New perspectives on aspen in the western US: phylogeography, regeneration ecology, and triploidy

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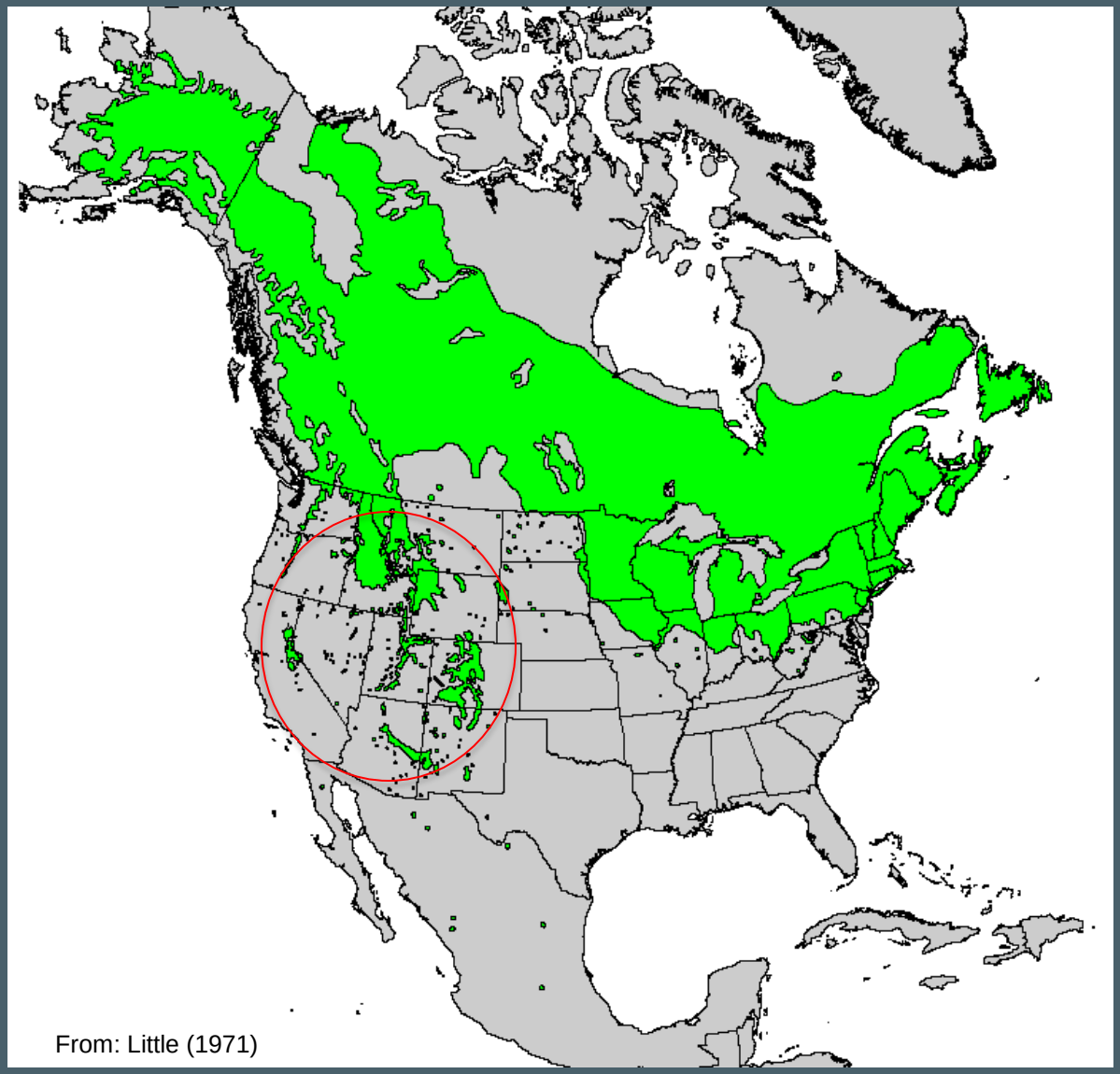
Swan Flat, Logan Canyon

1) Clonal dynamics & reproductive ecology

2) Phylogeography

3) Triploidy

Spatial & Ecological Amplitude



suckering → large clones

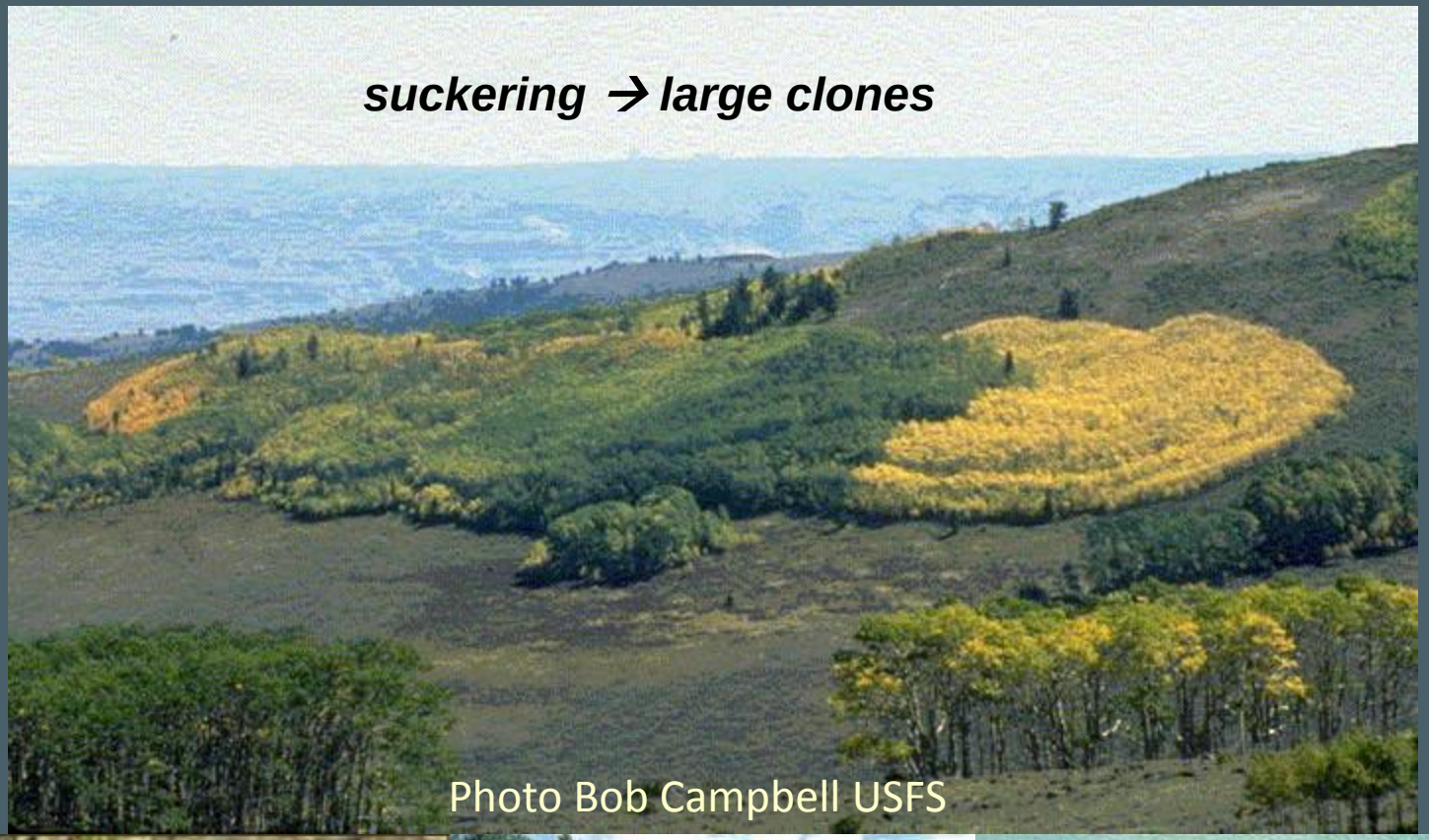


Photo Bob Campbell USFS

Aspen suckers from horizontal roots near the surface

Photo © University of Minnesota Extension

Pronounced phenotypic differences among clones

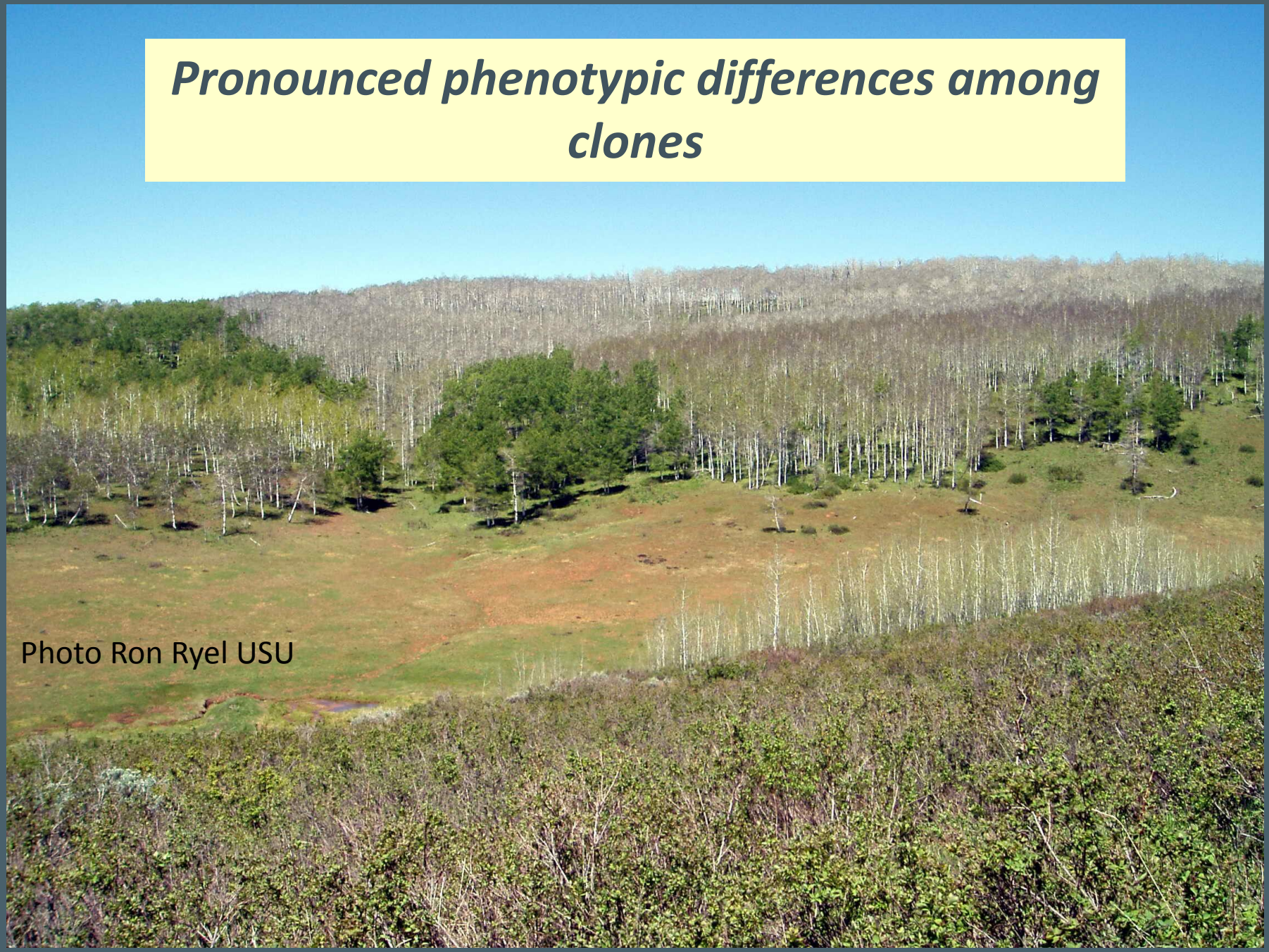


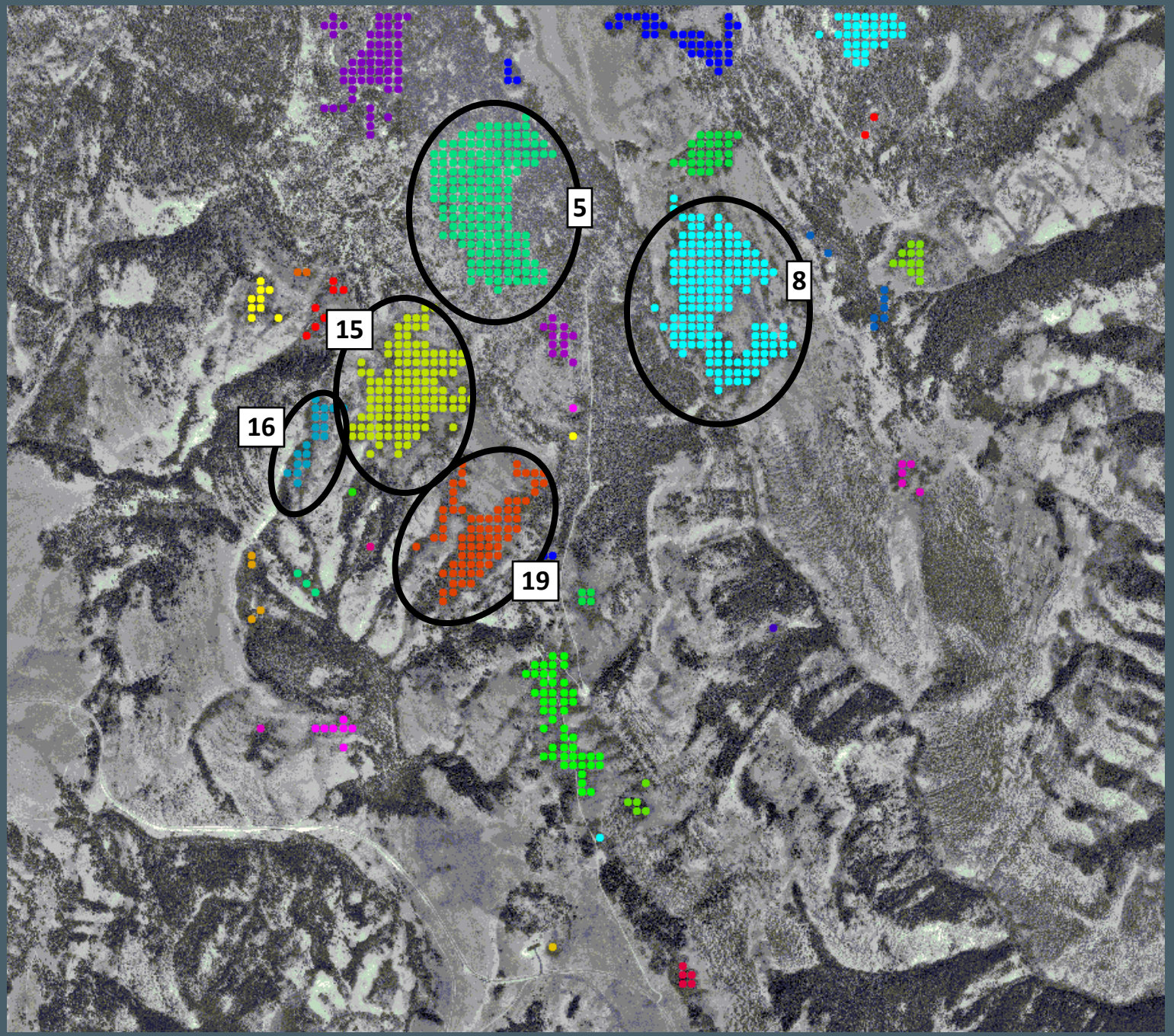
Photo Ron Ryel USU

Traditional View of Western Aspen Regeneration Ecology

Ancient clones & little or no sexual reproduction

Implications:

- establishment by seed long ago (diff't climate?)
- subdivided clones
- low clonal diversity
- permanent loss from landscapes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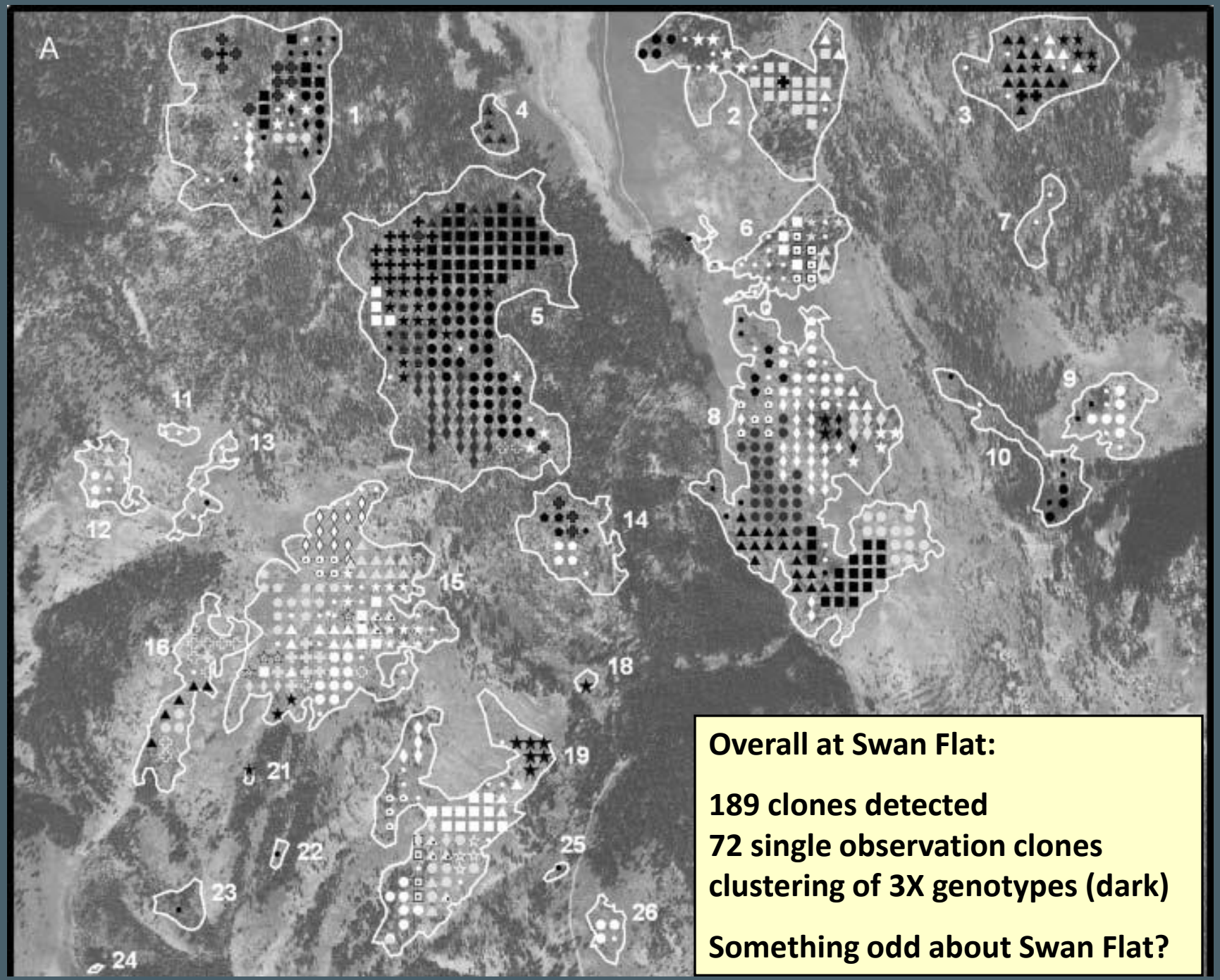
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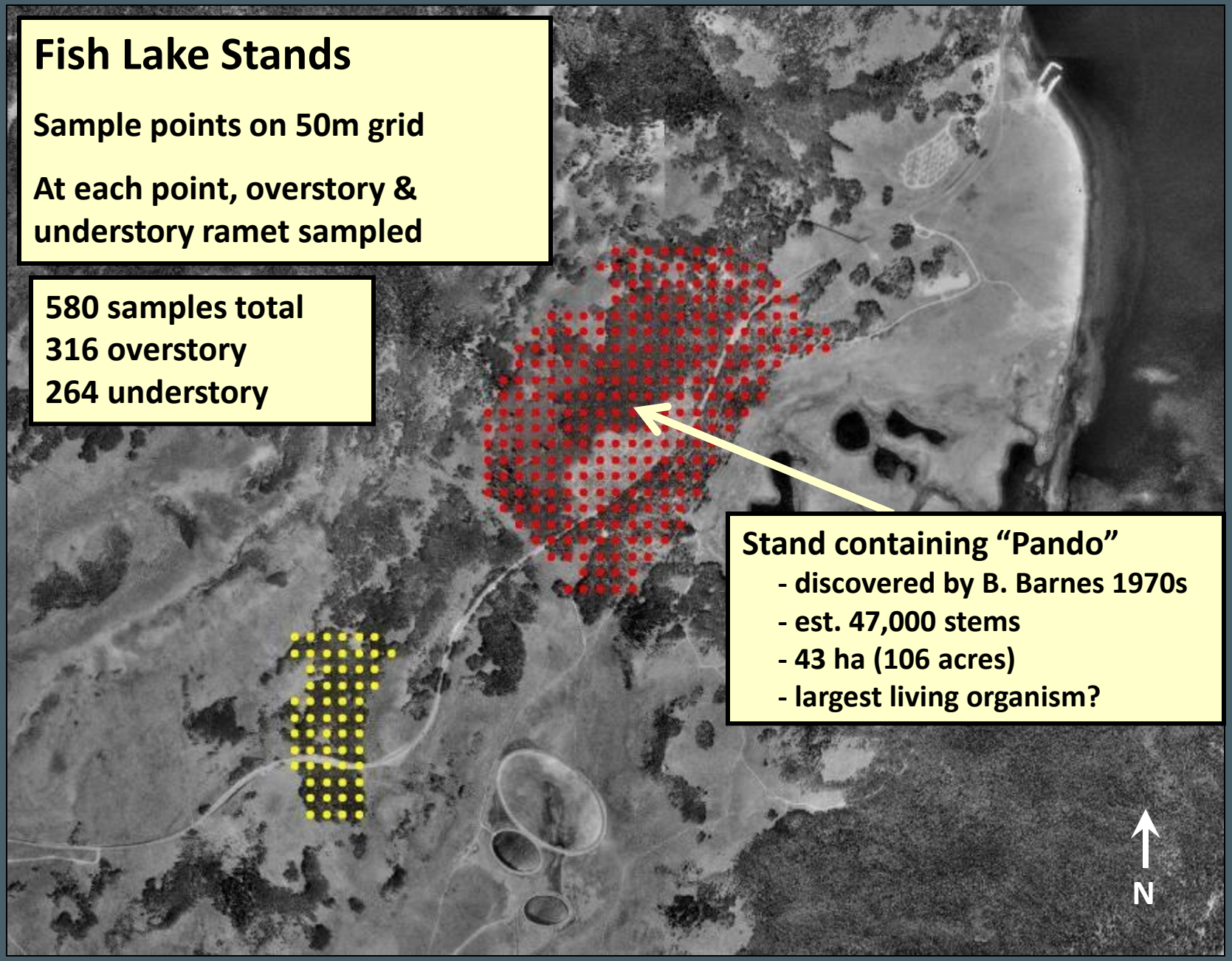
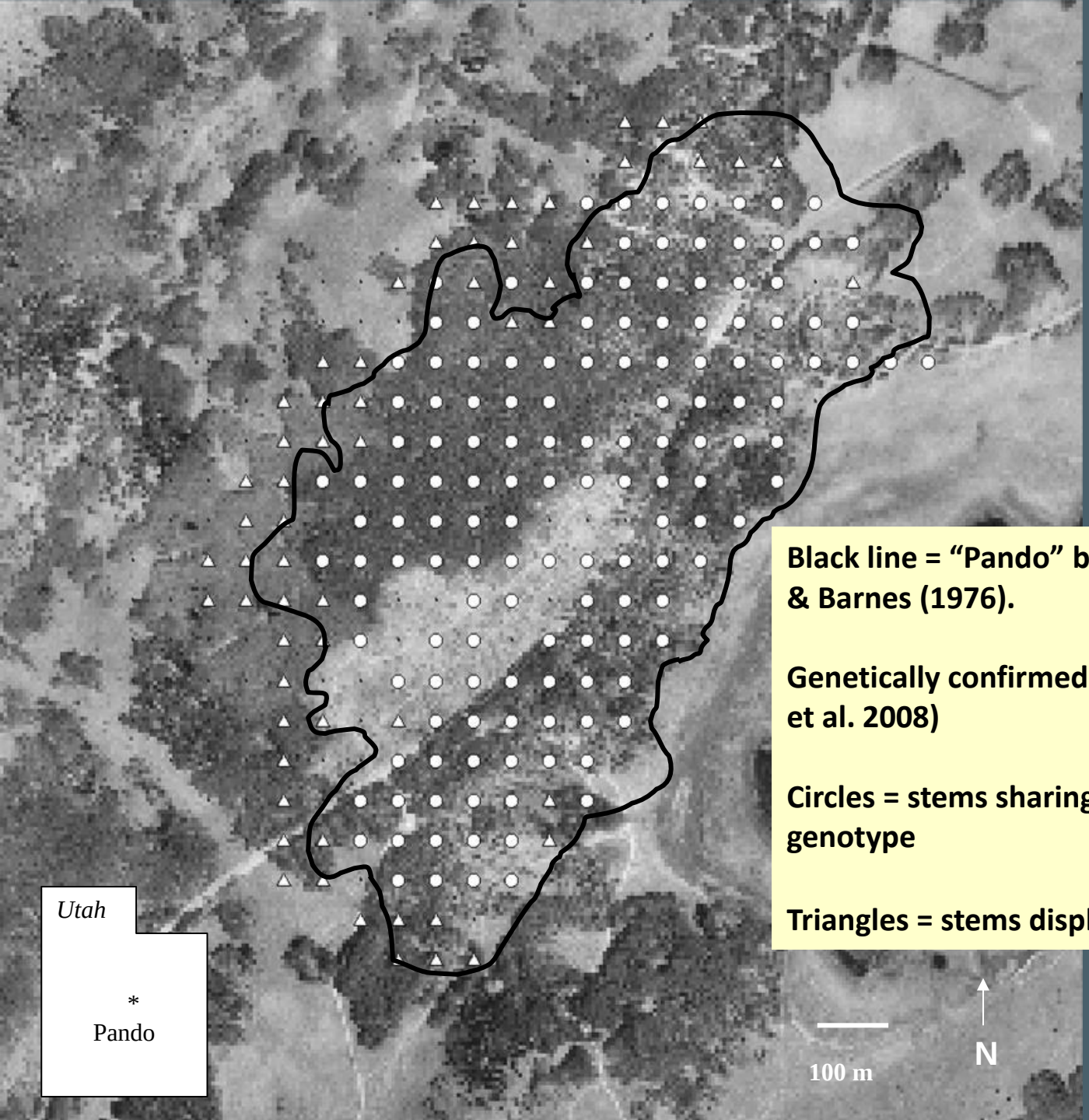
Overall at Swan Flat:
189 clones detected
72 single observation clones
clustering of 3X genotypes (dark)
Something odd about Swan Flat?


Fish Lake Stands
Sample points on 50m grid
At each point, overstory & understory ramet sampled
580 samples total
316 overstory
264 understory
Stand containing “Pando”
- discovered by B. Barnes 1970s
- est. 47,000 stems
- 43 ha (106 acres)
- largest living organism?
N



Black line = "Pando" boundary from Kemperman & Barnes (1976).

Genetically confirmed as ONE CLONE (DeWoody et al. 2008)

Circles = stems sharing the dominant "Pando" genotype

Triangles = stems displaying <u>other</u> genotypes.

Fish Lake Study Area

- **sampled 580 trees**
- **detected 61 genetically distinct clones**
- **most clones consisted of 1-2 ramets (i.e. many more clones were likely missed)**
- **only 3 of the 61 clones had > 10 ramets**
- **most understory samples matched overstory samples**


Photo Darren McAvoy USU


Photo Darren McAvoy USU

Natural aspen seedling establishment inside ponderosa pine plantations following Pumpkin fire (2000):

- *aspen showed up in 9 out of 16 plantations*
- *70 seedlings, 5-10 year old*
- *No aspen in area previously*
- *genetically all unique*
- *Fairweather et al. 2014 Forest Science*

Photo 2010 by Mary Lou Fairweather (USFS)

Photo 2010 by Mary Lou Fairweather (USFS).

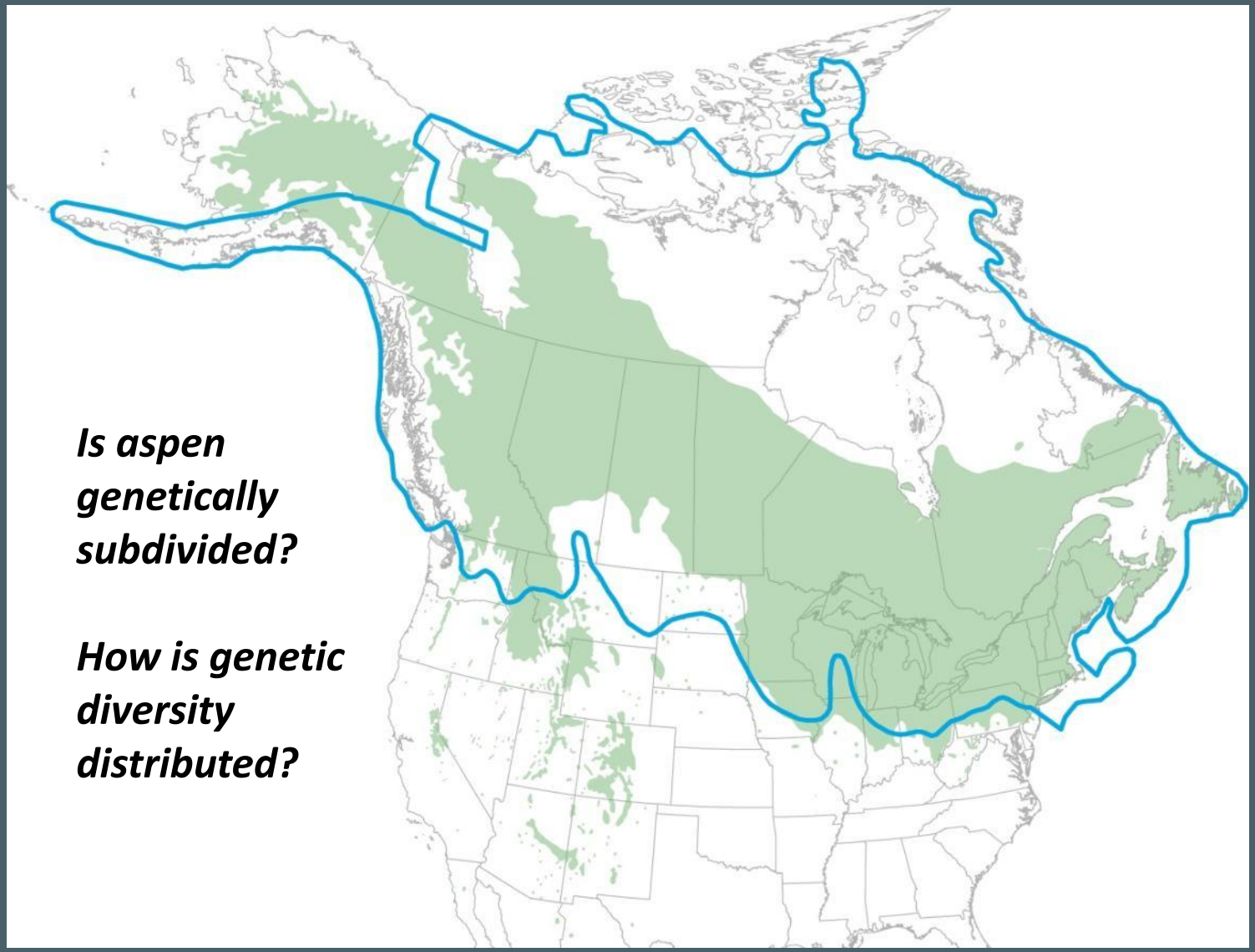
Aspen seeding event following 2010 Schultz fire in northern Arizona

(2011 photos by Mary Lou Fairweather, USFS)

Conclusions:

- pattern of clonal sizes suggest signatures of past seeding events
- recent seeding events suggest rain of fertile aspen seeds
- seedlings are surviving when protected from herbivory
- unlikely that sexual reproduction and clonal diversity are negligible, even in western landscapes.
- seeding events are likely episodic, but are 'windows of opportunity' for recolonizing new locations, increasing genetic diversity, and increasing adaptive potential.

Phylogeography



Is aspen genetically subdivided?

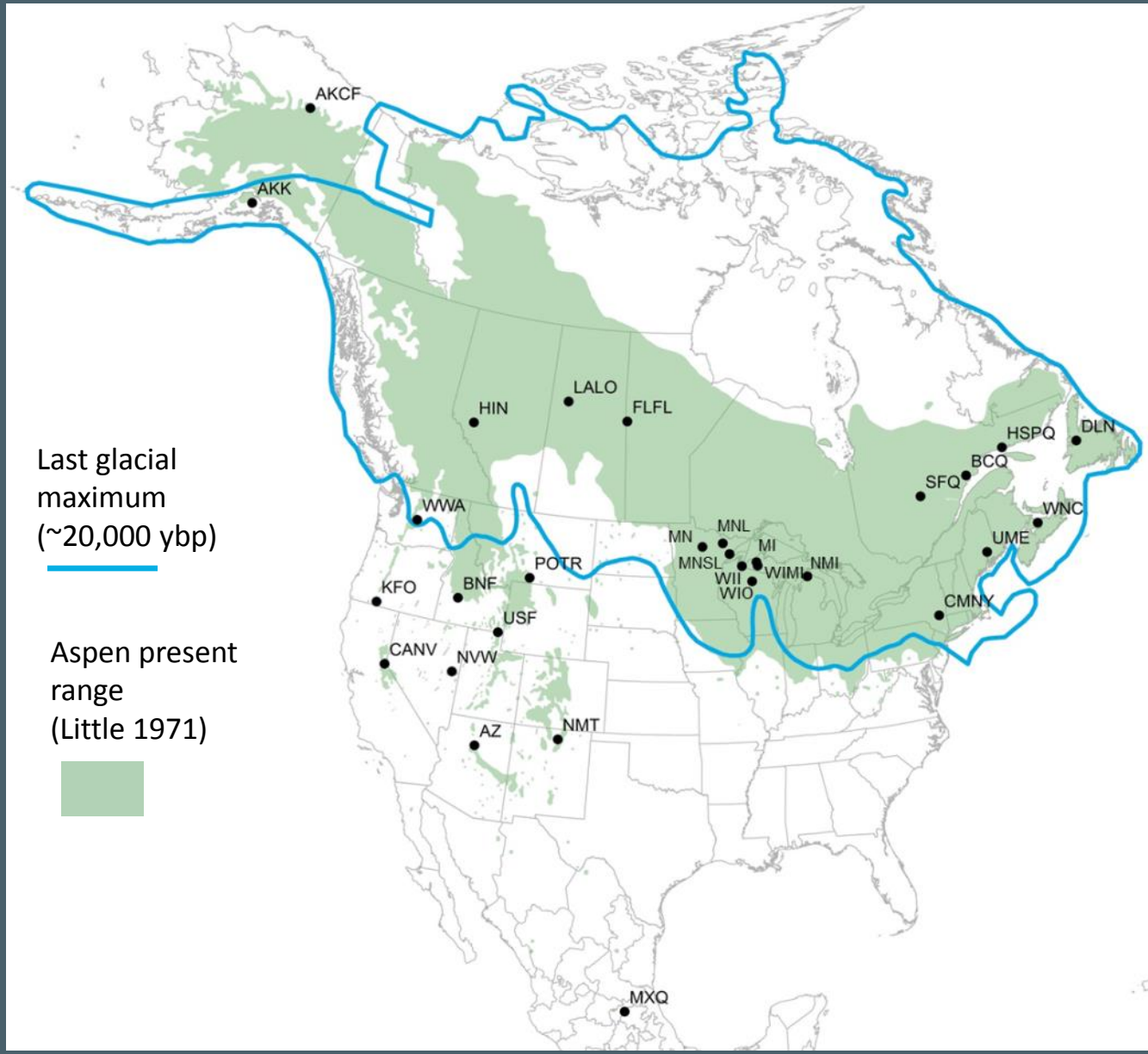
How is genetic diversity distributed?

Phylogeography Results

Based on genetic data from >1200 trees in 39 populations….

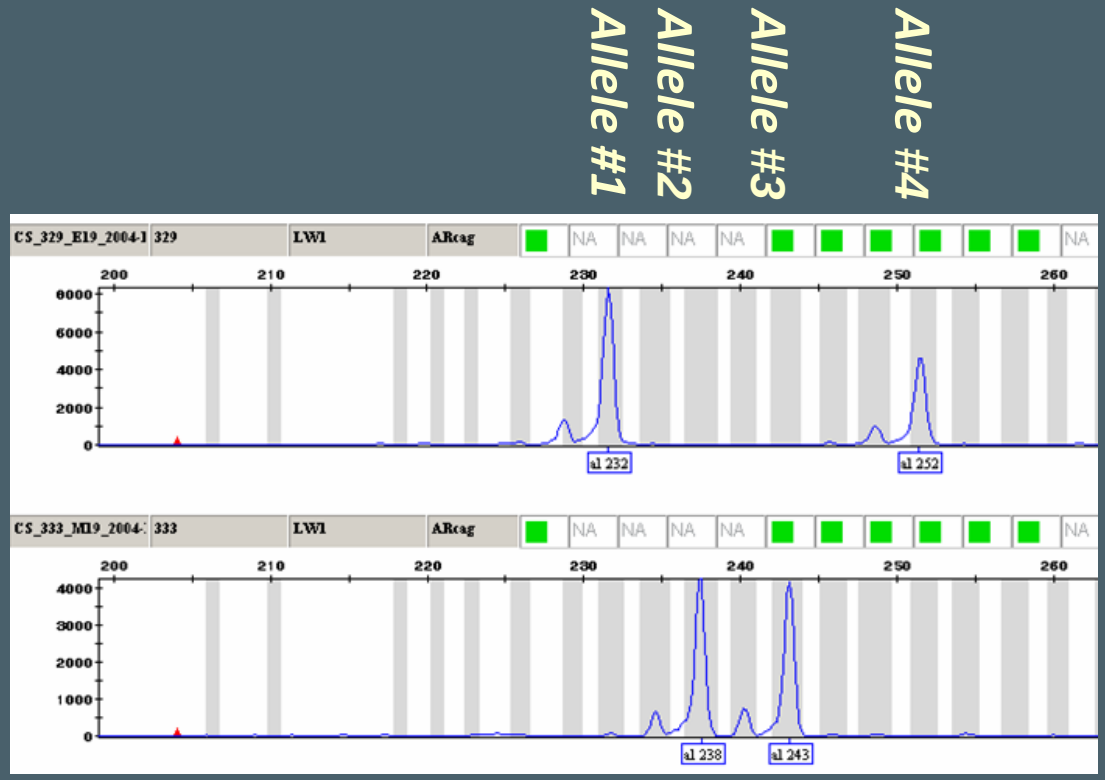
Is aspen genetically subdivided?

How is genetic diversity distributed?



Genetic tools: microsatellites

Highly variable nuclear genetic markers that can be used to distinguish individuals and populations

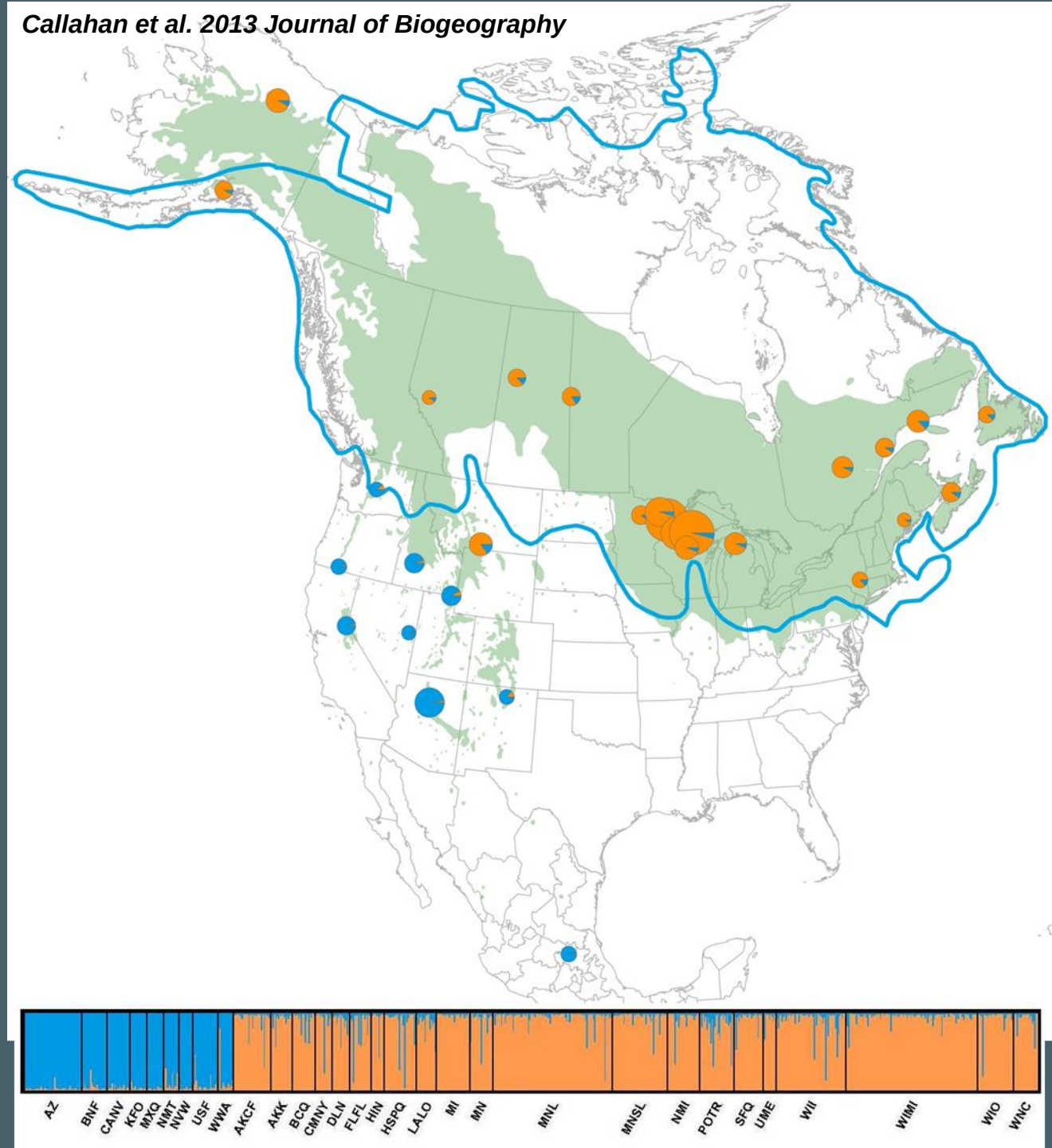


Phylogeography Results

Is aspen genetically subdivided?

YES,
There is a SW and a Northern cluster,

Distinct boundaries at this scale



Phylogeography Results

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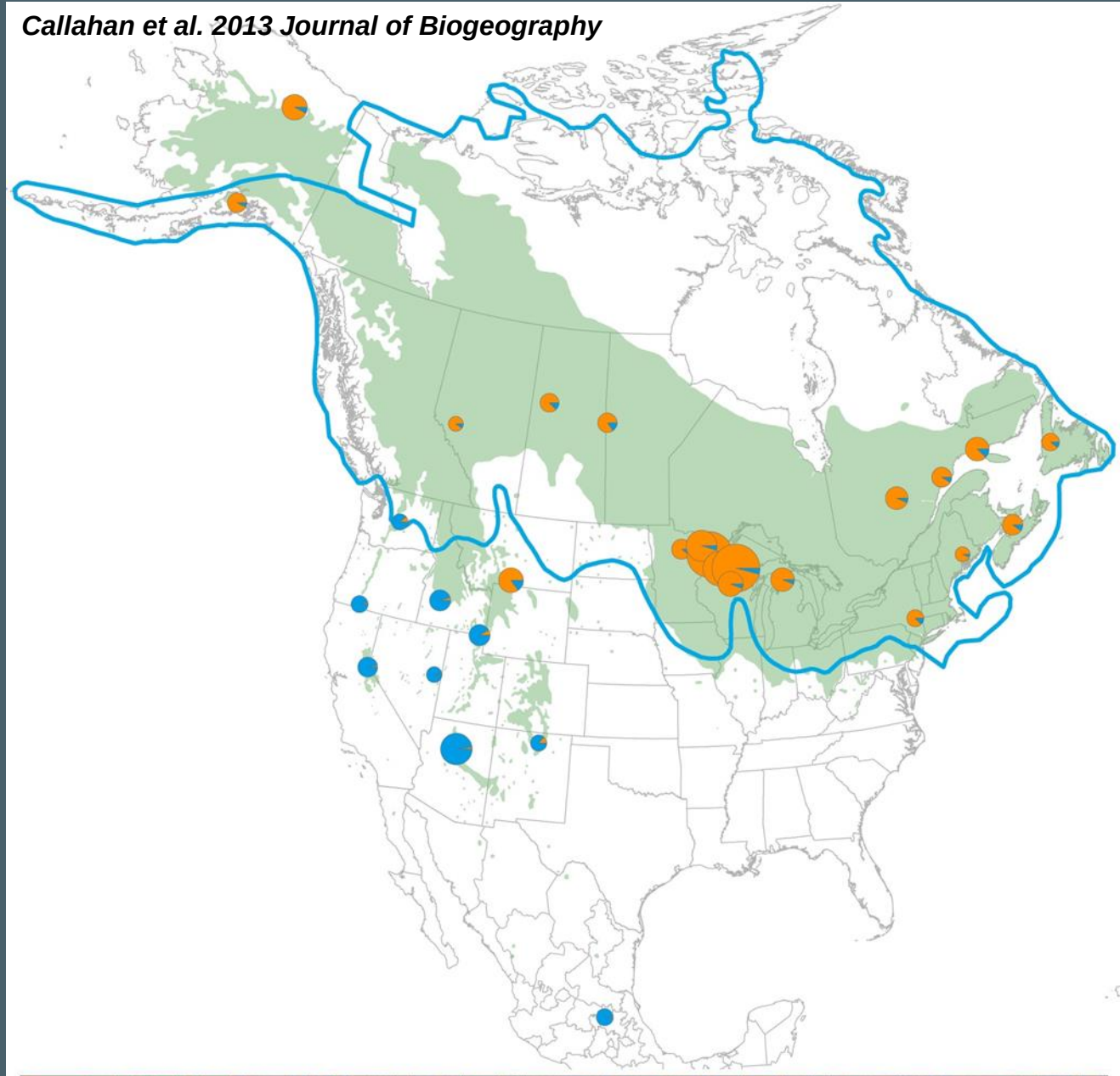
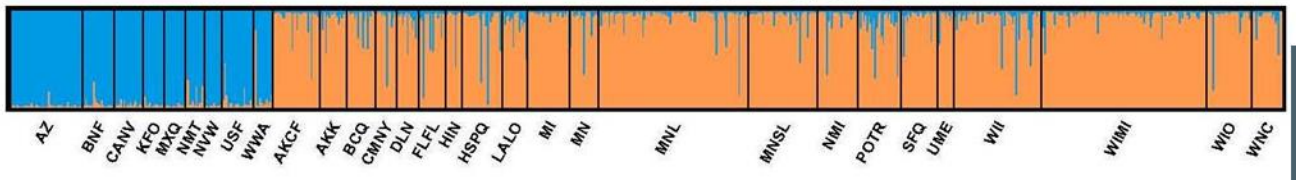
Distinct boundaries at this scale

The post-glacial expansion of aspen did <u>not</u> come from the SW.

Callahan et al. 2013 Journal of Biogeography





Phylogeography Results

Is aspen genetically subdivided?

YES,
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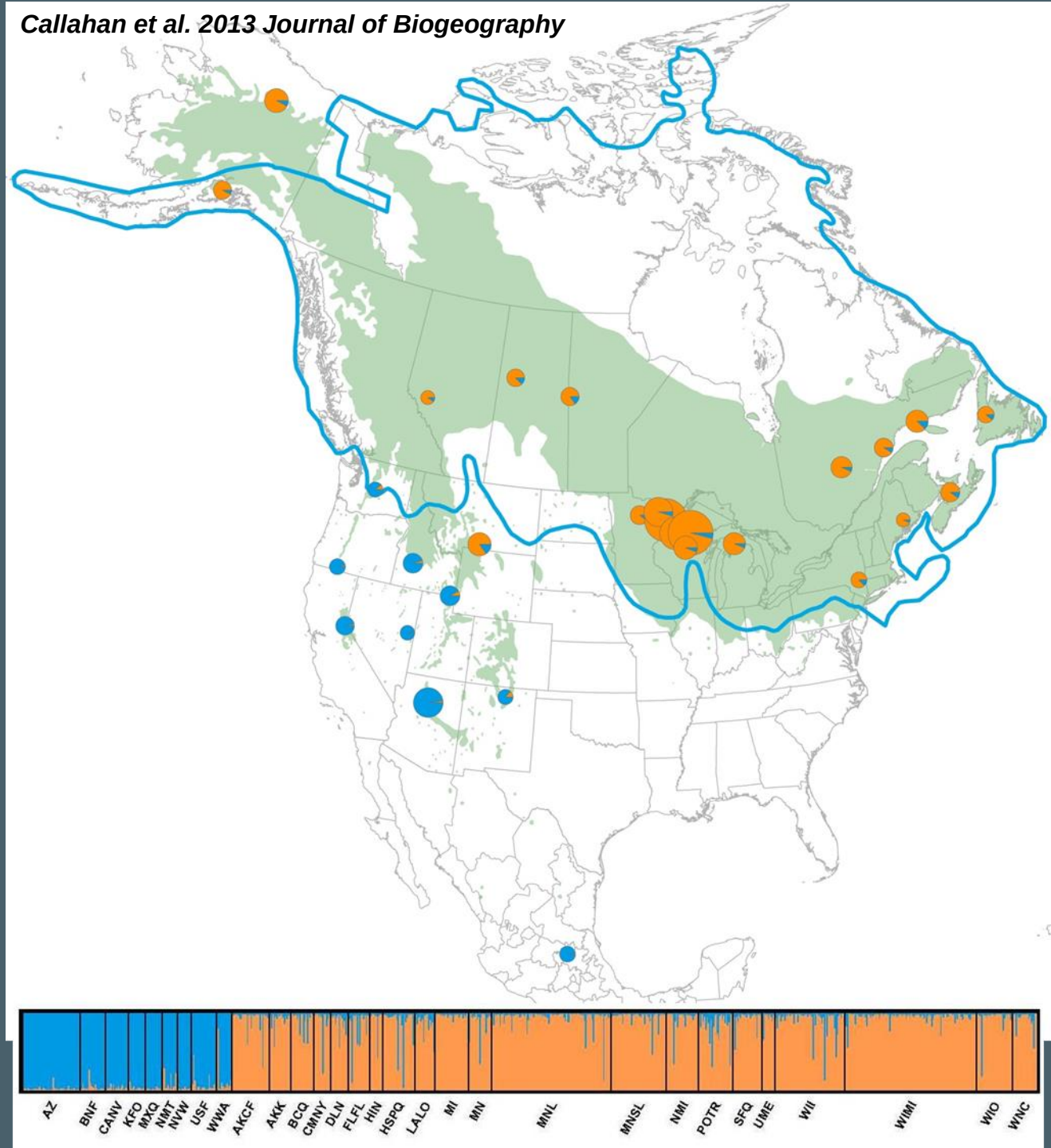
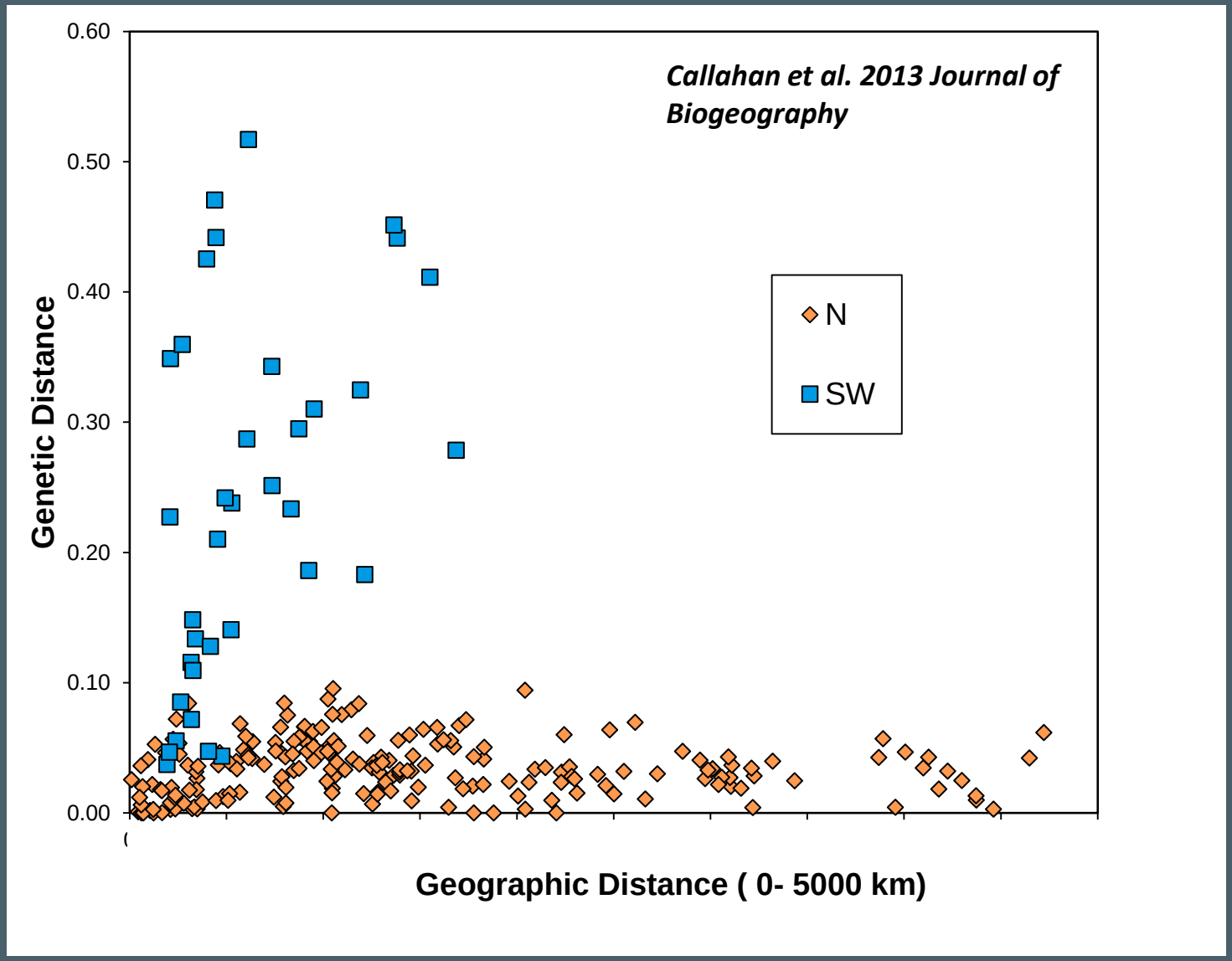
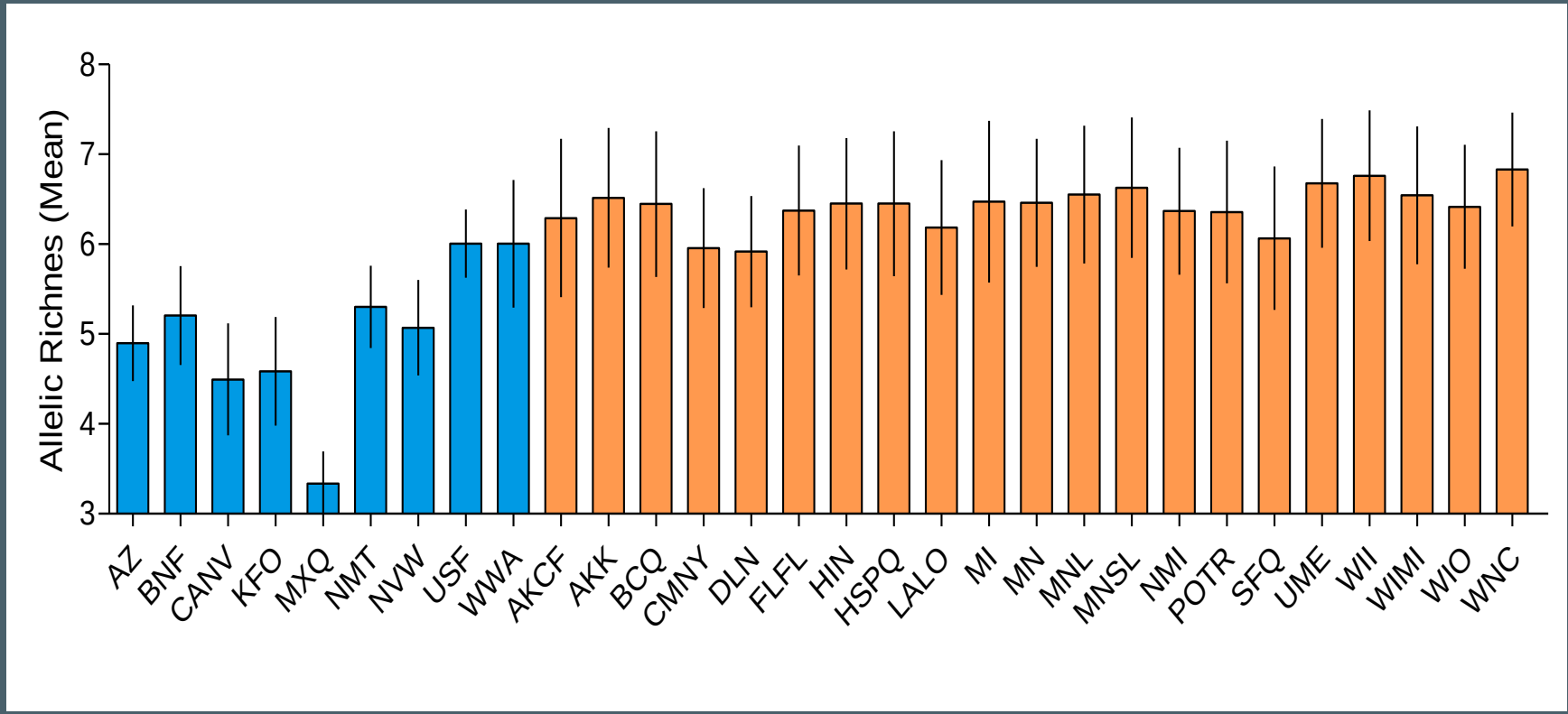
ADAPTIVE differences??



Northern populations are very similar to each other, SW populations are genetically distinct (consistent with isolation and genetic drift)



SW group: generally lower within-population diversity than N group

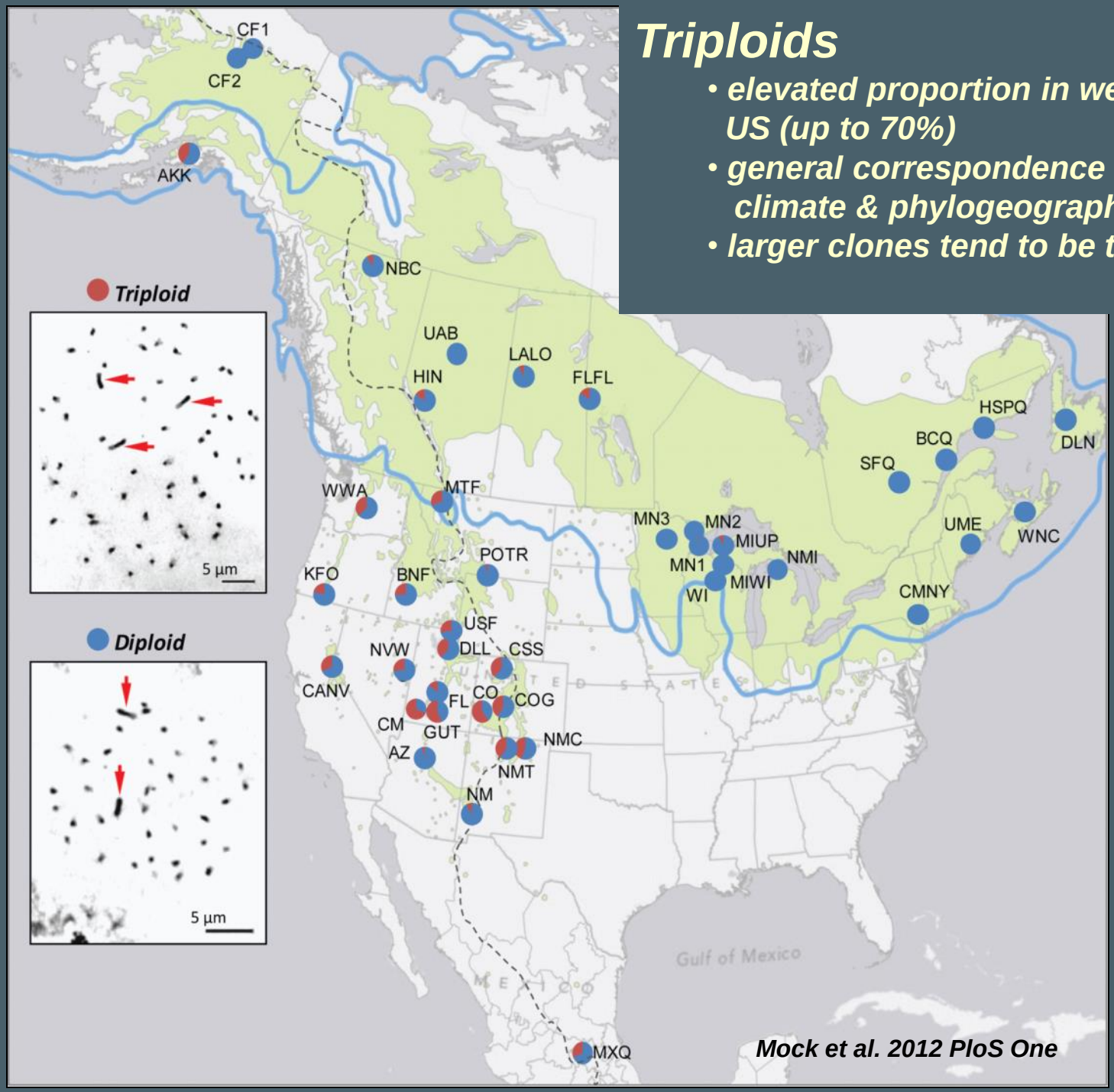


Management Implications (Phylogeography):

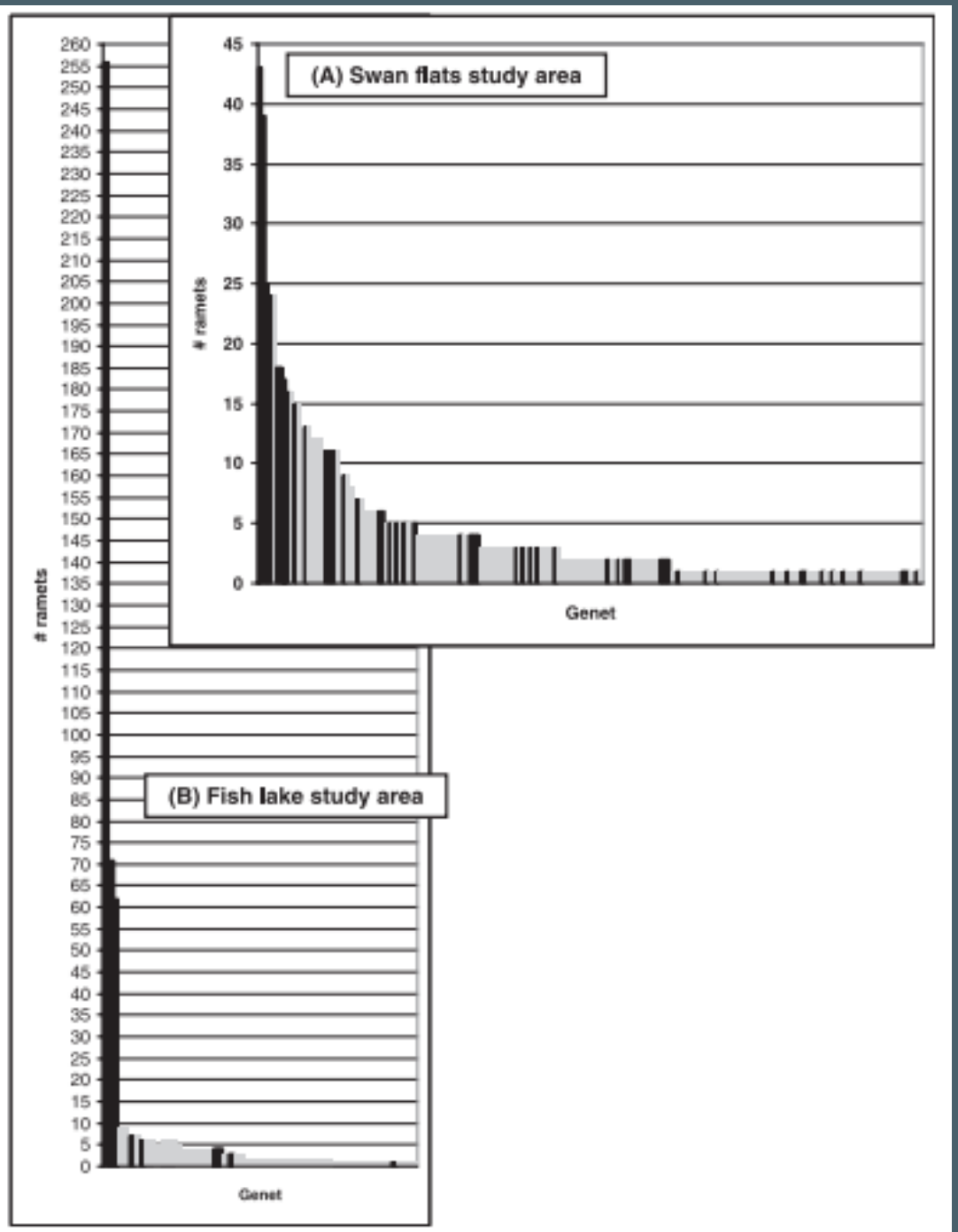
- **Different genetic clusters (N, SW) may be different ecotypes, which would impact germplasm transfer recommendations and assisted migration programs.**
- **Isolation and low within-population diversity in SW may become a problem as aspen habitats shrink with climate change.**
- **Research done only in the N or SW may not be relevant to aspen in both regions…aspen in these regions may respond differently to herbivory, diseases, climate, management, etc.**

Triploids

- *elevated proportion in western US (up to 70%)*
- *general correspondence with climate & phylogeography*
- *larger clones tend to be triploid*



Mock et al. 2012 PloS One

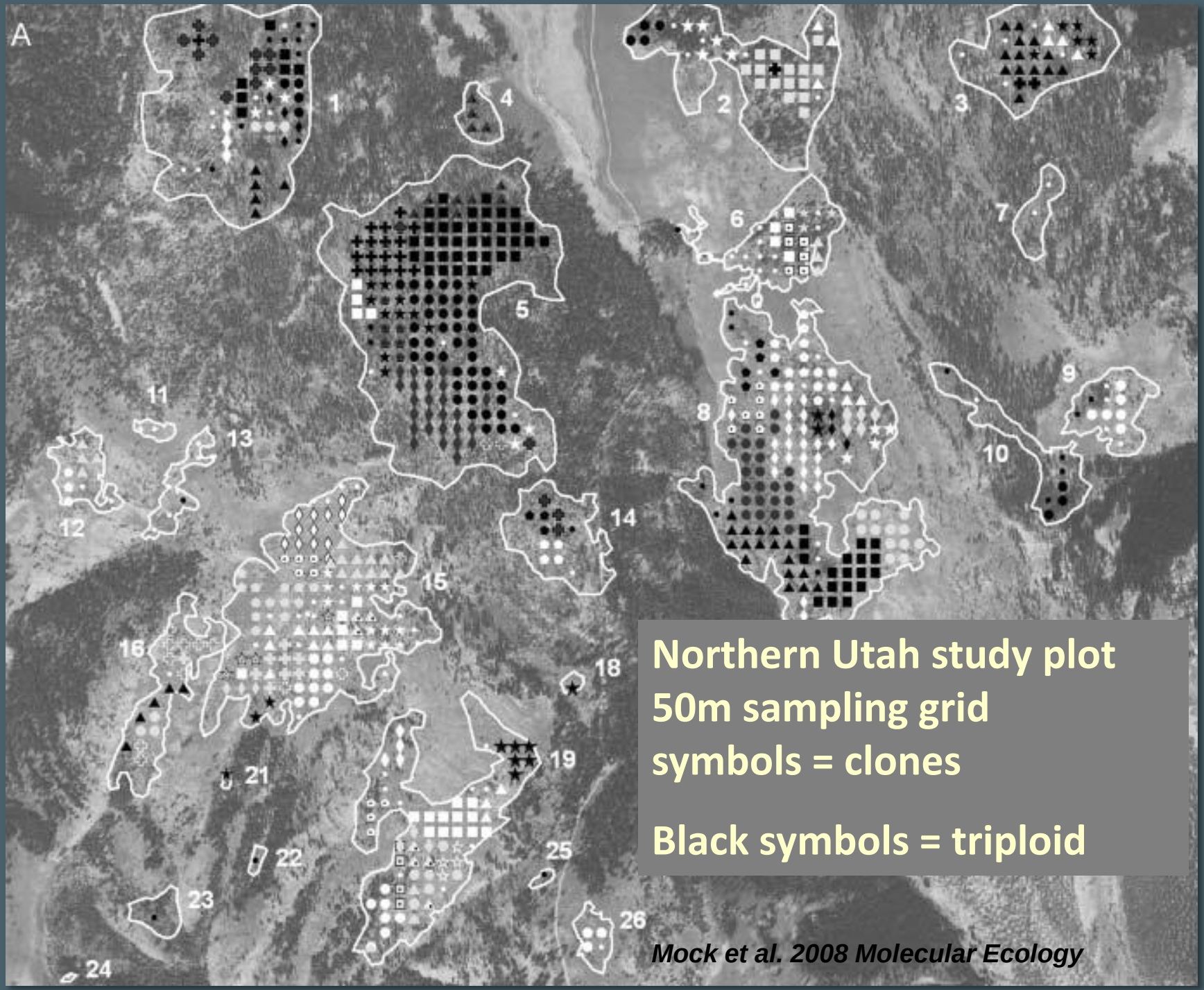


Distribution of clone sizes (# stems) in western US:

Larger clones tend to be triploids.

black = triploid clones
gray = diploid clones

Mock et al. 2008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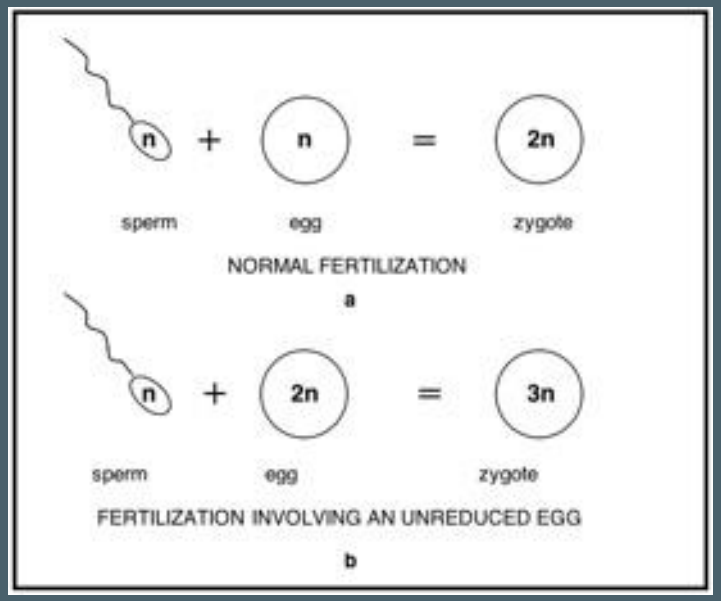
Northern Utah study plot
50m sampling grid
symbols = clones
Black symbols = triploid
Mock et al. 2008 Molecular Ecology

What we know about triploids



http://www.macroevolution.net/polyploid.html#.VDGUtfmhmuk

- Triploids likely result from union of unreduced (2x) gametes with normal (1x) gametes.
- Unreduced gametes, and hence triploids, should be quite rare. So if triploid clones are common, suggests strong selection.
- Triploid individuals should have very low fertility.
- Triploids should have larger cells (physiological advantage/vulnerability?)
- Better defended chemically? (Gardner, unpublished)
- Greater incremental growth early in stand development? (DeRose et al. in press)

If triploids have some vegetative advantage in western landscapes:

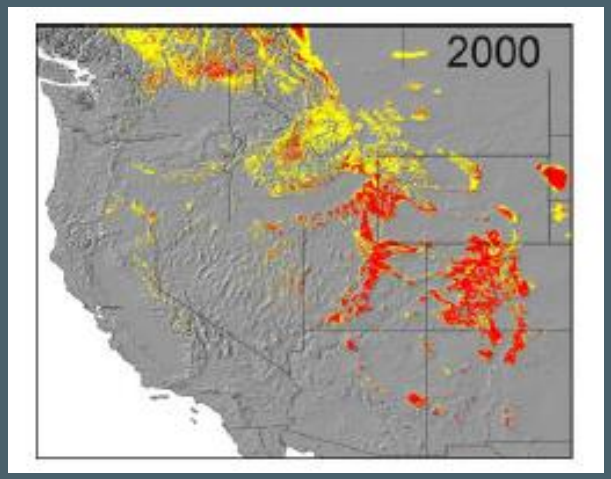
Seeding
- *smaller clones*
- *younger clones*
- *more diploids*
- *higher genetic diversity*
- *more evolutionary potential*

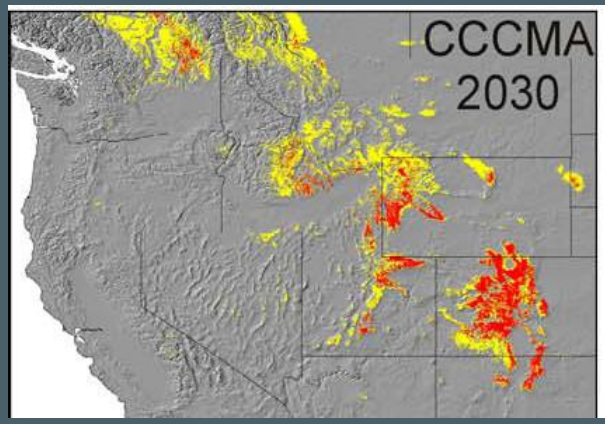
Coppicing

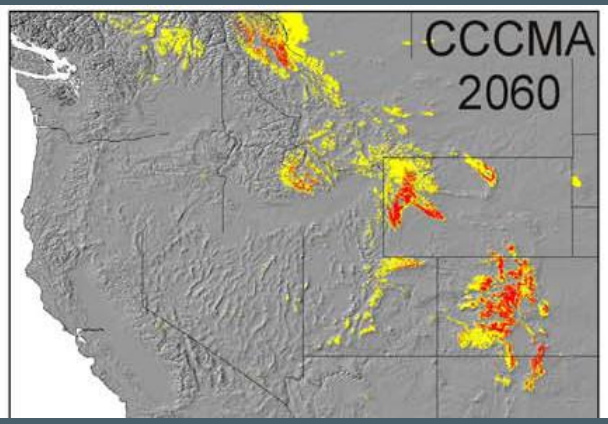
Windows of Opportunity (fire + moisture + low herbivore pressure)

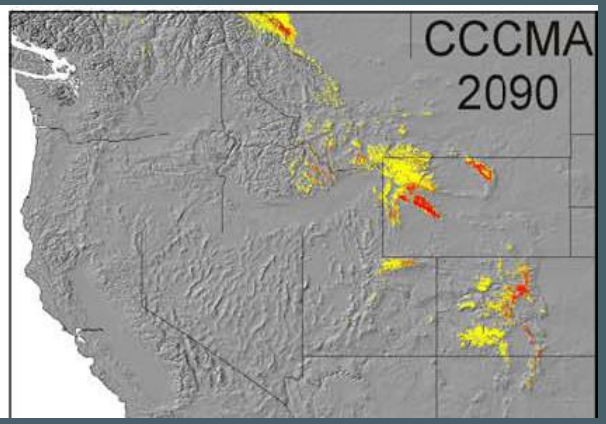
Suckering
- *bigger clones*
- *older clones*
- *more triploids*
- *lower genetic diversity*
- *less evolutionary potential*

Photo:
Mary Lou Fairweather









Bioclimate model predictions: loss of 46-94% of the aspen climate profile in the western US by 2090

Source: ***Rehfeldt et al. 2009 Forest Ecology & Management 58: 2353-2364***

Silvicultural approaches to enhance windows of opportunity for seedling establishment:

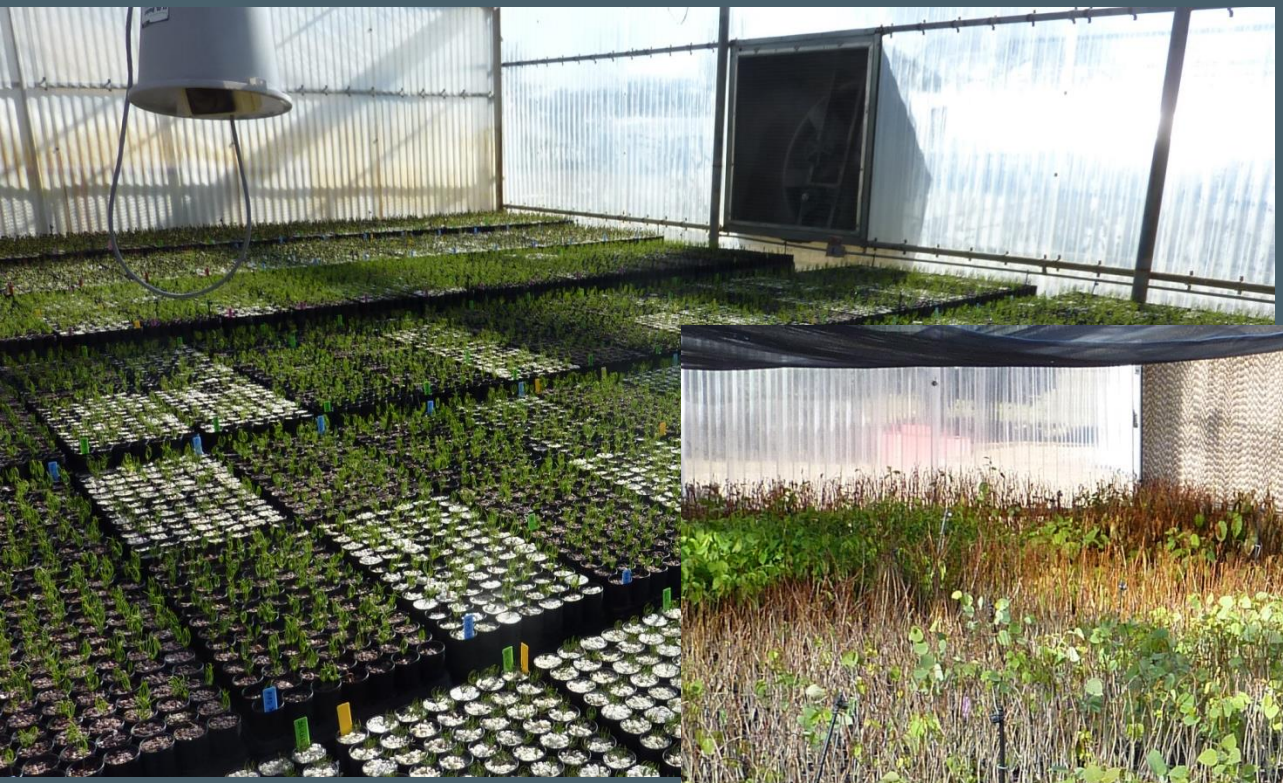
- *Leave seed trees/clones*

Silvicultural approaches to enhance windows of opportunity for seedling establishment:

- *Leave seed trees/clones*
- *Protect natural seedling establishment events (e.g. post fire)*

Silvicultural approaches to increasing establishment of seedlings:

- ***Leave seed trees***
- ***Protect natural seedling establishment events (e.g. post fire)***
- ***Develop protocols for seed sourcing, propagation & planting***



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