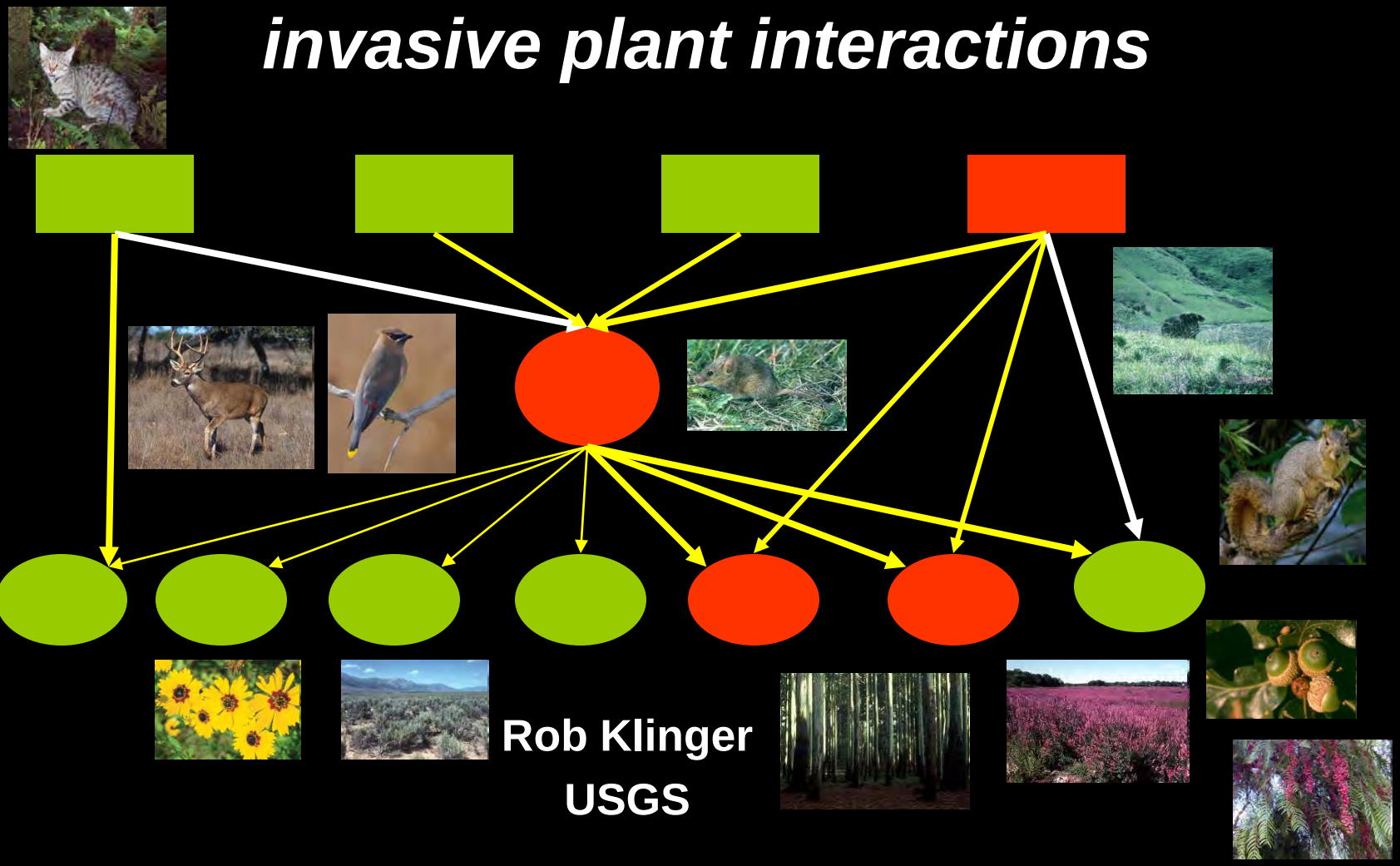
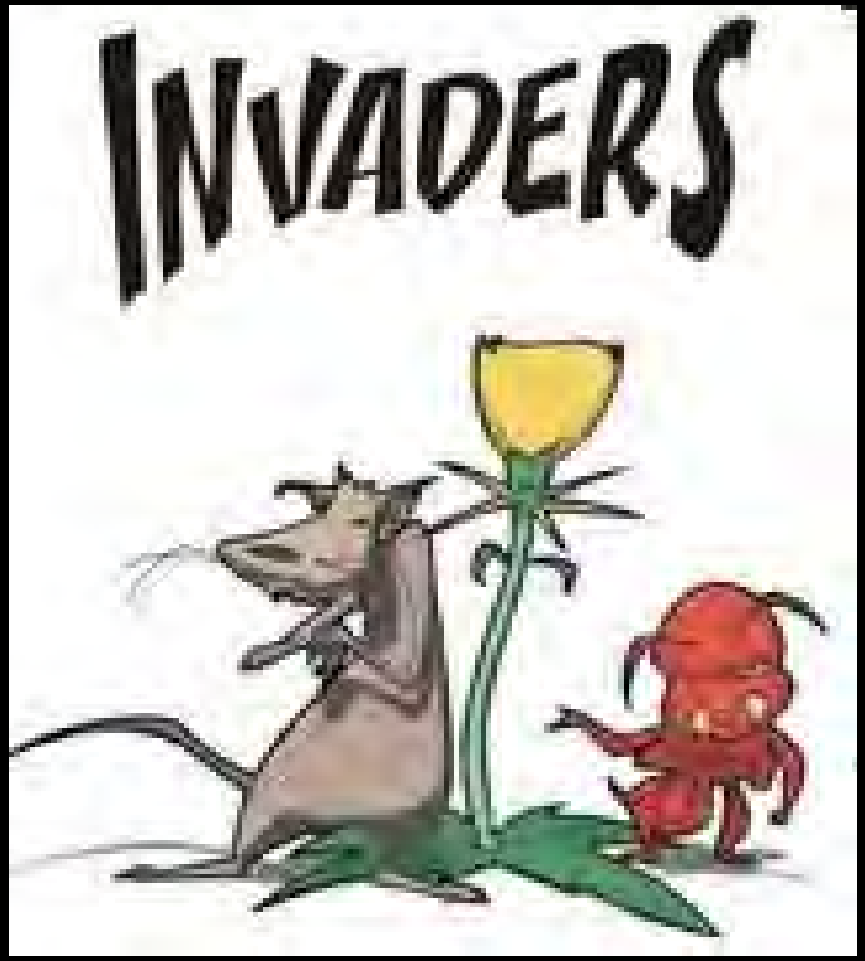
Desire, disappointment, surprises, and food webs: melding conservation and ecological perspectives to better understand animal-invasive plant interactions



Rob Klinger
USGS

Point of Talk

- **Start to "tie it all together"**
  - By "it" I mean plant-animal interactions (i.e. weeds and wildlife)
- **How am I going to do this?**
  - **Broad overview**
    - Look at history and early assumptions of the interactions
    - Put the interactions in a general ecological framework
  - **Specific example**
    - Fennel – terrestrial vertebrate interactions on Santa Cruz Island (1990-1999)
  - **Look at some recent work being done on the interactions**
  - **Conclude with some food for thought and potential future directions**



The Challenge

- Put talks from conference into a broader context…
- …but try not to get lost in the netherworld of abstract concepts…
- …while not to getting lost in specifics of individual case studies

New “Hot” Topic On An Old Issue

A pertinent observation…

"Just as there is honor among thieves, so there is solidarity and co-operation among plant and animal pests. Where one pest is stopped by natural barriers, another arrives to breach the same wall by a new approach. In the end every region and every resource get their quota of uninvited ecological guests."

Recognition of:

- barriers
- dispersal
- dispersal limitation
- multiple invaders

Aldo Leopold
Cheat Takes Over
A Sand County Almanac, 1949

Another pertinent observation…

"…the cheat-afflicted regions make a virtue of necessity and find the invader useful. Newly sprouted cheat is good forage while it lasts; like as not the lamb chop you ate for lunch was nurtured on cheat during the tender days of spring. Cheat reduces the erosion that would otherwise follow the overgrazing that admitted cheat. (This ecological ring-around-the-rosy merits long thought)."

Recognition of:

- trophic interactions
- conservation contradictions

Invasive Non-native Species:
The Dominant Historic Perspective (1880-1995)

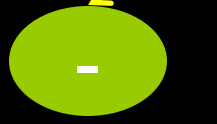
Non-native predators
and native prey

Invasive Non-native Species:
The Dominant Historic Perspective (1880-1995)

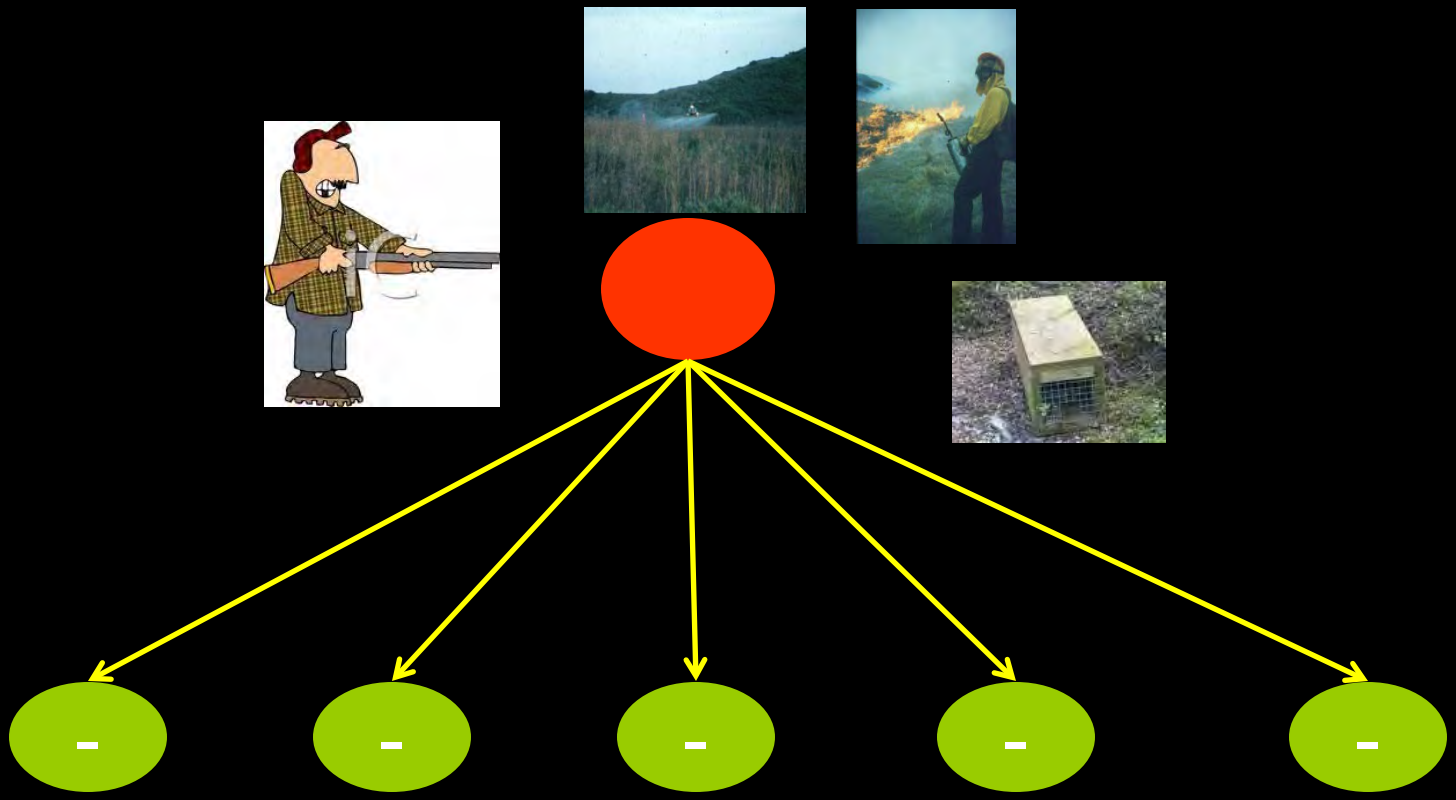
Non-native primary consumers and native plants

Invasive Non-native Species:
The Dominant Historic Perspective (1880-1995)

Non-native plants, native plants, and native wildlife



Invasive Non-native Species: The Desired Management Outcome



Temple (1990) “The Nasty Necessity”

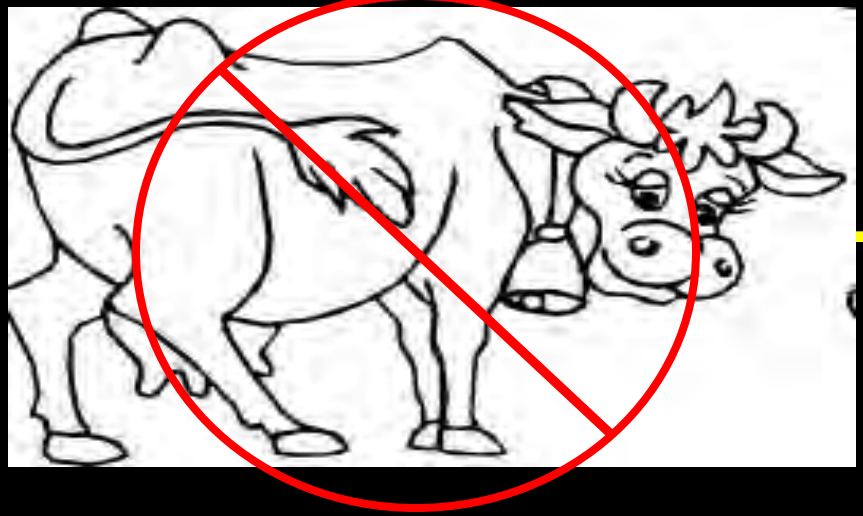
Invasive Non-native Species: The Desired Management Outcome

But a funny thing happened on the way to the forum…

+

Fitzgerald 1988, Murphy et al. 1998

But a funny thing happened on the way to the forum…



Brenton & Klinger 1994, Klinger et al. 1994, 2002, Bullock et al. 2002, Kessler 2002, Klinger 2007

…a mix of desirable…

…and surprising, often undesirable outcomes

Management outcomes are tremendously variable, complex, and often unpredictable

(Zavaleta et al. 2001, Zavaleta 2002)

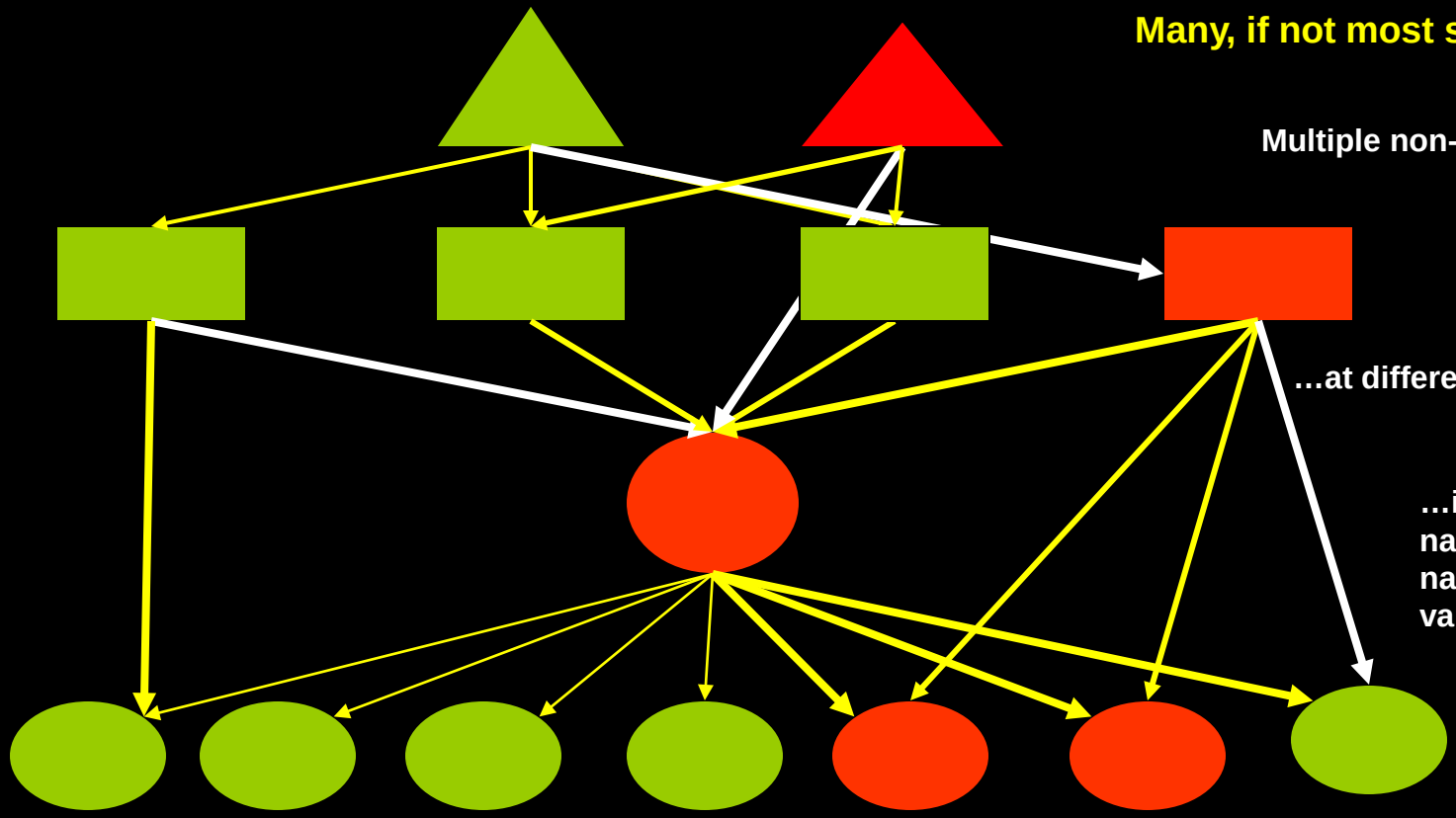
But Should We Have Been Surprised?

- Numerous ecological examples of what we considered surprises
  - From predators to prairie dogs…
  - From the Kaibab to the Klondike…
- We knew about
  - Apparent competition
  - Prey release
  - Prey switching
  - Trophic cascades

So Why The Surprises?

- We first thought as conservationists and then as ecologists
- Our desire to do good got ahead of some ecological realities
- We focused on the “bad guy” and overlooked the rest

Invasive Non-native Species: The Reality



Many, if not most systems have:

Multiple non-native species…

…at different trophic levels…

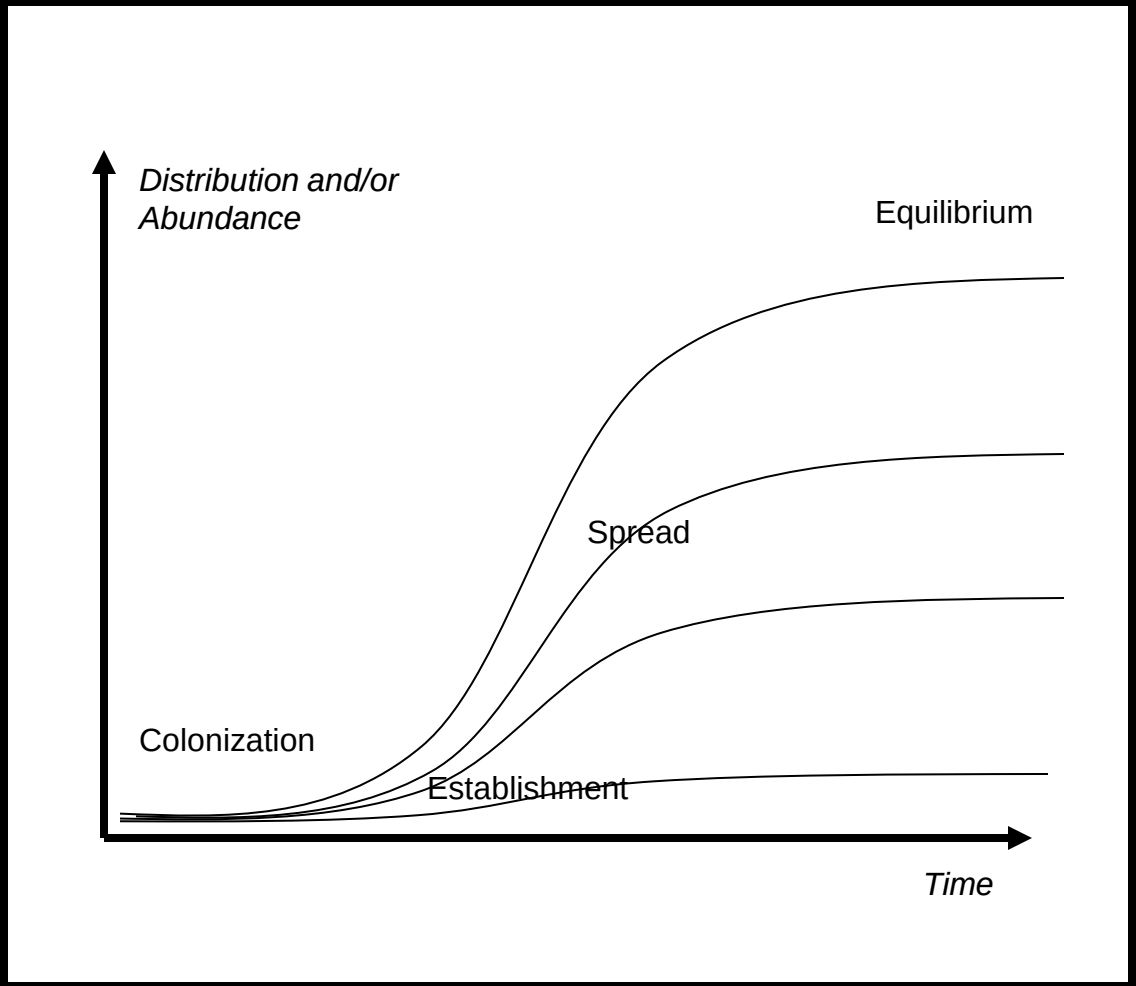
…interacting with native and non-native species in various ways…

…and filling different functional roles

- **Predators (including seeds)**
- **Seed dispersers**
- **Herbivores**
- **Pollinators**

…with a range of interaction strengths…

Grappling With The Reality



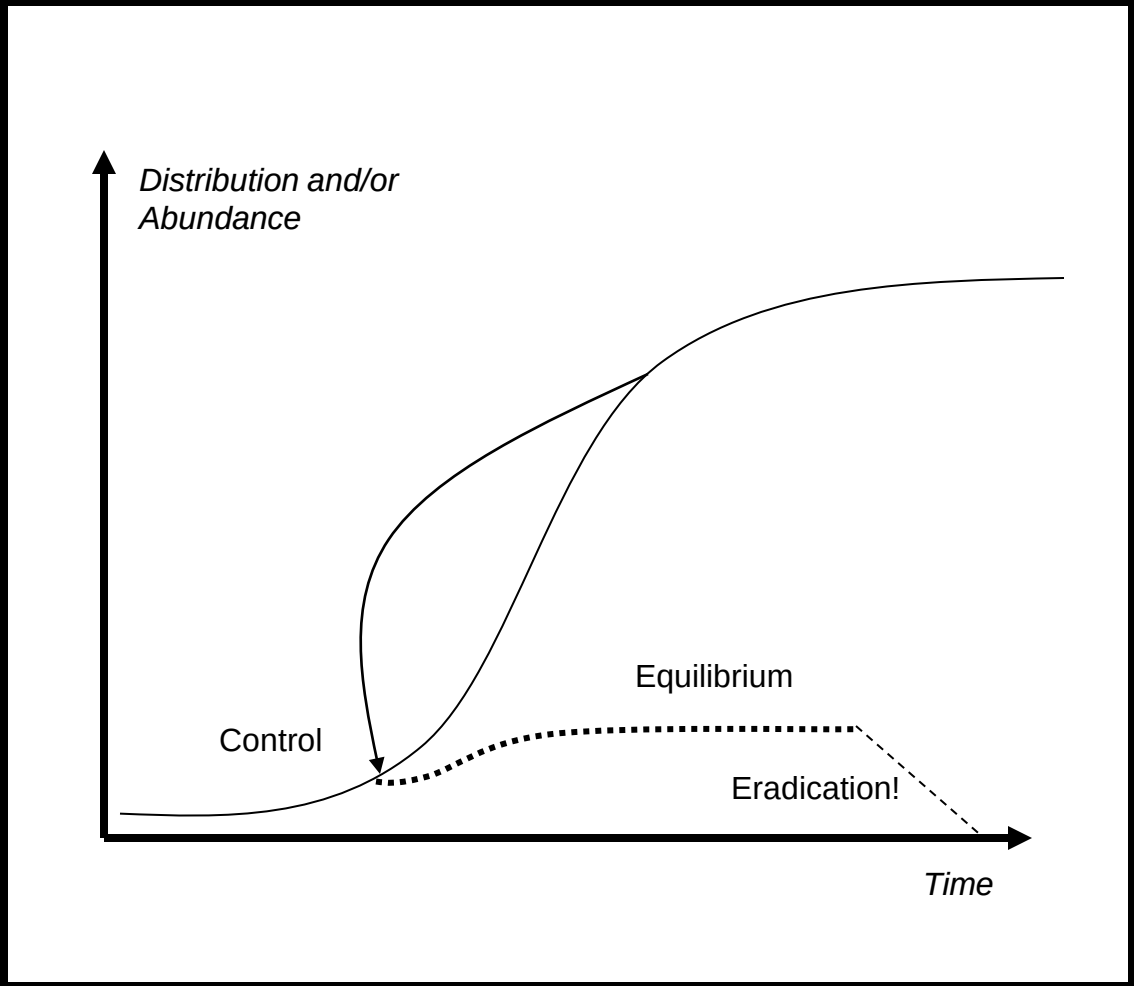
- Biological invasions are a special case of dispersal

Invasion is not a state. It is a ***process…***

…where species are added to an ecosystem…

…and species identity & environmental conditions determine “equilibrium” abundance

Grappling With The Reality



Management is the process of removing an invasive species from an ecosystem or shifting the distribution of its interaction strengths

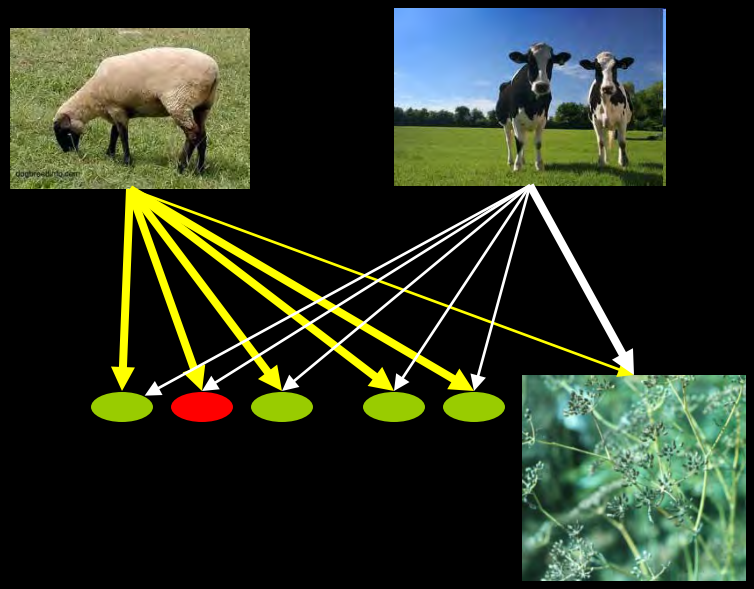
Dealing With Complexity Requires Objectivity

- What is the range of effects an invader can have in an ecosystem?
- Fennel on Santa Cruz Island

Brenton and Klinger 1994, 2001; Erskine-Ogden and Rejmánek 2005; Klinger 2007, Klinger et al. in review

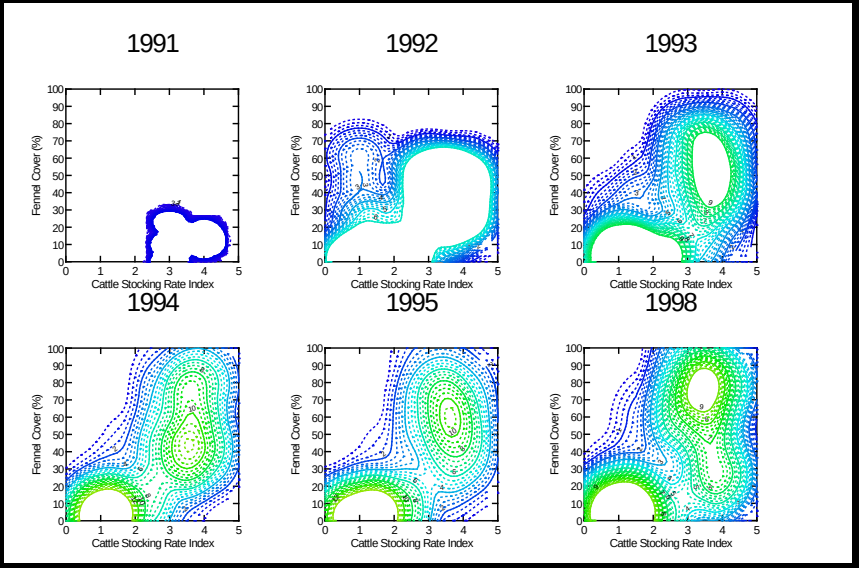
The Spread of Fennel

- Colonized SCI mid to late 1800's
- Patchy establishment by early 1900's



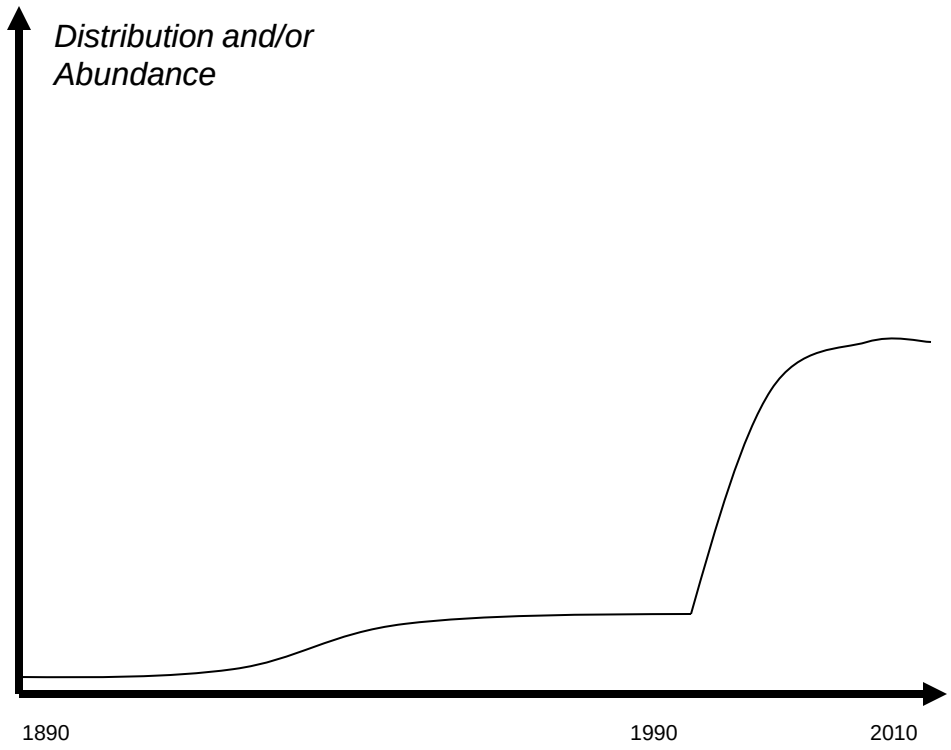
The Spread of Fennel

- Colonized SCI mid to late 1800's
- Patchy establishment by early 1900's
- Lag period
- Explosive spread 1990's
- Spread into previously unoccupied areas
- Greatest increase in cover was in areas with heavy cattle use



The Spread of Fennel

100-year lag period followed by burst of exponential spread



Ecological and Management Issues

Ecological

Management

- **Community Stability**
  - **Resistance**
  - **Resilience**
  - **Variability**
  - **Persistence**
- **Biodiversity**
  - **Species Richness**
  - **Species Diversity**
  - **Species Composition**
- **Feasibility of Control**
  - **Effects on community**

Fennel The Villain

- Such a dominant invader would have to be reducing native biodiversity, right?

Expectations

- Community Stability
  - Resistance depends on vegetation community
  - Low resilience
  - Relatively low variability
  - Relatively high persistence
- Diversity patterns
  - Decreased species richness
  - Low evenness
  - High beta diversity

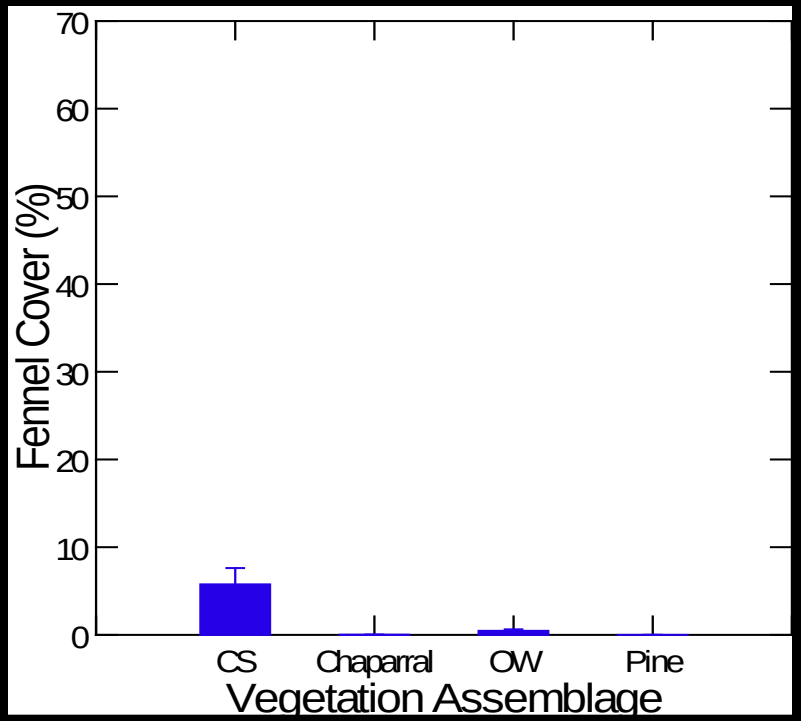
Stable but much more simple community

Two-Pronged Approach

- **Monitoring**
  - **Vegetation (1991-1995, 1998)**
  - **Birds (1991-1995, 1998)**
  - **Small mammals (1991-1995, 1998)**
- **Experiments**
  - **Fennel control**
    - **Phase 1 (1991-1994)**
    - **Phase 2 (1993-1997)**
    - **Phase 3 (1996-2001)**
  - **Fennel as a resource for small mammals and birds**

Vegetation

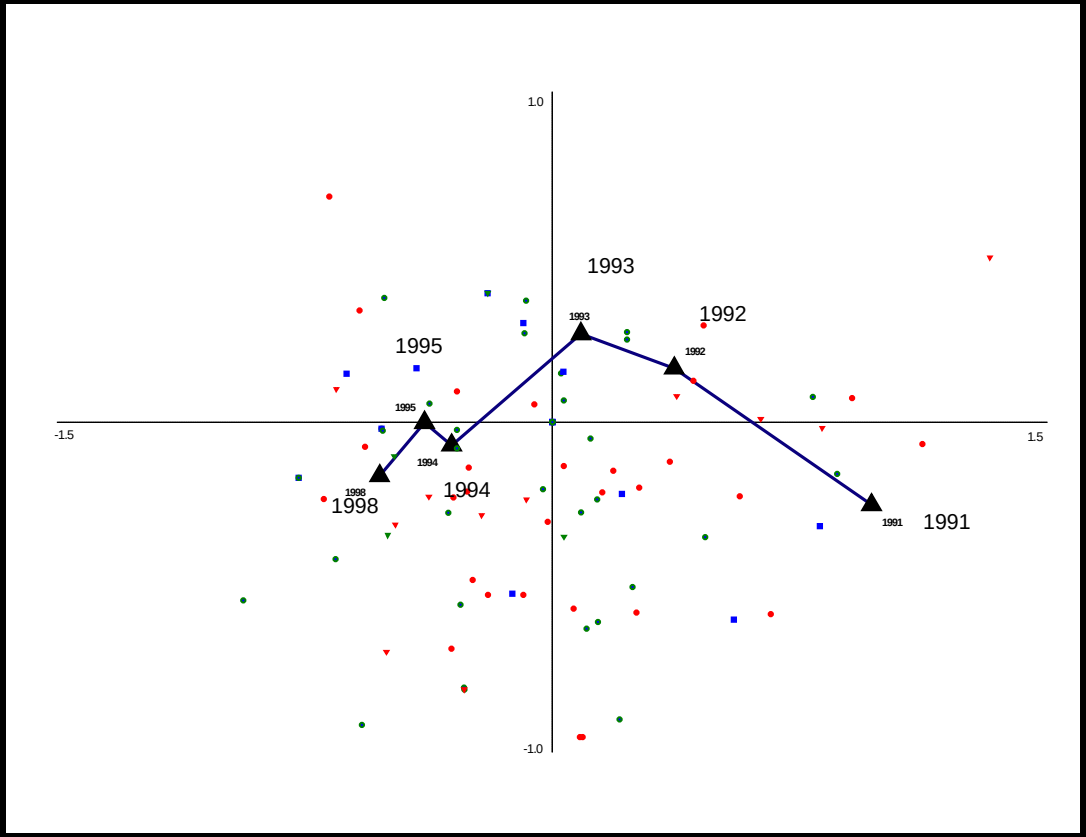
High Resistance In Woody Communities



Low Resistance In Grasslands

Vegetation

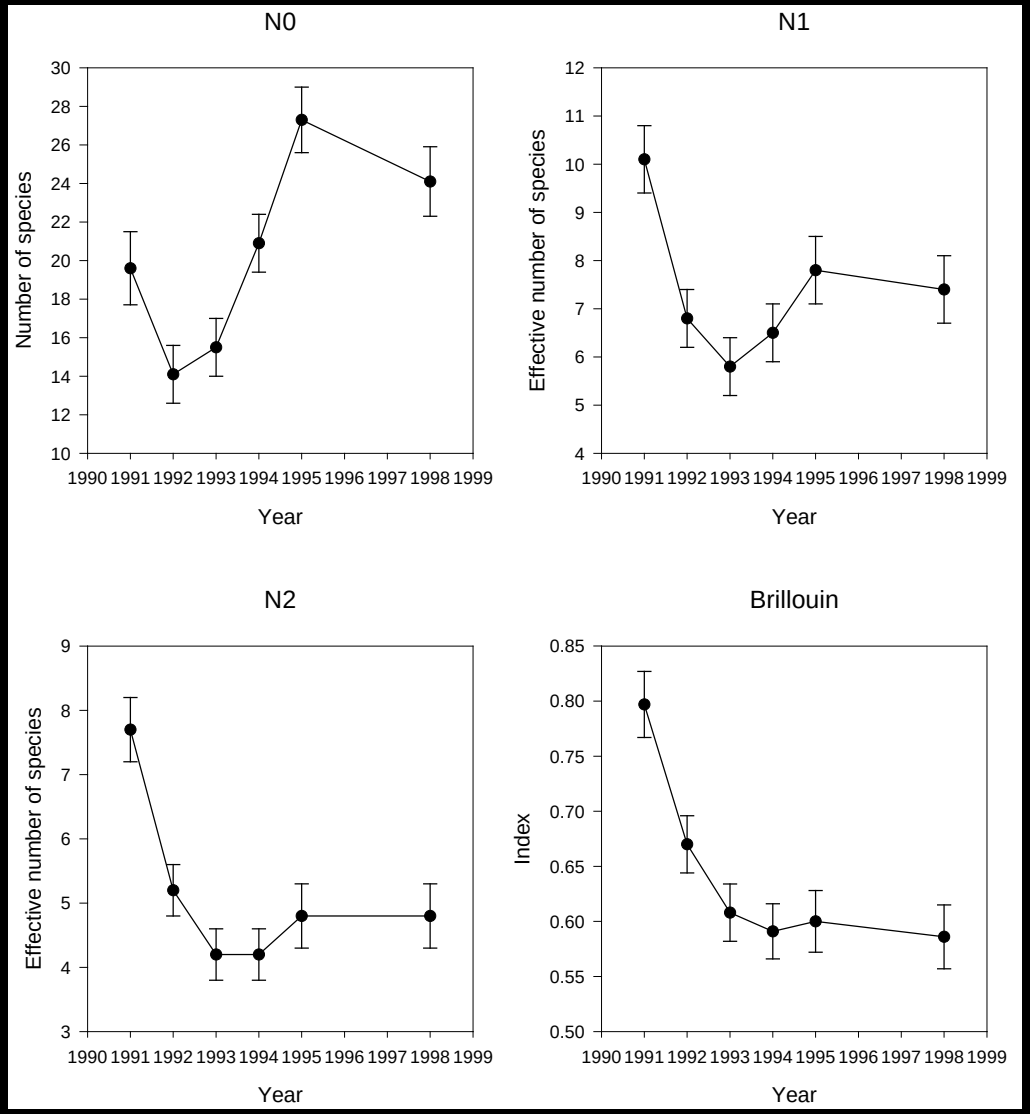
Low resilience in grasslands



Distance-based redundancy analysis

Vegetation

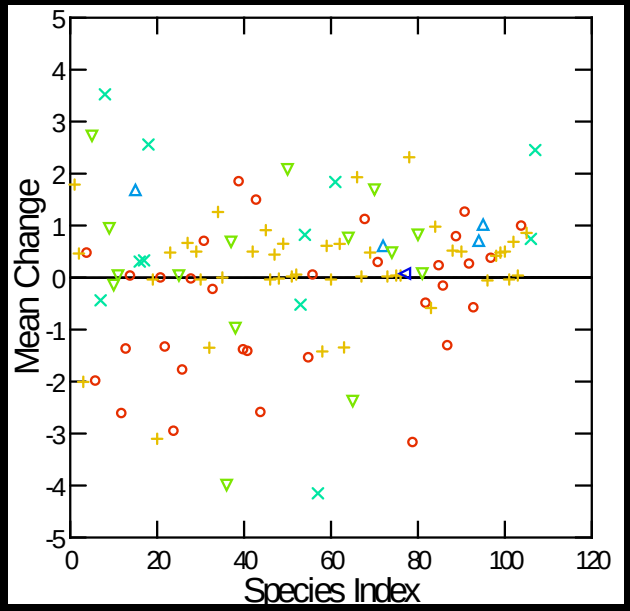
Complex diversity patterns



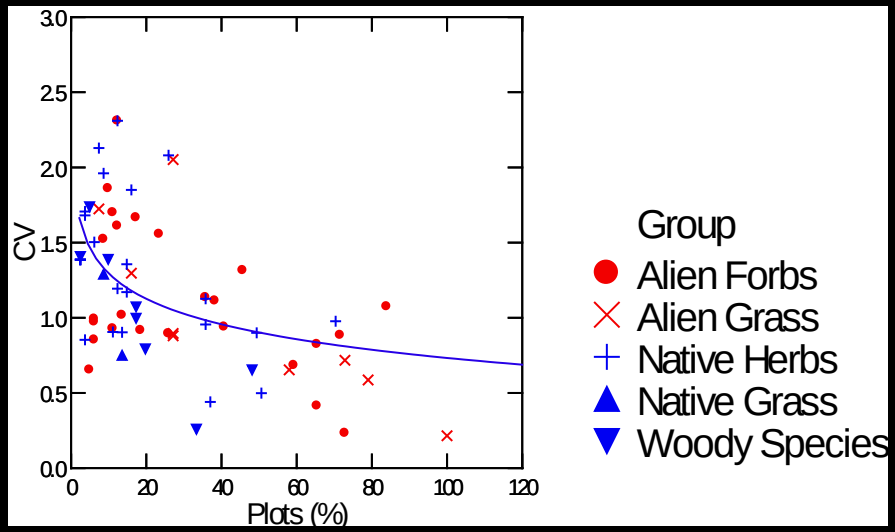
Generalized additive models

Vegetation

Highly variable variability



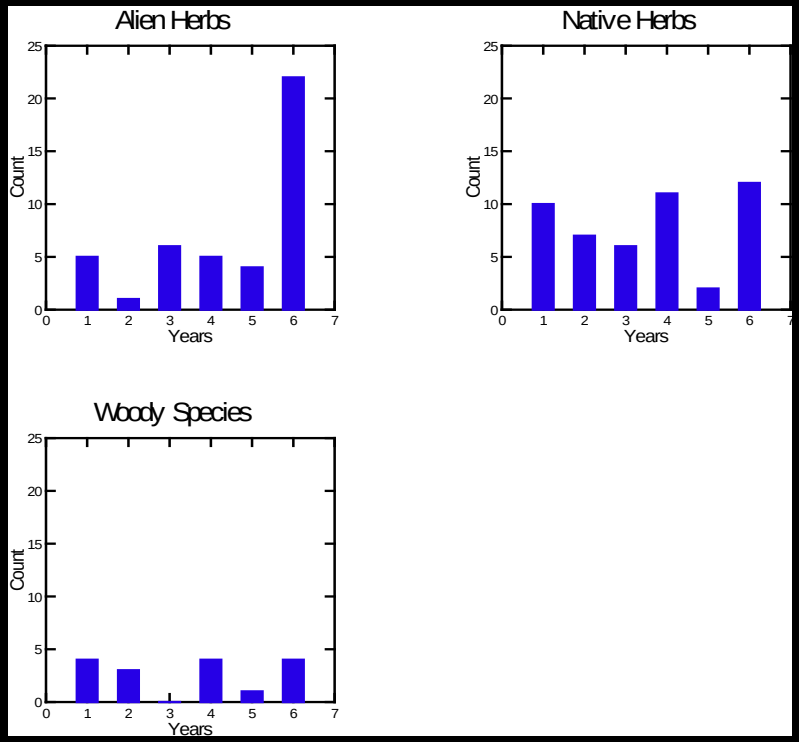
More extreme decreases than increases

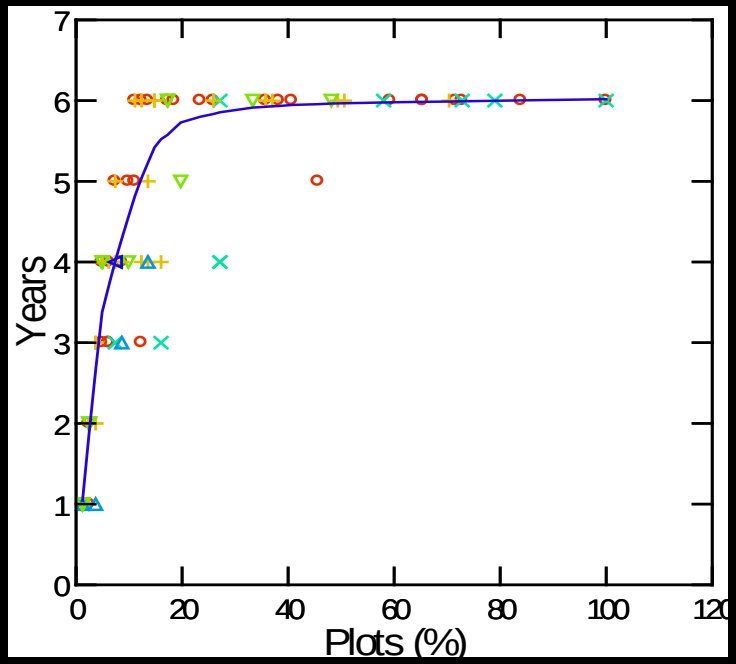


Species with wider distributions and greater abundance less variable

Vegetation

Persistence related to distribution





More restricted distribution = lower persistence

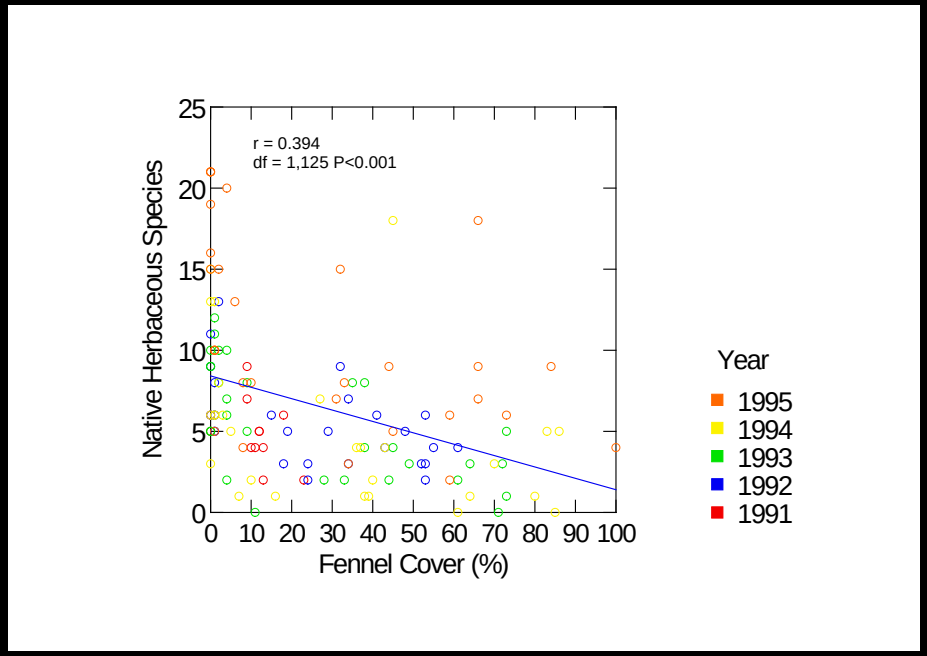
Natives significantly more restricted

Persistence varied among guilds

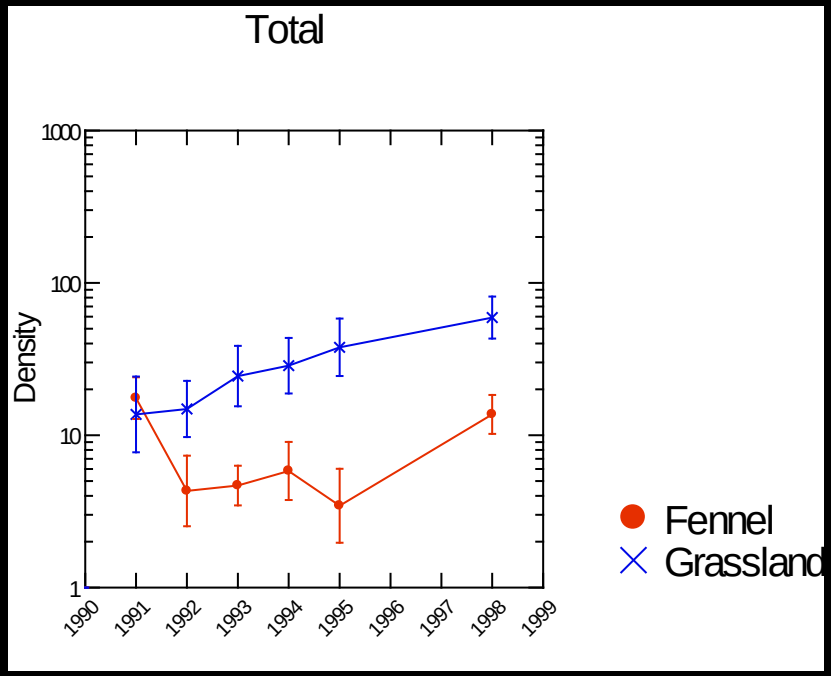
Natives had significantly lower persistence

Vegetation

Suppression or displacement of native species



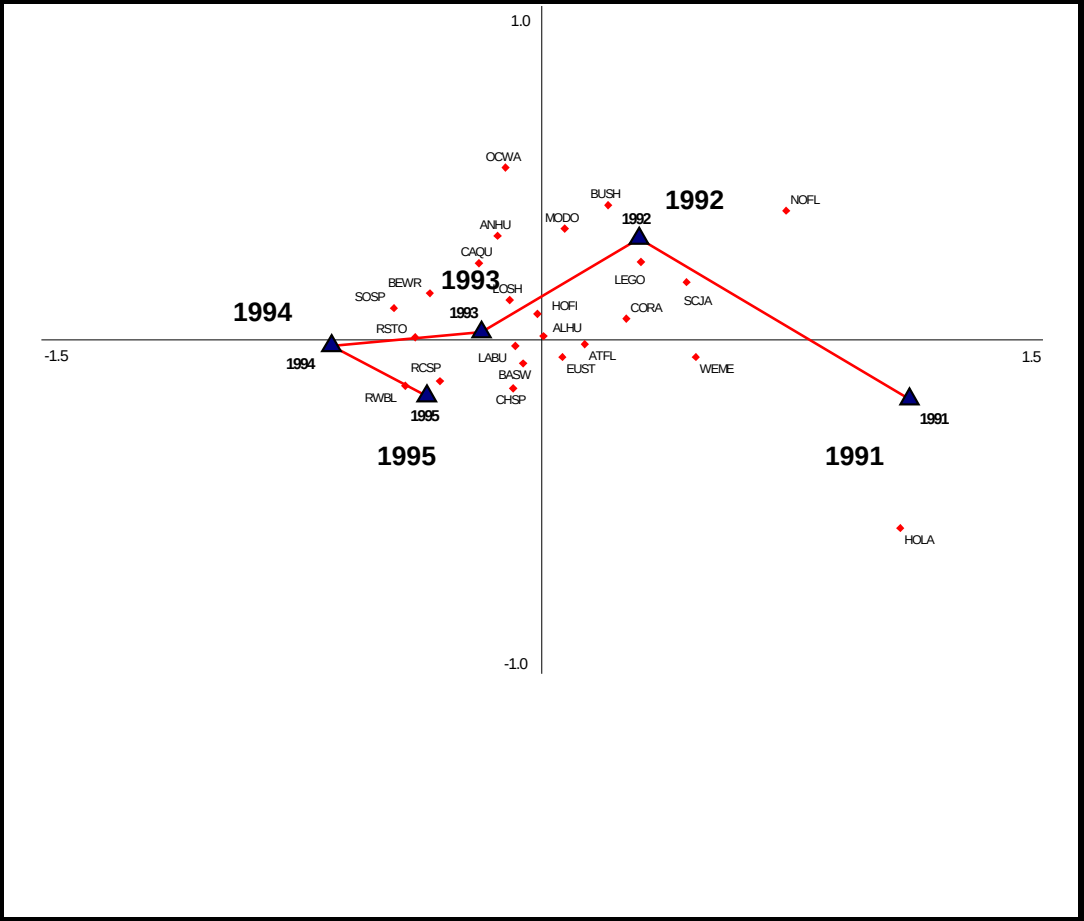
Native forb species dramatically decreased as fennel cover increased



Woody species regeneration lower in fennel stands than grasslands

Birds

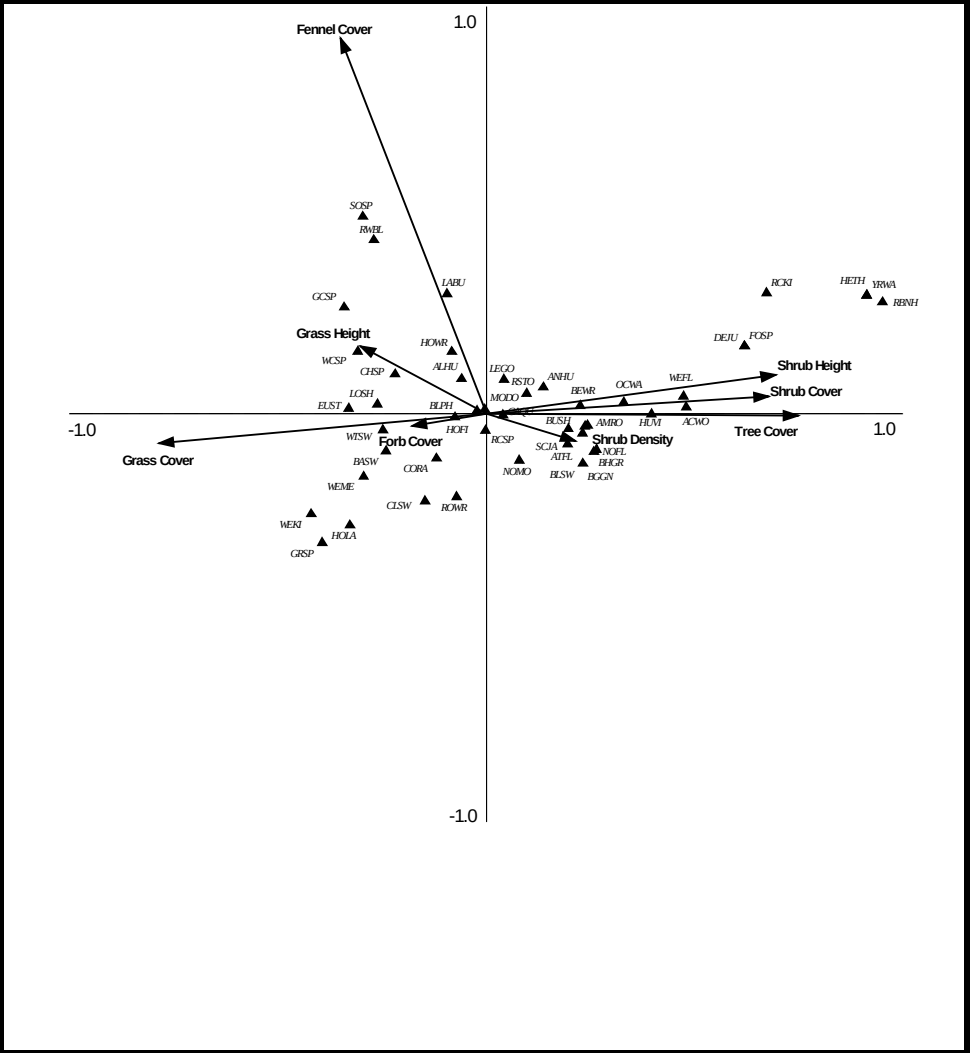
Low resilience



Distance-based redundancy analysis

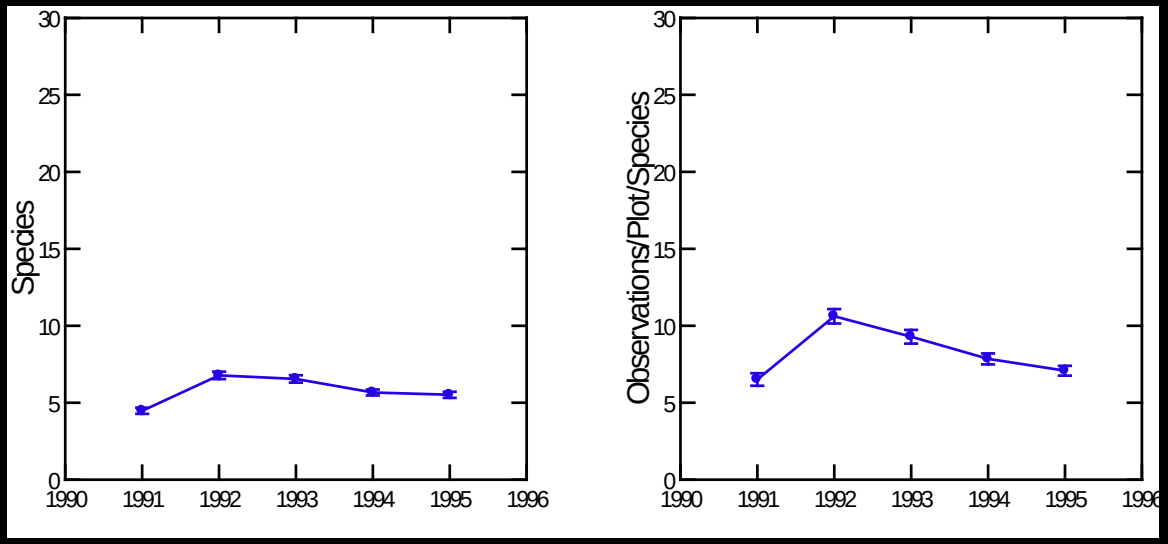
Birds

- Strong positive association with fennel
  - Song sparrow
  - Red-winged blackbird
  - Lazuli bunting
- Strong negative association with fennel
  - Horned lark
  - Western meadowlark
  - Ash-throated flycatcher

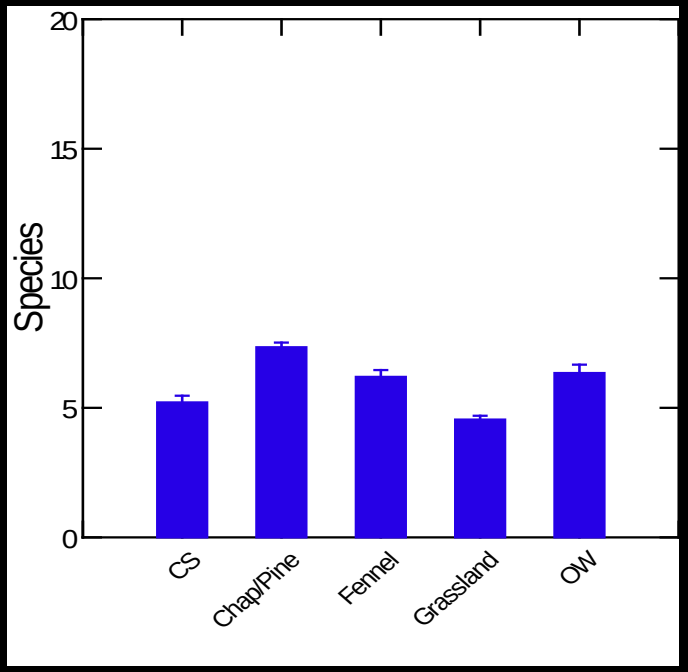


Canonical correspondence analysis

Birds

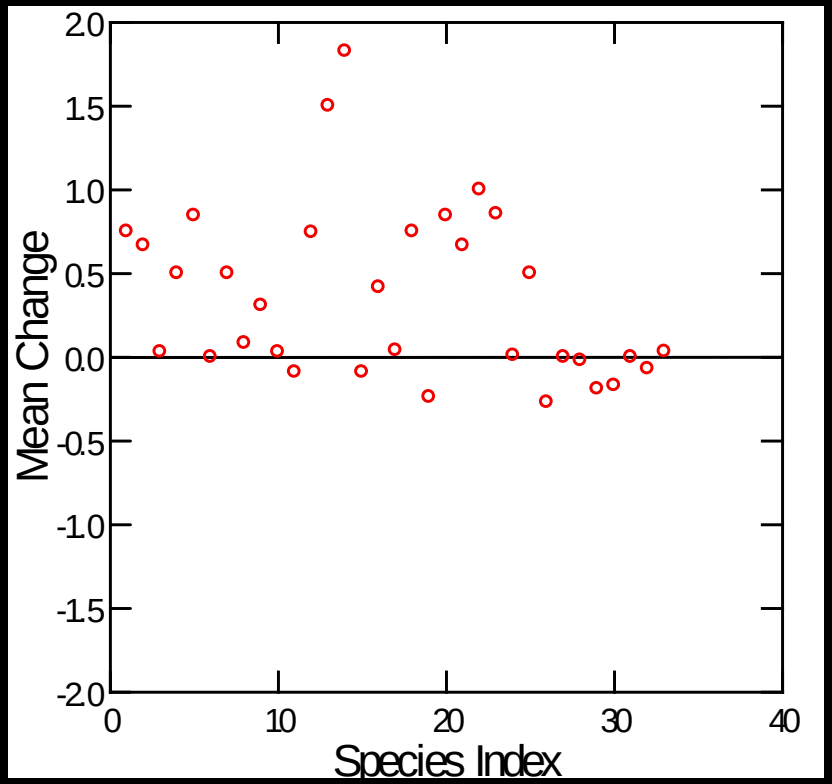


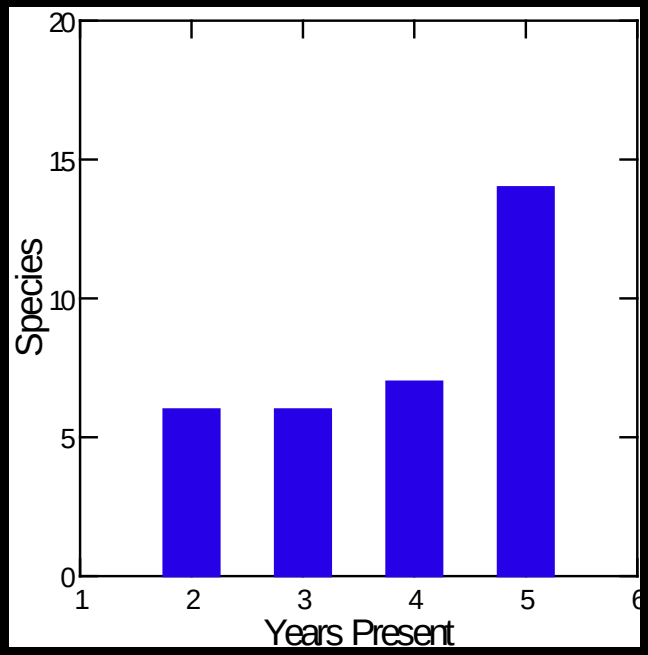
- Diversity patterns
  - Increase in α diversity and abundance
  - α and γ diversity as high or higher in fennel as all other vegetation types except chaparral



Birds

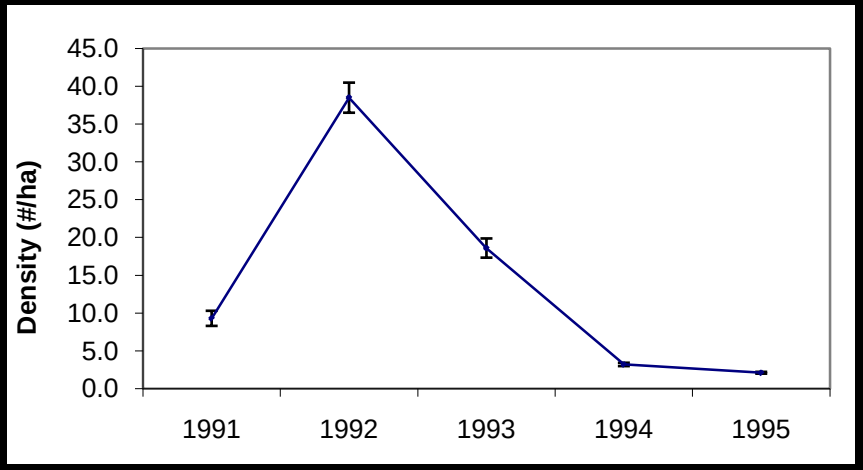
- Variability and Persistence
  - High variability but mostly positive
  - > 66% of species present 4 to 5 years

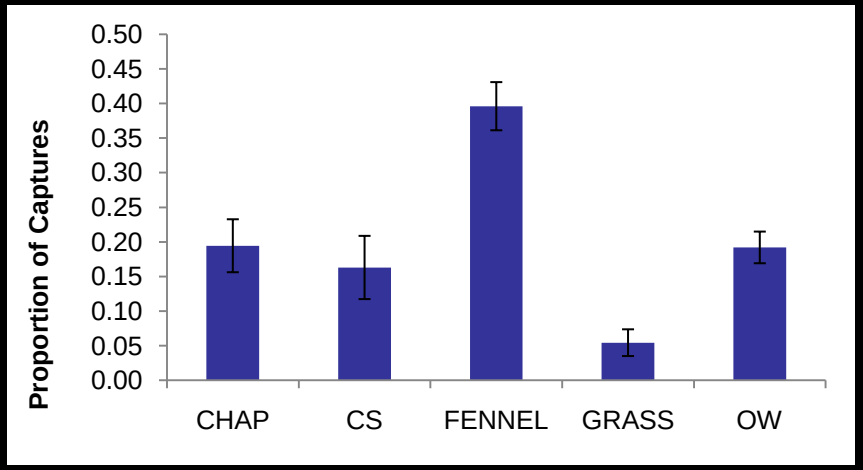




Small Mammals

- *Permyscus maniculatus* and *Reithrodontomys megalotis* occurred commonly in fennel stands
- 2 – 8X higher proportion of captures of *P. maniculatus* in fennel

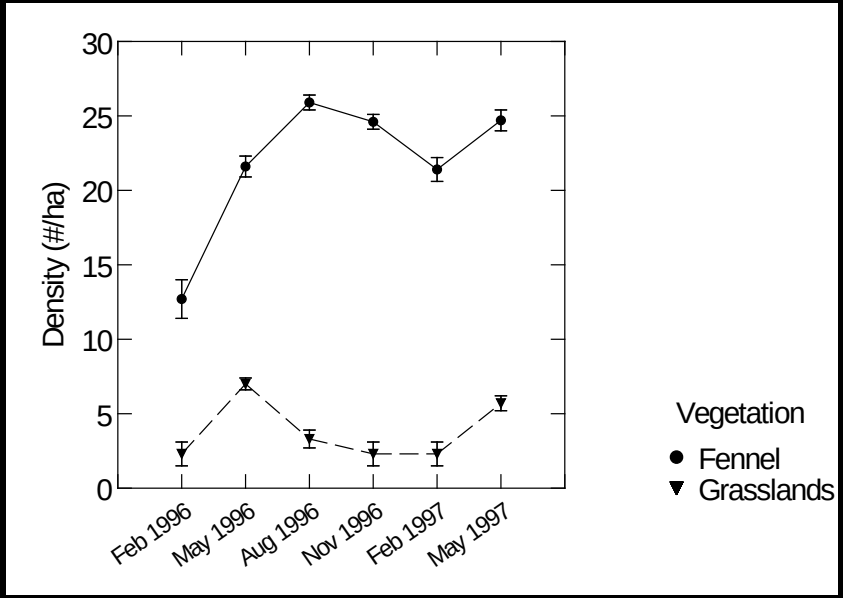


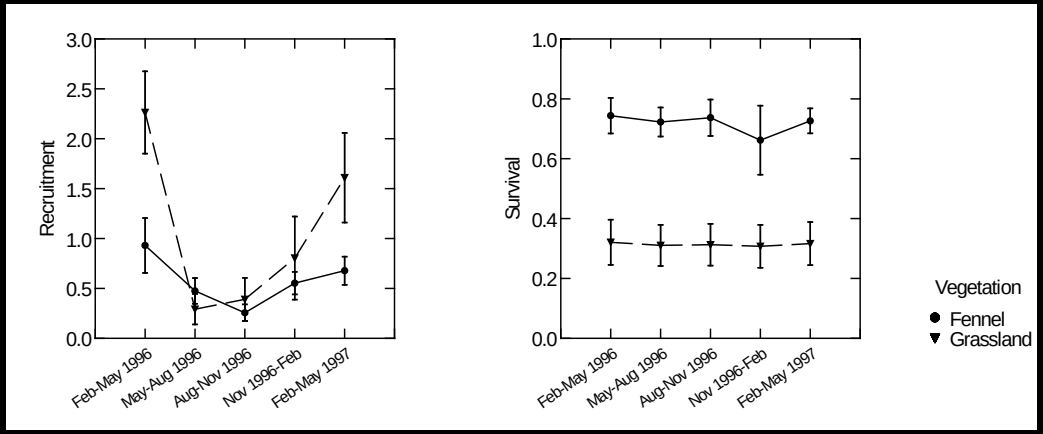


N = 10 grids 1991 to 1995

Small Mammals

- Demographic contrasts between fennel and grassland (1996-1997)
  - Seasonally higher recruitment rates in grassland
  - Consistently higher survival rates in fennel (> 2.5x)

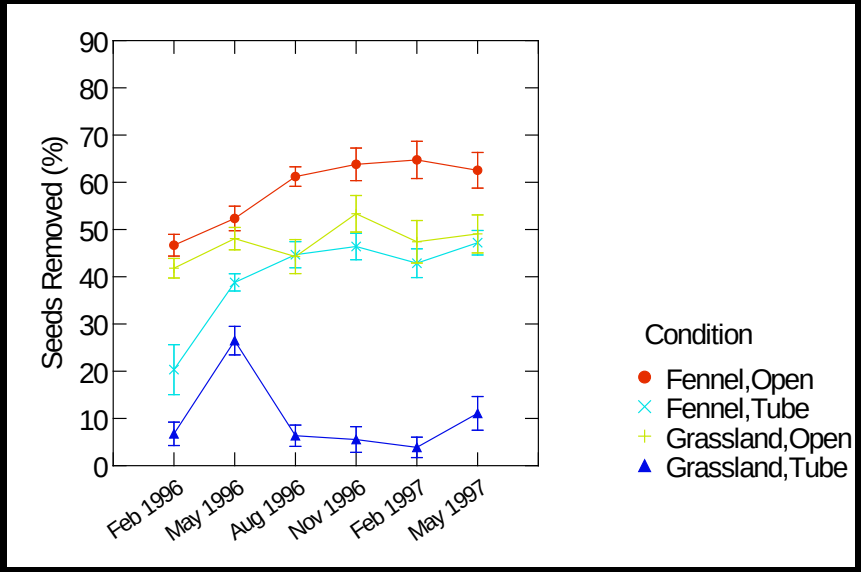




N = 6 grids (3 fennel, 3 grassland) trapped across six periods

Birds, Small Mammals & Fennel Seeds

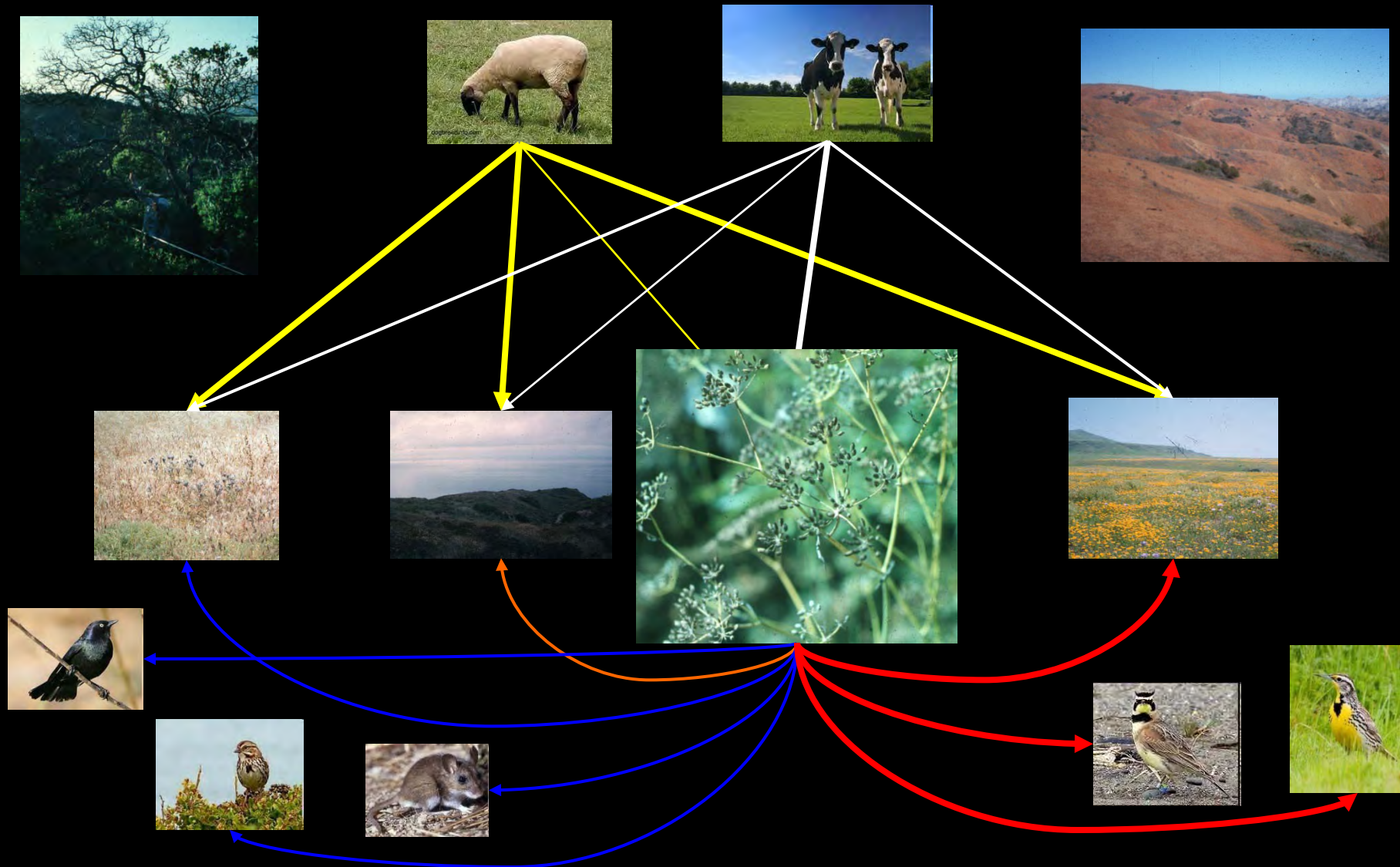
- Seed removal experiment
  - Fennel vs. Grassland
  - Open vs. PVC tube
  - 5 stations/grid sampled each trapping period (50 seeds/station)
- Most fennel seeds in fennel stands removed by small mammals
- Most fennel seeds in grassland removed by birds
- ***Seed fate not determined***



Expectations Revisited

- Stable but much more simple community?
  - Depends on measure of stability and taxa

The Fennel Ring-Around-The-Rosy

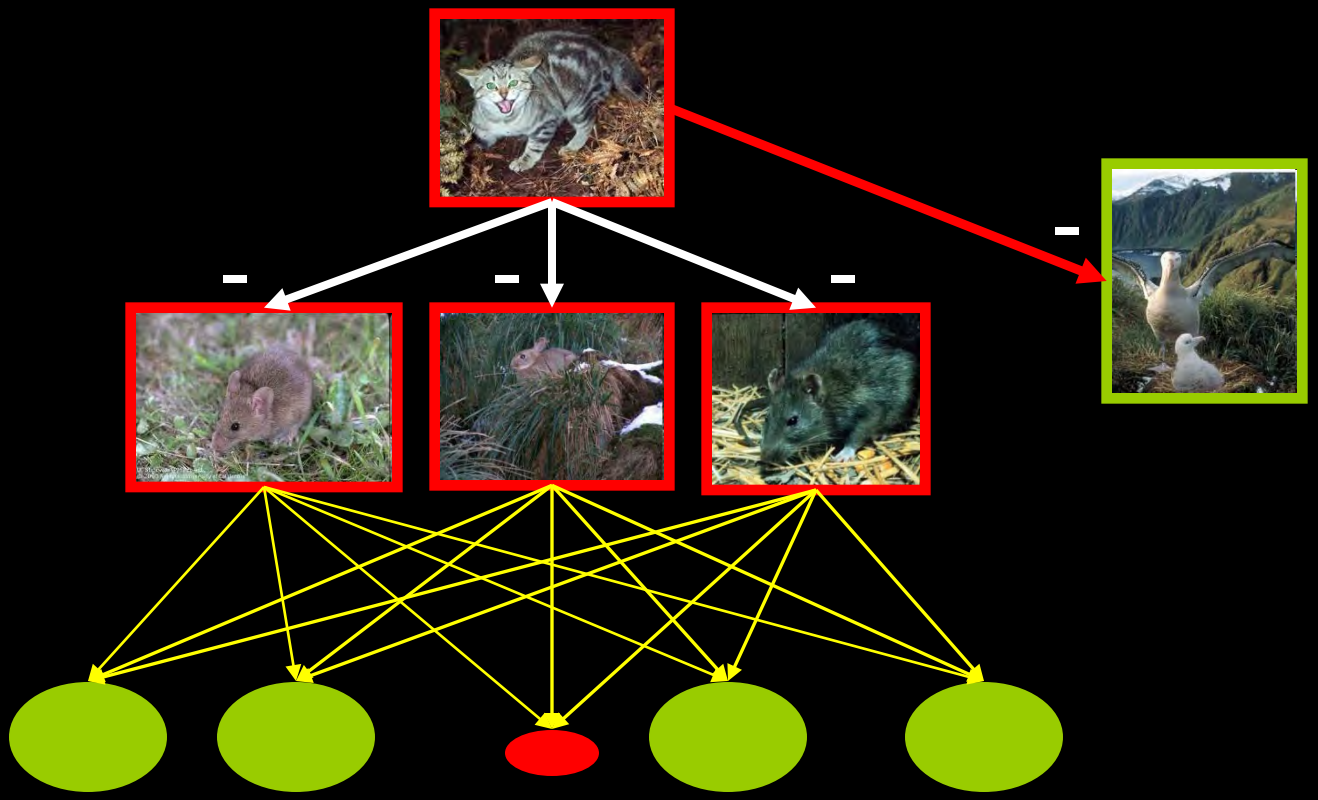


So Is Fennel A Villain?

- A native plant would probably say yes
- A lot of native vertebrates would probably say no

Recent Examples Of The Reality

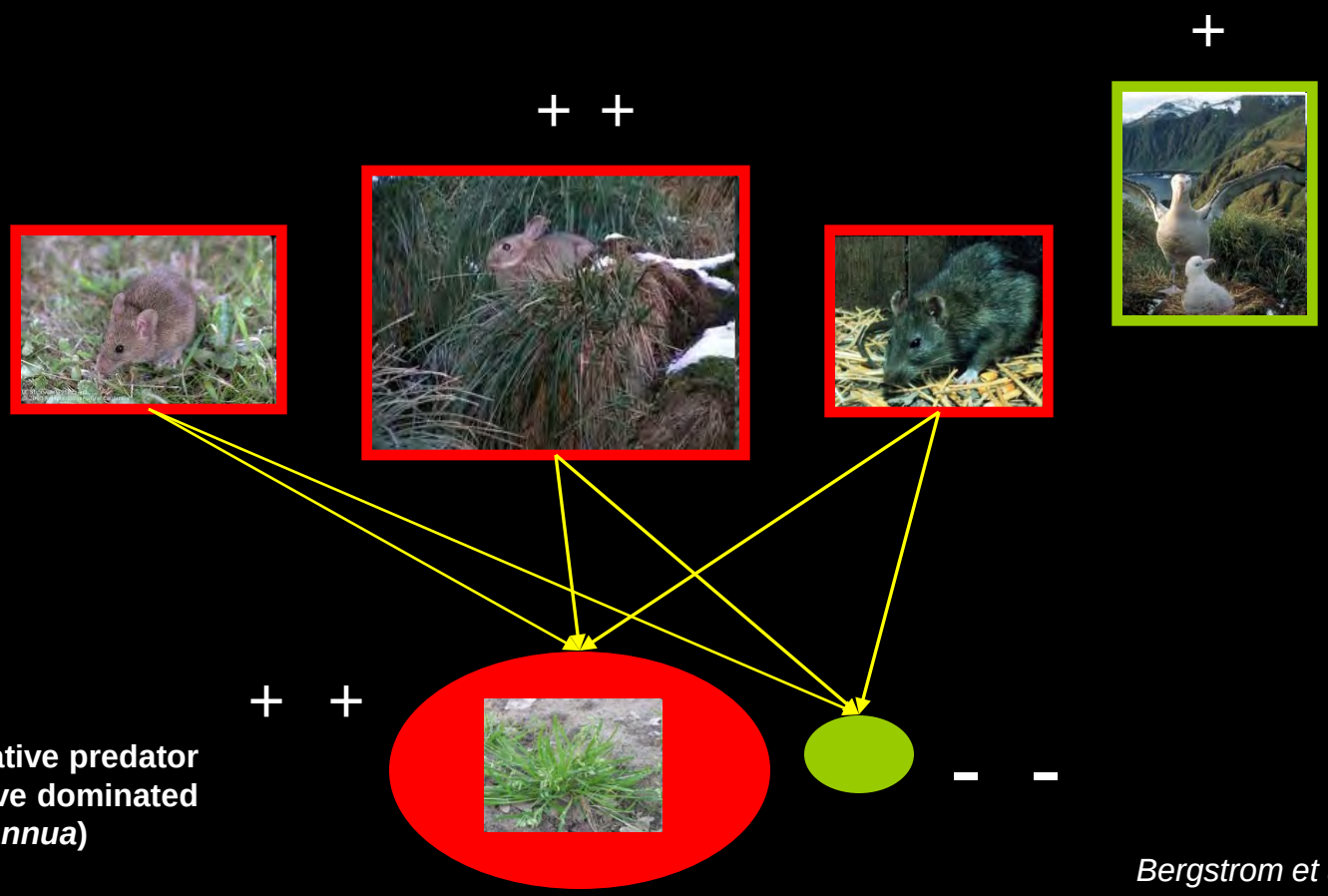
Species deletions and trophic cascades in an insular high latitude ecosystem



Bergstrom et al. 2009

Recent Examples Of The Reality

Species deletions and trophic cascades in an insular high latitude ecosystem

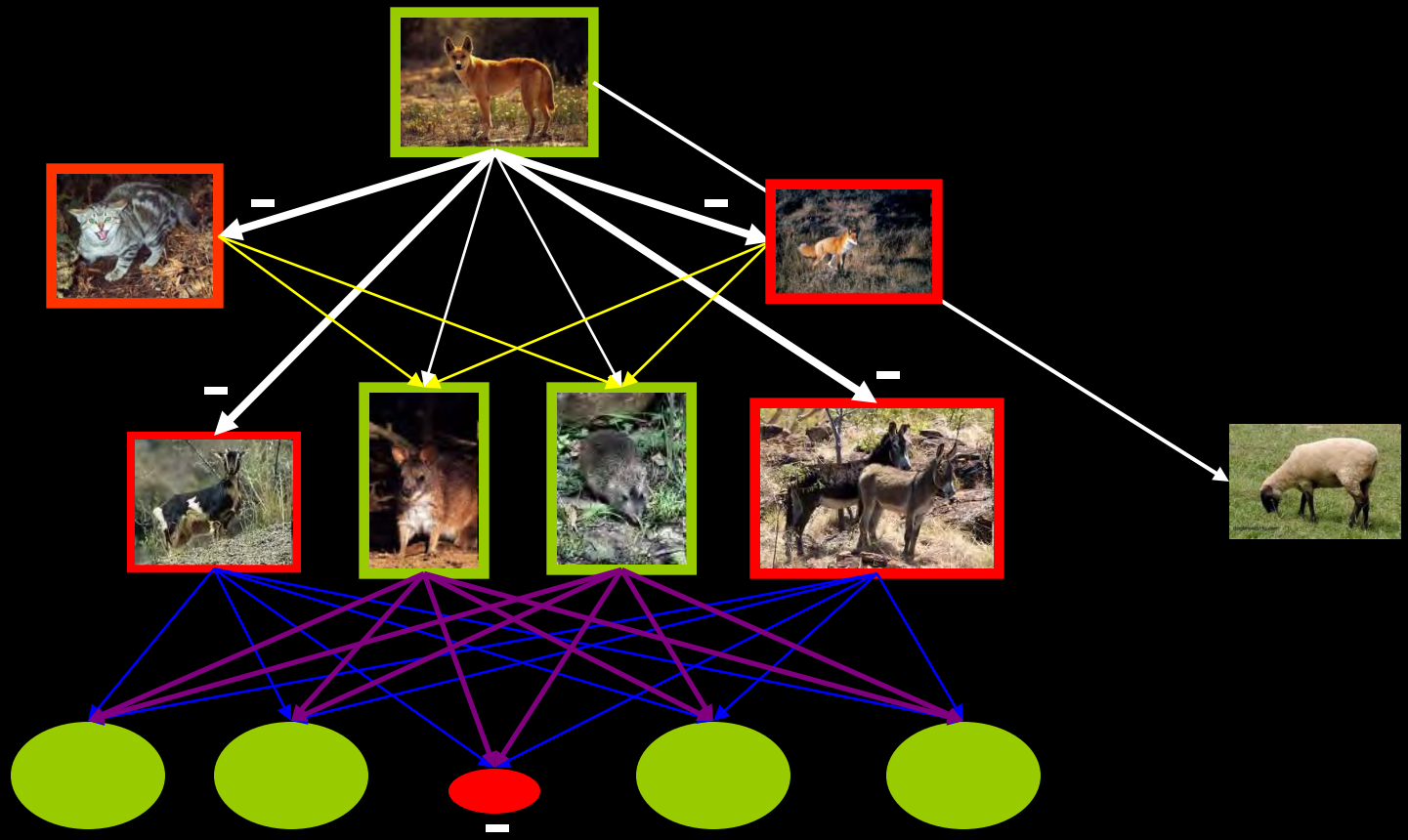


Control of non-native predator leads to non-native dominated vegetation (*Poa annua*)

Bergstrom et al. 2009

Recent Examples Of The Reality

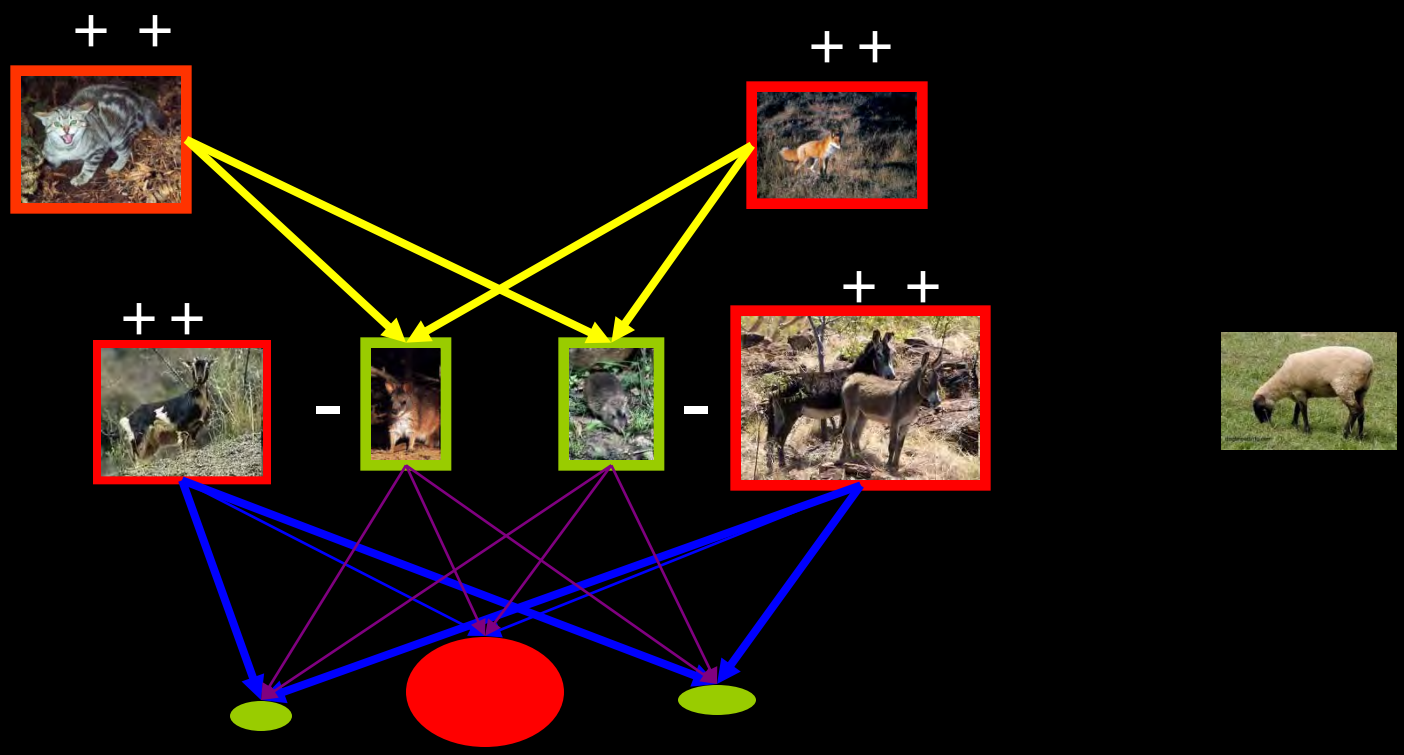
Species deletions and trophic cascades in an arid mainland ecosystem



Wallach et al. 2010

Recent Examples Of The Reality

Species deletions and trophic cascades in an arid mainland ecosystem



Control of native (more or less) predator leads to non-native dominated system

Wallach et al. 2010

Recent Examples Of The Reality

Species addition, apparent competition, habitat alteration, and diet switching in a coastal ecosystem

-

***Ammophila arenaria* appears to compete with endangered lupine.**

Dangremond et al. 2010

Recent Examples Of The Reality

Species addition, apparent competition, habitat alteration, and diet switching in a coastal ecosystem

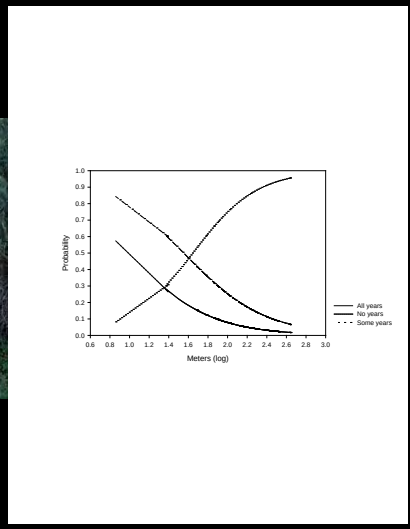
Ammophila arenaria **appears to compete with endangered lupine. But suppression of lupine is actually due to pre-dispersal seed predation by native deer mouse**

Dangremond et al. 2010

The Message Is Sinking In

- Studies on invasive plant-wildlife interactions are becoming increasingly more grounded in an ecological context
- Initial assumption is to not just look for “impacts”, but interactions
- Two examples
  - Seed dispersal and diet selection
  - Species additions to suppress non-native

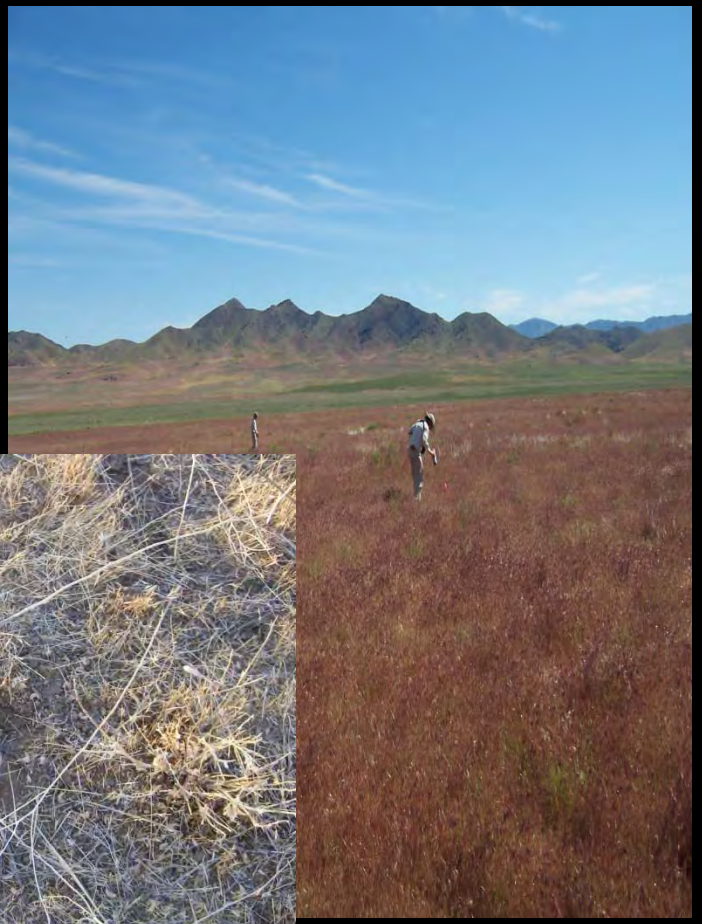
Frugivory And Invasion



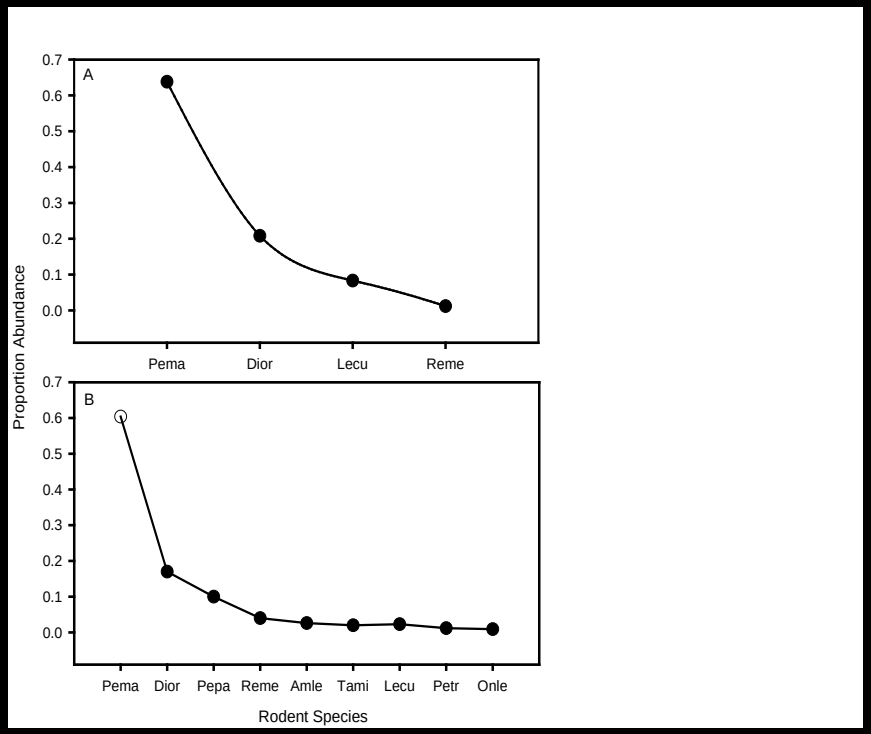
Relationship between native frugivores, non-native trees, and food availiability

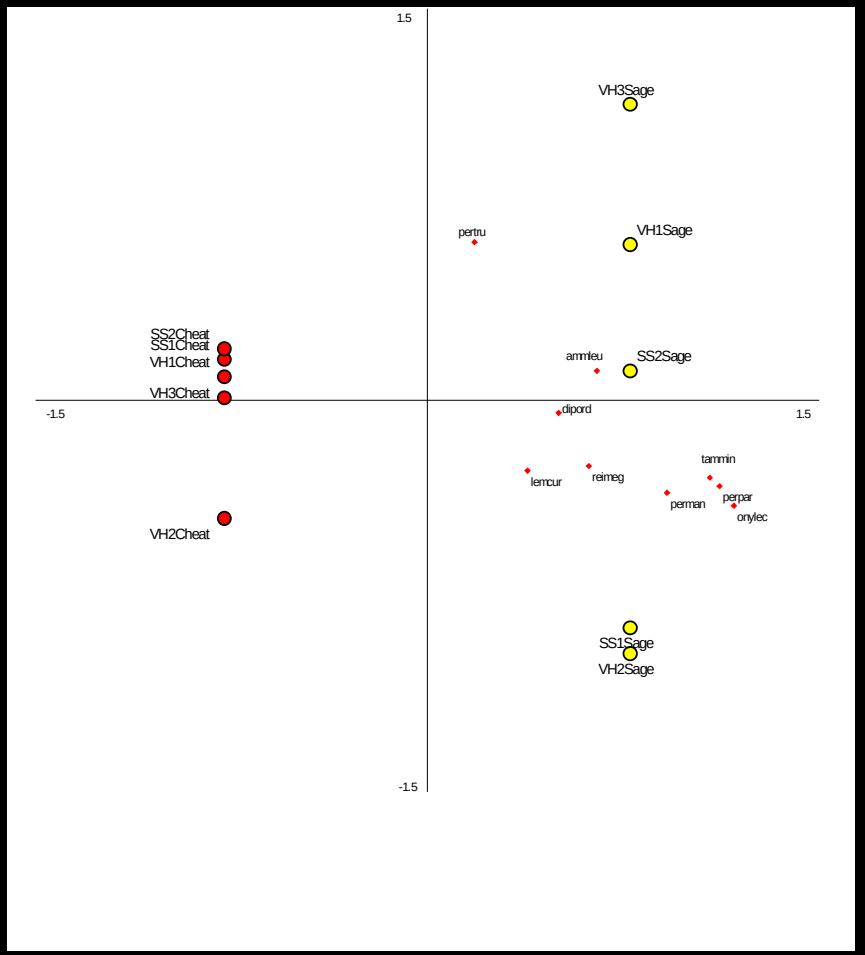
Combination of observation and experimental approaches

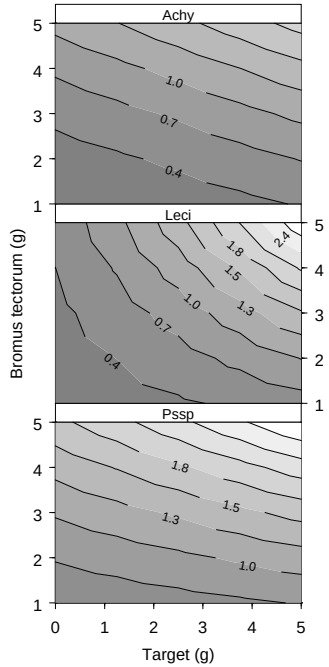
Cheatgrass, Native Seed, & Rodent Interactions in Great Basin



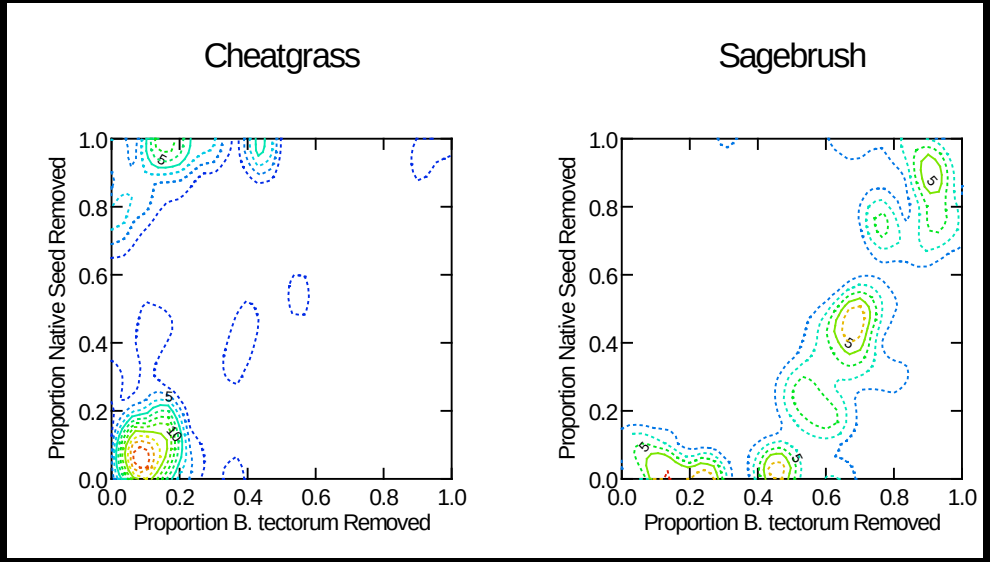
Cheatgrass & Animal Community Composition







Seed Exploitation: Native Cocktail vs. Cheatgrass



- **Native seeds facilitated removal and caching of cheatgrass by rodents**
- **Depended on seed species**
- **Pattern varied between sage-dominated and cheatgrass communities**

Quantified animal community structure then tied this to process (seed predation/dispersal)

Combination of observation and experimental approaches

Moving Ahead

- Species additions
- Three questions to ask
  - How long has the invader been in the system?
  - What is the range of their effects (positive as well as negative…i.e. "impacts")?
  - Are they doing something a native species doesn't do?

Moving Ahead

- Species deletions
- Three questions to ask
  - How long has the invader been in the system?
  - How many other invaders are in the system?
  - If you remove one invader will another replace it?

“Tying It Together”

- What did I see?
  - Clear progress since Monterey conference (February 2007)
  - More sophisticated perspectives and questions
- What did I hear?
  - Recognition of complexity and contradictions
  - A nod to realism
  - More “effects“ than “impacts” **(that’s a good thing folks!)**

Johnson, Pinnacles National Monument

Doran and Gustafson, grazing regimes

More Variety In Thinking

- Not so quick to believe our assumptions
- Not as prone to assume our desires will be met
- Expect surprises
  - Don’t let disappointment deter your efforts
- Thinking like ecologists first, then conservationists
  - Be patient

A Variety Of Approaches

- A lot of observation approaches
  - Realistic spatial and temporal scales
- Some experimental approaches
  - Strong on process and mechanism
- Some modeling
- Ideal is mix of all three

Murphy & Barrows. in progress

Dudley et al. in progress

That Is Progress