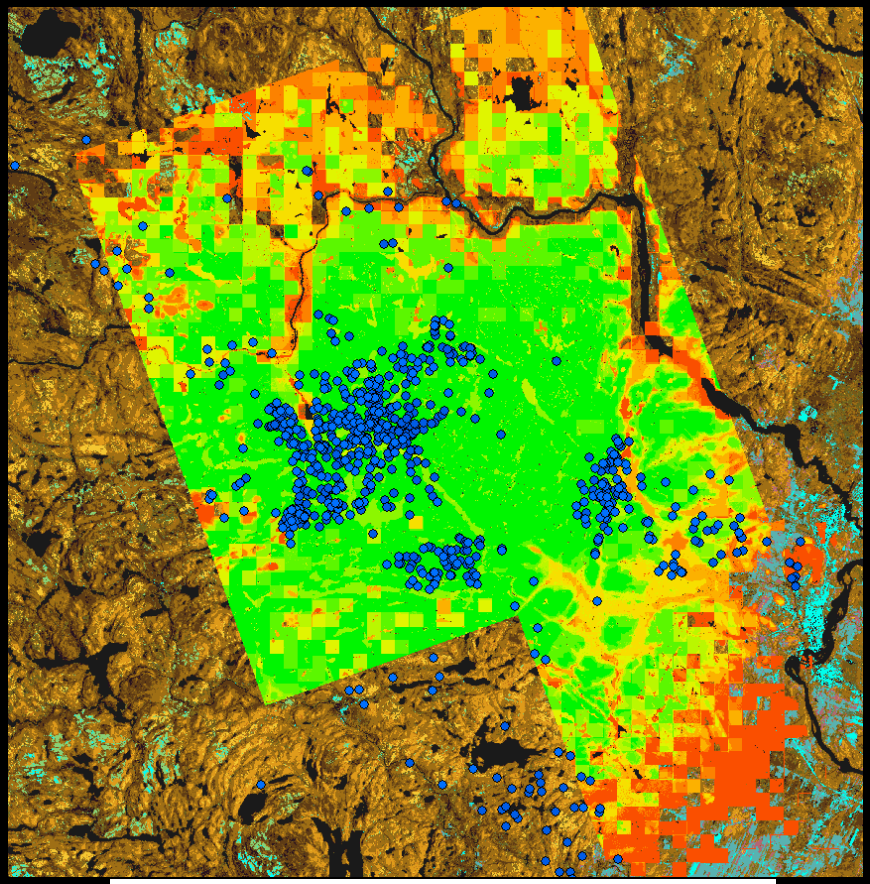
In broad terms:

- Use available data sources to model species distributions within and around parks.
- Techniques: variable but including genetic algorithms (e.g. Peterson et al.), habitat modelling (where necessary), other alternatives.
- New NCEAS report (in press) suggests different methods than those best supported in the literature. These are worth testing.


Osprey species distribution model
N
0 25 50 Kilometers
Kestrel species distribution model
N
0 25 50 Kilometers

Results

- Results for black bears in LMNP and GPE modelled from ground up (but without LC, frag, productivity):
- Based on hundreds of observations in a small area.
- Points essentially cover the region.
- Also attempting to model bear food source distributions (will probably require more data).



Observations from 1998 only.

Indicator applications

Immediate

1. Effect of disturbance on focal species distributions.
2. Rolling up to species richness: where are biodiversity hotspots?

Potential

1. Discovering new populations of a focal species (e.g. Raxworthy et al., *Nature*)
2. Assisting in evaluating impacts of disturbance in GPE on populations within park boundaries.
3. Projecting distribution change in response to anticipated disturbance.

Pitfalls

1. Assuming that species are truly in equilibrium with their environments.
2. Biased sampling of species' environmental "envelope".

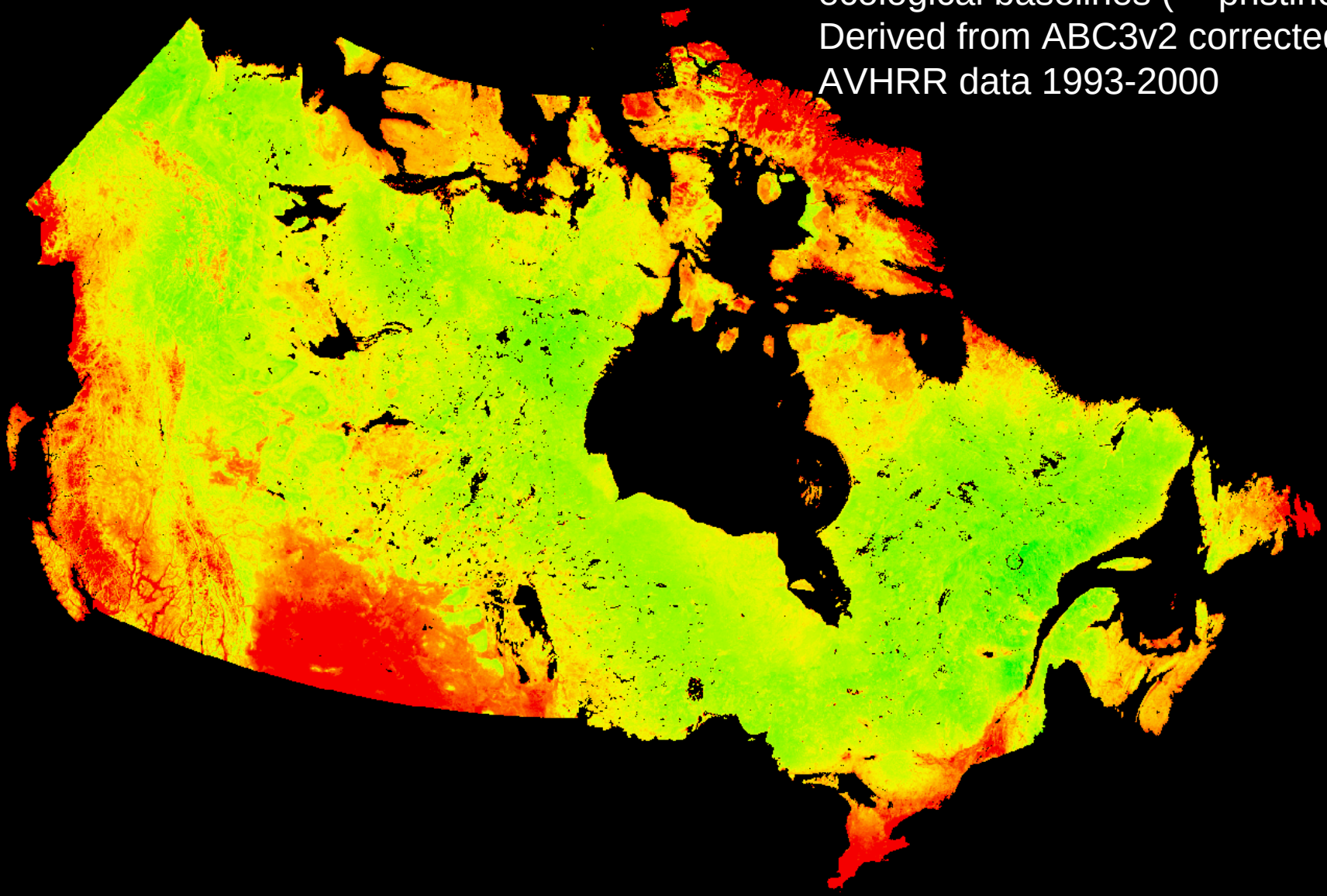
Indicator applications

- Iceberg paradigm for WP4
- Declines of focal species' distributions within the GPE (incl. park) redshifts the indicator.
- To the extent possible, changes in the indicator should be relative to best case (perhaps historical) diversity levels.
  - Probably omitting extinct species.
  - How to determine potential diversity?
    - Probably requires potential land cover, potential biophysical characteristics.

Conclusions

- Parks are the best ecological baselines we have (Sinclair & Byrom, 2006) and maintenance of their ecological integrity is essential.

- Given their extent and dispersion, remote sensing is the only way to provide rapid updates on their ecological integrity.

Conclusion

Potential iNDVI – observed iNDVI = **Ecosystem Function Deficit** for Canada, modelled using parks as ecological baselines (= “pristine”); Derived from ABC3v2 corrected AVHRR data 1993-2000