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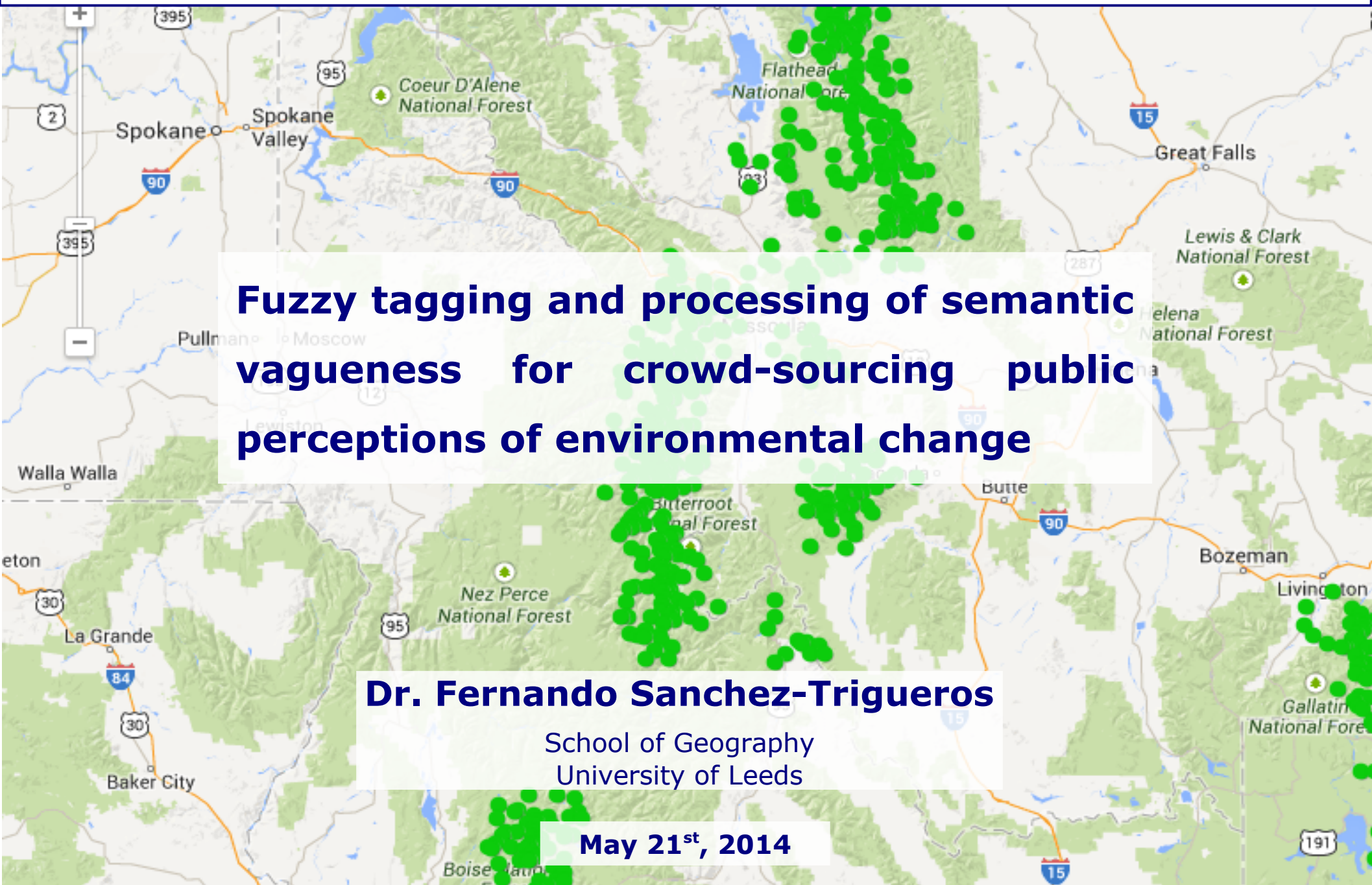


Fuzzy tagging and processing of semantic vagueness for crowd-sourcing public perceptions of environmental change

Dr. Fernando Sanchez-Trigueros

School of Geography
University of Leeds

May 21st, 2014

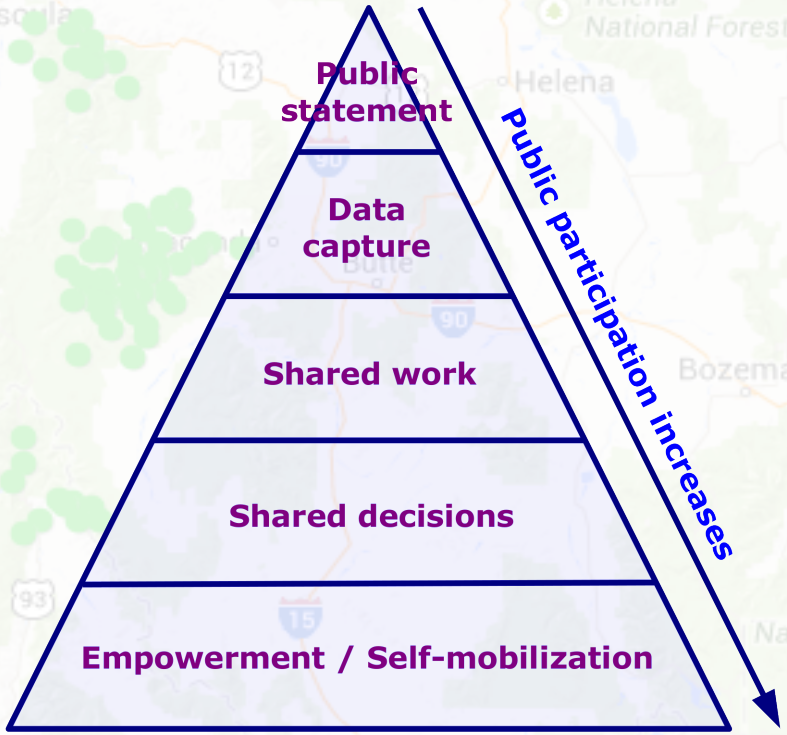
Outline

- Defining PPGIS
- Issues in PPGIS data analysis
- Setting up smart GI systems: the multimodal database
- Setting up smart GI systems: Natural Language Processing
- Capturing fuzziness in PPGIS research: the Map-Me tool
- Case study: Public perceptions of environmental change on the Flathead Indian Reservation

Defining PPGIS

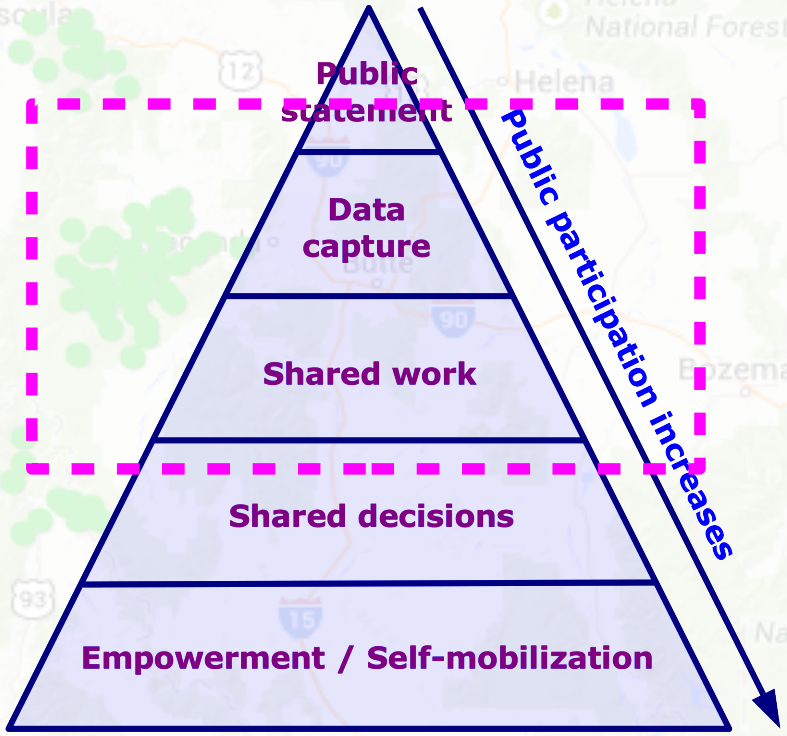
Public Participation

Involvement of stakeholders potentially affected by a decision, with capacity to influence the final decision. Based on the principle that those affected by a decision should participate in the decision-making process.



Public Participation GIS

Involvement of local groups in the creation of GIS data and its use in spatial decision-making processes.



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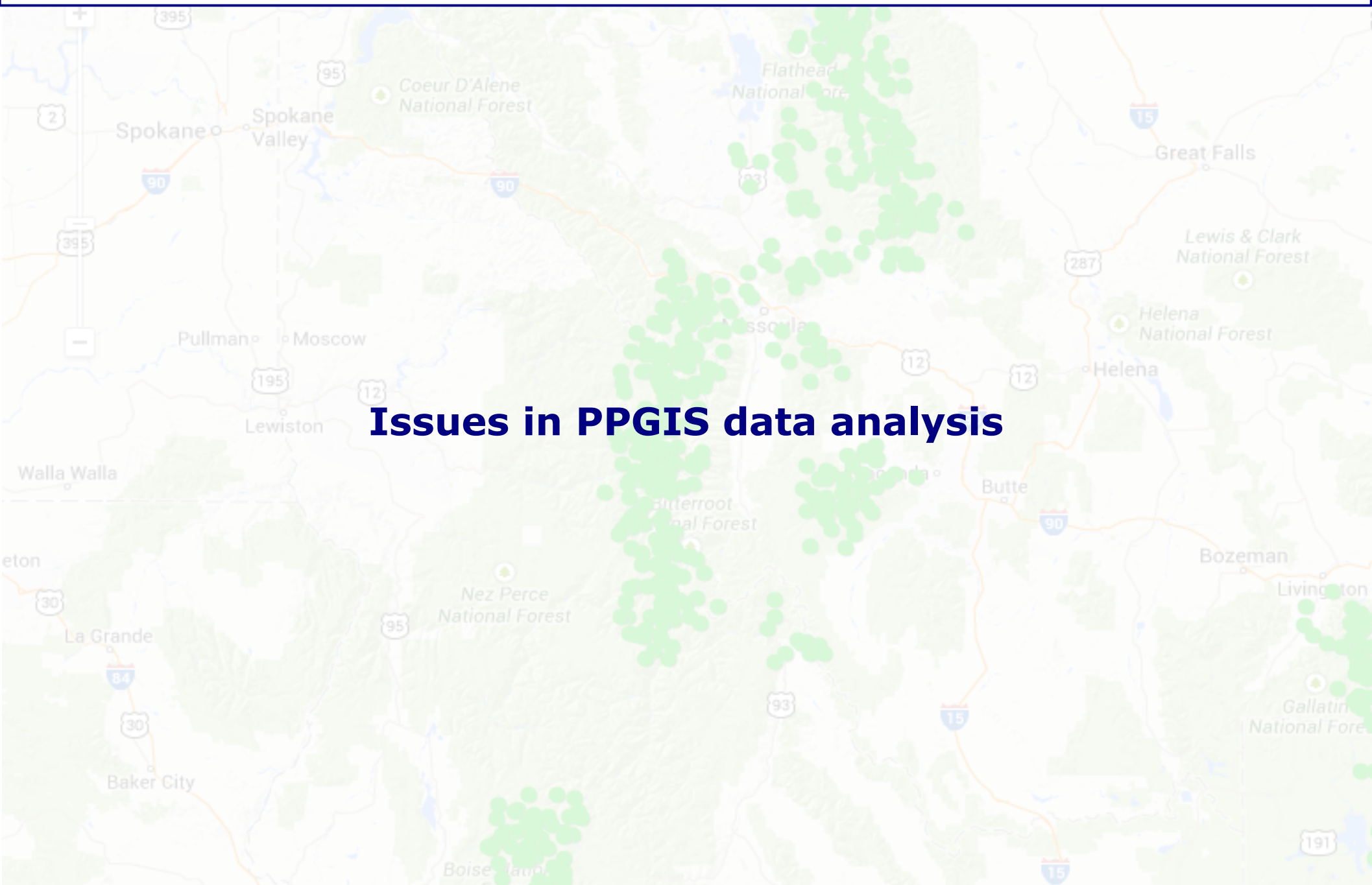
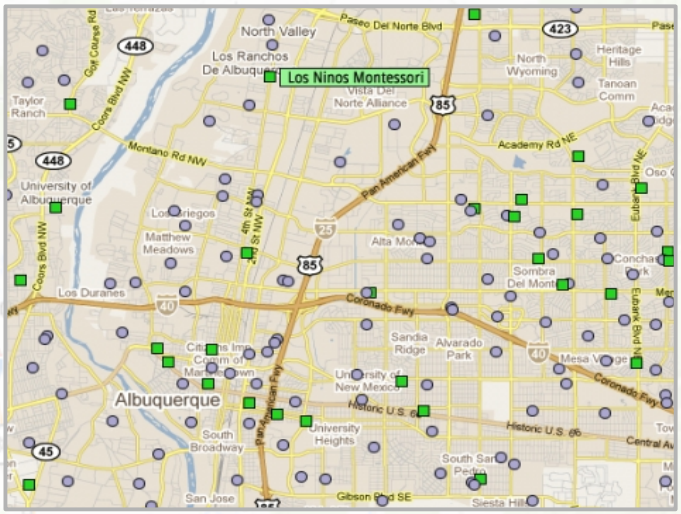
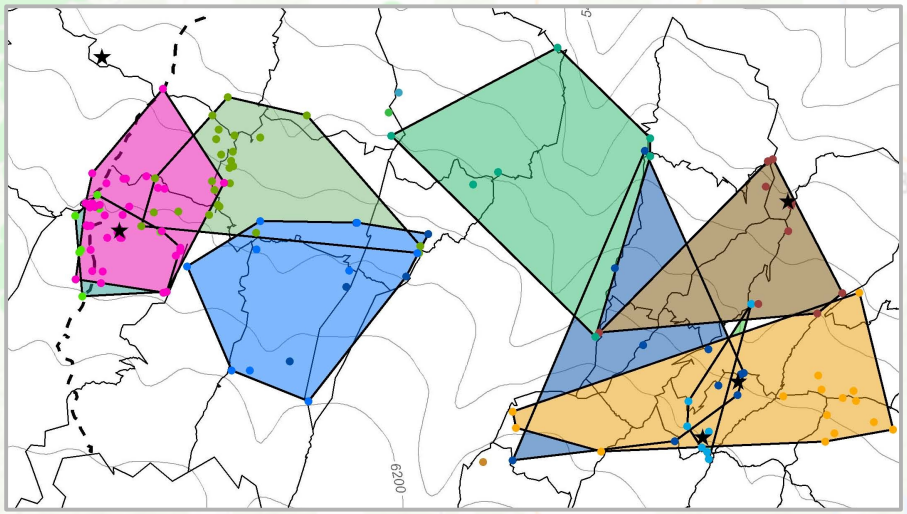


Issues in PPGIS data analysis

Data models for positional information

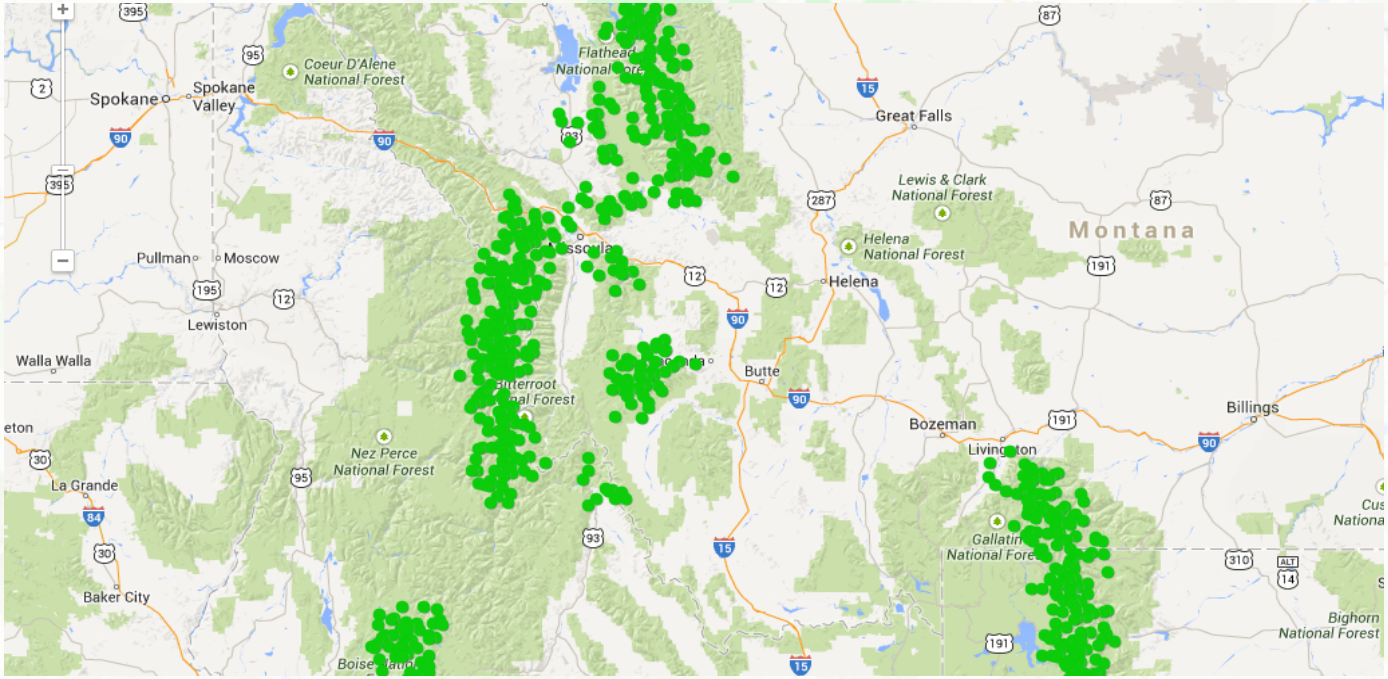
Crisp models: point, line and polygon abstractions assume that locations of marked phenomena are known with certainty. Methods of spatial analysis based on crisp objects lack robustness for the treatment of fuzzy locations.





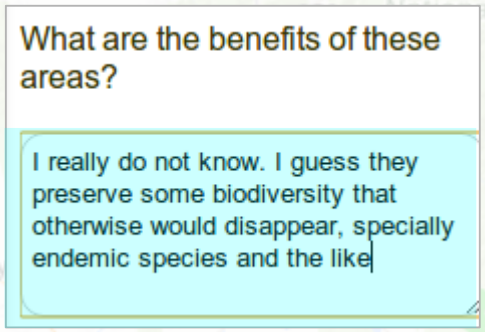
Data models for positional information

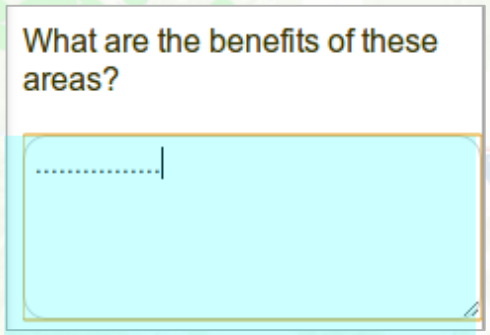
Fuzzy models: take account on the fact that locations of phenomena may be vaguely and/or imperfectly known by respondents, and so the marking.

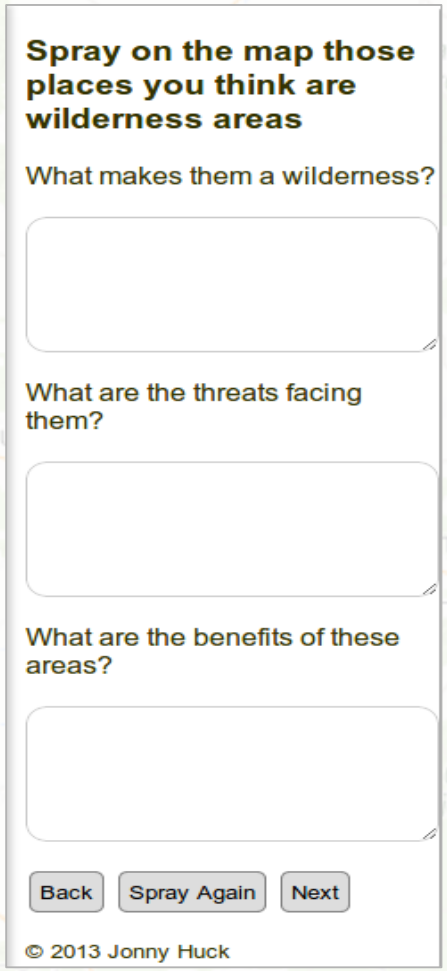


Issues with text data

Text tends to produce much larger volumes of data than measures, but their information is unevenly distributed among text units and could even be superfluous.

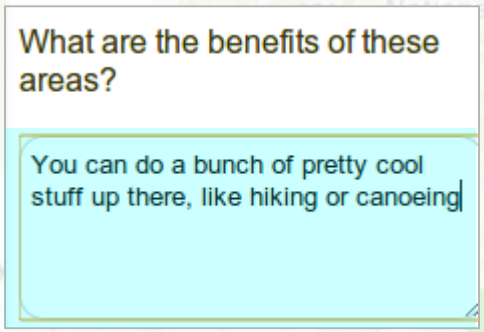


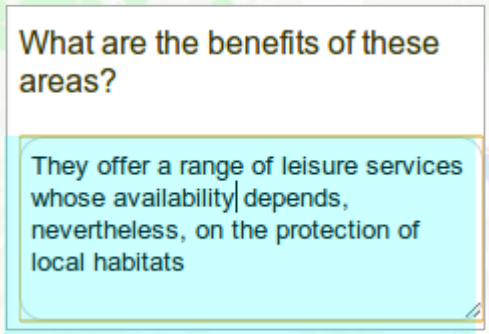


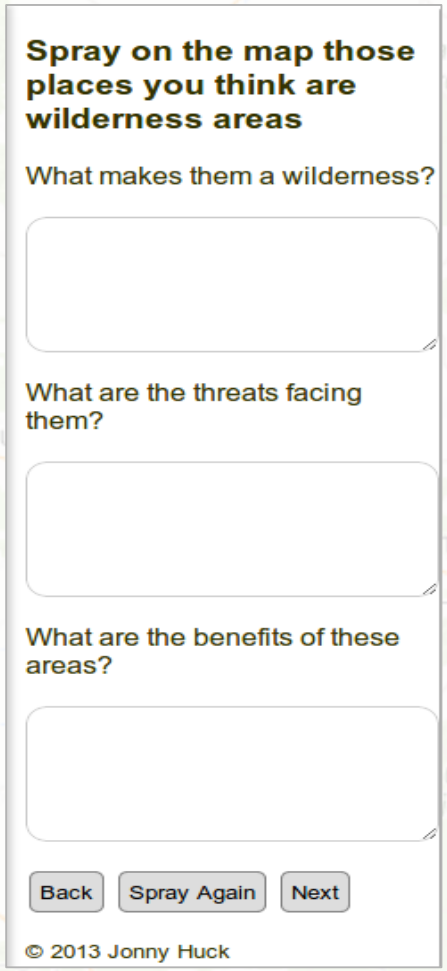


Issues with text data

Linguistic registers and patterns may not be uniform among participants (dialectal modes, specialist vocabulary, jargon, misspellings, typos, Internet typing slang) so methods are needed to identify similar ideas between documents.

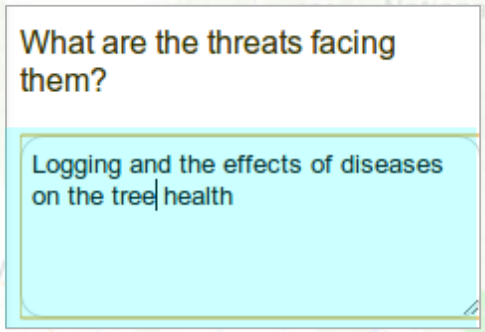


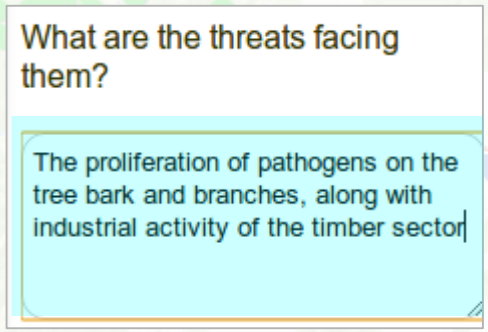


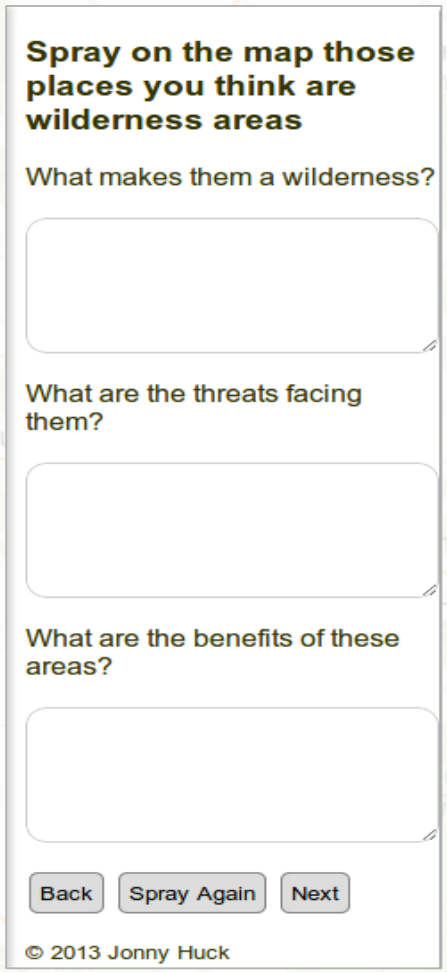


Issues with text data

Verbalized definitions may be semantically fuzzy, e.g. include polysemy, alternative textual entailments, conceptual generalizations (abstraction) or references to a whole by one or several of its parts.



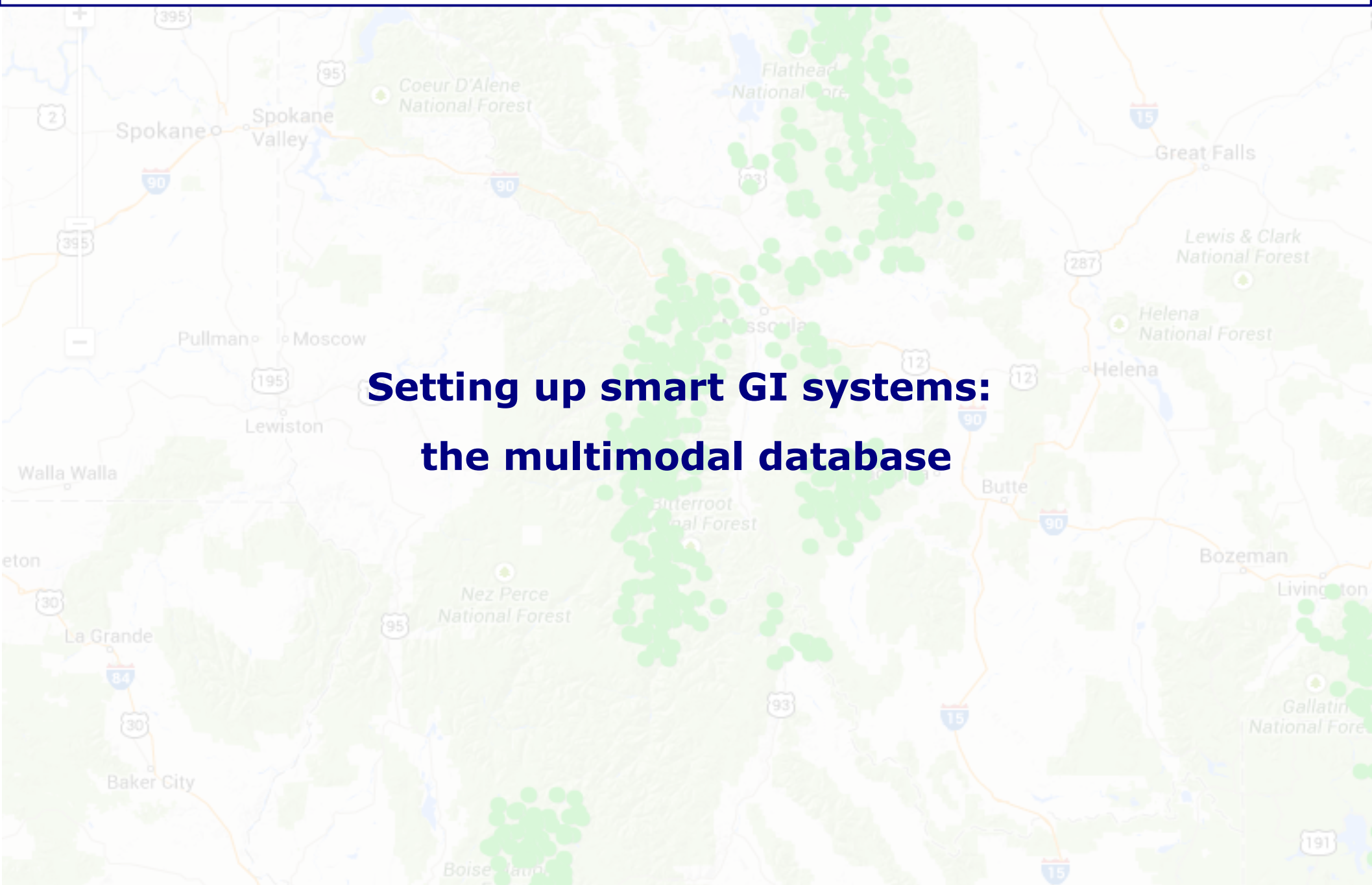




Issues with image data

The same phenomenon may be represented from different perspectives, at different scales, lighting, color intensity.

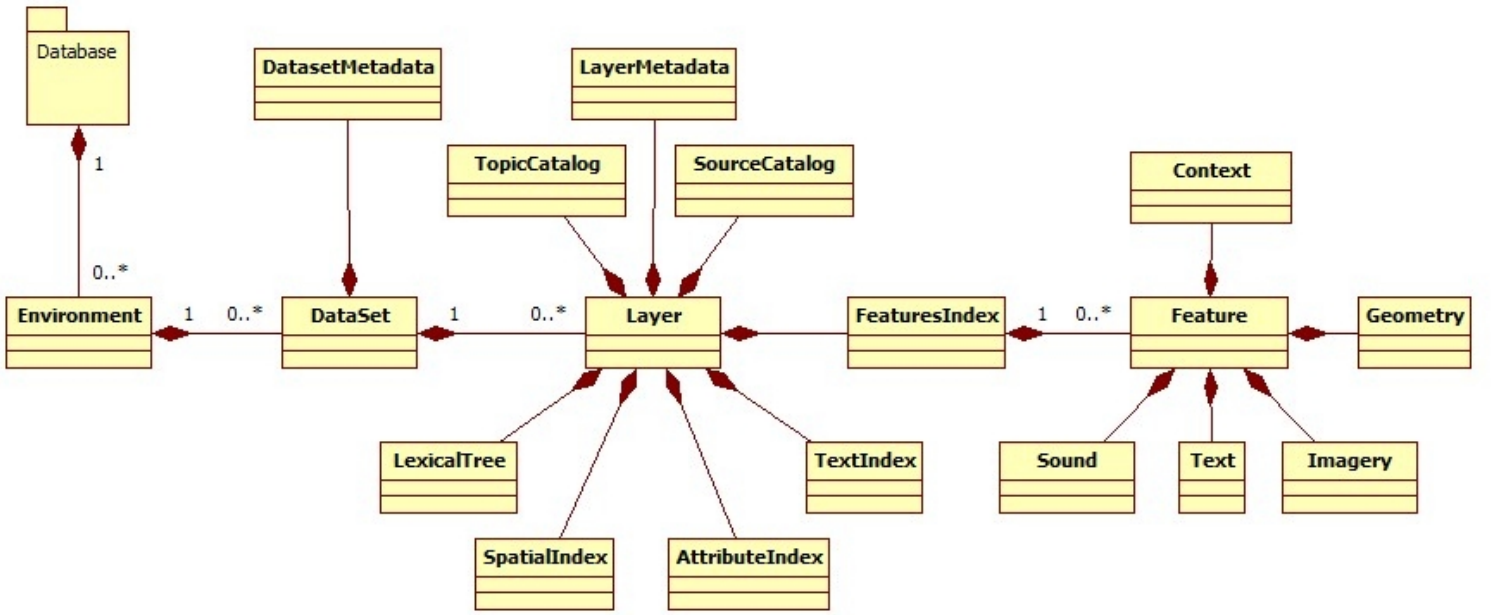
General Sherman tree (*Sequoiadendron giganteum*), Sequoia National Park (California)



Setting up smart GI systems: the multimodal database

Data organization

An Object-Oriented database turns out suitable for dealing with the complexity and heterogeneity of PPGIS data (spatiotemporal coordinates, documents, images...).



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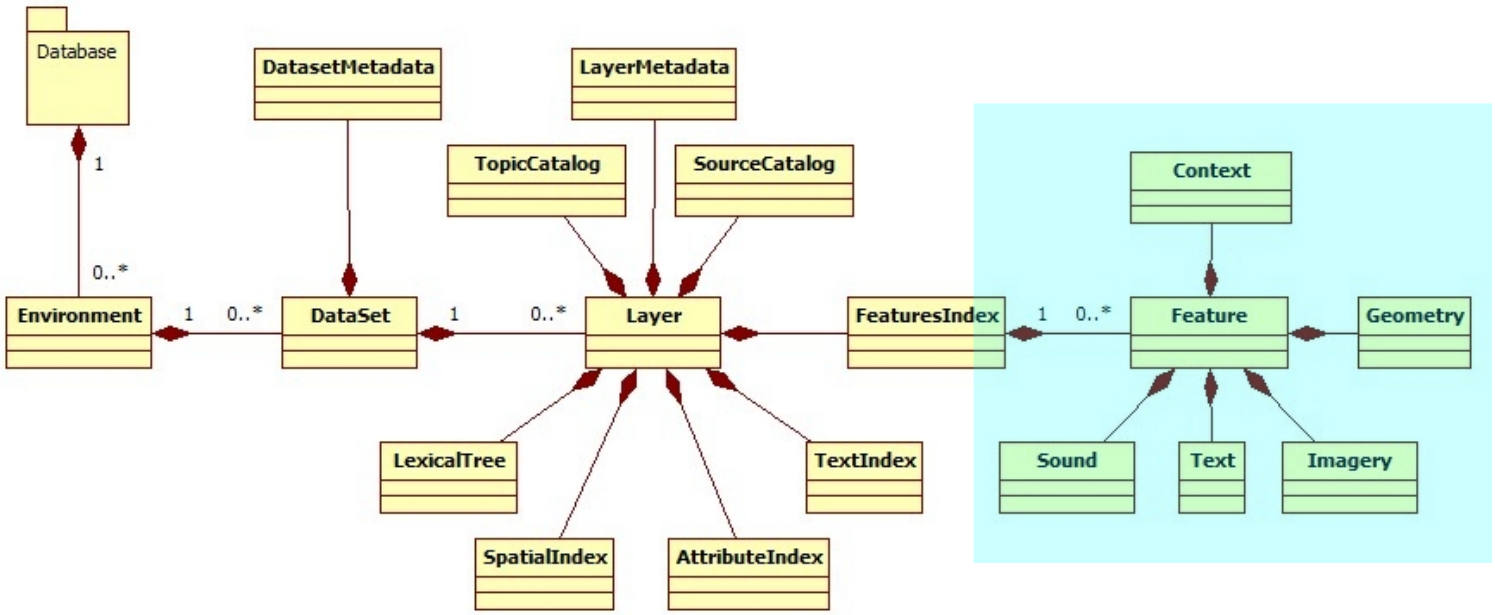
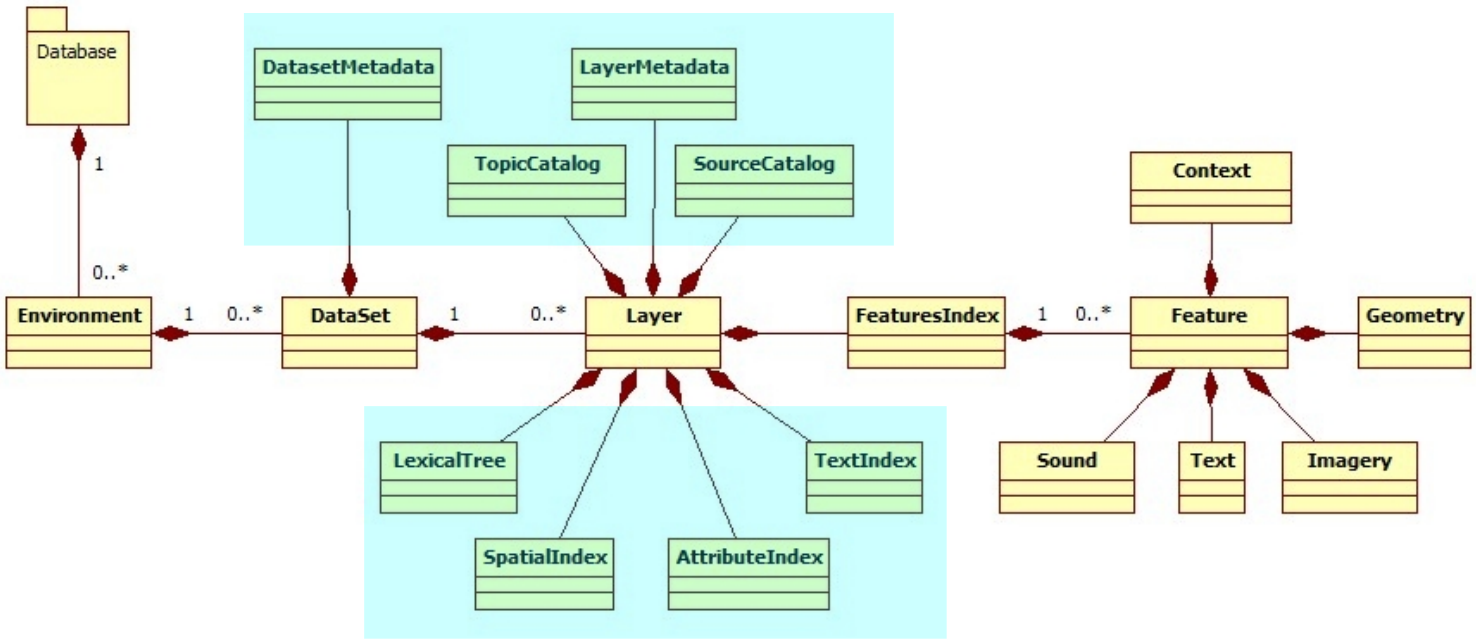
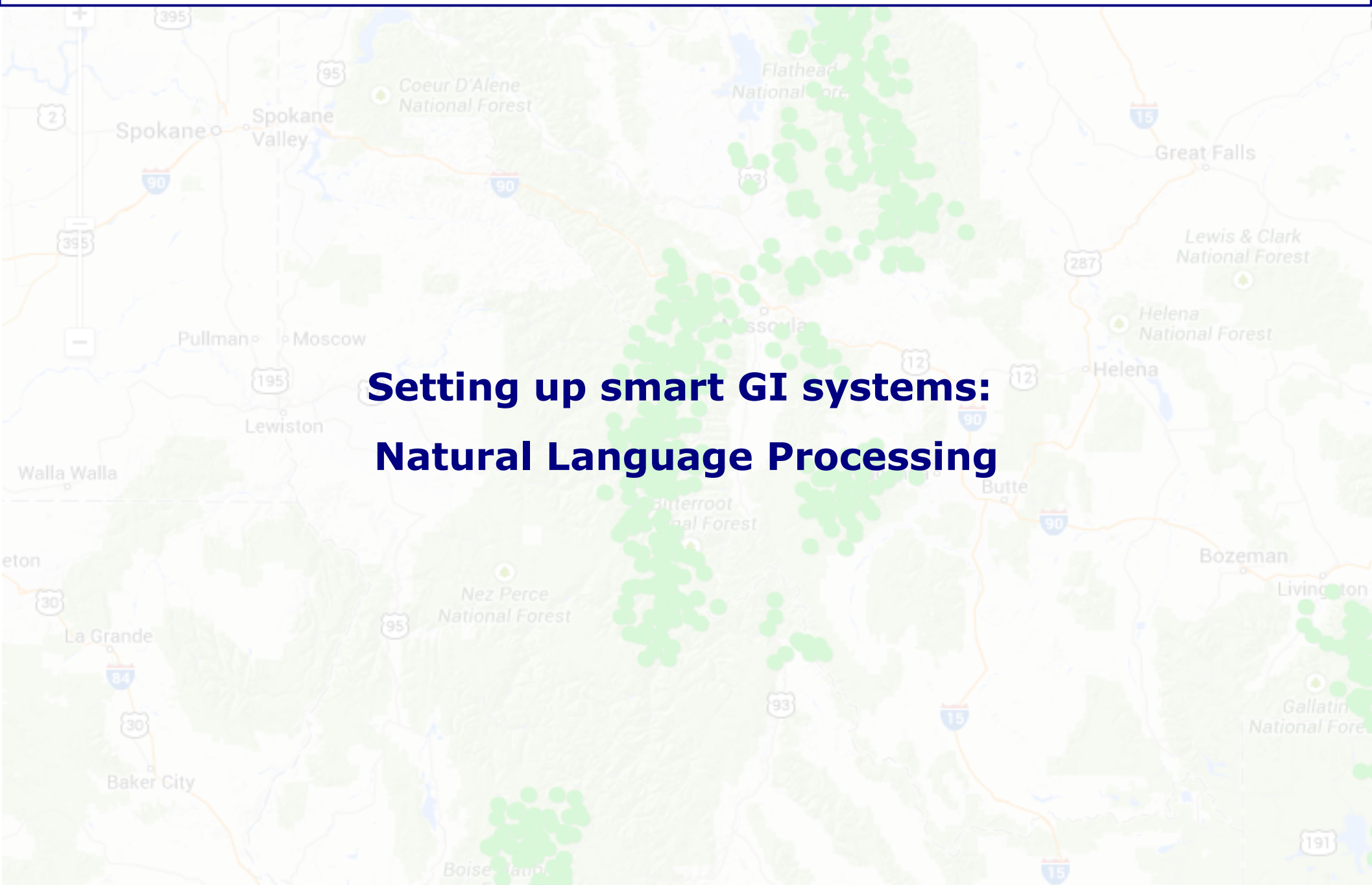


Data organization

Additional modules take on functionality for the improvement of queries of the multimodal database and the archiving of ancillary information about multimodal features.





Setting up smart GI systems:

Natural Language Processing

Information retrieval: language requirements

1) Evaluate the syntax and arguments of a semantic query.
2) Find those objects in the geodatabase that match the query.
3) Provide a spatial representation (e.g. a map) of retrieved features.

```
select features from layer 2014 in dataset parks where text
has the noun pine or a synonym,

then map them as overlays with these parameters: xres as 100

and yres as 100
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2) Find those objects in the geodatabase that match the query.
3) Provide a spatial representation (e.g. a map) of retrieved features.

```
select features from layer 2014 in dataset parks where text
implies that use of fire has good effects on forests,

then map them as overlays with these parameters: xres as 100

and yres as 100
```

Features of multimodal queries

- Integration of SQL, Natural Language Processing and Computer Vision functionality.
- Use of computational linguistic resources for tokenization, POS-tagging, syntactical segmentation and sentiment analysis.
- Use of syntactic corpora, dictionaries and concept hierarchies to deal with linguistic ambiguity (e.g. WordNet, Brown).
- The query language *per se* is determined by rules of standard English, following the Natural Language Programming paradigm.

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Taking account of positional fuzziness in PPGIS: the Map-Me tool

Co-authors: Jonny Huck, Steve Carver

Lead developer: Jonny Huck (2009-)

Precedents: Tim Waters and Andy Evans's *Tagger* (2003, 2007)

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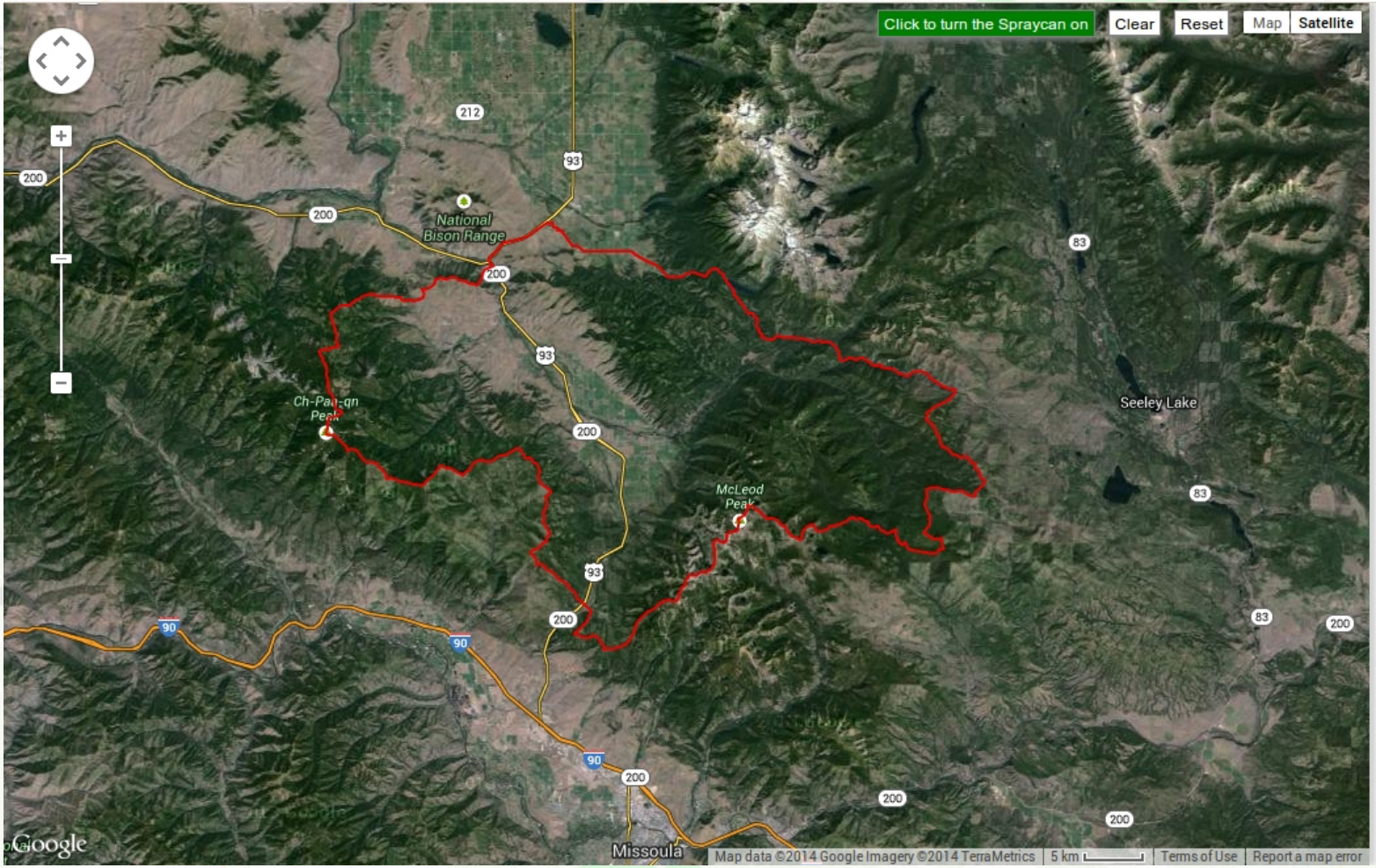
Map-Me interface



The area outlined in red is the Jocko Landscape. Please indicate an area that you believe has changed over the years.

What did this area used to be like and what is the source of your knowledge?

What is the area like now and what do you believe has caused the change from what it used to be like?

What would you like this area to be like in the future and why?

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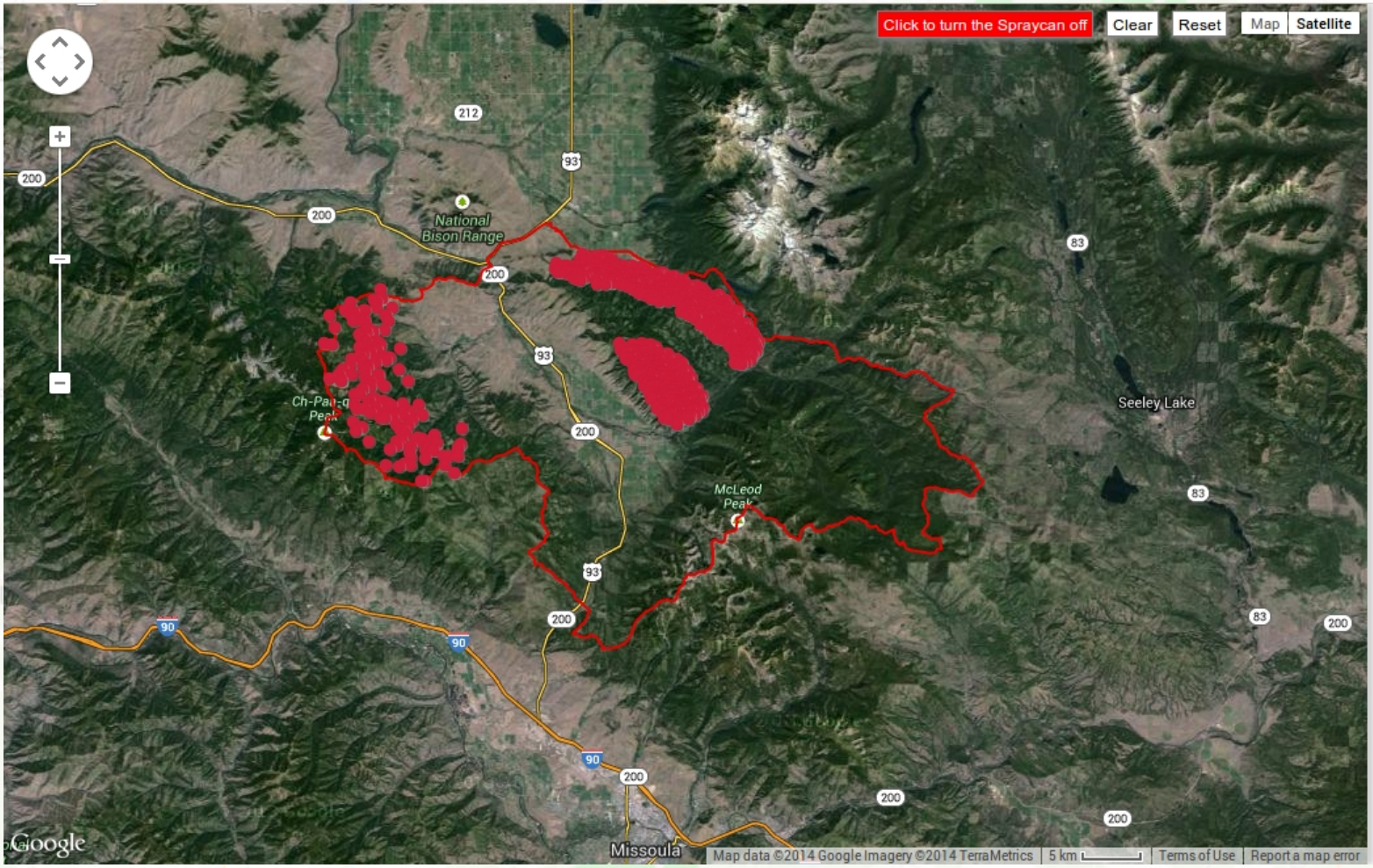
Fuzzy marker



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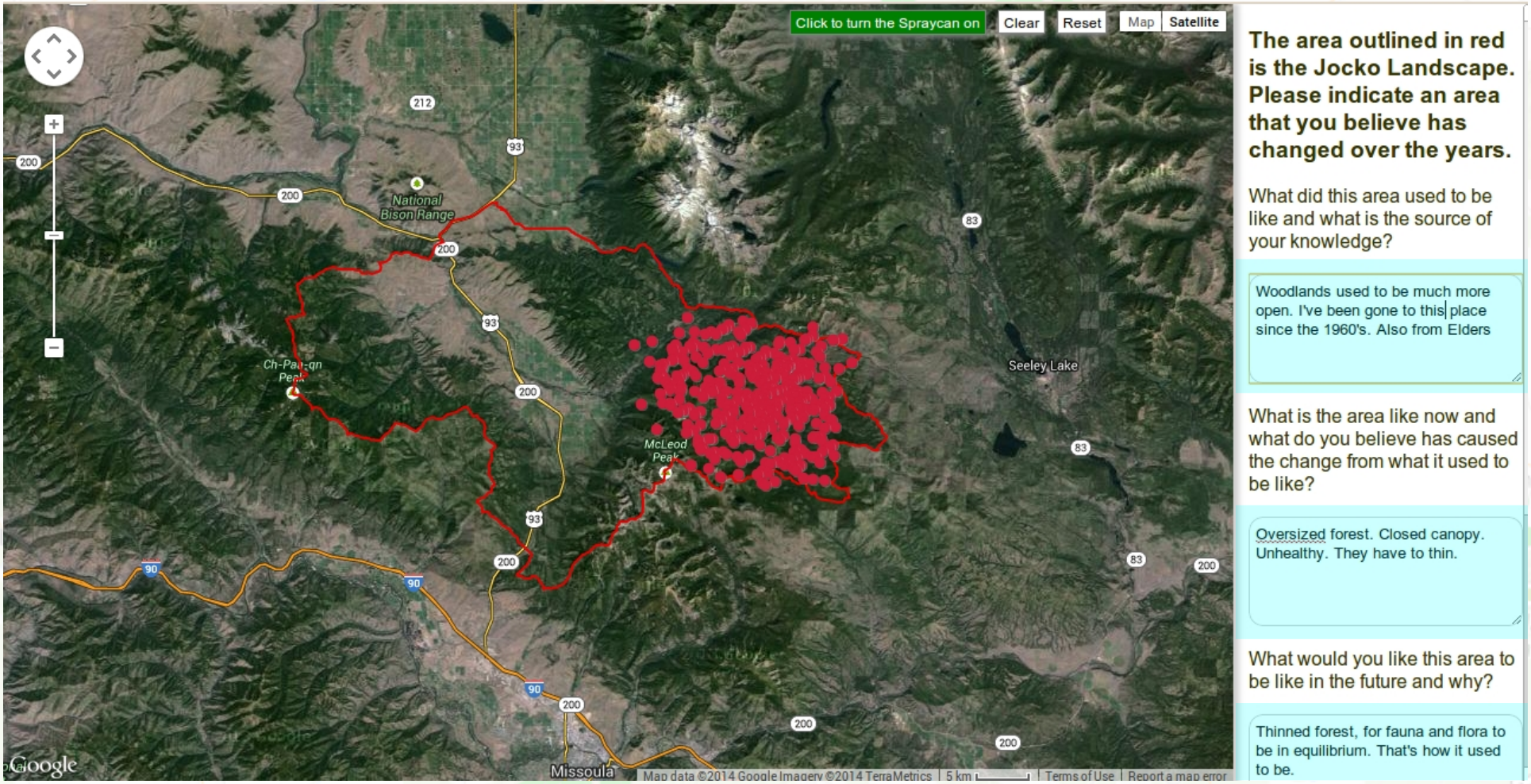
Location of text documents in space



The area outlined in red is the Jocko Landscape. Please indicate an area that you believe has changed over the years.

What did this area used to be like and what is the source of your knowledge?

Woodlands used to be much more open. I've been gone to this place since the 1960's. Also from Elders

What is the area like now and what do you believe has caused the change from what it used to be like?

Oversized forest. Closed canopy. Unhealthy. They have to thin.

What would you like this area to be like in the future and why?

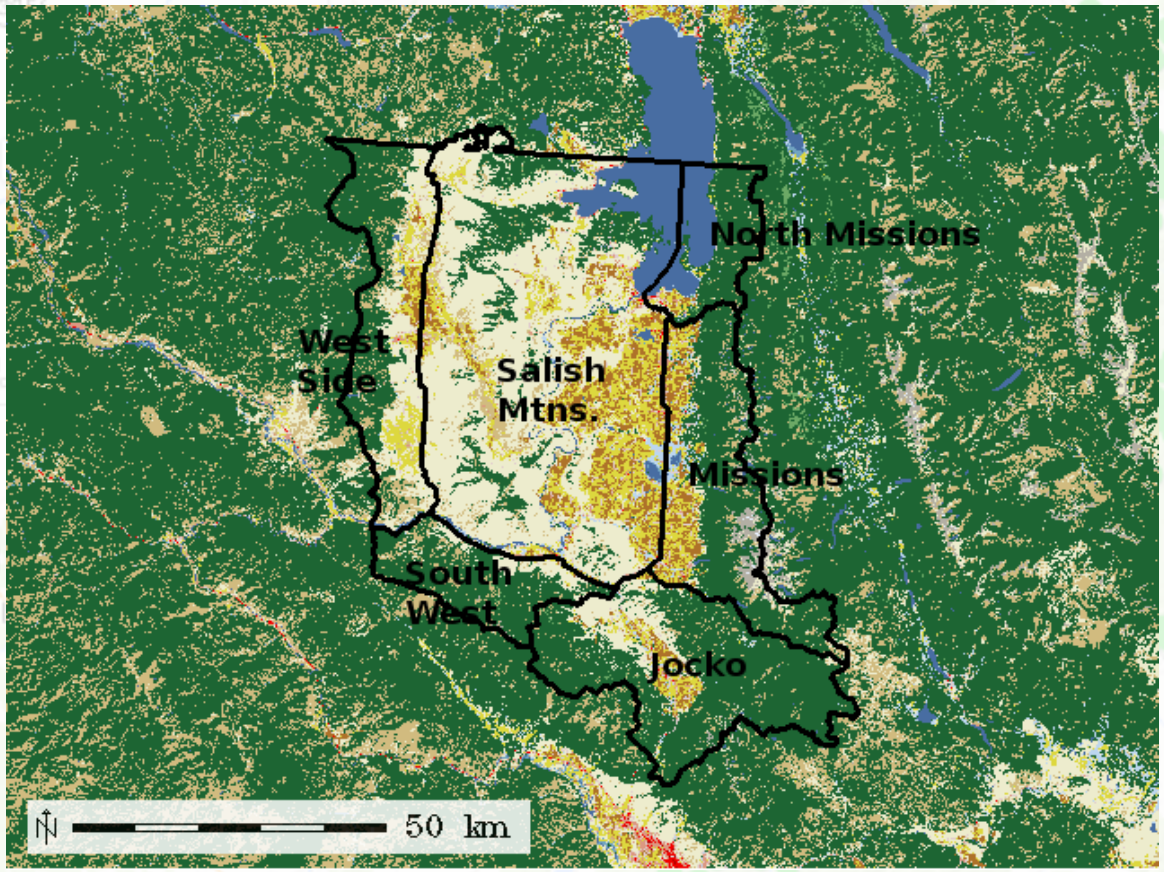
Thinned forest, for fauna and flora to be in equilibrium. That's how it used to be.

Case study:

Public perceptions of environmental change on the Flathead Indian Reservation

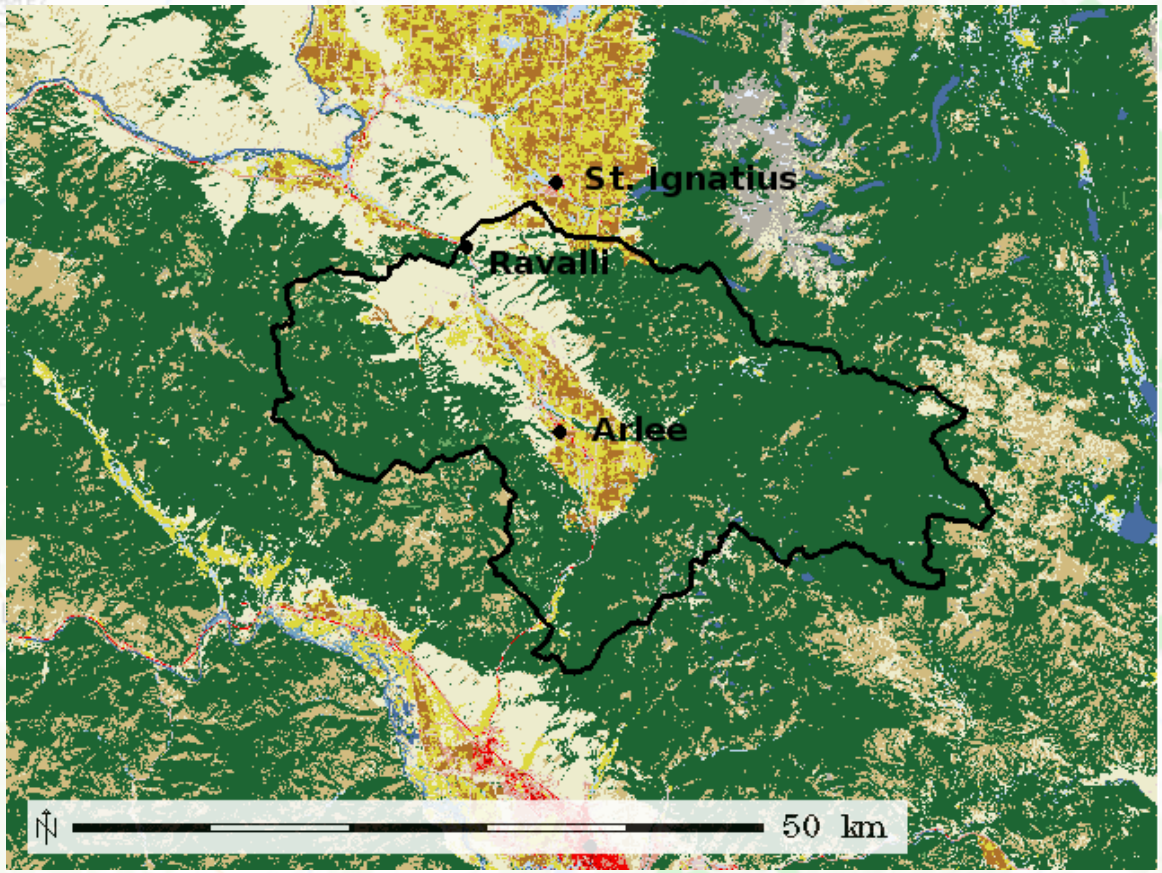
Principal Investigators: Roian Matt, Forest Management Department, CSKT; Alan Watson, Also Leopold Wilderness Research Institute, RMRS

Landscape units on the Flathead Reservation



- East side of the Rocky Mountains.
- West Montana.
- Composed of portions of Lake, Sanders, Missoula and Flathead counties.
- Confederated Salish and Kootenai Tribes of the Flathead Reservation.

The Jocko landscape unit



- Southernmost unit on the Reservation.
- ~700 people (Census Designated Places of Arlee and Ravalli).
- Mostly constituted by hill ranges and woodlands surrounding the valley of the Jocko River.

Issue: has fire suppression had a negative effect on the fire-adapted ecosystems of the Mission Mountains?

- Over the 20th century use of fire was largely banned in forests of the USA in order to prevent the effects of fire hazards.
- As a consequence, traditional techniques of prescriptive fire are no longer common practice on the Reservation.
- What have been the effects of this policy on natural ecosystems of the Reservation?
- What corrective measures would be needed in the future?

Effects of fire suppression

- Oversized tree communities.
- Anomalous accumulations of dead wood on the forest floor.
- Dense understoreys of brush and young trees.
- Closed forest canopies.

Effects of fire suppression

- Susceptible to destructive wildfires.
- Reduction of soil moisture.
- Decrease in sunlight to the forest floor.
- Proliferation of plant pathogens and disease.

Research plan

- Tribes designed and developed a PPGIS survey to determine perceived climate change impacts to resources in the Jocko landscape unit, by incorporating knowledge and opinions of residents and natural resource managers.
- Quantitative methods were applied to explore and test associations between participants' responses and both cultural and biophysical attributes of the landscape.

PPGIS questionnaire

i. Mark areas in the Jocko landscape unit that you believe to have changed over the years.
ii. What did these areas use to be like?
iii. How are they like at present?
iv. What would you like them to be like in the future?
v. What actions should be taken for this to happen?

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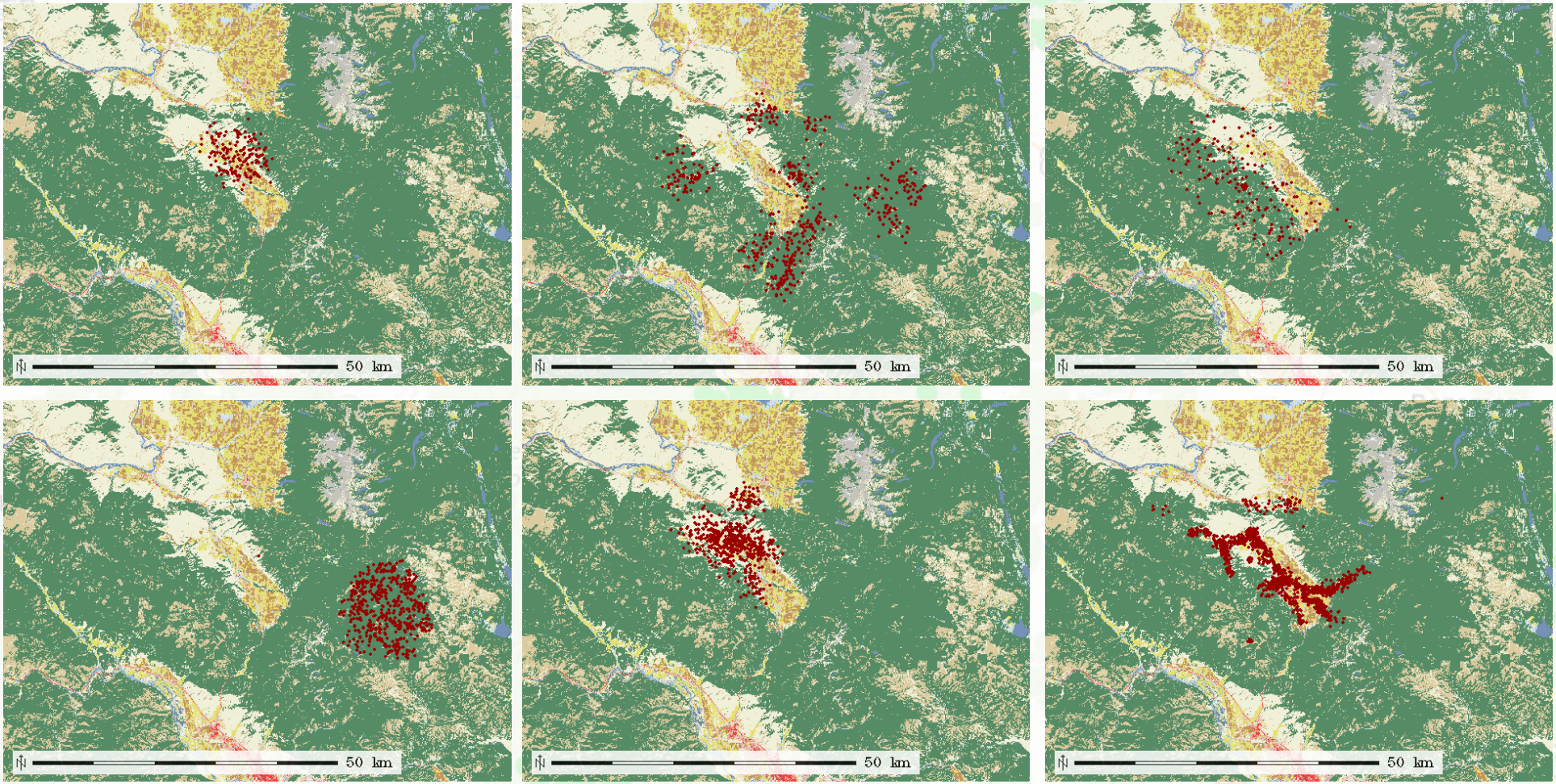
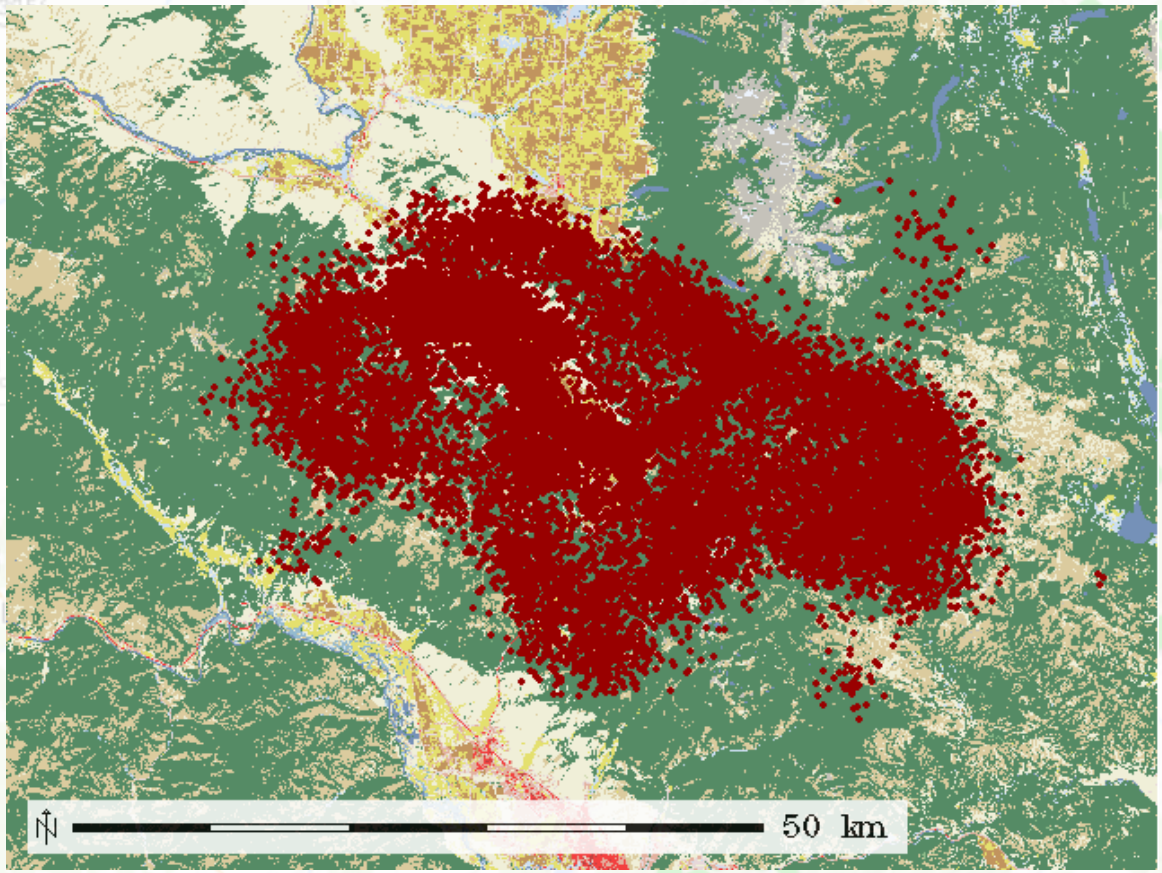
Some spray responses locating observed environmental changes in the last decades

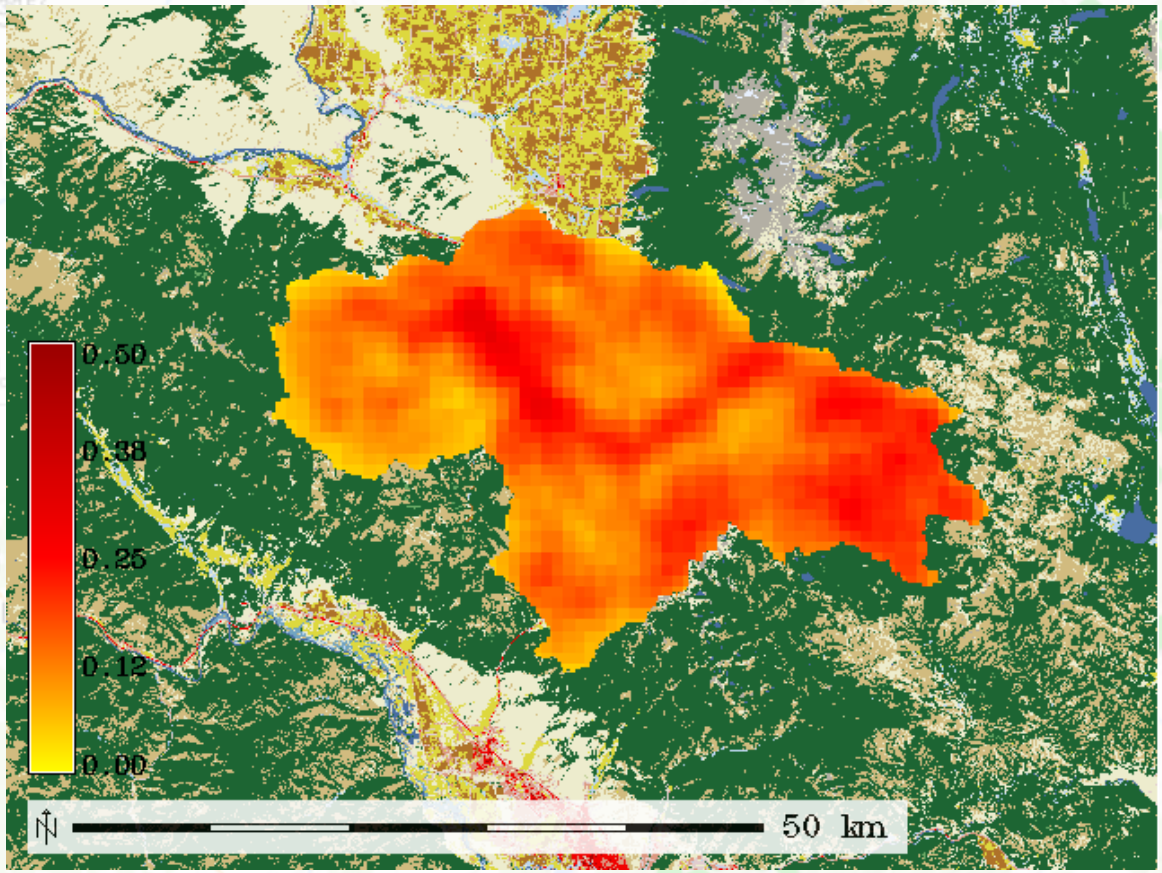


All spray responses locating observed environmental changes in the last decades



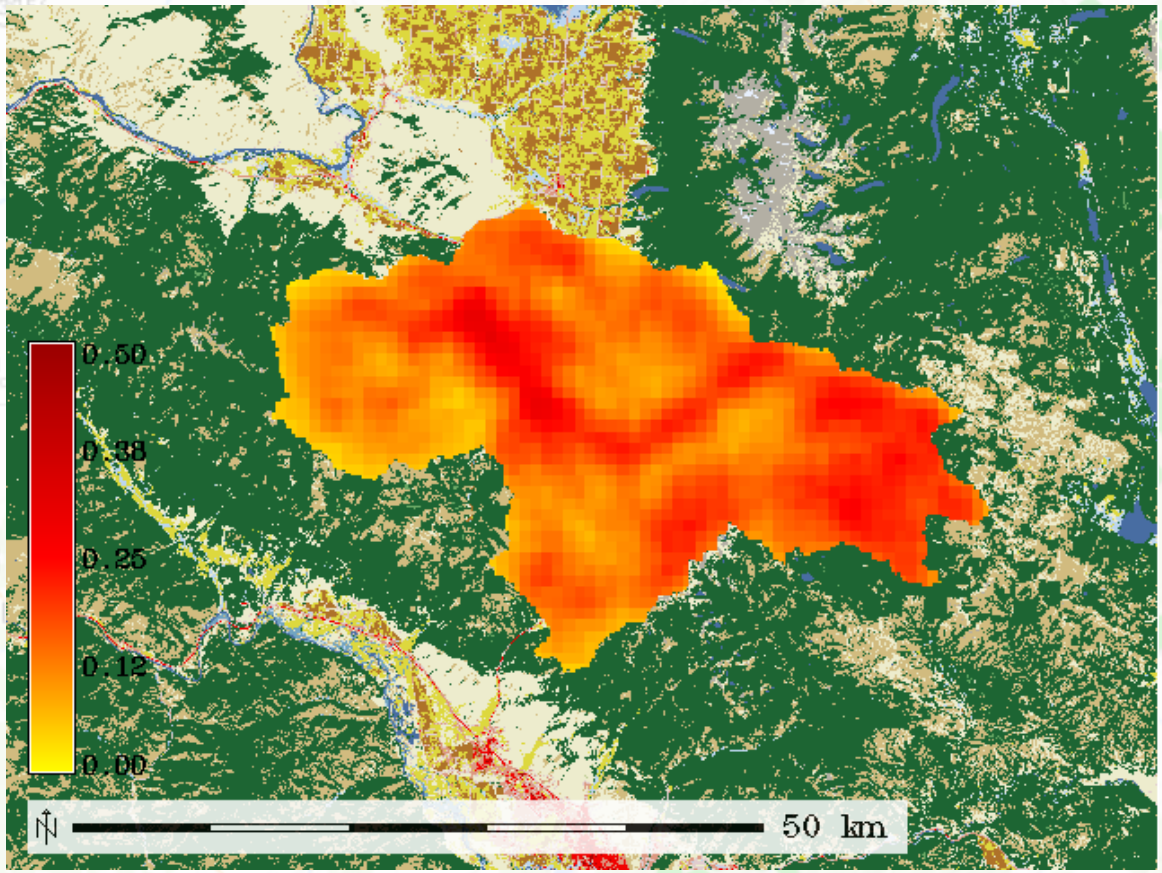
- More than 20,000 single blobs.
- 40 comments providing details about specific environmental changes.
- 29 spray patterns (so 11 comments were given without locations being marked).

How frequently, in the survey, is every location marked as a place that has undergone recent environmental changes?



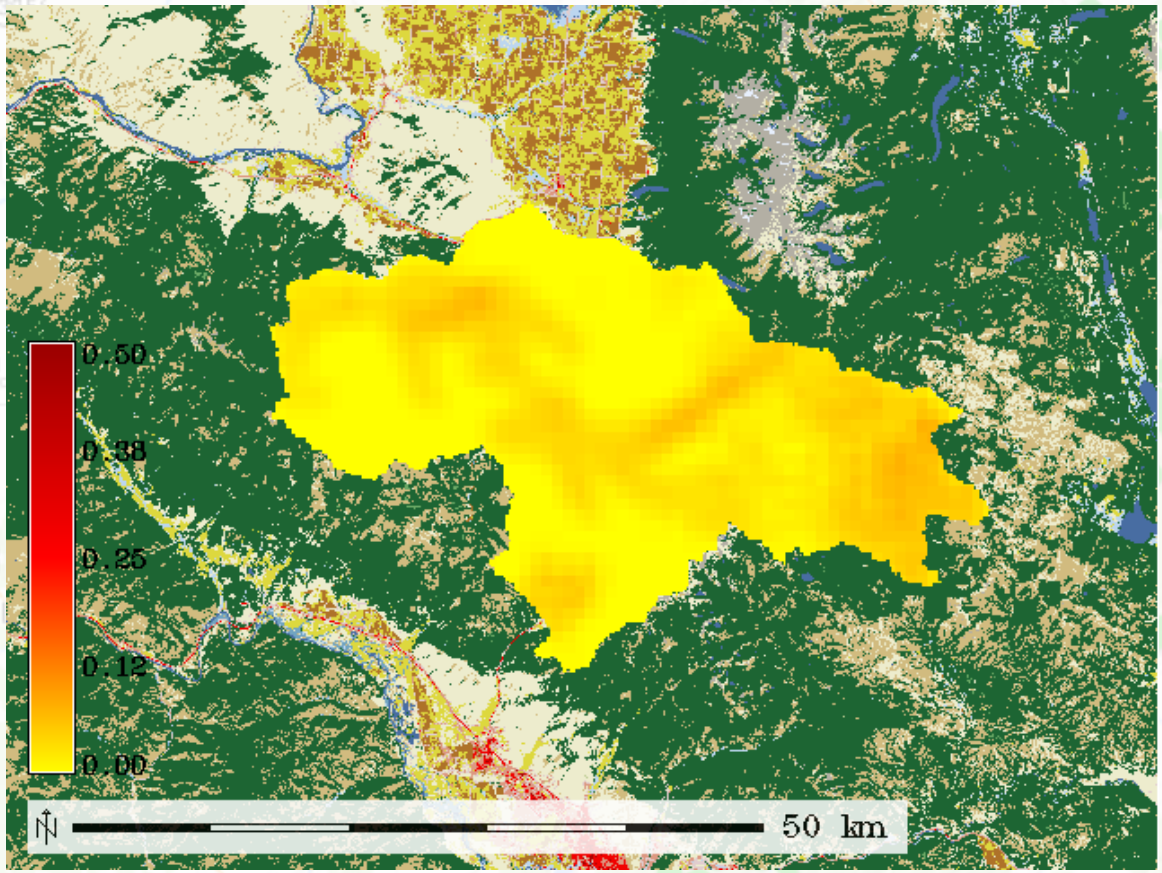
- Cell value = Number of overlapping spray patterns / Total number of spray patterns.
- Maximum number of overlapping spray patterns in a given location is 36 % of total number of spray patterns.

How frequently, in the survey, is every location marked as a place that has undergone recent environmental changes?



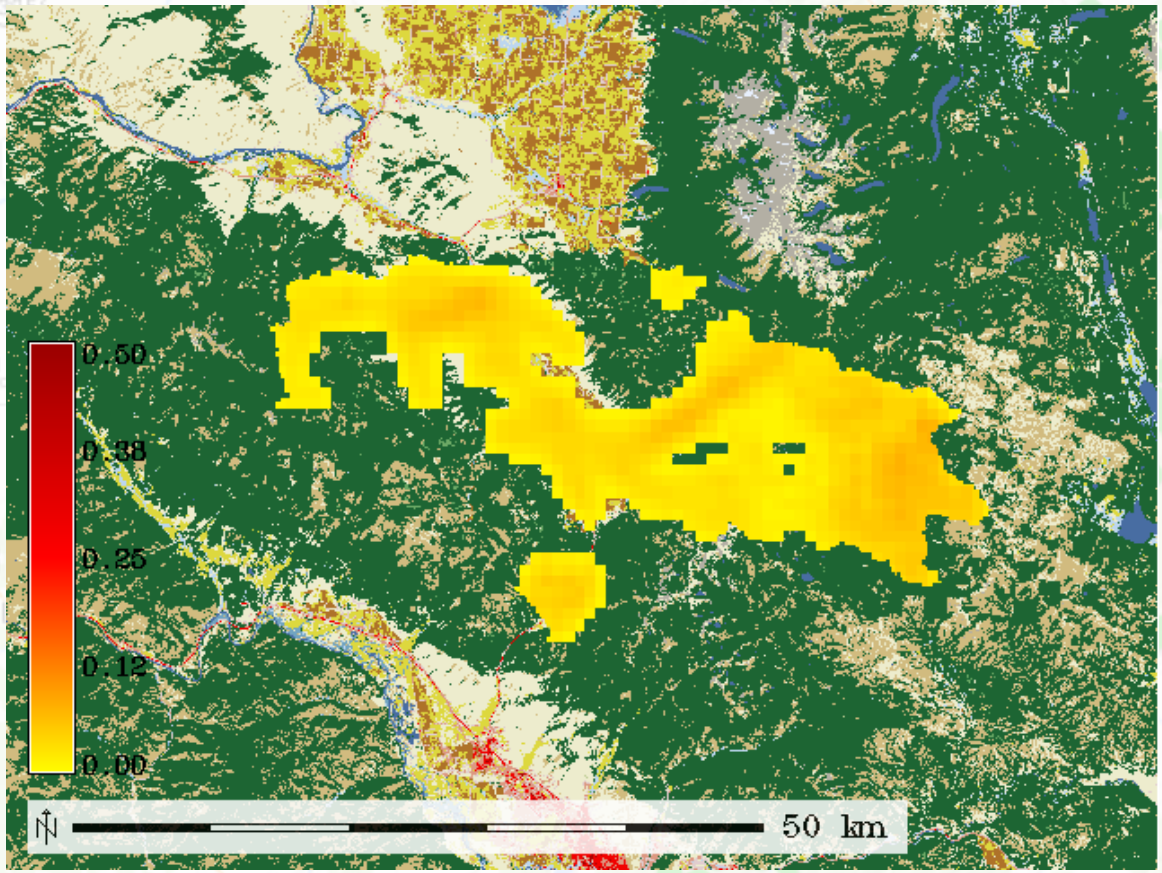
- Places where interviewees agree in having observed environmental changes concentrate along the Jocko river and in the primitive area of the Mission Mountains.

How frequently do marked places have comments supporting *in situ* use of prescribed fire?



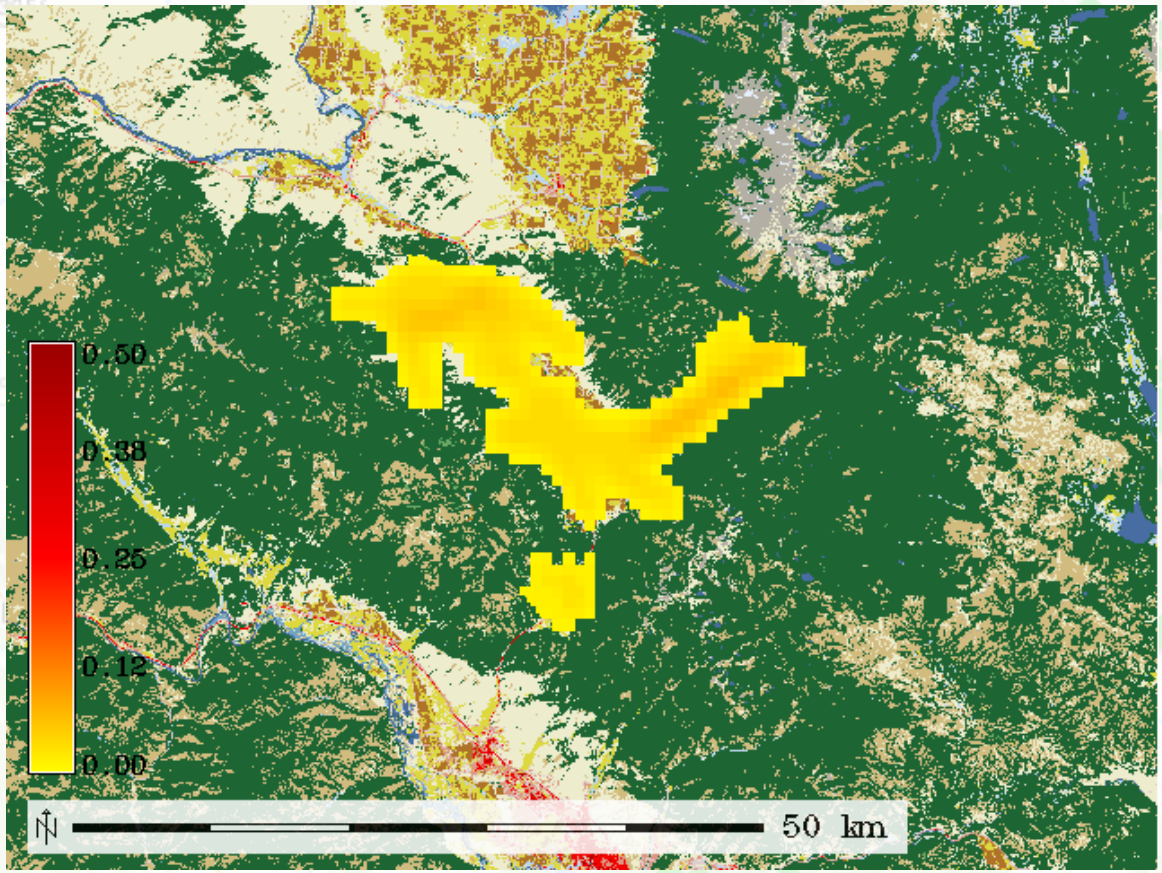
- 31 % of spray patterns support the use of prescribed fire in marked spots.
- Maximum number of overlapping spray patterns in a given location is 12 % of all spray patterns.

How frequently do marked places have comments supporting *in situ* use of prescribed fire? (frequency > 0)



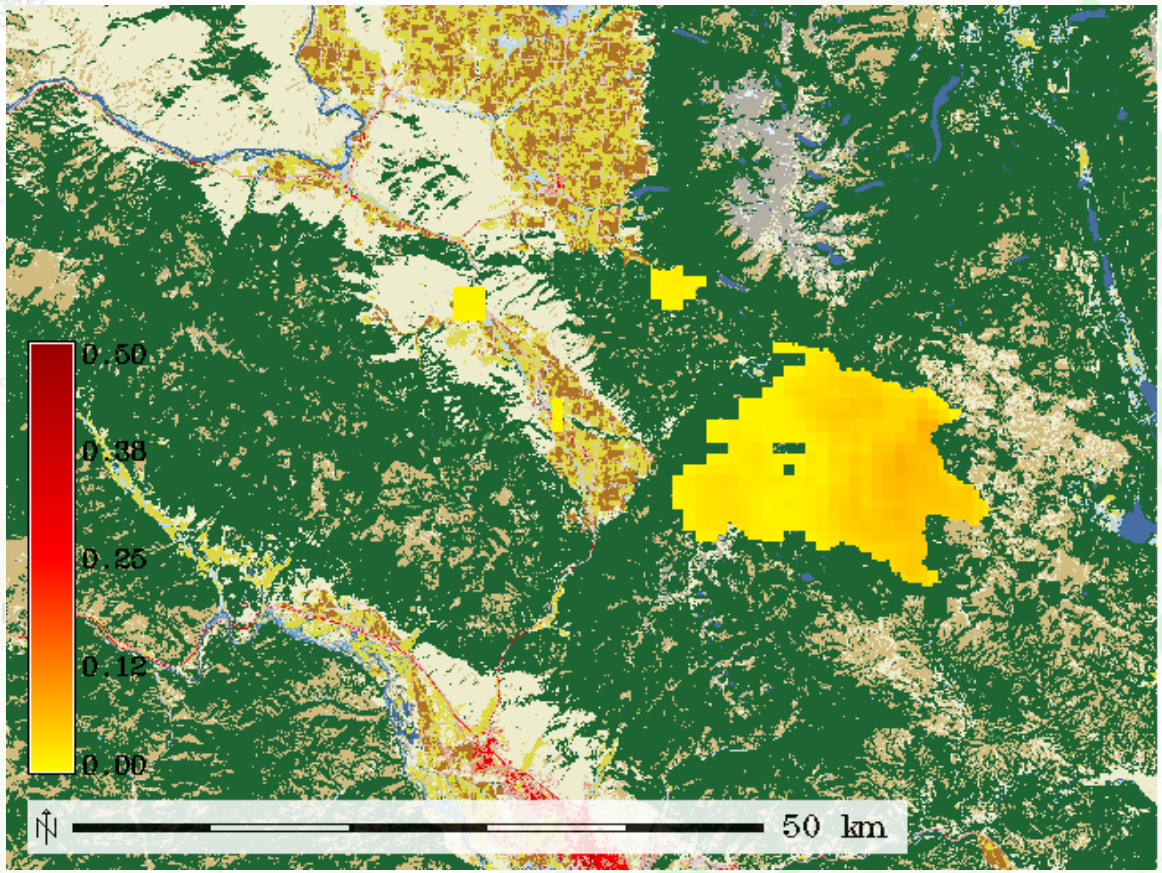
- 31 % of spray patterns support the use of prescribed fire in tagged spots.
- Maximum number of overlapping spray patterns in a given location is 12 % of all spray patterns.

How frequently do marked places have comments supporting *in situ* use of prescribed fire? (non tribal)



- Spots most frequently marked by non-tribal people concentrate along the Middle Jocko and in herbaceous lands between the basin and higher woodlands.

How frequently do marked places have comments supporting *in situ* use of prescribed fire? (tribal)



- Spots most frequently marked by tribal members concentrate in the mountain woodlands and summits of the eastern primitive area.

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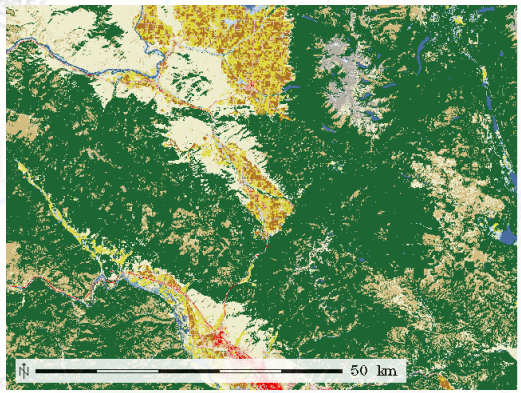
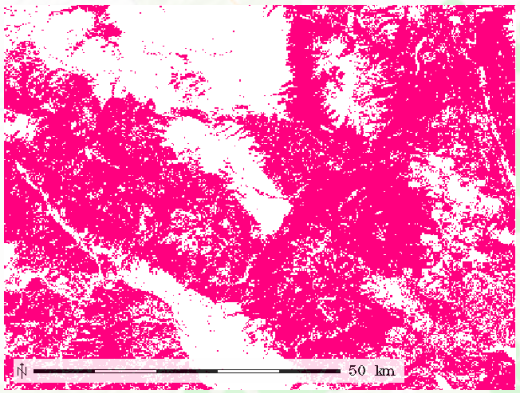
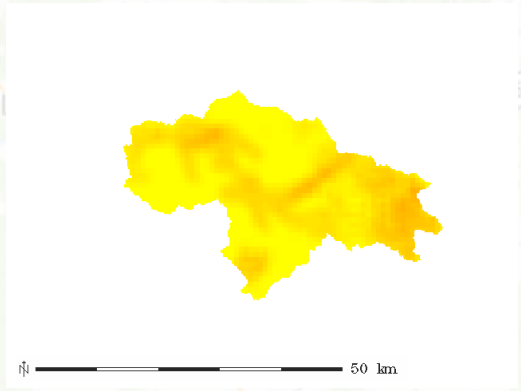
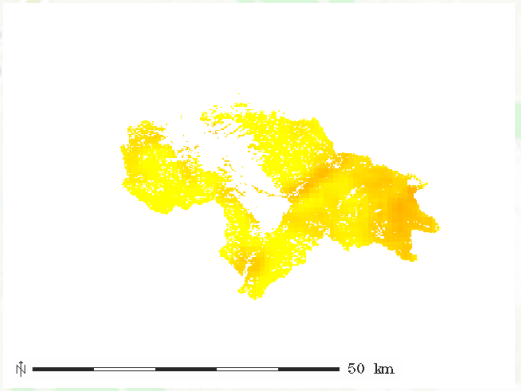
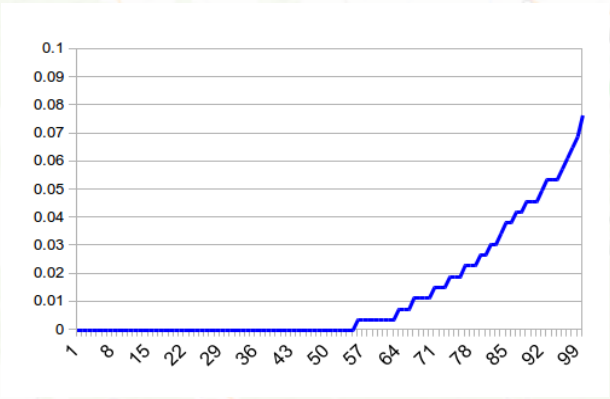
What is the spatial association between support of prescribed fire and land-use classes?











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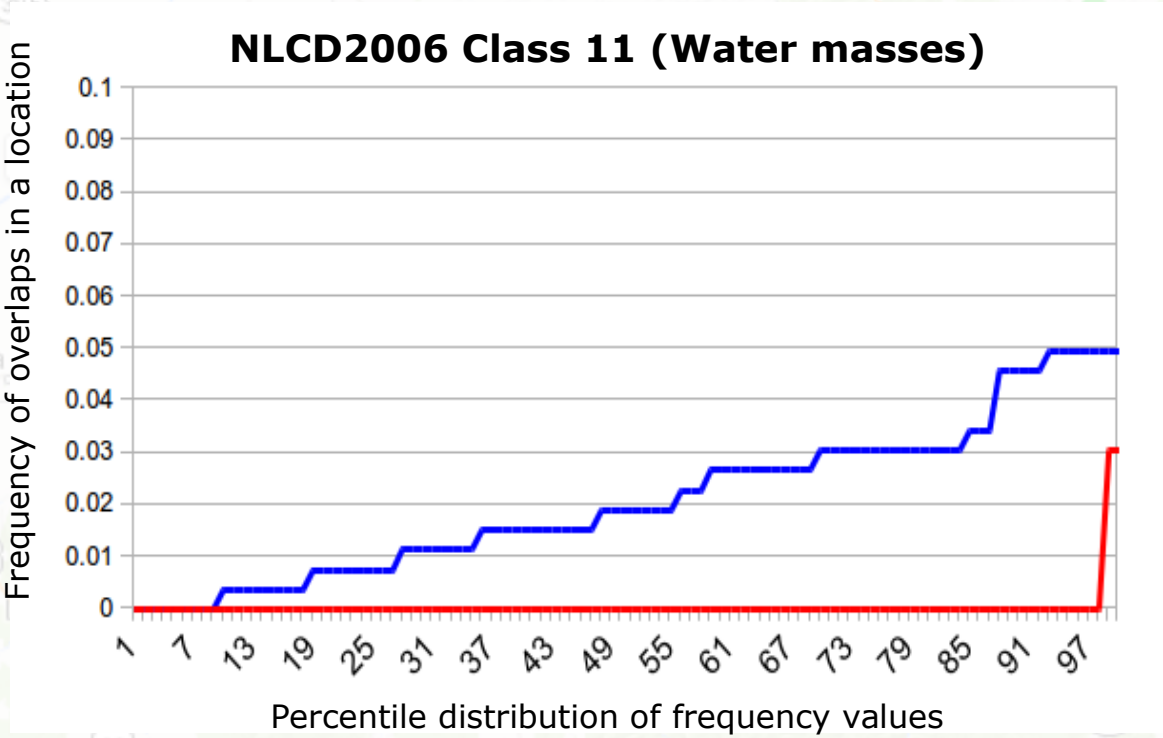

The frequency of respondents tagging this land-cover class rises regularly among tribal members, being negligible among non-tribal people.

Red: non-tribal residents
Blue: tribal residents

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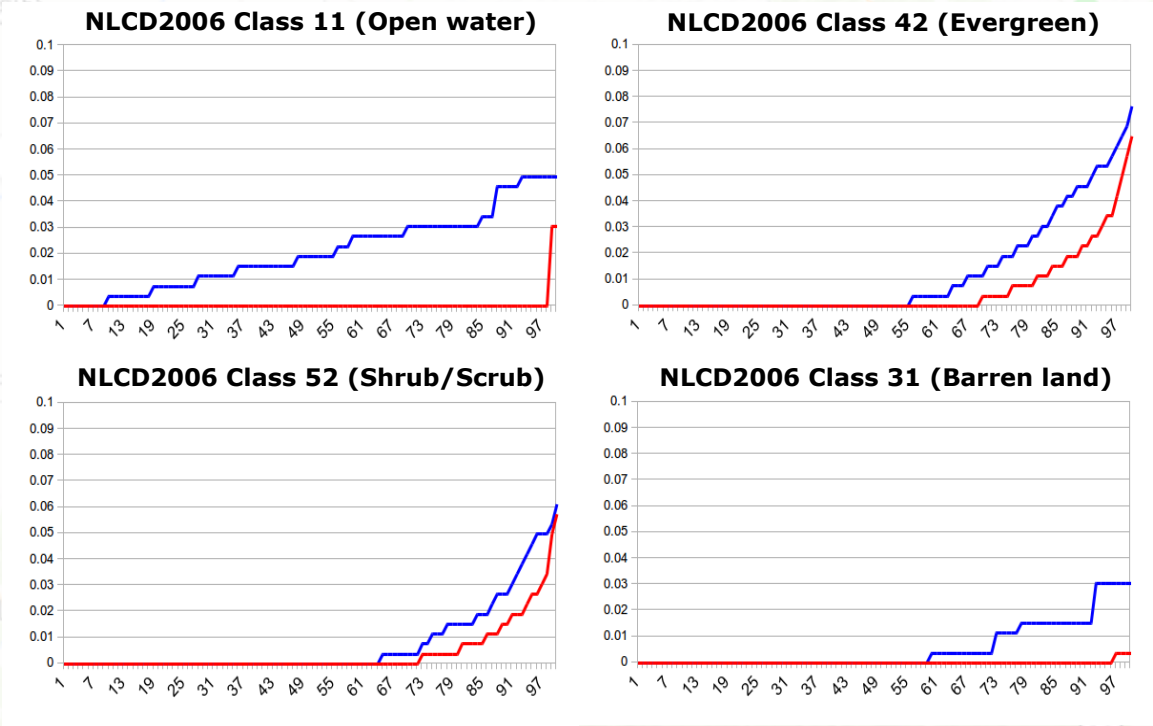

Most tagged land-cover classes among tribal members are mountain lake spots, evergreen forest, scrub land and moors.

Red: non-tribal residents
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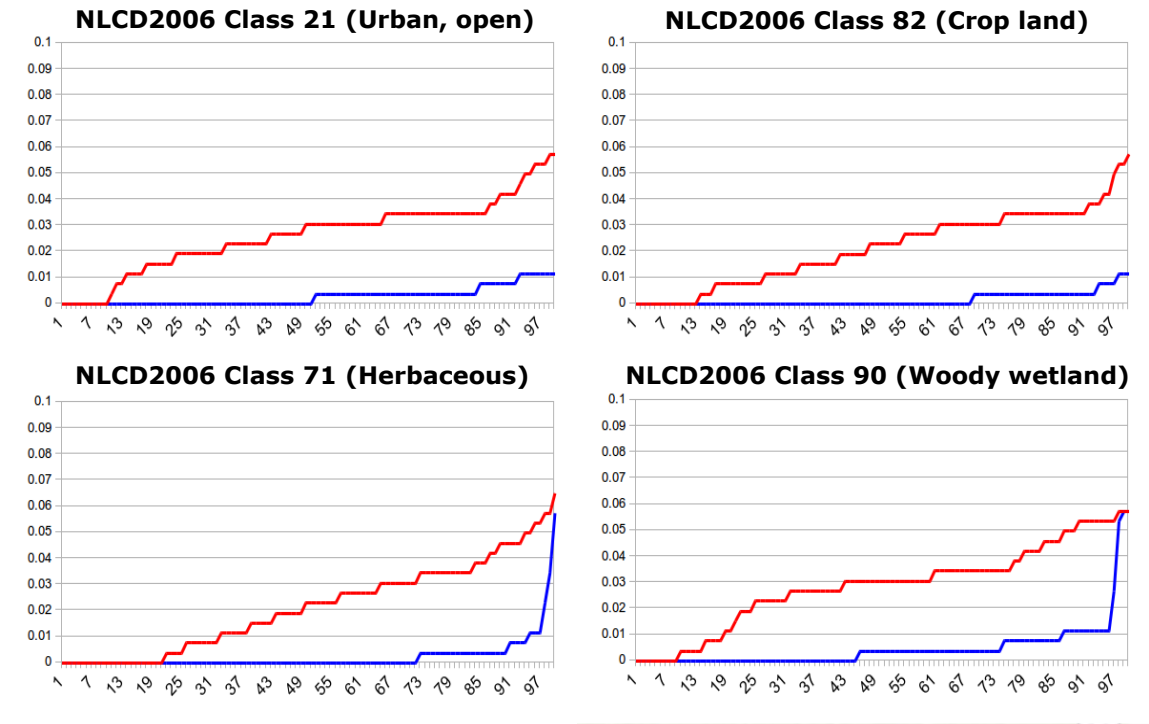

Most tagged land-cover classes among non-tribal people are open spots in developed areas, woody crops, pastures and woody wetlands along the Jocko.

Red: non-tribal residents
Blue: tribal residents

Next steps of the analysis

What is the likelihood for these spatial associations with specific geographies to be the product of chance?

- Testing of randomness hypotheses for multipoint objects:
  - Simulation of random spray patterns.
  - Bootstrapping (reshuffling the allocation of spray patterns to interviewees).
- Analysis of additional candidate covariates (e.g. evolution of fire regimes, land status).

Future goals for software development

- Use of larger text corpora and dictionaries.
- Building *ad hoc* text sources adapted to case studies.
- Implementing a potentially fully multimodal geodatabase, including semiotic modes such as image, video and sound.
- Optimize search trees to speed up database lookups.

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Thank you

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