Defining Restoration Success in Wyoming's Natural Gas Fields: Suggestions for Selecting Reference Sites and Improving Ecological Site Descriptions

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bp

UNIVERSITY OF WYOMING

WRRC
Wyoming Reclamation & Restoration Center

Restoration Success

- **Setting realistic and attainable goals for land reclamation and ecosystem restoration projects is considered to be an essential (and perhaps the most important) part for achieving restoration success** (e.g., Allen et al. 1997, Dickens and Suding 2013, Ehrenfeld 2000, Higgs 1997, Hobbs and Harris 2001, Hobbs and Norton 1996, March and Smith 2011, Parker 1997, Suding 2011, White and Walker 1997).
- **Undisturbed reference communities or pre-disturbance communities may provide good benchmarks for measuring restoration success** (e.g., Clewell 2009, Ruiz-Jaen and Aide 2005, SERI Primer 2004, Suding 2011).

What is Success?

What is Success?

SERI Primer (2004) Attributes for Restoration Success

- 1)Similar diversity and community structure in comparison with reference sites
- 2) Presence of indigenous species
- 3) Presence of functional groups necessary for long-term stability
- 4) Capacity of physical environment to sustain reproducing populations
- 5) Normal functioning
- 6) Integration with the landscape
- 7) Elimination of potential threats
- 8) Resilience to natural disasters
- 9) Self-sustainability

Regulatory Standards for Restoration Success

Field Office	Percent Cover	Erosion Control/Soil Stability **	Weeds **	Grass Richness** *	Forb Richness	Forb Density Or Frequency	Shrub Richness	Shrub Density or frequency	Plant Vigor **
Jonah Interagency Office	Greater than or equal to reference site	Site must be stable according to BLM Tech Note 346	No noxious weeds or highly competitive Invasives	At least 2 bunch grass species and 3 total species	Equal or greater than reference	At least 75% of reference	Equal to or greater than reference	At least 50% of reference with no more than 10% rabbitbrush	Plants must be resilient as displayed by root system, flowers, and see d heads
Pinedale Anticline Project Office	Plant community sufficient to minimize visual impacts, provide habitat and forage, impede noxious weed invasion	Plant community must stabilize soils	No state or federally listed noxious weeds. Active treatment in place for weedy bromes	At least 2 bunch grass species and 3 total species	Equal to or greater than reference within 5 years	At least 75% of reference within 5 years	Equal to or greater than reference within 5 years	At least 50% of reference within 5 years	Plants must be resilient as above. Removal of external influences required for a t least 1 year
Kemmerer BLM	Greater than or equal to 80% of reference site	Disturbed areas are immediately stabilized by mulching	Less than or equal to 10% of total vegetative cover						
Rawlins BLM	Greater than or equal to 80% of reference site	Erosion features equal to or less than reference	No noxious weeds						
WDEQ	Greater than or equal to 70% of reference	Grass must extend to any active roadway unless permanent anchor in place							

Restoration Ecology and Succession

- Restoration has been called “assisted succession” or “the manipulation of succession”
- Common thinking in the past that this change was intended to reach a set endpoint

(Luken 1990, Cox and Anderson 2004, Walker et al. 2007).

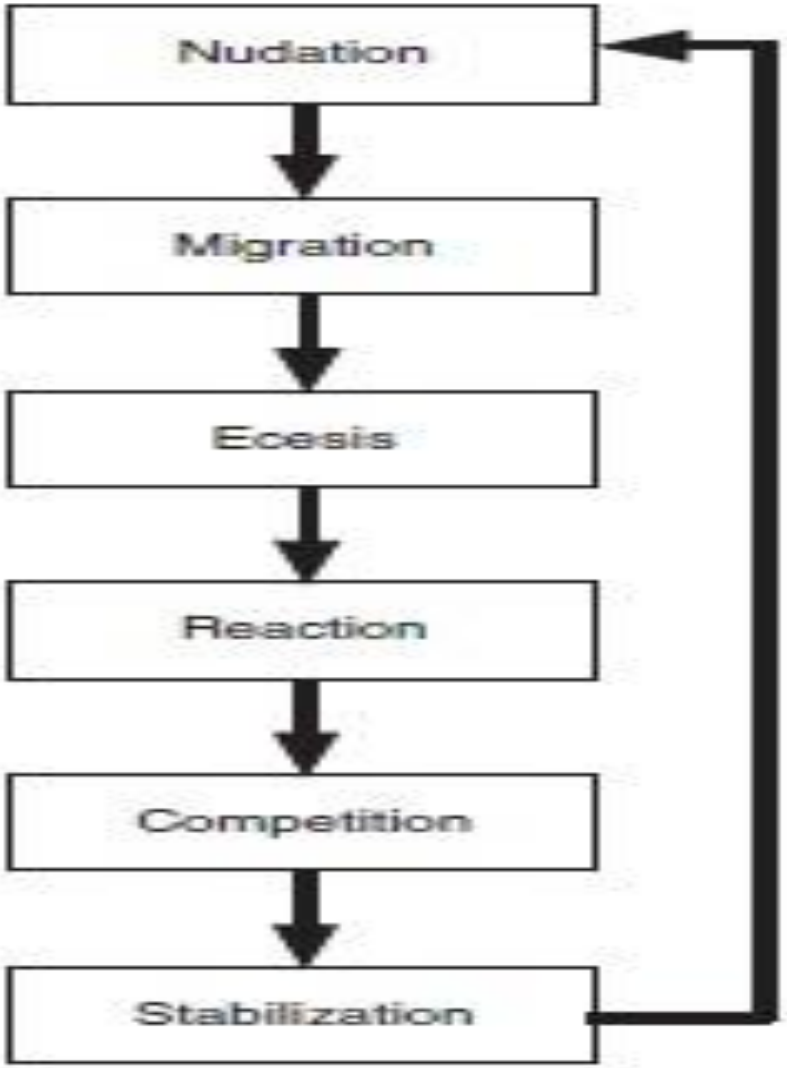

Fig. 1. The six causes of succession as identified by Clements (1916). In the contemporary view, stabilization is viewed as a net effect of the other causes, and not in itself a case of succession.

Pickett et al. 2008


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Restoration Ecology and Succession

- Restoration ecology is a newer field and the main objectives of restoration are often focused on outcomes and overlook the processes taken to get to an endpoint (Walker et al. 2007).

What is Succession?

Succession and Ecology

Succession and Ecology – How did it get here?

- 1825 -- Adolphe Dureau de la Malle (French naturalist) “Memoir on alternation or on alternative succession in the reproduction of plant species living in a community - is it a general law of nature?”
- 1859 – Henry David Thoreau (American author, poet, philosopher, abolitionist, naturalist, tax resister, development critic, surveyor, and historation) “The Succession of Forest Trees”
- 1899 – Henry Chandler (H.C.) Cowles (American Botanist and Ecology Pioneer) “The Ecological Relations of the Vegetation of the Sand Dunes of Lake Michigan”
- 1916 & 1920 – Frederic Edward Clements (American plant ecologist and pioneer in vegetation succession) – “Plant Succession” and “Plant Indicators”

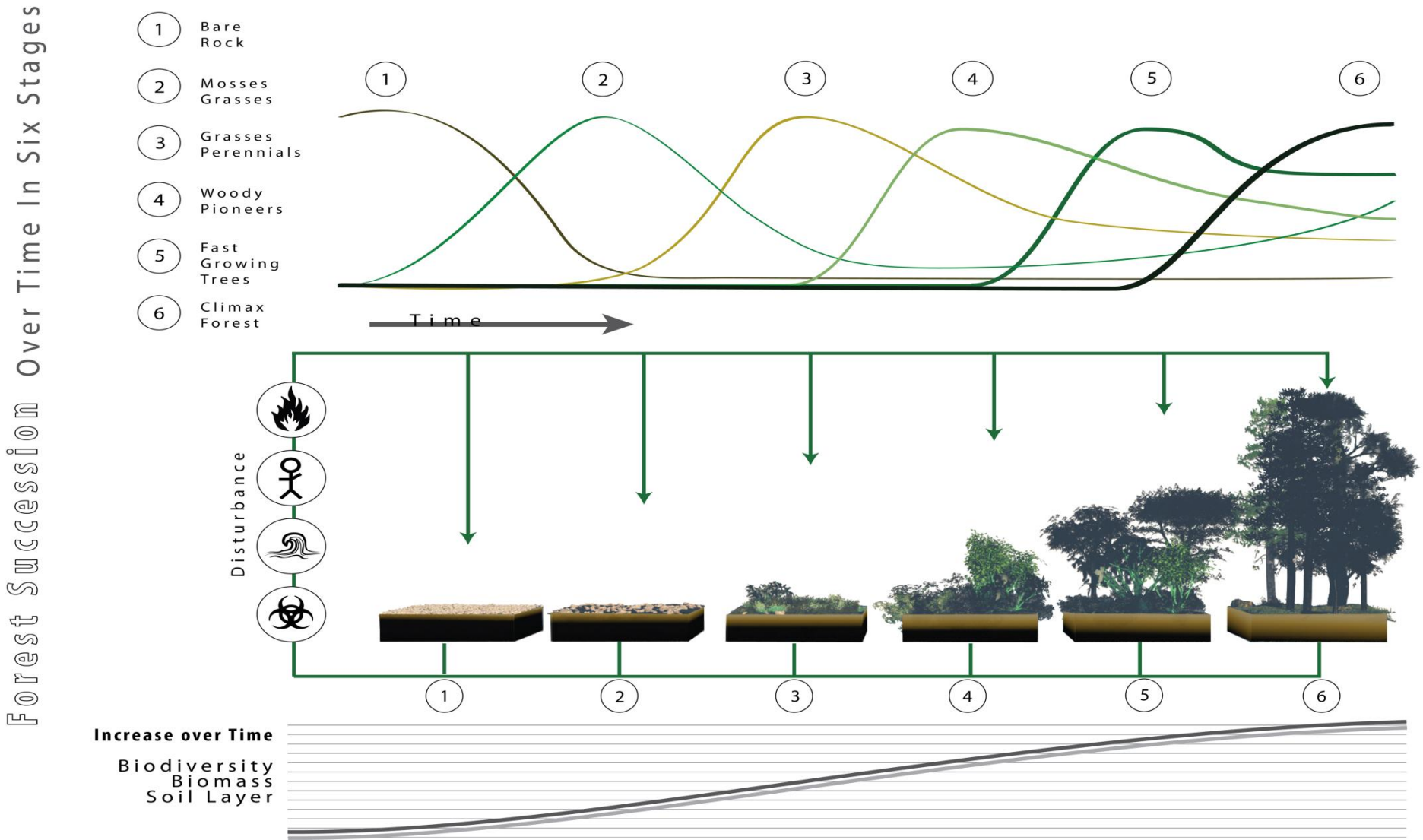
Cowles' Succession

- 1899 -- "The Ecological Relations of the Vegetation of the Sand Dunes of Lake Michigan" Cowles suggested that a 'dune-complex... is a restless maze, advancing as a whole in one direction, but with individual portions advancing in all directions.'
- 1911 -- Cowles suggests that different vegetation zones in North America are ultimately driven by the moisture supply throughout the region, and that original plant communities develop in a 'somewhat definite fashion to those that come after, a phenomenon that has been termed as succession.'

Clementsian Succession

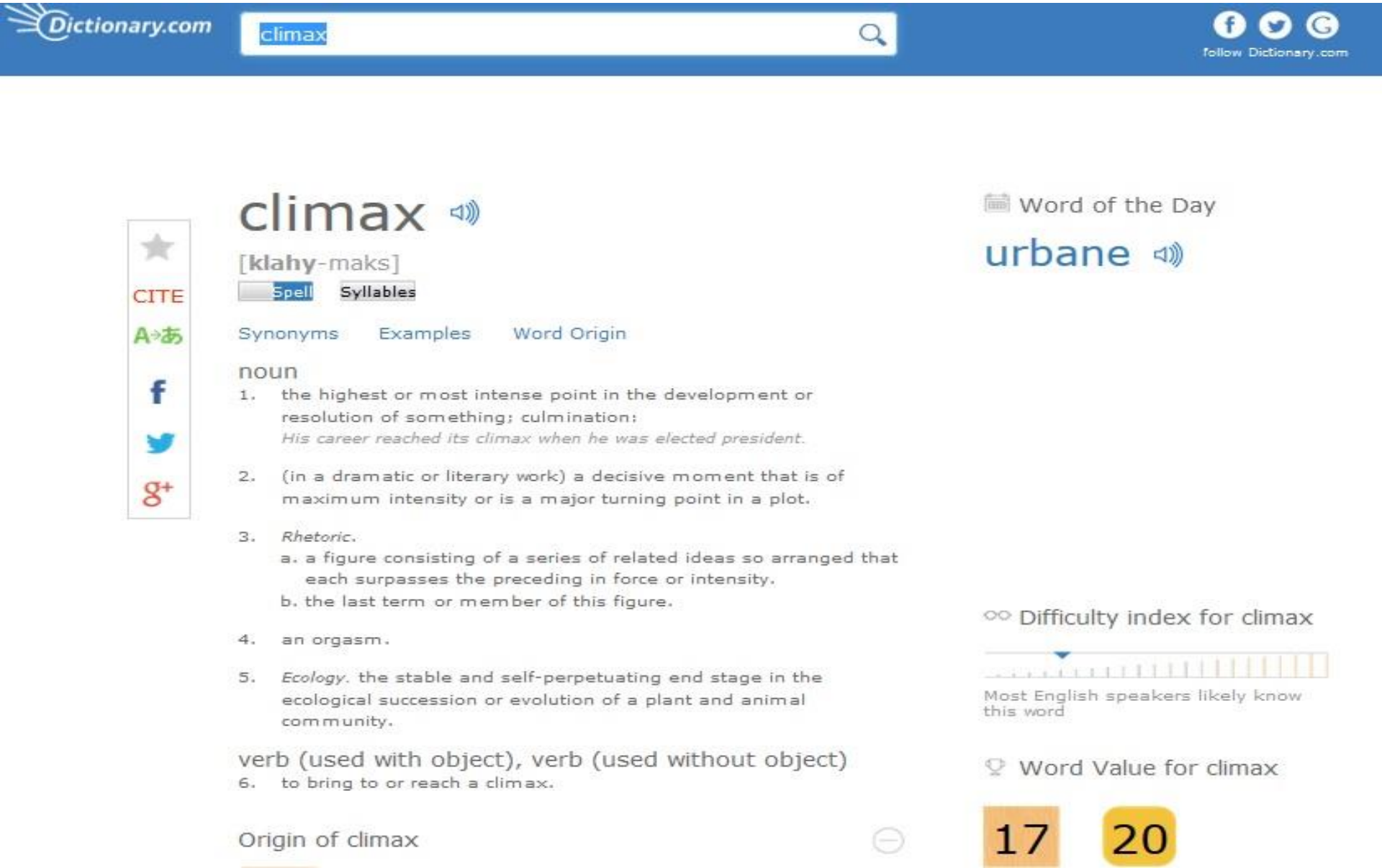
- 1916 -- Clements began his studies in grasslands (more stable than Cowles' dunes)
- "The treatment of the plant community as a 'complex organism' undergoing a life cycle and evolutionary history analogous to the individual organism' (Real and Brown 1991).
- Clements suggested that succession must be progressive, but acknowledged that disturbance could lead to 'retrogression', or a movement away from 'climax' conditions.

Clementsian Succession

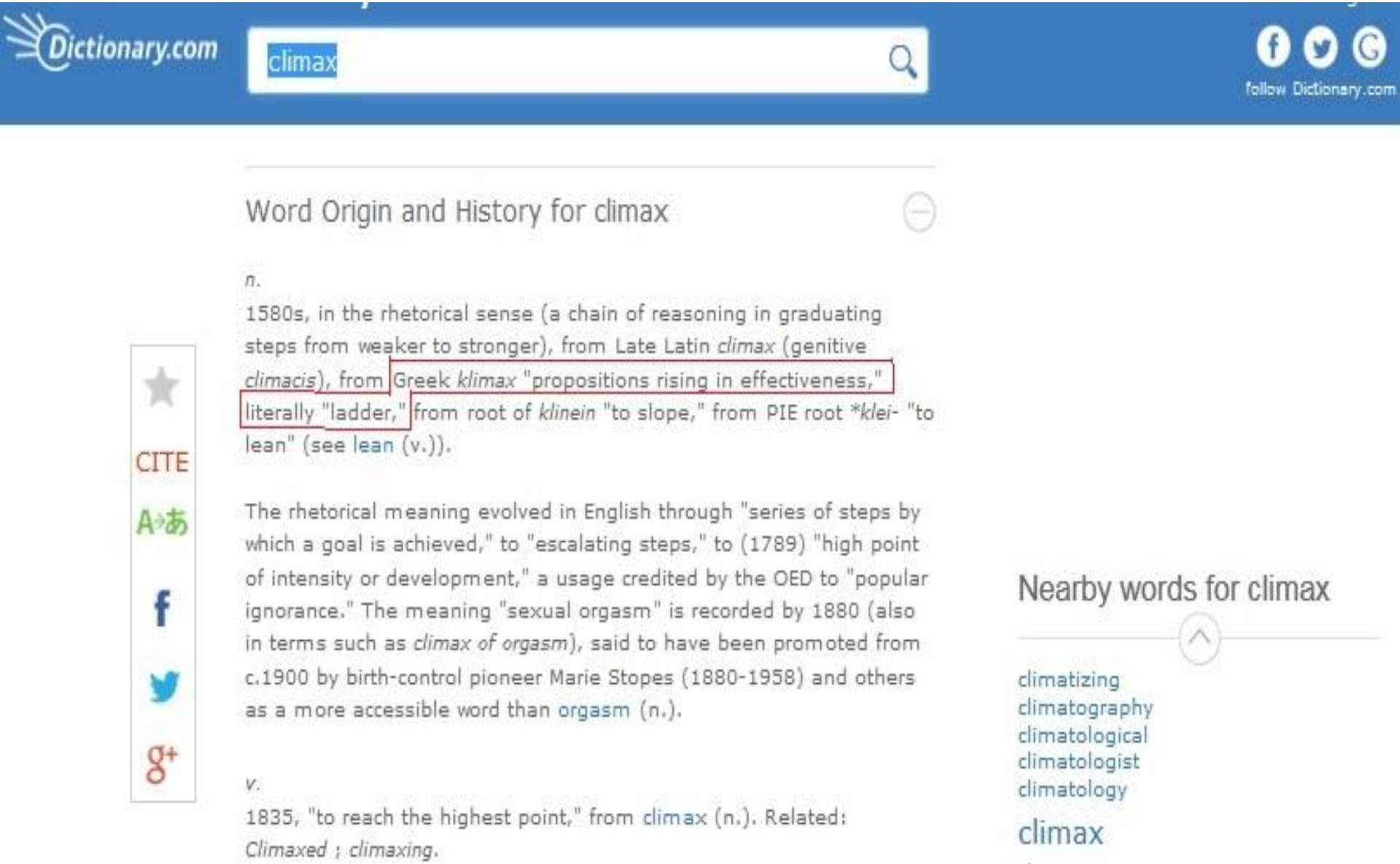


Succession and Ecology

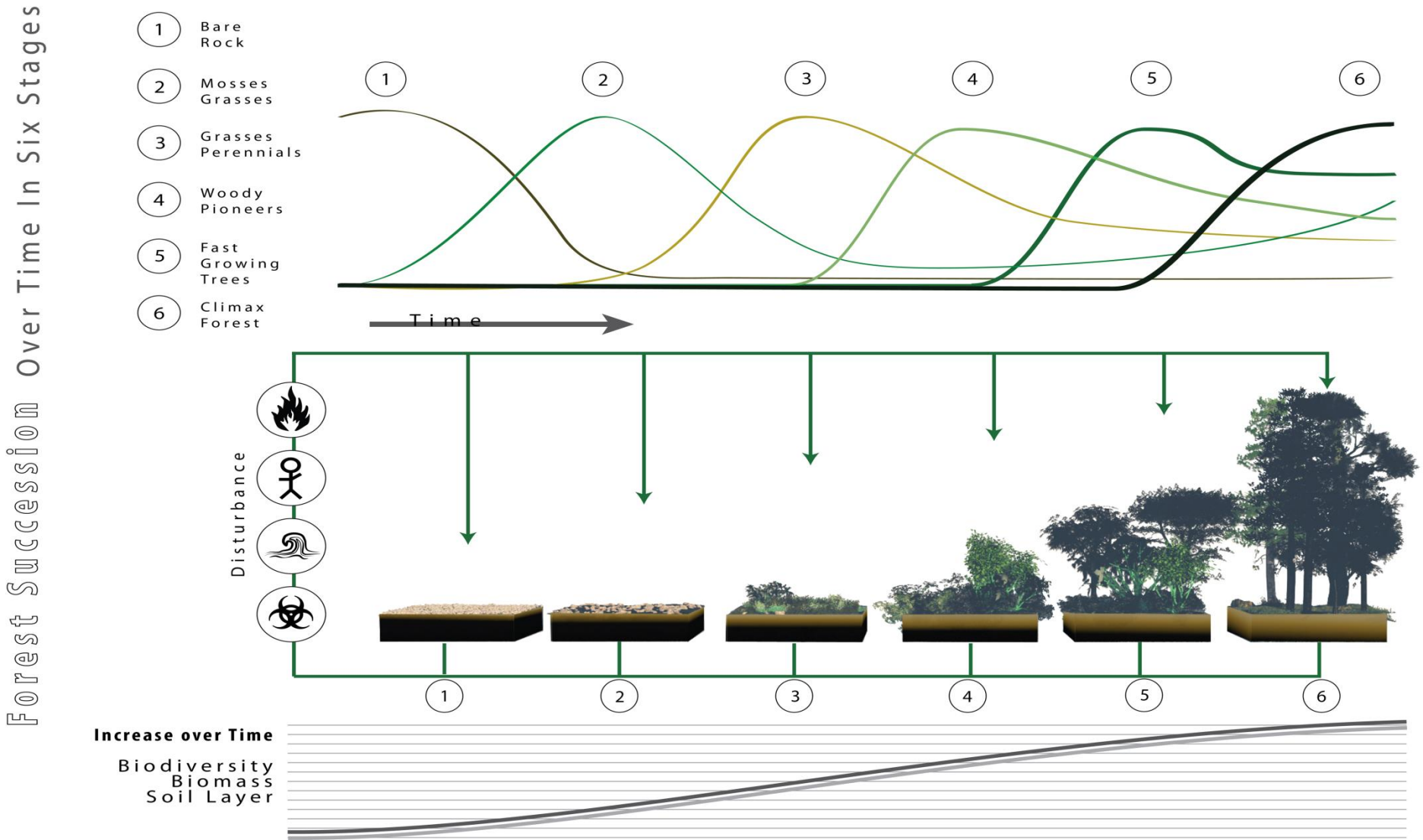
Climax – Definition



Climax – Word Origin



How do we view Climax? -- Ecology



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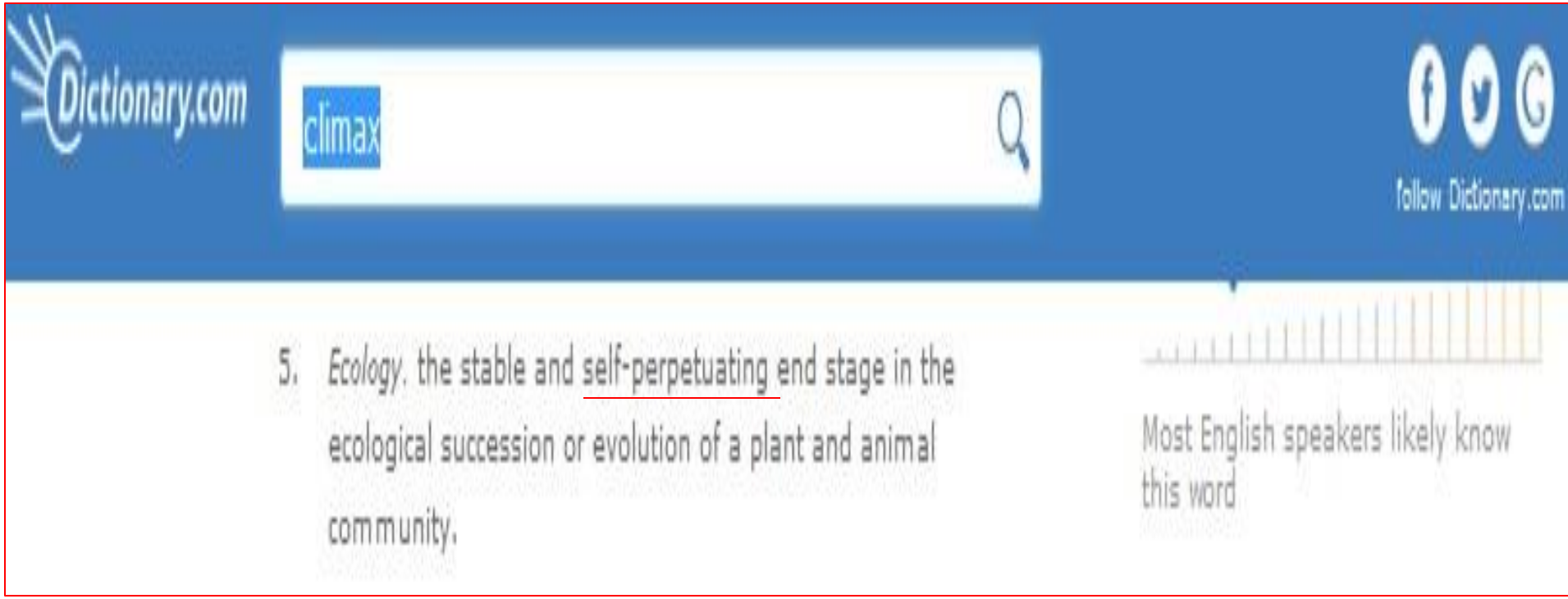


Does Climax fit into all areas of ecology?

- 1926 – Henry Gleason argues idea of complex organism, suggests no fixed end point ('climax community') for any group of plant species. Sir
- 1935 – Sir Arthur Tansley was also highly critical of Clements and some of the ideas behind succession. Simply not true that vegetation everywhere, all the time, is making progress towards a climax communi.ty

Robert Harding Whittaker and Succession

- 1948 – Graduated with PhD from University of Illinois
- 1956 – First to provide empirical evidence to challenge Clements' ideas on succession
- 1970 and 1972 – Whittaker's ideas began to bring Gleason and Tansley's ways of thinking back into popularity

Rangeland Management and E.J. Dyksterhuis

- 1949 – "Condition and Management of Rangeland Based on Quantitative Ecology"
- Proposed 'rangeland condition' or 'successional stage' model be used to guide rangeland management.
- Primary concerns in rangeland health at time were grazing and drought
- Disturbance due to grazing or drought could cause retrogression to a rangeland and the removal of disturbance would result in a linear progression of a plant community to reach a 'climax' community that would have been found prior to disturbance (Dyksterhuis 1949, Westoby et al. 1989, Borman and Pyke 1994).

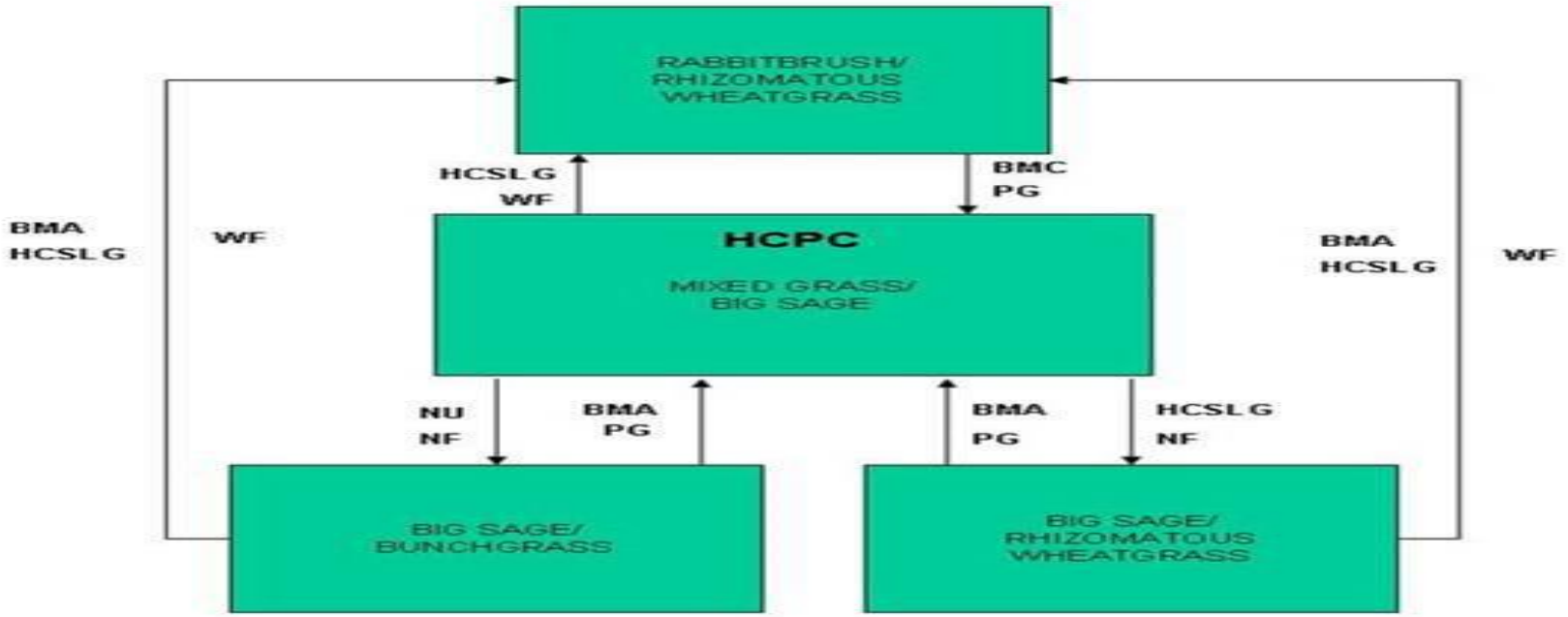
Rangeland Management and E.J. Dyksterhuis

- Rangeland condition is measured by comparing disturbed communities to adjacent undisturbed communities (considered to be 'climax communities').
- The disturbed community is then ranked based on a point on a linear trajectory between a heavily disturbed community and a climax, or undisturbed, community
- 4 Possible Conditions
  - Excellent, Good, Fair, Poor

Ecological Site Descriptions

Site Type: Rangeland
MLRA: 34A-Cool Central Desertic Basins and Plateaus

Loamy (Ly) 7-9GR
R034AY122WY



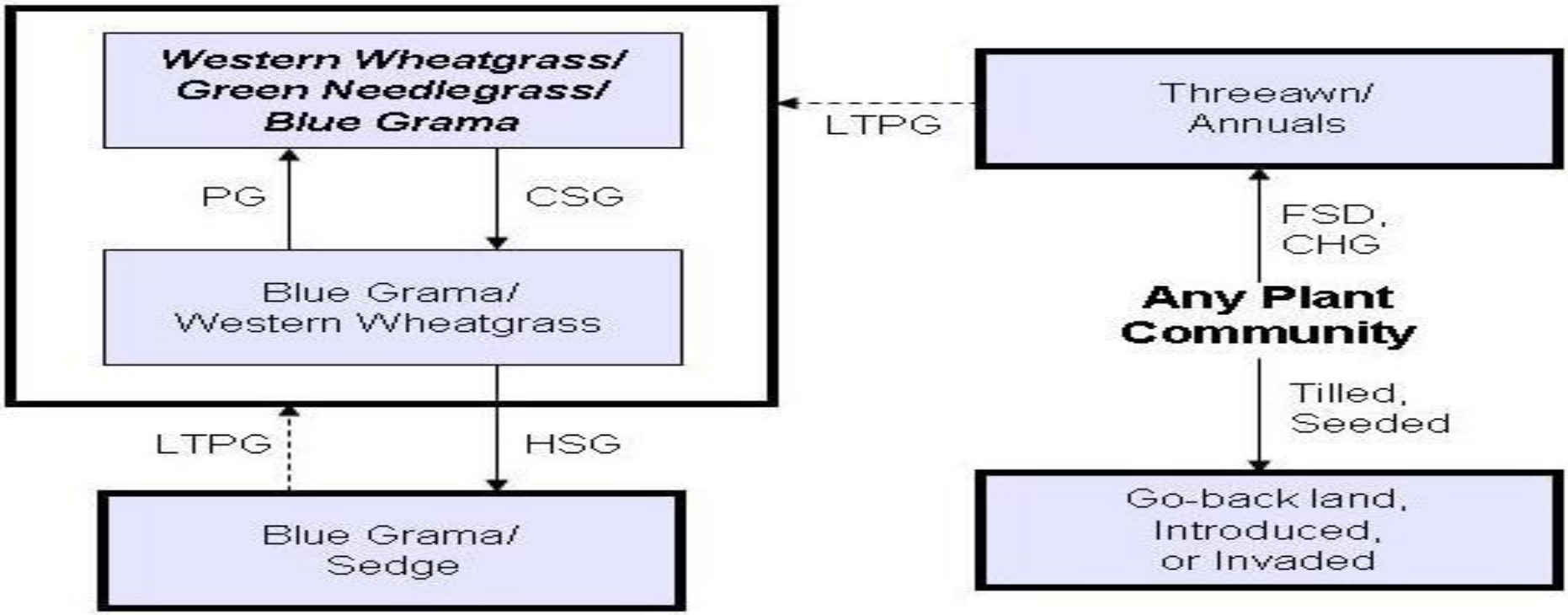
BMA – Brush Management (all methods)
BMC – Brush Management (chemical)
BMF – Brush Management (fire)
BMM – Brush Management (mechanical)
CSP – Chemical Seedbed Preparation
CSLG – Continuous Season-long Grazing
DR – Drainage
CSG – Continuous Spring Grazing
HB – Heavy Browse
HCSLG – Heavy Continuous Season-long Grazing
HI – Heavy Inundation
LPG – Long-term Prescribed Grazing
MT – Mechanical Treatment (chiseling, ripping, pitting)

NF – No Fire
NS – Natural Succession
NWC – Noxious Weed Control
NWI – Noxious Weed Invasion
NU – Nonuse
P&C – Plow & Crop (including hay)
PG – Prescribed Grazing
RPT – Re-plant Trees
RS – Re-seed
SGD – Severe Ground Disturbance
SHC – Severe Hoof Compaction
WD – Wildlife Damage (Beaver)
WF - Wildfire

Technical Guide
Section IIE

USDA-NRCS
Rev.11/11/04

Ecological Site Descriptions



CHG – Continuous heavy grazing; **CSG** – Continuous seasonal grazing; **FSD** – Frequent and severe defoliation; **HSG** – Heavy seasonal grazing; **LTPG** – Long-term prescribed grazing; **PG** – Prescribed grazing.

Interagency Ecological Site

Handbook for Rangelands

January 2013

"Helping People Help the Land"

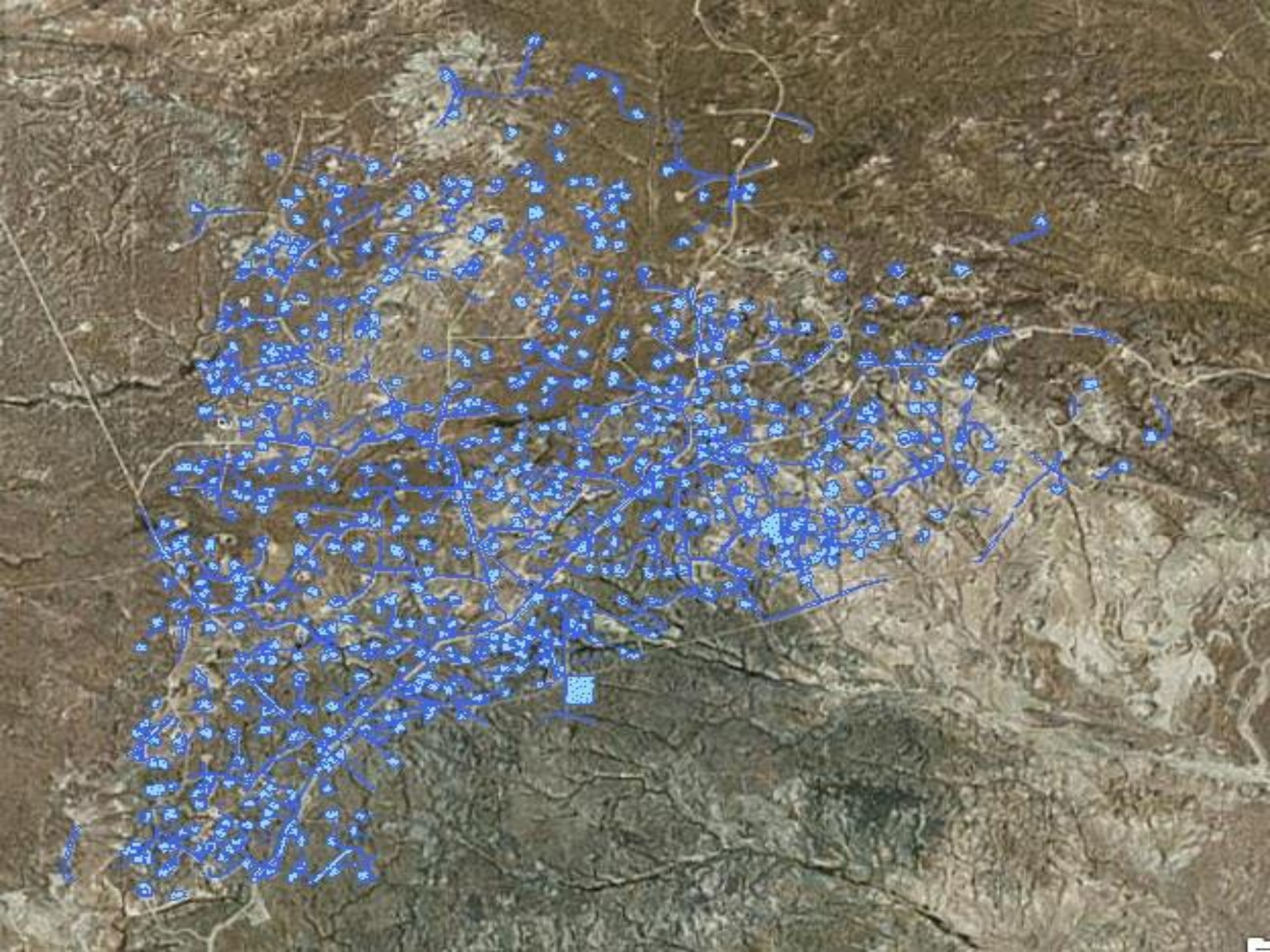
Ecological Site Descriptions

- "The BLM, USFS, and NRCS have a common objective of utilizing science-based technical processes to sustain and enhance natural resources and the environment. They have used different methods to stratify landscapes into units for planning, analysis, and decision making. Their jurisdictions are intermingled throughout much of the United States, including both private and public lands; therefore, a standardized method to define, delineate, and describe terrestrial ecological sites is more efficient than each agency having their own method.“ – Interagency Handbook
- “ESDs provide land managers the information needed for evaluating suitability of the land for various land-use activities, the capability to respond to mgmt. activities or disturbance processes, and the ability to sustain productivity over the long term.” –Interagency handbook

Ecological Sites

- “An ecological site is a distinctive kind of land with specific physical characteristics that differs from others kinds of land in its ability to produce a distinctive kind and amount of vegetation.” –National Range and Pasture Handbook
- “Ecological Sites provide a general ecological foundation for management” – Moseley et al. 2010
- “Where changes in **soils, aspect, topography, or moisture conditions** are abrupt, the boundaries of the ecological site conditions will be obvious. Where soils and plant communities change gradually along broad environmental gradients in areas of fairly uniform topography, ecological site distinctions are more difficult to specify…” – Moseley et al. 2010

Jonah Infill Natural Gas Field



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Map Unit Symb	API	No forbs present undisturbed	No forbs present disturbed	
5203	49-035-21391	1		2
5203	49-035-21509	7		2
5203	49-035-21558	5		2
5203	49-035-21844	7		2
5203	49-035-21899	5		4
5203	49-035-21918	2		3
5203	49-035-21923	3		2
5203	49-035-21991	4		3
5203	49-035-22066	7		5
5203	49-035-22234	1		2

Sampling Vegetation Attributes (BLM Tech. Ref. 1734-4)

Monitoring in Jonah Infill

- 2006 – CSR randomly placed five 1 m2 frames on well pads and adjacent reference areas for vegetation measurements (most between June 5 and June 8)
- 2007 – CSR randomly placed five 1 m2 frames on well pad and adjacent reference areas for vegetation measurements (all between July 11 and July 19)
- 2008 – CSR placed a 1 m2 frame 10 times along a 50 m transect on well pads and adjacent reference areas for vegetation measurements (in accordance with BLM tech. notice 1734-4) (most between June 11 and June 14)
- 2009 – CSR placed a 1 m2 frame 10 times over a 50 m transect on well pads and adjacent reference areas for vegetation measurements (in accordance with BLM tech. notice 1734-4) (most between July 13 and July 17)
- 2010 – CSR used either one 100 m or two 50 m transects and recorded basal ground cover at 200 points (in accordance with BLM tech. notice 1734-4) (all between June 1 and June 7)
- 2011 – CSR used either one 100 m or two 50 m transects and recorded basal ground cover at 200 points (in accordance with BLM tech. notice 1734-4) (all between July 6 and July 10)

- **There is no evidence that the same locations on pads or reference sites were monitored between years when the same method was used.

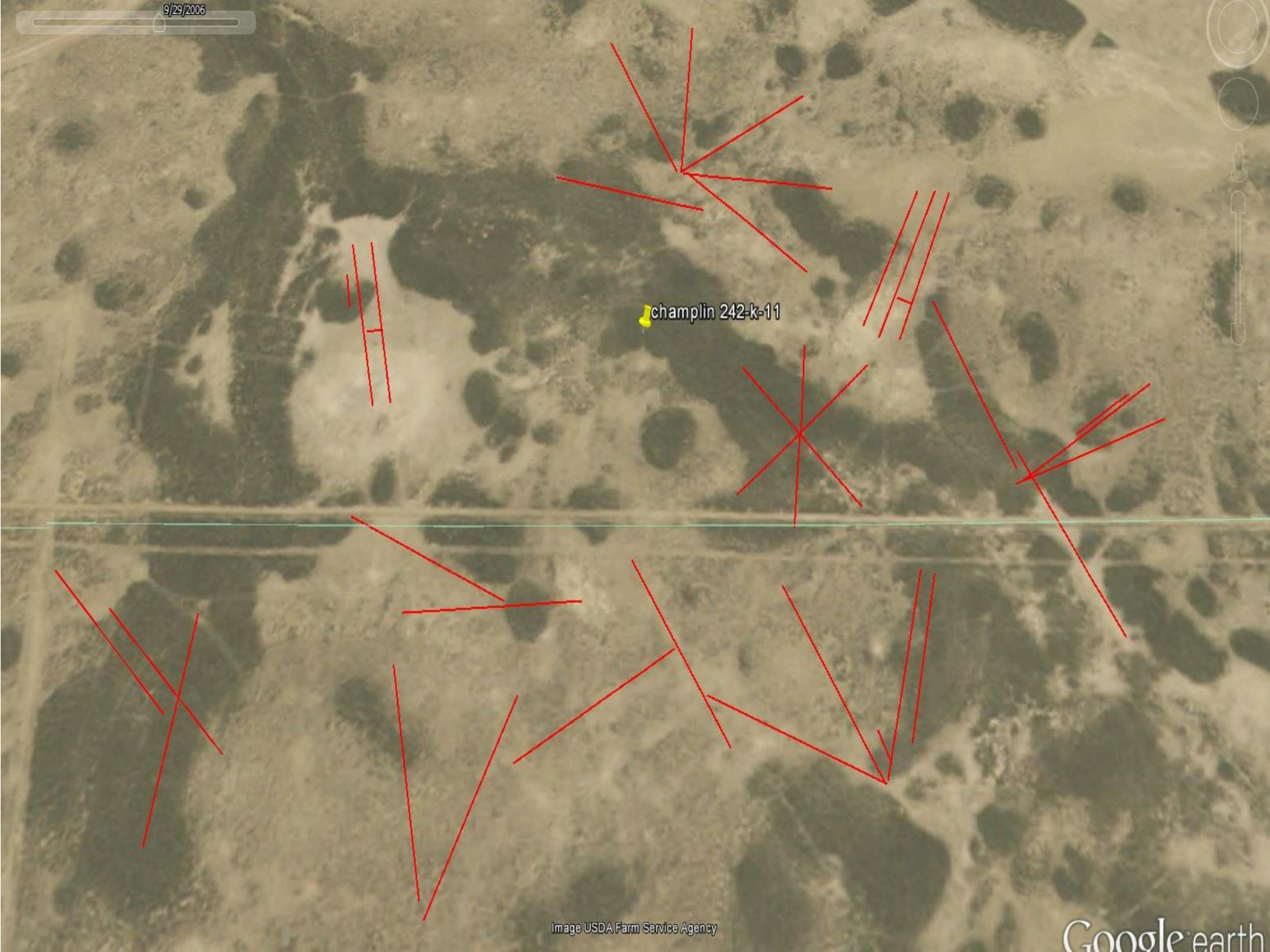
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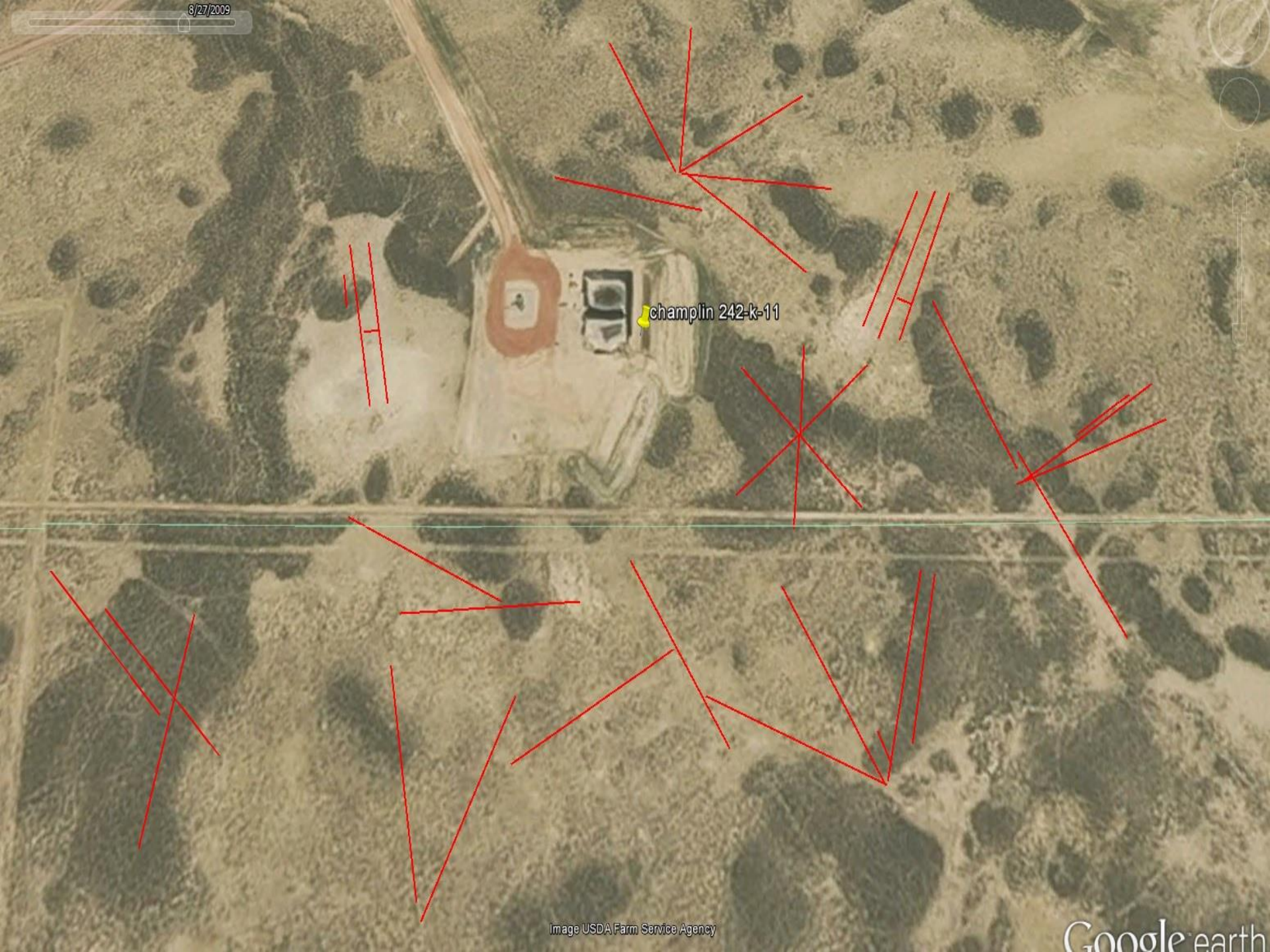
Image USDA Farm Service Agency
Google earth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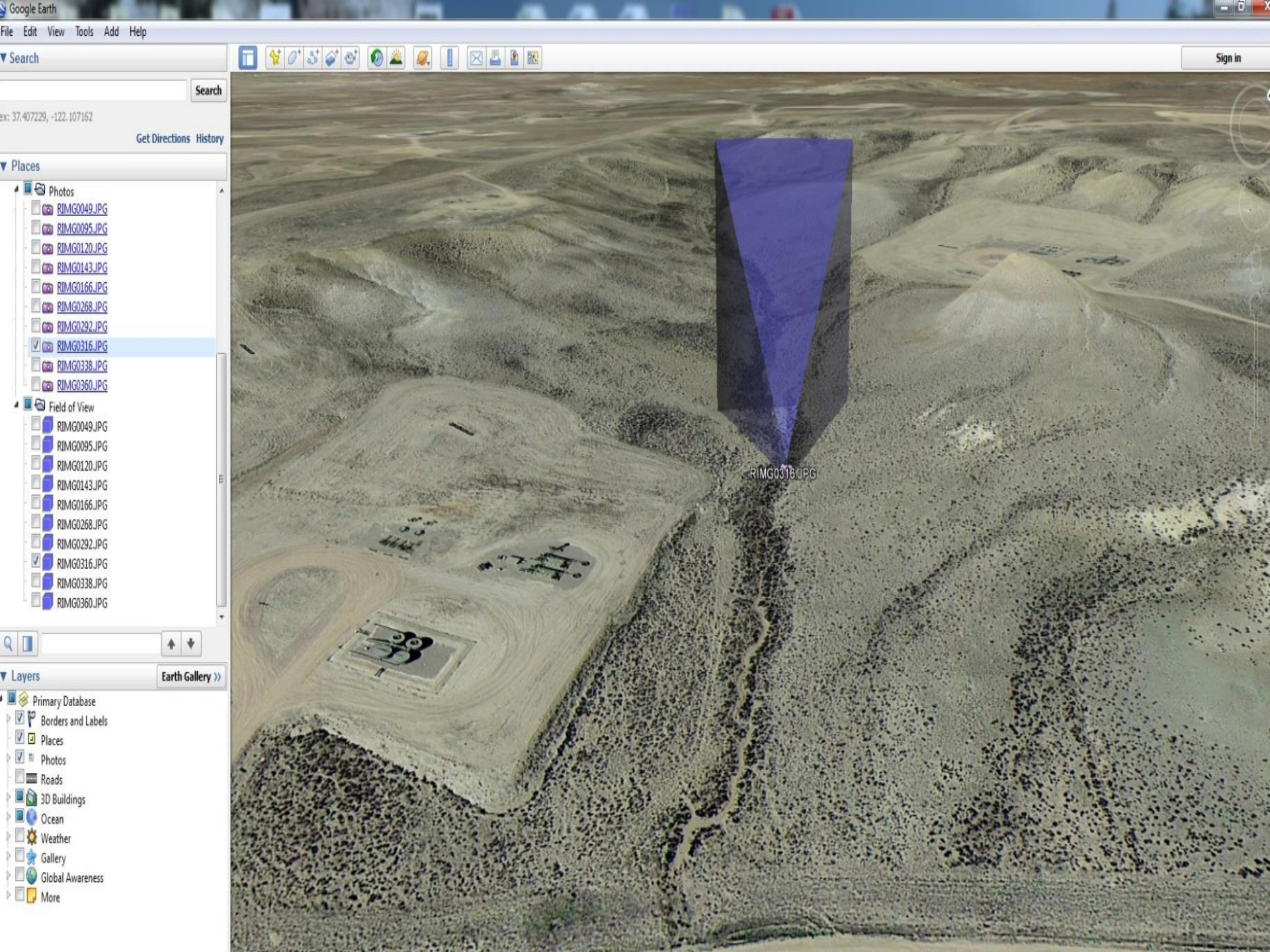
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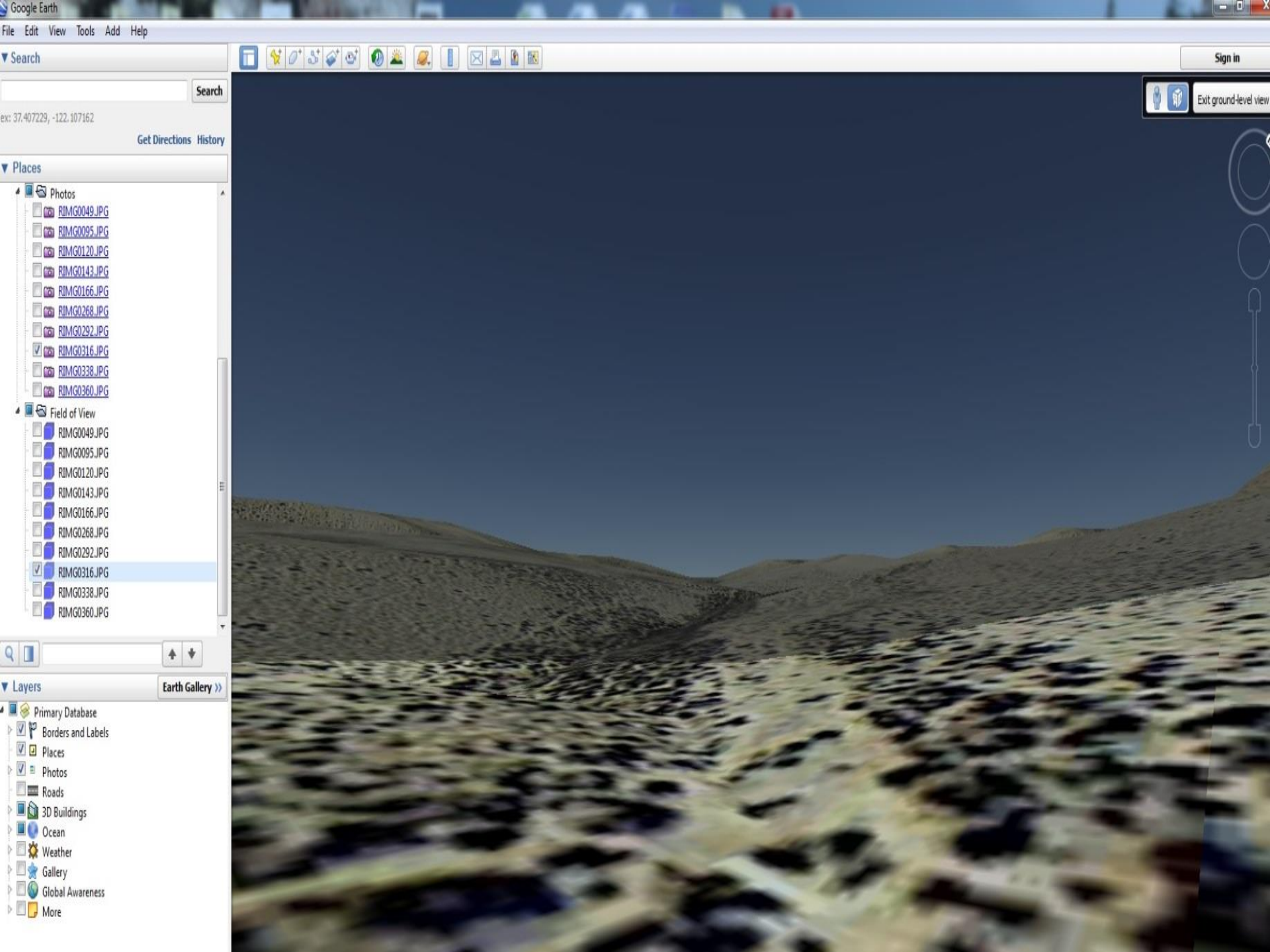
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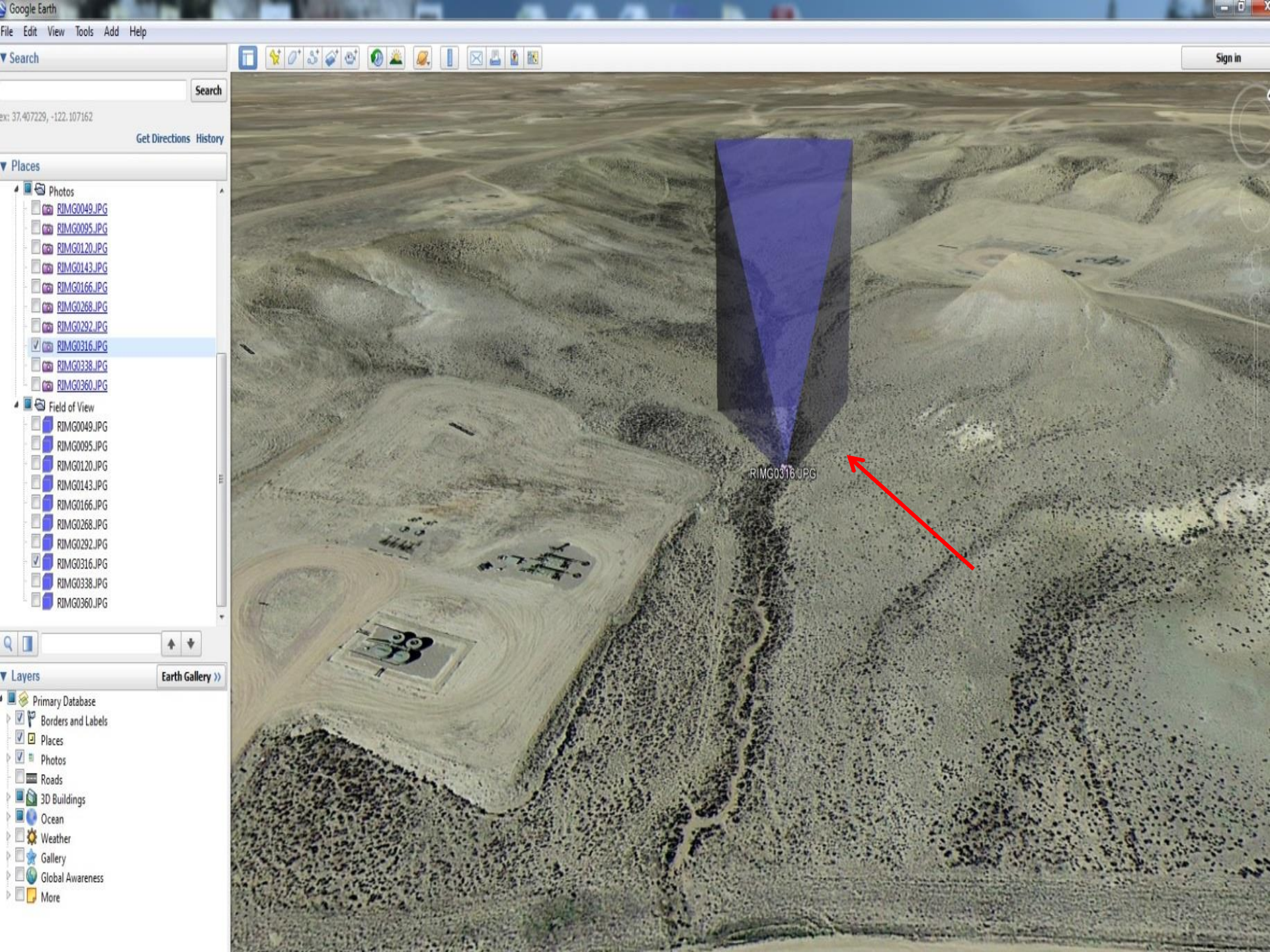
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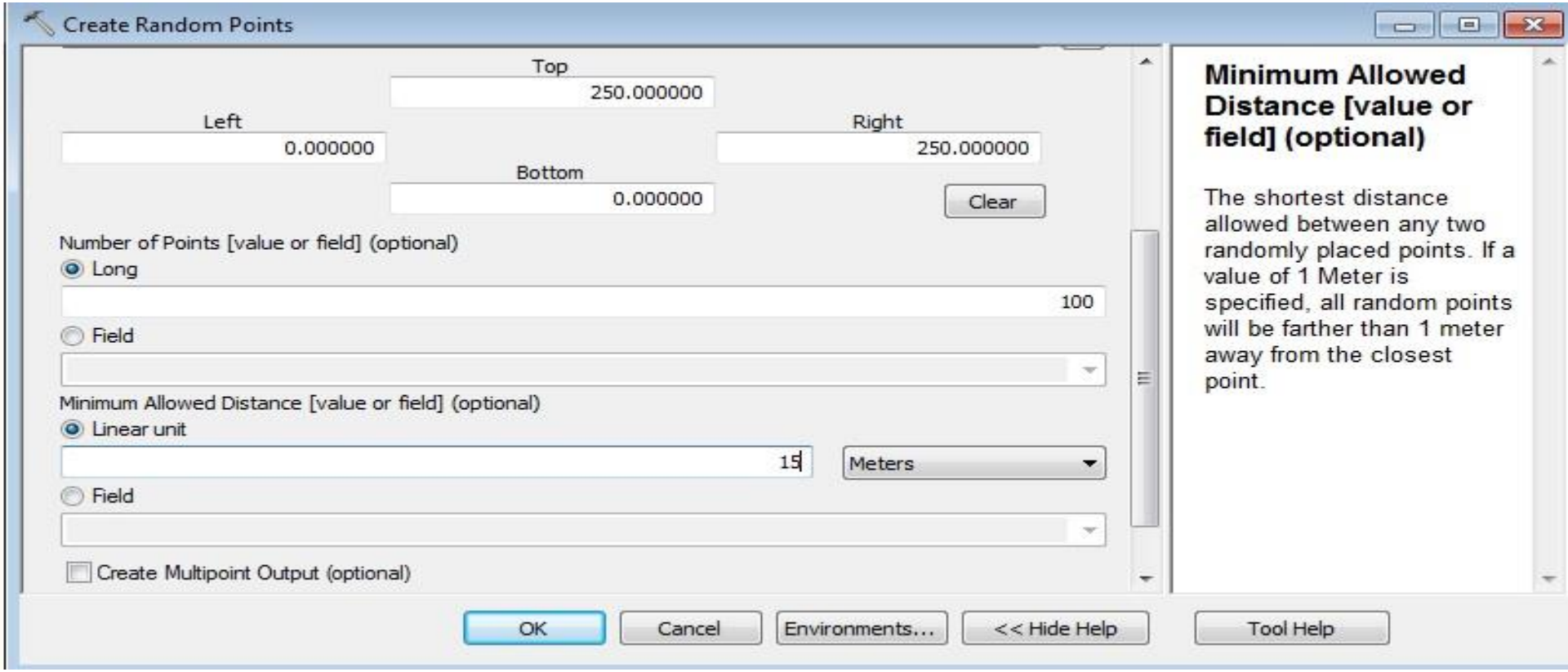
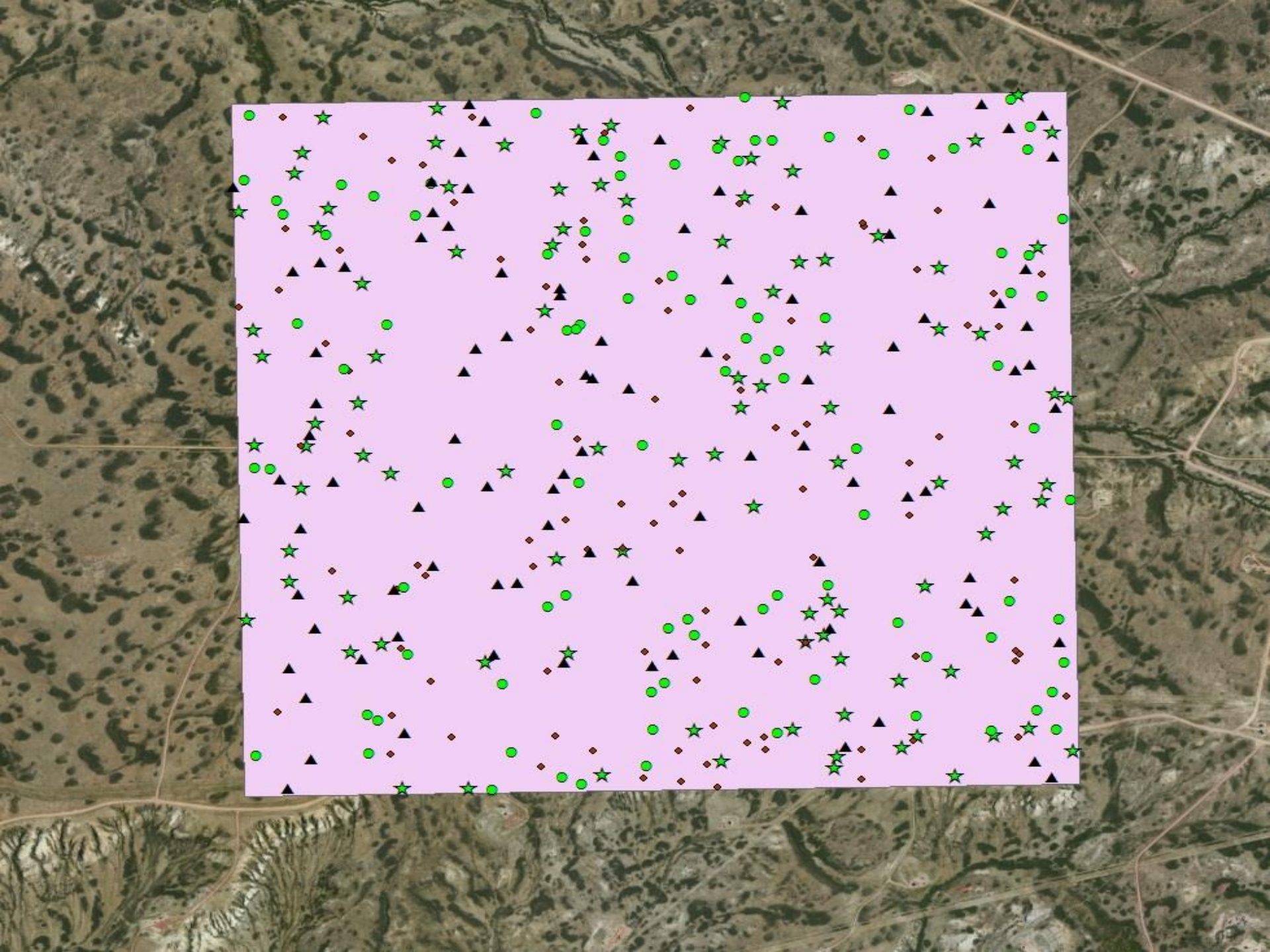
Spatially Well-balanced Sampling

- A sample that is well-spread over the population with few nearby units is said to be spatially balanced or called a spatially well-balanced sample….if the response has spatial trend, estimation can be greatly improved by selecting a spatially balanced sample." (Robertson et al. 2013)

Spatially Well-balanced Sampling



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W109° 52' 39.702"
N42° 44' 54.594"


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W:109° 52' 37.278"
N:042° 44' 53.124"

Insect Diversity

- On Rocky Mountain Bee Plant dominated well pad
  - Coleoptera – 14
  - Diptera – 5
  - Hemiptera – 5
  - Homoptera – 17
  - Hymenoptera – 2
- In undisturbed reference area
  - Diptera – 4
  - Hemiptera – 7
  - Homoptera – 6


2014/07/26
W:109° 51' 33.936"
N:042° 46' 06.09"


2014/07/26
W:109° 51' 35.904"
N:042° 46' 06.96"

Insect Diversity

- On-site with low grass diversity:
  - Coleoptera - 1
- Off-site with low grass diversity:
  - Coleoptera - 1

Conclusions

- Using Ecological Site Descriptions to group well pads together to aim towards a range of a values within a population may save money and make setting goals for success easier
- Sampling reference areas better with better methodologies than we currently have may improve Ecological Site Descriptions or allow them to be created in areas where they do not exist
- In instances where reference communities have been improperly managed, they may not be what we want to aim at for success
- In cases where pad construction has yet to occur, pre-disturbance inventory may be advantageous

Conclusions

- In arid systems, land reclamation and ecosystem restoration to pre-disturbance condition or a reference area may take a long time
- If land reclamation is aimed at ecosystem restoration instead of specifically land restoration, there may be benefits in rejuvenating surrounding areas
- In arid systems, succession may not be linear, especially on drastically disturbed lands
- In a changing climate, ESDs will most likely need to be consistently updated
- Regulatory success standards may benefit ecosystems by including more of SERI's primer restoration success standards
- In an era of Restoration Ecology, Rangeland Health may need to be reevaluated

Thank you!

- Questions? Comments?