

**Intermountain Forest Tree
Nutrition Co-op
and the
USDA Forest Service, RMRS
Armillaria root disease study**

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Review of *Armillaria* species in North America

Armillaria can be divided into 3 classifications

"Bad" *Armillaria*

NABS I and NABS VI

primary pathogens

"Good" *Armillaria*

NABS III, V, VII, X, and XI

primary saprophytes

Unknown

NABS II and NABS IX

pathogenicity

(NABS = North American Biological Species)

Armillaria species found on Nutrition Co-op plots throughout the Inland Northwestern United States.

"Bad" *Armillaria* - primary pathogen
NABS I – *Armillaria ostoyae*

- Common
- Known as a highly virulent pathogen of conifers
- Causes tree mortality
- Causes tree growth loss (often with no apparent visible symptoms)

Armillaria species found on nutrition co-op plots throughout the Inland Northwestern United States.

"Good" *Armillaria* – primary saprophytes

NABS III – *Armillaria calvescens*

NABS V – *Armillaria sinapina*

NABS VII – *Armillaria gallica*

- Closely related species
- Common
- Low pathogenicity; 5-10% found as bark fans
- Most individuals show no sign of pathogenicity and may be beneficial for tree growth and or protection.
- Difficult to identify

"Good" Armillaria – primary saprophyte
NABS X – currently unnamed

- Common
- Low pathogenicity; 5-10% found as bark fans
- Low level pathogenicity of NABS X may be attributed to NABS X x NABS III,V,VII hybrids
- Most individuals show no sign of pathogenicity and may be beneficial for tree growth and or protection.

Rhizomorph collection type

Robert L. Anderson, USDA Forest Service
forestryimages.com

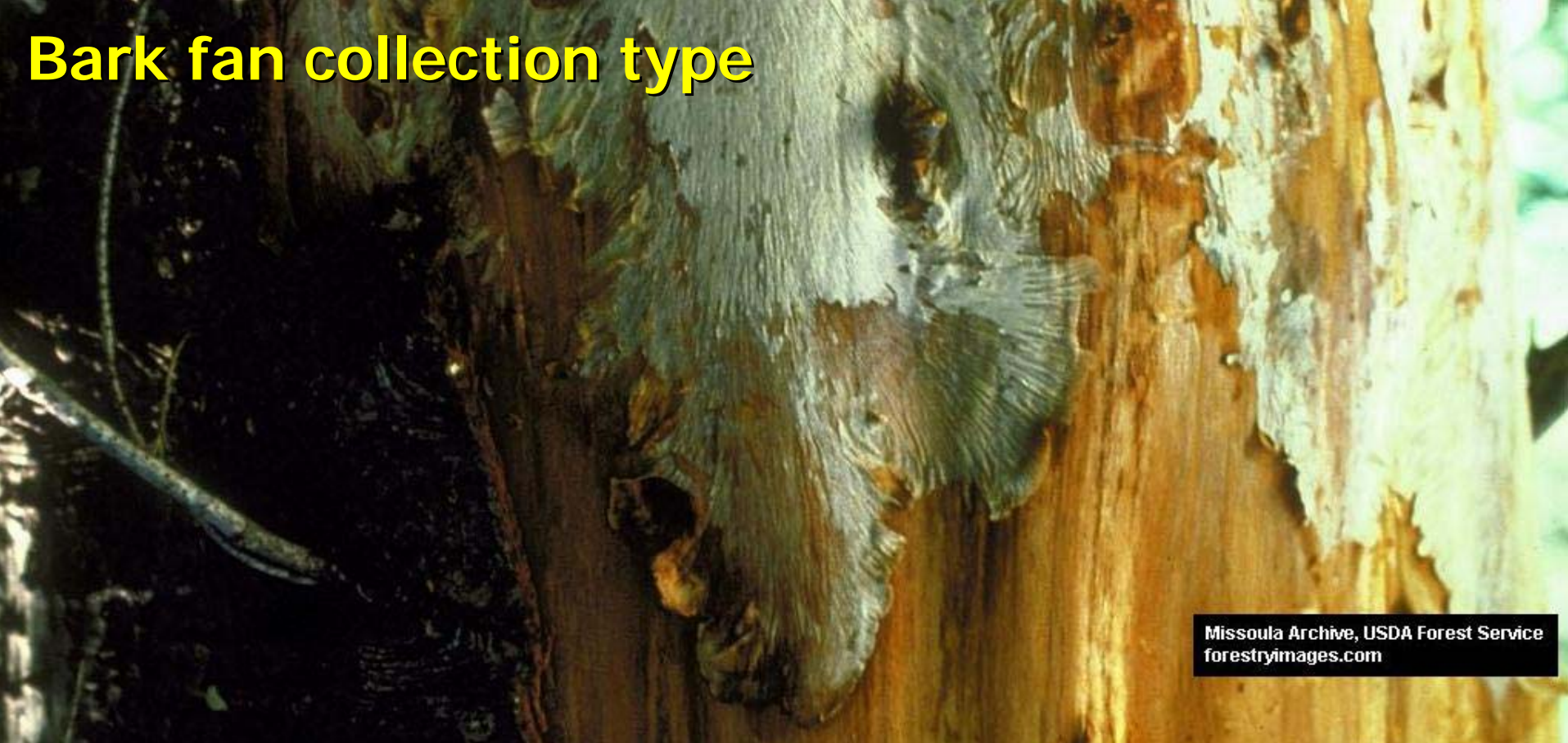


All species of *Armillaria* form rhizomorphs.

Most rhizomorphs are found on the surface of a root, some grow freely through the soil, and others can be found under the bark of a highly infected tree.

Presence of rhizomorphs does not necessarily indicate pathogenicity of an *Armillaria* individual.

Bark fan collection type



Missoula Archive, USDA Forest Service
forestryimages.com

Bark fans from live trees indicate high pathogenicity of an *Armillaria* individual.

Dead trees with bark fans do not necessarily indicate a pathogenic *Armillaria* individual.

Wood collection type

Robert L. Anderson, USDA Forest Service
forestryimages.com



Wood samples are usually taken from trees that have recently been killed or are infected with a pathogenic *Armillaria* individual.

Often dark lines known as zone lines can be seen in infected wood.

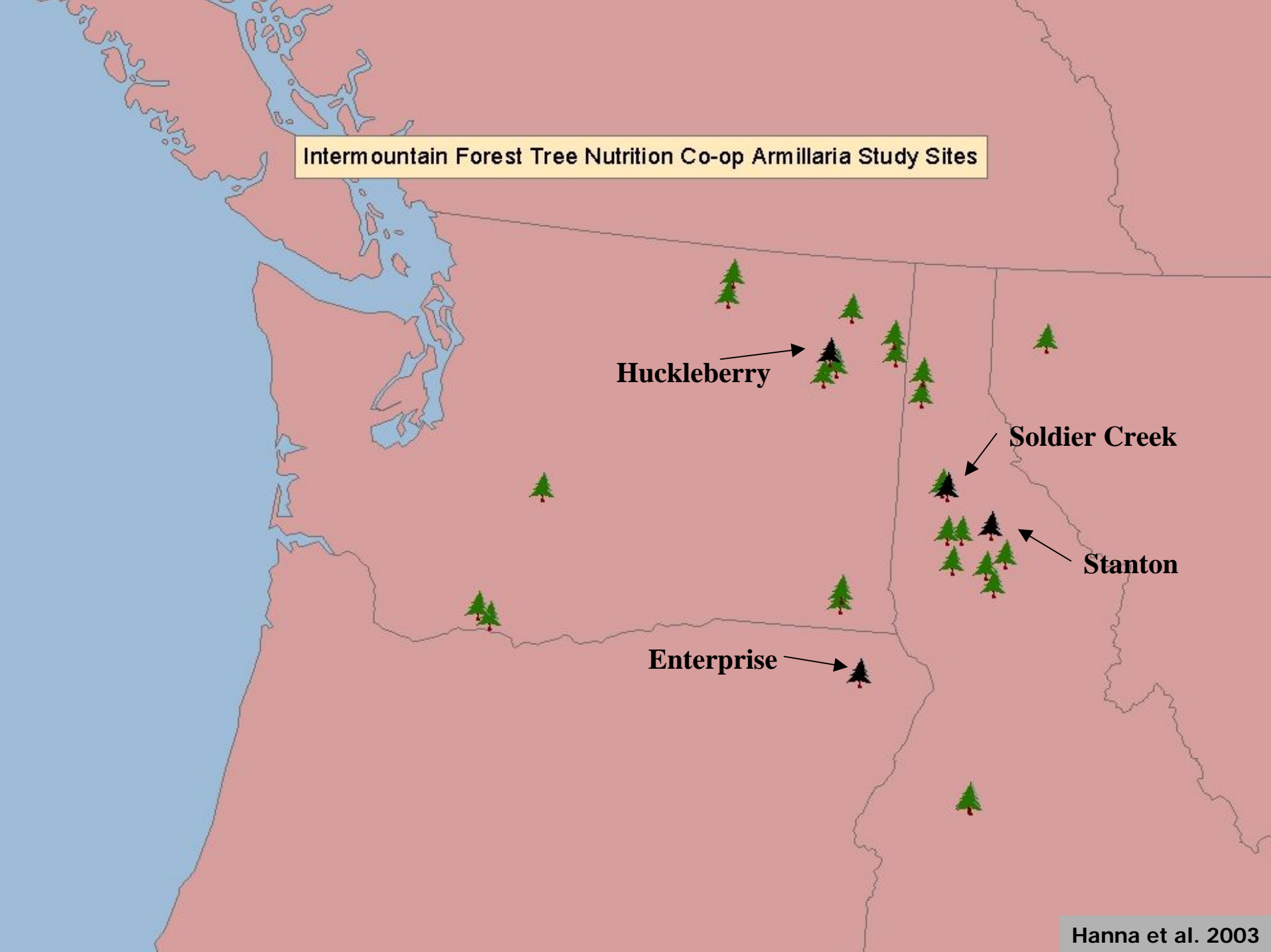
Intermountain Forest Tree Nutrition Co-op Armillaria Study Sites

Huckleberry

Soldier Creek

Stanton

Enterprise



Types of information collected from Nutrition Co-op sites

- Isolate ID
- Location
- Host Species
- Collection Type (Bark Fan, Rhizomorph, or Wood)
- Host Status (Dead or Alive)
- Habitat Type
- Fertilization Treatment
- Species ID
- Rock Type

Enterprise

- A. ostoyae Genet 1
- A. ostoyae Genet 2
- ★ Bark Fans Live Trees
- ☆ Bark Fans Dead Trees
- × Plot corners
- × Plot centers

Pseudotsuga merziesii / *Vaccinium caespitosum*
Douglas-fir / dwarf huckleberry

Plot 3
Control

Plot 4
300N & 0K

Plot 5
300N & 200K

Pseudotsuga merziesii / *Calamagrostis rubescens* - Aruv phase
Douglas-fir / pinegrass - bearberry phase

Pseudotsuga merziesii / *Calamagrostis rubescens* - Caru phase
Douglas-fir / pinegrass - pinegrass phase

Plot 2
200 N & 0K

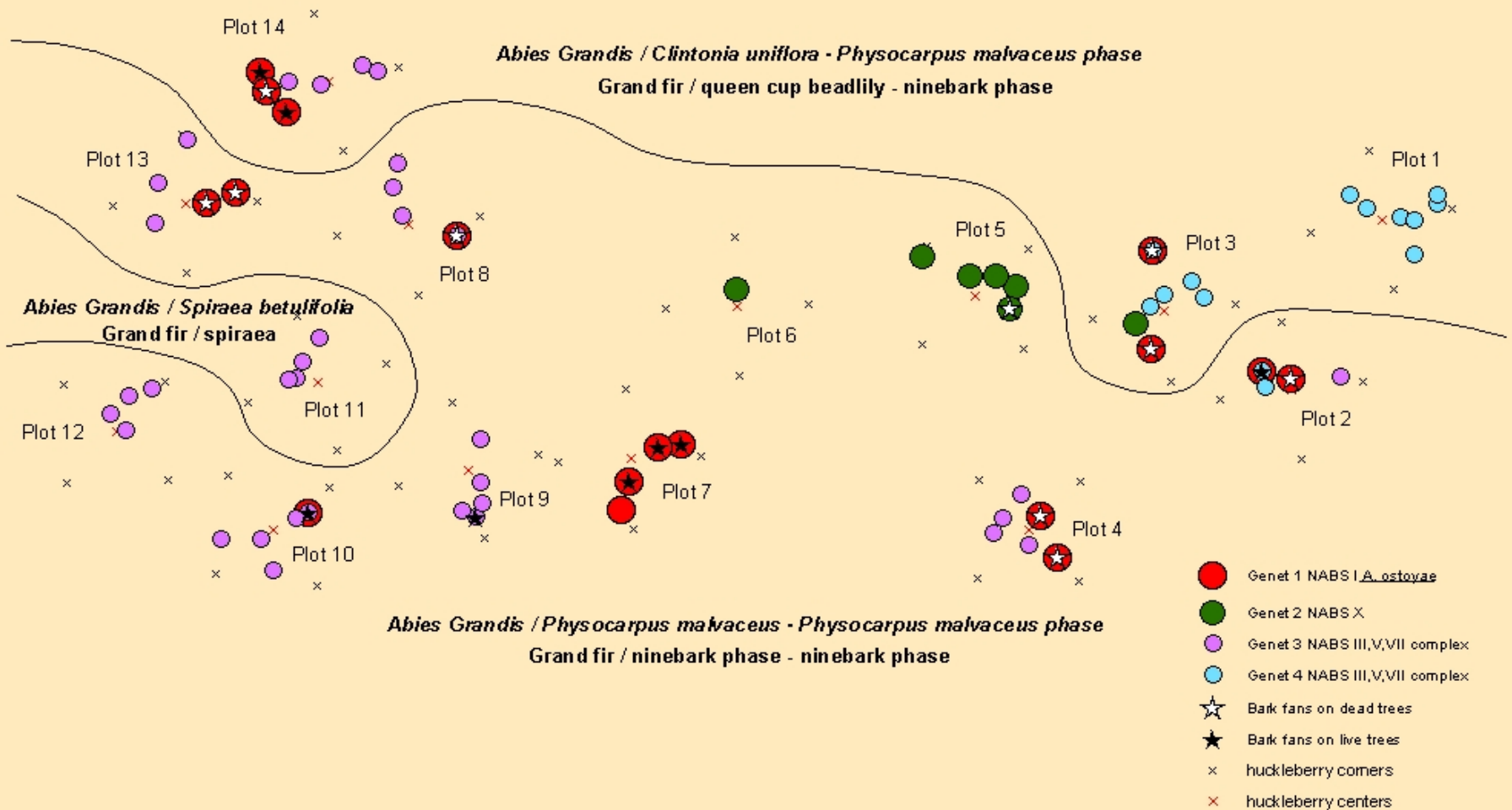
Plot 6
600N & 0K

Plot 1
100N & 0K

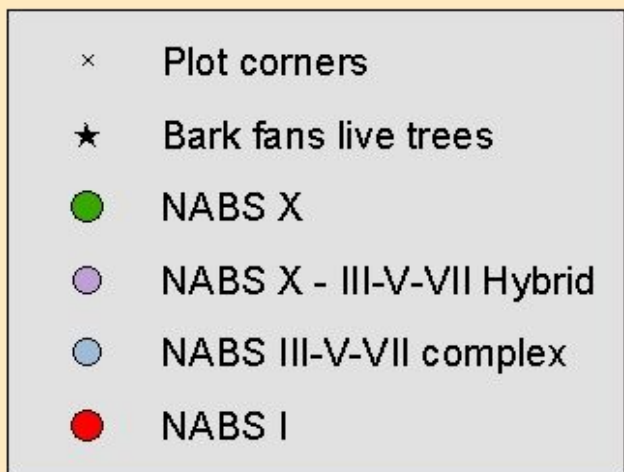
Plot 7
200K

Pseudotsuga merziesii / *Vaccinium caespitosum*
Douglas-fir / dwarf huckleberry

Huckleberry



Soldier Creek



Tsuga heterophylla / *Asarum caudatum*
western hemlock / wild ginger

Plot 7
Control

Plot 9
200N & OK

Plot 8
100N & OK

Plot 6
200N & OK

Plot 4
100N & OK

Plot 5
200N & OK

Plot 12
600N & OK

Plot 3
100N & OK

Tsuga heterophylla / *Clintonia uniflora*
western hemlock / queen cup beadlily

Plot 1
300N & 200K

Plot 2
300N & 200K2S04

Plot 14
300N & OK

Plot 13
200N & OK

Plot 10
300N & OK

Plot 11
300N & OK

Stanton Armillaria Distribution

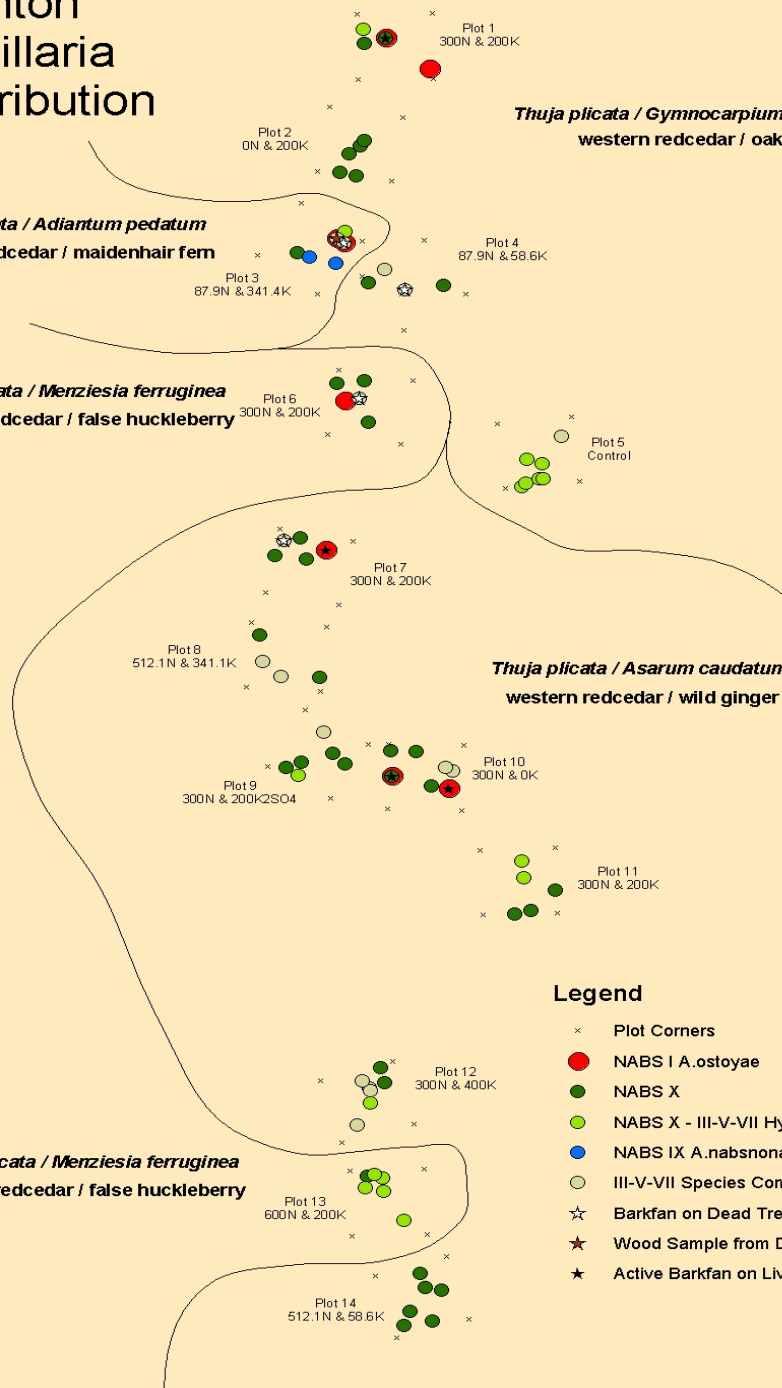
Thuja plicata / *Adiantum pedatum*
western redcedar / maidenhair fern

Thuja plicata / *Gymnocarpium dryopteris*
western redcedar / oak fern

Thuja plicata / *Menziesia ferruginea*
western redcedar / false huckleberry

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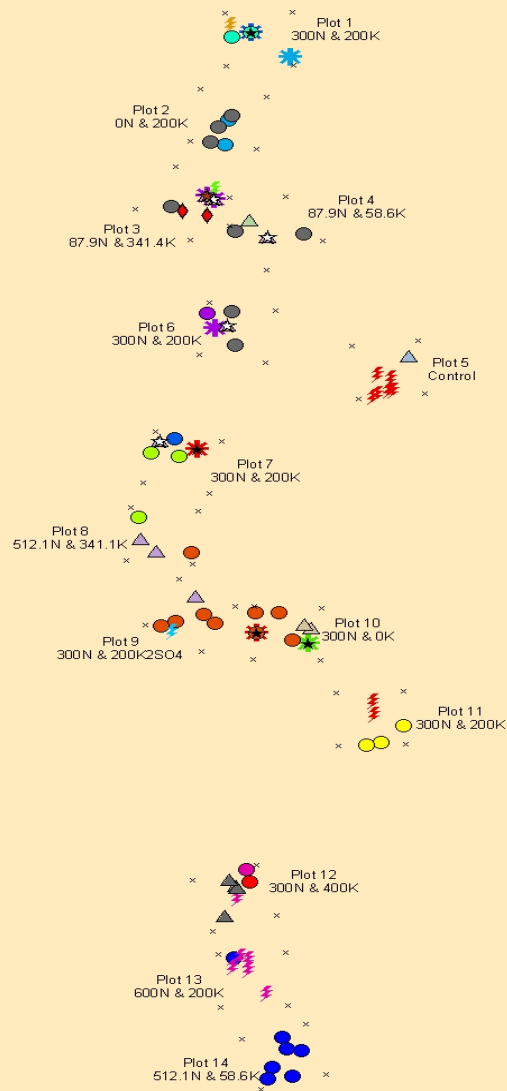
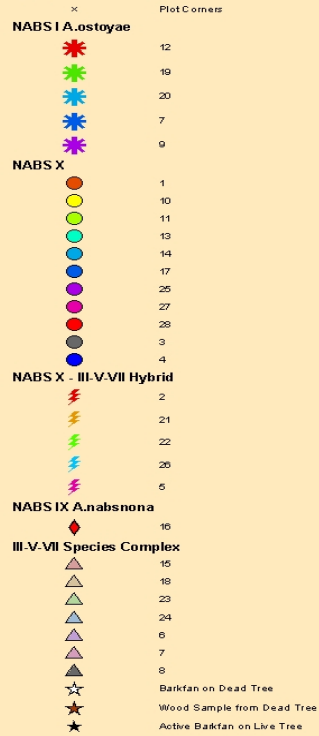


Legend

- × Plot Corners
- NABS I *A.ostoyae*
- NABS X
- NABS X - III-V-VII Hybrid
- NABS IX *A.nabsnona*
- III-V-VII Species Complex
- ☆ Barkfan on Dead Tree
- ★ Wood Sample from Dead Tree
- ★ Active Barkfan on Live Tree

Stanton Armillaria Genet Distribution

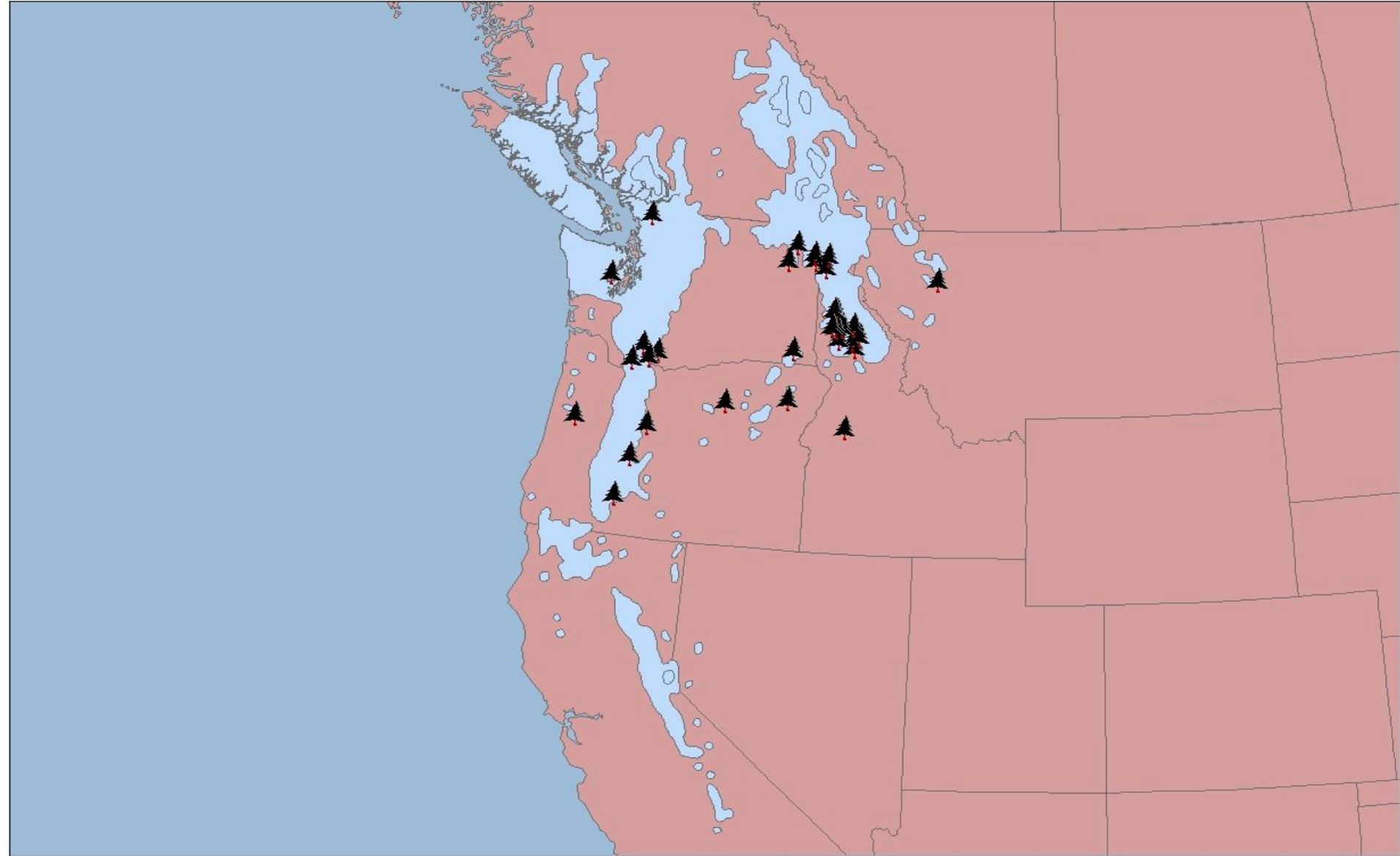
Legend



- NABS X may have important interactions with *A. ostoyae* on specific sites that may be beneficial to tree health.
- What factors may have contributed to the evolution of NABS X and what management practices can maintain NABS X on sites threatened by *A. ostoyae*?

Factors that may benefit NABS X

- Ash caps – NABS X may be adapted to survive in ash cap rich environments.
- Fire – NABS X is thought to occur deeper in the soil than other *Armillaria* species and this may enable it to better withstand fire events. Fire may also provide nutrients to the soil that NABS X prefers.
- White pine – NABS X is commonly found where there is white pine and may be especially adapted to white pine ecosystems.



NABS X



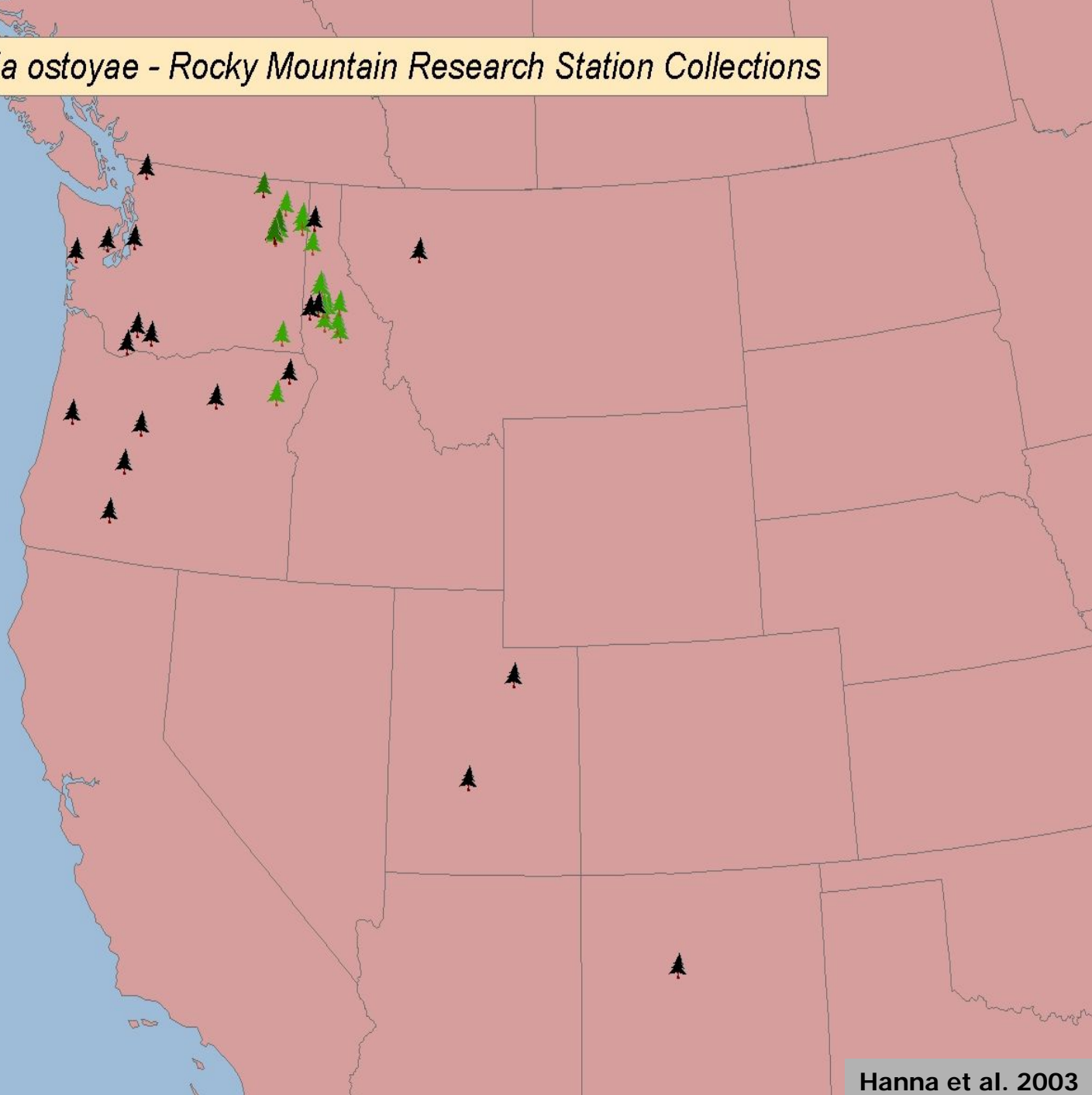
Historic White Pine Range

Management practices that may help maintain NABS X

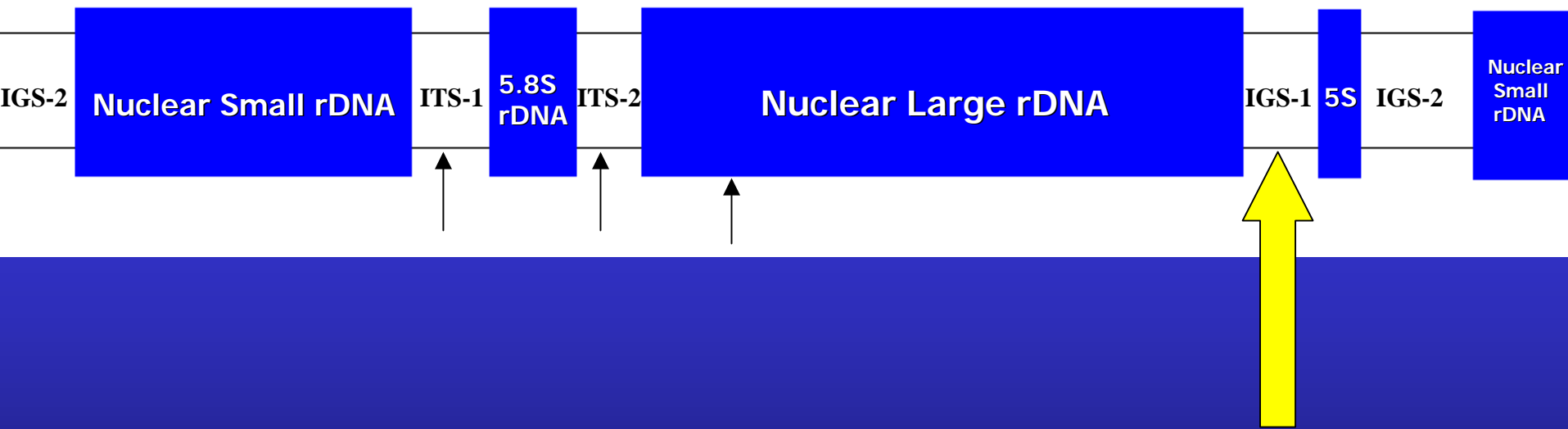
- Prescribed burning
- Planting white pine
- Fertilization (?)

Armillaria ostoyae - Rocky Mountain Research Station Collections

-  BOISE
-  IFTNC
-  USDA-FS



These regions of rDNA repeat many times



We amplify all the repeats of the IGS-1 region for a given isolate, then we obtain an IGS-1 region sequence

Phylogenetic tree showing genetic diversity of *Armillaria ostoyae*



Armillaria ostoyae - Groups

- NABS I - Group A
- NABS I - Group B
- NABS I - Group C
- NABS I - Group D

Armillaria ostoyae - Hybrids

- NABS I - A x B hybrid
- NABS I - A x C hybrid
- NABS I - B x C hybrid

Management Practices

Enterprise

- A. ostoyae Genet 1
- A. ostoyae Genet 2
- ★ Bark Fans Live Trees
- ☆ Bark Fans Dead Trees
- × Plot corners
- × Plot centers

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200 N & 0K

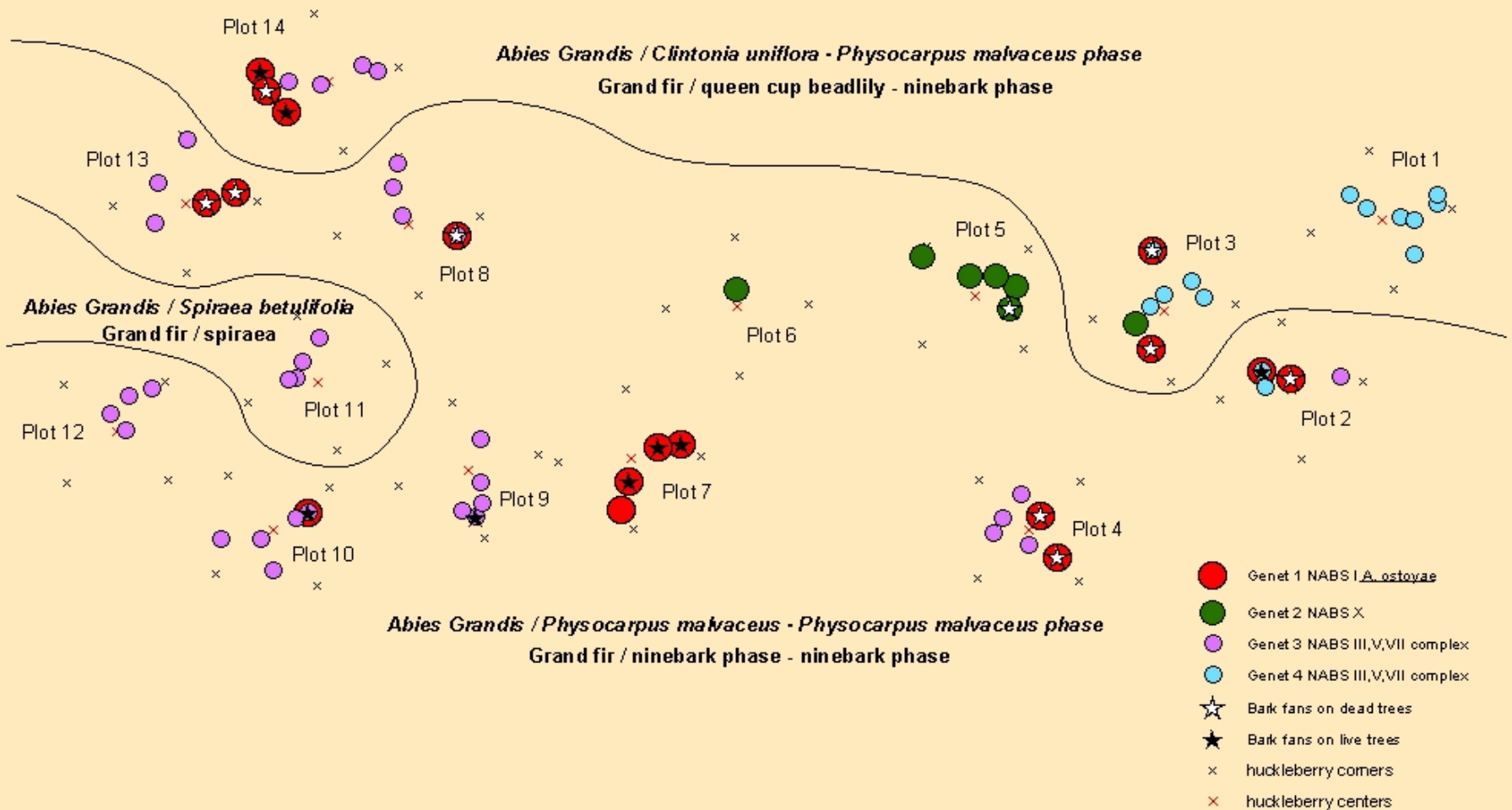
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600N & 0K

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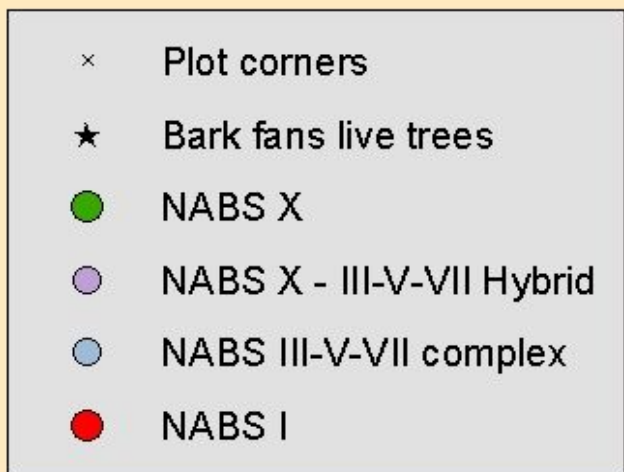
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200K

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Soldier Creek



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Stanton Armillaria Distribution

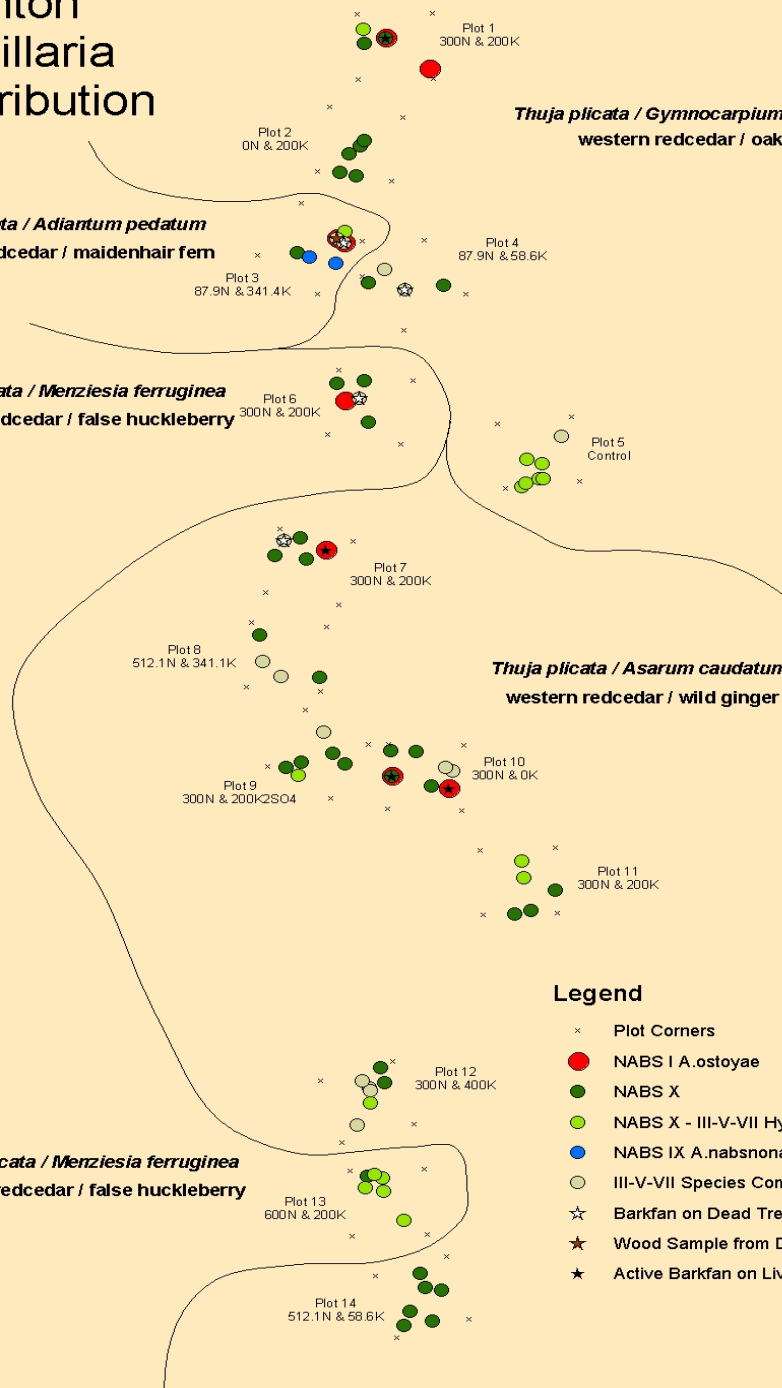
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Each species, hybrid, or grouping of *Armillaria* may occupy different preferred habitat type ranges.

Habitat Type is based on

Moisture

Light

Temperature

 Soil Characteristics

Rock Types

Armillaria is a primary driver of forest ecosystems in the Inland Northwest.

Not all *Armillaria* species are the same and not all individuals from the same species are the same.

Management decisions on sites where *Armillaria* is a problem are likely to be site specific and should include the consideration of which *Armillaria* species are present as well as habitat, soil, and rock type conditions.

Acknowledgements

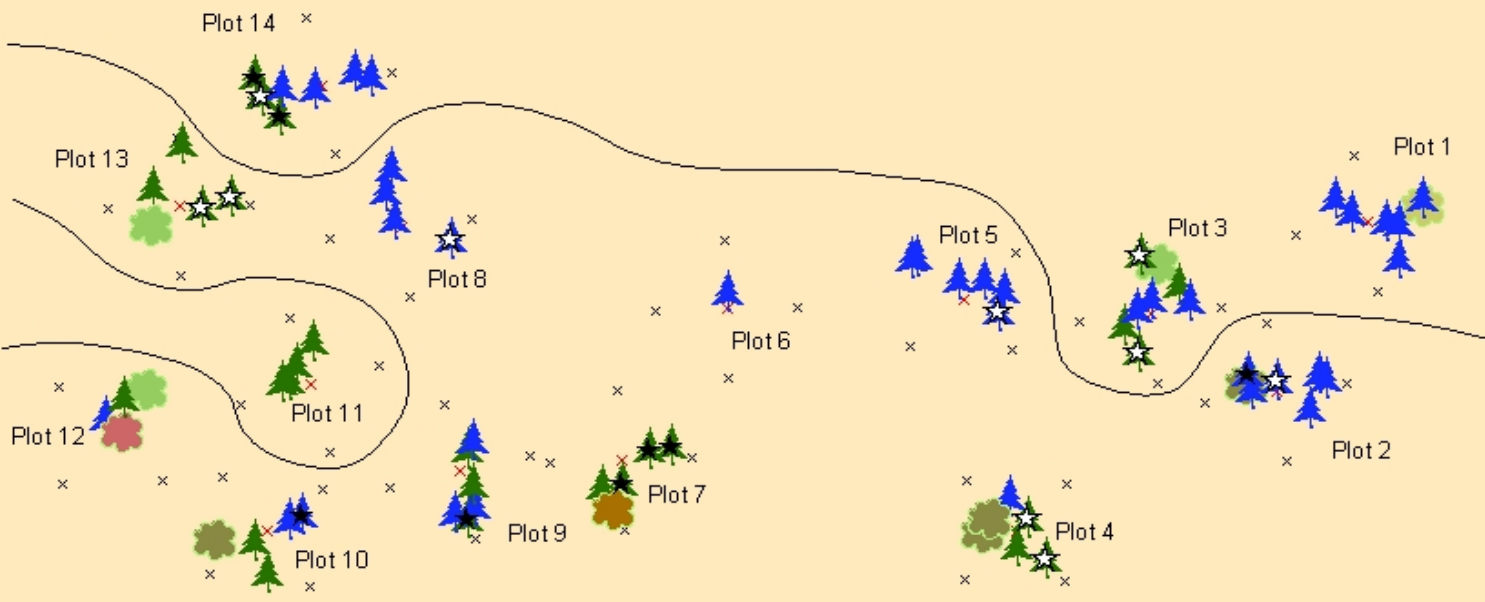
**Intermountain Forest Tree
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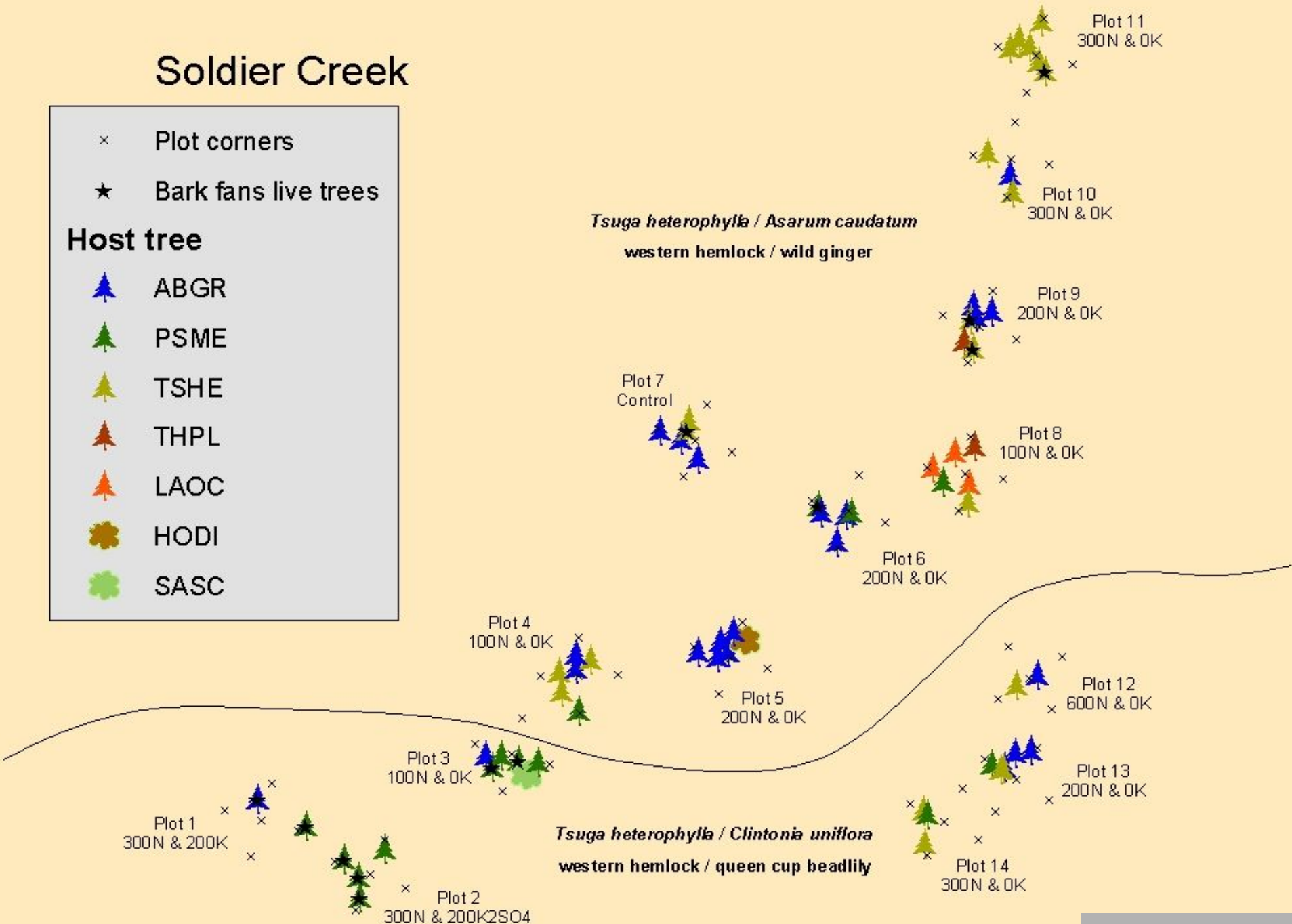
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Huckleberry

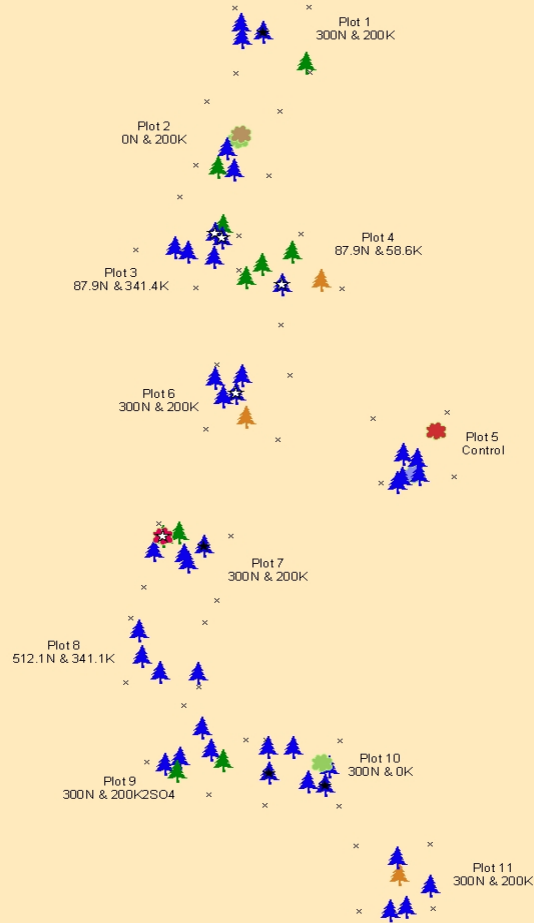


- Host tree**
- ABGR
 - PSME
 - ACGL
 - AMAL
 - HODI
 - SASC
 - ALNUS
 - ☆ Bark fane on dead trees
 - ★ Bark fane on live trees
 - × corners
 - × centers

Soldier Creek



Stanton Armillaria Host Trees



Legend

x Plot Corners

Host Type

-  ABGR
-  PSME
-  LAOC
-  THPL
-  PREM
-  ACGL
-  HARDWOOD
-  VAGL
-  ALNUS
-  Wood Sample from Dead Tree
-  Barkfan on Dead Tree
-  Active Barkfan on Live Tree

