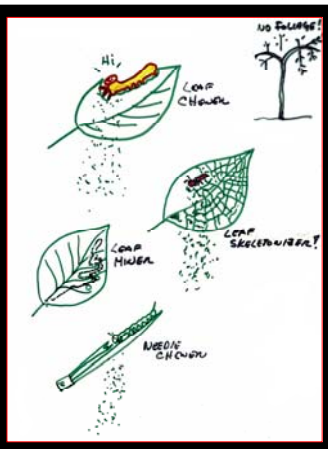
The Defoliators

Insect Defoliation Injury

Insect defoliation can be recognized readily by:

1. Absence of foliage,
2. Raining of frass, *i.e.* foliage particles and fecal pellets,
3. Many insects fee only on mesophyll cells, leaving the veins as a skeletal network, i.e. leaf skeletonizers,
4. Many are leaf miners and live between the cuticular layers of leaves or needles.

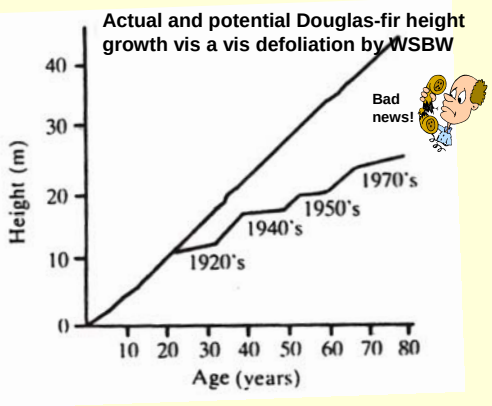


Now, when defoliation is severe, continuous, or repeated frequently trees die across the landscape.

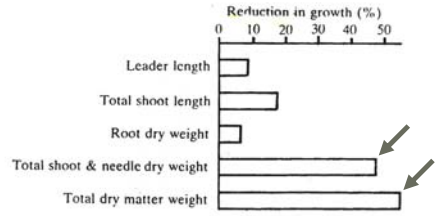
On the other hand, when defoliation is less frequent, or minor, this can happen:

- Growth loss occurs,
- Trees are weakened and 2^{o} insects attack, also
- Conifers suffer more severely than deciduous trees.

Actual and potential Douglas-fir height growth vis a vis defoliation by WSBW



Impact of the spruce aphid, *Elatobium abietinum,* on growth of Sitka spruce in England. In this study, effect of growth on 2-yr-old seedlings infested with aphids as compared with uninfested controls.



F.P. Keen.1952. Insect Enemies of Western Forests. USDA Forest Service, Misc. Publ. 273.

"The spruce aphid is by far the most destructive sap-sucking insect that defoliates spruce trees in the West. (During the 1940's)… it killed millions of BDF of Sitka spruce along the tidelands of the Oregon and Washington coast, Figure 22."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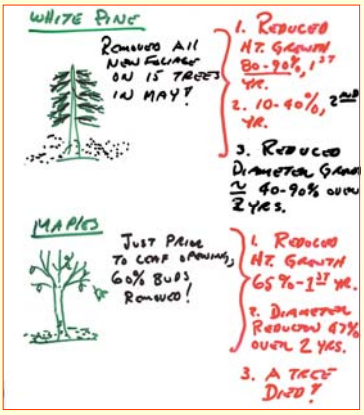
URE 22.—Sitka spruce along the Washington coast killed by the spruce aphid (Neomyzaphis abietina).

Prof. Herb Kullman, at the University of Minnesota had his students defoliate trees on the U.Minn. campus.

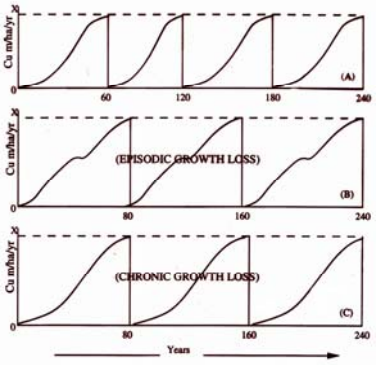


Impact of Defoliation on Forest Management Rotations

(A) Episodic growth loss, typical of WSBW and DFTM, three rotations in 240yrs.

(B) Normal growth, four rotations in 240yrs.

(C) Chronic growth loss, typical of WSBW on dry sites, three rotations in 240yrs.



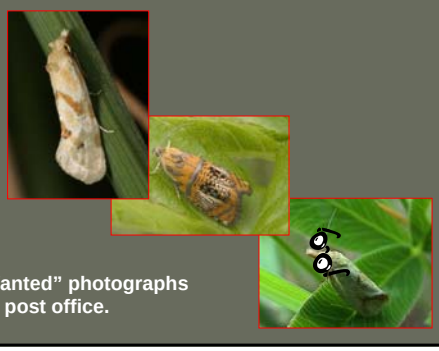
Let's Talk About the Western Spruce Budworm, *Choristoneura occidentalis* (Lepidoptera:Tortricidae)

Family: Tortricidae:

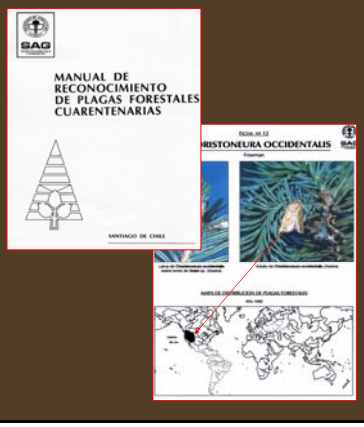
"Little Triangles"

" If larvae are disturbed they 'flip-out, go bananas' etc." Mandibles point forward, instead of downward.

The tortricids are among the most economically important tree defoliators in the world, as well as being awful agricultural pests. They are flat-out terrible!



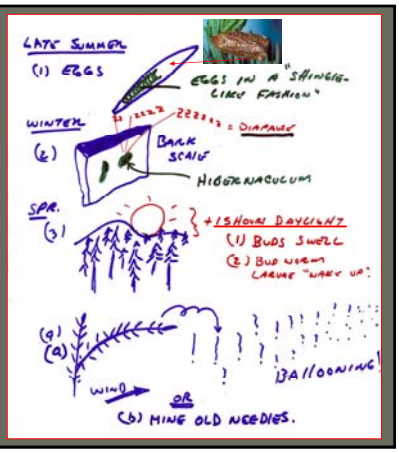
"Most Wanted" photographs from the post office.



The principal host trees for the WSBW, in order of preference:

- True firs; the *Abies* spp.
- Douglas-firs
- Spruces
- Larches

WSBW Life Cycle



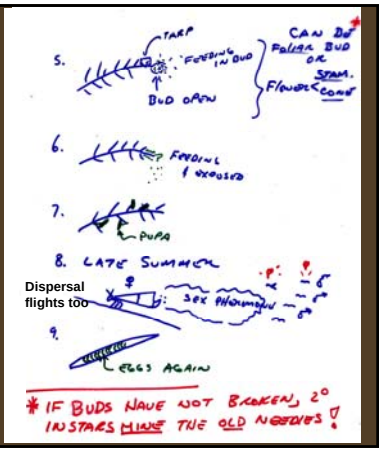
Ballooning WSBW larva

Wheeee !

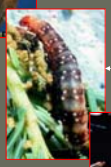
Of course the idea of the budworm 2^0 instar is to land on its host tree – Douglas-fir or true fir.

A 2^0 instar that successfully landed on a fir tree whose buds were starting to break open.

Life cycle of the WSBW continued.



←Tarpaulin made by 2⁰ instars

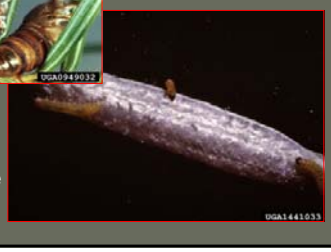


←Later instar feeding on new foliage

Last instar and pupae in late summer →

Late Summer

Adults emerging from pupae

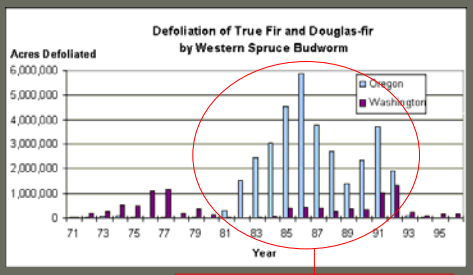


Still late summer, after eggs are laid, the 1⁰ instars emerge.

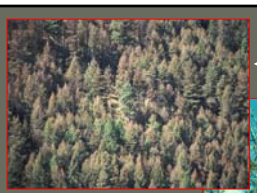
Hibernacula, diapause & over-wintering

Spring dispersal

The overarching problem of the WSBW is that outbreaks last a long, long time.



An 11-yr outbreak in Oregon



New-growth clipped off for three yrs.

New-growth clipped off for six yrs.

New-growth clipped off >six yrs.

After several years of an outbreak, bark beetles move and trees really start to die!

Understanding WSBW Outbreaks
Part I:

Site Characteristics

Susceptibility	Vulnerability
Probability of a WSBW Infestation	Probability of tree damage resulting from an infestation
Has to do with effects forest conditions have on WSBW populations	Has to do with damage caused by WSBW populations
Expressed as the WSBW population supported by the site, stand and landscape.	Expressed as tree & stand injury caused by WSBW defoliations.

Susceptibility & Vulnerability of Stands to WSBW vs. the Tree Species

LATE SUCCESSIONAL SPECIES ARE MOST SUSCEPTIBLE BECAUSE BUD BREAK TENDS TO BE IN SYNCHRONY WITH INSECT EMERGENCE!

Relationship Between Host Susceptibility To WSBW Attack, Synchrony of Budburst & Shade Tolerance of Host Trees

Host Species	Susceptibility To Attack	Synchrony With Budburst	Shade Tolerance
Subalpine Fir	•••••	•••••	•••••
White/Grand Fir	••••	••••	••••
Engelmann Spruce	•••	•••	•••
Douglas-fir	••	••	••

Which host is most in synchrony between budburst and WSBW emergence? Which host is most shade tolerant?

Susceptibility-Vulnerability Statements

1. Ponderosa pine in susceptible stands buffer against overall growth reduction for a given stand;

2. Douglas-firs in stands will increase their growth after the more susceptible firs are defoliated repeatedly (but after firs are killed, Douglas-firs are vulnerable).

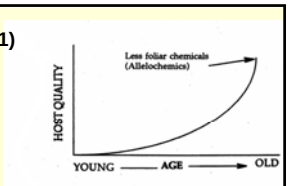
3. The most susceptible and vulnerable forests:
   - extensive fir stands
   - Douglas-firs stands with developing fir understory
   - Douglas-firs alone or in mixture with firs on exposed, dry sites (in these sites Douglas-firs break buds early).

Susceptibility-Vulnerability vs. Crown Class

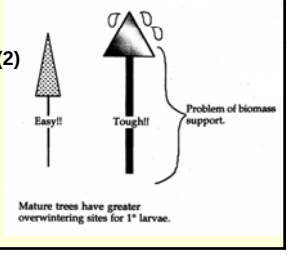
1. Dominant and codominant trees intercept dispersing larvae;
2. Females prefer to lay eggs on exposed crowns;
3. Intermediate and understory trees SUPPORT AN OUTBREAK, MOSTLY THE FIRS! Moreover, understory trees are suppressed and thus have high quality foliage, *i.e.* think, low in allelochemics;
4. Big final point ☛ multistoried, suppressed stands, with climax species in the understory are super SUSCEPTIBLE.

Susceptibility-Vulnerability vs. Stand Maturity

(1)



(2)



Mature trees have greater overwintering sites for 1° larvae.

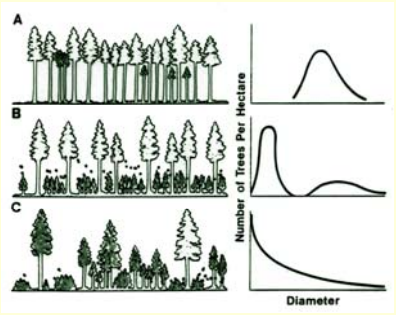
Stand Structure

(A) least susceptible
(B) medium susceptible
(C) highly susceptible

Least Susc. tends to be even aged

Understory development

Multistoried, good high quality food



Huge WSBW outbreaks in the West are becoming more common: that's a huge problem! Why, what are the underlying reasons?

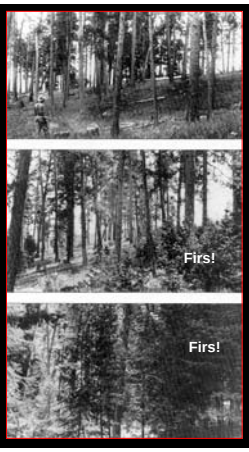
It's not just a cliché to say that fire suppression and the logging history of the west has led to unhealthy forests. It's true: I've lived through it.

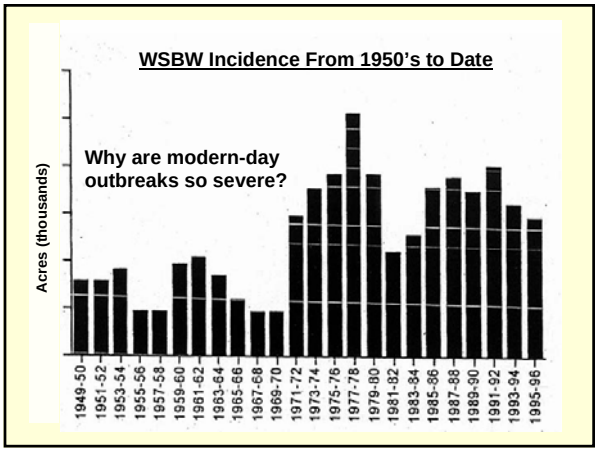
Let's start with fire suppression and the WSBW.

Open ponderosa pine stands of the 1950's

Ponderosa pine stands of the 1970's

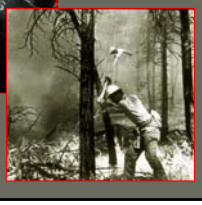
Choked, stagnant ponderosa pine stands of the 1990's





Fir trees exploding

Frequent backing fires as opposed to crown fires.



With huge exceptions fires were fuel-limited.

The other reason WSBW outbreaks weren't huge, landscape-level events from 1900's through the 1960's was that ponderosa pine was a major part of the ecosystem.

Moreover, ponderosa pine is a NON-HOST!!!

"Go mark those pines"

"…that's 30in…"

"…dump those pines here."

It's truly hard to imagine a more WSBW-prone forest:

1. Tall Doug-firs;
2. Multiple layers of true firs;
3. The firs are high quality food!!

Budbreak in firs vs. Douglas-firs

Look at this understory of grand fir: early in the season vs. later!

Even reproduction of firs and Douglas-firs are defoliated as larvae rain down from above!

1990 Yakama Nation

WSBW Damage in eastern Washington

1993 Yakama Nation