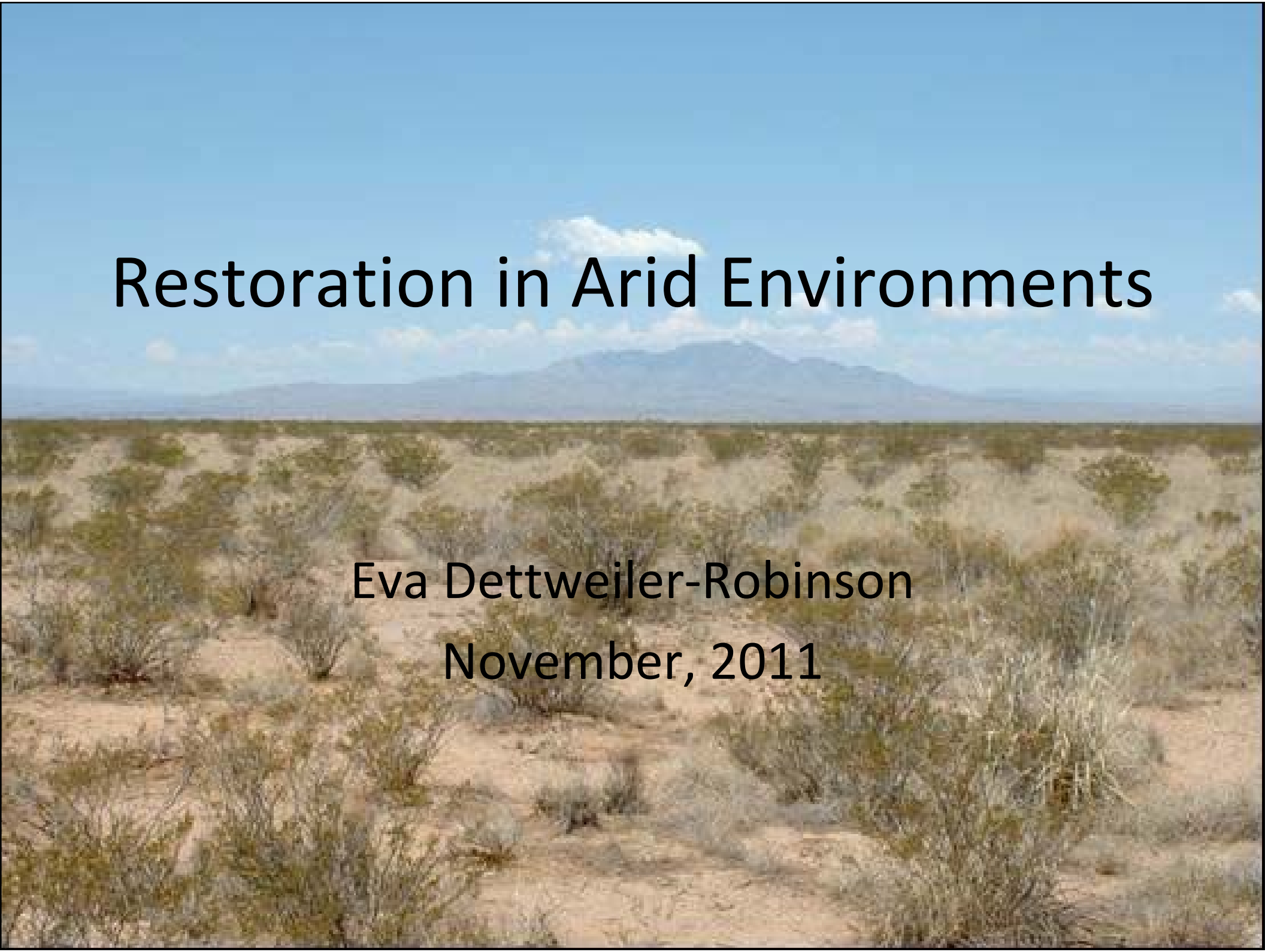


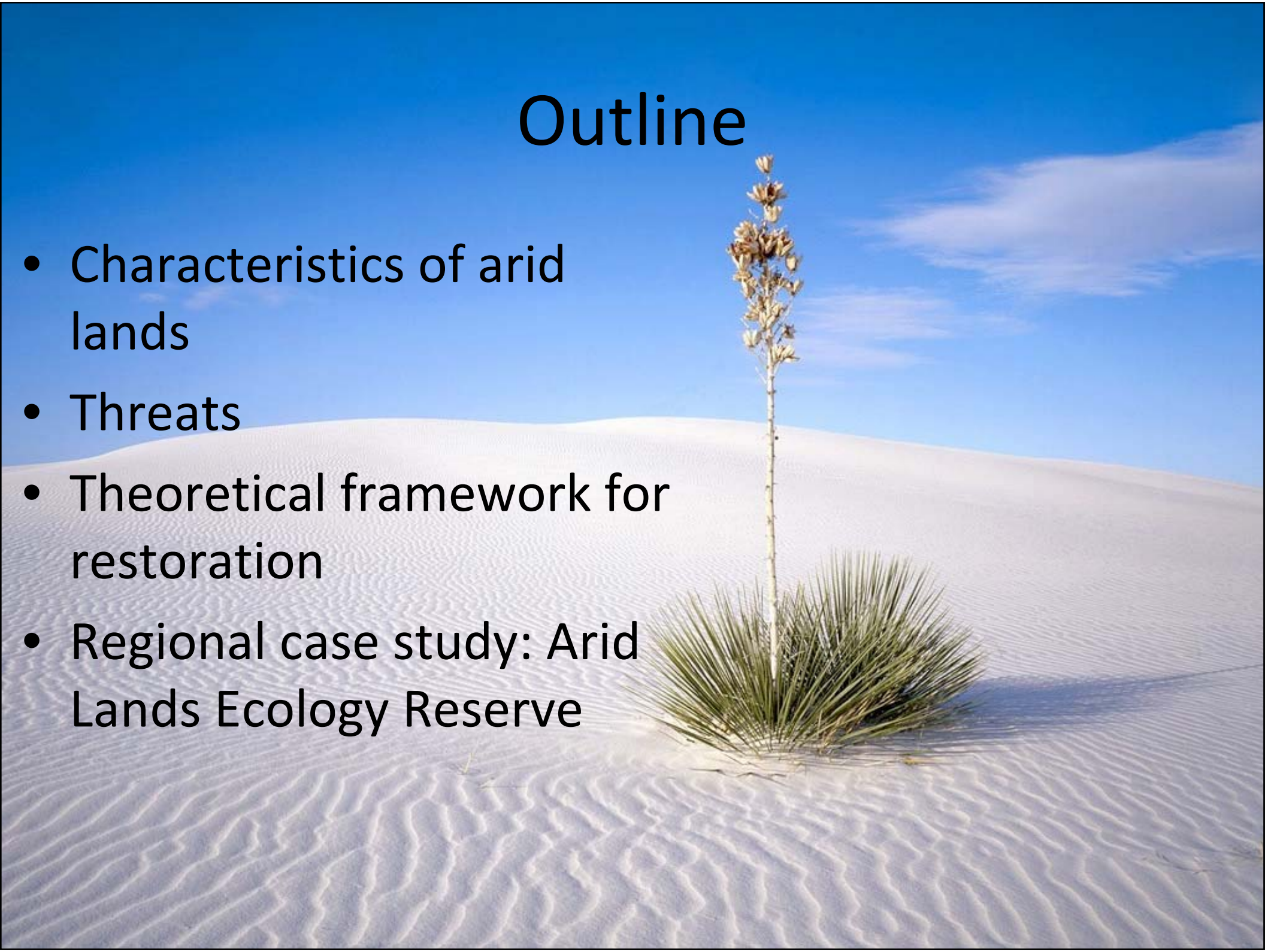
Restoration in Arid Environments

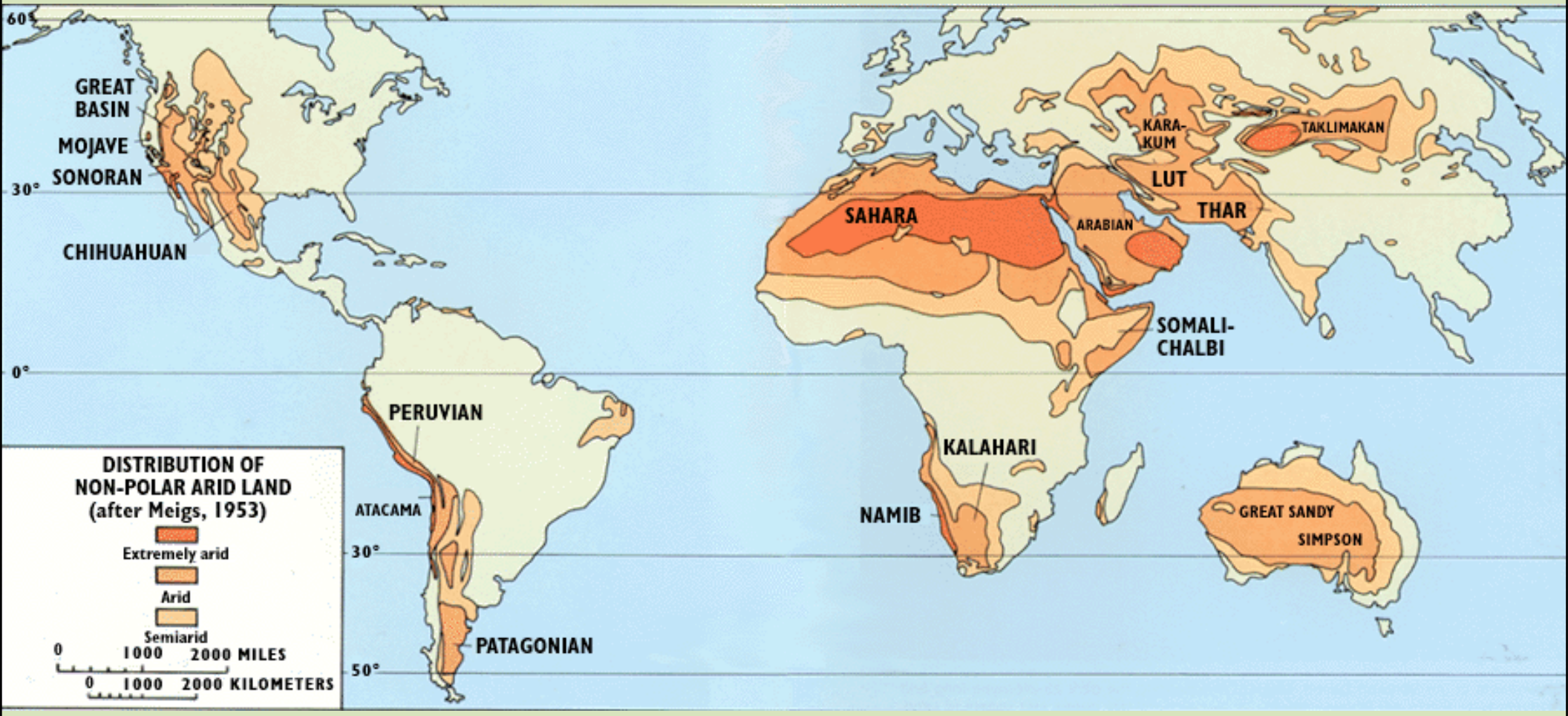
Eva Dettweiler-Robinson

November, 2011

Outline

- Characteristics of arid lands
- Threats
- Theoretical framework for restoration
- Regional case study: Arid Lands Ecology Reserve




DISTRIBUTION OF
NON-POLAR ARID LAND
(after Meigs, 1953)
Extremely arid
Arid
Semiarid
0 1000 2000 MILES
0 1000 2000 KILOMETERS
60°
30°
0°
30°
50°
GREAT BASIN
MOJAVE
SONORAN
CHIHUAHUAN
PERUVIAN
ATACAMA
PATAGONIAN
SAHARA
ARABIAN
KARA-KUM
TAKLIMAKAN
LUT
THAR
SOMALI-CHALBI
KALAHARI
NAMIB
GREAT SANDY
SIMPSON

Characteristics of deserts

Little rain; variable timing of precipitation

Wide temperature fluctuations

Intense radiation

Low nutrient soils

High wind

Stress vs. Disturbance

- Stress.
  - Eg: Desert organisms are adapted to seasonal and yearly fluctuations in precipitation. Drought is not uncommon.
- Disturbance:
  - Eg. Fire, grazing, or extreme drought can affect soil quality and vegetation for many years

Tracks in California from WWII exercises

Desert plants

- Vary widely in form, life history and adaptations
  - Drought avoidance and tolerance
  - Mycorrhizal fungi and rhizobia associations

Desert animals

- Ants, termites, insects – infiltration, herbivory, pollination
- Mammals, reptiles – trophic interactions, burrowing
- Birds – distribution of seeds and parasites, trophic interactions

Biological Soil Crust

Cyanobacteria, algae, fungi, bryophytes, lichens

Value

- Plant and animal species not found anywhere else
  - Endangered species
- Indigenous food crops
- Plant-derived drugs and other chemicals from drylands
- Flood control, water purification, dust control, sustainable livestock use

Threats

- Grazing
- Agriculture
- Roads
- Military activity
- Mining
- Recreation
- Pollution
- Changes to fire regime
- Invasive species
- Climate change

Abiotic Limits to restoration

- Loss of topsoil
  - late-successional species fail when planted into early successional soils.
- Moisture limitations
  - Pulses of establishment with rain events
- Landscape scale factors
  - Eg. Restore low land with good soils, but if the slope above fails…

Biotic Limits to restoration

- Inoculation not possible for most species of microorganisms
- Weeds
  - Arid systems tend to be open; disturbance adds new open spaces
- Animals
  - Herbivory, trampling
- Biodiversity
  - There are always more rare species than abundant species.
  - Tradeoff between species that establish and stabilize the soil, but their longevity and competitive ability reduce return of native species.

Theoretical Frameworks

Stress-Gradient Hypothesis

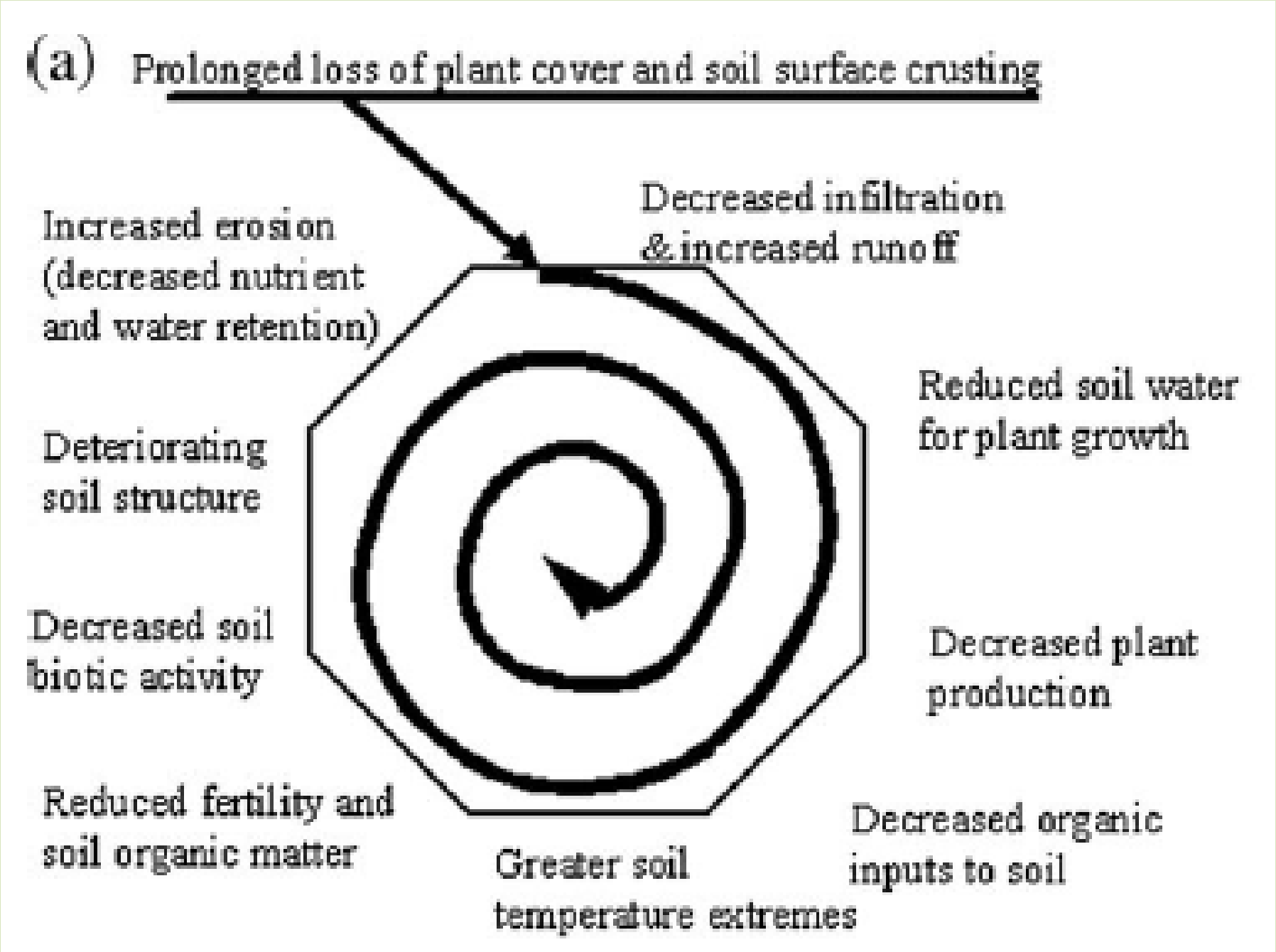
- As abiotic conditions become more stressful, facilitation interactions become more common
- Facilitation is where one species' structure or function benefits another species

- Eg. In areas of lower precipitation, seedlings rely more heavily on nurse plants.

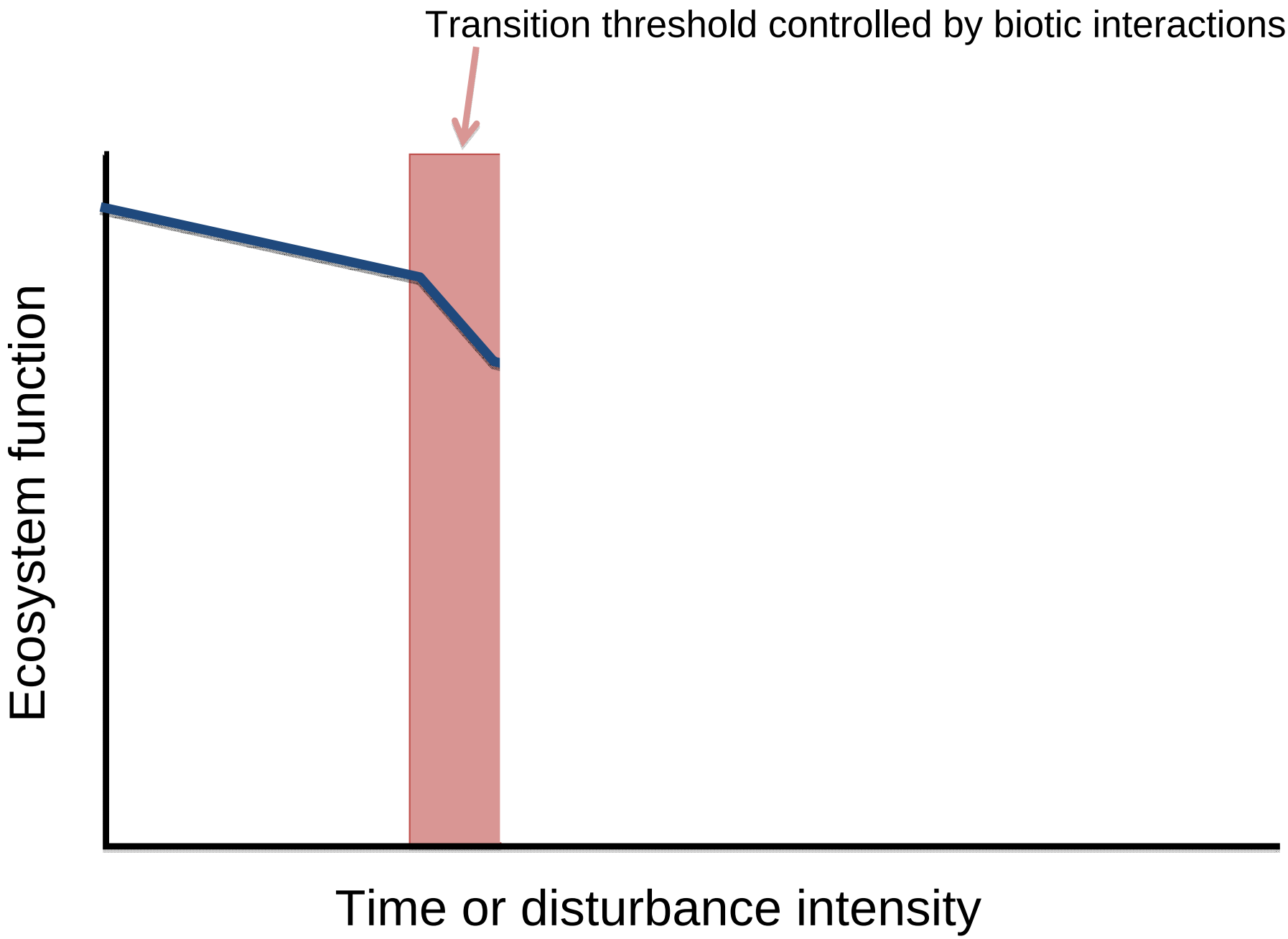
Theoretical Framework

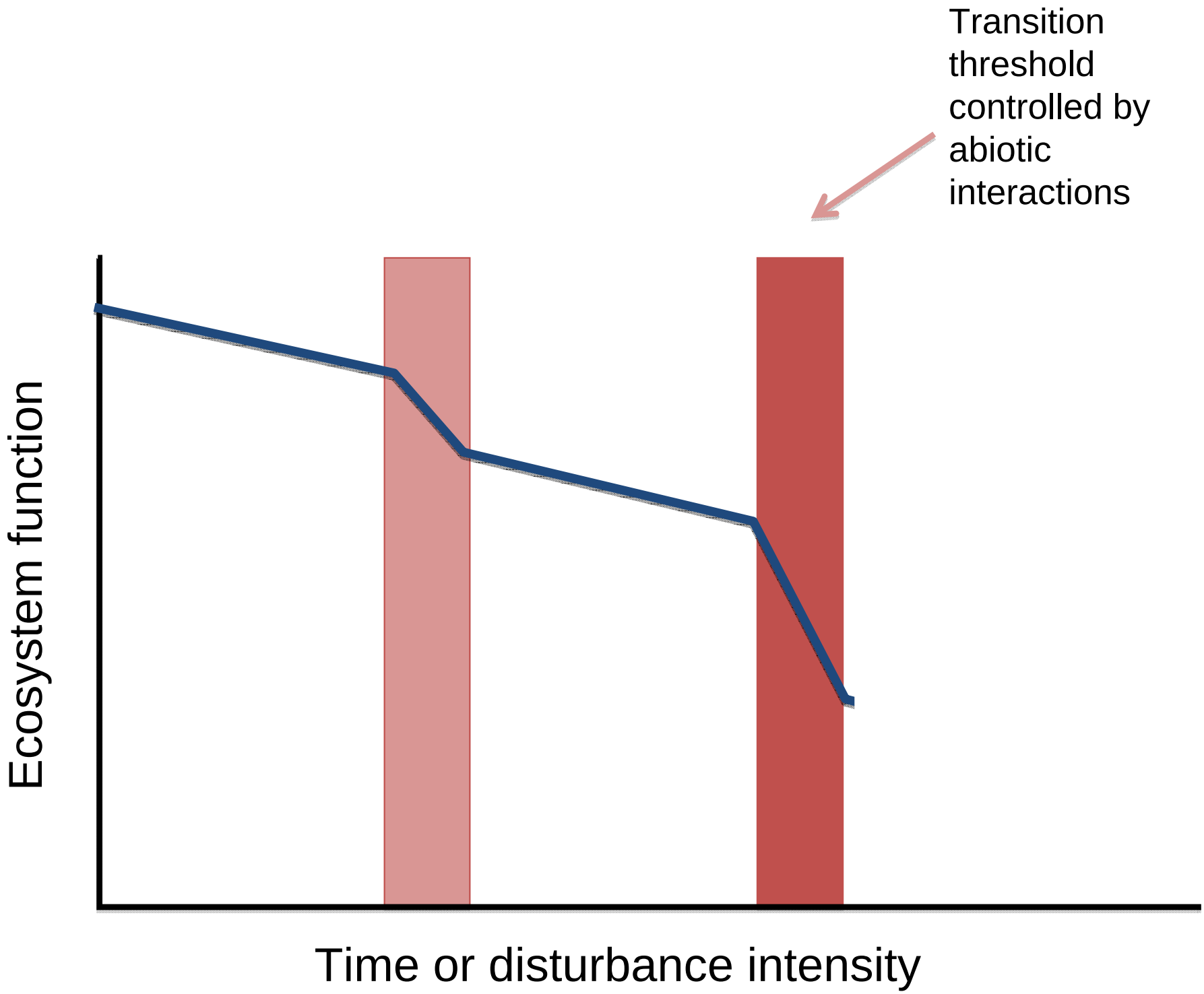
	STRUCTURE	FUNCTION
ABIOTIC (soil stability, hydrology, and nutrient dynamics)	Q. Eroded landforms A. Mechanical barriers	Q. Soil loss and surface water flow during rain A. Improve soil structure and H_2O infiltration rates
BIOTIC (plant-plant/ trophic interactions, dispersal)	Q. Undesirable species composition A. Removal and replanting	Q. Weeds outcompeting desired species A. Alter disturbance regime to favor desired species

Feedbacks

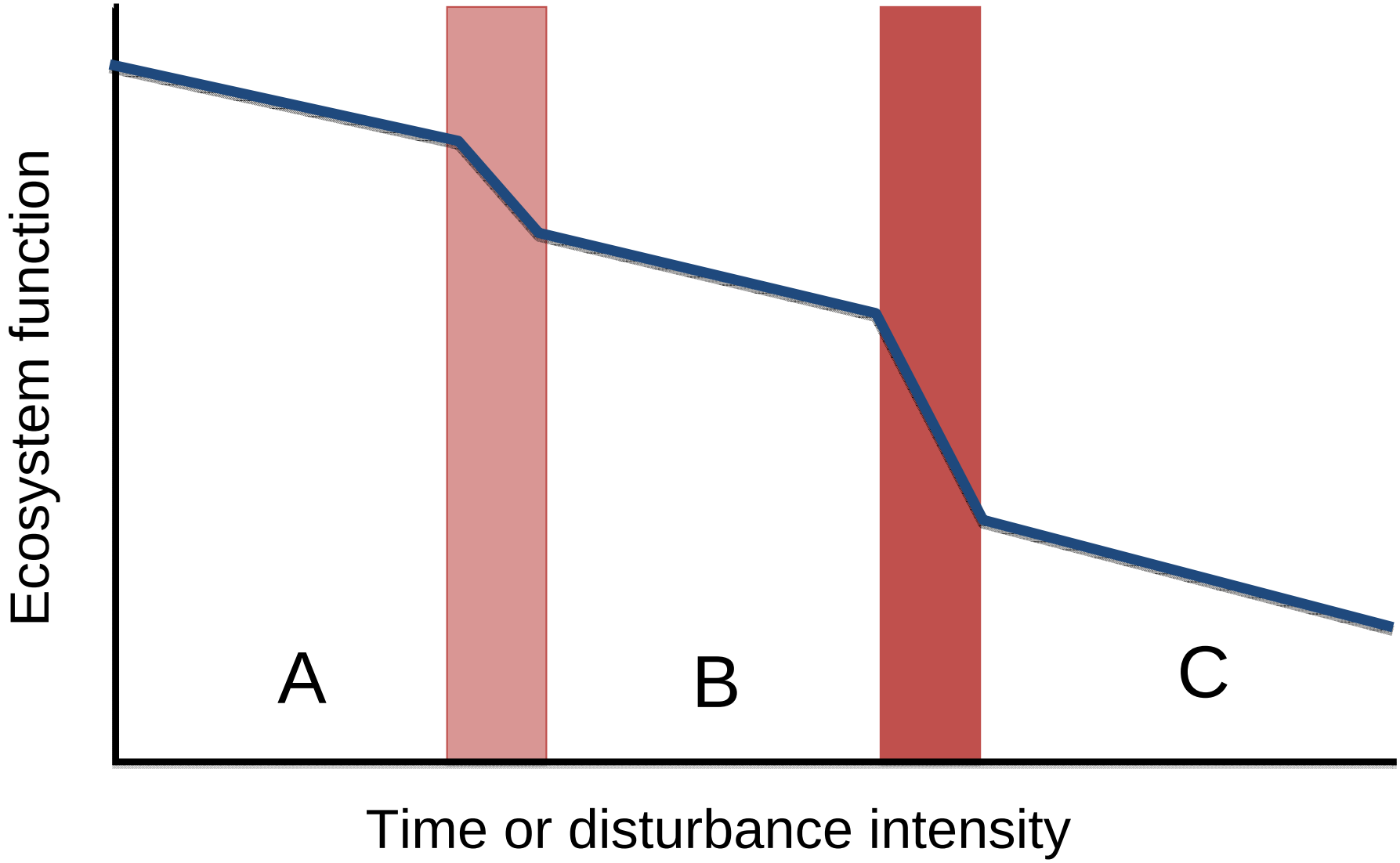

(a) Prolonged loss of plant cover and soil surface crusting
Decreased infiltration & increased runoff
Increased erosion (decreased nutrient and water retention)
Reduced soil water for plant growth
Deteriorating soil structure
Decreased soil biotic activity
Decreased plant production
Reduced fertility and soil organic matter
Decreased organic inputs to soil
Greater soil temperature extremes

Thresholds and alternative states

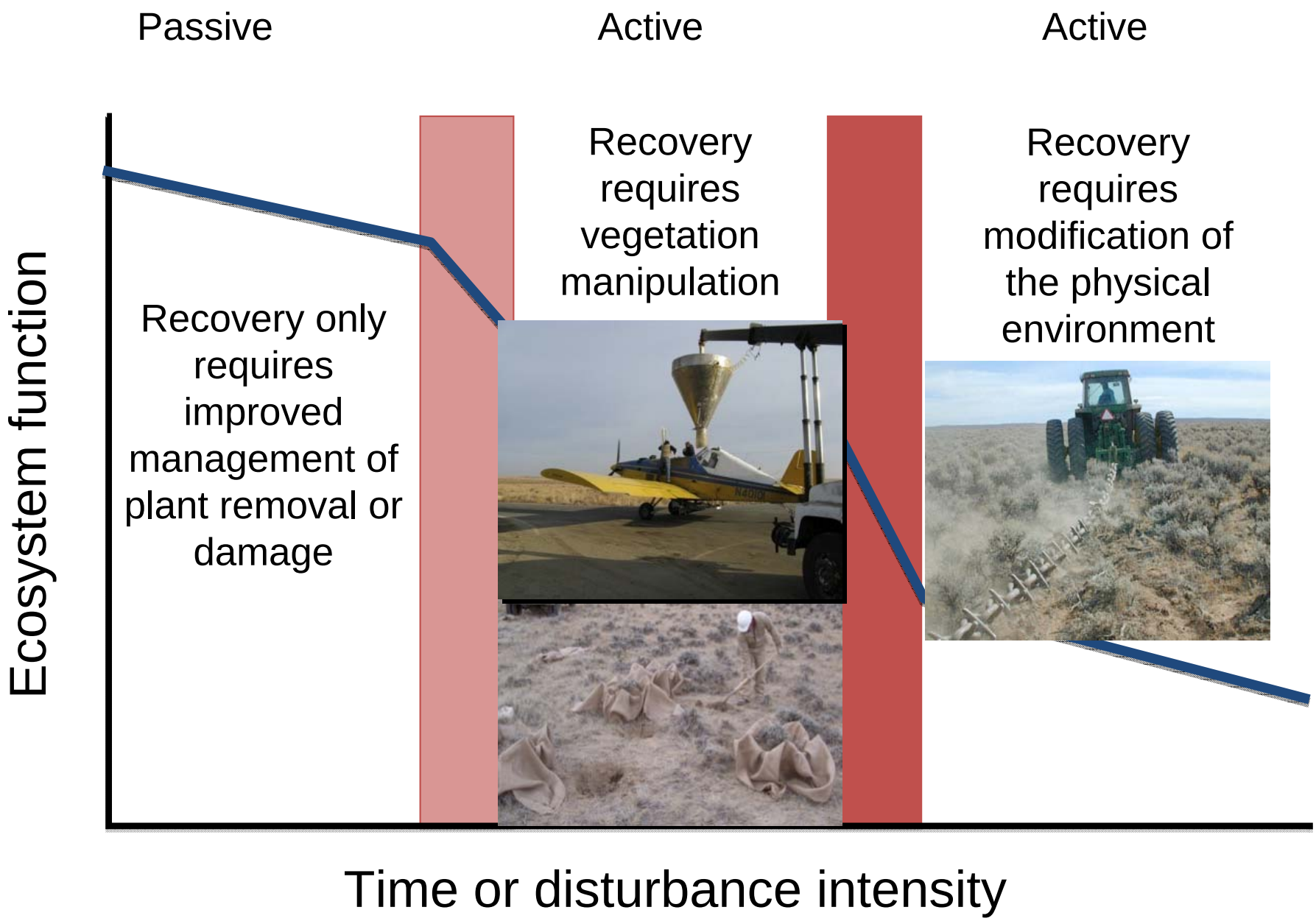



Transition threshold controlled by abiotic interactions
Ecosystem function
Time or disturbance intensity

Thresholds and alternative states



Passive vs. Active Restoration



Regional Case Study

- Arid Lands Ecology Reserve

- Large fires in 1986, 2000, and 2007

Sagebrush shrub-steppe

Source: INL

Cheatgrass-Fire Cycle

Vegetation response depends on elevation and history

- Earlier restoration is better! Before invasive species get a foothold
- Success of seeding may depend on precipitation
- Planting sagebrush isn't a viable possibility
  - If fires are not controlled!

What are the structural and functional aspects of these abiotic and biotic processes that may affect a restoration project's success or failure?

process	example	Structural	Functional
Plant – Plant relationships	Woody plants	-Intercept blowing particles -can lead to a decrease in fertility in inter-shrub areas which may affect other vegetation	- there is more moisture available from shading and roots pulling water from deeper levels. - litter increases nutrients available - they can be nurse plants.

Here are a few other examples I pulled out of the reading…

	Example	Structure	Function
Moisture	El Nino	Flush of resources	Response of multiple trophic levels
Plant - Soil	Loss of vegetation leads to erosion		
Intraspecific relationships	Planting density	Density affects # that survive, and their growth rate	Which plants can come into community; spread of disease, susceptibility to grazing
Interspecific relationships	Seed mix	Dependent on availability of resources for things with different requirements	How the combination of species modifies the site characteristics (eg, a legume vs. a shrub vs. a grass)
Plant-Animal	Microbes	Whether community is composed of beneficial or harmful	Can help seedlings in particular
	Dispersal		