Threshold and state concepts used in ESDs: Needs and applications

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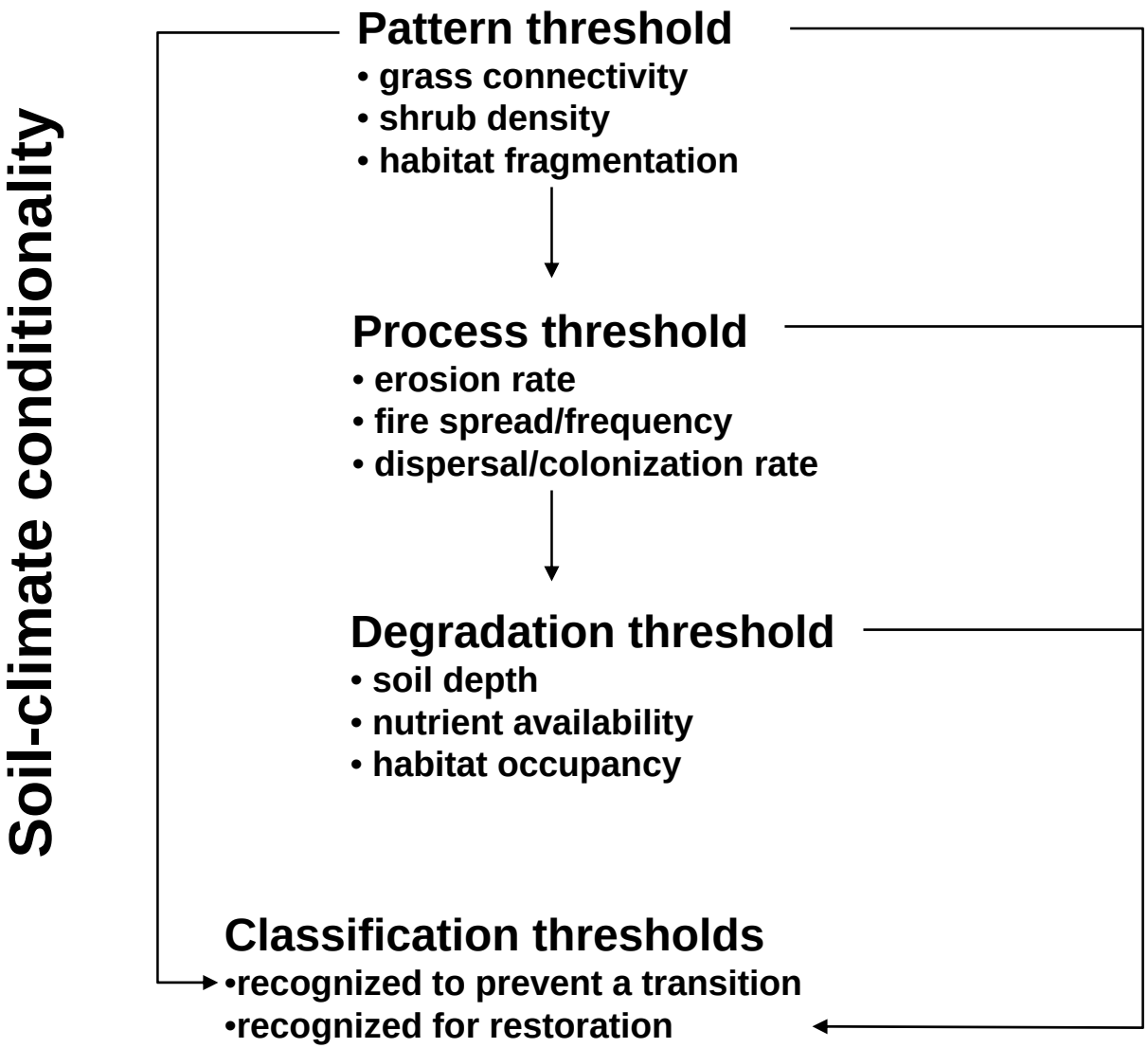
State and thresholds concepts lack empirical support and their utility and justification continues to be limited.

Critical Issues

A) How can model users recognize or measure thresholds?

B) How should we gather and use data to support the existence and nature of alternative states and land potential?

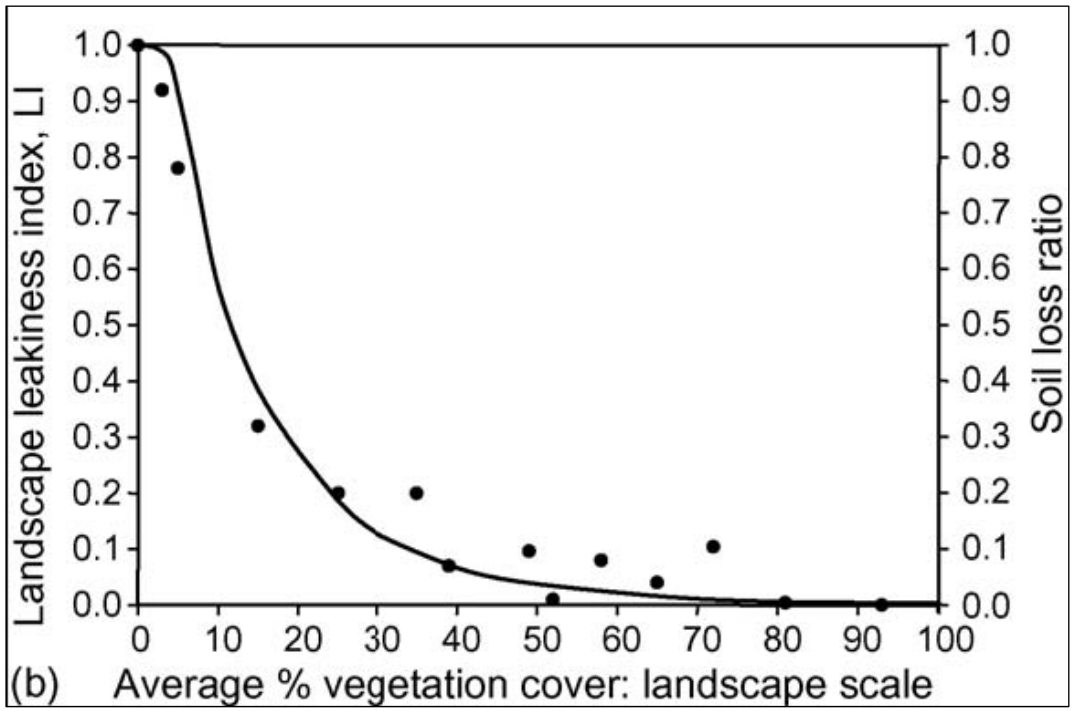
A) Thresholds as sequences of events, changes, and feedbacks



Bestelmeyer, Restoration Ecology, 2006

1) Pattern thresholds exist that can be quantitatively related to process

- Measures initiation of process that produces a transition
- Can be detected with cover values, stubble height, gap size



Ludwig et al., Ecological Indicators, in press

1b) Pattern may also be linearly related to process rates

•The lower the cover, the greater the erosion rate

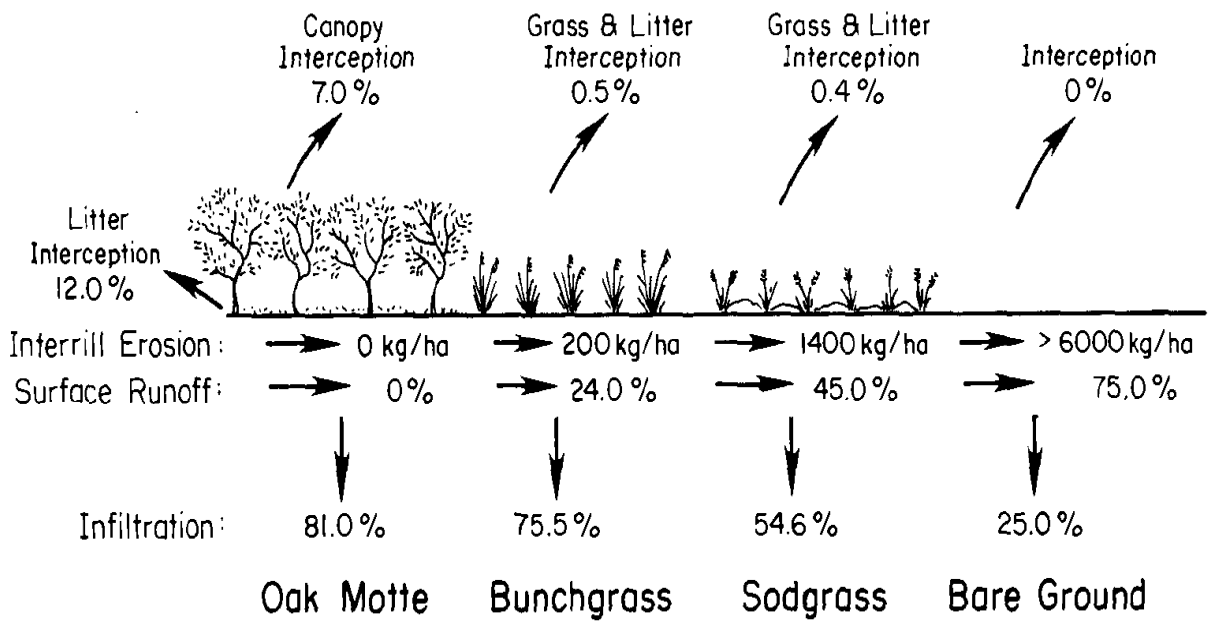


Figure 6.4. **Water budgets and amount of interrill erosion, runoff, and interception from oak, bunchgrass, sodgrass, and bare ground dominated areas, Edwards Plateau, Texas. Based on 10 cm of rainfall in 30 minutes (from Blackburn et al. 1986).**

Thurow, Grazing Management: an Ecological Perspective, 1991

2) Altered process rates have gradual or discrete environmental consequences

- Process rates * duration = degree of change (e.g., in organic matter content)

Nickel series, MLRA 42, typic aridic Calcareous Gravelly

Recent grassland loss, A horizon present

Crossed a pattern-process threshold

Dark A

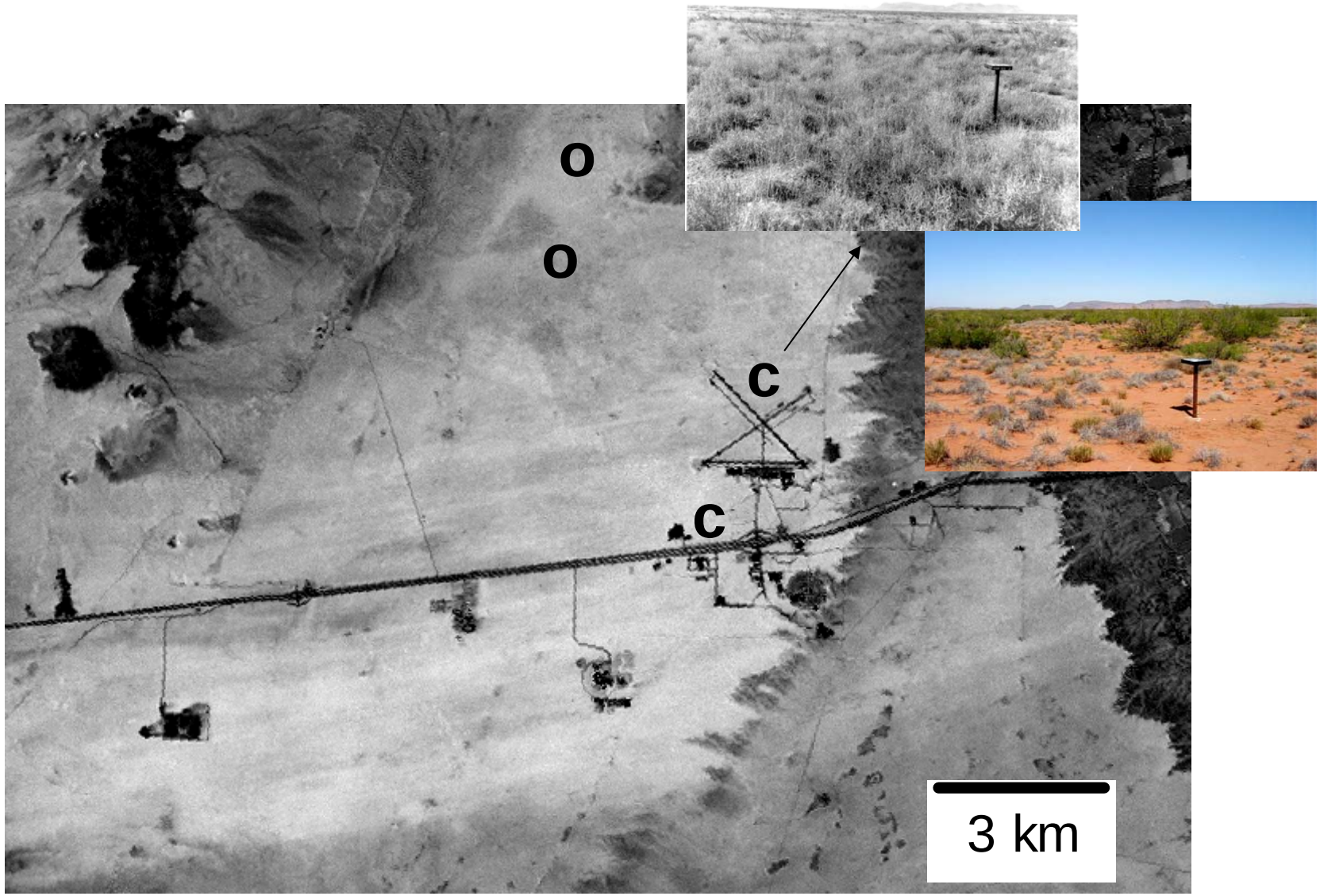
Light A

Grassland absent for decades, A horizon lost

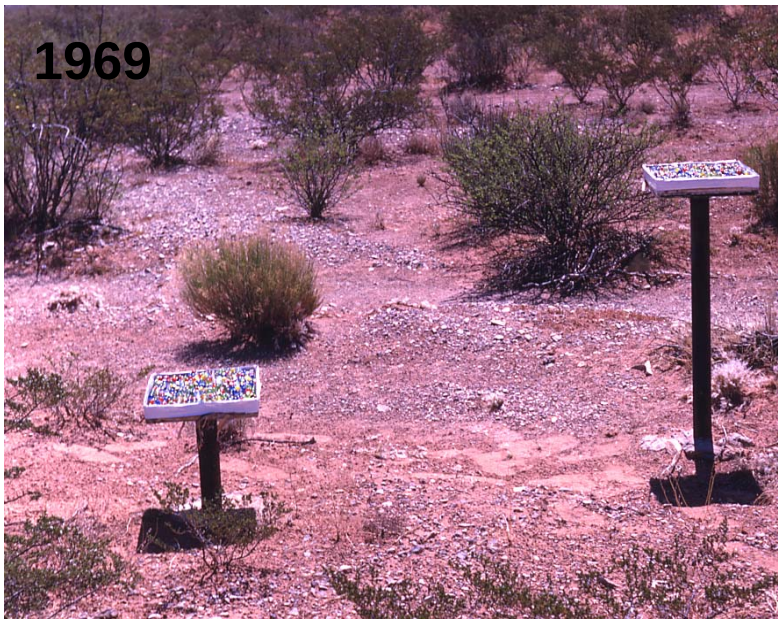
Has this crossed a degradation threshold?

3) At some critical values of an environmental/resource factor, the site becomes degraded, autogenic recovery does not occur, degradation may spread

4) Landscape processes (thresholds) may override local management



4b) Landscape processes may override local degradation and cause recovery



Middle piedmont slope
Gravelly loam ecological site, (gravelly) fine-loamy Calciargid

- **Exclosure ungrazed since 1911**
- **Surrounding area is eroding**
- **18 cm of sediment accumulation parallels grass recovery**

5) The meaning of pattern and incidence of threshold behavior varies predictably with soil properties

1.

30 years →

Fine-loamy, Calciargid

2.

→

Coarse-loamy, Calciargid

Solutions for improving support of threshold concepts

- Concepts that use numbers rather than metaphors (no more cups)
- Funding to support threshold-oriented experimentation in different ecological site types (i.e., what patterns lead to vulnerability and change in different contexts?)
- Attention to landscape context in experiments
- Collection of within-site spatial pattern, indicator, and landscape context information in vegetation/soil inventory based on experiment-based threshold mechanisms
- Discussion of within-site spatial pattern and landscape context effects in state-and-transition model text referencing the experiments

Solutions for improving utility of threshold concepts

A. Key indicators of vulnerability to transition:

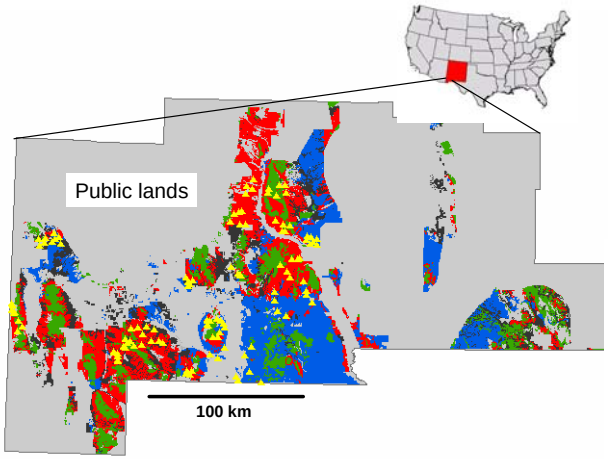
- Persistent high utilization of black grama, stubble heights < 3”, basal cover < 5%.
- Absence of stolons
- Bare patches interconnected and with many patches > 50 cm
- Evidence of soil movement, burial of grasses
- Proximity to eroding and expanding shrublands

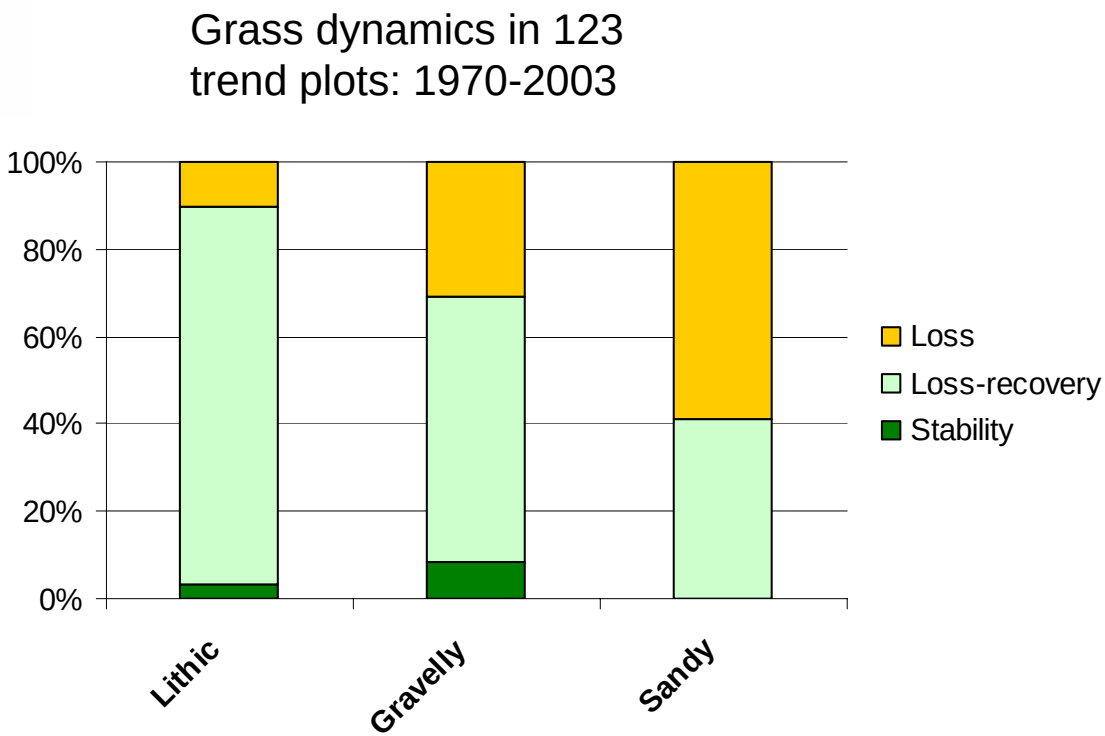
Solutions for improving utility of threshold concepts

B. Key indicators of opportunity for restoration:

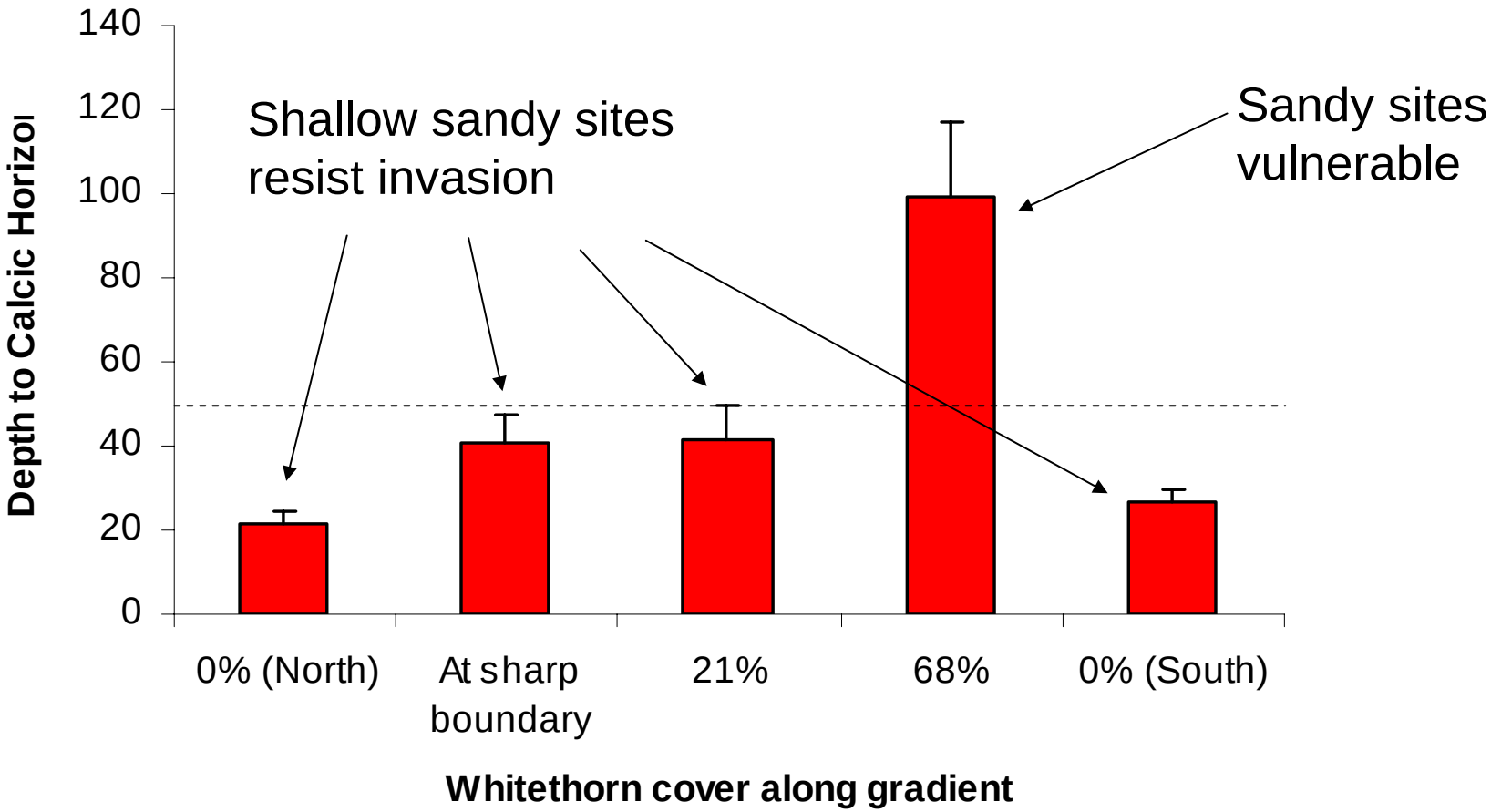
- Remnant grasses in shrub interspaces
- Grasses in shrub canopies
- Likelihood of two consecutive summers of high rain
- Darkened A horizon, minor erosion
- Proximity to seed sources

B. What kinds of data can NRCS and others gather to better understand alternative states and thresholds?





1) Linked soil and vegetation data can improve S&T models



2) ESD classes must be able to distinguish land with different potential

Reagan series: Basin floor

Which one is closest to potential vegetation?

The solution: data gathering as part of soil survey and ESD development

Elements of a successful approach

1) One or more *range cons* working with soil scientists

2) Range cons that *understand soils*

3) A *vegetation/soil surface sampling protocol* that matches the pace of soil sampling

4) A *coding system* that relates vegetation measurements, soil measurements, and coordinates at points

5) *Many points* with varying levels of detail at a regional scale, rather than a few points with unnecessarily high precision

6) A *database* to house these data and their relationships

A three-tiered sampling procedure

Based on Presidio County, TX and White Sands, NM Soil Surveys

Tier 1) “Traverse”--low intensity sampling, many points (100s)

-arbitrary points, often along roads

-soil to taxon or series or even prelim ecological site

-vegetation community classes, state class id

Purpose: Concept building, locations for Tier 2 samples

A three-tiered sampling procedure

Tier 1) “Traverse”--low intensity sampling, many points (100s)

Tier 2) “Transect”—medium intensity sampling, fewer points

-intervals within replicate map unit representatives

-can be used to examine causes of vegetation differences within and between map units

-rapid soil profile information (mini-pit, auger holes)

-vegetation cover estimates by species, soil surface indicators

Purpose: Data used to create and test ESD concepts and to develop S&T models and model text

A three-tiered sampling procedure

Tier 1) “Traverse”--low intensity sampling, many points (100s)

Tier 2) “Transect”—medium intensity sampling, fewer points

Tier 3) “Characterization”—high intensity sampling, few points
-replicate, representative pedons and states
-full soil characterization (232) in trench or pit
-line-point intercept, production, soil stability test augmented by "tier 2" above

Purpose: Create data ranges to populate ESIS for benchmark data on vegetation and soils

A general strategy for sampling

1. Rapid survey of map units across LRU (**Tier1**)

↓

2. How do map units differ, how many community types?

↓

3. Use spatial digital data/remote sensing to stratify landscape/preliminary map units

↓

4. Rapid survey of map unit delineations (**Tier1**)

↓

5. "Transect" a subset of map unit delineations with different communities (at least 3 replicates/community/map unit), id map unit component (**Tier2**)

↓

6. Evaluate data: important plant community differences are coupled with:
   a) no consistent soil differences=different states
   b) distinct soil or climate properties=different LRU and/or ecological sites

↓

7. Select representatives of states within an Ecological Site for intensive measurement (**Tier3**)

Tier 1: Traverse (ESD Quick data form)

Date:	Observers:
Area :	

Point	State/community	MU	Landform	Soil family/characteristics	Series	Easting	Northing	Elevation

Tobosa-honey mesquite community

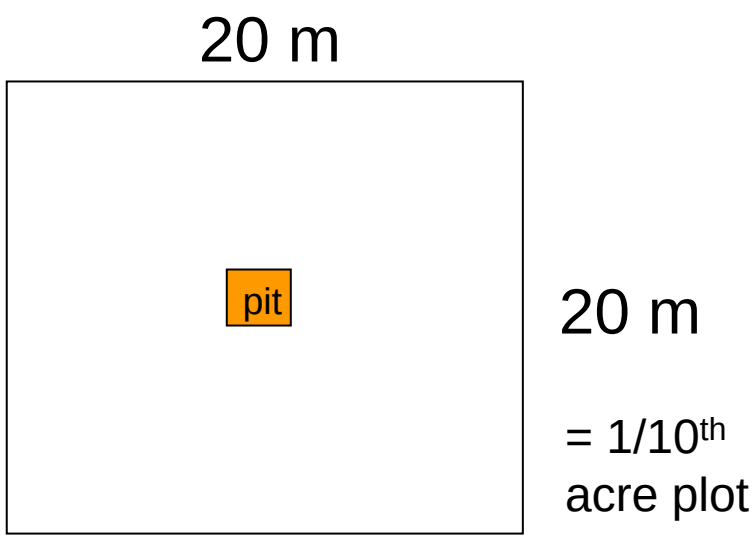
Very rapid identification of plant community from catalog of types generated at S&T workshops or in databases (geolocation also important!)

Tier 2: Transect (Plant Composition and Pattern form)

Modified Domin-Krajina cover estimate in 20x20 m plot

+--few	1--<0.1%	2--<1%	3--1-4%	4--5-10%	5--10-25%	6--25-33%	7--33-50%	8--50-75%	9--> 75%
+--<0.2m2	1--0.2-0.5m2	2--0.5-4m2	3--4-20m2	4--20-40m2	5--40-100 m2	6--100-132 m2	7--132-200	8-200-300	9--300-380

Woody	Class	**Grass**	Class	**Forb**	Class	**Other**	Class		
						Litter			Percent
						Cryptogram			Scale



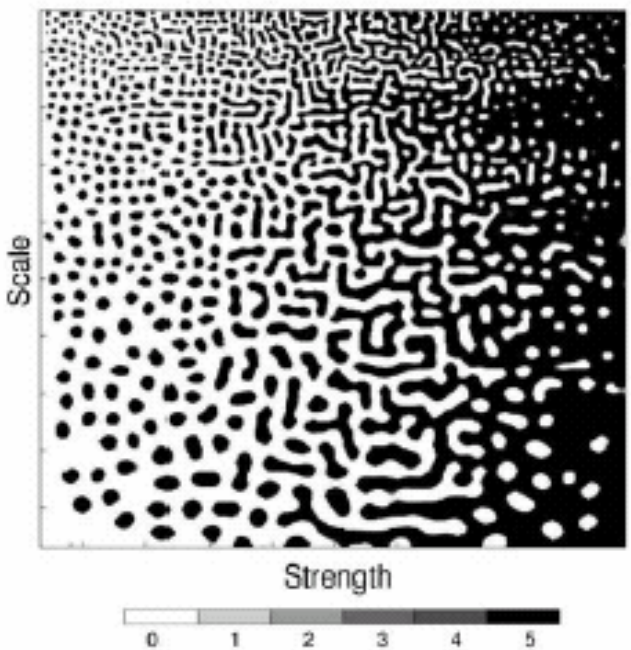
= 1/10th acre plot

Cover estimated ocularly using cover scale within a 20x20 m area around pit, can be performed rapidly during soil survey transecting (15 minutes)

Tier 2: Transect (Plant Composition and Pattern form)

Resource retention class in 20 x 20 m

Interconnected grass cover or dense bunchgrasses; and surrounding ellipsoid bare patches < 30 cm	
Grass cover interconnected and surrounding ellipsoid bare ground patches from 30-__cm	cm
Grass cover fragmented by elongate bare ground areas to __ cm wide but bounded in plot	cm
Grass cover fragmented by elongate bare ground areas to __ cm wide that across entire width of plot	cm
Bare ground interconnected in several directions and isolated grass patches up to __ cm	cm
Bare ground interconnected with scattered or no grass plants	



from Reitkerk et al., 2004, Science 305: 1926

A simple measure of patch structure that relates to the *potential for erosion*

Relates to Rangeland Health Indicators, but does not compare to a standard (because it is not defined yet)

Used in S&T model text to describe states

Tier 2: Transect (Plant Composition and Pattern form)

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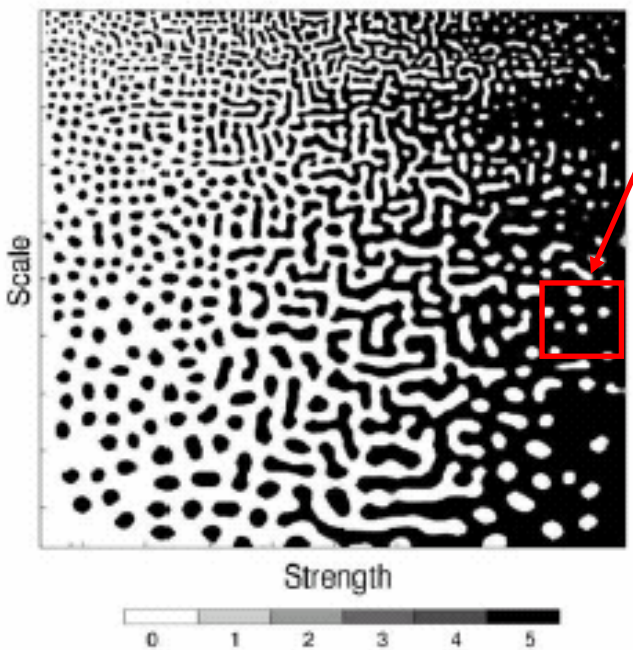

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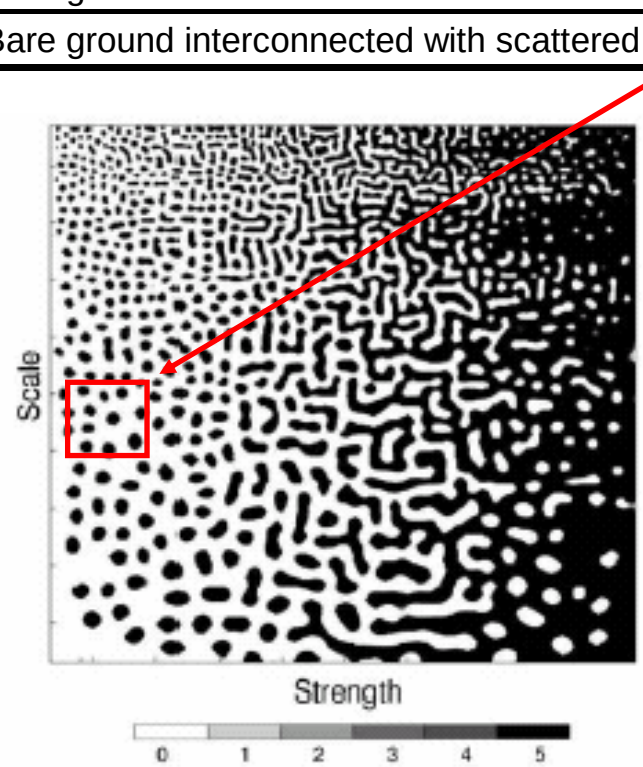

from Reitkerk et al., 2004, Science 305: 1926

Tier 2: Transect (Plant Composition and Pattern form)

Erosion pattern class in 20 x 20 m

	Check one
No evidence of erosion or deposition	
Erosion limited to small (< 50 cm) blowouts or rills, few pedestals	
Erosion across large (> 50 cm) bare patches, gullies, flow patterns, but low soil loss	
Erosion across large areas with minor deflation, coppicing, flow patterns, pedestals	
Erosion across large areas with deflation, coppicing, and truncation of horizons	
Deposition across large areas, may have rills, flow patterns.	

A simple measure of erosion pattern that describes the *consequences of erosion processes for soils*

Relates to Rangeland Health Indicators, but does not compare to a standard (because it is not defined yet)

Used in S&T model text to describe states

Tier 2: Transect (Plant Composition and Pattern form)

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Another simple measure related to rangeland health indicators and used in text

Tier 2: Transect (Soil form)

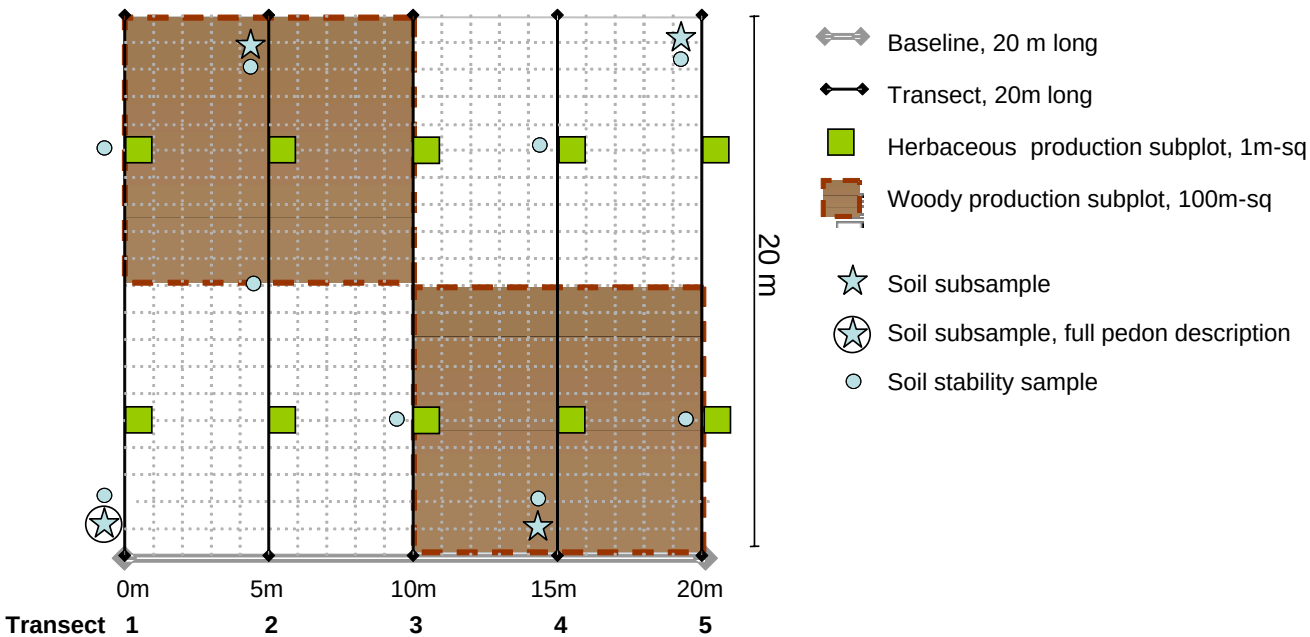
Surface soil properties

S = No crust; may be plant base or soil without any other surface feature	
WP = Weak physical or bilogical crust, may have few cyanobacterial sheaths dangling from ped, no darkening from cyanobacteria.	
SP = Strong physical crust	
PDB = Poorly developed biological crust assemblage, few to many cyanobacterial sheaths, may be slightly dark, can include some other morphological group (algal crust, lichen, moss	
SDB = Strongly developed biological crust assemblage, obvious dark cyanobacteria, rubbery algal moss or lichen crust.	
CB = Cracking or curling, rubbery algal crusts, with or without lichen	
RA = Uniform rock armor	
CEM = Cemented	
D = Duff	
EL = Embedded litter	

These classes are estimated visually in Tier 2 plots or can be used with more intensive techniques

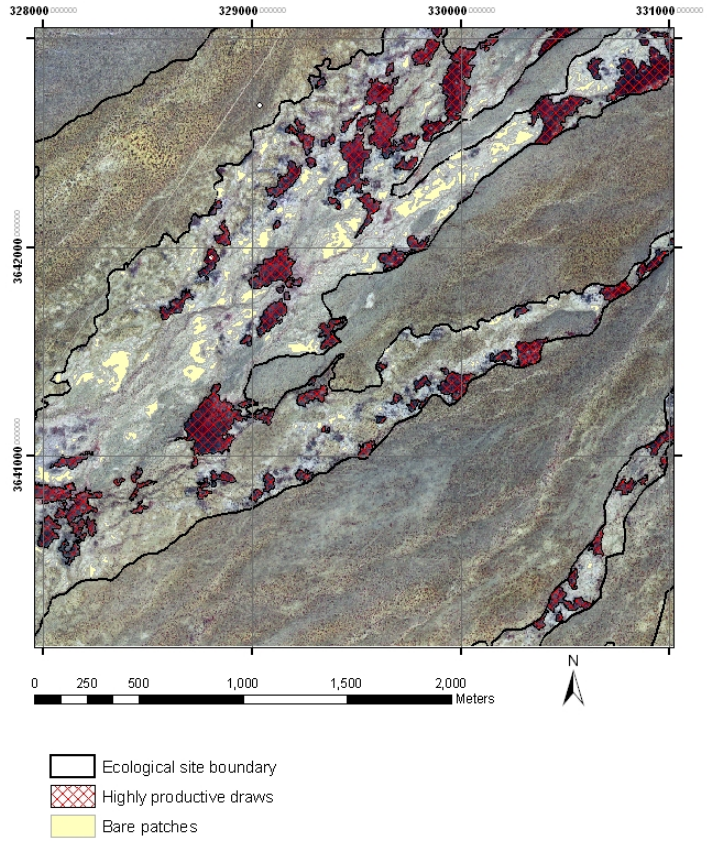
Tier 3: Intensive characterization: line point intercept vegetation, quantitative soil surface properties, production

20m x 20m plot, one stratum, four soil subsamples



LPI design yields 200 points for basal and canopy cover but maintains observations within 10-20 m of the soil pit

Tier 4 (future): incorporating high resolution remote sensed patterns within ESDs and recommended monitoring structures



Within a site, we describe the *pattern* of highly vegetated and bare areas to help define states expressed at larger scales than a 400m^2 plot

Microsoft Access - [Soil Taxon, Ecological Site and State Determination]

File Edit View Insert Format Records Tools Window Help

Type a question for help

Tahoma 8

Site 01015 Date 12/14/2004

Plot 1

Soil Taxon, Ecological Site and State Determination

Soil Taxonomy

Map Unit Symbol	Series	Particle Size Class:	Mineralogy:	Soil Temp Regime:	Depth Class:	Subgroup:	Greatgroup:
MO Mohave Sandy							

Reaction	Soil Moisture Regime	Cation Exchange Activity Class

Ecological Site Determination

Ecological Site ID	State within Ecological Site	Community within State

Line-point Intercept Indicators

Canopy Cover (%)	
Basal Cover (%)	
Bare Ground (%)	

Domin-Krajina and Line Point Intercept Summary Data

Species	Class	DK Midpt % Cover	LPI Canopy Cvr %	LPI Basal Cvr %	Prod (lbs/ac)	Notes
ARIST	1	0.05				
ARTE3	1	0.05				
BOER4	3	3				
BOGR2						
EPTR	1	0.05				
ERCI	1	0.05				
ERWR	+	0.01				
gravel	3	3				
GUSA2	3	3				
ISTE2	1	0.05				
LITTER	3	3				
MACA2	+	0.01				
OPIM	1	0.05				

Generate from LPI data

Return to Plot and Soil Form | Return to Plant Composition and Pattern Form | Enter/Edit Form Data | View/Enter Photo(s)

Form View NUM

Conclusions

- We need more experimentation with regard to various kinds of threshold processes (e.g., productivity loss, soil degradation, invasion) in different sites
- We need to produce **large** databases that link point data on vegetation, vegetation and soil surface pattern related to processes, and soil profile properties.
- We need to involve and motivate the research community and support scientific approaches to ESDs
- We need to maintain focus on management-relevant distinctions and policy issues in conducting research