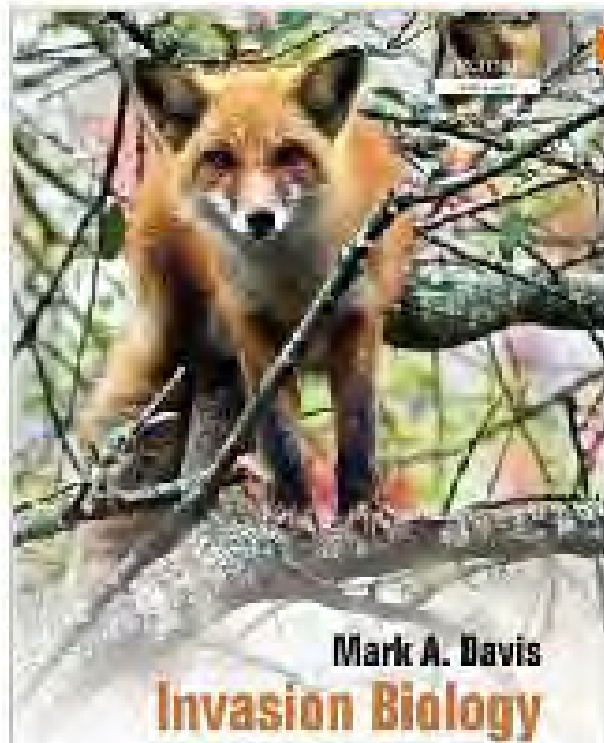
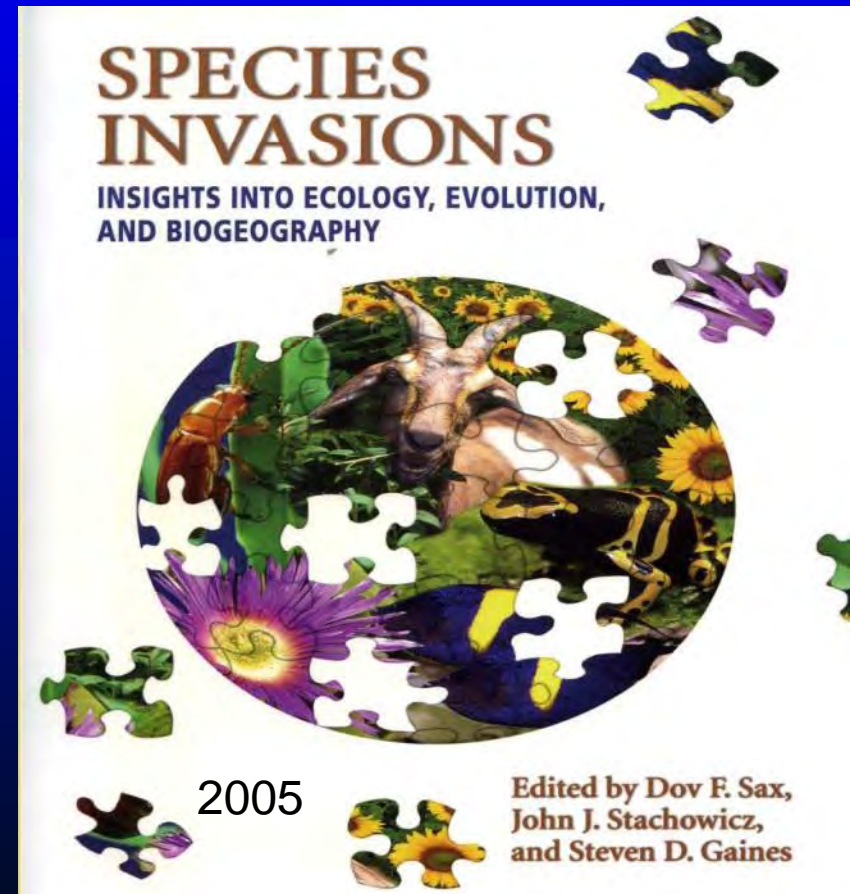


# The Fundamentals of Invasion Biology and Ecology

T. Seastedt, Oct 26, 2009



2009



## Talk goals:

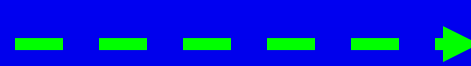
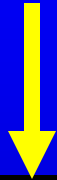
1. Identify the characteristics of 'the worst invaders'
2. Explain why some ecosystems are more invulnerable than others
3. Identify what species are most likely to cause major ecological and economic impacts.

## Terminology (from Davis 2009)

**Non-native:** a species whose presence is the result of human activities.

**Invasive:** a species capable of rapid spread  
and...  
one producing undesirable impacts

transported



lost

introduced



extirpated

established



Focus of  
Impact  
studies

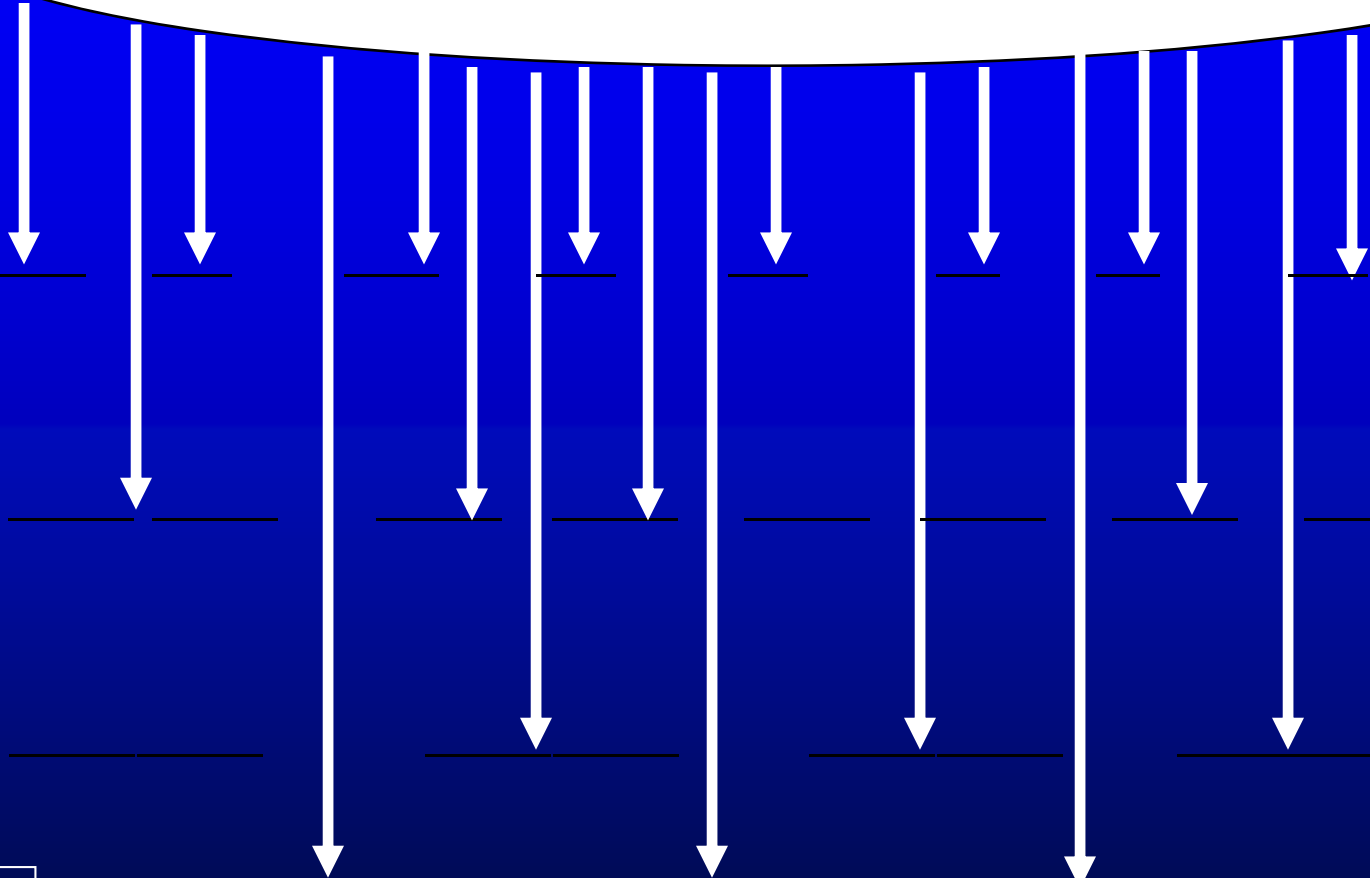
Noninvasive

Invasive

Included in  
Community  
Ecology  
studies



Broad



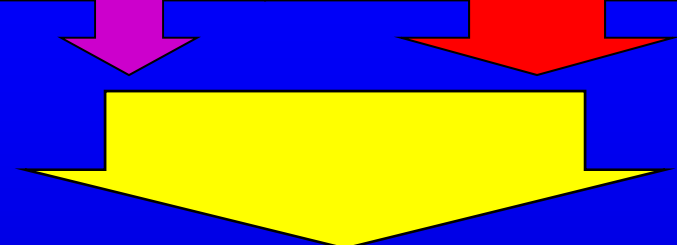
Climate filter

Disturbance filter

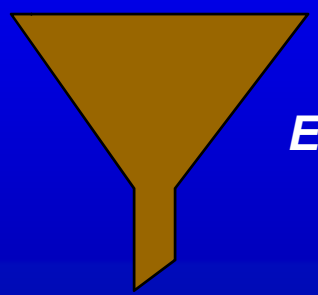
Biotic interactions

Fine Spatial Scale

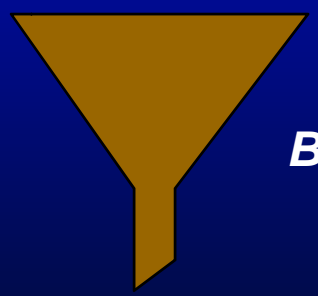
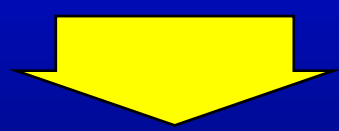




**Regional species pool**



*Environmental filter*



*Biotic filter*



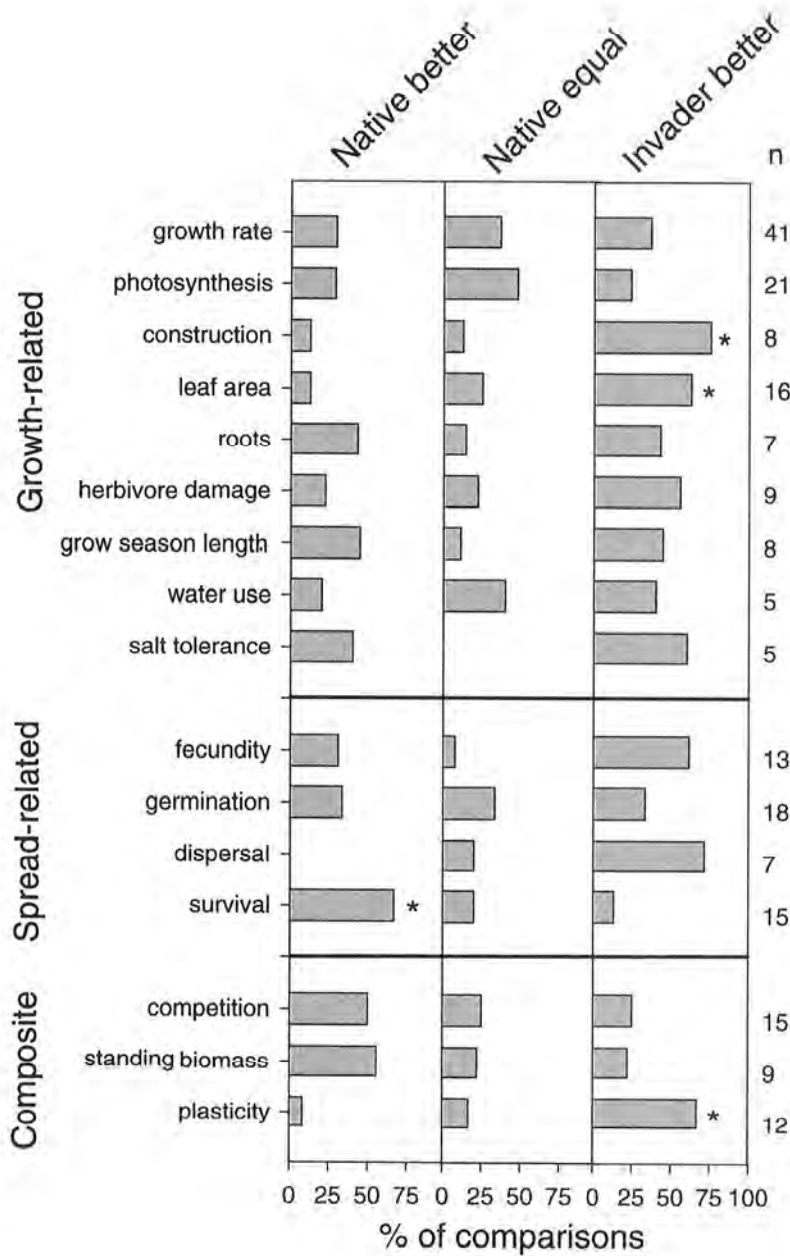
**Community**

Source: Hobbs

## Traits of instructor's study species:

Species	life form	longevity	photosynthesis
Caucasian Bluestem	grass	perennial	C <sub>4</sub>
Cheatgrass	grass	annual	C <sub>3</sub>
Spotted Knapweed	forb	perennial	C <sub>3</sub>
Diffuse Knapweed	forb	biennial	C <sub>3</sub>
Pepper Grass	forb	annual	C <sub>3</sub>
Toadflax	forb	perennial	C <sub>3</sub>

No single life form or plant trait can characterize the group of “invasive plants”



Summaries of studies have attempted to identify the traits of invasive species that make them “superior”...

Most studies find little in the way of differences...

(Daehler 2003).

One plant trait does appear more common among invasive species:

High growth potential; often high nitrogen content per unit of tissue.

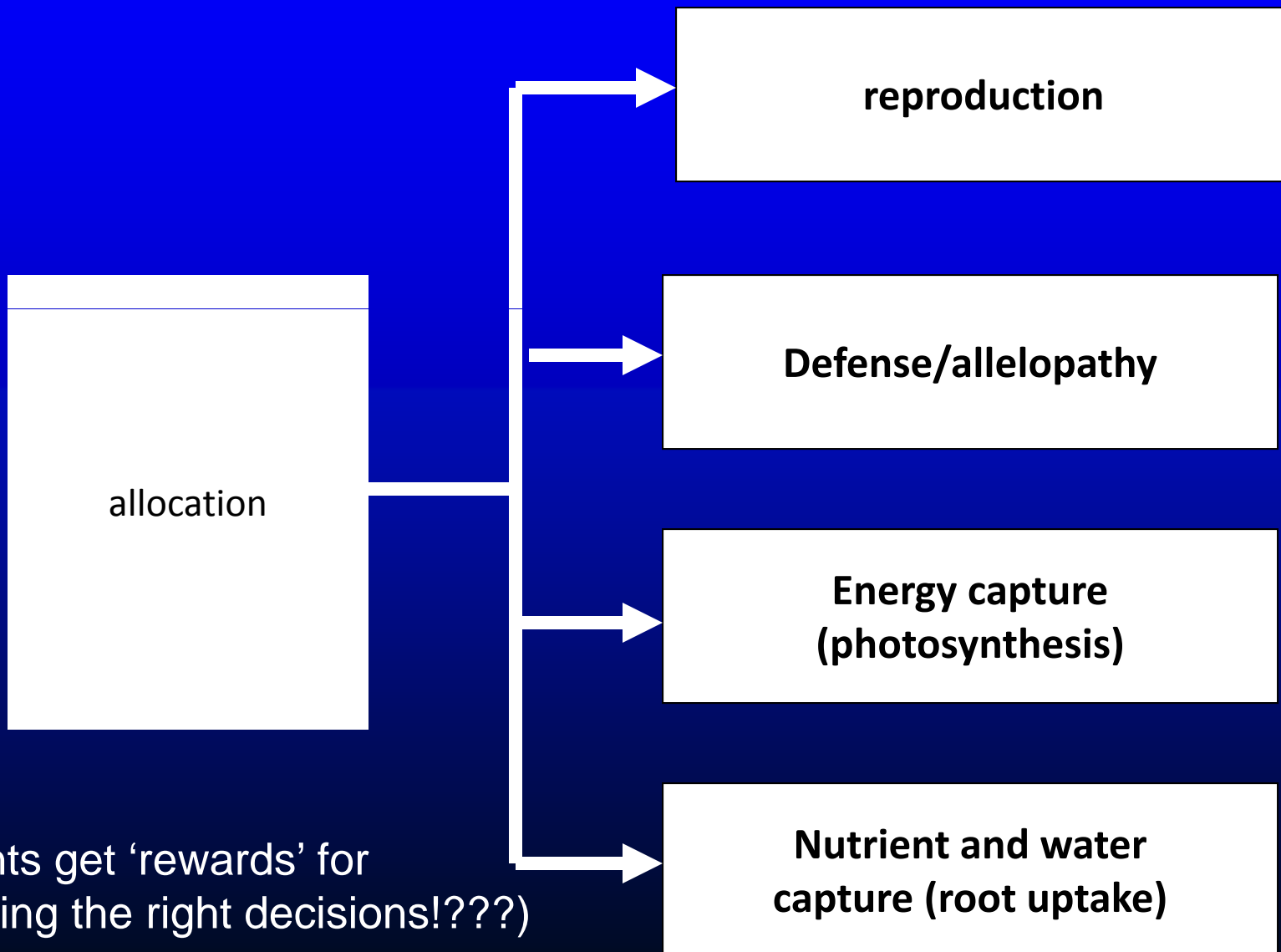
“exotic invasives ...are positioned...towards faster growth dynamics” (Leishman et al. 2007)

Two generalizations that do seem to fit abundant Invasive species:

- 1) Species “do something new” (different niche) or
- 2) have “superior fitness” (can out-compete the natives).

(MacDowell et al. 2009)

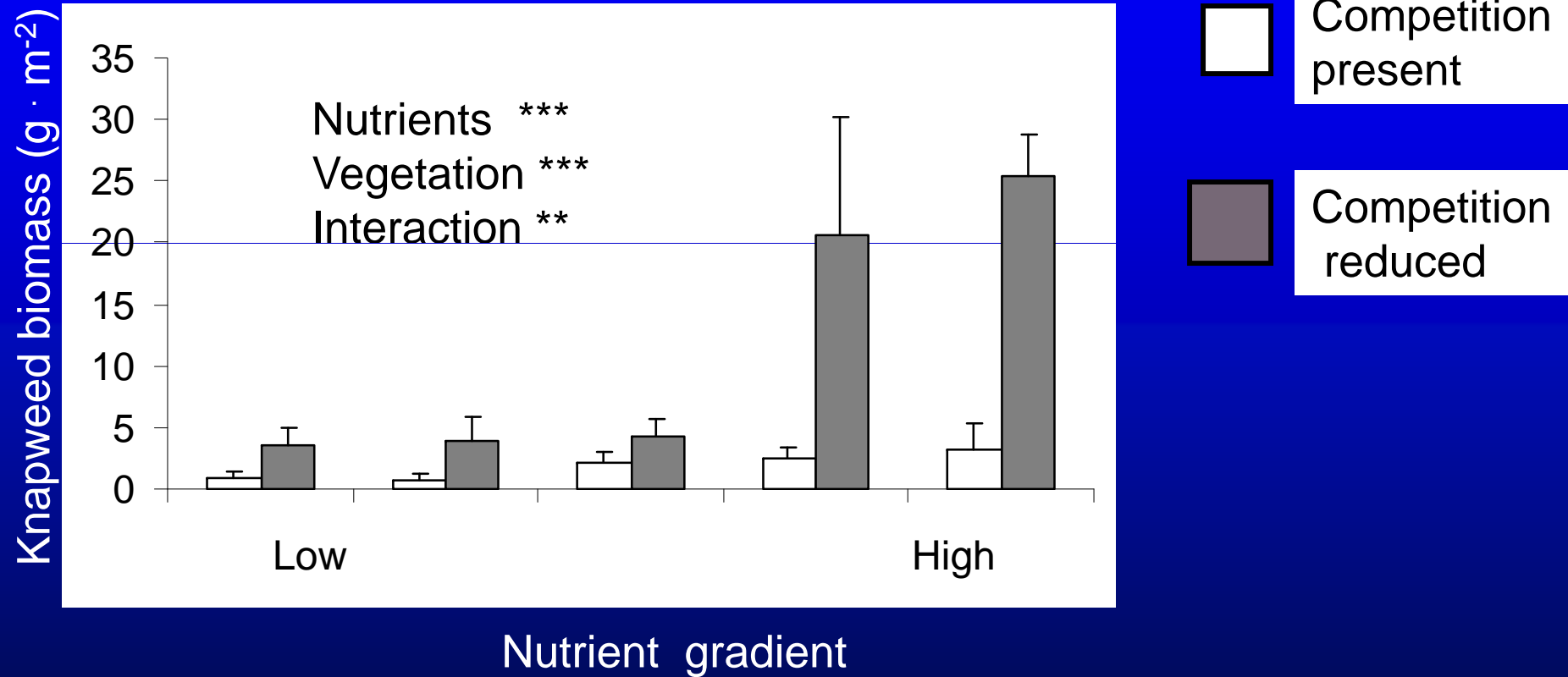
# Plants allocate resources to maximize fitness



(Plants get 'rewards' for making the right decisions!???)

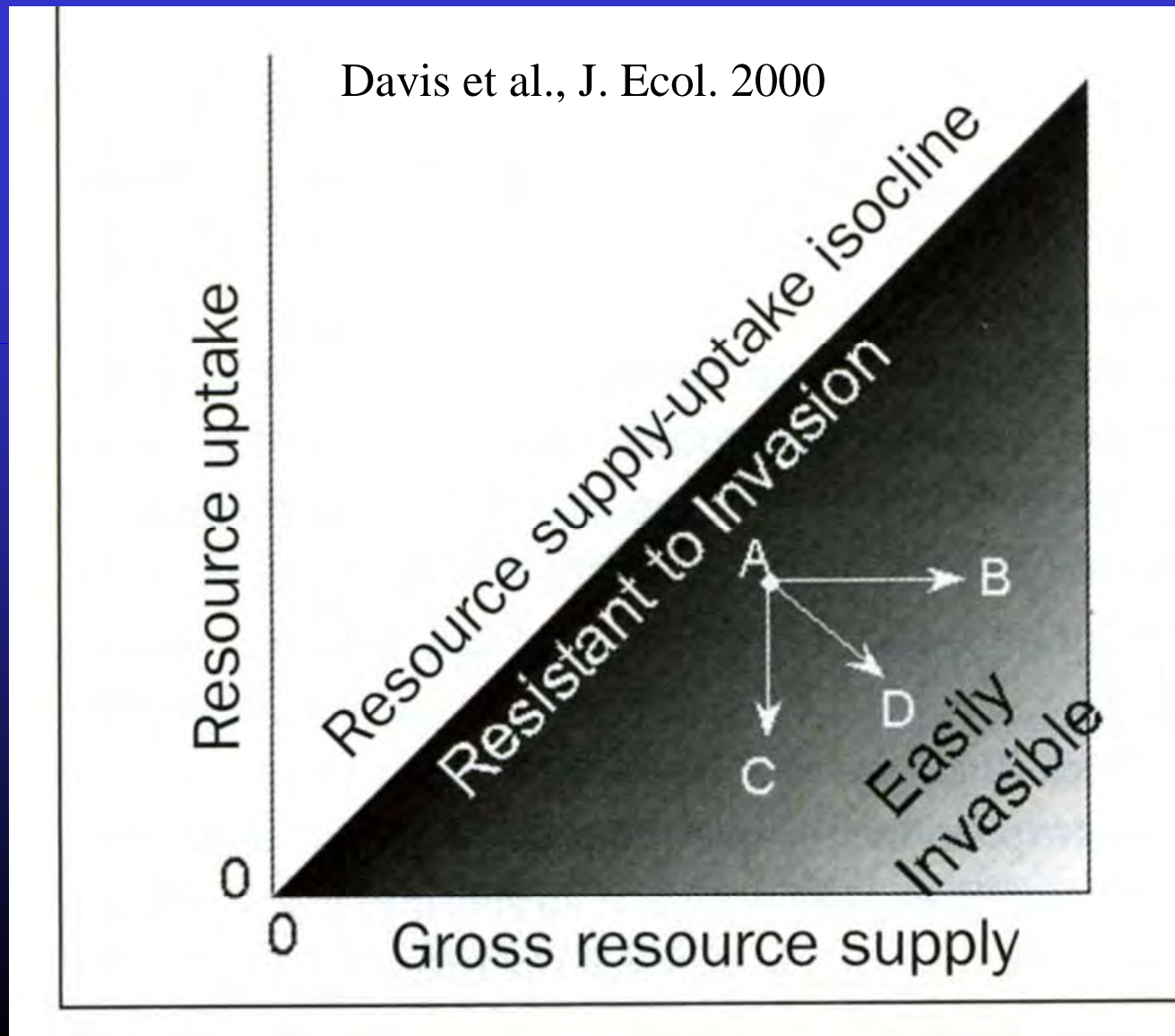
An Achilles heel of many aggressive invaders is their relative inability to invade intact communities.

# Establishment of diffuse knapweed (Seastedt and Suding 2007)

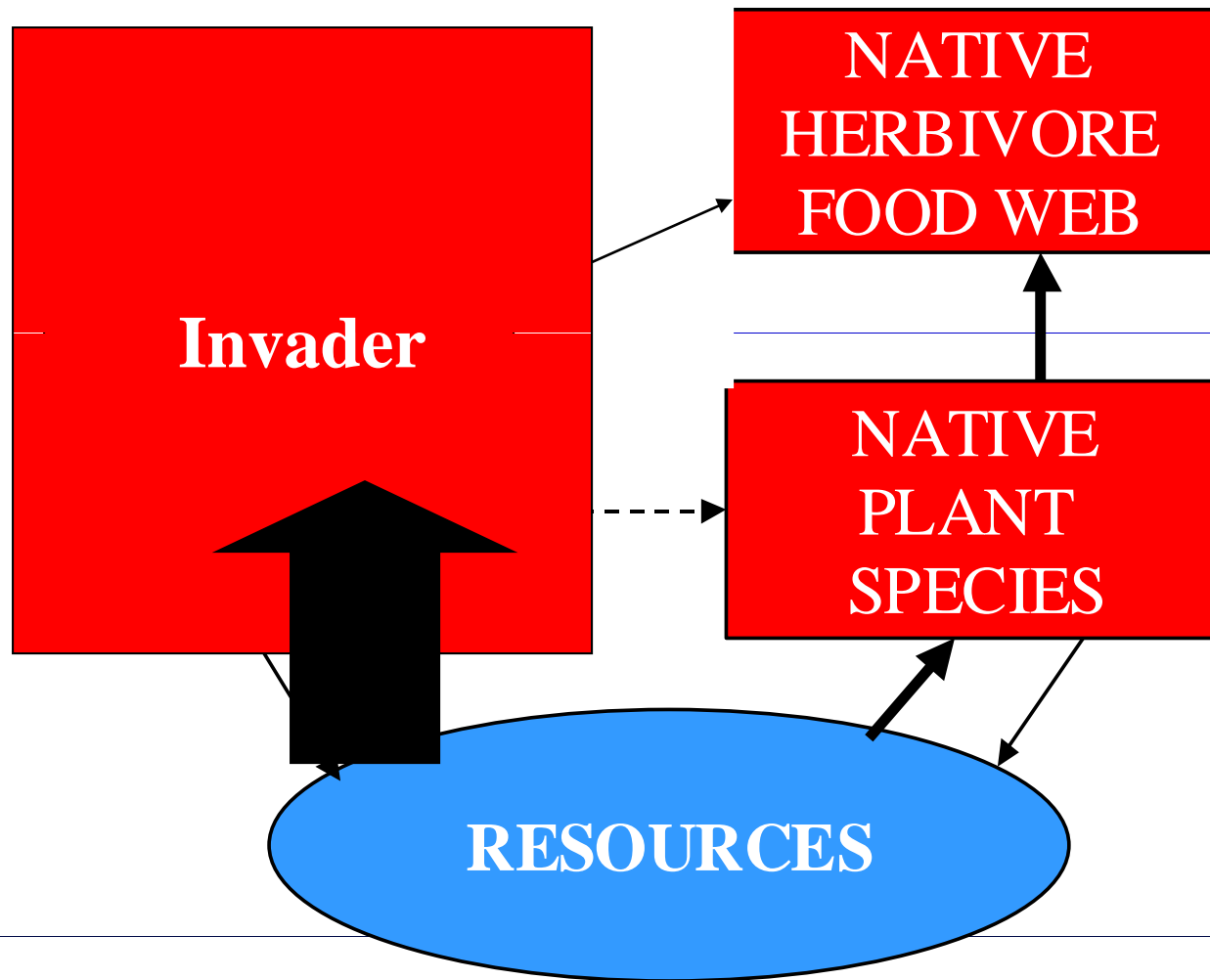


Seedling survivorship and growth (Invasion phase)

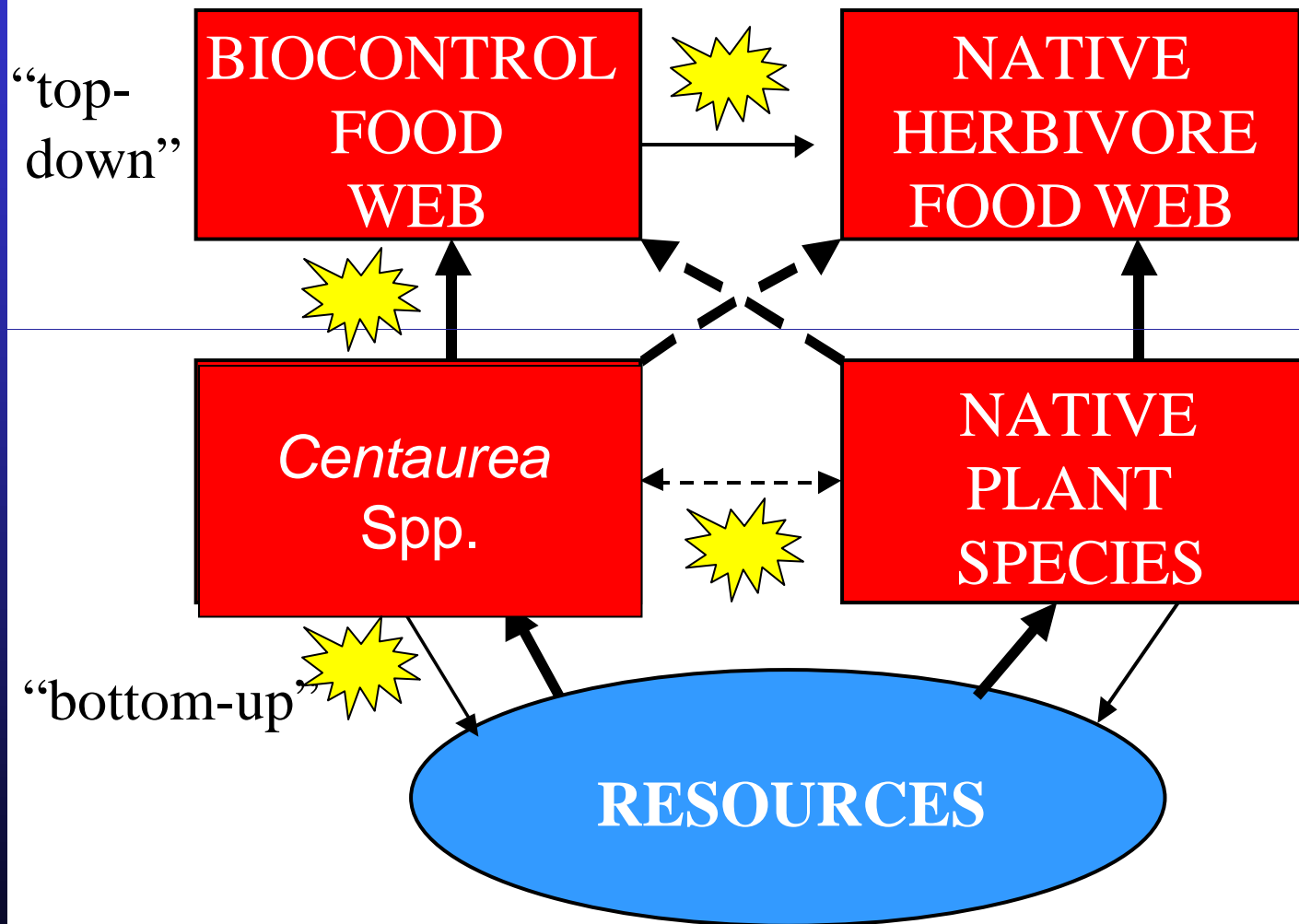
A plant community becomes susceptible to invasion whenever there is an increase in the amount of unused resources.



What allows an invader to obtain dominance...and in some cases unusually high dominance?



Invasibility and dominance can be due to multiple causal factors



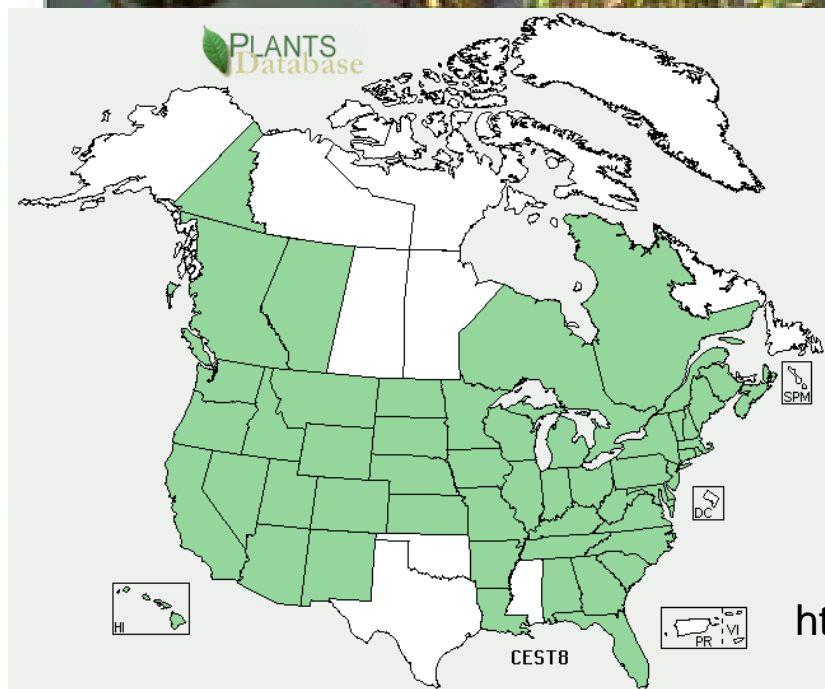


# Spotted knapweed

**“Wicked Weed of  
the West”**

J. Alper, Smithsonian  
Magazine, Dec. 2004

**Knapweed species:  
“The forb that won  
The west”**



<http://plants.usda.gov/java/profile?symbol=CEST8>

Since 2004, knapweeds (species of the genus *Centaurea*) have been identified in peer-reviewed and popular literature as:

allelopathic

aggressive competitors

sensitive to soil nutrients

stimulated by herbivory

or

or

or

or

not allelopathic

average competitors

insensitive to soil nutrients

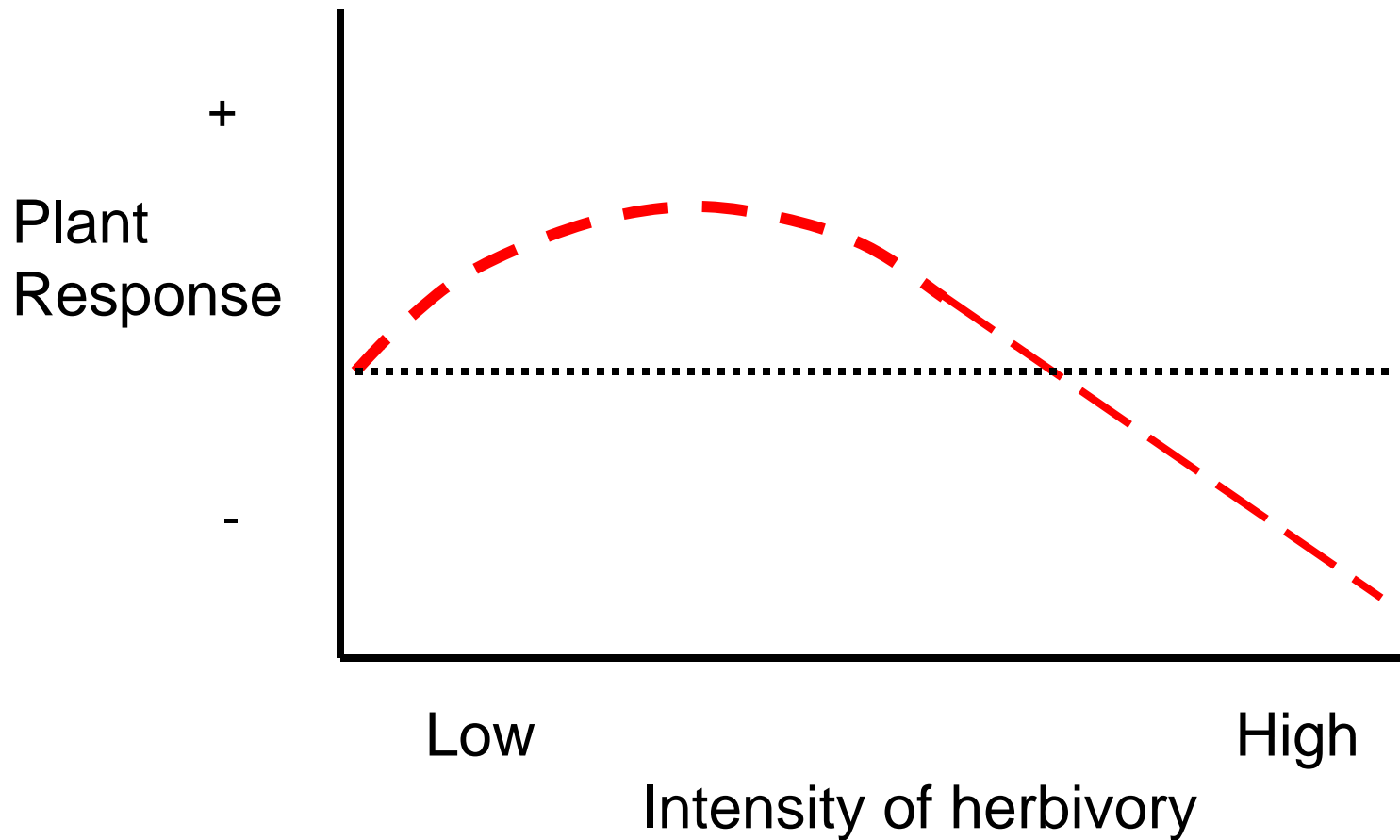
controlled by herbivory



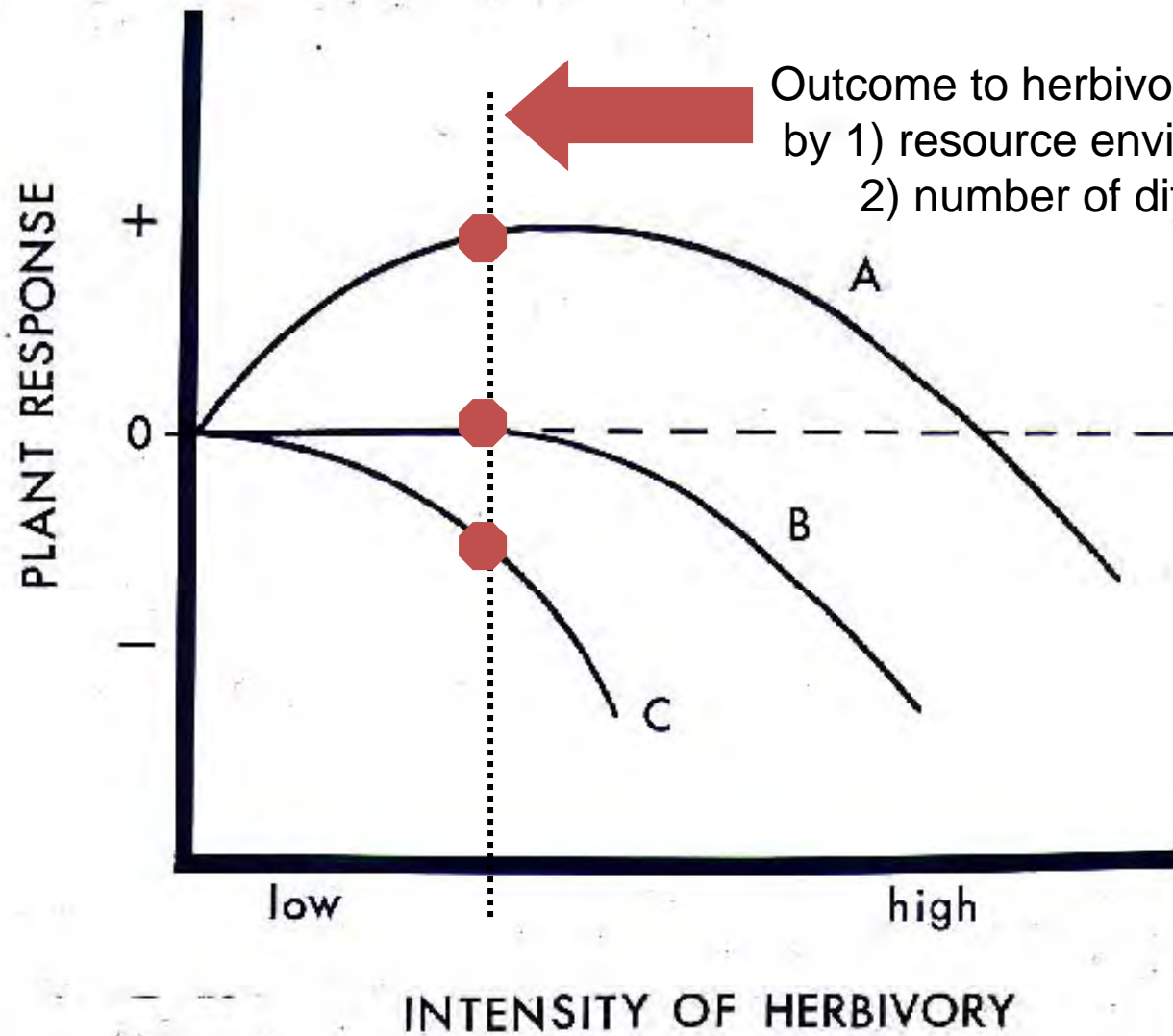
Knapweed is a great competitor because:

- 1) It poisons the competition (allelopathy)  
and/or....
- 2) It's great at preempting resources in  
head-to-head competition  
and/or....
- 3) It exhibits extreme plasticity in growth and  
exploits resource opportunities

Relationship between herbivory and plant growth and reproduction: Specific shape/inflection point controlled by other variables



Modified from McNaughton, 1979



## Plant Invasiveness as a random draw:

1. Insert a species into a community:

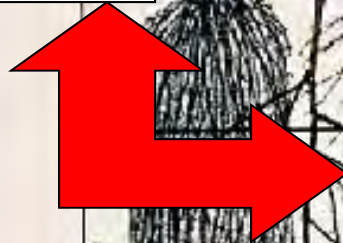
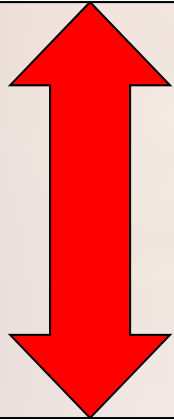
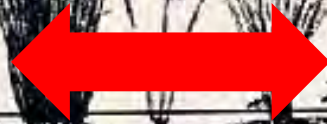
Score the species in terms of its response to:

- a) Climatic adaptation (-,0,+)
- b) Herbivores (-,0,+)
- c) Competitors (-,0,+)
- d) Soil symbionts (0,+)
- e) Soil pathogens (-,0)
- f) Soil service providers (-,0,+)

Assign probabilities to each option...The species that 'accidentally' scores multiple ++++ becomes the super-invader, those that score multiple ---- go extinct.

**INDIVIDUAL  
PLANT  
SPECIES**

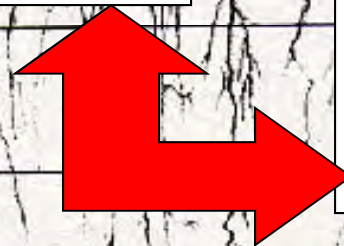
competition



**PRIMARY REGULATORS**  
Herbivores, parasites, pathogens symbionts



**SERVICE PROVIDERS**  
decomposers ecosystem engineers elemental transformers



**SECONDARY REGULATORS**  
hyper-parasites predators

Redrawn from Swift, Izac, and van Noordwijk (2004)

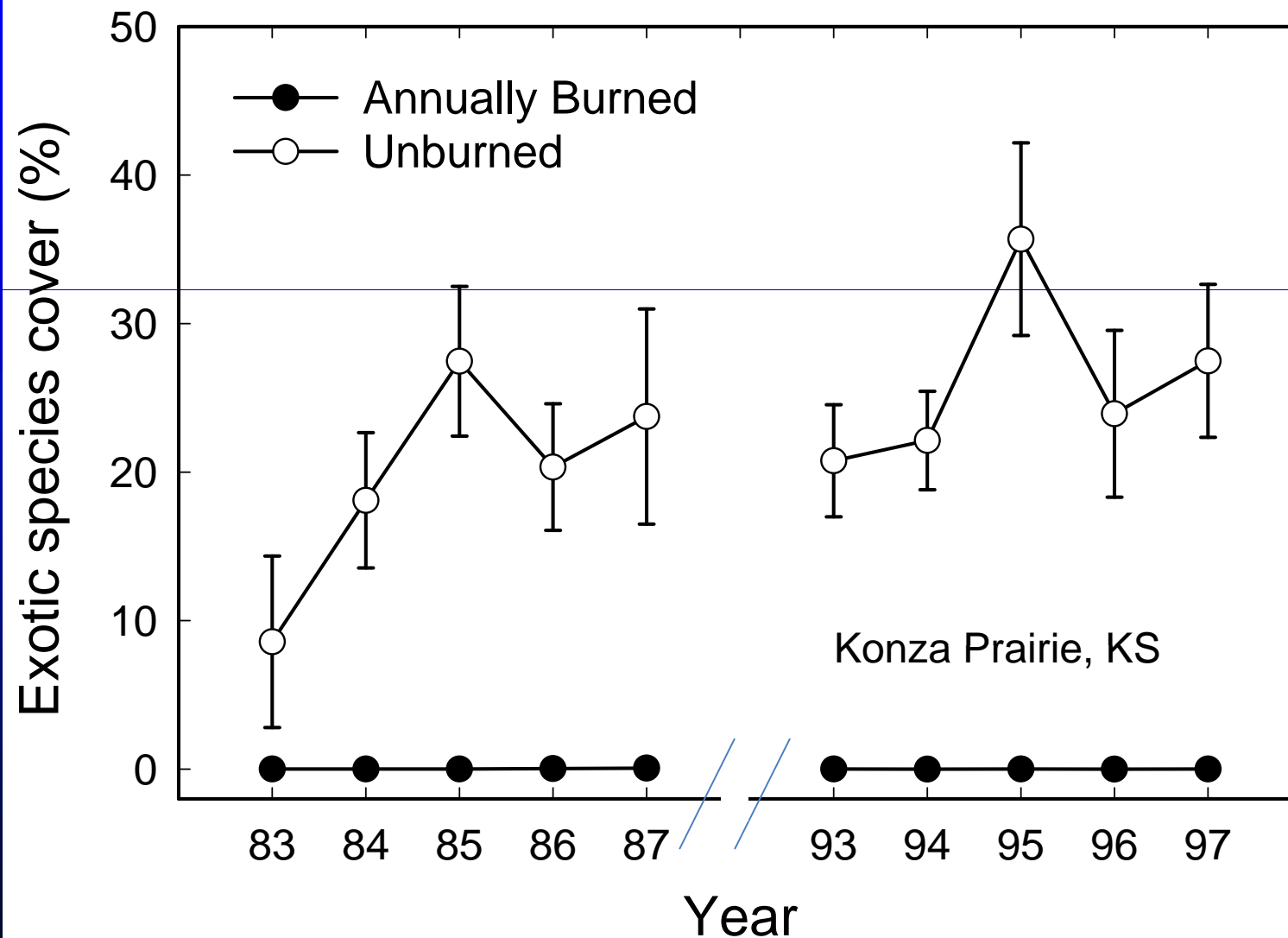
A number of studies from diverse habitats indicate that multiple herbivores can reduce knapweed densities\*



Source: Monika Chandler, Minnesota Dept. Agri.

# Long-term Dynamics (Smith and Knapp, unpublished)

Fire...an excellent tool for some species in some habitats...



As managers, we sometimes have the ability to control

- a) The herbivores present
- b) The amount and species composition of the competing plant species
- c) (rarely) soil resources

**Restoring competitors and natural enemies for long-term control of plant invaders**

Dana M. Blumenthal<sup>1</sup>, Andrew P. Norton, Timothy R. Seastedt  
Rangelands (this month)

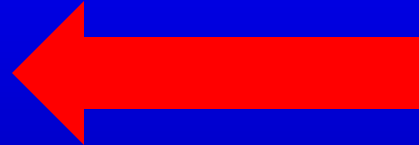
## IMPACTS:

“Invaders don’t just simply consume or compete with native species--they *can* change the rules for existence for all species by altering ecosystem processes such as primary productivity, decomposition, hydrology, geomorphology, nutrient cycling, or natural disturbance regimes.”

Vitousek et al. 1996

## Reasons for threatened species (Wilcove et al. 1998)

Habitat destruction	85%
Alien Species	49%
Pollution	24%
Overexploitation	17%
Disease	3%



(sum > 100 because categories are nonexclusive.)

# IMPACTS:

## INSIGHTS INTO BIOTIC INTERACTIONS

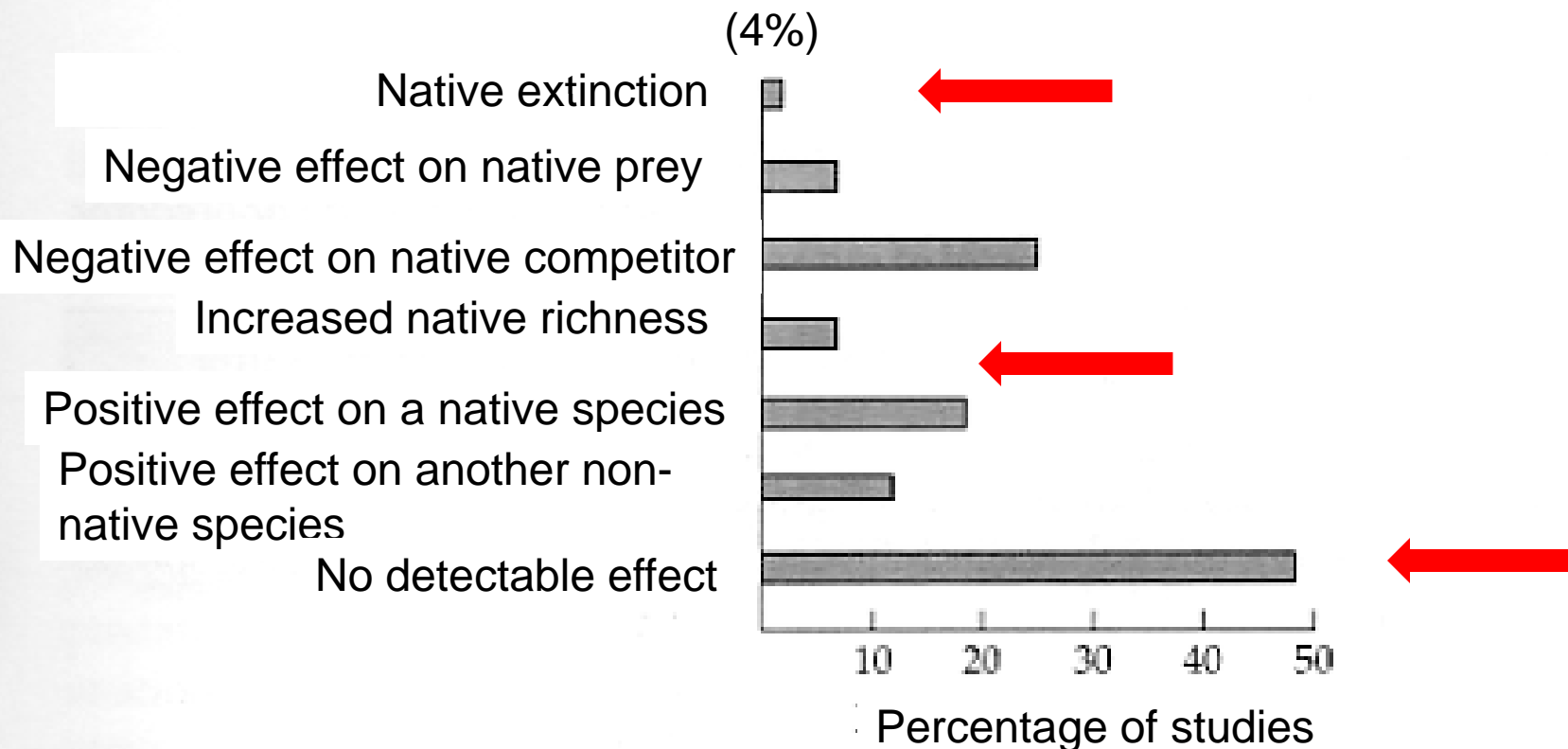


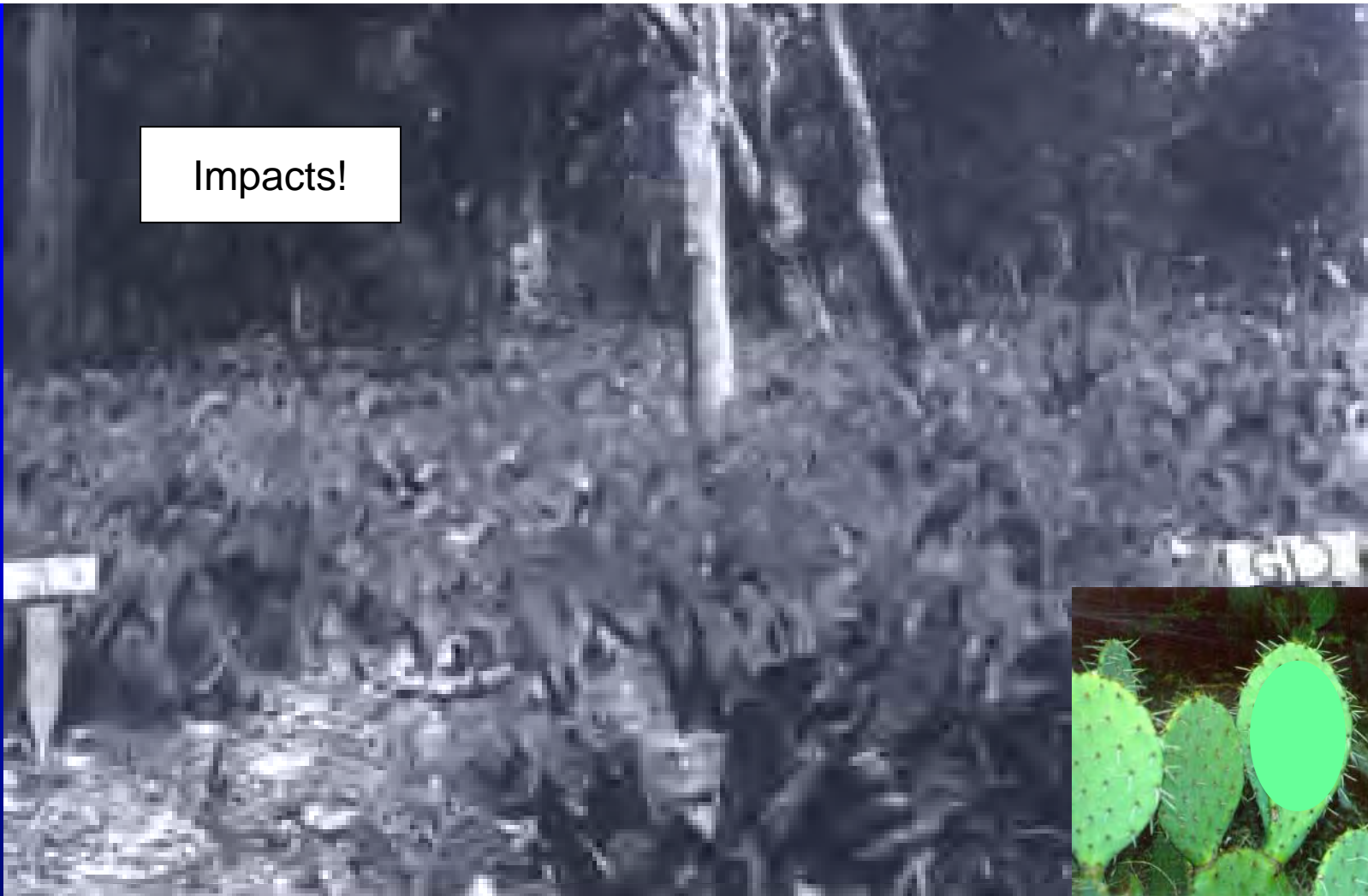
Figure 1.2 Percentage of 120 papers from literature review that found Evidence for each category of non-native impact

Source: Sax et al. 2005

What comes to mind when you envision the “worst invader?”



Impacts!



Many farms and homesteads in the region were abandoned. The Queensland Prickly Pear Land Commission wrote in 1924, "Revenue, homes, and even lives, of all it has taken its toll. .... we have millions of acres of nothing but a veritable wilderness of prickly pear."

Salt cedar, tamarisk...main impact may be groundwater?

...impact of control now a concern...





Cheatgrass invasion in  
Great Basin region

“Grasslandification” can alter fire return cycles and greatly alter ecosystem dynamics. (impacts vary with ecosystem type)

## Impacts:

- \* local site use goals
- \* ecosystem services
- \* conservation values

The species with the largest impacts are likely those that transform the system into a biogeochemical configuration that previously didn't exist on the site, i.e., the creation of novel ecosystems.

In general, such species alter water and nutrient status such that energy dynamics must be altered.