

Restoring keystone species through biotechnology

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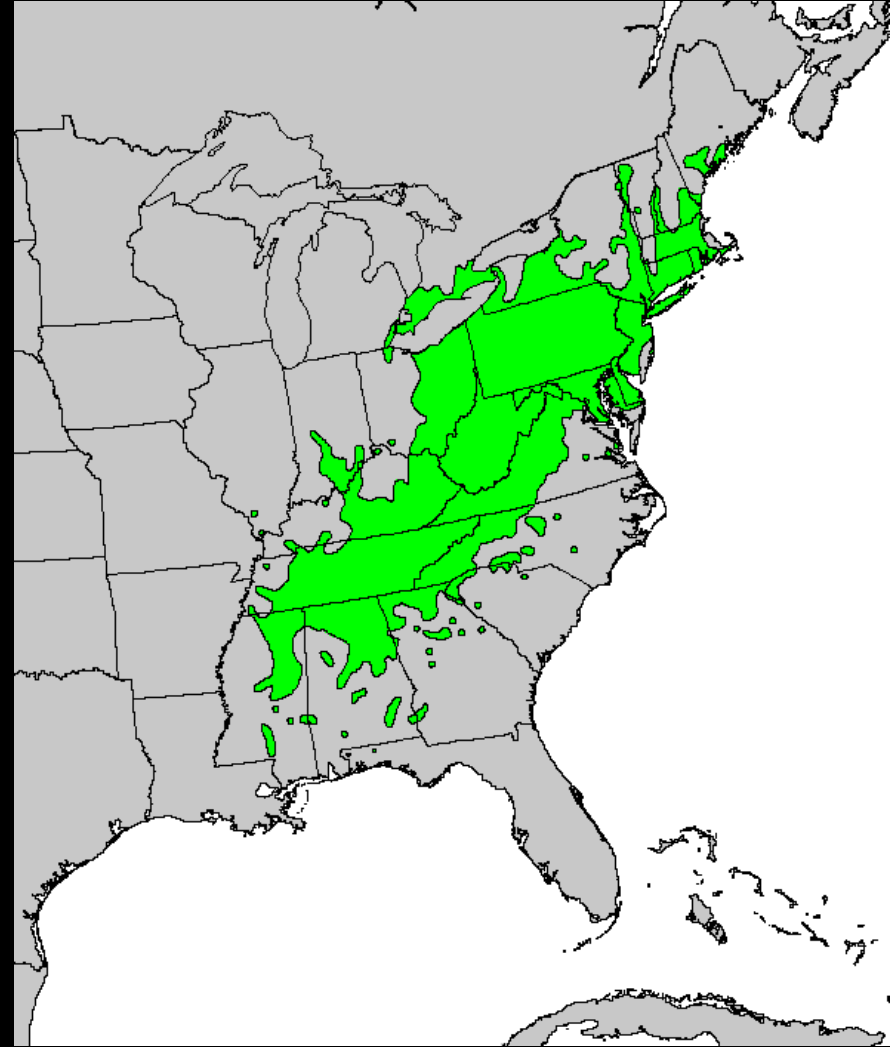
Eastern U.S. forest tree species that have been or potentially could be decimated by introduced pests or pathogens:

- American elm (Dutch elm disease)
- American beech (beech bark disease)
- Ash species (Emerald ash borer)
- Eastern & mountain hemlock (Hemlock woolly adelgid)
- Oak spp. (Sudden oak death/gypsy moth)
- Balsam fir (Balsam woolly adelgid)
- Flowering dogwood (dogwood anthracnose)
- Butternut (butternut canker)
- Walnut (Thousand canker disease)
- All Lauraceae (laurel wilt)



- **Keystone species**: disproportionate impact on ecosystem when compared to its abundance
- **Foundation species**: primary producers that dominates an ecosystem in abundance and influence
- Loss of such forest tree species: cascading effects on plant and animal communities, nutrient cycling, and carbon storage
- Reintroduction may help to 1) meet FLR targets and 2) restore population community and ecosystem function

The historical American chestnut



Chestnut blight

- Fungus (*Cryphonectria parasitica*)
- Girdling canker



#1 - Biocontrol with hypovirulence

Virulent
no virus

Hypovirulent
virulent virus

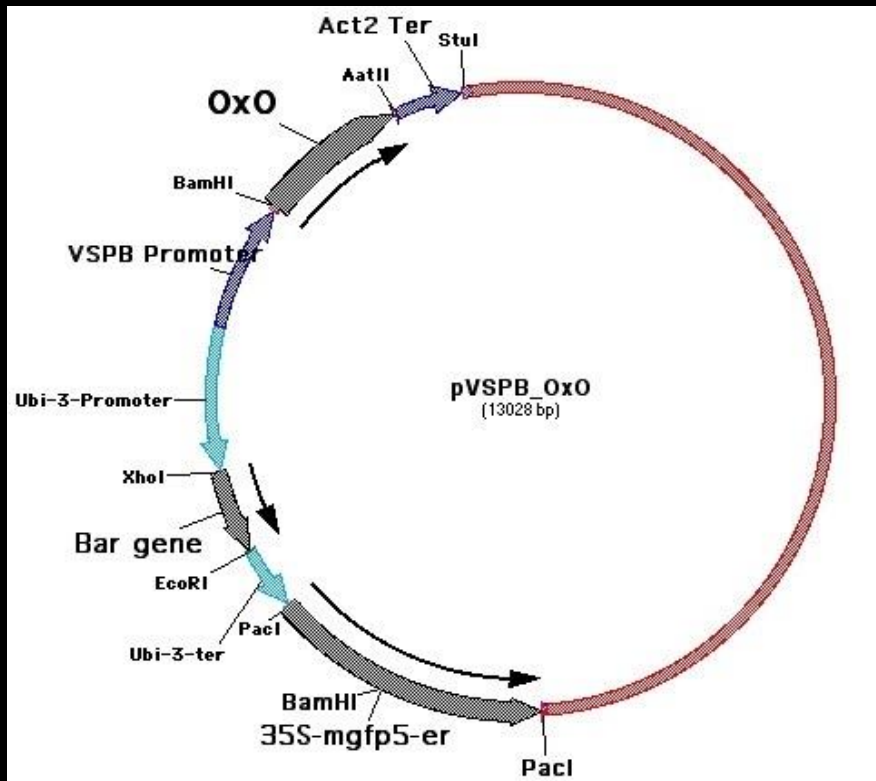
Hypovirulent
weak virus



e.g., Milgroom & Cortsei 2004 *Ann. Rev. Phytopath.*

#2 - Genetic engineering

- Two different approaches based upon source of genetic information: *Transgenic* or *Cisgenic*



1. Any genetic material that will confer blight resistance

OxO-gene construct to degrade oxalic oxidase

e.g., Zhang et al. 2013 *Transgenic Res.*

#2 - Genetic engineering

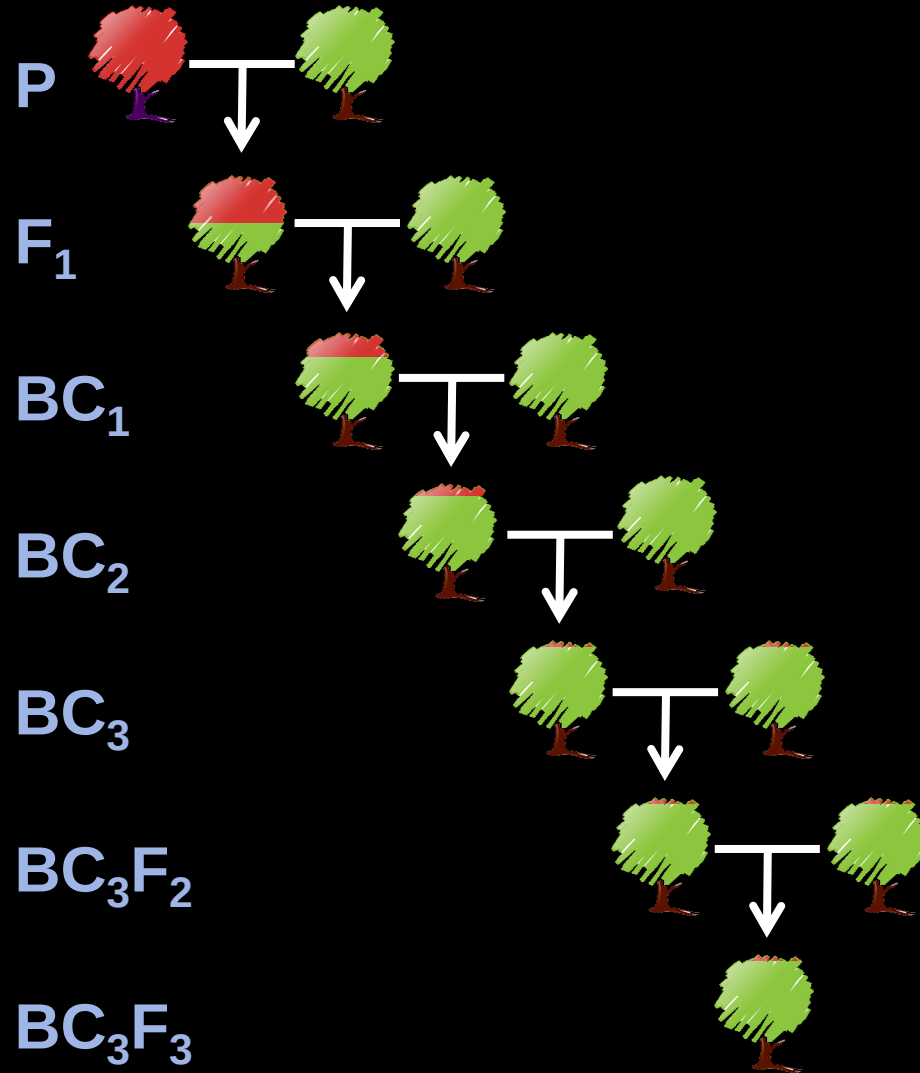
- Two different approaches based upon source of genetic information: *Transgenic* or *Cisgenic*

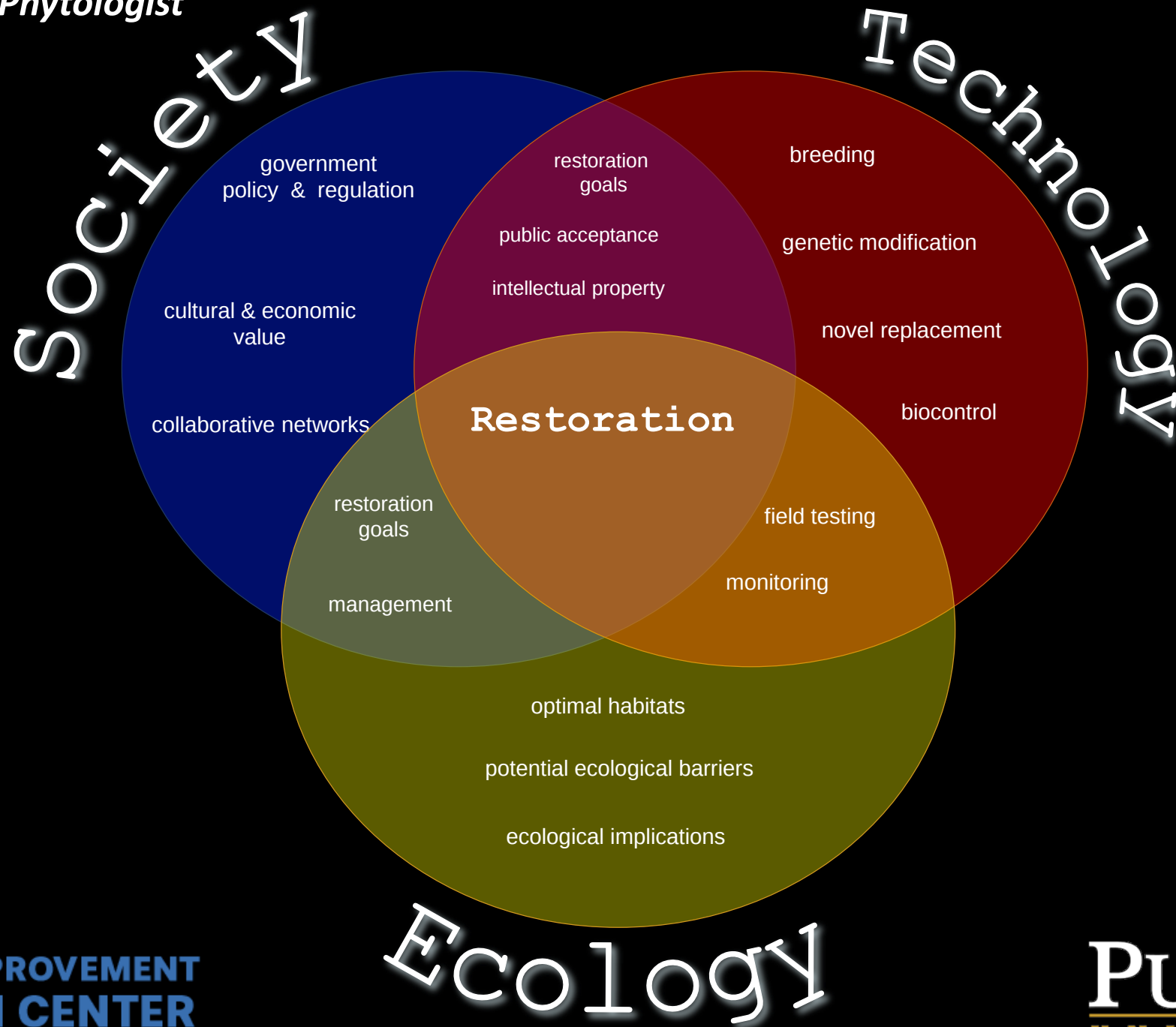


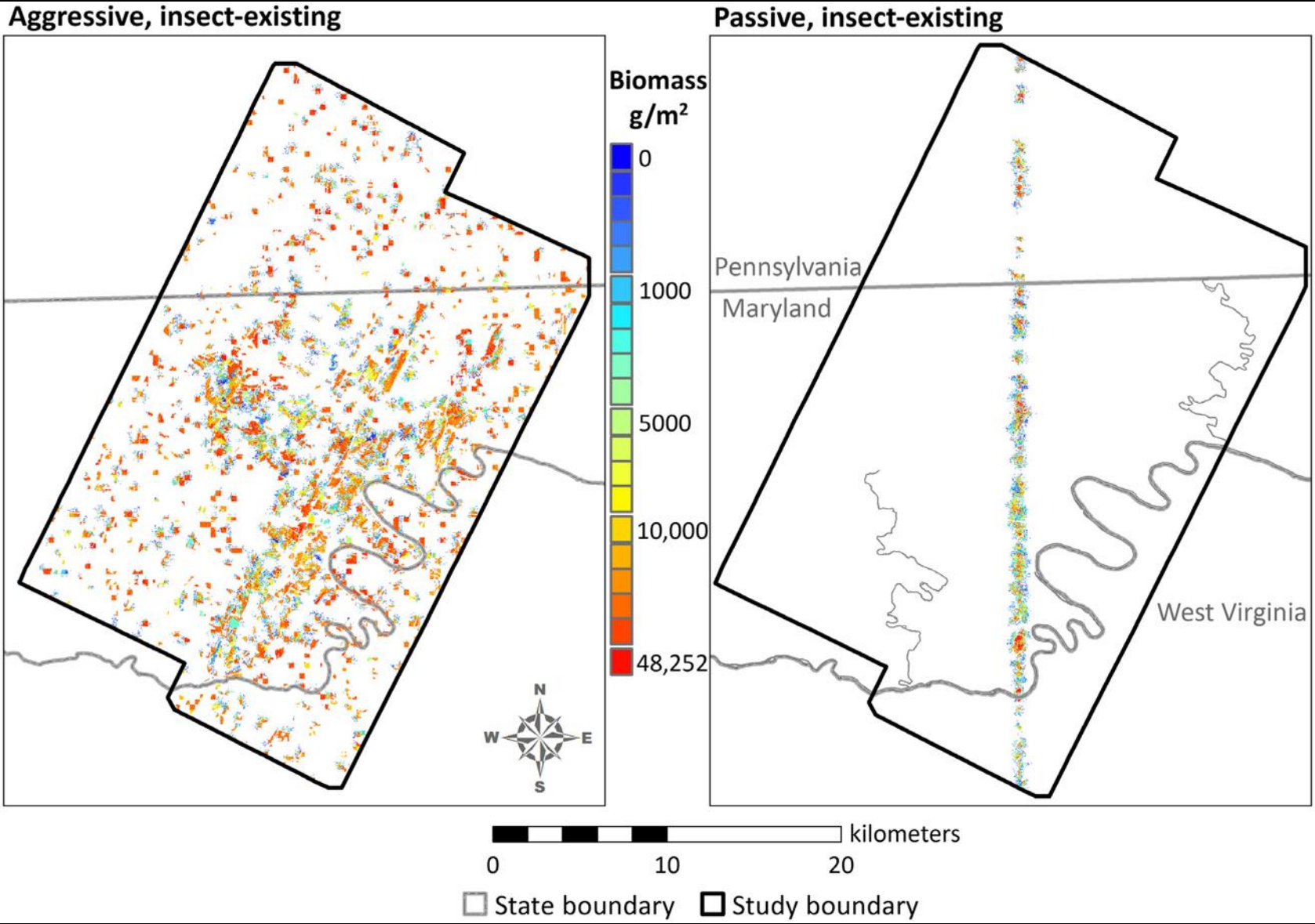
American Chinese Japanese European

2. Genes from closely related species
Chinese chestnut, Japanese chestnut

#3 – Classical tree breeding







Barriers to restoration

- **Society:** acceptance of GE trees or hybrids as “native species”
- Scale of reintroduction of foundation / keystone species under FLR
 - Production of resistant germplasm
 - Complex silviculture – many generations
 - Intensive management
 - Costs

- **Many forest tree species have been extirpated or are severely threatened by introduced pests and pathogens**
- **Reintroduction offers FLR an added opportunity to help meet targets of Bonn Challenge, while simultaneously restoring species**
- **Enabling insect and disease resistance in forest trees is complicated, but advances in biotechnology have made reintroduction feasible**
- **Societal and ecological barriers to FLR with threatened species remain – most effective is policy that confines the spread of pests and pathogens**