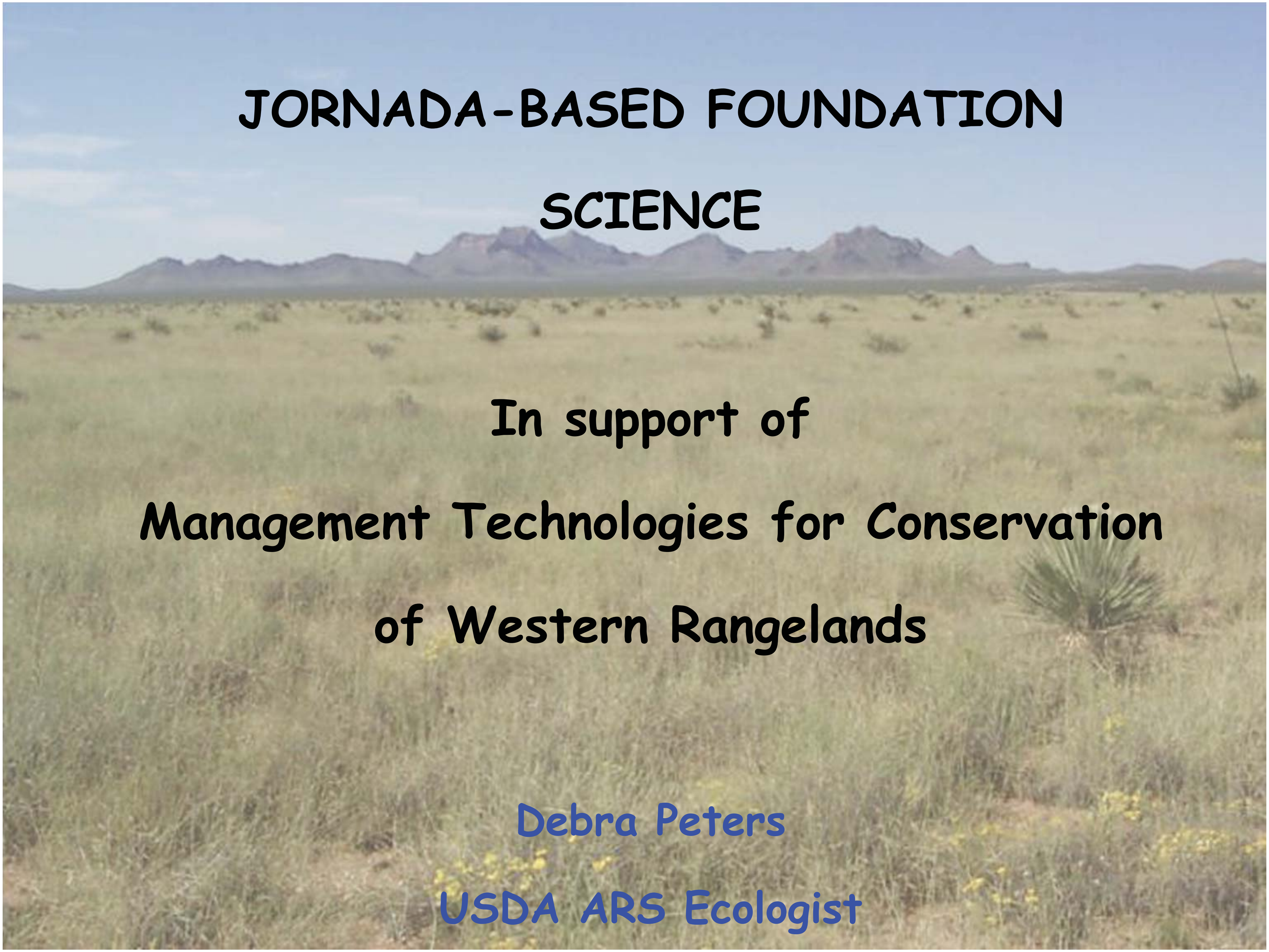


JORNADA-BASED FOUNDATION SCIENCE

In support of
Management Technologies for Conservation of Western Rangelands

Debra Peters

USDA ARS Ecologist

The **Jornada Experimental Range** was established in 1912.

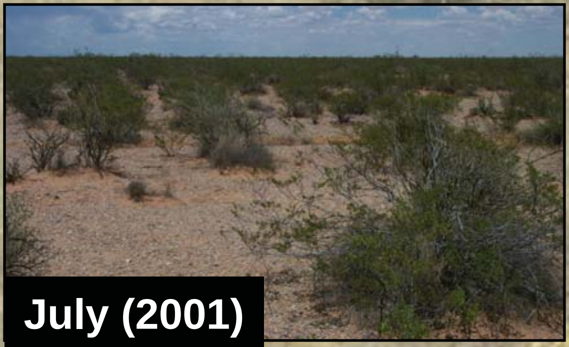
The 193,394 acre (78,266 ha) area was originally managed for two purposes:

1. **Livestock**
2. **Shrub control**

Early research focused on determining stocking rates and prescriptions for control of shrubs under low and variable rainfall (periodic drought).

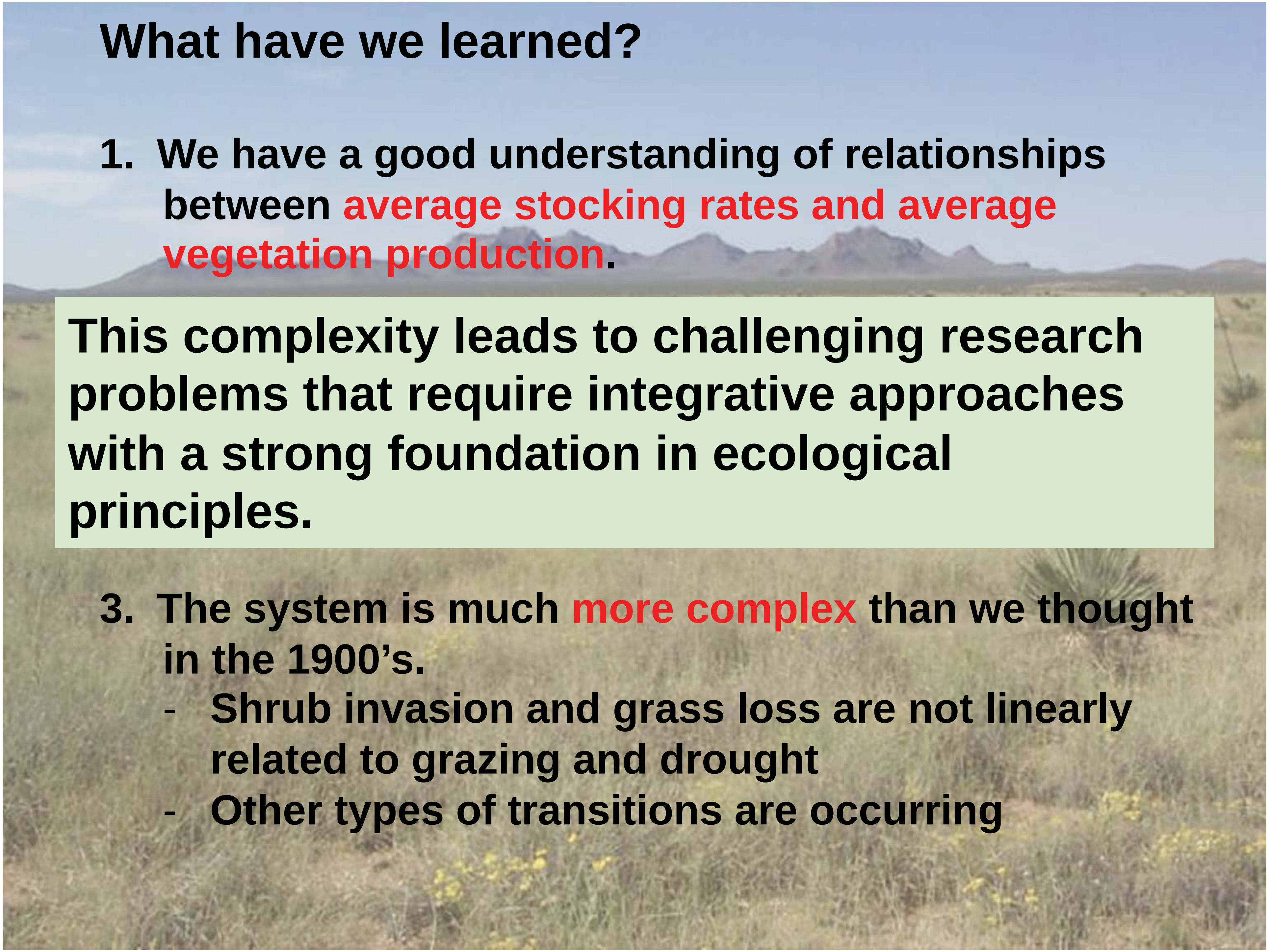
Early to mid-1900’s: mostly grasslands with many animals

April (1920)



July (2001)

At present: mostly shrublands with few animals



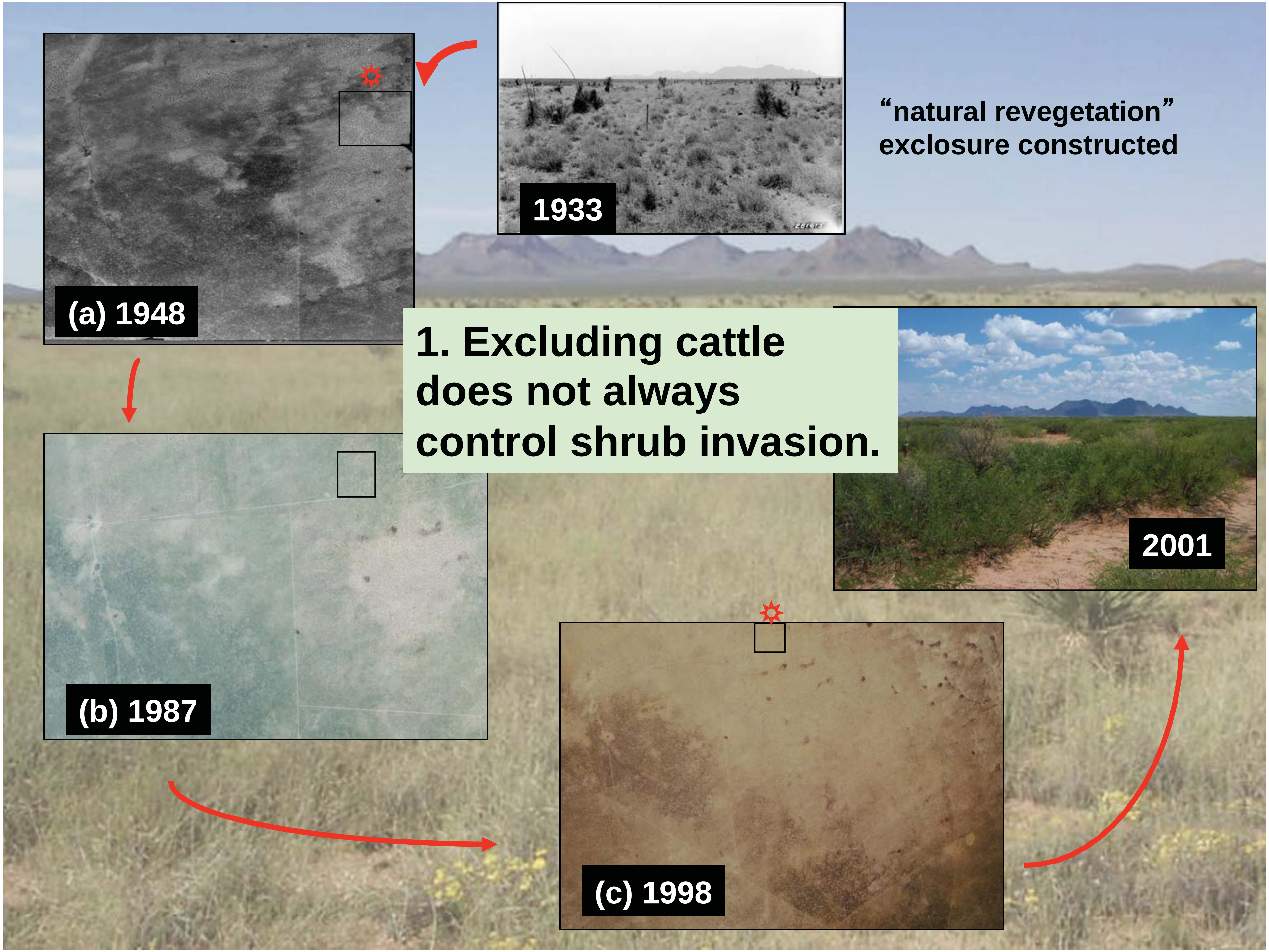
What have we learned?

1. We have a good understanding of relationships between average stocking rates and average vegetation production.

This complexity leads to challenging research problems that require integrative approaches with a strong foundation in ecological principles.

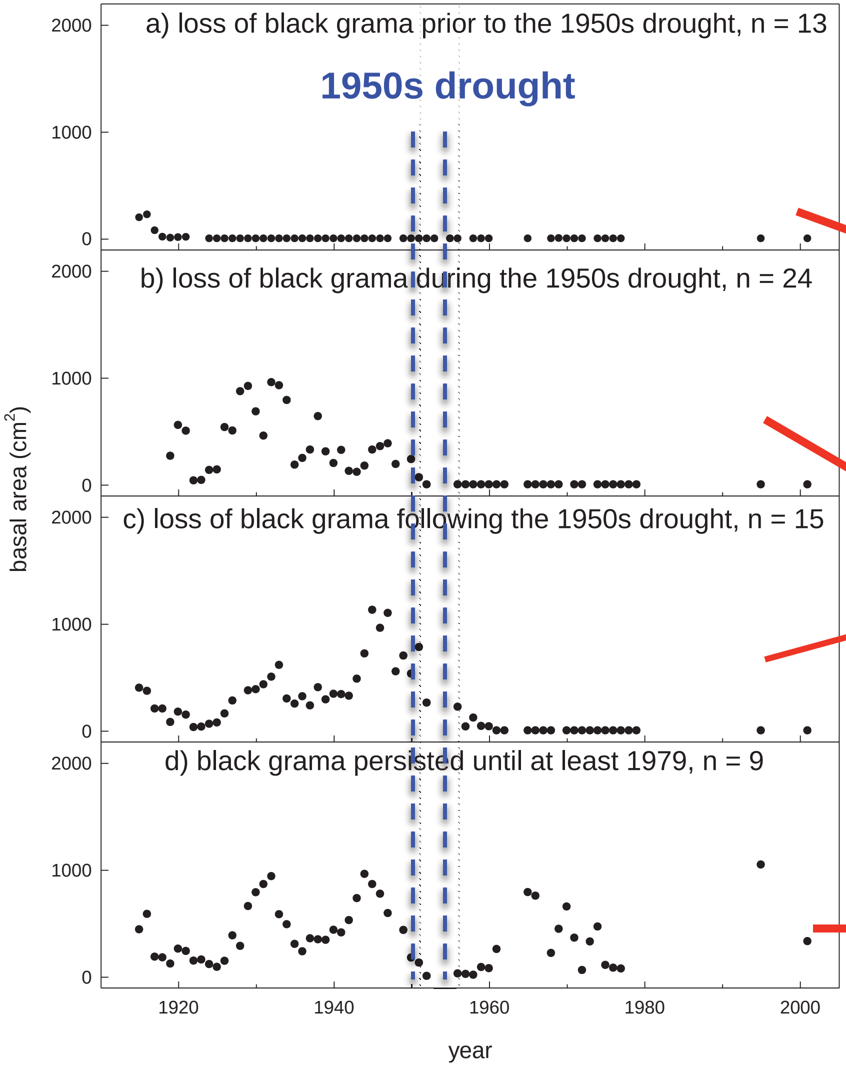
3. The system is much more complex than we thought in the 1900's.
   - Shrub invasion and grass loss are not linearly related to grazing and drought
   - Other types of transitions are occurring

1. Excluding cattle does not always control shrub invasion.

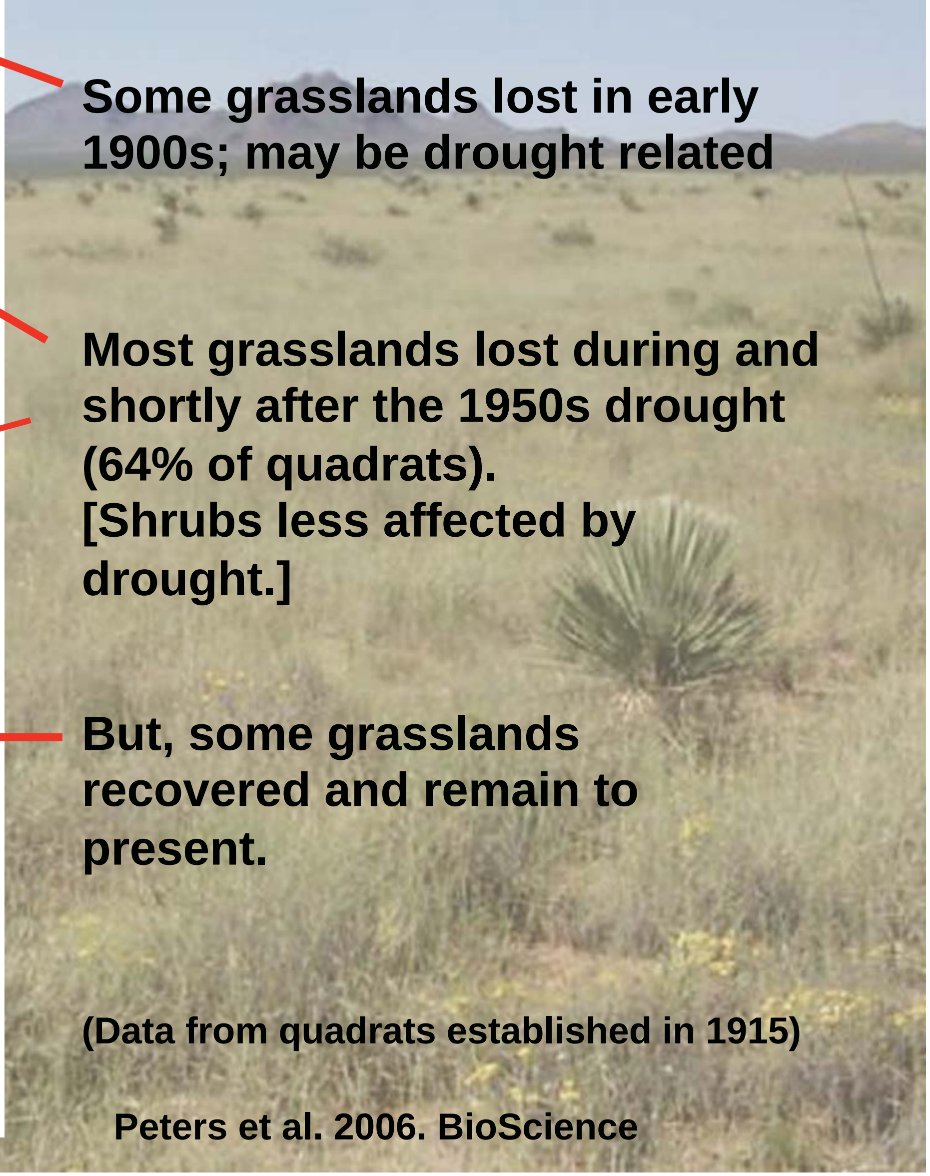


“natural revegetation”
exclosure constructed

2. Drought is important, but insufficient to explain all dynamics



Variation in black grama persistence among quadrats.
Examples of black grama loss prior to the 1950s drought (a), during the drought (b), following the drought (c), and persistent (d).



Some grasslands lost in early 1900s; may be drought related

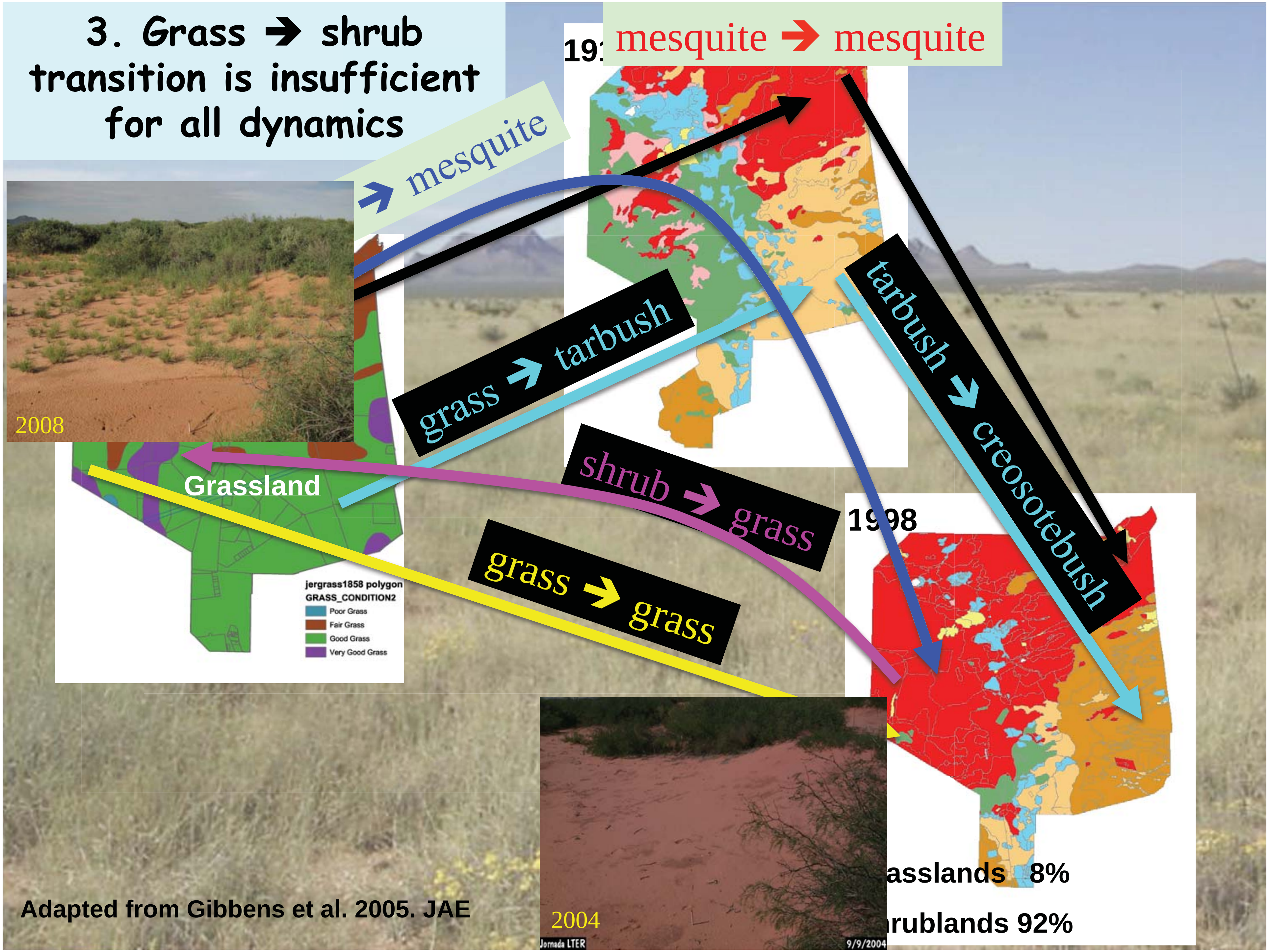
Most grasslands lost during and shortly after the 1950s drought (64% of quadrats).
[Shrubs less affected by drought.]

But, some grasslands recovered and remain to present.

(Data from quadrats established in 1915)

Peters et al. 2006. BioScience

3. Grass → shrub transition is insufficient for all dynamics



mesquite → mesquite

→ mesquite

grass → tarbush

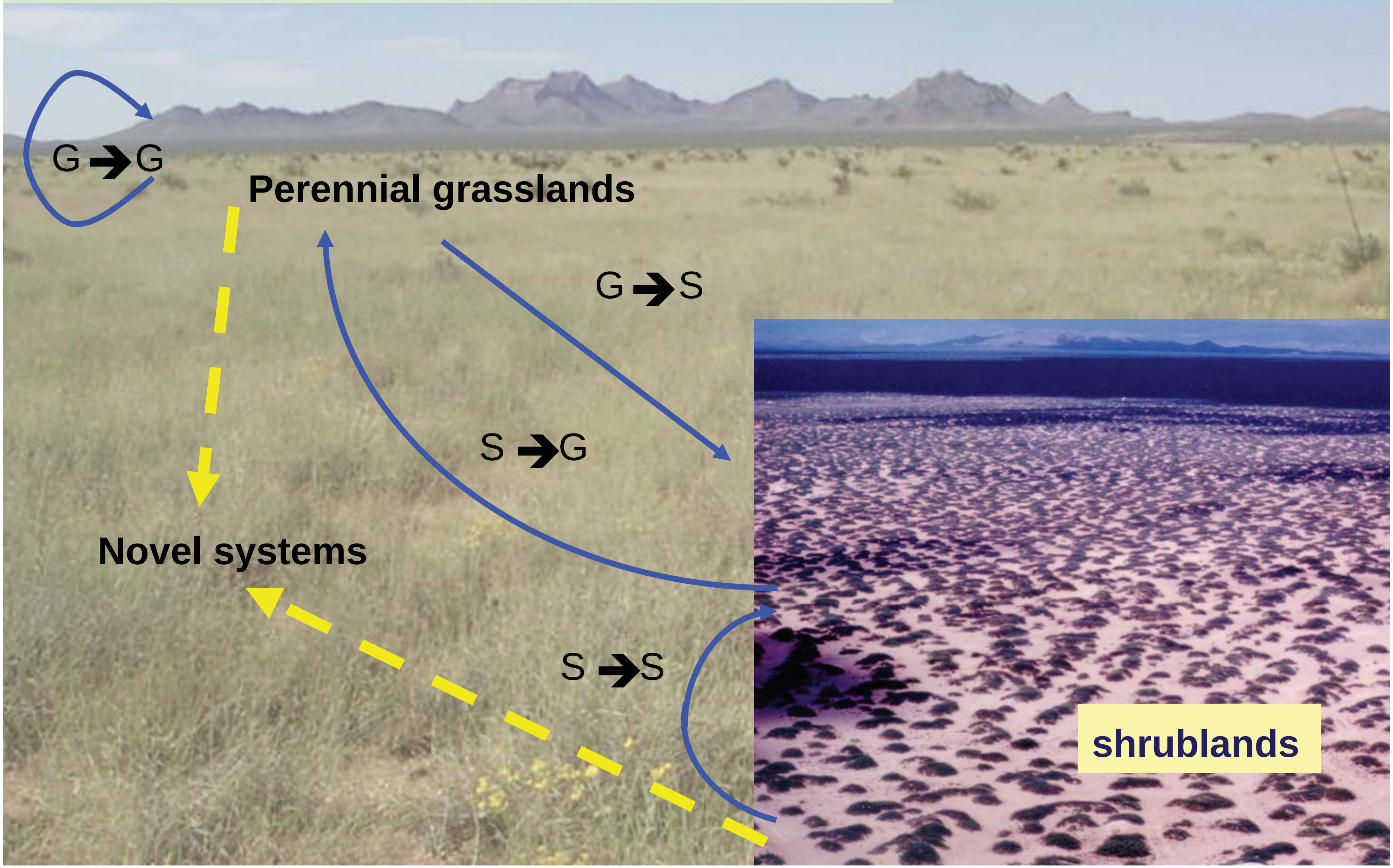
tarbush → creosotebush

shrub → grass

grass → grass

Adapted from Gibbens et al. 2005. JAE

Rangelands will continue to be dynamic in future -



G ➔ G

Perennial grasslands

G ➔ S

S ➔ G

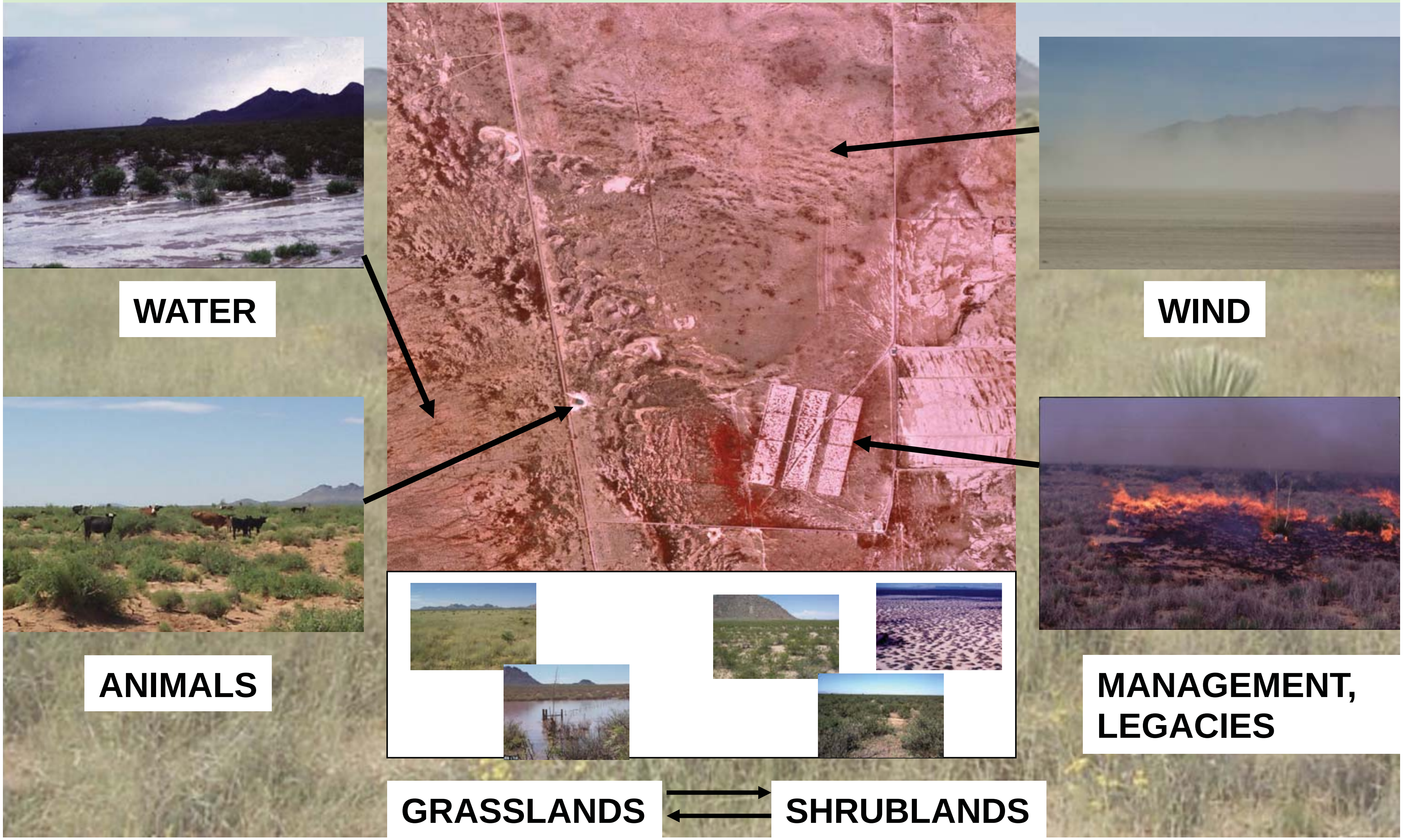
Novel systems

S ➔ S

shrublands

Sources of complexity in dynamics

SPATIAL CONTEXT: variation in abiotic drivers (climate, soils, geomorphology), biota (plants, animals, microbes), and management practices (past, current) interacting across scales



WATER

WIND

ANIMALS

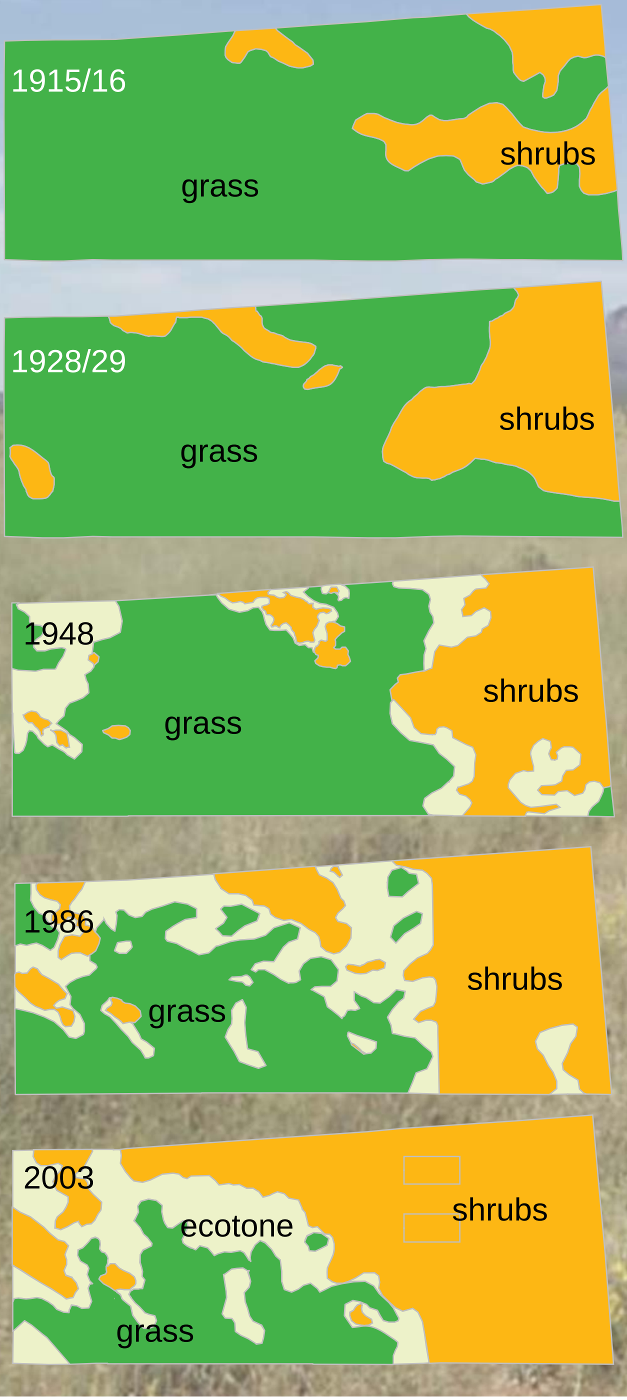
MANAGEMENT, LEGACIES

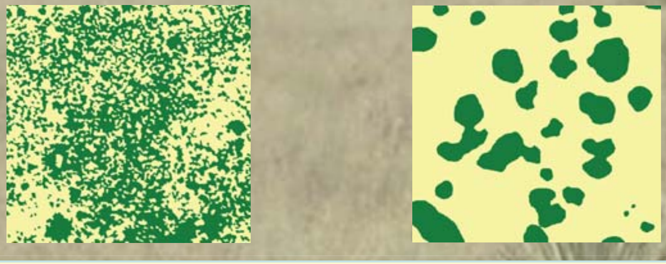
GRASSLANDS ⇄ **SHRUBLANDS**

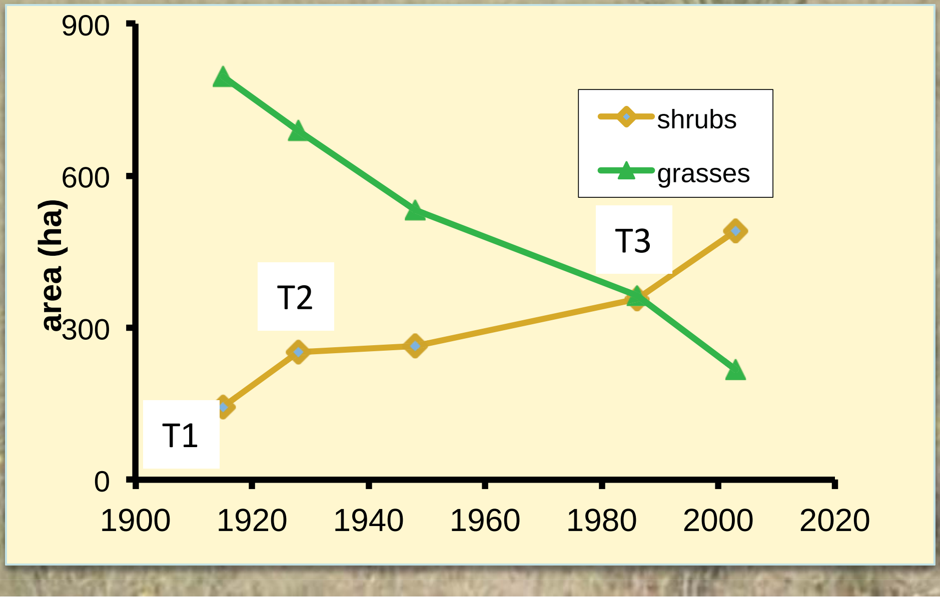
Sources of complexity in dynamics

TEMPORAL CONTEXT

- Threshold behavior (T1, T2, T3)
- Time lags
- Legacies
- Feedbacks

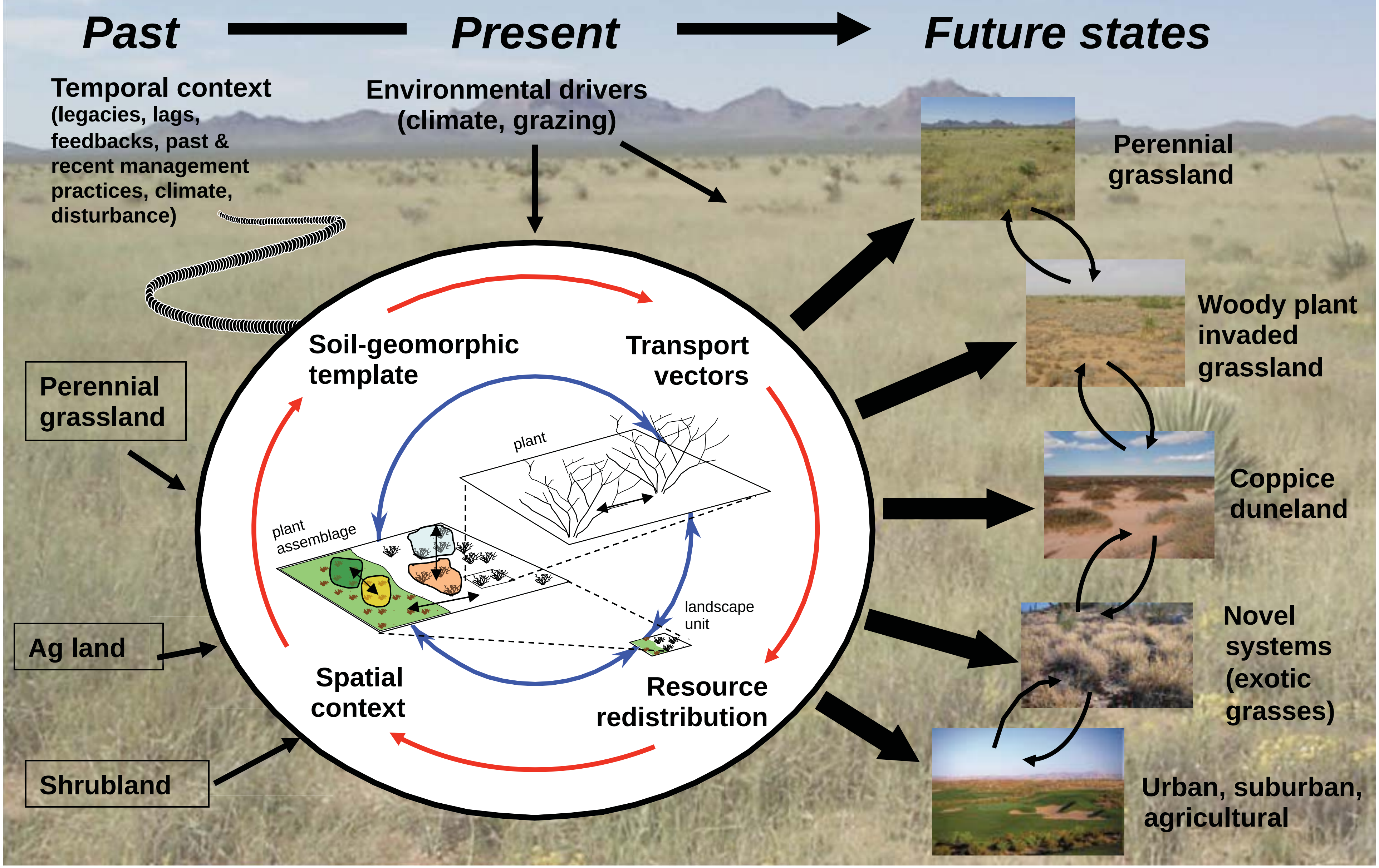






Jornada framework

(alternative states, multiple scales, spatial and temporal context)



Past — ***Present*** → ***Future states***

Temporal context
(legacies, lags, feedbacks, past & recent management practices, climate, disturbance)

Environmental drivers
(climate, grazing)

Perennial grassland

Ag land

Shrubland

Soil-geomorphic template

Transport vectors

Spatial context

Resource redistribution

Perennial grassland

Woody plant invaded grassland

Coppice duneland

Novel systems (exotic grasses)

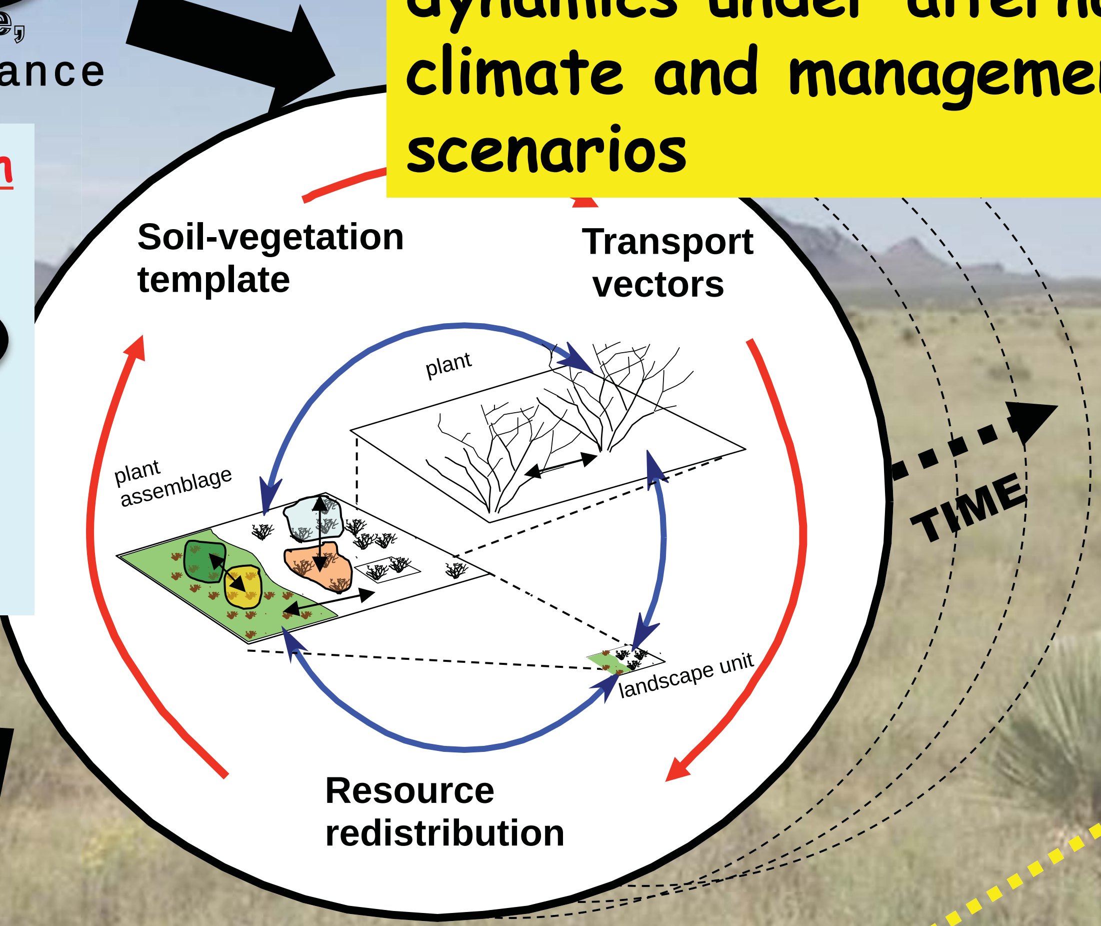
Urban, suburban, agricultural

Climate,
landuse,
disturbance

in order to predict future dynamics under alternative climate and management scenarios

Multi-faceted approach

- New experimental and observational data
- Syntheses of historic, long-term data
- Landscape models with regional applications
- Technologies and knowledge bases



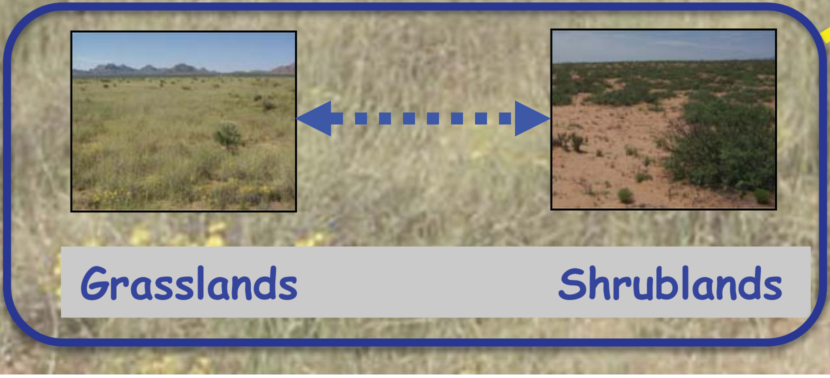
Soil-vegetation template

Transport vectors

Resource redistribution

TIME

Historic drivers
(grazing, drought)

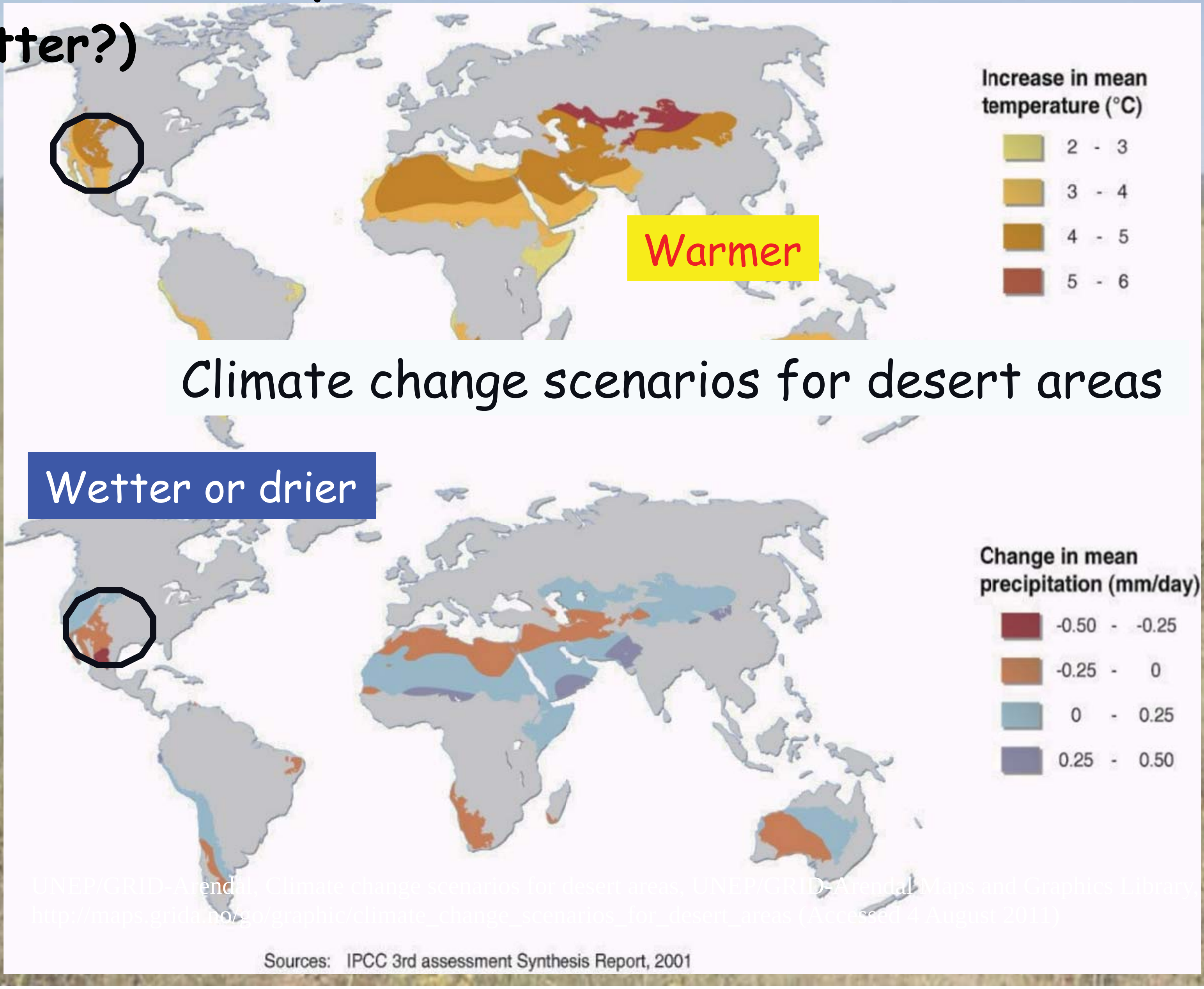


Grasslands

Shrublands

???

Future climate scenarios: warmer and either drier or wetter (drier – expect more shrubs but what if our future is wetter?)



Warmer

Climate change scenarios for desert areas

Wetter or drier

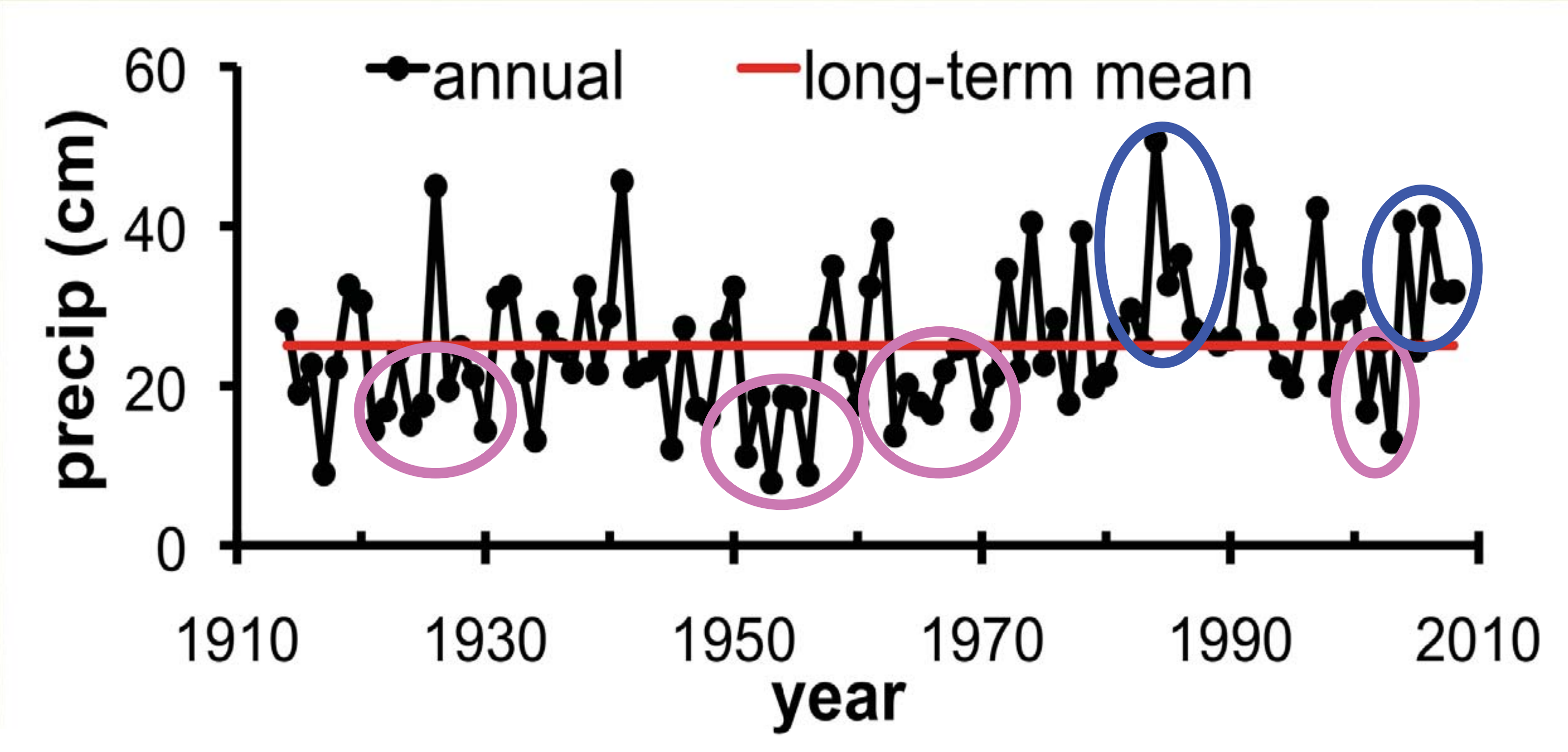
UNEP/GRID-Arendal, Climate change scenarios for desert areas, UNEP/GRID-Arendal Maps and Graphics Library, http://maps.grida.no/go/graphic/climate_change_scenarios_for_desert_areas (Accessed 4 August 2011)

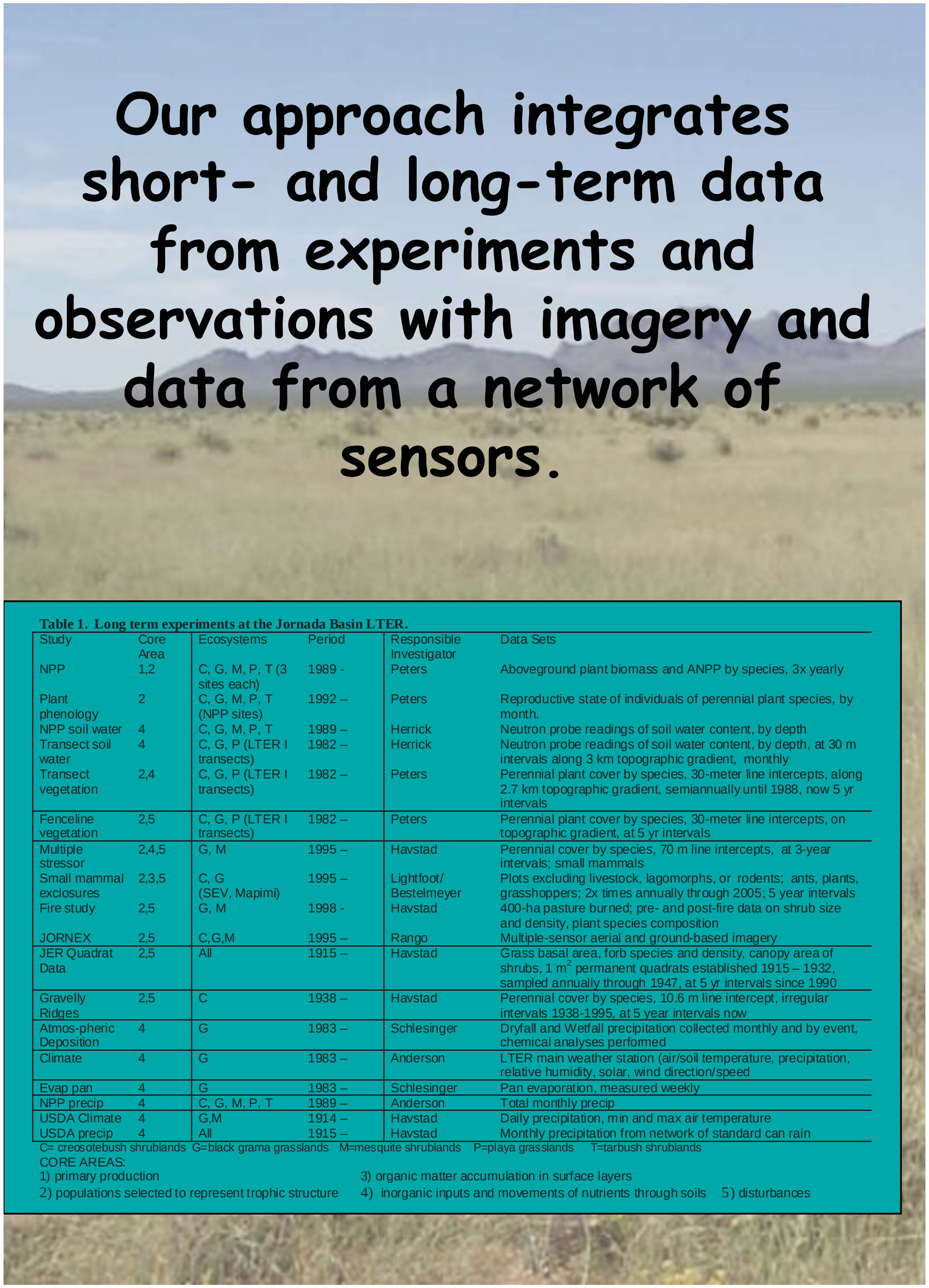
Sources: IPCC 3rd assessment Synthesis Report, 2001

Historic rainfall shows drought cycles and sequences of wet years

Use historic data in dry, average, and wet periods as insight to future dynamics

Focus on both patterns and processes





Our approach integrates short- and long-term data from experiments and observations with imagery and data from a network of sensors.

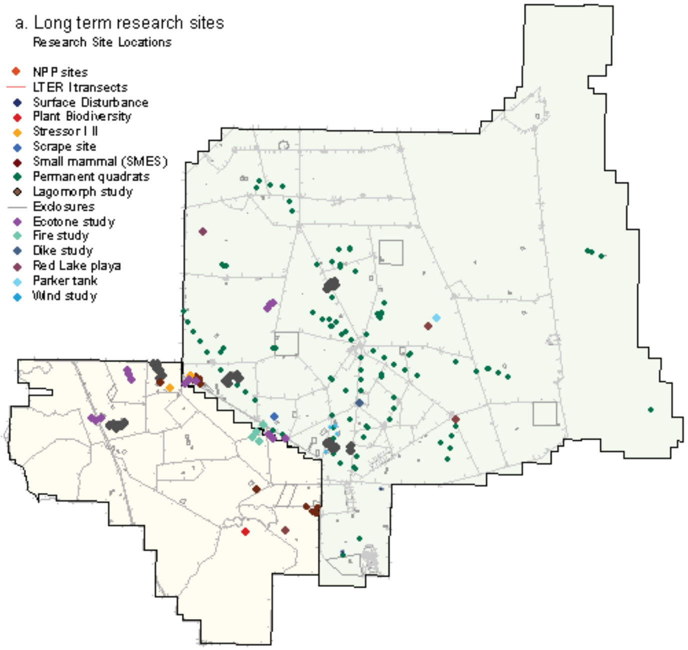
Table 1. Long term experiments at the Jornada Basin LTER.

Study	Core Area	Ecosystems	Period	Responsible Investigator	Data Sets
NPP	1,2	C, G, M, P, T (3 sites each)	1989 -	Peters	Aboveground plant biomass and ANPP by species, 3x yearly
Plant phenology	2	C, G, M, P, T (NPP sites)	1992 –	Peters	Reproductive state of individuals of perennial plant species, by month.
NPP soil water	4	C, G, M, P, T	1989 –	Herrick	Neutron probe readings of soil water content, by depth
Transect soil water	4	C, G, P (LTER I transects)	1982 –	Herrick	Neutron probe readings of soil water content, by depth, at 30 m intervals along 3 km topographic gradient, monthly
Transect vegetation	2,4	C, G, P (LTER I transects)	1982 –	Peters	Perennial plant cover by species, 30-meter line intercepts, along 2.7 km topographic gradient, semiannually until 1988, now 5 yr intervals
Fenceline vegetation	2,5	C, G, P (LTER I transects)	1982 –	Peters	Perennial plant cover by species, 30-meter line intercepts, on topographic gradient, at 5 yr intervals
Multiple stressor	2,4,5	G, M	1995 –	Havstad	Perennial cover by species, 70 m line intercepts, at 3-year intervals; small mammals
Small mammal exclosures	2,3,5	C, G (SEV, Mapimi)	1995 –	Lightfoot/ Bestelmeyer	Plots excluding livestock, lagomorphs, or rodents; ants, plants, grasshoppers; 2x times annually through 2005; 5 year intervals
Fire study	2,5	G, M	1998 -	Havstad	400-ha pasture burned; pre- and post-fire data on shrub size and density, plant species composition
JORNEX	2,5	C,G,M	1995 –	Rango	Multiple-sensor aerial and ground-based imagery
JER Quadrat Data	2,5	All	1915 –	Havstad	Grass basal area, forb species and density, canopy area of shrubs, 1 m^2 permanent quadrats established 1915 – 1932, sampled annually through 1947, at 5 yr intervals since 1990
Gravelly Ridges	2,5	C	1938 –	Havstad	Perennial cover by species, 10.6 m line intercept, irregular intervals 1938-1995, at 5 year intervals now
Atmos-pheric Deposition	4	G	1983 –	Schlesinger	Dryfall and Wetfall precipitation collected monthly and by event, chemical analyses performed
Climate	4	G	1983 –	Anderson	LTER main weather station (air/soil temperature, precipitation, relative humidity, solar, wind direction/speed
Evap pan	4	G	1983 –	Schlesinger	Pan evaporation, measured weekly
NPP precip	4	C, G, M, P, T	1989 –	Anderson	Total monthly precip
USDA Climate	4	G,M	1914 –	Havstad	Daily precipitation, min and max air temperature
USDA precip	4	All	1915 –	Havstad	Monthly precipitation from network of standard can rain

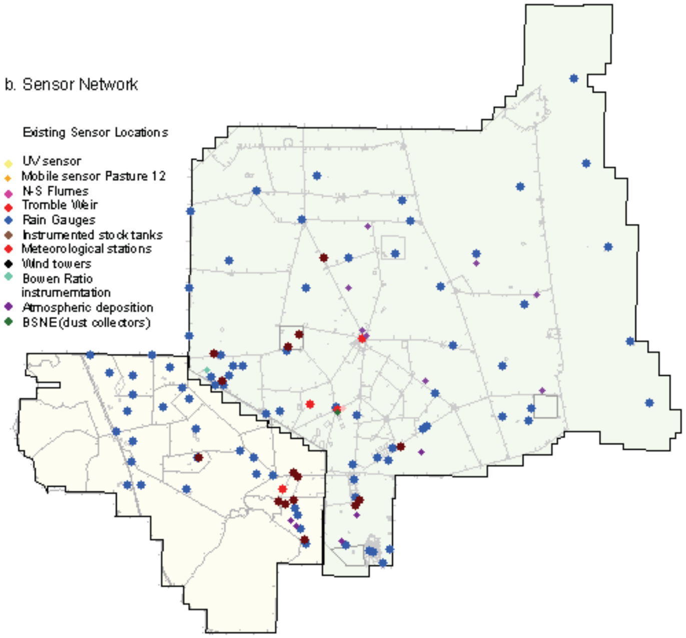
C= creosotebush shrublands G=black grama grasslands M=mesquite shrublands P=playa grasslands T=tarbush shrublands

CORE AREAS:

1) primary production
2) populations selected to represent trophic structure
3) organic matter accumulation in surface layers
4) inorganic inputs and movements of nutrients through soils
5) disturbances

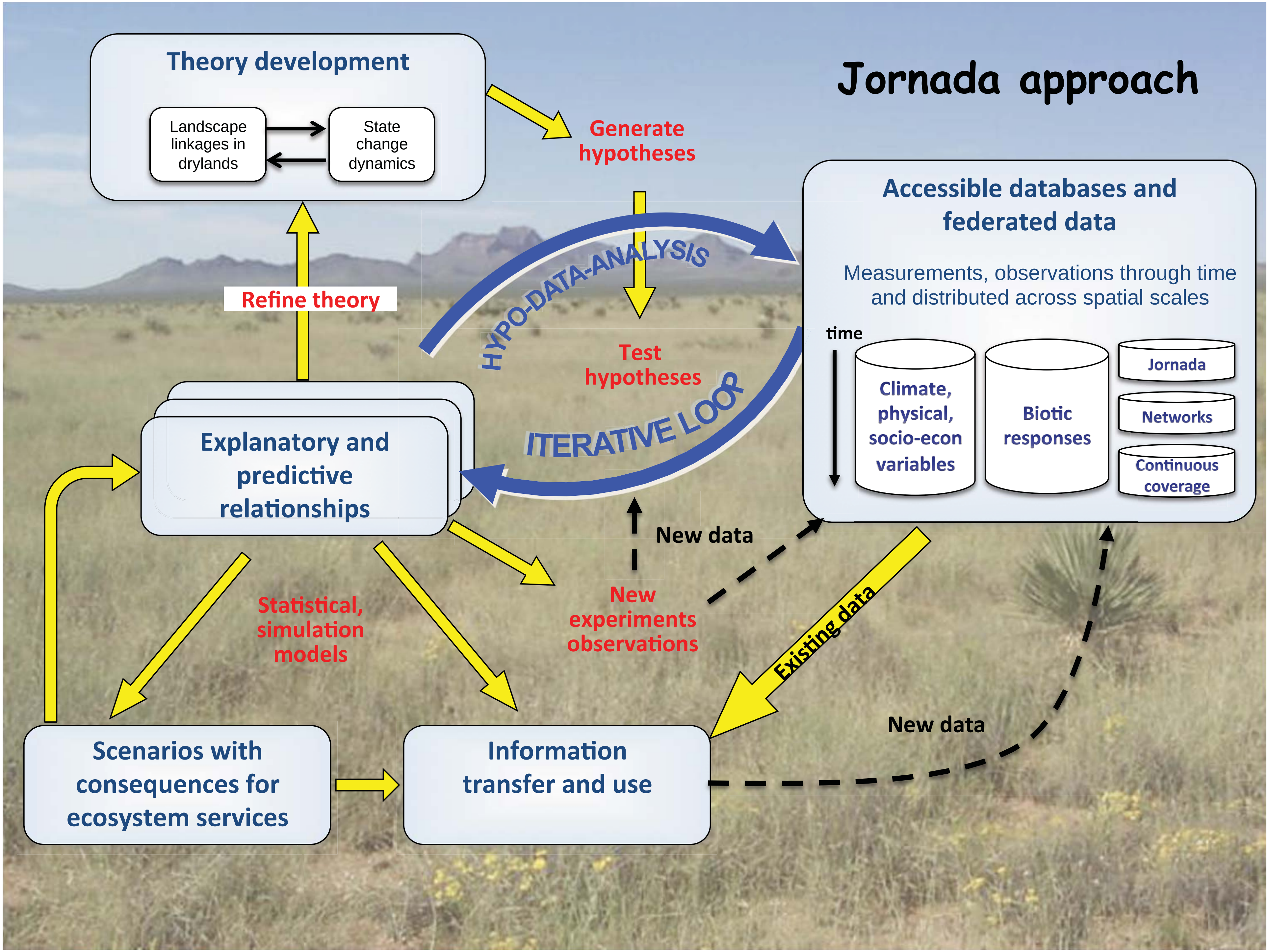


a. Long term research sites



b. Sensor Network

Jornada approach



Theory development

Landscape linkages in drylands

State change dynamics

Generate hypotheses

Accessible databases and federated data

Measurements, observations through time and distributed across spatial scales

time

Climate, physical, socio-econ variables

Biotic responses

Jornada

Networks

Continuous coverage

HYPO-DATA-ANALYSIS

Test hypotheses

ITERATIVE LOOP

Refine theory

Explanatory and predictive relationships

New data

New experiments observations

Statistical, simulation models

Existing data

New data

Scenarios with consequences for ecosystem services

Information transfer and use

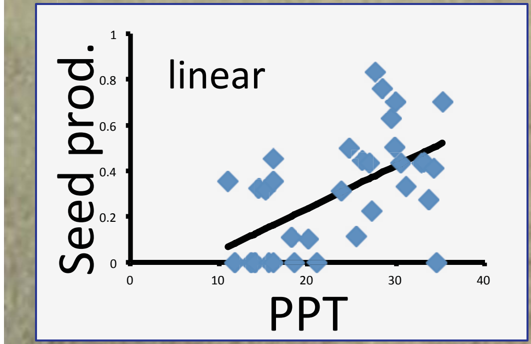
Goal: to predict plant production (ANPP) for mesquite shrublands at the Jornada under alternative climate scenarios

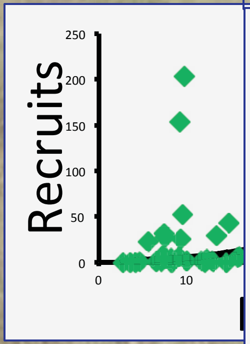
Theory

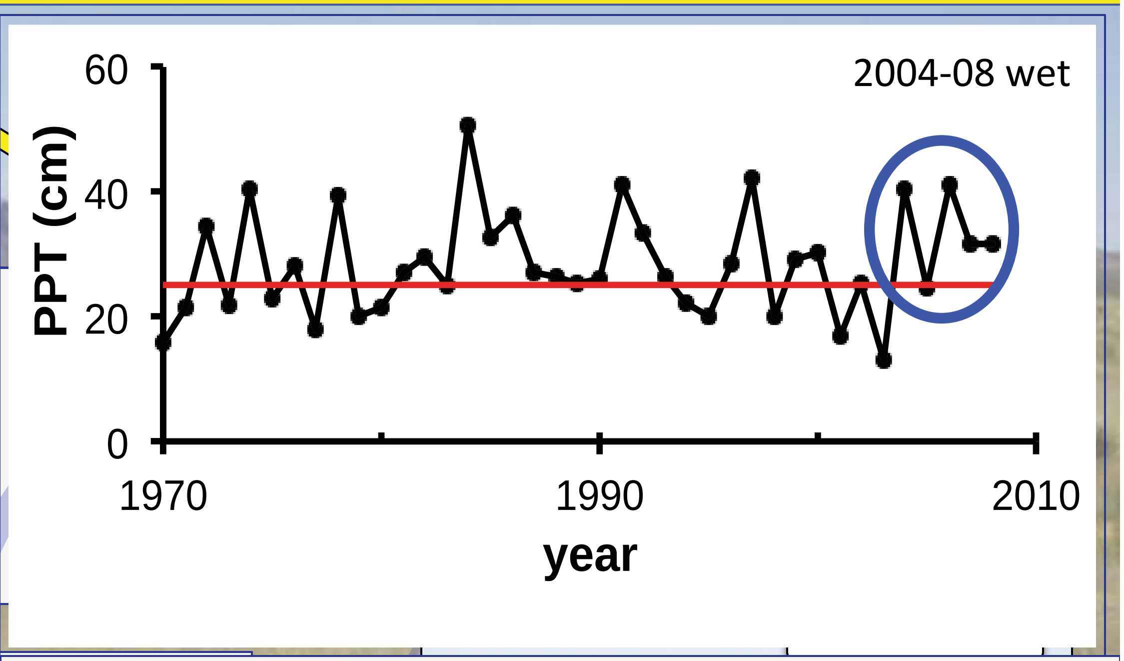
Water drives plant production in drylands

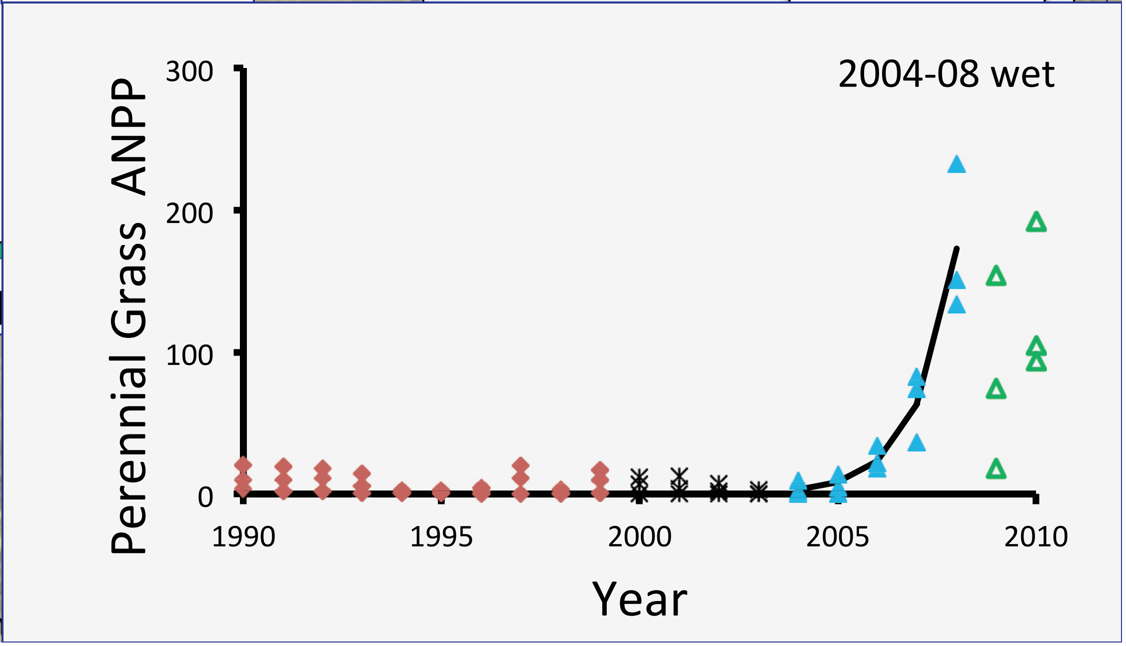
Explanatory relationships

H: grass recruitment processes explain ANPP responses to PPT.





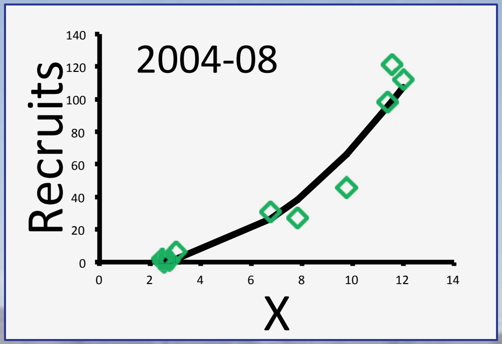


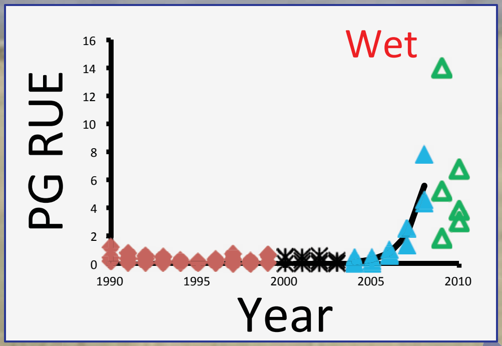


X includes PPT$_{summ}$

What processes lead to cumulative effects on recruits through time?

RUE = rain-use efficiency (grams production/cm water) in wet period – more water is available to grasses for given amount of rain



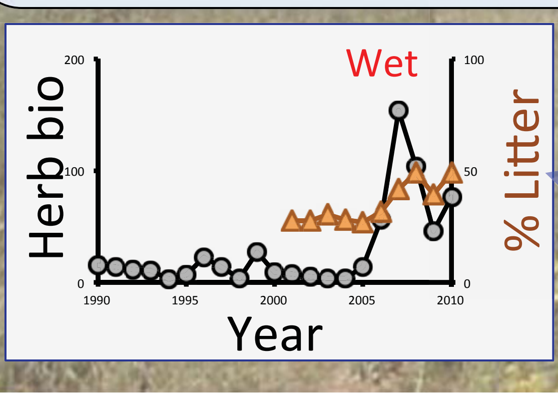


Refined theory

Water drives ecosystem dynamics in drylands but relationships and processes depend on multi-year patterns in PPT

Explanatory relationships

H: litter accumulation, via its effects on plant available water, explains recruitment responses through time in wet period.



Access database

Jornada database

Measurements, observations through time at multiple locations

time

PPT

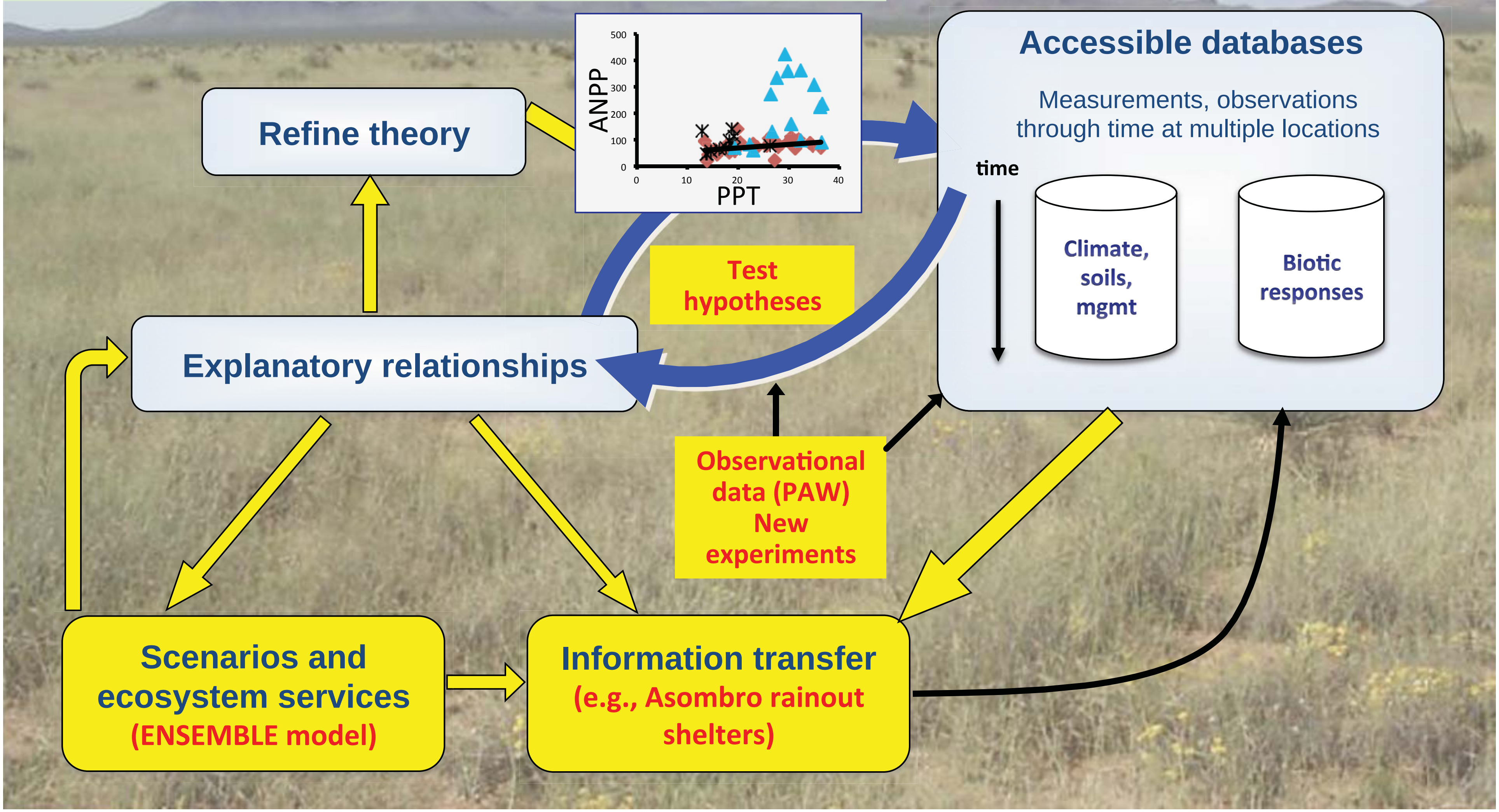
Grass ANPP
Herbaceous biomass, litter

Test hypothesis

Mechanistic explanation for non-linear relationships between ANPP and PPT in dry-average-wet periods

General characteristics

- Iterative approach
- Strategic use of historic and new data
- Link patterns and processes
- Integration and synthesis
- Understanding and prediction



Refine theory

Accessible databases

Measurements, observations through time at multiple locations

Climate, soils, mgmt

Biotic responses

Test hypotheses

Explanatory relationships

Observational data (PAW)
New experiments

Scenarios and ecosystem services
(ENSEMBLE model)

Information transfer
(e.g., Asombro rainout shelters)