Surprises from the Biosphere?

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AGCI

Climate Scenarios and Projections: Known, Unknown and Unknowable
Biosphere Surprises

- Known
- Unknown
- Unknowable
Biosphere Surprises

- Known
  - Theory

Consensus + Observations

Models
Biosphere Surprises: Known

- Theory—1st Principles
  - Space
    - Biotic Factors
    - Abiotic Factors
  - Time
    - Biotic Factors
    - Abiotic Factors
Biosphere Surprises: Known

- Theory—1st Principles
  - Space
    - Biotic Factors
      - Predator-Prey Interactions
    - Competition Interactions

Biosphere Surprises: Known

- Theory—1st Principles
  - Space
    - Abiotic Factors
      - Average Climate

Example: “Root’s 2.5 Rule”
\[ \text{NBMR} = 2.5 \text{ BMR} \]
Biosphere Surprises: Known Theory—1st Principles

- Space
  - Abiotic Factors
    - Average Climate
    - Climate Extremes
  - Day Length (AKA Foraging Time)
Biosphere Surprises: Known

- Theory—1<sup>st</sup> Principles
  - Time
    - Biotic
      - Predator-Prey
    - Competition
Biosphere Surprises: Known

- Theory—1st Principles
  - Time
    - Abiotic
    - Day Length
    - Heating Degree Days
Sandhill Cr.
Number of Days Changed in 10 Years

Frequency of Species
Biosphere Surprises: Known

- Theory—Fairly well
- Observations
- Models
- Consensus
Biosphere Surprises: Known

- Observations (Space & Time)
  - Prehistoric data spotty
  - Historic data infrequent
- Non-traditional data
Biosphere Surprises: Known

- Theory—Fairly well
- Observations—Few
- Models
- Consensus
Biosphere Surprises:

Known

- Models
  - Climate Envelopes
  - Others
Baltimore Oriole
(Icterus galbula)
2100 Fossil Intensive

Change in Temperature

Latitude

10% Chance
50% Chance
90% Chance
Biosphere Surprises: Known

- Theory—Fairly well
- Observations—Few
- Models—“Simple”
- Consensus
Biosphere Surprises: Known

- Consensus
- Meta-analysis
Rules for Including Studies

- Examined Changes in Temp.
  - Not Precipitation
- ≥ 10 Years
- Two Types of Studies
  - Tier 1
  - Tier 2
Animal and Plant Studies

- >2500 Studies on Species and Climate Change
  - 78 Met Tier 1 Criteria
  - 56 Met Tier 2 Criteria
Tier 1 Studies (IPCC)

- Trait Shows Statistical Trend Over Time, AND
- Trait Statistically Associated with Temperature, OR
- Temperature Shows Statistical Trend Over Time
Tier 2 Studies

- Trait Shows Trend Over Time
- Trait Associated with Temp.
- Temp. Shows Trend Over Time
- Temp. Trend Cited from Other Studies
Locations of Studies

Arctic
North Sea
Asia  Russia  North America  Europe
Pacific Ocean  Central America
Australia  New Zealand
Antarctic Ocean
Antarctica
Species 1859+

- **Animals**
  - Invertebrates
  - Fishes
  - Amphibians
  - Reptiles
  - Birds
  - Mammals

- **Plants**
  - Grasses
  - Forbs
  - Trees
Species with No Change

- Of the 1859+ Species
  - ~20% (386+) Showed No Change
Type of Changes

- Range Shifts
- Abundance Shifts
- Phenology Shifts
- Morphology Shifts
Meta-Analysis

- “Vote” Counting
  - Combine all Changes
  - Changing in Expected Direction or Not
Vote Counting

- 1473+ Changed Over Time
  - ~20% (277+) Changed Opposite to Expected
  - ~80% (1196+) Changed in Direction Expected
Biosphere Surprises: Known

- Theory—Fairly well
- Observations—Few
- Models—“Simple”
- Consensus—Strong
Biosphere Surprises

- Known

  Theory

Consensus

Observations

Models
Biosphere Surprises:

- Known
- Unknown
- Unknowable
Biosphere Surprises: Unknown

- Synergistic with Land-use Change
  - Theory
  - Models
  - Observations
  - Consensus
Biosphere Surprises:

- Known
- Unknown
- Unknowable
Biosphere Surprises:

- Unknowable
  - Let me count the ways....
Thank you for listening!