

ASSESSING TRANSFERABILITY OF LANDSAT-DERIVED NDWI VALUES ACROSS SPACE AND TIME

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IMPORTANCE OF WATER IN WESTERN US

◉ Driver

- Vegetation dynamics
- Wildlife habitat
- Agriculture
- Recreation

◉ Wyoming has several un-gauged reservoirs and dams

- Information on water that is stored is not available
- Remotely sensed data can be used to obtain info on the amount of water stored

REMOTE SENSING

◉ What is remote sensing?

- Is the art & science of collecting data without physical contact
- Sensors mounted in platforms (satellites, airplanes, Unmanned aerial systems, balloons) collect data
- Visible and infrared portions of the spectrum

LANDSAT

◉ Collection of Earth Observation Satellites

- Landsat 1-5, 7, 8 (launched in Feb 2013)
- Started in 1970s

◉ Landsat 5

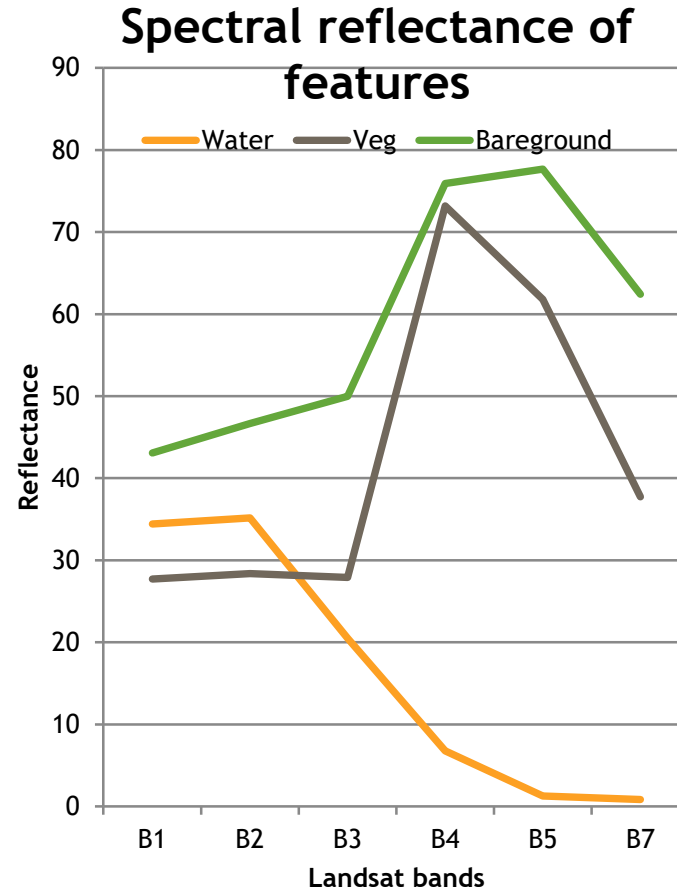
- Launched in 1982
- Collected data until Nov 2011
- 3 visible bands
 - Blue, green and red
- 3 infrared bands
 - Near infrared 1 & 2, shortwave infrared

GOAL

- To map water surface area using Landsat data
- Several techniques exist for mapping water
 - Unsupervised classification
 - Rule-based classification
 - Compute an index from the image, and define rules for each class

MAPPING WATER WITH LANDSAT DATA

- Normalized Difference Water Index (NDWI) is a widely used index
 - Different formulas exist
 - We used for NDWI:
 - $(B2 - B4) / (B2 + B4)$
 - Ranges between -1 and +1
 - Water $B2 > B4$ (+ve)
 - Others $B2 < B4$ (-ve)



WATER REFLECTANCE

⦿ NDWI

- Previous studies have shown that water has a value of >0
- This is used as a threshold for identifying water

⦿ However reflection changes with location

- Topography
- Water characteristics
 - water depth, presence of biological materials, and turbidity

RESEARCH QUESTIONS:

- ⦿ Does the threshold value of >0 holds true for some lakes in North Central Wyoming?
- ⦿ If we adjust this threshold
 - for one lake, can this range be transferred to adjacent lakes?
 - Alternatively we have to develop a range for each lake
 - for a lake based on one year, can we transfer that range to other years?
 - Alternatively we have to develop ranges for each year

STUDY AREA

○ North Central Wyoming

■ Lakes studied:

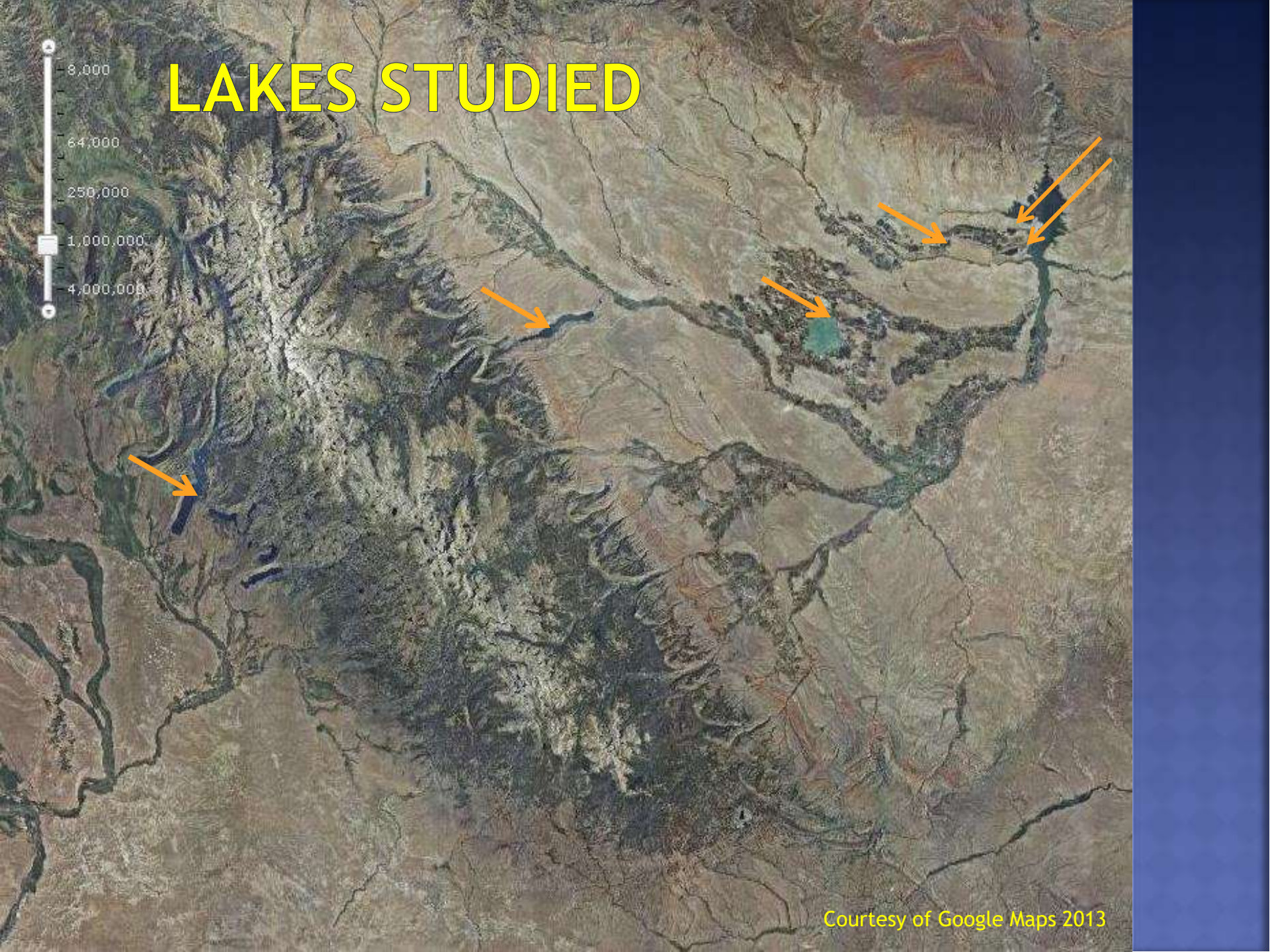
- Bull Lake
- Sand Mesa Reservoir
- Lake Cameahwait
- Middle Reservoir
- Ocean Lake
- Boulder Lake

■ Extend over space (1994)

■ Extend over Time (1994, 2006, 2009)

- Boulder Lake

LAKES STUDIED



DATA

- ⦿ Landsat

- 1994, 2006, 2009 (August)

- ⦿ Digital Ortho Quarter Quads (DOQQs)

- USDA and other federal and state agencies
 - 1994, 2002, 2006, 2009 and 2012
 - Summer images of 1994, 2006, and 2009 were used
 - 1994 - B&W (single band); 2006 - true color; 2009 - color infrared

DATA PROCESSING

- Pseudo ground truth data were collected
 - Used high resolution images-DOQQ images
 - Collected Coordinates of what and where
 - Linked DOQQ images to Landsat Images
 - Extracted reflectance values off Landsat based on independent pseudo classification collected from DOQQ images
 - Water
 - Edge
 - Vegetation &
 - Bare ground

RESULTS

Water	X	Y	B1	B2	B3	B4	B5	B7	NDWI
	43 12 17.8925 N	108 35 26.8605 W	37	38	25	8	1	1	
	43 9 55.2236 N	108 35 51.6178 W	34	36	20	7	1	1	
	43 10 52.2412 N	108 37 35.9570 W	32	31	17	5	1	1	
	43 12 15.4087 N	108 35 53.6123 W	38	38	25	8	1	0	
	43 11 5.4298 N	108 35 58.0231 W	34	36	19	6	1	0	
	43 10 48.9160 N	108 37 51.9055 W	32	31	18	6	1	0	
	43 11 17.8888 N	108 34 44.2554 W	35	35	20	6	2	1	
	43 10 12.6443 N	108 38 5.7953 W	35	38	25	8	1	1	
	43 11 32.1828 N	108 34 28.7001 W	36	38	22	8	2	1	
	43 11 51.4012 N	108 37 38.6603 W	31	31	16	7	2	2	
	43 11 30.5496 N	108 36 33.6799 W	34	33	17	5	1	1	
	43 10 3.7659 N	108 36 50.3860 W	35	37	22	7	1	1	
			34	35	21	6.8	1.3	0.8	

$$\text{NDWI} = (\text{B2} - \text{B4}) / (\text{B2} + \text{B4})$$

WATER & EDGE CONFUSION

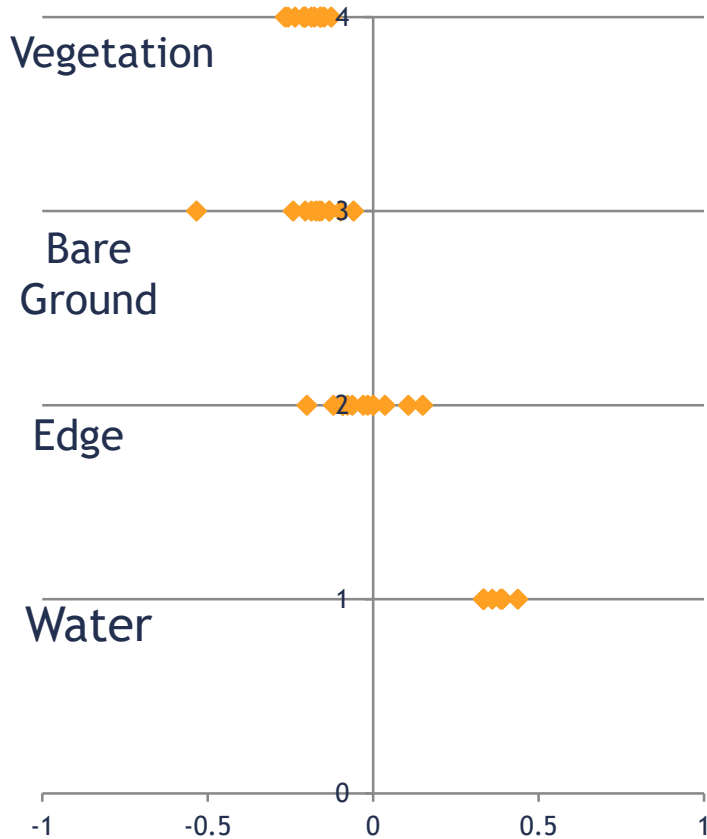
- ◉ Edge (defining edge was not easy)
 - Shoreline boundary - bare ground and vegetation
 - Landsat pixels are bigger (30m x 30m) than DOQQ (1m x 1m)



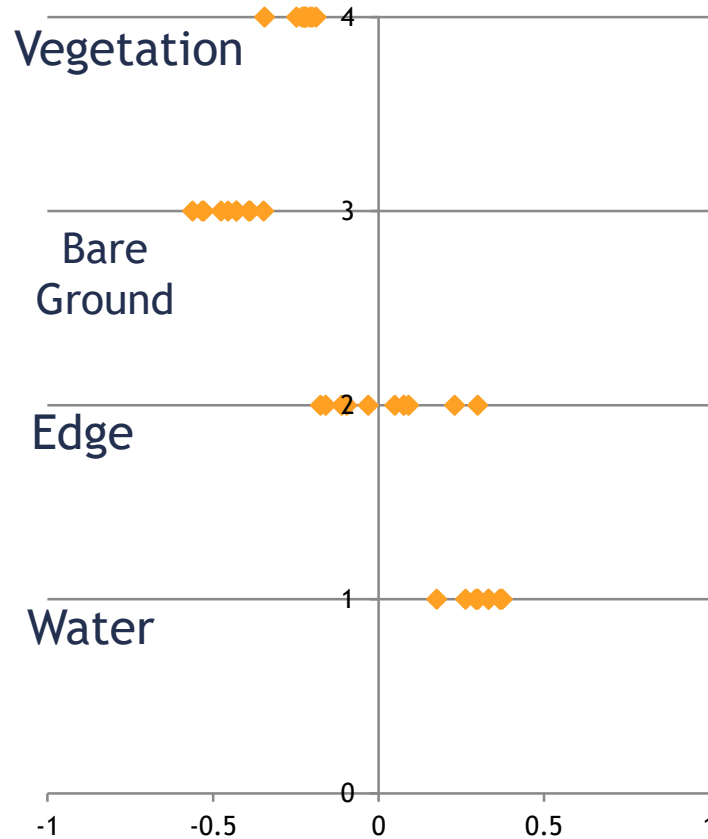


RESULTS: THRESHOLD > 0

Bull Lake (1994)

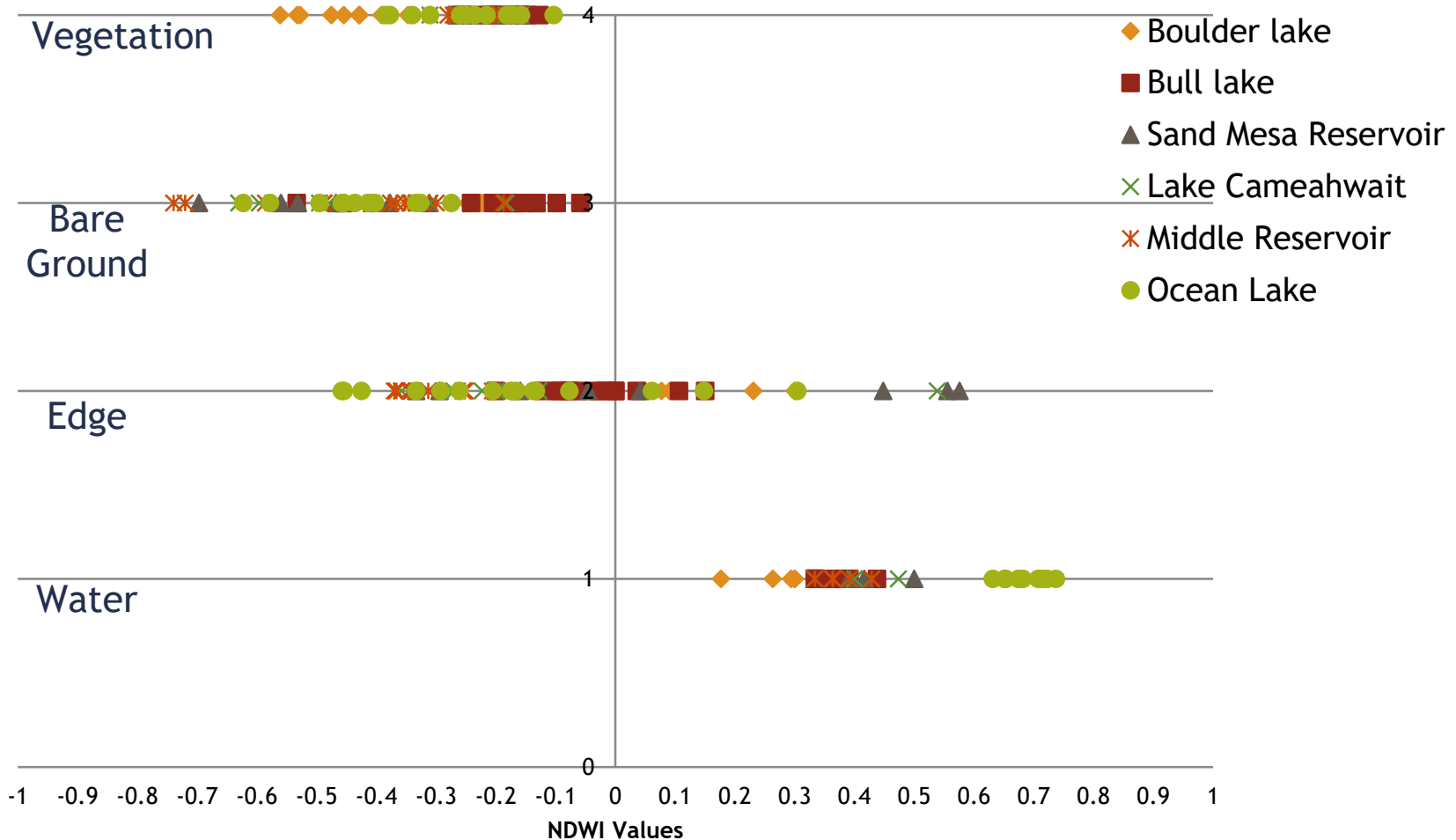


Boulder Lake (1994)



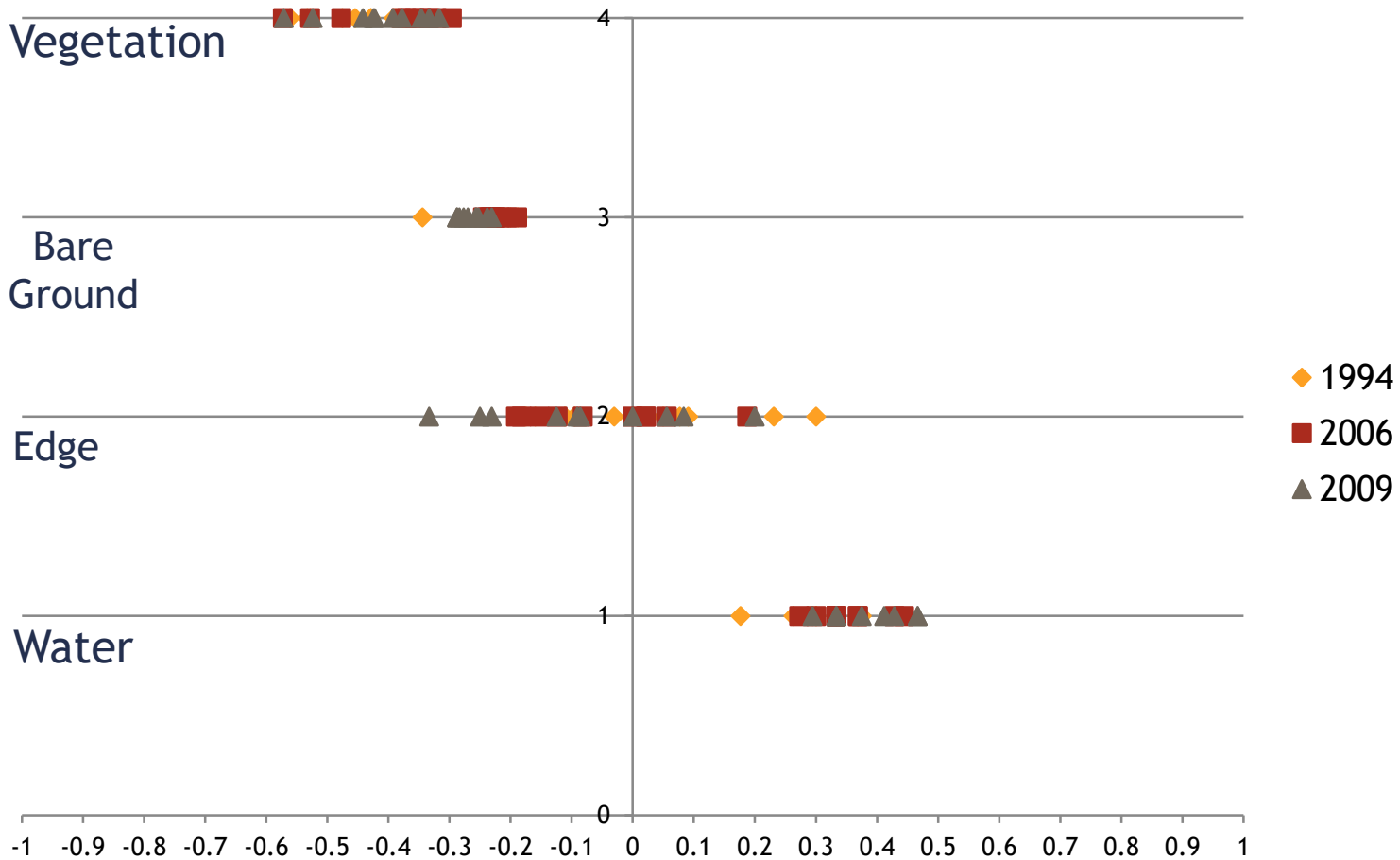
RESULTS: TRANSFER TO OTHER LAKES

NDWI values of lakes (1994)



RESULTS: TRANSFER TO OTHER YEARS

NDWI values of Boulder Lake



WATER & EDGE CONFUSION

⦿ Time of imagery

- Landsat - acquired in August
- DOQQ - exact dates are not known
- Seasonal differences

⦿ Human interpretation

- 1994 were B&W - difficult to interpret

RESULTS

- ⦿ Rule-based classification of NDWI can be used to map water bodies in NC Wyoming
 - Adjusting the NDWI threshold to >0.2 might reduce misclassification of edges as water
 - Reduce the possibility of edge misclassified as water.
- ⦿ Future studies
 - Use high-resolution satellite data instead of DOQQ (exact date will be known)
 - Include additional lakes with different characteristics (depth, color, vegetation)
 - Repeat for other years

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- ◉ WyGISC for DOQQ Images

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WORKS CITED

- HANQIU XU. (2006). Modification of normalized difference water index (NDWI) to enhance. *International Journal of Remote Sensing*, 3025-3033.
- Lei Ji, L. Z., & Wylie, B. (2009). Analysis of Dynamic Thresholds for. *PHOTOGRAMMETRIC ENGINEERING & REMOTE SENSING*, 1307-1317.

QUESTIONS?