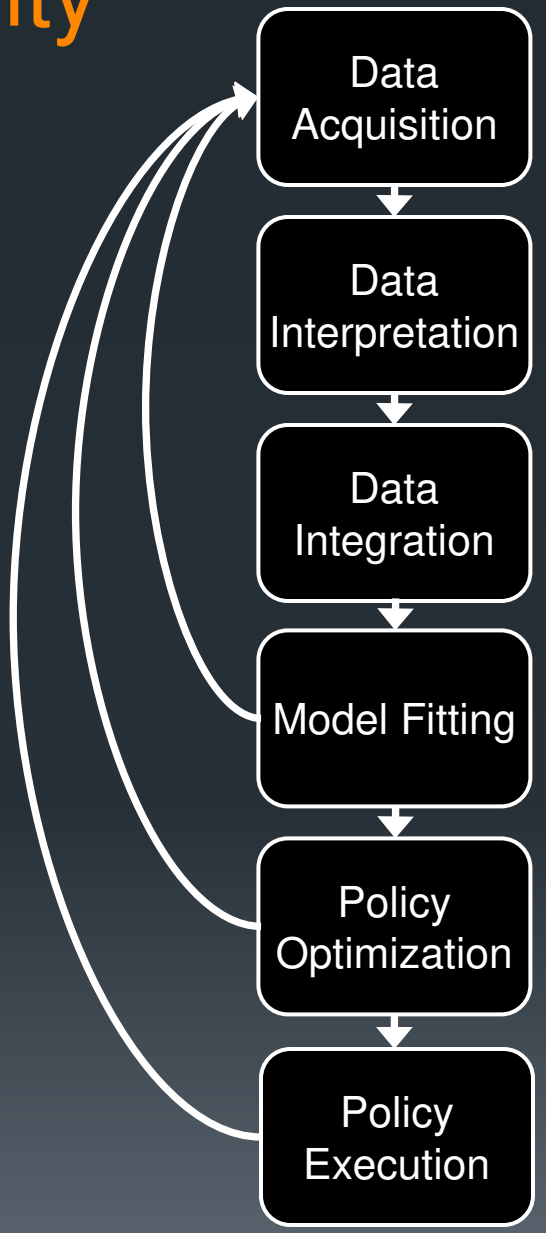
Machine Learning for Sustainable Development and Biological Conservation

Tom Dietterich
Distinguished Professor, Oregon State University
President, Association for the Advancement of Artificial Intelligence

Computational Sustainability

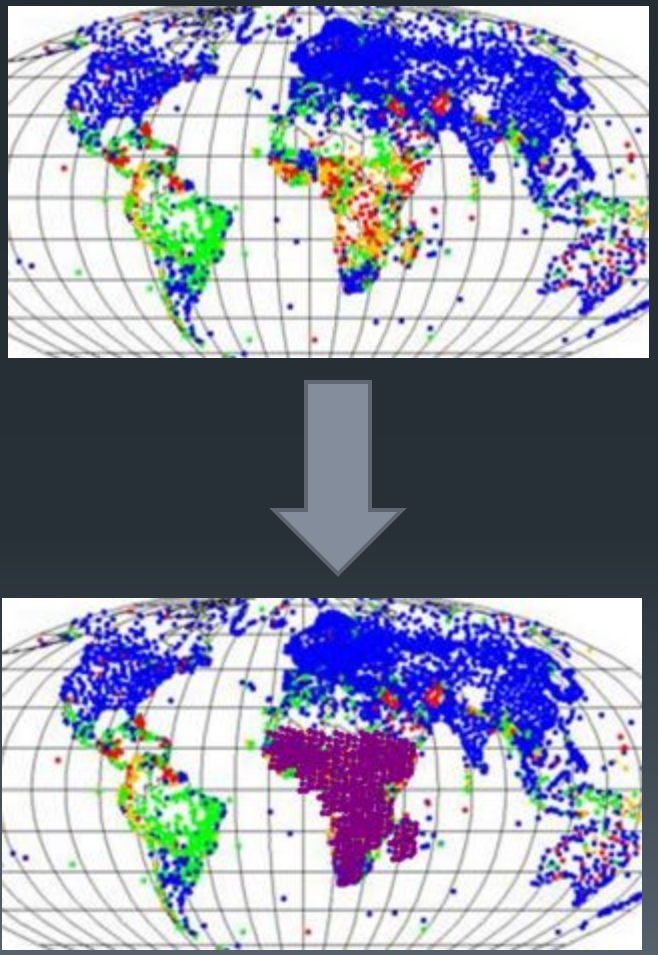
- The study of computational methods that can contribute to the sustainable management of the earth's ecosystems



Data Acquisition

Data Acquisition

- Africa is very poorly sensed
  - Only a few dozen weather stations reliably report data to WMO (blue points in map)
- Project TAHMO (tahmo.org)
  - TU-DELFT & Oregon State University
  - Deploy 20,000 stations across Africa
  - Provide data to farmers and to enable crop insurance industry
  - Increase agricultural productivity
- Computational Problem
  - Where to place the weather stations?
  - Krause, Singh & Guestrin, 2008

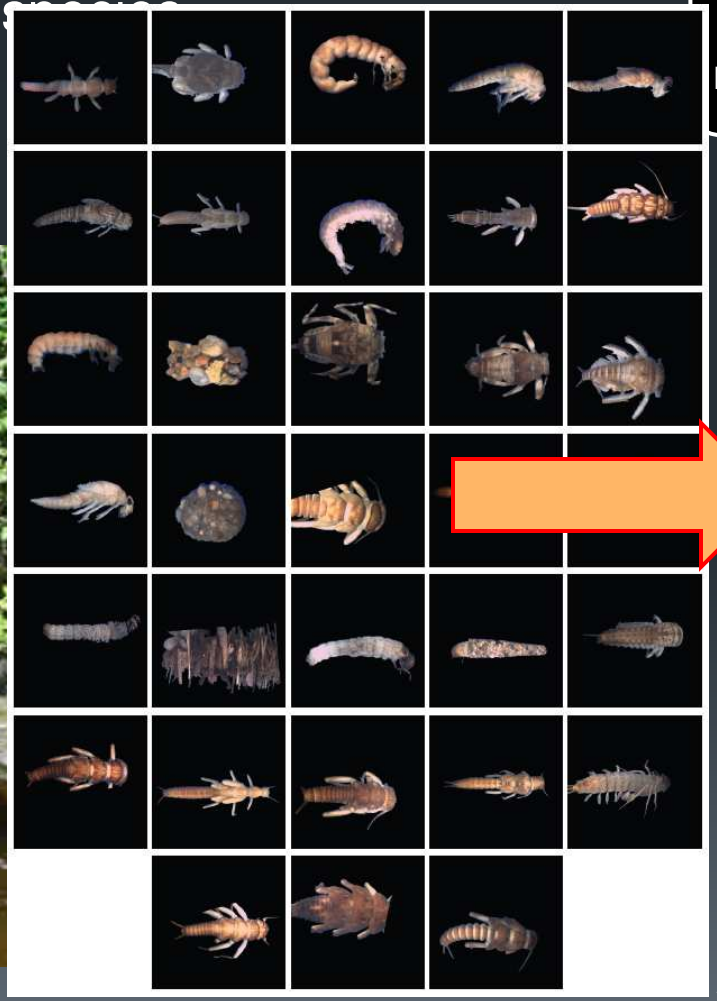


TAHMO

Data Interpretation

- Insect identification for population counting
- Raw data: image
- Interpreted data: Count by species
- Method: Computer Vision
- Lytle, et al., 2010

www.epa.gov



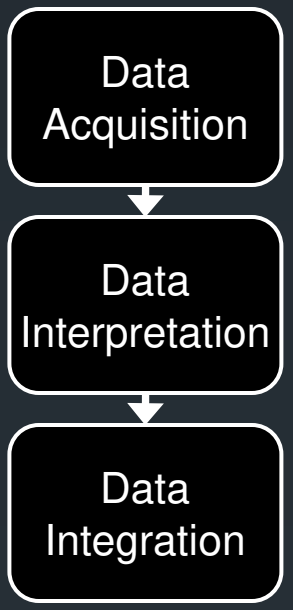
Data Acquisition

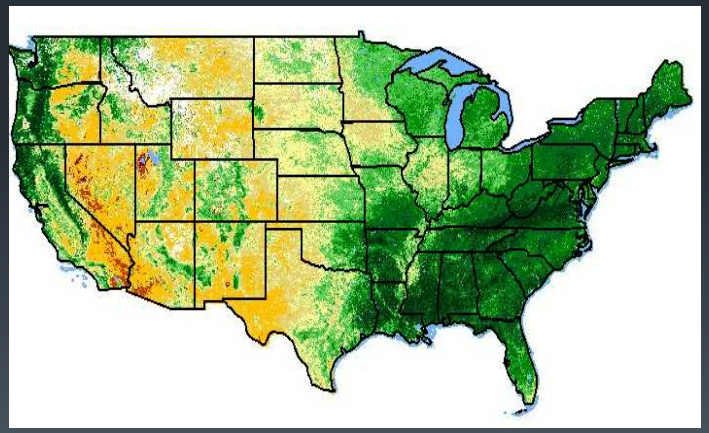
Data Interpretation

Species	Count
Limne	3
Taenm	15
Asiop	4
Epeor	25
Camel	19
Cla	12
Cerat	21

Data Integration

- Virtually all ecosystem prediction problems require integrating heterogeneous data sources
  - Landsat (30m; monthly)
    - land cover type
  - MODIS (500m; daily/weekly)
    - land cover type
  - Census (every 10 years)
    - human population density
  - Interpolated weather data (15 mins)
    - rain, snow, solar radiation, wind speed & direction, humidity

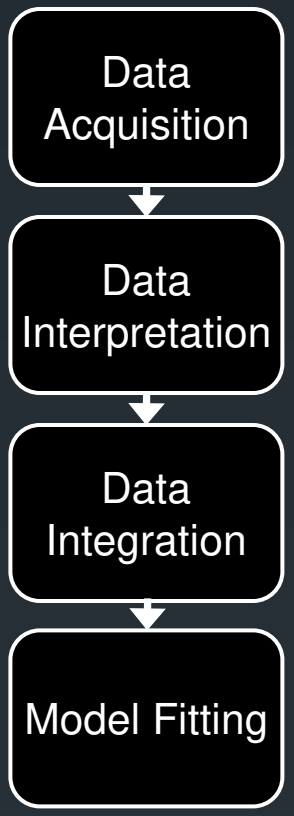




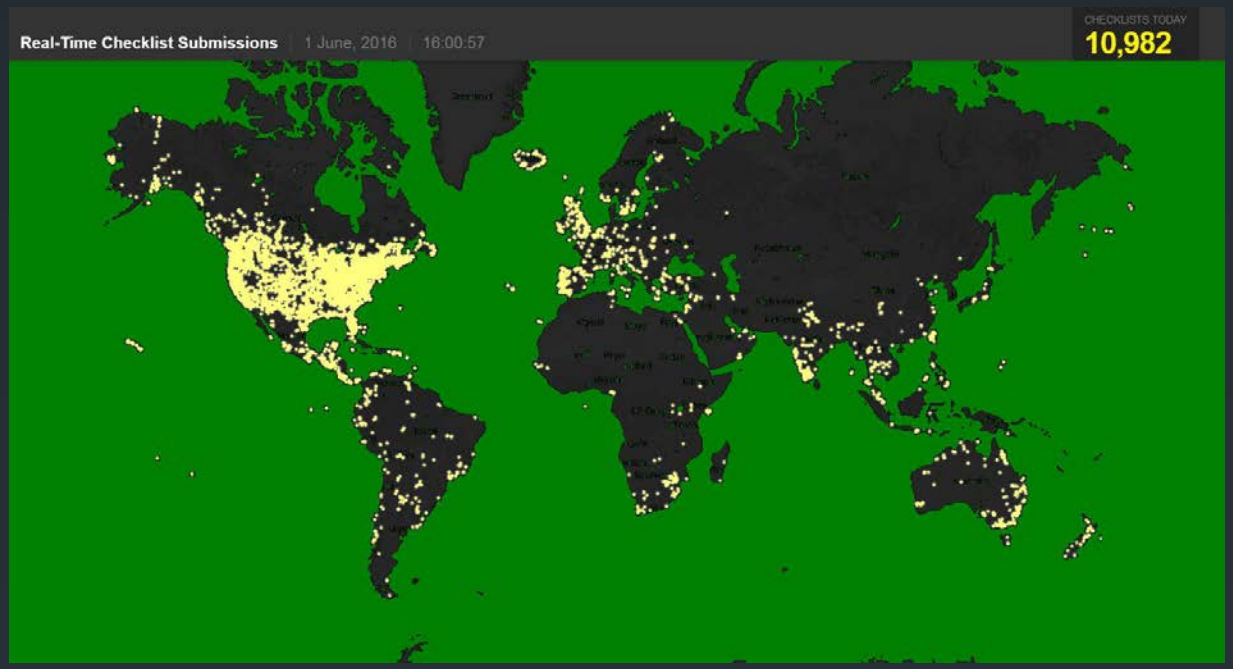
Landsat NDVI:
http://ivm.cr.usgs.gov/viewer/

Model Fitting with Machine Learning

- Species Distribution Models
  - create a map of the distribution of a species
- Migration and Dispersal Models
  - model the trajectory and timing of movement



eBird Project



- Volunteer Bird Watchers
- Time, place, duration
- Species seen

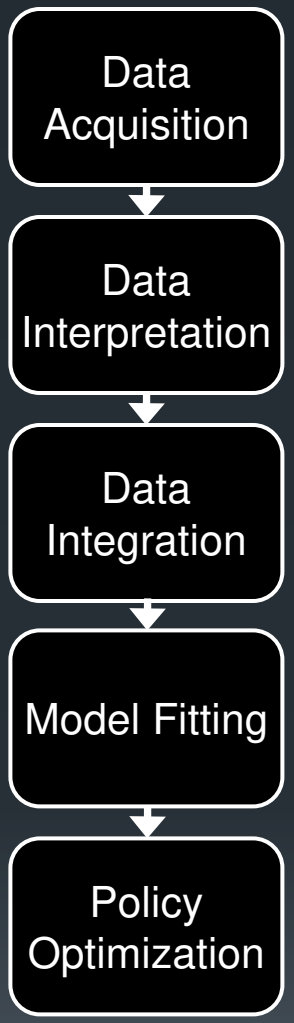
- 8,000-12,000 checklists uploaded per day
- Computational Method: Collective Graphical Model (Sheldon et al., 2011)

Fitted Migration Model
Ruby-Throated Humming Bird

Sheldon, Sun, Liu, Dietterich unpublished

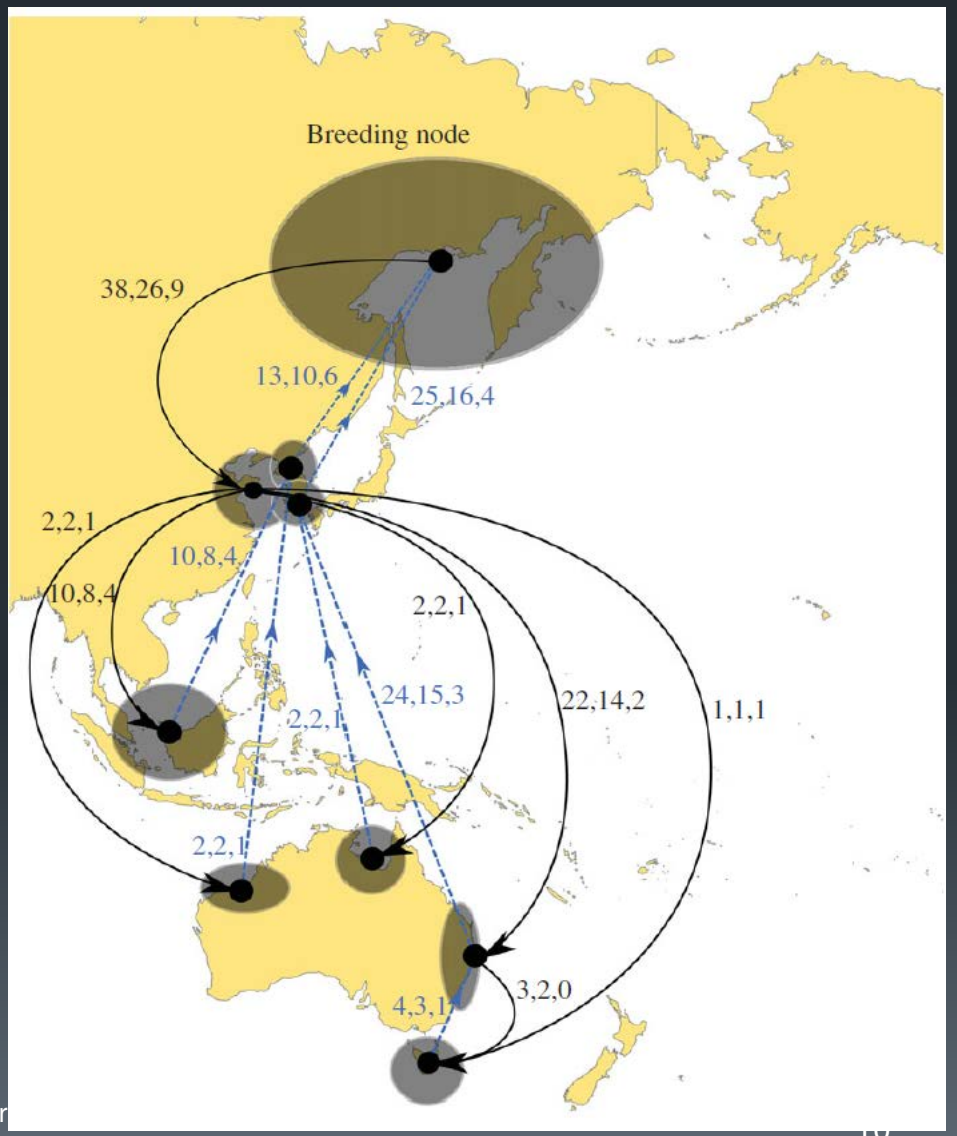
Policy Optimization

- Compute optimal policies for managing ecosystems
- Incorporate uncertainty about the future
- Computational Tools
  - MDPs (Markov Decision Problems)
  - POMDPs (Partially-Observable MDPs)
  - Point-based solvers (Pineau, 2003; Poupart, et al. 2005; Kurniawati et al, 2008)

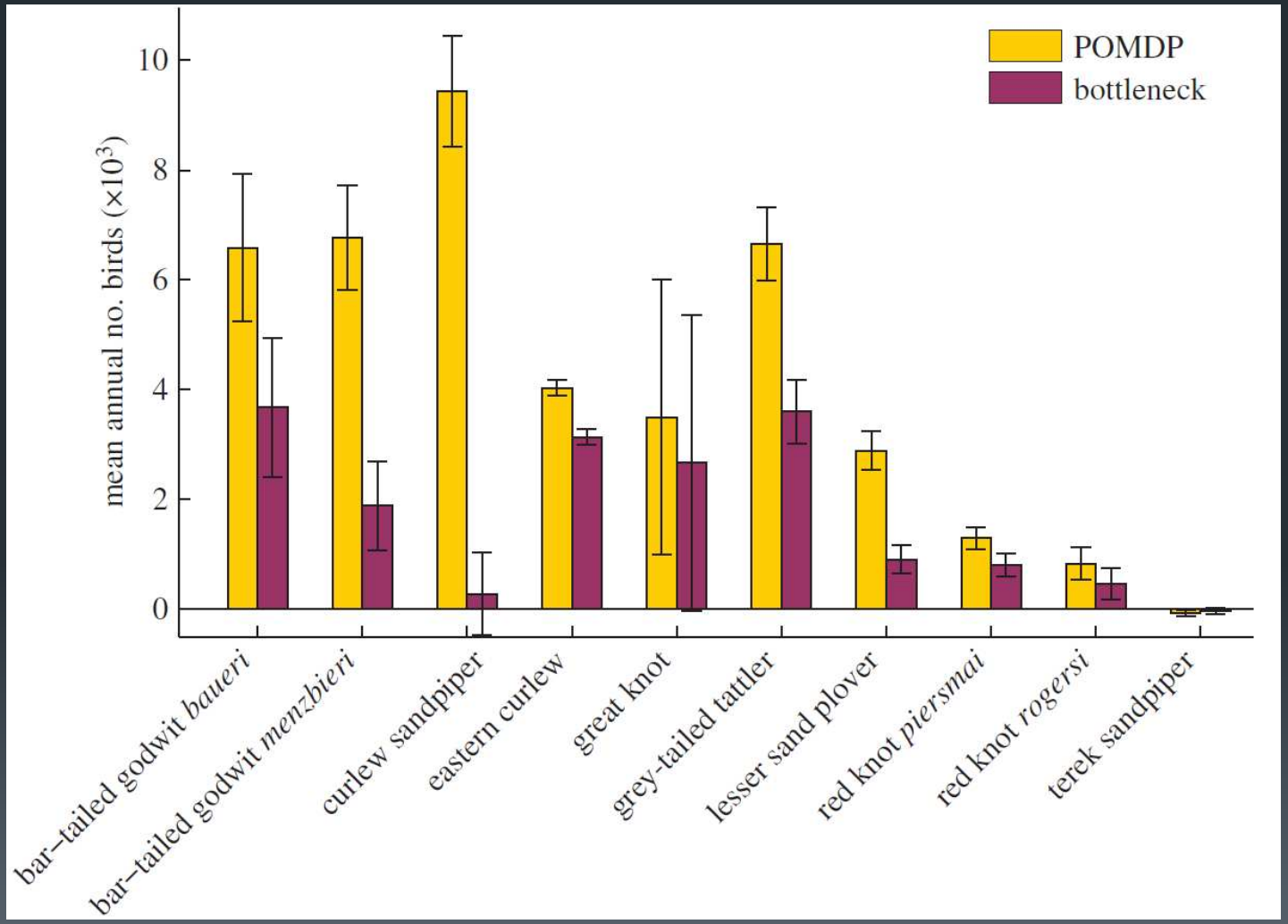


Protecting Coastal Habitat to Protect Migrating Birds from Sea Level Rise

- East Asia-Australia migratory pathways
- Sea Level Rise destroys habitat unless areas further inland have been protected
- Timing and location of protection depends on the timing of future sea level rises
- POMDP formulation
- Nicol, et al. 2015

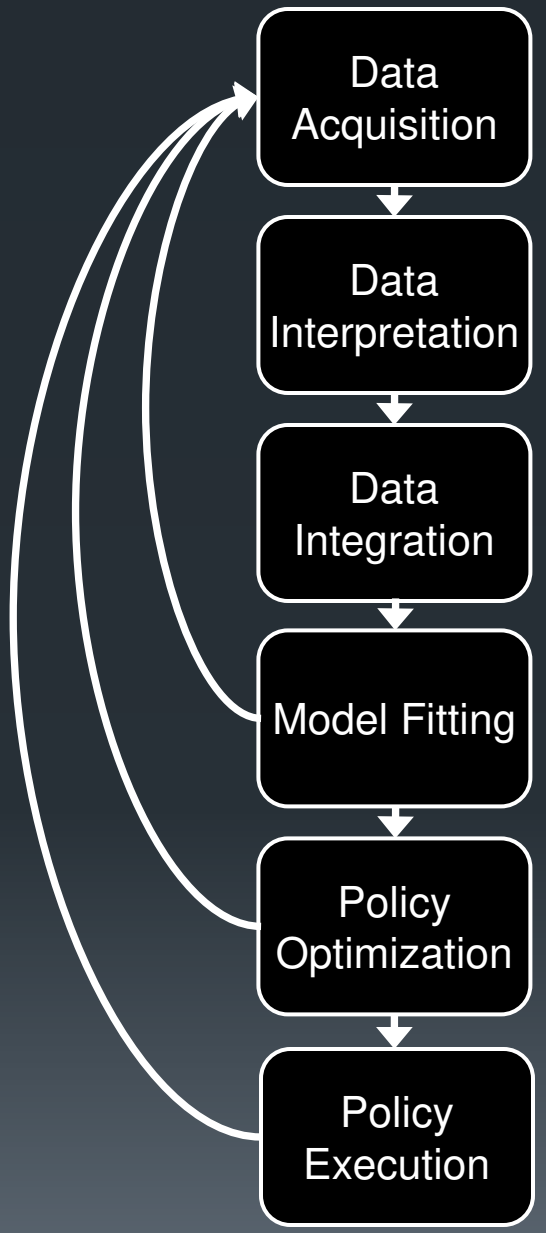


Results: Much More Successful than Existing Bottleneck Heuristic



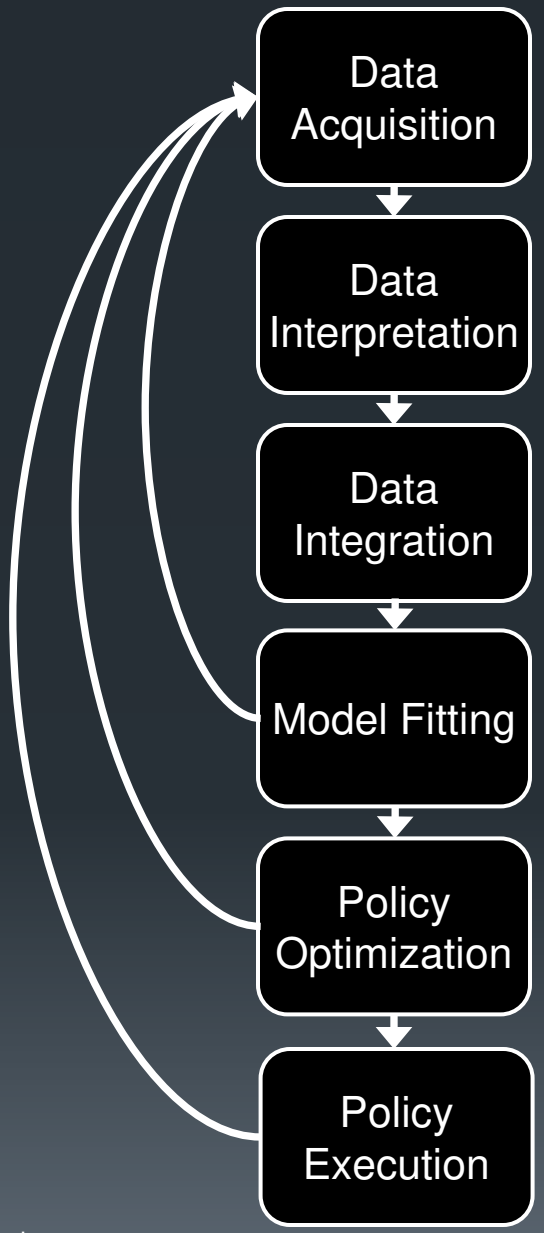
Policy Execution

- Repeat
  - Observe Current State
  - Update Models and Re-Optimize
  - Choose and Execute Optimal Action



Summary

- Locating weather stations in Africa
- Images → Insect Species
- Multiscale Data
- Bird Migration Models fit to eBird Data
- Where and when to purchase coastal habitat?
- Action!



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