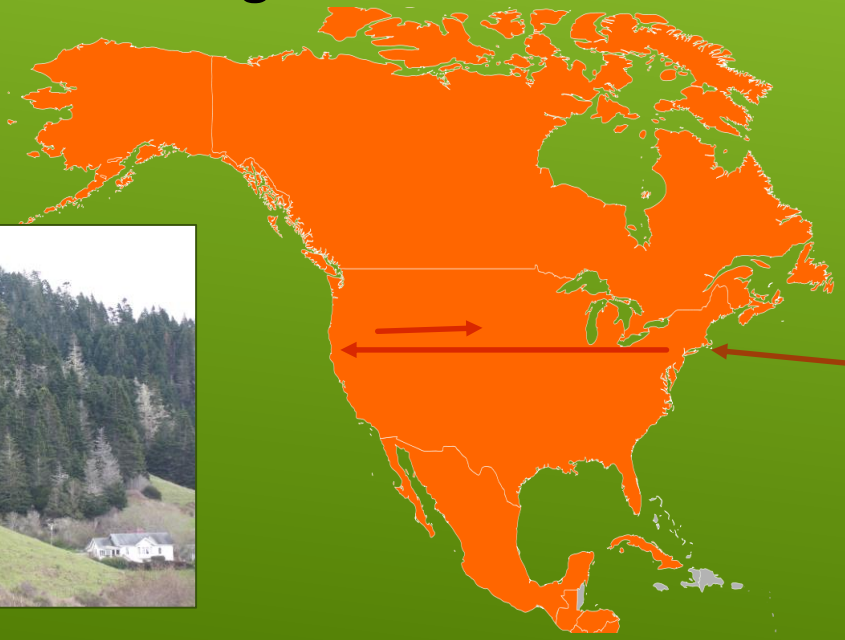
BALSAM WOOLY ADELGID IN CALIFORNIA

Balsam woolly adelgid, *Adelges piceae*, (Ratzeburg) (Hemiptera: Adelgidae)

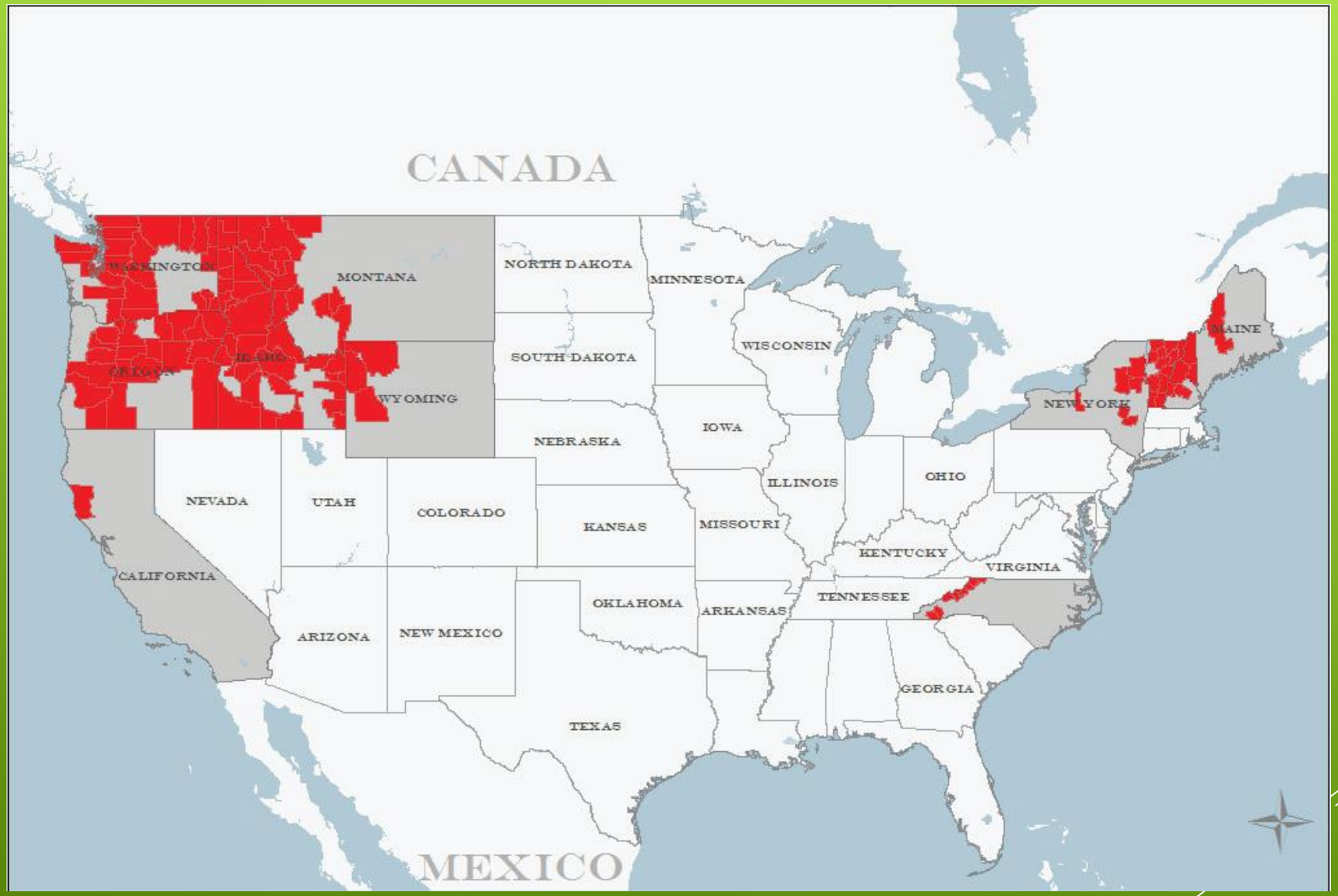
BWA was introduced into eastern North America from Europe around 1900. Later, it appeared on the west coast

- California, 1928 on ornamental firs near San Francisco
- Oregon, 1930 on grand fir near Salem

In Europe, host trees are relatively insensitive to attack and the insect is not considered a significant forest pest.



USDA Forest Service, Northern Research Station and Forest Health Protection. “Alien Forest Pest Explorer - species map.” Database last updated 28 July 2016. <http://foresthealth.fs.usda.gov/portal/Flex/APE> (access date).



County Observation

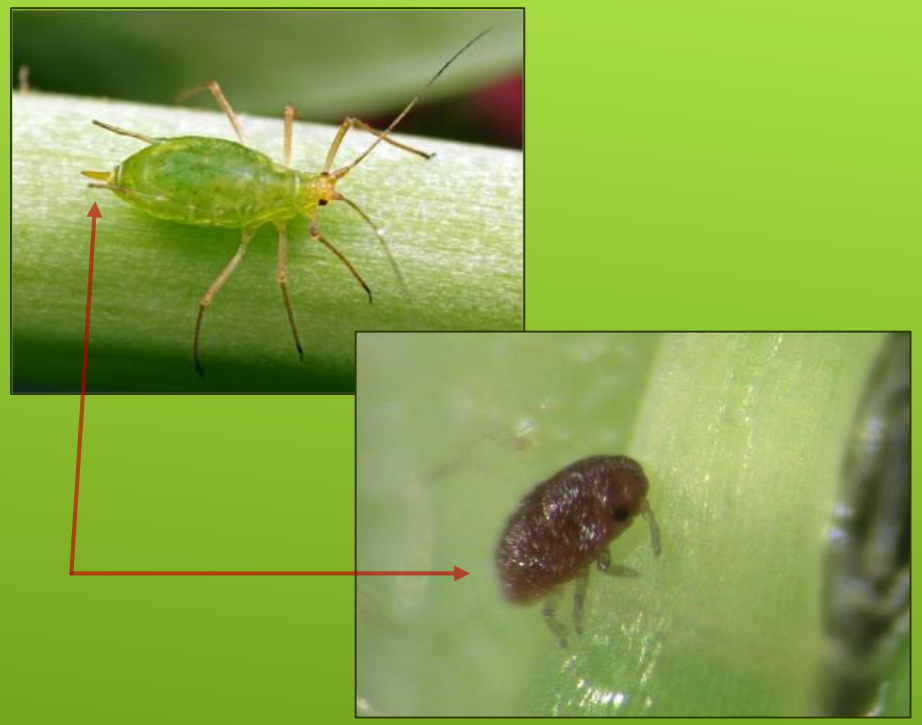
State Report

The principle hosts of BWA in the Pacific Northwest, in order of susceptibility, are subalpine fir (*A. lasiocarpa*), Pacific silver fir (*A. amabilis*), and grand fir (*A. grandis*). Other native true firs, such as noble fir (*A. procera*), Shasta red fir (*A. magnifica* var. *shastensis*), and white fir (*A. concolor*) appear generally resistant in native stands, but are susceptible when growing among principal hosts or outside their native range.

Subalpine fir

Grand fir

White fir



Unlike aphids, the adelgids have no tail-like cauda and no cornicles. Adelgids have much simpler life cycles in that they only lay eggs, and never give birth to live nymphs as aphids do.

The Adelgidae is a small family of the Hemiptera closely related to the aphids.

Two unique features of this adelgid are:

1) All individuals are female, each capable of starting a new infestation alone, and
2) All are flightless.

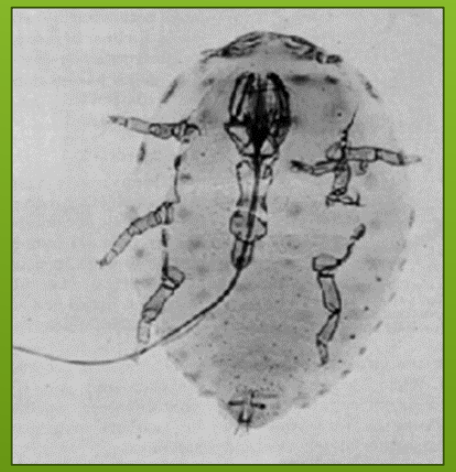
The insect has two generations in the Pacific Northwest. Timing of the lifecycle varies with climate and elevation.

Newly hatched crawlers disperse within a tree or are carried longer distances by wind currents and perhaps incidentally by birds or mammals as hitchhikers. Crawlers most often select as feeding sites roughened areas such as bark lenticels, branch and twig nodes, and bud bases.

Once a crawler selects a place to feed and inserts its mouthparts into the bark, that individual never moves from that location. They overwinter anchored to the bark in a dormant state. In the spring, the immature adelgid resumes feeding and development, molting several times before transforming into an adult. Adult adelgids are blackish purple, look roughly spherical in shape, and produce a covering of wax threads that appears as white, woolly dots about the size of pin heads on the surface of the tree's bole, limbs, and buds. Eggs are produced under the adults and are orange in color.

BWA is very small, 1 mm or less in length, and relatively inconspicuous except for a covering of white wax-like threads that gives the insect its name.

It feeds in areas on the host tree with thin bark, or in bark crevices, by inserting its long stylet-mouthparts into living cells.



When BWA feeds it injects a salivary substance into the tree, causing the formation of abnormal wood structure that interferes with the normal transport of water and nutrients within a tree. Inside the stems this results in dense red rings similar to compression wood at feeding sites in the bole, and gall-like structures and calluses when feeding on branches and twigs. Heavy stem infestations can kill a tree in just a few years, while crown infestations tend to cause progressive decline for many years before the tree death occurs.

BWA INFESTATION TAKES TWO FORMS: INFESTATION OF THE BOLE AND OF THE CROWN

The more severe form of BWA attack is the stem infestation that involves high population densities feeding on the tree's main bole. Severe stem infestations have been reported to kill trees in as little as three to five years. In Oregon, long-term impact plots established in BWA infested subalpine fir stands have shown 40% - 79% tree mortality over a 35-45 year period (Mitchell and Buffam, 2001).

Bole infestation levels frequently vary. Differences are thought to be determined by the amount of irregularities in the bark surface.

When adelgid populations concentrate on the outer branch nodes they produce gouting that inhibits new growth. The inhibition of new growth from gouting coupled with the natural shedding of older needles eventually result in tree crowns having a thin, sickly appearance. Tree decline from branch gouting is slow, but persistent infestations of this type can kill trees. Gouts on branch tips and nodes persist on trees for many years and are an indicator of BWA presence.

Branch infestation (gout) commonly occurs on the outer nodes and inhibits new growth leading to crown deformities.

Top Curl

Stunted terminal growth

Stunted lateral growth

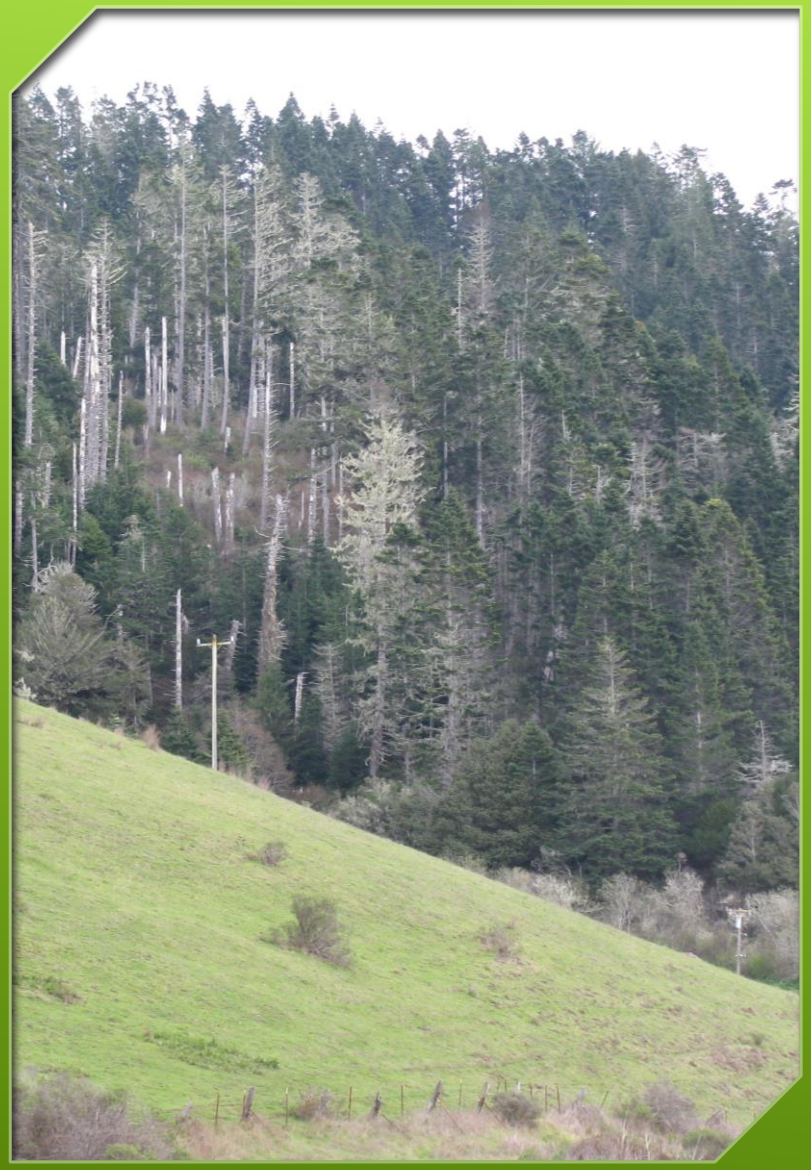
STAND AND LANDSCAPE LEVEL IMPACTS

- Changes in forest structure
  - Tree mortality contributing to snag formation and eventually the down woody fuels
  - Canopy gaps may be formed when heavy stem infestations cause rapid tree mortality
- Changes in species dominance
- Changes in snow retention
- Chronic infestations contribute to tree stress and may predispose trees to mortality from other agents

SURVEYS AND OBSERVATIONS

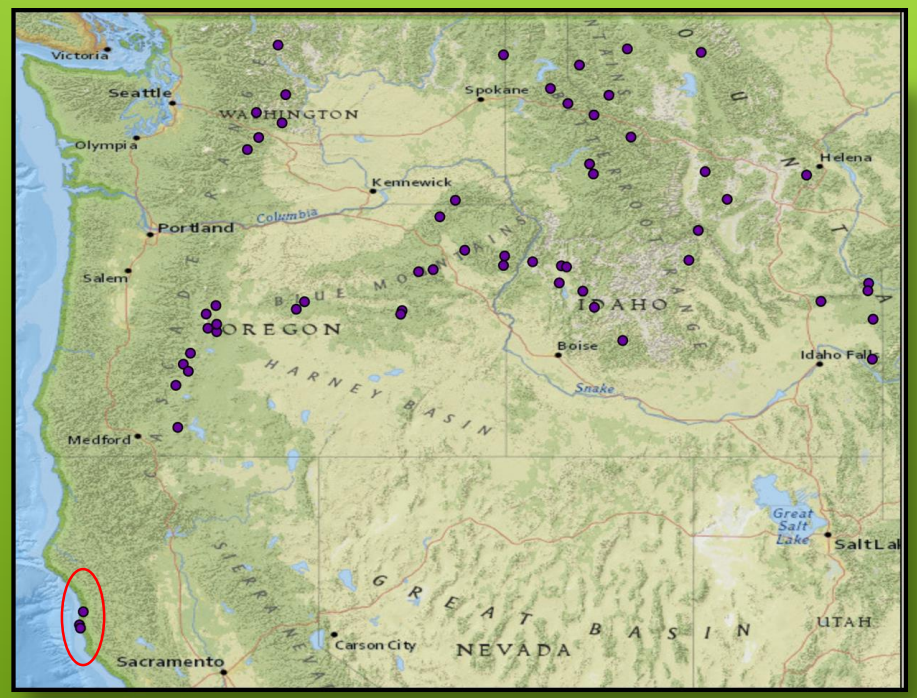
- Over the years various types of surveys have been used to monitor the spread of BWA
  - Aerial surveys indirectly detect established BWA populations by the appearance of infested trees and have used fading crowns or branches as a signature (Rocky Mountains, Northeastern Area, Pacific Northwest)
  - Ground surveys have used the presence of branch gouting or stem infestations as an indication of BWA presence (Rocky Mountains, Pacific Northwest, CA)
  - Roadside surveys using host maps and specified stopping intervals (Pacific Northwest)
  - Reports by concerned land-owners and managers after tree mortality has occurred (CA)

Reports of dying grand fir led to visit to Fort Bragg in 2012.



Reports from the Sonoma and Mendocino coast of dying grand firs led to visit to Fortuna in 2017.

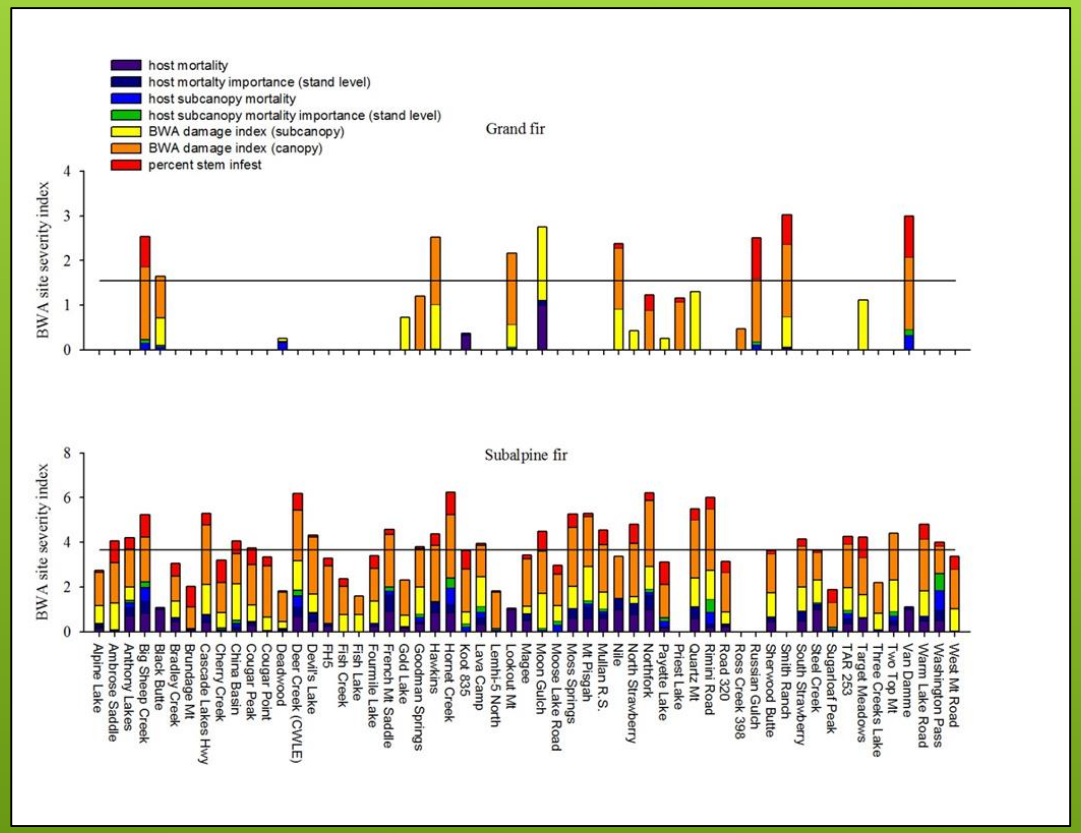
2012 PNW RESEARCH OBJECTIVES



Using 57 sites across known BWA range

1) Develop a user-friendly stand-level severity rating system
2) Gather environmental data to predict spread and impact as BWA moves into new areas
3) Identify drivers of infestation severity and impact to aid in management decisions

1) Develop a user-friendly stand-level severity rating system



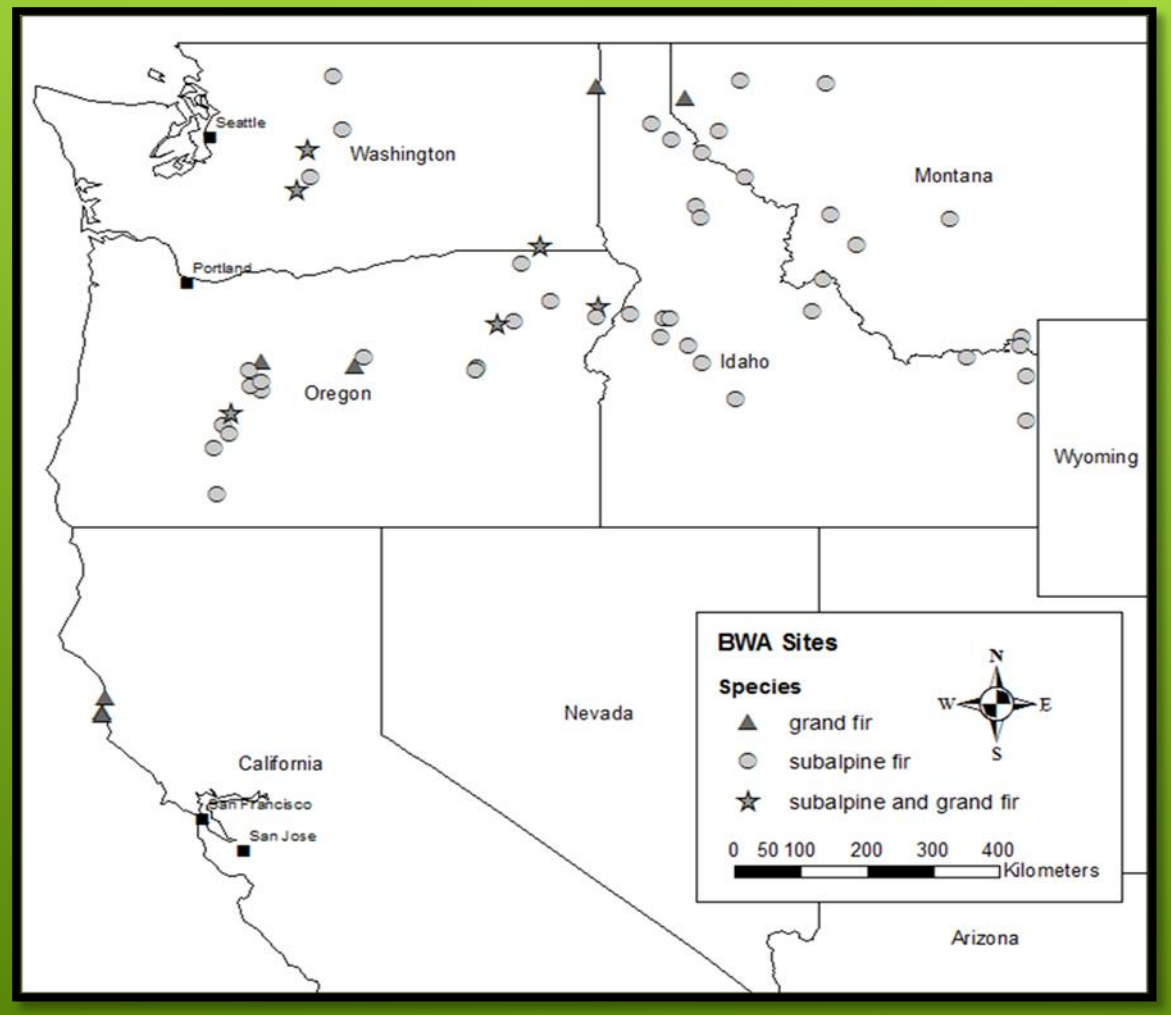
- Combined data into stand level severity indices
- Examined relationships between severity index components (e.g.) canopy vs. subcanopy damage, host mortality and importance vs. total severity)
- Examined species-specific damage patterns

PNW developed a new rating system for two western host species: grand fir and subalpine fir. Unlike other severity scales, this rating system integrates individual host and stand characteristics into a comprehensive index representing stand-level damage and provides a number of advantages over existing systems for the mountainous west.

Variable	Rating	Rating Description					
		0	1	2	3	4	5
Dieback[a]	0-5	0%	1-24%	25-49%	50-74%	75-99%	100%
Crown Deformity[b]	0-3	None	One deformity observed	Two deformities observed	Three deformities observed		
Gout	0-3	Undetectable	Light swelling, indistinct without close examination	Moderate swelling, distinct on bare and foliated branch tips	Severe swelling, distinct, prominent branch distortion		
Percent mortality (host)	0-1	Overstory basal area (m^2/ha) or understory density (stems/ha) dead host / total host basal area or density					
Percent mortality (stand)	0-1	Overstory basal area (m^2/ha) or subcanoopy density (stems/ha) dead host / total basal area or density for all species					

a – overstory dieback values measured as average of crown thirds and understory dieback evaluated as one value for the entire stem

b – types of crown deformities noted, but total number of deformities per stem used in index calculation

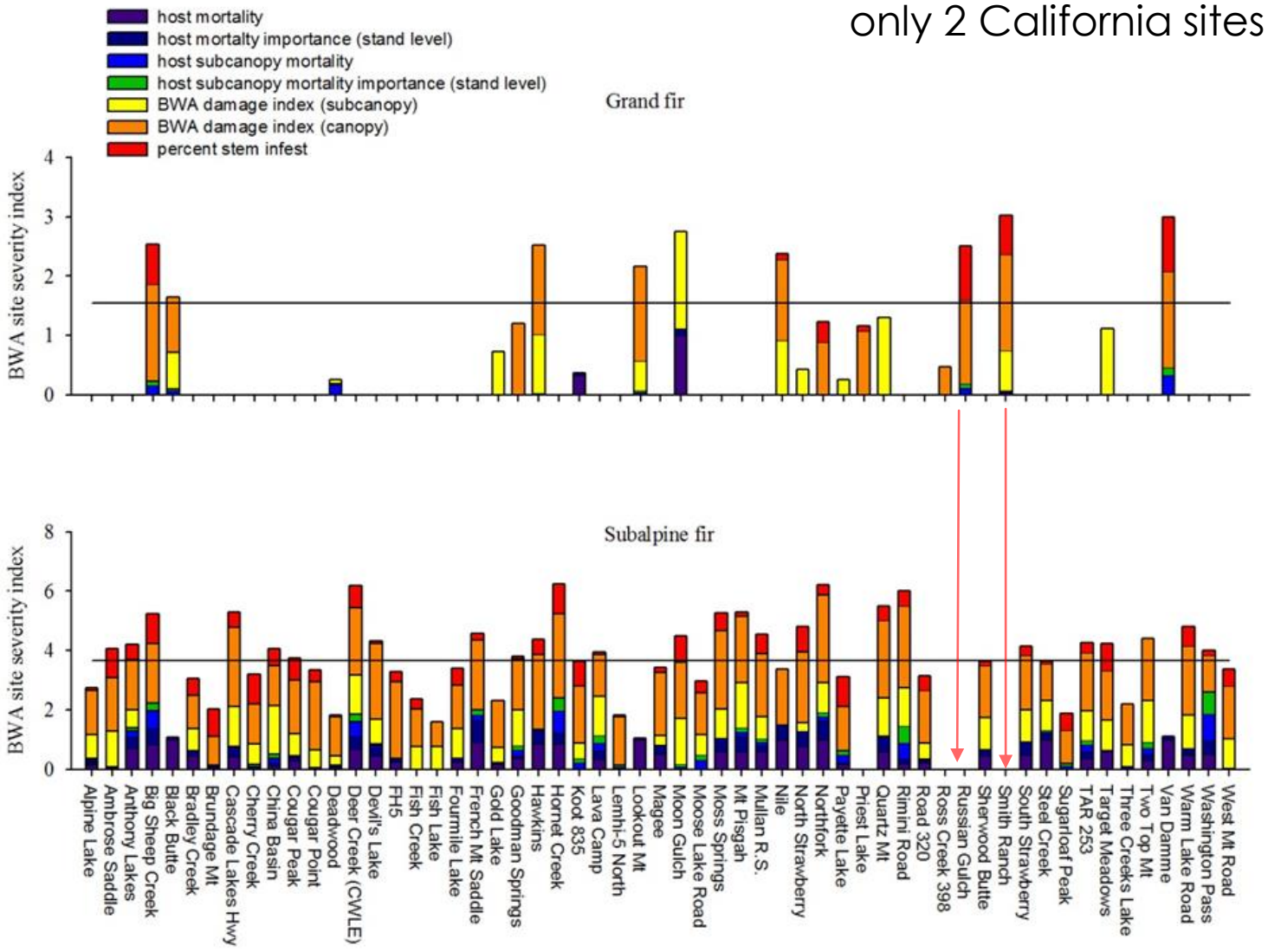


4 sites with <u>only</u> grand fir

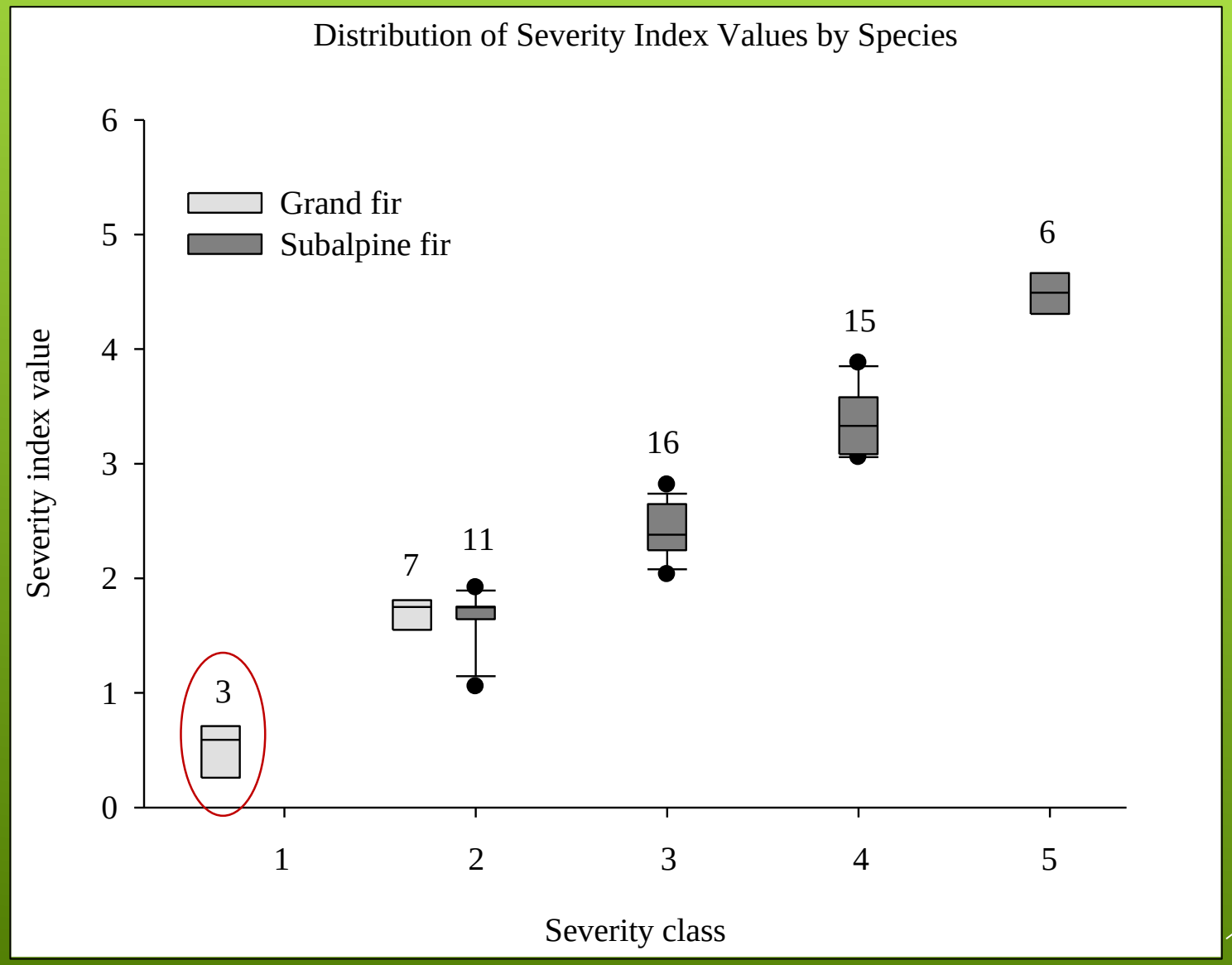
Only 2 California sites

Only 2 coastal sites

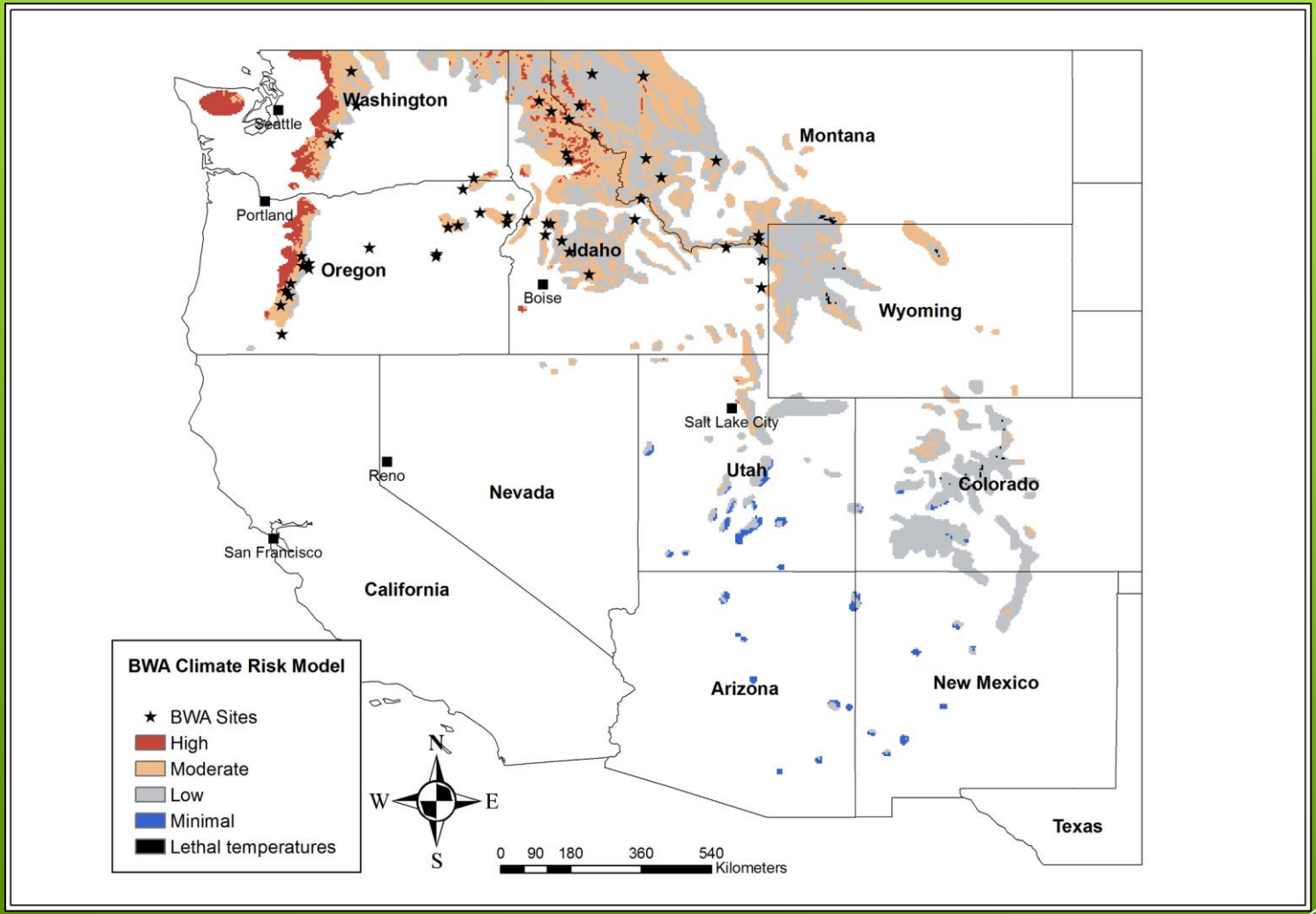
only 2 California sites



Grand fir stands showed significantly lower severity index values than subalpine fir stands



2) Gather environmental data to predict spread and impact as BWA moves into new areas (*for subalpine fir*)



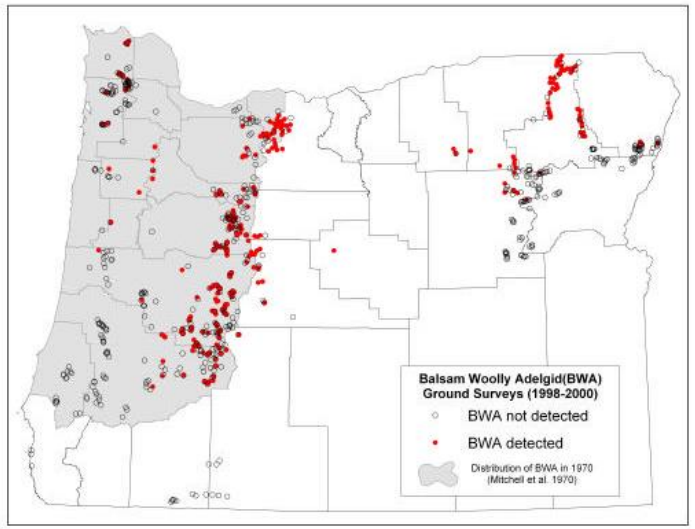
Citation: Hrinkevich KH, Progar RA, Shaw DC (2016) Climate Risk Modelling of Balsam Woolly Adelgid Damage Severity in Subalpine Fir Stands of Western North America. PLoS ONE11(10): e0165094. https://doi.org/10.1371/journal.pone.0165094

In Oregon, stem infestations and rapid tree death were reported as more common in the lower elevation ranges of host species. Stem infestations come and go depending on conditions favorable to BWA populations, but BWA does not seem to completely disappear from a site as long as host trees are present.

Balsam Woolly Adelgid Occurrence on True Fir in Oregon

Oregon Department of Forestry
Pest Management Report
October 2004

David L. Overhulser, Oregon Department of Forestry
Iral R. Ragenovich, USDA Forest Service – FHP
Michael McWilliams, Oregon Department of Forestry
Elizabeth A. Willhite, USDA Forest Service - FHP



WHAT WE KNOW:

- Grand fir stands have significantly lower severity index values than subalpine fir stands
- Subalpine fir is more susceptible than grand fir
- Lot of work occurring in the Pacific Northwest and the Rocky Mountain Regions

WHAT WE WOULD LIKE TO KNOW:

- Given that coastal California sites differ greatly from interior sites
  - Temperature ranges and variations
  - Precipitation ranges and patterns
  - Snow accumulations
  - Fog
  - Wind patterns
  - Etc.

  Is there a difference in susceptibility between coastal and interior grand fir that is not expressed in the data

WHAT WE KNOW:

- Stem infestations and rapid tree death are reported as more common in the lower elevation ranges of host species in Oregon and Washington (Overhulser et. al 2004)
- Stem infestations come and go depending on conditions favorable to BWA populations, but BWA does not seem to completely disappear from a site as long as host trees are present

WHAT WE WOULD LIKE TO KNOW:

- Given that coastal sites differ greatly from interior sites
  - Temperature ranges and variations
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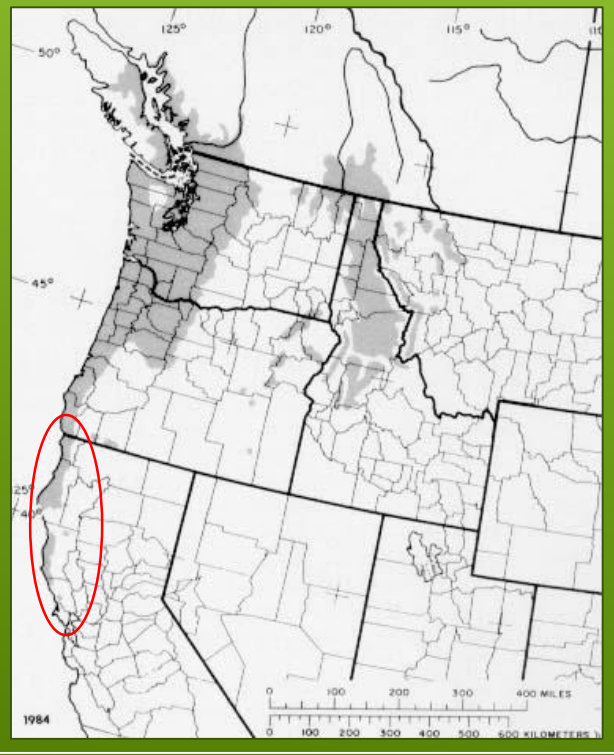
WHAT WE KNOW:

- BWA reported in CA grand fir:
  - 1930's – San Francisco
  - 2012 – Fort Bragg
  - 2017 – Fortuna
- Distribution of grand fir in California



WHAT WE WOULD LIKE TO KNOW:

- **Locations that may be known or suspected but not reported**
- New locations as they appear
  - **Where else should we be looking?**
- How is it being spread?

WHAT WE KNOW:

- BWA reported in CA grand fir:
  - 1930's – San Francisco
  - 2012 – Fort Bragg
  - 2017 – Fortuna
  - 2017 – Possible finding of BWA on subalpine fir in Russian Wilderness
- Subalpine fir is a rare tree in California

WHAT WE WOULD LIKE TO KNOW:

- **Locations that may be known or suspected but not reported**
- New locations as they appear
  - **Where else should we be looking?**
- How is it being spread?

WHAT WE KNOW:

- More than 23 species of natural enemies were imported and released into the United States against BWA. Six species reported as established but rare:
  - *Aphidecta obliterata* (L.) and *Scymnus impexus* (Mulsant) (Coleoptera: Coccinellidae),
  - *Laricobius erichsonii* (Rosenhauer) (Coleoptera: Derodontidae),
  - *Aphidoletes thompsoni* Möhn (Diptera: Cecidomyiidae),
  - *Cremifania nigrocellulata* Czerny and *Leucopis obscura* (Hal.) (Diptera: Chamaemyiidae)

WHAT WE WOULD LIKE TO KNOW:

- The date and location of biological control releases made in California
- Monitoring results from biological control releases – if monitoring was not done, that would also be good to know
- What site characteristics provide better environment for biological control agents – can they be effective on the coast?

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