Lecture 3.4: Fire effects on vegetation

First-order fire effects

- Occur during or immediately after a fire
- Localized to the burned area

Some examples of 1st order fire effects:

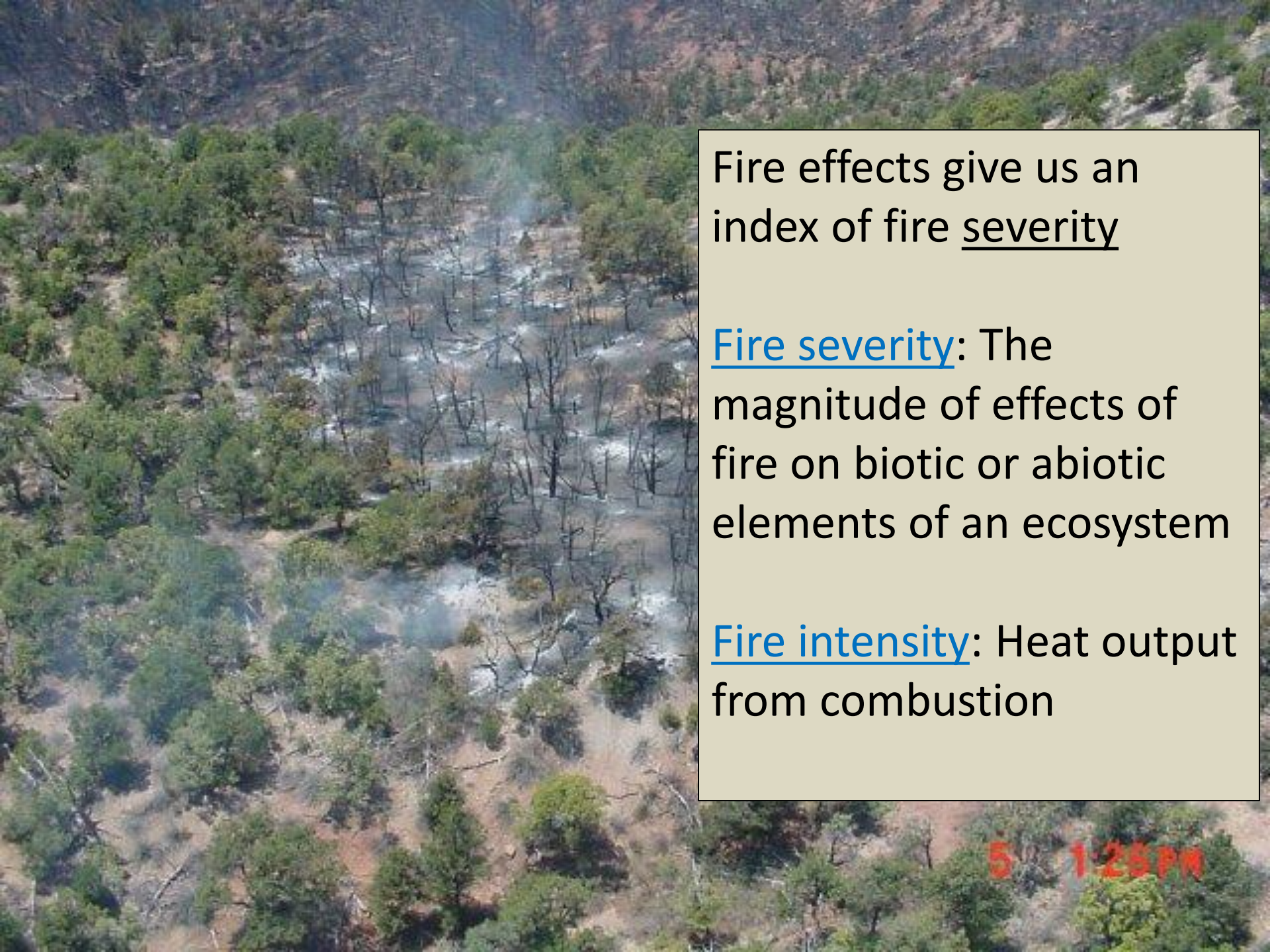
- Burned or scorched foliage
- Tree cambium or meristems killed by heat > 65 ^{o}C
- Terrestrial animal mortality from heat exposure
- Mortality of aquatic organisms from heating of streams
- Litter or duff layers consumed (fine fuels)
- Germination of seeds that use smoke as a “cue”
- Structure and chemistry of soil profile altered by heating
- Smoke effects on air
- Release of sequestered carbon into the atmosphere
- Volatilization of soil nitrogen

Second-order fire effects

- Second-order effects arise as a consequence of first-order effects
- May involve:
  - delayed effects in time
  - displaced effects in space
  - effects on higher levels of biological organization (communities, ecosystems)

Some examples of 2nd order fire effects:

- erosion resulting from rain on damaged soils
- altered competition between species (e.g. fire tolerant *vs.* fire sensitive, trees *vs.* shrubs)
- increased tree growth resulting from available (mineralized) nitrogen
- mass attack of weakened trees by bark beetles
- changes in the abundance and distribution of disease organisms and parasites
- altered age and size structure in species populations resulting from differential mortality
- creates openings in forests and or woodlands



Fire effects give us an index of fire severity

Fire severity: The magnitude of effects of fire on biotic or abiotic elements of an ecosystem

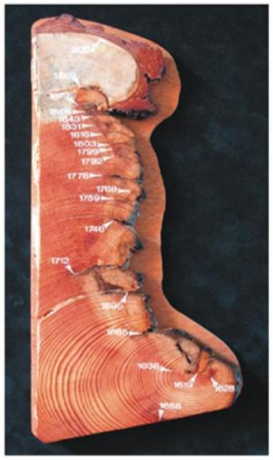
Fire intensity: Heat output from combustion

How does fire affect plants?

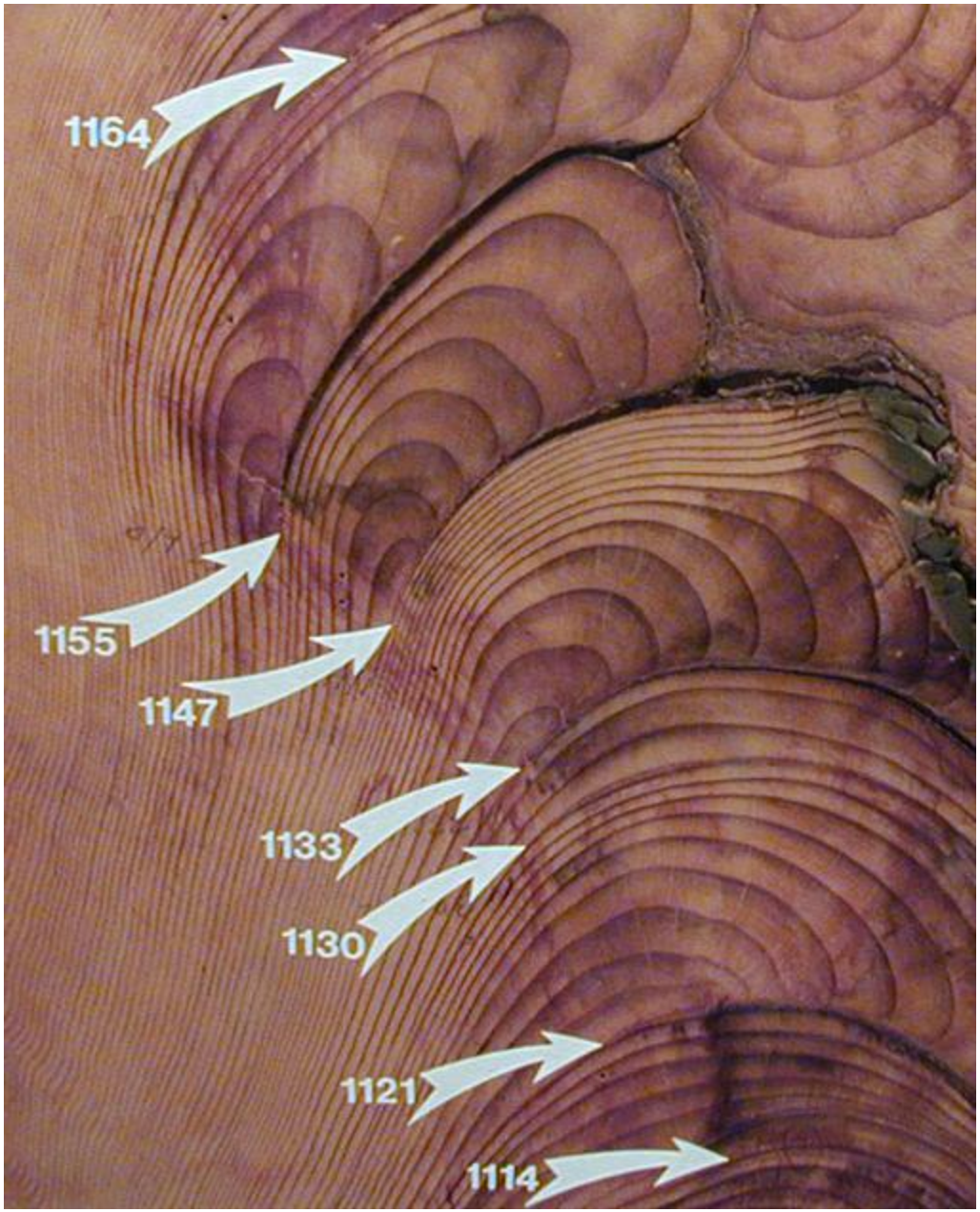
- Individual plants
- Plant populations and communities
- Landscape structure

How do fire scars form on living trees?

In the case of trees (esp. conifers and many temperate angiosperms:



1. Heat penetrates bark and kills cambium (living tissue around circumference of bole)
2. Killed cambium cells can't divide, so growth stops on that radius
3. Tree sends living tissue around the wound and eventually heal
4. Fire scar embedded in subsequent growth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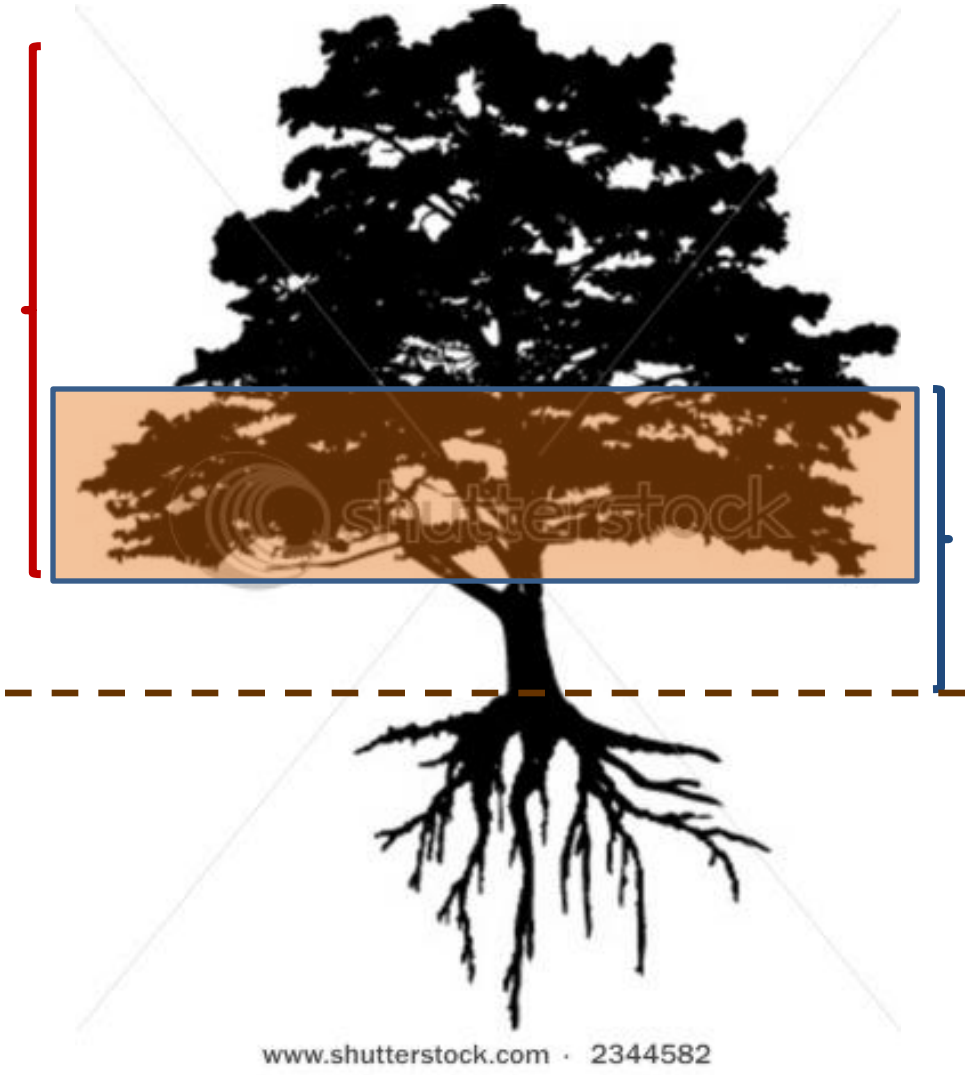
Fire effects on tree canopy (leaves)

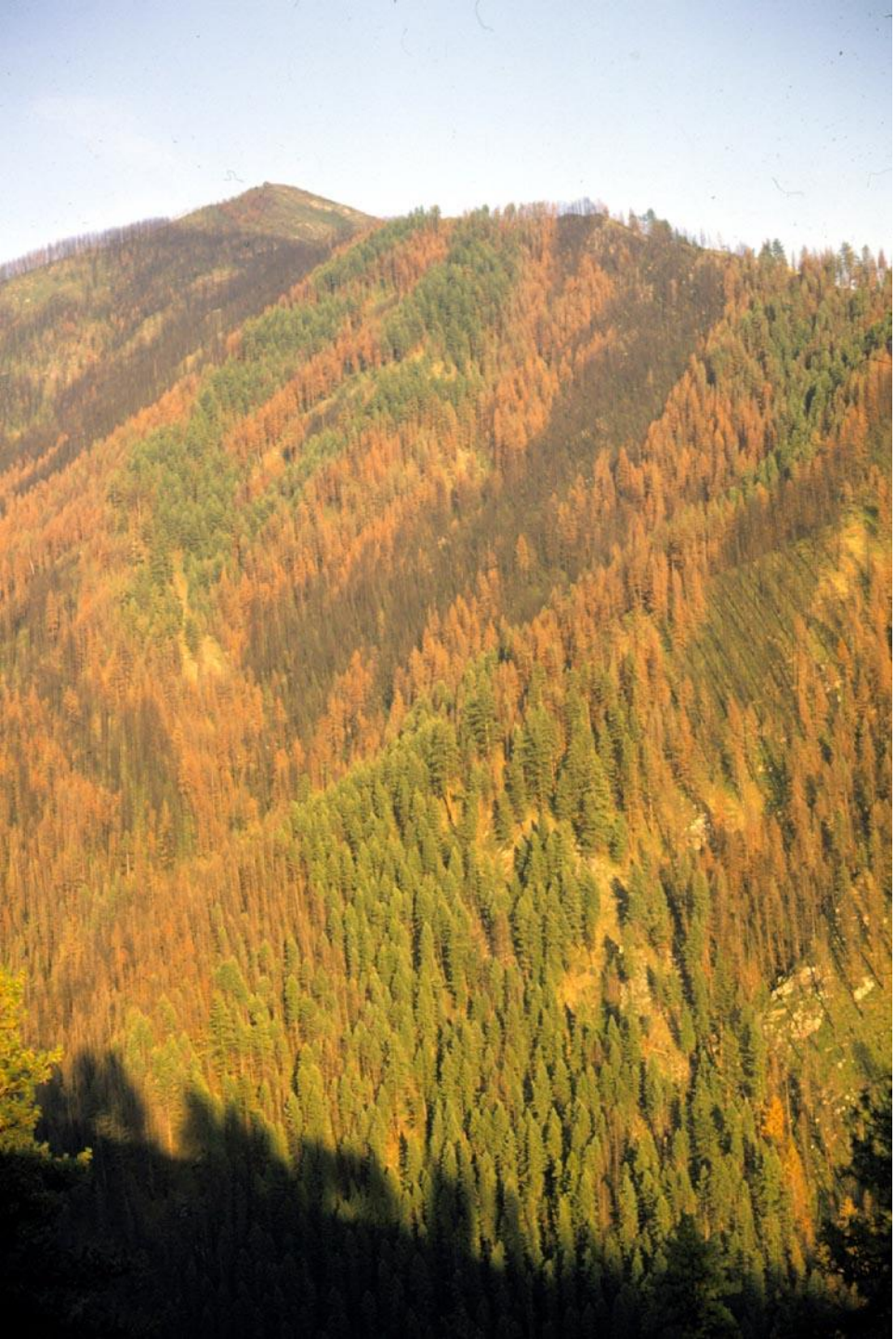
Canopy effects are among the most immediate and visible first-order effects

Measures of canopy effects



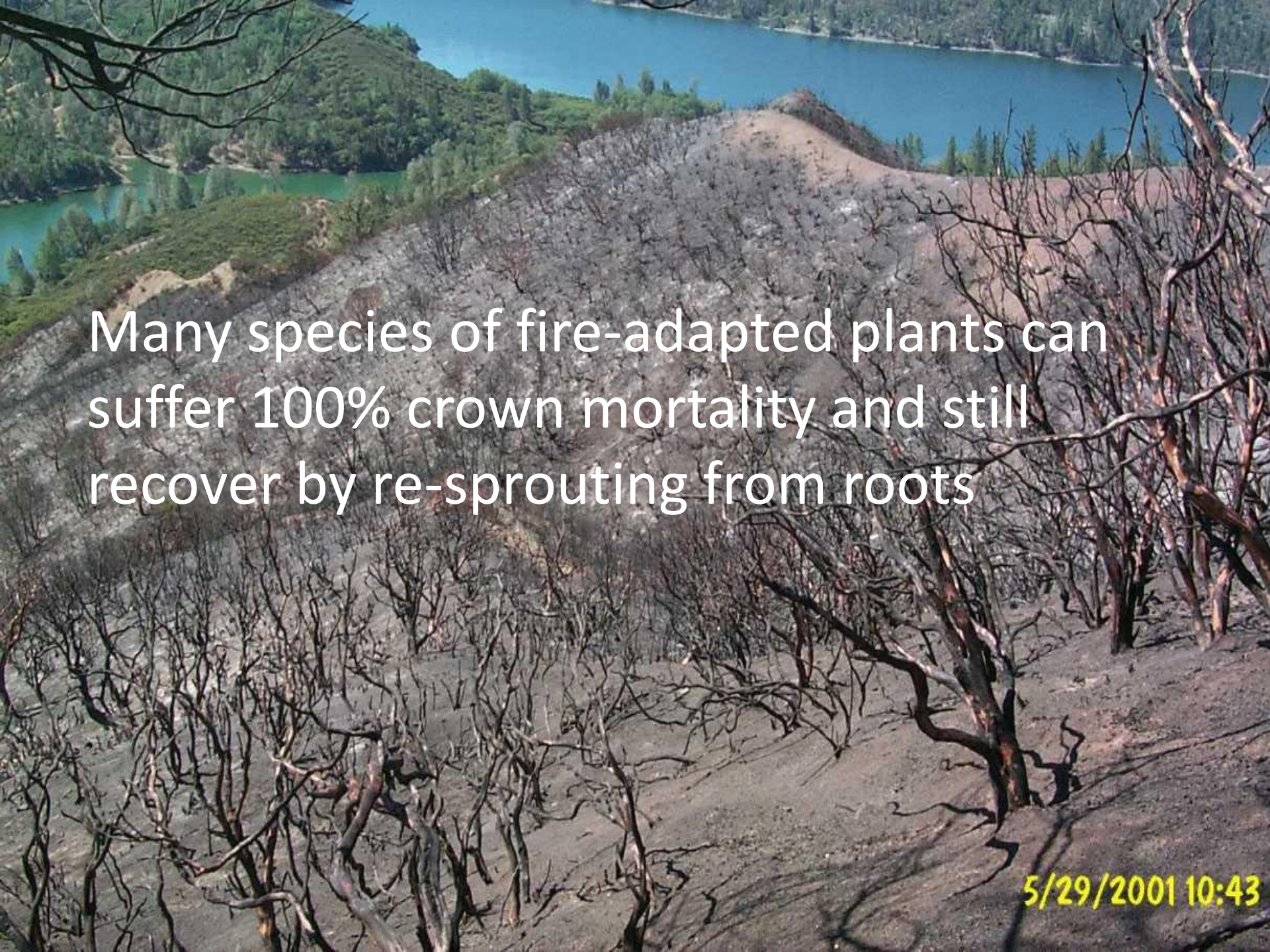
1. Scorch height (measured from ground up, in m)

2. Percent canopy killed (usually % of canopy height from base to top)



Canopy effects also predict tree mortality, and thus many other second-order ecosystem fire effects

Brown reading: Some species can survive high levels of canopy damage, others not


Many species of fire-adapted plants can suffer 100% crown mortality and still recover by re-sprouting from roots
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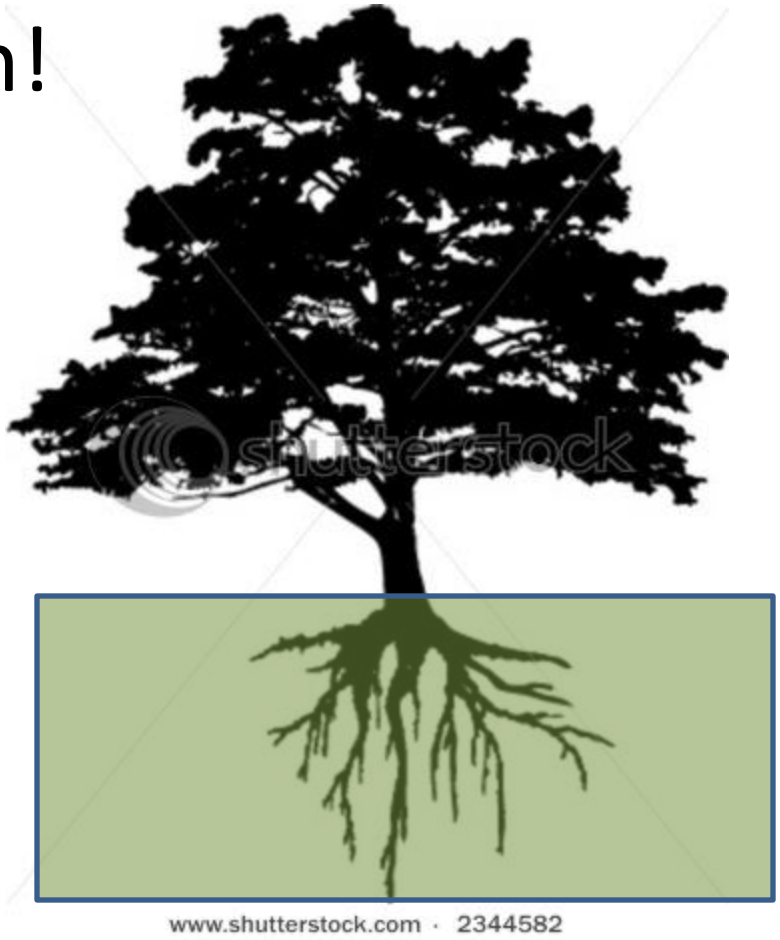
Don’t forget belowground fire effects to vegetation!

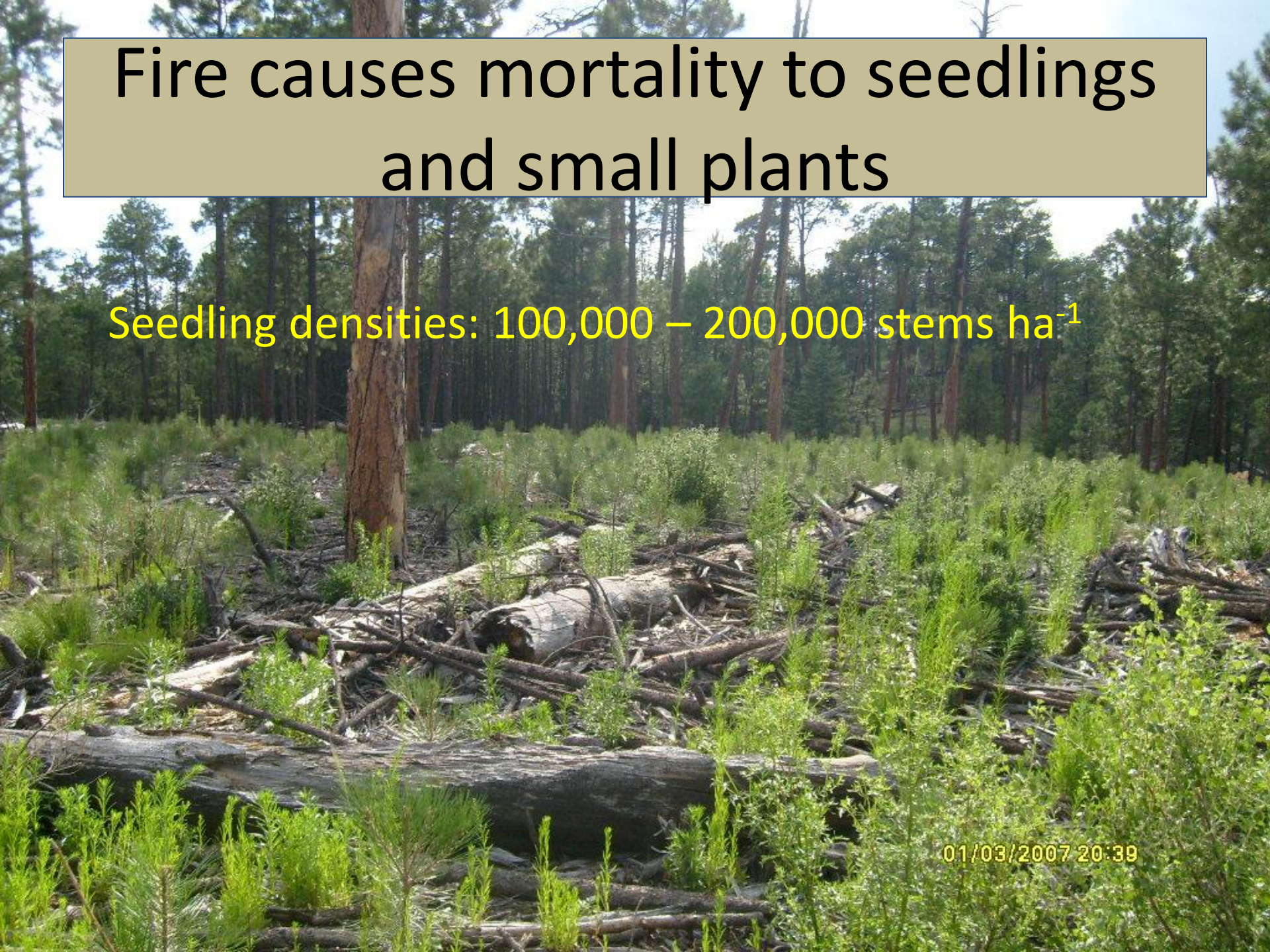
1. Soil heating kills fine roots, the main way that trees gather water and nutrients
2. Fire can damage the cambium of larger roots, which hold trees in place
3. Fire mobilizes nitrogen and phosphorous, and can lead to a post-fire growth increase



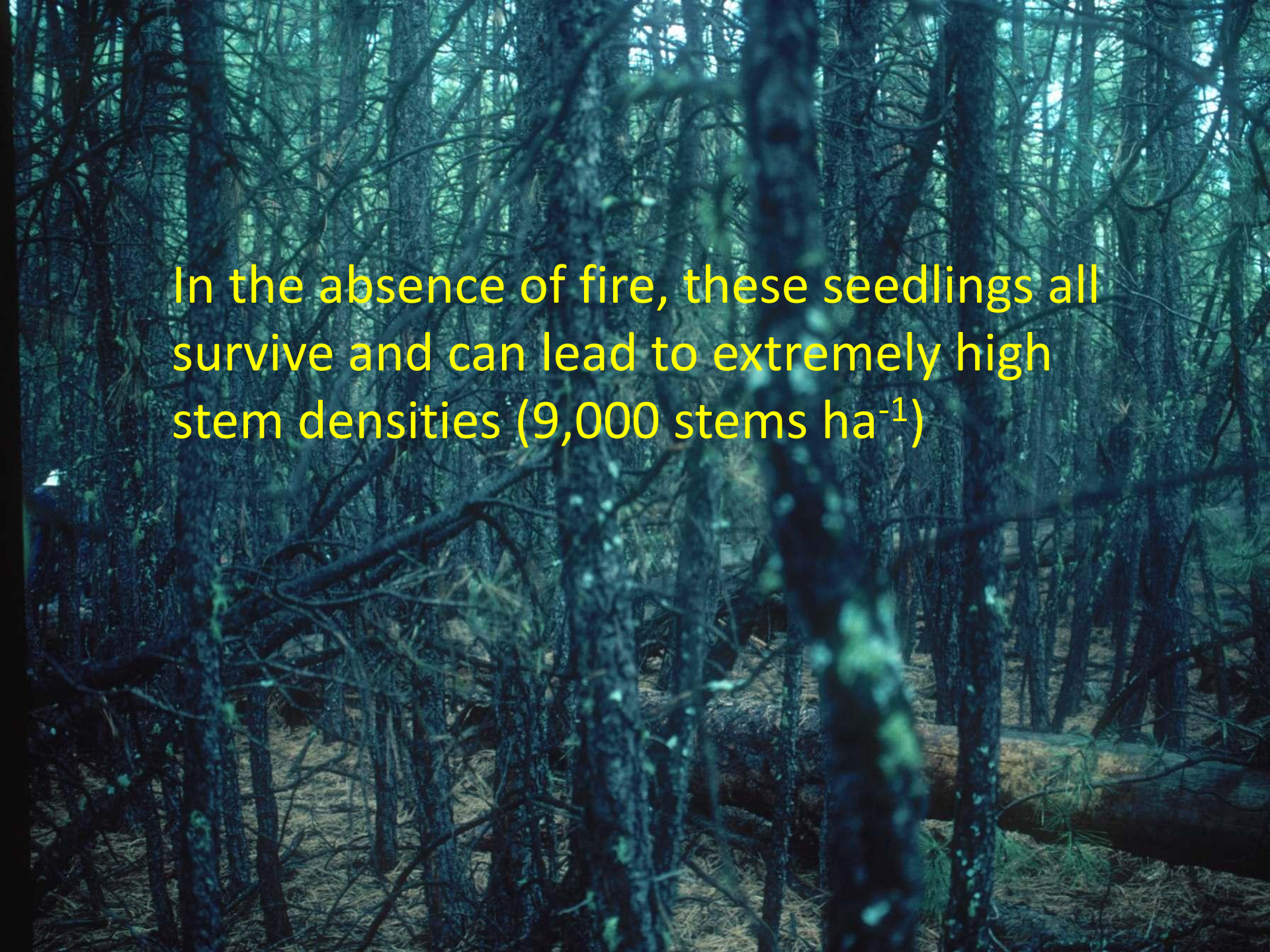
Plant population effects

1. Changes to population density (kills off many small trees, leaves larger ones)
2. Post-fire germination (smoke and heat cues)
3. Can favor fire-tolerant species over fire-sensitive species

Fire causes mortality to seedlings and small plants




Stand densities in SW ponderosa pine under historical disturbance regime 90–150 stems ha-1


In the absence of fire, these seedlings all survive and can lead to extremely high stem densities (9,000 stems ha^{-1})

Post-fire regeneration

- Seeds of some species require fire for seed germination (e.g. *Penstemon barbatus*)
- Some species (*e.g. Populus tremuloides*) can colonize clonally post-fire
- Some species are serotinous; they have canopy seed banks that drop seed right after a crown fire (*Pinus contorta*, Lodgepole pine)
- Post-fire regeneration of other species by seed dispersal may be years or decades later

Many species use fire as a cue for germination – WHY?

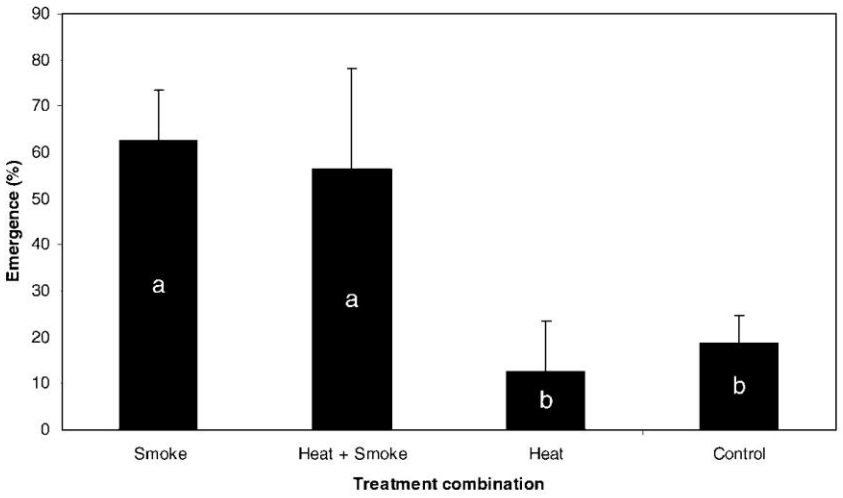


FIG. 1.—Mean emergence of *Penstemon barbatus* across treatment combinations in a 2-factor, split-plot factorial experiment using basalt soil with 2 levels (none, exposure to 100 C for 30 minutes) of the whole plot factor heat, and 2 levels (none, 60 ml of 10% liquid smoke) of the subplot factor liquid smoke. Means without shared letters differ at $P < 0.05$ (Fisher's LSD). Error bars are 1 SD

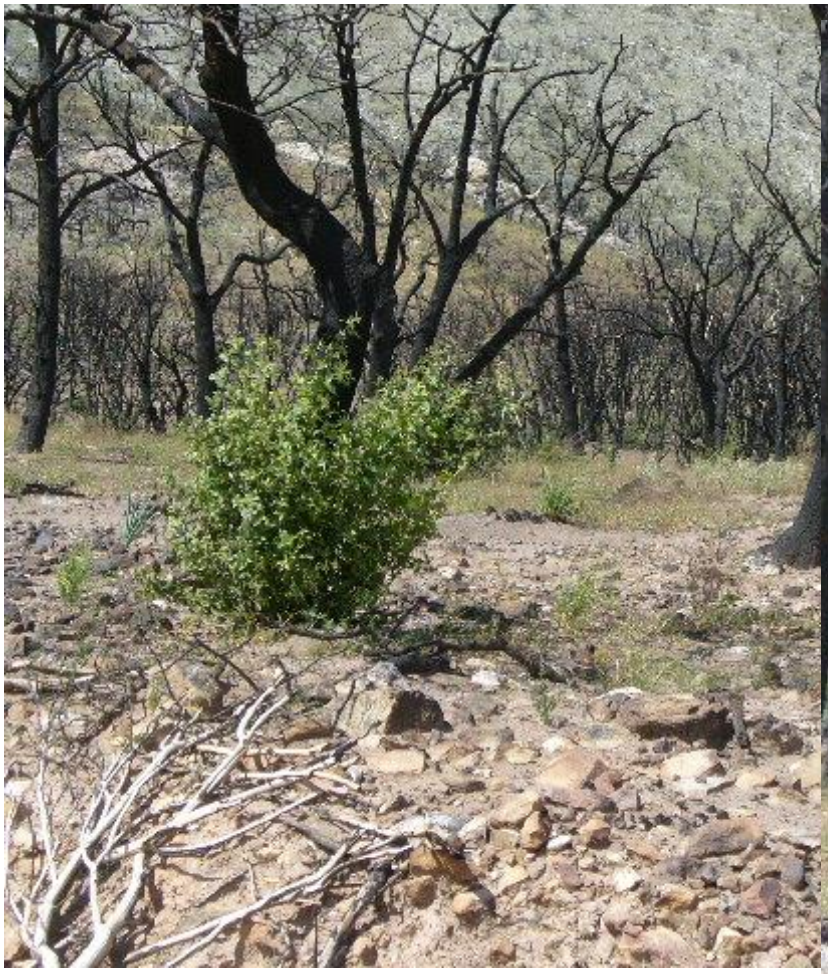
Graph: Abella 2006, *American Midland Naturalist.* Photo of *Penstemon barbatus*: University of California-Berkeley Botanical Garden.

Miller Fire 2011, Gila Wilderness, NM


Monument Fire 2011, Huachuca Mts

Notice the different effects in low (oak woodland) and high (conifer forest) elevation plant communities

How might they be differentially adapted to high-intensity fire?



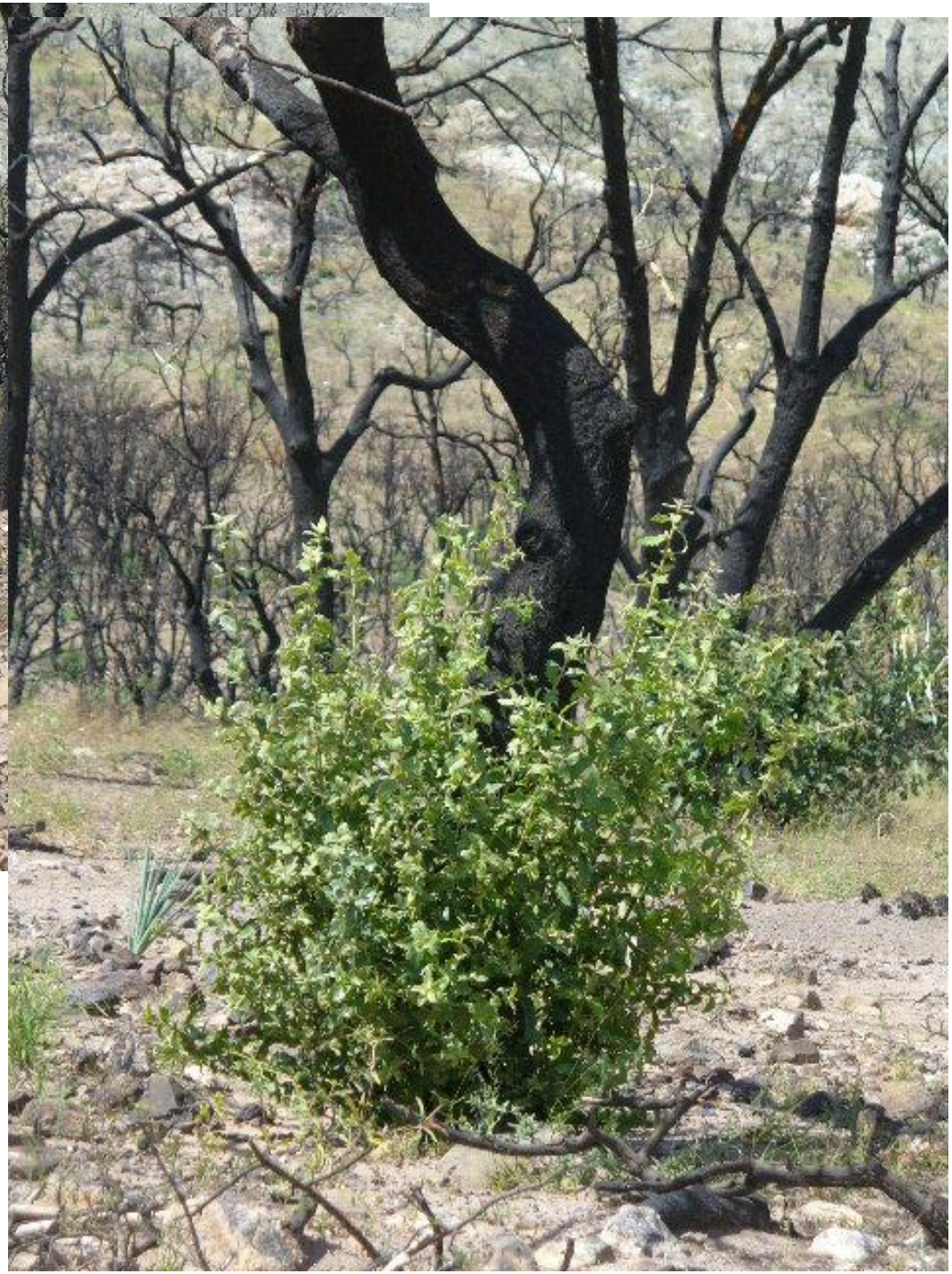
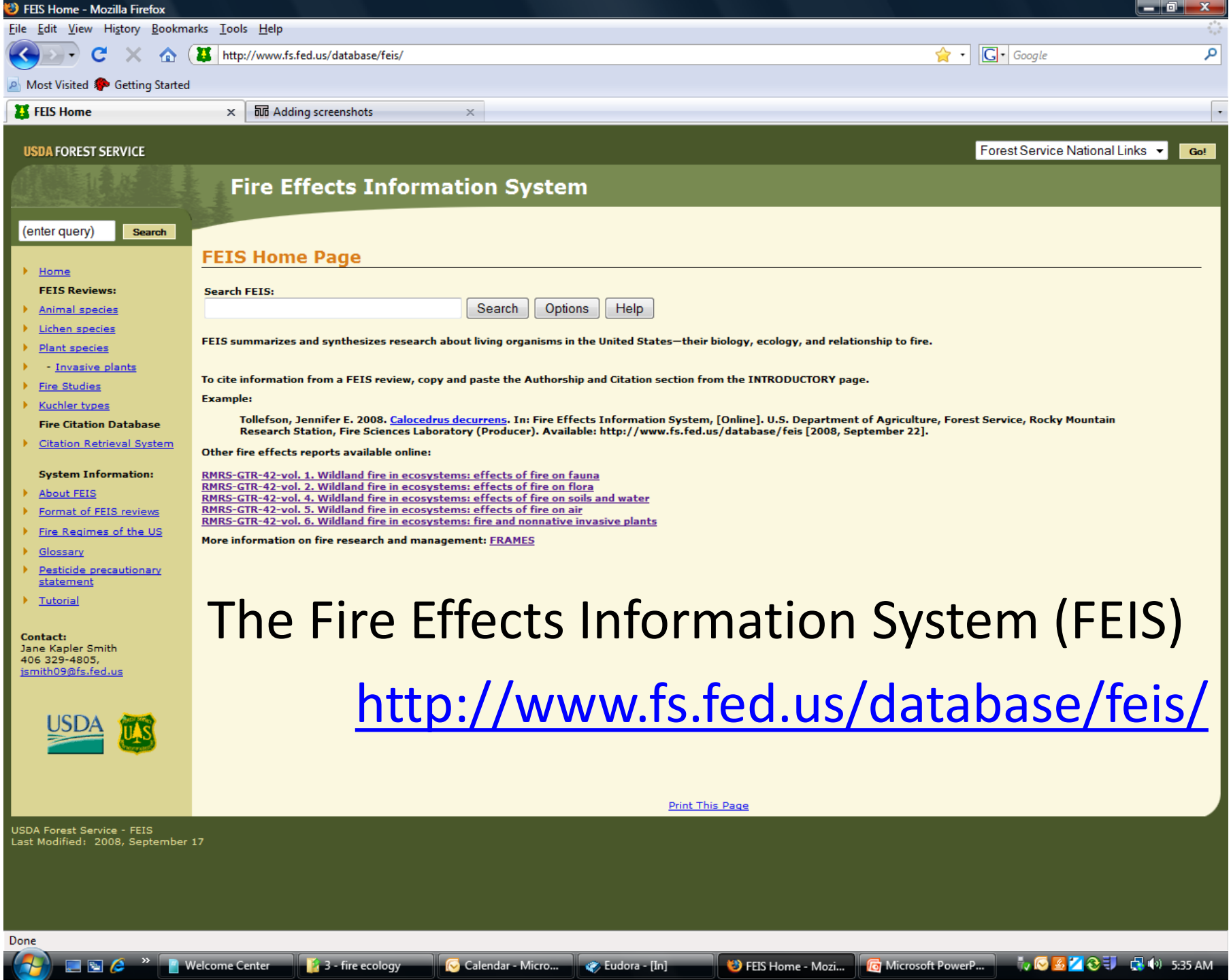


Photo: Ellis Margolis (UA), Sangre de Cristo Mts, New Mexico

Landscape structure

1. Patch sizes and shapes
2. Severity classes (unburned to high severity)
3. Possible changes in composition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Next week:
Fire and the carbon cycle
Birds
Insects
Coming up: Take-home exercise 3 (fire ecology)