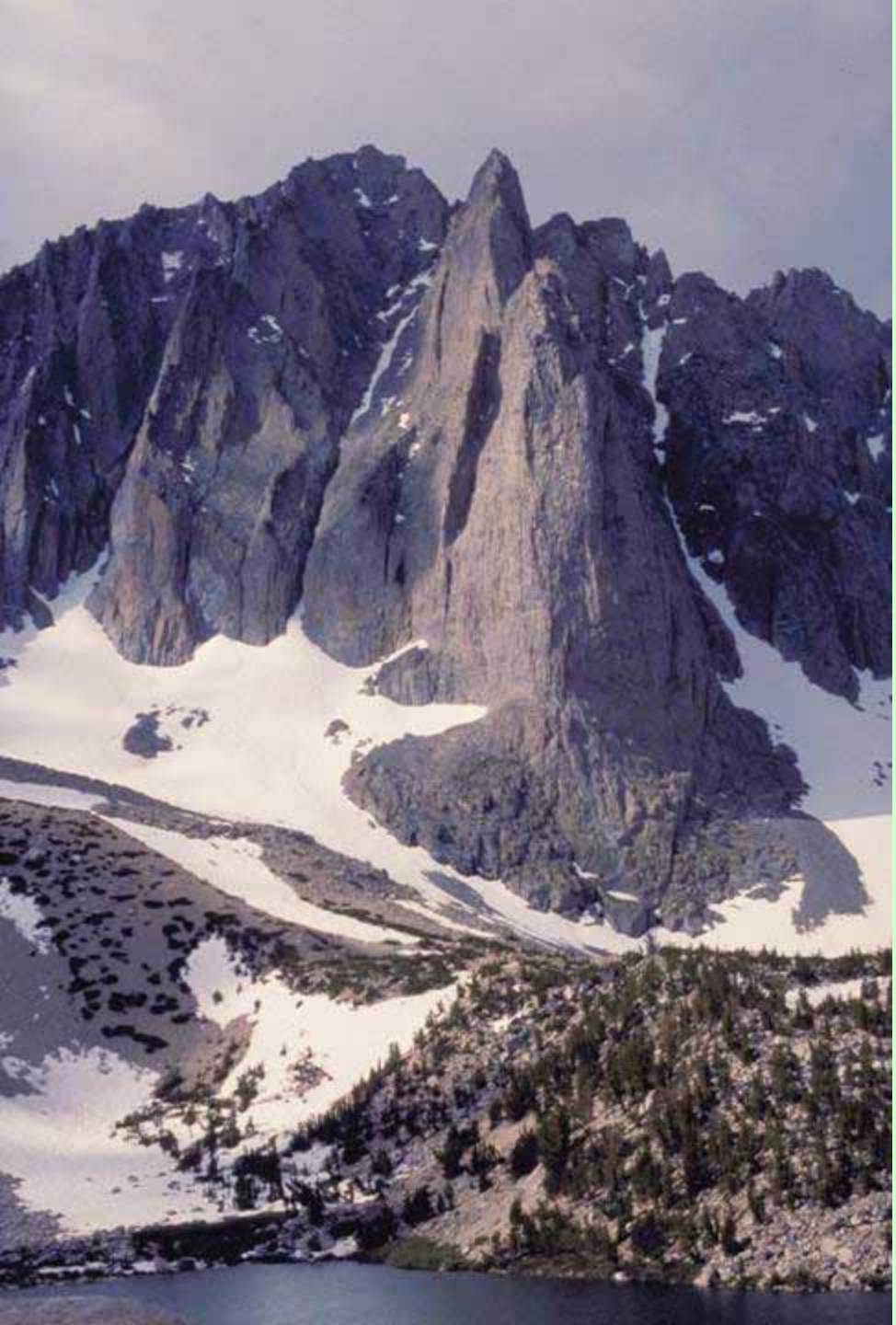


Climate-induced Elevation Shifts in a Sierra Nevada Food Web: How Do the Predators Respond?

John Smiley[1], Elizabeth Dahlhoff[2], and Nathan Rank[3]

[1]University of California White Mountain Research Station

[2]Santa Clara University

[3]Sonoma State University

Temple Crag, Big Pine Creek


Willow Leaf Beetle
second stage larva

Chemical defense

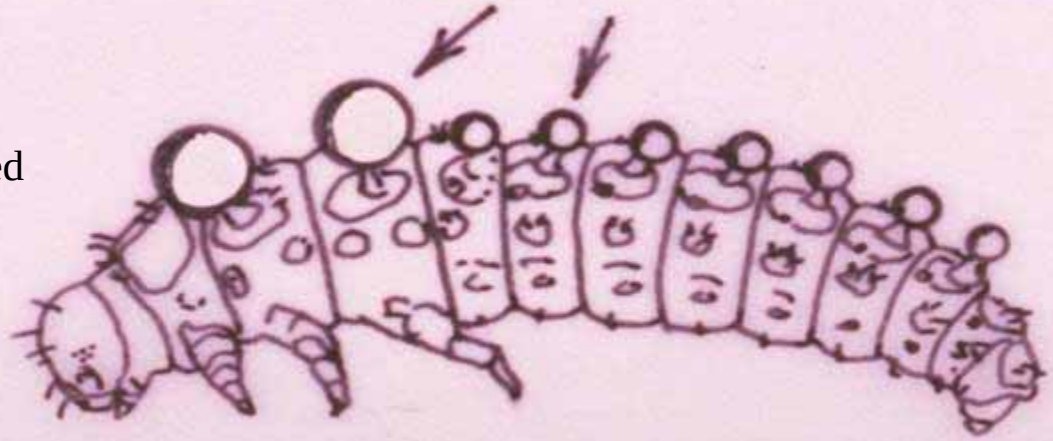
at rest

prodding

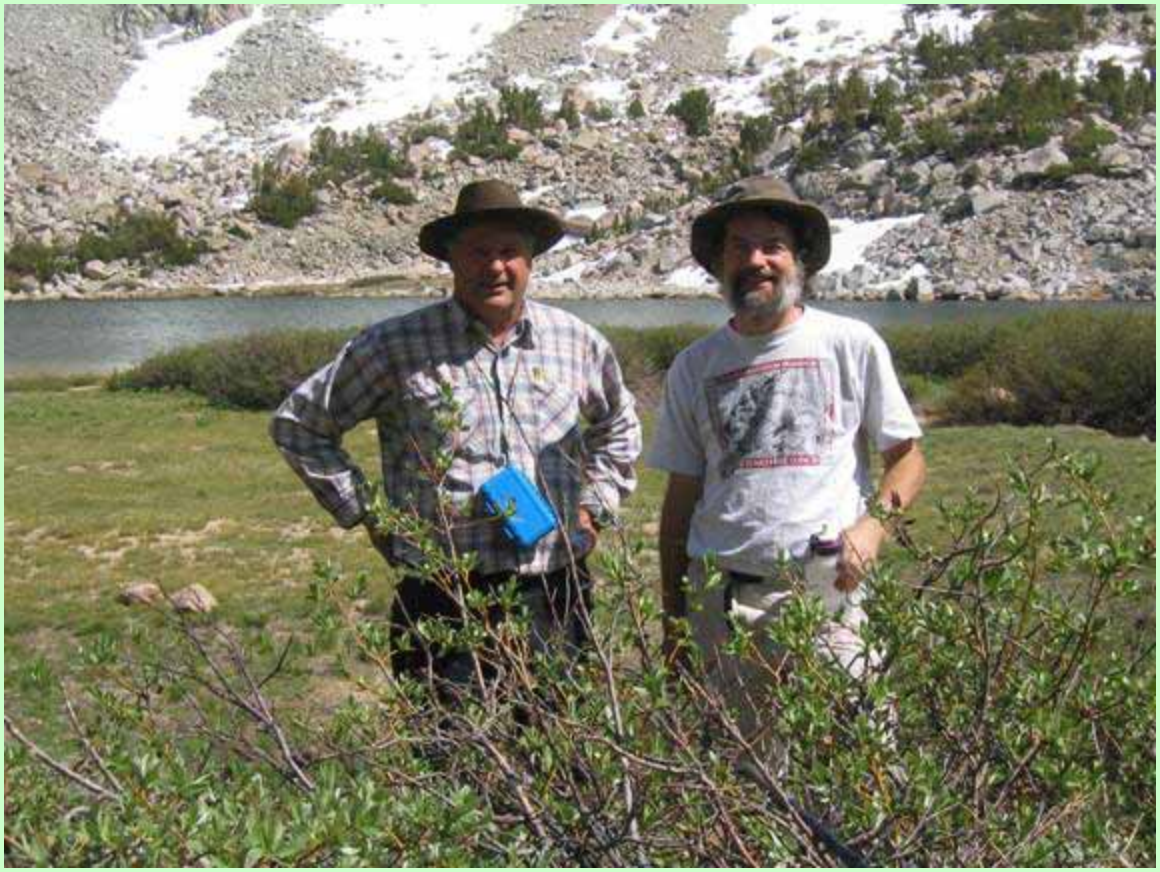
Glands retracted

Secretion droplets (essential oils such as salicylaldehayde and benzaldehyde)

Glands everted




third stage larva and pupae



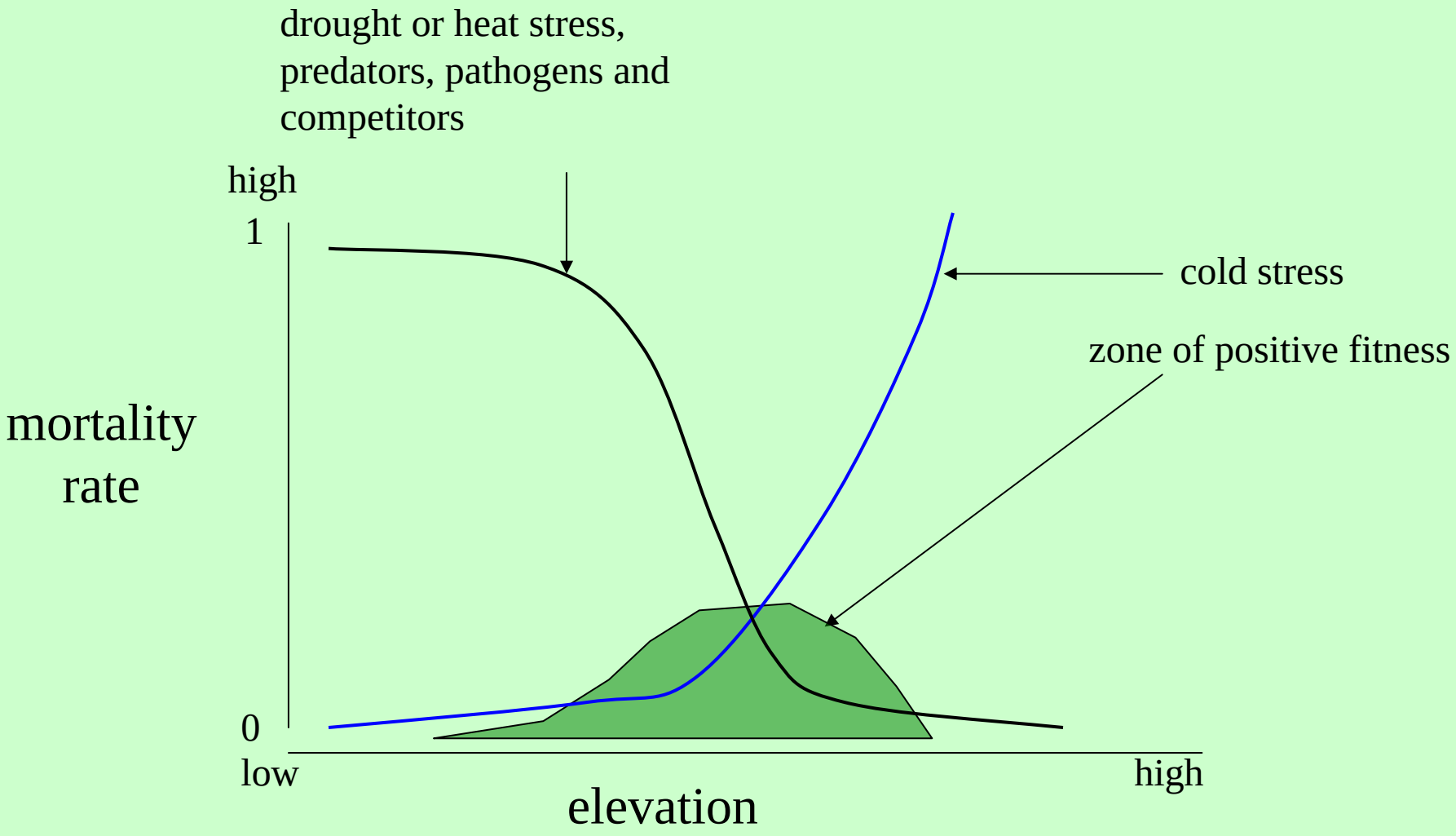
John Smiley and Nathan Rank at Upper Tyee Lake in Bishop Creek drainage

“team beetle”

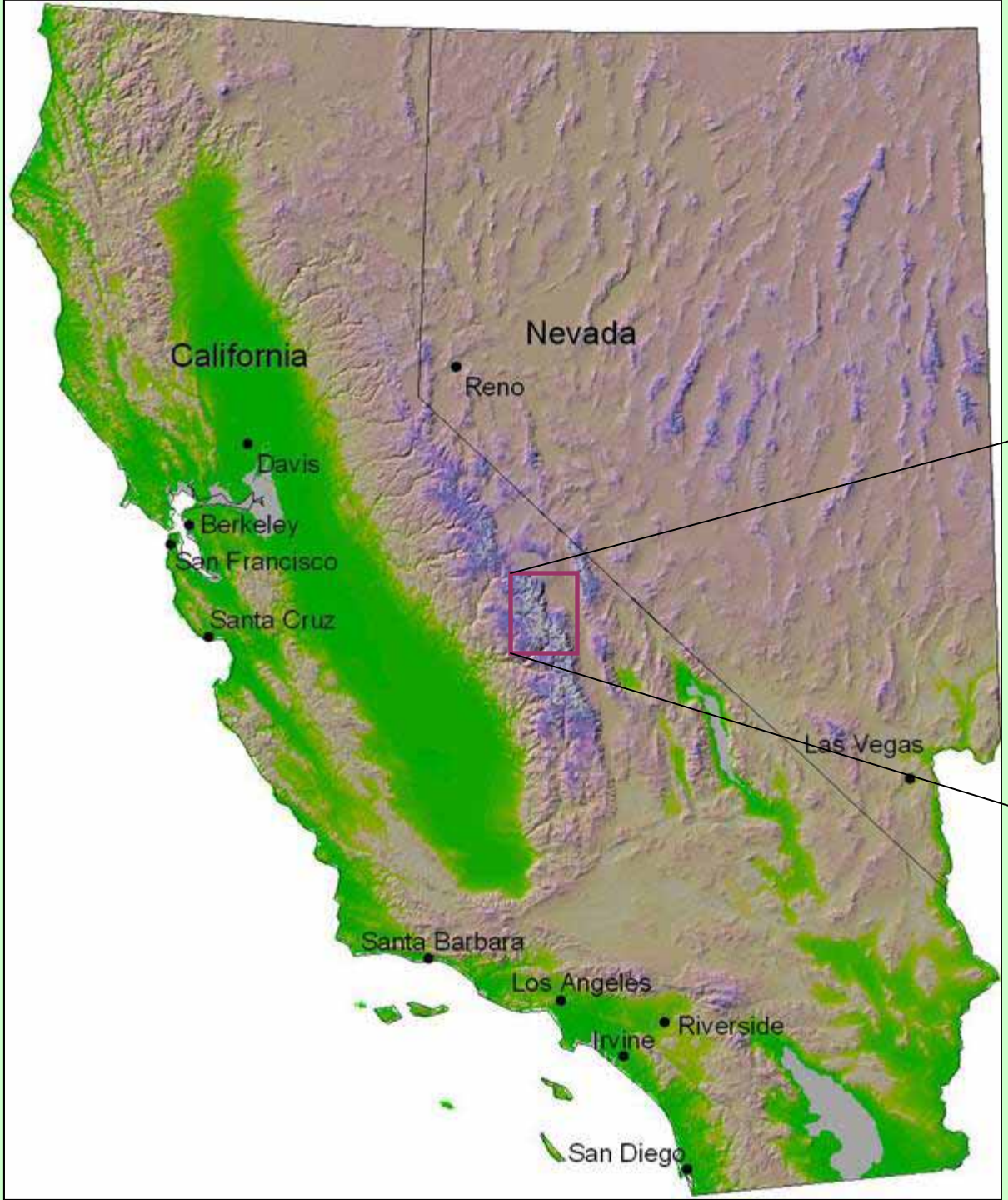
Work supported by: National Science Foundation and our respective institutions

Elizabeth Dahlhoff

Montane-alpine elevation gradients are often asymmetrical with respect to plant and animal fitness:

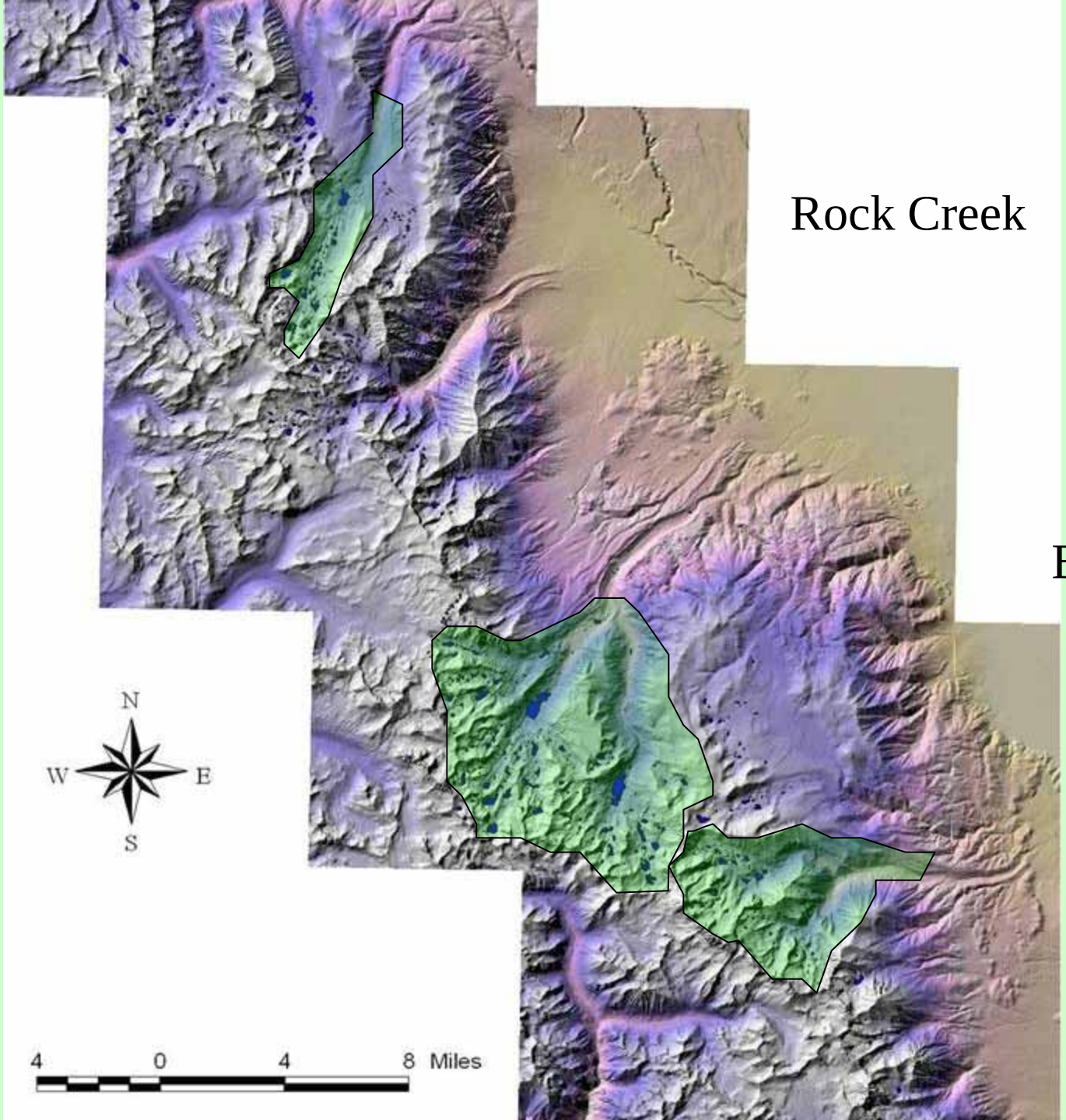


- History of “Beetle Project”
- Beetle Range Changes since 1981
- Willow Foliage Air Temperatures and Snow Cover in E. Sierra Drainages
- Predatory Insect Range Changes
- Wasp Behavioral Ecology During Extinction and Colonization of New Sites



Central-eastern Sierra Nevada

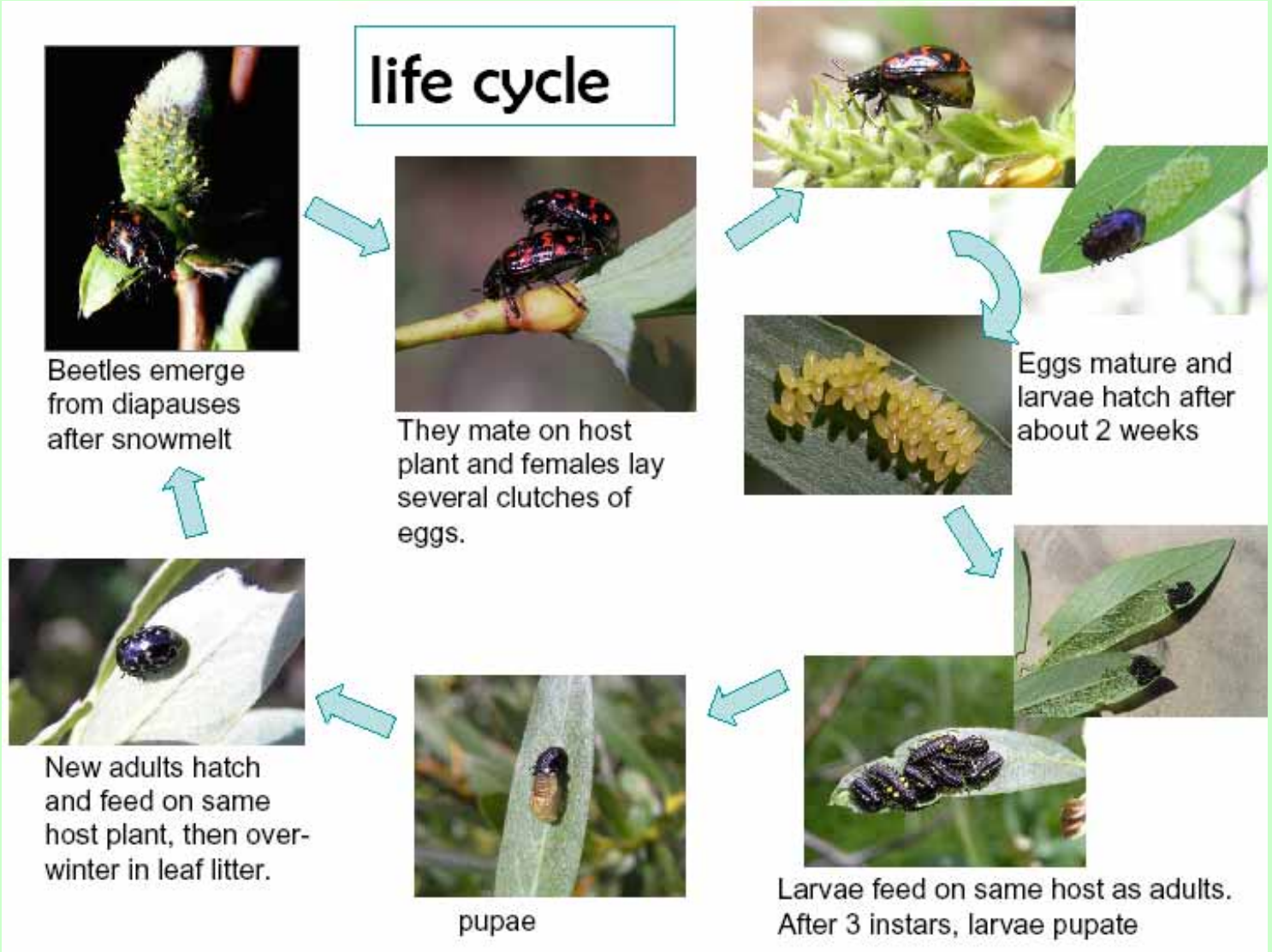
Base of Operations:
White Mountain Research Station
Owens Valley Laboratories

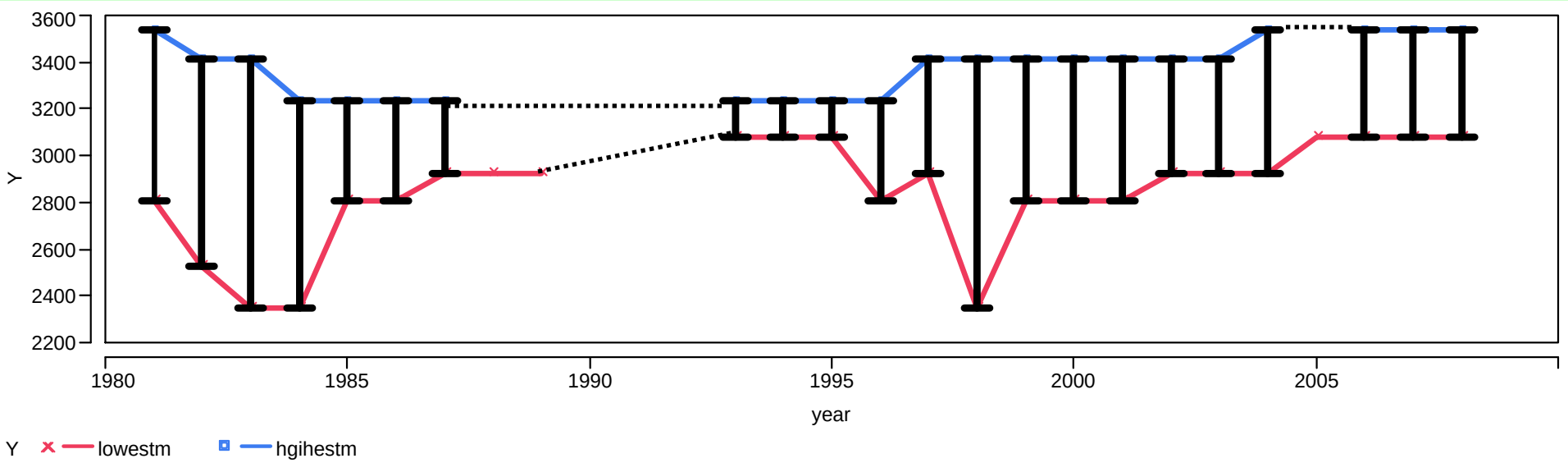

Rock Creek
Bishop Creek
Big Pine Creek
N
W
E
S
4 0 4 8 Miles

We have studied a willow-insect food chain since 1981.

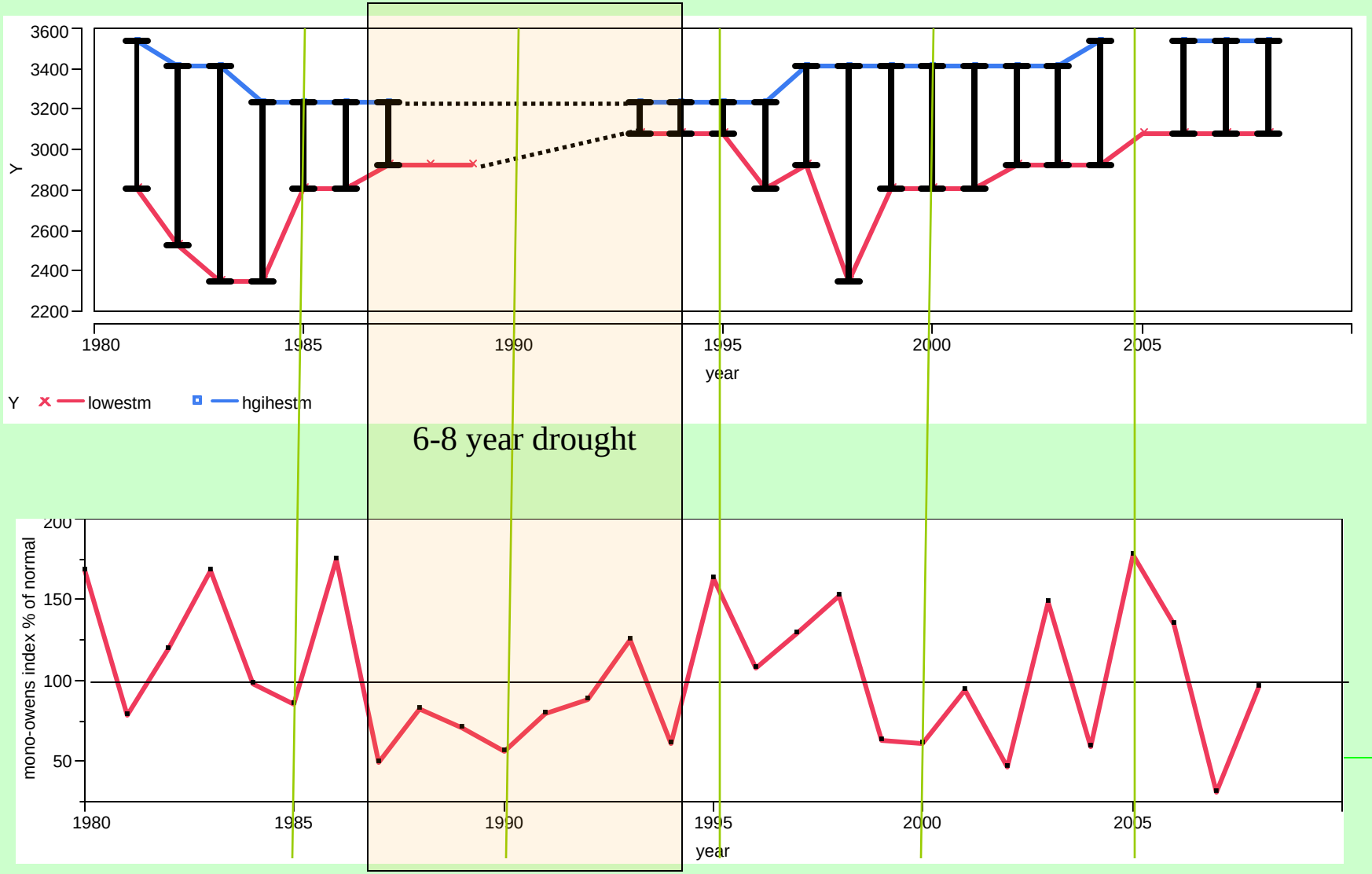
Salix orestera Sierra Willow

Willow Leaf Beetle *Chrysomela aeneicollis*

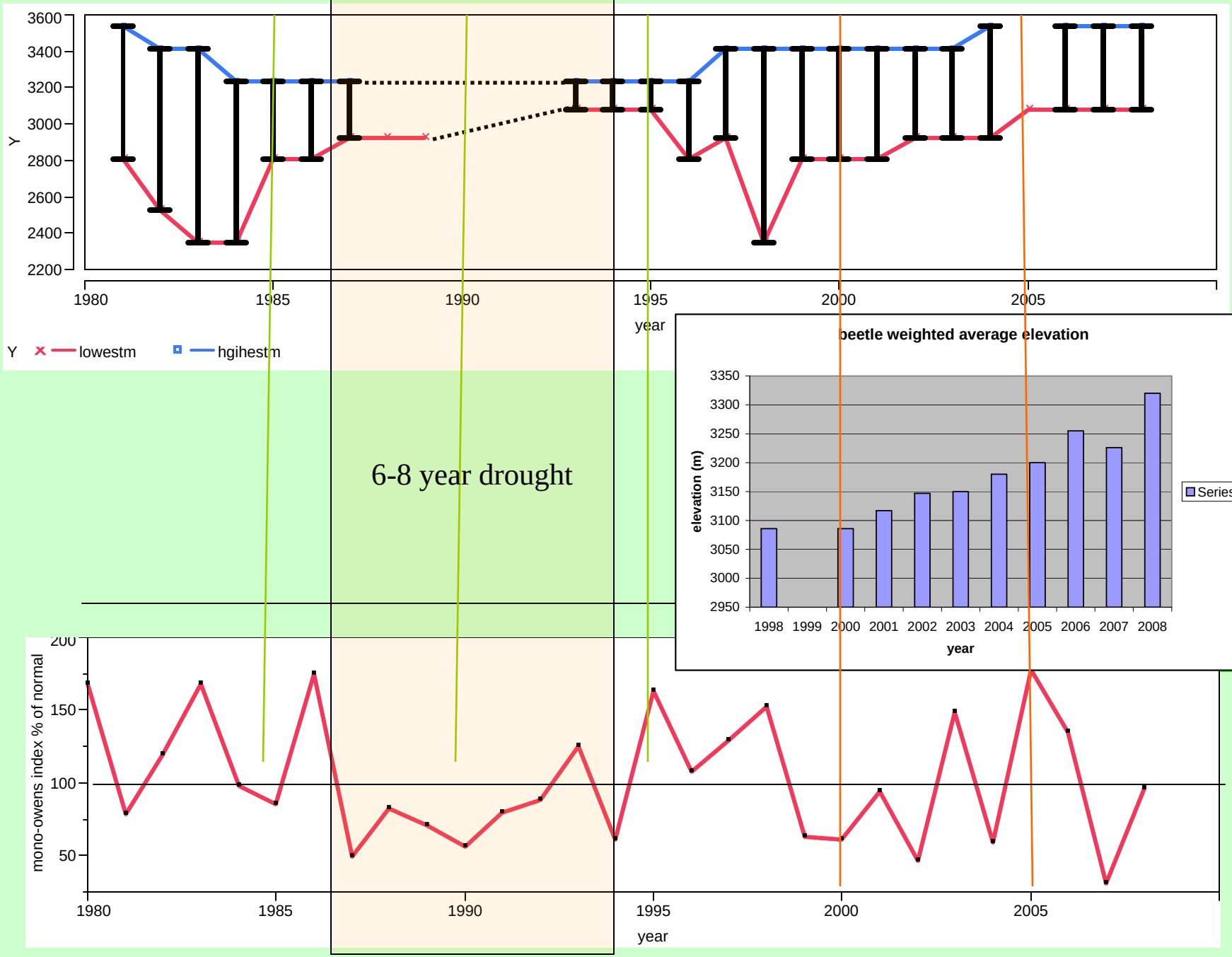




C. aeneicollis elevational range:
Long term record from Big Pine Creek
Are there decadal trends?: yes!



C. aeneicollis elevational range and winter snow % of normal:
Long term record from Big Pine Creek & Owens Valley region


3600
3400
3200
3000
2800
2600
2400
2200
Y
1980
1985
1990
1995
2000
2005
year
Y
lowestm
hgihestm
6-8 year drought
beetle weighted average elevation
3350
3300
3250
3200
3150
3100
3050
3000
2950
elevation (m)
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
year
Series1
200
150
100
50
mono-owens index % of normal
1980
1985
1990
1995
2000
2005
year

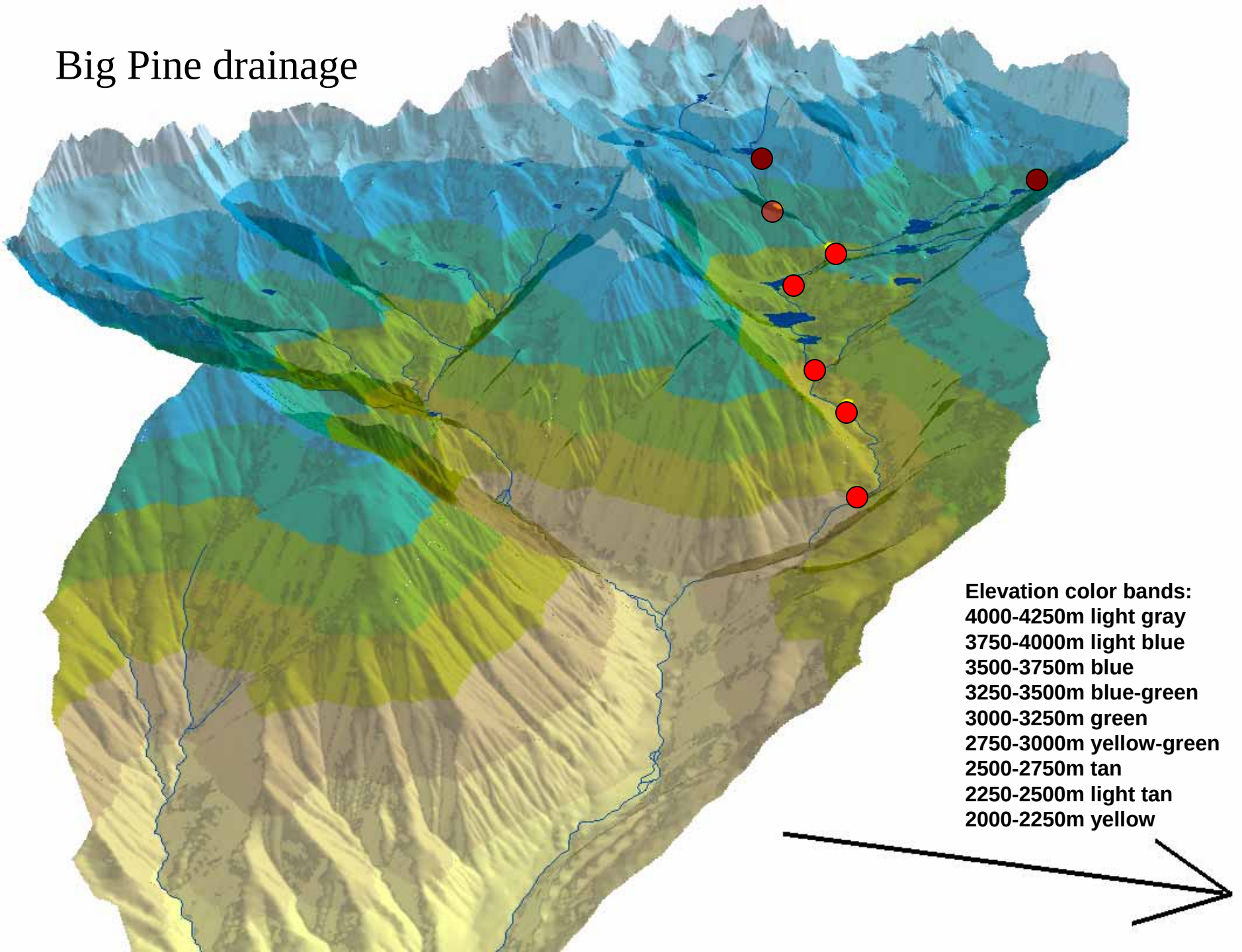
Willow Foliage Air Temperature Survey

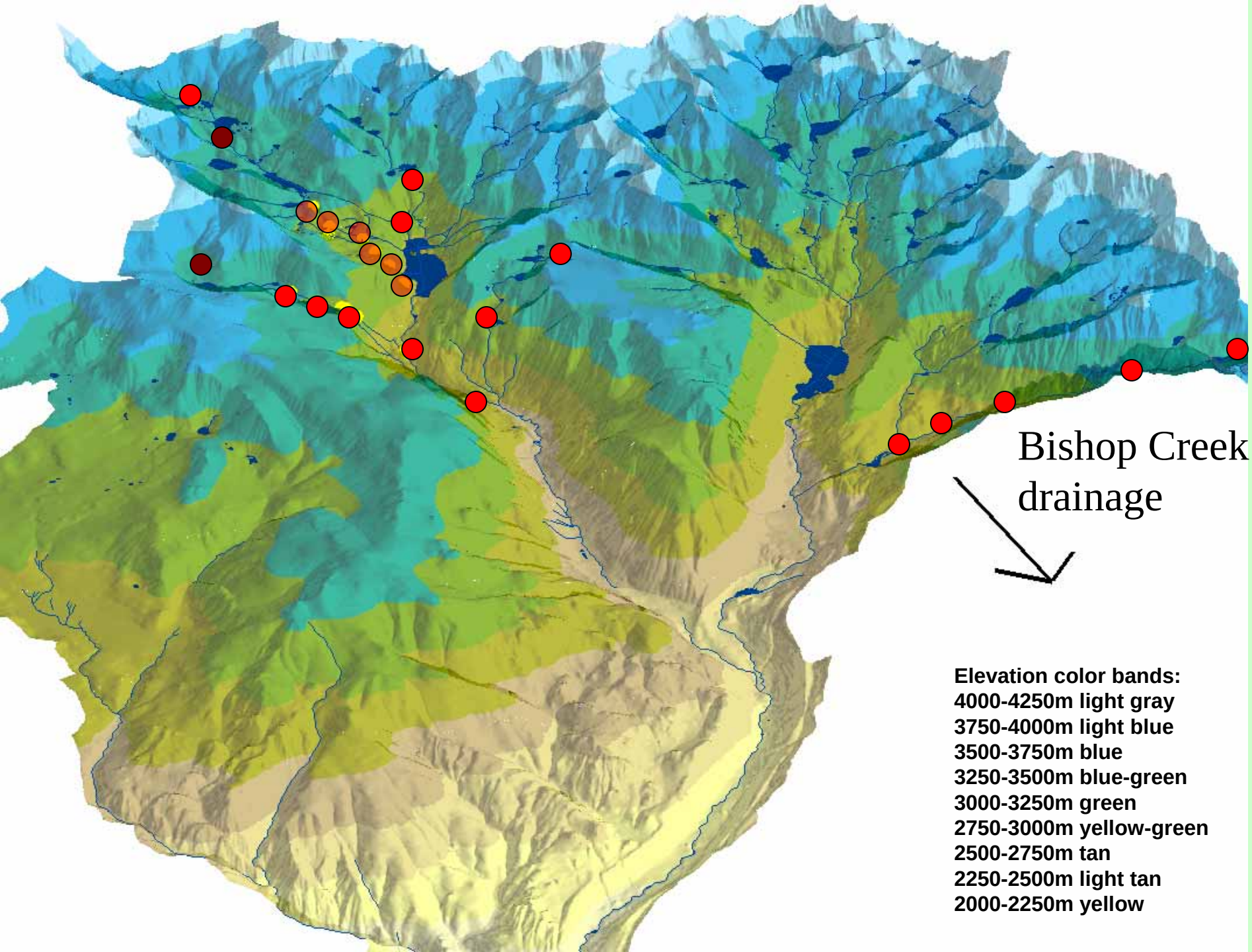
- Air temps recorded every 30 min. year round
- 21 “core” sites recorded since summer 2000 (9 years)
- Now 34 sites, including treeline and above in 8 drainages
- Full data set in “Hoboware” format
- Filtered and cleaned set in filemaker database: daily max, min, and average ~70k records

White plastic cups were used as radiation shields, hung upside down from 1-2 cm diameter willow branch, with HOBO “pendant” temperature logger suspended inside.

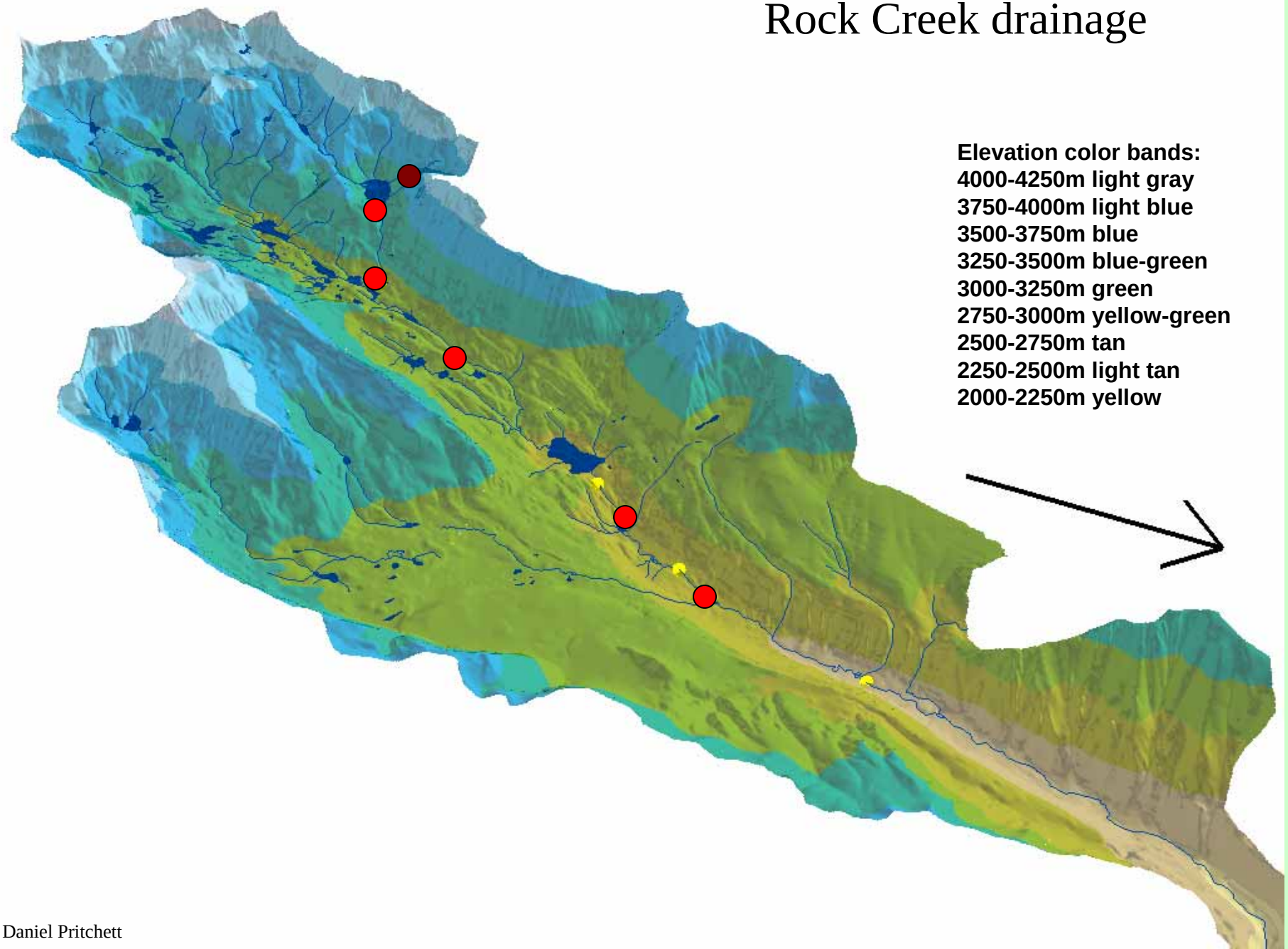
Shown: *S. orestera* above Green Lake, elev. 3410m (11,200’)

Big Pine drainage



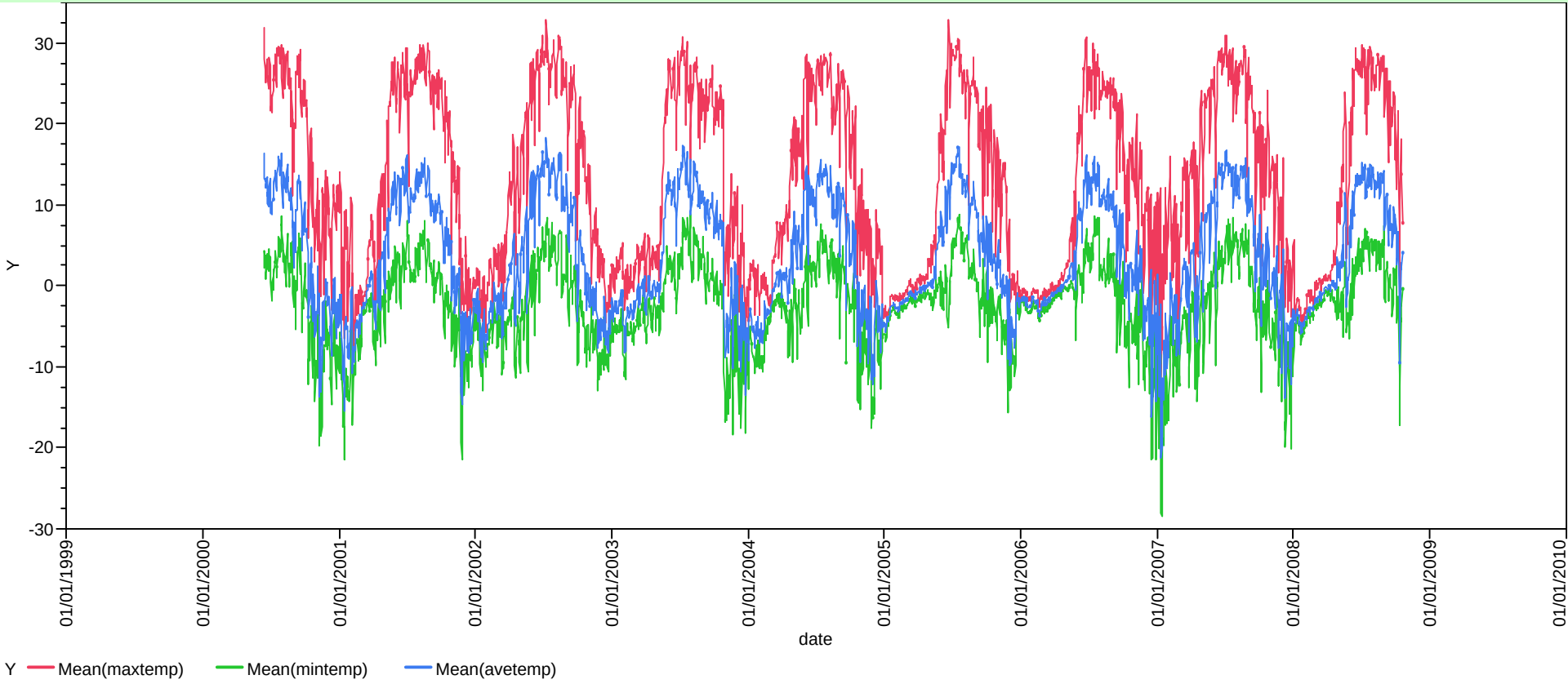

Bishop Creek
drainage
Elevation color bands:
4000-4250m light gray
3750-4000m light blue
3500-3750m blue
3250-3500m blue-green
3000-3250m green
2750-3000m yellow-green
2500-2750m tan
2250-2500m light tan
2000-2250m yellow

Rock Creek drainage



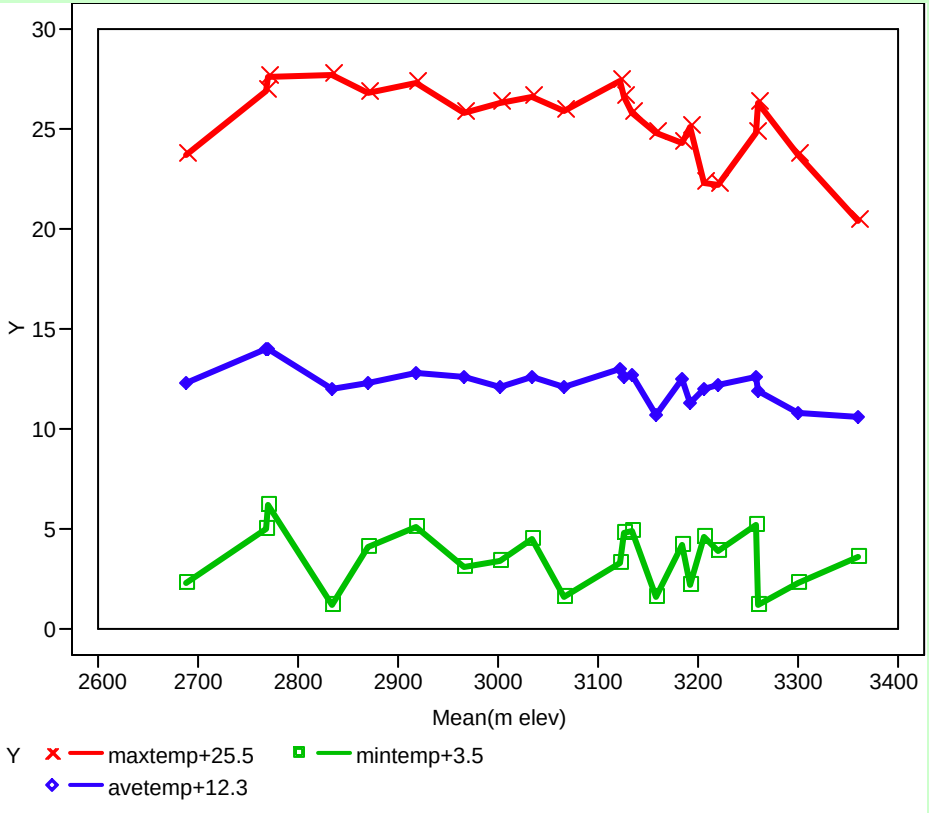
Elevation color bands:
4000-4250m light gray
3750-4000m light blue
3500-3750m blue
3250-3500m blue-green
3000-3250m green
2750-3000m yellow-green
2500-2750m tan
2250-2500m light tan
2000-2250m yellow

Daniel Pritchett



Foliage air temperatures, averaged over 18 “core” sites (= daily “weather”). Note snow burial periods in spring, and late snow years in ’05, ’06, and ’08.

Foliage air temperature, all sites, summer only:

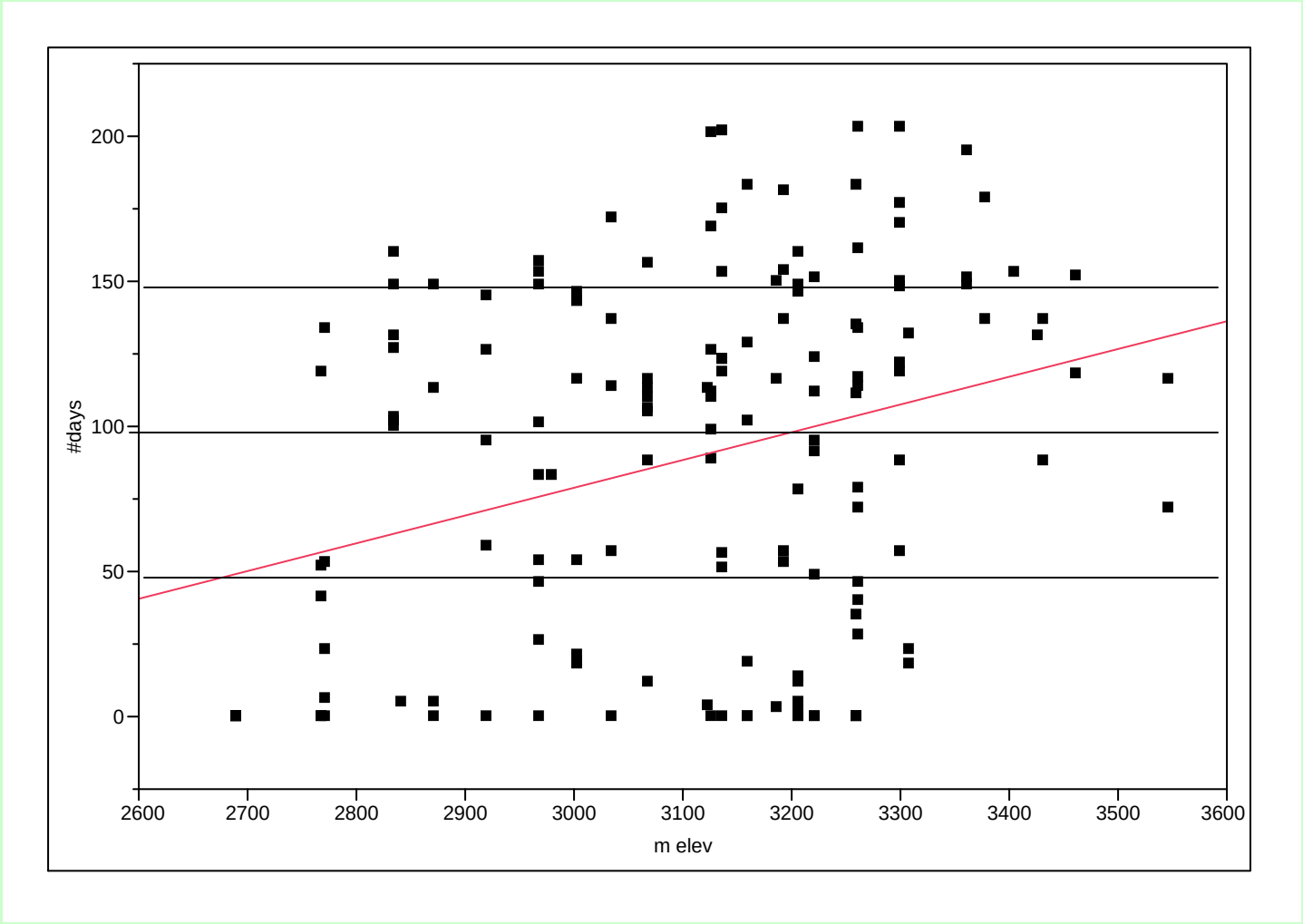


daily maximum lapse rate = 5.8 °C/km elev.

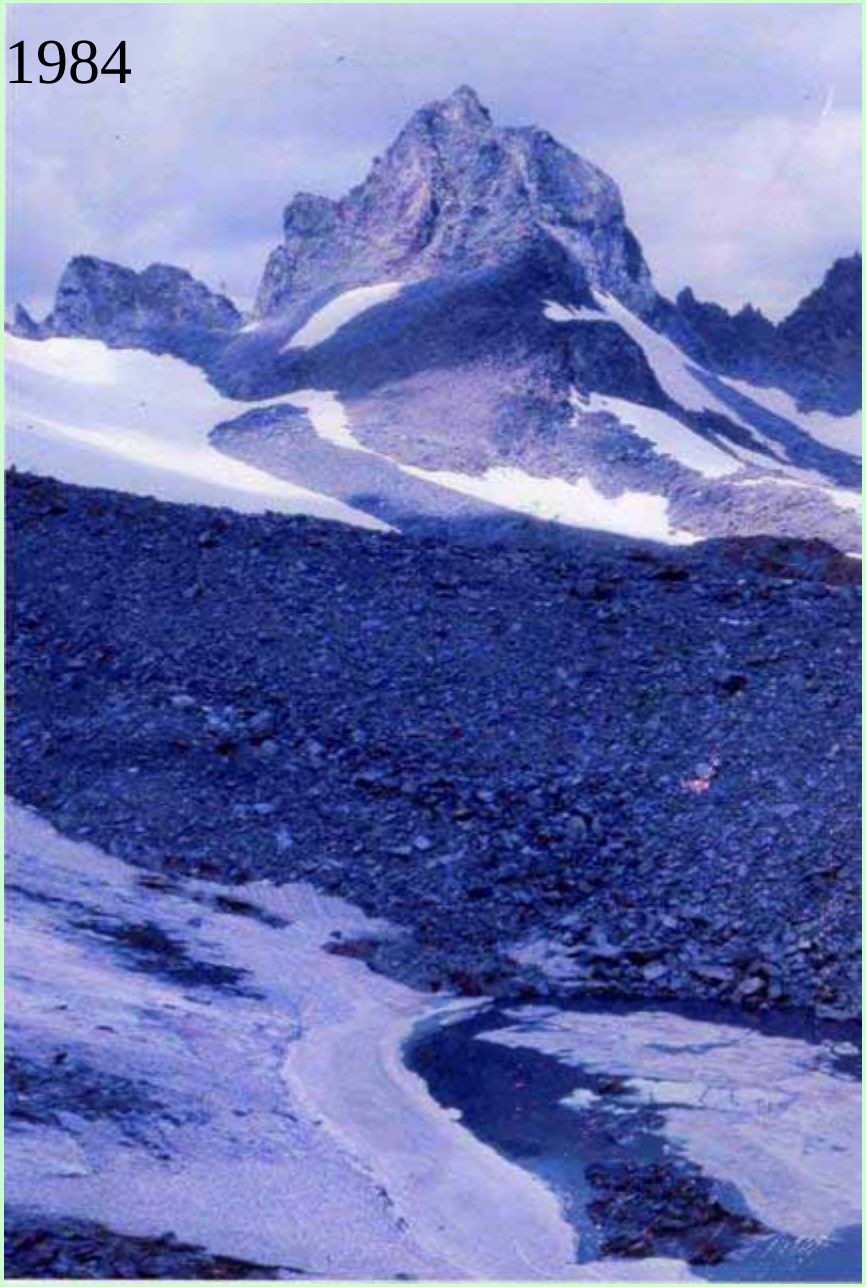
daily average lapse rate = 2.8 °C/km elev.

daily minimum lapse rate = n.s.

#Days logger is buried under snow, as function of elevation

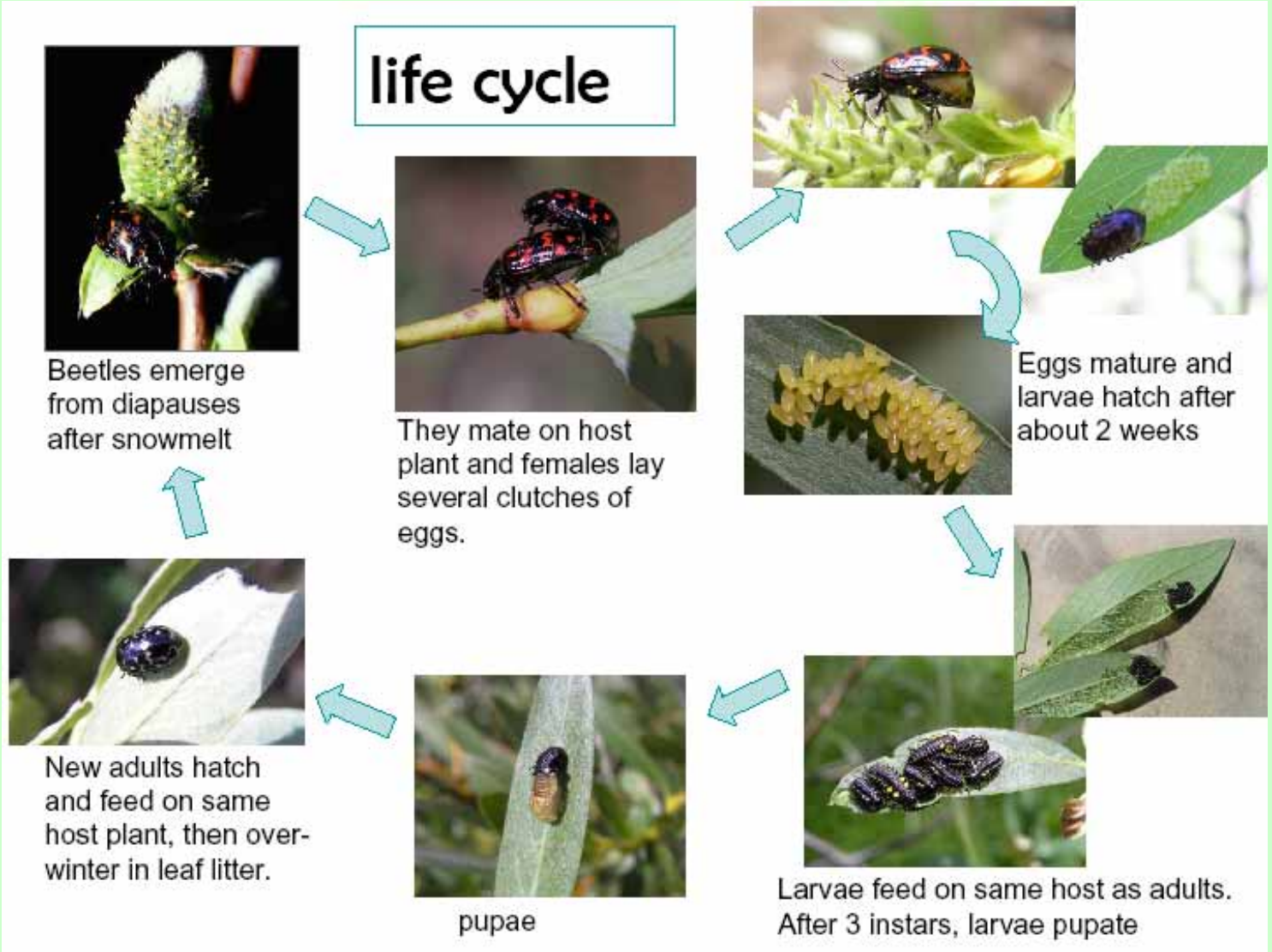


Slope ~ 10 days for each 100m elevation



North Palisades Glacier

Willow Leaf Beetle *Chrysomela aeneicollis*



wasp: *Symmorphus cristatus*
Hymenoptera: Vespidae

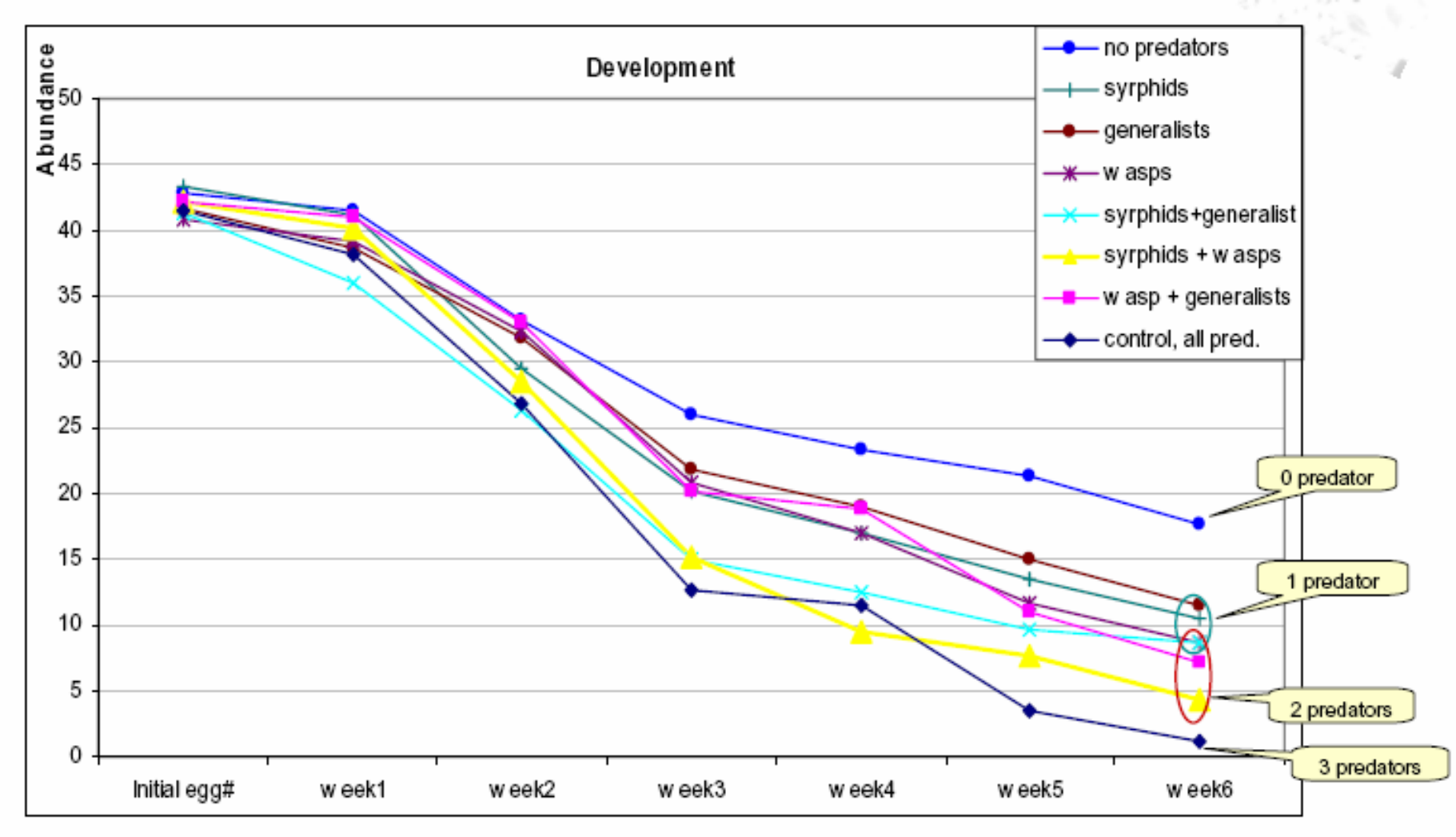
beetle: *Chrysomela aeneicollis*
Coleoptera: Chrysomelidae

Ants: *Formica* sp.
Hymenoptera: Formicidae

fly larva: *Parasyrphus melanderi*
Diptera: Syrphidae

Survivorship of Willow Leaf Beetle Eggs and Larvae: 8 Predator Exclusion Treatments[1]

Note: some mortality (not measured) probably caused by cannibalism



[1] Sonja Otto thesis project (2005), Darmstadt University, Germany

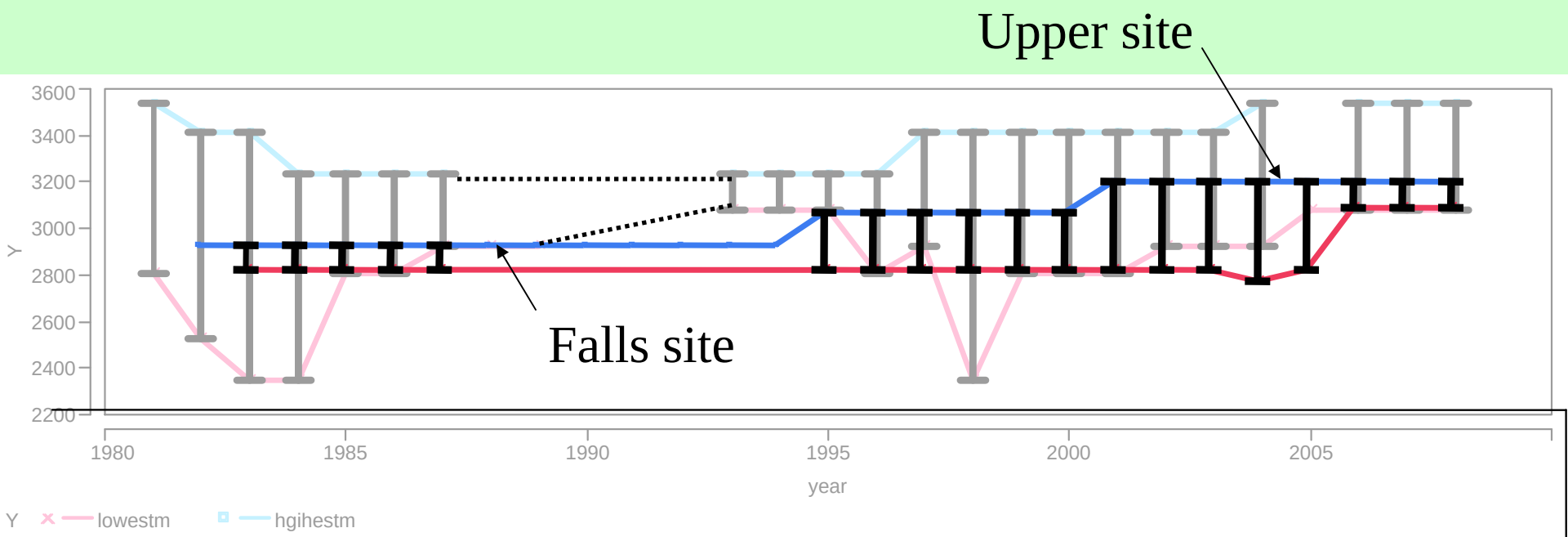
Hole-nesting wasp
Symmorphus cristatus
Hymenoptera: Eumenidae

Behavioral ecology of wasp: *Symmorphus cristatus* at Falls site, 2900m, Big Pine Creek. Key foraging season = July and early August

Lodgepole pine borer
Cerambycidae: Coleoptera
(tribe Lepturini)

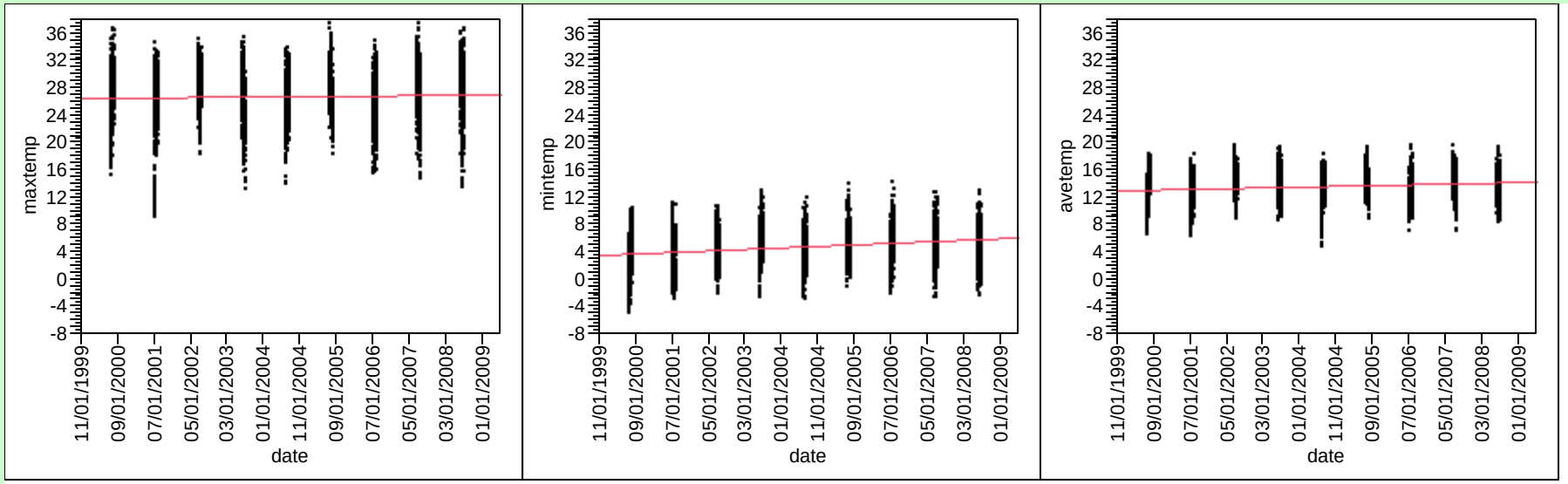
Cuckoo Wasp *Chrysis nitidula*
Hymenoptera: Chrysidae

Parasitic Bee-fly
Anthrax irrorata
Diptera: Bombiliidae



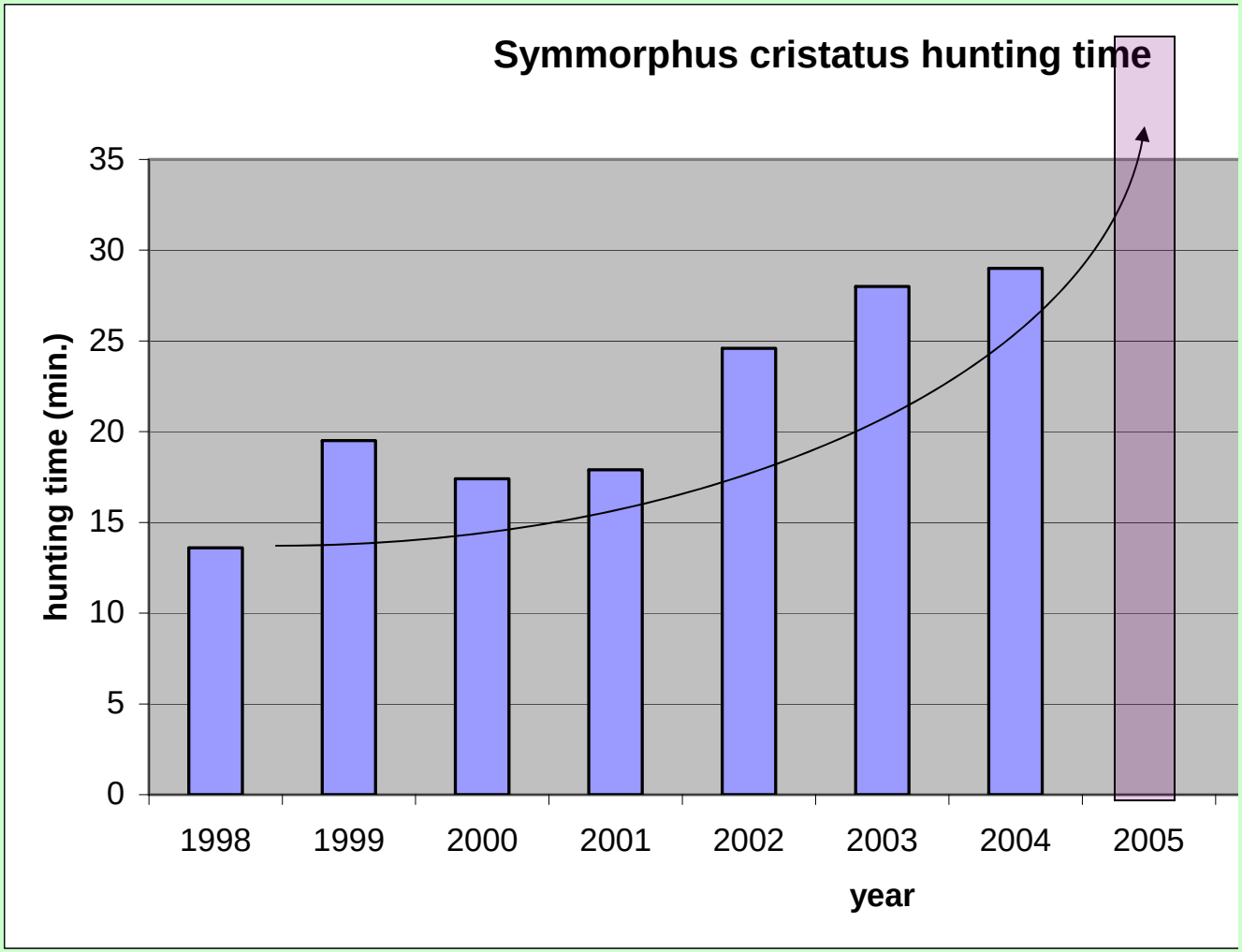
S. cristatus elevational range:
Long term record from Big Pine Creek
(note: prey most abundant along upper orange band)

July daily foliage air temperature records 2000-2008, core sites only



Max Min Ave

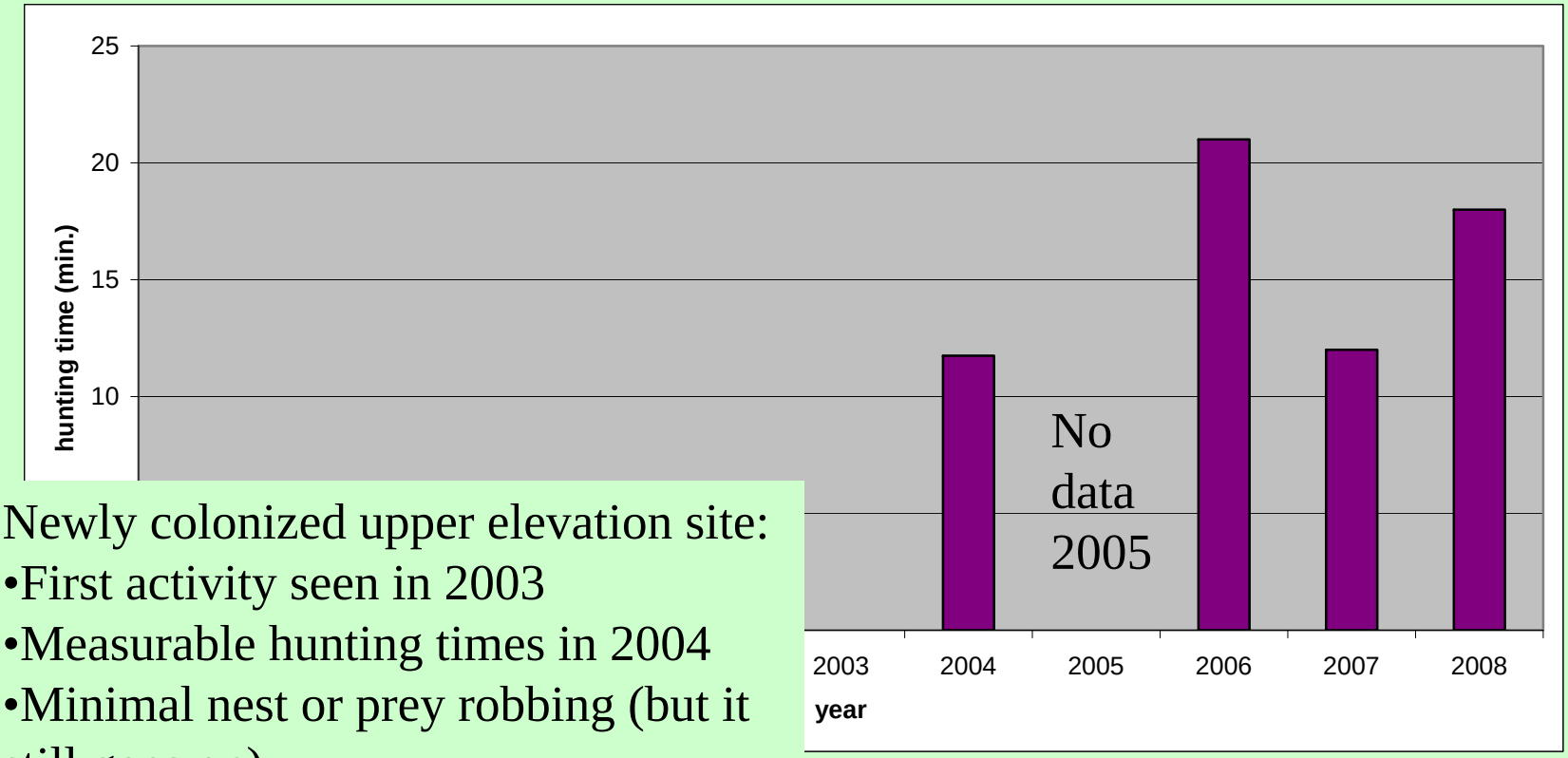
Falls site (2970m): wasps failed in 2006



2003-2005

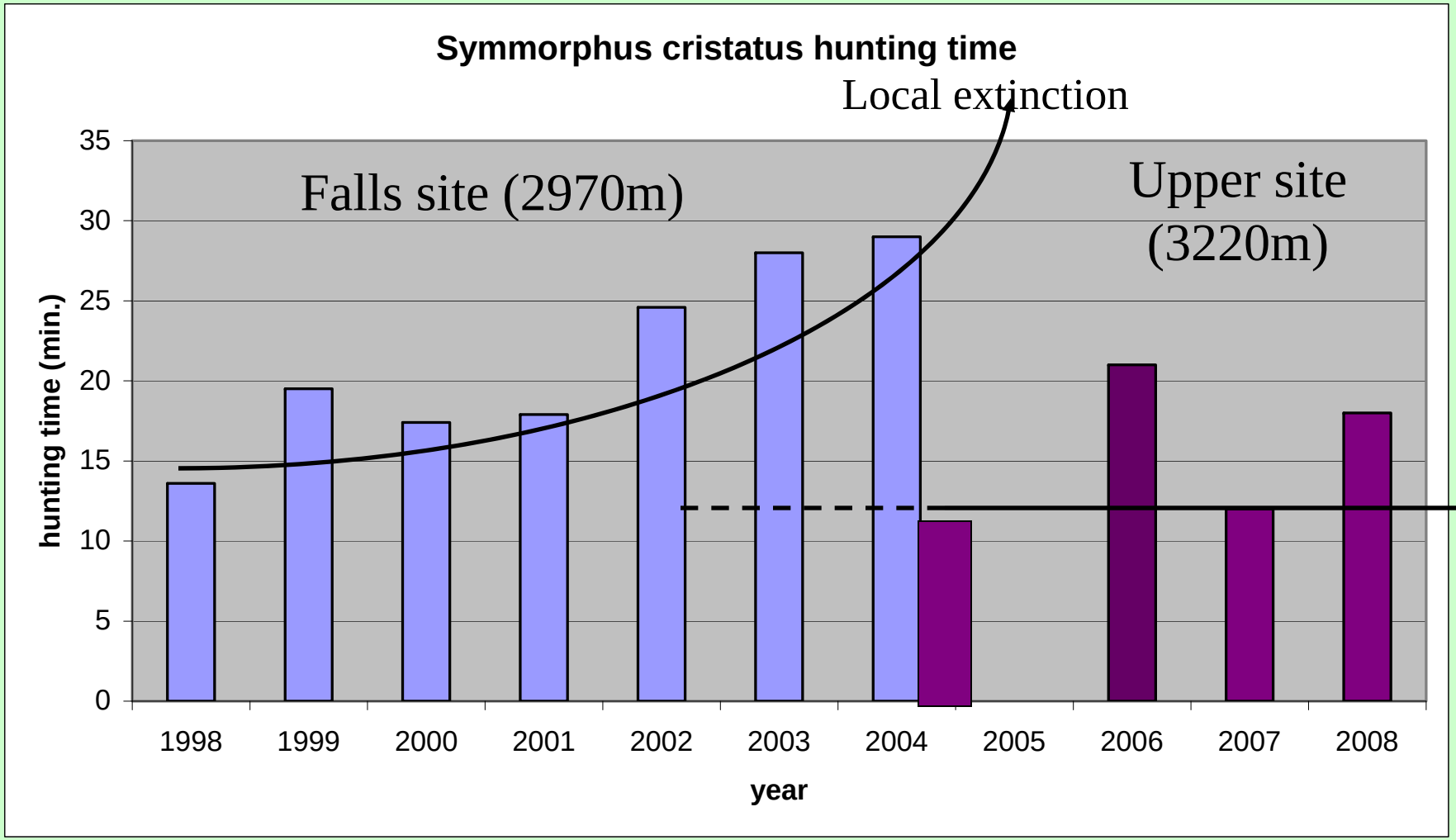
- Longer hunting times (too long to measure)
- More nest stealing.
- More prey stealing.
- Nest building efficiency unaffected, but fewer nests completed.
- Nests with fewer provisioned cells.
- More opportunities for hyperparasites such as Cuckoo Wasp and *Anthrax* beefly

Upper site (3220 m); colonized in 2002-03

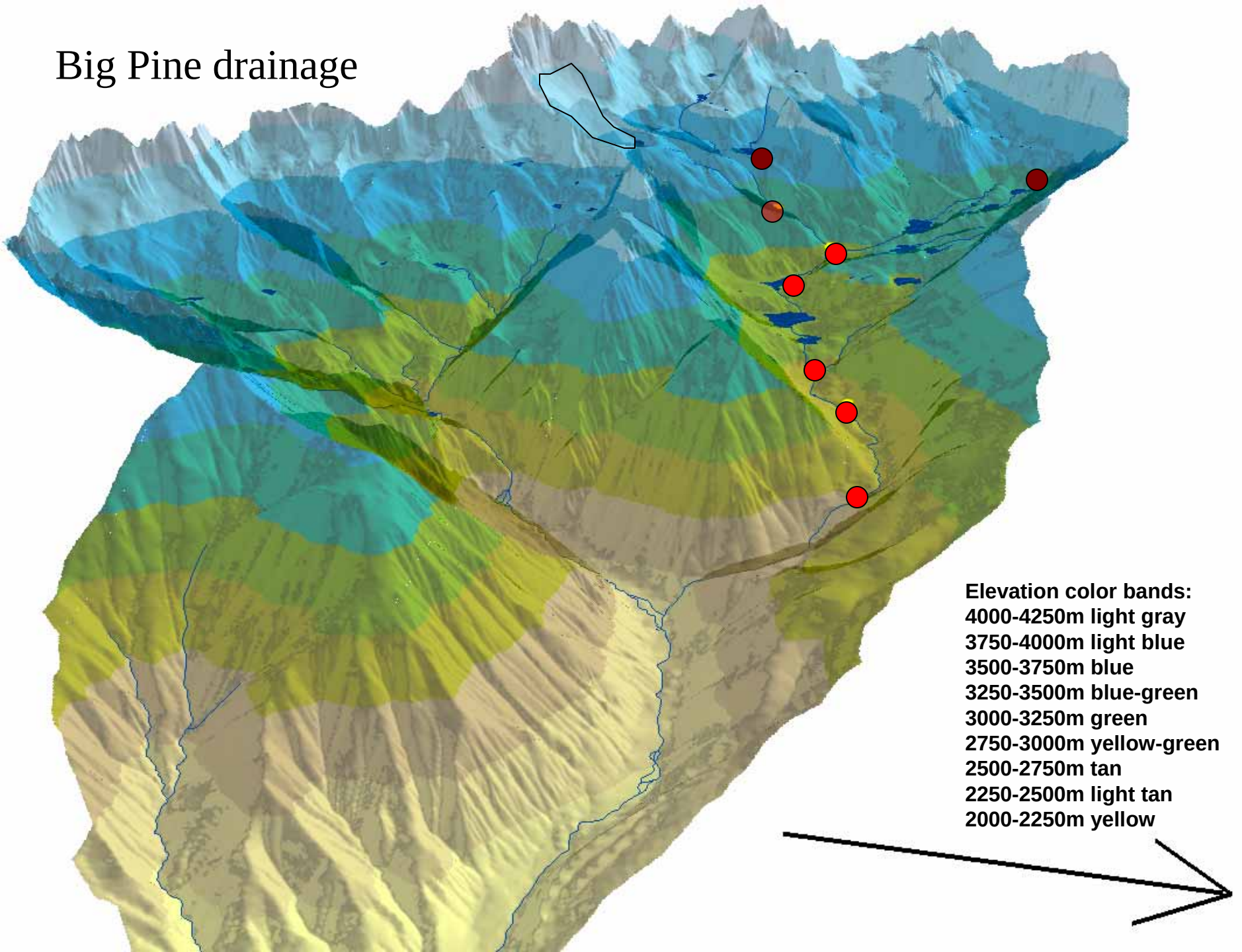


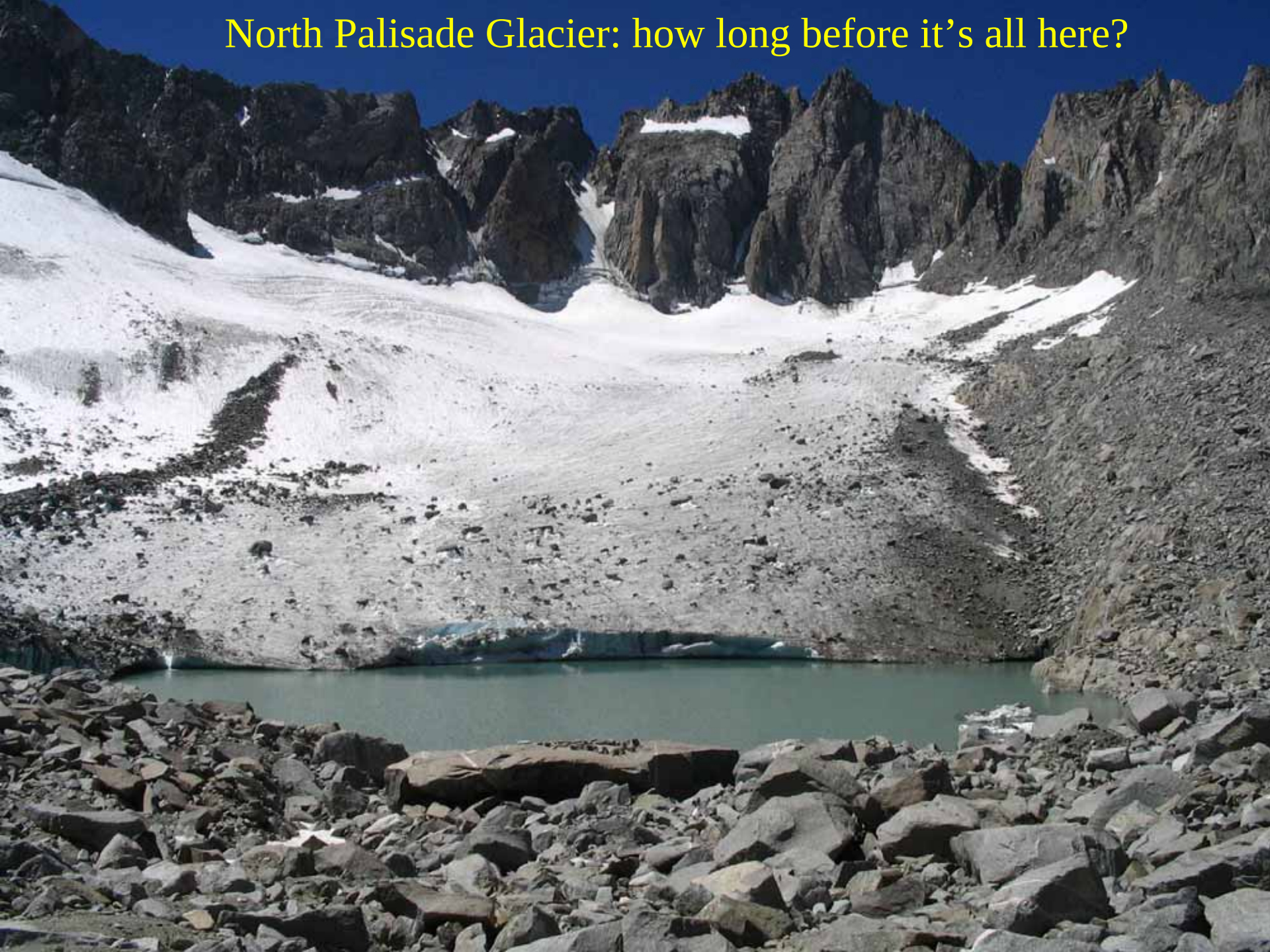
Newly colonized upper elevation site:

- First activity seen in 2003
- Measurable hunting times in 2004
- Minimal nest or prey robbing (but it still goes on)
- Cuckoo Wasps present, but *Anthrax* beeflies rare.
- Few nest holes, but boring beetles active in some logs.
- Nest building efficiency normal


Symmorphus cristatus hunting time
Local extinction
Falls site (2970m)
Upper site (3220m)
hunting time (min.)
0
5
10
15
20
25
30
35
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
year

Big Pine drainage




North Palisade Glacier: how long before it's all here?