Precipitating Changes

climate-shift impacts on Texas freshwater wildlife

12 May 2006

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For organisms, global warming isn’t just about air temperature

- Precipitation amounts
- Precipitation timing
- Temperature impacts on water bodies

Precipitation and water temperature are connected

- Higher mean annual precipitation
- Less frozen precipitation
- More droughts & floods (variability)
- More intense precipitation events

- Precipitation amounts
- Precipitation timing

- Modeling doesn't yet clearly resolve shifts in within-year variation
- These changes are occurring
- What every gardener & farmer knows: the timing of rain matters

Changes in precipitation patterns alter water temperatures

Ambient temperature & organism impacts

Shifting air temperatures

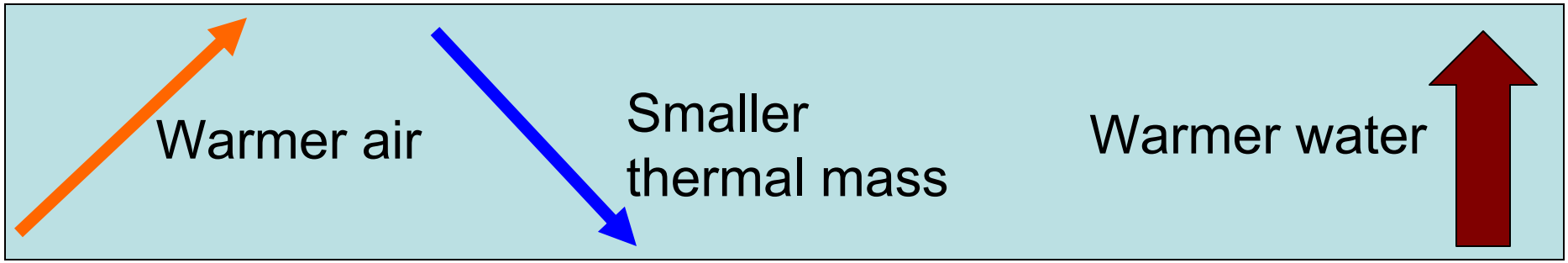
ambient water temperature

- Metabolism
- Growth rate
- Survivorship
- Escape speed

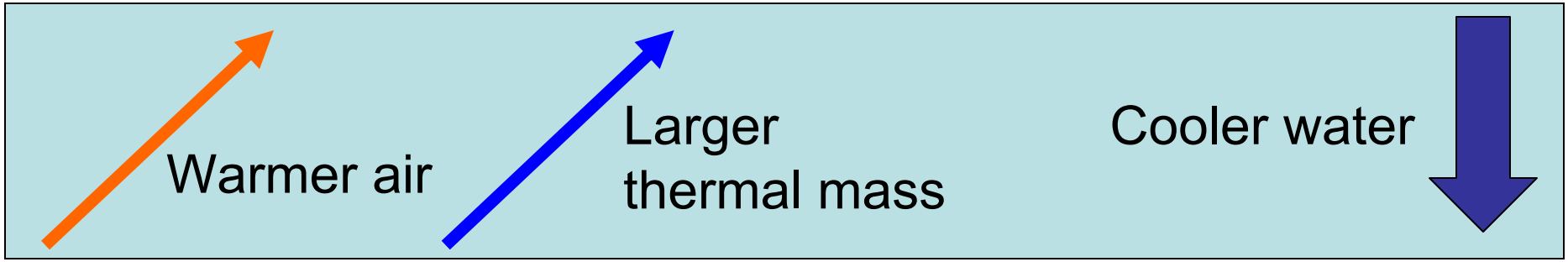
thermal mass

Shifting precipitation: timing, amounts

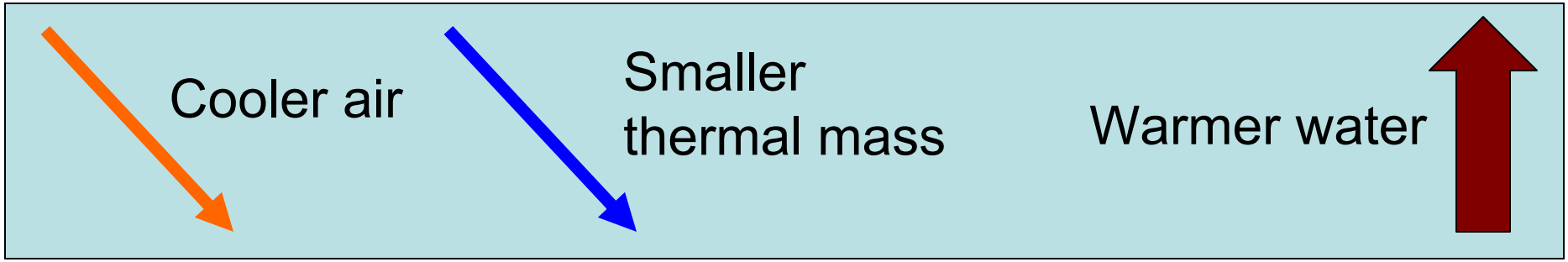
Droughts: Warmer air, less rain



Floods: Warmer air, more rain



Harsh winters: Cooler air, less rain



Species temp-precip impacts

Changes in where you find a species
Changes in timing (phenology)

Indirect impacts

Loss of habitat
Trophic cascades
Population instability
Species extinctions

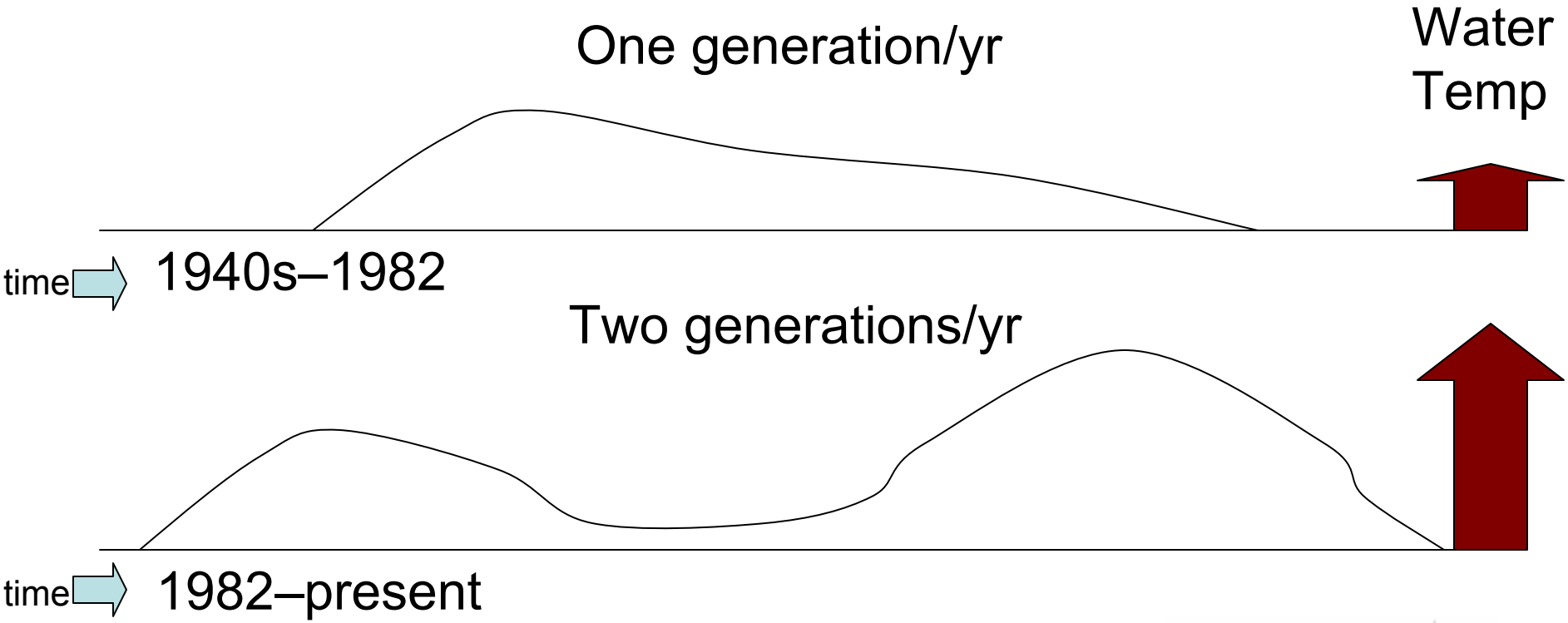
Direct impacts

- Metabolism
- Growth rate
- Survivorship
- Escape speed

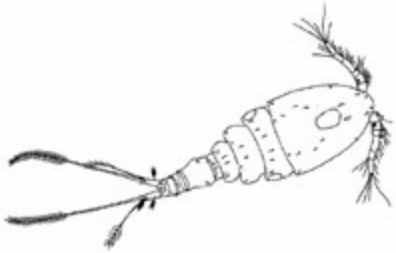
ambient water temperature

Species temp-precip impacts

Direct impacts on copepod blooms



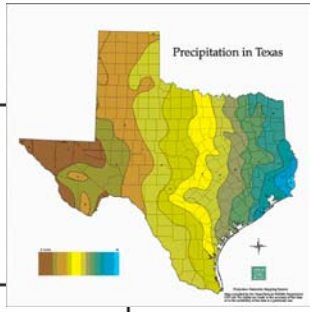
Many planktonic species will increase in productivity with higher temperatures and more nutrient-rich runoff

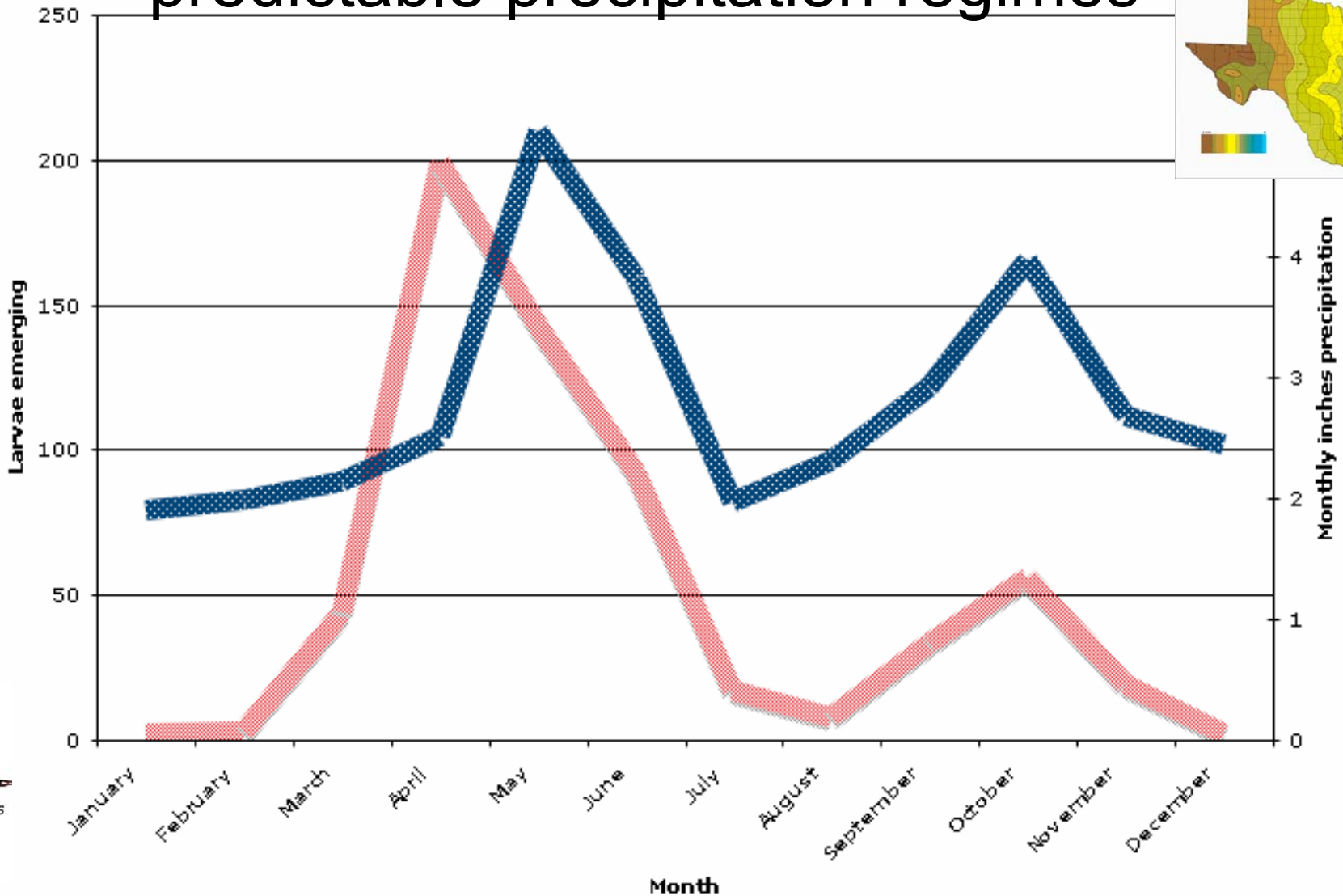


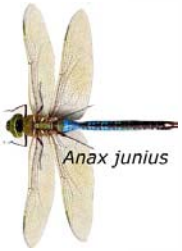
Schindler, 2005

Species temp-precip impacts

Many species depend on predictable precipitation regimes

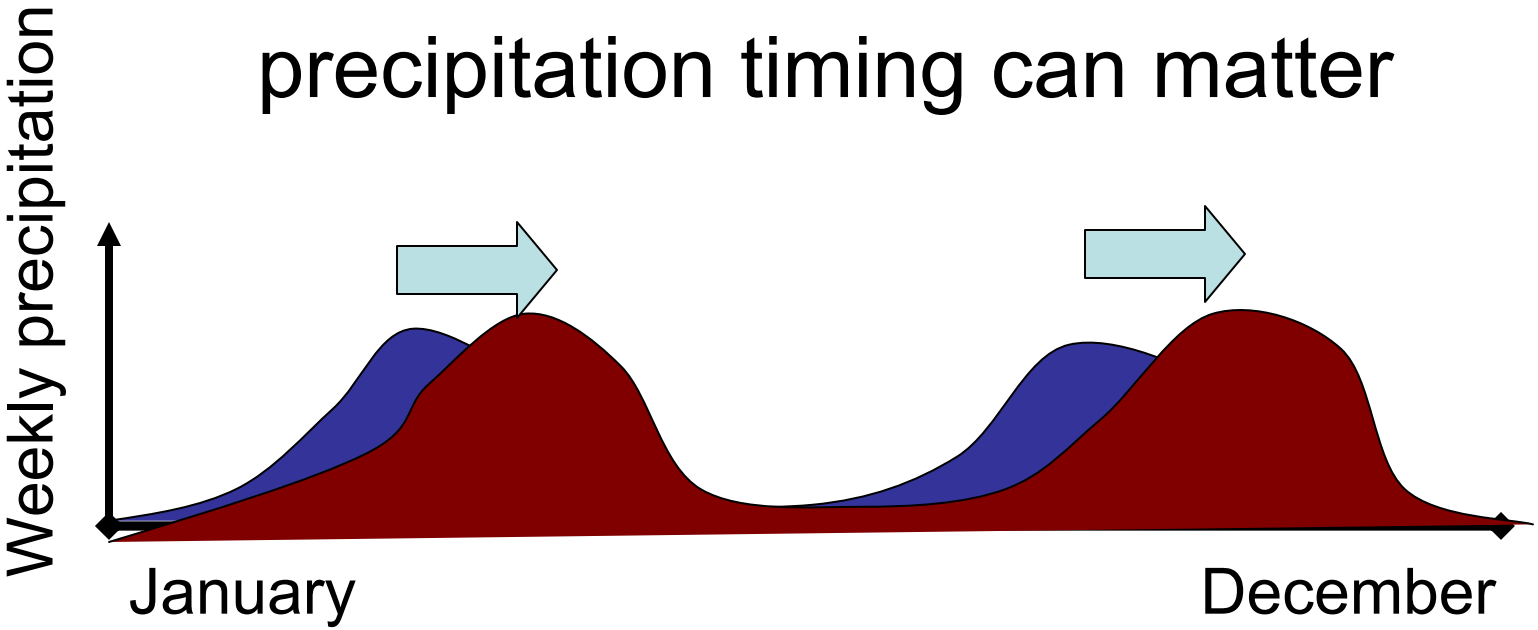






Species temp-precip impacts

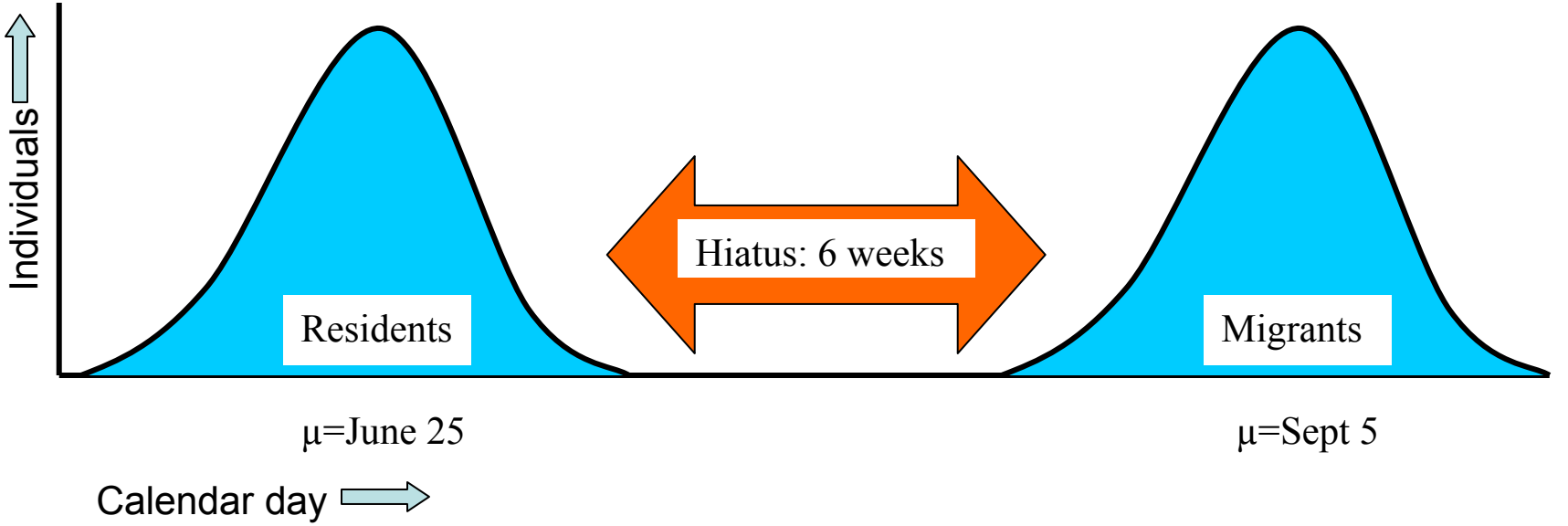
Even small shifts in precipitation timing can matter



For many species, the **seasonal** timing of precipitation is important

Species temp-precip impacts

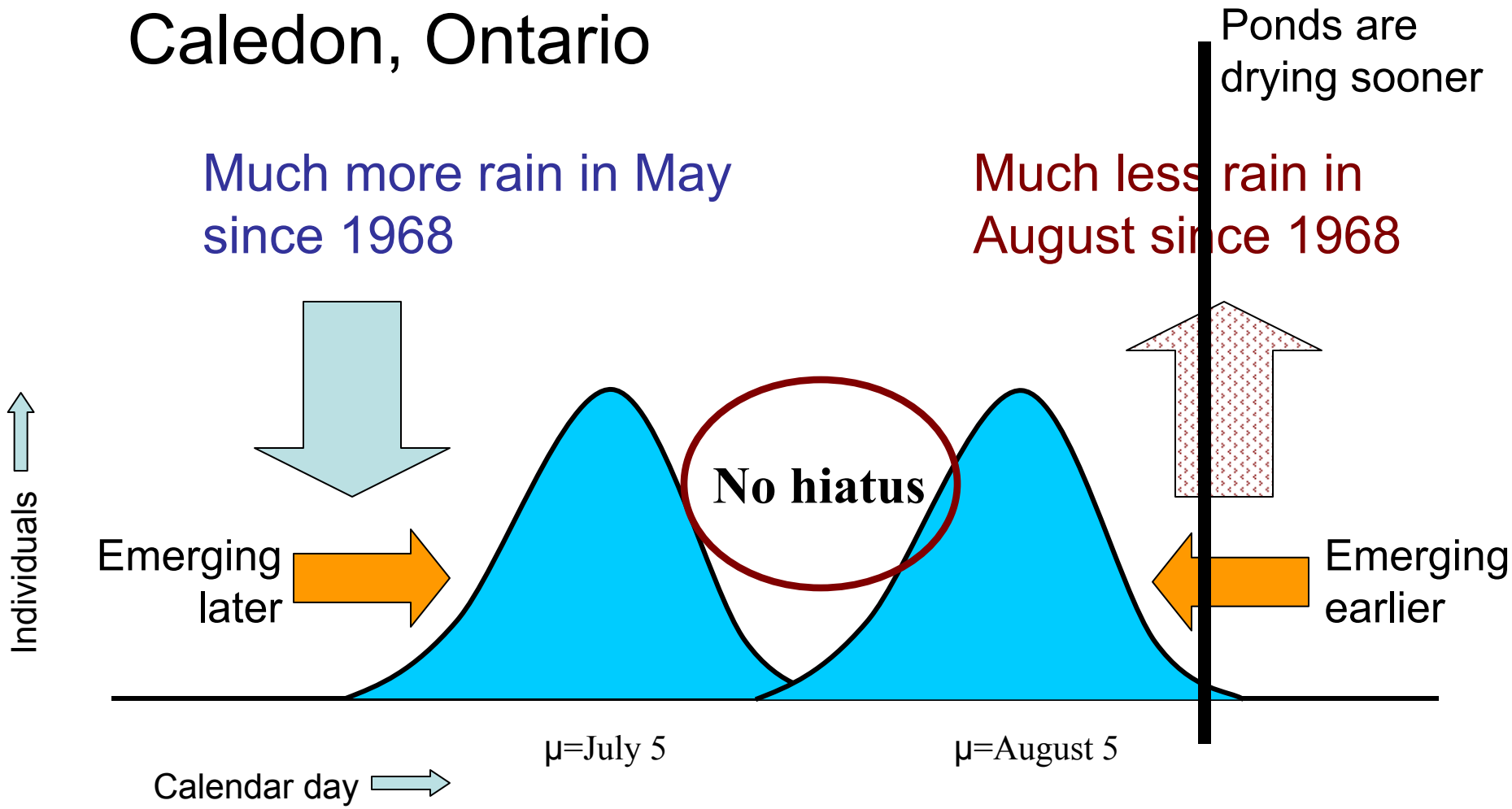
Dragonfly emergence 1967–68: Caledon, Ontario



Source: Trottier 1971

Species temp-precip impacts

Dragonfly emergence 2003–05: Caledon, Ontario

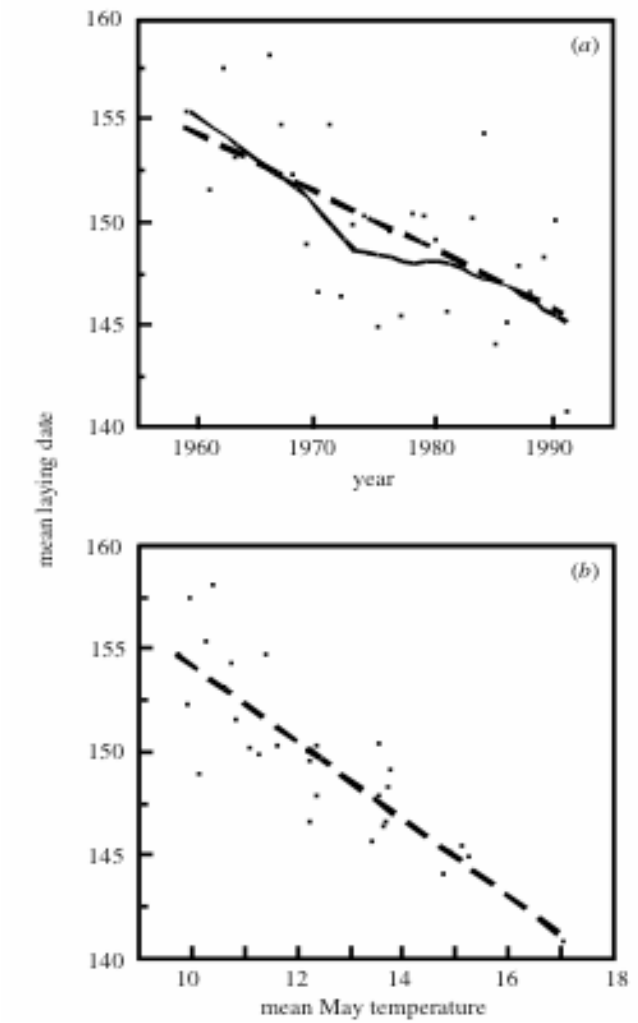


More thermal mass, cooler water

Less thermal mass, warmer water

Species temp-precip impacts

Moving up the food chain: Tree swallows

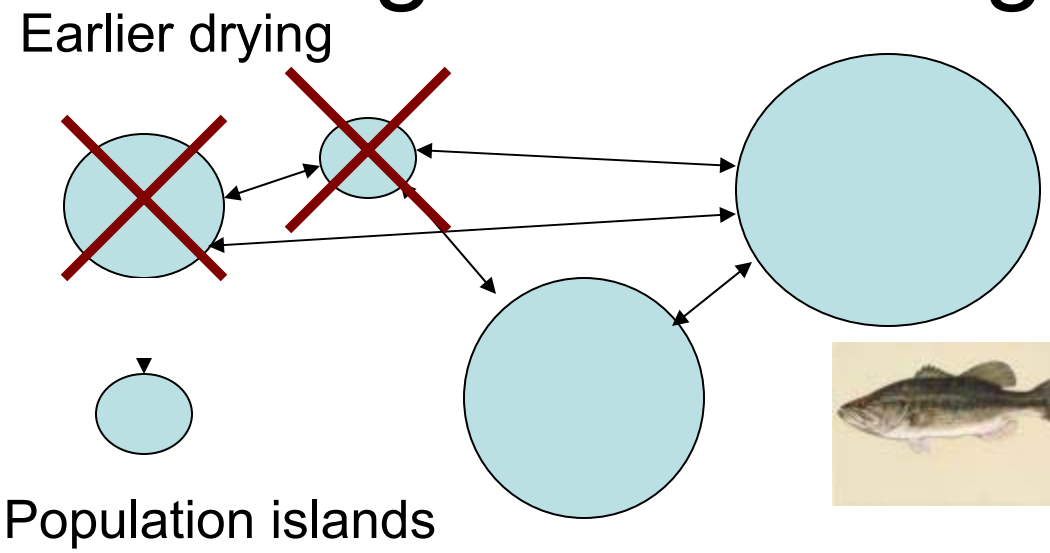


- Surveyed over 21,000 breeding records
- Egg-laying date advanced nine days between 1959–1991
- Mechanisms driving change are uncertain; may be connected to advance in aquatic insect prey emergence

Dunn & Winkler 1999

Species temp-precip impacts

Range shifts: range & habitat loss



For most species, habitat is organized in population networks

Range shifts: range expansion

More tropical birds, butterflies, mosquitoes, dragonflies in Texas, Florida, California

Difficult to isolate climate change from other causes

Which aquatic species are most vulnerable?

Transformation/disappearance of habitat: about 60 of 110 sp.

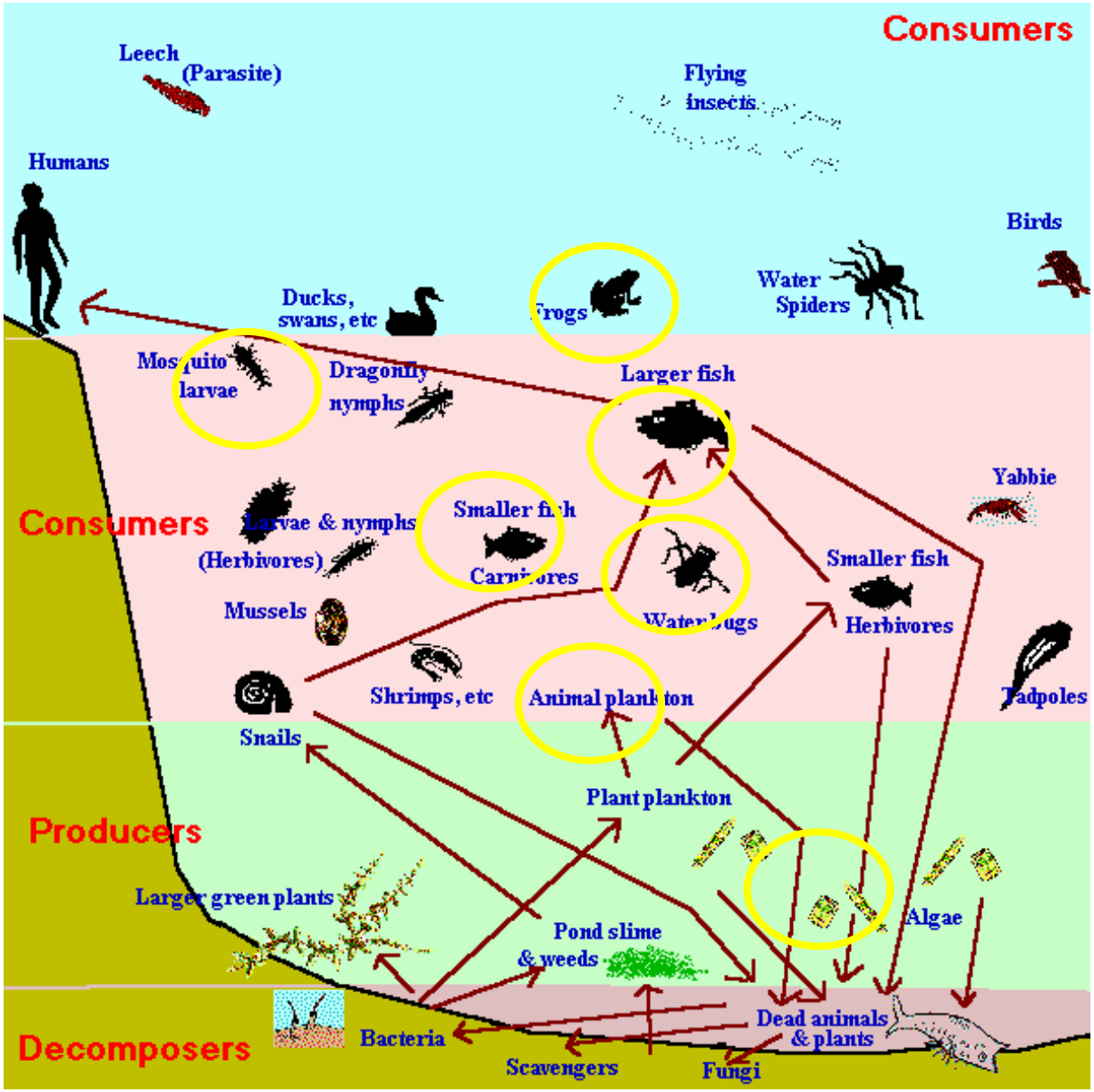
Limited range/specialized habitat

Already under threat from land-use changes, invasive species

Poor dispersers

The most vulnerable species are those that are losing or will lose existing habitat and that are unable to reach suitable habitat elsewhere

Community impacts: trophic cascades



Single species:

- Shifting phenology
- Fluctuating populations
- Shifting ranges

Multiple species: ?

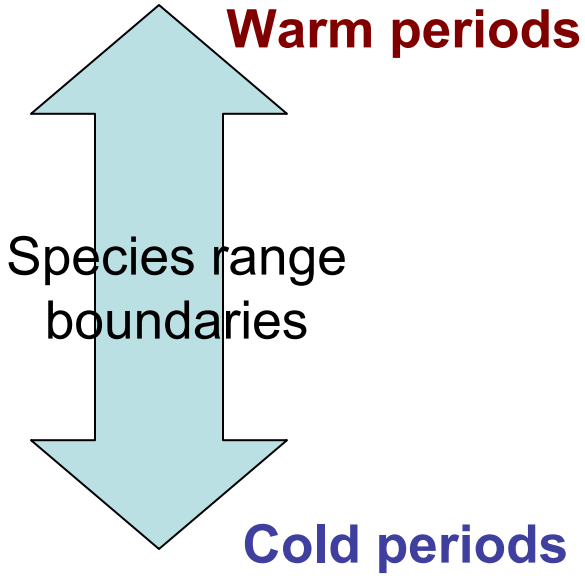
- Complex
- Nonintuitive
- Nonlinear
- Hard to isolate from other factors

Why is climate change different now?

The short answer: because everything else is different now too

10,000 years ago:
Free movement

21rst Century:
Restricted movement



The new context

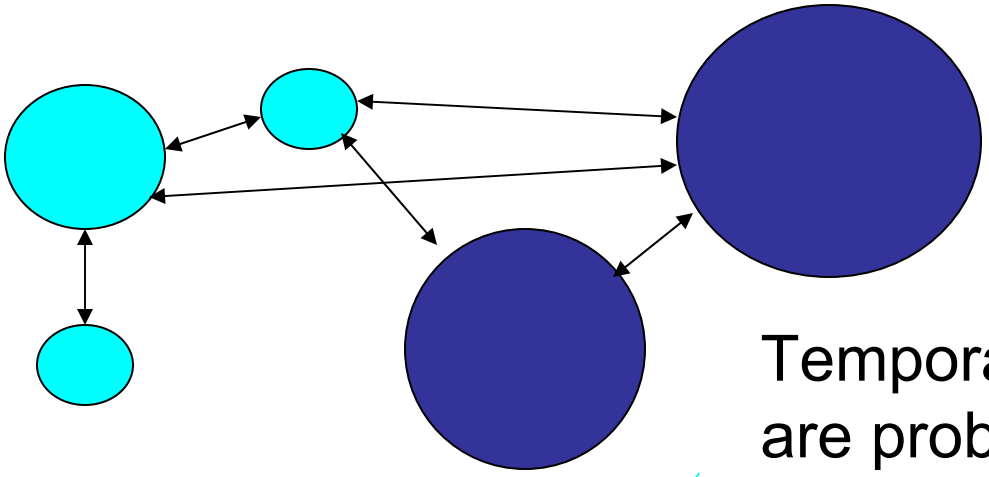
- Land-use changes
- Habitat destruction
- Water pollution
- Invasive species
- Development
- Stocking of nonlocal populations

Two take-home messages for the big changes afoot

1. **Global warming is more than increasing air temperature;** precipitation cycles are changing, and water temperatures are shifting in ways that are different than air temperature

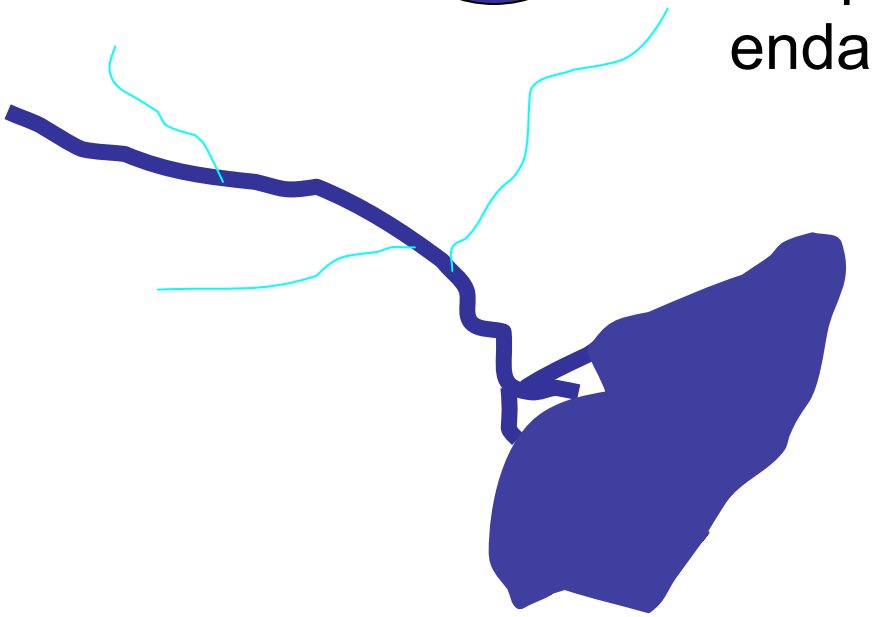
2. From a conservation perspective, we need to think beyond a few endangered/ threatened species; **impacts are observable and widespread**

Changing our emphasis: *from* **species** *to* **habitats**



Freshwater systems are **permanent** or **temporary**

Temporary freshwater systems are probably the most endangered habitat in Texas



Threats:

- Droughts and higher climate variability
- Land-use changes in agriculture and development
- Little regulatory protection
- Low awareness

The outline of a habitat-centered focus

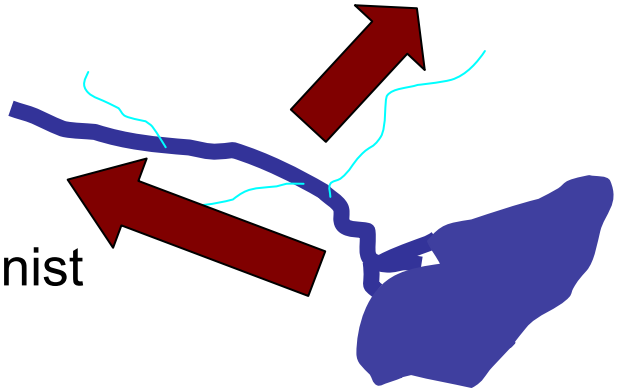
Large-scale strategies:

- slow down human greenhouse gas emissions
- give species and ecosystems more time to adapt

Regional scales

- Develop and maintain habitat escape routes as climate continues to shift

TNC Adaptationist Strategy



Heat + nutrient-rich runoff

eutrophic systems

- Improve water quality and reduce nonclimate pressures

- develop a regional plan to recognize & protect temporary ponds and streams

Storm-water systems **are** temporary aquatic systems

Local scales

Increase the number of local small fish-free aquatic systems that can survive dry periods

Improve the quality of local streams and ponds

Monitor what happens in your local watershed— for yourself and those organisms you share it with

Acknowledgments

many thanks to

Environmental Defense

Lone Star Chapter, Sierra Club

National Wildlife Foundation

Funding

Camille Parmesan, PhD

John Abbott, PhD

Tom Juenger, PhD

Environmental Science Institute

National Science Foundation

UT Section of Integrative Biology

UT Vice President of Research

Field Assistance

Nathan Burnett

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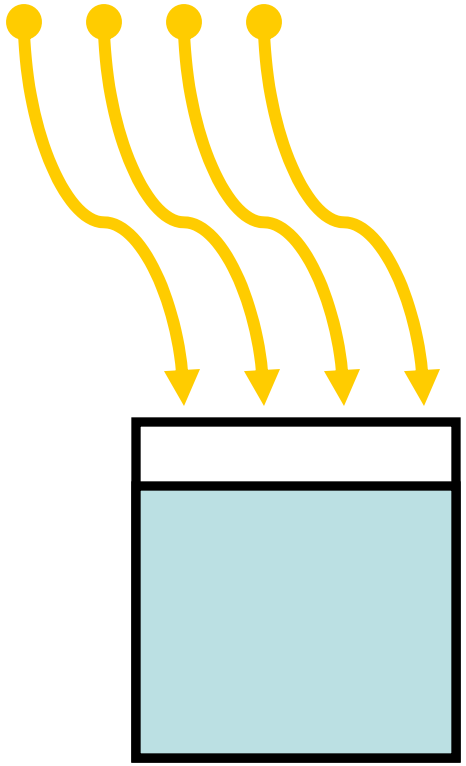
What determines water temperature?

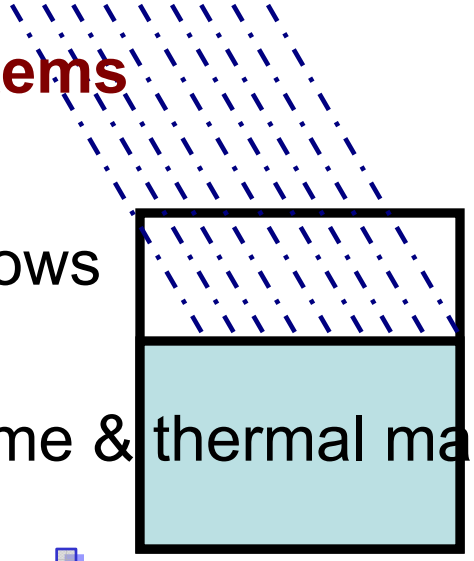
Large FW systems

Air temperature &
direct solar inputs



Small FW systems

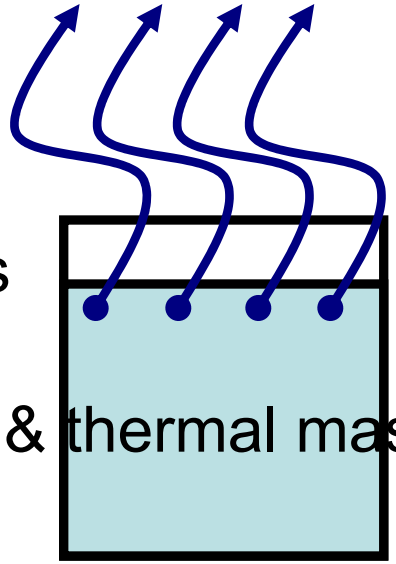
Precipitation inflows



Increasing volume & thermal mass

thermal mass

Evaporation outflows



Decreasing volume & thermal mass

Freshwater systems cover 1.7% of the earth's surface but contain 15% of animal species

Temporary and permanent freshwater systems have distinct groups of species