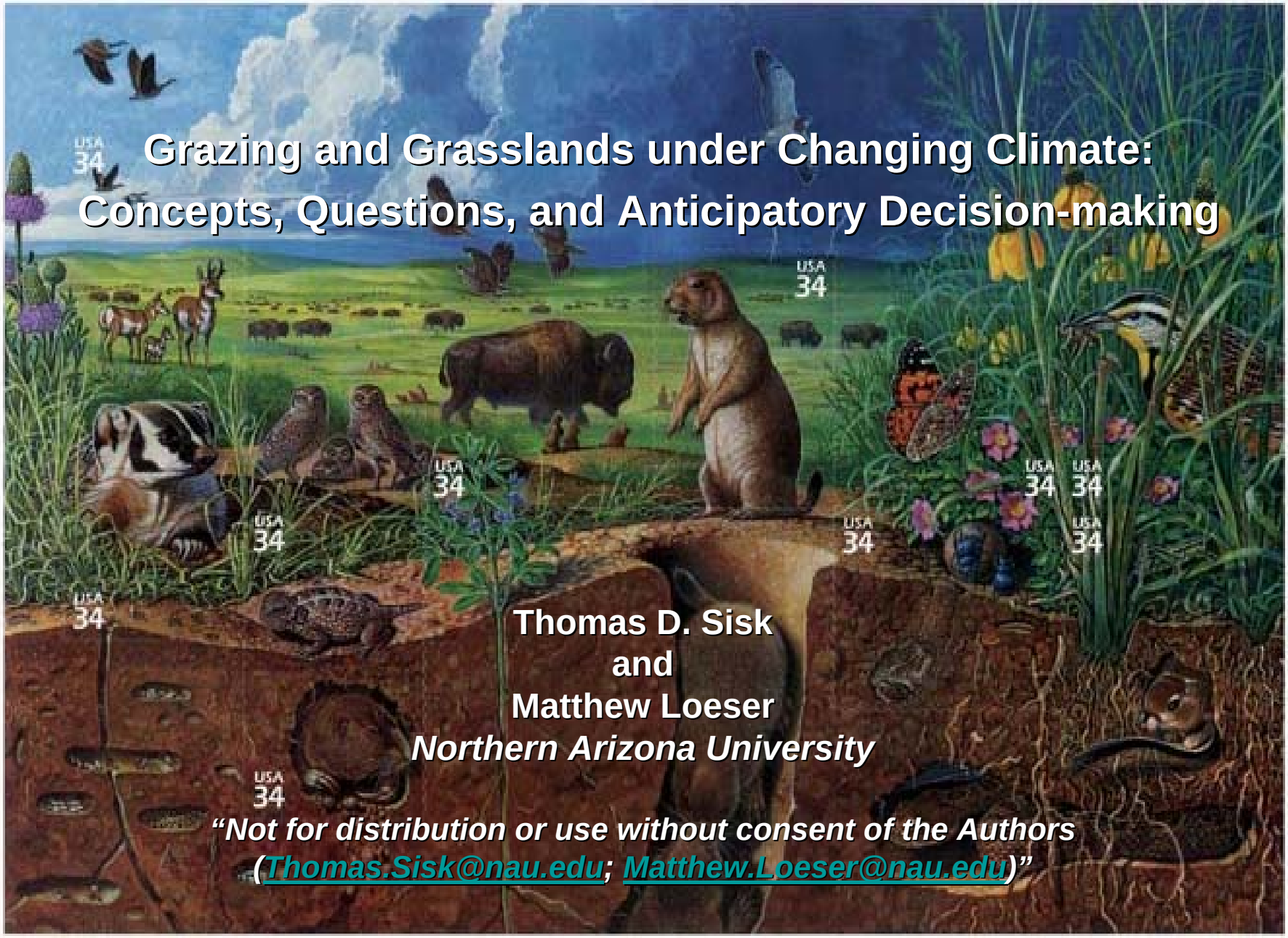


Grazing and Grasslands under Changing Climate: Concepts, Questions, and Anticipatory Decision-making

Thomas D. Sisk
and
Matthew Loeser
Northern Arizona University

(Thomas.Sisk@nau.edu; Matthew.Loeser@nau.edu)"

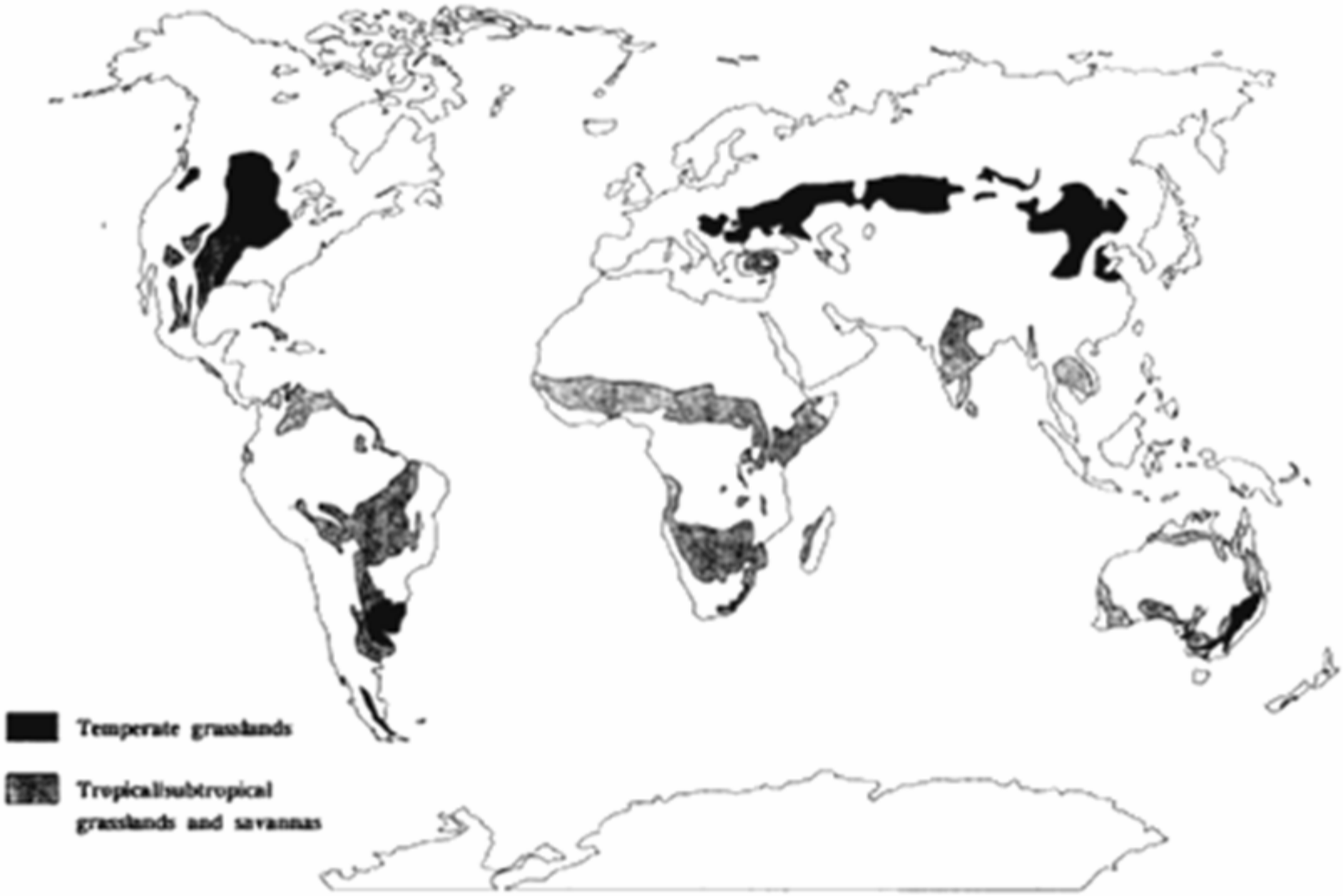
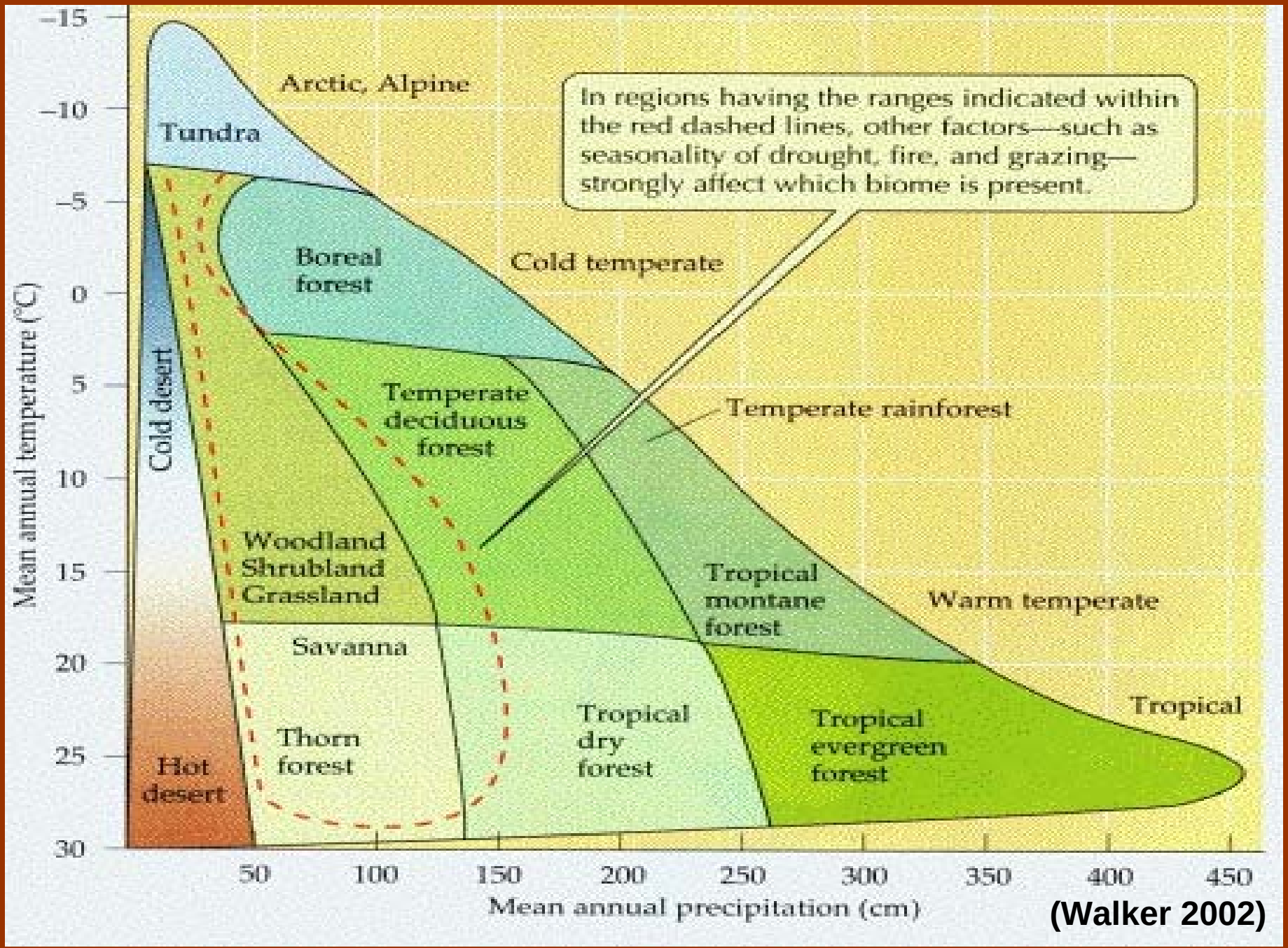
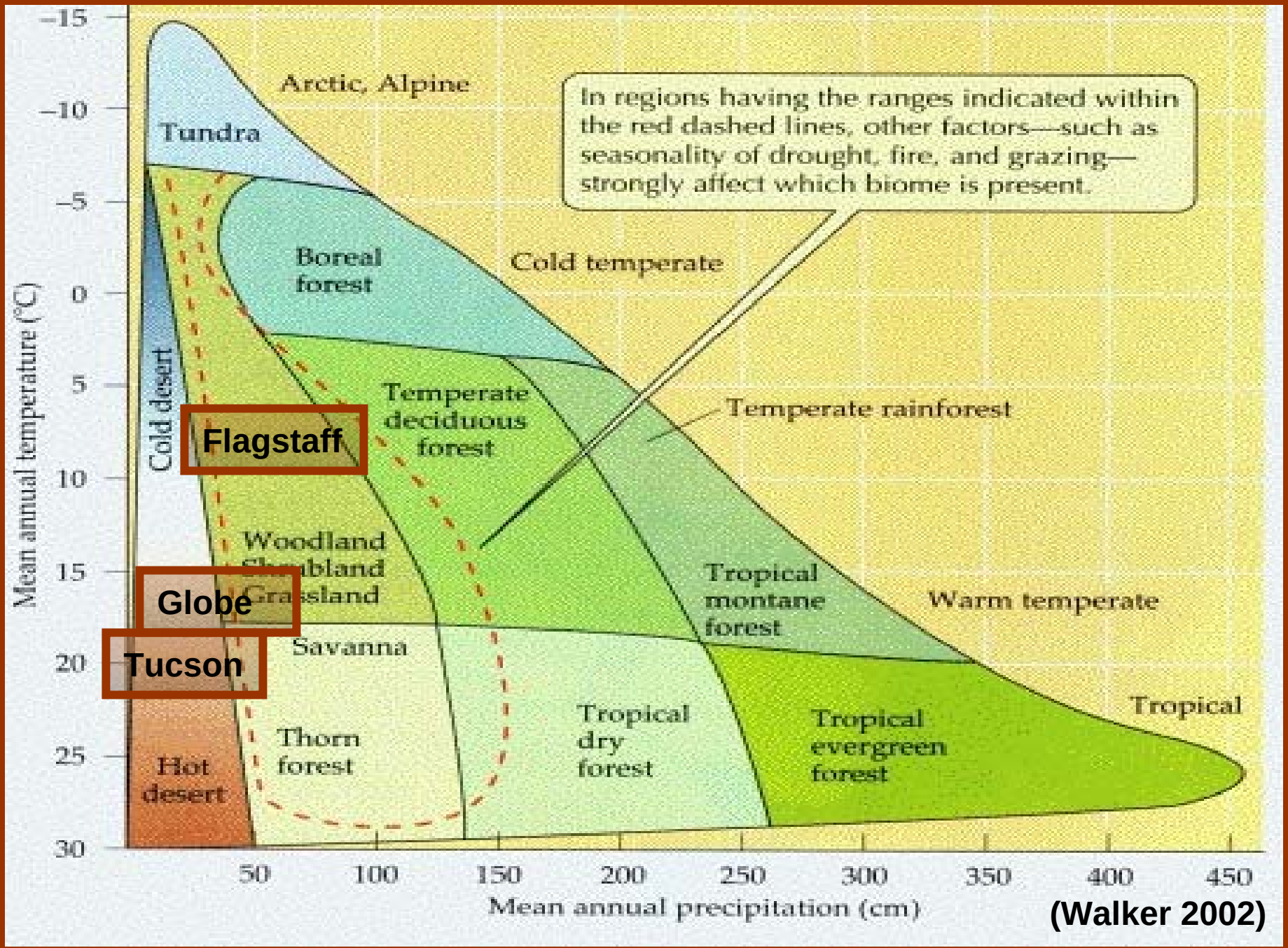


Figure 6.1 Map of the global distribution of temperate grasslands (adapted from Bailey 1989)


Arctic, Alpine
Tundra
In regions having the ranges indicated within the red dashed lines, other factors—such as seasonality of drought, fire, and grazing—strongly affect which biome is present.
Boreal forest
Cold temperate
Cold desert
Temperate deciduous forest
Temperate rainforest
Woodland Shrubland Grassland
Tropical montane forest
Warm temperate
Savanna
Tropical
Thorn forest
Tropical dry forest
Tropical evergreen forest
Hot desert
Mean annual temperature (°C)
−15
−10
−5
0
5
10
15
20
25
30
50
100
150
200
250
300
350
400
450
Mean annual precipitation (cm)

(Walker 2002)


Arctic, Alpine
Tundra
In regions having the ranges indicated within the red dashed lines, other factors—such as seasonality of drought, fire, and grazing—strongly affect which biome is present.
Boreal forest
Cold temperate
Cold desert
Flagstaff
Temperate deciduous forest
Temperate rainforest
Globe
Tucson
Woodland
Savanna
Tropical montane forest
Warm temperate
Tropical
Tropical dry forest
Tropical evergreen forest
Thorn forest
Hot desert
Mean annual temperature (°C)
−15
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0
5
10
15
20
25
30
50
100
150
200
250
300
350
400
450
Mean annual precipitation (cm)

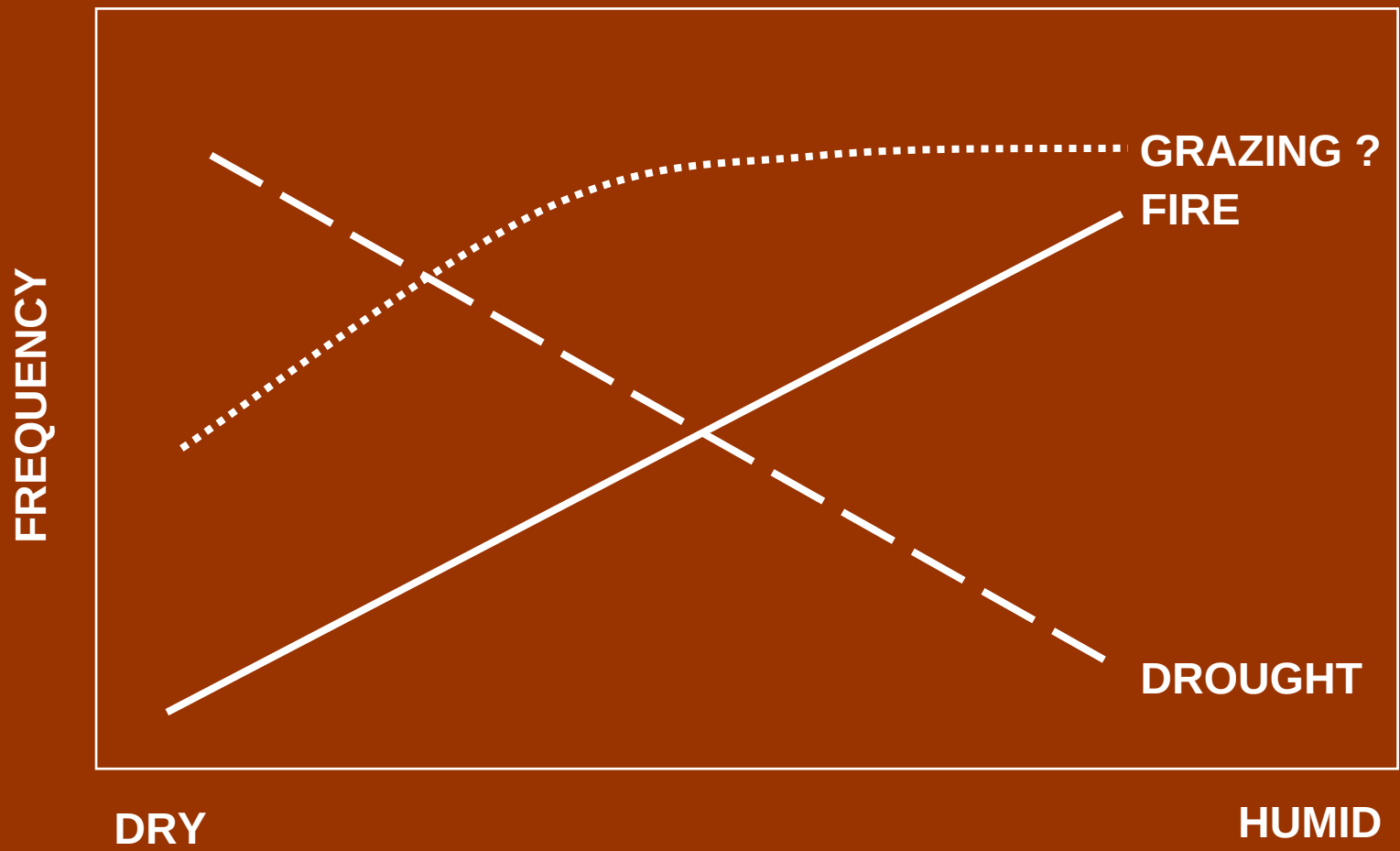
(Walker 2002)

3 Properties of Grassland Plant Communities

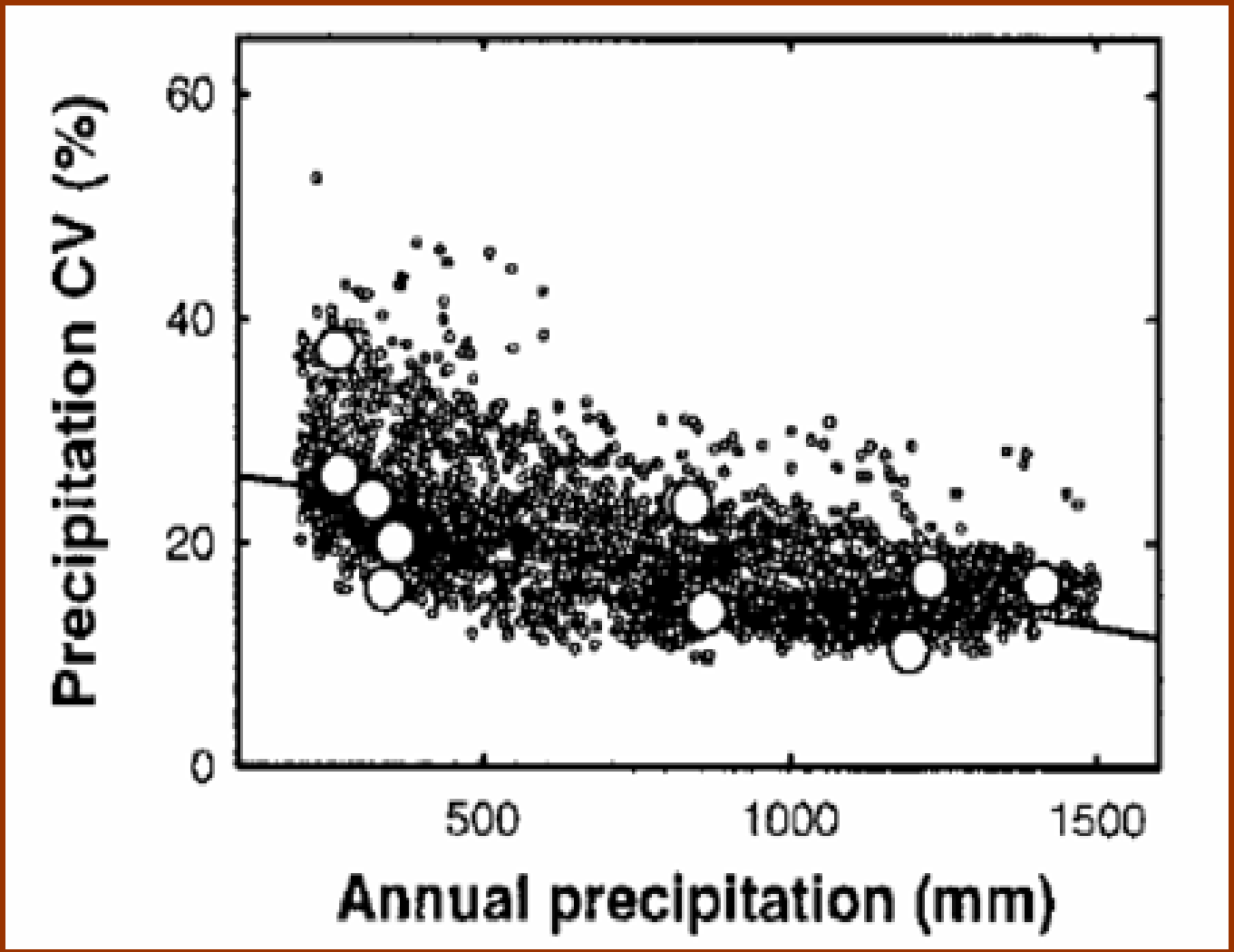
- High turnover of aboveground plant organs
- Location of meristems near the soil surface
- Large fraction of biomass and activity belowground

The results of selection pressures from drought, fire, and herbivores

Selection Pressures: Drought, Fire, Herbivores

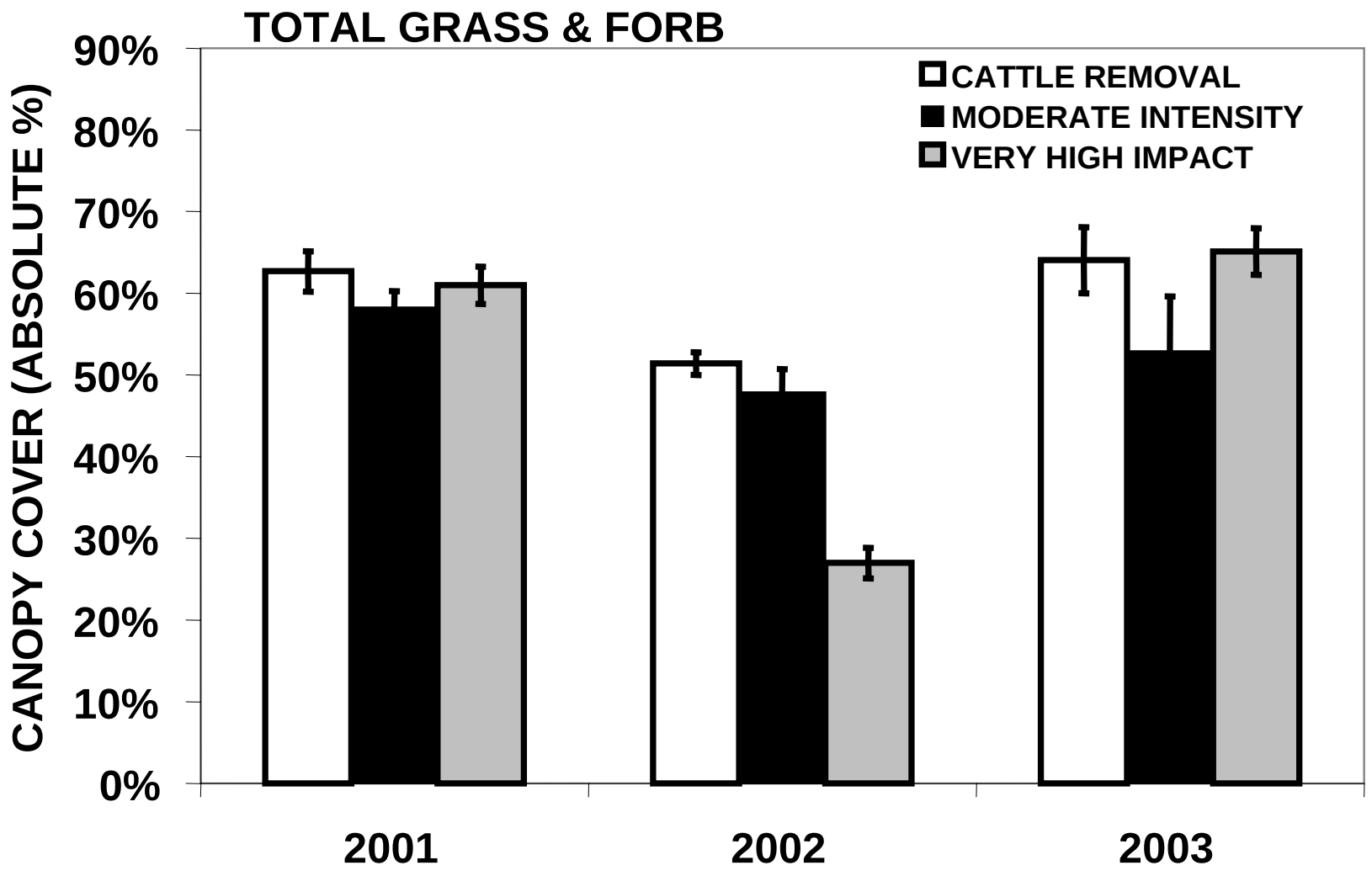


Climate Variation in Grasslands



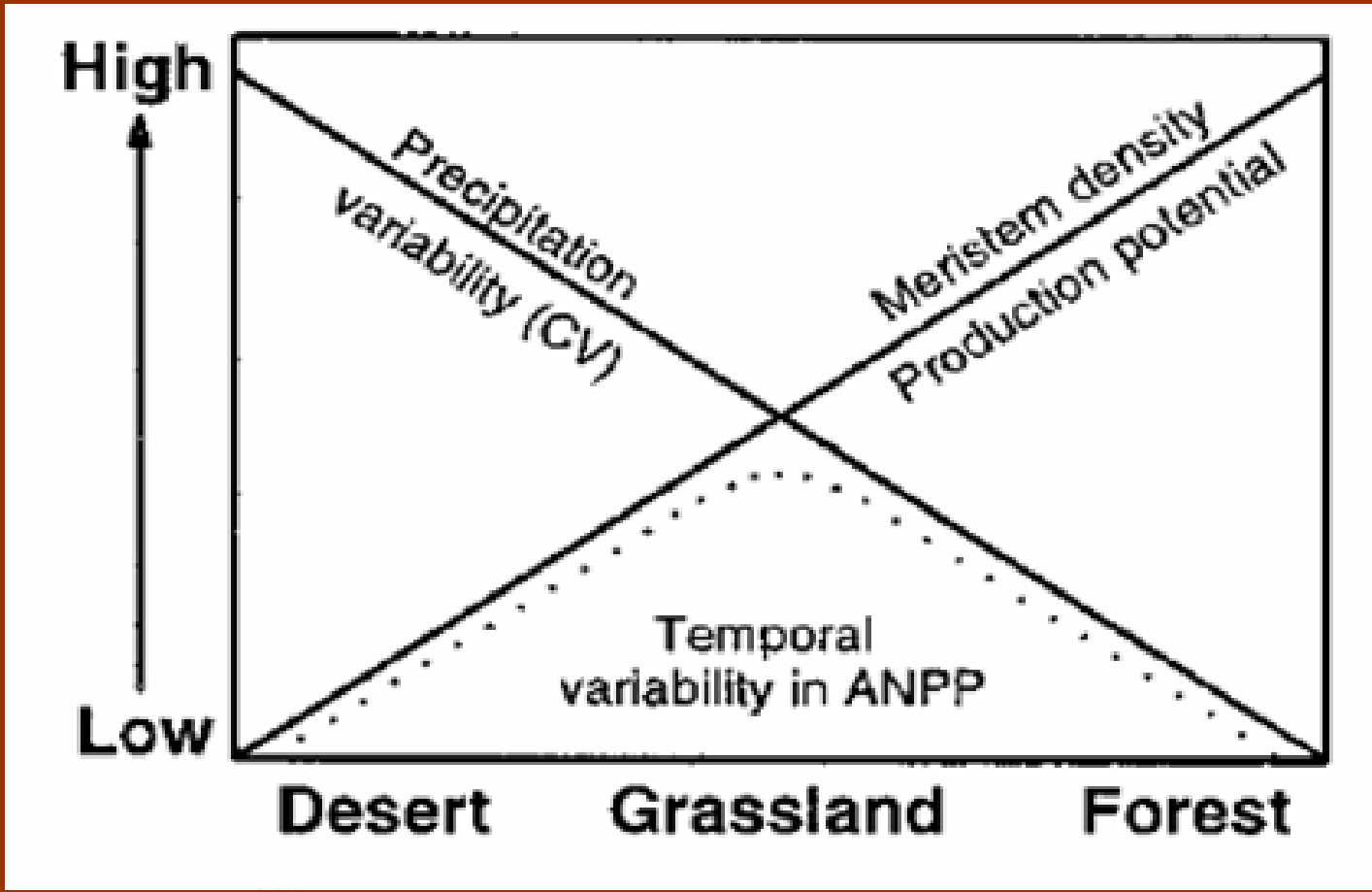
(Knapp and Smith 2001)

Climate / Grazing Interactions



(Loeser, unpubl. Data)

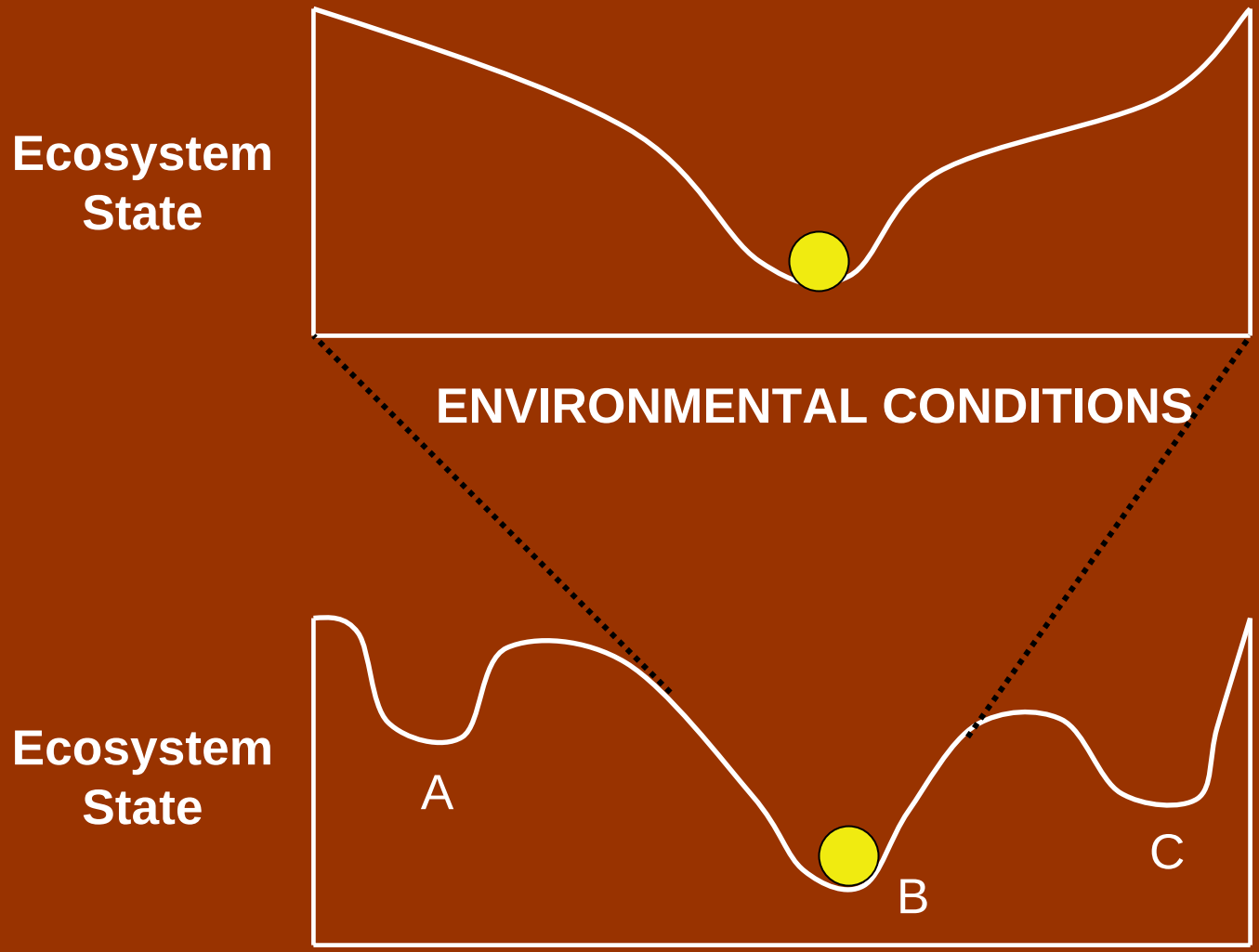
Variability in Grassland Productivity



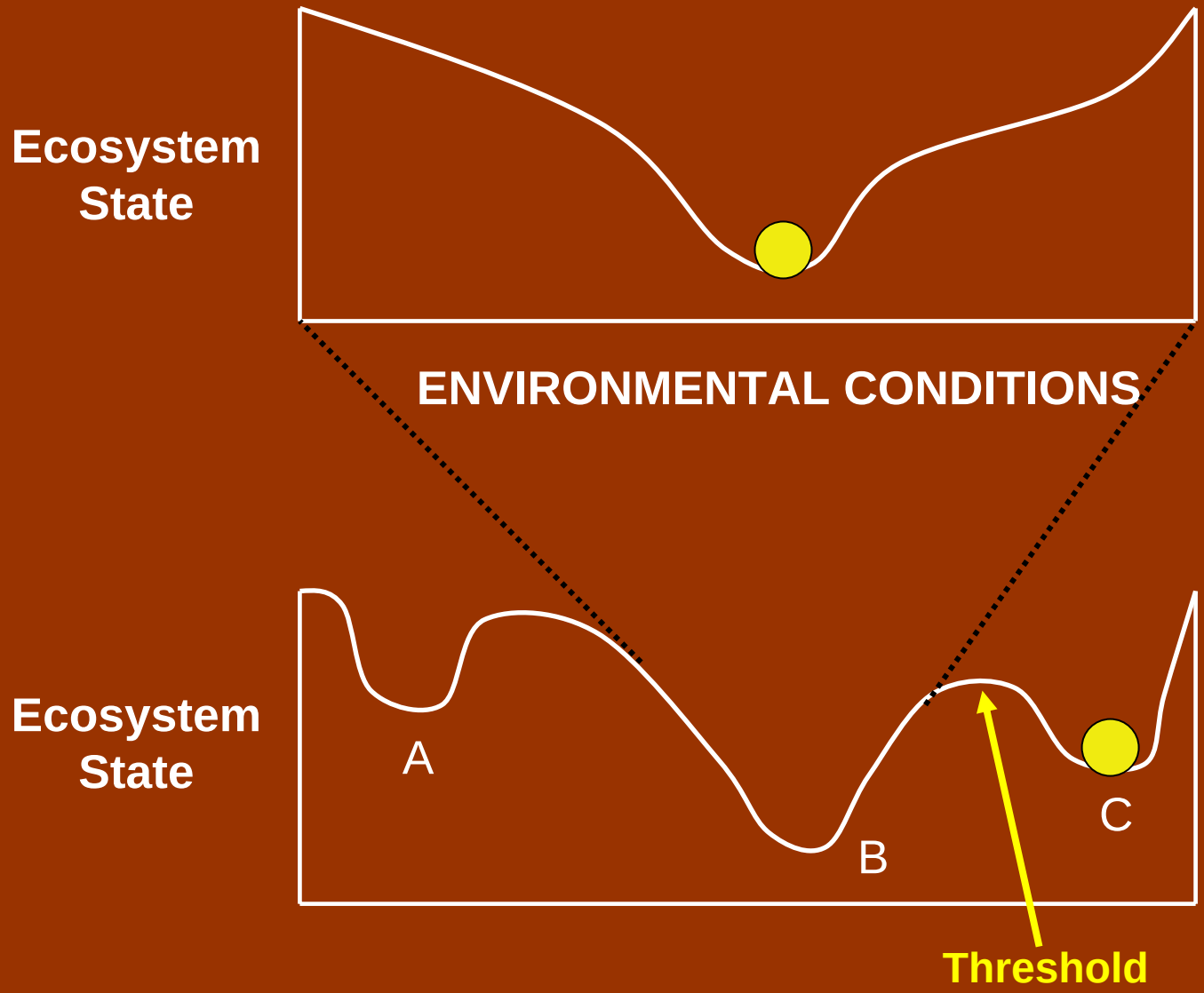
(Knapp and Smith 2001)

What are the thresholds that exceed the resilience (evolutionary history) of grasslands?

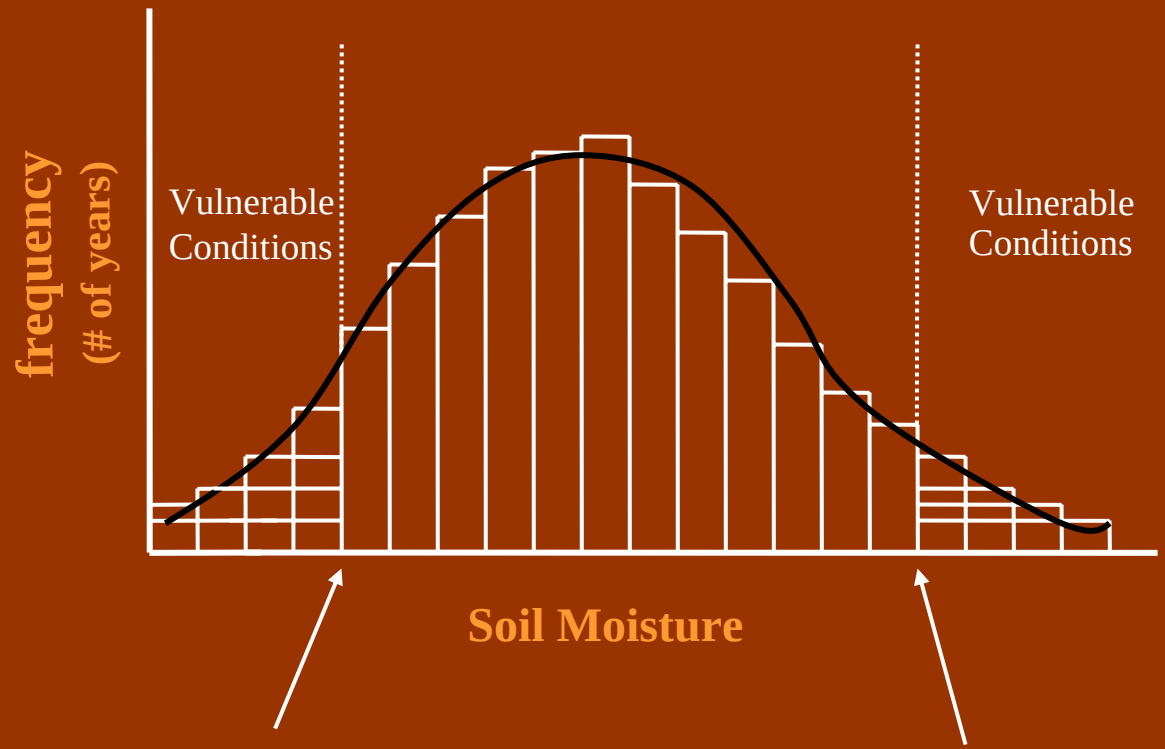
Thresholds, the Simple Version



Thresholds, the Simple Version



Thresholds and Vulnerability

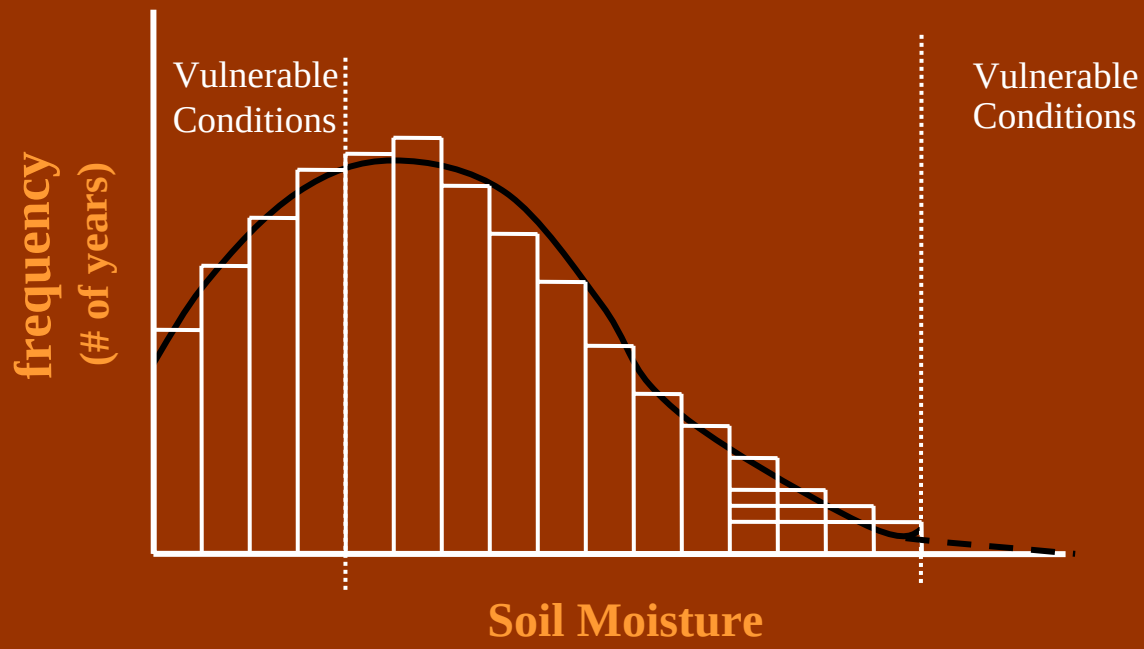


Threshold conditions:
Drought

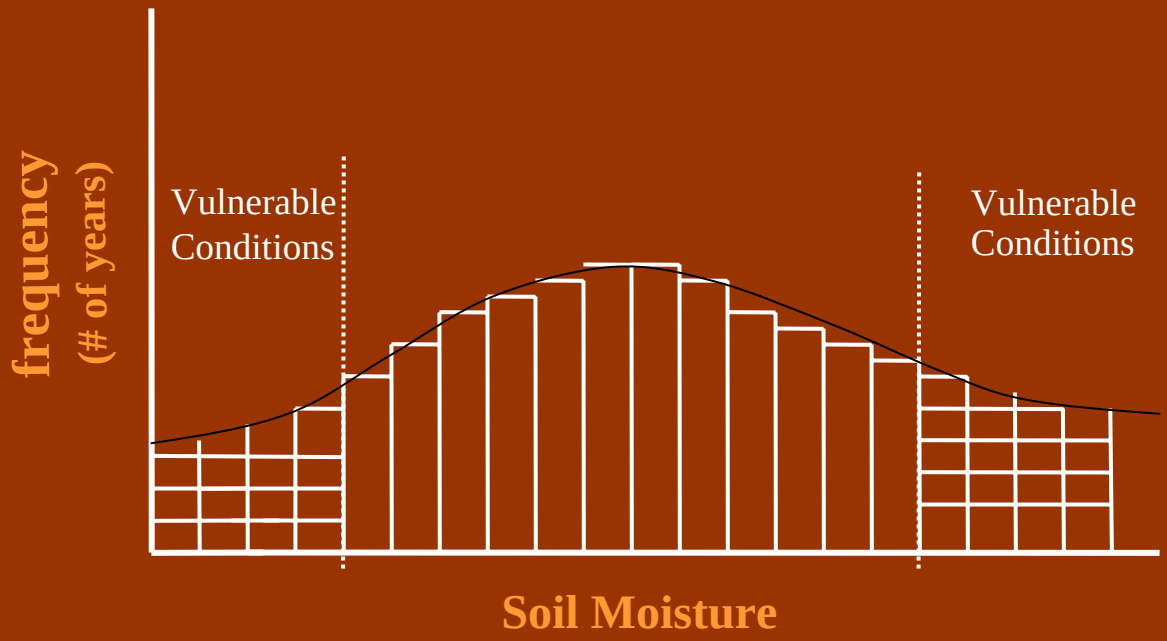
Unstable Equilibria

Threshold conditions:
Compaction/Erosion

Climate Change: One Hypothesis



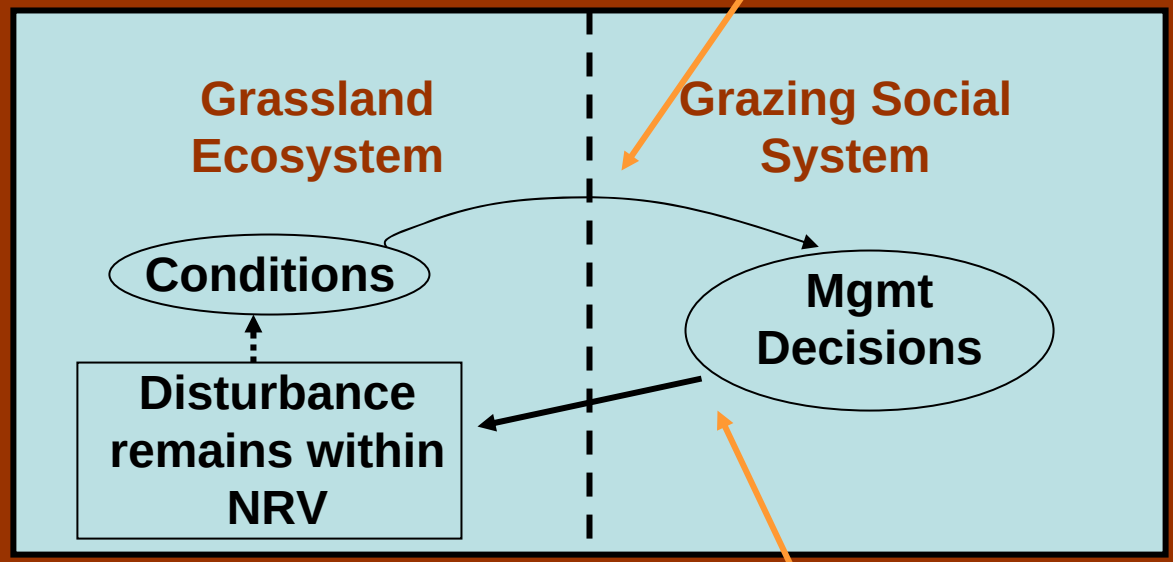
An Alternative Hypothesis:



Ecological & Social Dynamics Under Climate Change

Meeting management challenges

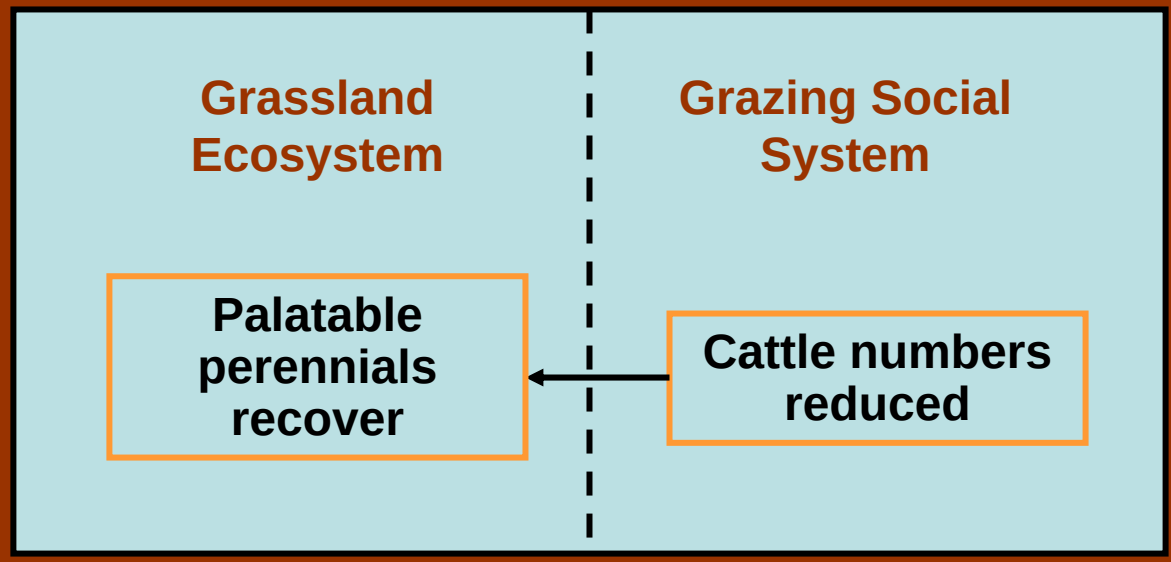
via monitoring



via “smart” decisions

Scenarios of Ecological & Social Dynamics Under Climate Change

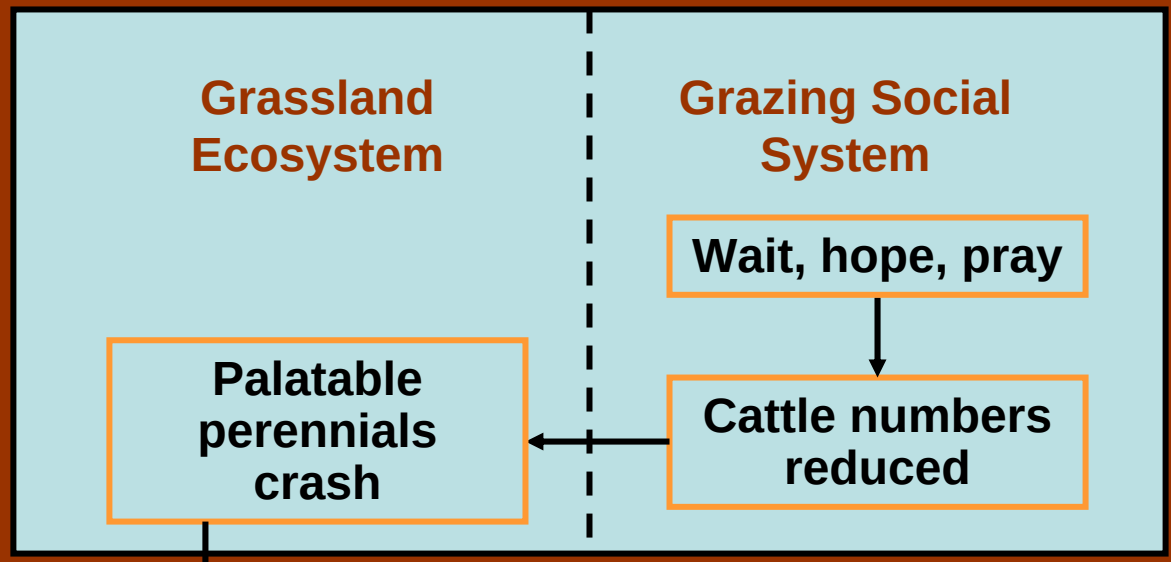
Grazing Under Drought Conditions:



"Just in time" Scenario

A More Likely Scenario…

Grazing Under Drought Conditions:



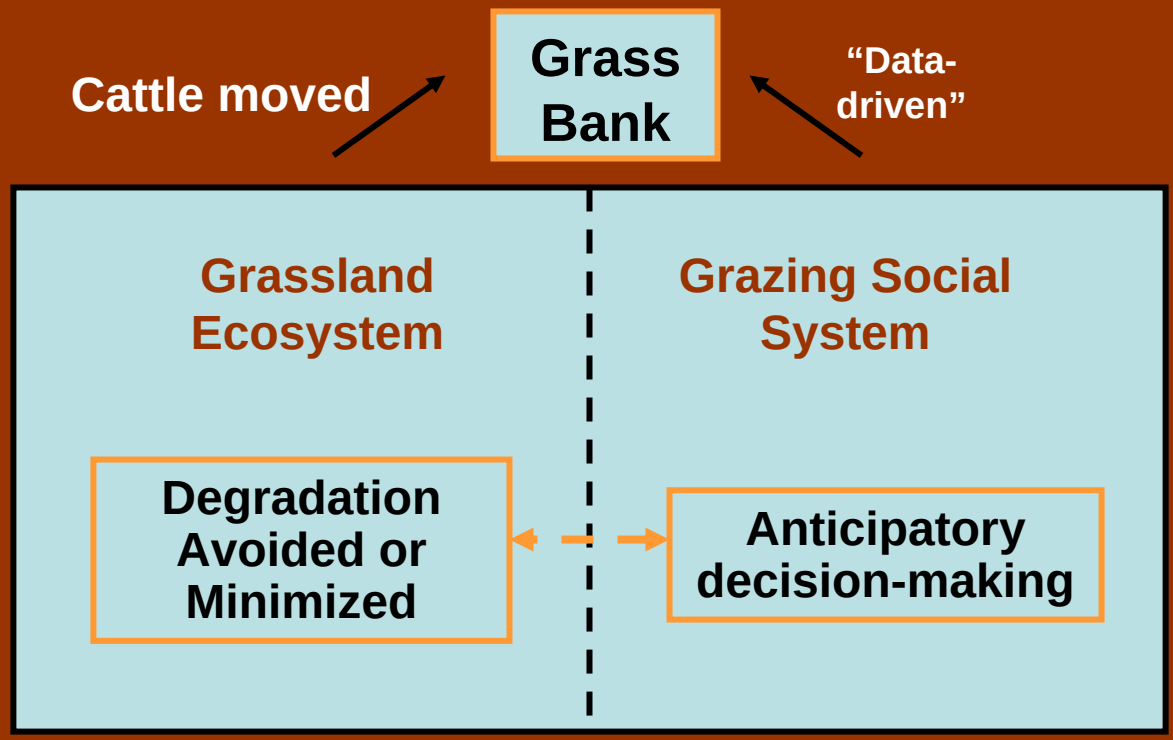
Threshold crossed = degradation

Annual grassland; shrub encroachment; barren land; etc.

"Too late"
Scenario

Progressive Scenario

Under Drought Conditions:

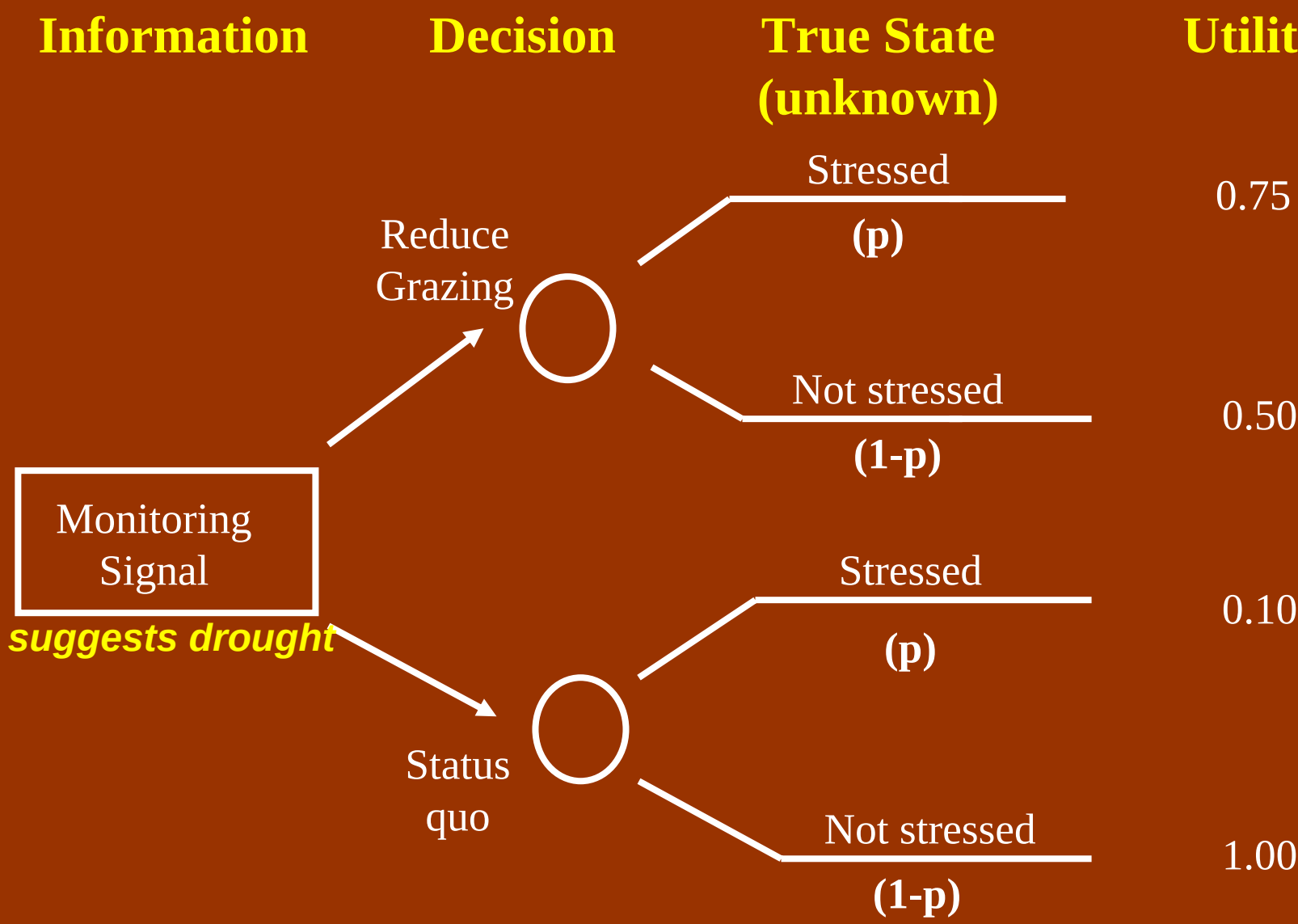


Requires monitoring and an adaptive decision framework…

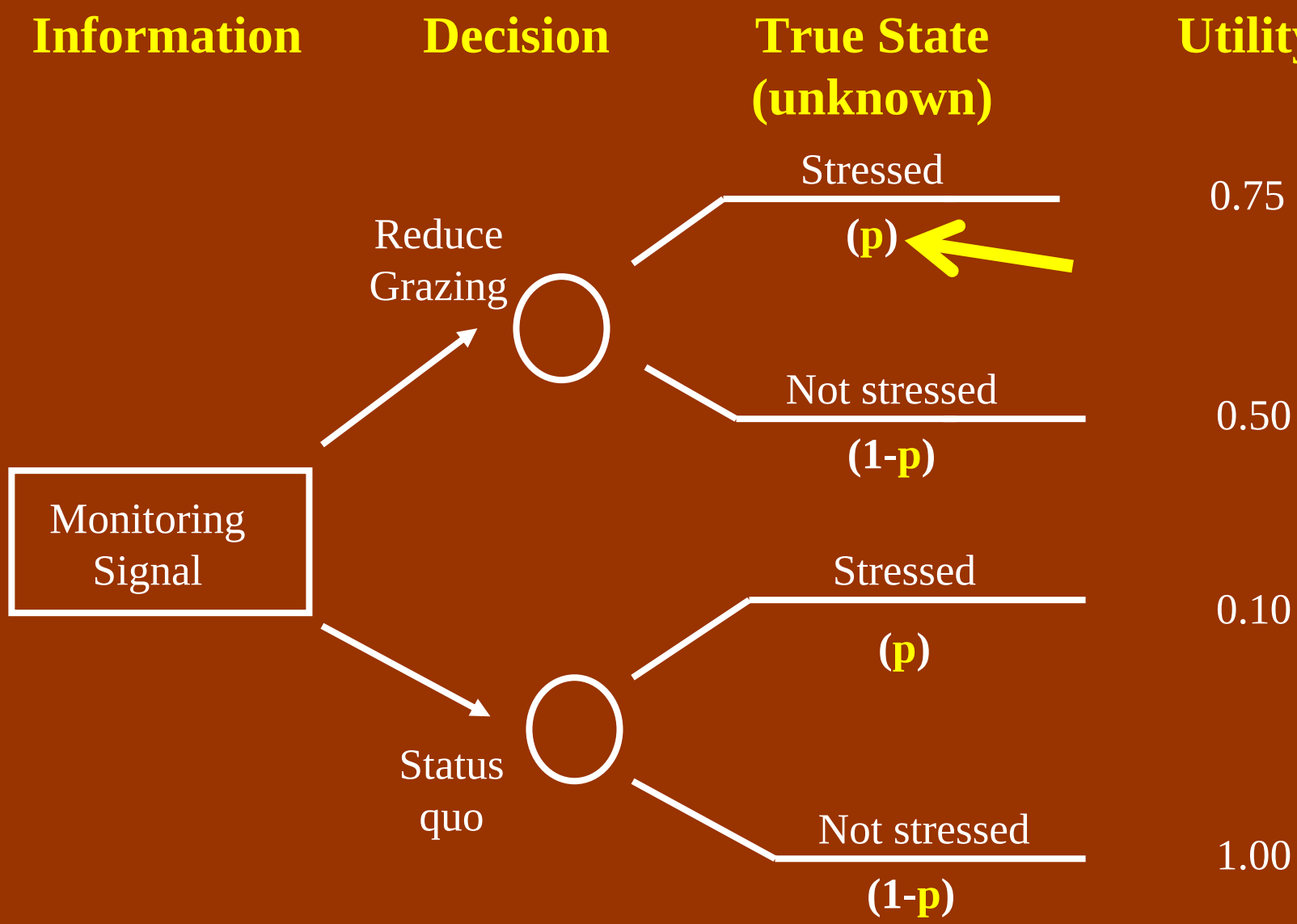
Smarter Decision-making

Making management decisions in the context of uncertain conditions and system responses

Decision Theory Framework



Decision Theory Framework




Keys Steps:
Anticipating Change
Understanding Thresholds
Acknowledging Ecological-Social Linkages
Appropriate Monitoring
Making Better Decisions Under Uncertainty

Questions – *1) Grass and Grasslands*

- How does the adaptation of grassland plants prepare them for environmental variability?
- Are grasslands plants more or less capable of coping with climate change?
- Grassland communities / ecosystems?
- What leads to vulnerability in grasslands?
- Ecological resiliency vs. resistance to change…
  - What are the trade-offs?
- What is the relationship between the frequencies of drought and fire?

Questions – *2) "Socio-ecology"*

- Almost all grasslands are directly coupled with human systems; implications?
- Social / ecological responses are complex; what are the feedbacks?
- What are the most likely drivers of catastrophic shifts in grassland composition, organization, and function?

Questions – *3) What's Important?*

What is the important science to be done?

- Studies of effects of cattle removal?
- Experiments on response to various climate conditions? Grazing intensities? Interactions?
- Development of informative and practical monitoring plans for early warning?
- Decision theory to better integrate social and ecological system dynamics?