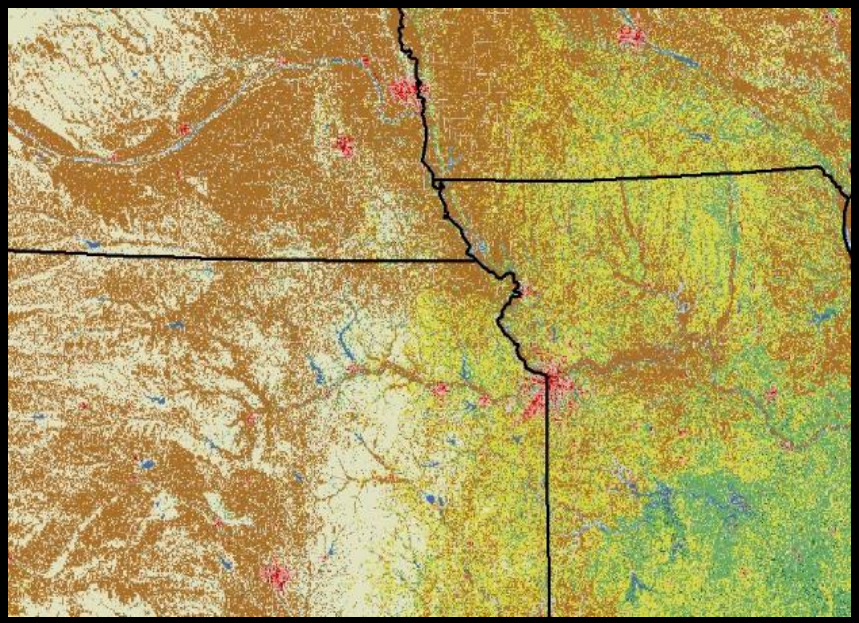
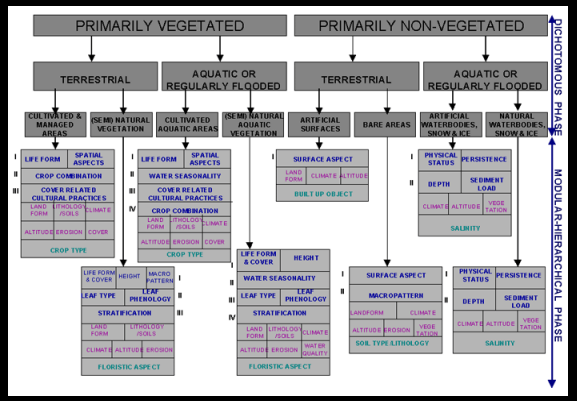
# Crowdsourcing landscape perceptions to validate land cover classifications

Kevin Sparks, Alexander Klippel, Jan Oliver Wallgrün, David Mark



# Dataset creation process

Sensor(s) → Classification Scheme → Land Cover Dataset




http://www.jpl.nasa.gov/missions/ocean-surface-topography-mission-jason-2-ostm-jason-2/

http://www.fao.org/docrep/003/x0596e/x0596e01f.htm

http://nationalmap.gov/landcover.html

## Variation in the data

a) differing land cover classes

b) changed meanings of shared terminology

c) differences in interpretation and perception of the land cover classes

## Inaccuracies

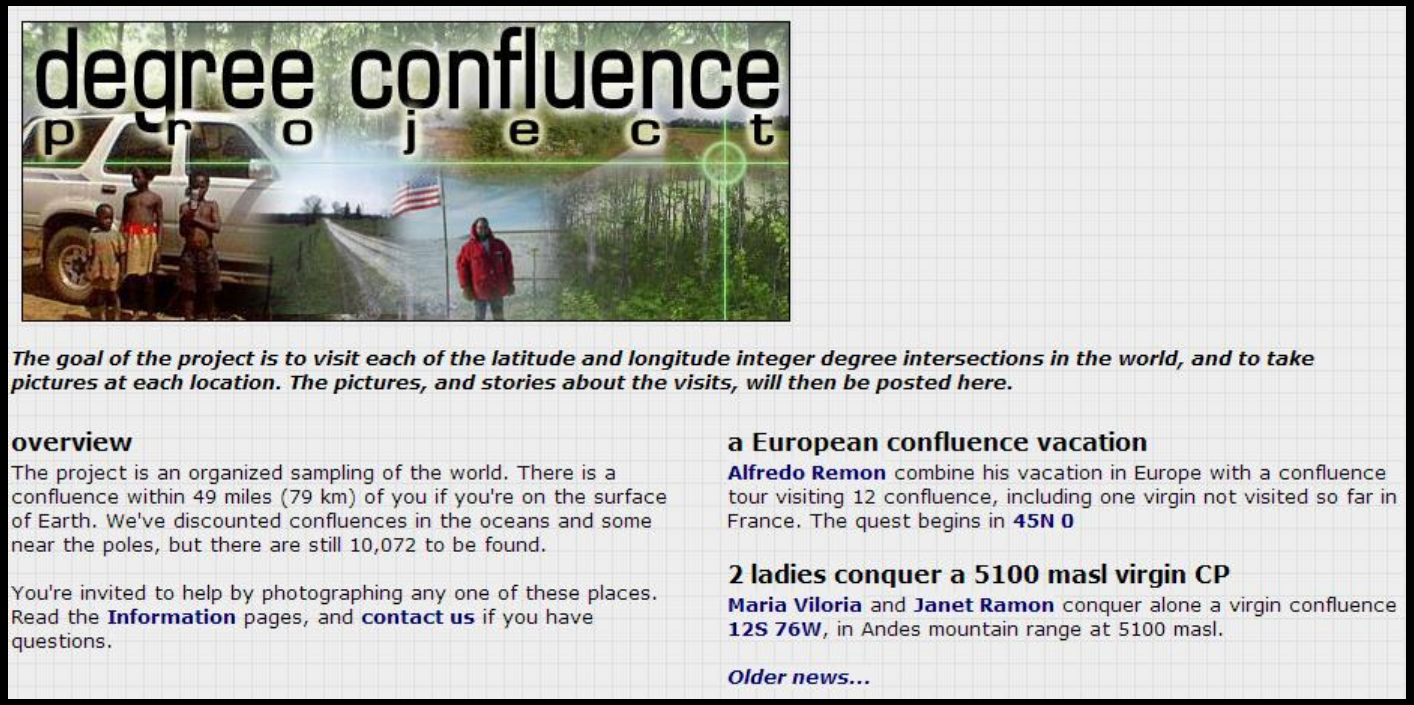
a) The vast majority do not meet the “commonly recommended target” of 85% accuracy

b) No upward trend in classification accuracy in the past 2 decades

# Data

(Crowdsourcing via confluence.org)

In order to attempt to be as unbiased as possible, being as objective as possible during data selection is critical



- Sudan (19)
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- Switzerland (5)
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- Tajikistan (4)
- Tanzania (24)
- Thailand (43)
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- Togo (4)
- Trinidad and Tobago (2)
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- Turkmenistan (1)
- Turks and Caicos Islands (1)
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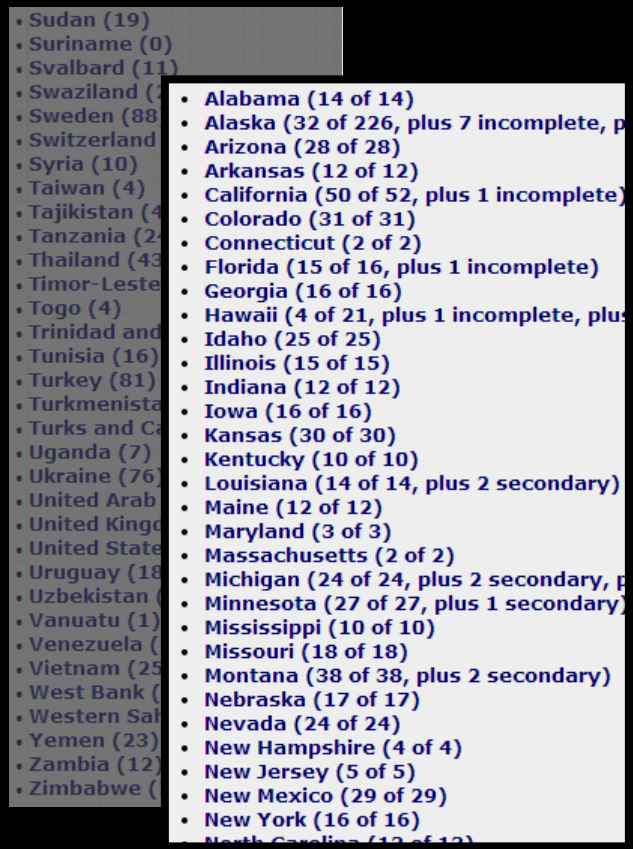
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Montana (38 of 38, plus 2 secondary)
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**29°N 97°W**
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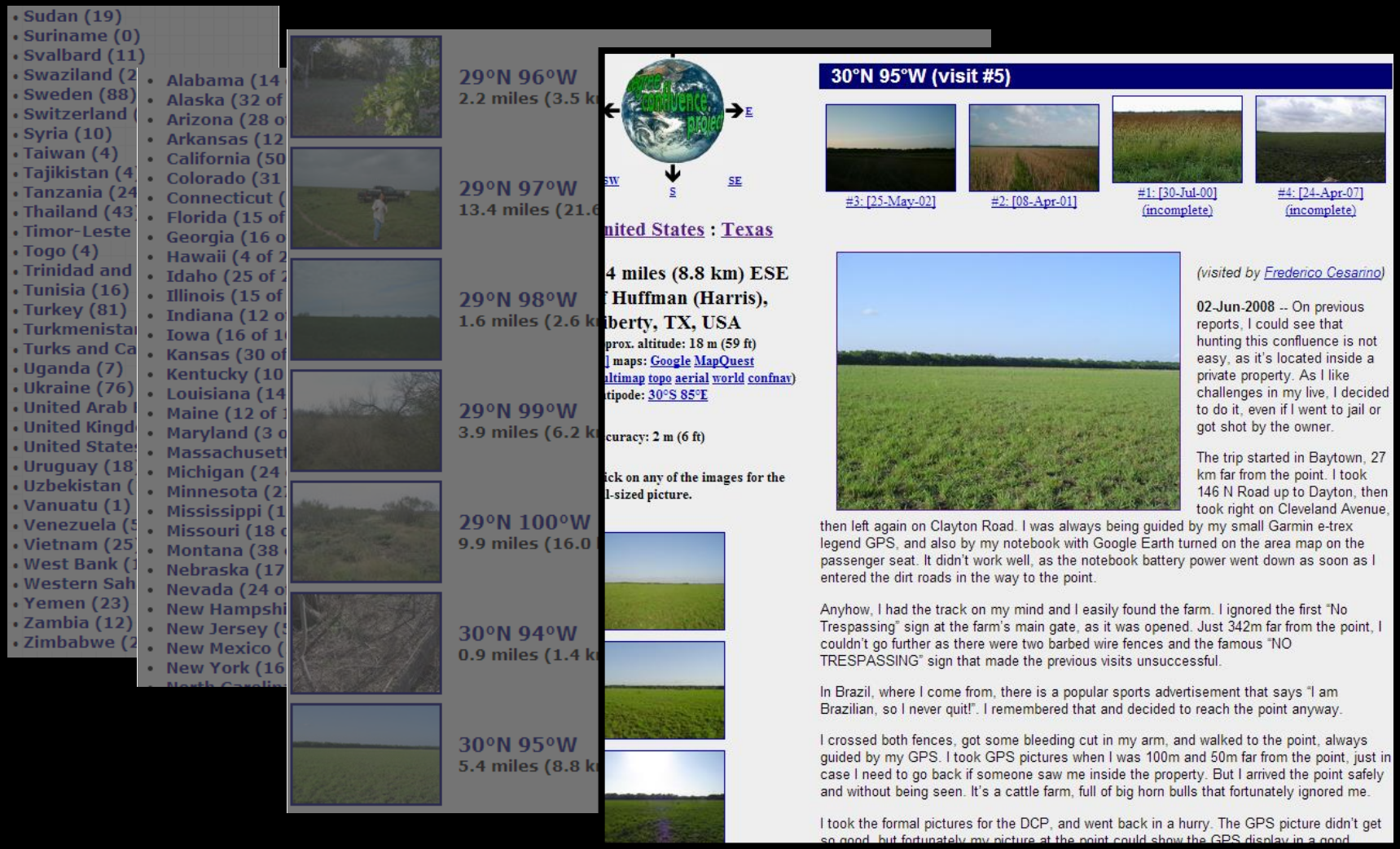
**29°N 98°W**
1.6 miles (2.6 km) NE of Falls City, Karnes, TX, USA

**29°N 99°W**
3.9 miles (6.2 km) S of Moore, Frio, TX, USA

**29°N 100°W**
9.9 miles (16.0 km) WNW of La Pryor, Zavala, TX, USA

**30°N 94°W**
0.9 miles (1.4 km) NE of Central Gardens, Jefferson, TX, USA

**30°N 95°W**
5.4 miles (8.8 km) ESE of Huffman (Harris), Liberty, TX, USA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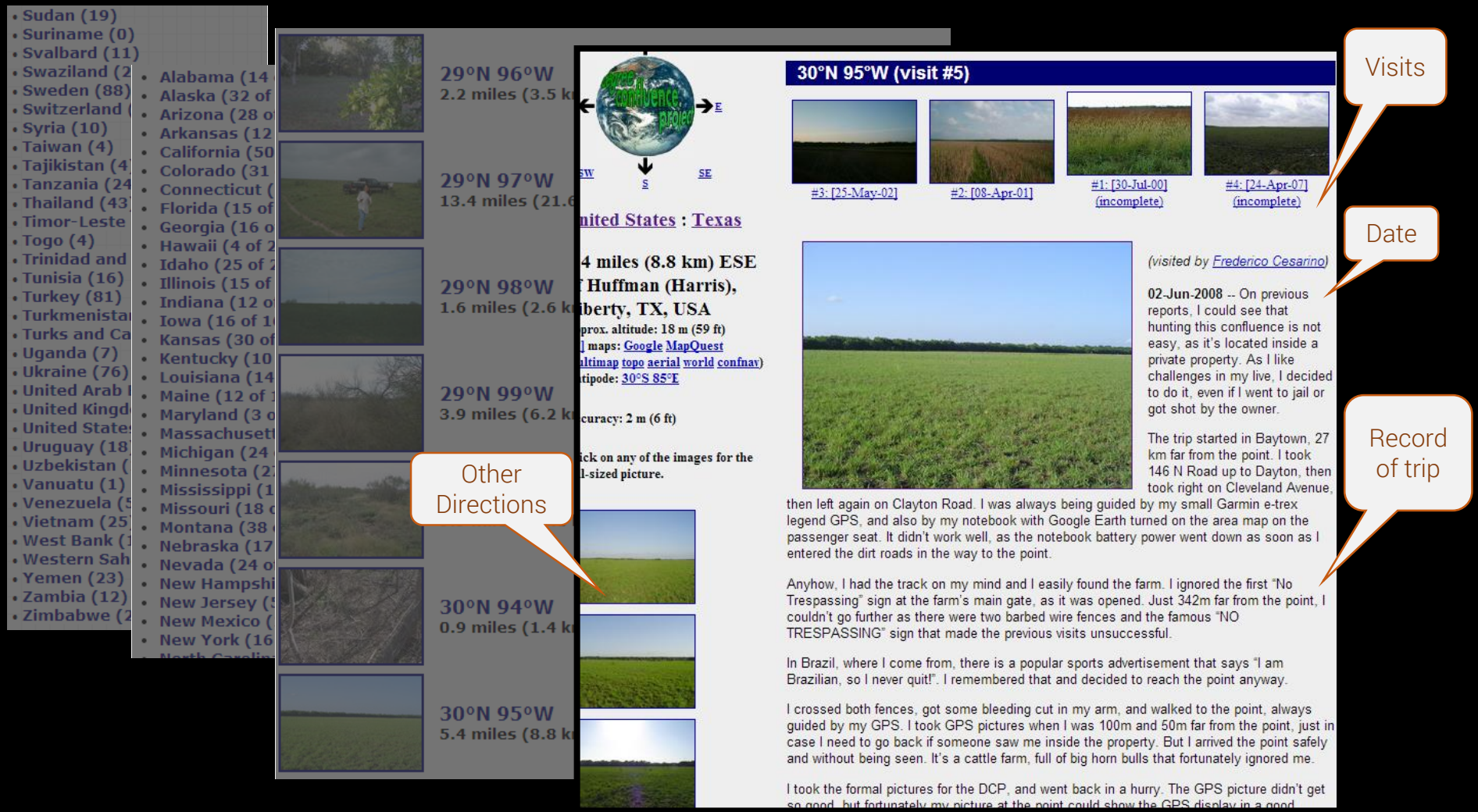
#2: [08-Apr-01]
#1: [30-Jul-00] (incomplete)
#4: [24-Apr-07] (incomplete)
(visited by Frederico Cesarino)
02-Jun-2008 -- On previous reports, I could see that hunting this confluence is not easy, as it's located inside a private property. As I like challenges in my live, I decided to do it, even if I went to jail or got shot by the owner.
The trip started in Baytown, 27 km far from the point. I took 146 N Road up to Dayton, then took right on Cleveland Avenue, then left again on Clayton Road. I was always being guided by my small Garmin e-trex legend GPS, and also by my notebook with Google Earth turned on the area map on the passenger seat. It didn't work well, as the notebook battery power went down as soon as I entered the dirt roads in the way to the point.
Anyhow, I had the track on my mind and I easily found the farm. I ignored the first "No Trespassing" sign at the farm's main gate, as it was opened. Just 342m far from the point, I couldn't go further as there were two barbed wire fences and the famous "NO TRESPASSING" sign that made the previous visits unsuccessful.
In Brazil, where I come from, there is a popular sports advertisement that says "I am Brazilian, so I never quit!". I remembered that and decided to reach the point anyway.
I crossed both fences, got some bleeding cut in my arm, and walked to the point, always guided by my GPS. I took GPS pictures when I was 100m and 50m far from the point, just in case I need to go back if someone saw me inside the property. But I arrived the point safely and without being seen. It's a cattle farm, full of big horn bulls that fortunately ignored me.
I took the formal pictures for the DCP, and went back in a hurry. The GPS picture didn't get so good, but fortunately my picture at the point could show the GPS display in a good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Visits
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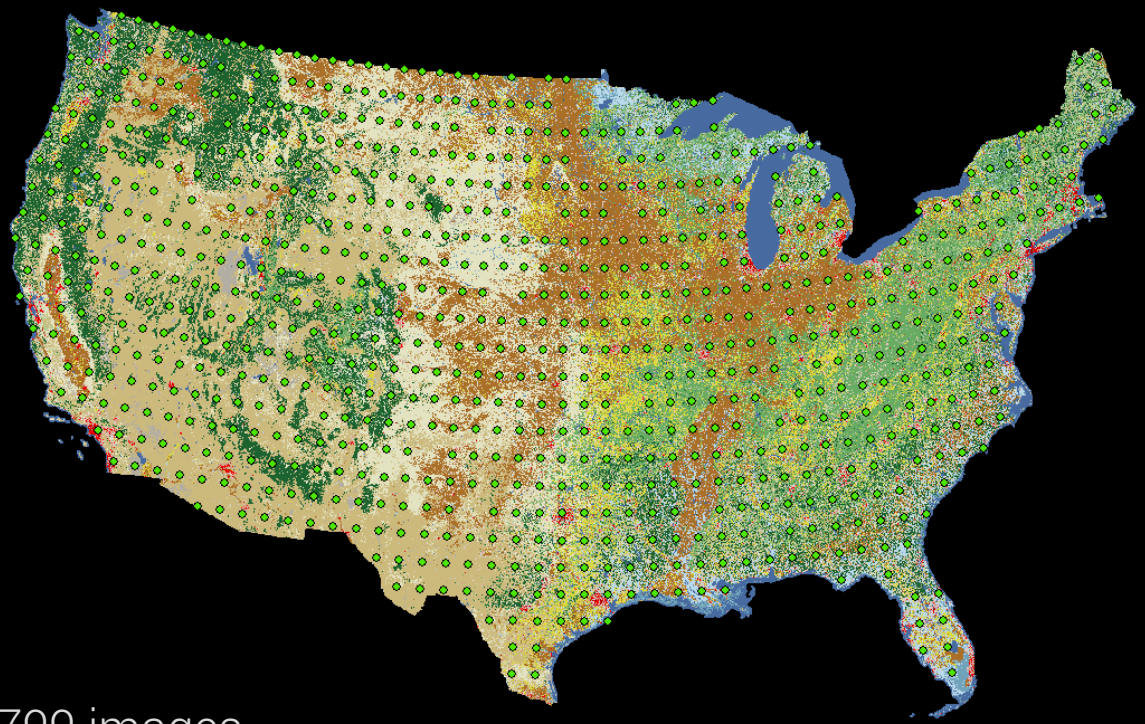
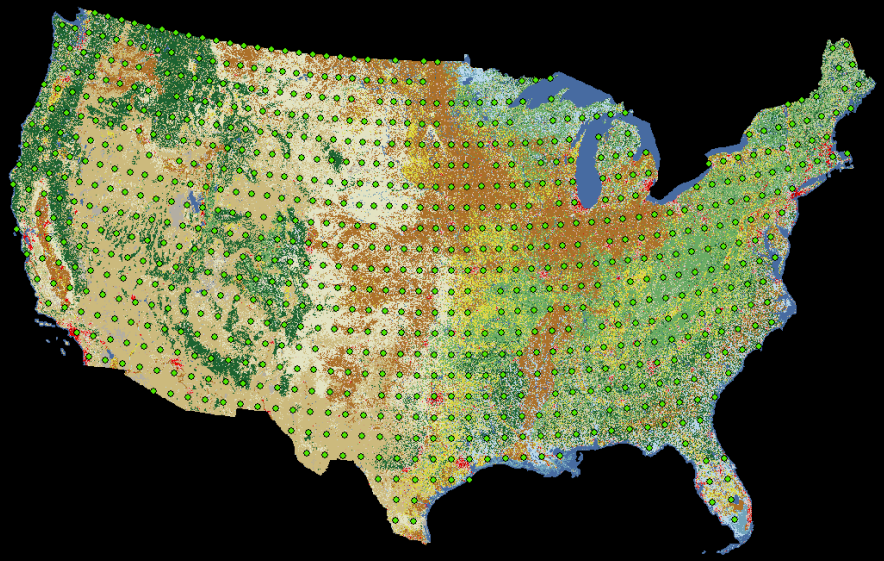
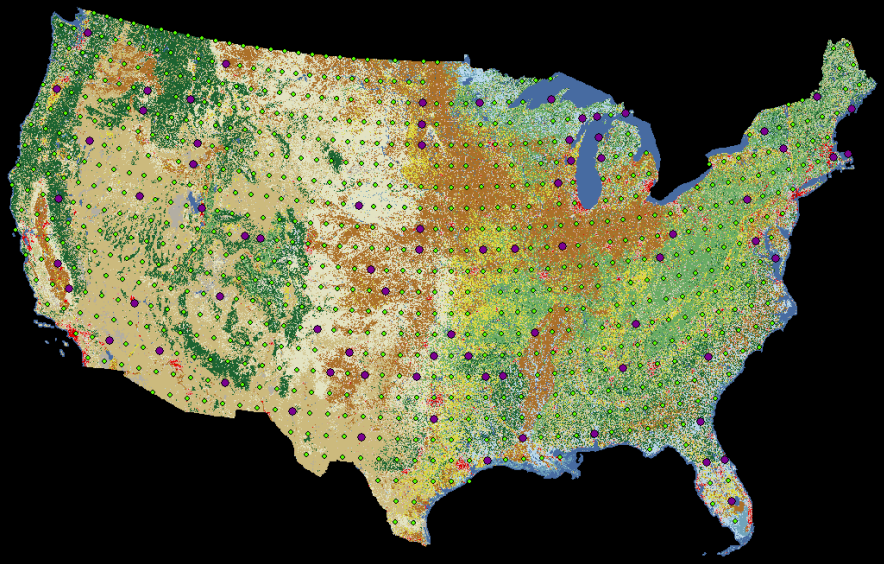
Record of trip
Other Directions



799 images





NLCD Land Cover Classification Legend

- 11 Open Water
- 12 Perennial Ice/ Snow
- 21 Developed, Open Space
- 22 Developed, Low Intensity
- 23 Developed, Medium Intensity
- 24 Developed, High Intensity
- 31 Barren Land (Rock/Sand/Clay)
- 41 Deciduous Forest
- 42 Evergreen Forest
- 43 Mixed Forest
- 51 Dwarf Scrub*
- 52 Shrub/Scrub
- 71 Grassland/Herbaceous
- 72 Sedge/Herbaceous*
- 73 Lichens*
- 74 Moss*
- 81 Pasture/Hay
- 82 Cultivated Crops
- 90 Woody Wetlands
- 95 Emergent Herbaceous Wetlands

* Alaska only

| | Counts | |
|---|---|---|
| "0" (Canada) | 17 | |
| barren | 11 | |
| cultivated crops | 128 | |
| developed, Medium Intensity | 3 | |
| developed, Low Intensity | 18 | |
| developed, Open Space | 28 | |
| emergent heraceous wetlands | 8 | |
| forest | 208 | |
| grassland | 99 | |
| open water | 17 | |
| pasture/hay | 52 | |
| shrub/scrub | 185 | |
| woody wetlands | 25 | |
| | 799 | Total |

## Stratified Random Sample

11 land cover classes

7 samples from each class

# Participant Image Classification

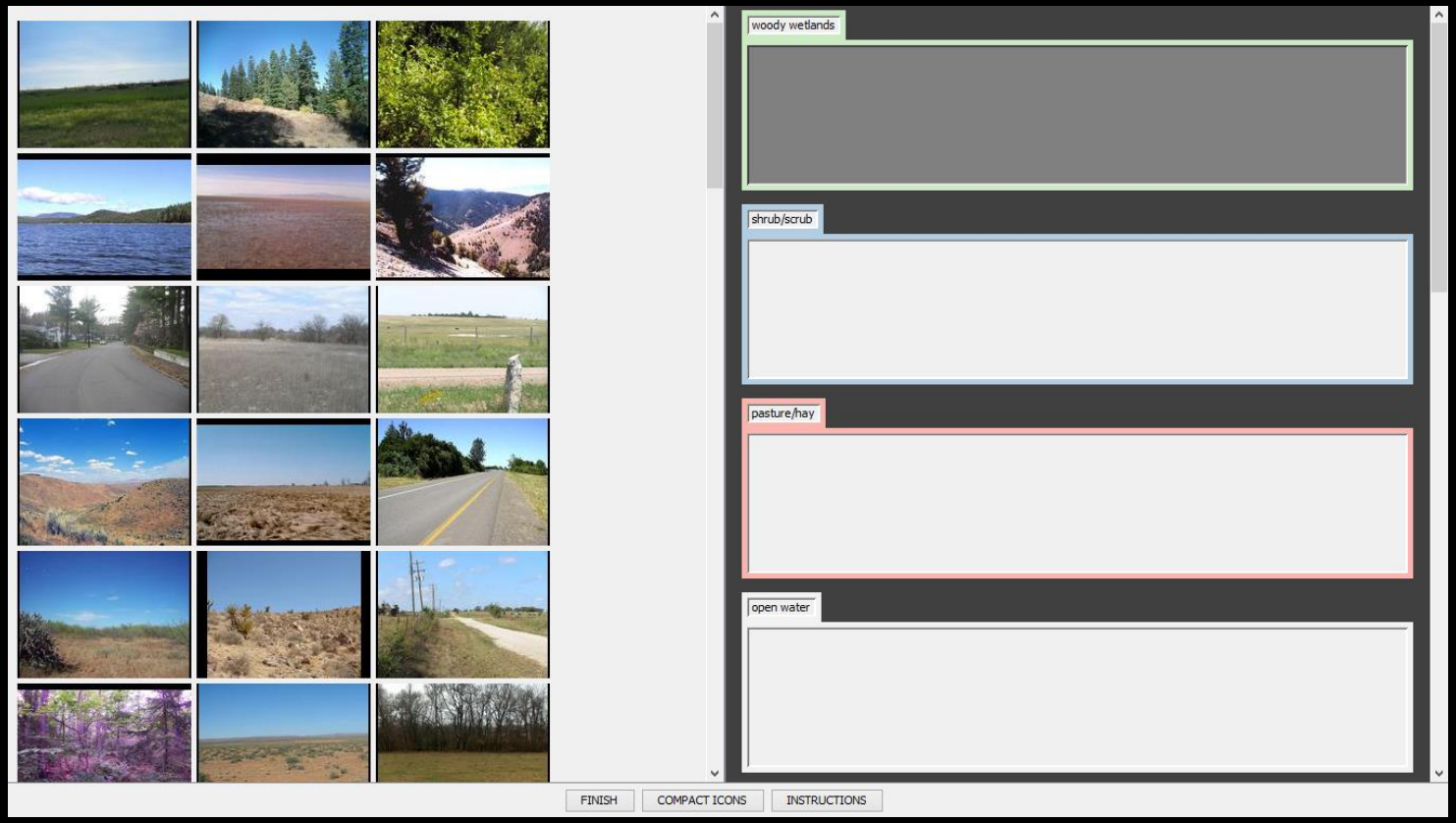
(Crowdsourcing via AMT)

(Crowdsourcing.. The crowdsourced data)

# Amazon Mechanical Turk

Grouping Task Interface (*catscan*)

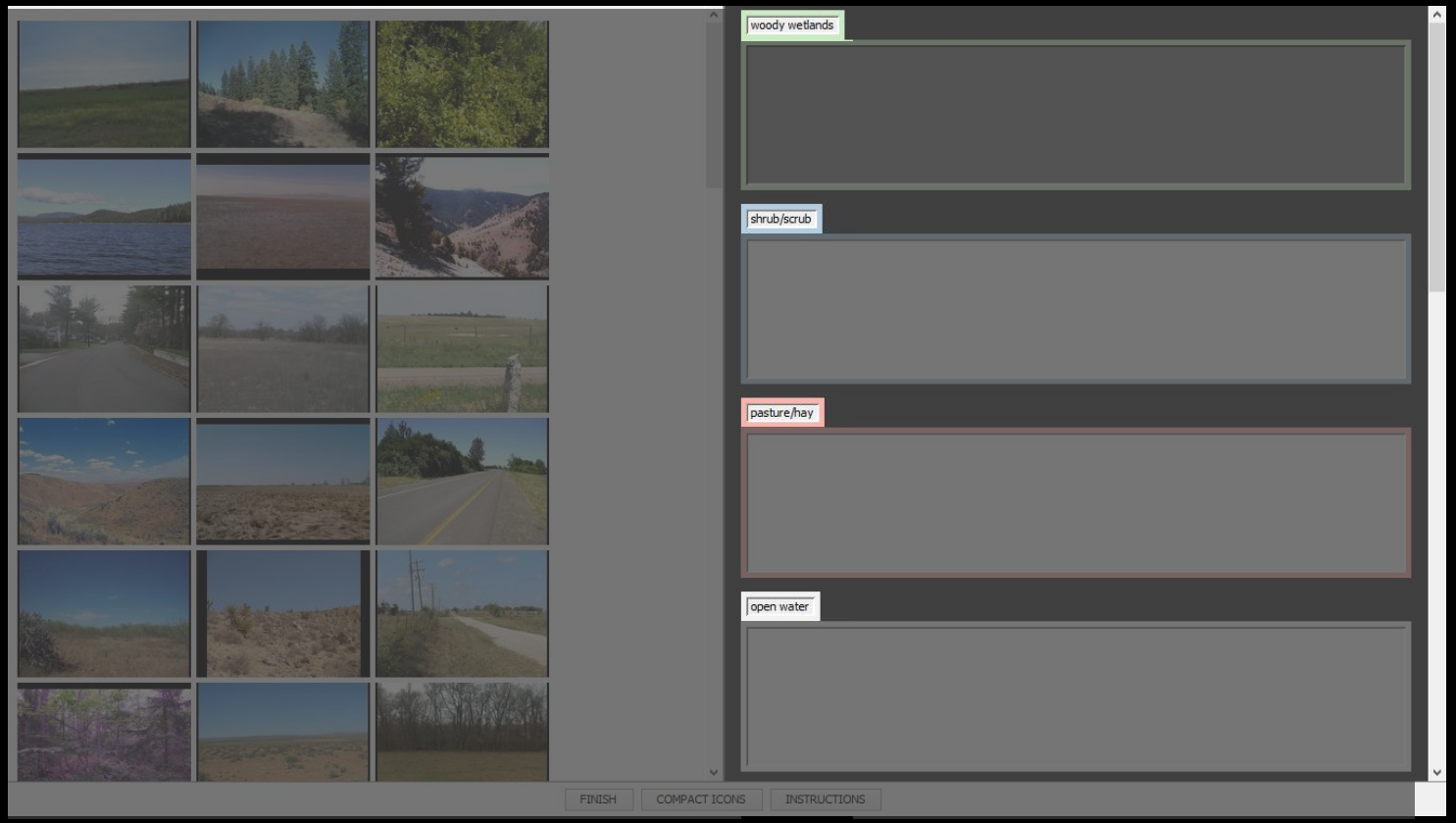
Experiment 1



Grouping Task Interface (*catscan*)

non-free classification

# Experiment 1



Overall Classification accuracy = 40.19%

ChiSquare = 411.78
df = 10
p < .001

| | BA | CC | dL | dO | EW | FO | GS | OW | PH | SS | WW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Correct | 1.57 | -0.77 | 4.47 | -1.13 | -9.63 | 8.08 | -1.31 | 13.14 | -7.82 | -0.77 | -5.83 |

Standardized residuals comparing the number of correct/incorrect classified images across all 11 LCCs.

# Confusion Matrix

Percent correct (diagonal) and percent misclassified (rows).

5 – 25% indicated by pink

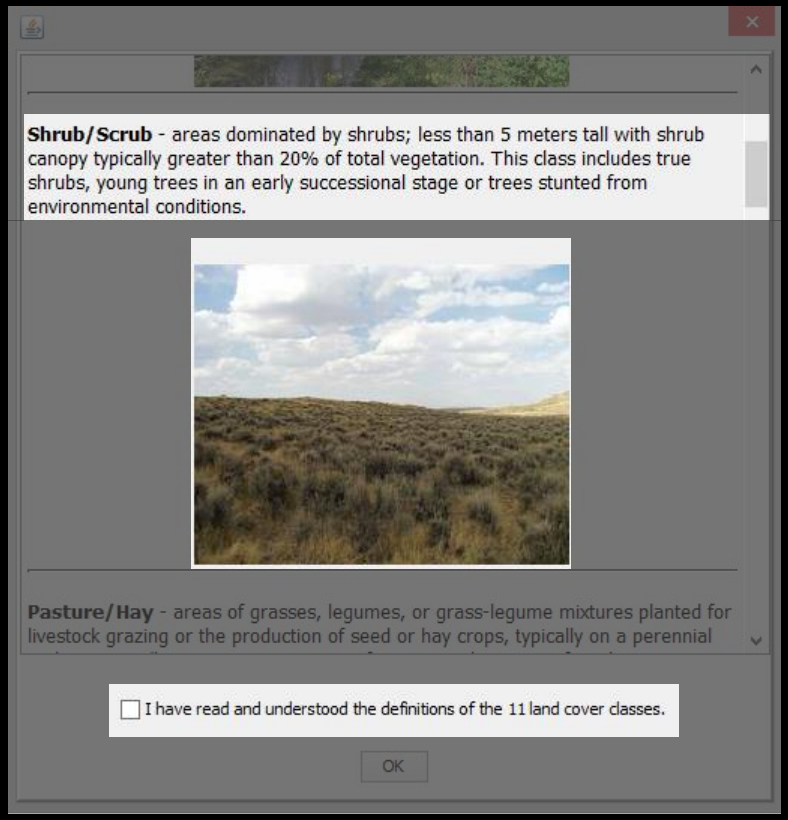
25 – 50% indicated by bright red

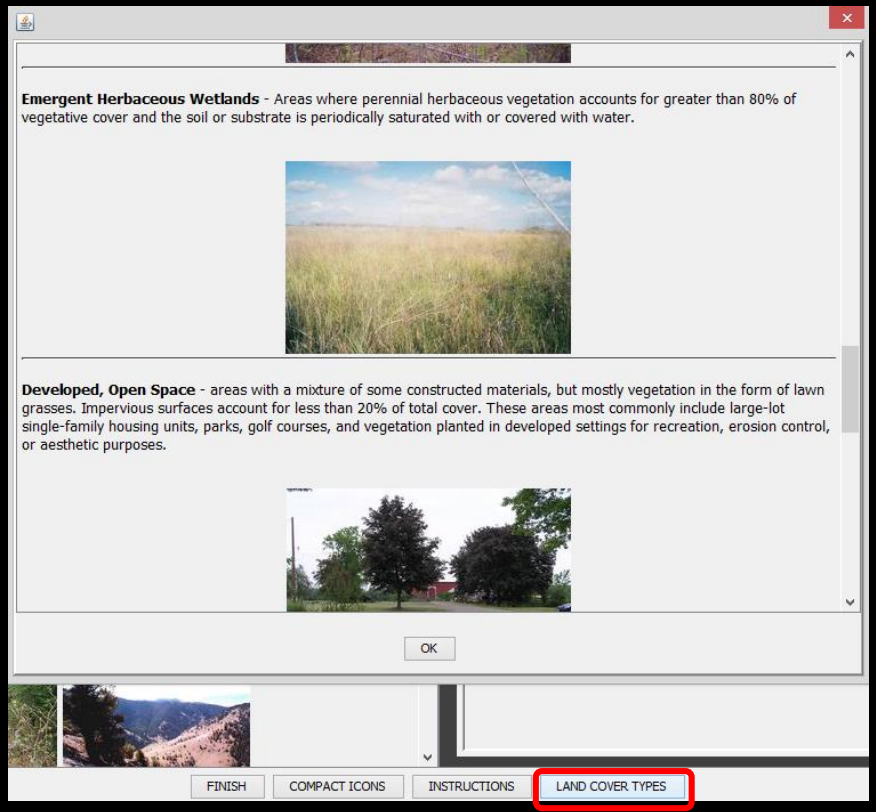
above 50% are dark red

| | BA | CC | dL | dO | EW | FO | GS | OW | PH | SS | WW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BA | 46.43 | 2.86 | 0 | 0 | 7.14 | 0.71 | 2.86 | 0 | 2.86 | 36.43 | 0.71 |
| CC | 9.29 | 37.14 | 0 | 2.14 | 2.86 | 0 | 34.29 | 0.71 | 11.43 | 2.14 | 0 |
| dL | 0 | 0 | 57.86 | 30 | 0 | 0 | 7.86 | 0 | 2.86 | 1.43 | 0 |
| dO | 0.71 | 0 | 46.43 | 35.71 | 0.71 | 0 | 2.86 | 0 | 7.86 | 5.71 | 0 |
| EW | 6.43 | 5 | 0 | 0 | 2.14 | 33.57 | 12.14 | 0.71 | 17.86 | 16.43 | 5.71 |
| FO | 0.71 | 0.71 | 0 | 0 | 2.86 | 72.14 | 0 | 0 | 1.43 | 20 | 2.14 |
| GS | 23.57 | 13.57 | 0.71 | 0.71 | 0.71 | 0 | 35 | 0 | 15 | 10 | 0.71 |
| OW | 0 | 0 | 0 | 0 | 0.71 | 0.71 | 0.71 | 92.14 | 0 | 0 | 5.71 |
| PH | 14.29 | 2.14 | 2.86 | 3.57 | 3.57 | 12.14 | 34.29 | 0 | 9.29 | 14.29 | 3.57 |
| SS | 45 | 0.71 | 0.71 | 0 | 0.71 | 0.71 | 10 | 0 | 3.57 | 37.14 | 1.43 |
| WW | 0 | 1.43 | 1.43 | 0 | 1.43 | 71.43 | 0 | 0 | 0 | 7.14 | 17.14 |
| Total | 13.31 | 5.78 | 10 | 6.56 | 2.08 | 17.4 | 12.73 | 8.51 | 6.56 | 13.7 | 3.38 |

# Grouping Task Interface (*catscan*) example/definition intervention

# Experiment 2



# Overall Classification accuracy = 44.35%

The improvement in classification after the intervention is statistically significant ($\chi^2 = 5.2807$, df = 1, p = .02)

ChiSquare = 398.65
df = 10
p < .001

| | BA | CC | dL | dO | EW | FO | GS | OW | PH | SS | WW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| correct | -0.55 | -0.01 | 0.87 | 3.37 | -8.75 | 8.72 | -0.72 | 12.29 | -8.22 | 0.34 | -7.33 |

Standardized residuals comparing the number of correct/incorrect classified images across all 11 LCCs.

# Confusion Matrix

Percent correct (diagonal) and percent misclassified (rows).

5 – 25% indicated by pink

25 – 50% indicated by bright red

above 50% are dark red

| | BA | CC | dL | dO | EW | FO | GS | OW | PH | SS | WW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BA | 42.14 | 0.71 | 0.71 | 0 | 7.14 | 0 | 0.71 | 2.14 | 0.71 | 45.71 | 0 |
| CC | 8.57 | 44.29 | 0 | 0.71 | 3.57 | 0 | 30 | 1.43 | 10 | 0.71 | 0.71 |
| dL | 0 | 0 | 47.86 | 47.14 | 0 | 0 | 3.57 | 0 | 1.43 | 0 | 0 |
| dO | 0 | 0 | 37.86 | 57.86 | 0.71 | 0 | 2.14 | 0 | 1.43 | 0 | 0 |
| EW | 3.57 | 1.43 | 0 | 0 | 9.29 | 34.29 | 6.43 | 0 | 20.71 | 17.14 | 7.14 |
| FO | 1.43 | 0 | 2.86 | 0.71 | 4.29 | 79.29 | 0 | 0 | 1.43 | 5.71 | 4.29 |
| GS | 15.71 | 14.29 | 0 | 0 | 0.71 | 0 | 41.43 | 0 | 13.57 | 13.57 | 0.71 |
| OW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 93.57 | 0 | 0 | 6.43 |
| PH | 12.14 | 4.29 | 2.86 | 1.43 | 6.43 | 10.71 | 32.86 | 0 | 11.43 | 17.86 | 0 |
| SS | 35.71 | 0.71 | 0.71 | 0 | 5 | 2.14 | 6.43 | 0 | 3.57 | 45.71 | 0 |
| WW | 0 | 0 | 0.71 | 0.71 | 3.57 | 77.86 | 0 | 0 | 0 | 2.14 | 15 |
| Total | 10.84 | 5.97 | 8.5 | 9.87 | 3.7 | 18.57 | 11.23 | 8.83 | 5.84 | 13.5 | 3.11 |

Grouping Task Interface (*catscan*)
expert classification

# Experiment 3

Four experts were solicited that have ecological and geographic information science backgrounds with experience in working with land cover data.

Experts were provided the class definitions and visual prototypes, just like in experiment 2, but on printed out sheets of paper.

Each expert viewed the original DCP images on a computer screen, one at a time.

# Overall Classification accuracy = 48.37%

The improvement in classification from experiment 2 to 3 is not significant.
($\chi^2 = 1.52$, df = 1, p = .22)

ChiSquare = 114.22
df = 10
p < .001

| | BA | CC | dL | dO | EW | FO | GS | OW | PH | SS | WW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| correct | -3.78 | 2.16 | 3.35 | -0.21 | -3.38 | 3.35 | -2.99 | 5.73 | -0.21 | 1.37 | -5.37 |

Standardized residuals comparing the number of correct/incorrect classified images across all 11 LCCs.

# Percent agreement

| | A | B | C | D |
|---|---|---|---|---|
| A | | 61% | 63% | 65% |
| B | | | 66% | 63% |
| C | | | | 63% |
| D | | | | |
| Full agreement | | | | 43% |

Percent agreement between the experts, A-D. Full agreement indicates the percentage that all 4 experts agreed on the same classification given a DCP image.

# Confusion Matrix

Percent correct (diagonal) and percent misclassified (rows).

5 – 25% indicated by pink

25 – 50% indicated by bright red

above 50% are dark red

| | BA | CC | dL | dO | EW | FO | GS | OW | PH | SS | WW |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BA | 14.29 | 3.57 | 0 | 0 | 14.29 | 3.57 | 0 | 0 | 0 | 64.29 | 0 |
| CC | 0 | 67.86 | 0 | 0 | 0 | 0 | 0 | 0 | 25 | 7.14 | 0 |
| dL | 0 | 3.57 | 78.57 | 10.71 | 0 | 0 | 3.57 | 0 | 3.57 | 0 | 0 |
| dO | 0 | 0 | 46.43 | 46.43 | 0 | 0 | 0 | 0 | 7.14 | 0 | 0 |
| EW | 0 | 17.86 | 0 | 0 | 17.86 | 42.86 | 3.57 | 0 | 3.57 | 10.71 | 3.57 |
| FO | 0 | 0 | 0 | 0 | 0 | 78.57 | 0 | 0 | 3.57 | 17.86 | 0 |
| GS | 0 | 14.29 | 0 | 0 | 14.29 | 0 | 21.43 | 0 | 21.43 | 28.57 | 0 |
| OW | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 0 | 0 | 0 |
| PH | 0 | 21.43 | 0 | 0 | 0 | 0 | 25 | 0 | 46.43 | 7.14 | 0 |
| SS | 17.86 | 0 | 0 | 0 | 0 | 3.57 | 17.86 | 0 | 0 | 60.71 | 0 |
| WW | 0 | 0 | 0 | 0 | 0 | 92.86 | 0 | 0 | 0 | 7.14 | 0 |
| Total | 2.92 | 11.69 | 11.36 | 5.19 | 4.22 | 20.13 | 6.46 | 9.09 | 10.06 | 18.51 | 0.32 |

# Discussion

a) The overall match between participants' classifications and NLCD is rather low (40.19 - 48.37%).

b) Accuracy increased statistically significantly using an intervention of providing definitions and prototypical images.

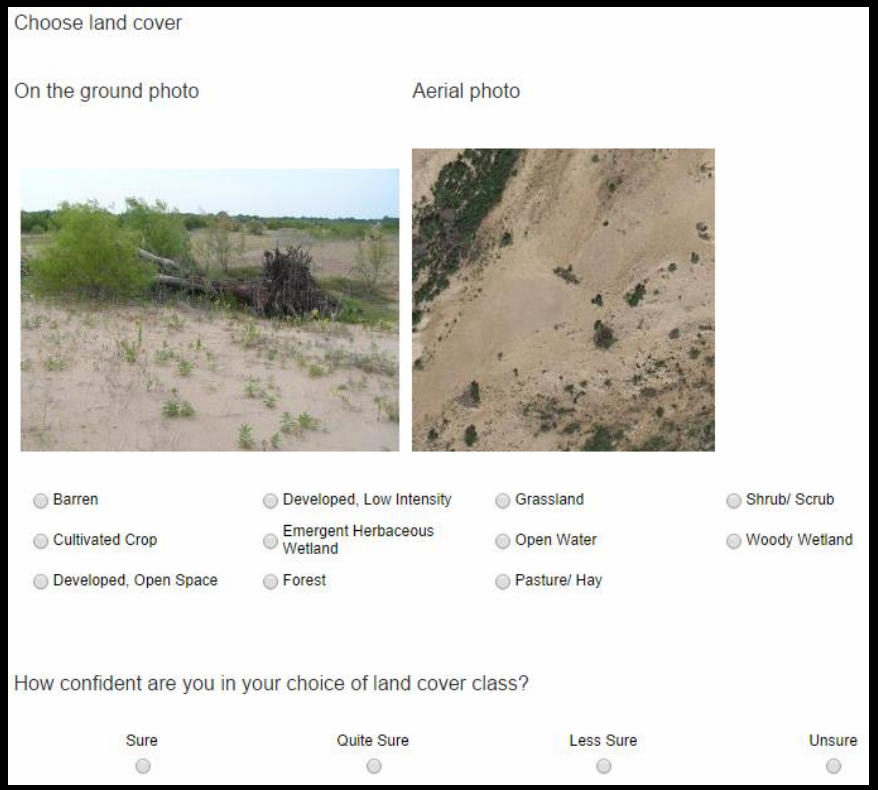
c) The misclassifications are not random but rather systematic.

d) General relationships between classes persist but changes occur in magnitudes of accuracy.

   I. almost exclusive confusion of 'woody wetland' (WW) being misclassified as 'forest' (FO)
   II. 'barren' (BA) and 'shrub/scrub' (SS) are confused with each other
   III. the 'developed' classes are confused with each other
   IV. the 'emergent herbaceous wetlands' (EW), 'grassland' (GS), and 'pasture/hay' (PH) are confused across many classes.

# Future Outlook

## Coupling aerial and ground




## Feature based classification

# THE END

Thank you for your time