

Treatment.

Pheromone Traps

↳ Attractant  
Chemicals

↓ Reduces tree damage

↓ Reduces POP size

Tree or stand scale. \$\$\$\$\$



Insecticide!

→ Sprayed on  
trees before  
bark beetles enter  
tree. \$\$\$



High ecological cost

Best to avoid!

Drought and B.B. vulnerability

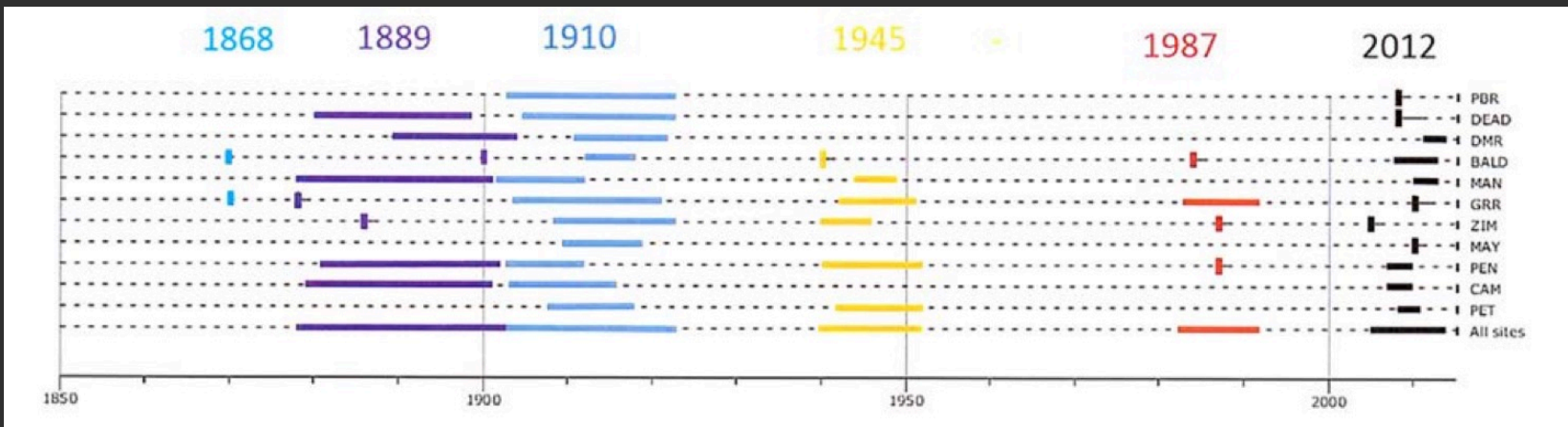
Phloem is made by photosynthesis:



Phloem has a high water cost...

1) Drought =  $\downarrow$  Phloem =  $\downarrow$  Resin response  
=  $\uparrow$  vulnerability to B.B.





Megadrought Wet Dry Wet  
 Nergren 2020

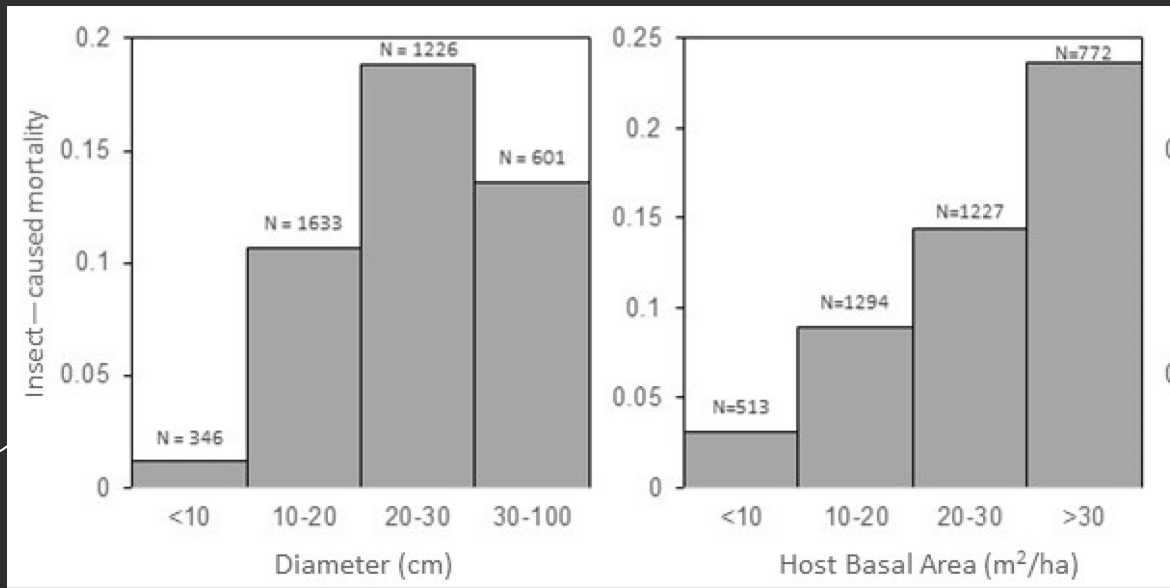
Larger trees  
have thicker  
phloem

→ Decreased  
growth in recent  
years =  $\uparrow$  likelihood  
to die from BB

Tree and stand traits that favor BB outbreaks

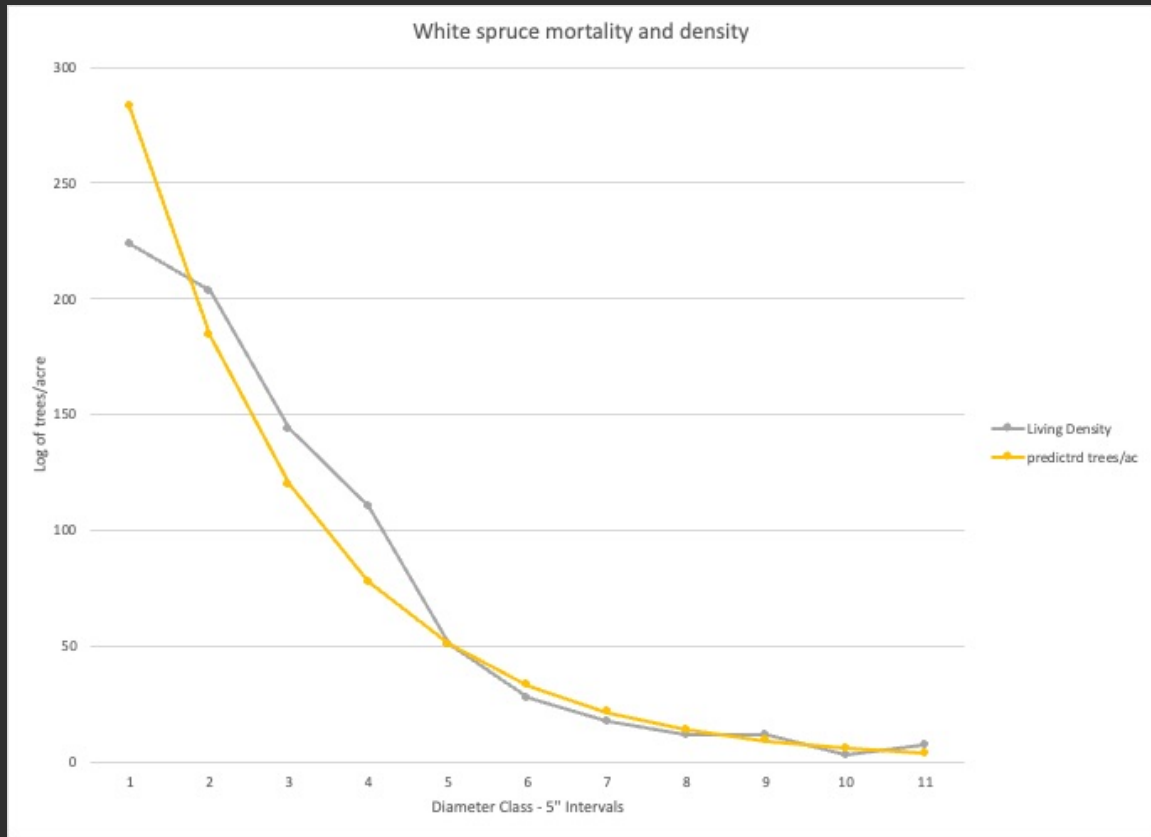
Stand level  $\uparrow$  host BA =  $\uparrow$  mortality

Silviculture!





Reverse-J  
Un even aged  
Stand



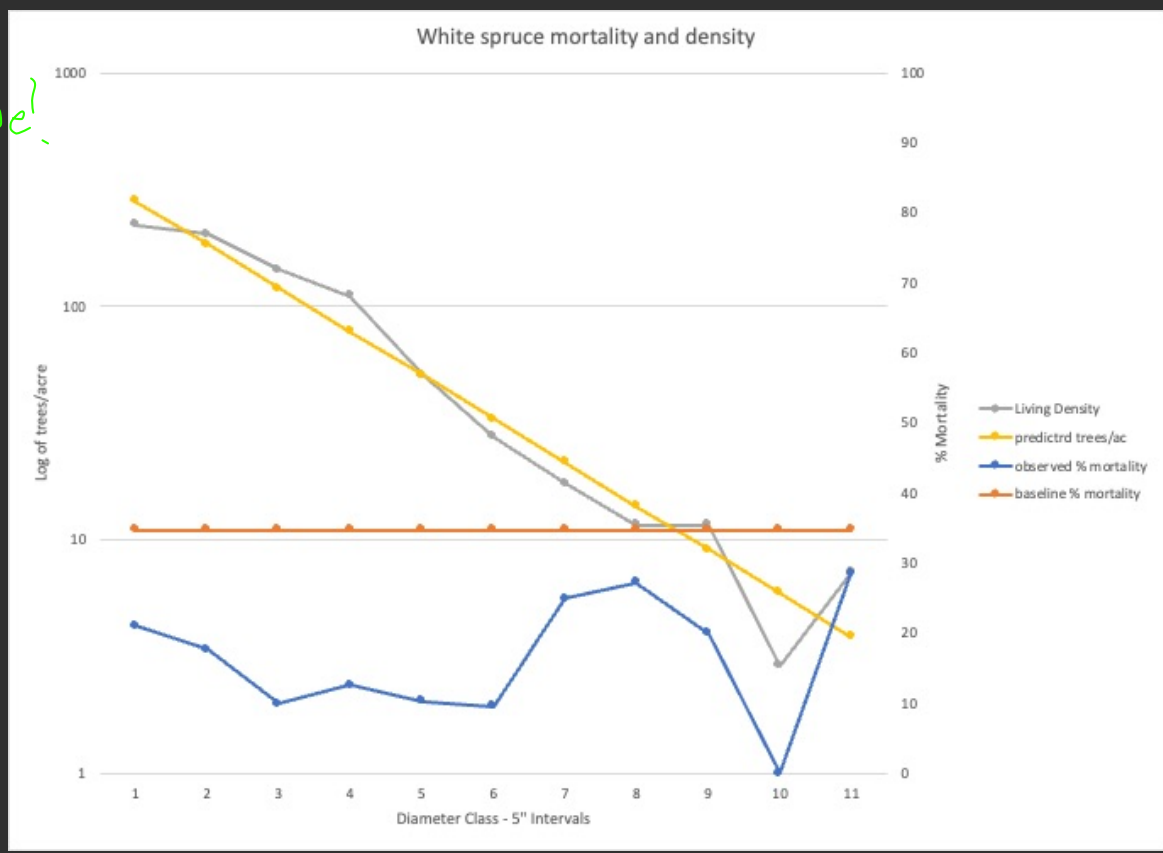
Obs mort < baseline!

= ↑ Density  
across all  
D-classes

= ↑ Beetle food

= Positive

density dependent  
out-break



This to bring  
obs mort to baseline



BB and  
Fire interactors



Green-infested

hard to ignite  
rapid spread

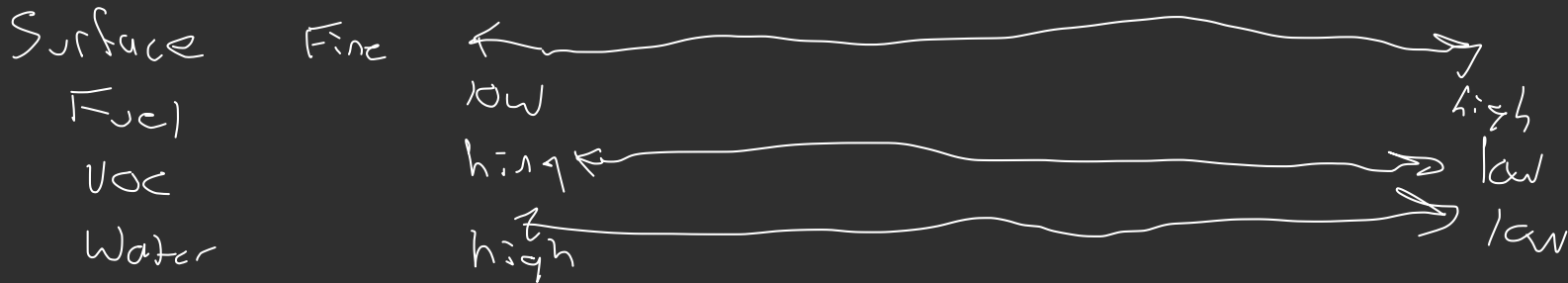
Yellow

Red

Gray

Bark Beetle Attack Phases

Easy to ignite  
high to spread





East Troublesome Fire 2020, Colorado



Beetle kill lodge pole

120,000 Acres in  
16 hours



Spruce Bud Worm

Adult

Larvae



UGA1441043

Lepidoptera

# Tests!



• Engelmann Spruce



• Blue Spruce



• Corkbark fir



• White fir



• Douglas fir

Late July



Adult Moths

- Flight and mating season

Late July

Adult Moths



Female Lays Eggs

- Lays 20-150 Eggs on underside of leaves

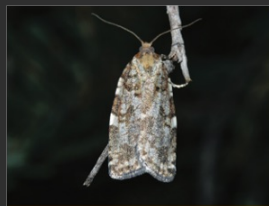
August





Late July

Adult Moths



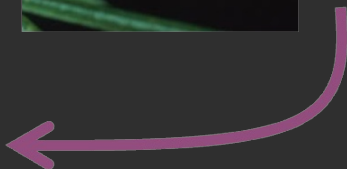
Female Lays Eggs



August

Eggs Hatch

- 1<sup>st</sup> Instar Emerges
- Does not feed
- Shelters under bark or lichen



Late July

Adult Moths



Female Lays Eggs



August

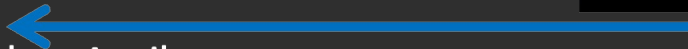
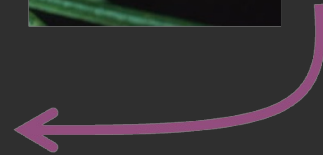
Eggs Hatch  
• 1<sup>st</sup> instar

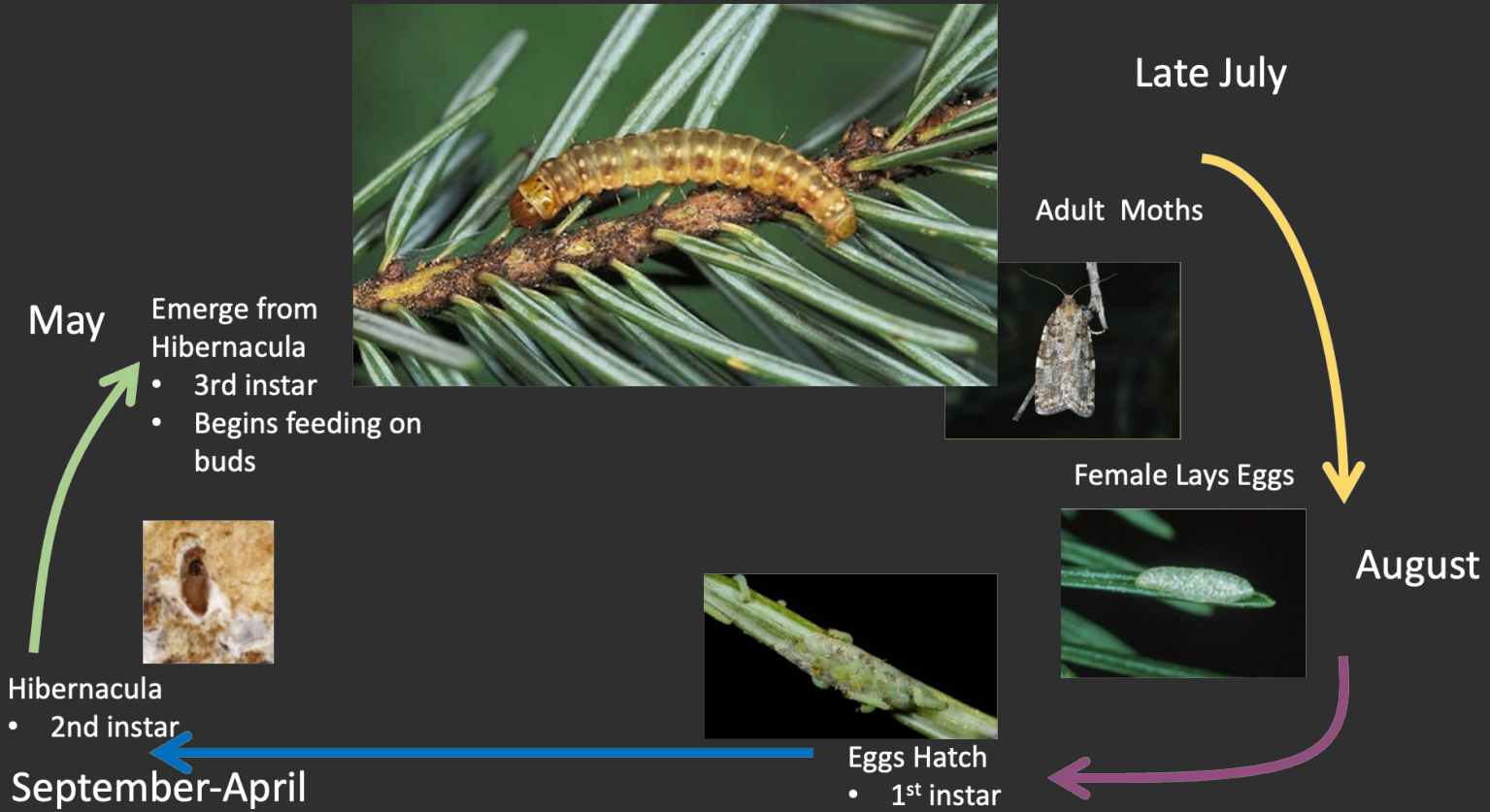


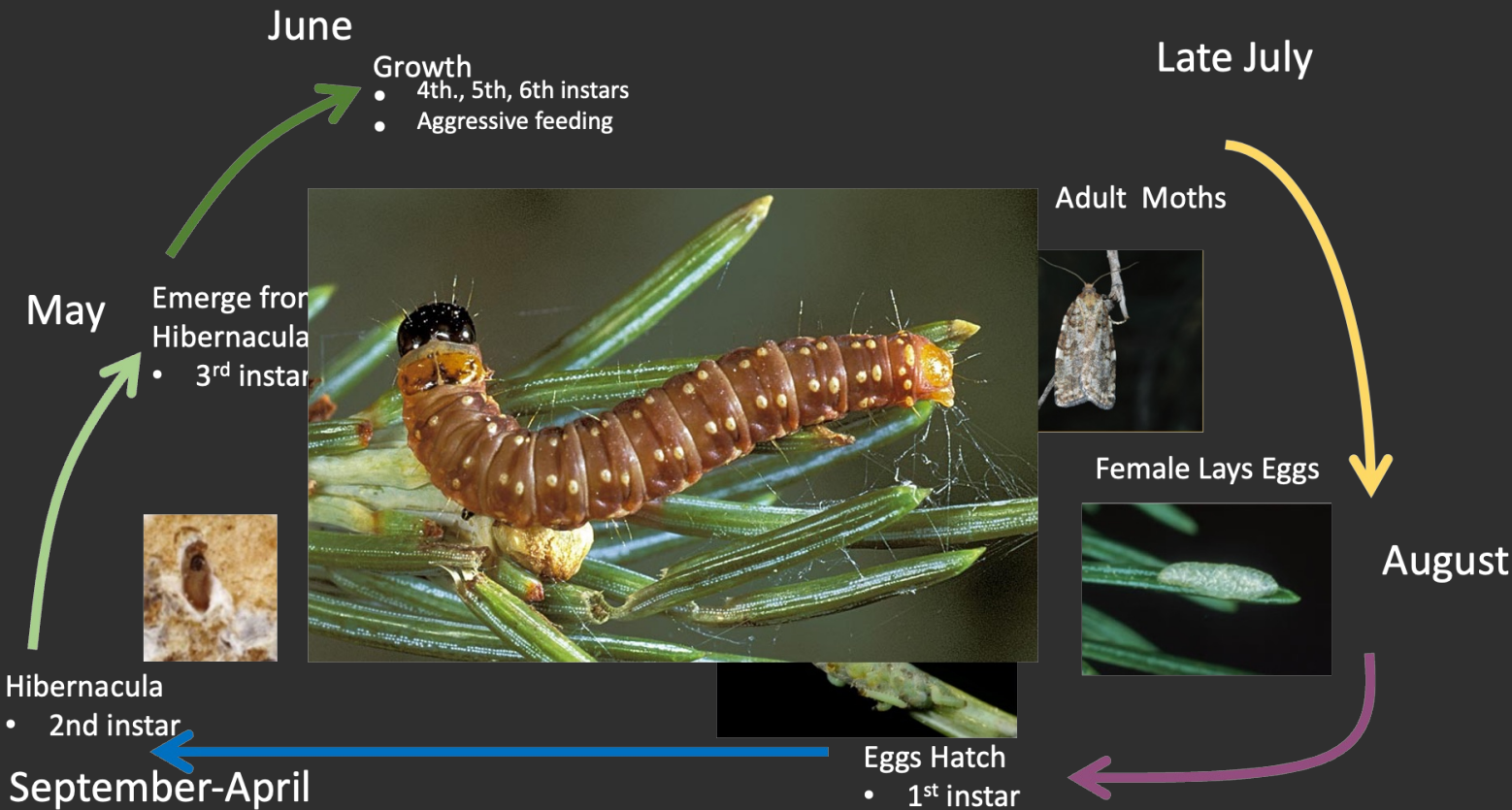
Develop hibernacula

- 2nd instar
- Over winter in protected areas

September-April







June

Growth

- 4th., 5th, 6th instars
- Aggressive feeding

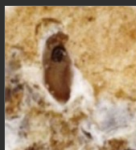
Late July

Adult Moths

May

Emerge from Hibernacula

- 3<sup>rd</sup> instar

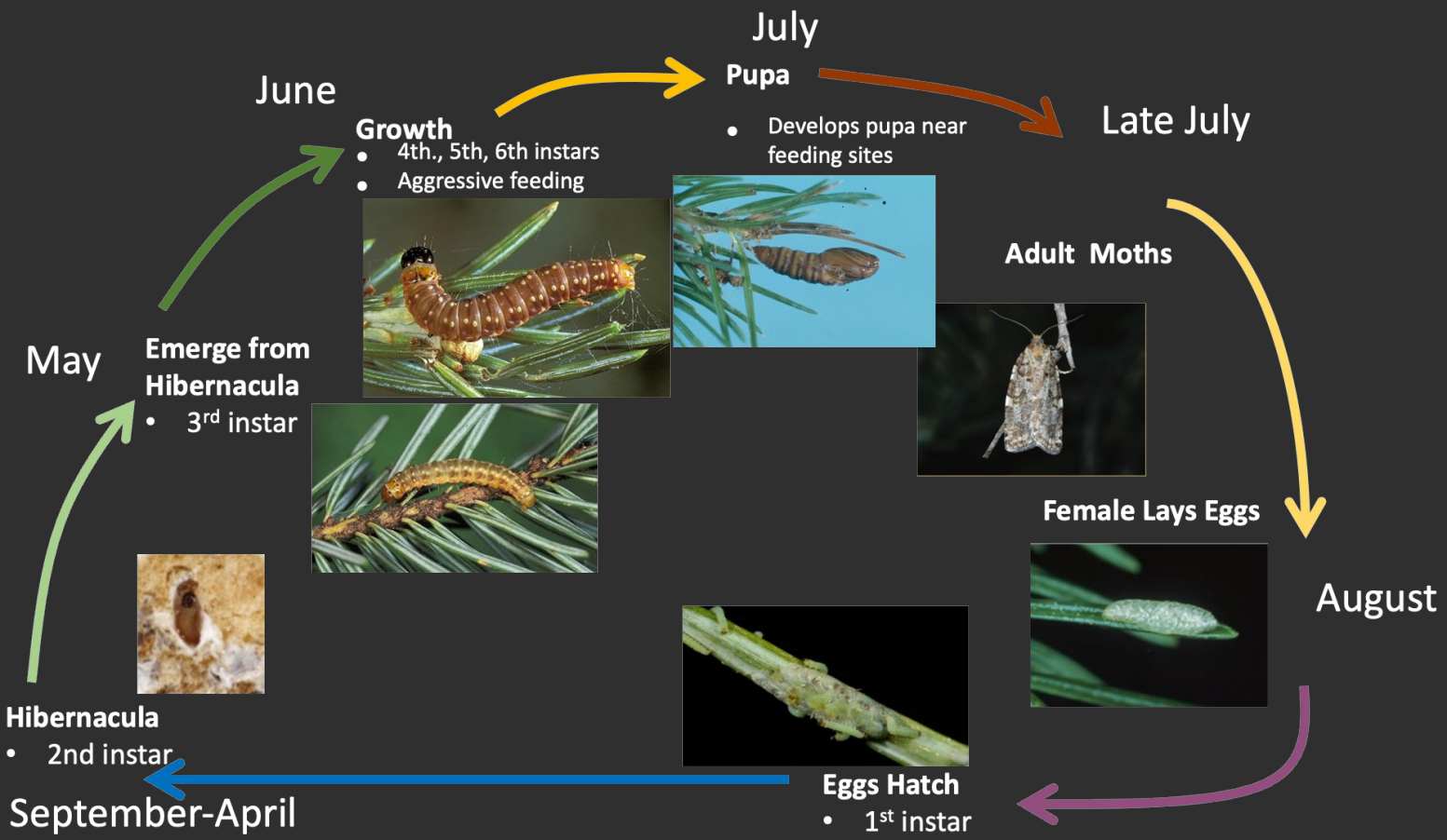


August

Hibernacula

- 2<sup>nd</sup> instar

September-April



July

June

Late July

August

May

Emerge from Hibernacula

Growth

Pupa

Adult Moths

Female Lays Eggs

Hibernacula

Eggs Hatch

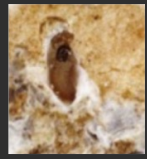
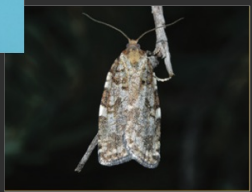
- 4th., 5th, 6th instars
- Aggressive feeding

- Develops pupa near feeding sites

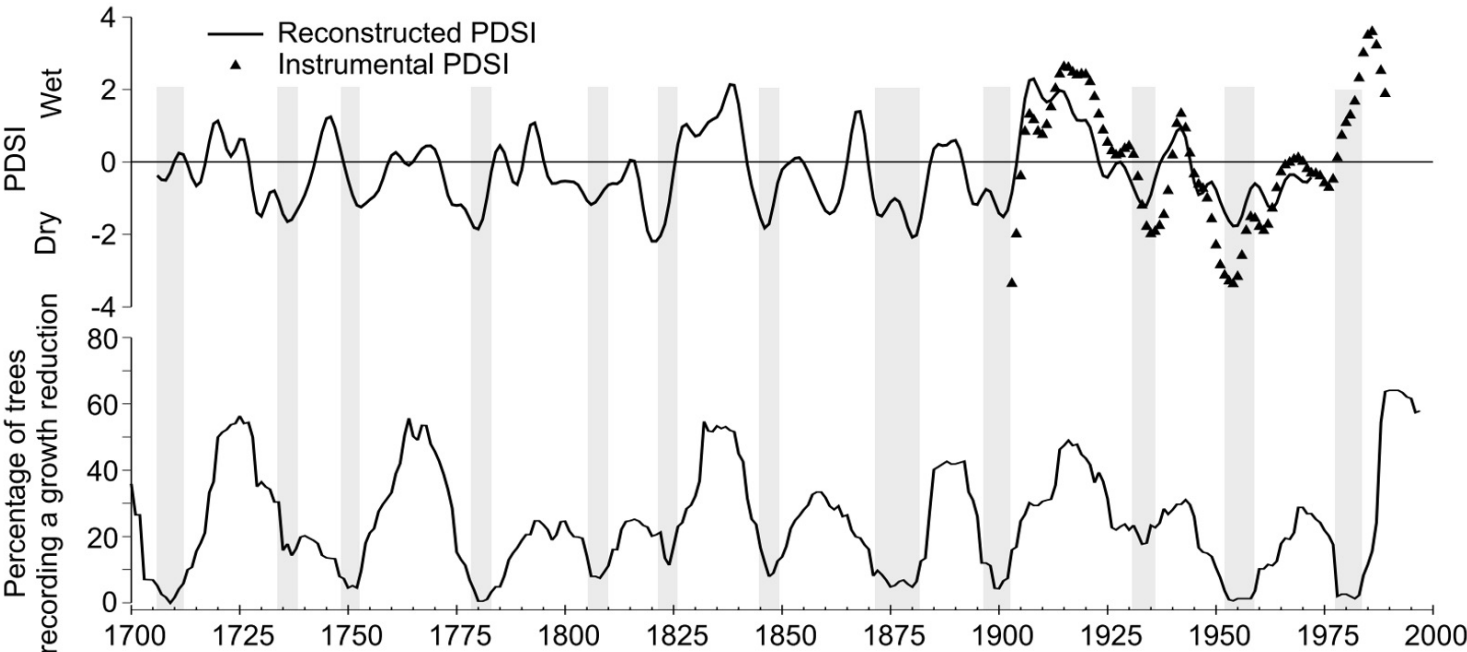
- 3<sup>rd</sup> instar

- 2nd instar

- 1<sup>st</sup> instar



**Fig. 5.** Instrumental and tree-ring-reconstructed summer Palmer drought severity index (PDSI) (top) and percentage of host trees recording a reduction in growth on the Rio Grande National Forest, Colorado (bottom). PDSI series were smoothed with a 13-weight digital filter. Vertical shaded lines were aligned with troughs in the outbreak series that had less than 25% of trees recording an outbreak.



Bare branches covered in *Usnea*



Reddening leaves



Photo: Colorado State Forest Service



# Bird predators of spruce budworm



Western Tanager



Evening Grosbeak



Yellow-rumped Warbler

Photos: Cornell Lab of Ornithology

Dry fuel

→ Junco is a great

fire brand

→ ↑ spotting

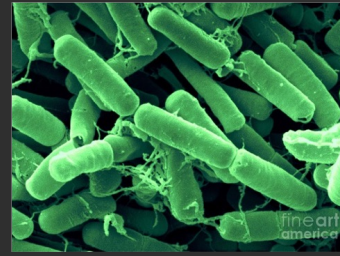


# Managing spruce budworm

- Chemical management

- Insecticides -> *Bacillus thuringiensis* (Bt)

- Can be broadcast over large areas but ecological implications are uncertain
    - Recommended for high-value trees only



1955

Aircraft based pest management  
(Johnson 2016)

Aerial Control Programs  
Photos: USDA FS

Integrated EIS for  
Oregon and  
Washington.  
(Johnson 2016)

1989

