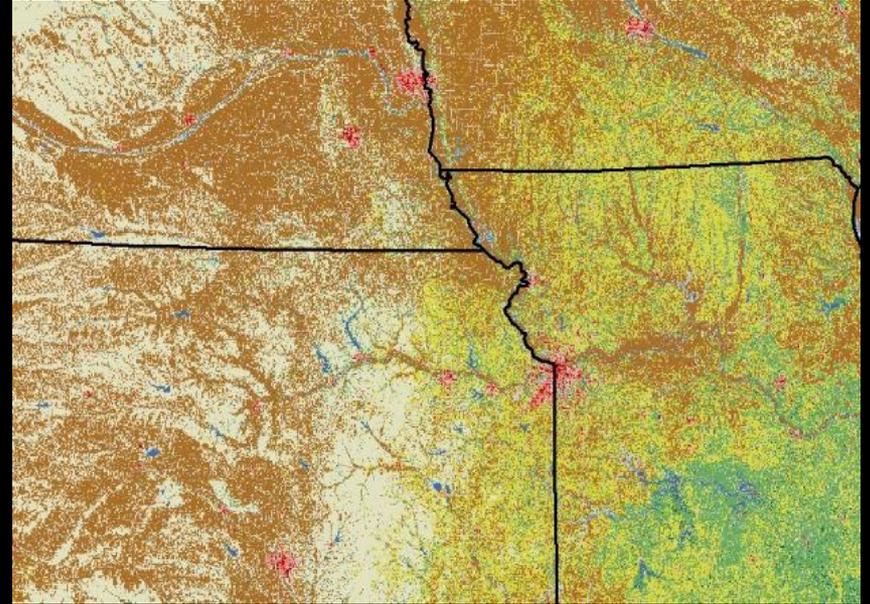


Crowdsourcing landscape perceptions to validate land cover classifications

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



Dataset creation process

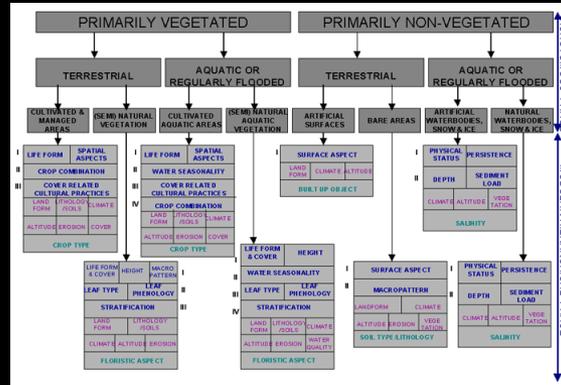
Sensor(s)



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



The goal of the project is to visit each of the latitude and longitude integer degree intersections in the world, and to take pictures at each location. The pictures, and stories about the visits, will then be posted here.

overview

The project is an organized sampling of the world. There is a confluence within 49 miles (79 km) of you if you're on the surface of Earth. We've discounted confluences in the oceans and some near the poles, but there are still 10,072 to be found.

You're invited to help by photographing any one of these places. Read the **Information** pages, and **contact us** if you have questions.

a European confluence vacation

Alfredo Remon combine his vacation in Europe with a confluence tour visiting 12 confluence, including one virgin not visited so far in France. The quest begins in **45N 0**

2 ladies conquer a 5100 masl virgin CP

Maria Vilorio and **Janet Ramon** conquer alone a virgin confluence **12S 76W**, in Andes mountain range at 5100 masl.

Older news...

- Sudan (19)
- Suriname (0)
- Svalbard (11)
- Swaziland (2)
- Sweden (88)
- Switzerland (5)
- Syria (10)
- Taiwan (4)
- Tajikistan (4)
- Tanzania (24)
- Thailand (43)
- Timor-Leste (2)
- Togo (4)
- Trinidad and Tobago (2)
- Tunisia (16)
- Turkey (81)
- Turkmenistan (1)
- Turks and Caicos Islands (1)
- Uganda (7)
- Ukraine (76)
- United Arab Emir. (10)
- United Kingdom (49)
- United States (913)
- Uruguay (18)
- Uzbekistan (16)
- Vanuatu (1)
- Venezuela (54)
- Vietnam (25)
- West Bank (1)
- Western Sahara (1)
- Yemen (23)
- Zambia (12)
- Zimbabwe (21)

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- Uzbekistan (2)
- Vanuatu (1)
- Venezuela (2)
- Vietnam (25)
- West Bank (2)
- Western Sahara (2)
- Yemen (23)
- Zambia (12)
- Zimbabwe (2)
- Alabama (14 of 14)
- Alaska (32 of 226, plus 7 incomplete, plus 2 secondary)
- Arizona (28 of 28)
- Arkansas (12 of 12)
- California (50 of 52, plus 1 incomplete)
- Colorado (31 of 31)
- Connecticut (2 of 2)
- Florida (15 of 16, plus 1 incomplete)
- Georgia (16 of 16)
- Hawaii (4 of 21, plus 1 incomplete, plus 2 secondary)
- Idaho (25 of 25)
- Illinois (15 of 15)
- Indiana (12 of 12)
- Iowa (16 of 16)
- Kansas (30 of 30)
- Kentucky (10 of 10)
- Louisiana (14 of 14, plus 2 secondary)
- Maine (12 of 12)
- Maryland (3 of 3)
- Massachusetts (2 of 2)
- Michigan (24 of 24, plus 2 secondary, plus 1 incomplete)
- Minnesota (27 of 27, plus 1 secondary)
- Mississippi (10 of 10)
- Missouri (18 of 18)
- Montana (38 of 38, plus 2 secondary)
- Nebraska (17 of 17)
- Nevada (24 of 24)
- New Hampshire (4 of 4)
- New Jersey (5 of 5)
- New Mexico (29 of 29)
- New York (16 of 16)
- North Carolina (12 of 12)

- Sudan (19)
- Suriname (0)
- Svalbard (11)
- Swaziland (2)
- Sweden (88)
- Switzerland (1)
- Syria (10)
- Taiwan (4)
- Tajikistan (4)
- Tanzania (24)
- Thailand (43)
- Timor-Leste (1)
- Togo (4)
- Trinidad and Tobago (1)
- Tunisia (16)
- Turkey (81)
- Turkmenistan (1)
- Turks and Caicos Islands (1)
- Uganda (7)
- Ukraine (76)
- United Arab Emirates (1)
- United Kingdom (1)
- United States (1)
- Uruguay (18)
- Uzbekistan (1)
- Vanuatu (1)
- Venezuela (5)
- Vietnam (25)
- West Bank (1)
- Western Sahara (1)
- Yemen (23)
- Zambia (12)
- Zimbabwe (2)
- Alabama (14)
- Alaska (32 of 48)
- Arizona (28 of 31)
- Arkansas (12 of 17)
- California (50 of 58)
- Colorado (31 of 38)
- Connecticut (1 of 5)
- Florida (15 of 20)
- Georgia (16 of 21)
- Hawaii (4 of 19)
- Idaho (25 of 33)
- Illinois (15 of 21)
- Indiana (12 of 17)
- Iowa (16 of 22)
- Kansas (30 of 37)
- Kentucky (10 of 15)
- Louisiana (14 of 22)
- Maine (12 of 18)
- Maryland (3 of 4)
- Massachusetts (1 of 2)
- Michigan (24 of 31)
- Minnesota (2 of 3)
- Mississippi (3 of 4)
- Missouri (18 of 24)
- Montana (38 of 44)
- Nebraska (17 of 23)
- Nevada (24 of 31)
- New Hampshire (1 of 2)
- New Jersey (1 of 2)
- New Mexico (1 of 2)
- New York (16 of 22)
- North Carolina (1 of 2)



29°N 96°W
2.2 miles (3.5 km) NW of Bay City, Matagorda, TX, USA



29°N 97°W
13.4 miles (21.6 km) N of Victoria, Victoria, TX, USA



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

- Sudan (19)
- Suriname (0)
- Svalbard (11)
- Swaziland (2)
- Sweden (88)
- Switzerland (1)
- Syria (10)
- Taiwan (4)
- Tajikistan (4)
- Tanzania (24)
- Thailand (43)
- Timor-Leste (1)
- Togo (4)
- Trinidad and Tobago (1)
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- Vietnam (25)
- West Bank (3)
- Western Sahara (1)
- Yemen (23)
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- Zimbabwe (2)
- Alabama (14)
- Alaska (32 of 50)
- Arizona (28 of 50)
- Arkansas (12 of 50)
- California (50 of 50)
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- Missouri (18 of 50)
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- Nebraska (17 of 50)
- Nevada (24 of 50)
- New Hampshire (1 of 50)
- New Jersey (5 of 50)
- New Mexico (1 of 50)
- New York (16 of 50)
- North Carolina (1 of 50)



29°N 96°W
2.2 miles (3.5 km)



29°N 97°W
13.4 miles (21.6 km)



29°N 98°W
1.6 miles (2.6 km)



29°N 99°W
3.9 miles (6.2 km)



29°N 100°W
9.9 miles (16.0 km)



30°N 94°W
0.9 miles (1.4 km)



30°N 95°W
5.4 miles (8.8 km)



United States : Texas

4 miles (8.8 km) ESE
of Huffman (Harris),
Liberty, TX, USA

prox. altitude: 18 m (59 ft)
| maps: [Google MapQuest](#)
[altimap](#) [topo](#) [aerial](#) [world](#) [confnav](#)
| tipode: [30°S 85°E](#)

accuracy: 2 m (6 ft)

Click on any of the images for the full-sized picture.



30°N 95°W (visit #5)



#3: [25-May-02]



#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 life, 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

- Sudan (19)
- Suriname (0)
- Svalbard (11)
- Swaziland (2)
- Sweden (88)
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- Taiwan (4)
- Tajikistan (4)
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- Tunisia (16)
- Turkey (81)
- Turkmenistan (0)
- Turks and Caicos Islands (0)
- Uganda (7)
- Ukraine (76)
- United Arab Emirates (0)
- United Kingdom (0)
- United States (19)
- Uruguay (18)
- Uzbekistan (0)
- Vanuatu (1)
- Venezuela (5)
- Vietnam (25)
- West Bank (3)
- Western Sahara (0)
- Yemen (23)
- Zambia (12)
- Zimbabwe (2)
- Alabama (14)
- Alaska (32 of 3)
- Arizona (28 of 15)
- Arkansas (12 of 7)
- California (50 of 5)
- Colorado (31 of 10)
- Connecticut (0 of 4)
- Florida (15 of 20)
- Georgia (16 of 5)
- Hawaii (4 of 1)
- Idaho (25 of 2)
- Illinois (15 of 14)
- Indiana (12 of 1)
- Iowa (16 of 1)
- Kansas (30 of 1)
- Kentucky (10 of 1)
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29°N 96°W
2.2 miles (3.5 km)

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29°N 99°W
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30°N 94°W
0.9 miles (1.4 km)

30°N 95°W
5.4 miles (8.8 km)

Other Directions

United States : Texas

4 miles (8.8 km) ESE
of Huffman (Harris),
Liberty, TX, USA
approx. altitude: 18 m (59 ft)
| maps: [Google MapQuest](#)
[altimap](#) [topo](#) [aerial](#) [world](#) [confnav](#)
| tipode: [30°S 85°E](#)
| accuracy: 2 m (6 ft)

Click on any of the images for the full-sized picture.

30°N 95°W (visit #5)

#3: [25-May-02] #2: [08-Apr-01] #1: [30-Jul-00] (incomplete) #4: [24-Apr-07] (incomplete)

(visited by [Frederico Cesarino](#))

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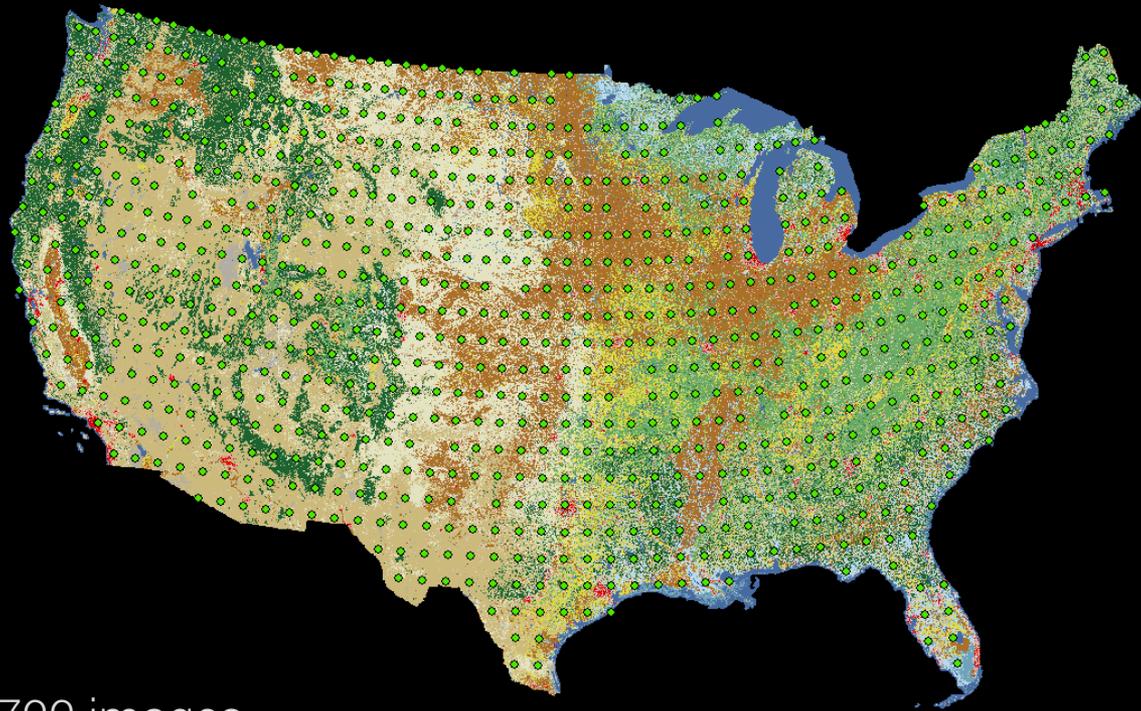
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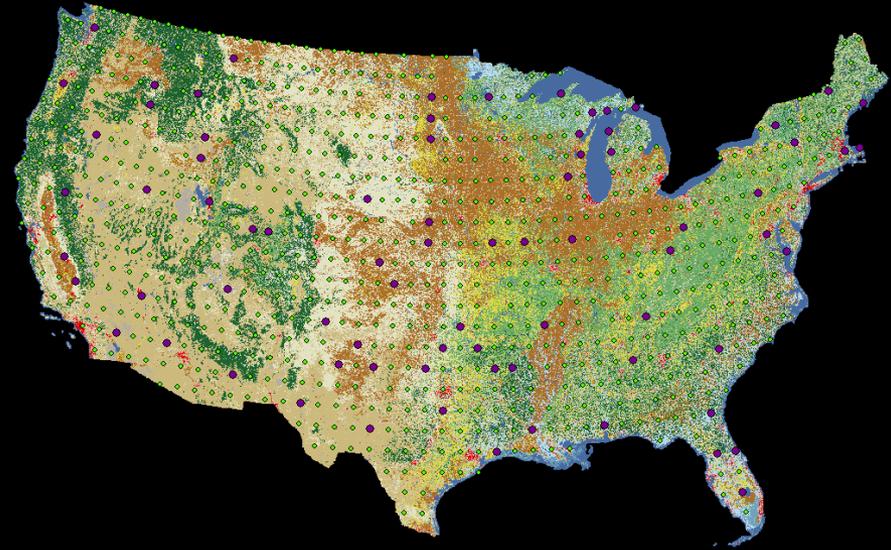
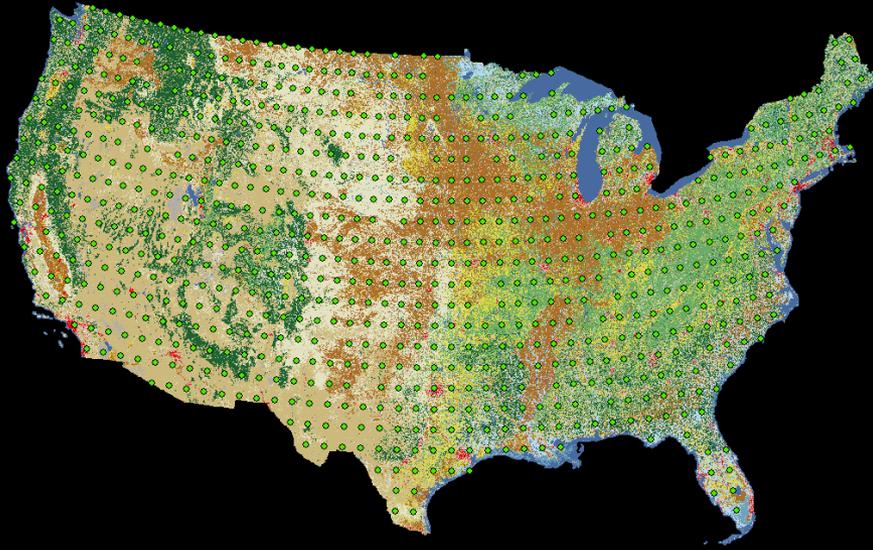
Visits

Date

Record of trip



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)

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amazonmechanicalturk
Artificial Intelligence

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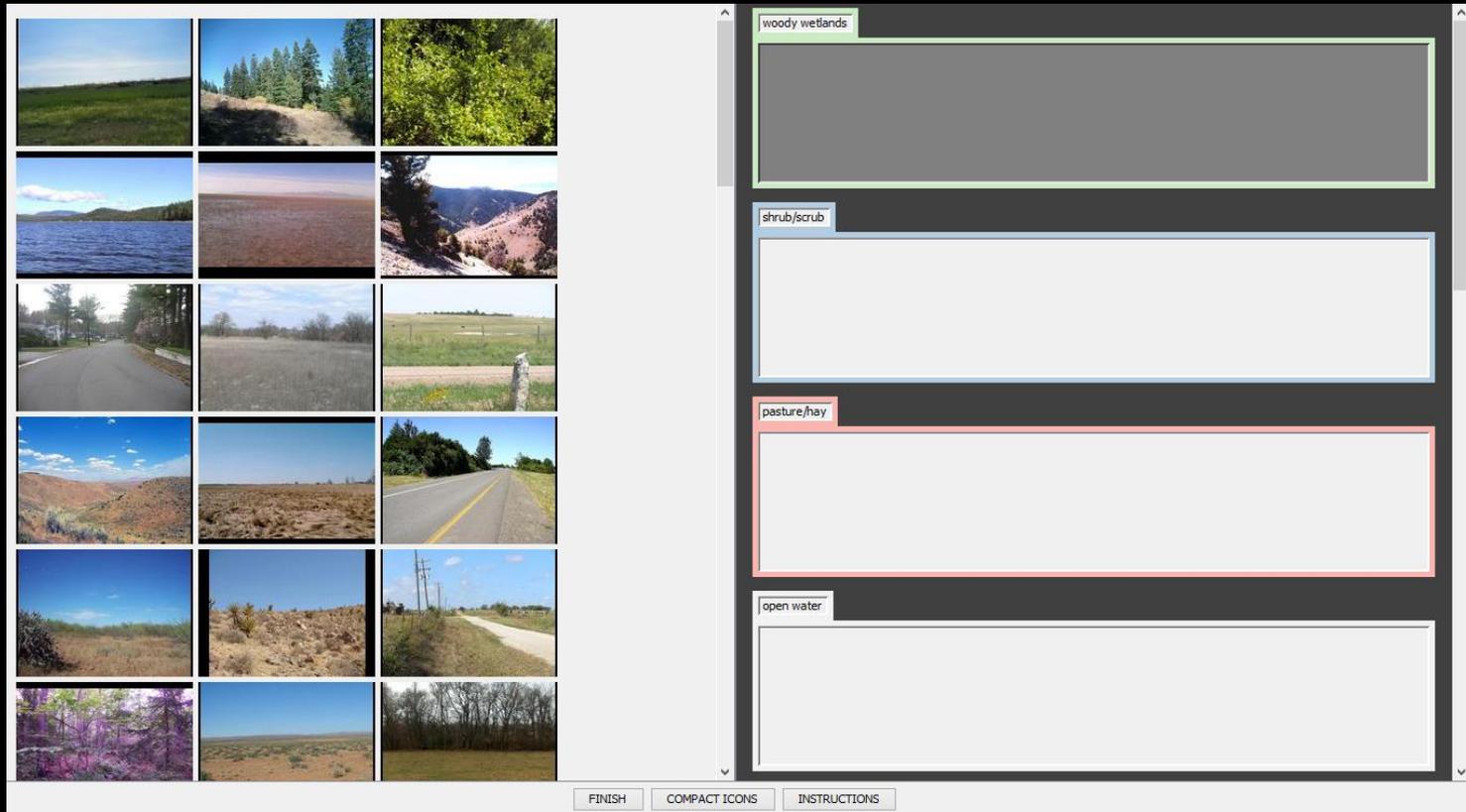
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- Get thousands of HITS completed in minutes
- Pay only when you're satisfied with the results

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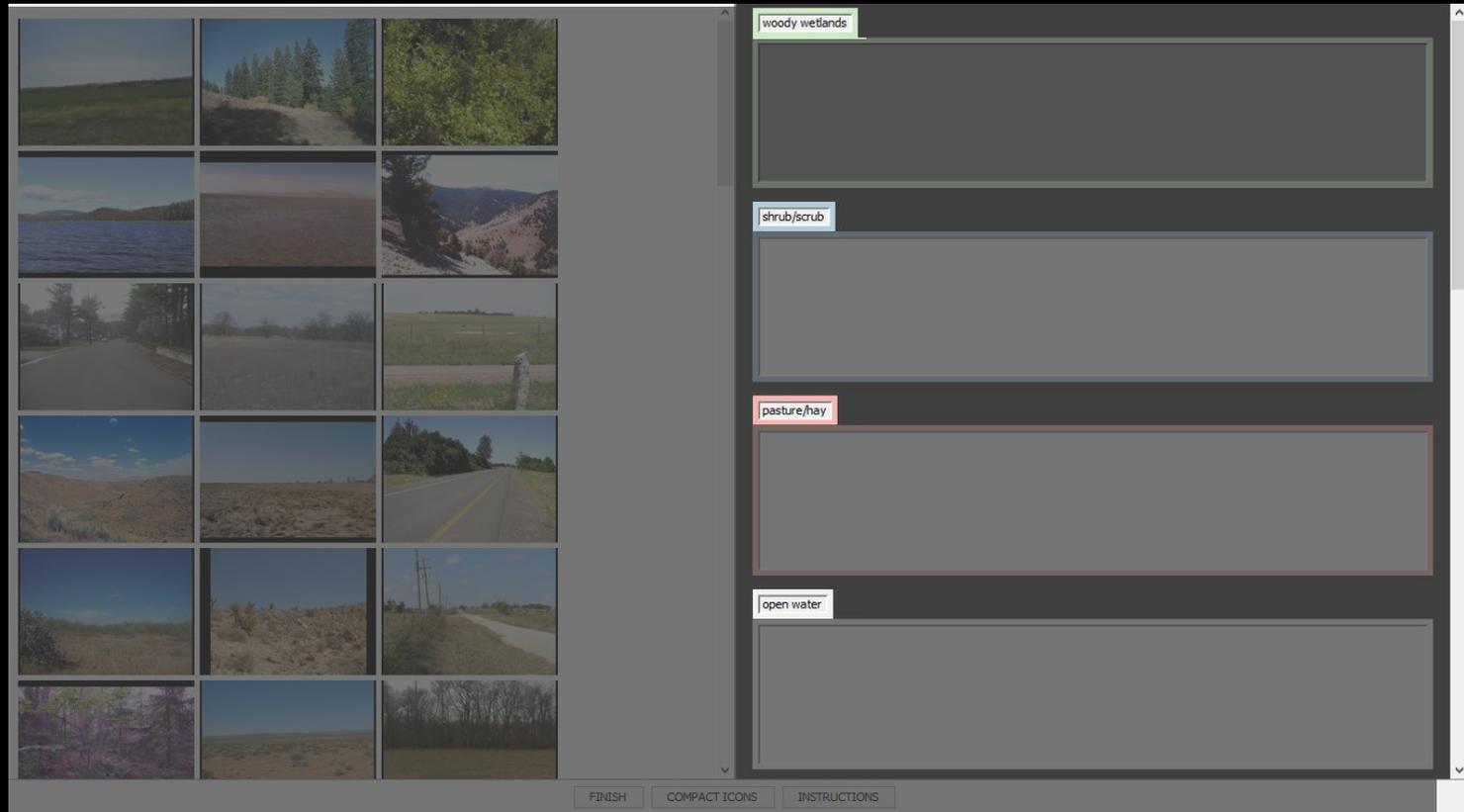
Grouping Task Interface (*catscan*)

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

	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

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

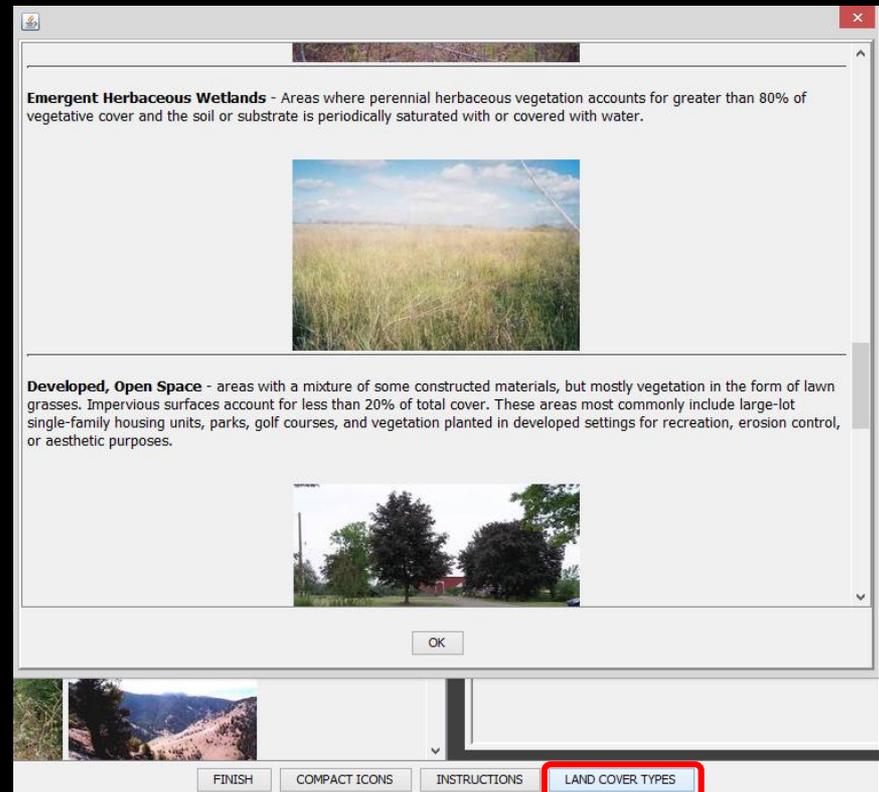
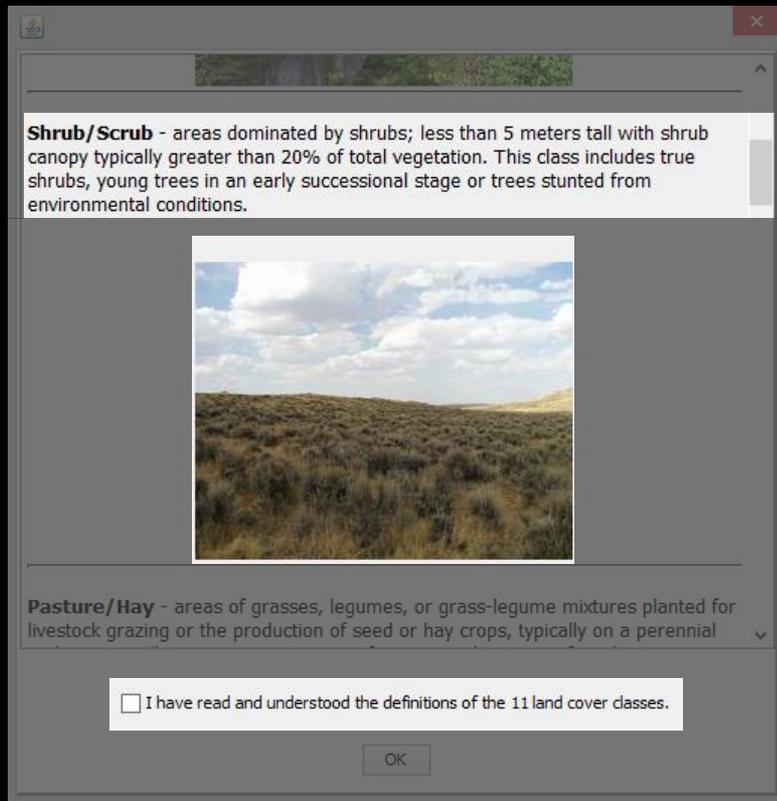
5 – 25% indicated by pink

25 – 50% indicated by bright red

above 50% are dark red

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

	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

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

5 – 25% indicated by pink

25 – 50% indicated by bright red

above 50% are dark red

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

	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

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

5 – 25% indicated by pink

25 – 50% indicated by bright red

above 50% are dark red

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

Choose land cover

On the ground photo Aerial photo




Barren

Developed, Low Intensity

Grassland

Shrub/ Scrub

Cultivated Crop

Emergent Herbaceous Wetland

Open Water

Woody Wetland

Developed, Open Space

Forest

Pasture/ Hay

How confident are you in your choice of land cover class?

Sure

Quite Sure

Less Sure

Unsure

Feature based classification

Rate the percentage of each land cover feature's presence in the image.

	0	10	20	30	40	50	60	70	80	90	100
Water	<div style="width: 25%; height: 15px; background-color: #ccc;"></div>										
Impervious Surfaces	<div style="width: 25%; height: 15px; background-color: #ccc;"></div>										
Trees	<div style="width: 25%; height: 15px; background-color: #ccc;"></div>										
Shrubs	<div style="width: 25%; height: 15px; background-color: #ccc;"></div>										
Crops	<div style="width: 25%; height: 15px; background-color: #ccc;"></div>										
Grasses/Legumes	<div style="width: 25%; height: 15px; background-color: #ccc;"></div>										
Herbaceous Vegetation	<div style="width: 25%; height: 15px; background-color: #ccc;"></div>										

Select the presence of the following

soil/substrate saturated or covered with water

shrub canopy less than 5 meters tall

bedrock/sand

tree canopy less than 5 meters tall

land subject to management or tillage

THE END

Thank you for your time