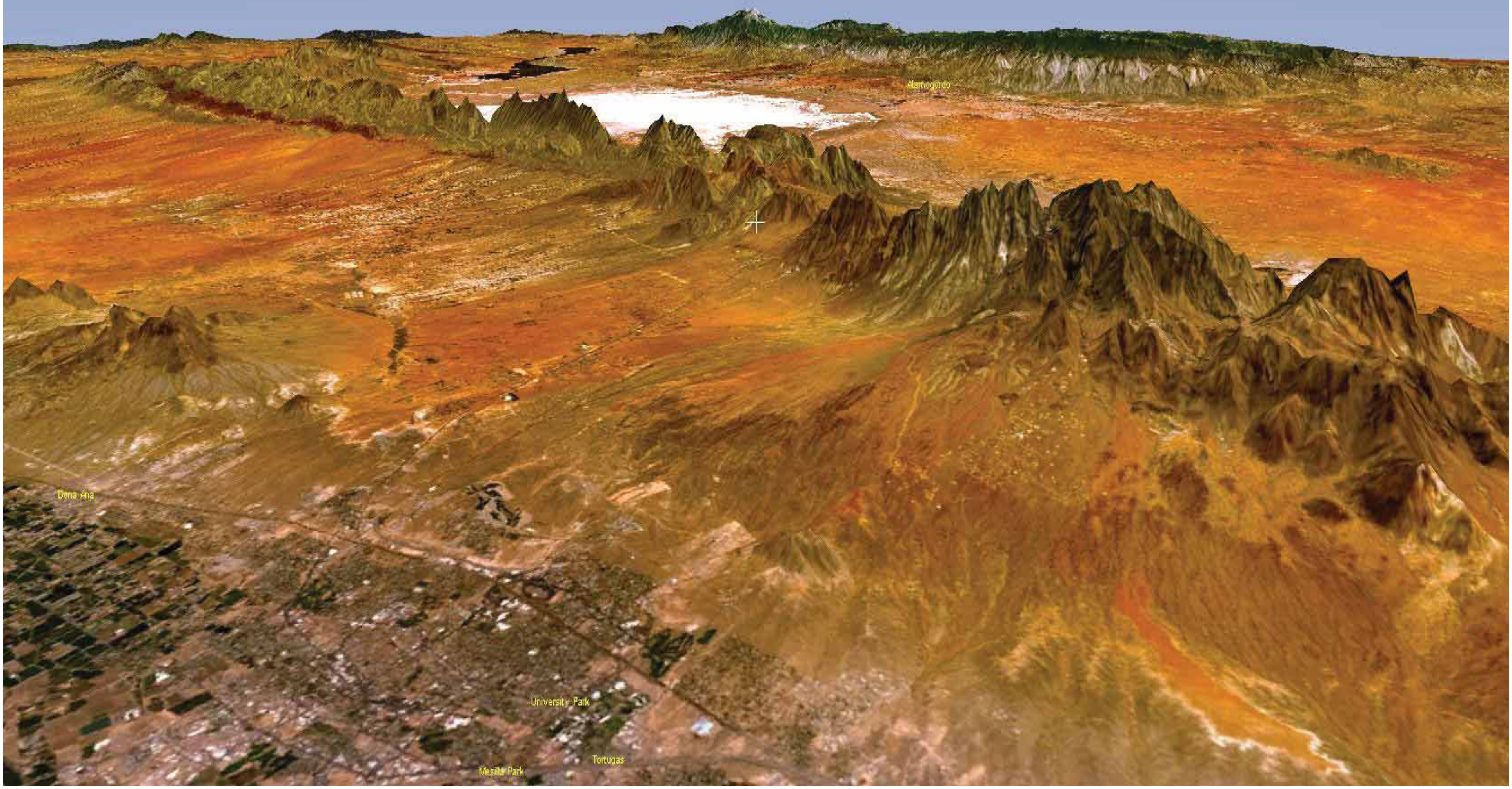
Monitoring and Assessment Design and Interpretation Using Ecological Sites and State-and-Transition Models



Assessment and monitoring are methods to interpret **change**

- **Assessment**: Evaluate change relative to a standard or reference

“This is a degraded community, it used to be perennial grassland”

- **Monitoring**: Detect ongoing change and interpret its consequences

“If this community is degrading, then we will see declines in perennial grasses”

Basic assessment and monitoring elements

• **Method**: What are the measurements and how are they gathered in a sample (e.g., line-point intercept on a 50-m transect)

• **Design**: How the number and placement of transects is decided and how other site data is collected

-*Spatially-unbiased sample*: Every location within the region you will report about has a chance of being sampled

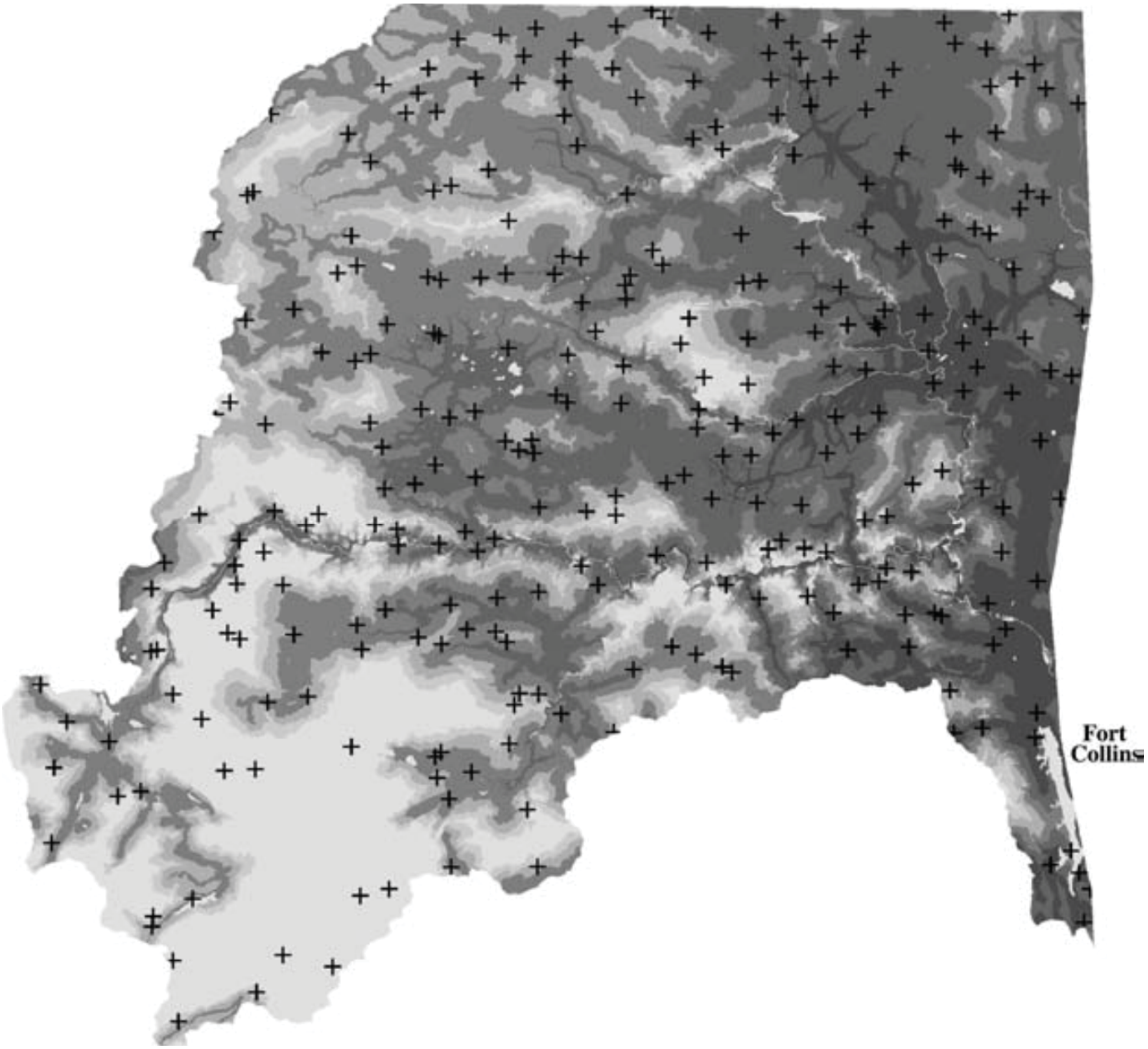
-*Stratification*: Transects are distributed according to different classes of land (e.g., forest vs. grassland or different soums) that may change in different ways

- *Landscape processes*: Transects will detect change at different rates depending upon how degradation spreads in a landscape, need to be aware

-*Patchiness*: Transects may occur within or cross different patch types that change in different ways

-**Interpretation**: How the resulting data from many samples are summarized and reported to make a conclusion (can summarize by area or vegetation type)

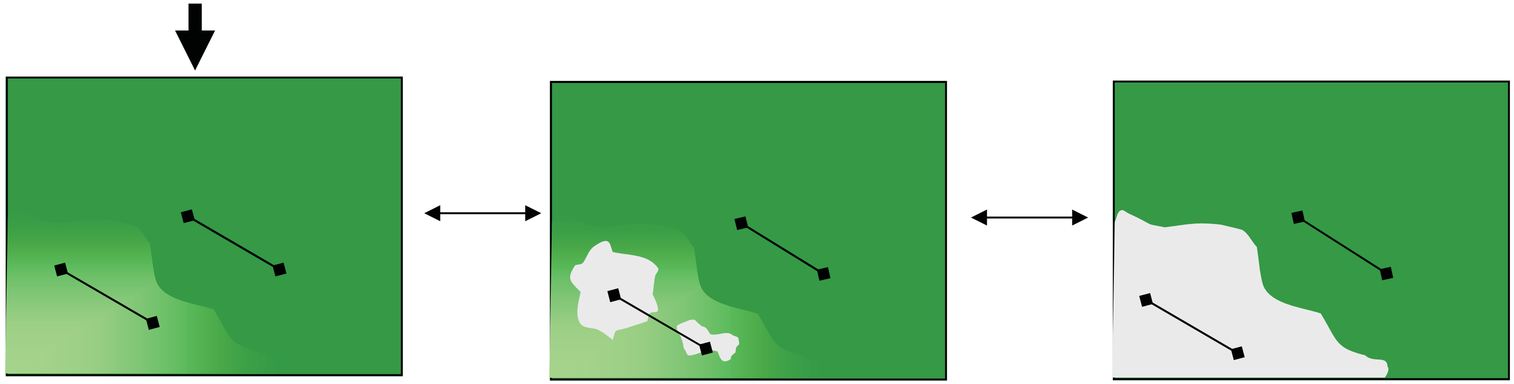
Spatially-unbiased or spatially-balanced design



Every part of the study region has a non-zero probability of being sampled, but the probability can be different depending on accessibility

Stratification

Disturbance/climate change

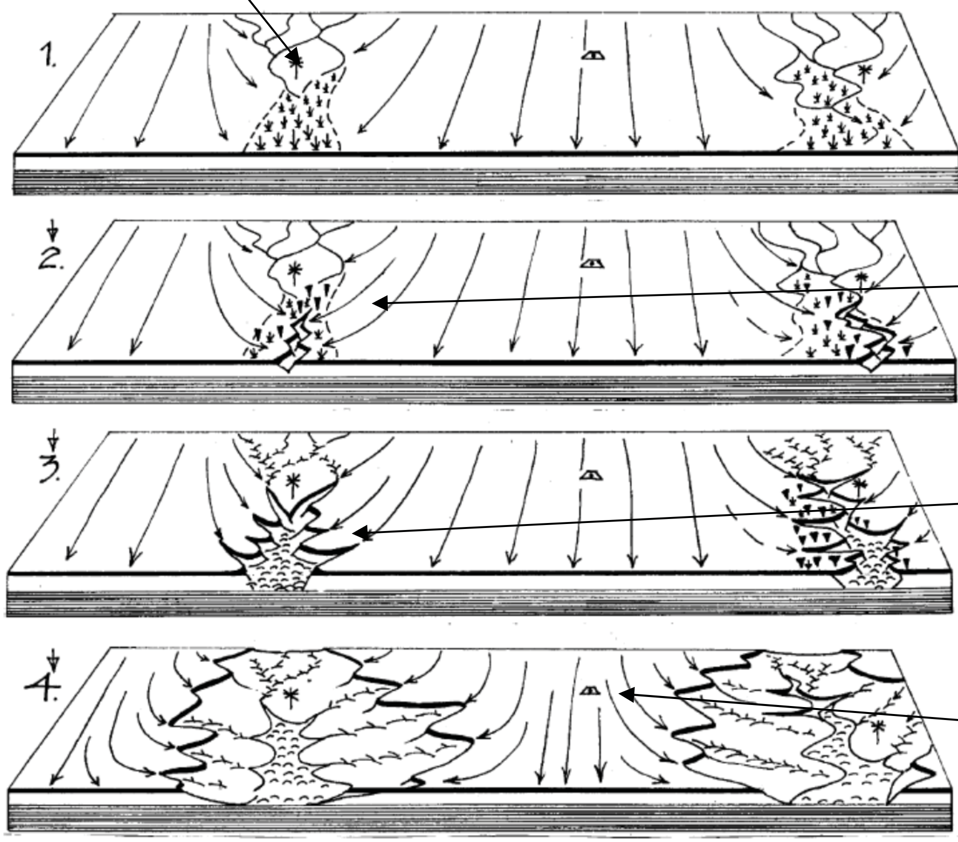


Some soil types change faster than others

Transects should be divided across important differences in soils

Landscape processes

Degradation starts in draws

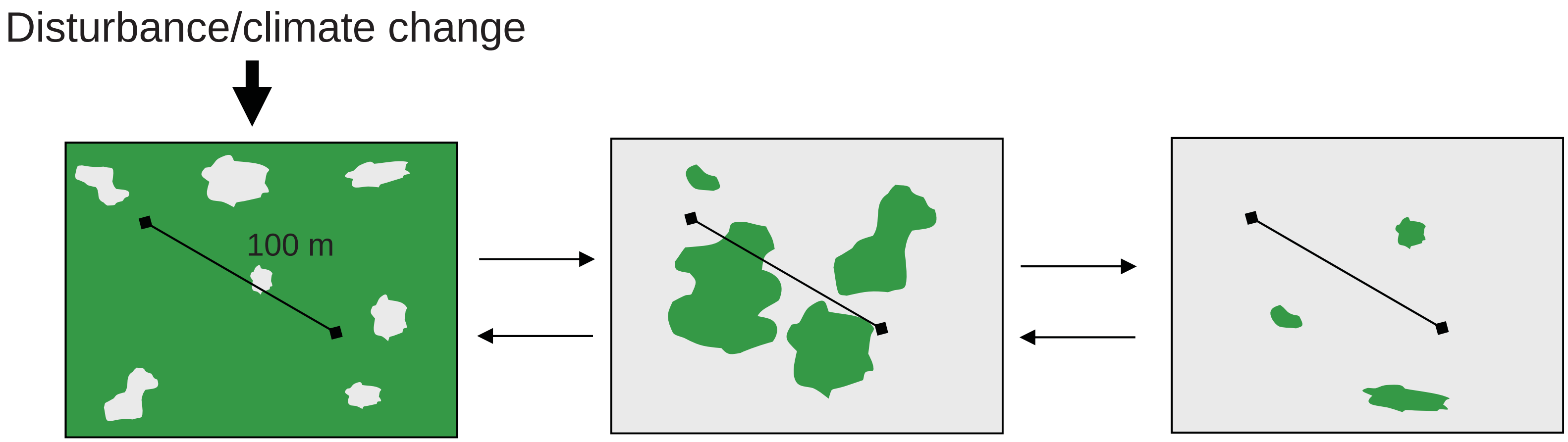


Water runoff is concentrated leading to increasing erosion

Upland areas start to erode

Monitoring transect is unaffected until degradation of area is already great

Patchiness





Some vegetation patches disappear first, others remain even under the worst conditions

Site potential of monitoring location is needed for stratification and interpretation

- **Ecological site:** defines site potential based on the soil, landform, and climate of a site

"It used to be perennial grassland because it is a sandy loam soil on an alluvial plain in the 200-250 mm precipitation zone of southern New Mexico, USA"

Possible changes in the future depends on the condition of vegetation and soils

• **State-and-transition model:** defines states and transitions among states, and the causes of transitions, for each ecological site

"Because perennial grasses have been eliminated and the soil is degraded, this site is unlikely to recover"

Topic 1) What are ecological sites?

A land classification system based on groups of soils that:

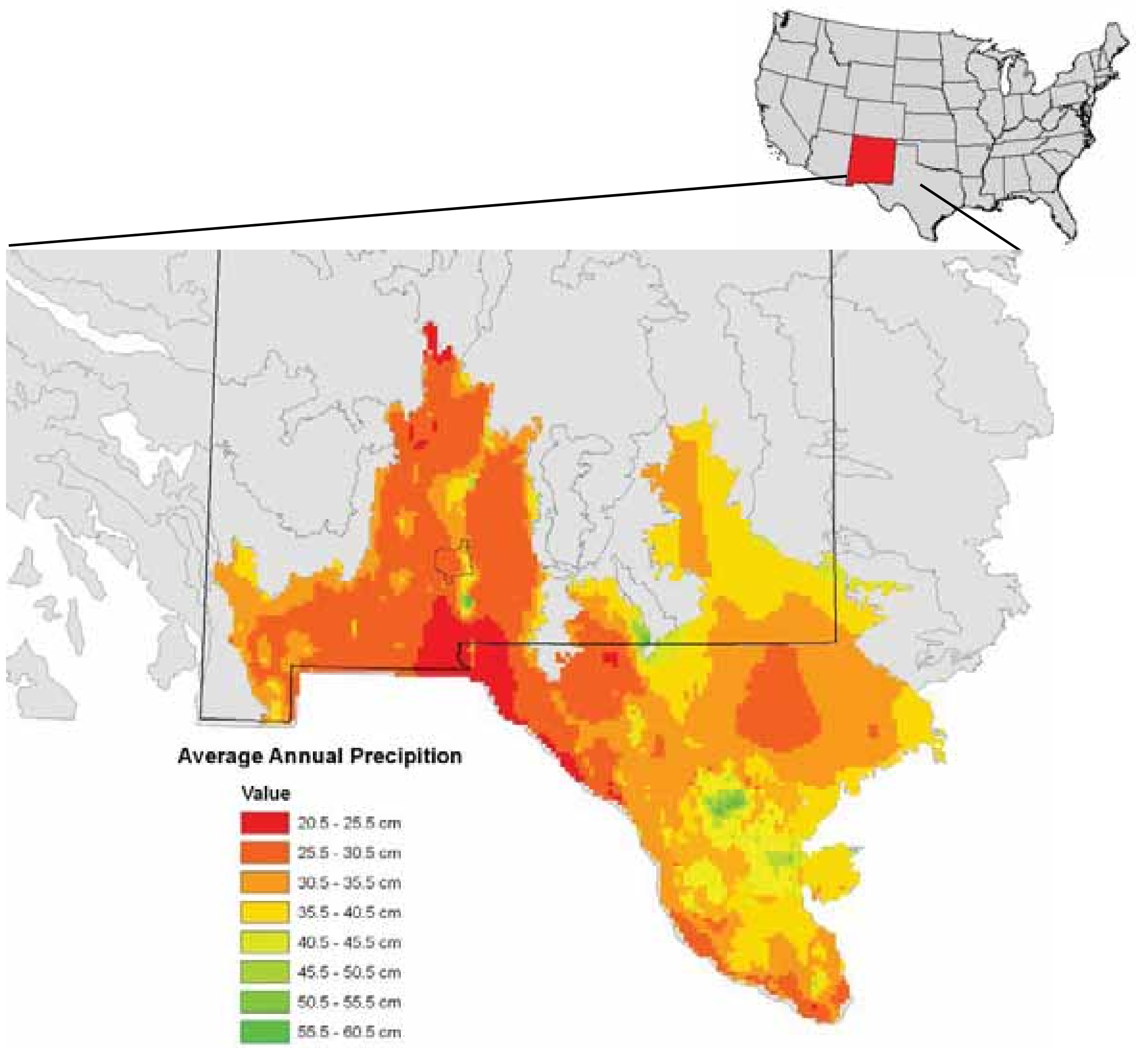
1) potentially produce similar kinds and amounts of vegetation

2) respond to disturbances and drivers similarly (e.g., grazing and climate variation)

A. What is site potential?

- Production amounts and community types that would be predicted based on an area's soil properties, topographic position, and current climate
- Potential is difficult to quantify
- Estimated based on observations of 1) historical vegetation, 2) undisturbed areas, 3) areas that are considered to be well-managed, and 4) logic/experience

B. Climate zones define broad patterns of potential



In general, 5 cm increments of mean annual precipitation alter degradation frequency

C. Soil-landscape properties that affect potential within climate zones

Type	*Variable (units)*
Hydrology	
	Water table depth *(m)*
	Flooding duration *(days)*
Soil physical properties	
	Soil texture of surface *(class)*
	Fragment content *(%)*
	Argillic horizon development *(class)*
	Soil depth to restrictive layer *(cm)*
Lithology/geology	
	Bedrock type *(class)*
Topography/landform	
	Landscape position *(class)*
Chemistry	
	Soil salinity/sodicity *(mmhos)*
	Soil gypsum content/distribution in profile *(%/cm)*
	Soil carbonate content/distribution in profile *(%/cm)*

C_i. Soil-landscape properties that affect potential

Flooding duration *(days)*

Draw

Flooding is typically 2 hours

(2200 kg/ha of perennial grass)

Bottomland

Standing water typically 2 days

(3900 kg/ha of perennial grass)

Playa

Standing water typically for 2 weeks

(0 kg/ha of perennial grass)

All are similar soils!

C_{ii}. Soil-landscape properties that affect potential

Water table depth *(m)*

- ***Shallow water, woodland in the desert***

C_{iii}. Soil-landscape properties that affect potential

Soil texture of surface *(class)*

- ***Medium-textured soils retain increased plant-available water compared to sandy and clayey soils***

- ***A sandy soil surface over a finer-textured horizon can improve water retention and productivity***

C_{iv}. Soil-landscape properties that affect potential

Fragment content *(%)*

• ***Increasing fragment content reduces rooting substrate and water-holding capacity***

C_v. Soil-landscape properties that affect potential

Depth to restrictive layer *(cm)*

• ***Shallow indurated horizons and clay-rich horizons reduce shrub invasion***

C_{vi}. Soil-landscape properties that affect potential

Landform and Landscape position *(class)*

• ***Increased production where water and sediment collects***

C_{vii}. Soil-landscape properties that affect potential

Salinity *(mmhos)*

- ***Halophytic vegetation can tolerate high salt content***

D. Ecological sites differ in response to disturbance

1970s-80s

2003

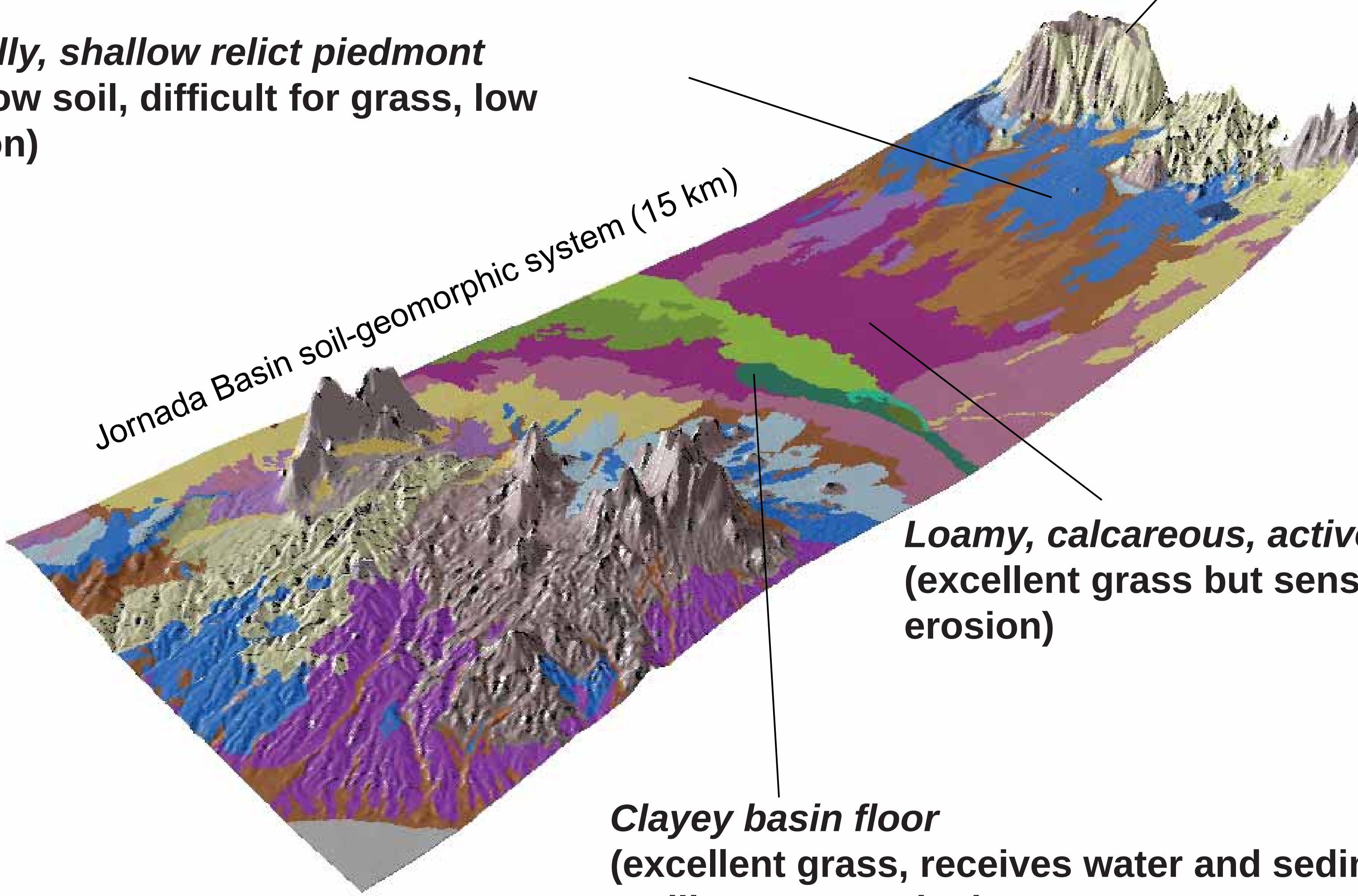
Sandy soils
(high erodibility)

Clayey soils
(low erodibility)

E. Landform and soil maps show *differences in site potential and key landscape processes*

Limestone Hills (many soil pockets, good for grass, low erosion)

Gravelly, shallow relict piedmont
(shallow soil, difficult for grass, low erosion)



Loamy, calcareous, active piedmont
(excellent grass but sensitive to erosion)

Clayey basin floor
(excellent grass, receives water and sediment, very resilient, no erosion)

4. Field sampling at points: characterize soil profiles and vegetation

1) Excavate hole with shovel or soil auger

2) Distinguish different soil horizons
   - Color (visually)
   - Structure (visually and with knife)
   - Hand texture (sandy, silty, clayey feel)
   - Salts (EC, pH, or visual)
   - Carbonate content (1 N Hydrochloric acid)
   - Fragment content (soil sieve)
   - Restrictive horizon depth (tape)
   - Parent rock (visual)

3) Observe landscape position
   - Does water run in or off?
   - Adjacent erosion, sand dunes?
   - Slope, aspect, landform from GIS

4) Measure vegetation around hole
   - Rapid ocular estimation (not monitoring) or line-point intercept

Topic 2. What is a state-and-transition model

Diagrams, text descriptions, and associated data that describe possible changes in vegetation and soils within particular ecological sites

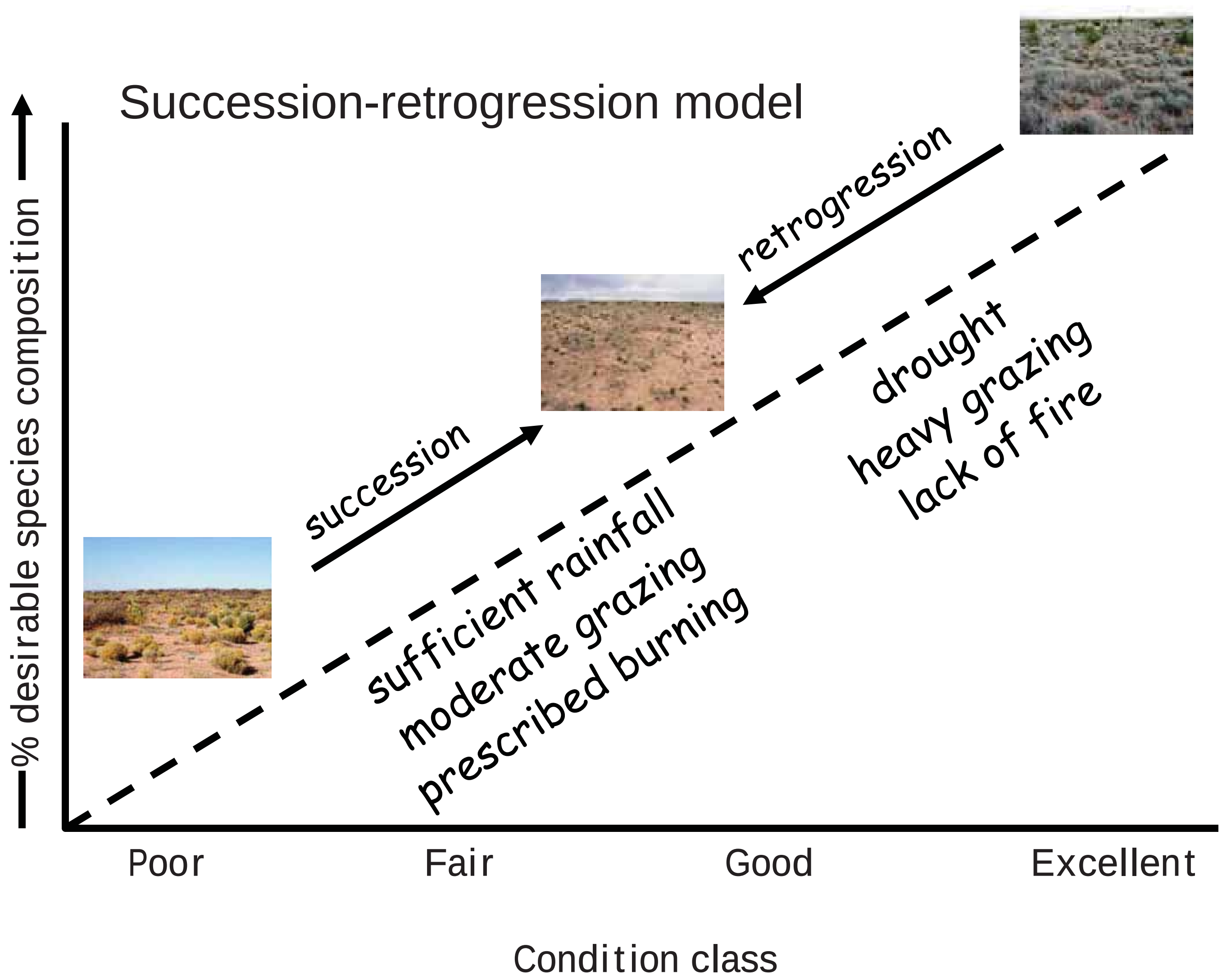
1) *Conceptual models for how vegetation changes for one or more ecological sites*

2) *Combine science information and traditional (local ecological) knowledge*

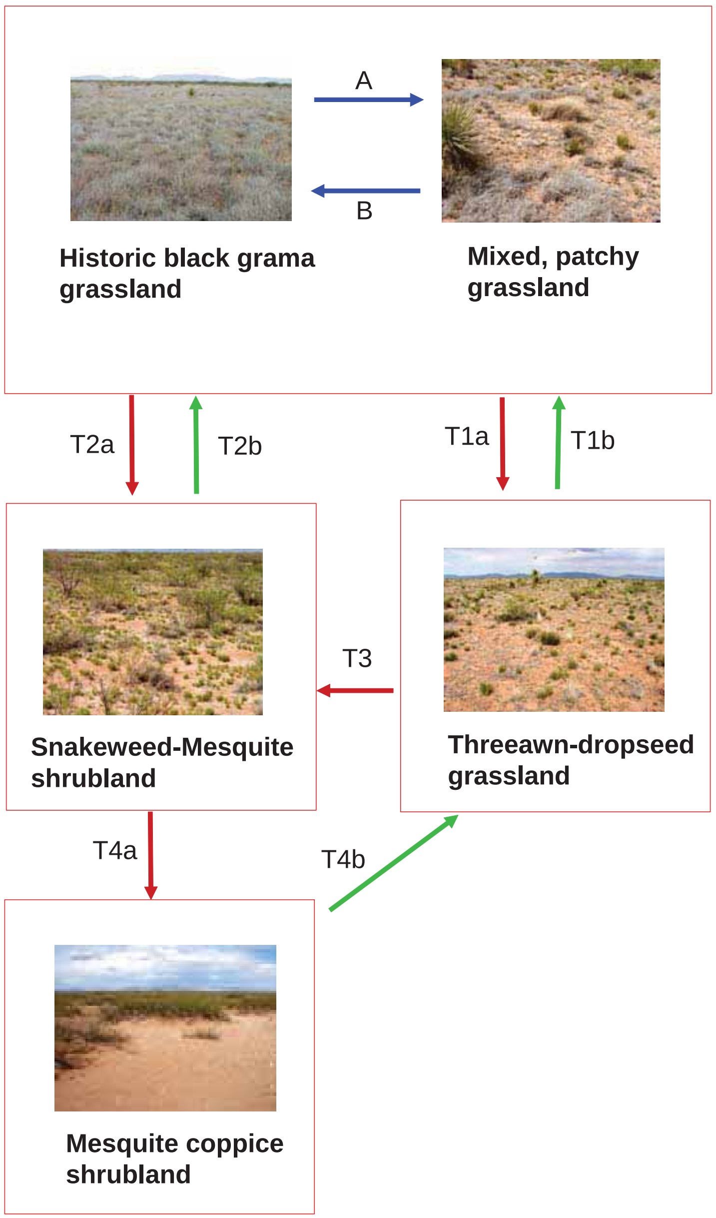
3) *They aid development of management hypotheses and interpretation of assessment and monitoring data*

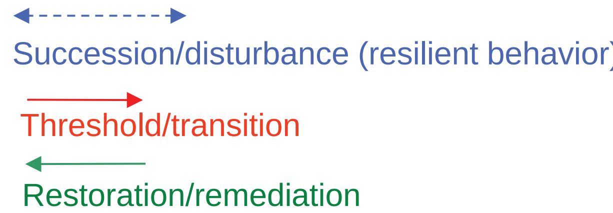
4) *Can be maintained and periodically updated by responsible government agencies*

A. The succession-retrogression model



B. A state-and-transition model of the same system





Key to arrows

A. Continuous grazing or drought, recovery with prescribed grazing (**B**).

T1a. Continued grazing causes black grama loss. Restoration with plantings and 2 consecutive summers of above-average rainfall (**T1b**).

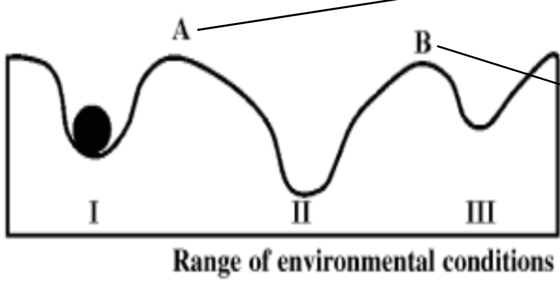
T2a. Continuous grazing, winter rain, plus lack of fire leads to mesquite proliferation and black grama extinction. Restoration with shrub control, plantings, summer rain, and fire management (**T2b**).

T3. Mesquite spread with high winter rain

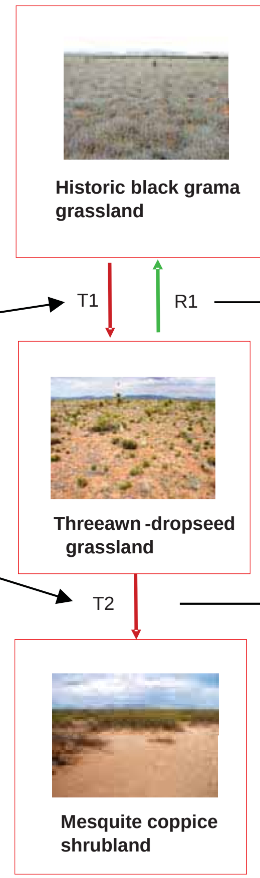
T4a. Inappropriate stocking during drought with soil disturbance leads to high soil erosion rates in shrub interspaces. Restoration of some grass cover with bulldozing, seeding and summer rain (**T4b**.)

C. State-and-transition models can describe thresholds

"Ball-and-cup" metaphor



stolen from Briske et al., 2003



Key to arrows

T1. Continuous grazing causes black grama mortality and inhibits stolon-based reproduction

R1. Reduced grazing, recovery from remnant plants with 2 consecutive summers of above-average rainfall.

T2. Continuous grazing on remaining perennial grasses and shrub competition increases bare ground connectivity, erosion ensues, and shrub interspaces no longer support grass

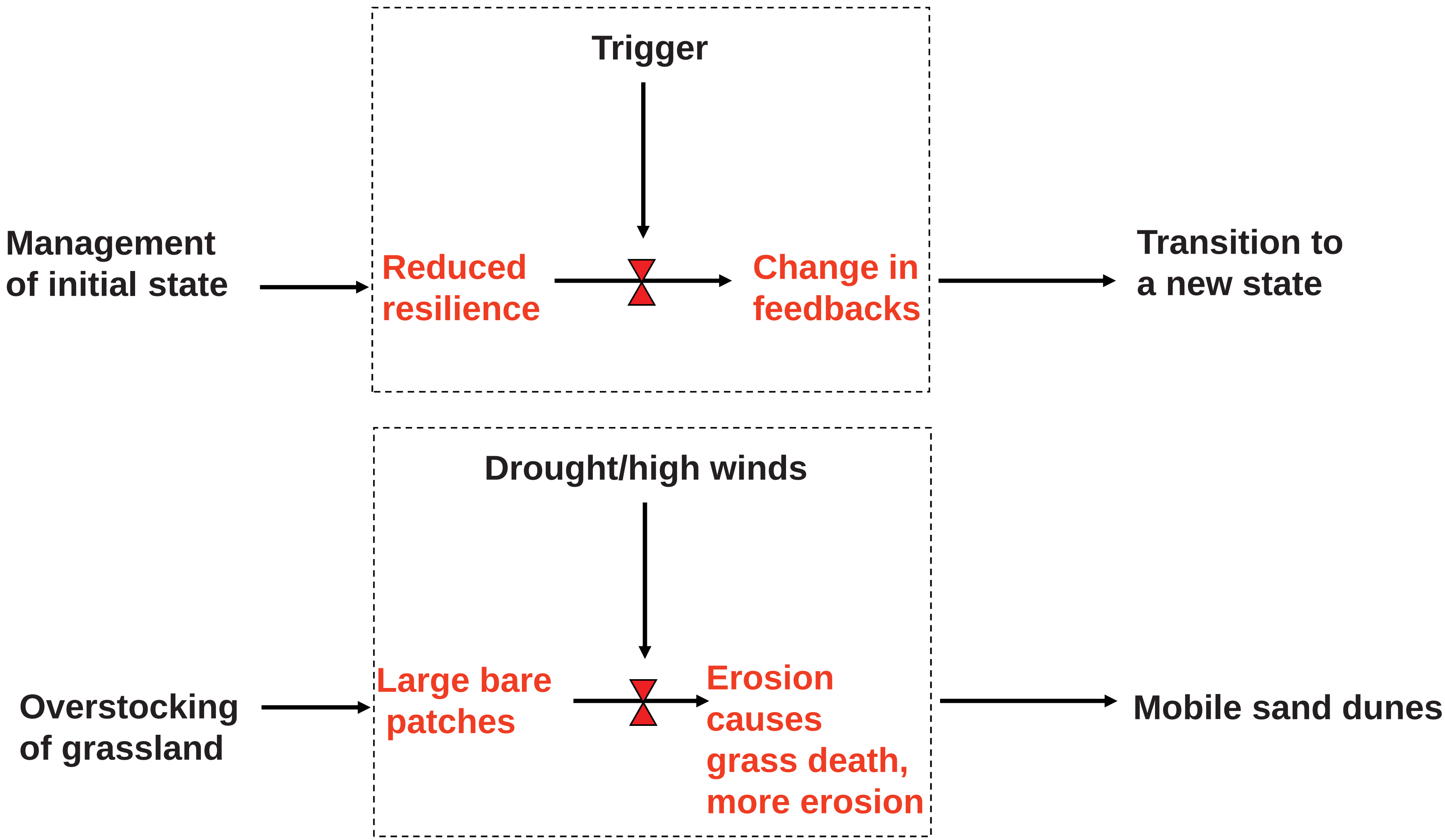
D_i. What is a threshold?

Practical definition: restoration is difficult or impossible

D_{ii}. What is a threshold?

Changes in plant cover and surface-soil properties that lead to persistent changes in vegetation = alternative states.

Can be estimated using rangeland health assessment.



E. Alternative states and phases based on STMs

Sandy ecological site, Chihuahuan Desert, USA

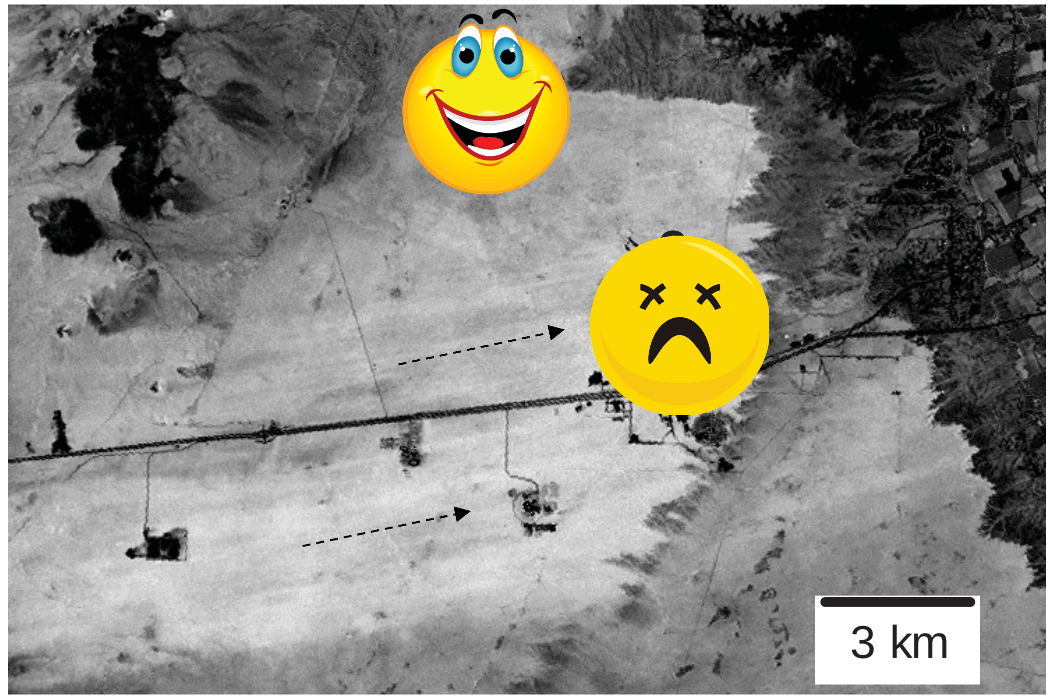
State	***Black grama***	***Black grama***	***Mesquite duneland***
Phase	***Reference community, at potential***	***At-risk community, could be restored***	***Low grass community, black grama gone***
Indicators	***Small bare patches, reproducing grass***	***Large bare patches, small shrubs***	***Interconnected bare patches, eroded soil***

E. Alternative states should include indicators of soil health

High bare ground, but high organic matter may allow recovery

High bare ground, mature shrubs, low organic matter may preclude recovery

E. Alternative states may occur due to landscape processes



Erosion from dunefield caused this transition, nearby areas protected by mountains

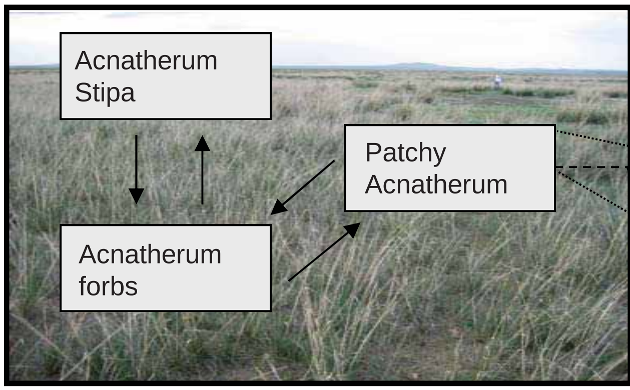
E. Concepts for alternative states and examples

Type	Example
1. Reference	*Stipa grandis* state
2. Native reproduction is limited	*Cleistogenes/Artemisia frigida/Potentilla* state
3. Native competitors dominant, altered processes	*Stellera chamajasmae* state (some soil compaction)
4. Exotic species dominant, altered processes	*Bromus tectorum* state (USA) (high frequency of fire)
5. Hydrologically impaired	Gullied state
6. Local soil degradation	*Thymus mongolicus* state, truncated soil
7. Landscape soil degradation	Mobile dune/shrublands state

A complete example based on field work in Inner Mongolia

Saline flats ecological site: Natrargid, 300-500 mm zone (typical steppe)

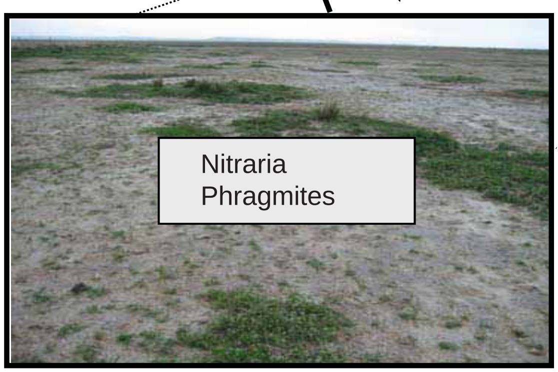
Reference State
High perennial grass cover, high grass diversity, bare patches small and unconnected. Perennial grasses minimize soil, nutrient and water movement from high-intensity storms.



At-risk Community Phase: Perennial cover low in Interspaces between Acnatherum patches, low litter low root mass, some soil movement

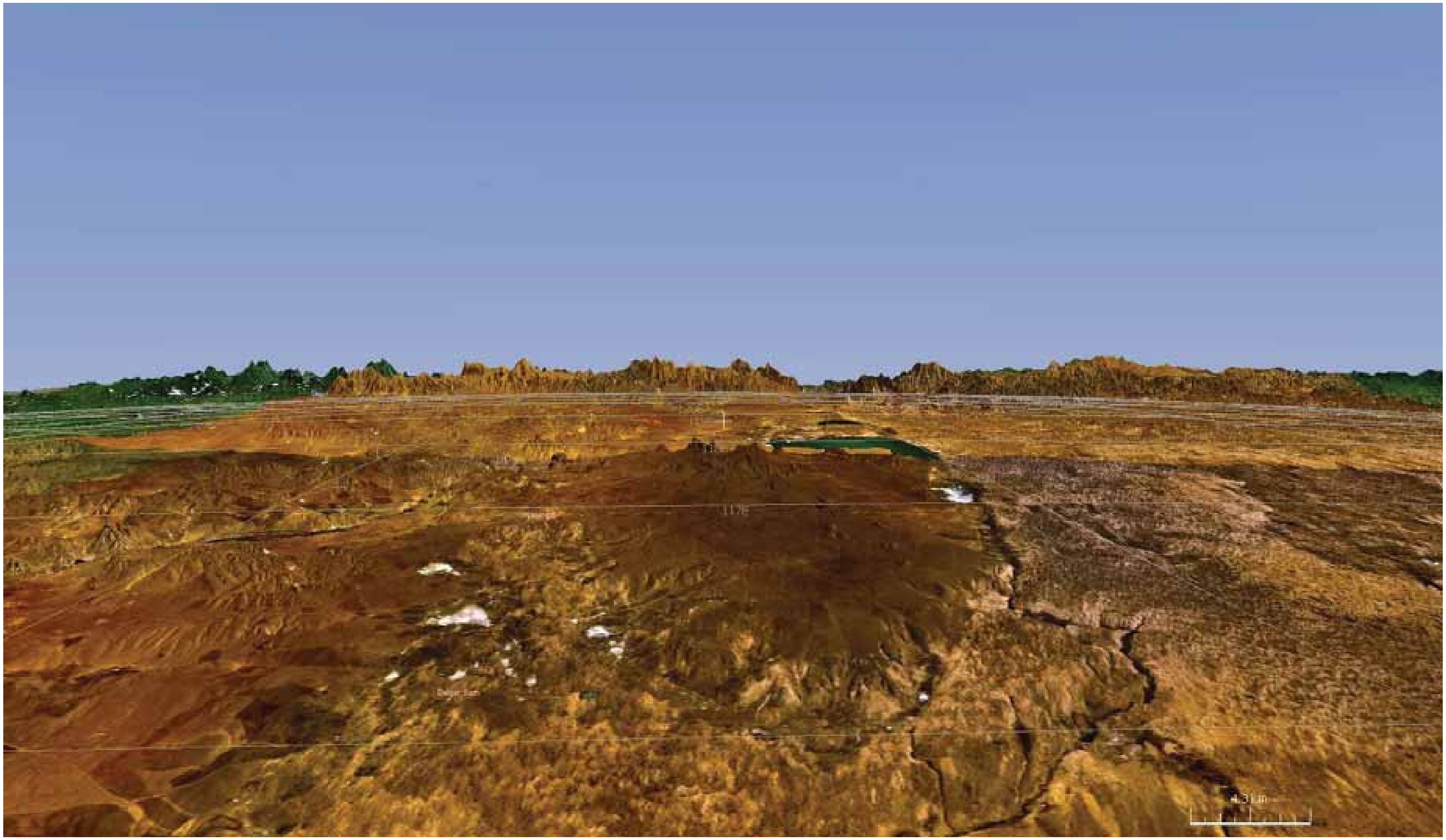
Transition: Heavy grazing/drought followed by an intense rainfall event to initiate soil degradation. Soil structure loss, reduced inflitration, and/or loss of soil surface horizons, increased salinity, remaining vegetation declines

Restoration pathway:
Unknown,
may require decades with no grazing.
High salinity difficult to reverse.



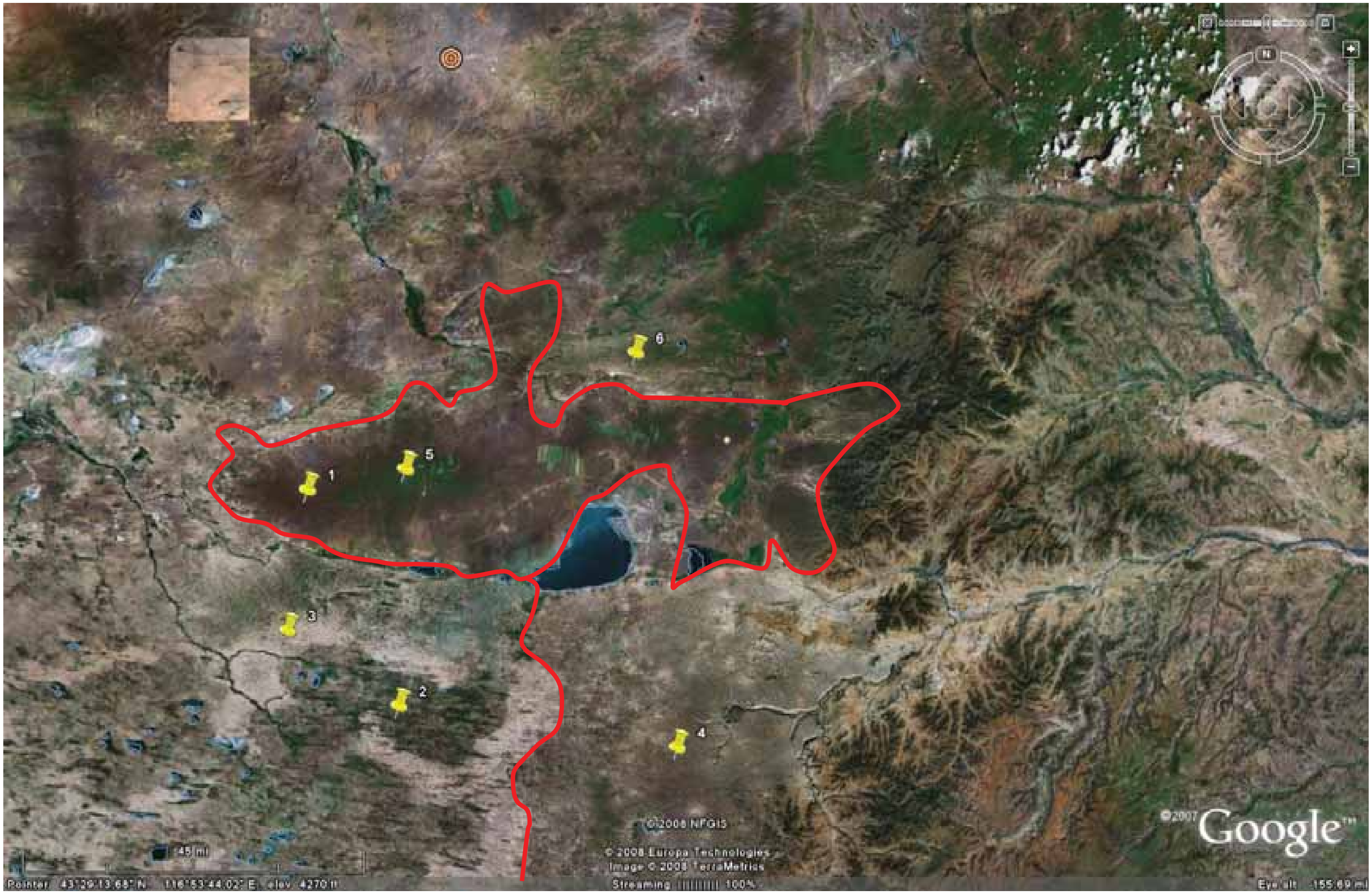
Alternative State
Patchy dominance by halophytes, sealed soil surface, no subsoil structure. Reduced infiltration leads to increasing salinity and low available water in rooting zones of grasses, sealed soil prevents grass establishment

F. Web tools for recognizing landforms



NASA World Wind (http://worldwind.arc.nasa.gov), LandSat imagery, visible color.

F. Web tools for recognizing landforms

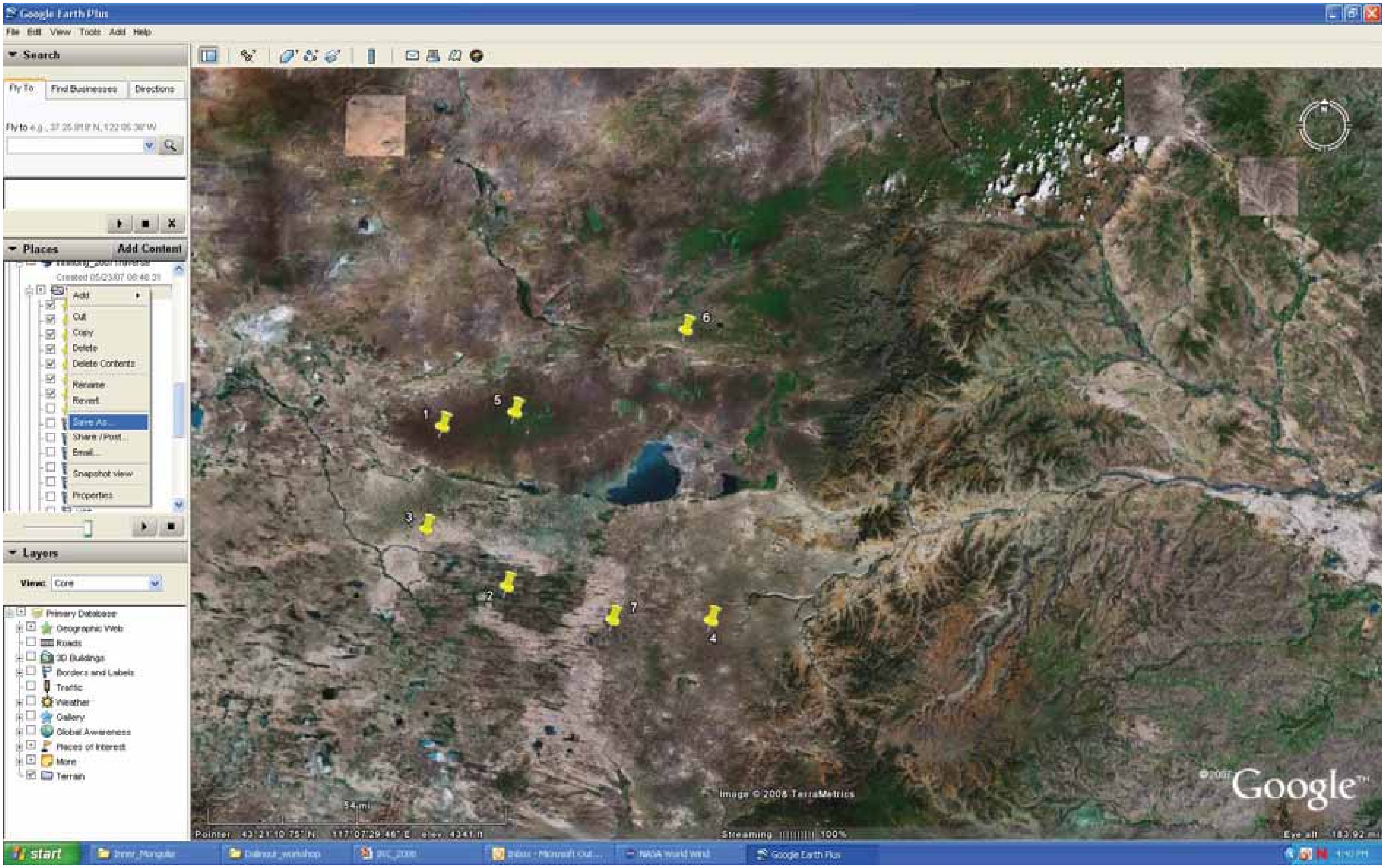


Google Earth (http://earth.google.com/), high resolution imagery

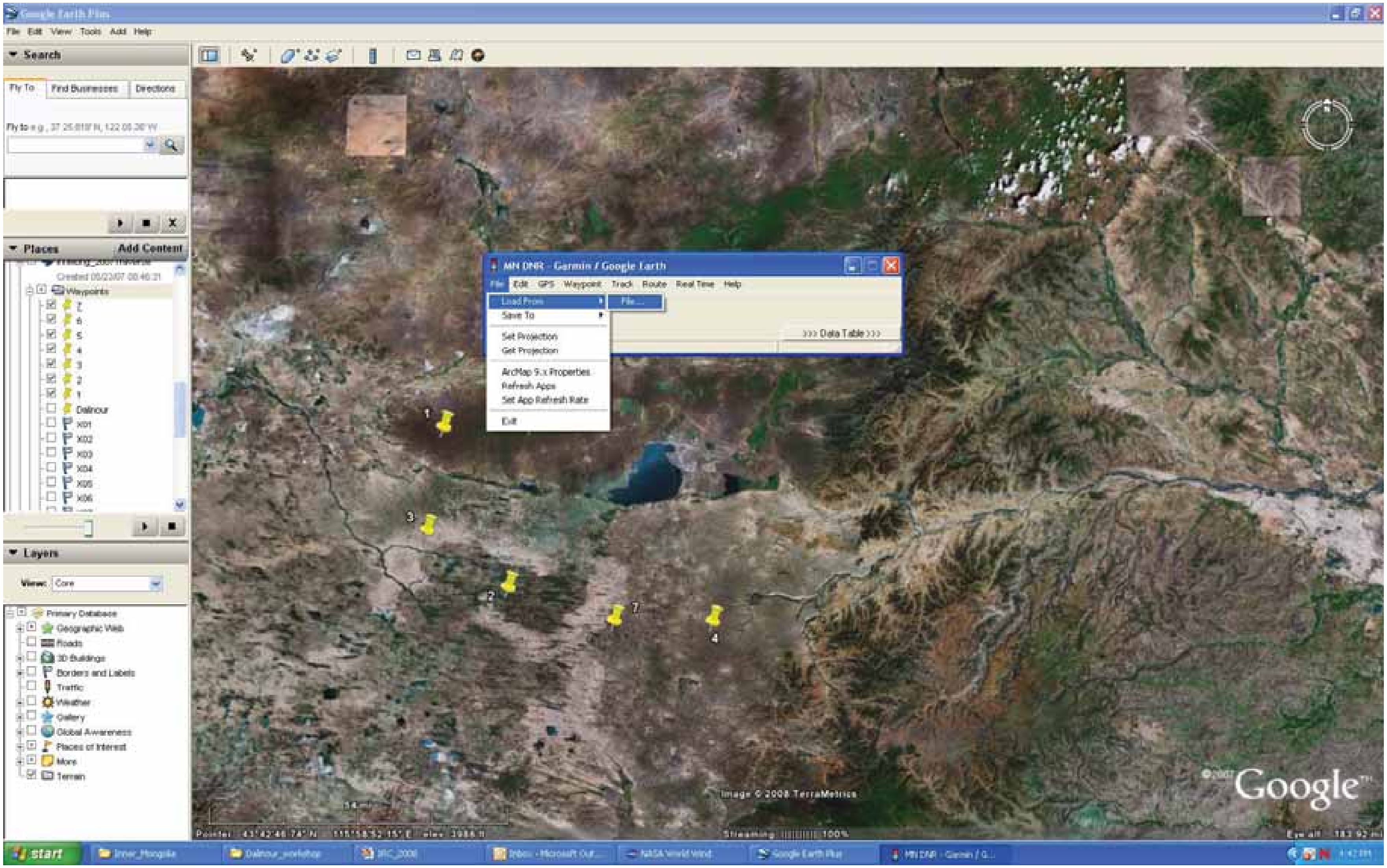
F. Web tools for recognizing reference and other community phases

Google Earth (http://earth.google.com/), high resolution imagery

F. Using Google for field inventory: save selected points to .kml

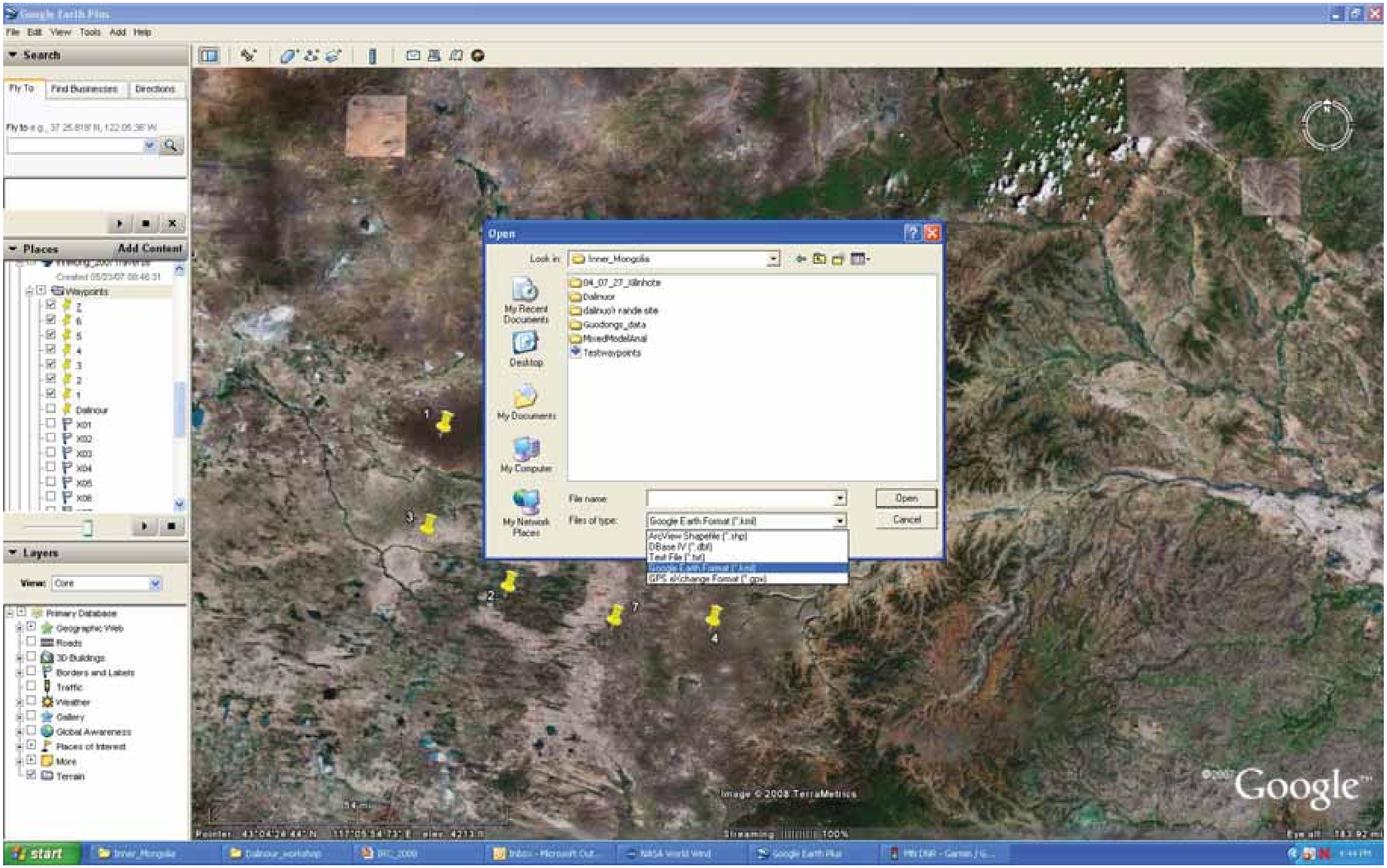


F. Using Google for field inventory : load .kml file in DNR Garmin software (free)

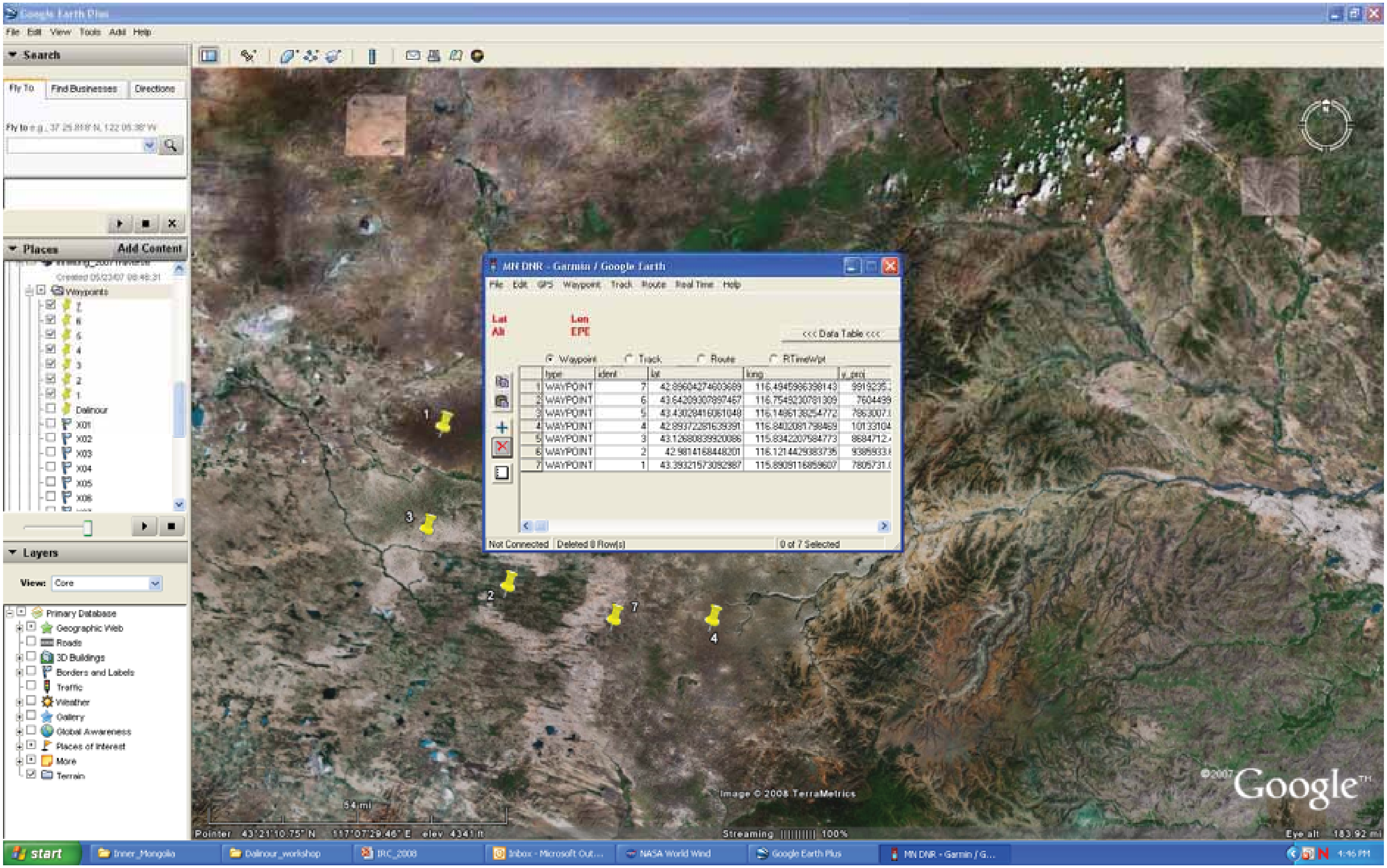


http://www.dnr.state.mn.us/mis/gis/tools/arcview/extensions/DNRGarmin/DNRGarmin.html

F. Using Google for field inventory : load .kml file in DNR Garmin software (free)



F. Using Google for field inventory : load waypoints to GPS, navigate to points

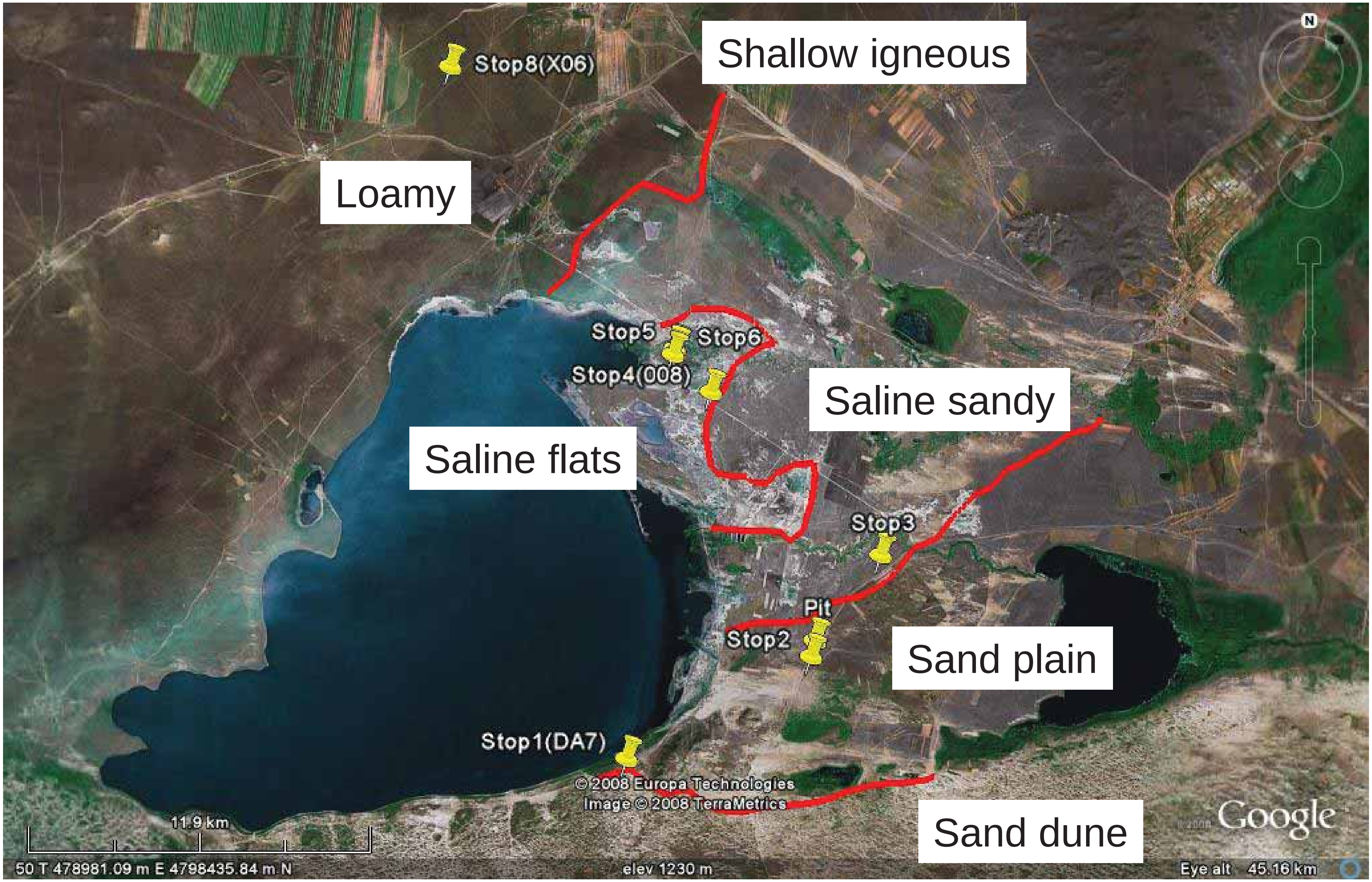


F. Rapid field inventory: “Traverse methods”

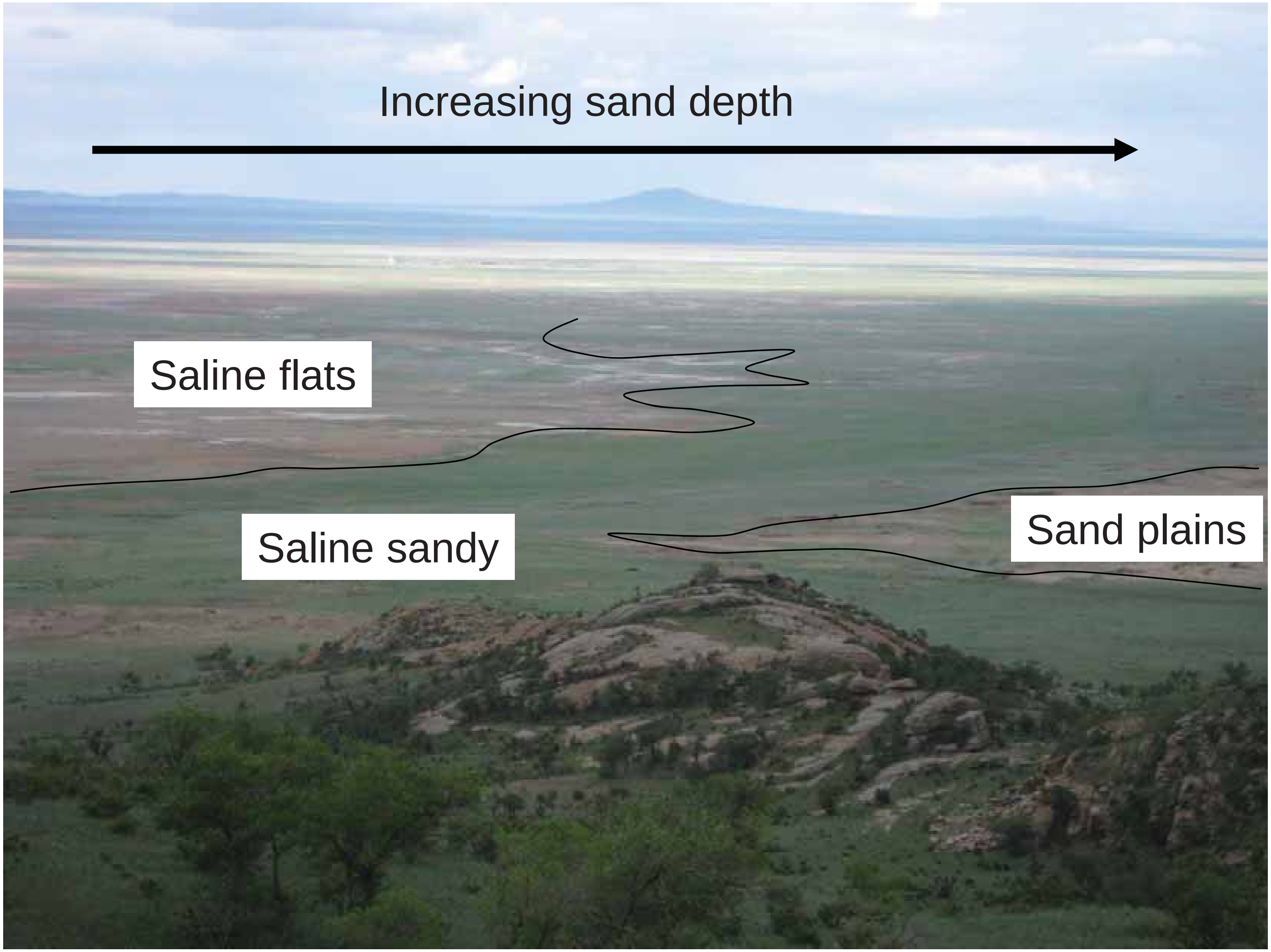
Site:	Plot:		State & Co.:	MLRA:	LRU:
Investigators:	Date:	Location:			

WP	Elev	Pic #	Slope	Aspect	Ecosite	State	Veg comm	Plant Spp	% cvr	ht (cm)	% PG w/ SH	Res Ret Class	__ cm	Eros Pat Class	Soil Characteristics/Notes

F. Developing simple maps of ecological sites



F. Ecological sites are part of a soil continuum



F. Ecological sites are part of a soil continuum

Name: Sand plain
Concept: > 50 cm of
Loamy sand or sand over similar soils or buried soils/bedrock

Indicator plants: *Caragana*

Transition processes: wind/water erosion, dune formation

F. Ecological sites are part of a soil continuum

Name: Saline sandy
Concept: < 50 cm of loamy sand or sand over saline soil

Indicator plants: *Acnatherum*

Transition processes: Erosion exposes saline soil

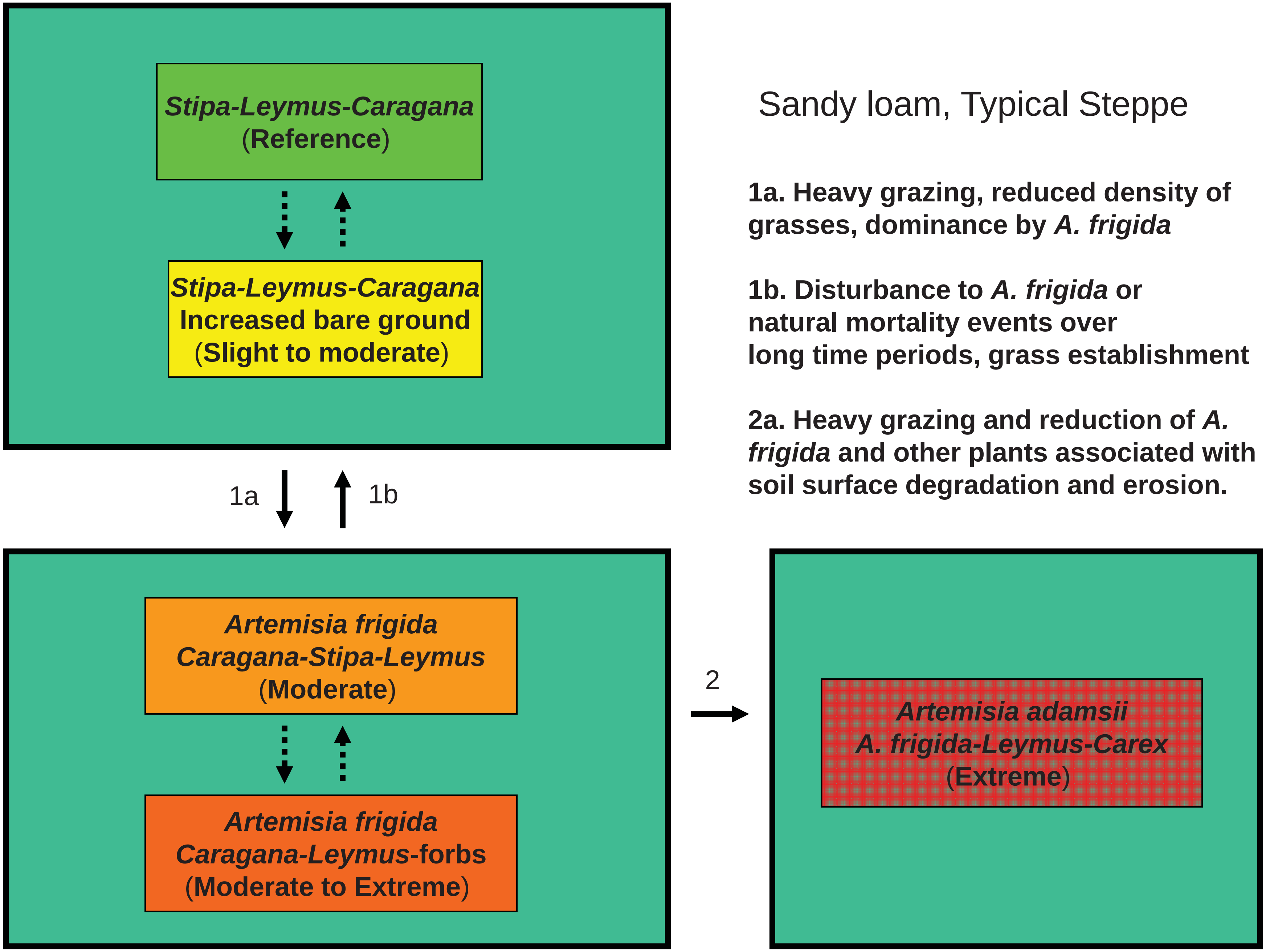
F. Ecological sites are part of a soil continuum

Name: Saline flats
Concept: Silt loam to loam over stratified silty clay loam and loamy fine sand

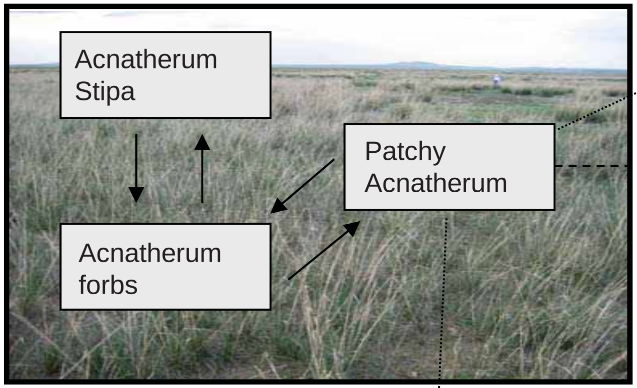
Indicator plants: *Nitraria*, *Sueda*

Transition processes: Fragile site, changes to soil structure, infiltration, salinity

G. Rangeland health assessment related to the state-and-transition model



G. The “at-risk” community phase is the key to the state-and-transition model



At-risk Community Phase: Perennial cover low in Interspaces between Acnatherum patches, low litter low root mass, expanding erosion

At-risk community phase should feature evidence of (3) pedestals, (4) bare ground, (6) wind-scoured areas, (8), soil surface resistance to erosion, (9) soil surface loss/degradation

How would you monitor this site?