

*What's the Reference?  
Ecological sites and state &  
transition models: an interagency  
reference for inventory,  
assessment, monitoring and  
management*



*Part I: What's the reference - using IIRH together with S&T models*

*Part II: Ecological site identification*

*Part III: Reference sheet development*



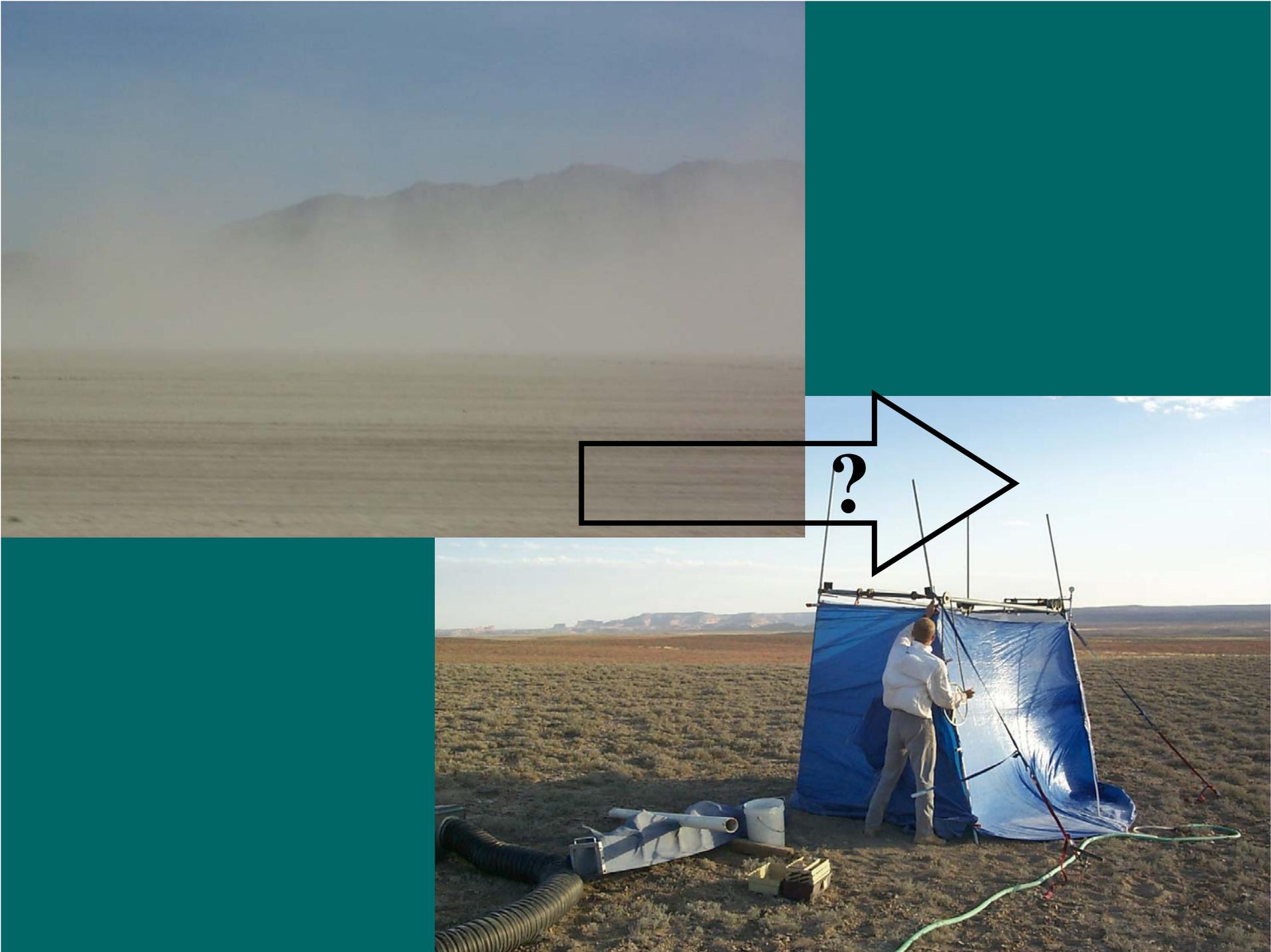
# *Part I: What's the reference?*











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- The rangeland health reference is based on what is ***possible*** (long-term ecological potential) for a particular soil and climate combination (i.e. ***ecological site***)
- S&T models indicate what is ***realistic*** (based on short-term potential and limited resource availability) (i.e. communities in an ***ecological state***)

*Knowing what's possible provides:*

- consistent standards for inventory, assessment & monitoring*
- complete range of management options*

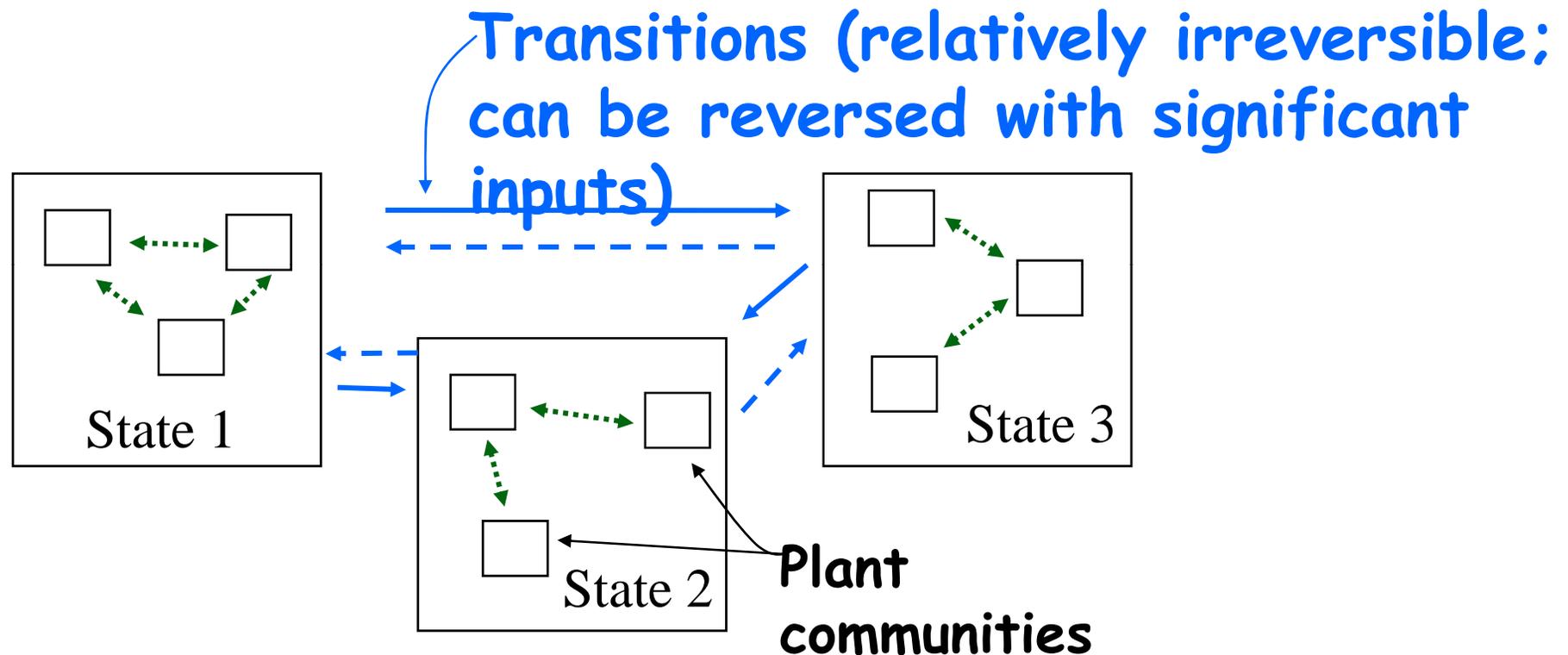


*Knowing what's realistic provides:*

- *a secondary standard for inventory, assessment & monitoring*
- *rationale for focusing limited resources on*  
*specific areas*

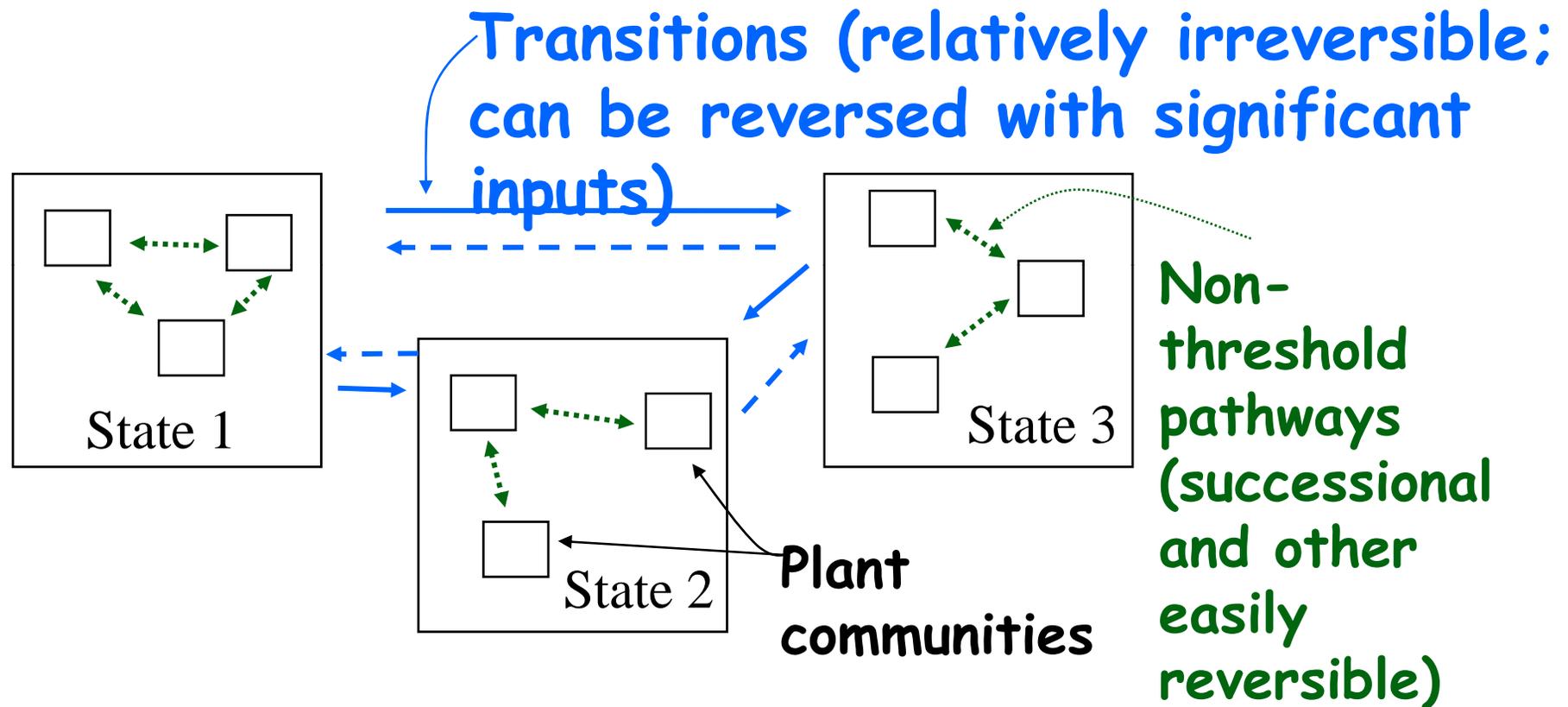


# State and Transition Diagram for an Ecological Site



Based on Bestelmeyer et al. 2003 and Stringham et al. 2003 (both in J. Range Management)

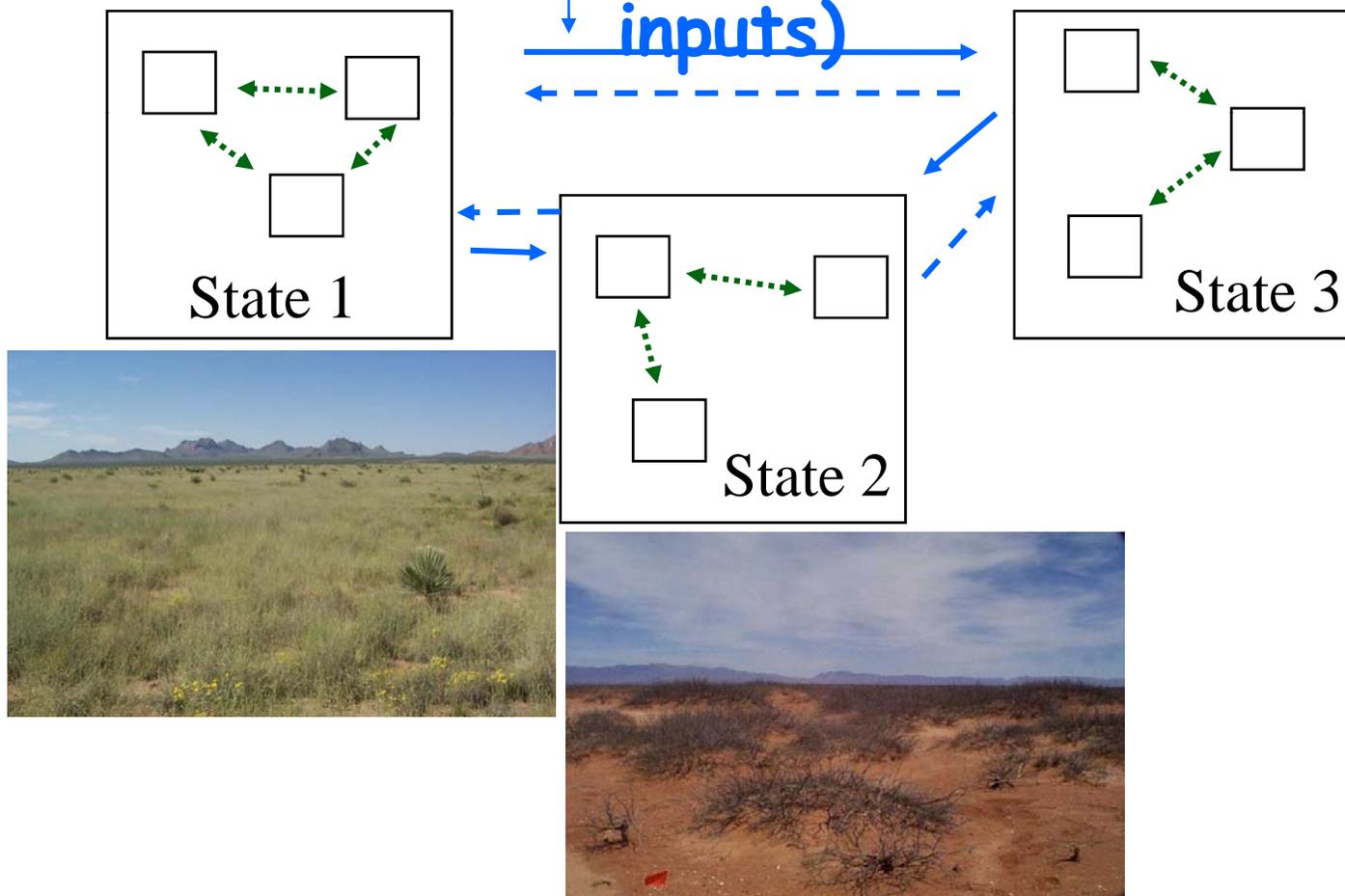
# State and Transition Diagram for an Ecological Site



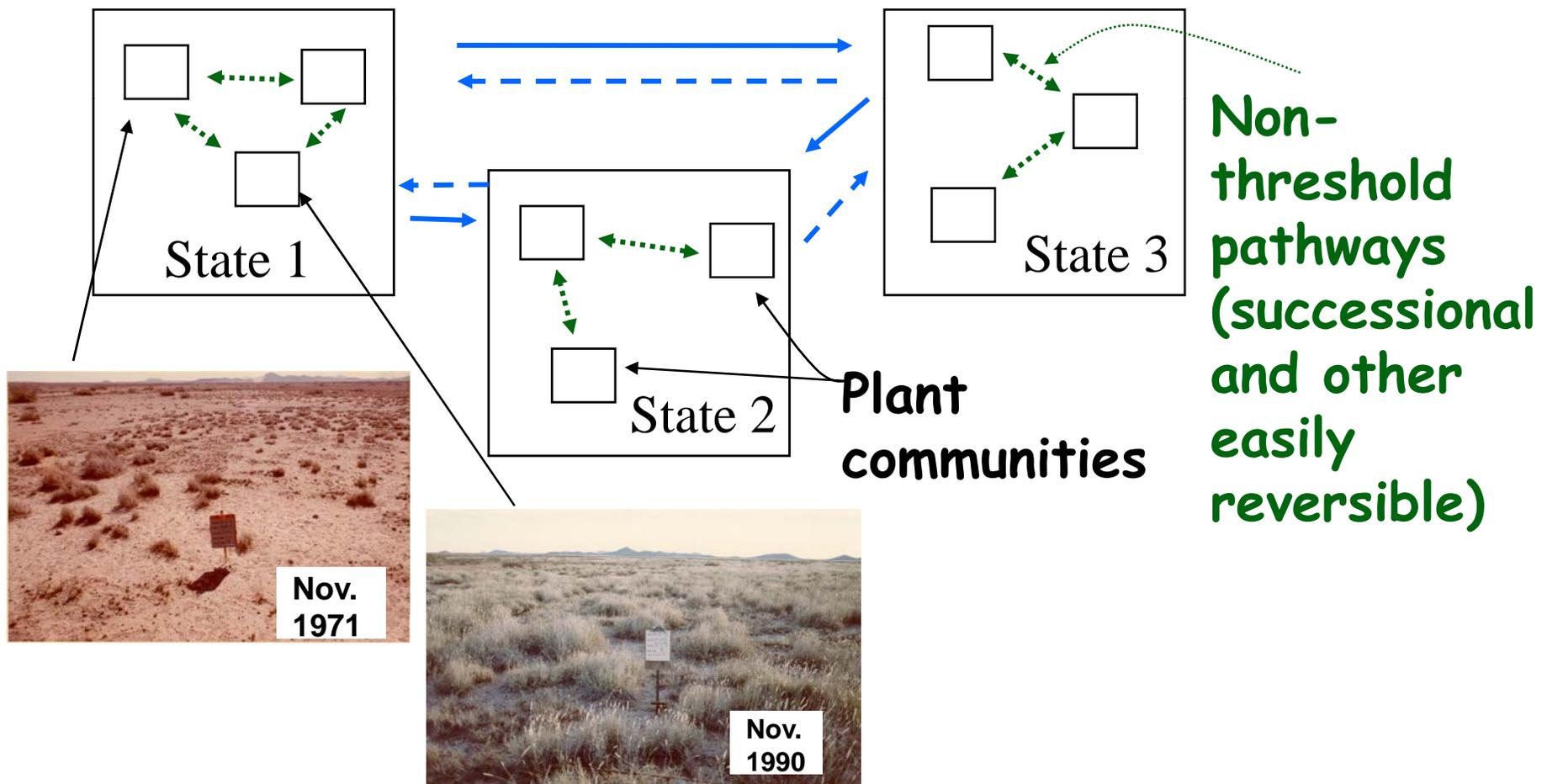
Based on Bestelmeyer et al. 2003 and Stringham et al. 2003 (both in J. Range Management)

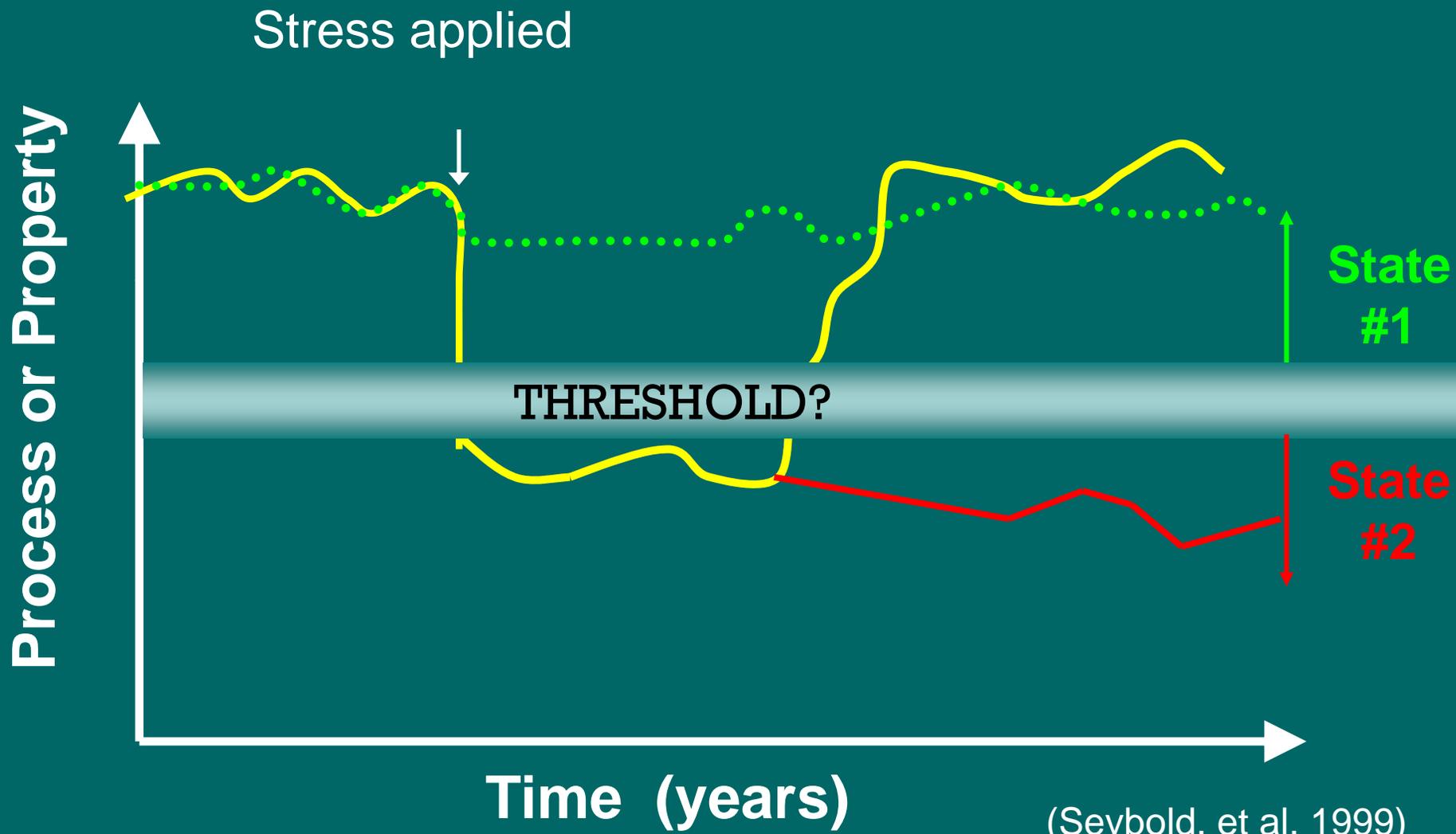
# State and Transition Diagram for an Ecological Site

Transitions (relatively irreversible; can be reversed with significant inputs)



# State and Transition Diagram for an Ecological Site





*What's possible?*

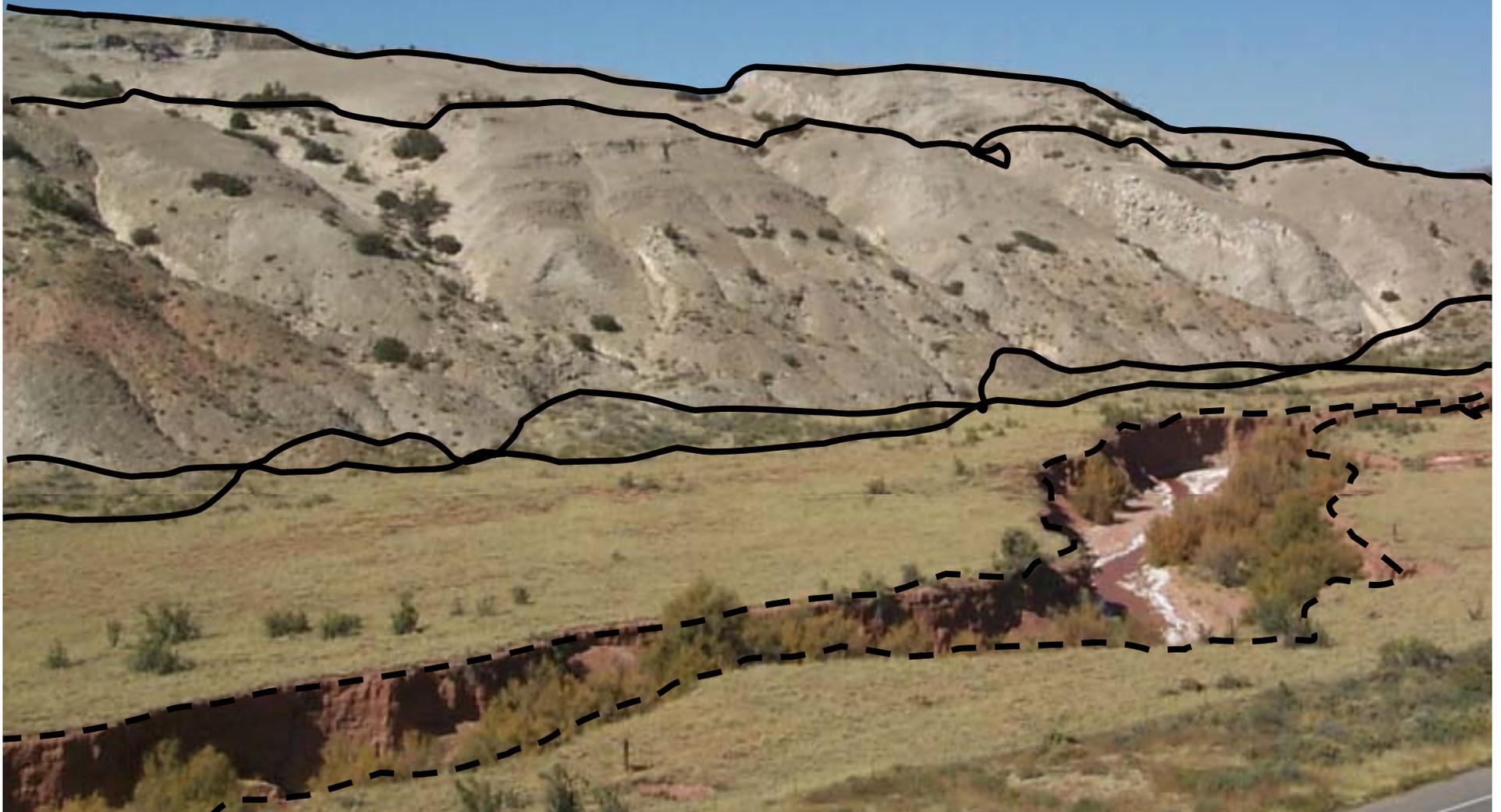


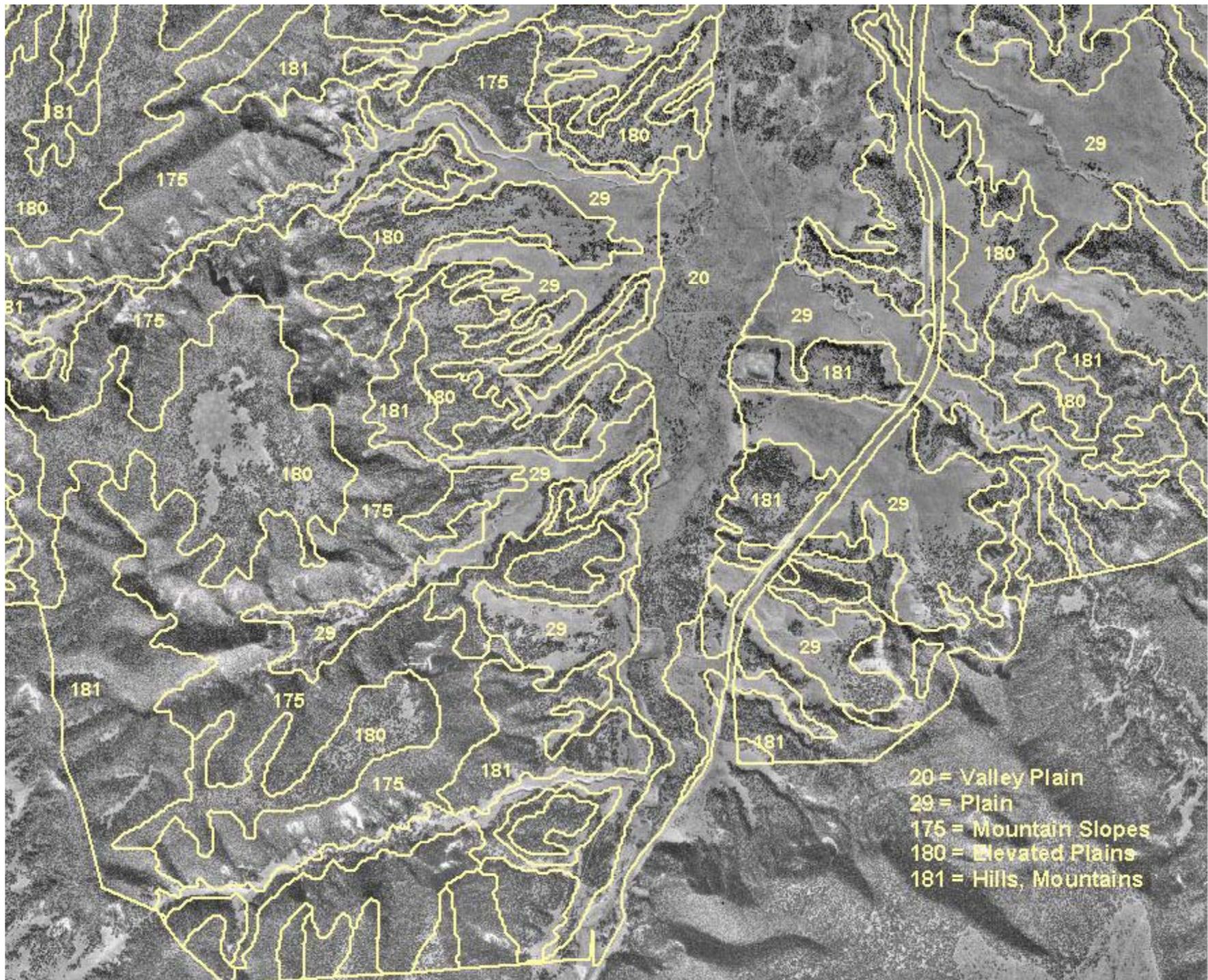
*What's possible depends on soils  
and climate (= ecological site)*

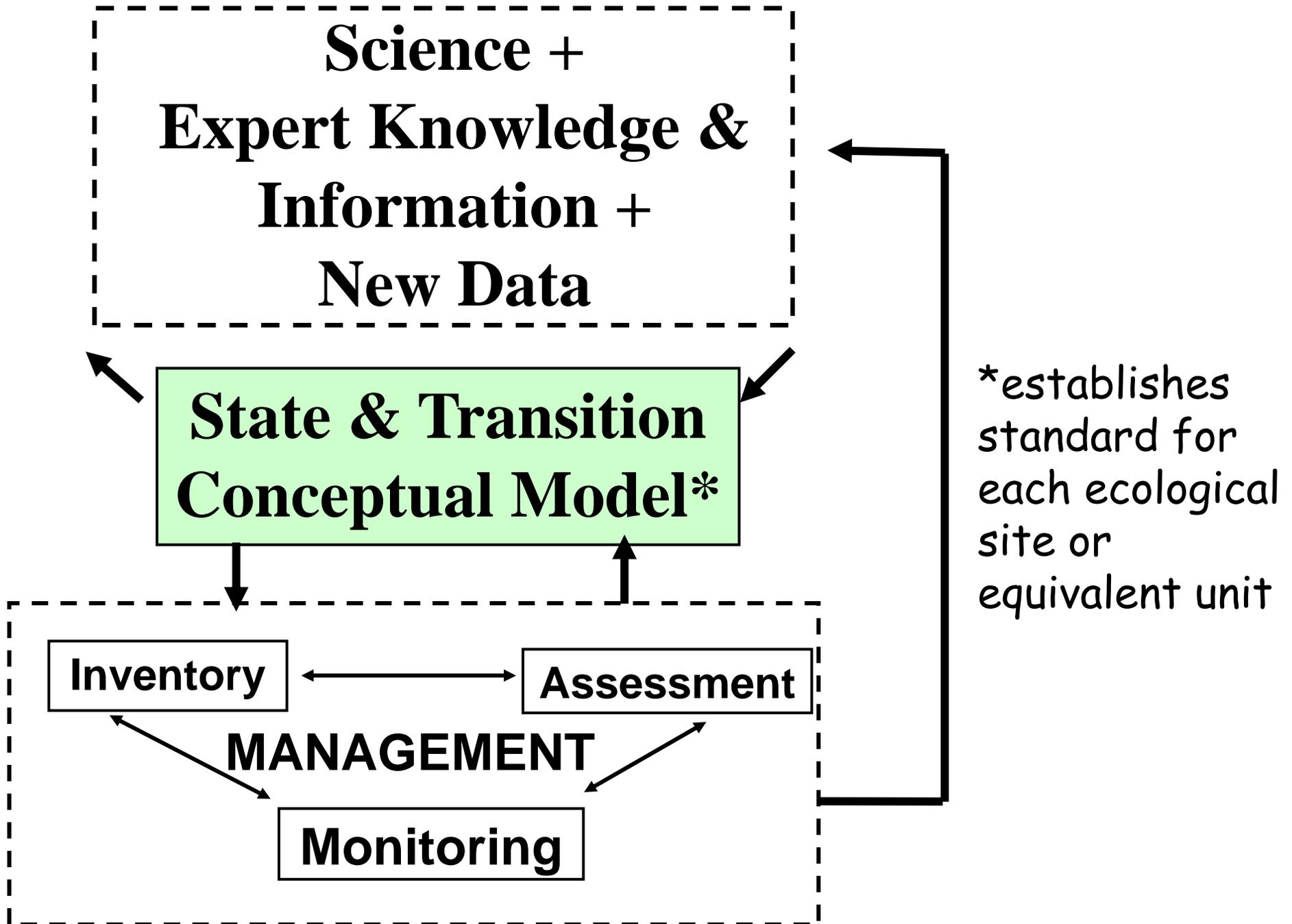




By stratifying the land based on its ecological potential, ecological sites (and functionally equivalent units) tell us what is *possible*







## *SUMMARY -- S&T models*

- ◆ *Ecological site-based state & transition conceptual models* can be used in two ways.
  - 1) The "*reference state*" = what is *possible* based on ecological site potential
  - 2) Communities within a *current state* = what is *realistic*

## ***SUMMARY*** -- IIRH and S&T are used together:

- To determine departure from the reference state
  - » None to Slight - expected for the ecological site and falls within the range of variation for the indicator (no threshold crossed)
  - » SM, M, ME - indicates that a threshold is being approached or has already been crossed
  - » Extreme to Total - Up to and including maximum possible departure for the indicator
- To identify specific issues of concern (erosion, hydrology, biotic integrity)
- To help identify and communicate management options

*Part I: What's the reference - using IIRH together with S&T models*

*Part II: Ecological site identification*

*Part III: Reference sheet development*



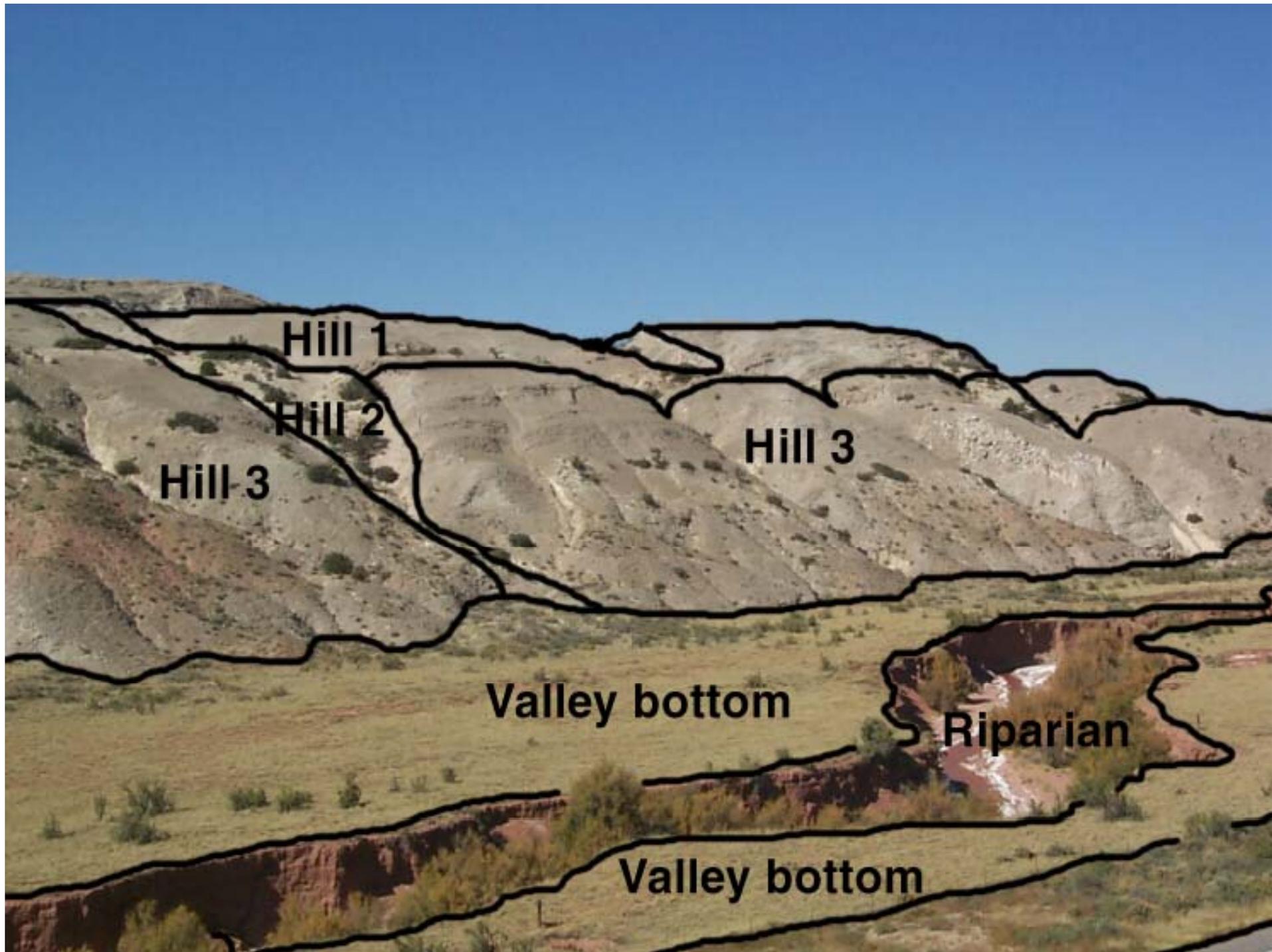
# *Objectives*

1. Understand the factors that are used to define ecological sites
2. Understand how to use a soil survey to identify ecological sites

## *Ecological Site definition:*

- ◆ An ecological site kind of land with specific physical characteristics (soil, topography, climate) which differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation in its response to management.
- ◆ In other words, a kind of land with similar potential.
- ◆ Other stratification systems can also be used.





Hill 1

Hill 2

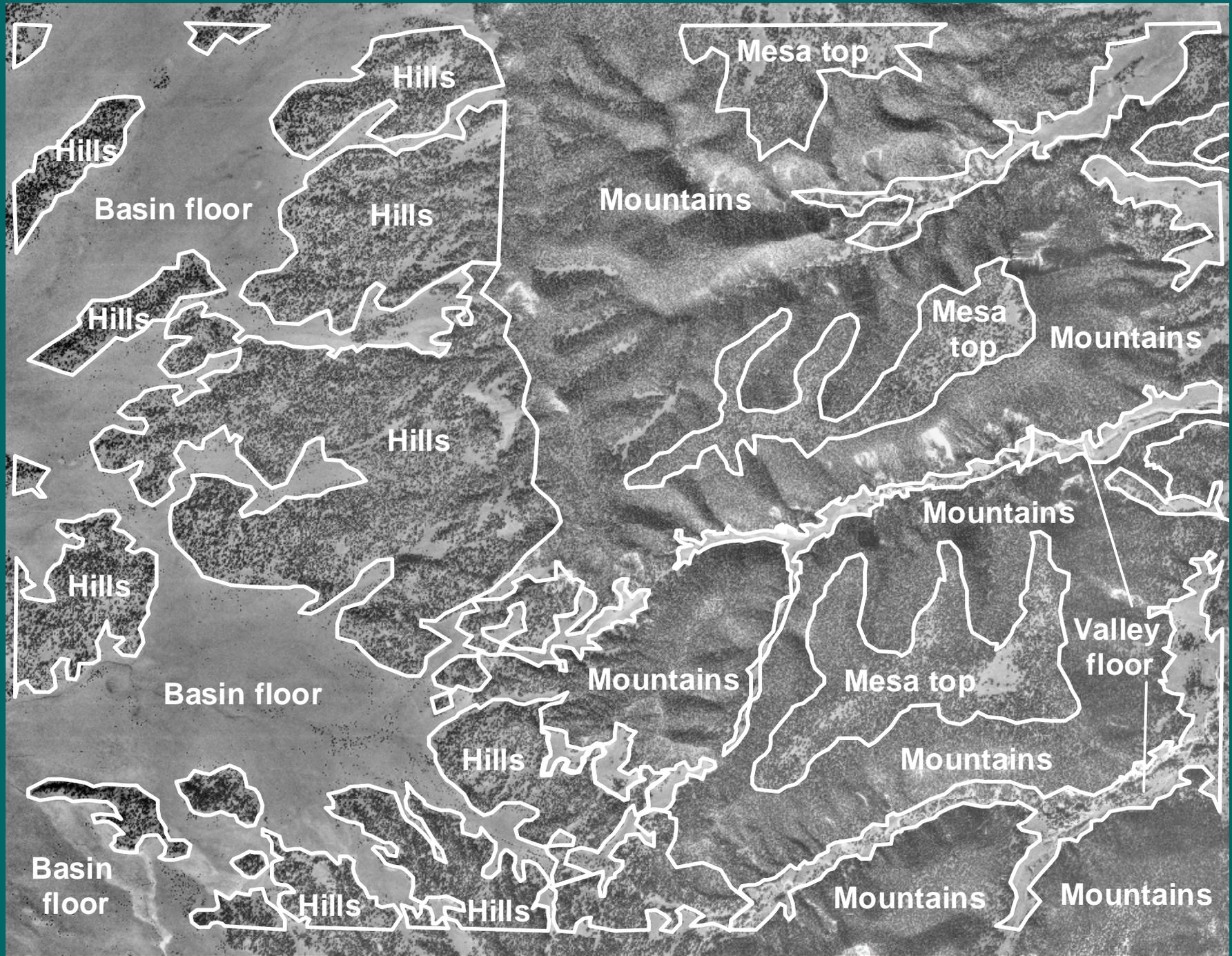
Hill 3

Hill 3

Valley bottom

Riparian

Valley bottom



# Soil maps – an intro

- ◆ **Soil map unit:** includes one or more dominant *soil map unit components* + inclusions (minor map unit components)
- ◆ Soil map unit *component*: soil series + slope and surface texture modifier
  - *Soil series* is similar to a plant species
  - *Soil map unit component* is similar to a sub-species
  - Soil map unit components repeat across the landscape, and can be part of more than one map unit

# *Soil map units*

- ◆ Soils are grouped into soil mapping units because we often cannot map soils at the scale at which they occur

## *A soil map unit (what's on the map) can be:*

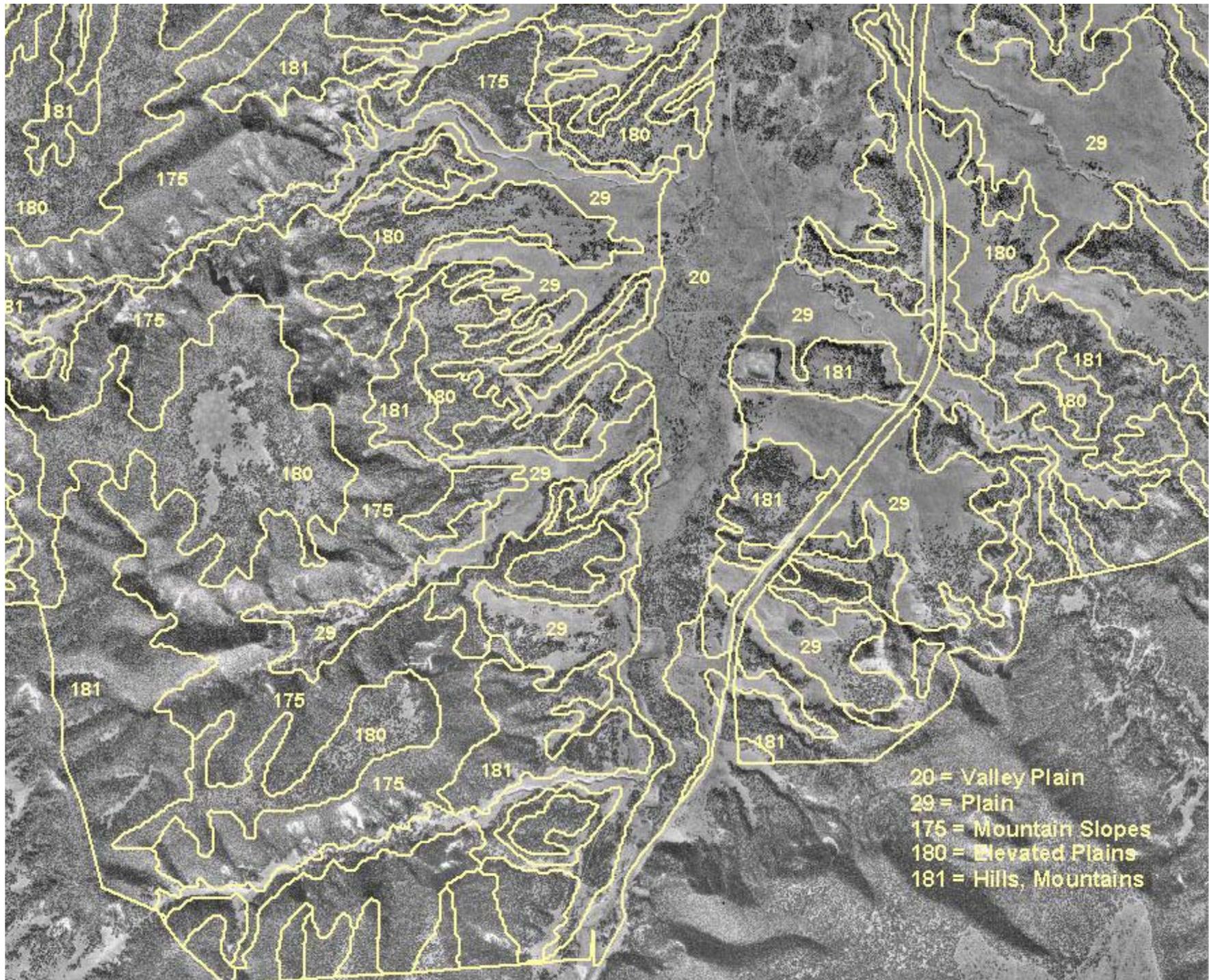
- ◆ An **ASSOCIATION** of two or more soils that occur in a repetitive and *predictable* pattern (e.g. low ridges & swales)
- ◆ A **COMPLEX** of two or more soils that usually do not occur in a *predictable* pattern at a mappable scale (e.g. coarse and fine soils in a river floodplain)
- ◆ A single soil series (but even these map units usually have “inclusions” too small to be mapped). Sometimes call a **CONSOCIATION**

# *Using soils to identify ecological sites*

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.



# *Creating ecological site maps*

- ◆ Ecological site maps can be developed from soil maps
- ◆ Like soil maps, ecological site map units include associations and complexes of multiple ecological sites

# *Ecological Site Identification Exercise*

*(complete exercise with maps under “other” in left column of [http://usda-ars.nmsu.edu/JER/Monit\\_Assess/monitoring.php](http://usda-ars.nmsu.edu/JER/Monit_Assess/monitoring.php))*

- 1) Find a soil map unit that is a complex *or* association on the map, and list the soil components it includes
- 2) Find and list a soil map unit that is *not* a complex or association. Can we assume that all areas within this map unit are the named soil?
- 3) List the complete ecological site ID for each soil component listed in #2 (e.g.025XY019NV)
- 4) It is possible for soil series to include components in different ecological sites. Are any of the series on your map in more than one ecological site?

# Soil & Site Identification Exercise

## (hints)

- 1) Find a soil map unit that is a complex or association on the map, and list the soil components it includes (*use “Index to Map Units”: Association= $\geq$ 2 components and the word “association”; Complex= $\geq$ 2 components*).
- 2) Find and list a soil map unit that is *not* a complex or association. Can we assume that all areas within this map unit are the named soil? (*use “Index to Map Units”: Consociation=1 component*).
- 3) List the complete ecological site ID for each soil component listed for the soil map unit in #2 (*listed under “Range sites” at the end of the soil map unit description*).
- 4) It is possible for soil series to include components in different ecological sites. Are any of the series on your map in more than one ecological site?

# Soil & Site Identification Exercise (answers)

- 1) Find a soil map unit that is a complex or association on the map, and list the soil components it includes  
*1010: see "Composition" on page 362*  
*1032: see "Composition" on page 368*  
*1050: see "Composition" on page 370*
- 2) Find and list a soil map unit that is *not* a complex or association. *The map unit is 1030.*  
Can we assume that all areas within this map unit are the named soil?  
*No – No – the map unit description lists 3 inclusions.*

## ***Soil & Site Identification Exercise (answers)***

(3) List the complete ecological site ID for each soil component listed in #2

### ***Chiara silt loam, 2-15% slopes soil map unit***

	<b>Ecological Site</b>			
<b>Soil map unit component</b>	<b>MLRA</b>	<b>Sub-MLRA</b>	<b>Eco Site</b>	<b>State</b>
Chiara silt loam, 2-15% slopes	025	XY	019	NV
Inclusion 1	028	BY	010*	NV
Inclusion 2	025	XY	019	NV
Inclusion 3	025	XY	019	NV

\* Loamy 8-10" P.Z. (Precipitation Zone) in MLRA (Major Land Resource Area) 28B (Central Nevada Basin and Range).

# Soil & Site Identification Exercise (answers)

- 4) It is possible for soil series to include components in different ecological sites. Are any of the series on your map in more than one ecological site?

*Yes – 1032 (Chiara-Kelk Association) includes two map unit components for the Kelk soil series that are associated with different ecological sites:*

*Kelk very fine sandy loam, 2-8% slopes = **025XY019NV**  
("more sloping Kelk soil")*

*Kelk very fine sandy loam, 0-2% slopes\* = **024XY006NV**  
("nearly level Kelk soil")*

*\*page 370, end of 1032 description*

## *Review: a soil map unit (drawn on the map) can be:*

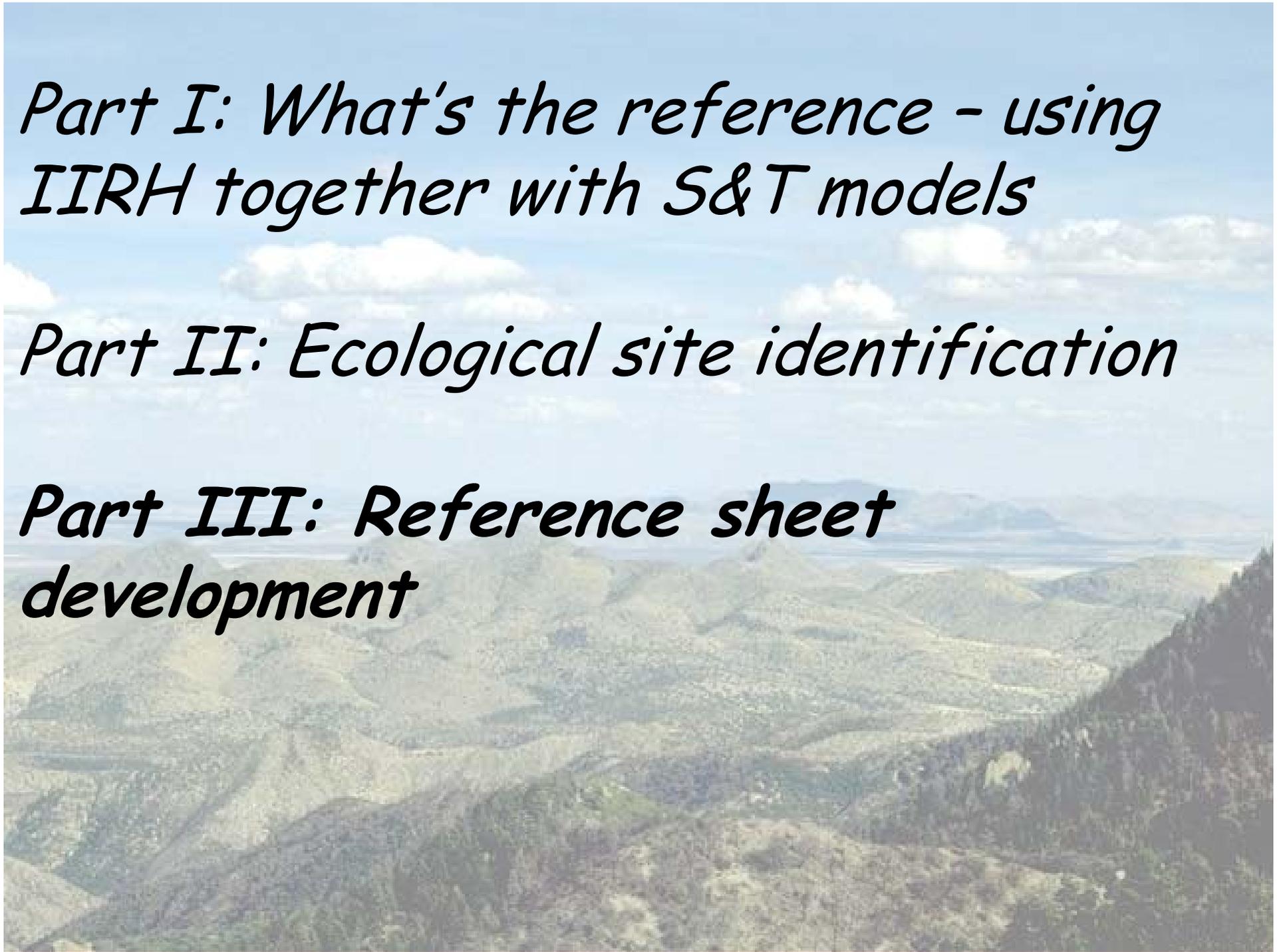
- ◆ An **ASSOCIATION** of two or more soils that occur in a repetitive and *predictable* pattern (e.g. low ridges & swales)
- ◆ A **COMPLEX** of two or more soils that usually do not occur in a *predictable* pattern at a mappable scale (e.g. coarse and fine soils in a river floodplain)
- ◆ A single soil series (but even these map units usually have “inclusions” too small to be mapped). Sometimes call a **CONSOCIATION** (e.g. *the Chiara used in the example*)

**Note: like soil maps, ecological site map units include associations and complexes of multiple ecological sites**

*Part I: What's the reference - using IIRH together with S&T models*

*Part II: Ecological site identification*

*Part III: Reference sheet development*



# *A reference sheet for each Ecological Site is developed for the “reference state”*

**Indicators.** For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for each community within the reference state, when appropriate & (3) cite data. Continue descriptions on separate sheet.

**1. Number and extent of rills:** Minimal on slopes less than 5% and increasing slightly as slopes increase up to 15%. Rills spaced 15-50 ft. apart when present on slopes of 10-15% under average when present. After wildfires, high human or herbivore impacts, extended drought or , or combinations of these disturbances, rills may double in numbers on slopes from 10-15% after high intensity summer thunderstorms.

**2. Presence of water flow patterns:** Generally up to 20 feet apart and short (less than 10 feet long) with numerous obstructions that alter the water flow path. On slopes of 10-15%, flow patterns increase in number and length (30% increase in both number and length. Flow pattern length and numbers may double after wildfires, high human or herbivore impacts, extended drought, or combinations of these disturbances if high intensity summer thunderstorms occur.

# Generating the ecological reference worksheet

Capture  
temporal and  
disturbance  
variability!

Rev. 12/15/02

## Ecological Reference Worksheet (Example)

**Author(s)/participant(s):** J. Christensen, B. Call, B. Bestelmeyer, R. Placker, D. Trujillo, L. Hauser, D. Coalson, P. Smith, & J. Herrick

**Contact for lead author:** \_\_jchristensen@web.com/334-556-7890\_\_ **Reference site used? Yes/No: No**

**Date:** 03/23/2002 **MLRA:** \_\_42\_\_ **Ecological Site:** \_\_Limy\_\_ This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community *cannot* be used to identify the ecological site.

**Indicators.** For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for **each** community within the reference state, when appropriate & (3) cite data. Continue descriptions on separate sheet.

**1. Number and extent of rills:** *None*

**2. Presence of water flow patterns:** *None, except following extremely high intensity storms, when short (less than 1 m) flow patterns may appear; minimal evidence of past or current soil deposition or erosion.*

**3. Number and height of erosional pedestals or terracettes:** *None*

**4. Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are *not* bare ground):** *20 – 30 % bare ground; bare patches should be less than 8-10 inch diameter; occasional 12 inch patches associated with shrubs. Larger bare patches also associated with ant mounds and rodent disturbances*

**5. Number of gullies and erosion associated with gullies:** *None*

**6. Extent of wind scoured, blowouts and/or depositional areas:** *None*

**7. Amount of litter movement (describe size and distance expected to travel):** *Minimal and short, associated with water flow patterns following extremely high intensity storms. Litter also may be moved during intense wind storms*

**8. Soil surface (top few mm) resistance to erosion (stability values are averages – most sites will show a range of values):** *Stability class (Herrick et al. 2001) anticipated to be 5-6 at surface and subsurface under vegetation and 4-5 at surface and subsurface in the interspaces. These values need verification at reference sites.*

**9. Soil surface structure and SOM content (include type and strength of structure, and A-horizon color and thickness):** *2-4 inch dark brown A horizon with medium granular structure (Otero County Armesa series description refers to platy structure; probably not from a true reference site).*

**10. Effect of plant community composition (relative proportion of different functional groups) & spatial distribution on infiltration & runoff:** *High grass canopy and basal cover and small gaps between plants should reduce raindrop impact and slow overland flow, providing increased time for infiltration to occur. High root density of blue grama can limit infiltration. High herbaceous vegetation on this site will result in less rain necessary to sustain this site because more water is retained.*

**11. Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** *None.*

**12. Functional/Structural Groups (list in order of descending dominance by above-ground weight using symbols: >>, >, = to indicate much greater than, greater than, and equal to):** *Blue grama > Black grama > warm season bunchgrasses > Yucca = shrubs >> sub-shrubs = succulents; Forbs 0 – 8 % depending on the year.*

**13. Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** *Grasses will nearly always show some mortality and decadence*

**14. Average percent litter cover ( \_\_\_\_\_ %) and depth ( \_\_\_\_\_ inches).**  
*20 – 25 % litter cover and 0.25 inch depth*

**15. Expected annual production (this is TOTAL above-ground production, not just forage production):**  
*\_\_\_\_\_ #/acre or t/ha (choose one) 650 to 1200 pounds/acre based on ecological site description. Could be even higher on particularly good years.*

**16. Potential invasive (including noxious) species (native and non-native). List species which characterize degraded states and which, after a threshold is crossed, “can, and often do, continue to increase regardless of the management of the site and may eventually dominate the site”:** *Possibly creosote bush which is an invader on similar ecological sites; snakeweed is cyclical, so not regarded as an invasive plant on this ecological site.*

**17. Perennial plant reproductive capability:** *all species should be capable of reproducing*

Rev. 12/15/02

# Generating the ecological reference worksheet

Reference Worksheet defines the “None to Slight” Category in the Evaluation Worksheet

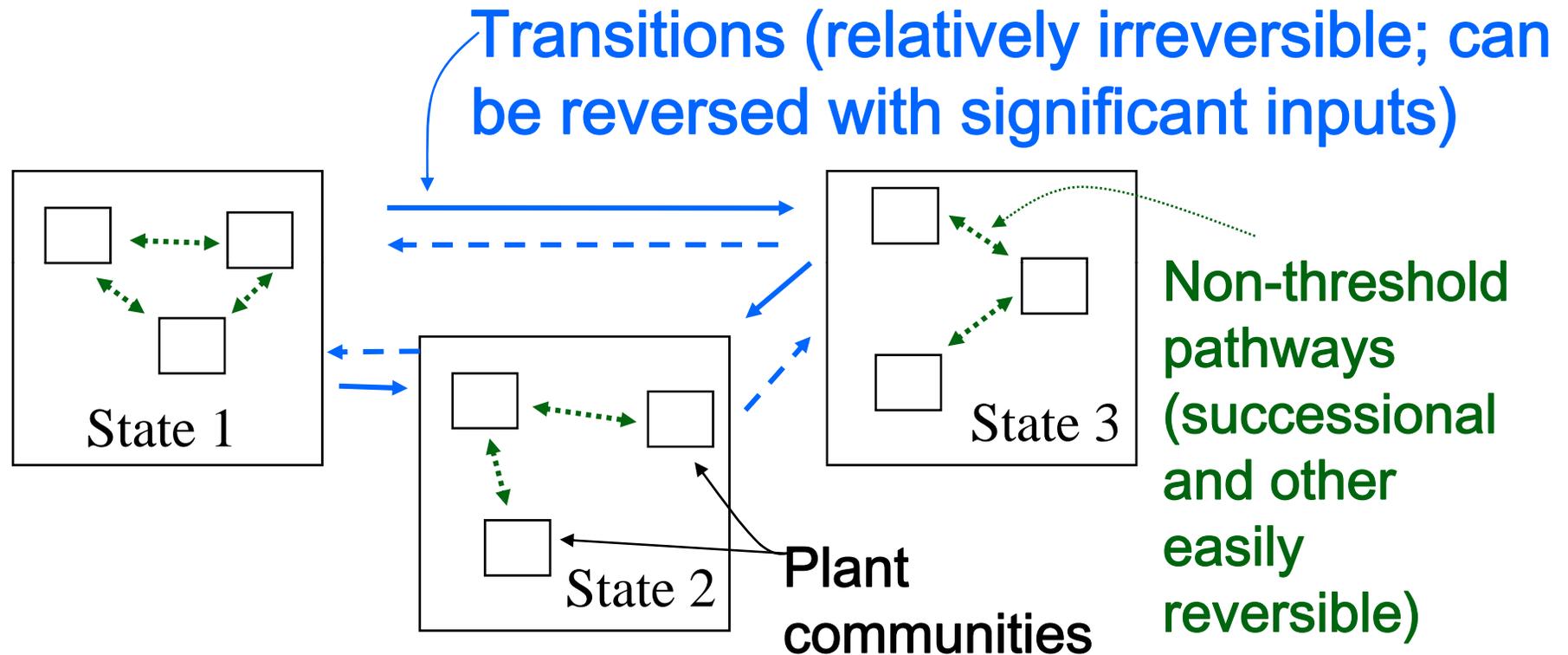
Table 2. Example of a revised descriptor for the bare ground indicator.

Indicator	Departure from Ecological Site Description/Ecological Reference Worksheet				
	Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
<b>4. Bare ground</b>	Greater than 75% bare ground with entire area connected. Only occasional areas where ground cover is contiguous, mostly patchy and sparse.	60-75% bare ground. Bare patches are large (>24" diameter) and connected. Surface disturbance areas becoming connected to one another. Connectivity of bare ground broken occasionally by contiguous ground cover.	45 – 60% bare ground with much connectivity especially associated with surface disturbance. Individual bare spaces are large and dominate the area.	30-45% bare ground. Bare spaces greater than 12" diameter and rarely connected. Bare areas associated with surface disturbance are larger (> 15") and may be connected to other bare patches.	Ecological Reference Worksheet: 20-30% bare ground; bare patches should be less than 8-10" diameter and not connected; occasional 12" patches assoc. w/shrubs. Larger bare patches also assoc. w/ant mounds & small mammal disturbances.
Generic Descriptor	Much higher than expected for the site. Bare areas are large and generally connected.	Moderate to much higher than expected for the site. Bare areas are large and occasionally connected.	Moderately higher than expected for the site. Bare areas are of moderate size and sporadically connected.	Slightly to moderately higher than expected for the site. Bare areas are small and rarely connected.	Amount and size of bare areas match that expected for the site.

*A reference sheet is developed for the “Reference State” of each ecological site...*

The state where the functional capabilities represented by soil and site stability, hydrologic function, and biotic integrity are performing at a near-optimum level under the natural disturbance regime.

# State and Transition Diagram for an Ecological Site



Based on Bestelmeyer et al. 2003 and Stringham et al. 2003 (both in J. Range Management)

# *Generating the reference worksheet*

- ◆ What do you need to define potential for an ecological site?

# Generating the reference worksheet

- ◆ What do you need to define potential for an ecological site?
  - Ecological Site Descriptions

Date Proposed: 3/69 South Slope 8-12" P.Z.  
Author(s): RK/GKB 025XV015NV  
MLRA: 25 APTSM/AGSP

## Ecological Site Description

UNITED STATES DEPARTMENT OF AGRICULTURE  
SOIL CONSERVATION SERVICE

NEVADA  
Range Site Description

**A. PHYSICAL CHARACTERISTICS**

**1. PHYSIOGRAPHIC FEATURES**

This site occurs on southerly facing sideslopes of hills, erosional fan remnants and rock-pediment remnants. Slopes range from 15 to 75 percent, but slope gradients of 30 to 50 percent are most typical. Elevations are 5500 to 6500 feet.

**2. CLIMATIC FACTORS**

Average annual precipitation is 8 to 12 inches. Mean annual temperatures is 45 to 50 degrees F. The average growing season is about 100 to 120 days.

**3. SOIL FACTORS**

The soils in this site are typically moderately deep and well drained. Surface soils are medium to moderately fine textured and are normally less than 10 inches thick. Subsoils are moderately fine to fine textured. Most of these soils are modified with 35 to 50 percent rock fragments through the soil profile. Available water capacity is low to moderate. On the southerly exposures of this site, more sunlight is received and the soils tend to warm and promote plant growth earlier in the spring than on adjacent sites. High evapotranspiration potentials on this site result in depletion of the available soil moisture supply early in the growing season. Runoff is medium to rapid. Potential for sheet and rill erosion is moderate to high depending on slope. A surface cover of gravels and/or cobbles on these soils provides a stabilizing affect on surface erosion conditions.

For a listing of soils correlated to this range site and representative pedon, see Appendix II.

**4. VEGETATION FACTORS**

**a. Potential Native Vegetation**

The plant community is dominated by bluebunch wheatgrass. Other plants of importance are Thurber needlegrass and Wyoming big sagebrush.

Potential vegetative composition is about 80% grasses, 5% forbs and 15% shrubs.

Technical Guide  
Section IIE

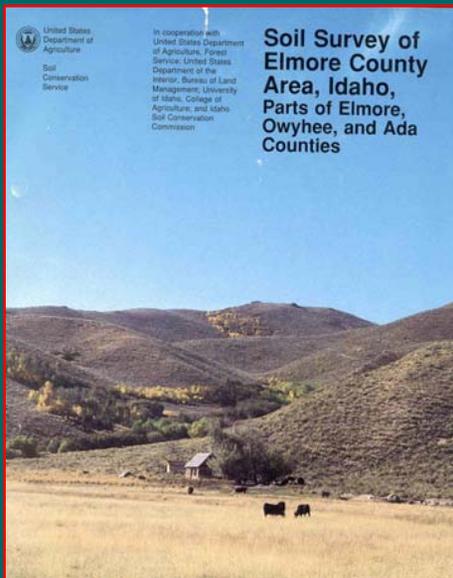
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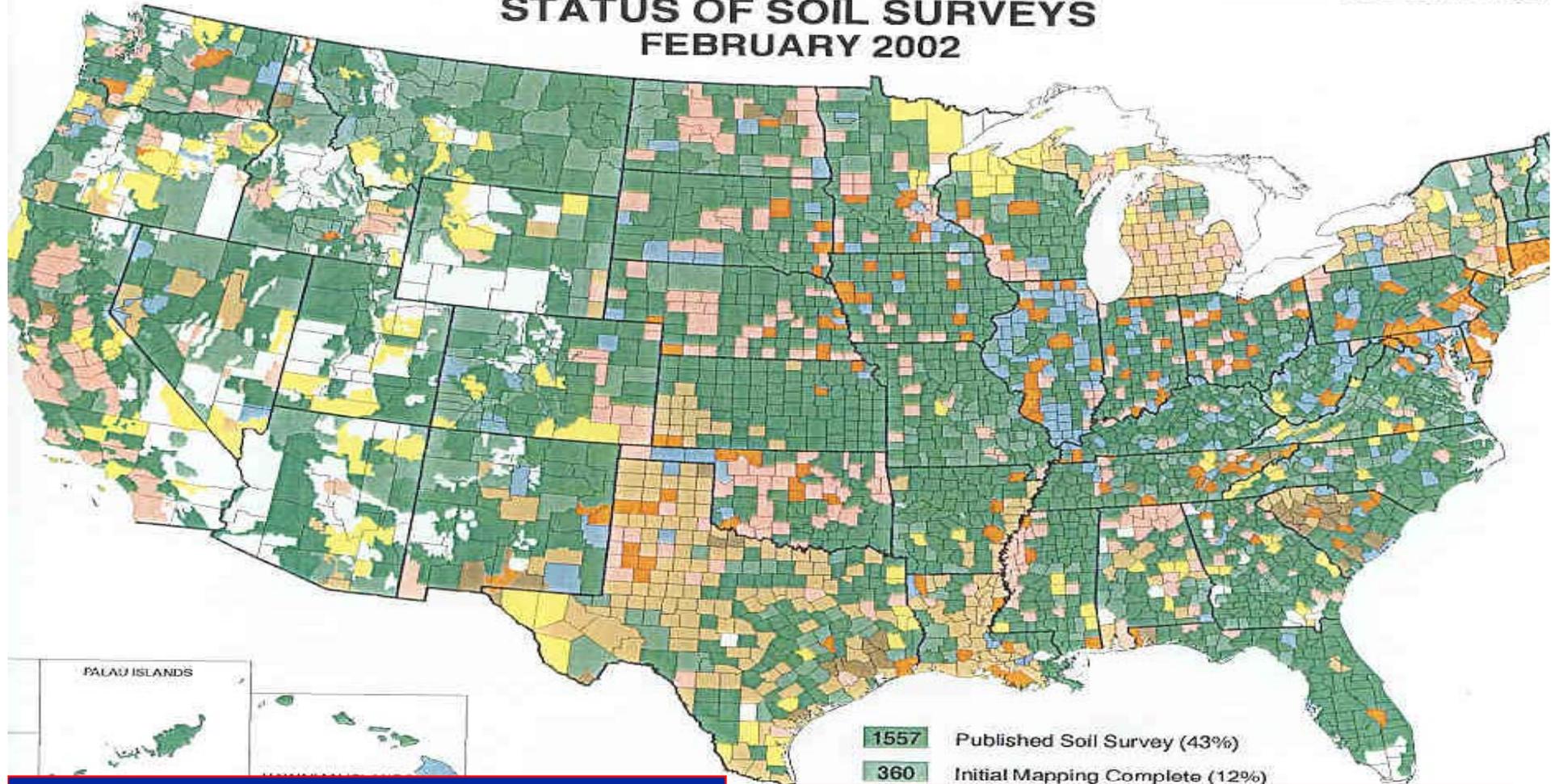
<http://plants.usda.gov/esis>

# Generating the reference worksheet

- ◆ What do you need to define potential for an ecological site?
  - Ecological Site Descriptions
  - **Soil survey information**



# STATUS OF SOIL SURVEYS FEBRUARY 2002



**STATSGO Soil Mapping**  
Available at 1:250,000 scale  
(<http://soils.usda.gov>)

**SSURGO Soil Mapping**  
Available at 1:24,000 scale  
(<http://soils.usda.gov>)

National Soil Information System Replicate Data Base, Iowa State University, 2/02.  
g Digital Soil Survey Areas, Revised 2/02.  
ren, 95 °W & 23N, NAD27.  
topography & Geospatial Center, Fort Worth, Texas, 2002.

Numbers in legend boxes are number of Soil Survey Areas.  
Percentages are of U.S. landmass.

# *Generating the reference worksheet*

- ◆ What do you need to define potential for an ecological site?
  - Ecological Site Descriptions
  - Soil survey information
  - **Ecological Reference Areas**

# *Ecological Reference Area(s)*

“A landscape unit in which ecological processes are functioning within a normal range of variability and the plant community has adequate resistance to and resiliency from most disturbances”



# *Ecological Reference Area(s)*



# *Generating the reference worksheet*

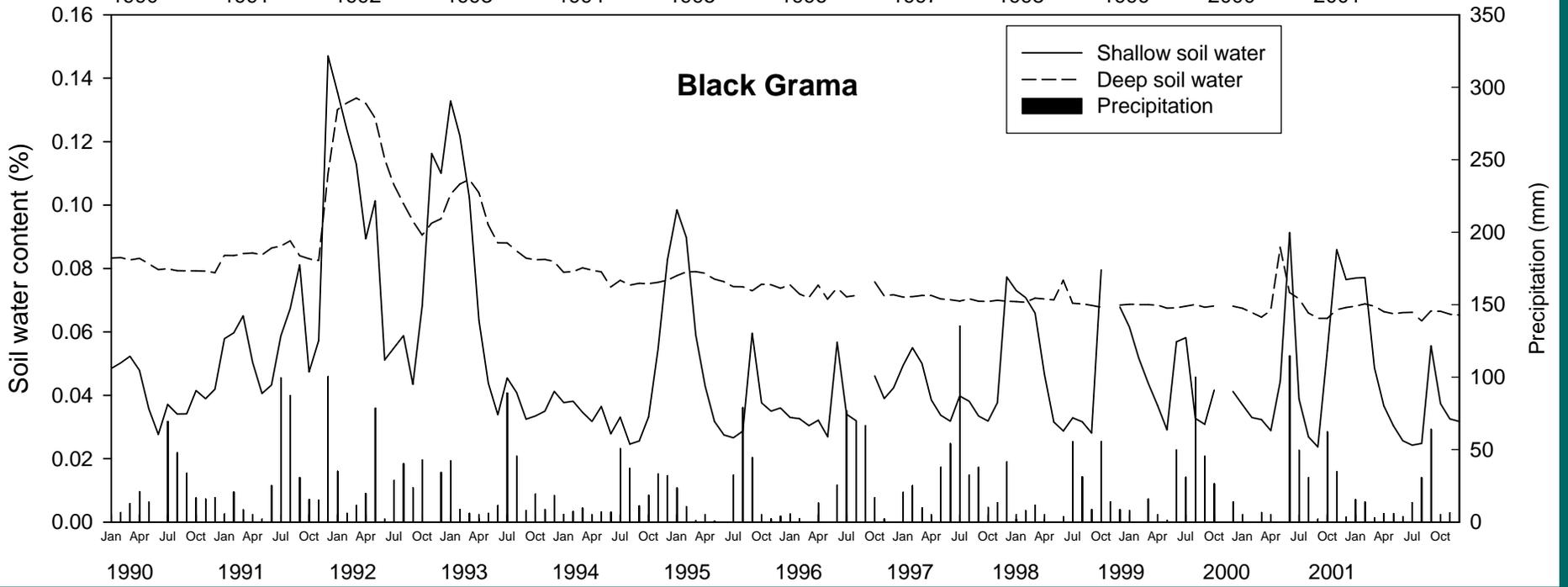
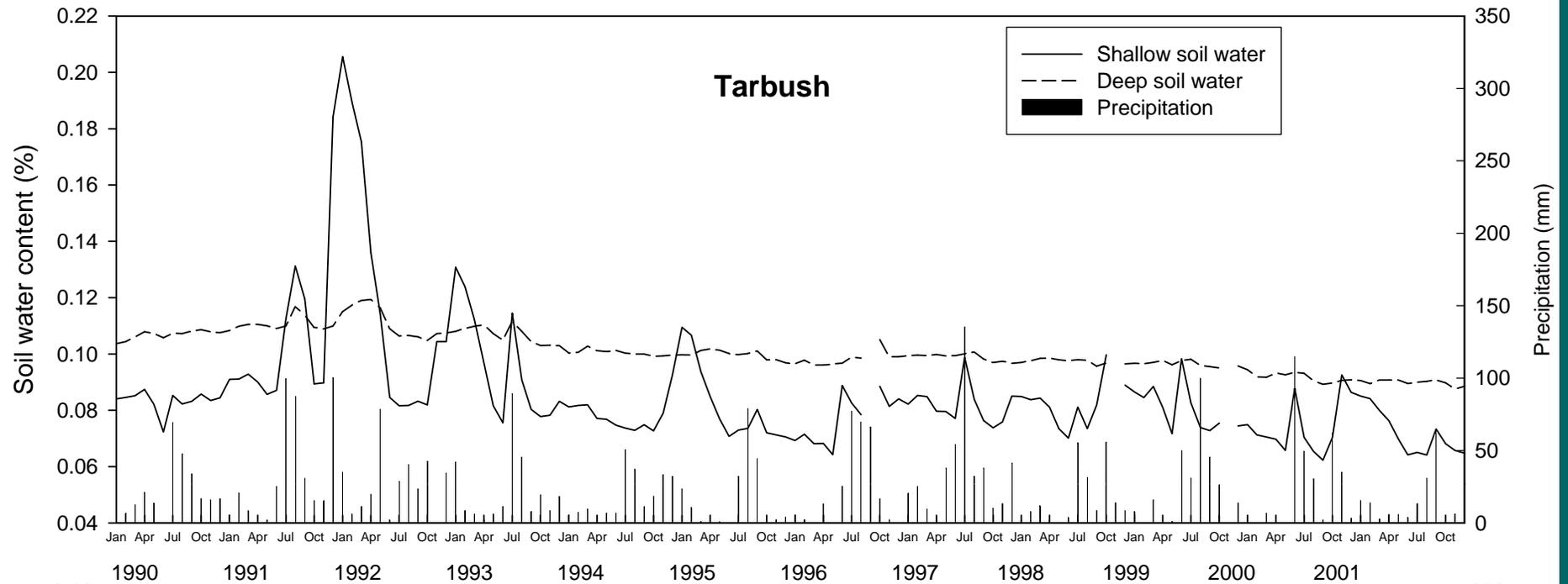
- ◆ What do you need to define potential for an ecological site?
  - Ecological Site Descriptions
  - Soil survey information
  - Reference sites
  - Expert knowledge  
(old timers and brilliant ecologists)





# *Generating the reference worksheet*

- ◆ What do you need to define potential for an ecological site?
  - Ecological Site Descriptions
  - Soil survey information
  - Ecological Reference Area(s)
  - Expert knowledge (old timers and brilliant ecologists)
  - Other data (e.g. from LTER and other long-term studies)



# *Generating the ecological reference sheet*

- ◆ How do you evaluate the quality of the information?



# *Generating the ecological reference sheet*

- ◆ How do you evaluate the quality of the information?
  - Go to the source, or people who knew it
  - Compare different sources



*No Reference Worksheet---  
don't bother going to the field!*

