

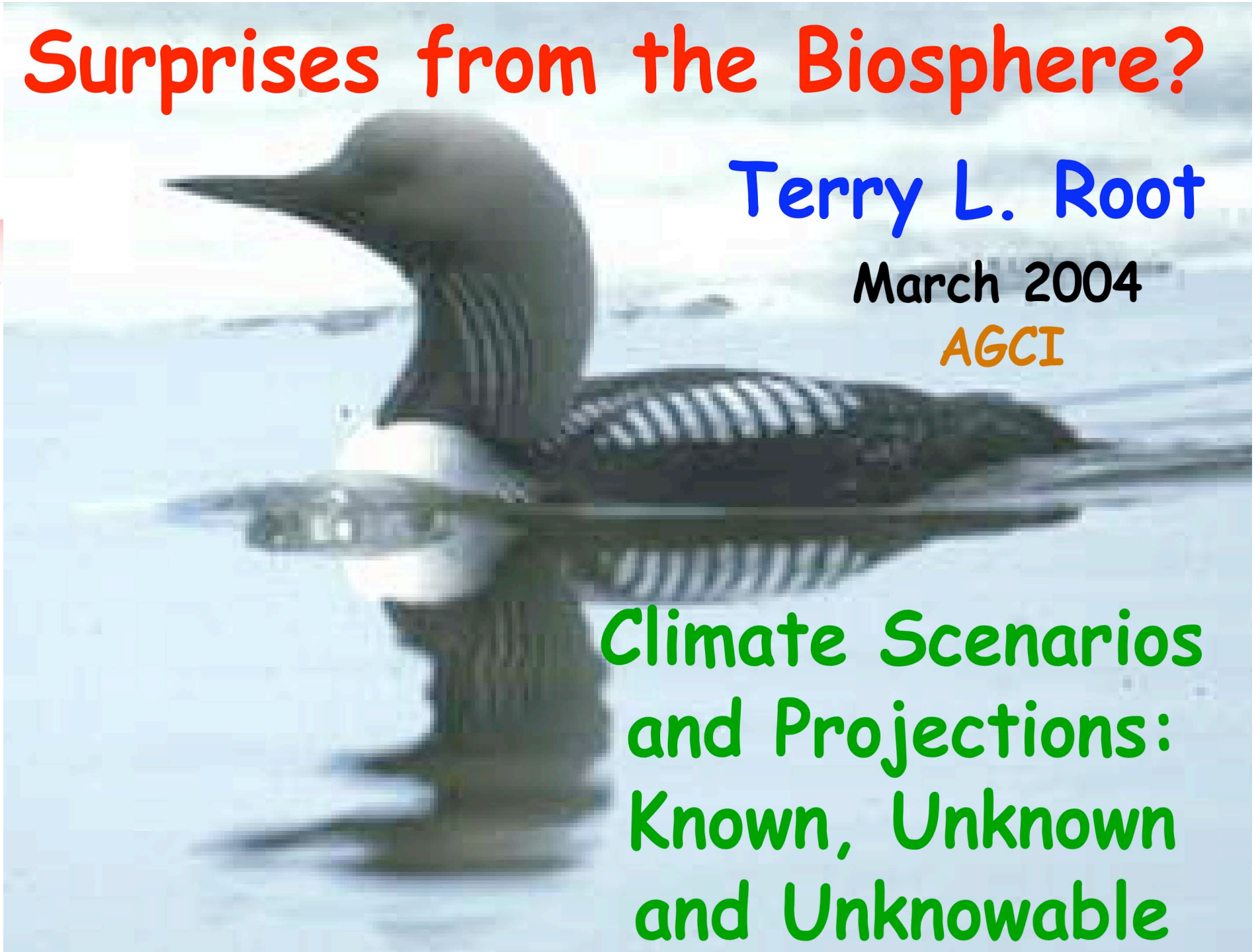
Surprises from the Biosphere?

Terry L. Root

March 2004

AGCI

Climate Scenarios
and Projections:
Known, Unknown
and Unknowable



Biosphere Surprises

- Known
- Unknown
- Unknowable

Biosphere Surprises

■ Known
Theory

Consensus

Observations

Models

Biosphere Surprises: Known

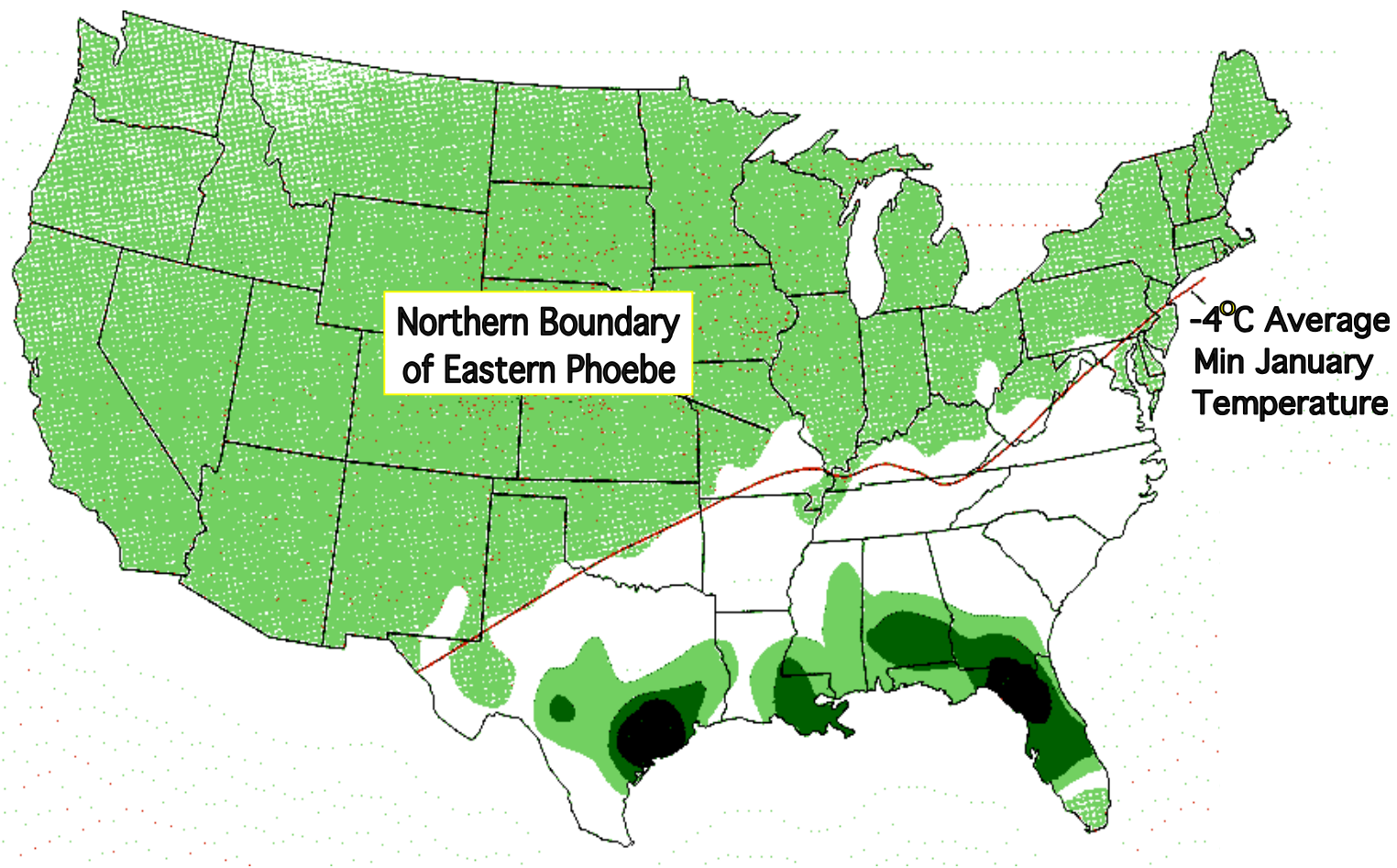
- Theory—1st Principles
 - Space
 - Biotic Factors
 - Abiotic Factors
 - Time
 - Biotic Factors
 - Abiotic Factors

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"



Metabolic Rate

BMR

NBMR

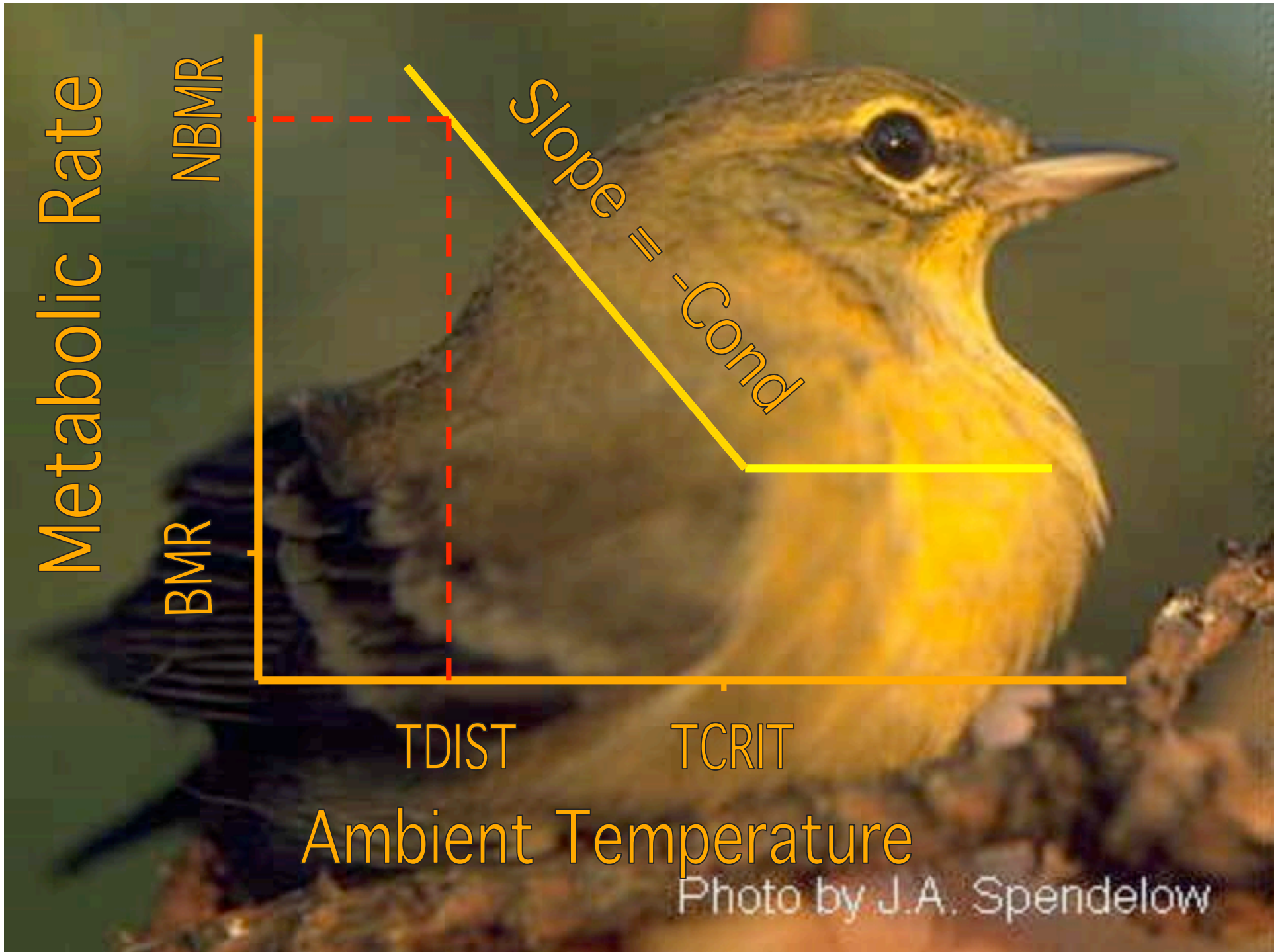
Slope = $-\text{Cond}$

TDIST

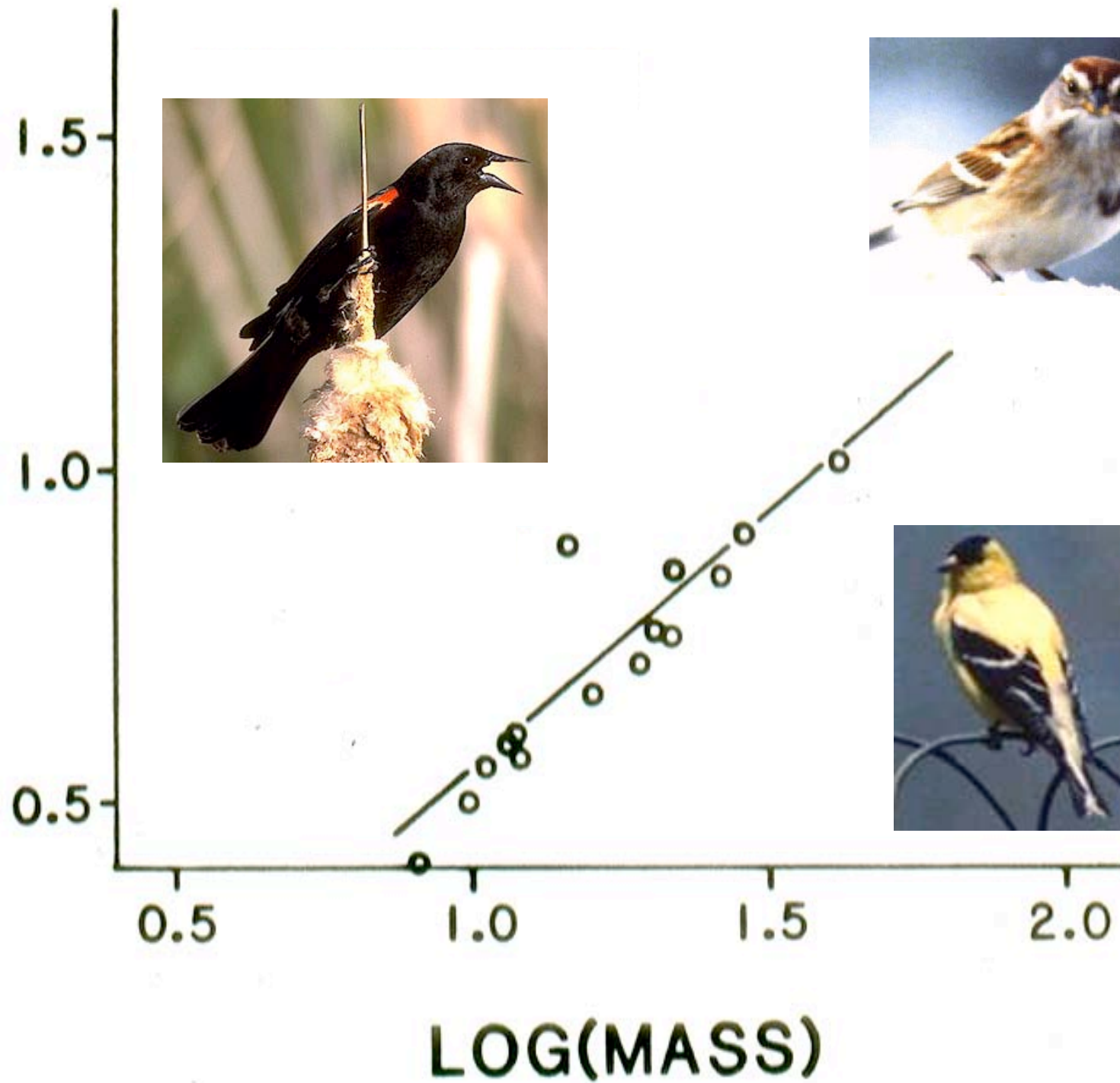
TCRIT

Ambient Temperature

Photo by J.A. Spendelow

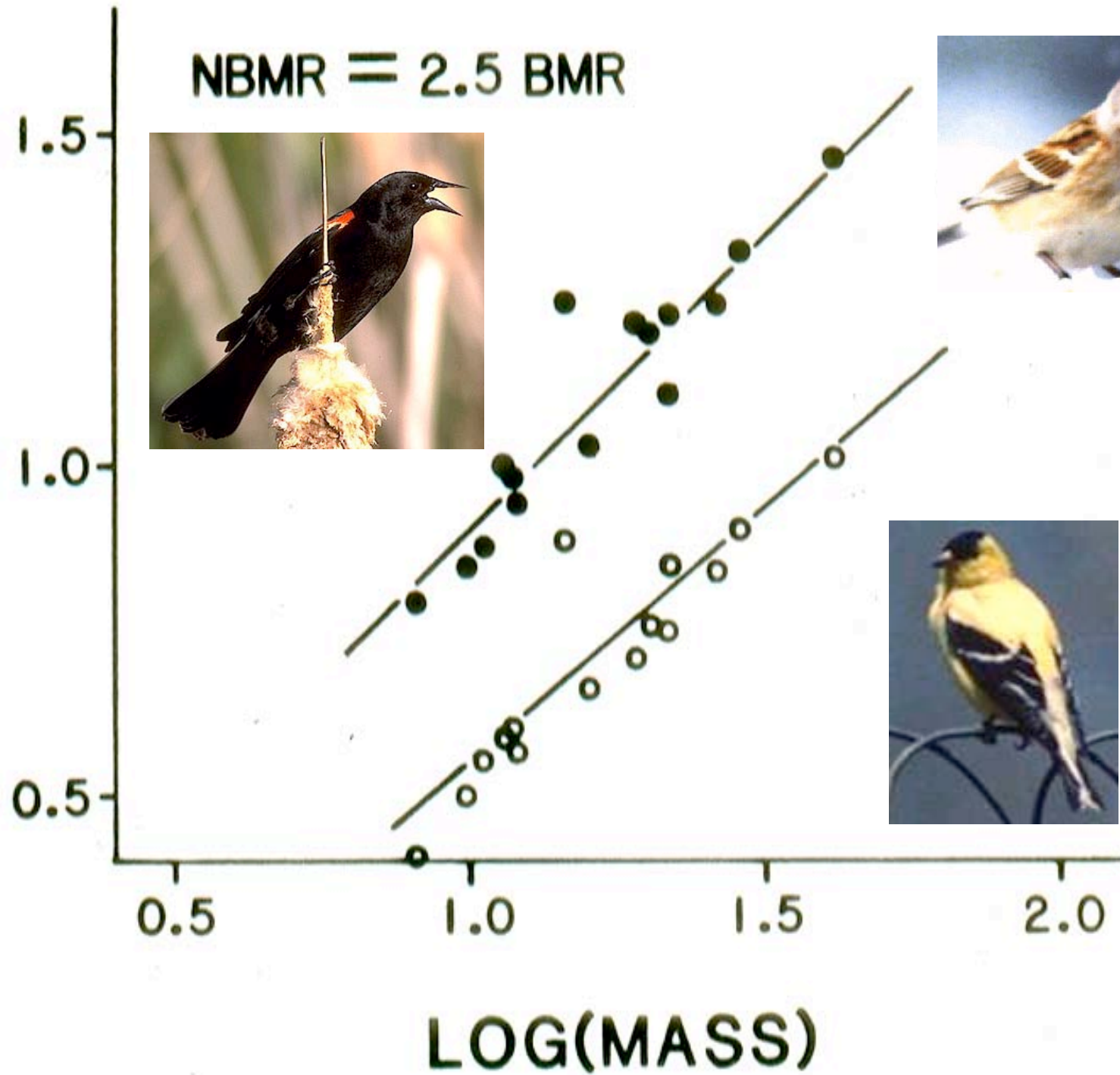


LOG(METABOLIC RATE)



LOG(METABOLIC RATE)

NBMR = 2.5 BMR



Biosphere Surprises: Known

Theory—1st Principles

- Space
 - Abiotic Factors
 - Average Climate
 - Climate Extremes
 - Day Length

Biosphere Surprises: Known

- Theory—1st Principles
 - Time
 - Biotic
 - Predator-Prey
 - Competition

Biosphere Surprises: Known

- Theory—1st Principles
 - Time
 - Abiotic
 - Day Length
 - Heating Degree Days

Song Sparrow

28-Jun

29-May

29-Apr

30-Mar

29-Feb

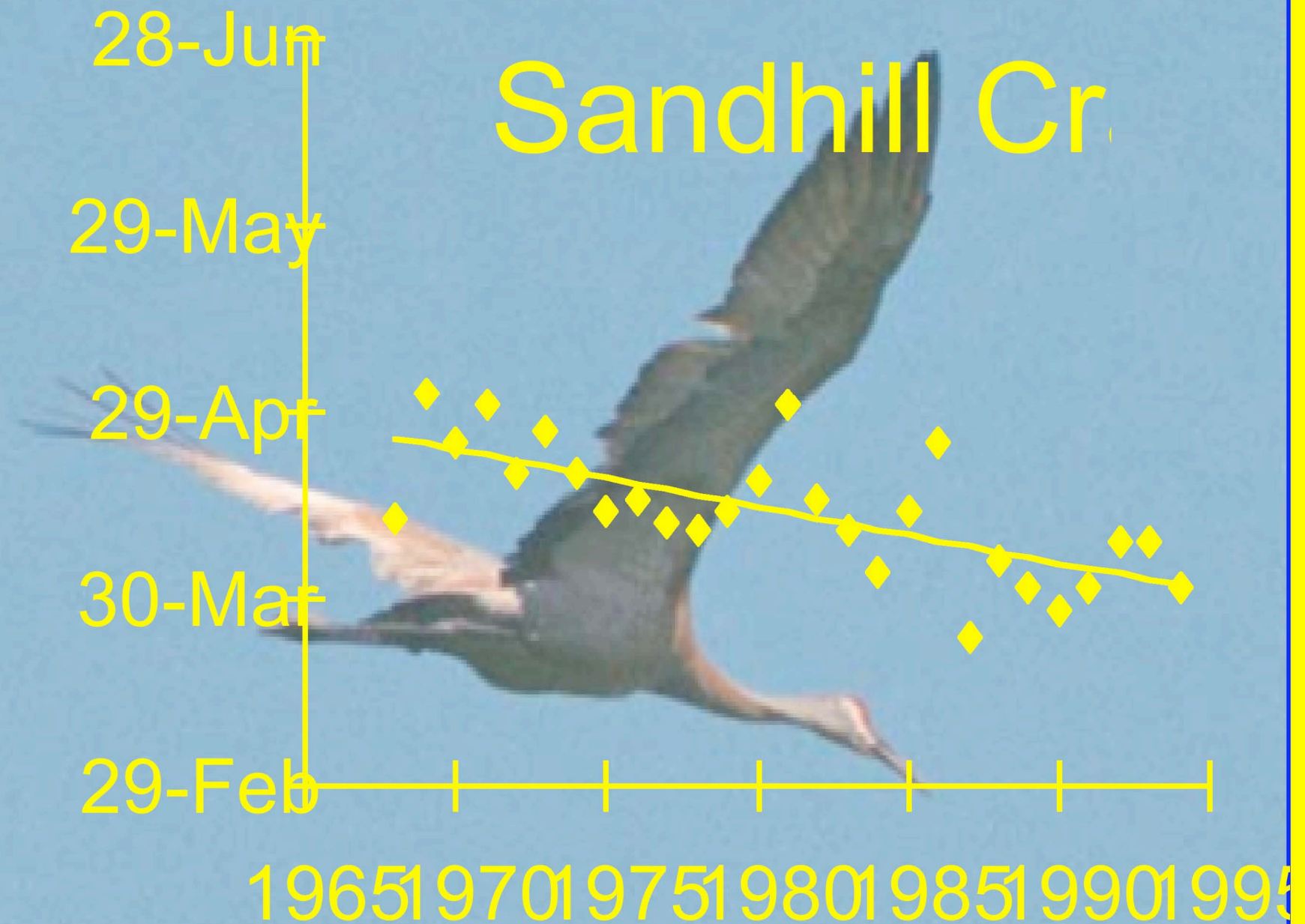
1965 1970 1975 1980 1985 1990 1995

Song Sparrow

www.birdperch.com



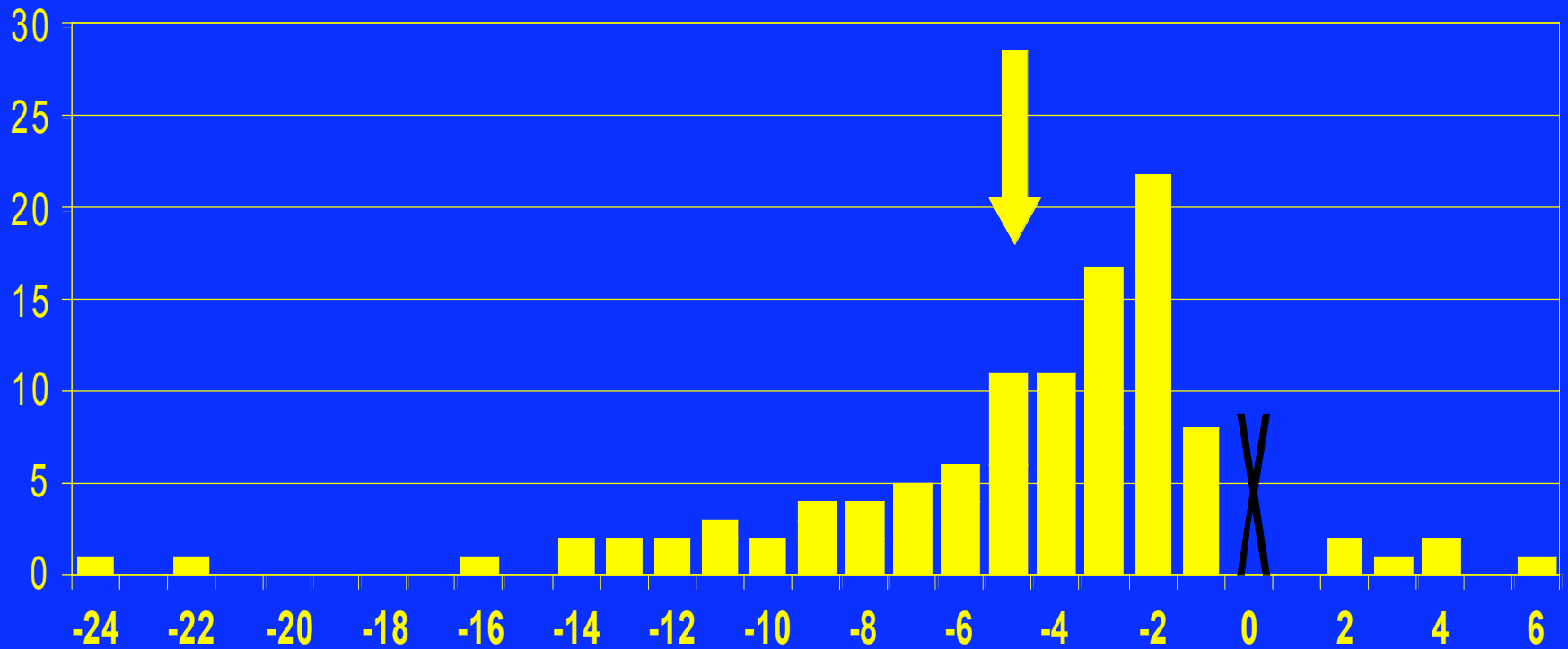
Sandhill Cr.



Sandhill Crane

www.birdperch.com

Frequency of Species



Number of Days Changed in 10 Years

Biosphere Surprises: Known

- Theory—Fairly well
- Observations
- Models
- Consensus

Biosphere Surprises: Known

- Observations (Space & Time)
 - Prehistoric data spotty
 - Historic data infrequent
 - Non-traditional data



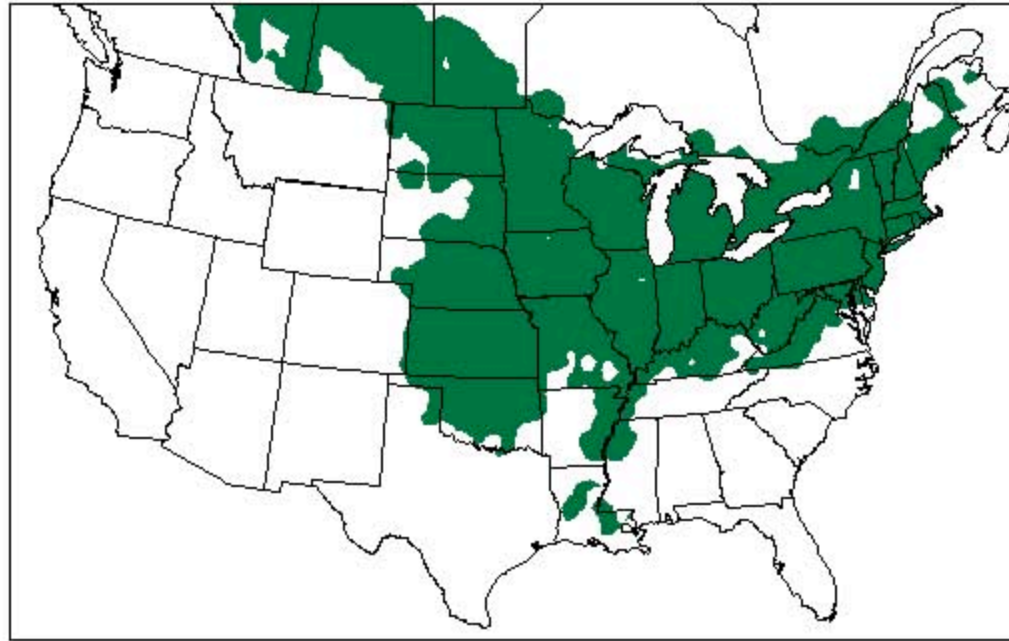
Biosphere Surprises: Known

- Theory—Fairly well
- Observations—Few
- Models
- Consensus

Biosphere Surprises: Known

- Models
 - Climate Envelopes
 - Others

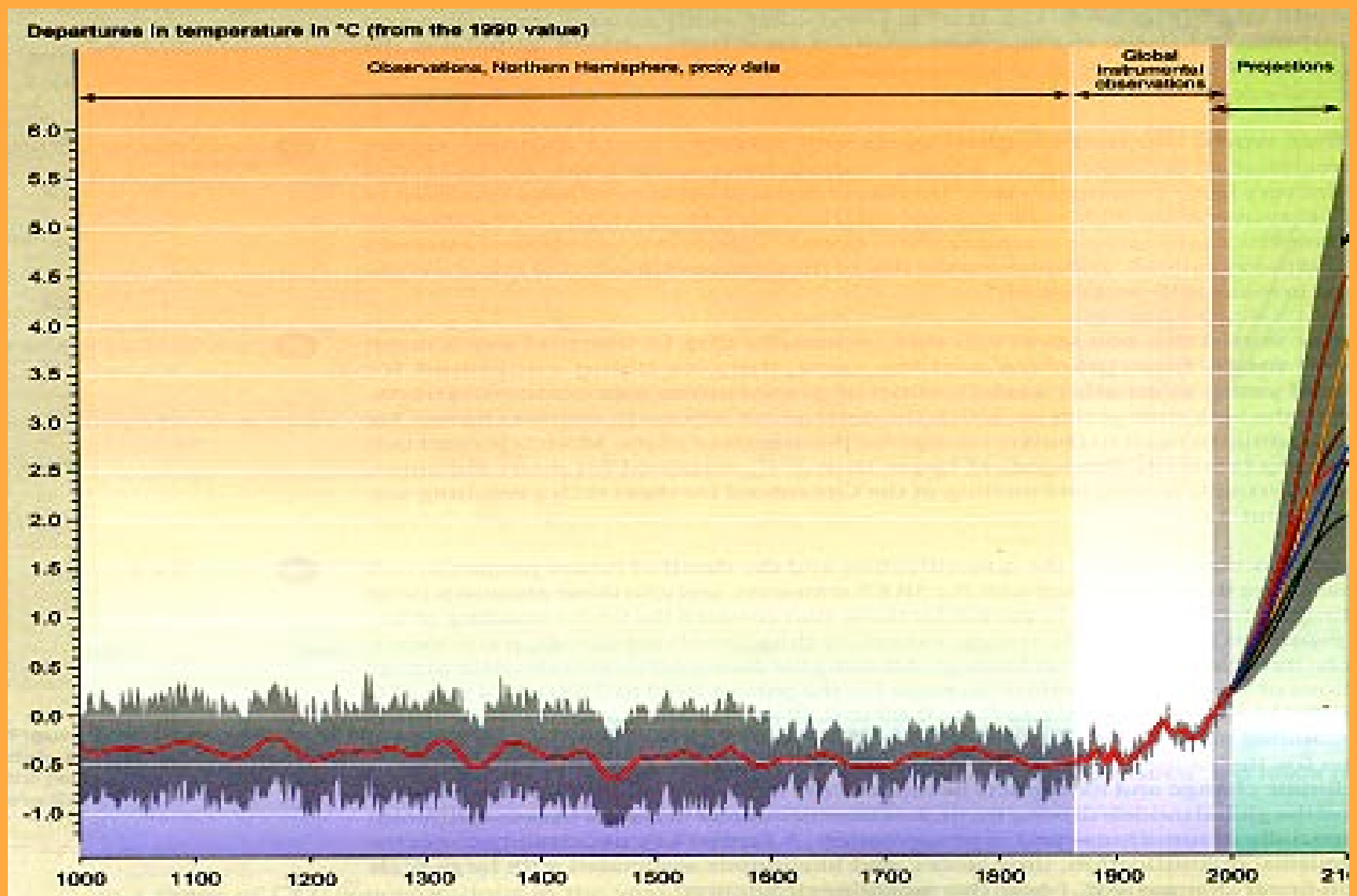
Current Distribution



Baltimore Oriole
(*Icterus galbula*)

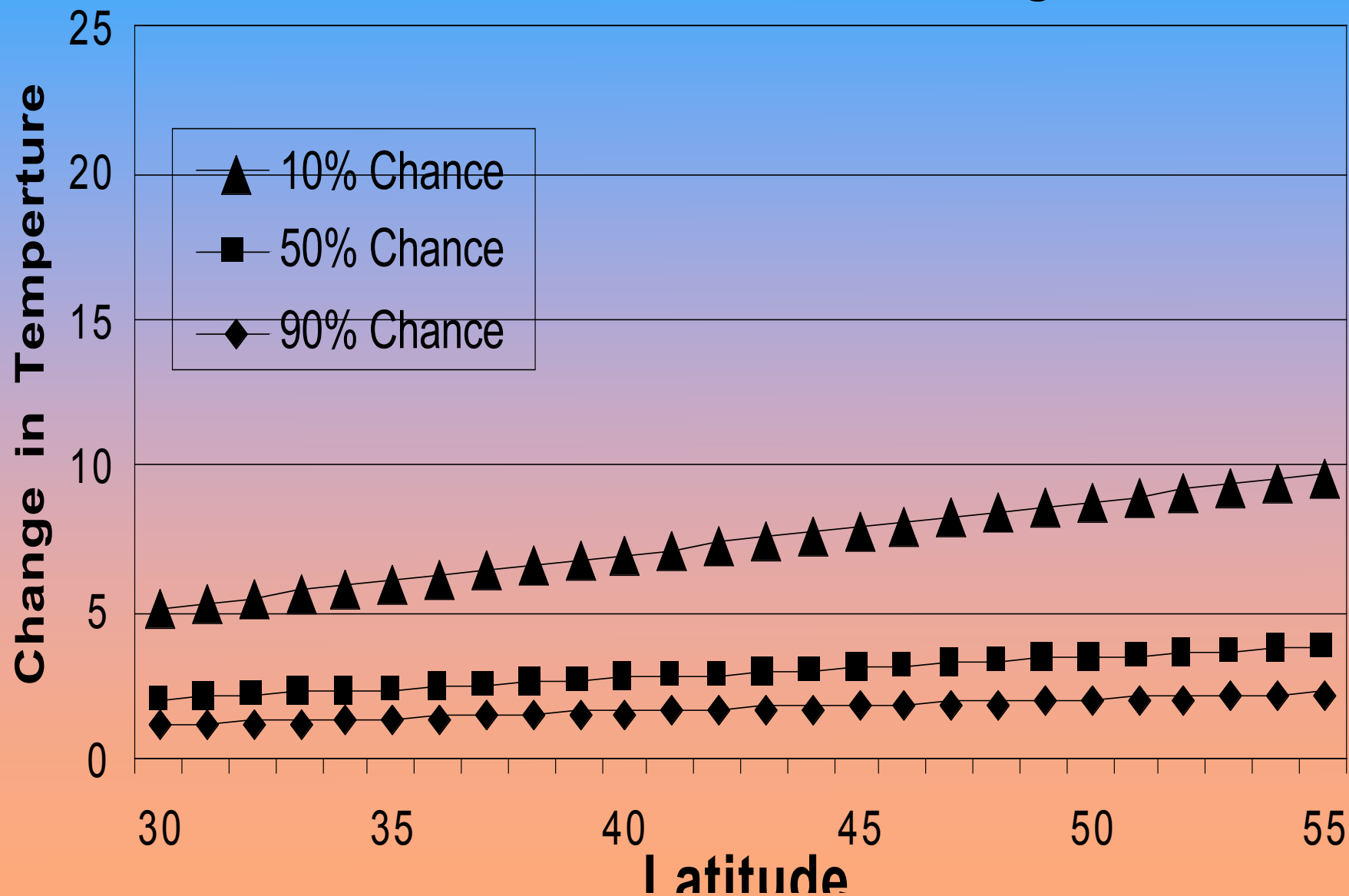
Projected Distribution (2xCO₂)



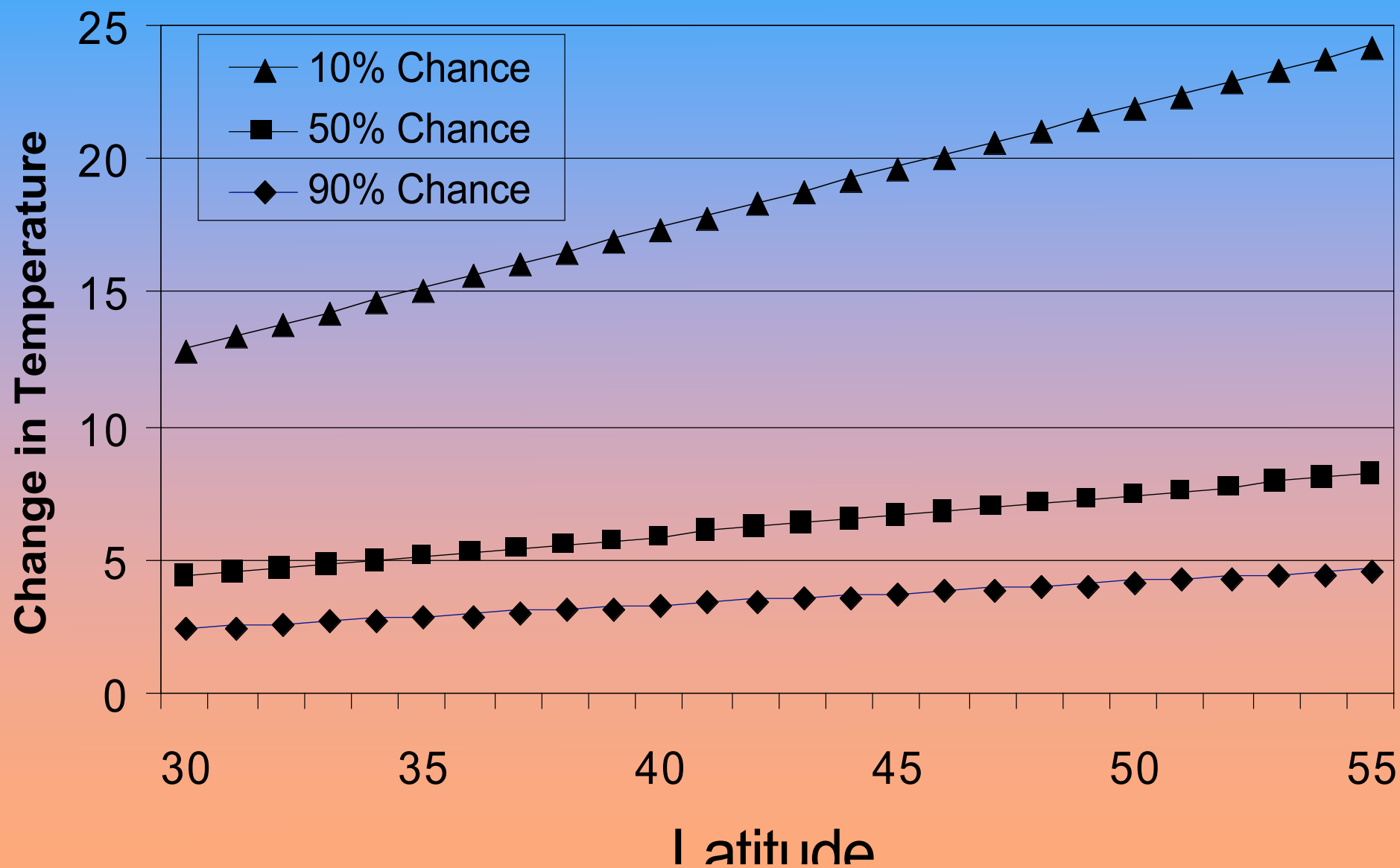




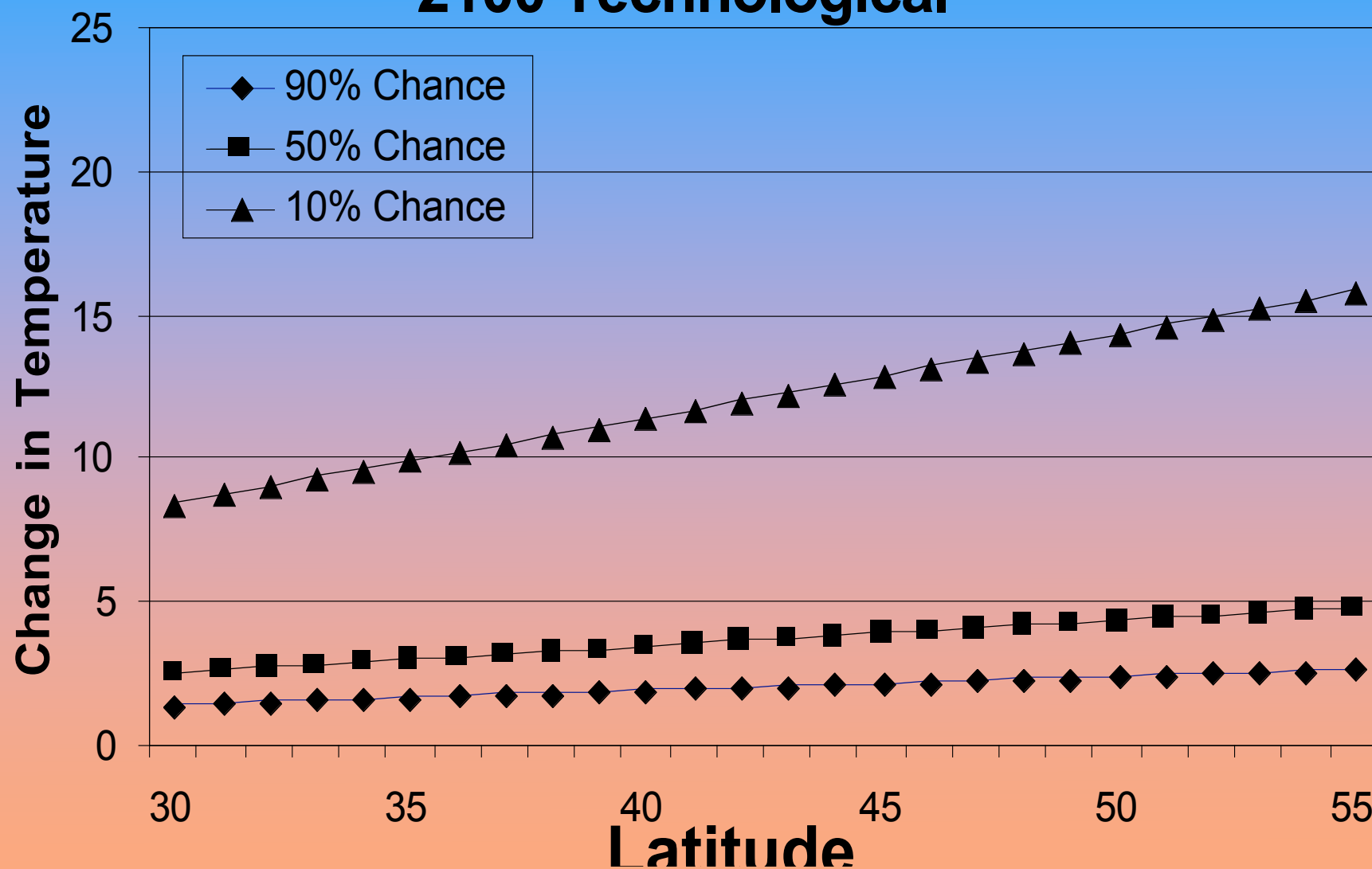
2050 Fossil Intensive & Technological



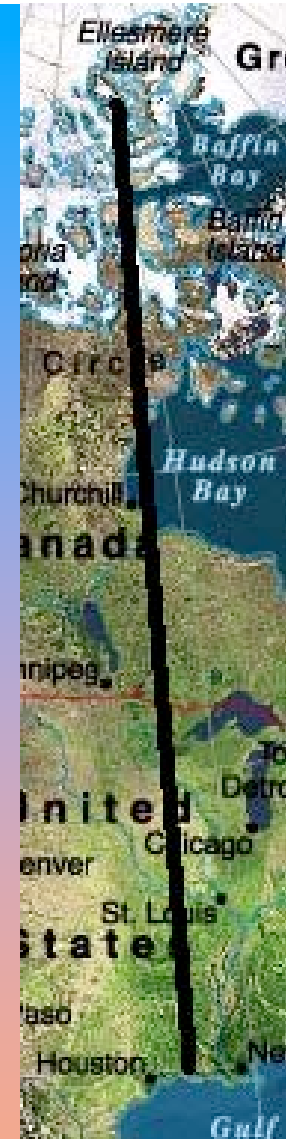
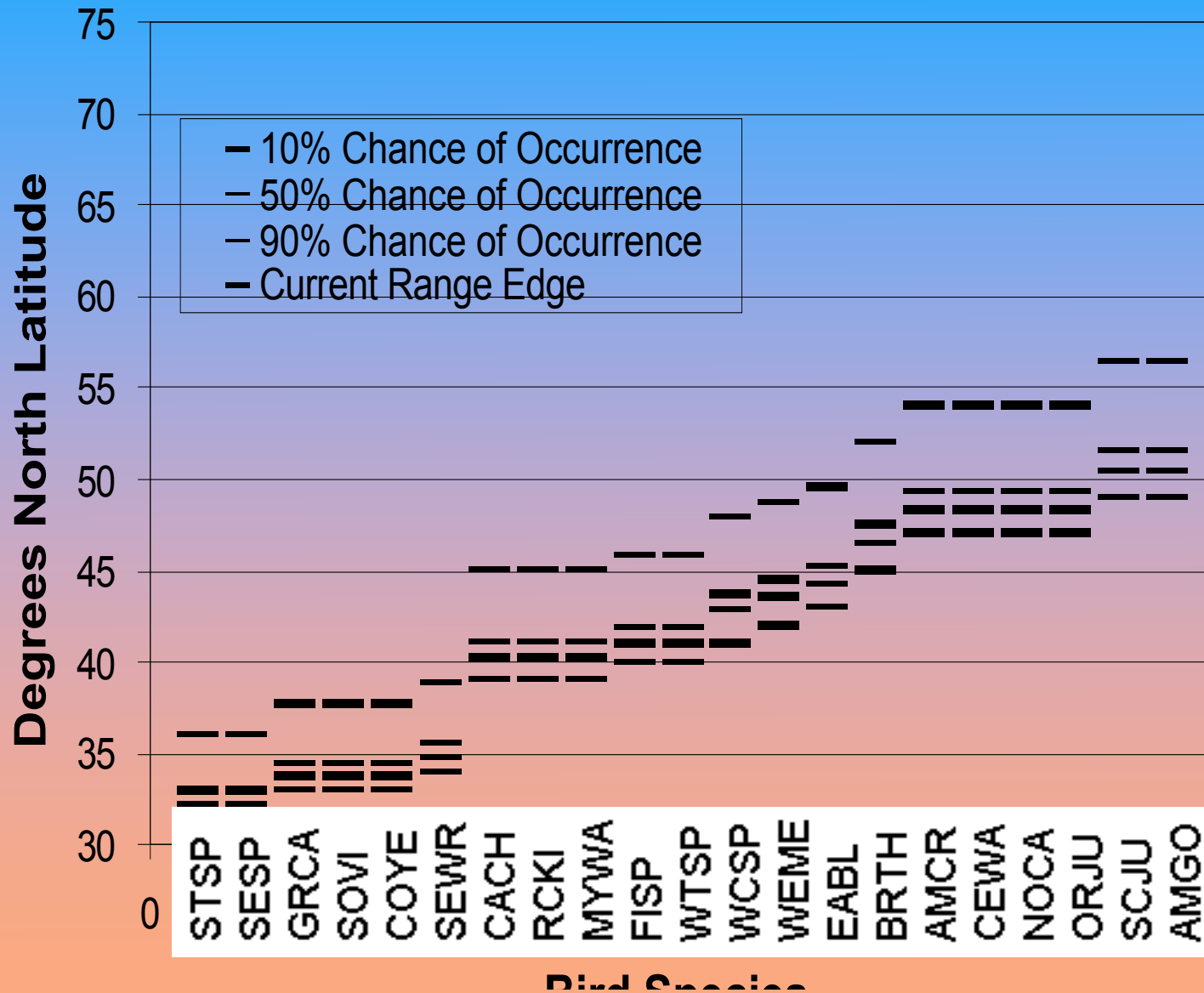
2100 Fossil Intensive



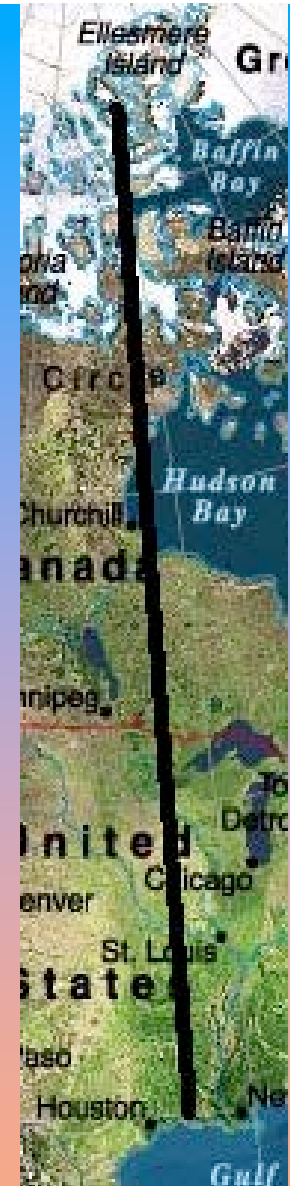
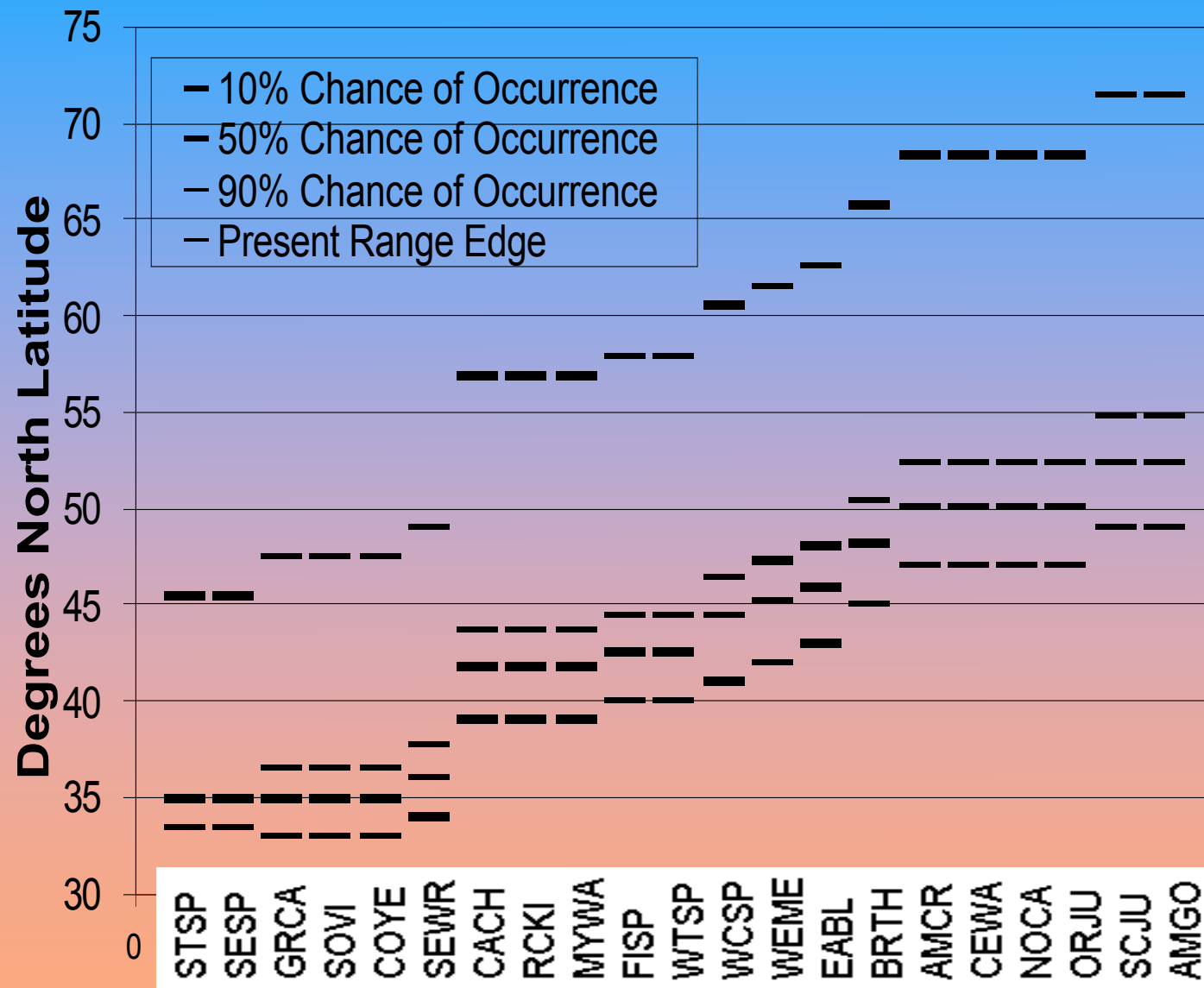
2100 Technological



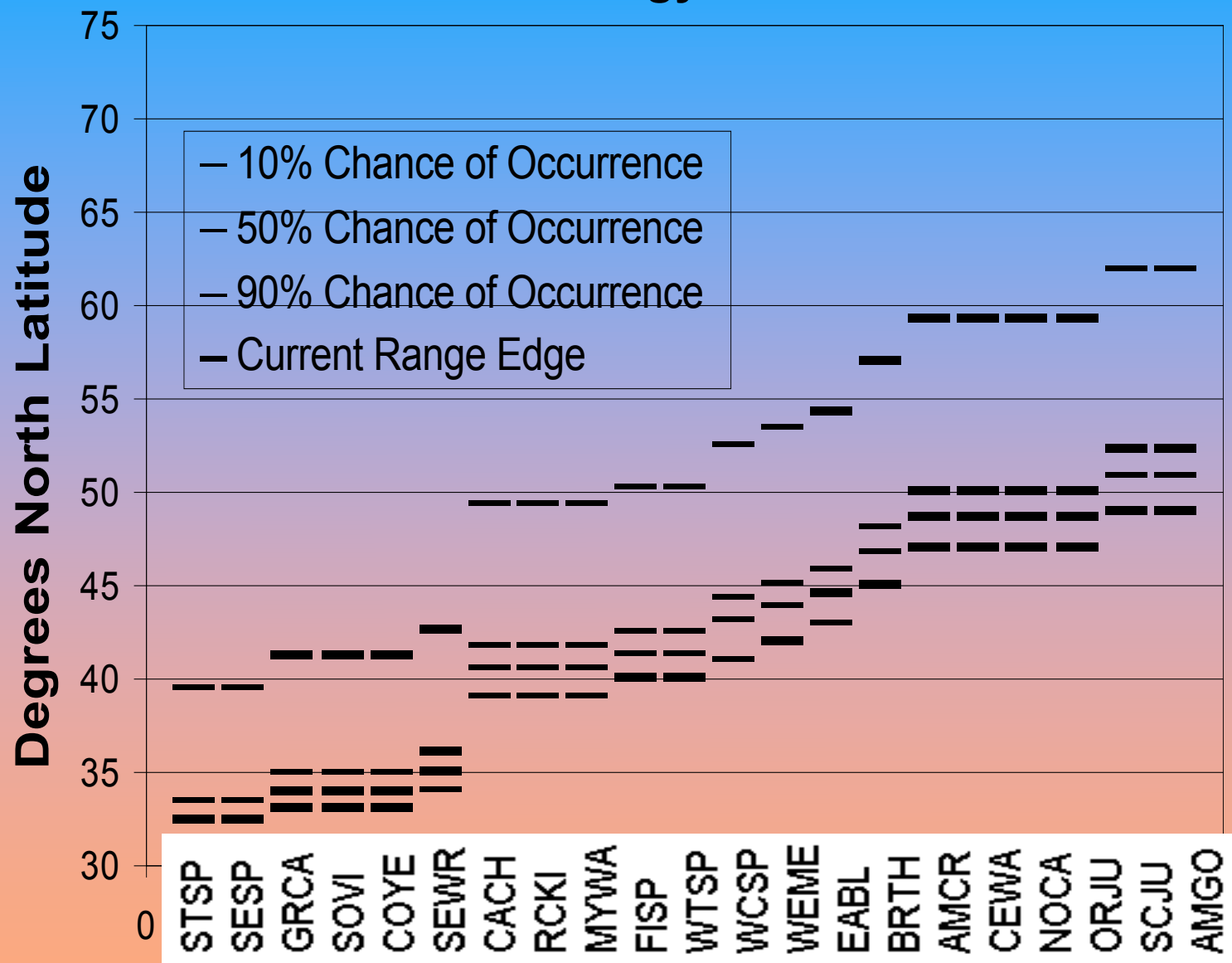
Technology and Fossil Intensive 2050



Fossil Intensive 2100



Technology 2100



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
- AND
- ◆ Trait Associated with Temp.
- OR
- ◆ Temp. Shows Trend Over Time
- OR
- ◆ 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

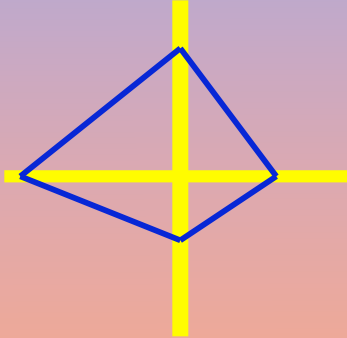
Biosphere Surprises: Known

- 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!

Photograph by Mari Howe