Principles of Ecological Site Development

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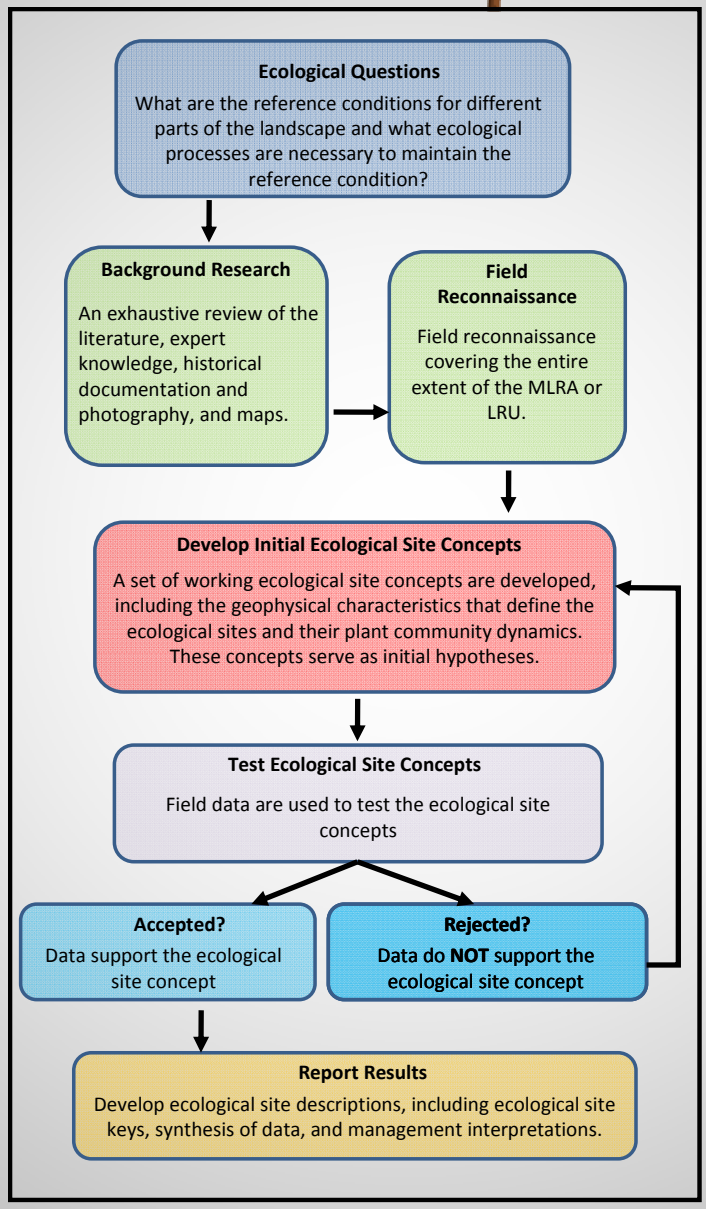
- Developing ecological site concepts
- Grouping soils to ecological sites
- Developing the STM
- Testing, refining & correlating ecological sites and STMs

Ecological Site Concept

- Like a ‘species concept’
- Defines the distinguishing geophysical properties of a site and its STM
- Ecological site and STM development occur together

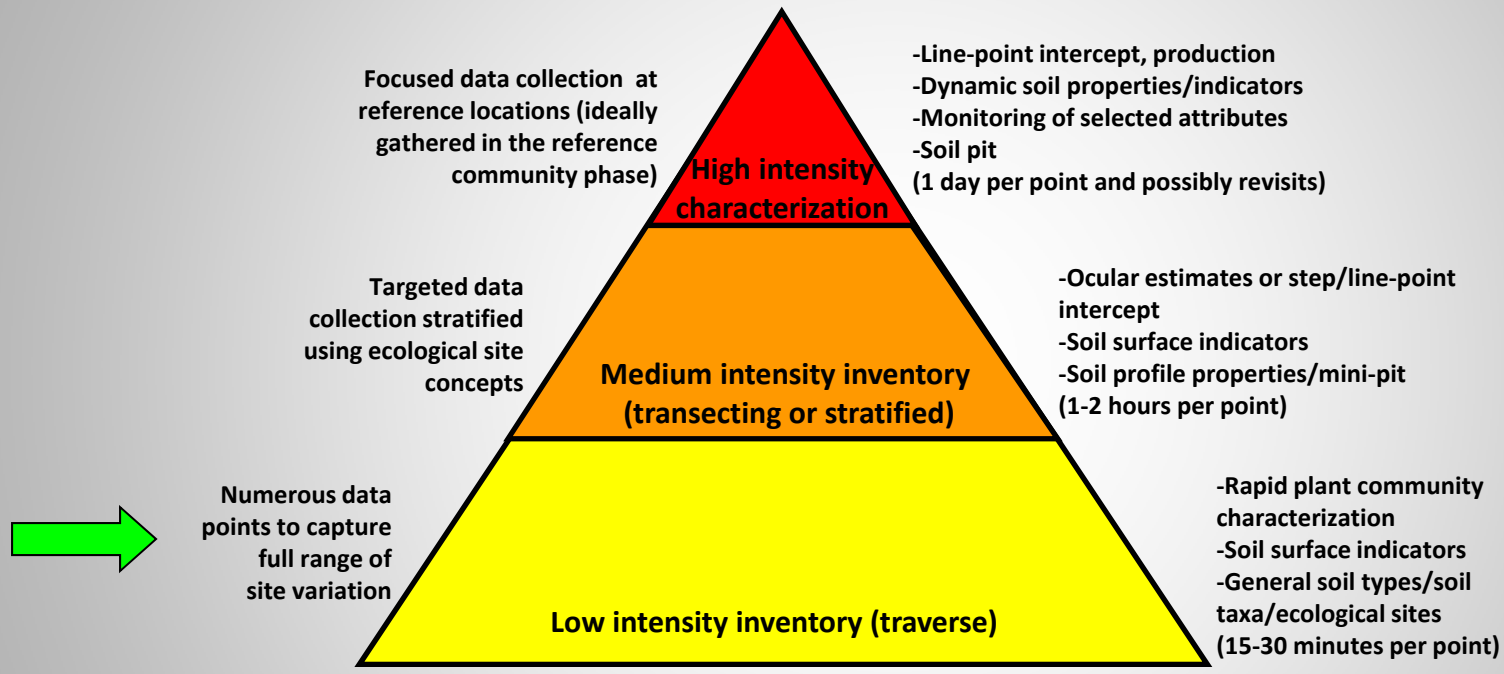
Ecological Site Development-Approach

MLRA or LRU →



Moseley et al., 2010

Ecological Site Development-Data support



Moseley et al., 2010

Developing Concepts

- Background research
  - How should ecological potential vary across the landscape?
  - Existing mapping of soils, geology, weather & climate, vegetation, hydrology etc.
  - Interview with “local knowledge” experts
  - Historical documentation (survey records, journals and diaries, photos, etc)
  - Science literature, published studies in the area

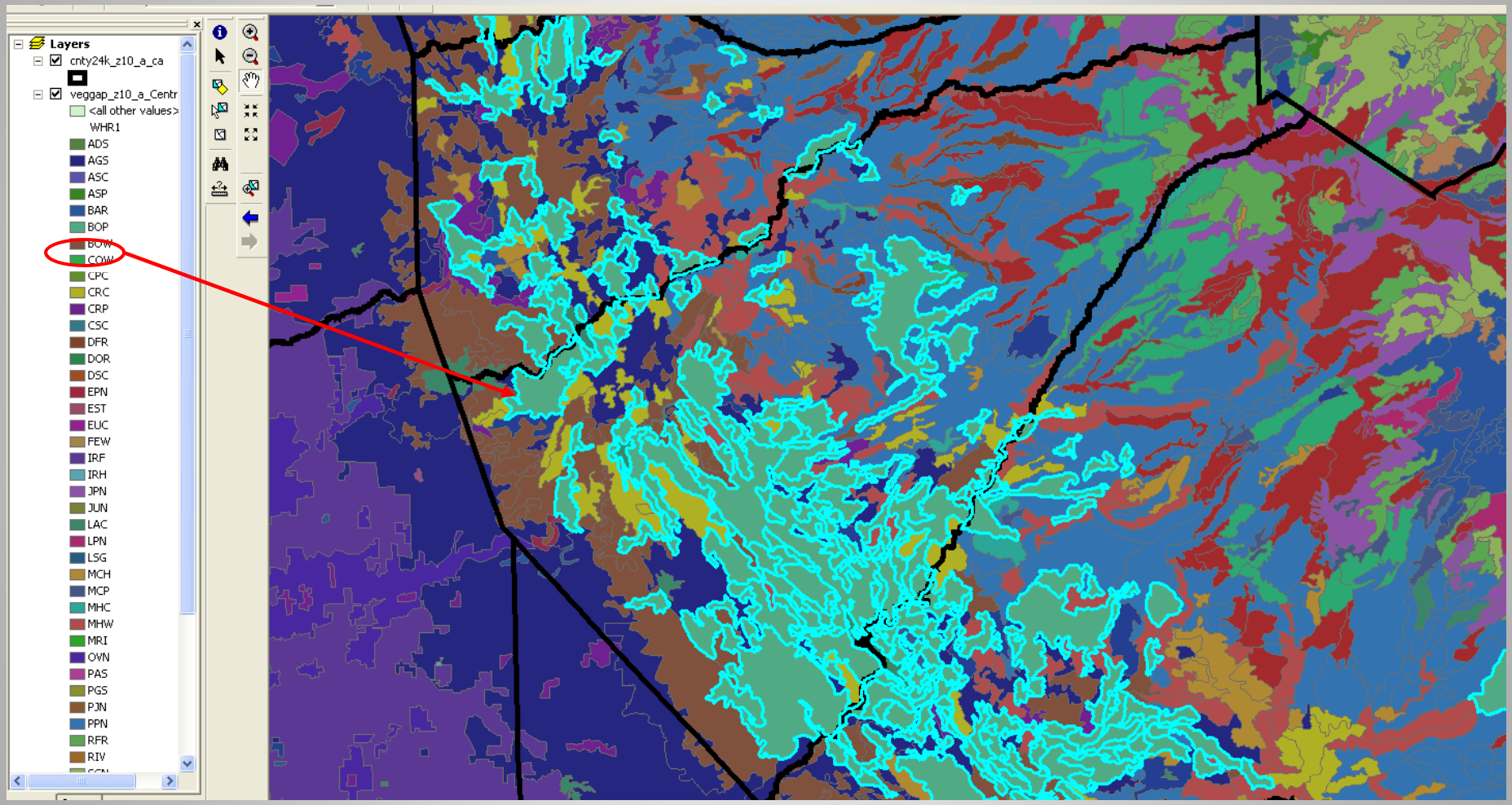
Developing Concepts

Background research should result in rudimentary groupings of climate zones/elevation zones, parent materials, soil properties, and vegetation and wildlife communities, and provide information on common land uses and management concerns.

Developing Concepts

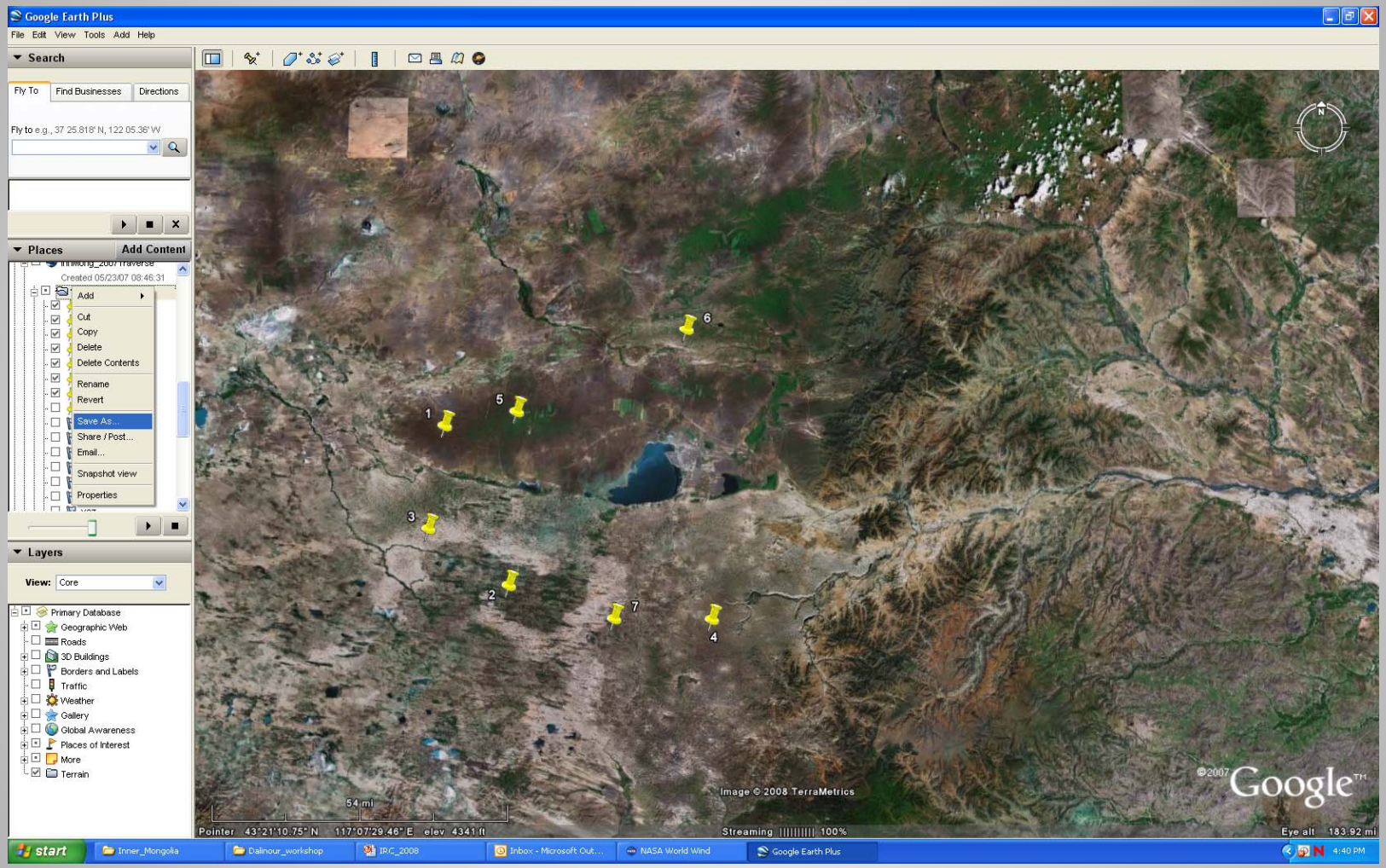
- Reconnaissance (refining initial concepts)
  - Correlations among soil properties and vegetation
  - Variability in plant community-soil relationships
  - Local knowledge: historical events, vegetation-soil relationships, and the origins of landscape patterns
  - Reference sites (exclosures, airports)
  - Observations across MLRA or LRU
  - Systematic, low intensity records

Developing Concepts



Defining extent for reconnaissance using Blue Oak-Foothill Pine GAP Layer

Developing Concepts



Google-guided reconnaissance

Developing Concepts

- After research and reconnaissance, develop initial sites concepts
- Initial site concepts represent a hypothesis that can be tested
- Clearly specify the climatic, topographic, and soil properties that distinguish the site from others

Developing Concepts

- Climate
  - Precipitation amounts (averages and extremes)
  - Precipitation timing
  - Temperature (averages and extremes)
  - Growing season (length and relationship to precipitation)
  - Wind speeds

Developing Concepts

- Topographic properties
  - Elevation
  - Aspect
  - Slope
  - Landscape Position
  - Contributing or accepting resources

Developing Concepts

- Soil Properties
  - Surface texture (importance for water infiltration, retention, soil erodibility)
  - Surface modifiers (gravels, stones, boulders, hummocks, etc)
  - Subsoil horizons (texture, type)
  - Depth to root restrictive horizons, water table, or bedrock (type)
  - Chemistry (Sodium, Calcium, Gypsum, etc)

Developing Concepts

- Specify a range in characteristics that vary at different spatial scales
  - Relatively fine scales of soil properties
  - Broader scale elevation and climatic variations

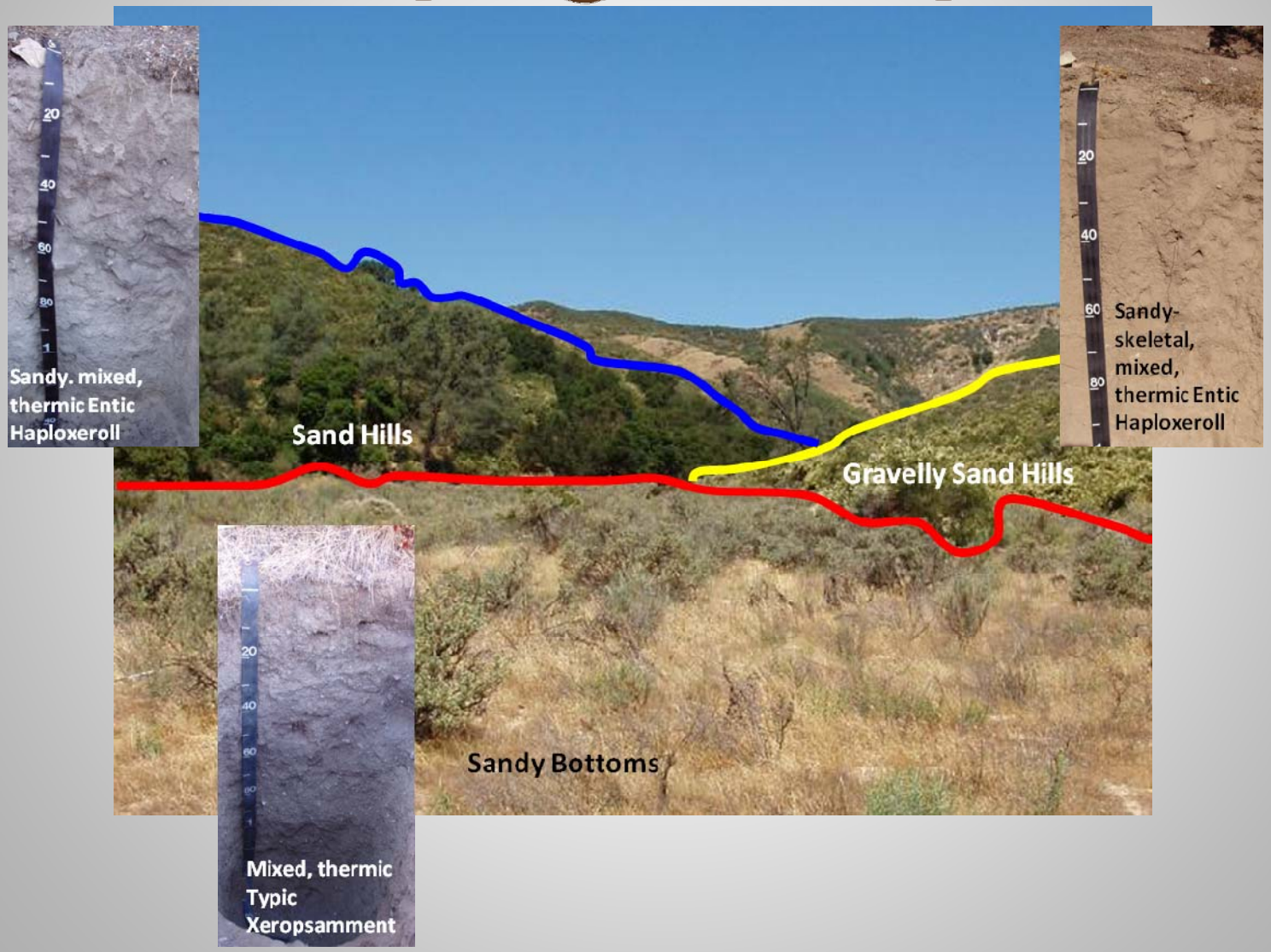
Developing Concepts

- Existing vegetation can not be a primary ecological site criterion because it is easily manipulated therefore highly variable.
- Nonetheless, certain species can be used to assist in ecological site definition and identification because they provide clues to soil and climatic conditions.
- The ecological site concept should be developed, using geophysical attributes that enable identification of the ecological site without vegetation on the site.

Developing Concepts

- Where changes in soils, aspect, topography, or moisture conditions are abrupt, boundaries of the ecological site will be obvious
- Where these factors change gradually along broad environmental gradients, ecological site distinctions are more difficult identify and may require data collection before solid ecological site concepts can be developed

Developing Concepts



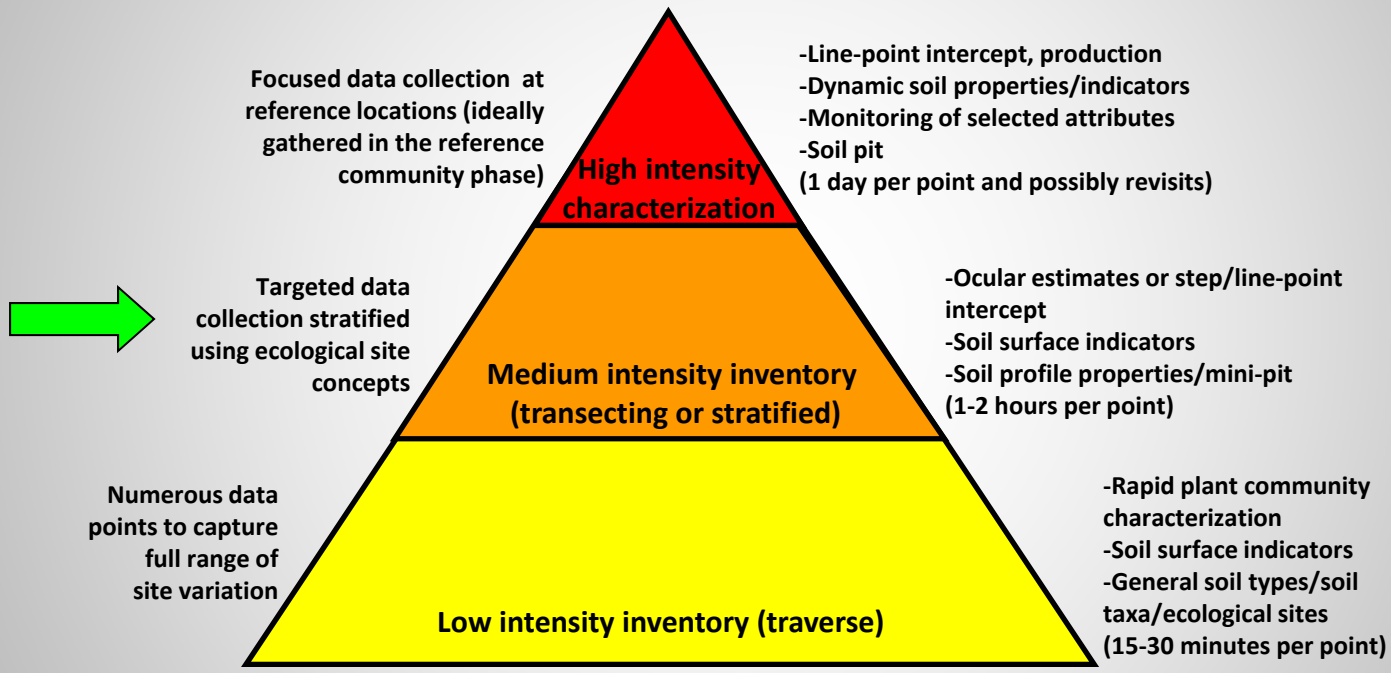
Developing Concepts

- Ecological site concepts are multivariate constructs. They are built from the relationships of several, interacting attributes that collectively produce similar environments for plant communities, similar ecological dynamics, and similar response to disturbances.

Example ecological site concepts

Preliminary Ecological Site	Elevation (ft)	Landform	Geology	Aspects	Slopes	Soil Texture	Soil Depth	Dominant Reference Vegetation	Data Collection Needs?
1	1500 – 3500	Mountains	Granite	South West	Steep	Sandy	Deep	Chamise-Buckbrush	High variation – extensive data needs
2	1200 – 3800	Mountains	Granite	North East	Steep	Loamy Sand	Moderately Deep	Bigberry manzanita - Scrub oak	High variation – extensive data needs
3	500 – 1000	Upper Stream Terraces	Rhyolite	Neutral	Flat	Sandy Clay Loam	Deep	Valley oak-Sedge	Low variation – minimum data needs
4	1500 – 3500	Footslopes	Volcanic Breccia	North East	Steep	Sandy Loam	Shallow to bedrock	Hollyleaf cherry-Toyon	High variation – extensive data needs

Testing ecological site concepts



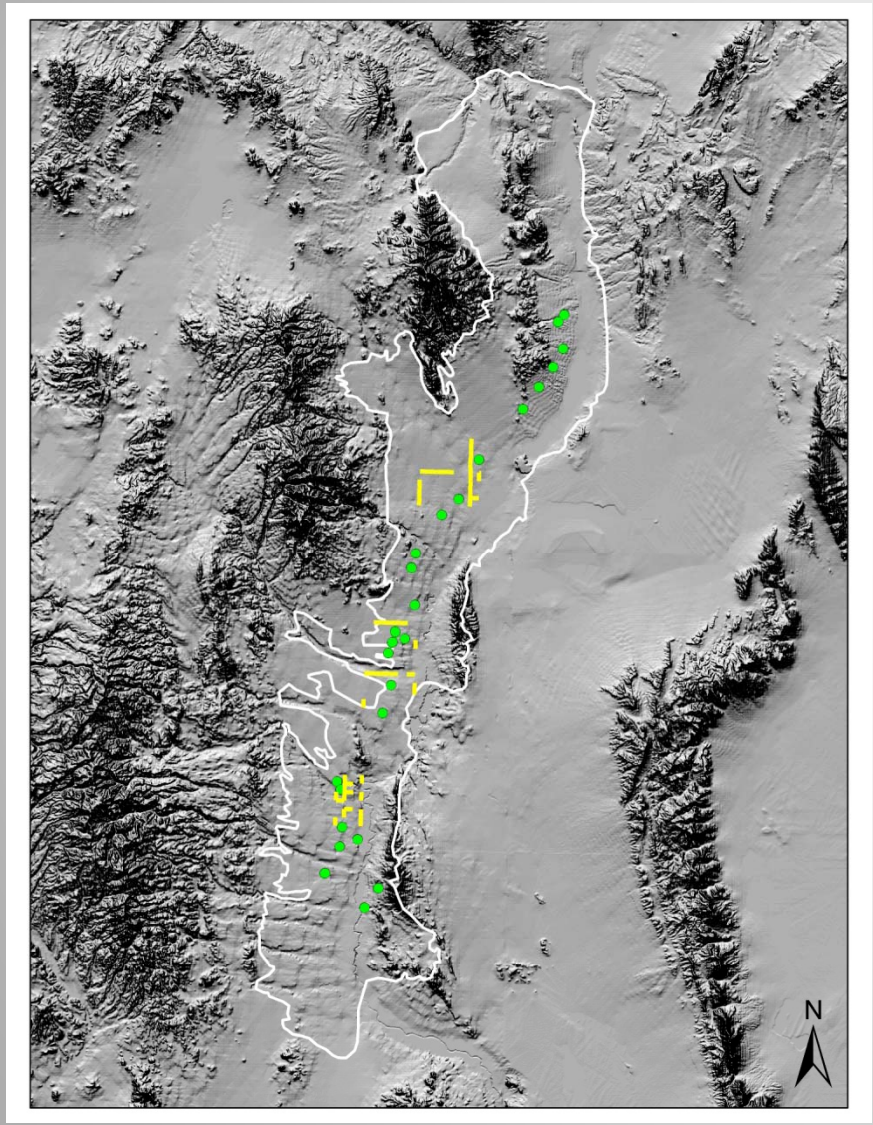
Testing ecological site concepts

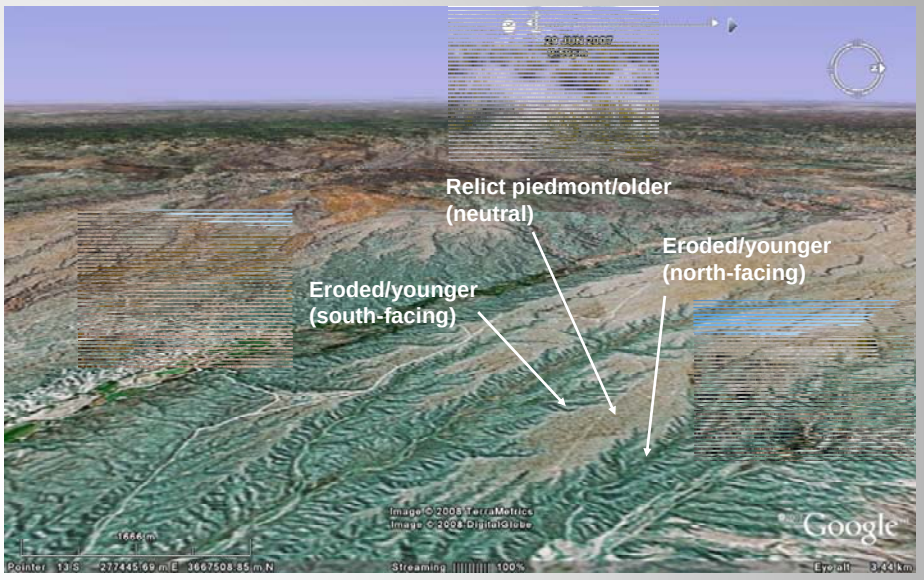
- Systematic inventories of two types:
  - Stratified random based on repeated samples of different ecological site delineations, especially those for which data are needed
  - Areas deliberately selected due to information contained in them (e.g., reference areas, degraded areas, areas with known management histories connected to local knowledge)

Testing ecological site concepts

- Stratified random inventory:
  - GIS layers (DEM, geology, soils, imagery) used to estimate locations of ecological sites and random points are selected
  - Google Earth and NASA WorldWind
  - Replication sufficient to build statistical models
  - Samples can be clustered (transecting or groups)
  - Samples can be stratified by landscapes

Testing ecological site concepts





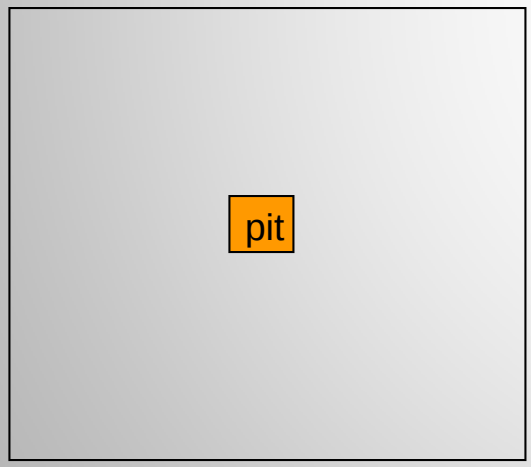
-extent of this sampling area defined by a modified STATSGO map unit
-chosen because of mix of states
-stratified random sampling (green points)
-also looked at General Land Office survey records for historical perspective (1857-1920)

Testing ecological site concepts

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

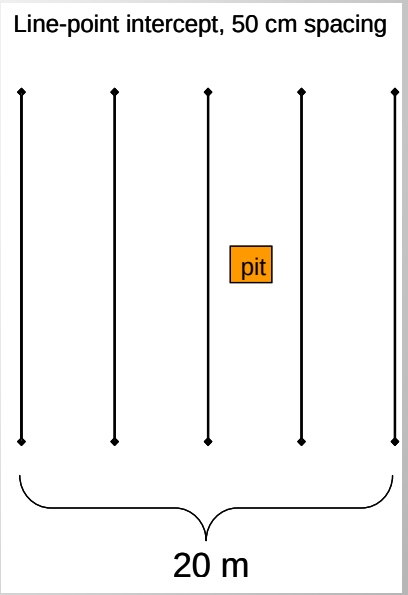
Woody	Class	**Grass**	Class	**Forb**	Class	**Other**	Class		
						Litter			Percent
						Cryptogram			Scale



20 m

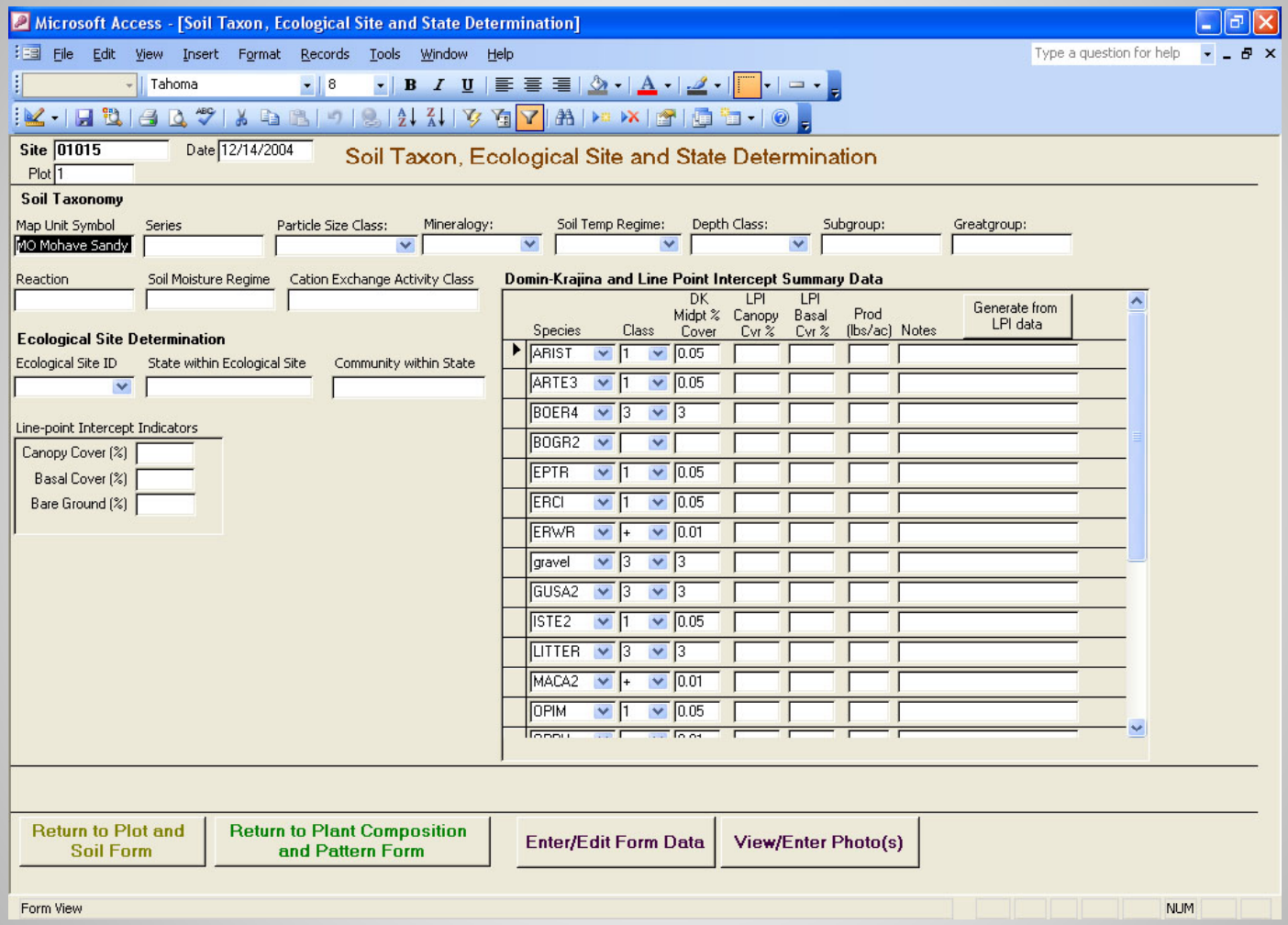
= 1/10th acre plot

or



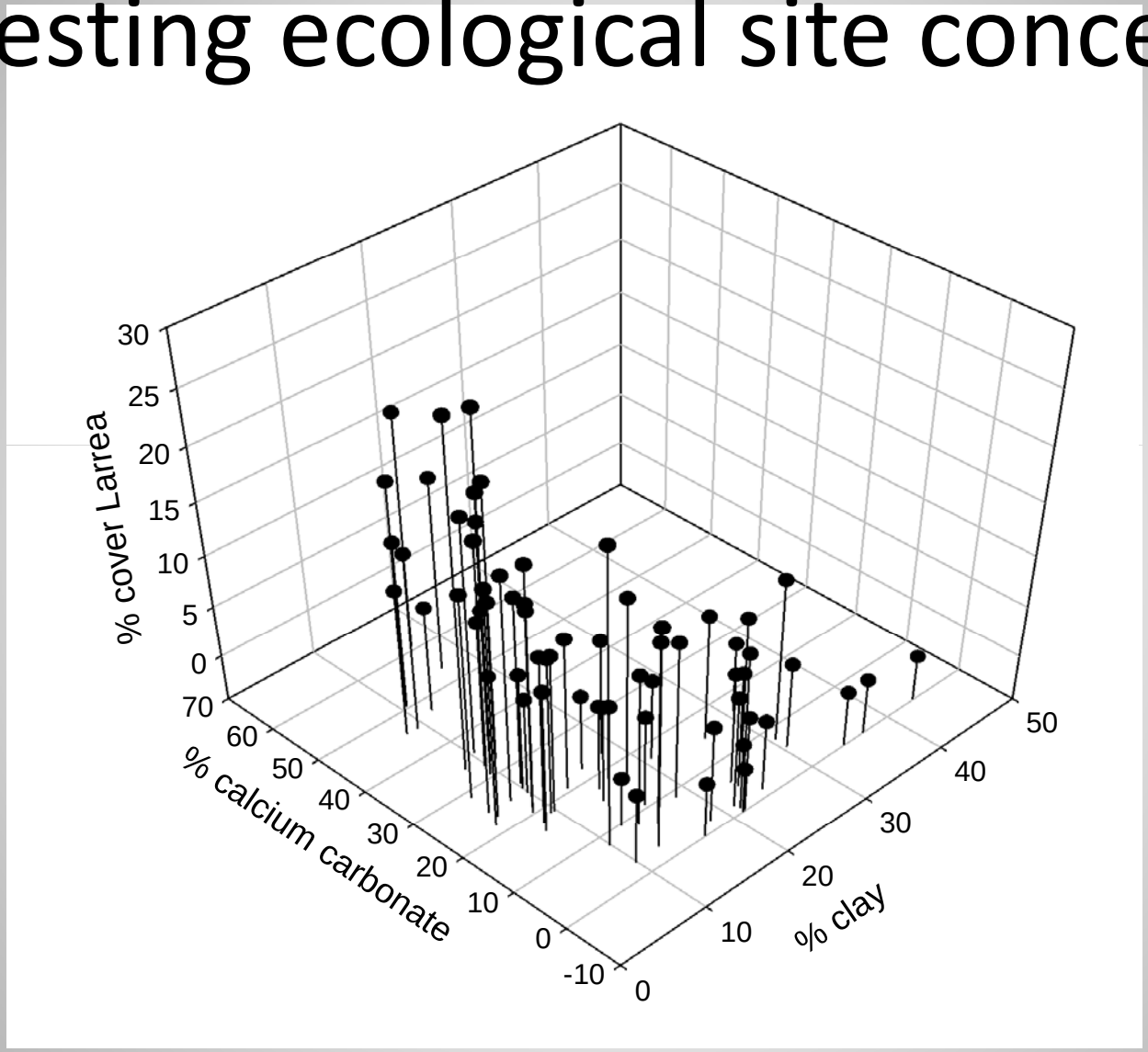
Link observations of vegetation and soils: cover estimated ocularly or using LPI, but must be quick enough to get replication

Testing ecological site concepts



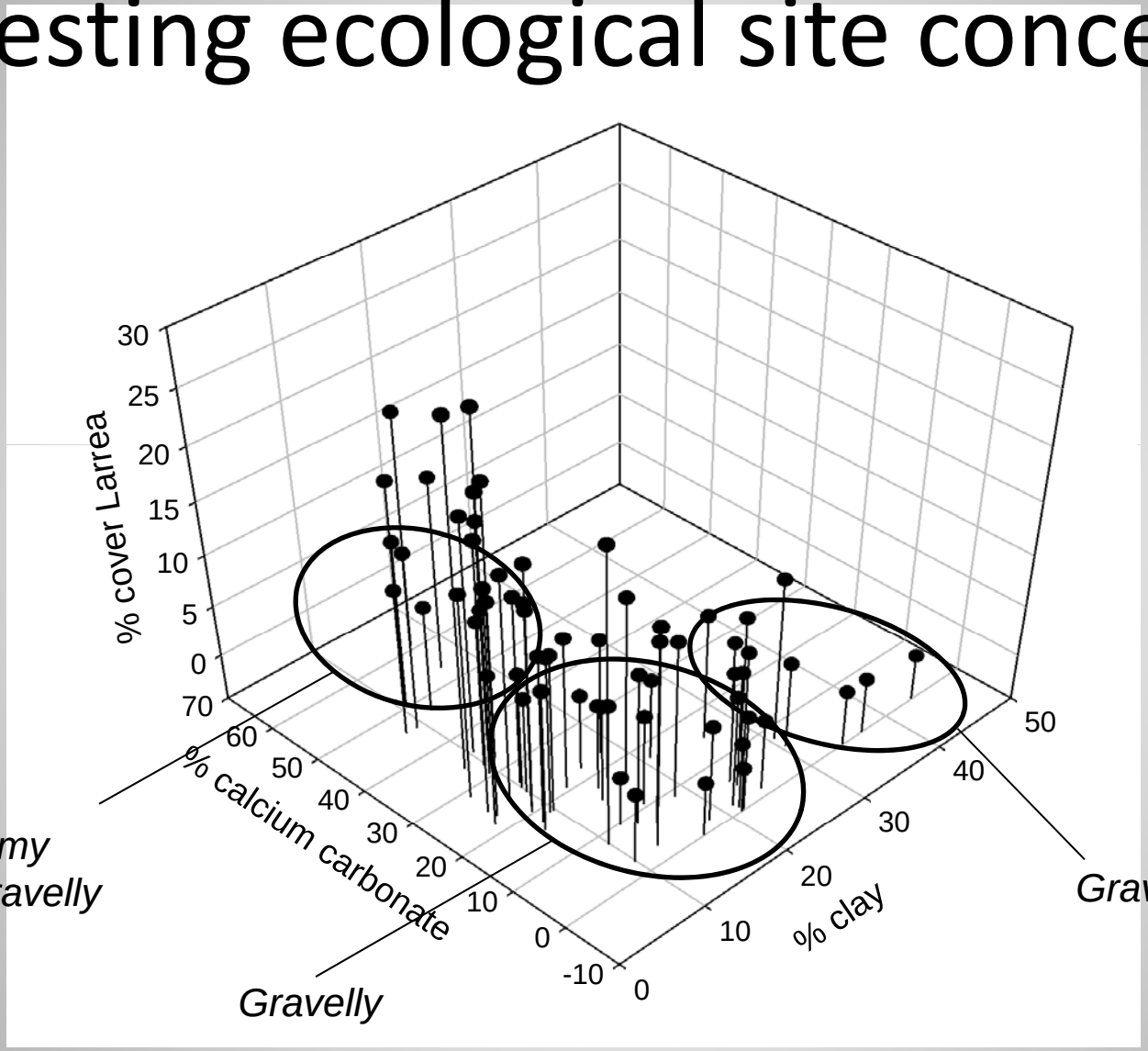
Vegetation and soils data must be databased together (JER and others have used the DIMA database)

Testing ecological site concepts



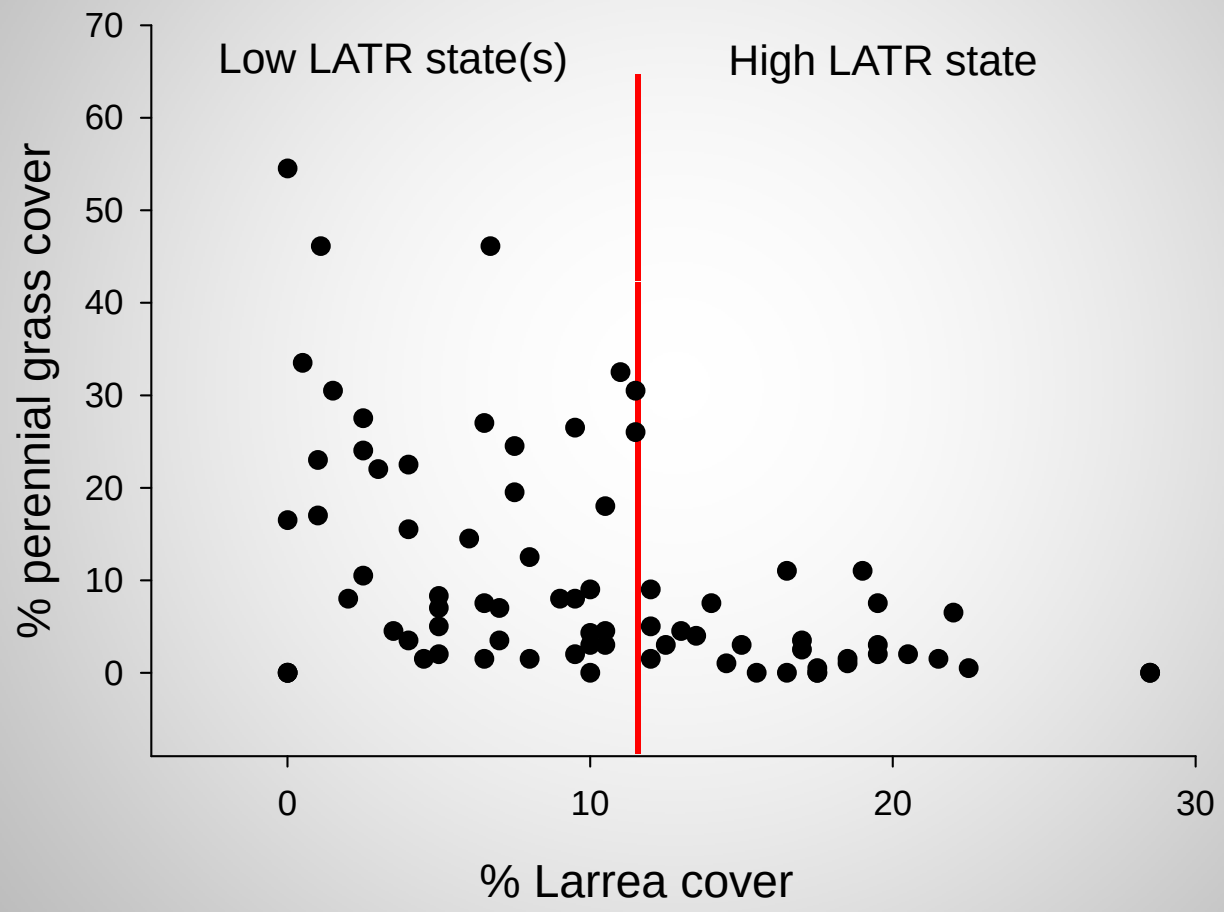
Larrea cover has complex relationships to clay and carbonate in argillic horizon

Testing ecological site concepts



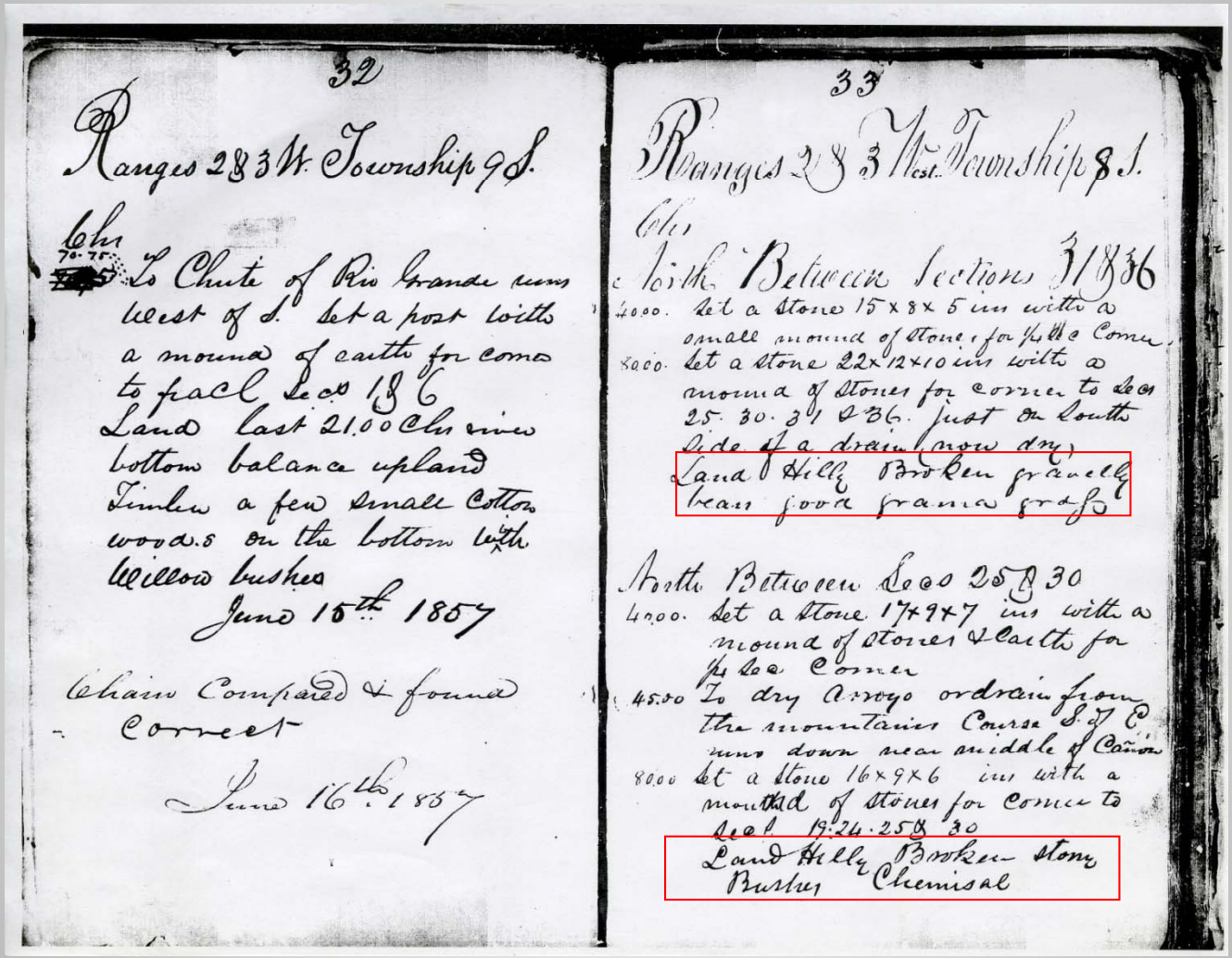
Three ecological sites potentially represented in this sample

Testing ecological site concepts



Inventory data support existence of alternative states (12% creosotebush canopy cover is a good break)

Testing ecological site concepts



32

Ranges 2 & 3 W. Township 9 S.

Chs
70.75 To Chute of Rio Grande runs West of S. set a post with a mound of earth for corner to secs 18 & 19
Land last 21.00 Chs river bottom balance upland
Timber a few small Cottonwoods on the bottom with Willow bushes
June 16th 1857

Chains Compared & found Correct
June 16th 1857

33

Ranges 2 & 3 West Township 9 S.

Chs
North Between Sections 31 & 36
40.00. Set a stone 15 x 8 x 5 ins with a small mound of stones for 1/4 Sec Corner
80.00. Set a stone 22 x 12 x 10 ins with a mound of stones for corner to secs 25. 30. 31 & 36. just on South side of a drain (now dry)
Land Hilly Broken gravelly bean good grama grass

North Between Secs 25 & 30
40.00. Set a stone 17 x 9 x 7 ins with a mound of stones & earth for 1/4 Sec Corner
45.00 To dry Arroyo or drain from the mountains Course S 27 E runs down near middle of Cañon
80.00 Set a stone 16 x 9 x 6 ins with a mound of stones for Corner to secs 19. 24. 25 & 30
Land Hilly Broken stony Bushy Chemisal

Historical evidence tied to inventory: in the 1850s, evidence of grass-dominated and *Larrea*-dominated patches in area: which soil?

Developing ecological site descriptions

How should we decide the ecological sites to be recognized?

USDA-NRCS NRPH (2007)

Presence (or absence) of one or more species that make up 10 percent or more of the reference plant community by air-dry weight.

A 20 percent (absolute) change in composition, by air-dry weight, between any two species in the reference plant community.

A difference in average annual herbaceous production of:

-50% @ 200–500 lb/ac

-30% @ 500–1,000 lb/ac

-20% @ 1,000 lb/ac or greater

Other considerations? (e.g., responses to management)

Soil-site correlation

Nickel-Tencee-Delnorte complex, moderately sloping, soil map unit

		Ecological Site			
Soil map unit component		**MLRA**	**Sub-MLRA**	**Eco Site**	**State**
Nickel very fine gravelly sandy loam		042	XB	Gravelly	NM
Del Norte gravelly loam		042	XB	Gravelly	NM
Tencee very gravelly sandy loam		042	XB	*Limy gravelly	NM
*proposed new site					

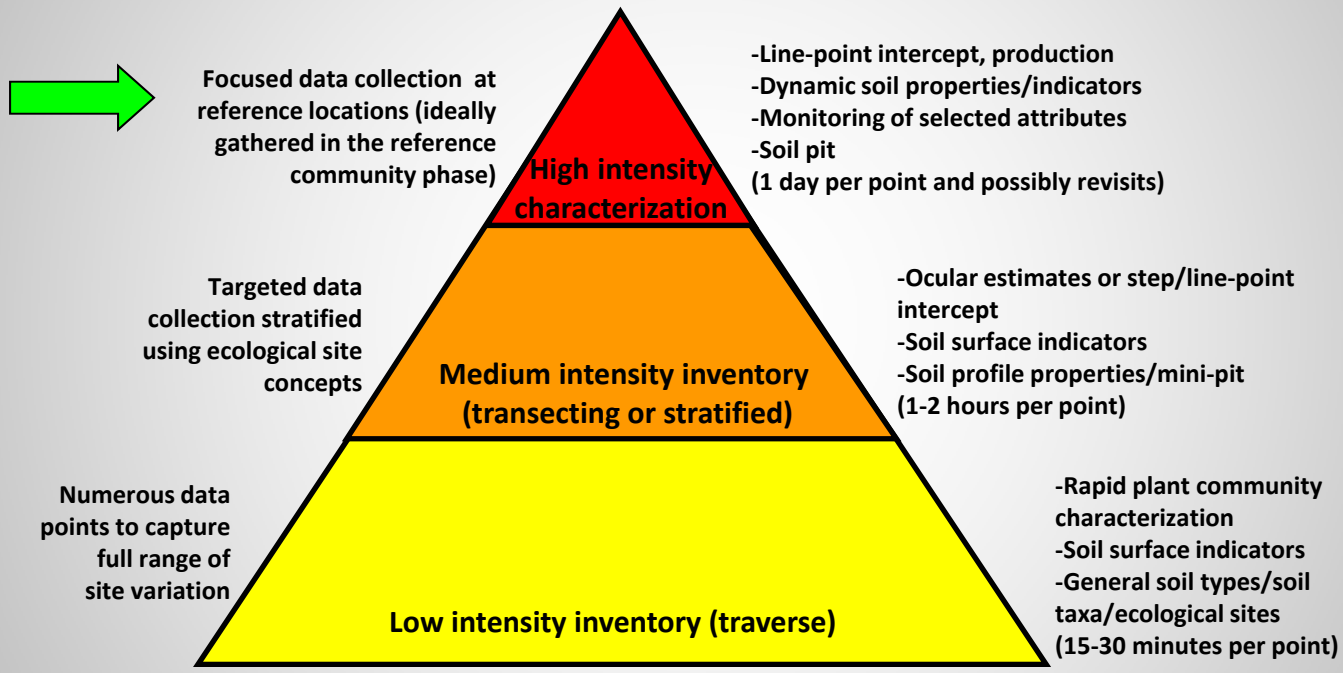
Soil-site correlation “rules”

An ***ecological site*** can include more than one soil series, provided that the soils are similar

A ***soil map unit*** can include more than one ecological site. Soil map units often include many different soils, with different potentials to support plant communities

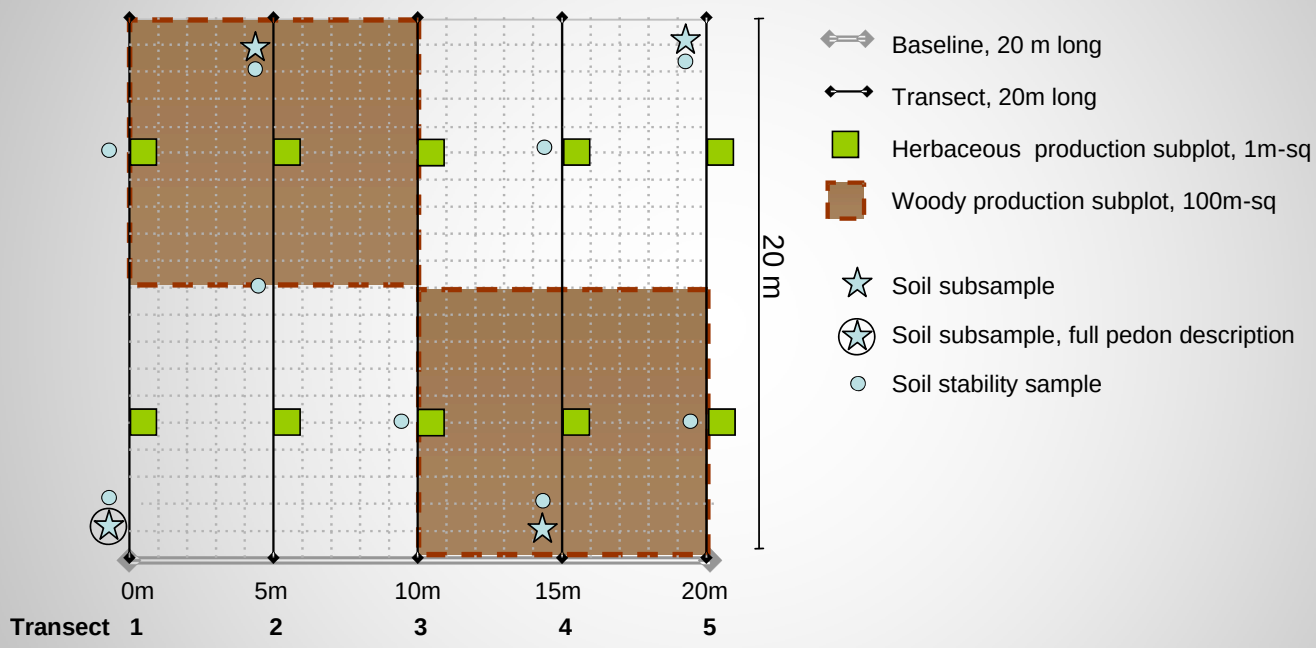
Even a ***soil series*** can include more than one ecological site. Soil surface texture often varies within a soil series. Soil surface texture is very important in distinguishing ecological sites.

High intensity Samples



High intensity Samples

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



- Three replicates per state per site
- Consider monitoring to document temporal variations due to climate

Develop interpretations

- High intensity data and other data:
  - Domestic animal uses/forage
  - Wildlife habitat (by state or community)
  - Hydrologic functions
  - Recreation
  - Future options (carbon sequestration, dust control, more detail on wildlife habitat)

Developing State-and-Transitions Models
Deep Sand Savannah Ecological Site

- 1750 – 2000 m elevation
- Flat to rolling dune topography
- Aeolian sand deposits – Deep, fs, lfs; lfs, fsl
- 33 – 40 cm average annual precipitation
- 75 % of precipitation comes during late growing season (late July, August and early Sept.)
- 130 – 160 day growing season (early May to early Oct)

Historical Accounts

- Golden-grassed plains
  - Spanish mission early 1600's– (Horgan, 1954)
    - Abandoned 1671
- Good grass cover, scattered piñon and juniper (McLeullough, 1882)
- Treeless but very grassy with sabinos (junipers) dotting it (Bandelier, 1884)

Natural Range of Variability

- Fire maintained grassland or savannah aspect (Natural and human ignition)
  - 4 – 6 years (Frost, 1998)
  - 6 – 11 years (Baisan & Swetnam, 1997)
  - 16 – 20 years (Allen, 1989)
- Drought/Wet Years
- Herbivory
  - Blacktailed Jackrabbit
  - Pronghorn Antelope

Pre-Anglo/American Settlement

- Tall and mid warm season bunchgrasses
- Mid and short warm and cool season grass understory
- Forbs – variable with season and weather
- Woody – spatially and temporally variable depending on time since last fire
- Annual Production ~ 1200 kg/ha

Deep Sand Savannah

Post-Anglo/American Settlement Dynamics

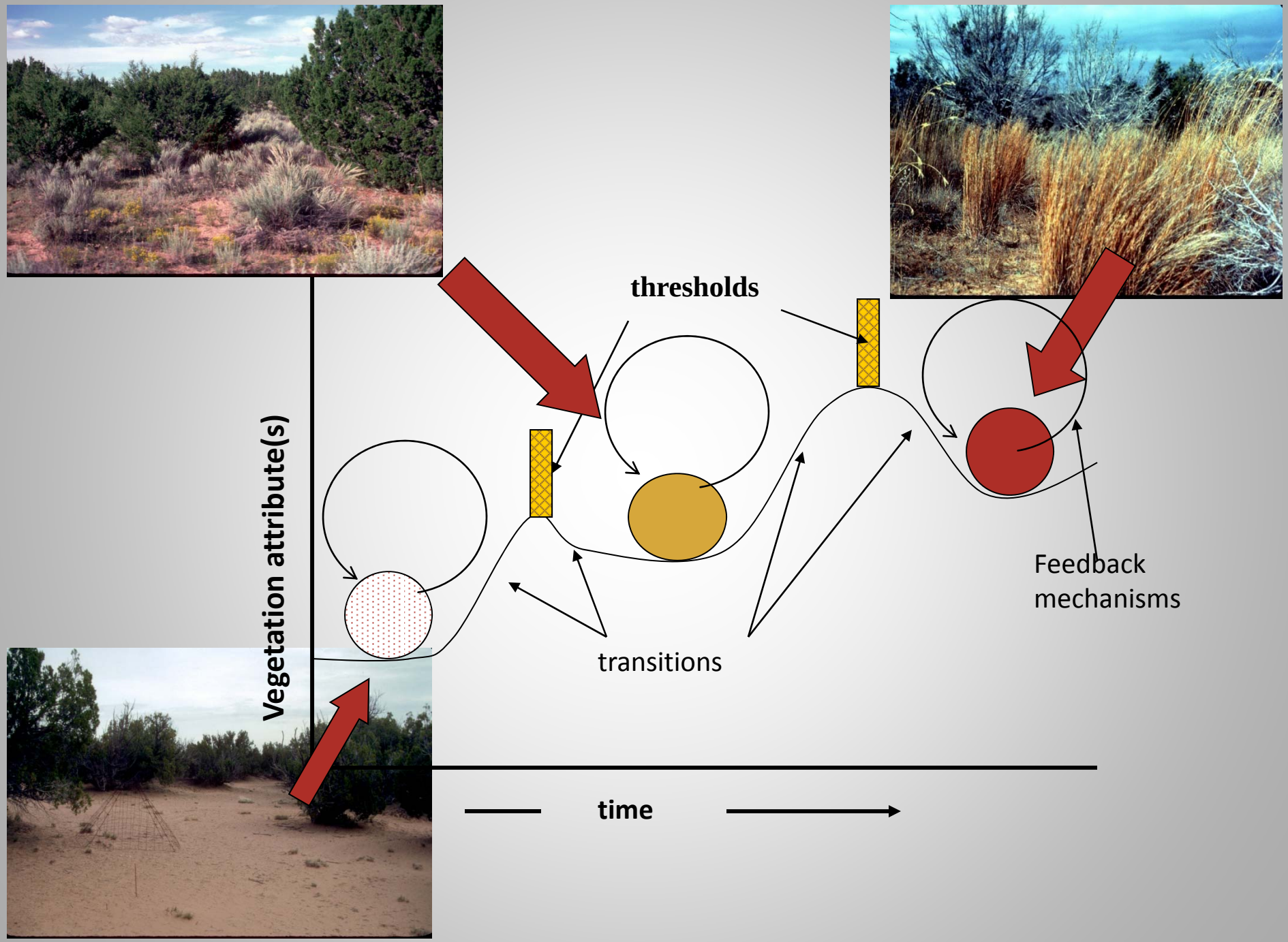
- Large herds of livestock
  - 1870 - 1880 – < 1 million sheep & 137,000 cows
  - 1890 – 5 million sheep & 1.3 million cows
  - 1906 – 6 million sheep & 1 million cows
  - 1979 – 600,000 sheep & 1.5 million cows
  - 2007 – 127,000 sheep & 1.5 million cows
- Fire suppression
  - Lack of fine fuel
  - Active suppression

Present

- One-seed juniper > 4 m tall
- Juniper canopy cover 15 - 25%
- Annual herbaceous production 100 – 200 kg/ha

Local Knowledge and Expertise

Deep Sand Savannah

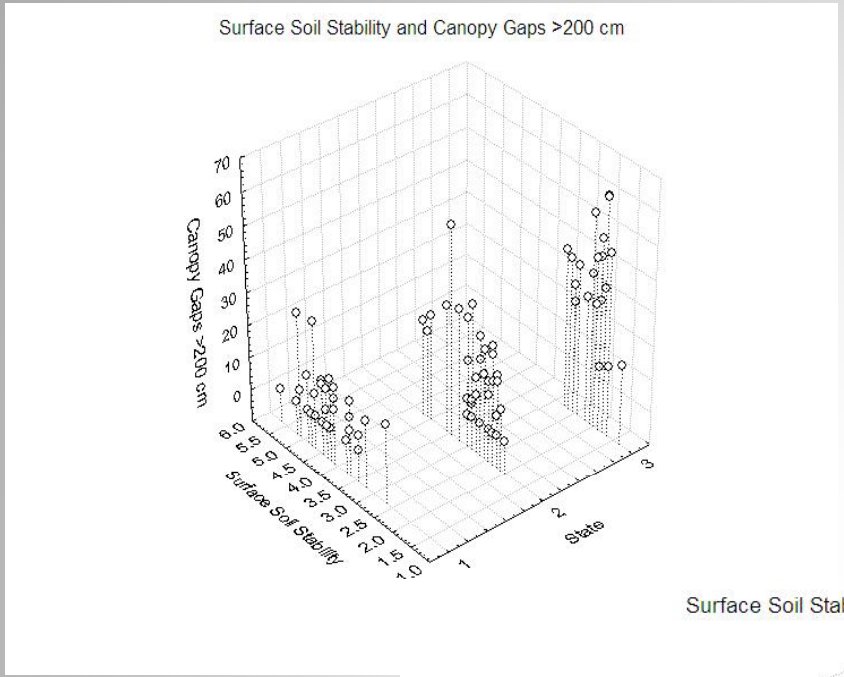

thresholds
Vegetation attribute(s)
transitions
Feedback
mechanisms
time

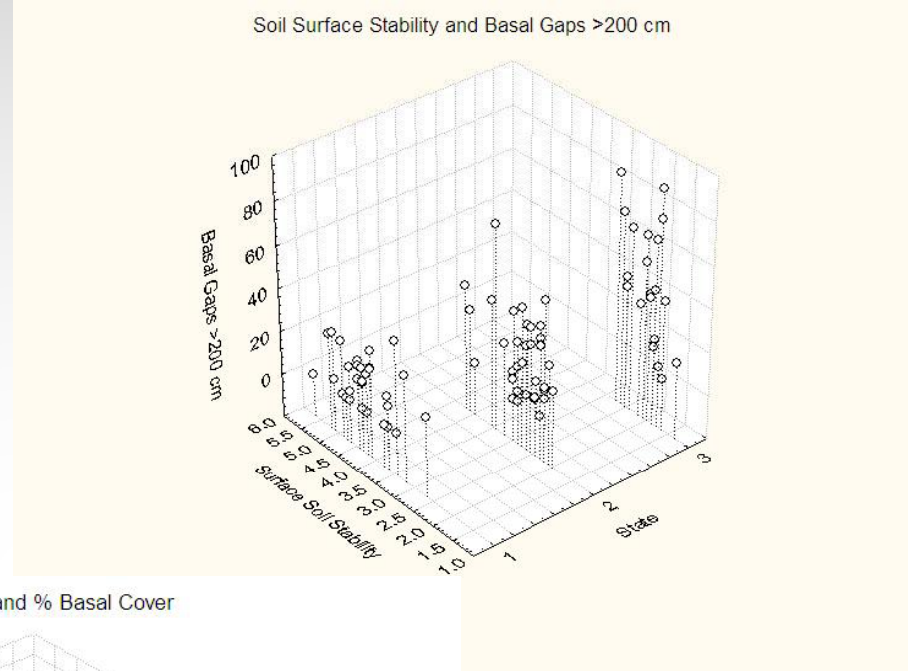
State-and-Transition Model

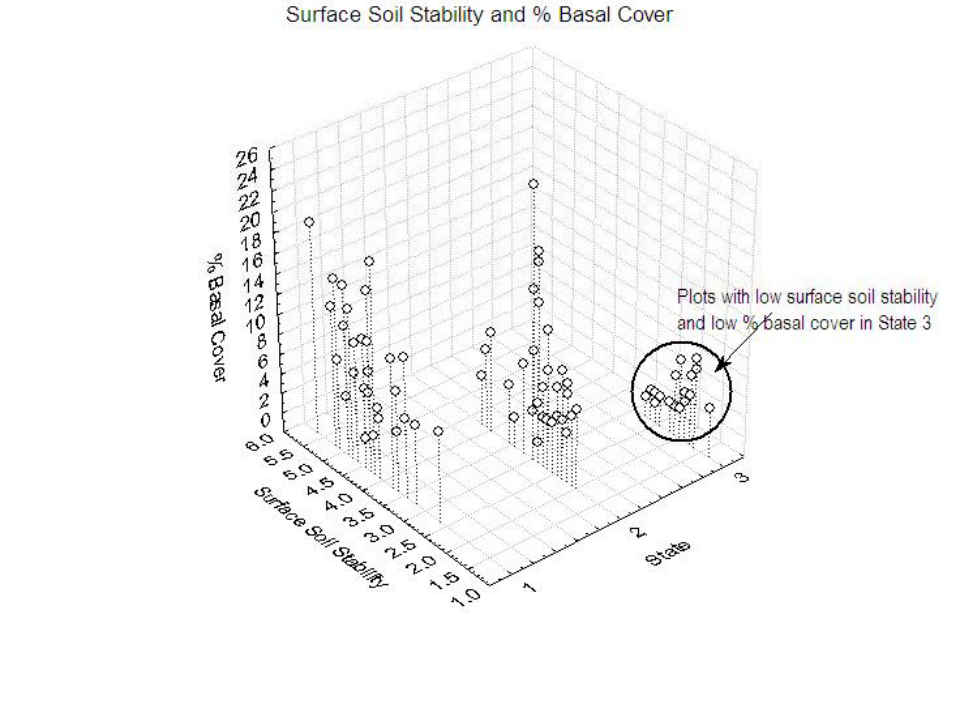
	Reference State 1.0	Juniper State 2.0	Eroded State 3.0
Surface Soil Stability	>4.0	2.6 – 3.0	< 2.4
Subsurface Soil Stability	>2.4	1.6 – 1.8	< 1.6
Canopy Gaps > 200cm	<10%	10% - 20%	> 28%
Basal Gaps > 200cm	< 17%	17% - 29%	> 33%
Basal Cover	>7%	5% - 9%	< 4%
Juniper Foliar Cover	<17%	18% - 27%	>20%
Herb. Foliar Cover	>45%	>45%	<41%
Bare Ground	<33%	28% - 37%	>39%

Values are within 95% C.I. of the mean.

State-and-Transition Model







State-and-Transition Model

- Reference State
  - Six transects
    - Both soil stability measurements <95% C.I.
    - At least one gap measurement >95% C.I.
  - Two transects
    - Surface or subsuface <95% C.I.
    - Both gaps measurements >95% C.I.
- Juniper State
  - Five transects
    - Both soil stability measurements >95% C.I.
    - At least one other variable >95% C.I.

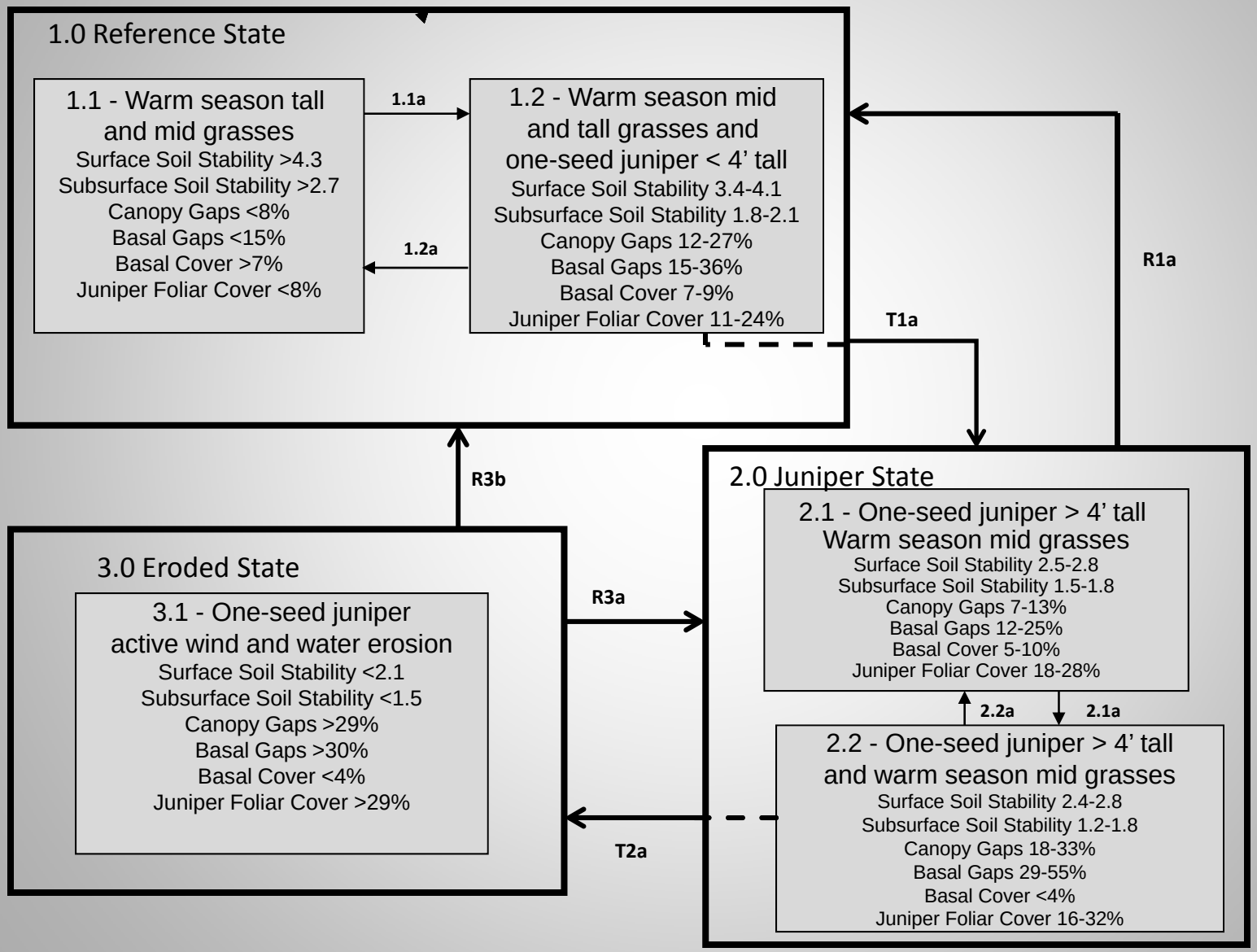
Means and 95% C.I. for these 13 transects were computed
Repeated this process for Juniper State and Eroded State
Developed quantitative matrix of components for each community phase

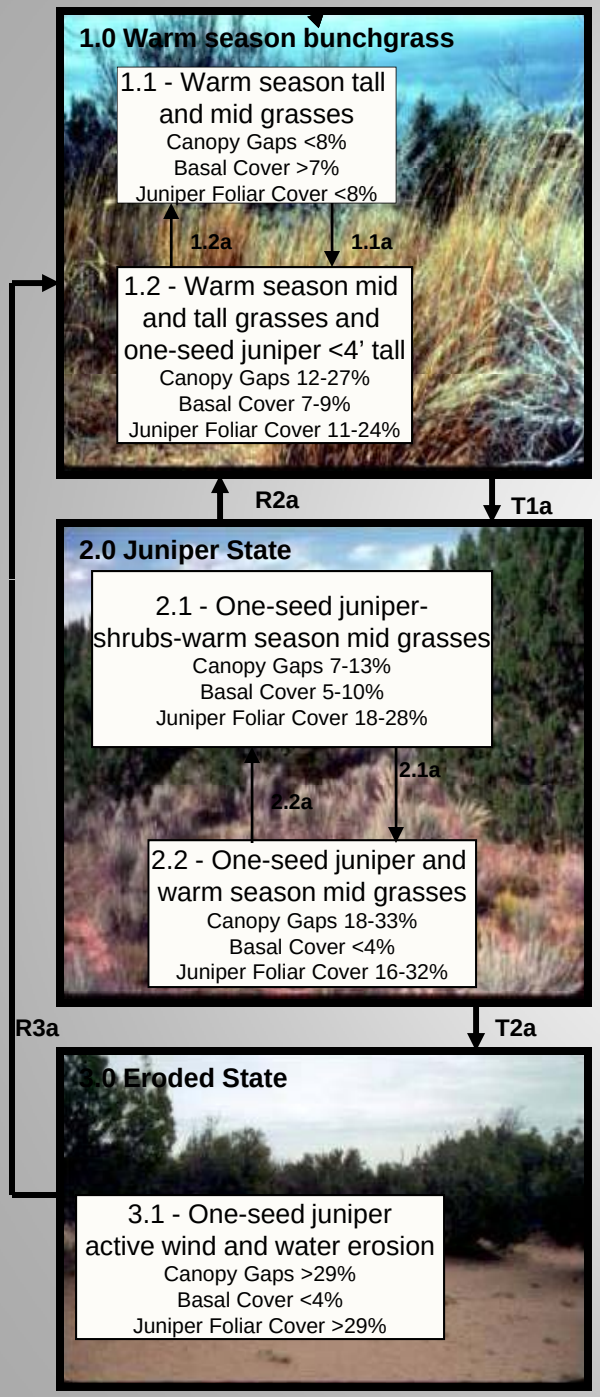
State-and-Transition Model

State	Reference State		Juniper State		Eroded State
Community Phase	1.1	1.2	2.1	2.2	3.1
Surface Soil Stability	>4.3	3.4 – 4.1	2.5 – 2.8	2.4 – 2.8	<2.1
Subsurface Soil Stability	>2.7	1.8 – 2.1	1.5 – 1.8	1.2 – 1.8	<1.5
Canopy Gaps > 200cm	<8%	12 – 27%	7 – 13%	18 – 33%	>29%
Basal Gaps > 200cm	<15%	15 – 36%	12 – 25%	29 – 55%	>30%
Basal Cover	>7%	5 – 9%	5 – 10%	<4%	<4%
Juniper Foliar Cover	<8%	11 – 24%	18 – 28%	16 – 32%	>29%
Herb. Foliar Cover	>46%	40 – 54%	47 – 57%	32 – 46%	<30%
Bare Ground	<32%	24 – 42%	27 – 37%	33 – 47%	>39%

Value ranges within 95% C.I. of the mean

State-and-Transition Model

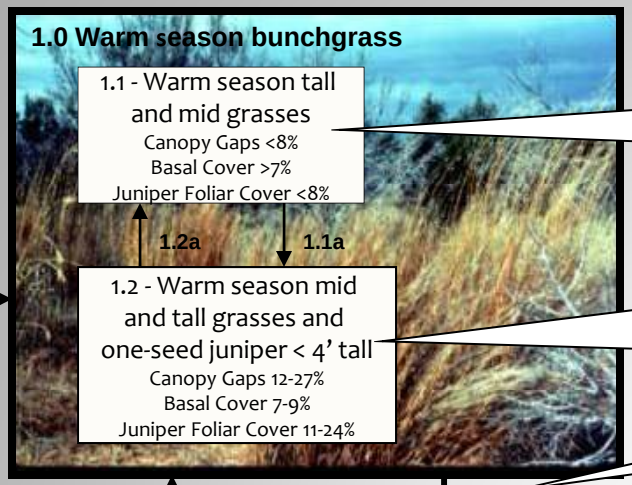




1.0 Warm season bunchgrass (reference state): Two community phases
Diagnosis & Indicators: High perennial grass cover and production. Surface soil stability >3.4, one-seed juniper less than 4'tall.
Feedbacks & Ecological Processes: Organic matter inputs allows for increased soil moisture, herbaceous production, root turnover and litter increasing soil surface stability, infiltration and nutrient cycling.
1.1 Warm season tall and mid grasses (reference phase): Canopy gaps <8%, basal cover >7% and juniper foliar cover <8%, surface soil stability >4.3, subsurface soil stability >2.7, bare ground <32%.
1.2 Warm season mid & tall grasses and one-seed juniper <4' tall (at-risk phase): Canopy gaps 12-27%, basal cover 7-9%, juniper foliar cover 11-24%, juniper <4' tall, surface soil stability 3.4-4.1, subsurface soil stability 1.8-2.1, bare ground 24-42%.
Management: Management actions focus on activities that maintain herbaceous production and organic matter inputs. Prescribed burning or other actions to limit juniper establishment and growth are necessary.
Transition-1a: *Slow variables and triggers*: Elimination of fire and overgrazing causing increase juniper establishment and growth.
Thresholds: Surface soil stability <3.4, basal cover <7%, juniper foliar cover >24%, juniper >4' tall.
Restoration Pathway-R2a: Decrease juniper canopy cover and height, increase organic matter inputs.

2.0 Juniper State (alternative state 2): Two community phases
Diagnosis & Indicators: Juniper canopy cover controls the soil moisture, herbaceous production and organic matter inputs. Juniper >4' tall, Surface Soil Stability 1.2-1.8.
Feedbacks & Ecological Processes : Juniper use of moisture, decreasing herbaceous production, decreasing organic matter inputs, and nutrient cycle, decreasing infiltration and surface soil stability.
2.1 One-seed juniper-shrubs-warm season mid grasses: Juniper >4' tall, with foliar cover 18-28%, understory shrubs common, canopy gaps 7-13%, basal cover 5-10%, surface soil stability 2.5-2.8, subsurface soil stability 1.5-1.8, bare ground 27-37%.
2.2 One-seed juniper warm season mid grasses (at-risk phase): Juniper >4' tall, with foliar cover 16-32%, understory shrubs missing, canopy gaps 18-33%, basal cover <4%, surface soil stability 2.4-2.8, subsurface soil stability 1.2-1.8, bare ground 33-47%.
Management: Management actions focus maintaining understory shrub and herbaceous production and ground cover. Manipulation of brush species, prescribed burning and other management focused to maintain or improve herbaceous production and shrub cover.
Transition-2a: *Slow variables and triggers*: Juniper canopy increase causing decrease in shrubs understory and herbaceous production and cover causing decrease in organic matter inputs.
Thresholds: Surface soil stability <2.4, bare ground >40%, canopy gaps >30%, basal cover <4%.

3.0 Eroded State (alternative state 3) one community phase-3.1: Active wind & water erosion .
Diagnosis & Indicators: Juniper foliar cover >29%, surface soil stability <2.1, subsurface soil stability <1.5, canopy gaps >29%, basal cover <4%, bare ground >39%.
Feedbacks & Ecological Processes: Juniper use of all available moisture, eliminates organic matter inputs, decreases soil surface stability, increases wind and water erosion.
Restoration Pathway-R3a: Restoration practices planned must decrease juniper canopy with little or no surface disturbance, increase herbaceous production and allow for litter accumulation to improve organic matter inputs to stabilize soil surface.



1.1a: " …time since last fire or by a series of dry years followed by wet years. … opportunity for juniper seedling establishment increases. … decreases herbaceous production, crown cover and organic matter input into the soil, … allow juniper seed germination and establishment…"

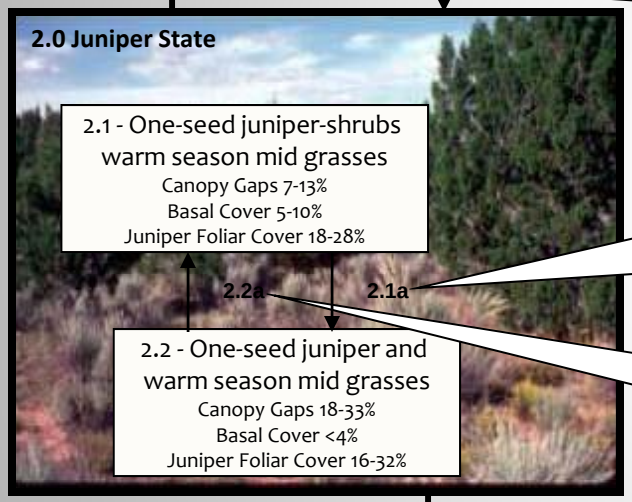
1.2a:"…fire frequency allows for ground fires that remove juniper seedlings and established plants less than 1.5 meters tall…"

T1a: "… slow variables and triggers for this transition are the elimination of fire due to decrease in fine fuels allowing juniper canopy. The threshold values…surface soil stability < 3.4, basal cover <7%, juniper foliar cover >24%, juniper >4' tall…"

R2a

T1a

R2a:"…removal of juniper canopy cover to < 5% with minimal soil surface disturbance… management actions that increases herbaceous production and favors the establishment and growth of warm season tall and mid grasses…"

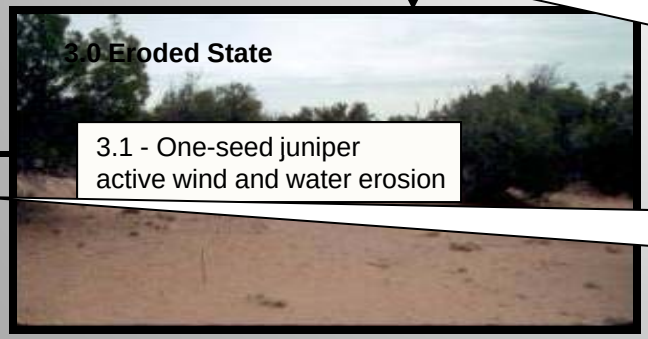


2.1a:"…juniper canopy increases with time since last fire ...other management action to reduce juniper canopy…increase in juniper canopy decreases shrub and herbaceous production and cover…shrubs and tall grasses decrease or are eliminated…drought years followed by wet years will allow for increase in juniper establishment..."

2.2a:"…management actions that decrease juniper canopy and increase herbaceous and shrub production…can include prescribed burning, chemical or mechanical brush management, while other management actions are aimed at increasing herbaceous production…"

T2a

T2a:"…slow variables and trigger for this transition are increase in juniper seedling establishment and juniper cover…caused by management actions that lead to decreased herbaceous production and decreased organic matter inputs…by lack of management actions that actively reduce juniper canopy cover…threshold values...surface soil stability <2.4, bare ground >40%, canopy gaps >30%, basal cover <4%. …"



R3a

R3a:"…management and restoration planned must decrease juniper canopy to <5%...little or no surface disturbance, management actions must increase herbaceous production…allow for litter accumulation…improve organic matter inputs to stabilize soil surface…"


Thank You