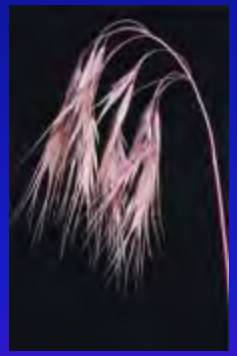
 davis@macalester.edu

Managing Ecosystems to Reduce Invasibility

Challenges, Pitfalls, and Opportunities



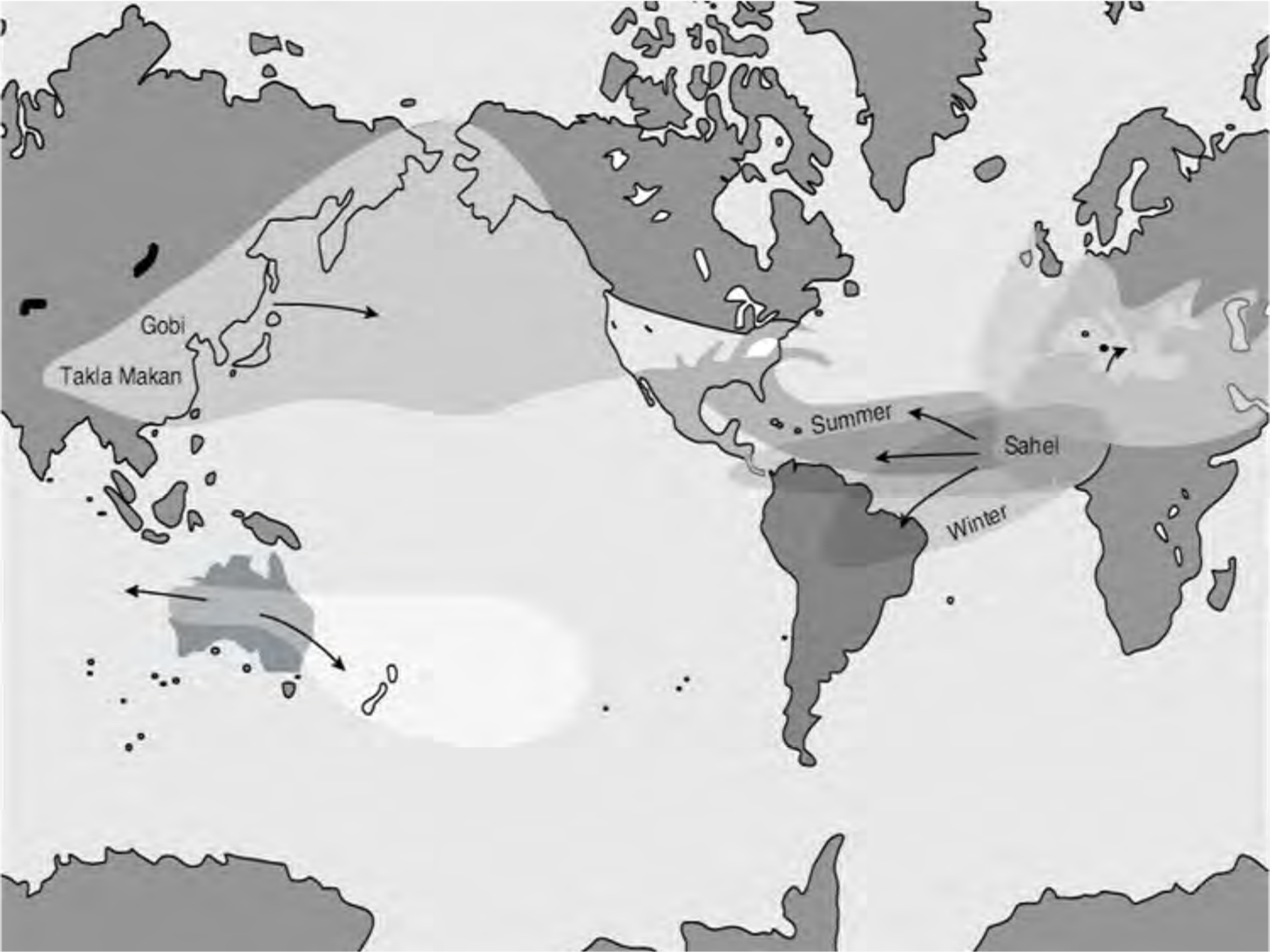



Mark Davis
Macalester College

Recognize
Complexity and Change

Manage
The System, not the Species

Embrace Humility


Gobi
Takla Makan
Summer
Sahel
Winter

OCEANIA


CHINA
Taipei
Taiwan
PHILIPPINES
Manila
Philippine Sea
Northern Mariana Islands (U.S.)
Saipan
Hagåtña
Guam (U.S.)
Wake Island (U.S.)
Midway Islands (U.S.)
HAWAIIAN ISLANDS (U.S.)
Hawaii
Johnston Atoll (U.S.)
North Pacific Ocean
FEDERATED STATES OF MICRONESIA
CAROLINE ISLANDS
Koror
PALAU
Palikir
MARSHALL ISLANDS
Majuro
Kingman Reef (U.S.)
Palmyra Atoll (U.S.)
Tarawa
KIRIBATI (GILBERT ISLANDS)
Howland Island (U.S.)
Baker Island (U.S.)
Jarvis Island (U.S.)
Nauru District
NAURU
KIRIBATI
PHOENIX ISLANDS
LINE ISLANDS
KIRIBATI
Kiritimati
INDONESIA
PAPUA NEW GUINEA
Port Moresby
SOLOMON ISLANDS
Honiara
TUVALU
Funafuti
Tokelau (N.Z.)
Cook Islands (N.Z.)
Rarotonga
Niue (N.Z.)
Apia
SAMOA
Pago Pago
Papeete
ARCHIPEL DES TUAMOTU
Coral Sea Islands (AUSTRALIA)
Coral Sea
FIJI
Suva
TONGA
Nuku'alofa
Port Vila
VANUATU
New Caledonia (FRANCE)
Nouméa
French Polynesia (FRANCE)
Adamstown
Pitcairn Islands (U.K.)
AUSTRALIA
Canberra
Kingston
Norfolk Island (AUSTRALIA)
KERMADEC ISLANDS (N.Z.)
South Pacific Ocean
Tasman Sea
NEW ZEALAND
North Island
Wellington
South Island
Christchurch
CHATHAM ISLANDS (N.Z.)
Dunedin
Invercargill
Hobart
Tasmania
Indian Ocean
Scale: 1:36,000,000 at 30°S
Mercator Projection

USDA created by Lincoln in 1862

‘to procure, propagate, and distribute ….new and valuable seeds and plants.’

Plant Quarantine Act passed in 1912

Impacts of Non-Native Invasive Species

1. Human health and safety

2. Economic (including ecological services)

3. Ecological (impacts on biodiversity)

Impacts of Non-Native Invasive Species

1. Human health and safety

2. Economic (ir)

3. Ecological (i

Emerging Infectious Diseases

(SARS), West-Nile encephalitis,
avian influenza,
Ebola hemorrhagic fever,
dengue hemorrhagic fever

Impacts of Non-Native Invasive Species

1. Human health and safety

2. Economic (including ecological services)

3. Ecological (in

Ecological Services

provisioning of clean water, timber

soil retention

pollination of crops, orchards

seed dispersal

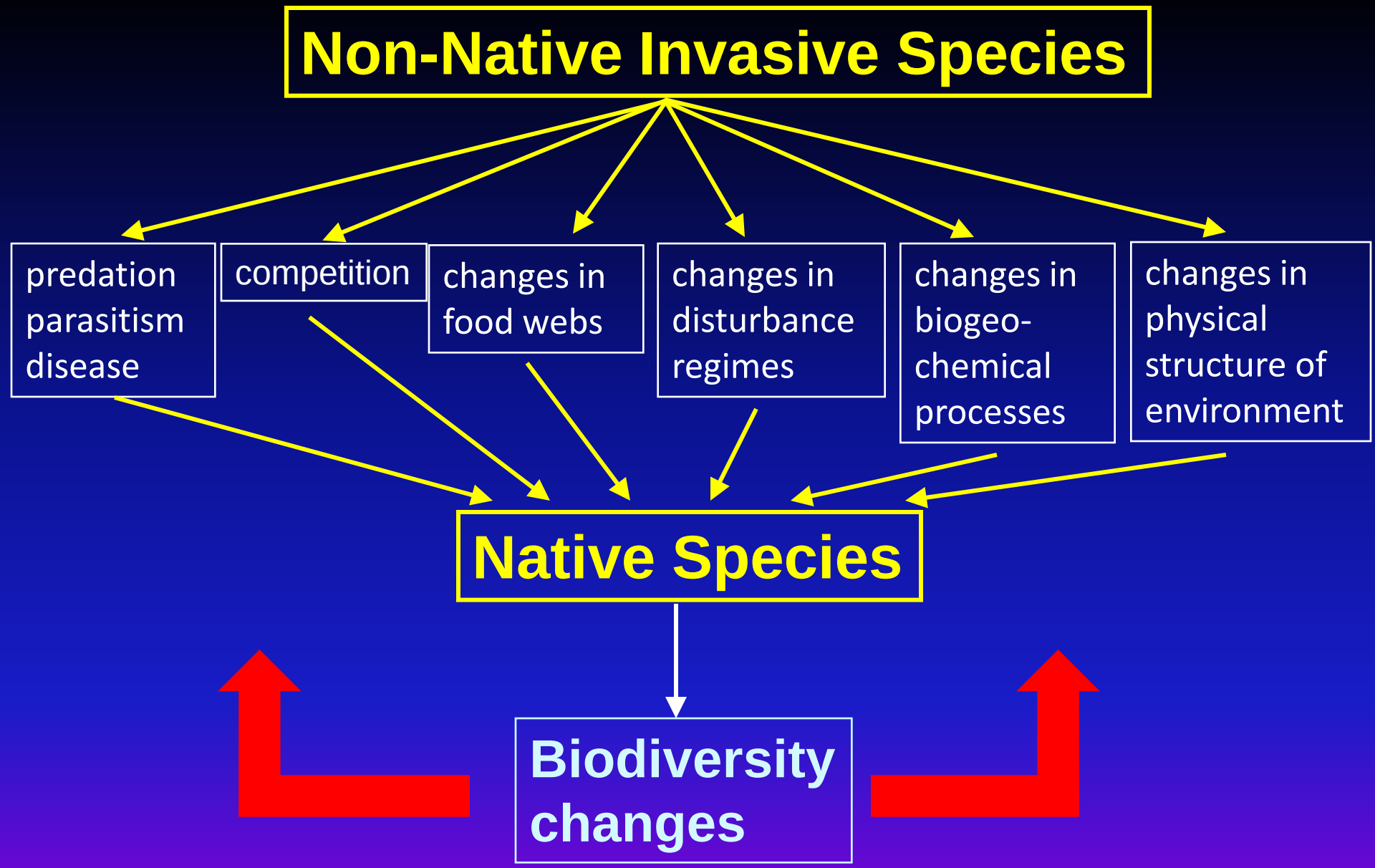
providing recreation opportunities

Impacts of Non-Native Invasive Species

1. Human health and safety

2. Economic (including ecological services)

3. Ecological (impacts on biodiversity)


Non-Native Invasive Species
predation
parasitism
disease
competition
changes in
food webs
changes in
disturbance
regimes
changes in
biogeo-
chemical
processes
changes in
physical
structure of
environment
Native Species
Biodiversity
changes

Effects of Introduced Species

Positive Effects of Introduced Species

- habitat modification
- trophic subsidy
- pollination
- predatory release
- competitive release

Rodriguez 2006

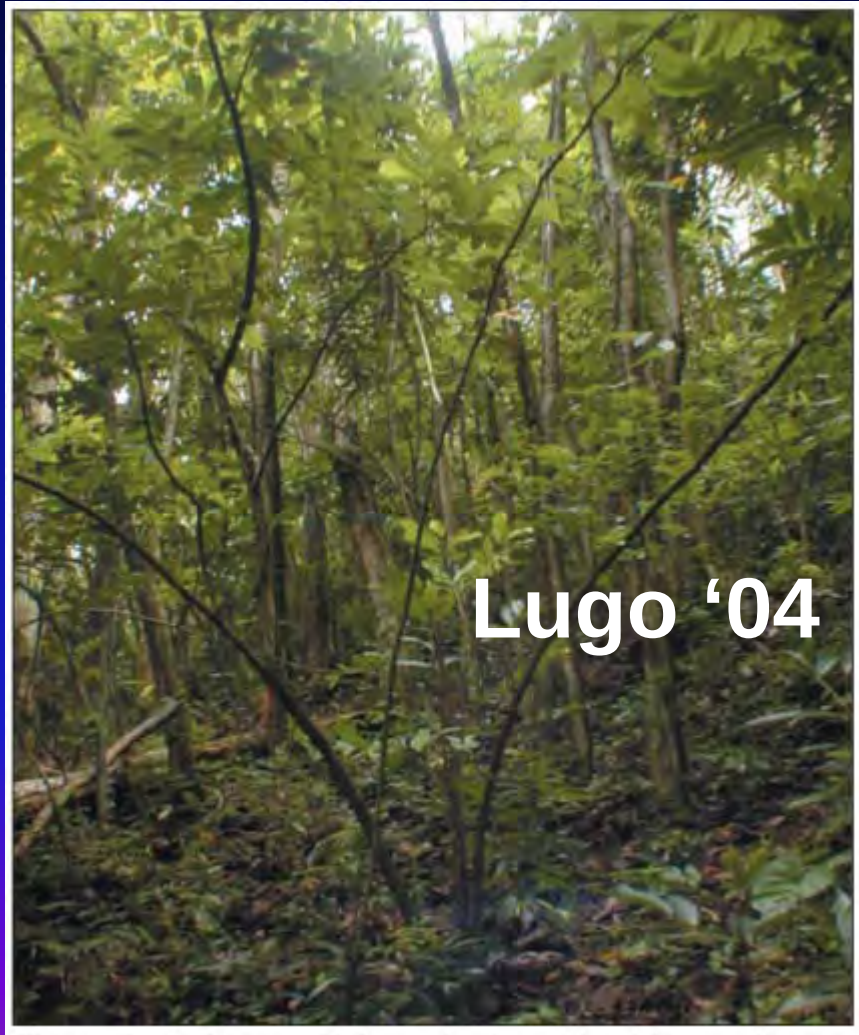


Figure 5. A 25-year-old forest dominated by African tulip trees (Spathodea campanulata). The understory is experiencing an invasion by native tree species under the canopy of the African tulip tree.

Positive Effects of Introduced Species

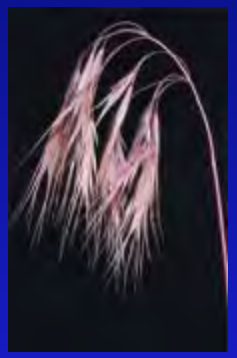
- habitat modification
- trophic subsidy
- pollination
- predatory release
- competitive release

Rodriguez 2006

Undesirable Effects → Management

The Invasion Process






The Invasion Process

Conditions in the new environment

Traits of the species

Number of propagules

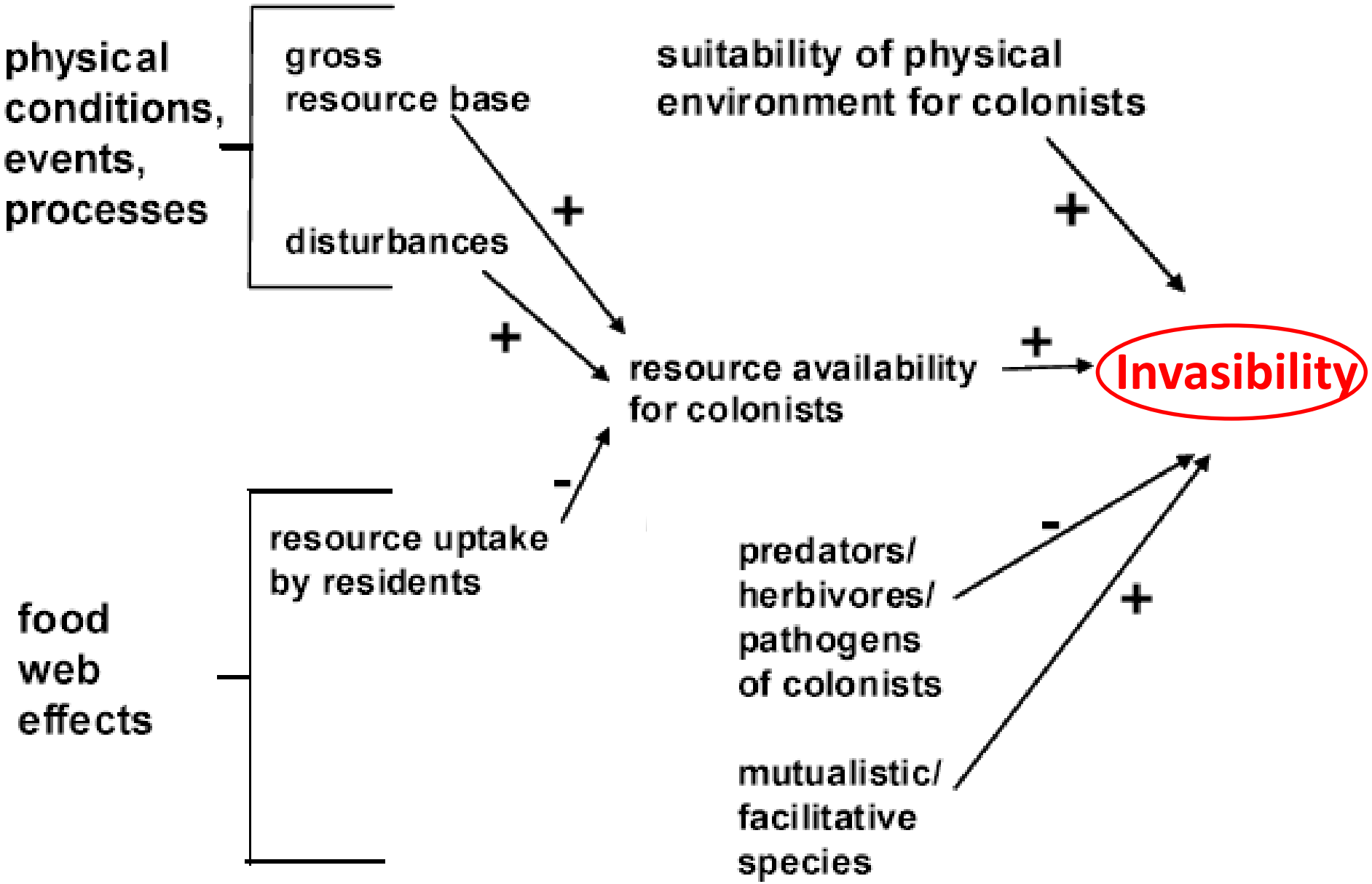
Conditions in the new environment

=

Invasibility

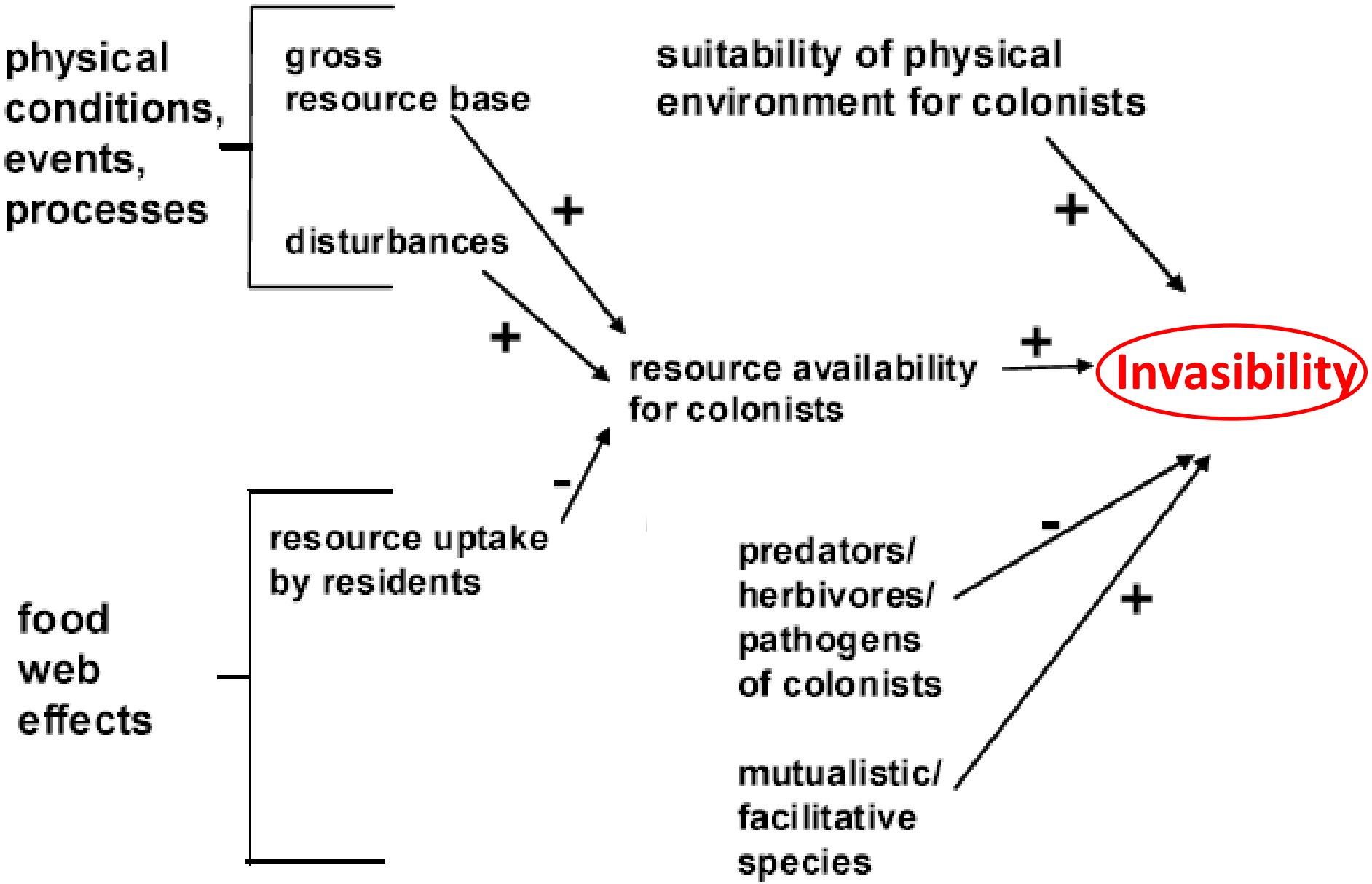
=

The susceptibility of an environment to the colonization and establishment of individuals from species not currently part of the resident community.


physical conditions, events, processes
gross resource base
disturbances
suitability of physical environment for colonists
+
+
+
+
resource availability for colonists
Invasibility
-
resource uptake by residents
food web effects
predators/ herbivores/ pathogens of colonists
-
+
mutualistic/ facilitative species

Invasibility Caveats

- Invasibility fluctuates in space and time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Invasibility Caveats

Invasibility fluctuates in space and time

Invasibility is species specific

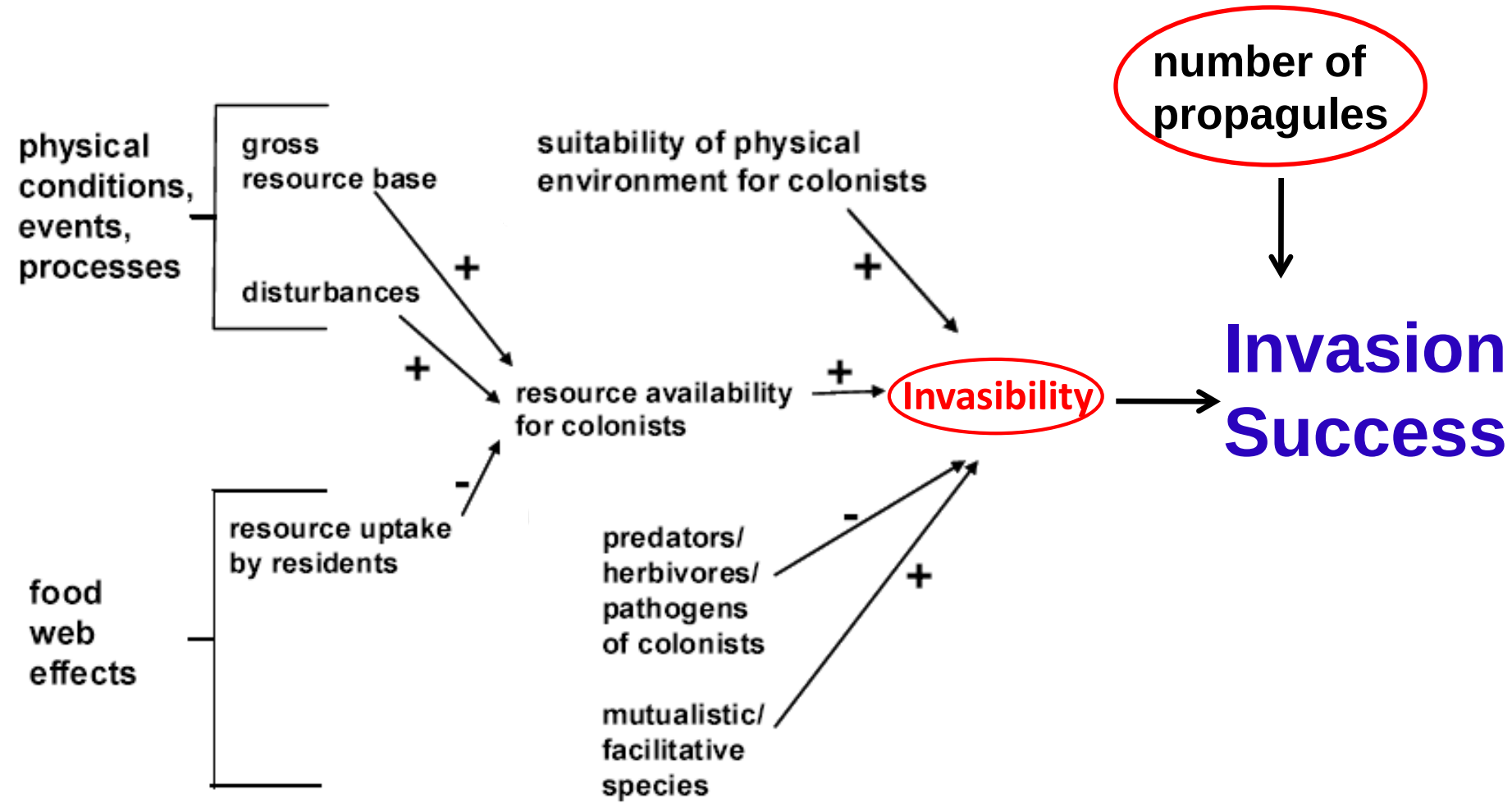
The Invasion Process

Conditions in the new environment

Traits of the species

Invasibility

Number of propagules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Invasion Success
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mutualistic/ facilitative species

If

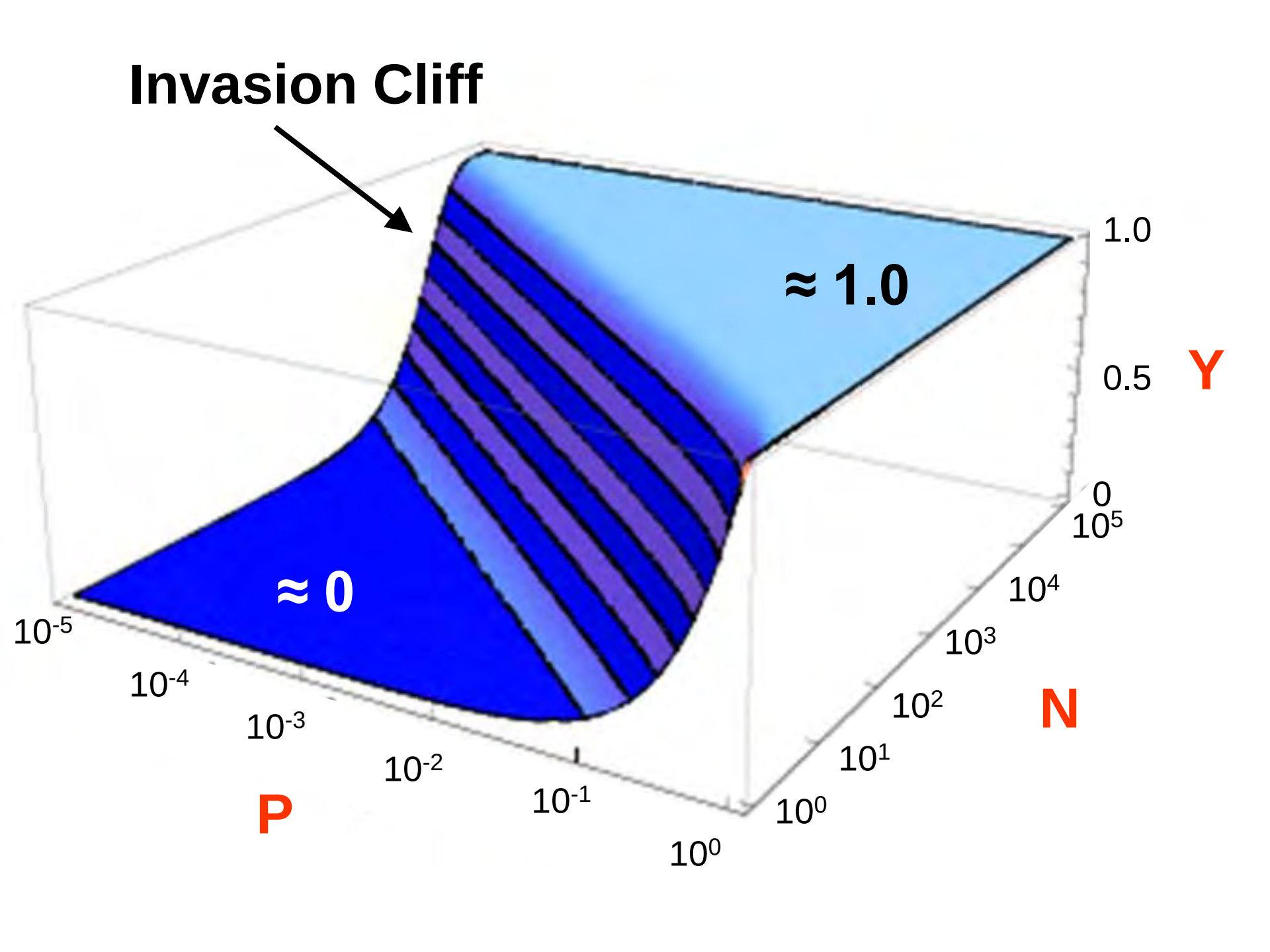
Invasion Success = establishment of at least one individual organism

Invasibility = probability of establishment of an arriving propagule

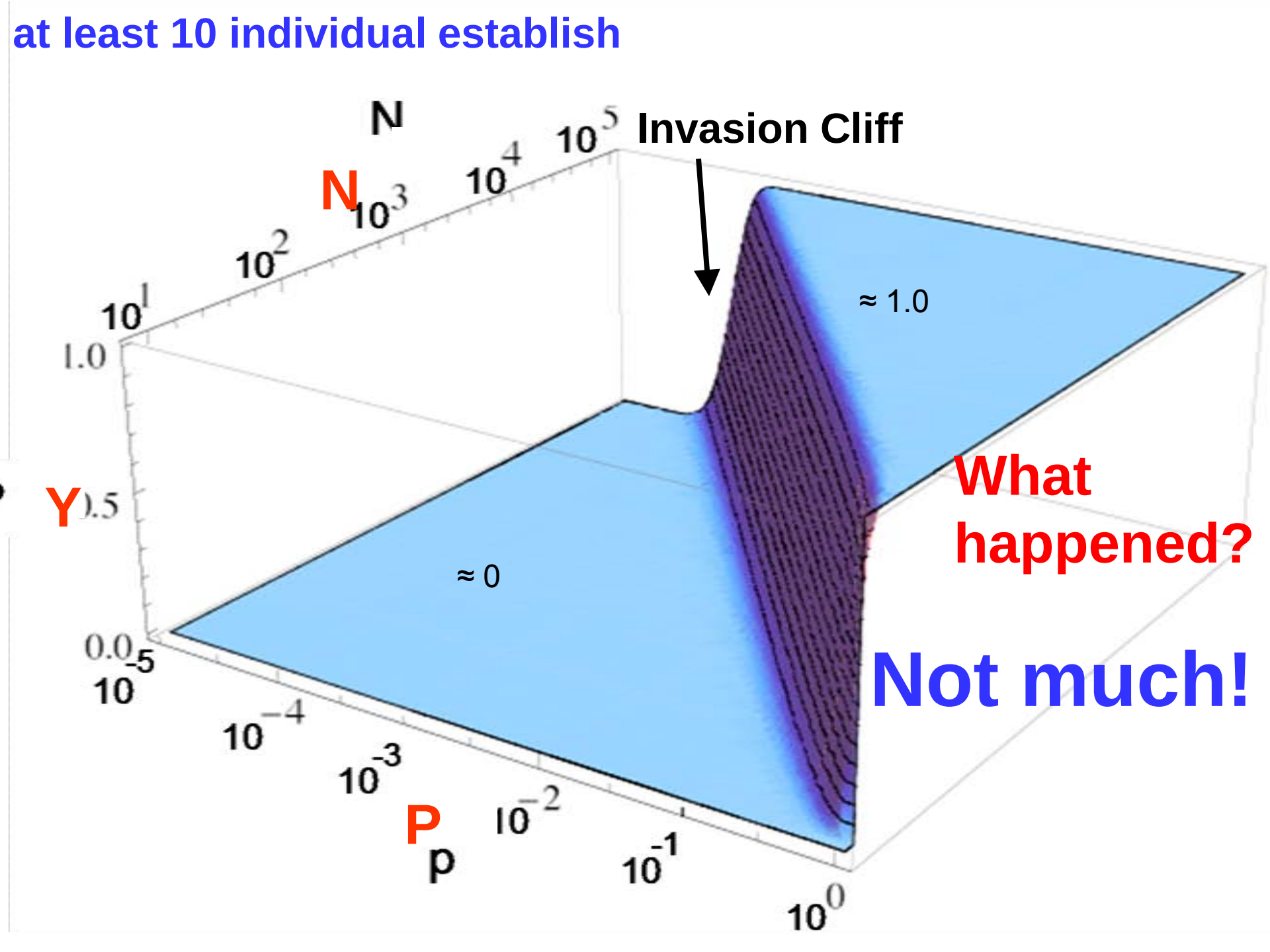
Then

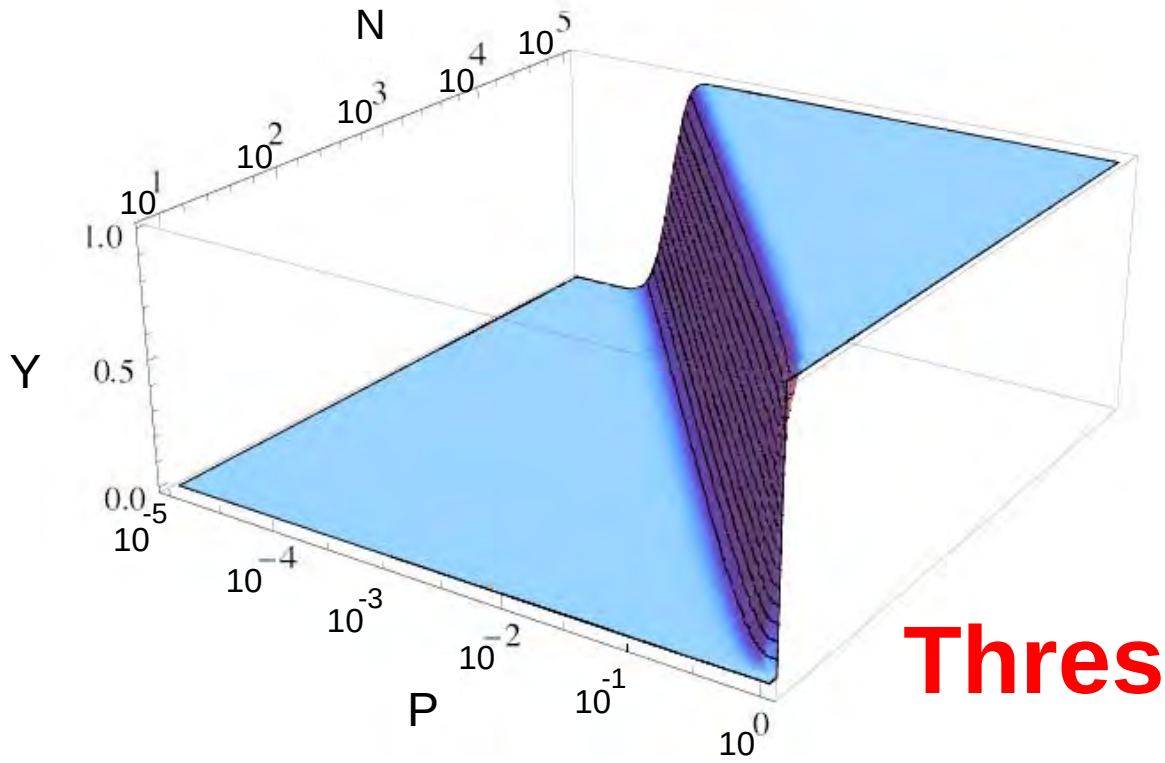
The probability of invasion success (Y)

$$= 1-(1-P)^N$$


Invasion Cliff
≈ 1.0
≈ 0
1.0
0.5
0
Y
10^{5}
10^{4}
10^{3}
10^{2}
10^{1}
10^{0}
N
10^{-5}
10^{-4}
10^{-3}
10^{-2}
10^{-1}
10^{0}
P

at least 10 individual establish





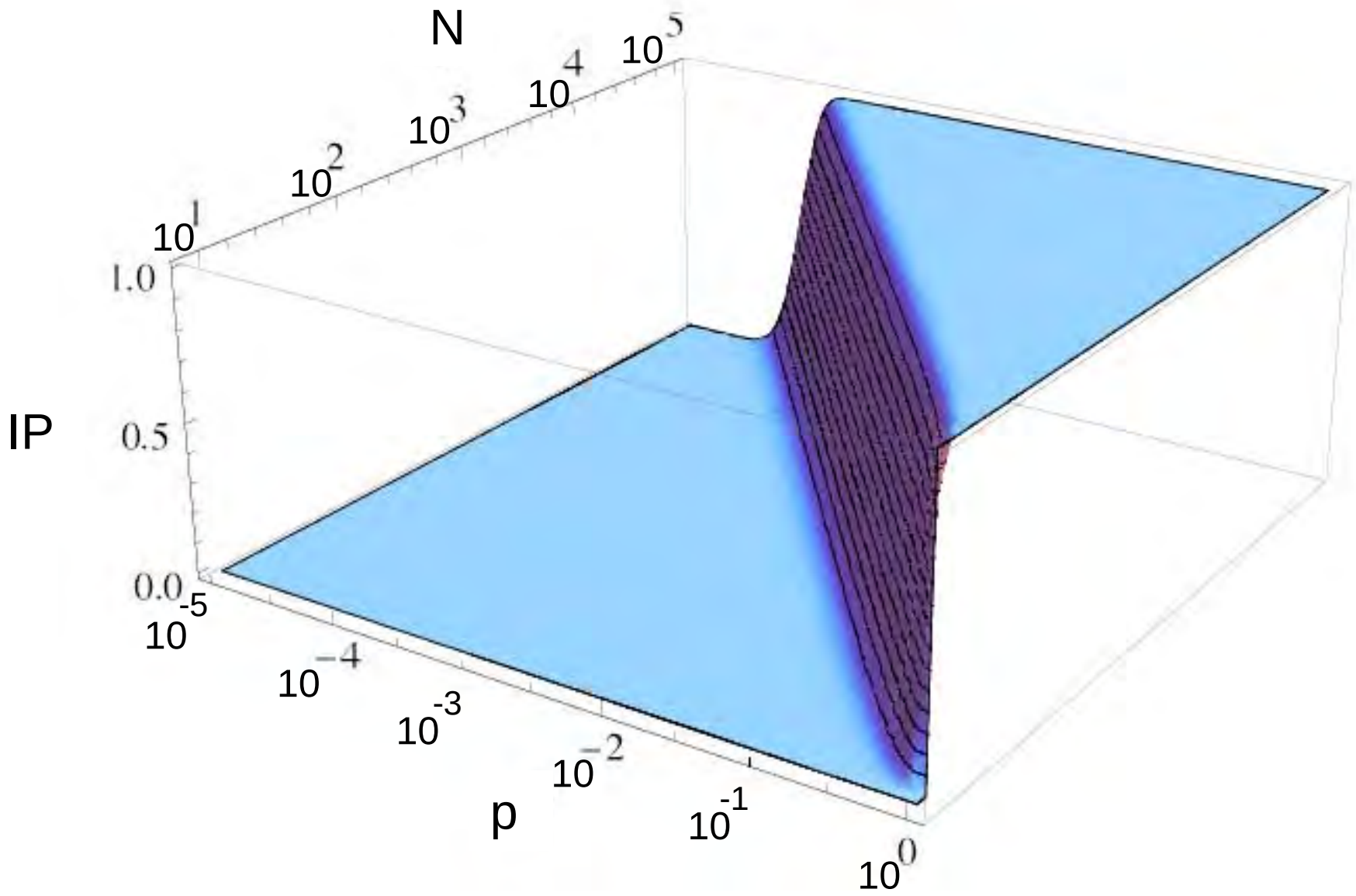
Threshold Dynamics

Lags - Irruptions

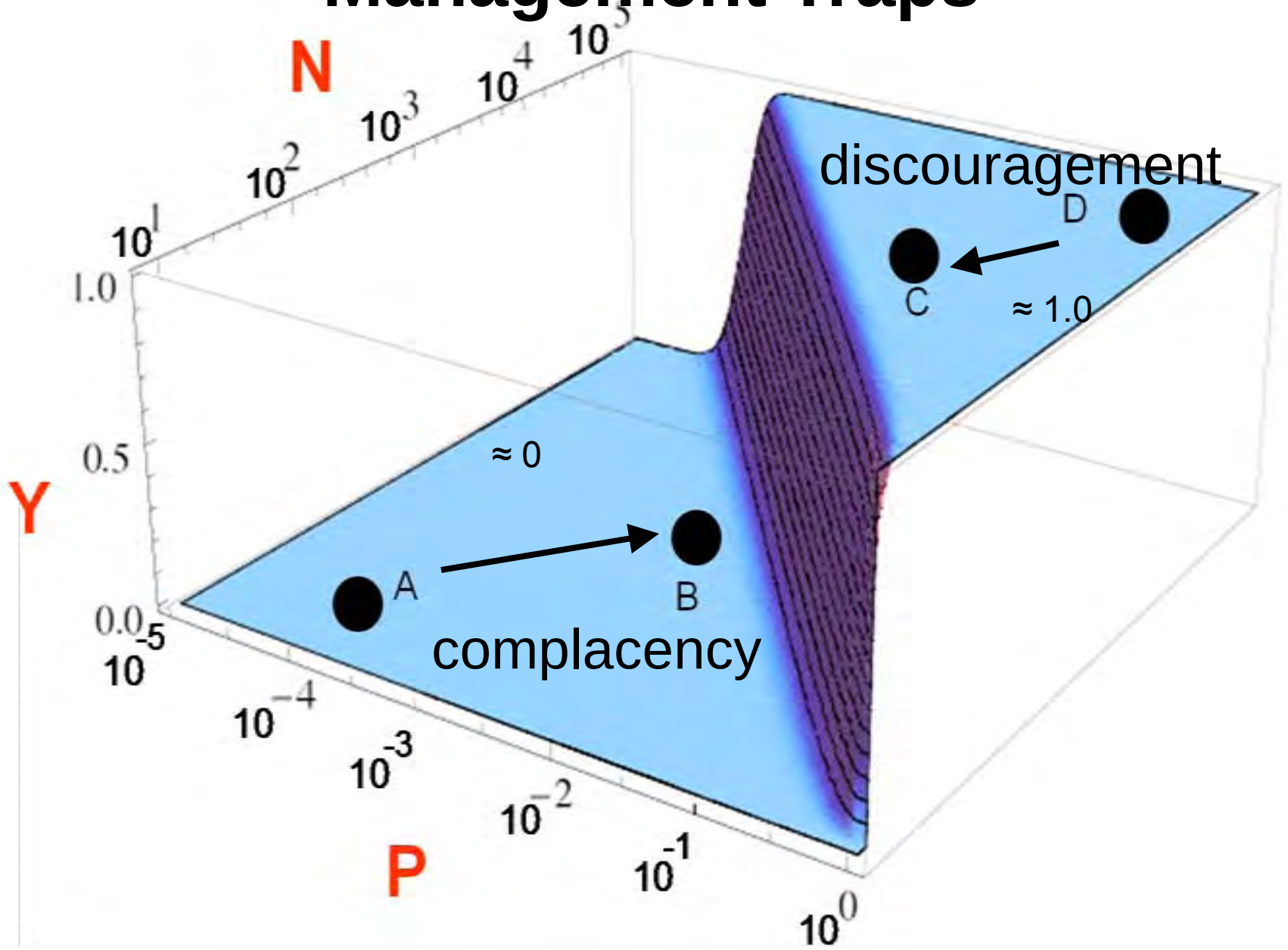
Collapses

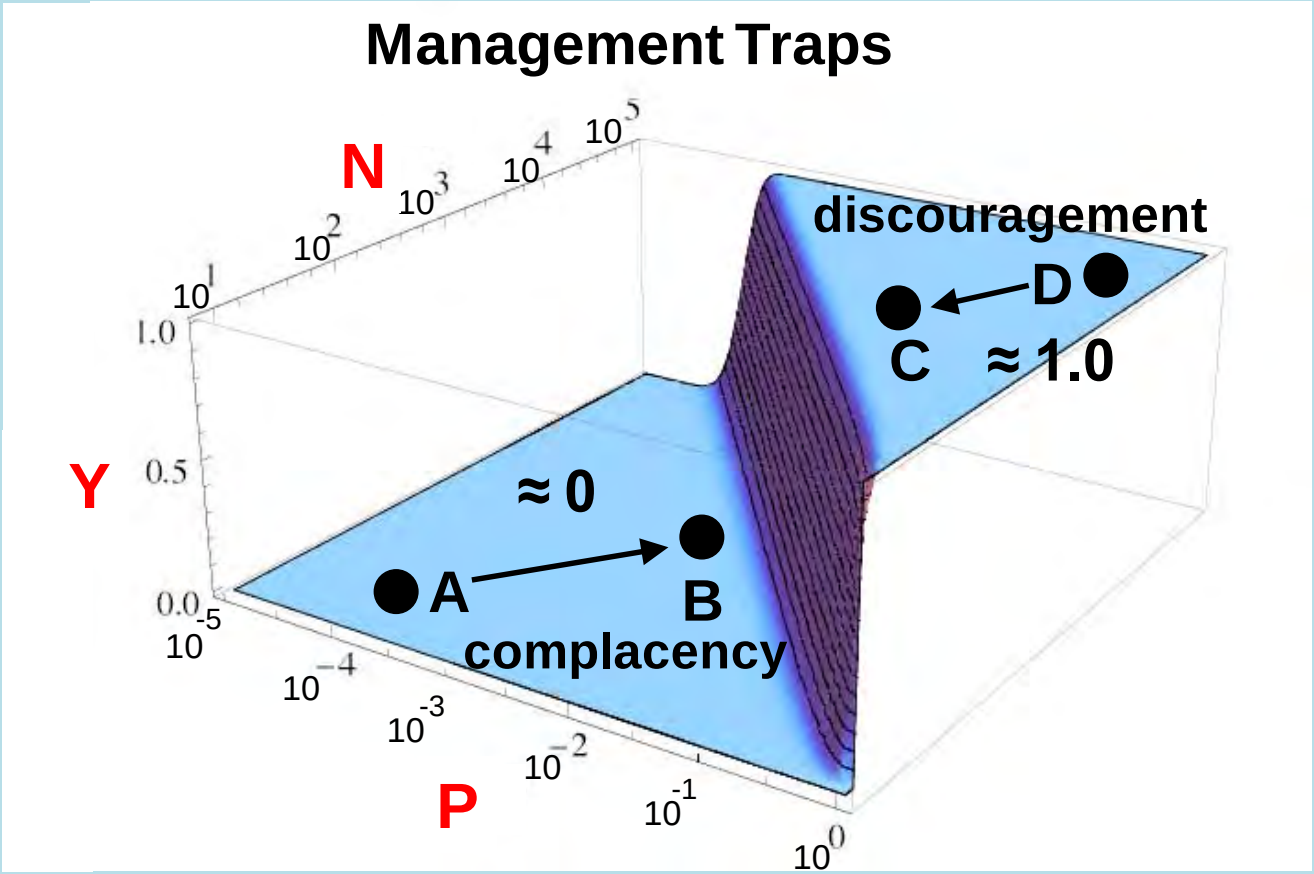
Difficult to predict

Management Implications



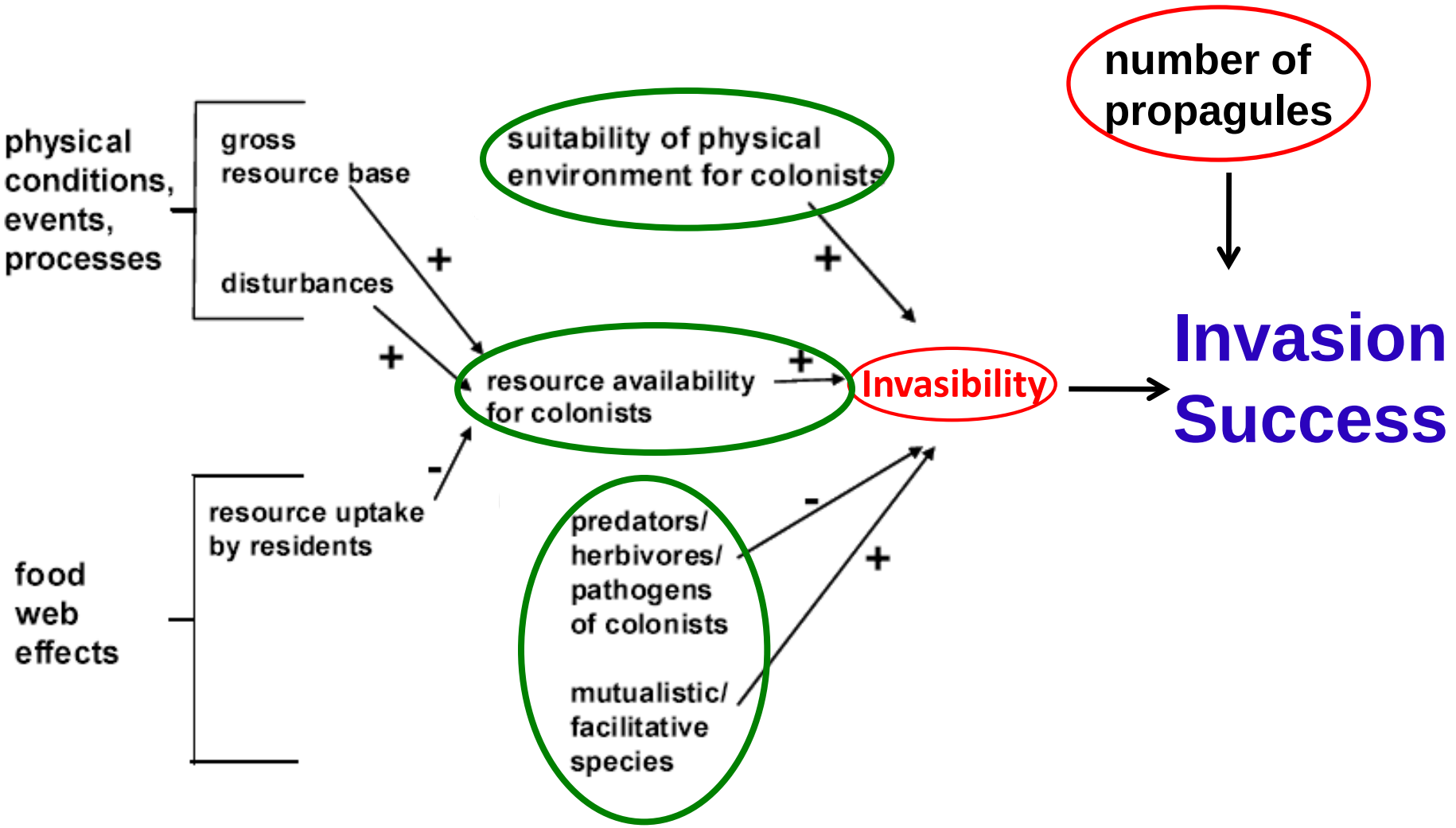
Management Traps





How to avoid these traps?

The long-term effectiveness of a particular management approach cannot be evaluated solely on the short-term presence/absence/abundance of the target species.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food web effects
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mutualistic/ facilitative species
-
+

Other Management Challenges/Pitfalls

- Distinguishing change from harm

Minnesota DNR Invasive Species Program

Program Purpose

Curb the spread and minimize harmful effects of nonnative species that can:

1. **cause displacement of, or otherwise threaten, native species in their natural communities; or**

2. **threaten natural resources or their use in the state.**

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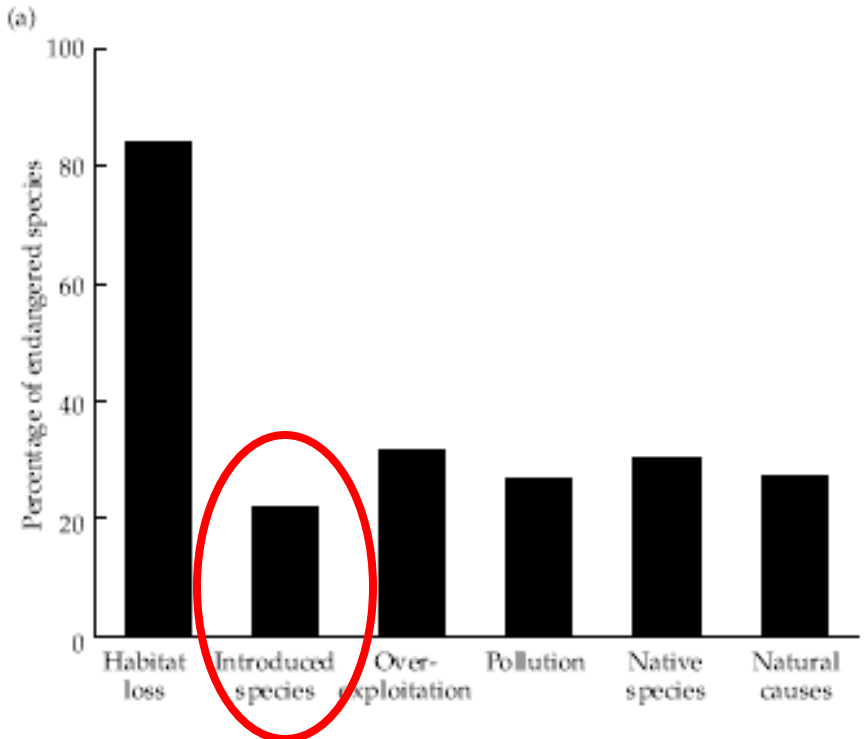
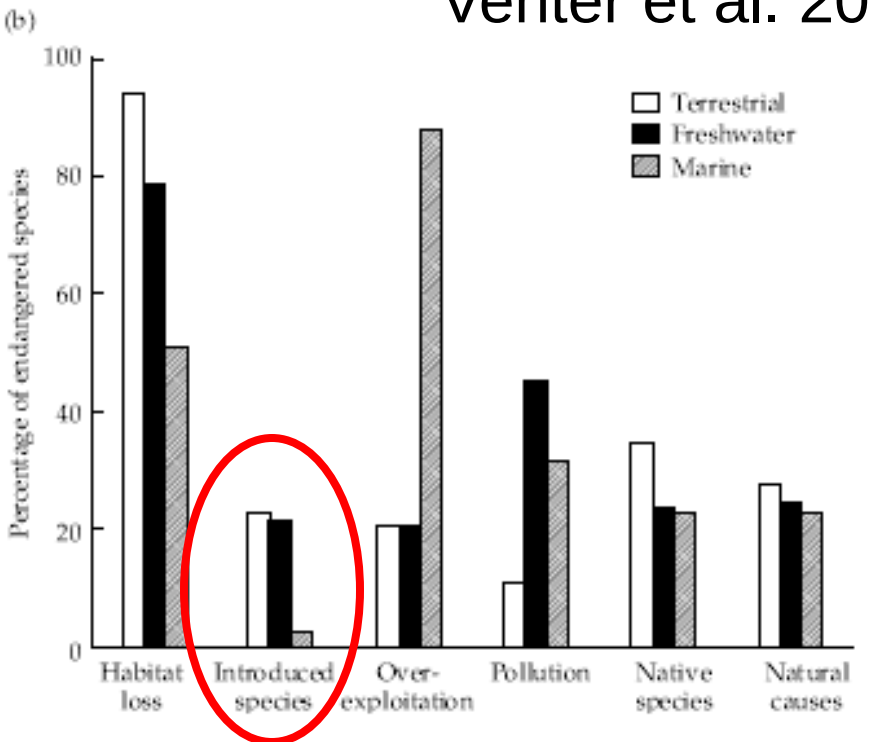
Biological invasions are the world's 2nd greatest extinction threat. (Wilcove et al. 1998)

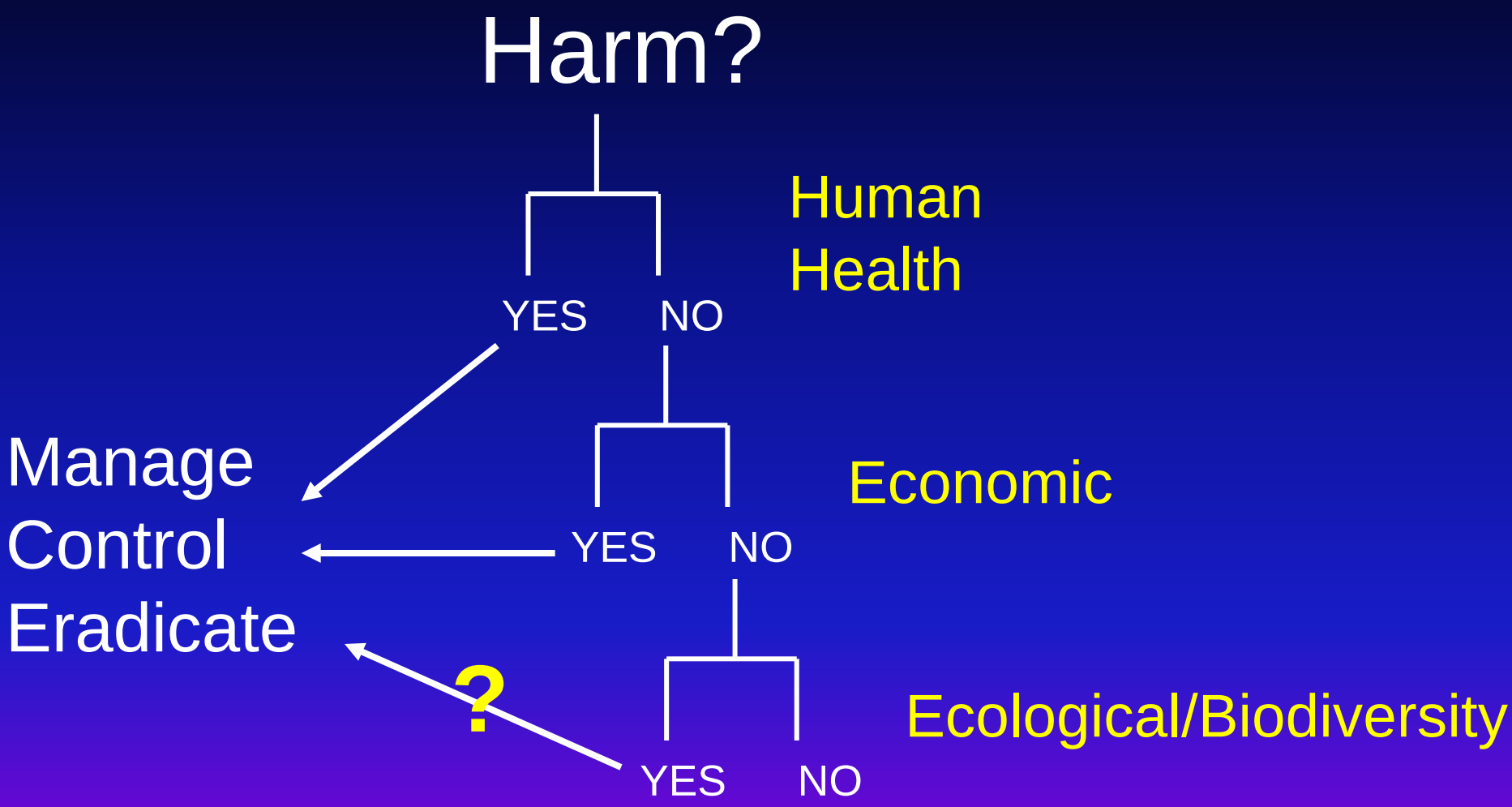
- Little to no empirical data
- Just United States
- Included Hawaii

Canada



Venter et al. 2006




Harm?
Human Health
YES
NO
Economic
YES
NO
Ecological/Biodiversity
YES
NO
?
Manage
Control
Eradicate

Other Management Challenges/Issues

Distinguishing change from harm

Not making things worse!

Frontiers in Ecology and the Environment
October 2006

Lessons from agriculture may improve the management of invasive plants in wildland systems

RG Smith, BD Maxwell, FD Menalled, and LJ Rew

The current motivating concept underlying our view of invasive plant species is that they are dangerous and destructive invaders that drive native plant communities to extinction and must be eradicated at almost any cost. This negative view of non-native plants has resulted in the adoption and implementation of control efforts that may not be entirely successful and have the potential to result in severe non-target effects. The history of weed control in agroecosystems may provide insights on how to deal with non-native plant species in non-croplands, and shed light on some of the potential consequences of current control programs for the environment and for non-target organisms. Alternative research and management foci, based on knowledge gleaned from agricultural systems, may improve the effectiveness and sustainability of non-native plant species management in range- and wildlands.

Smith et al. 2006

problems with the war on invasives

Musical Chairs

Smith et al. 2006

Courtesy of L Noble

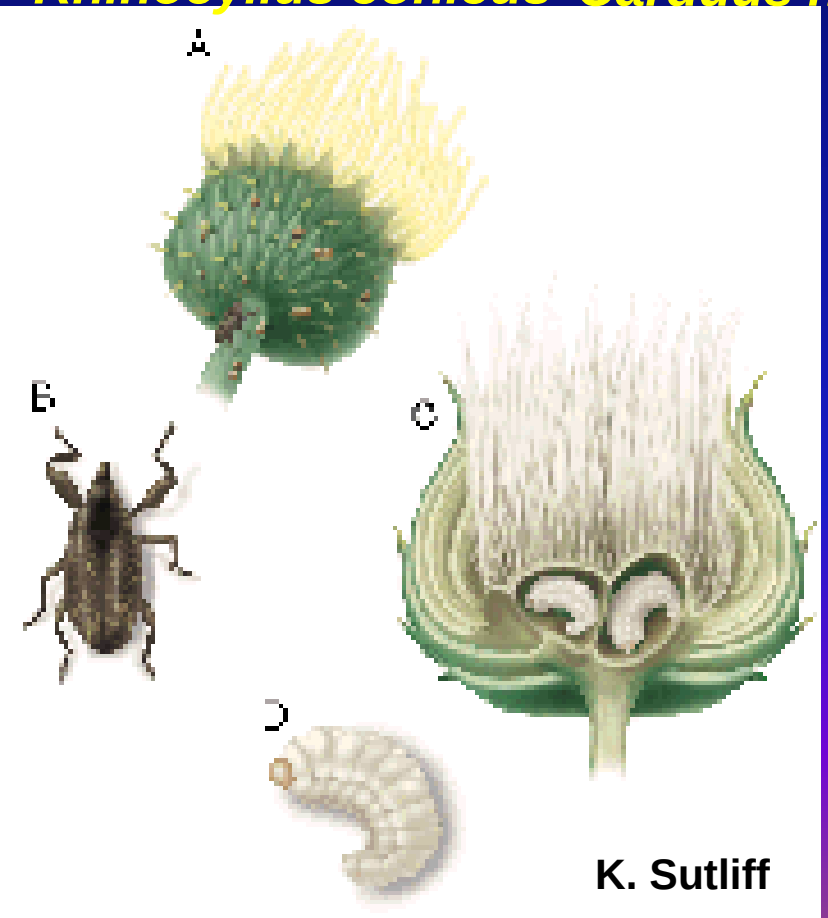
Figure 4. A mountain meadow in the northern Rocky Mountains treated with herbicide to remove leafy spurge (Euphorbia esula). This control measure resulted in the removal of all vegetation and the return of Canada thistle (Cirsium arvense).

Friendly Fire

Smith et al. 2006

Eurasian weevil
Rhinocyllus conicus

Musk thistle
Carduus nutans



K. Sutliff

Cirsium canescens

S. Louda

Friendly Fire

Ecology Letters, (2006) **9**: 443–450 doi: 10.1111/j.1461-0248.2006.00896.x

LETTER

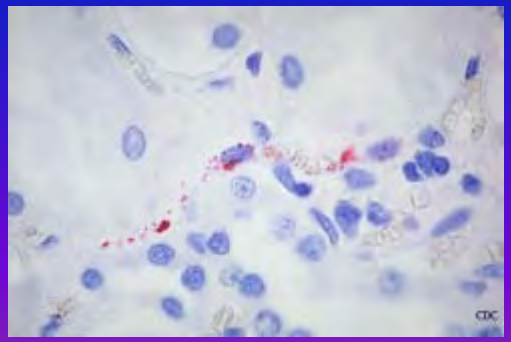
Biological control agents elevate hantavirus by subsidizing deer mouse populations

Dean E. Pearson* and Ragan M.Callaway

gall flies (*Urophora*)

knapweed (*Centaurea*)

Peromyscus maculatus



hantavirus

Misguided Management Axiom

To get what you want,

get rid of what you don’t want.

Macquarie Island

2007
before cats eradicated

Macquarie Island

2007
before cats eradicated

2008
after cats eradicated


To get what you want,
get rid of what you don't want

Treat the Causes not the Symptoms

disturbances, resource enrichment

propagule pressure

In Conclusion

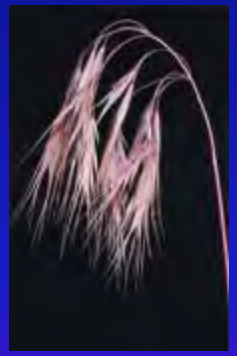
Manage the system, not the species

Managing invasibility should be part of any comprehensive site management plan

Managing Ecosystems to Reduce Invasibility

Challenges, Pitfalls, and Opportunities



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