POLLINATORS IN A CHANGING CLIMATE

WHAT IS CLIMATE CHANGE?

SCIENTISTS ALARMED AT THE RATE OF CLIMATE CHANGE & THAT RATE IS DUE TO HUMAN ACTIVITIES

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- Climate change refers to the sum of all local long-term changes in temperature & precipitation
- Climate is already changing!
- Scientists predicted this would happen as early as 1957

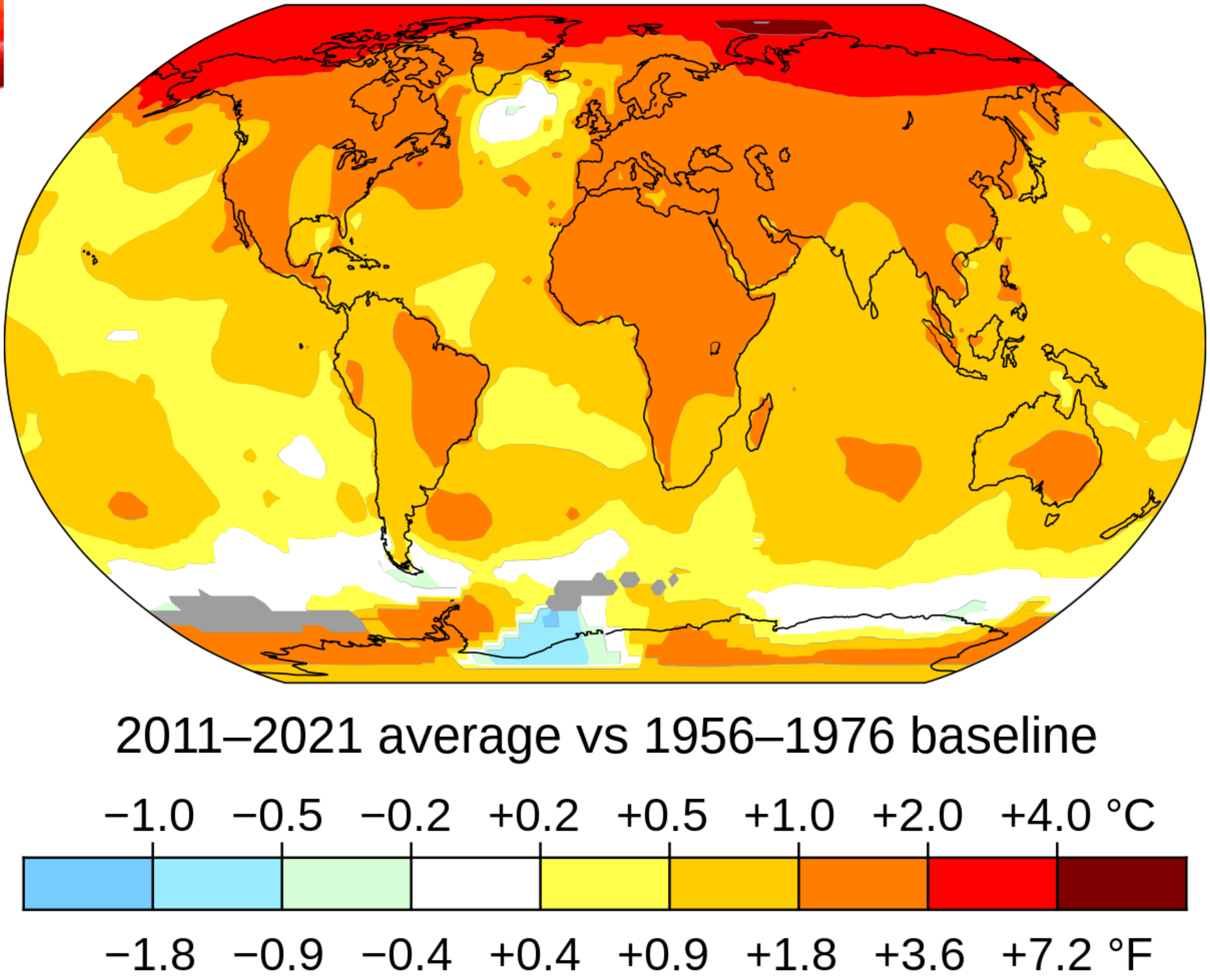
CLIMATE AFFECTS MORE THAN TEMPERATURE ALONE

- Temperature affects the water cycle: where, when, & amount of precipitation
  - Average US precipitation increased ~5% in last ~50 years. North may get wetter, Southwest likely drier.
- Temperature & precipitation becoming more variable while severity increasing because warmer air can hold more moisture
  - More frequent/severe monsoons, tornados, hurricanes
- Warmer temperature → sea level rise due to expansion of oceans & melting glaciers/polar ice caps on land.
  - Ice cap melting affects ocean currents & cloud cover

CONSEQUENCES OF CLIMATE CHANGE: INCREASED INTENSITY & FREQUENCY

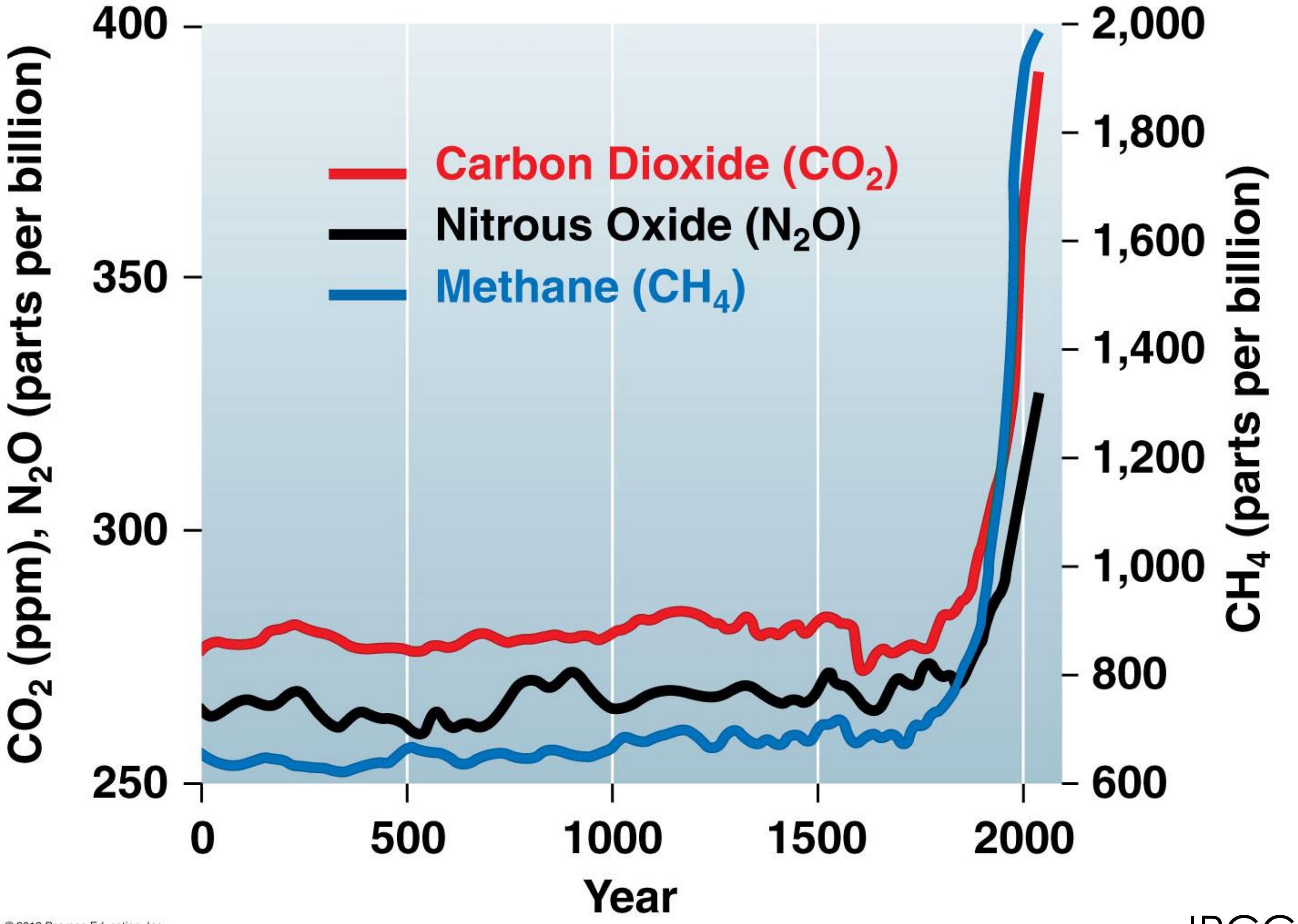
- Intense droughts
- Water scarcity & flooding
- Severe fires
- Rising sea levels
- Melting polar ice
- Catastrophic storms
- Declining biodiversity

Temperature change in the last 50 years



CLIMATE CHANGE

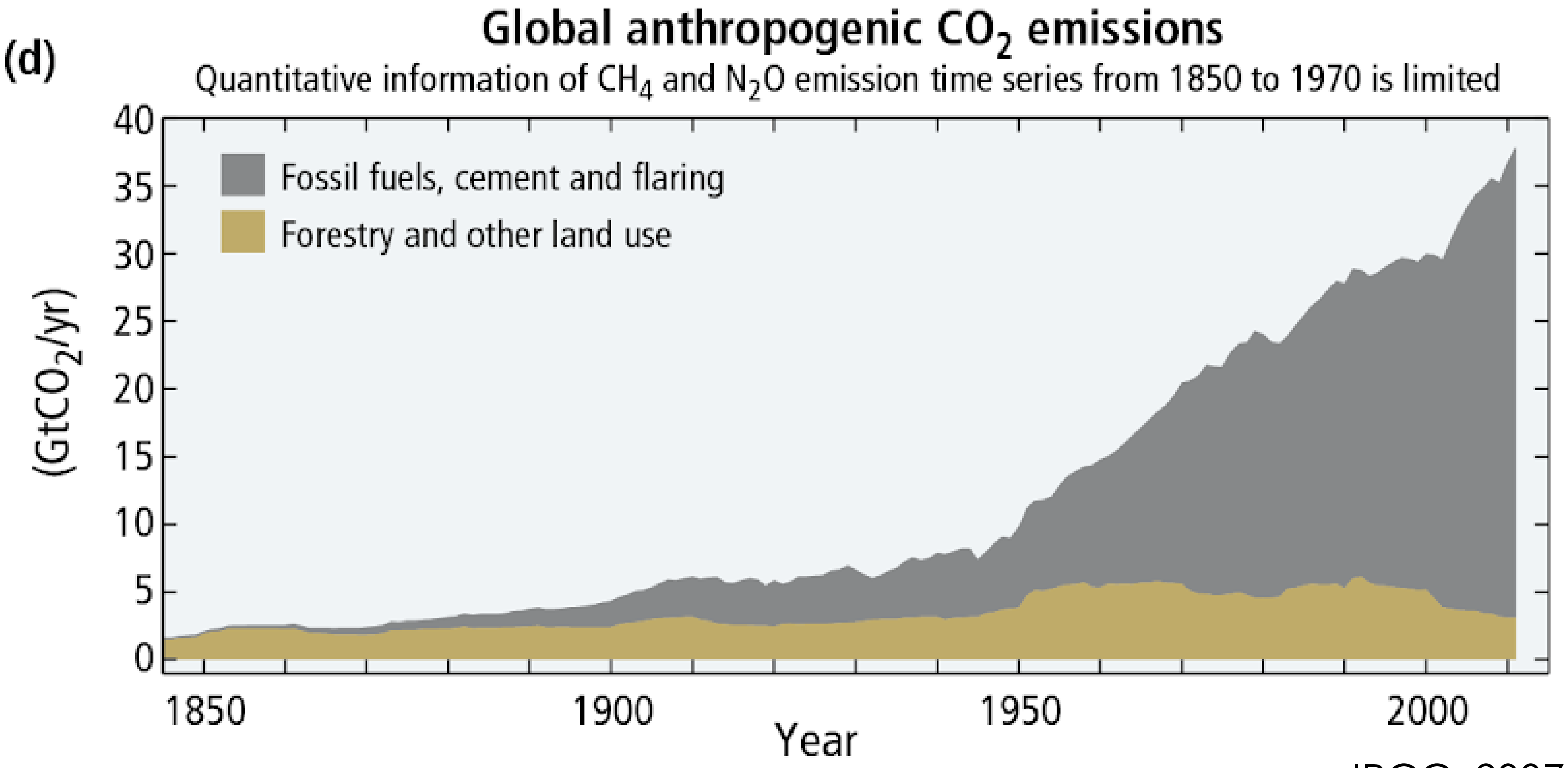
⇧ CO_2, CH_3, $NO_{2,3}$, SO_2, DUST, & CHLOROFLUOROCARBONS (aerosol spray and packing materials) IN ATMOSPHERE



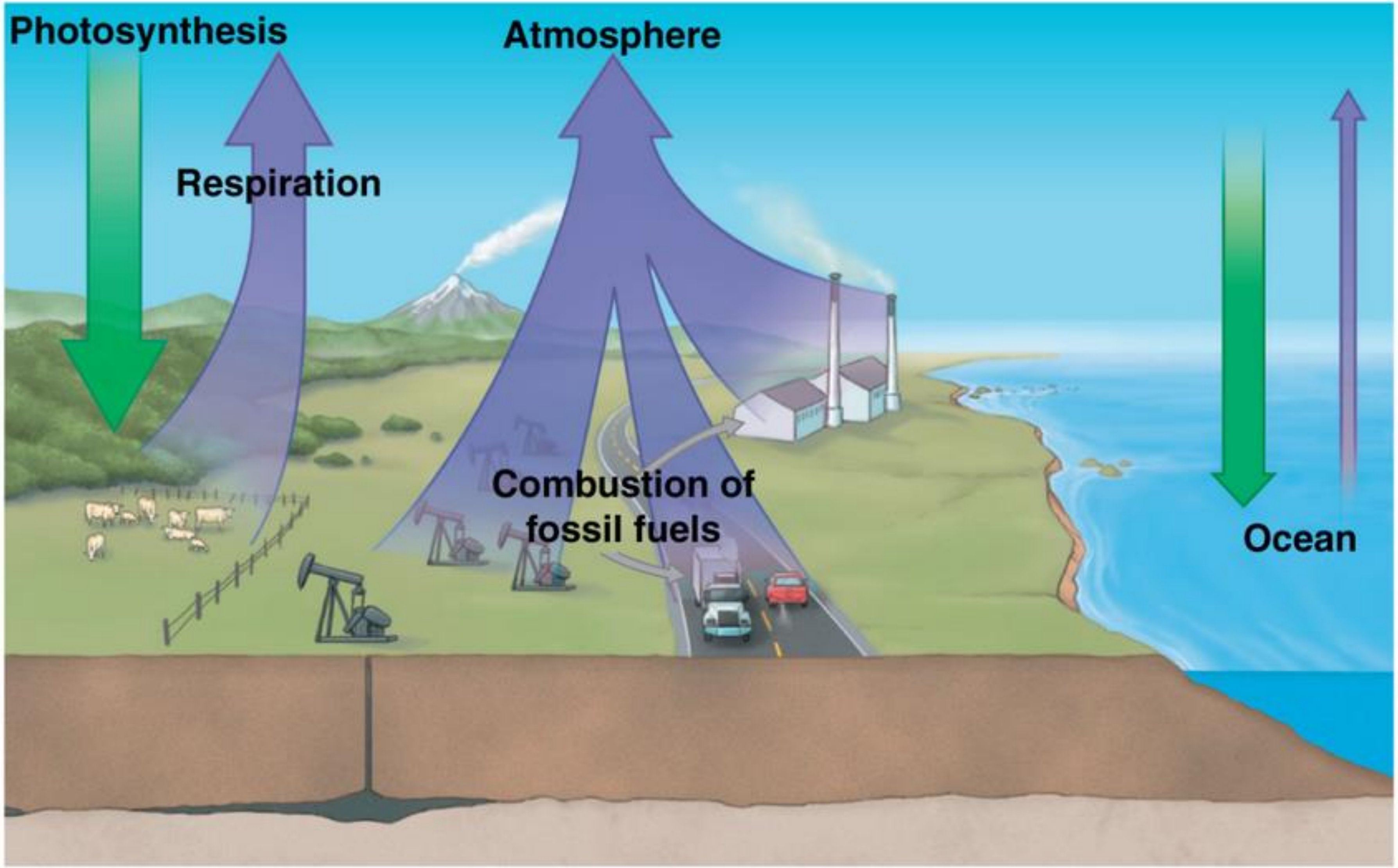
IPCC, 2007

CLIMATE CHANGE

Increase in atmospheric CO2 = best documented signal of human alterations



IPCC, 2007



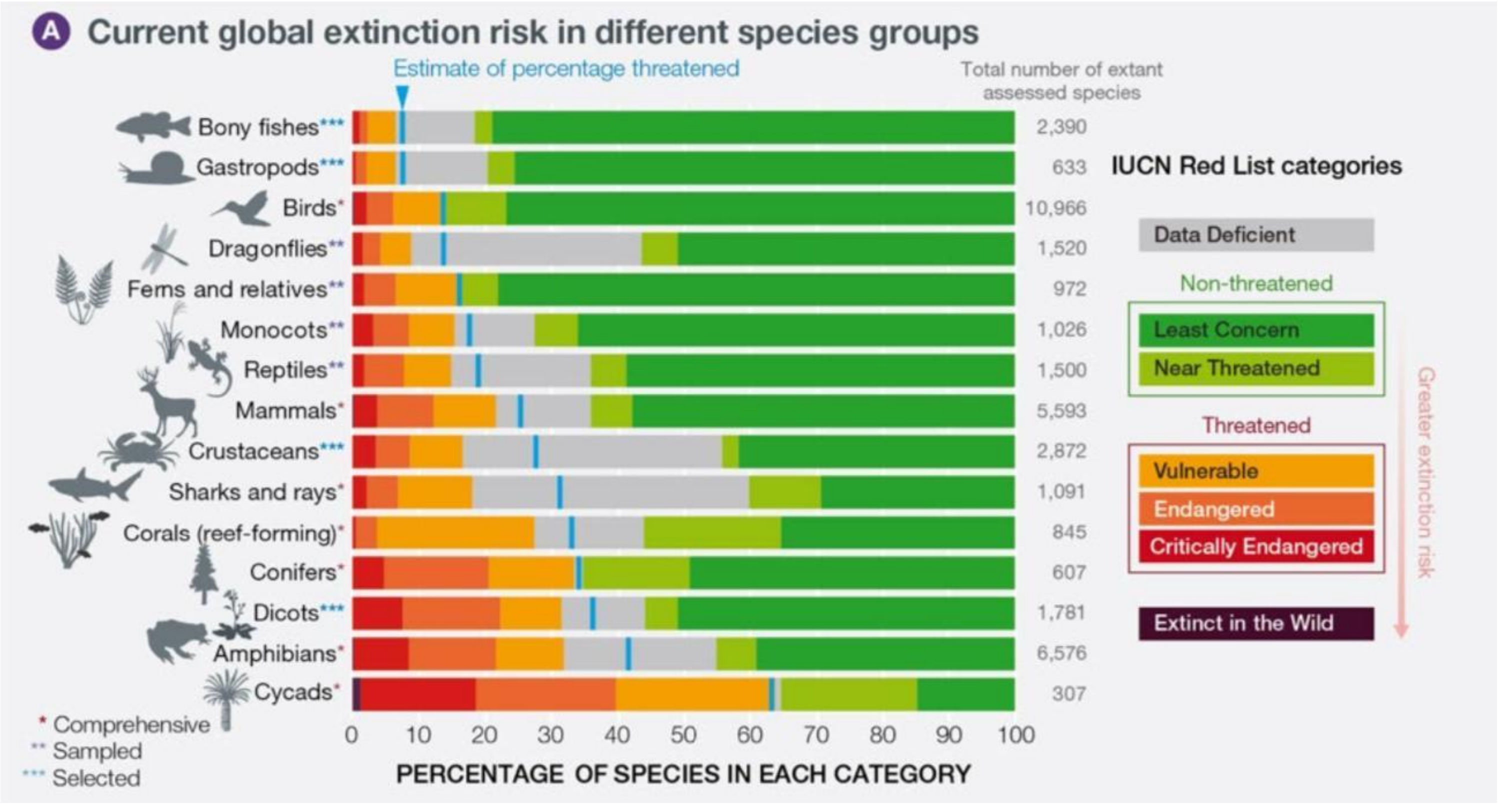
Global Climate change is directly associated with the Carbon cycle

CLIMATE CHANGE WILL HAVE LARGE EFFECTS ON THE BIOSPHERE

- Phenology – timing of life events
- Distribution & migration patterns, including invasive species
- Community structure, interactions among species
- Sea level rise and acidification

TRICKLE EFFECTS

The increased intensity of weather events results in significant mortality, with a major role in determining species' geographic ranges



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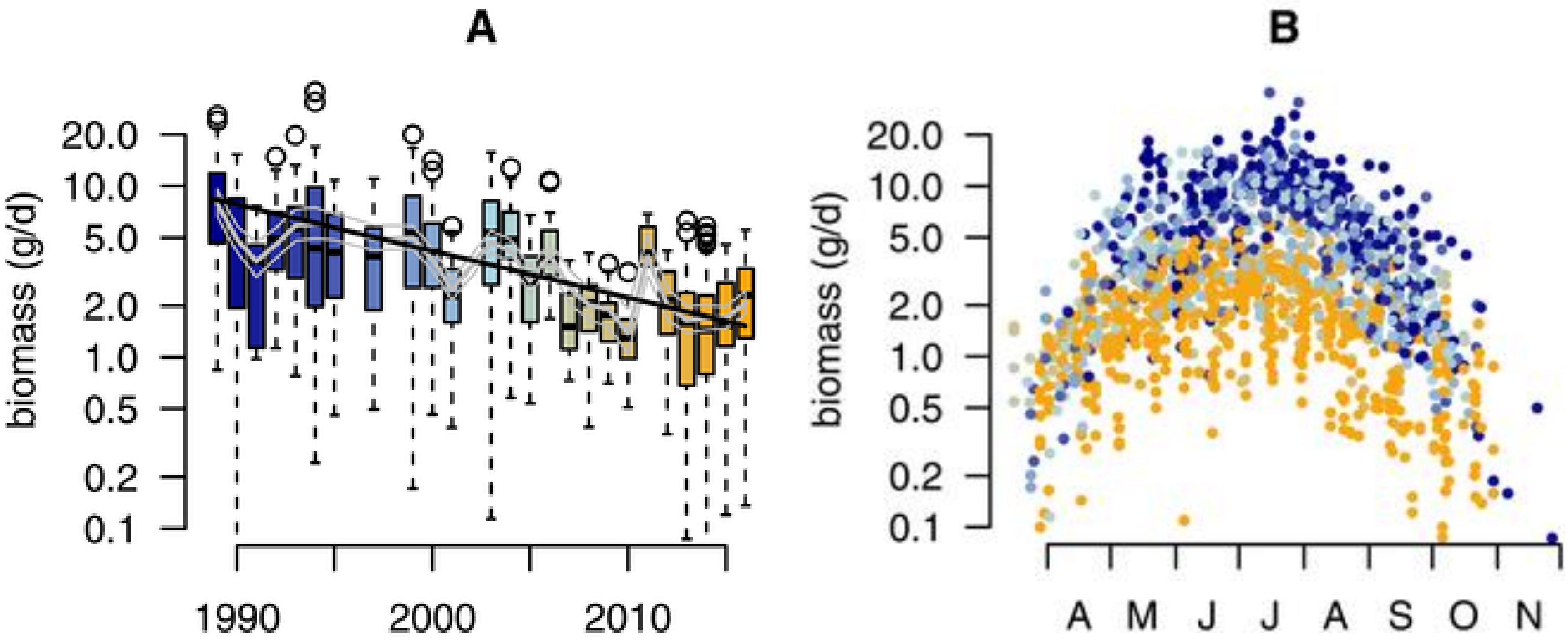
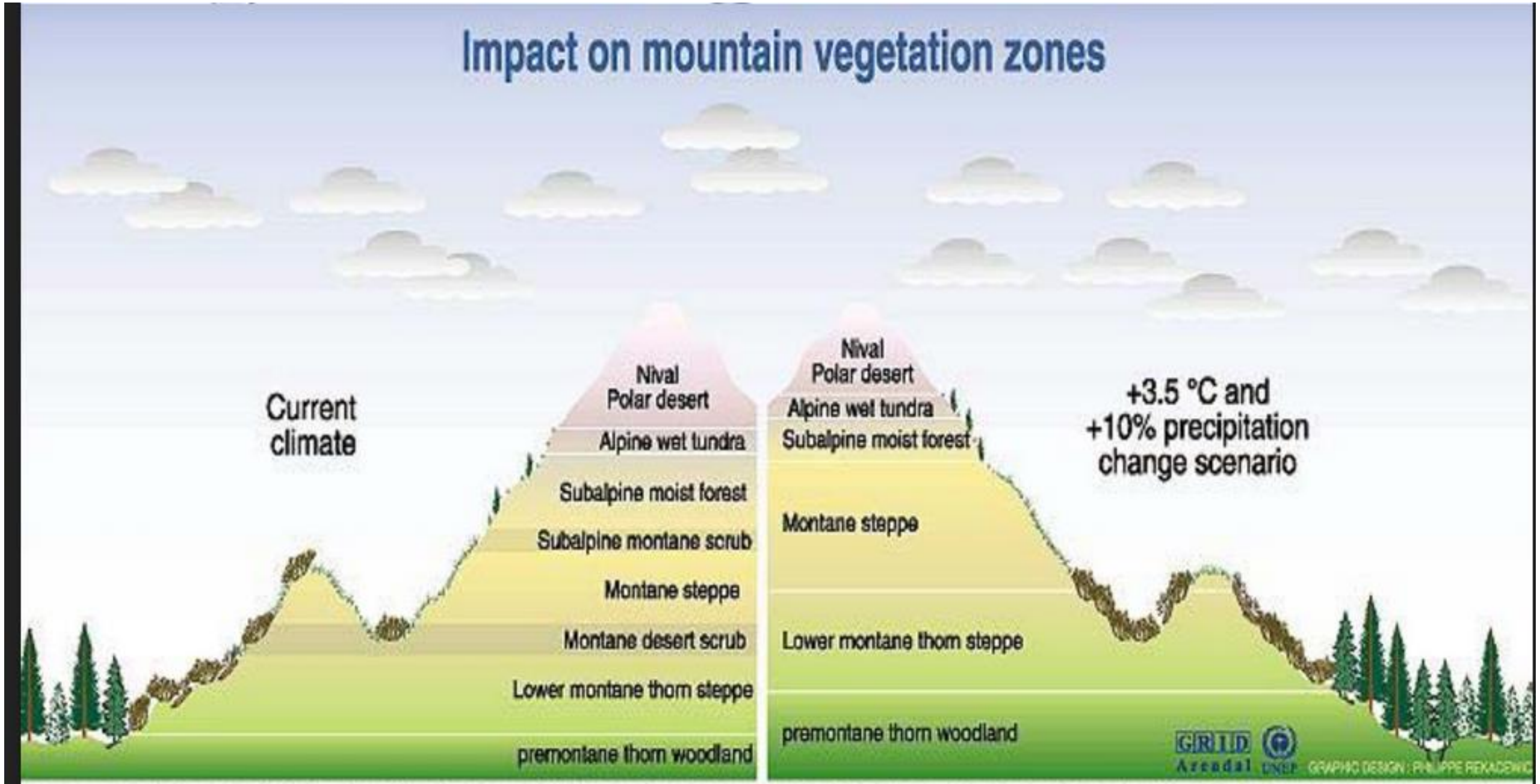


Hallmann et al (2017)

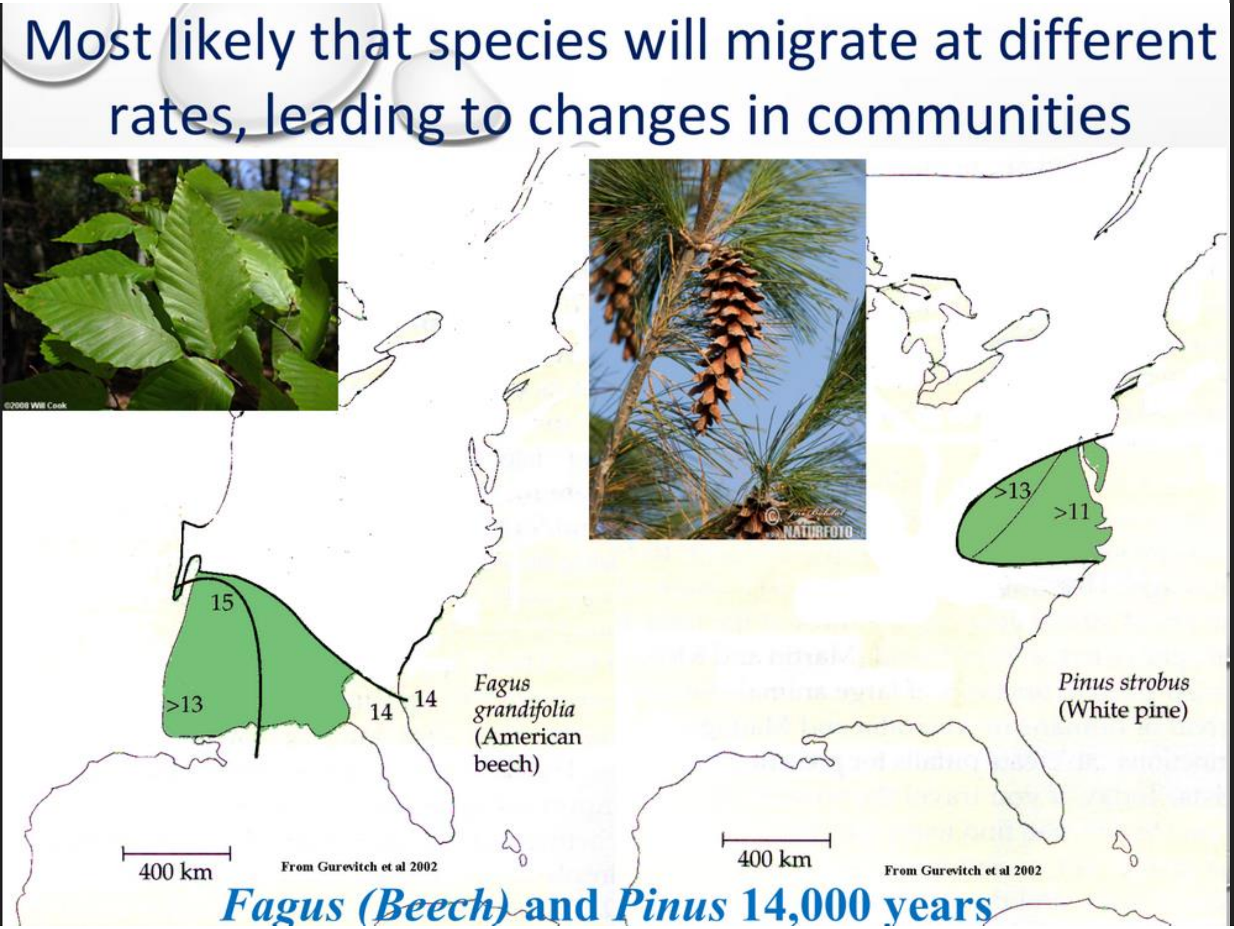
MIGRATIONS AT DIFFERENT RATES

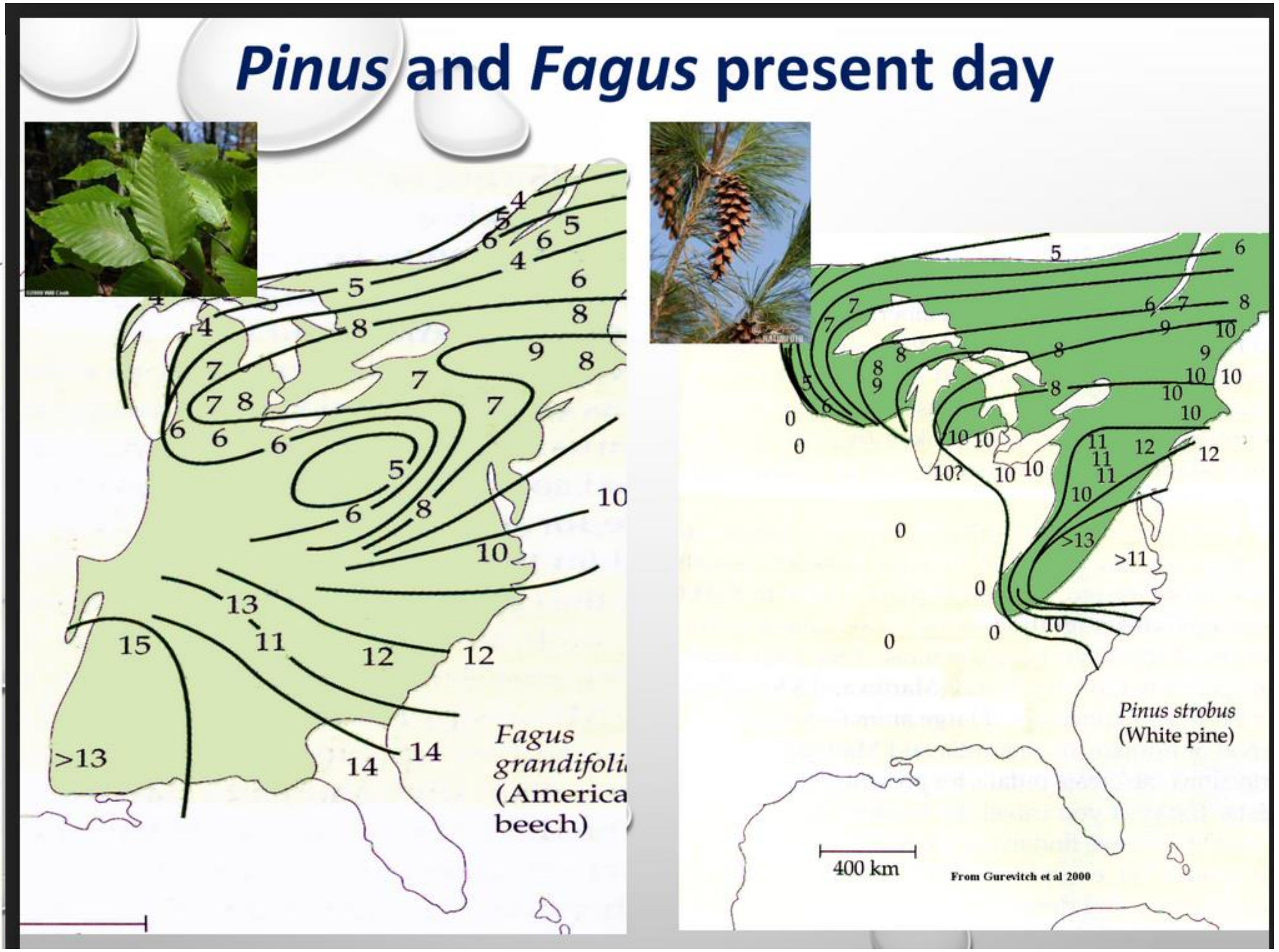
Climate change combined with species ecology, models predict shifts in species distribution and/or performance



Sources: Martin Benitson, Mountain environments in changing climates, Roulledge, London, 1994; Climate change 1995, Impacts, adaptations and migration of climate change, contribution of working group 2 to the second assessment report of the intergovernmental panel on climate change (IPCC), UNEP and WMO, Cambridge press university, 1996.

MIGRATIONS AT DIFFERENT RATES





MIGRATION AT DIFFERENT RATES

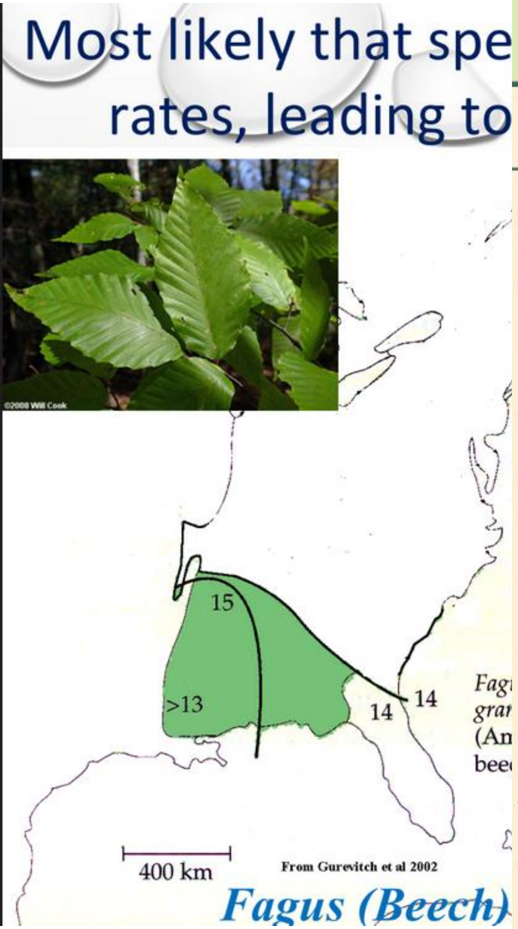
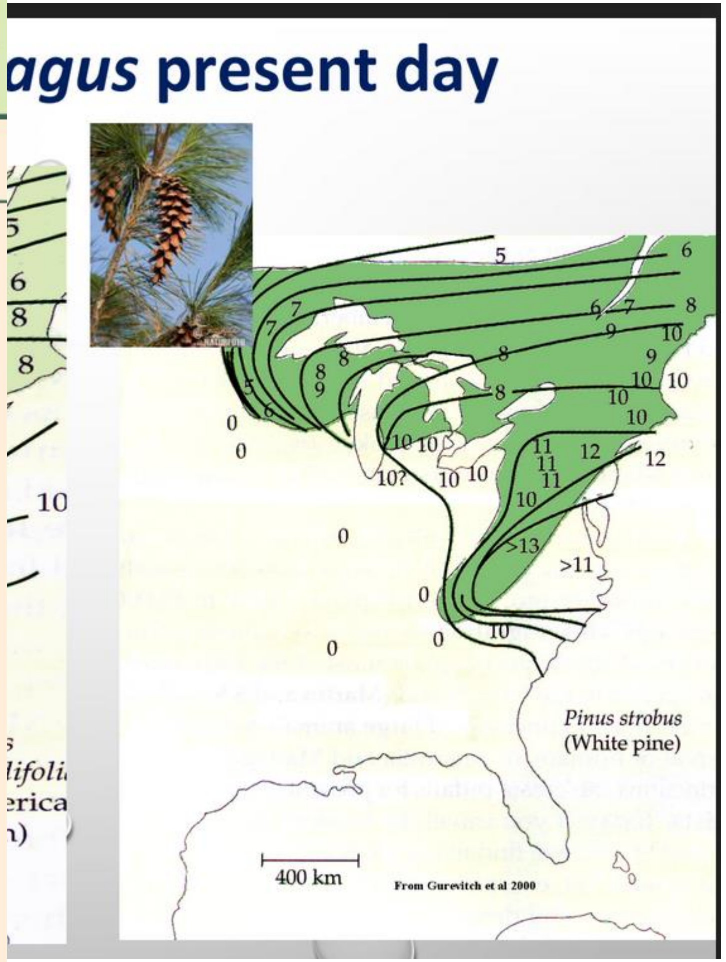


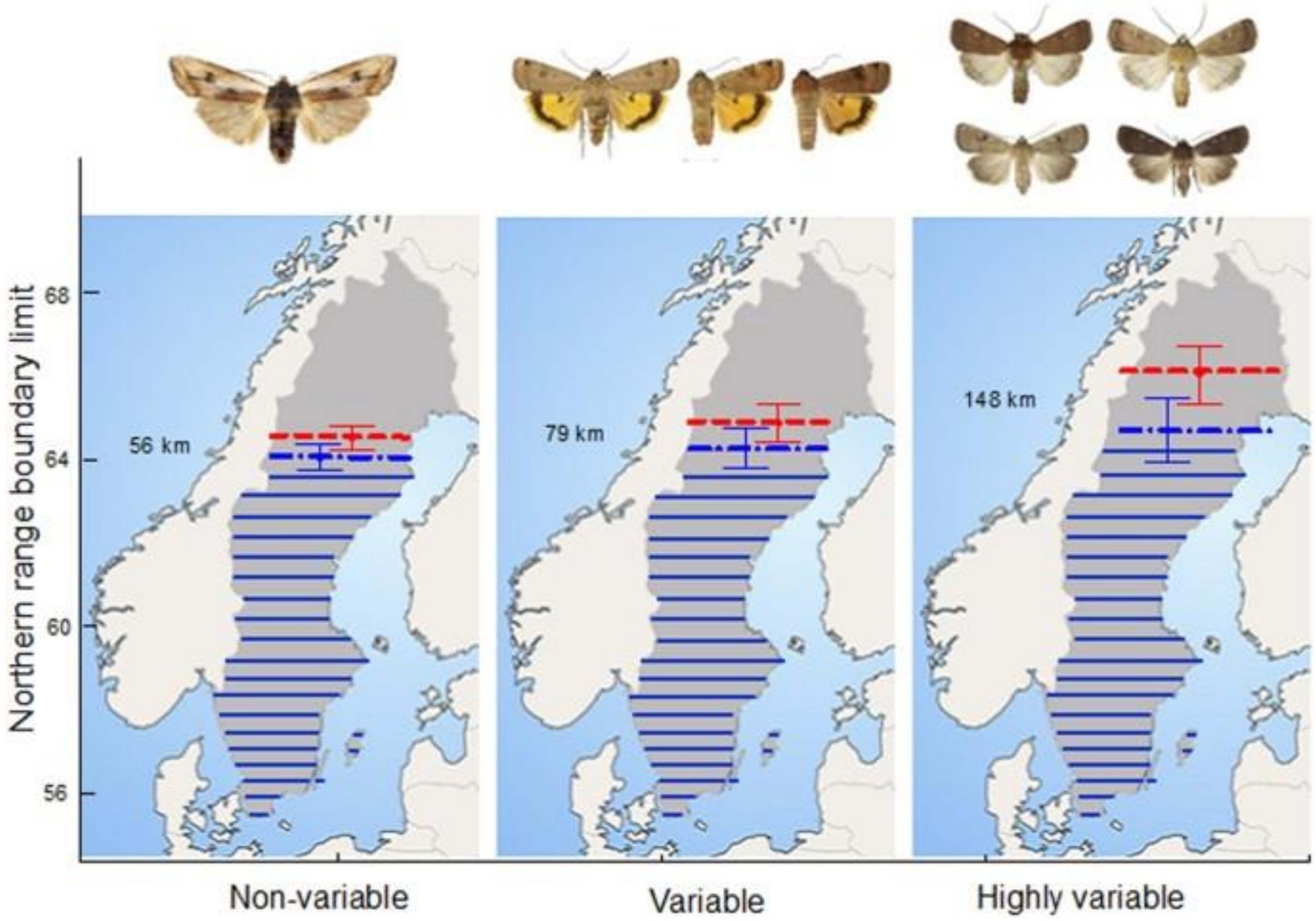
TABLE 20.1 Average rates of northward range expansion for trees in eastern North America following the most recent glacial retreat

Species	Rate (m/yr)	Dispersal agent
Pinus banksiana/resinosa	400	Wind
Pinus strobus	300–350	Wind
Quercus spp.	350	Animals
Picea spp.	250	Wind
Larix laricina	250	Wind
Ulmus spp.	250	Wind
Tsuga canadensis	200–250	Wind
Carya spp.	200–250	Animals
Abies balsamifera	200	Wind
Acer spp.	200	Wind
Fagus grandifolia	200	Animals
Castanea dentata	100	Animals



SHIFTING OF SPECIES

- Meta-analysis of 764 species found average rate of poleward migration 16.9 km/decade
- Temperature increases directly affect development time
  - Decreasing the time needed to complete life
  - Opens new habitat for colonization
- Major concern is if tree migration can keep up with rates of climate change

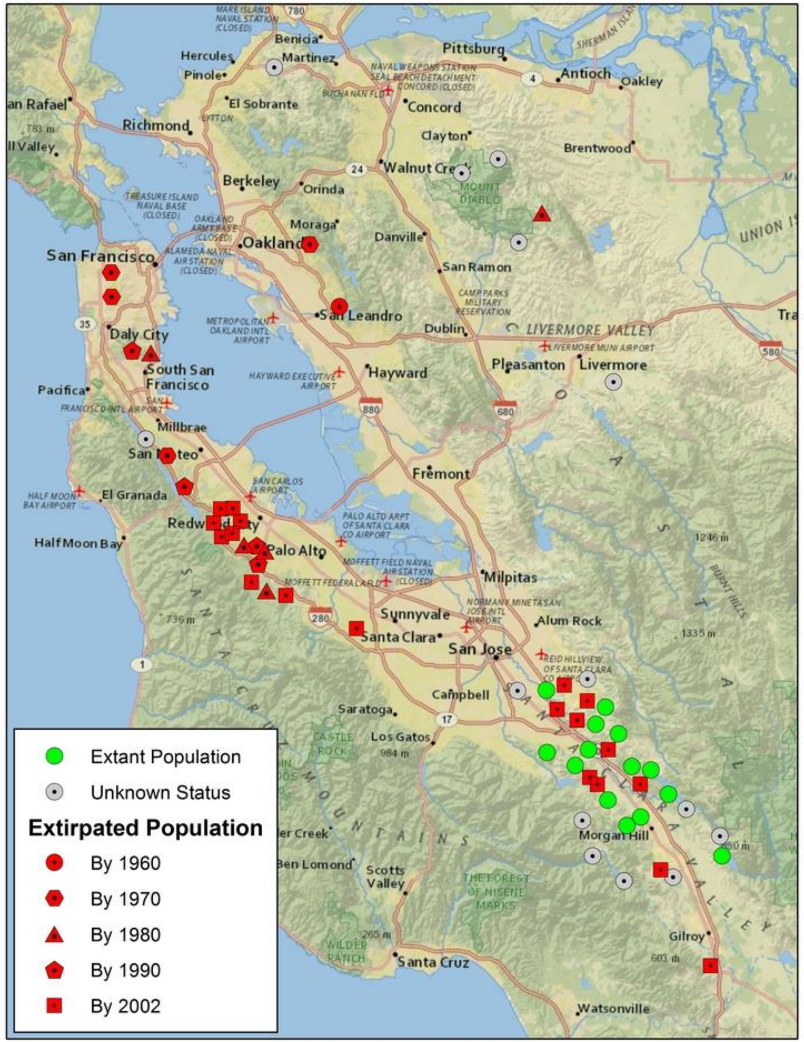


Forsman 2016

2014 1974

BAY CHECKERSPOT BUTTERFLY

EUPHYDRYAS EDITHA BAYENSIS

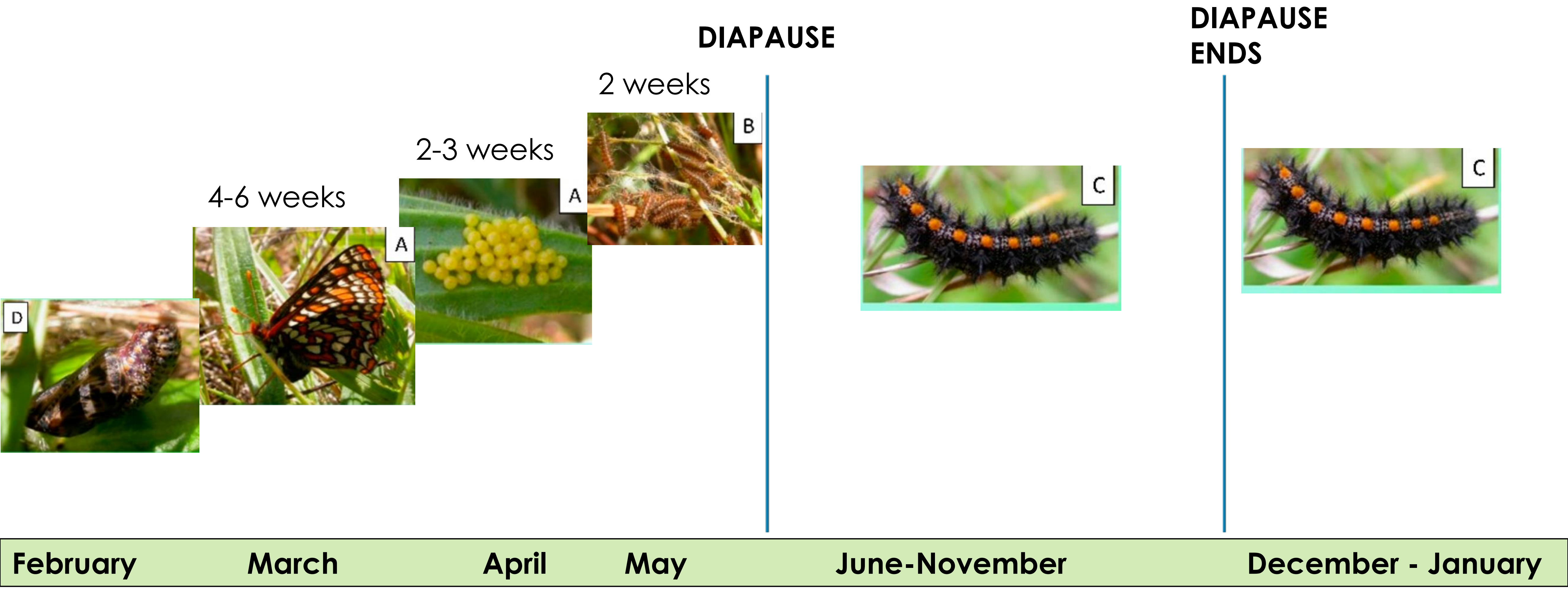


GRASSLAND HOST PLANTS

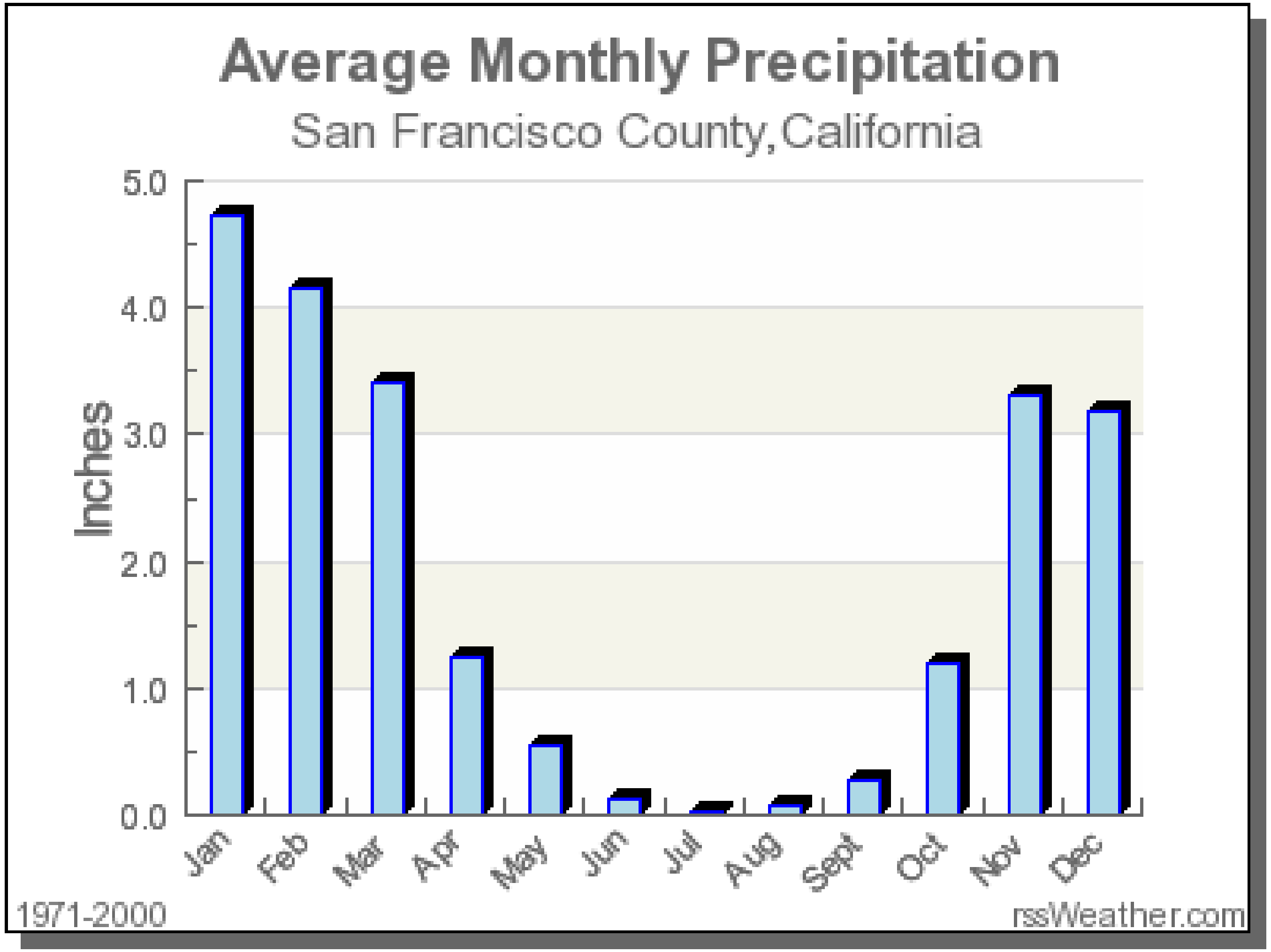
Orthocarpus, owls clover
Alternative host

Plantago erecta
Native host

LIFE CYCLE

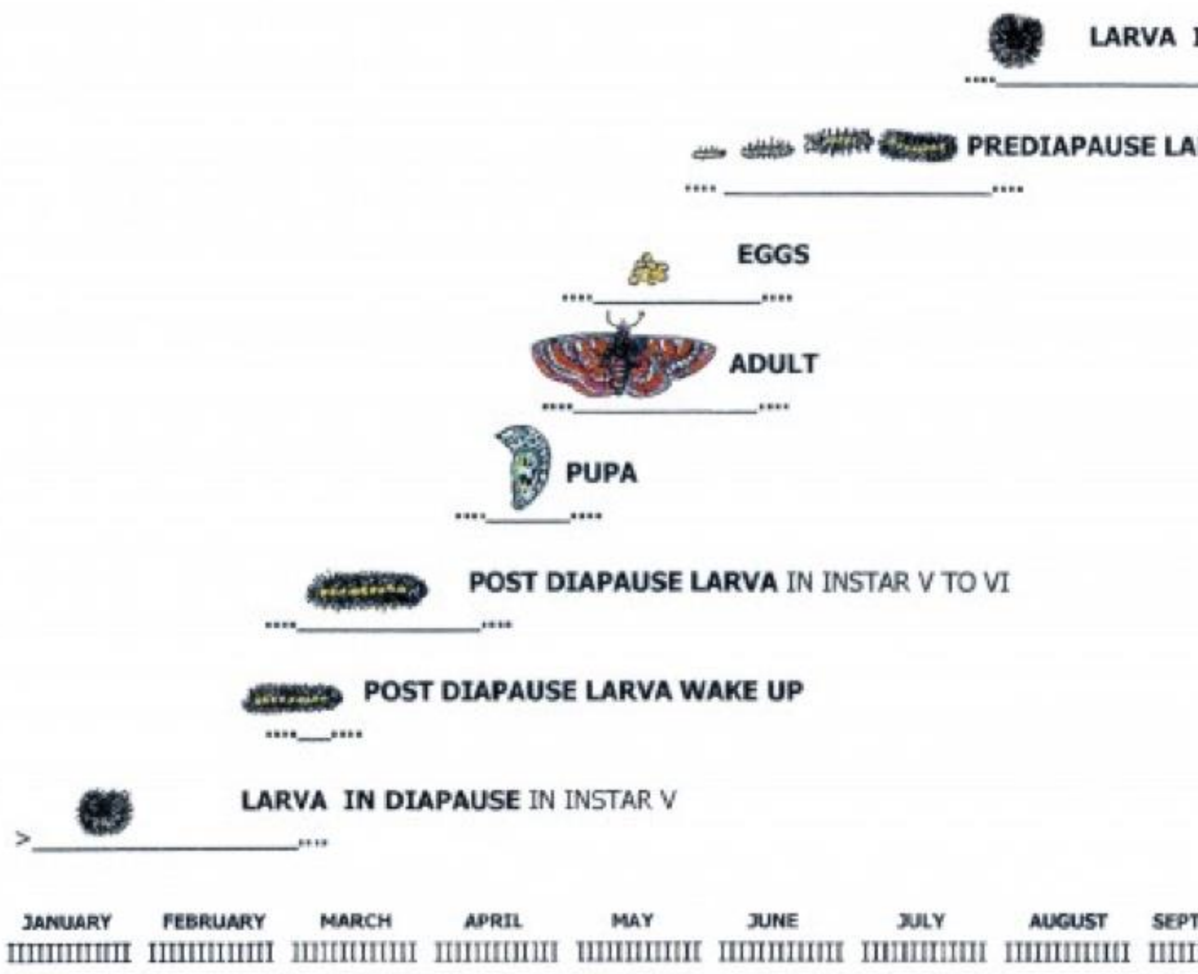

DIAPAUSE
DIAPAUSE ENDS
2 weeks
2-3 weeks
4-6 weeks
D
A
A
B
C
C
February
March
April
May
June-November
December - January

LIFE CYCLE



Harrison 1988

LIFE CYCLE

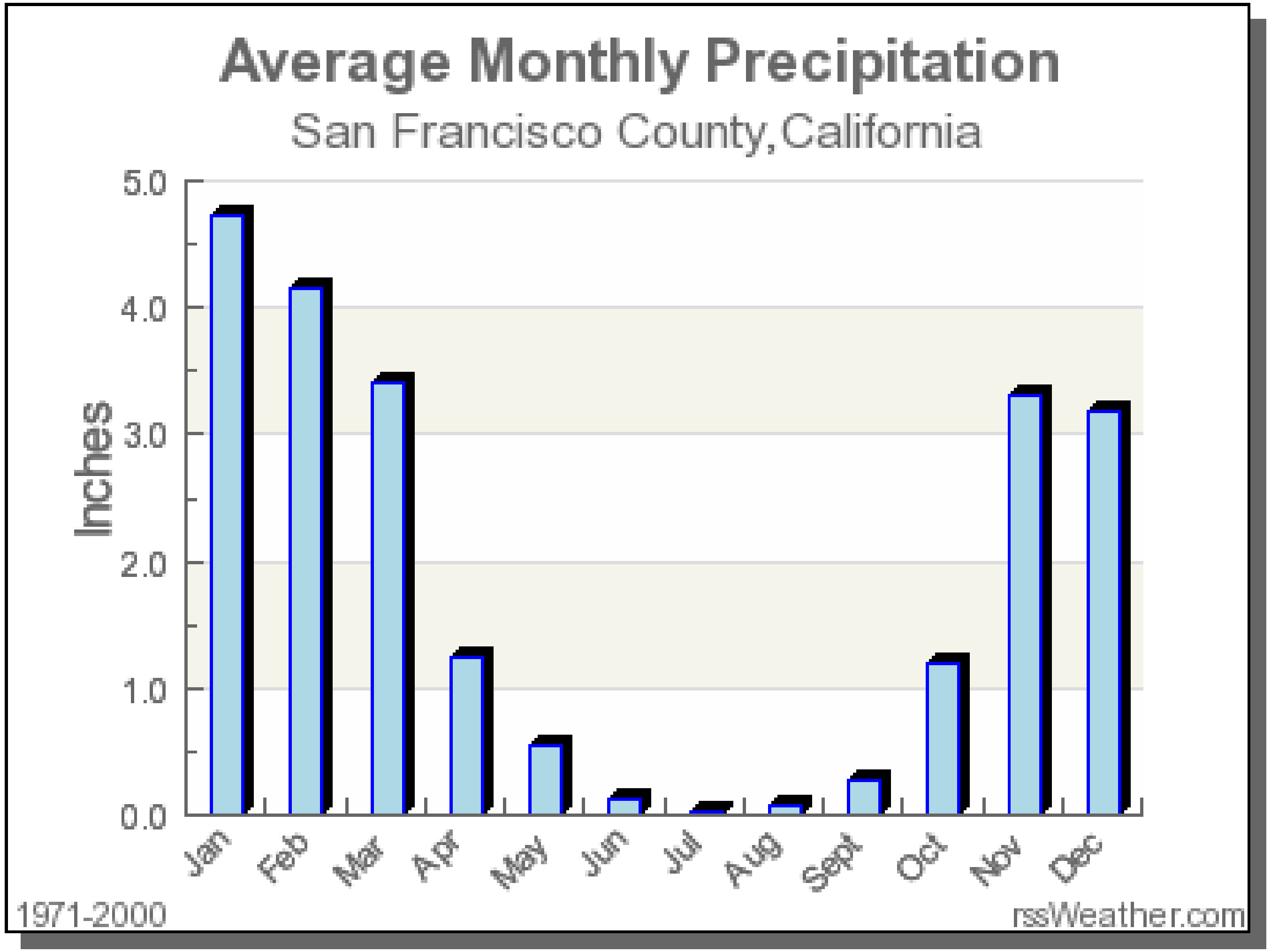


- Rainfall is the biggest factor in determining checkerspot numbers
- Delicate synchrony bt butterfly's annual life cycle & that of host plant

Harrison 1988

LIFE CYCLE

Frequent of drought since late 1800s

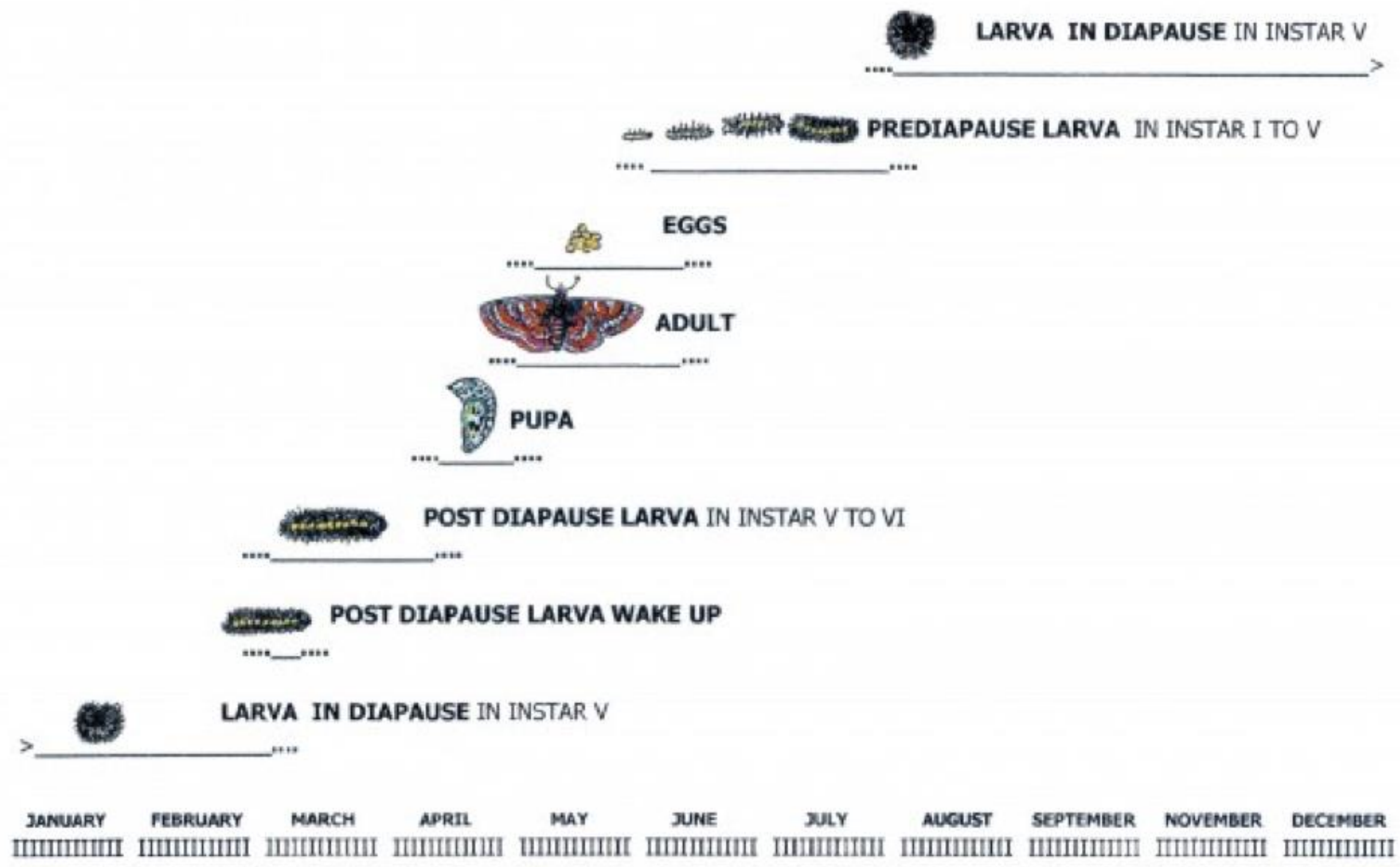


Harrison 1988

EFFECTS OF CLIMATE CHANGE AND HABITAT LOSS

- Extremes in annual precipitation reduced the temporal overlap of larvae and plants

- Extinct within 3 decades



EFFECTS OF CLIMATE CHANGE AND HABITAT LOSS

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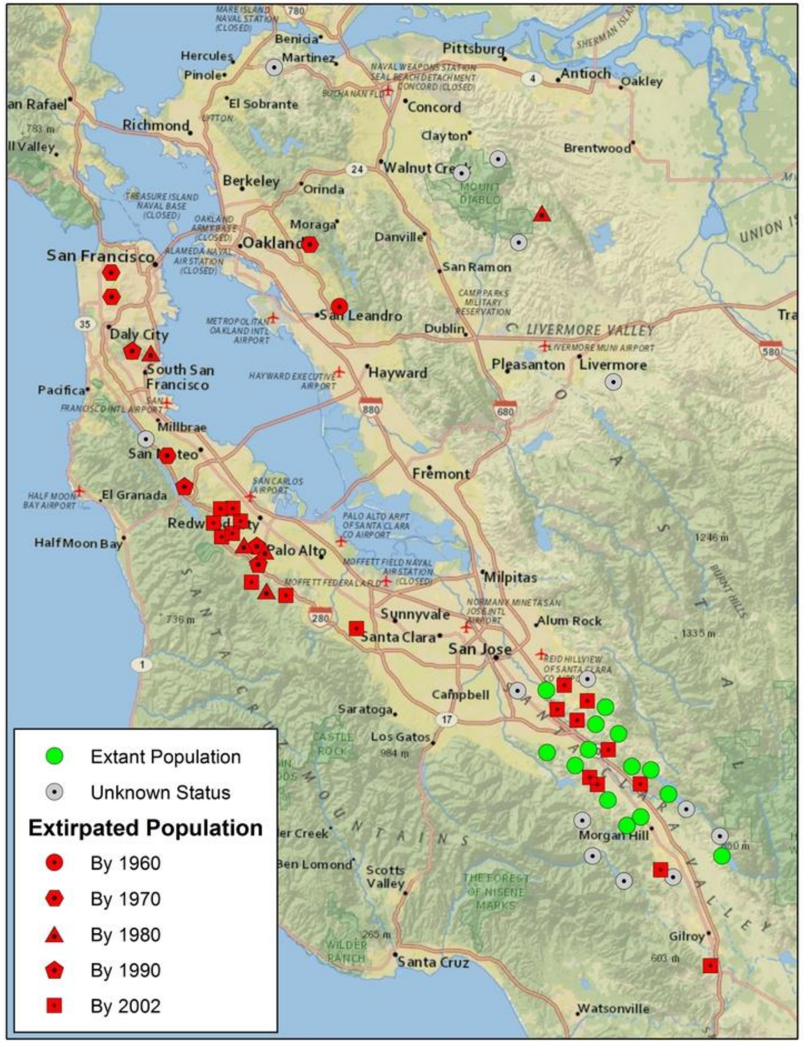
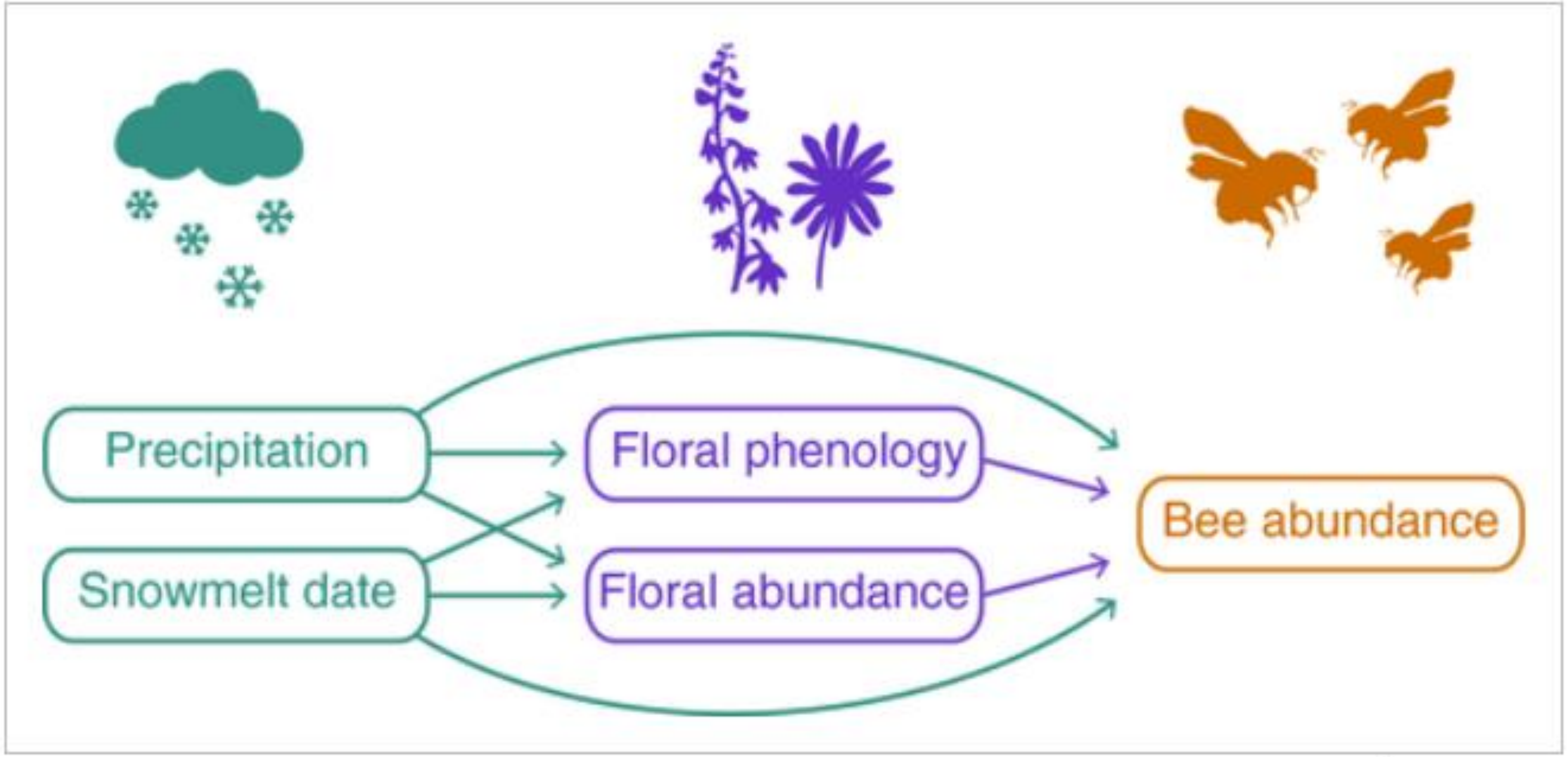
- If local extinctions did occur, populations may have been reestablished by individuals from adjacent habitats.



PLANT – POLLINATOR PHENOLOGY



TAISETSU MOUNTAINS NORTHERN JAPAN


Vulnerability of phenological synchrony between plants and pollinators in an alpine ecosystem (Kudo 2014)

TAISETSU MOUNTAINS NORTHERN JAPAN

B. diversus tersatus

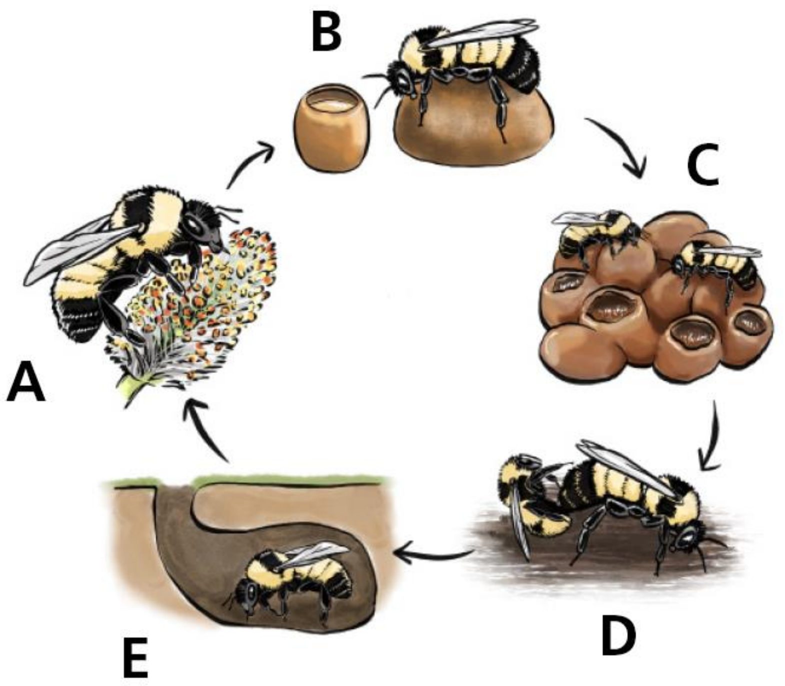
Bombus hypocrita sapporoensis

Bombus yezoensis

Kudo 2014

TAISETSU MOUNTAINS NORTHERN JAPAN

- Areas less snow accumulation, flowering from early June through mid-summer.
  - Important for queen bees
- Area more snow, onset of flowering delayed until mid-summer lasting until late in the growing season
  - Important for worker bees during colony development & new queen



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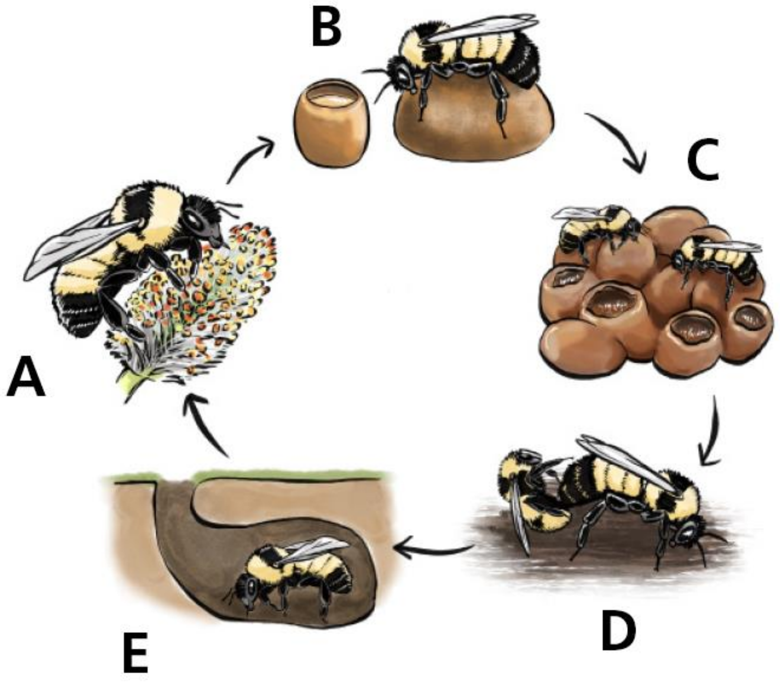
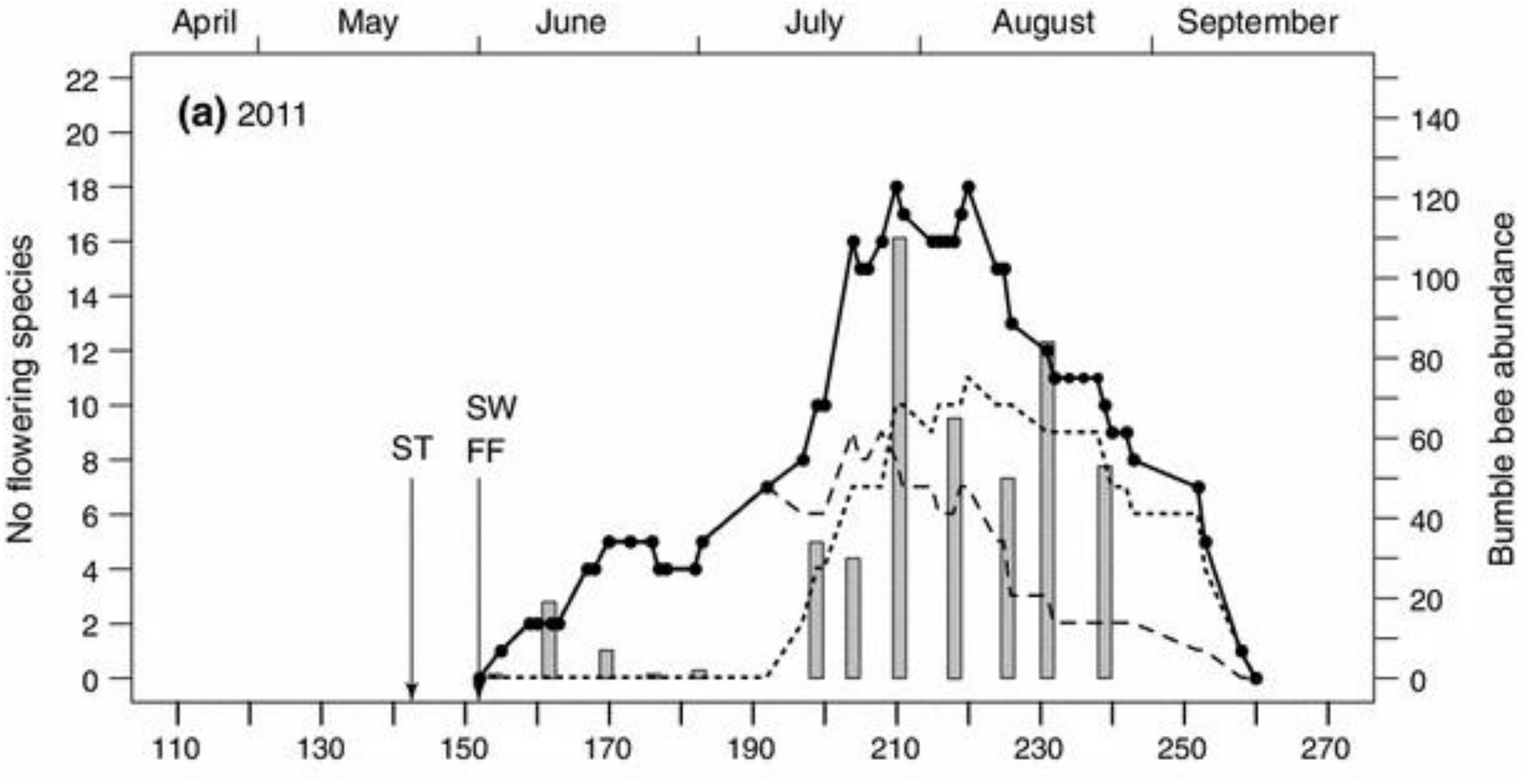
- **Species interactions of alpine habitats may be disrupted if phenological mismatch between plants and bees occurs owing to climate variations** (Kudo 2014)



TAISETSU MOUNTAINS NORTHERN JAPAN

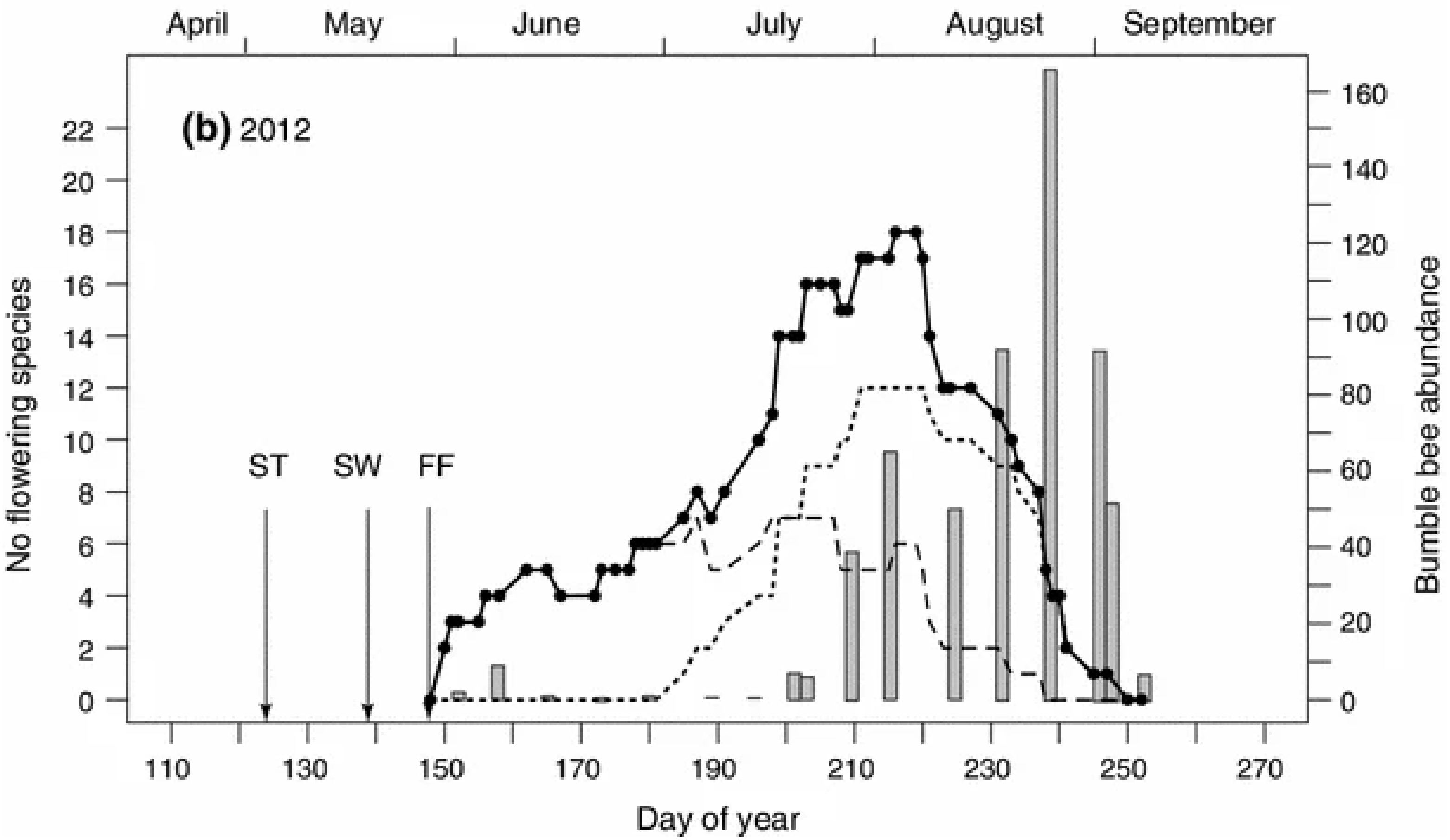
- Abundance of bees was largely concordant with the number of flowering species at a regional scale
- phenological mismatch only 2–3 days



Kudo 2014

TAISETSU MOUNTAINS NORTHERN JAPAN

- Bee abundance obviously deviated from the flowering phenology
- Phenological mismatch was only 8–9 days



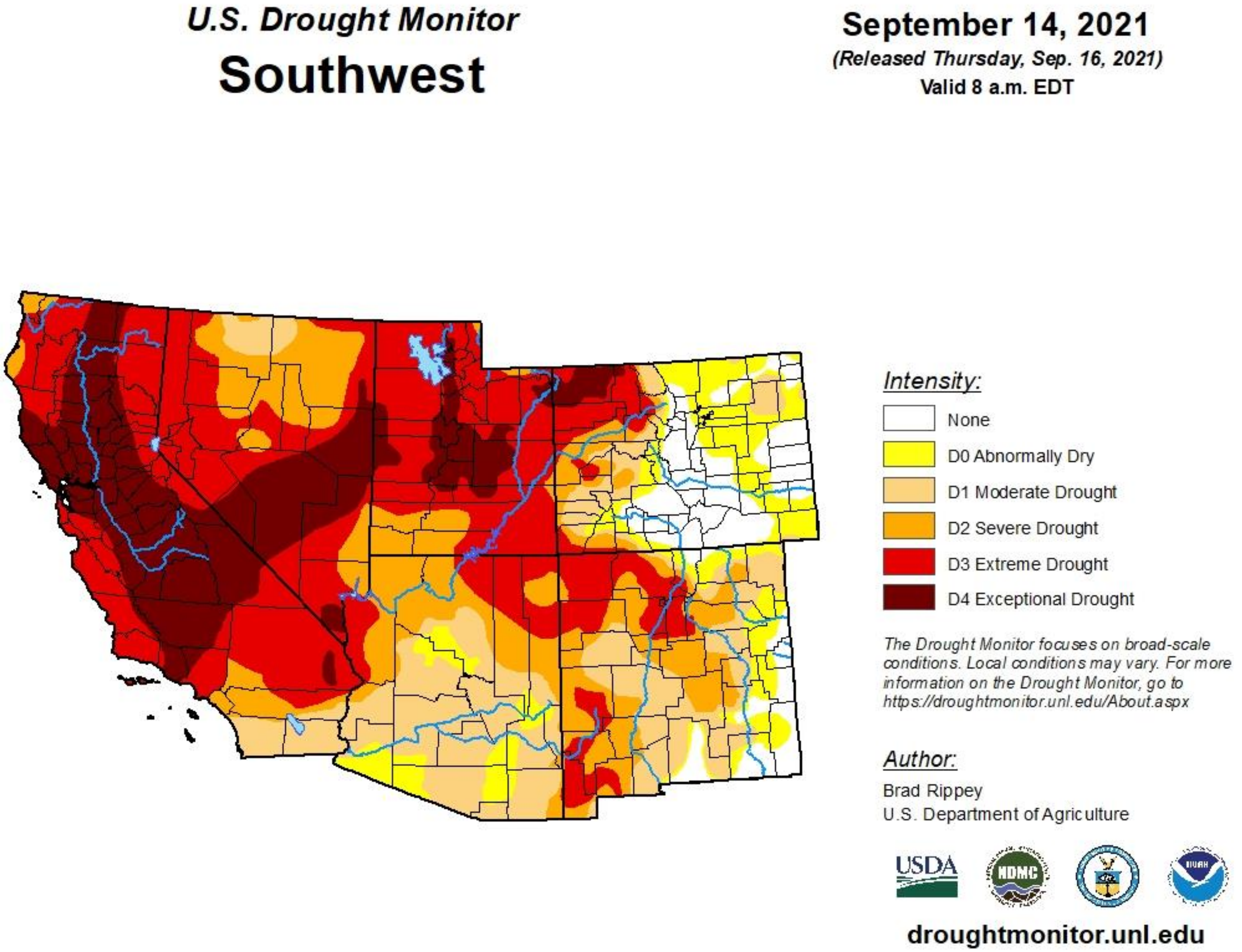
Kudo 2014

LOCATION?


St
Lasaine Ave
Marilla St
Aldea Ave
Marilla St
Superior St
Superior St
Louise Ave
Superior St
Encino Ave
Aldea Ave
Citronia St
Citronia St
Citronia St

LOCATION?

SE US WATER RESTRICTIONS

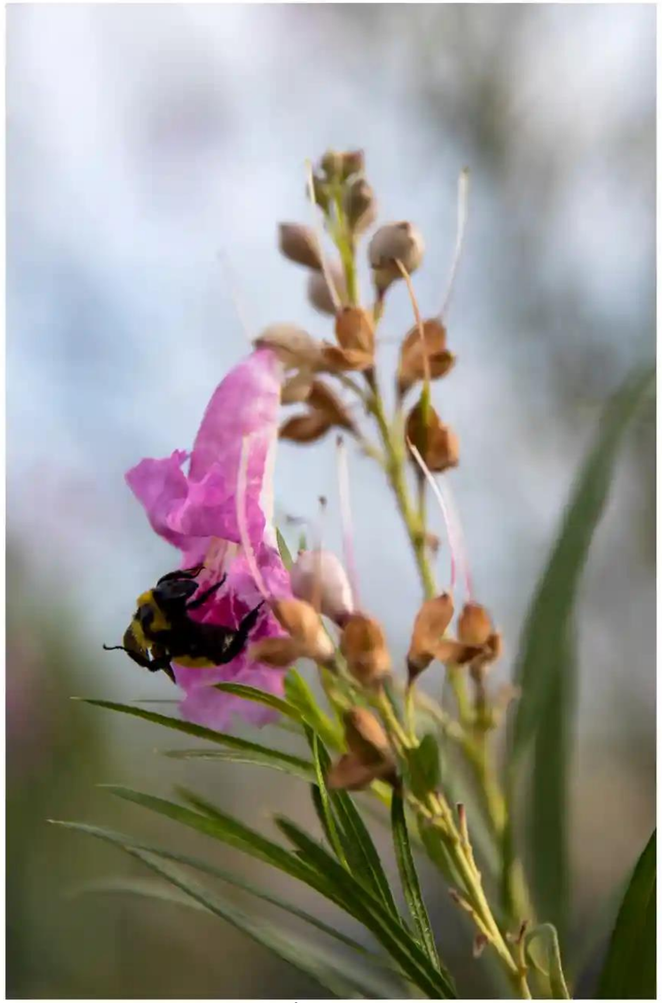


- Drinking, agricultural & tribal water supplies
- Electricity supply generated from hydroelectric plants;
- Fishing and recreational activities
- Ground water depletion

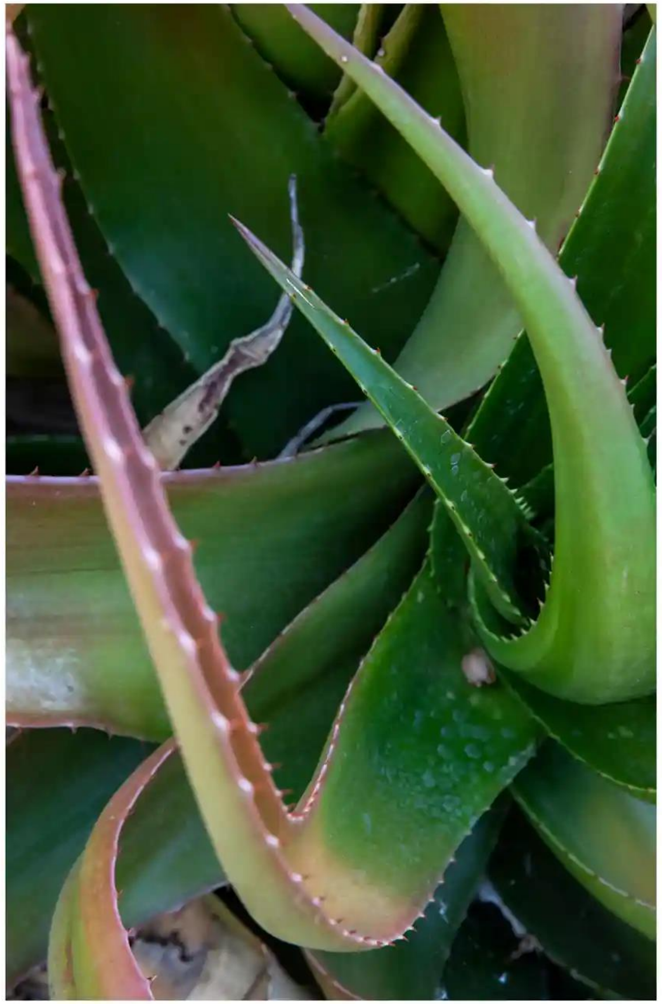
MY LAWN IS BETTER THAN YOUR LAWN" EVOLVING INTO "MY LAWN IS MORE ECOLOGICALLY FRIENDLY THAN YOUR LAWN"

WHO SAYS LAWNS ARE IRREVERSIBLE?

- >1,000 CA residents a month made plans to replace their lawns with more drought-friendly landscapes
- Save money on water bills
- Construction of corridors and refugia for wildlife



Desert-willow tree



WHO SAYS LAWNS ARE IRREVERSIBLE?

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FUTURE

- Global analysis found **> 40%** of pollinator species may be at risk of extinction (IPBES 2016)
- A recent analysis by Xerces Society and
  the International Union for Conservation of Nature found **28% of bumble bee species in North America are at risk of extinction**

Manage resources so that future generations have an adequate supply for their survival

The Sustainable Development Goals or Global Goals are a collection of 17 interlinked global goals designed to be a "shared blueprint for peace and prosperity for people and the planet