

# *To Plant, or Not to Plant?*

## Regulation of Invasive Plants in the Mid-Atlantic States

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# *To Plant, or Not to Plant?*

## Regulation of Invasive Plants in the Mid-Atlantic States

### PART 1: Plant Invasions



# Quick Write: Reading Response

1. What are the common and scientific names of the plant you read about?
2. What is its growth form?
  - a. Tree
  - b. Shrub
  - c. Vine
  - d. Herb
  - e. Grass
3. On what continent did it evolve?
4. Why was it introduced to North America?
5. Why are people concerned about its spread?

# What is a native plant?



*Cercis canadensis*  
redbud

# What is a native plant?

PA Native Plant Society:

*“A native plant is one that occurs naturally in a particular region, ecosystem, or habitat **without direct or indirect human intervention.**”*



*Cercis canadensis*  
redbud

# What is a native plant?

US Environmental Protection Agency:

*“found in your area **before Europeans settled** (when extensive land clearing began and exotic plants were first introduced from overseas).”*



*Cercis canadensis*  
redbud

# Benefits of native plants: Biodiversity

- Niche (role) in local ecosystem
- Relationships: Direct and indirect
  - Food webs
    - Birds
    - Insects
    - Mammals
    - Microbiota
    - Pest management
  - Shelter/structure
- Biodiversity



Photo: Michael Hodge CC BY 2.0



Photo: Penny Jazayr CC BY 4.0

*Papilio troilus*  
spicebush swallowtail butterfly

Larval host plant:  
*Lindera benzoin*  
spicebush

# Benefits of native plants: Sense of place

What makes a place unique?

What makes it feel like home?

Photo: Fran Trudeau CC2.0

Photo: Spisharam CC2.0

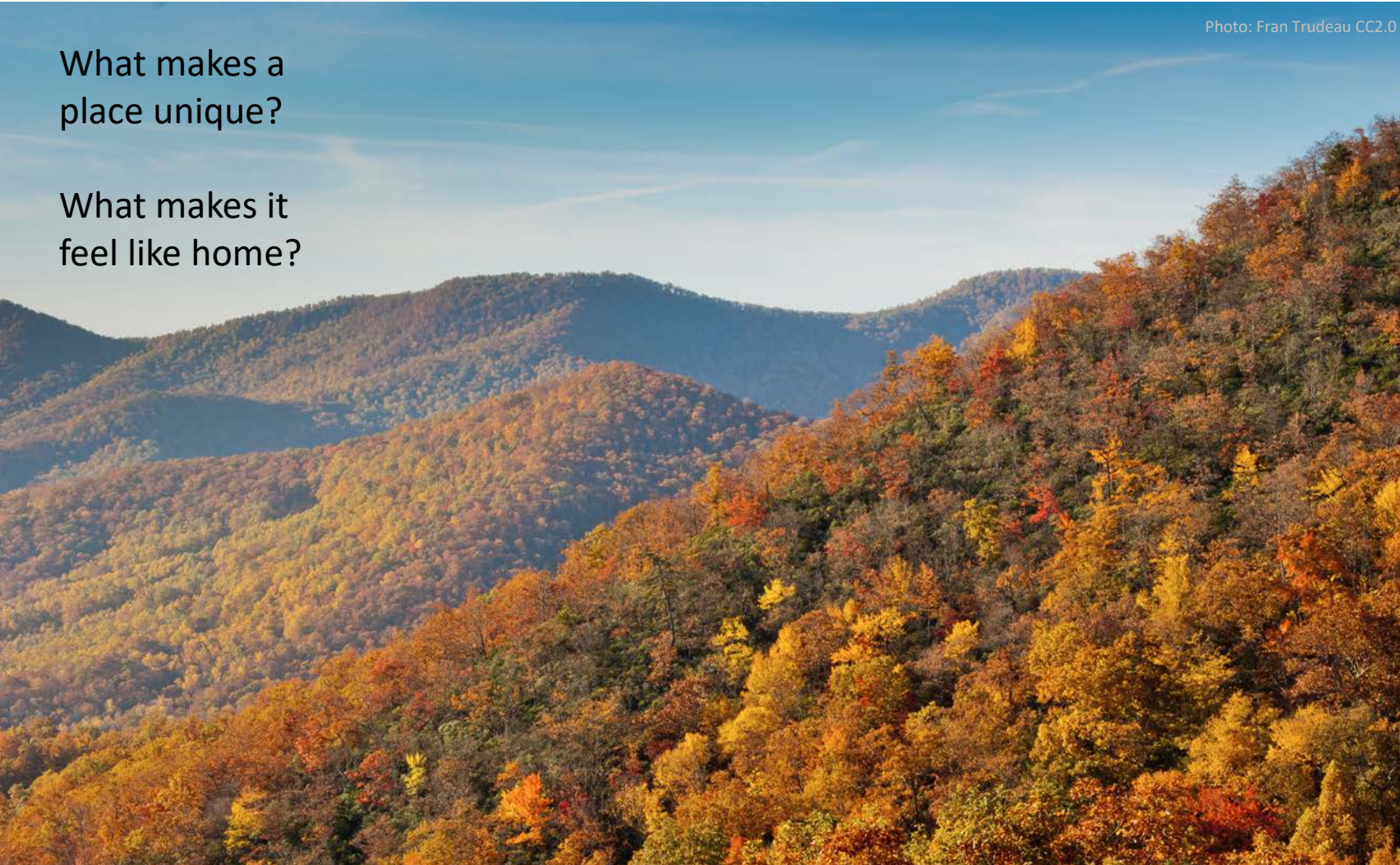


Photo: Fredlyfish4 CC4.0



# Benefits of native plants:

## Maintenance costs

- Adapted to local conditions\*
- Maintenance\*
  - N and P pollution
  - Time
  - Water
  - Energy (sweat and carbon)
  - Waste

\*If sited correctly

*Acer rubrum*  
red maple



# Non-native plants

- Introduced by people
  - Faster
  - Further
  - More frequently
  - Across barriers
  - With particular traits



*Taraxacum officinale*

Dandelion

Native to Eurasia

Introduced to North America as a food plant

# Data visualization: World air traffic in 24 hours



Movement of species  
by people:

- Faster
- Further
- More frequently
- Across barriers
- With particular traits

# Non-native plants: Intentional introductions

- Utilitarian
  - Food
  - Forage
  - Fuel
  - Lumber
  - Medicine

*Pseudotsuga menziesii*  
**Douglas-fir**  
Native to North America  
Introduced globally for timber

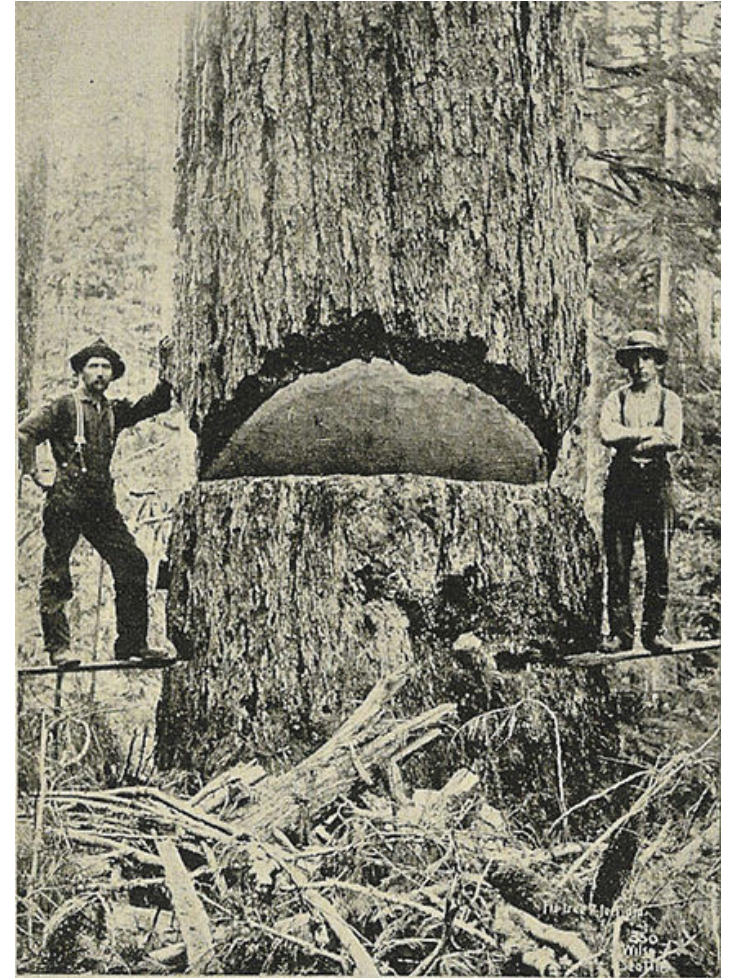


Photo: Wilse, 1900

# Non-native plants: Intentional introductions

- Utilitarian

- Food
- Forage
- Fuel
- Lumber
- Medicine

- Utilitarian traits

- Tasty/nutritious
- Good for animals to eat
- Fast-growing
- Strong wood, straight trunked
- Chemically defended

***Robinia pseudoacacia***  
**black locust**

Native to North America  
Introduced to Europe for wood



Photo: J. Crowle CC2.0

# Non-native plants: Intentional introductions

*Rhododendron spp.*  
Azaleas and Rhododendrons

Native to Asia

Globally used as ornamental plants

- Aesthetic and Cultural
  - Familiarity
  - Beauty
  - Landscape



# Non-native plants: Intentional introductions

*Rhododendron spp.*  
Azaleas and Rhododendrons

Native to Asia

Globally used as ornamental plants

- Aesthetic and Cultural

- Familiarity
- Beauty
- Landscape

- Aesthetic traits

- “There’s no place like home”
- Culturally valued beauty standards
- Create familiar landscape patterns and uses



# Non-native plants: Accidental introductions

- Weeds of agriculture
- Hitchhikers

*Salsola kali* (Amaranthaceae)  
tumbleweed

*Since 1995, a snowman made of tumbleweed has been annually installed near a major highway intersection in downtown Albuquerque, New Mexico by the City's Metropolitan Arroyo Flood Control Authority.*



Photo: *The Big 1 tumbleweed snowman*  
Mike Kline 2006 CCA2.0



# Non-native plants: Accidental introductions



- Traits of unintentional introductions
  - Seeds that resemble or can hide with crops
  - High seed production
  - Rapid growth
  - Tolerate variety of conditions
    - Light
    - Water
    - Soil
  - Traits that increase fitness (survival and reproduction) in disturbed environments

*Microstegium vimineum*

Japanese stiltgrass

Introduced to North America as a packing material

UGA1378044

# What is an **invasive species**?

*Microstegium vimineum*  
Japanese stiltgrass



Photo: Forest & Kim Starr CC 3.0

*Pueraria montana* var. *lobata* - kudzu  
Fabaceae – Pea family  
Native to Japan

# What is an **invasive species**?

United Nations Convention  
on Biological Diversity:

“species whose **introduction**  
**and/or spread outside their**  
**natural past or present**  
**distribution threatens**  
**biological diversity.”**



Photo: Forest & Kim Starr CC 3.0

*Pueraria montana* var. *lobata* - kudzu  
Fabaceae – Pea family  
Native to Japan

# What is an **invasive species**?

USDA:

“plants, animals, or pathogens that are **non-native** (or alien) to the ecosystem under consideration and whose **introduction** causes or is likely to cause harm.”

- Introduced by people
- Cause, or are likely to cause, ecological and/or economic harm



Photo: Forest & Kim Starr CC 3.0

*Pueraria montana* var. *lobata* - kudzu  
Fabaceae – Pea family  
Native to Japan

# Choosing words: Discuss with your neighbor

What do these terms have in common? How do they differ?

How do the words we use influence our view of species?

- Alien
- Native
- Exotic
- Noxious
- Foreign
- Introduced
- Invasive
- Pest
- Non-native
- Casual
- Weed
- Naturalized
- Transformer
- Established





Photo: Kudzu covered field near Port Gibson, Mississippi, USA, by G. Smith 2006 CCA 2.0

Peterson, Lee R., 2017, "Social Ecological Systems Case Study: To Plant, or Not to Plant? Regulation of Invasive Plants of the Mid-Atlantic States." National Center for Socio-Environmental Synthesis Teaching Case Study Collection

*Pueraria montana* var. *lobata*  
kudzu

# Invasive species

*Pueraria montana var. lobata*

kudzu

Fabaceae – Pea family

Reduces:

- Biodiversity
- Regeneration
- Habitat
- Crop and forest production

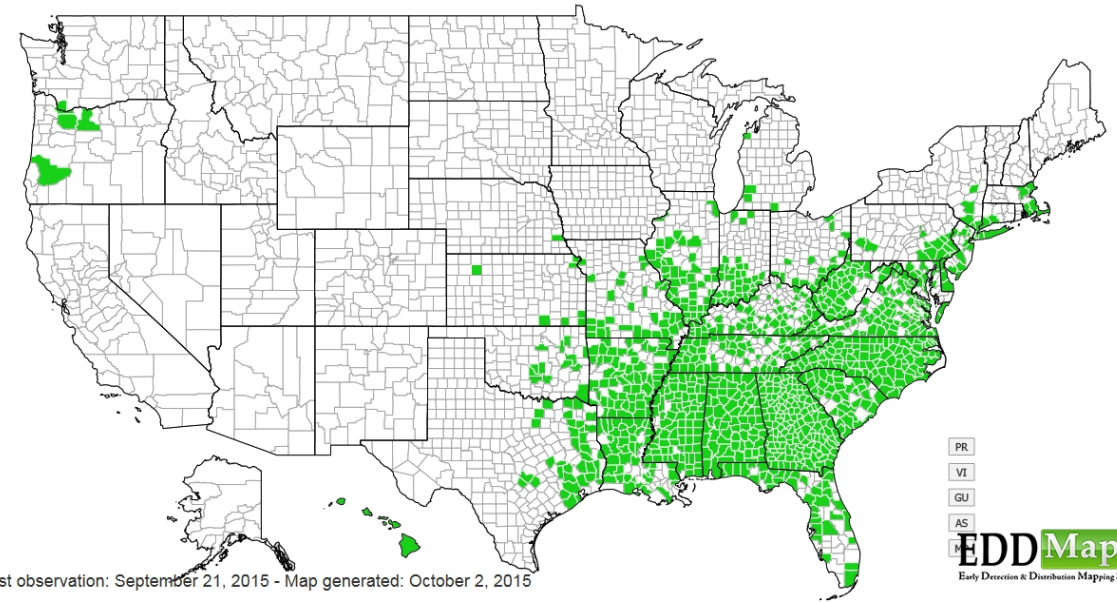


Photo: Kudzu covered field near Port Gibson, Mississippi, USA, by Gsmith 2006 CCA2.0



# Invasive species: Impacts

## Genetic

- Hybridization
- Swamping



North American and European cordgrasses have hybridized to produce highly invasive hybrids.

# Invasive species: Impacts

Genetic

Individual

- Behavior
- Fitness



North American monarch butterflies (*Danaus plexippus*) lay eggs on invasive dog-strangling vine (*Vincetoxicum nigrum*) when related native milkweed host plants are scarce, but the larvae do not survive when feeding on this plant.

# Invasive species: Impacts

Genetic

Individual

Population

- Competition
- Predation
- Physical



European spotted knapweed (*Centaurea stoebe*) produces chemicals that slow the growth of native plants and increase its ability to capture resources in grazing lands of the western U.S.

# Invasive species: Impacts

Genetic

Individual

Population

Community

- Mass extinction
- Trophic cascades



American chestnut (*Castanea dentata*) was once a towering dominant canopy species in forests of eastern North America, producing abundant nuts on which many species (including humans) depended.

Decimated by an invasive fungus (*Cryphonectria parasitica*, infection shown above right), most trees found today are root sprouts like the one above, which are infected before reaching maturity. Restoration efforts involve breeding with resistant Chinese species.

# Invasive species: Impacts

Genetic

Individual

Population

Community

Ecosystem

- Nutrient cycling
- Primary productivity



Fire tree (*Morella faya*) was introduced to Hawaii in the late 1800s. A mutualism with nitrogen-fixing bacteria allow it to colonize lava flows, enriching the soil and changing the direction of plant community development after volcanic eruptions.

# Invasive species: Impacts

Genetic

Individual

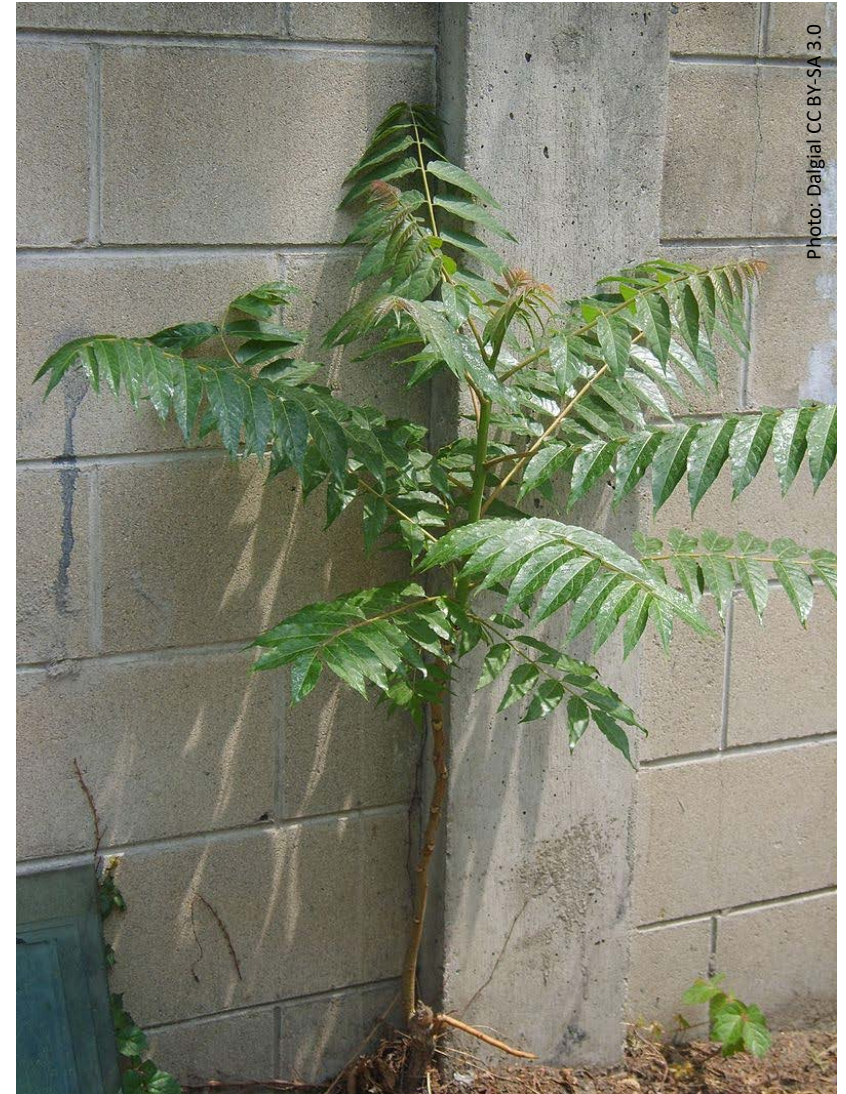
Population

Community

Ecosystem

Landscape, regional, and global

- Homogenization
- Extinction



Plants that travel with people and are well adapted to human-changed environments become more common globally, making different places the same, like this tree of heaven (*Ailanthus altissima*), resident of global cities, here in Seoul.

# Invasive species

Why do some non-native species become invasive?

Why don't all of them?



Photo: Kudzu covered field near Port Gibson, Mississippi, USA, by Gsmith, 2006 CCA2.0

*Pueraria montana var. lobata*  
kudzu

# Invasion is a Process

- Stages of invasion
  1. Transportation
  2. Introduction
  3. Establishment
  4. Spread
  5. Impact
- Can stop at any stage



Photo: Kudzu covered field near Port Gibson, Mississippi, USA, by Gsmith, 2006 CCA2.0

*Pueraria montana var. lobata*  
kudzu



# The Invasion Process

Time



Invasion Stage

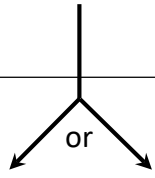
# The Invasion Process

Invasion Stage

**Transportation**

Time

Transportation  
from native range

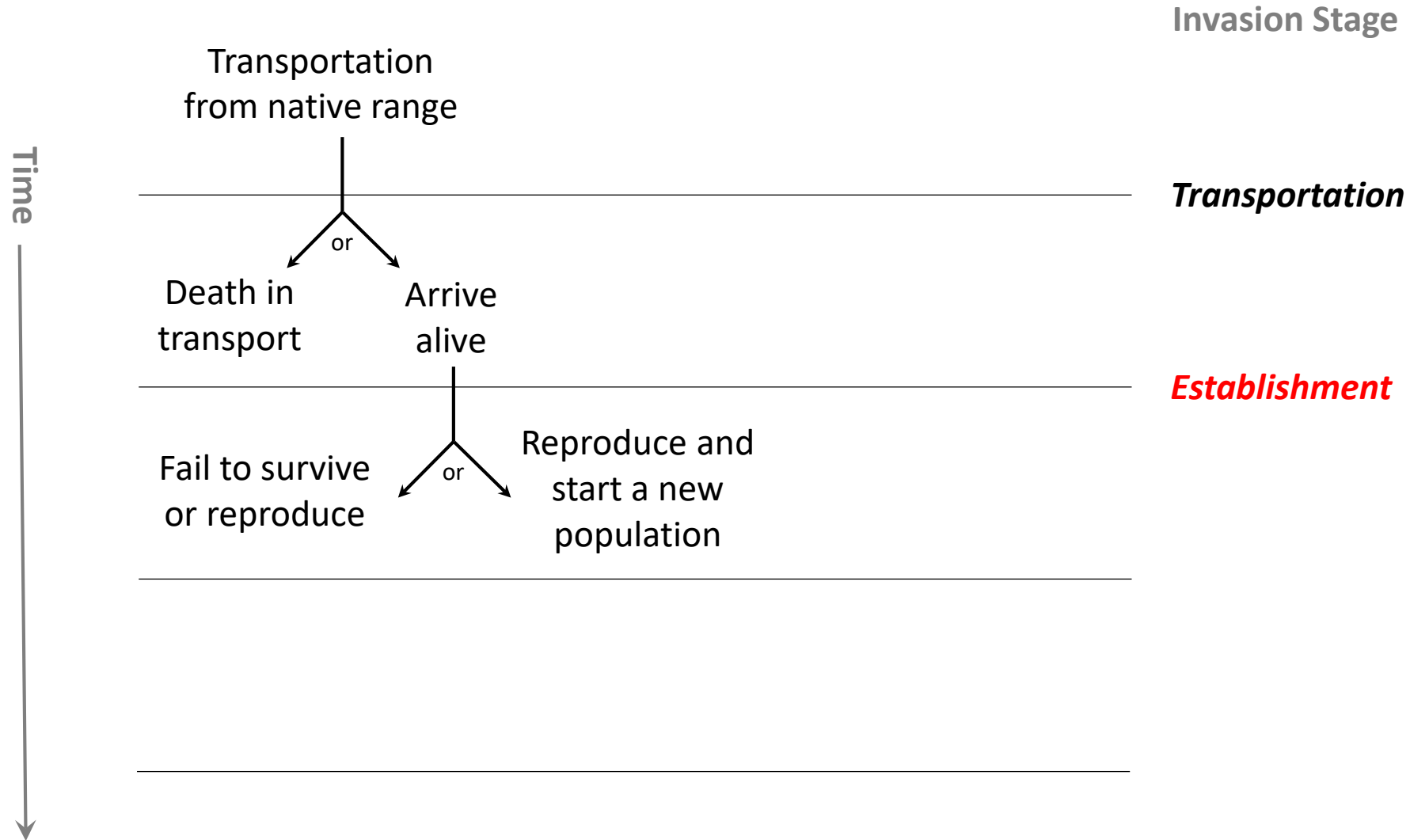


or

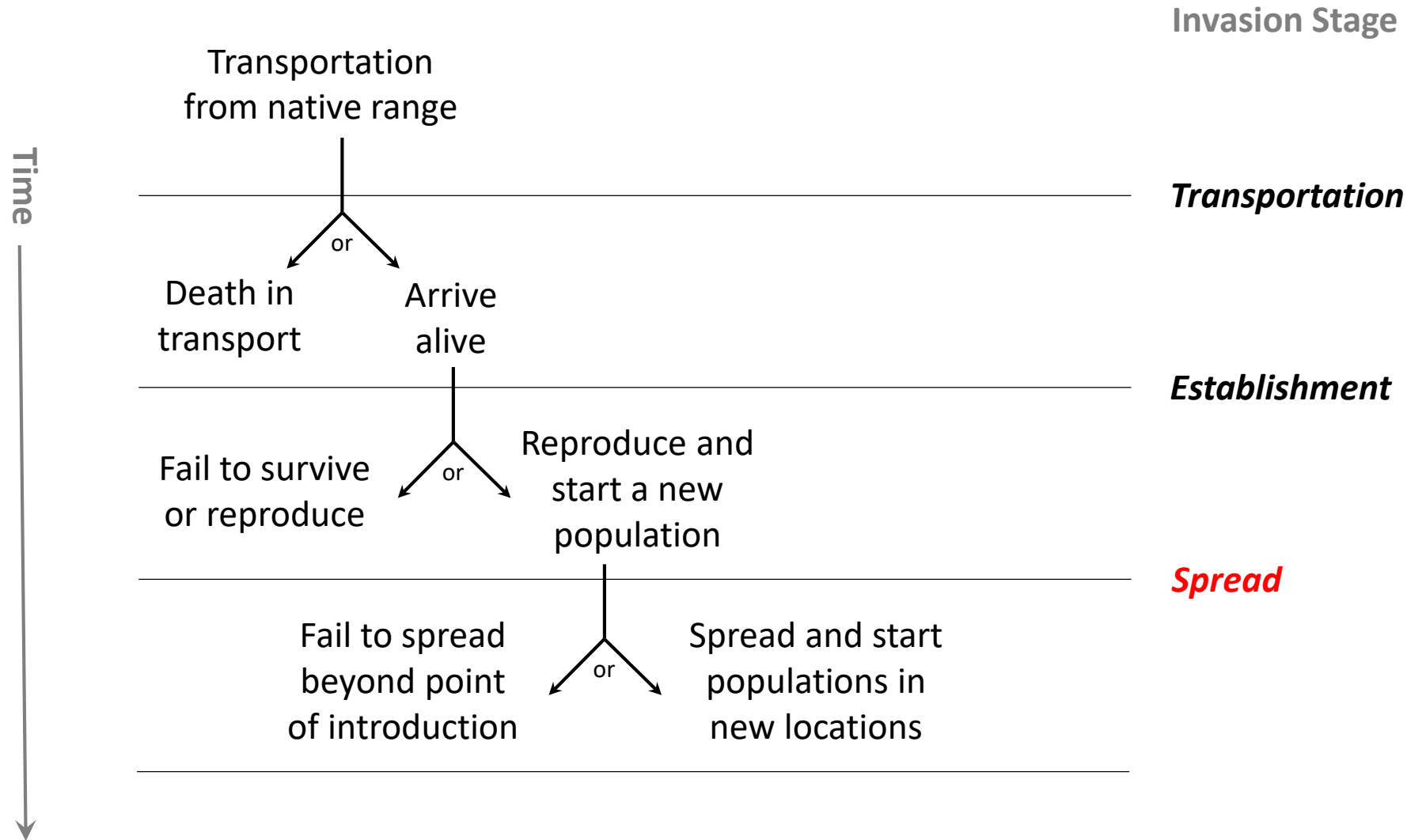
Death in  
transport

Arrive  
alive

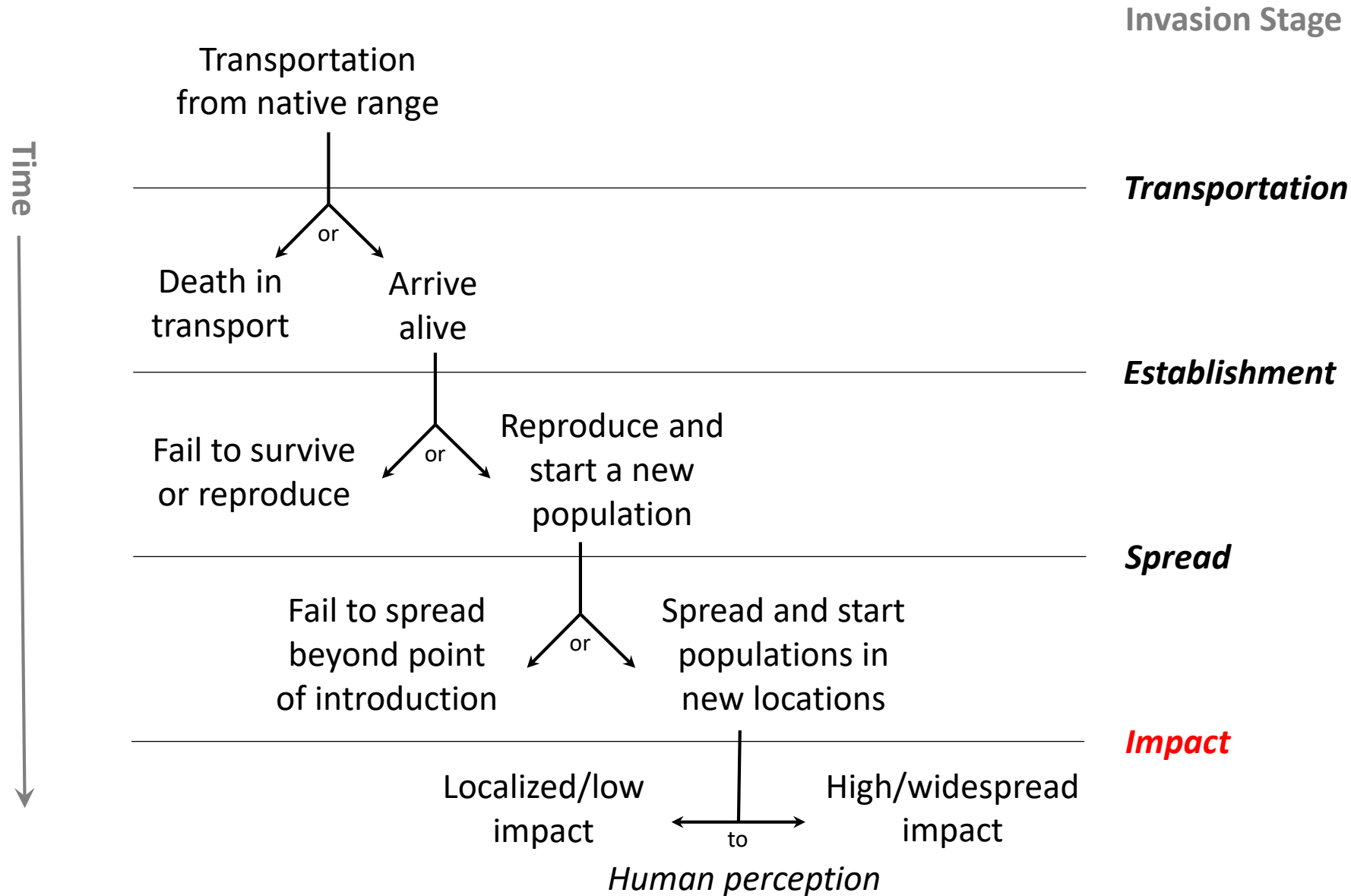
# The Invasion Process



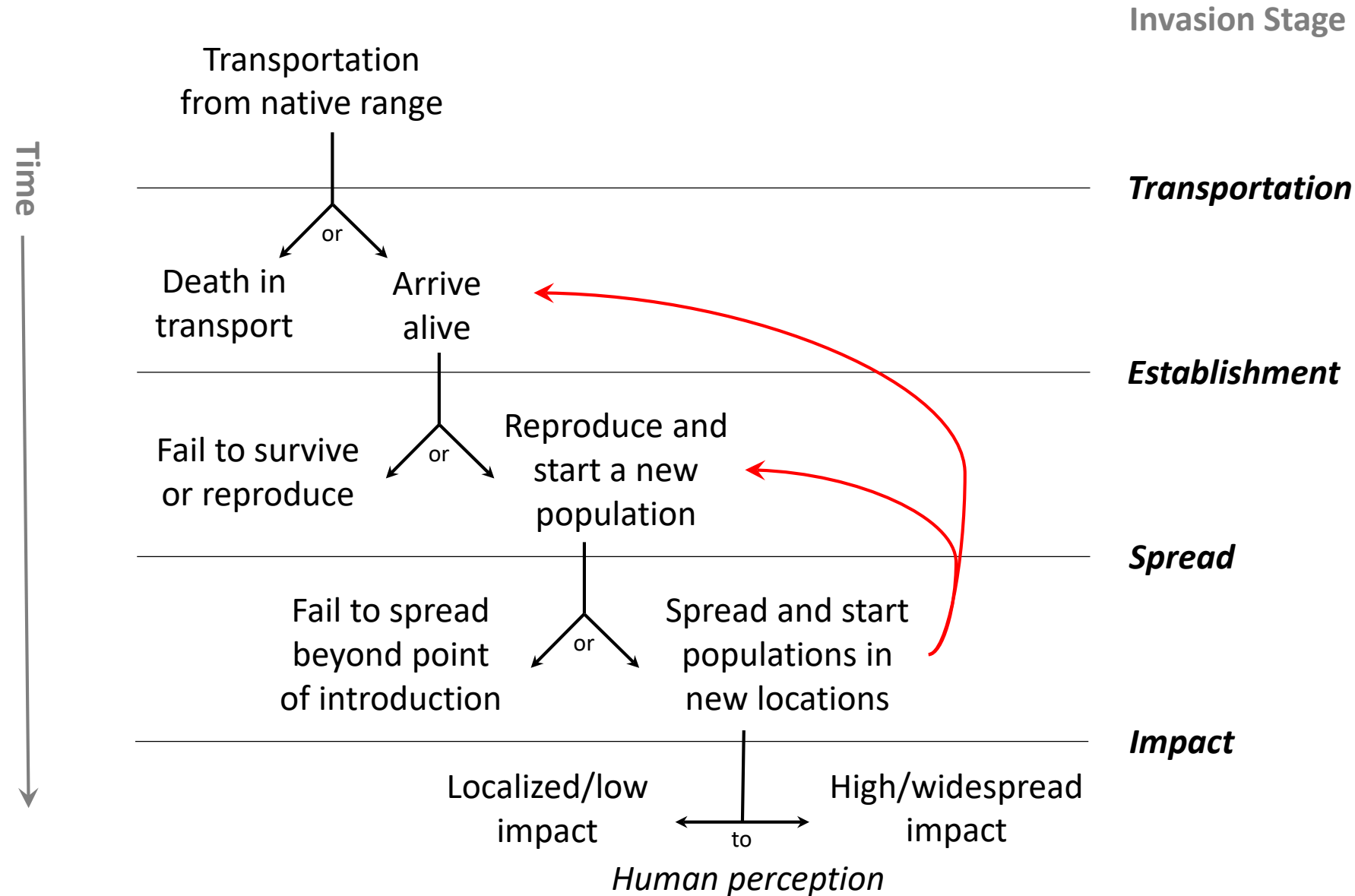
# The Invasion Process



# The Invasion Process



# The Invasion Process



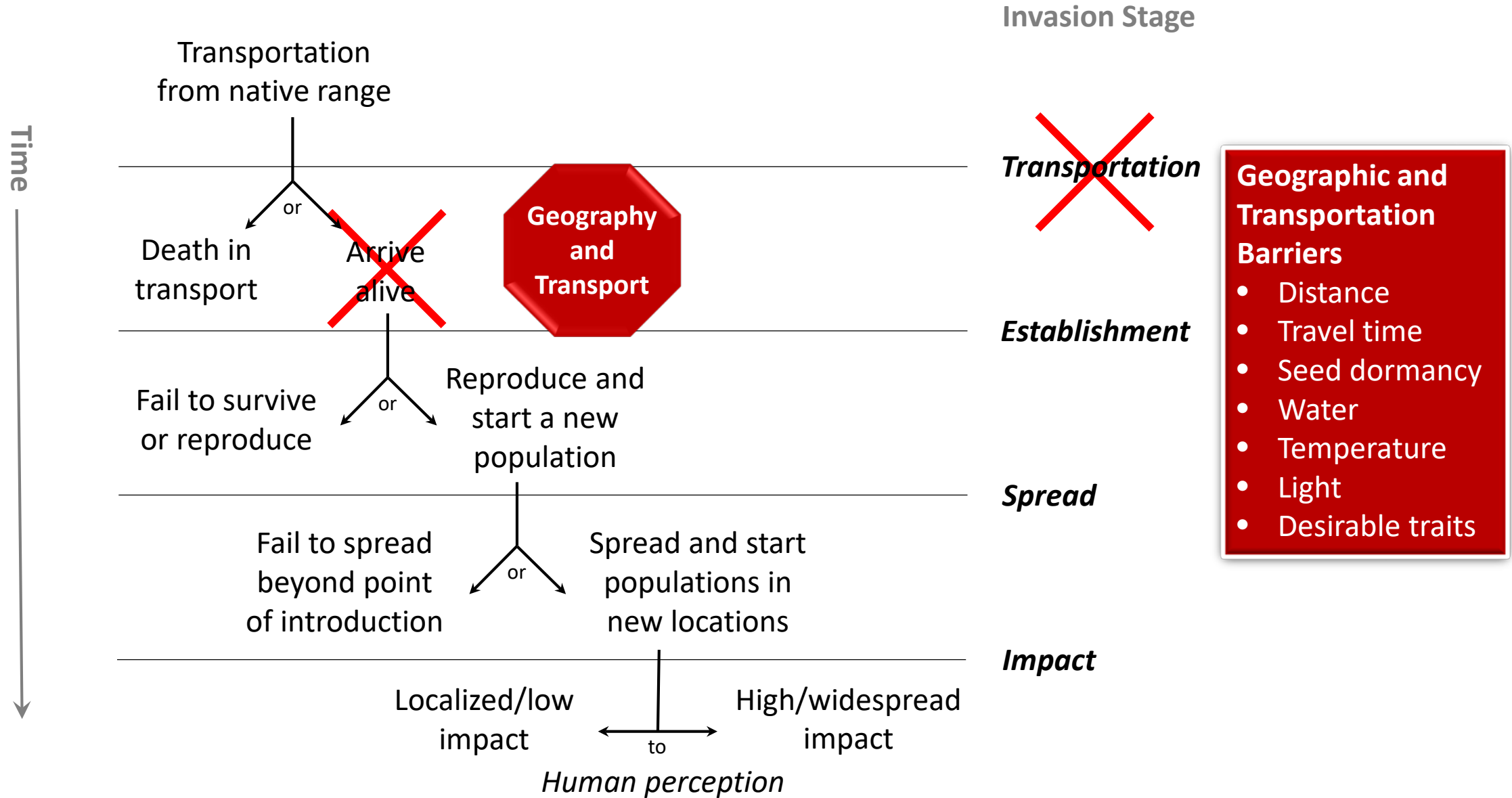
# Why don't all non-native species become invasive?

## Barriers to invasion

1. Geography
2. Local environment
3. Reproduction
4. Dispersal
5. Establishment
  - Habitats disturbed by people
  - Habitats less disturbed by people

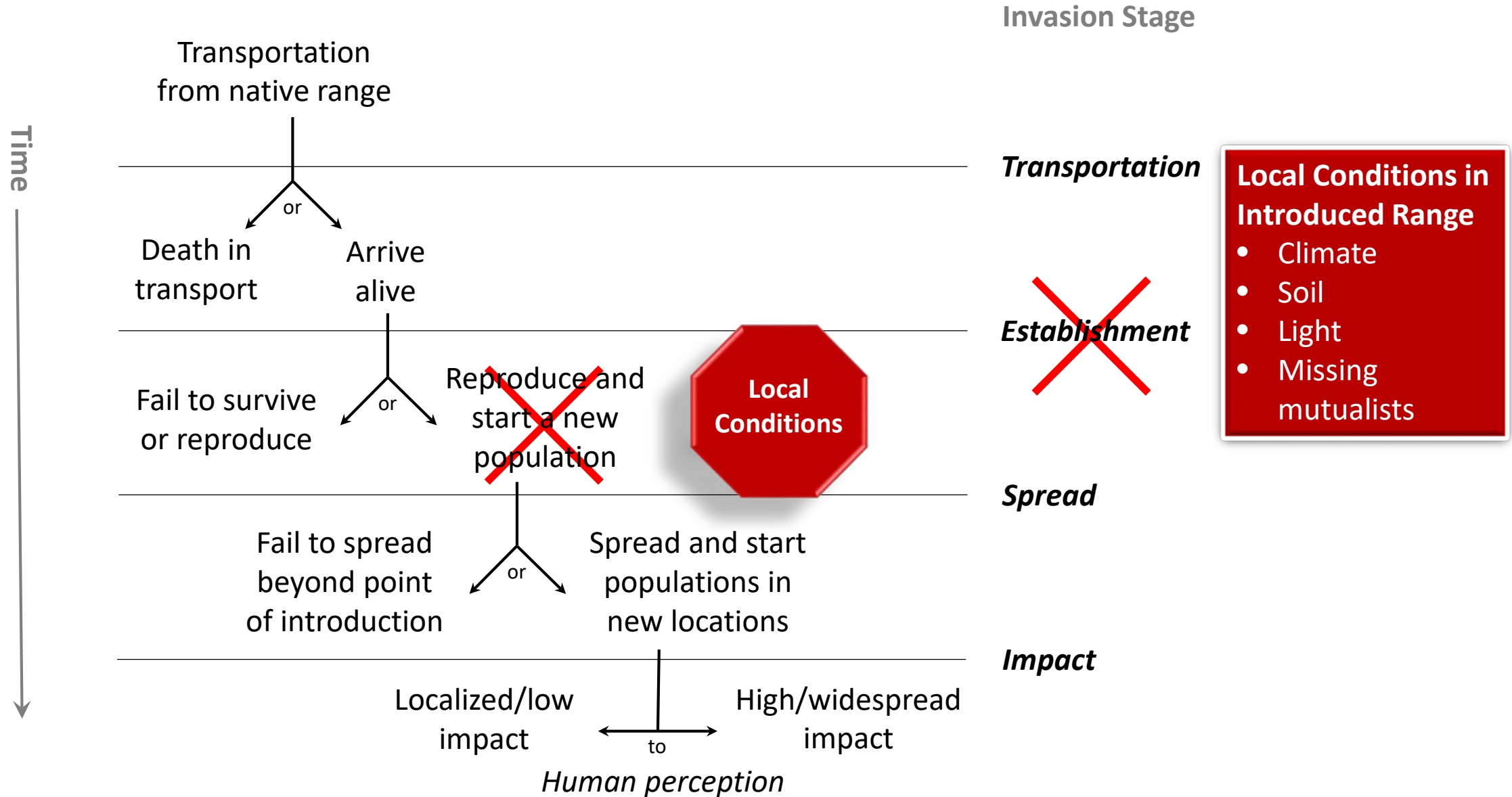


# Barriers to Invasion

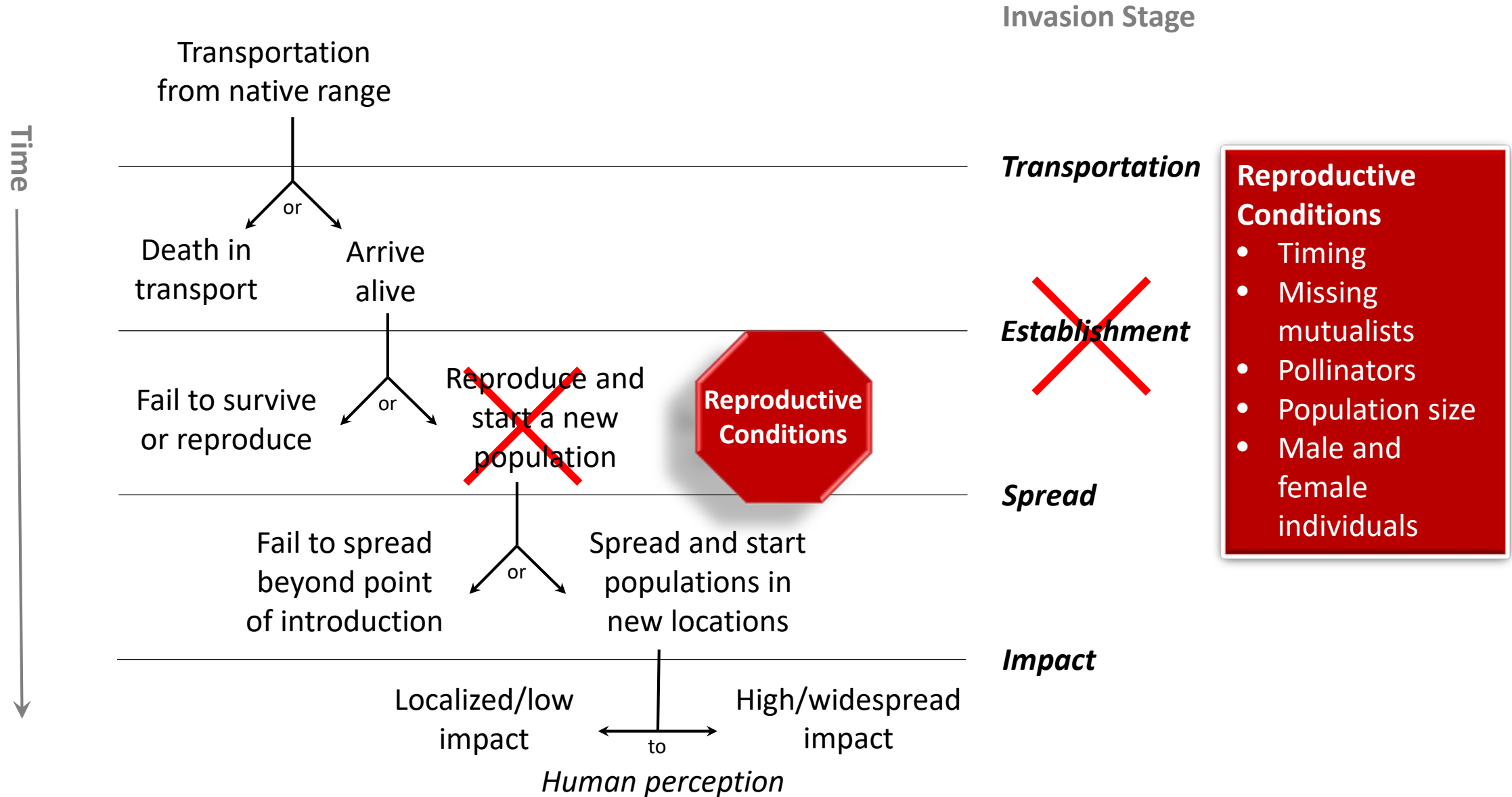




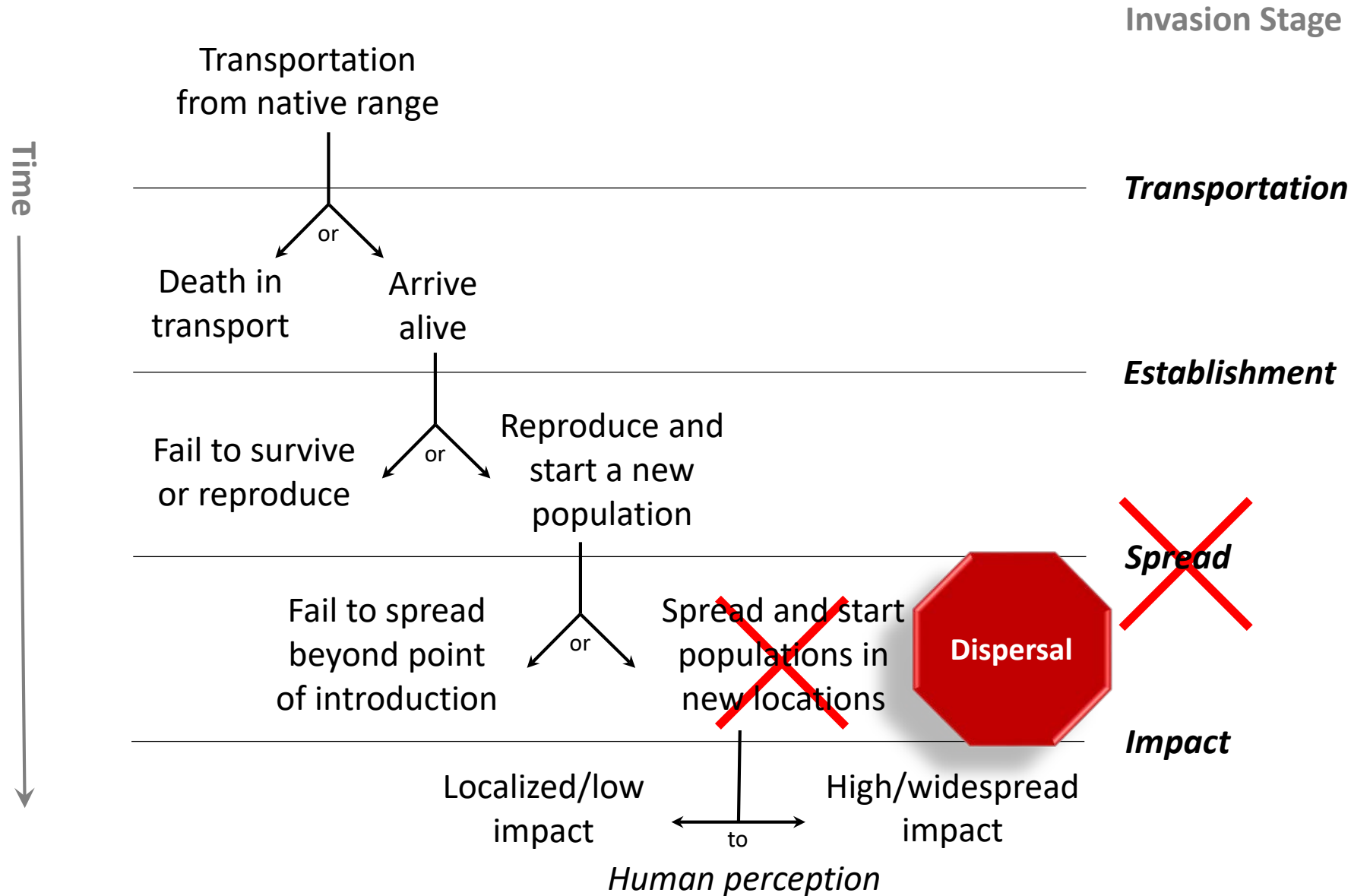
# Barriers to Invasion



# Barriers to Invasion



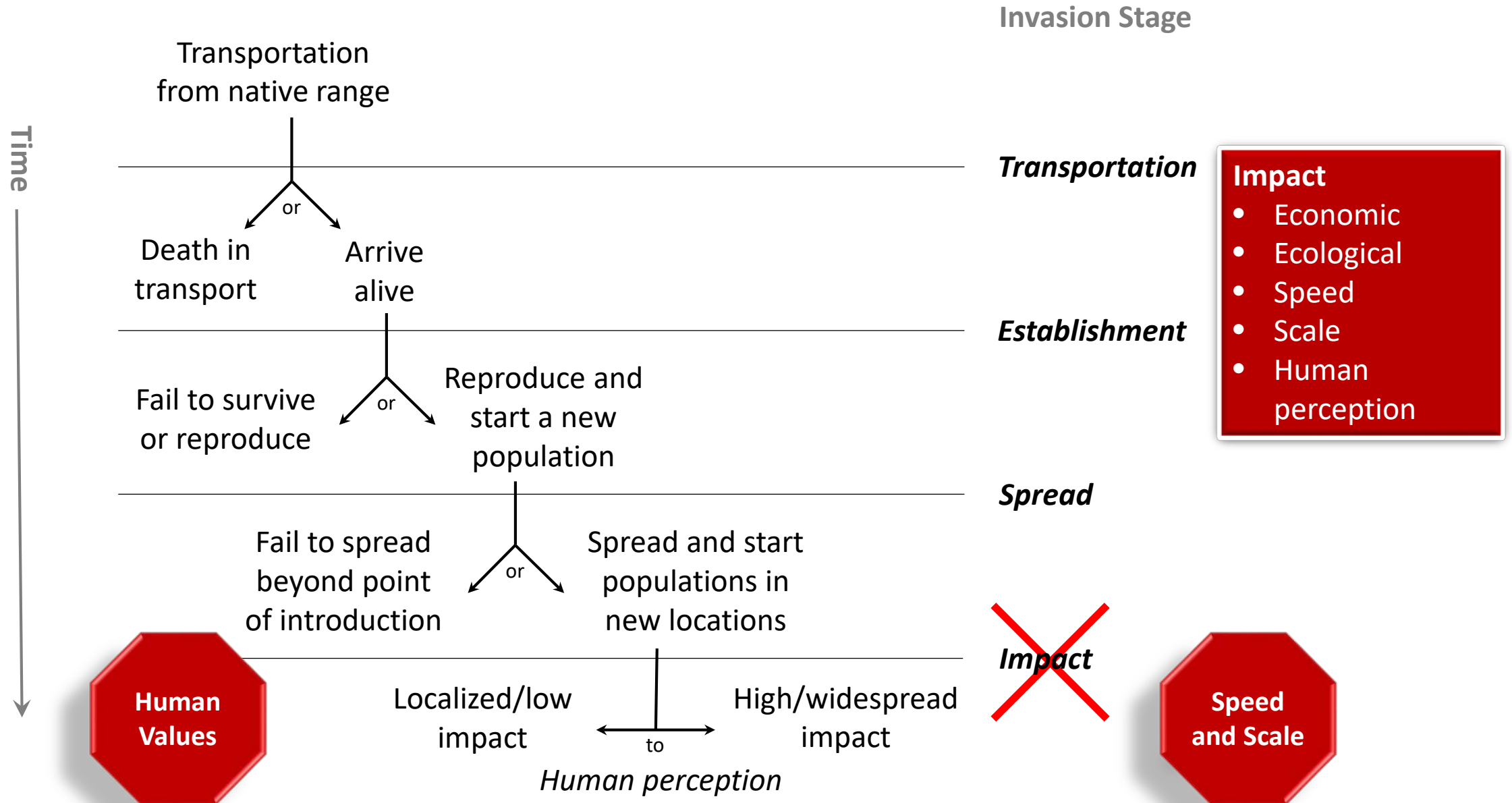
# Barriers to Invasion



**Dispersal from Initial Established Populations**

- Dispersal mode
- Human help
- Physical & geographical barriers
- Habitat availability

# Barriers to Invasion



## Causes of Invasion

Why do some species become invasive?  
Why don't all of them?



*Prunus persica*  
Peach



*Pueraria montana* var. *lobata*  
Kudzu

Photo: Kudzu covered field near Port Gibson, Mississippi, USA, by Gsmith 2006 CCA2.0

Photo: Zeynel Gebeci CCA 4.0

States. National Center for Socio-Environmental Synthesis Teaching Case Study Collection

Johnson, Lea R., 2017, Social-Ecological System Case Study: To Plant, or Not to Plant? Regulation of Invasions

# Causes of Invasion: Community Properties?

- Propagule pressure
- Biotic resistance
- Invasion meltdown
- Enemy release
- Habitat filtering
- Empty niche
- Mutualist facilitation
- Evolutionary imbalance

Can interactions between species hinder or facilitate invasion?



# Causes of Invasion: Community Properties?

- Propagule pressure
- Biotic resistance
- Invasion meltdown
- Enemy release
- Habitat filtering
- Empty niche
- Mutualist facilitation
- Evolutionary imbalance

Number of individuals introduced at once  
Number of introductions  
Viable population size  
Genetic diversity



# Causes of Invasion: Community Properties?

- Propagule pressure
- **Biotic resistance**
- Invasion meltdown
- Enemy release
- Habitat filtering
- Empty niche
- Mutualist facilitation
- Evolutionary imbalance

Community resists invasion  
Diversity of species and  
functional traits



Effects of functional and taxonomic diversity on invasive plant species are being tested in urban vacant lots in Baltimore.



# Causes of Invasion: Community Properties?

- Propagule pressure
- Biotic resistance
- **Invasion meltdown**
- Enemy release
- Habitat filtering
- Empty niche
- Mutualist facilitation
- Evolutionary imbalance

Invasive species facilitate one another  
Increase in fitness



Figs have obligate pollination mutualisms with small wasps. The common edible fig, *Ficus carica*, is invasive in California. Both the tree and its pollinating wasp were introduced for fruit production.

# Causes of Invasion: Community Properties?

- Propagule pressure
- Biotic resistance
- Invasion meltdown
- **Enemy release**
- Habitat filtering
- Empty niche
- Mutualist facilitation
- Evolutionary imbalance

Missing interactions that keep  
population sizes lower in native range  
Predators  
Pathogens



Japanese beetle on elderberry  
C. Fannin 2007 CCA2.0

Japanese beetles are an important pest of both crops and wild plants across the Eastern United States.

# Causes of Invasion: Community Properties?

- Propagule pressure
- Biotic resistance
- Invasion meltdown
- Enemy release
- **Habitat filtering**
- Empty niche
- Mutualist facilitation
- Evolutionary imbalance

Species adapted to human-altered sites  
Transportation to favorable locations



Photo: Pancrat 2009 GNU1.2

Porcelain-berry (*Ampelopsis brevipedunculata*) is planted in sunny, open locations to cover fences and slopes.

# Causes of Invasion: Community Properties?

- Propagule pressure
- Biotic resistance
- Invasion meltdown
- Enemy release
- Habitat filtering
- **Empty niche**
- Mutualist facilitation
- Evolutionary imbalance

Niche: ecological role  
Available resources  
Empty versus occupied  
Functional and taxonomic diversity



Photo © Lea Johnson 2016

Where predators have been removed, herbivores can become overabundant, leaving behind only plants they cannot eat or do not prefer.

# Causes of Invasion: Community Properties?

- Propagule pressure
- Biotic resistance
- Invasion meltdown
- Enemy release
- Habitat filtering
- Empty niche
- **Mutualist facilitation**
- Evolutionary imbalance

Help from native or non-native species  
Pollination  
Dispersal



Photo: Pancrat 2009 GNU1.2

Many non-native invasive vines found in forest patches of the Eastern U.S. reproduce via bird-dispersed berries.

# Causes of Invasion: Community Properties?

- Propagule pressure
- Biotic resistance
- Invasion meltdown
- Enemy release
- Habitat filtering
- Empty niche
- Mutualist facilitation
- **Evolutionary imbalance**

Species in isolated & smaller places have evolved with less competition



*Ficaria verna* & *Hedera helix*, College Park MD  
Photo © Lea Johnson 2016

Eurasian species Fig buttercup (*Ficaria verna*) and English Ivy (*Hedera helix*) in early spring on the Mid-Atlantic US coast.

# Causes of Invasion: Species Invasiveness?

- Tens rule
- Residence time
- Taxonomic affiliation
- Phenotypic plasticity
- Evolution of invasiveness
- Novel weapons

How do species' inherited traits influence whether or not they become invasive?



Photo: Pancrat 2009 GNU1.2

Porcelain-berry (*Ampelopsis brevipedunculata*)

# Causes of Invasion: Species Invasiveness?

- Tens rule
- Residence time
- Taxonomic affiliation
- Phenotypic plasticity
- Evolution of invasiveness
- Novel weapons

Observation:

1 in 10 introduced → survival

1 in 10 surviving → pest

(Williamson and Fitter 1996,  
Williamson & Brown 1986)

**But:**

Not in all systems

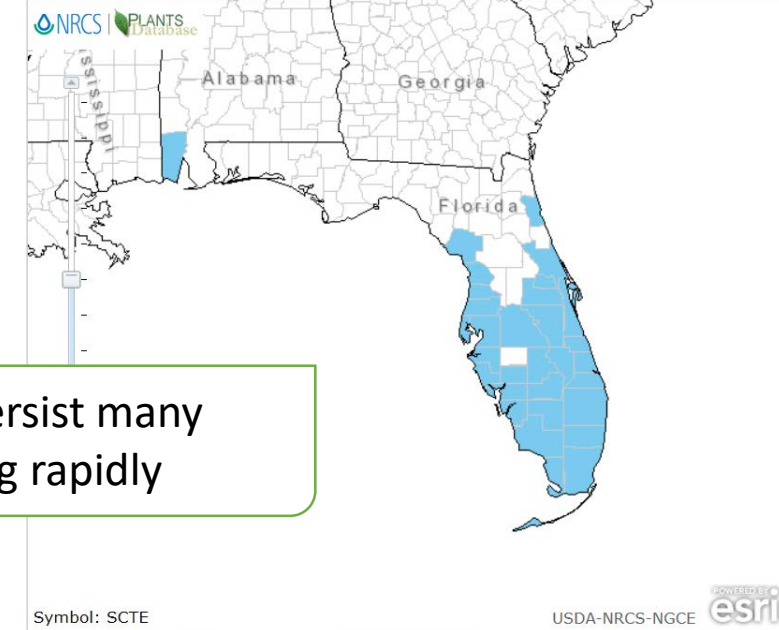
Not “pest” doesn’t necessarily  
mean no impact



# Causes of Invasion: Species Invasiveness?

- Tens rule
- Residence time
- Taxonomic affiliation
- Phenotypic plasticity
- Evolution of invasiveness
- Novel weapons

Species sometimes persist many years before spreading rapidly



*Schinus terebinthifolius*  
Brazilian peppertree  
Ornamental, introduced to FL in 1880s  
Rapid spread starting in 1950s



Photo: *Schinus terebinthifolius* - Jardín Botánico Canario by James Steakley CC BY 3.0

# Causes of Invasion: Species Invasiveness?

- Tens rule
- Residence time
- **Taxonomic affiliation**
- Phenotypic plasticity
- Evolution of invasiveness
- Novel weapons

## Relatedness and evolutionary lineages

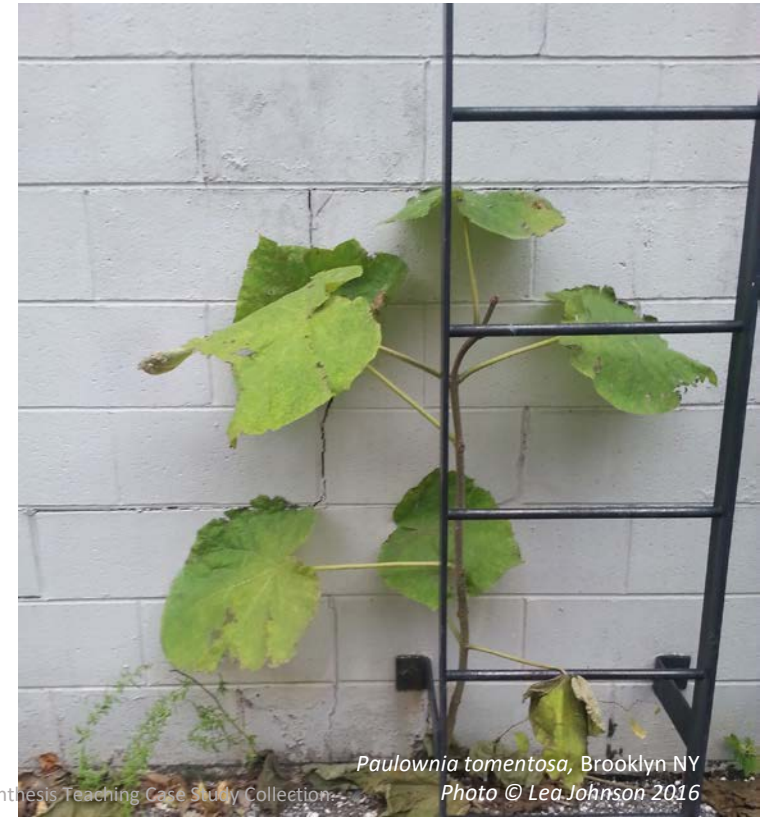


Members of the family *Celastrales* that are native to temperate Asia and invasive in North America include (L to R) burning bush (*Euonymus alatus*), wintercreeper (*E. fortunei*) and oriental bittersweet (*Celastrus orbiculatus*).

# Causes of Invasion: Species Invasiveness?

- Tens rule
- Residence time
- Taxonomic affiliation
- **Phenotypic plasticity**
- Evolution of invasiveness
- Novel weapons

Growth in response to environmental conditions  
Stress responses  
Broad tolerance



*Paulownia tomentosa*, Brooklyn NY

Photo © Lea Johnson 2016

# Causes of Invasion: Species Invasiveness?

- Tens rule
- Residence time
- Taxonomic affiliation
- Phenotypic plasticity
- **Evolution of invasiveness**
- Novel weapons

Genetic diversity  
Multiple introductions  
Introductions from multiple populations  
Hybridization  
Lag time



North American and European cordgrasses have hybridized to produce highly invasive hybrids.

# Causes of Invasion: Species Invasiveness?

- Tens rule
- Residence time
- Taxonomic affiliation
- Phenotypic plasticity
- Evolution of invasiveness
- **Novel weapons**

Defensive and offensive traits  
Not present in native species  
Herbivore resistance: thorns, palatability  
Allelopathy



Salt cedar (*Tamarix ramosissima*) exudes salts that change soil chemistry, inhibiting growth of native species along rivers in the Southwestern United States. Its fine branches produce fuel that can increase fire frequency in these habitats.

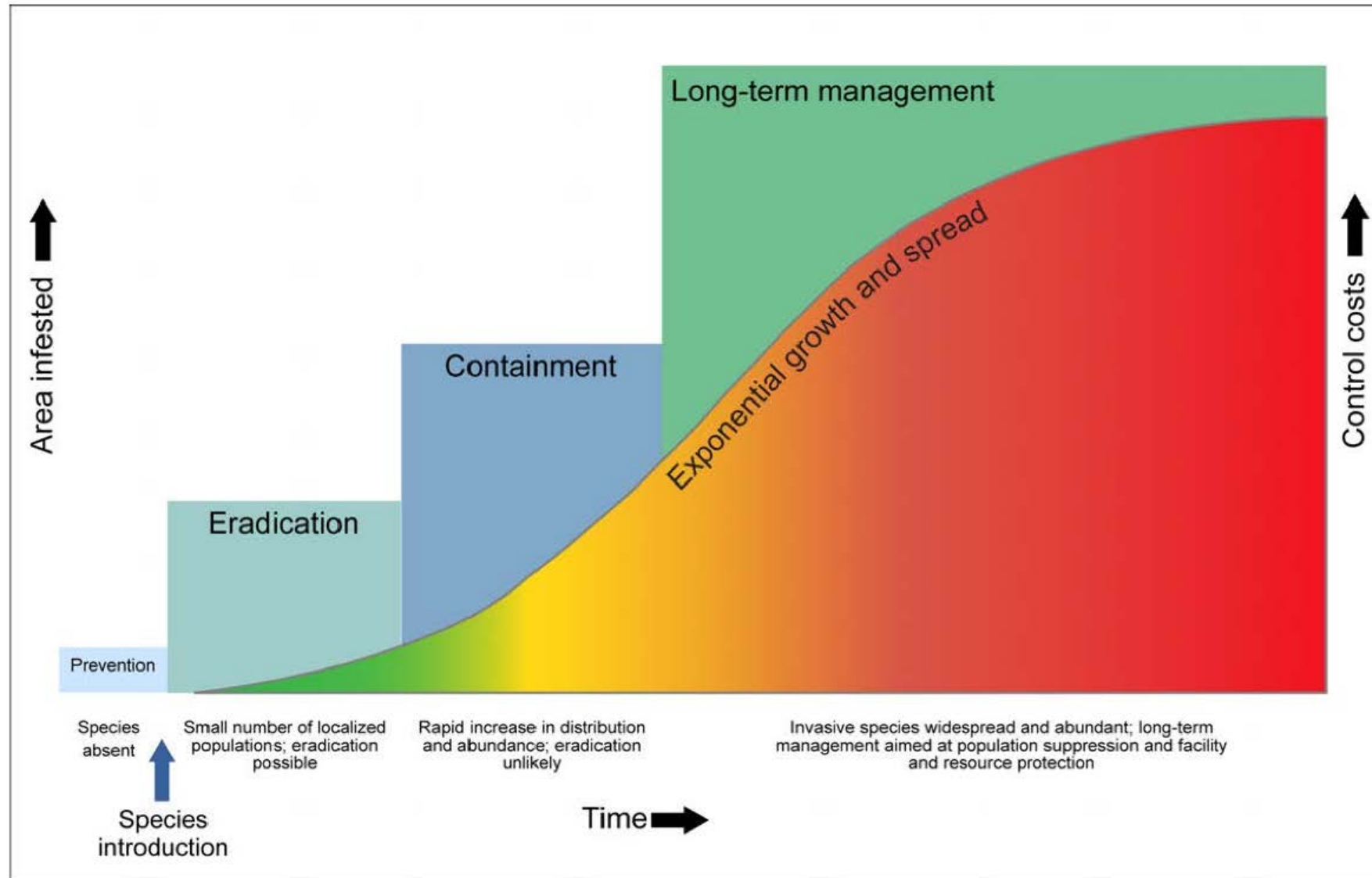
# Managing Invasions: What response is appropriate, and when?



*Pueraria montana var. lobata*

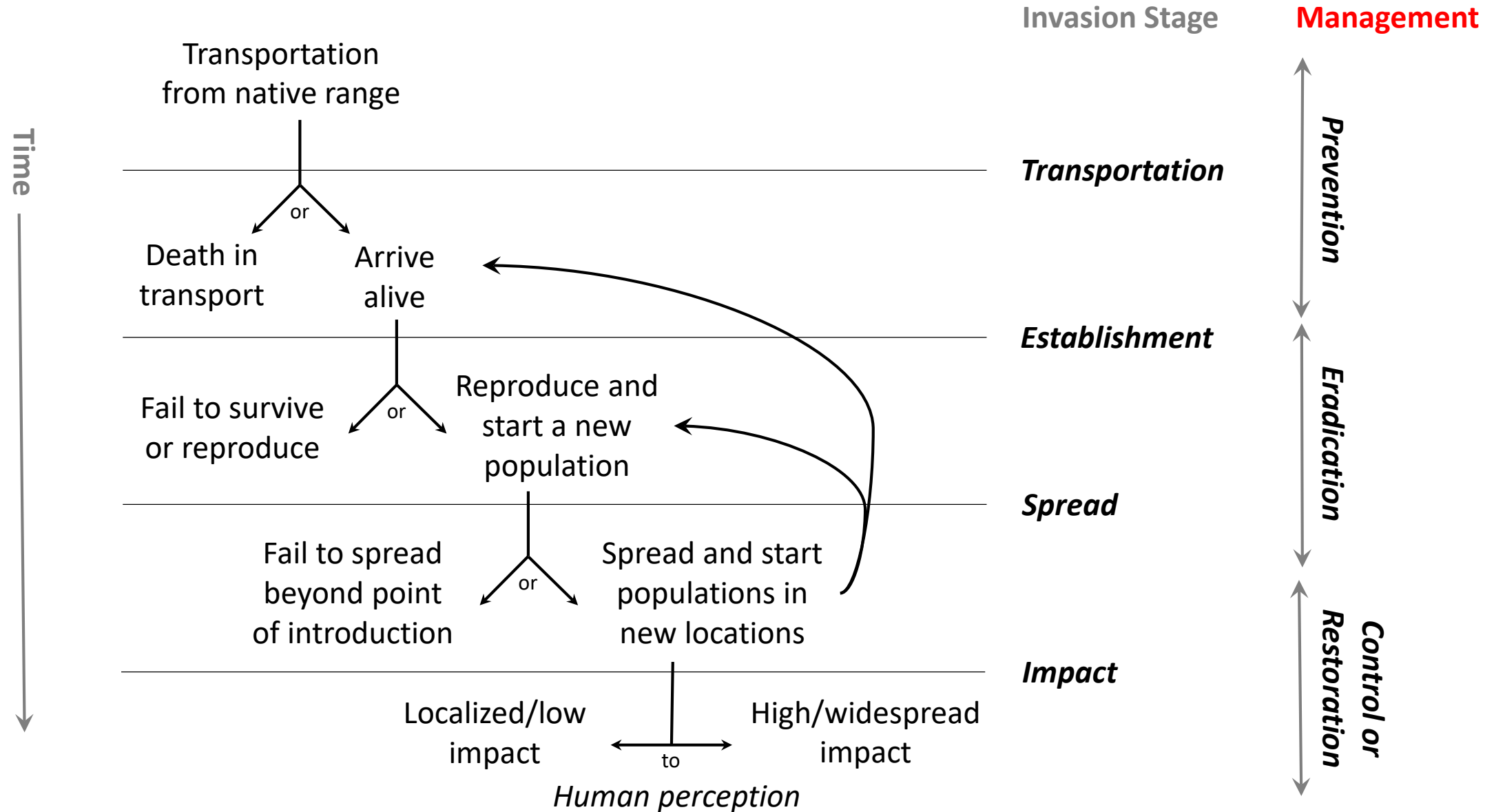
kudzu

# Managing Invasions: Invasion Curve Model



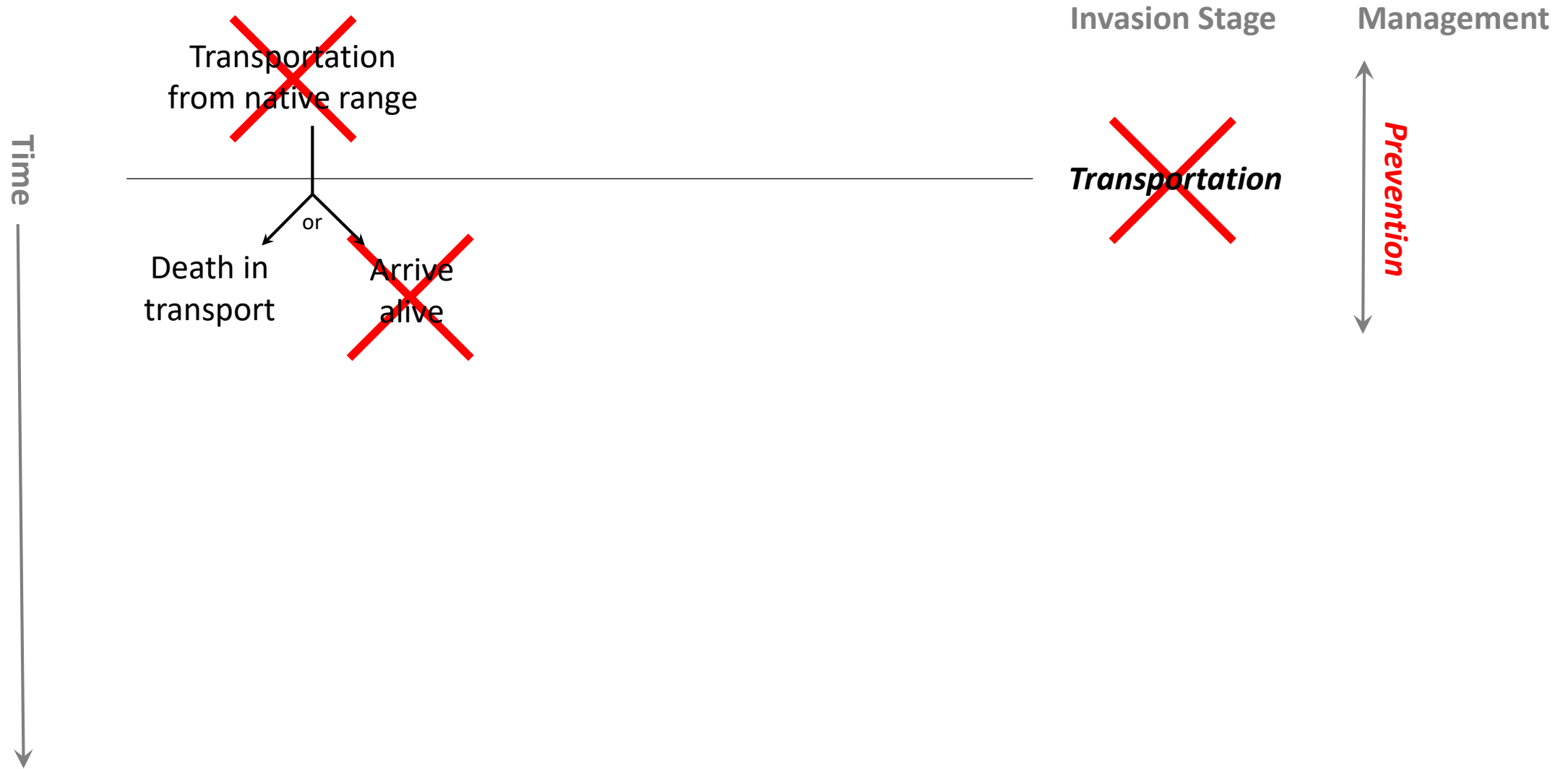
Sources: National Invasive Species Council; U.S. Department of Agriculture; National Park Service; U.S. Fish and Wildlife Service; Rodgers, L, South Florida Water Management District; Department of Primary Industries, State of Victoria, Australia; and GAO. | GAO-16-49

# Managing Invasions: Managing the Process

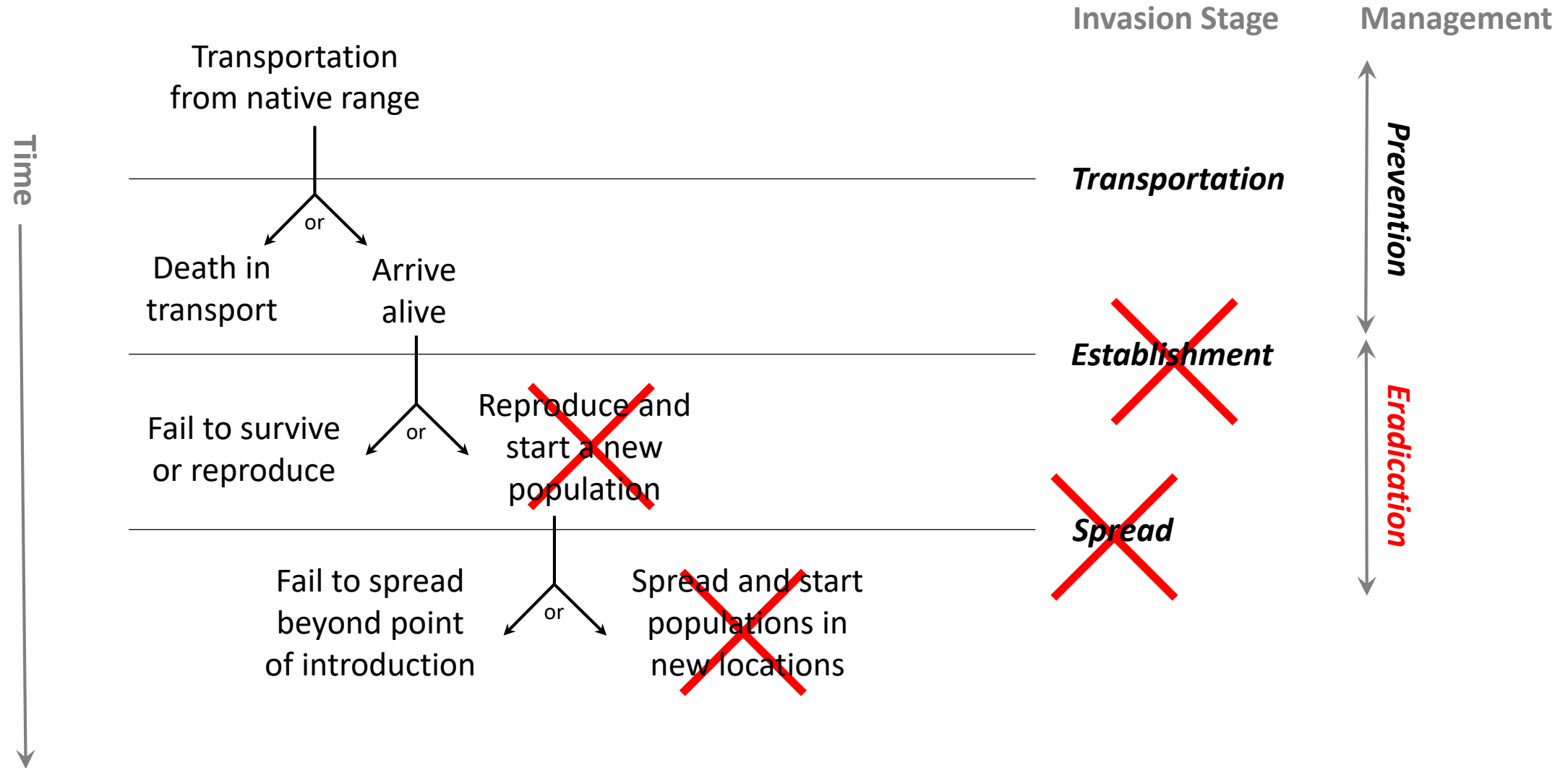




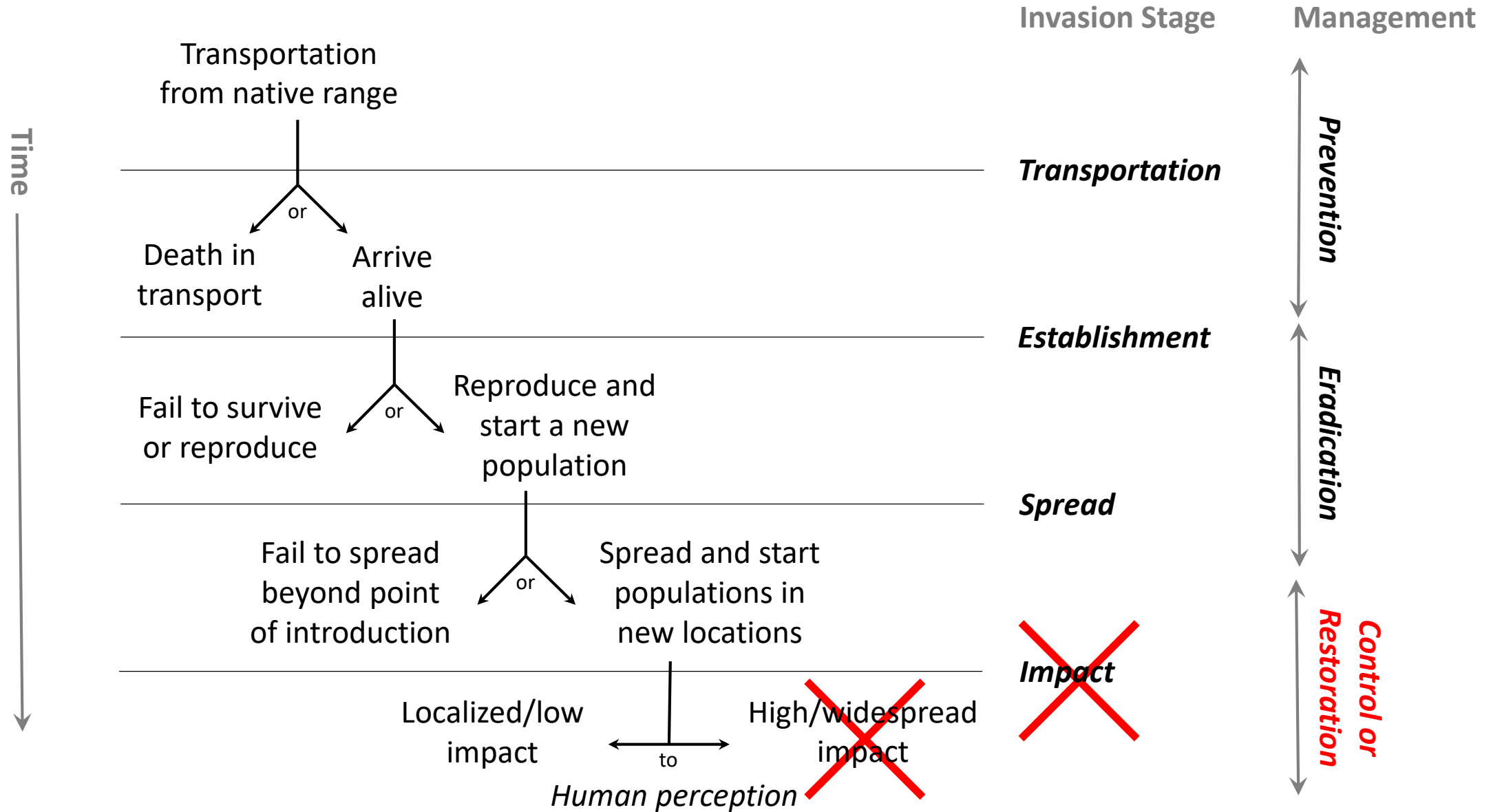
# Managing Invasions: Managing the Process



# Managing Invasions: Managing the Process



# Managing Invasions: Managing the Process



# Quick Questions

## Lecture comprehension

1. In what phase of invasion is kudzu found now in the Southeastern US? In California?
  - a. Transportation
  - b. Establishment
  - c. Spread
  - d. Impact (high)
  - e. Impact (low)
2. What management strategy might be appropriate for this species now in the Southeastern US? In California?
  - a. Prevention
  - b. Eradication
  - c. Control or restoration

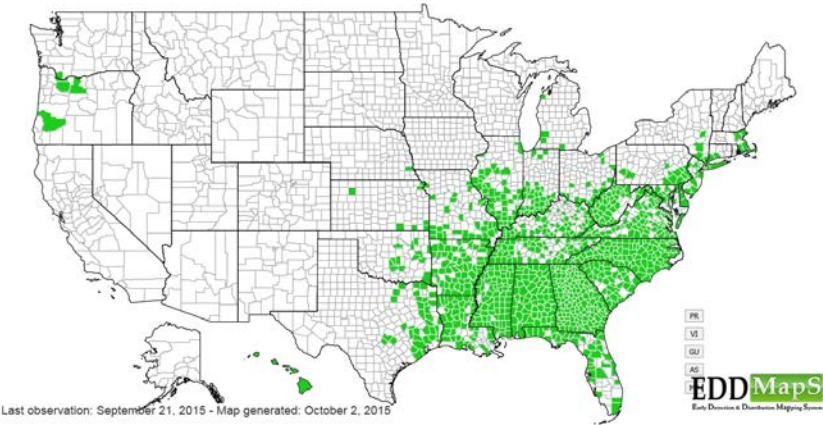


Photo: Forest & Kim Starr CC 3.0