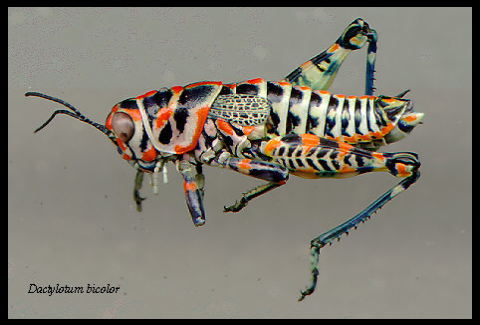
# Grasshoppers as important indicators of changes in climate and land use





**César R Nufio**

**Dept of Ecology & Evolutionary Biology, CU Museum**

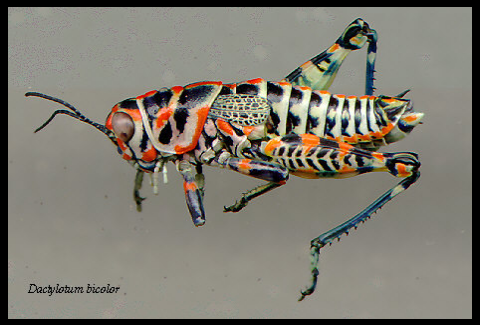
# Grasshoppers as important indicators of changes in climate and land use

1. Grasshoppers in grassland ecosystems

2. Grasshoppers and climate change

   -Gordon Alexander's 1958-1960 grasshopper survey along an elevational gradient

3. Urban fragmentation- the importance of Kingfisher Point






http://www.ndsu.nodak.edu/entomology/hopper/orthoptera_home.htm

## Grasshoppers

**Are important components of grassland ecosystems**

- as herbivores

## Grasshoppers

**Are important components of grassland ecosystems**

- as herbivores

*on the National Bison Range, Montana* **18,500 acres**

Densities of **25 grasshoppers per square meter** …and at that density there are approximately **412** tons of grasshoppers …the tonnage of grasshoppers is about **120** percent the tonnage of big herbivorous mammals.

Built for Speed: A Year in the Life of Pronghorn. -Byers (2003)

## Grasshoppers

**Are important components of grassland ecosystems** ***on the African Savanna***

- as herbivores

TABLE 3. Grass consumption by grasshoppers in African savannas, compared with consumption by mammalian herbivores. The Serengeti supports large populations of ungulates, and also herbivorous rodents. Nyslsvley supports domestic cattle as well as native ungulates.

| | Serengeti, Tanzania (Sinclair, 1975) | | | Nylsvley, South Africa (Gandar, 1982a, b) | |
|---|---|---|---|---|---|
| | Long grassland | Short grassland | Kopjes | *Burkea* savanna | *Acacia* savanna |
| Biomass consumed (kg $ha^{-1}$ $yr^{-1}$) | 456 | 194 | 484 | 130 | 406 |
| Per cent total herbivore consumption | 28 | 11 | 56 | 40 | 73 |

## Grasshoppers

**Are important components of grassland ecosystems**

- as herbivores - food resources



http://sagribow.sulekha.com/blog/post/2011/03/get-the-food-mom-feeding-time-shots-too-good

http://www.ofnc.ca/fletcher/newsletter/Blog/June2008/SOSP-grasshopper.jpg

## Grasshoppers

**Are important components of grassland ecosystems**

- as herbivores - food resources


http://www.ofnc.ca/fletcher/newsletter/Blog/June2008/SOSP-grasshopper.jpg

# Grasshoppers

**Are important components of grassland ecosystems**

as herbivores - food resources

Global News Blog

## Uganda's booming grasshopper industry leaps over tradition

**Ugandan tradition dictates that only women and children catch grasshoppers, but high profit margins have brought men into the industry, too.**

A vendor sells fresh grasshoppers in Kampala, Uganda.

Wang Ying/Newscom/File

Enlarge

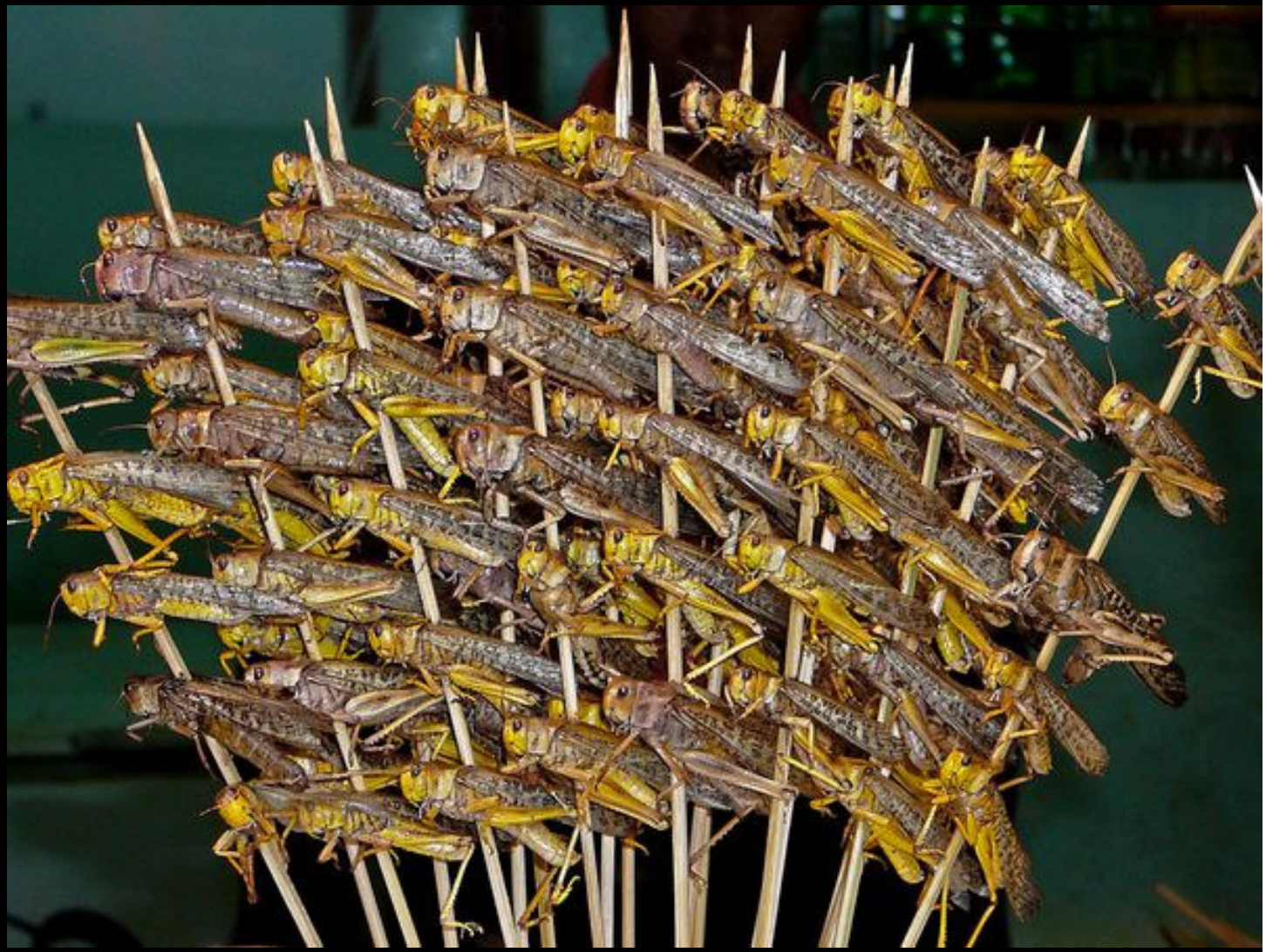
**Southern Mexico**

**Japan**

## Grasshoppers

**Are important components of grassland ecosystems**

- as herbivores
-as food resources



**Grasshoppers, China**

http://travel.nationalgeographic.com/travel/countries/street-food-photos/

## Grasshoppers

**Are important components of grassland ecosystems**

- as herbivores - as nutrient cyclers - food resources

- **relatively diverse (133 species in CO; 72 FR), vary in a variety of life history traits**

Diapause

Diet

Size

Winged or wingless

Relative abundance

Time of the season

Spatial distribution




http://www.ndsu.nodak.edu/entomology/hopper/orthoptera_home.htm

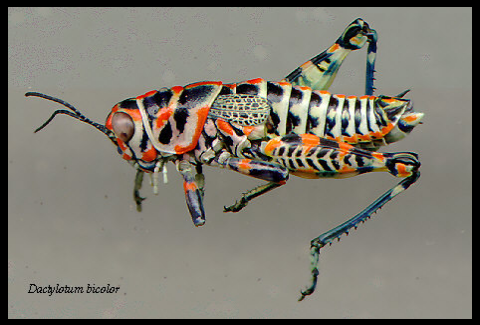
# Grasshoppers as important indicators of changes in climate and land use

1. Grasshoppers in grassland ecosystems

2. Grasshoppers and climate change

   -Gordon Alexander's 1958-1960 grasshopper survey along an elevational gradient

3. Urban fragmentation- the importance of Kingfisher Point





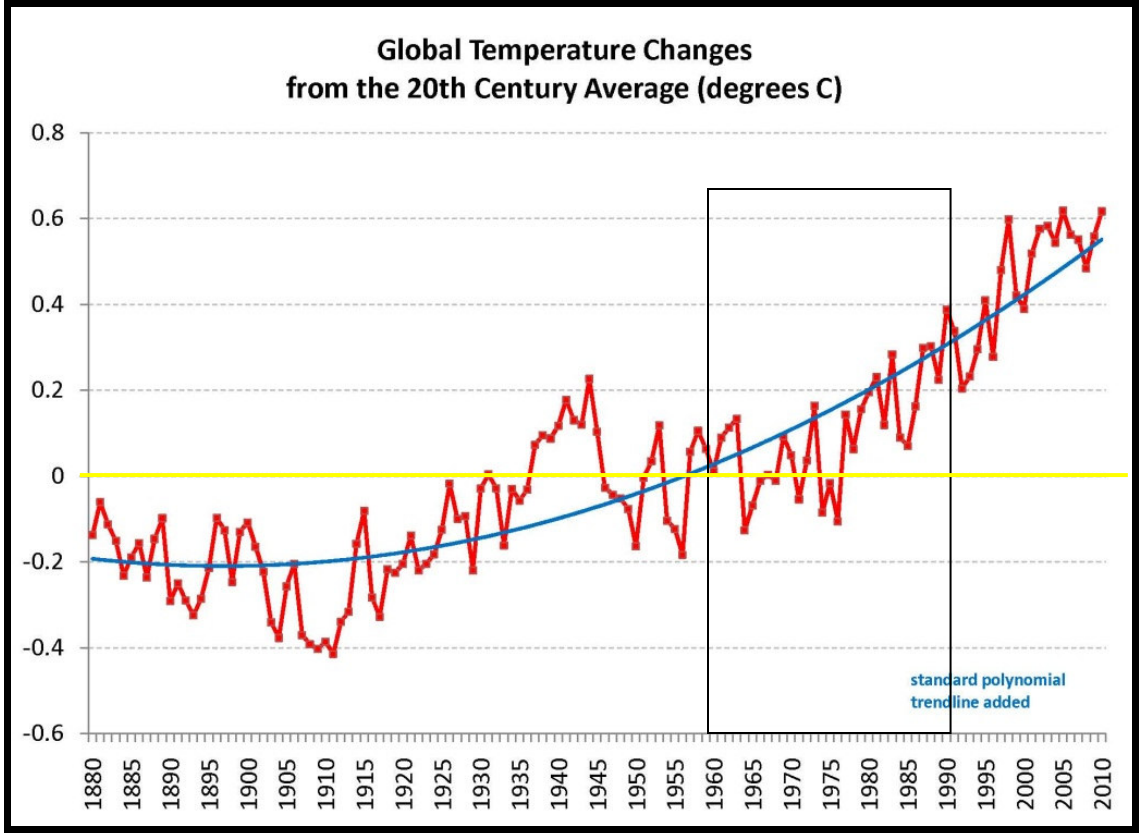

http://www.ndsu.nodak.edu/entomology/hopper/orthoptera_home.htm

## Climate Change

**Over the last century, global temperatures have increased by $0.74 \pm 0.18\ C^0$**
**$1.30 \pm 0.32\ F^0$**

(IPCC 2007)

Deviations from 1961-1990 average

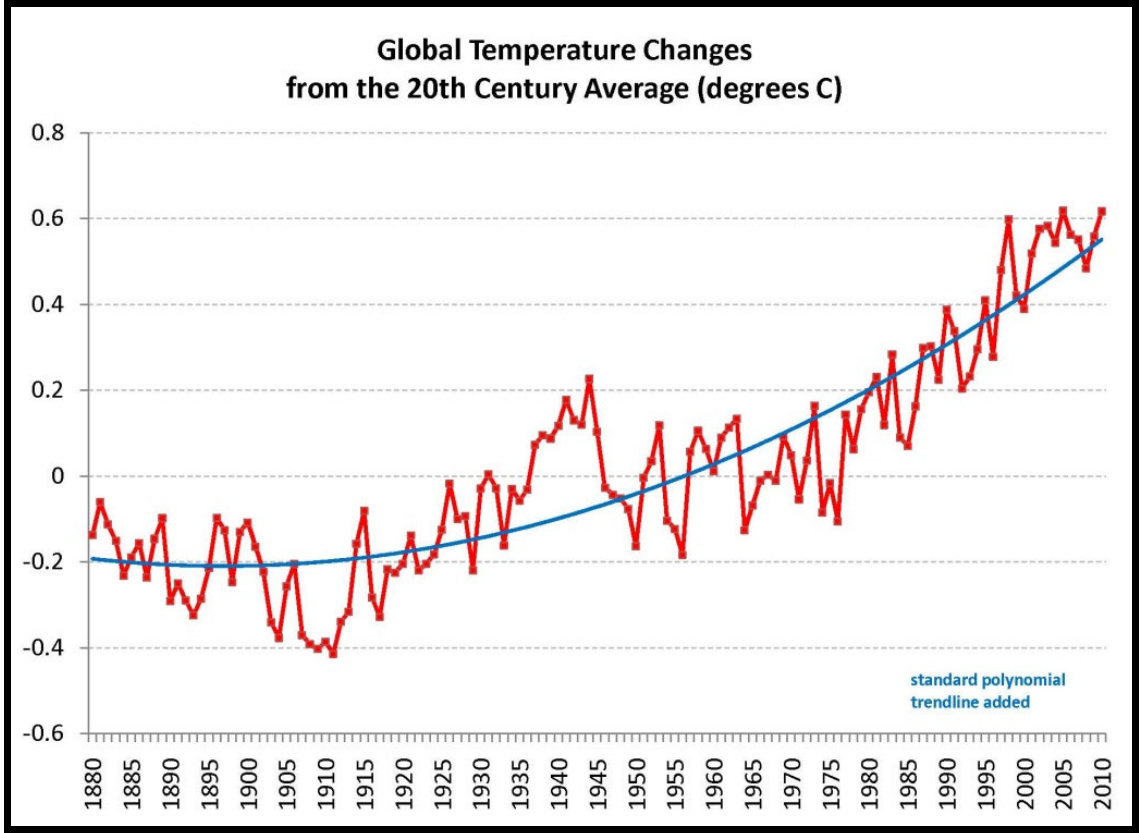


## Climate Change

**Over the last century, global temperatures have increased by** $0.74 \pm 0.18\ C^0$
$1.30 \pm 0.32\ F^0$

(IPCC 2007)

Deviations from 1961-1990 average

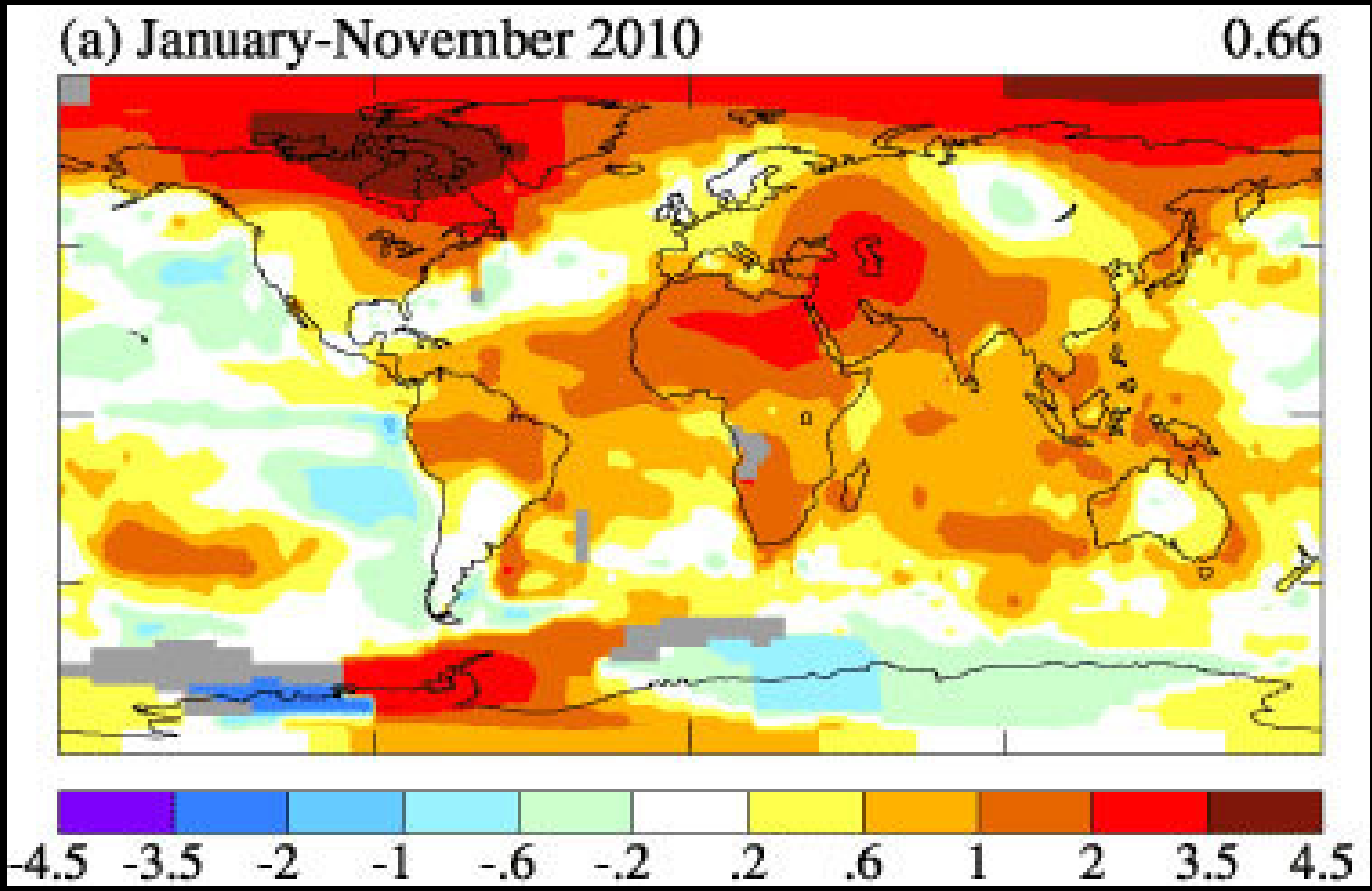



**The hottest 10 years on record in order**

**2010**
**2005**
**1998**
**2003**
**2002**
**2009**
**2006**
**2007**
**2004**
**2001**

**2001-2010 10 of the 12 hottest years in the last 130**

# Surface temperature Anomaly (C°)




Courtesy NASA

## Warming temperatures may affect organisms in a variety of ways

i. **Phenology** (timing of annual biological events)

ii.

iii.

# Phenology: The timing of annual biological events

***For plants***: first flush of leaves , first flowering or fruiting dates, when leaves turn in the fall



***For animals***: breaking of hibernation or diapause, egg-laying dates, timing of migration, when different life stages are reached

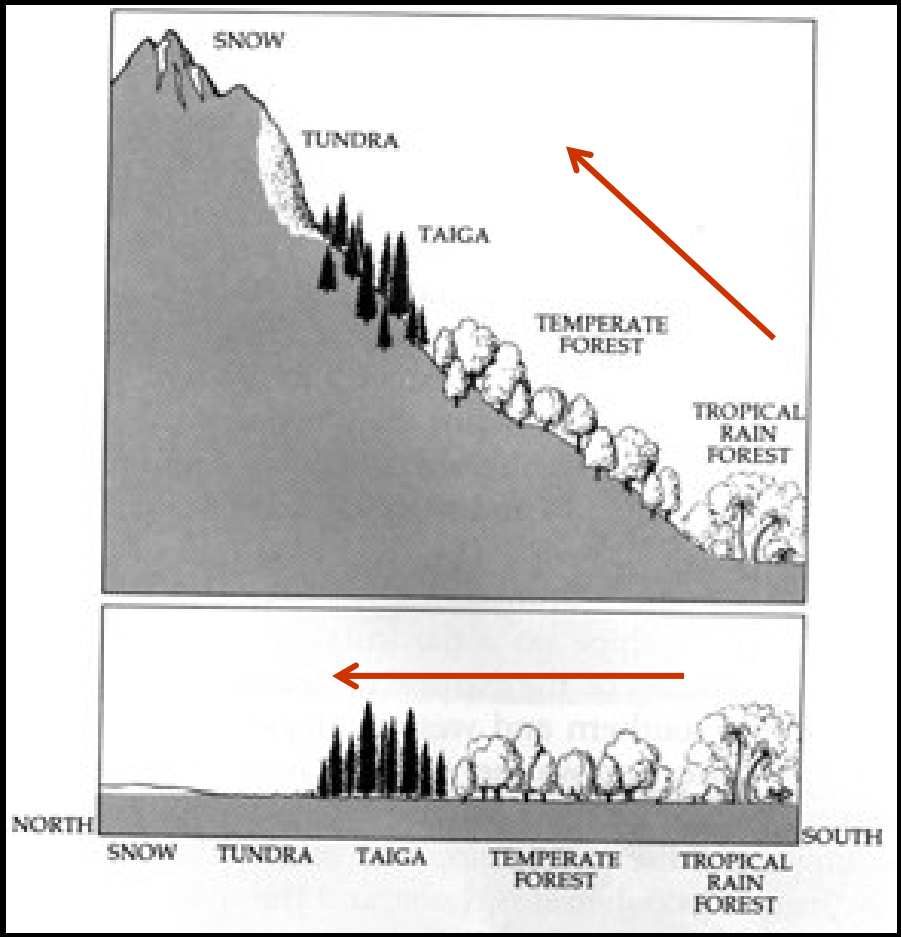


# Warming temperatures may affect organisms in a variety of ways

i. **Phenology** (timing of annual biological events)

ii. **Distributions**

iii.



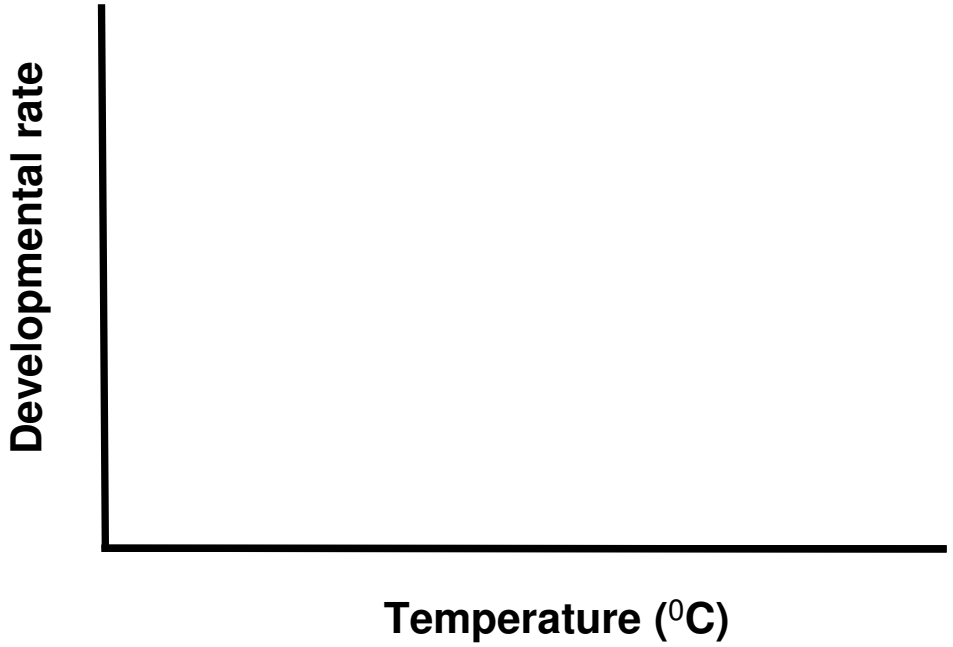
# Warming temperatures may affect organisms in a variety of ways

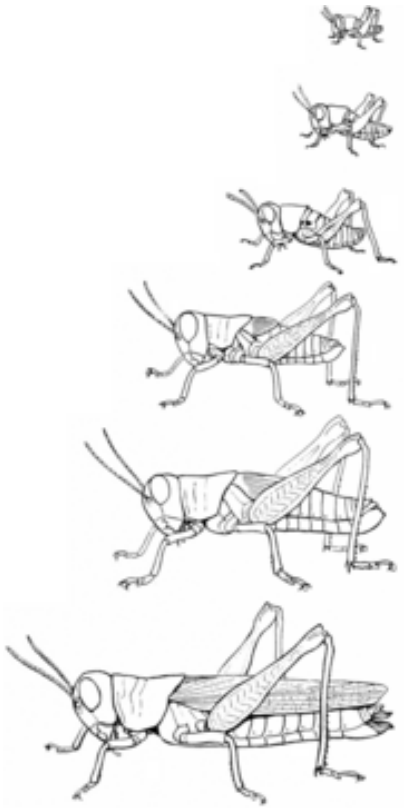
i. Phenology (timing of annual biological events)

ii. Distributions

iii. Local Extinctions

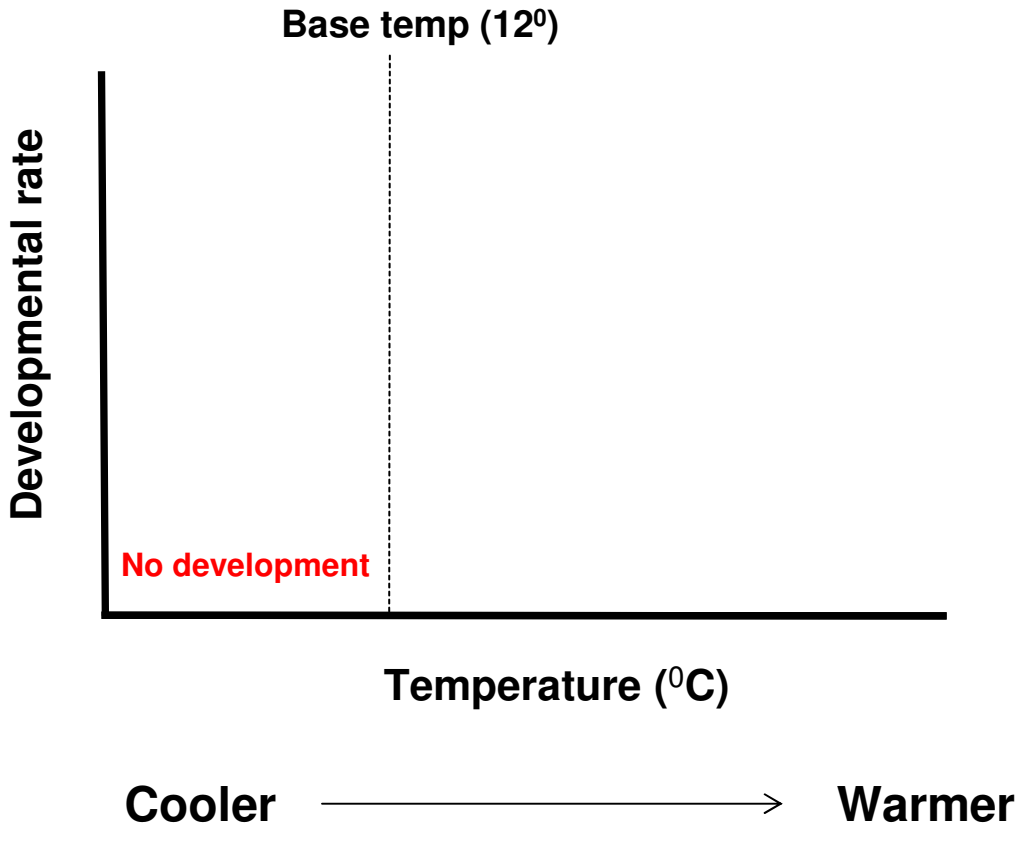
**For Insects, plants and other ectotherms, development is related to temperature**

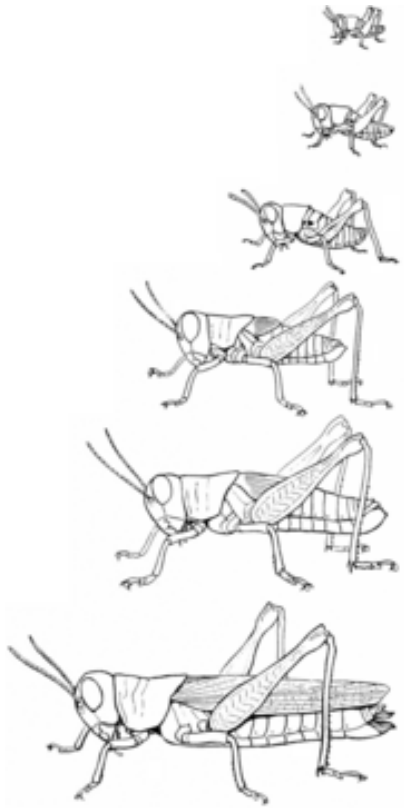


Trudgill *et al.* 2005

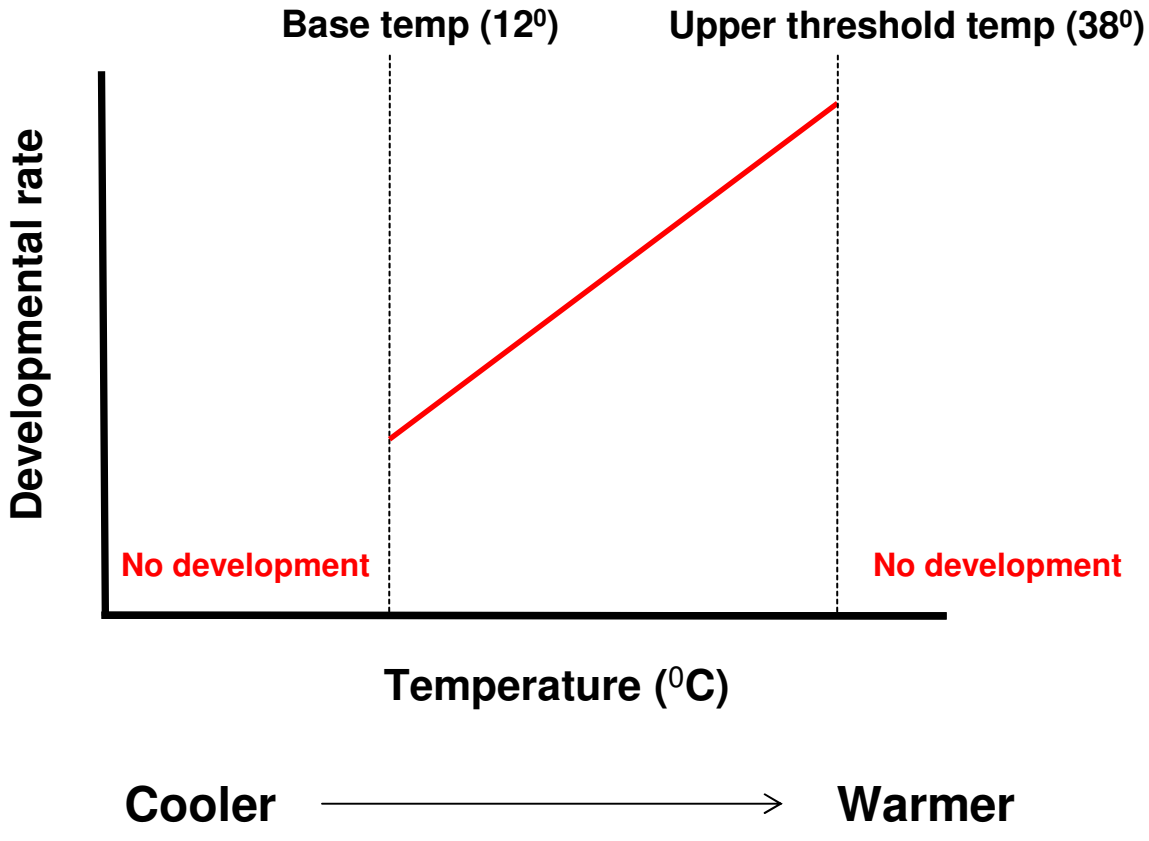
**For Insects, plants and other ectotherms, development is related to temperature**

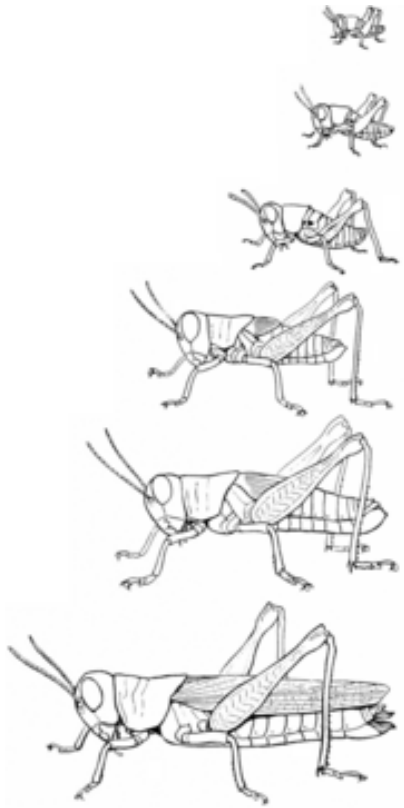


Trudgill *et al.* 2005

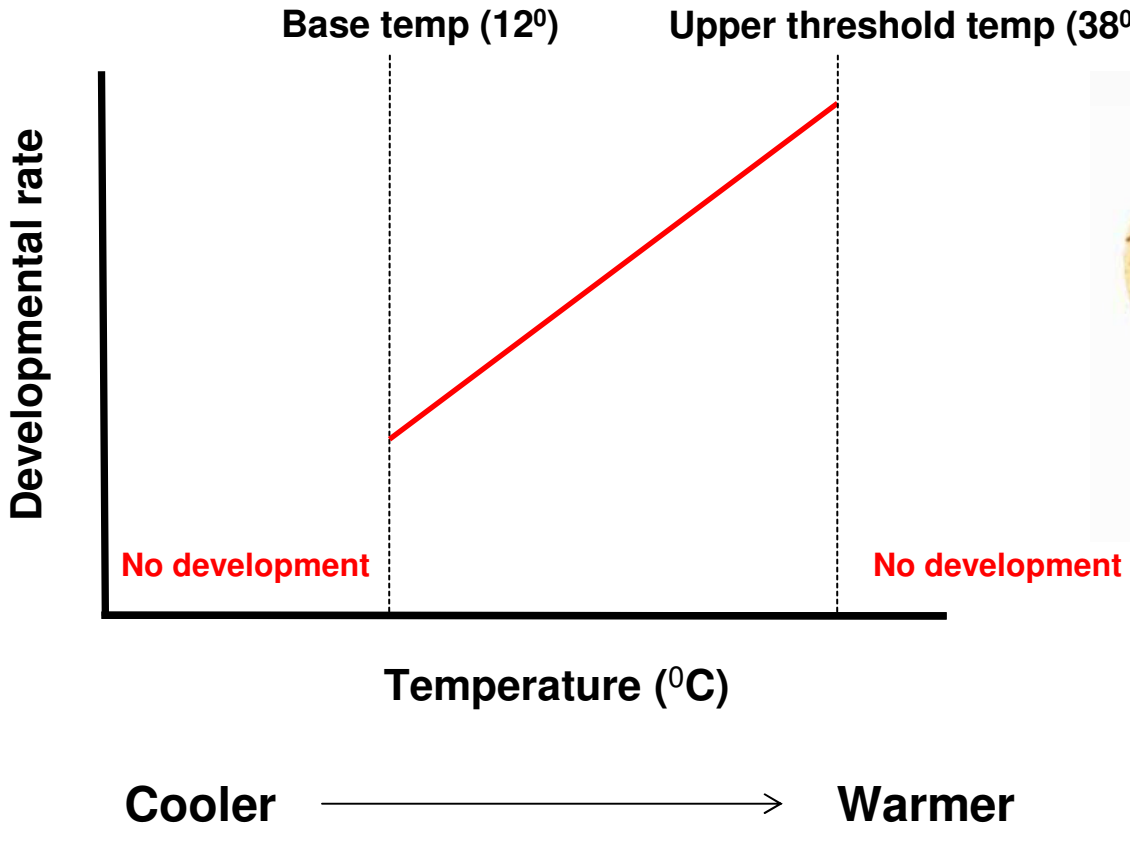
**For Insects, plants and other ectotherms, development is related to temperature**



Trudgill *et al.* 2005

**For Insects, plants and other ectotherms, development is related to temperature**




Trudgill *et al.* 2005

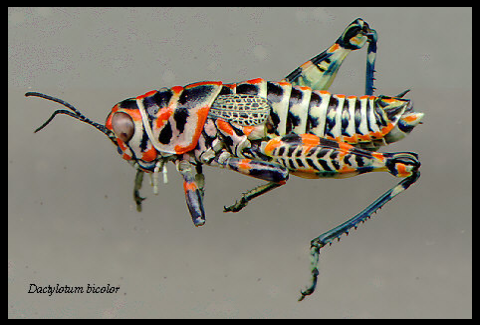
# Grasshoppers as important indicators of changes in climate and land use

1. Grasshoppers in grassland ecosystems

2. Grasshoppers and climate change

   -Gordon Alexander's 1958-1960 grasshopper survey along an elevational gradient

3. Urban fragmentation- the importance of Kingfisher Point






http://www.ndsu.nodak.edu/entomology/hopper/orthoptera_home.htm

## Gordon Alexander

Faculty member in CU's
Biology department (1939 - 1966)

**Interested in:**

The biology of organisms living along elevational gradients

http://alexander.colorado.edu

Don Van Horn

**1958-1960 Gordon Alexander survey**

NSF supported project ($25,000)

Goal: document species, distributions & phenology of local grasshoppers

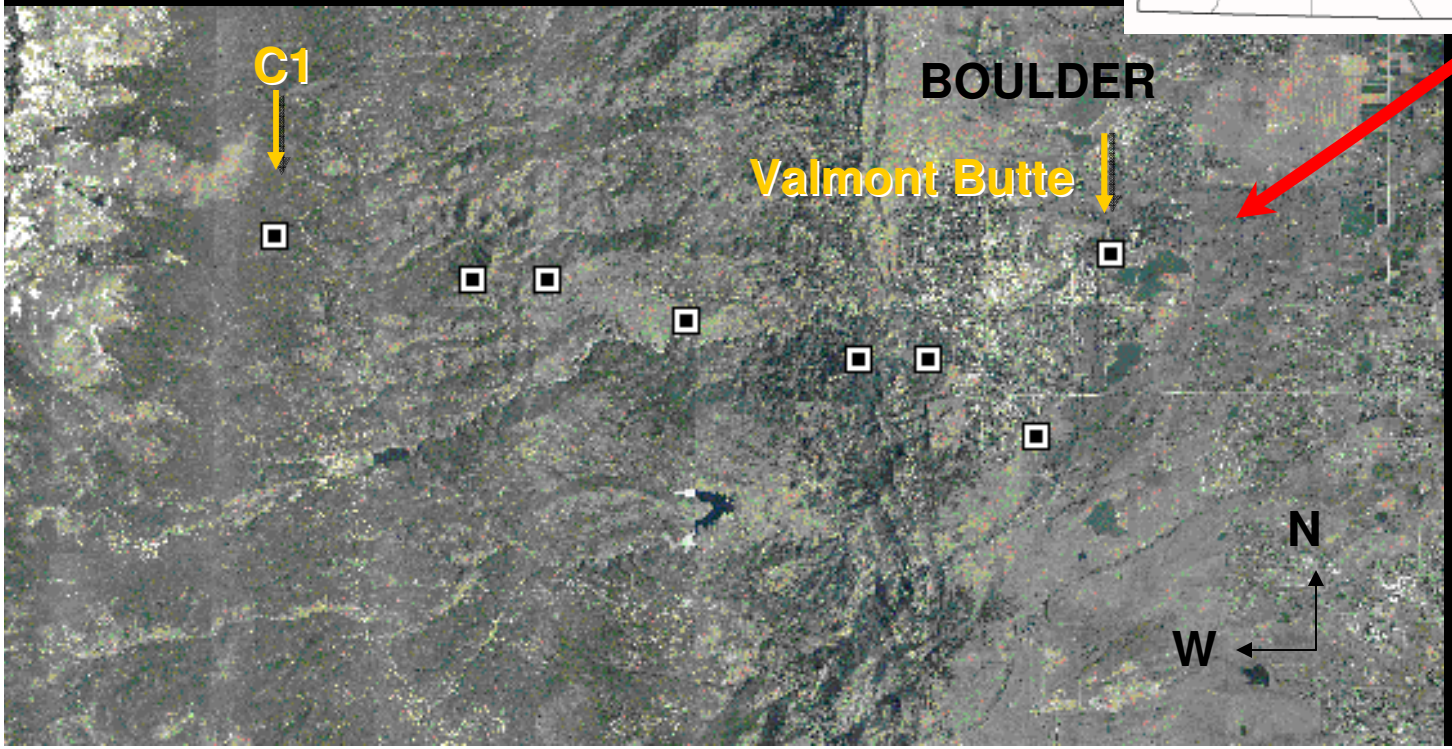

Don Van Horn


Don Van Horn

**1958-1960 - Surveyed grasshoppers at 8 main sites** (weekly basis, March-Sept)

- Valmont Butte to weather station C1 (foothills to subalpine gradient)

- 1,615 m (5,300 ft) to 3,048 m (10,000 ft)

1958-1960 Survey

**Chautauqua Mesa (1959)**

Don Van Horn


2.5 miles south of Boulder

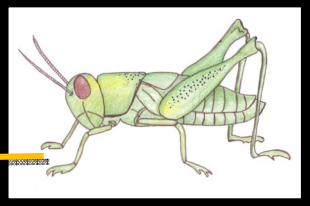

2.5 miles south of Boulder

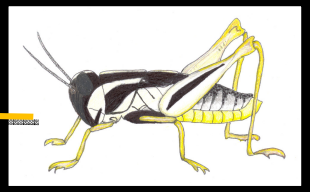

Fairview High School

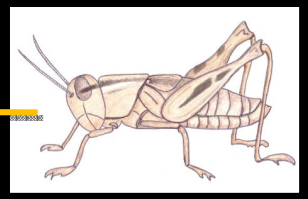
## Each survey event reflected the developmental stages of grasshoppers within each community

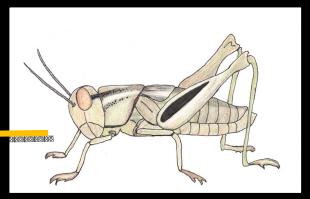
### Juveniles from a typical sample

### Juveniles

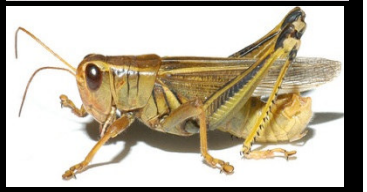








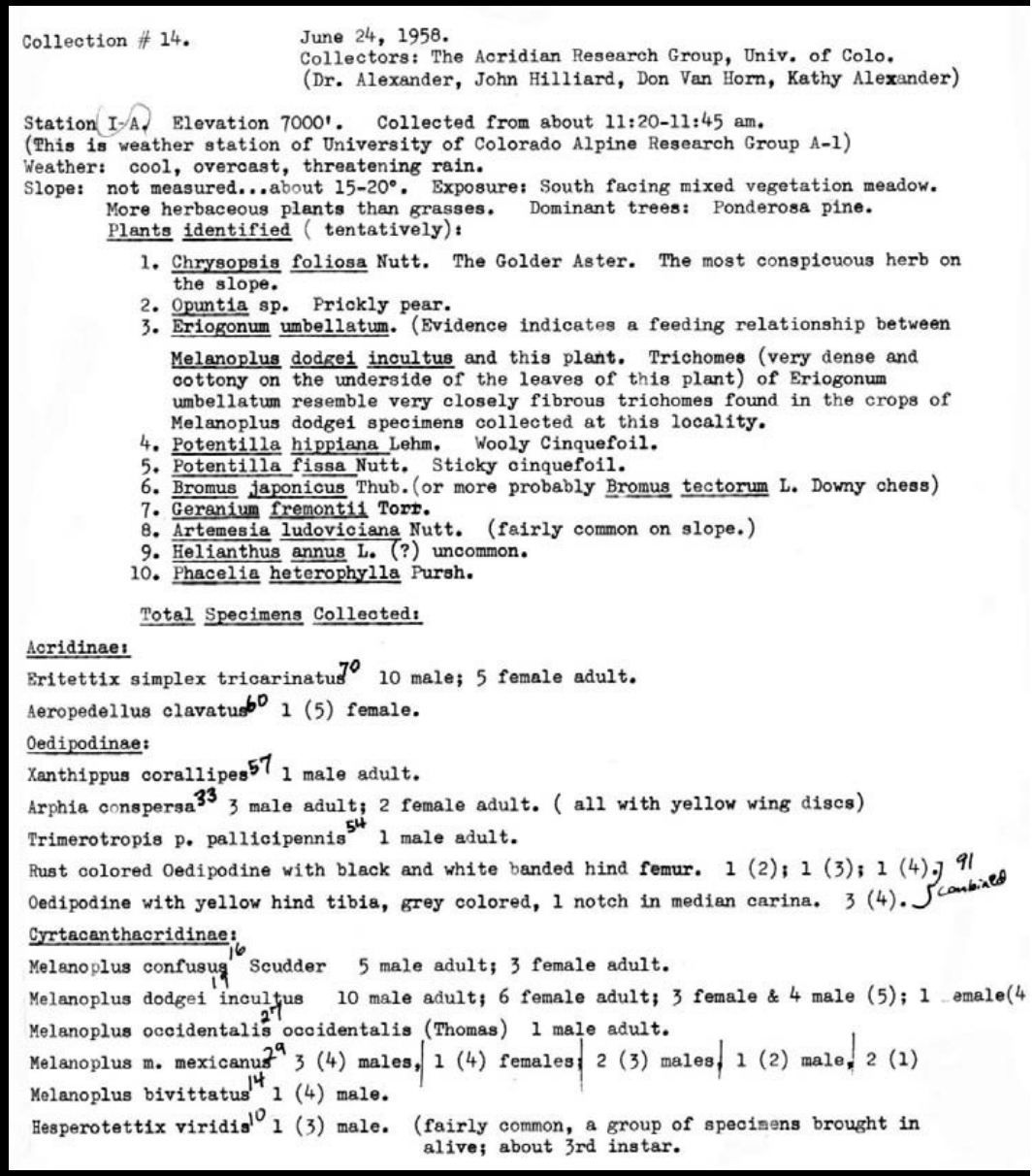
### Adults



## 1958-1960 Gordon Alexander Grasshopper Survey

**Alexander kept extensive field notes for all weekly collecting events at each site**

- species present
- developmental stages



Collection # 14. June 24, 1958.
Collectors: The Acridian Research Group, Univ. of Colo.
(Dr. Alexander, John Hilliard, Don Van Horn, Kathy Alexander)

Station I-A. Elevation 7000'. Collected from about 11:20-11:45 am.
(This is weather station of University of Colorado Alpine Research Group A-1)
Weather: cool, overcast, threatening rain.
Slope: not measured...about 15-20°. Exposure: South facing mixed vegetation meadow.
More herbaceous plants than grasses. Dominant trees: Ponderosa pine.
Plants identified ( tentatively):

1. Chrysopsis foliosa Nutt. The Golder Aster. The most conspicuous herb on the slope.
2. Opuntia sp. Prickly pear.
3. Eriogonum umbellatum. (Evidence indicates a feeding relationship between Melanoplus dodgei incultus and this plant. Trichomes (very dense and cottony on the underside of the leaves of this plant) of Eriogonum umbellatum resemble very closely fibrous trichomes found in the crops of Melanoplus dodgei specimens collected at this locality.
4. Potentilla hippiana Lehm. Wooly Cinquefoil.
5. Potentilla fissa Nutt. Sticky cinquefoil.
6. Bromus japonicus Thub.(or more probably Bromus tectorum L. Downy chess)
7. Geranium fremontii Torr.
8. Artemesia ludoviciana Nutt. (fairly common on slope.)
9. Helianthus annus L. (?) uncommon.
10. Phacelia heterophylla Pursh.

Total Specimens Collected:

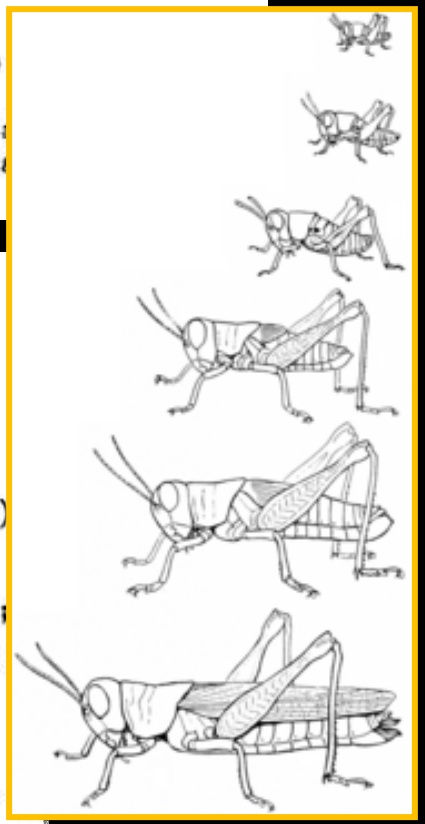
Acridinae:
Eritettix simplex tricarinatus 70 10 male; 5 female adult.
Aeropedellus clavatus 60 1 (5) female.

Oedipodinae:
Xanthippus corallipes 57 1 male adult.
Arphia conspersa 33 3 male adult; 2 female adult. ( all with yellow wing discs)
Trimerotropis p. pallicipennis 54 1 male adult.
Rust colored Oedipodine with black and white banded hind femur. 1 (2); 1 (3); 1 (4). 91 combined
Oedipodine with yellow hind tibia, grey colored, 1 notch in median carina. 3 (4).

Cyrtacanthacridinae:
Melanoplus confusus 16 Scudder 5 male adult; 3 female adult.
Melanoplus dodgei incultus 19 10 male adult; 6 female adult; 3 female & 4 male (5); 1 female(4
Melanoplus occidentalis occidentalis 27 (Thomas) 1 male adult.
Melanoplus m. mexicanus 29 3 (4) males, 1 (4) females; 2 (3) males, 1 (2) male, 2 (1)
Melanoplus bivittatus 14 1 (4) male.
Hesperotettix viridis 10 1 (3) male. (fairly common, a group of specimens brought in alive; about 3rd instar.

Collection # 14. June 24, 1958.
Collectors: The Acridian Research Group, Univ. of Colo.
(Dr. Alexander, John Hilliard, Don Van Horn, Kathy Alexander)

Station I-A. Elevation 7000'. Collected from about 11:20-11:45 am.
(This is weather station of University of Colorado Alpine Research Group
Weather: cool, overcast, threatening rain.
Slope: not measured...about 15-20°. Exposure: South facing mixed veget
More herbaceous plants than grasses. Dominant trees: Ponderos
Plants identified ( tentatively):



Acridinae:

Eritettix simplex tricarinatus 70 10 male; 5 female adult.

Aeropedellus clavatus 60 1 (5) female.

Oedipodinae:

Xanthippus corallipes 57 1 male adult.

Arphia conspersa 33 3 male adult; 2 female adult. ( all with yellow wing discs)

Trimerotropis p. pallicipennis 54 1 male adult.

Rust colored Oedipodine with black and white banded hind femur. 1 (2); 1 (3);

Oedipodine with yellow hind tibia, grey colored, 1 notch in median carina. 3

Cyrtacanthacridinae:

Melanoplus confusus Scudder 5 male adult; 3 female adult.

Melanoplus dodgei incultus 10 male adult; 6 female adult; 3 female & 4 male

Melanoplus occidentalis occidentalis (Thomas) 1 male adult.

Melanoplus m. mexicanus 29 3 (4) males, 1 (4) females; 2 (3) males, 1 (2) male, 2 (1)

Melanoplus bivittatus 14 1 (4) male.

Hesperotettix viridis 10 1 (3) male. (fairly common, a group of specimens brought in alive; about 3rd instar.

Grasshoppers have 5 developmental stages before they become adults

## 1958-1960 Gordon Alexander survey

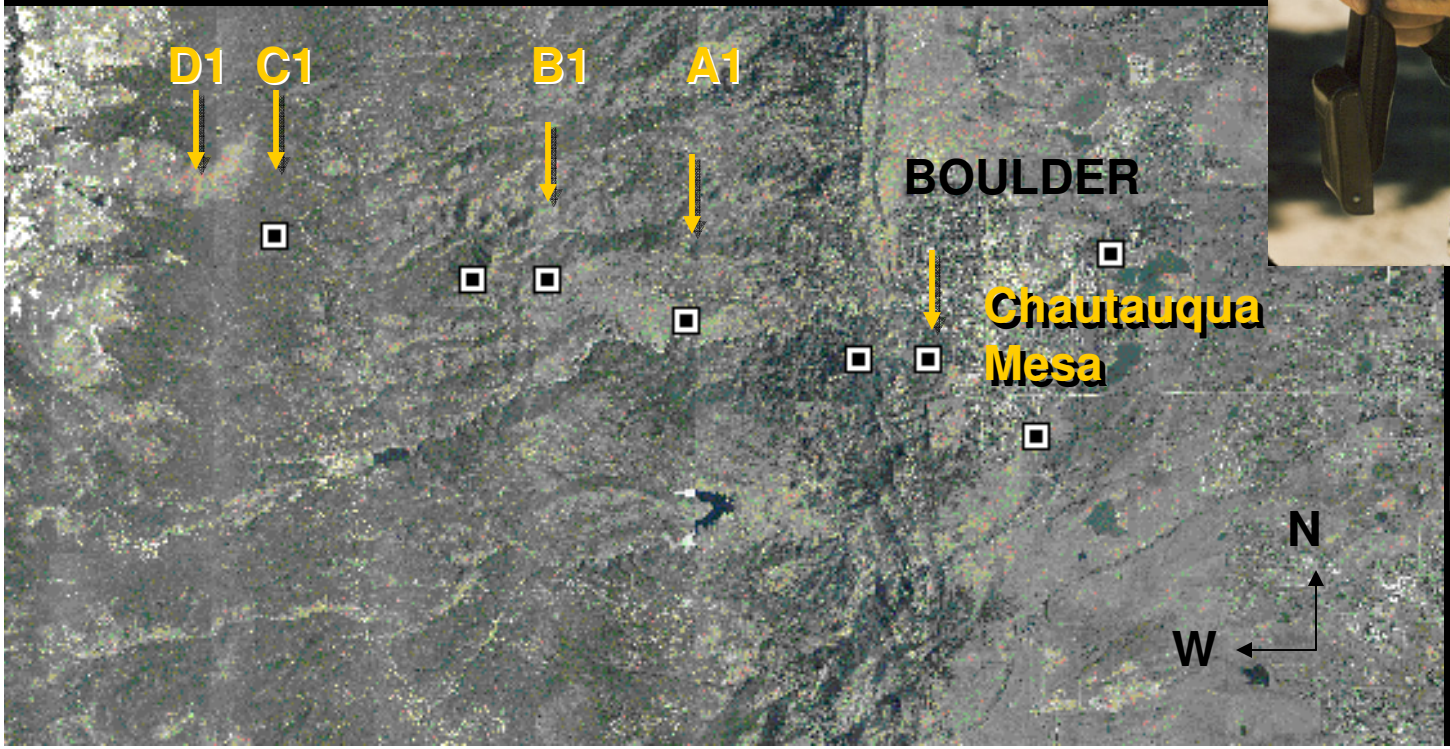
- Processed 65,000 grasshoppers, 73 species

-13,500 pinned and labeled

## 1958-1960 Gordon Alexander survey

- 4 sites adjacent to weather stations

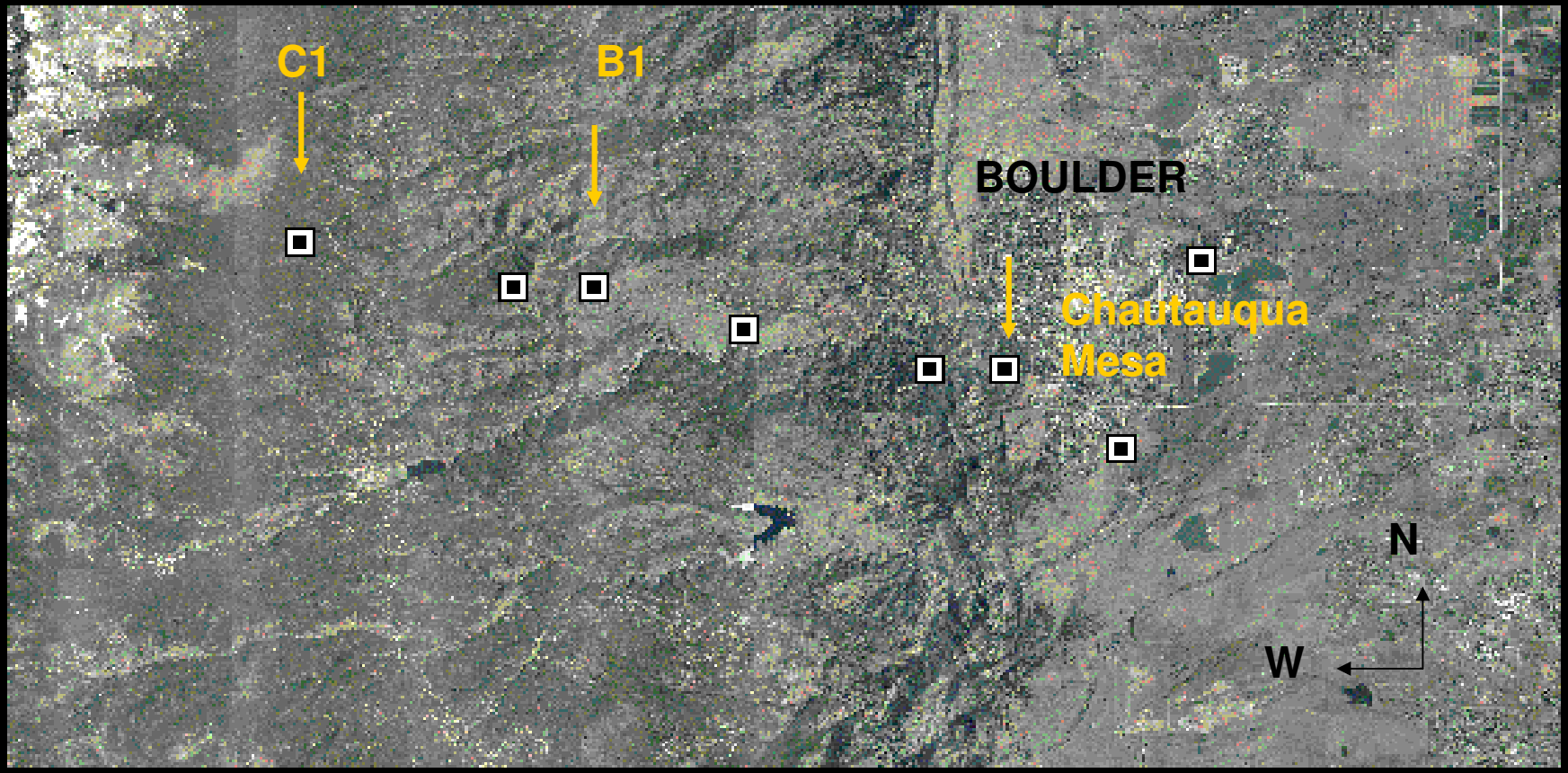
- A1- D1 Stations set up in the early 1950's
  (currently maintained by Niwot LTER)




Dr. John Marr

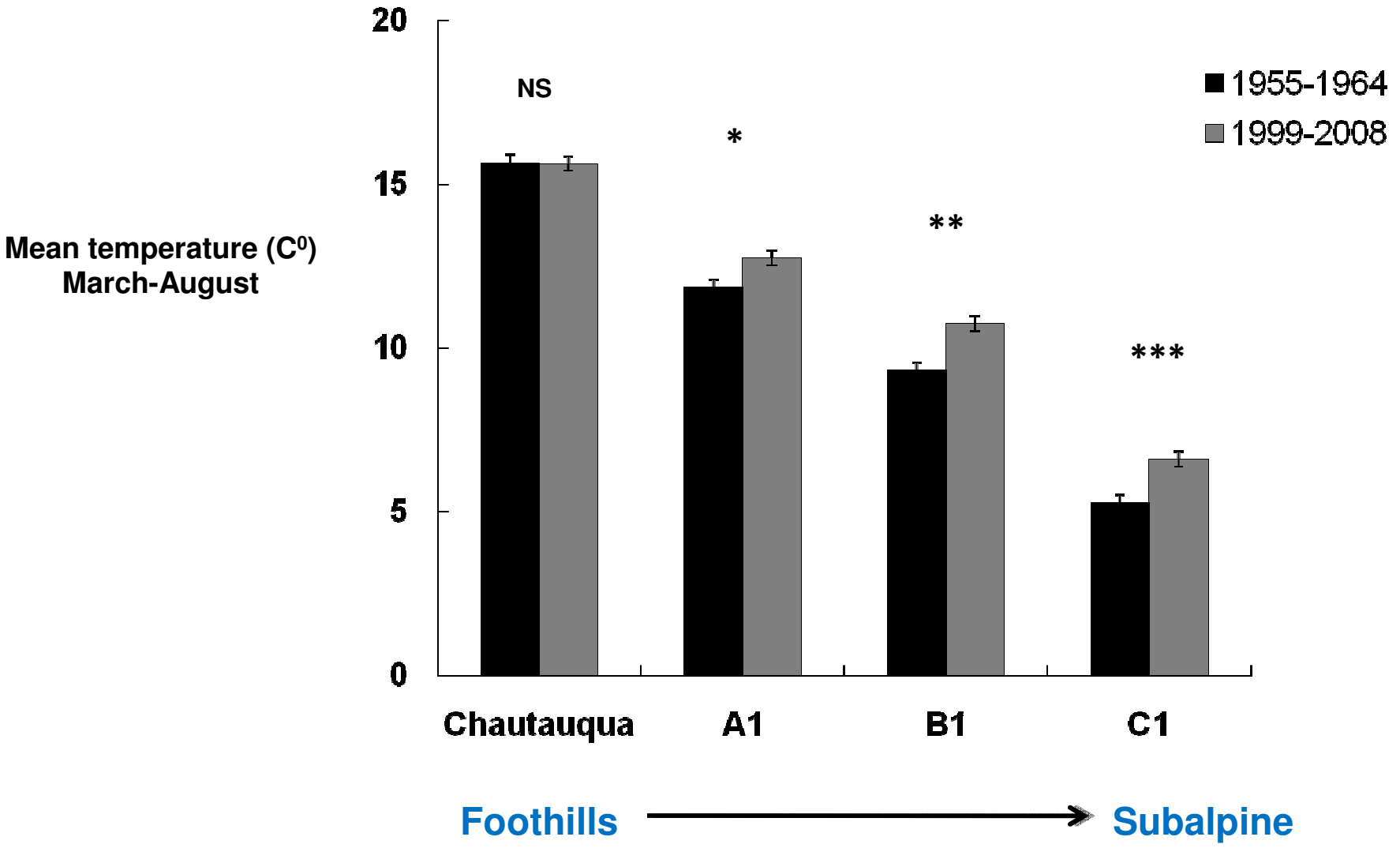
Founded INSTAAR
Mnt Research station

## How has climate changed along Alexander's elevational gradient?



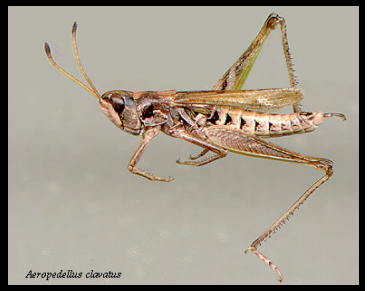

Elevation-dependent temperature trends in the Rocky Mountain Front Range over a 54-year and a 20-year record --- Chris McGuire *et al.*

# How has climate changed along Alexander's elevational gradient?



## **Chautauqua Mesa - 1752m** (5750ft)









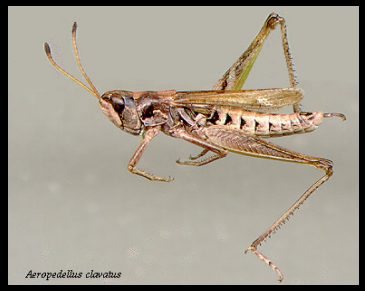
***Gerald M. Fauske***

Given no significant change in temp, has the time to reach adulthood changed?

| Station | Species | Earliest ordinal date to adulthood 1959-1960 | Change in timing to adulthood 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| **Chautauqua Mesa** | | | | | |
| | *Aeropedullus clavatus* | 152 | ------- | | |
| | *Melanoplus confucus* | 155 | ------- | | |
| | *M. sanguinipes* | 176 | ------- | | |
| | *M. bivittatus* | 181 | ------- | | |
| | *Hesperotettix viridis* | 186 | ------- | | |
| | *M. dawsoni* | 186 | ------- | | |

## **Chautauqua Mesa - 1752m** (5750ft)









*Gerald M. Fauske*

Given no significant change in temp, has the time to reach adulthood changed?

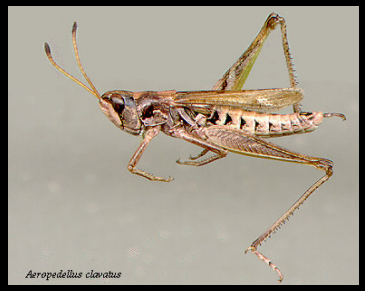
| Station | Species | Earliest ordinal date to adulthood 1959-1960 | Change in timing to adulthood 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| Chautauqua Mesa | | | | | |
| | *Aeropedullus clavatus* | 152 | ------- | -11 | |
| | *Melanoplus confucus* | 155 | ------- | | |
| | *M. sanguinipes* | 176 | ------- | | |
| | *M. bivittatus* | 181 | ------- | | |
| | *Hesperotettix viridis* | 186 | ------- | | |
| | *M. dawsoni* | 186 | ------- | | |

**2007**
**1/6 earlier**

**2008**
**0/ 6 earlier**

## Station B1 - 2591m (8500ft)









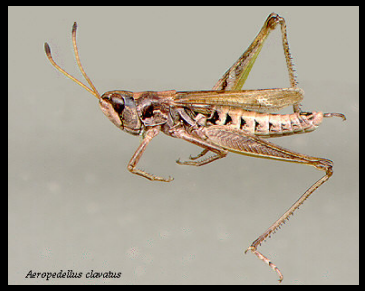
***Gerald M. Fauske***

Given 2 $C^0$ (3.6 $F^0$) change in temp has the time to reach adulthood changed?

| Station | Species | Earliest ordinal date to adulthood 1959-1960 | Change in timing to adulthood 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| Station B1 | | | | | |
| | *Aeropedellus clavatus* | 172 | | | |
| | *Melanoplus dodgei* | 172 | | | |
| | *Camnula pellucida* | 202 | | | |
| | *Circotettix rabula* | 207 | | | |
| | *M. dawsoni* | 215 | | | |
| | *Chloealtis abdominalis* | 216 | | | |
| | *M. packardi* | 216 | | | |

## Station B1 - 2591m (8500ft)









*Gerald M. Fauske*

Given 2 $C^0$ (3.6 $F^0$) change in temp has the time to reach adulthood changed?

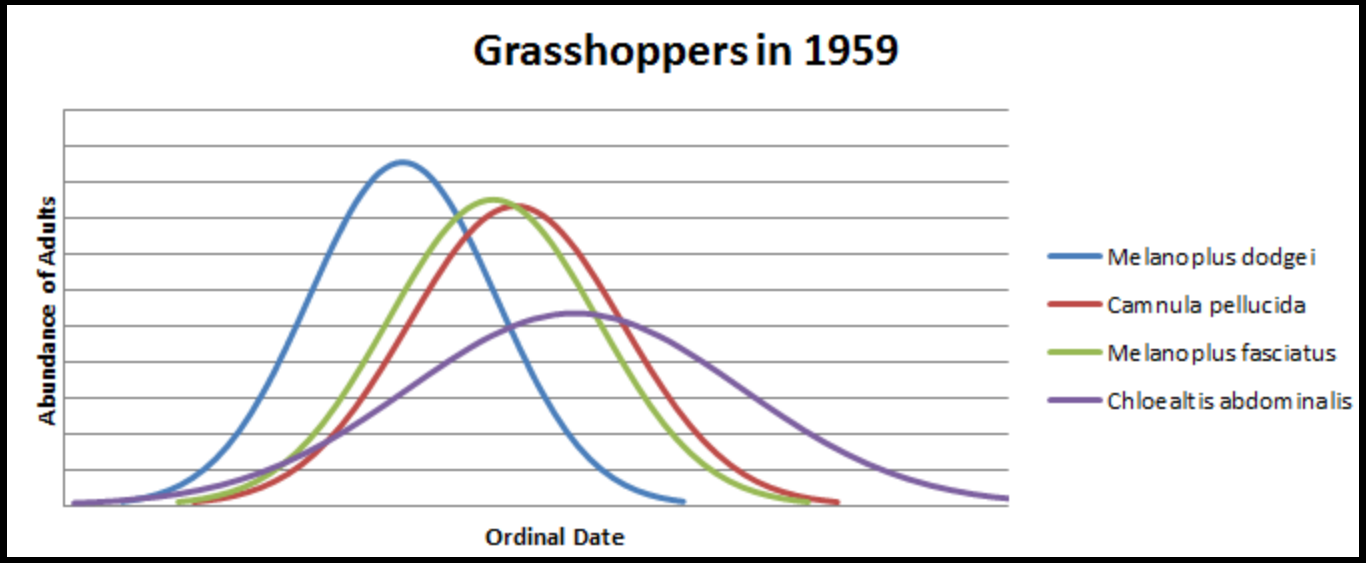
| Station | Species | Earliest ordinal date to adulthood 1959-1960 | Change in timing to adulthood 2006 | 2007 | 2008 |
|---|---|---|---|---|---|
| Station B1 | | | | | |
| | *Aeropedellus clavatus* | 172 | -13 | -17 | -10 |
| | *Melanoplus dodgei* | 172 | -13 | -17 | -10 |
| | *Camnula pellucida* | 202 | -14 | | -11 |
| | *Circotettix rabula* | 207 | -19 | -10 | -16 |
| | *M. dawsoni* | 215 | -27 | -18 | -8 |
| | *Chloealtis abdominalis* | 216 | -21 | -19 | -18 |
| | *M. packardi* | 216 | -36 | -26 | -18 |
| | | Mean | -20 d | -16 d | -13 d |

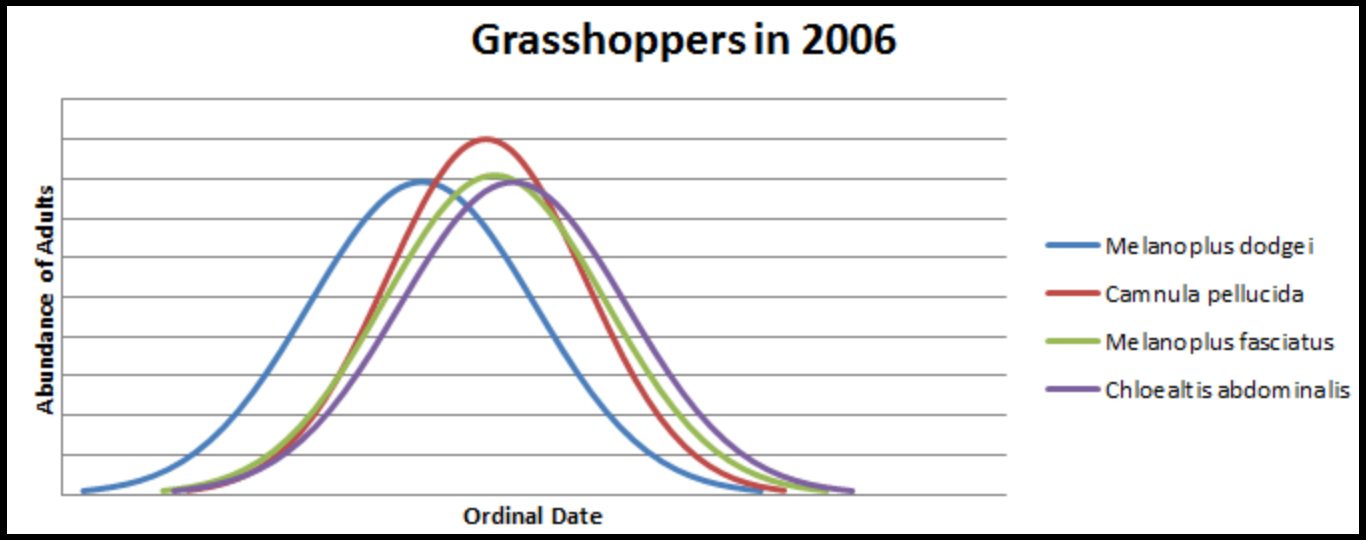
**2006**
**7/7 earlier**

**2007**
**6/7 earlier**

**2008**
**7/7 earlier**

## Station B1 - 2591m (8500ft)



**Using a community level approach at four collecting areas with detailed weather data**

**Conclusions**

**Warming is elevation dependent**

- **mid- high elevations warmed more than lower elevations**

**Using a community level approach at four collecting areas with detailed weather data**

**Conclusions**

**Warming is elevation dependent**

**mid- high elevations warmed more than lower elevations**

**Higher sites showed greater community level responses**

| | | |
|---|---|---|
| **Chautauqua Mesa** | **1/6** | **earlier** |
| **Station B1** | **7/7** | **earlier** |

**Using a community level approach at four collecting areas with detailed weather data**

**Conclusions**

**Warming is elevation dependent**

**mid- high elevations warmed more than lower elevations**

**Higher sites showed greater community level responses**

| | | |
|---|---|---|
| **Chautauqua Mesa** | **1/6** | **earlier** |
| **Station B1** | **7/7** | **earlier** |

**Species that become adults later in the season (at B1) are more strongly affected by warming**

**Most studies show that early species display greatest advancement**

- *flowering plants, diatoms, dragonflies (Fitter & Fitter 2002, Hassall 2007, Adrian et al 2006)*

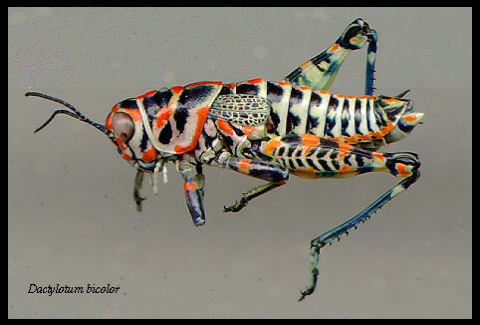
# Grasshoppers as important indicators of changes in climate and land use

1. Grasshoppers in grassland ecosystems

2. Grasshoppers and climate change

   -Gordon Alexander's 1958-1960 grasshopper survey along an elevational gradient

3. Urban fragmentation- the importance of Kingfisher Point





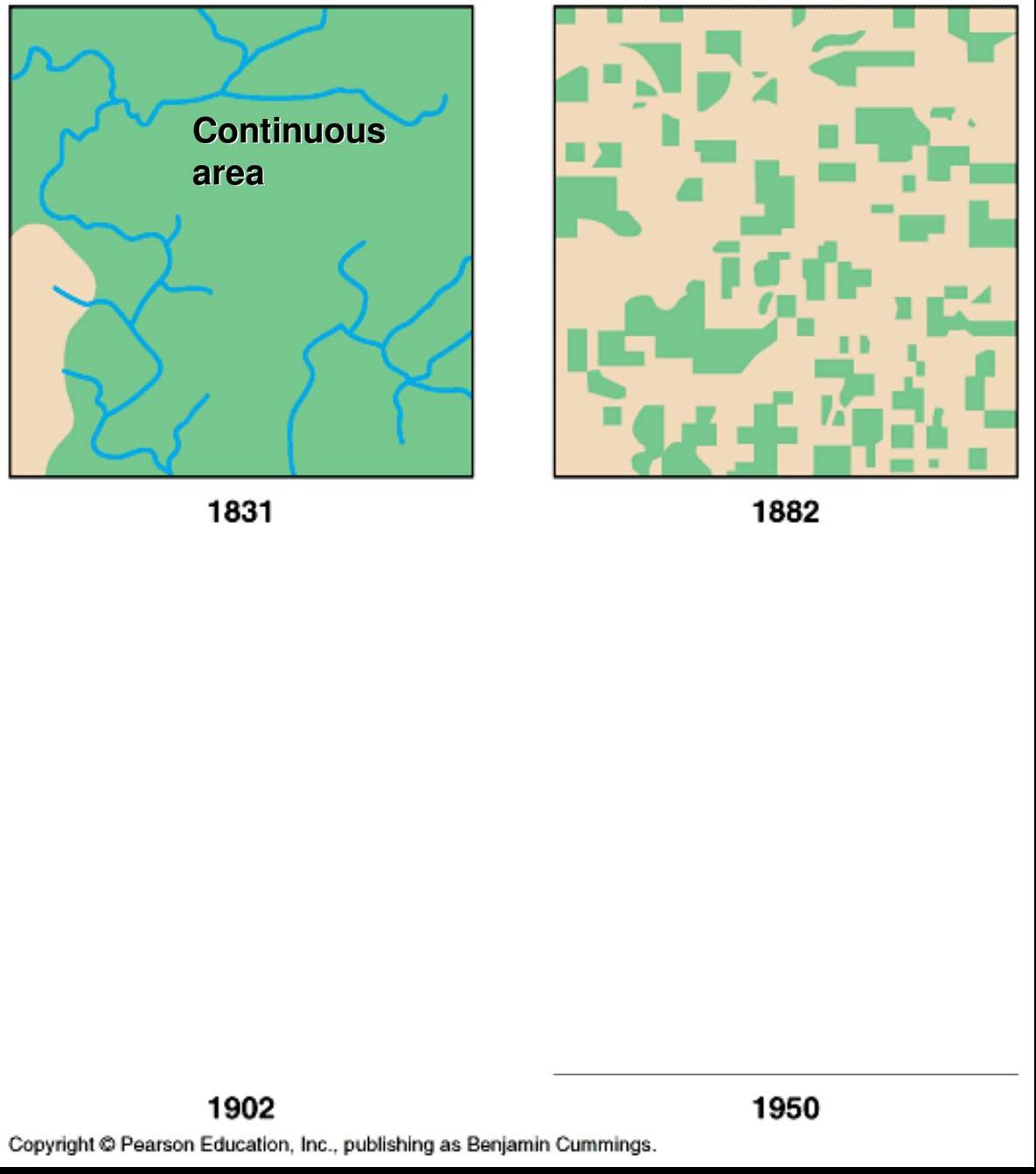

http://www.ndsu.nodak.edu/entomology/hopper/orthoptera_home.htm

## The history of habitat reduction and fragmentation in a Wisconsin forest




**Fragmented areas become smaller & farther away from other fragments**

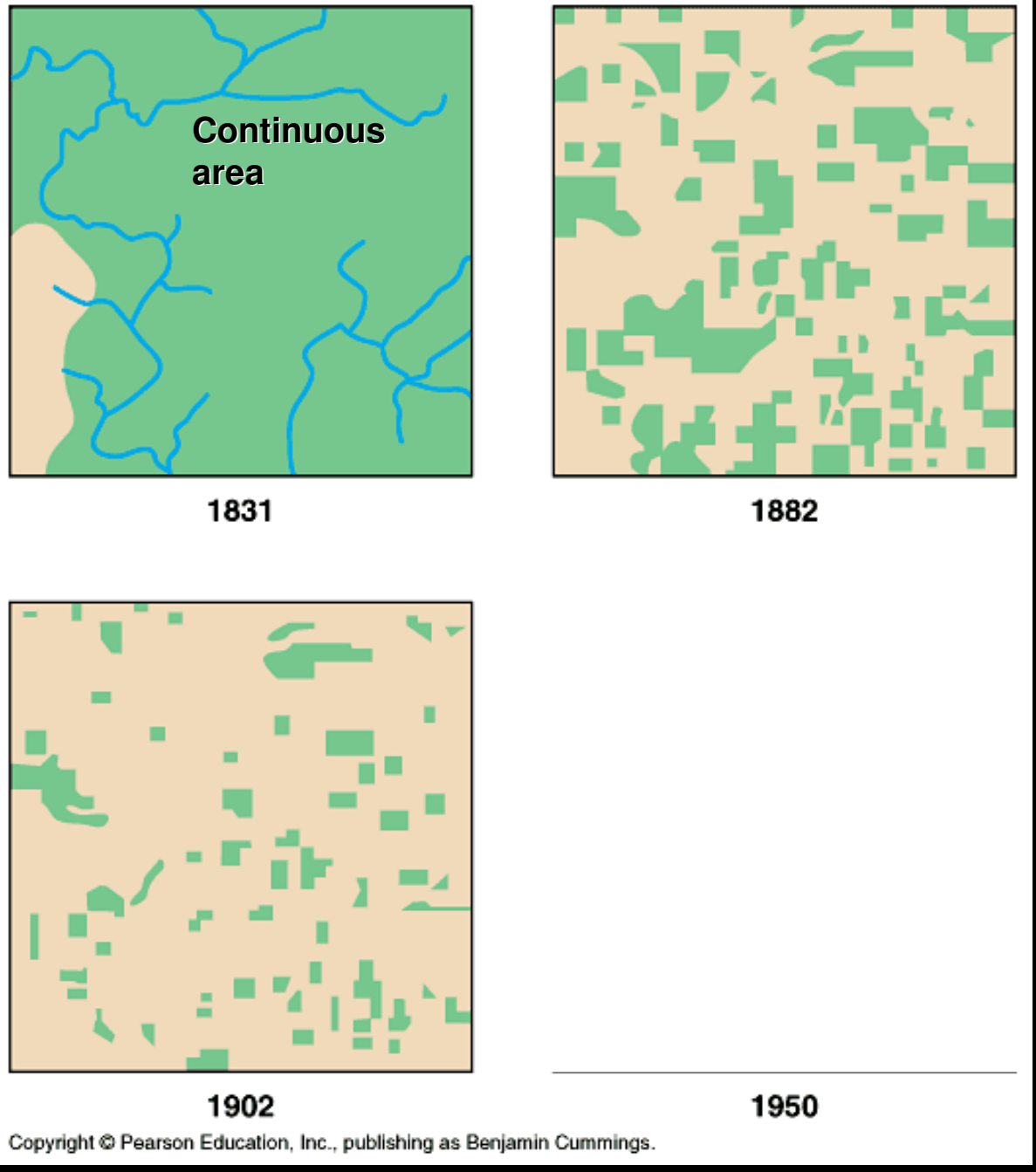
## The history of habitat reduction and fragmentation in a Wisconsin forest






**Fragmented areas become smaller & farther away from other fragments**

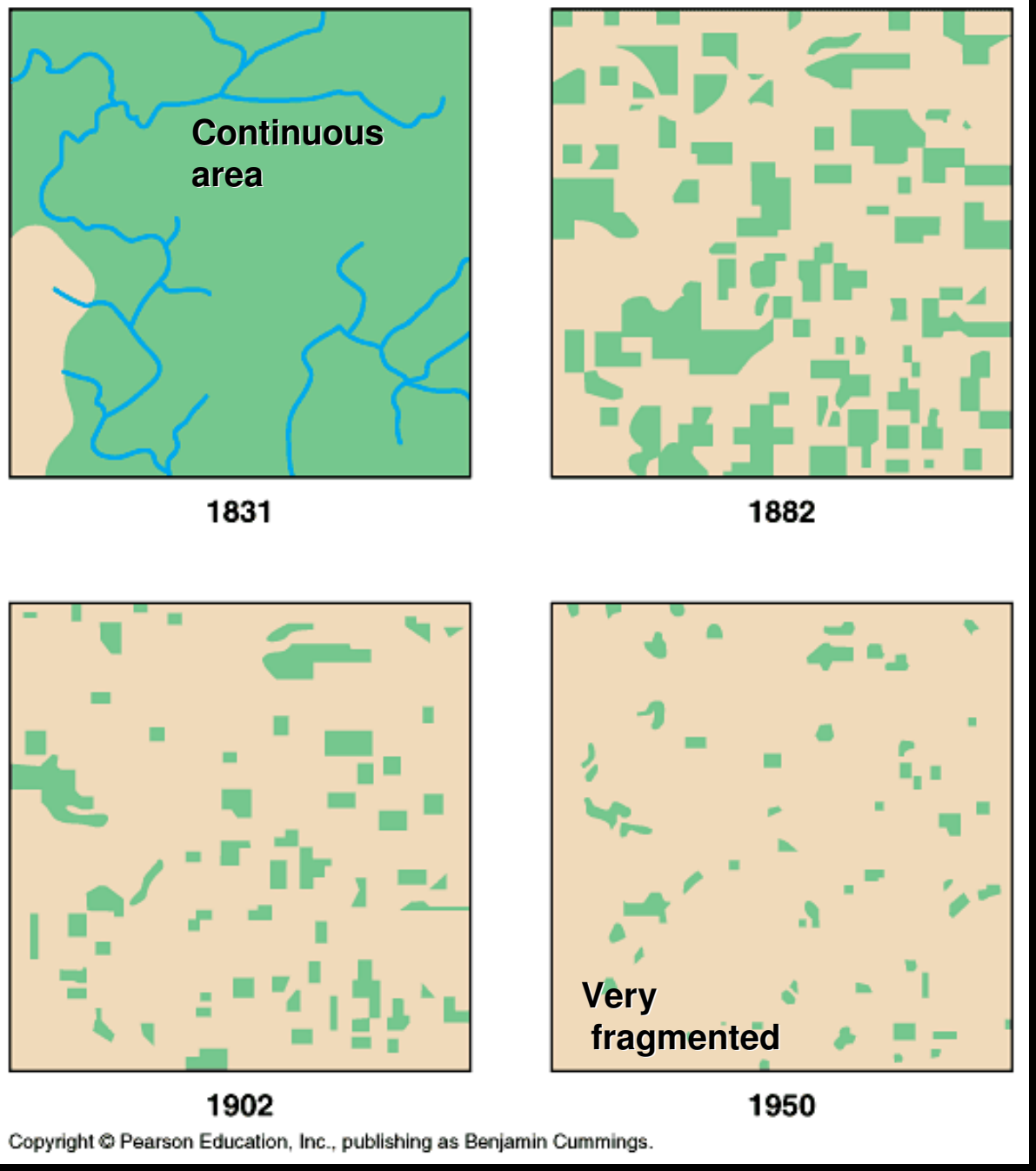
## The history of habitat reduction and fragmentation in a Wisconsin forest






**Fragmented areas become smaller & farther away from other fragments**

## The history of habitat reduction and fragmentation in a Wisconsin forest






**Fragmented areas become smaller & farther away from other fragments**

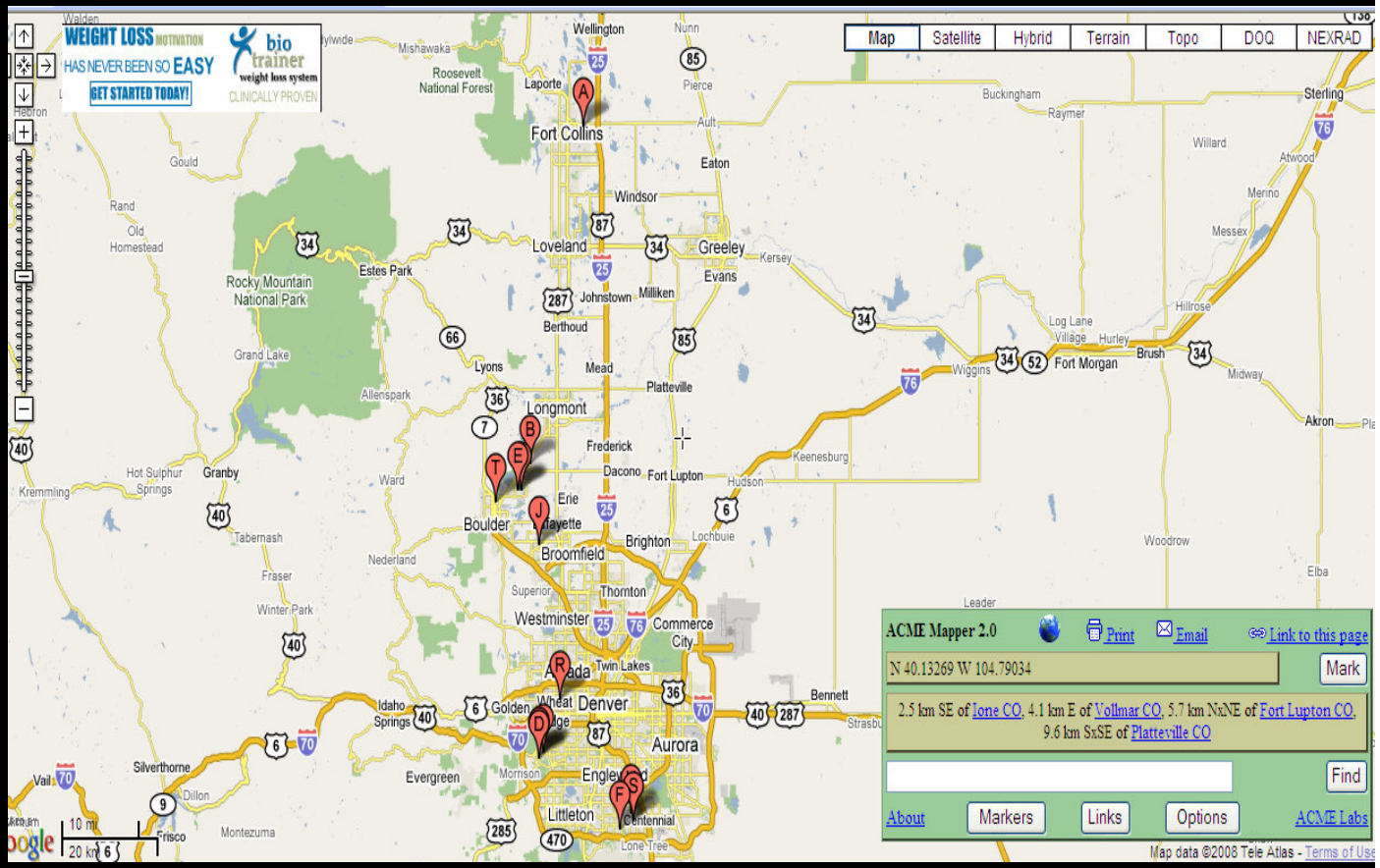
## Fragmented areas become smaller & farther away from other fragments

Continuous

## *Grasshopper Survey Methods*

**Sampled 13 fragments (0.85-37.31 ha) Boulder, Denver Fort Collins areas**

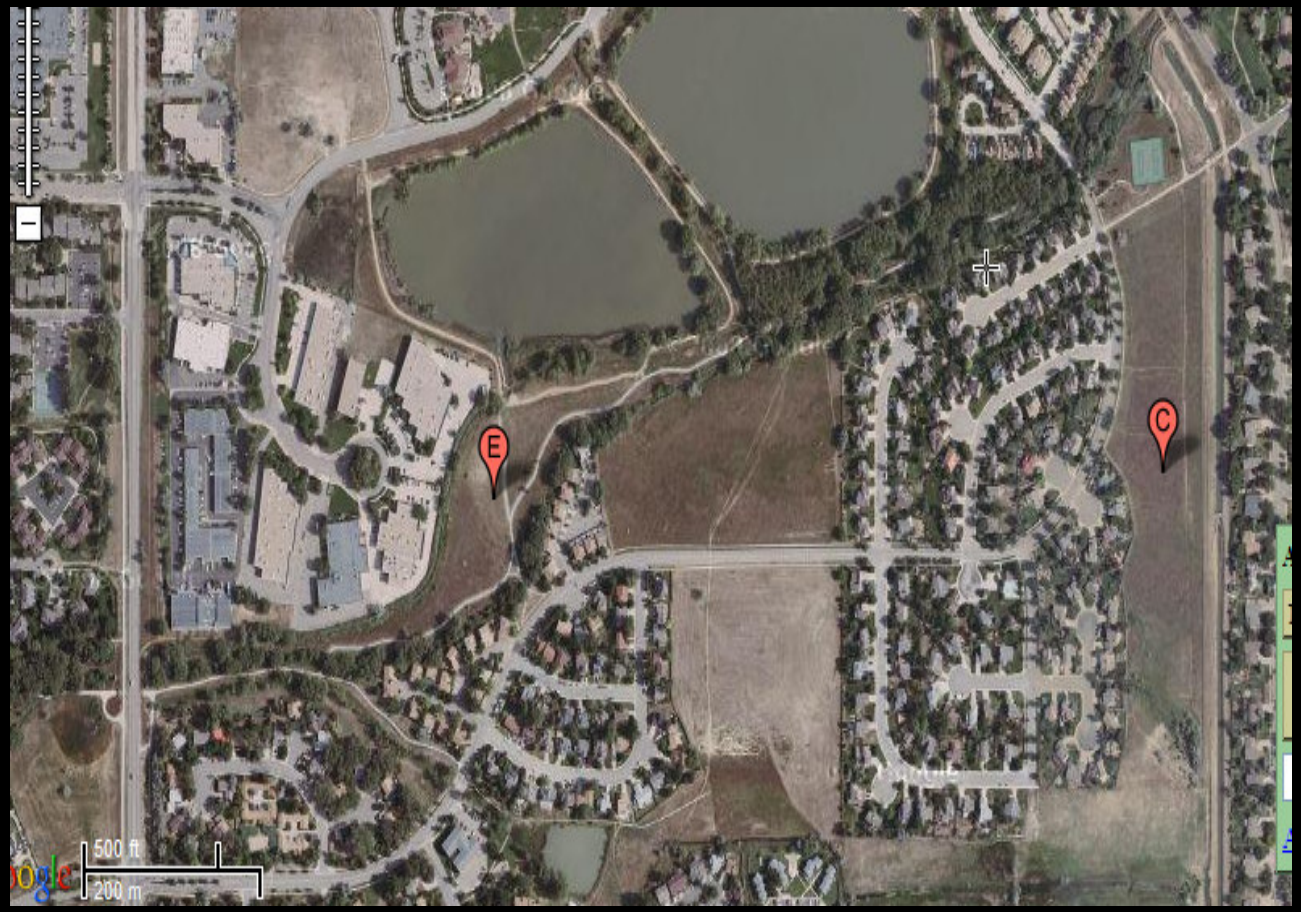
| Fragment | Area (ha) |
|---|---|
| Manor Care | 0.85 |
| Loveland | 1.76 |
| Twin Lakes | 1.84 |
| Red Fox | 3.94 |
| Niwot Estate | 4.92 |
| Forest Dump | 6.04 |
| Ute Trail | 6.78 |
| Tamarisk | 10.3 |
| Holly | 10.94 |
| Ravines | 11.04 |
| Willow Spring | 21.66 |
| Kingfisher Point | 32.43 |
| Crown Hill Park | 37.31 |



## *Grasshopper Survey Methods*

**Sampled 13 fragments (0.85-37.31 ha) Boulder, Denver Fort Collins areas**

| Fragment | Area (ha) |
|---|---|
| Manor Care | 0.85 |
| Loveland | 1.76 |
| Twin Lakes | 1.84 |
| Red Fox | 3.94 |
| Niwot Estate | 4.92 |
| Forest Dump | 6.04 |
| Ute Trail | 6.78 |
| Tamarisk | 10.3 |
| Holly | 10.94 |
| Ravines | 11.04 |
| Willow Spring | 21.66 |
| Kingfisher Point | 32.43 |
| Crown Hill Park | 37.31 |




**Twin Lakes & Red Fox**

## *Grasshopper diversity and fragment size*


**Found a total of 38 unique species**

**On average there were 16 species at a site**

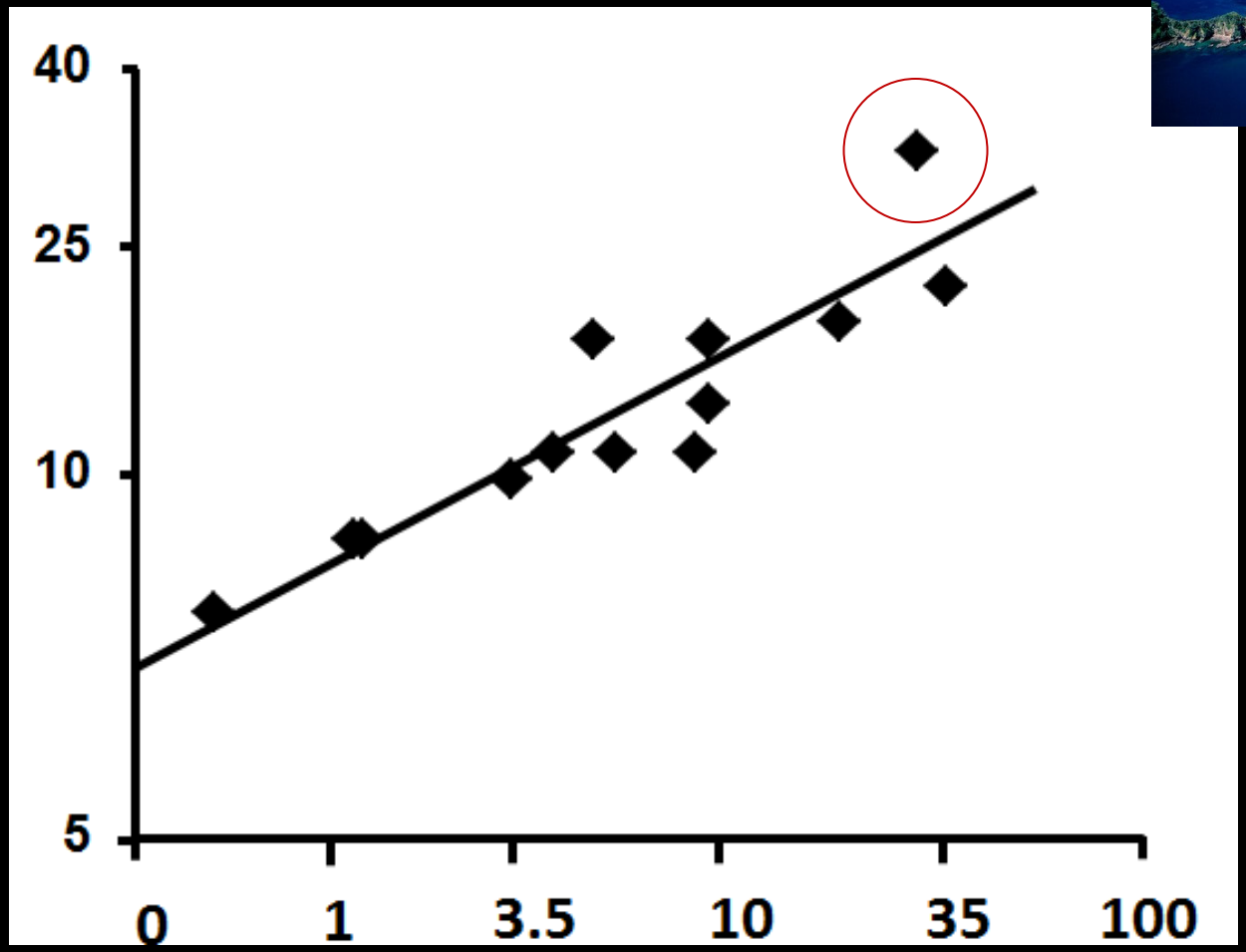
**At Kingfisher Point – 32 species**
**(But there may be more)**

## *Grasshopper diversity and fragment size*

***Hesperotettix speciousa***

***"Western green grasshopper"***

## *Grasshopper diversity and fragment size*



## Why are there fewer species at smaller sites?

*1. Habitat diversity*

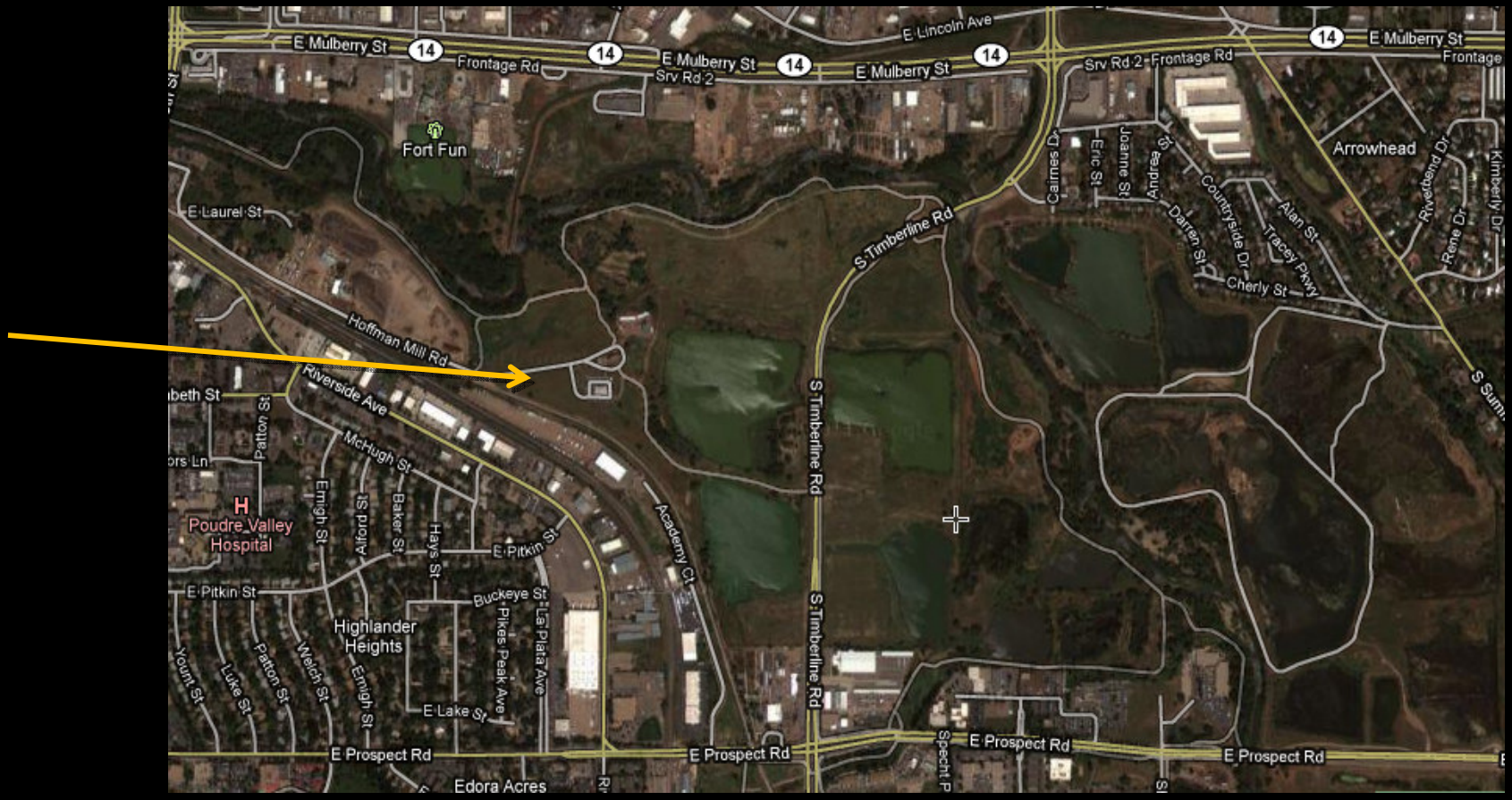
*2. Rarity*

# Why are there fewer species at smaller sites?

## *1. Habitat diversity*

# *1. Habitat diversity*

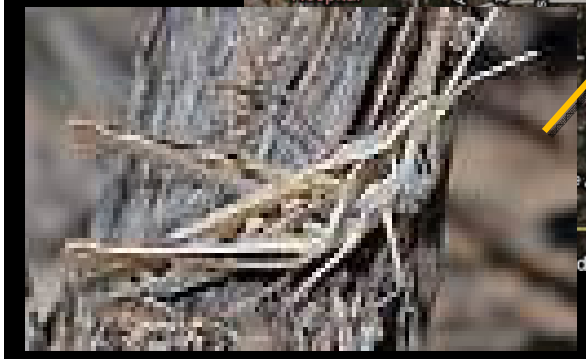
**Kingfisher Point**



# 1. Habitat diversity

**Kingfisher Point**

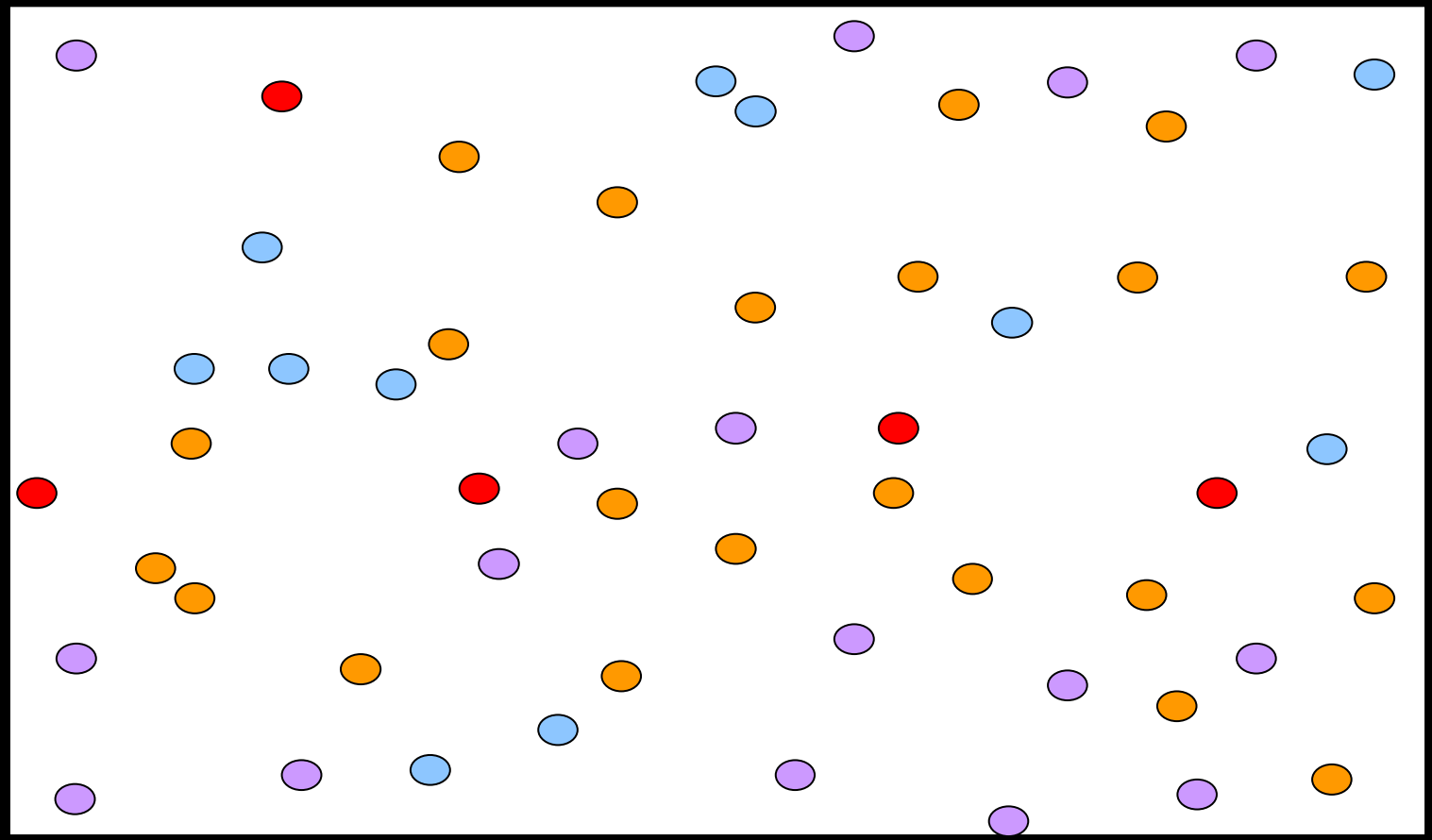


# Why are there fewer species at smaller sites?

*1. Habitat diversity*

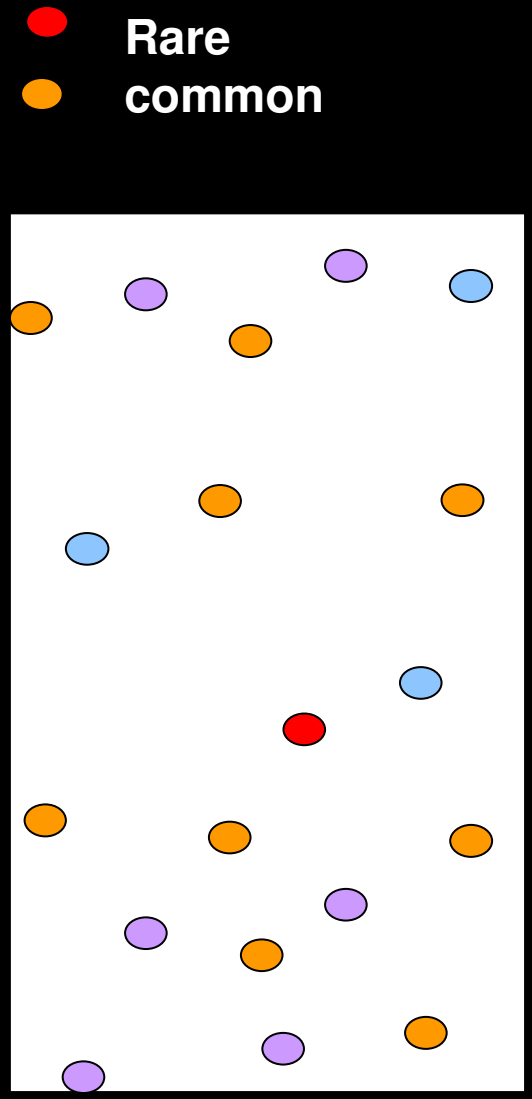
*2. Rarity*



# Why are there fewer species at smaller sites?

*1. Habitat diversity*

*2. Rarity*

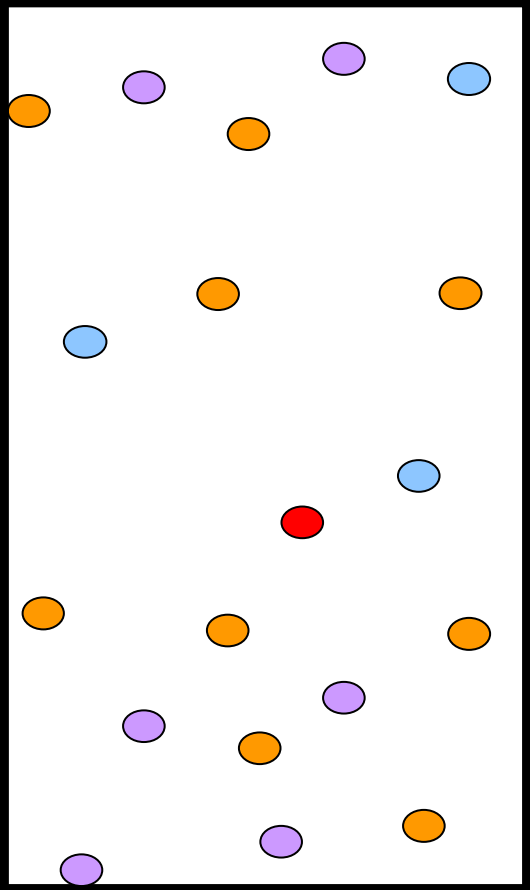


# Why are there fewer species at smaller sites?

*1. Habitat diversity*

*2. Rarity*

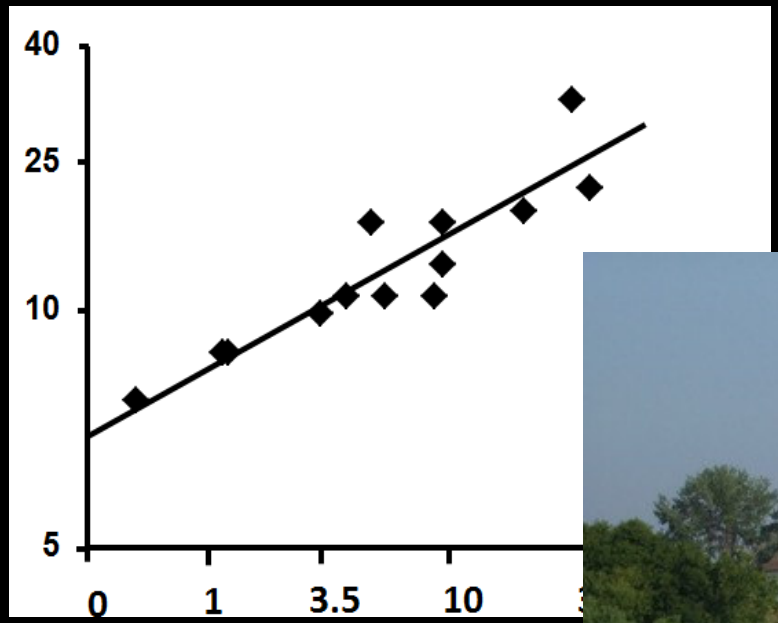
Rare
common



**Many of the species that are unique to the largest sites are rare/ uncommon**

**Small sites full of very common species**

# Kingfisher point is important for a variety of animal




- Preserves habitat and uncommon/ rare species

Fort Collins Natural Areas Program offices from Kingfisher Point Natural Area, Karl Manderbach

Grasshopper behavior

**Measure:**

- Ambient temp
- Ground temp
- Body temp