Utah Wetland Functional Classification

by Richard Emerson
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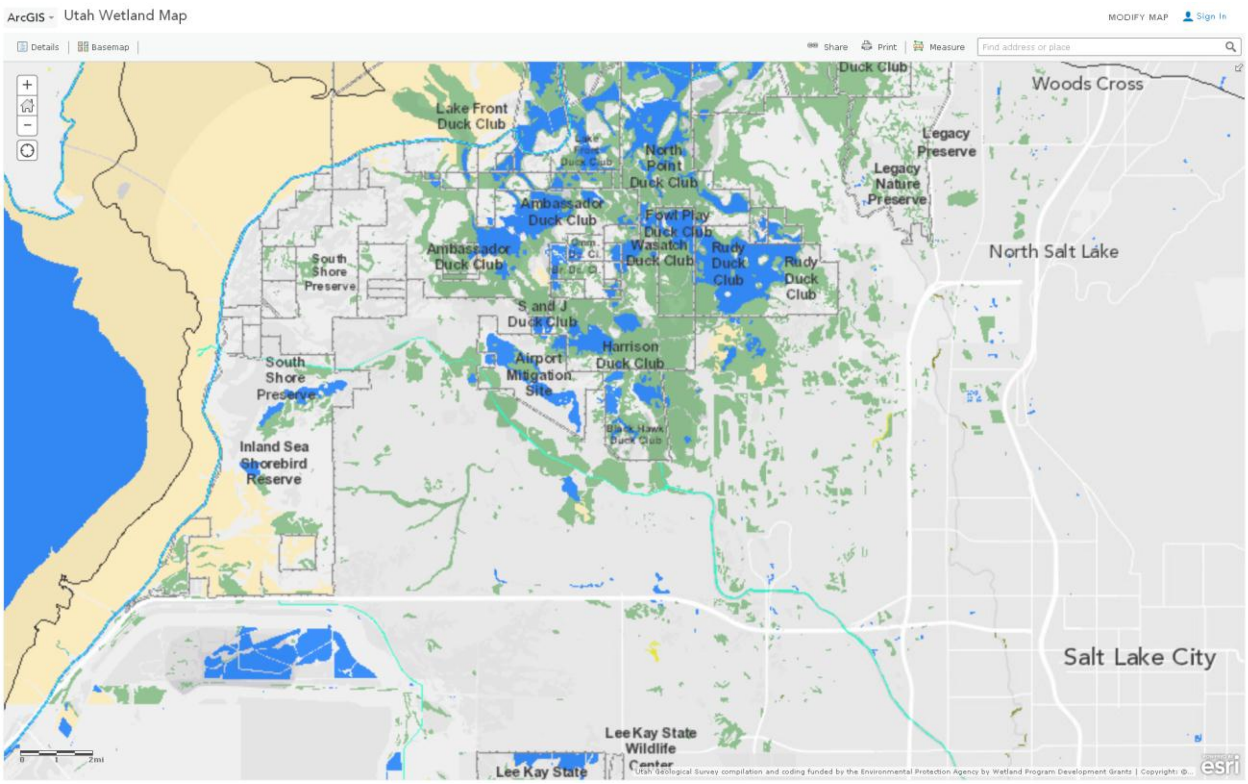

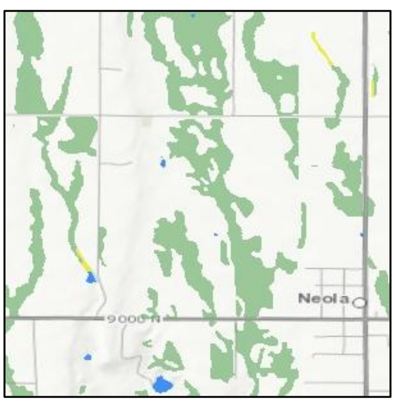

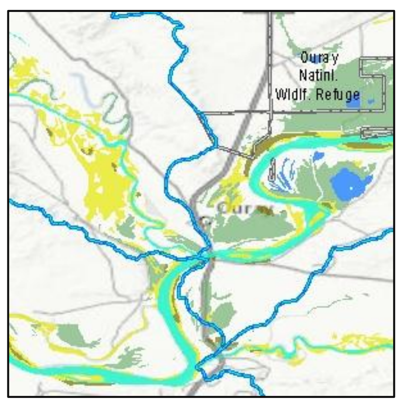

Utah Geological Survey
a division of
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Abstract

The most comprehensive wetland classification system for the state of Utah is the National Wetland Inventory (NWI). While the NWI is the most complete and accessible classification system, the 366 unique wetland type identifiers in the state are often difficult to interpret and have little relevance to natural resource managers. Consequently, NWI data are often overlooked as a viable wetland data source, which often restricts opportunity for interagency cooperation as many agencies develop their own wetland GIS datasets and workflows. Many agencies would benefit from a simplification and functional reclassification of NWI data accessible to all. To address these concerns, the Utah Geological Survey reclassified the state's wetlands to provide GIS data users a universal dataset for consistent use. The reclassification scheme was based on the hydrogeomorphic (HGM) approach, modified from recent work in Bear River Bay of Great Salt Lake, and focused largely on geomorphic, hydrodynamic, and vegetation characteristics. Of special concern within the Great Salt Lake ecosystem are impounded wetlands, which occupy over 25% of Great Salt Lake wetlands and have unique functional and management criteria as critical habitat for migratory shorebirds and waterfowl. A key aspect of this work was to refine the previous interpretation of impounded wetlands through the consideration of attributes more closely related to wetland function. Wetland landscape profiles were developed to assist in prioritizing conservation areas and integrating wetlands into watershed planning efforts. The accuracy of this crosswalk method is approximately 70% with the majority of the error attributed to erroneously mapped NWI data due to land use or land management changes.

1.0 Introduction

The National Wetlands Inventory (NWI) is the nation's most relied upon dataset for wetland mapping; as such, it is used by a variety of disciplines to provide accurate maps and wetland spatial data (Stelk, 2013). The United States Fish and Wildlife Service is the agency responsible for providing national wetland information to the public. The primary mechanisms through which this information is conveyed include the NWI database and the semi-decadal Status and Trends reports (e. g. Dahl, 2006). It is also the most widely available wetland dataset for the nation, including Utah. NWI data are available for approximately 40% of the state and for most wetlands associated with Great Salt Lake. Most of the state's wetlands were mapped in the mid to late 1980s. While other data exist for the state's wetlands, the NWI provides the widest coverage and covers Great Salt Lake in its entirety whereas other databases do not. Most of the NWI around Great Salt Lake was published in the 1980s with some revisions released in 2008.

The objective of this project was to reclassify, or "crosswalk", the current NWI dataset for Great Salt Lake to a more functional system, then report the methodology and effectiveness of the crosswalk. An important component of this objective included evaluation of the accuracy of each classification system as well as provide a wetland profile of Great Salt Lake. Since the bulk of the work is a GIS exercise, all available NWI data were reclassified for the state in an attempt to provide a more useful and uniform classification for all wetland GIS users. This was done at the request of the Utah Division of Wildlife Resources (UDWR) so that they could obtain a more uniform dataset to inform their various working groups. This project directly supports UDWR's Comprehensive Wildlife Conservation Strategy (CWCS) by identifying priority habitat for Tier I aquatic species. CWCS is a congressionally mandated program used to protect wildlife and habitat to prevent species from being listed under the Endangered Species Act (Sutter and others, 2005). This project also directly supports the Utah Wetland Program planning initiative to develop a comprehensive mapping strategy for the state (Hooker and Jones, 2013).

1.1. Landscape

Utah's environmental contrasts, from arid desert valleys and canyons to alpine mountains, make it a challenge to apply a single classification to all of the state's wetlands. Terminal basin lakes, like Sevier Lake and Great Salt Lake, can further complicate this effort. Both of these lakes occupy parts of the Bonneville basin with high-salinity water that fluctuates in response to climatic variations on multi-

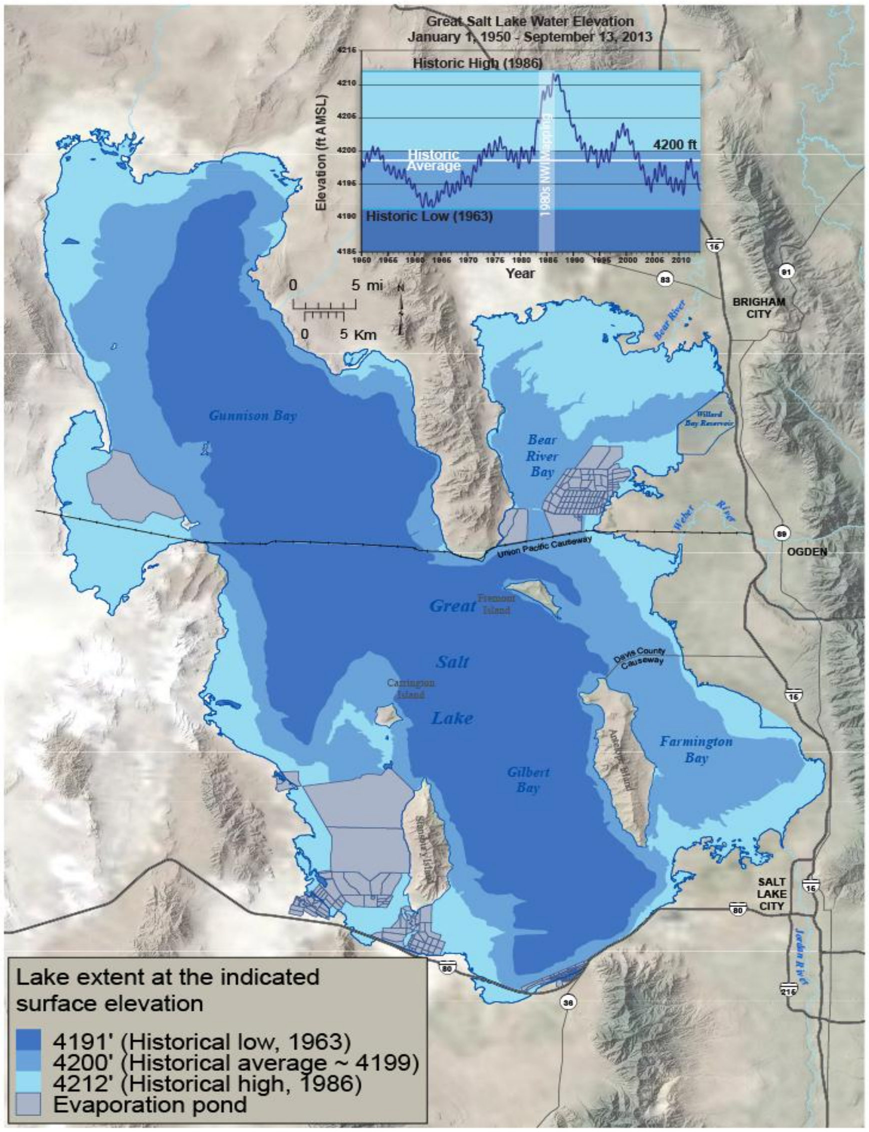

Figure 1.1. *Generalized bathymetry of Great Salt Lake (Baskin and Allen, 2005; Baskin and Turner, 2006).*

scale intervals. As water and salinity levels fluctuate, the wetlands around these lakes are in constant flux as they expand or contract in response to these influences. The NWI classification system has a very rigid set of parameters regarding water inundation period, substrate, and vegetation, which does not provide users with an appropriate level of flexibility needed for the rapidly changing wetland conditions associated with Great Salt Lake wetlands. Wetland types appear to be closely related to water levels at the time they are mapped. The two periods of NWI mapping (1980s and 1998) coincided with times of higher than average water levels in Great Salt Lake. Great Salt Lake remained above the 4200 ft benchmark for a decade from 1982-1992. In 1986 the highest water level ever recorded for Great Salt Lake was 4211.6 ft above sea level and resulted in heavy damage to water control levees, dikes, canals and ditches. Since that time, extensive rebuilding efforts have altered hydrology and caused wetland classes to change significantly in some areas. The water retreated to below average reaching 4197.5 ft in 1994 and rose again in the late1990s to peak at 4204.2 ft in 1999, 5 ft higher than the historic (1950-2013) average of 4199.4 ft. Waterlevels remained above 4200 ft from 1997-2001. These are critical elevations in Bear River Bay as the mouth of the bay is approximately 4195 ft at the Union Pacific Causeway and the elevation at the Bear River delta is approximately 4205 ft. This 10-ft elevation difference occurs over a distance of 16 miles, which creates expansive lacustrine fringe mudflats averaging less than 0.012 percent slope. Water levels between 2008 and 2013 have fluctuated between 4193.5 and 4198.9 ft, and represent one of the lowest periods for Great Salt Lake (figure 1.1).

2.0 Methodology

This method relies heavily on work done for a previous EPA-funded project by Emerson and Hooker (2011) that reclassified Bear River Bay wetlands in the northeastern portion of Great Salt Lake. The 2011 schema was modified from Sumner and others (2010) to include additional NWI classes and added functional classes and descriptor fields. While Sumner and others' (2010) original work created five classes with no modifiers, the Bear River Bay reclassification system included seven classes and three modifiers. We further developed the Bear River Bay reclassification system to include all of the wetlands of the state and attempted to refine the crosswalk as our knowledge of the state's wetlands expanded for the work presented here.

2.1 Reclassification

The 2011 wetland reclassification included the following seven types: open water, high fringe, low fringe, emergent, playa, riverine, and forest/shrub. The current classification combines the high and low fringe types as these two types function similarly and the distinction between the two was often made based on non-static water levels within reservoirs like Lake Powell or terminal lakes like Great Salt Lake at the time of mapping. While forest and shrub wetlands were combined in the original Bear River Bay reclassification due to their very small extent here, these two classes were split into forested and scrub/shrub in order to differentiate the wetland types where these types are more abundant. We added one additional class, waterpocket, which is a unique "pothole" feature typically formed by differential weathering of bedrock, typically sandstone in Utah's southern canyonlands. This reclassification also added four columns to the existing Cowardin and others (1979) classification schema, which consists of (1) Type, (2) Modifier, (3) Function, (4) HUC8, (5) Riparian, and (6) Source. A full description of each column is outlined below.

2.1.1. Wetland Types

The primary identification field for the crosswalked NWI data is called Type. The eight primary fields – Emergent, Open Water, Mudflat Fringe, Playa, Riverine, Forested, Scrub/Shrub, and Waterpocket are descriptive enough to be applied across Utah's various ecosystems, yet specific enough to provide useful analysis at a variety of scales. The types can be easily derived by standard queries written using structured query language (SQL) in ArcMap. While the translation was mostly a one-to-one relationship, near-shore lacustrine unconsolidated shore classes with a temporarily or permanently flooded water

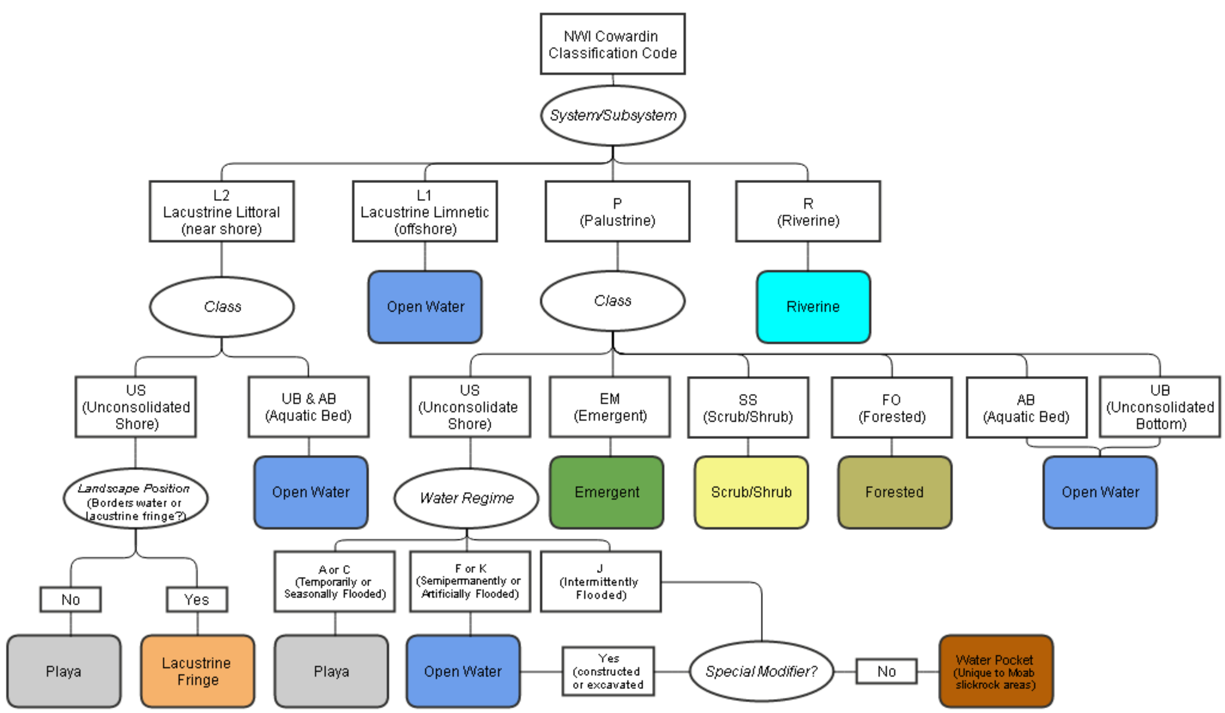

Figure 2.1. *NWI crosswalk flowchart.*

regime (L2USA/C) were put through a GIS spatial exercise to determine if the class belonged to playa or fringe. All features that bordered an open water or fringe class were classified as fringe. An assumption was made that water will run off these surfaces into the adjacent permanent water body, whereas those that did not share a border with one of these two classes were assumed to be isolated basins and classified as playa. All other queries return NWI classes unique to one of the eight functional classes by following the crosswalk flow chart in Figure 2.1. Table 2.1.1 defines each classification generated by this functional crosswalk.

Table 2.1.1. *Wetland type descriptions.*

Utah Type	Description
Open Water	Perennial water bodies
Fringe Mudflat	Mostly non-vegetated wetlands near the shoreline of lakes and reservoirs where water availability is controlled by lake levels and where the primary movement of water is sheet-flow - often expansive mudflats or barren ground during low water-level periods around the fringes of reservoirs and endorheic lakes
Emergent	Palustrine wetland with emergent vegetation often associated with groundwater discharge or shallow surface flow
Playa	Ephemeral ponds, depressional features, or expansive mineral flats where evapotranspiration exceeds water supply or through-flow; a mineral soil must be present
Riverine	Perennial stream constrained to a channel (includes canals and ditches)
Forested	Associated with woody vegetation greater than 6 meters in height, commonly found around the margins of rivers, montane lakes, or springs
Scrub/Shrub	Associated with woody vegetation less than 6 meters in height
Waterpocket	Bedrock pothole where little to no soil is present and water is supplied only by precipitation

2.1.2. Modifiers

An important aspect of the NWI data are the special modifiers that are attributed to the data to denote special instances such as artificially constructed or drained wetlands. These modifiers were retained and added to a separate column in text format to ease user's ability to understand the data. Table 2.1.2 identifies these special modifiers and the definitions from Cowardin and others (1979).

Table 2.1.2. *Modifier descriptions.*

NWI Special Modifier Code	Utah Modifier	Description
b	Beaver	Wetlands resultant of or influenced by beaver activity
h	Impounded	Water is typically retained by dams or dikes with the purpose of modifying or creating a wetland
x	Excavated	Human built basin or channel
d	Drained	Water level has been artificially lowered
r	Artificial	Water levels are typically human controlled for agricultural or wildlife use

2.1.3. Land Use

In addition to the special modifiers, a field was added to allow for special wetland land use (Table 2.1.3). Additional queries were made to determine function, such as canal or pond. Land use was added to some features by overlaying the water-related land use layer to extract important land use categories such as evaporation ponds and tailings. This is not a comprehensive list of land use or wetland function, but rather an attempt to identify features within the NWI that may not be wetland so that they can be easily queried from analysis or sample frame design. Additional refinement of attributes was made through aerial photo interpretation.

Figure 2.1.3. *Utah land use descriptions.*

Utah Land Use	Description
Canal	Riverine class with an excavated special modifier code
Evaporation Pond	Excavated or impounded classes spatially coincident with evaporation ponds from the Utah Division of Water Resources' water-related land use GIS layer
Sewage Treatment Pond	Excavated or impounded classes spatially coincident with sewage lagoons from the Utah Division of Water Resources' water-related land use GIS layer
Pond	Constructed or impounded PUB or PUS systems, built to provide fresh water for stock, recreation, municipal water use, or industrial use
Tailings	Determined from aerial photo interpretation or USGS topo maps
Historic Wetland	Culled NWI data due to land use change, mostly urbanization
Pond	Impounded or excavated palustrine water bodies

2.1.4. Watershed

In addition to wetland attributes, spatial information was added regarding the watershed(s) containing each wetland feature. In the lower basins, it is not uncommon for expansive emergent, fringe, and open water wetland types to receive water input from multiple watersheds. This is especially true in the Great Salt Lake HUC 8, where a complex network of canals and ditches divert water across watershed boundaries. We chose to attribute the wetlands with each of the watersheds that it occupied by using spatial join and relate functions in ArcMap.

2.1.5. Riparian

At the request of UDWR, we added a riparian field to identify wetlands along riparian corridors. Riparian wetlands and wetlands immediately intersecting NHD flow lines were initially selected as riparian wetlands. By successively iterating a spatial selection of wetlands within a 40-meter buffer of selected wetlands, we were able to include wetlands in the riparian zone. Wetlands connected to lacustrine and mudflat fringe were then removed from the selection to avoid misclassifying these wetlands as riparian.

2.1.6. Source

This field denotes the source of the data. Thus far we have compiled data from the NWI and the U.S. Forest Service. Since the release of this data for review, we have received data from UDWR and private contractors. We expect to update this data periodically in the future.

3.0 Results

3.1. Functional Crosswalk

The final compiled dataset resulted in 135,762 NWI wetland polygons for the state which were successfully reclassified to one of the eight wetland types. The accuracy of the reclassification was then determined through aerial photo interpretation by randomly distributing 1000 points across the reclassified polygons. To eliminate bias, the interpretations were accomplished with the image analyst not knowing the results of the classification at each point. A combination of multispectral imagery of at least 1 meter resolution from the 2006-2013 timeframe/period were used to interpret wetland types (AGRC, 2013). At some locations it was not possible to determine wetland type from aerial photos so they were eliminated from the accuracy assessment resulting in 945 points used in the accuracy assessment (Table 3.1.).

		NWI Reclassification								
		Emergent	Forest	Fringe Mudflat	Open Water	Playa	Riverine	Scrub/ Shrub	Water-pocket	Total
Wetland Type From Photo Interpretation	Non-Wetland	22			3	8	***71****			104
	Emergent	332		7	26	8	6	4		383
	Forest	2	5					2		9
	Fringe Mudflat	22		40	7	19	1	1		90
	Open Water	15		5	118	2	1	1		142
	Playa	20		5	5	46				76
	Riverine	3	1		1	1	41	1		48
	Scrub/Shrub	13	1		1	2	10	65		92
	Waterpocket								1	1
	Total	429	7	57	161	86	130	74	1	945
	Reclassification Accuracy	77.4%	71.4%	70.2%	73.3%	53.5%	31.5% *(69.5%)**	87.8%	100.0%	**68.6% (74.1%)***

Table 3.1*. Functional crosswalk accuracy* ******(Adjusted accuracy after removing NHD buffered riverine polygons).*

The original NWI paper maps captured streams as linear wetland features by subjectively digitizing stream corridors using aerial photos. This was to improve the hydrography of the wetland dataset by connecting wetlands distributed along riparian zones. During the digitization process, polygons were digitized while these linear stream features were not. In an effort to capture these missed linear features, some areas have riverine features generating by applying a buffer to NHD flow lines. These buffered lines improve the hydrography of the dataset by enhancing the ability to relate wetlands within a system (Griffin, 2013). While the intention of these new data is to increase functionality of the NWI, it presents problems for data analysis in Utah as Riverine wetlands are dramatically overstated and in many cases there are no wetland features associated with the NHD lines (figure 3.1). While hydrologically correct, most of these flow-paths do not contain water except during flash flood events and are devoid of hydrophytic vegetation and hydric soils, and as such, are not wetland features. By removing the erroneous Riverine classes, Riverine wetland reclassification improves to 69.5% while increasing the overall accuracy to 74.1%. The accuracy of the automated reclassification is similar to the maximum attainable accuracy (76%) through physical reclassification of each polygon as reported by Emerson and Hooker (2011) for Bear River Bay. They further state that misclassifications are primarily due to one of

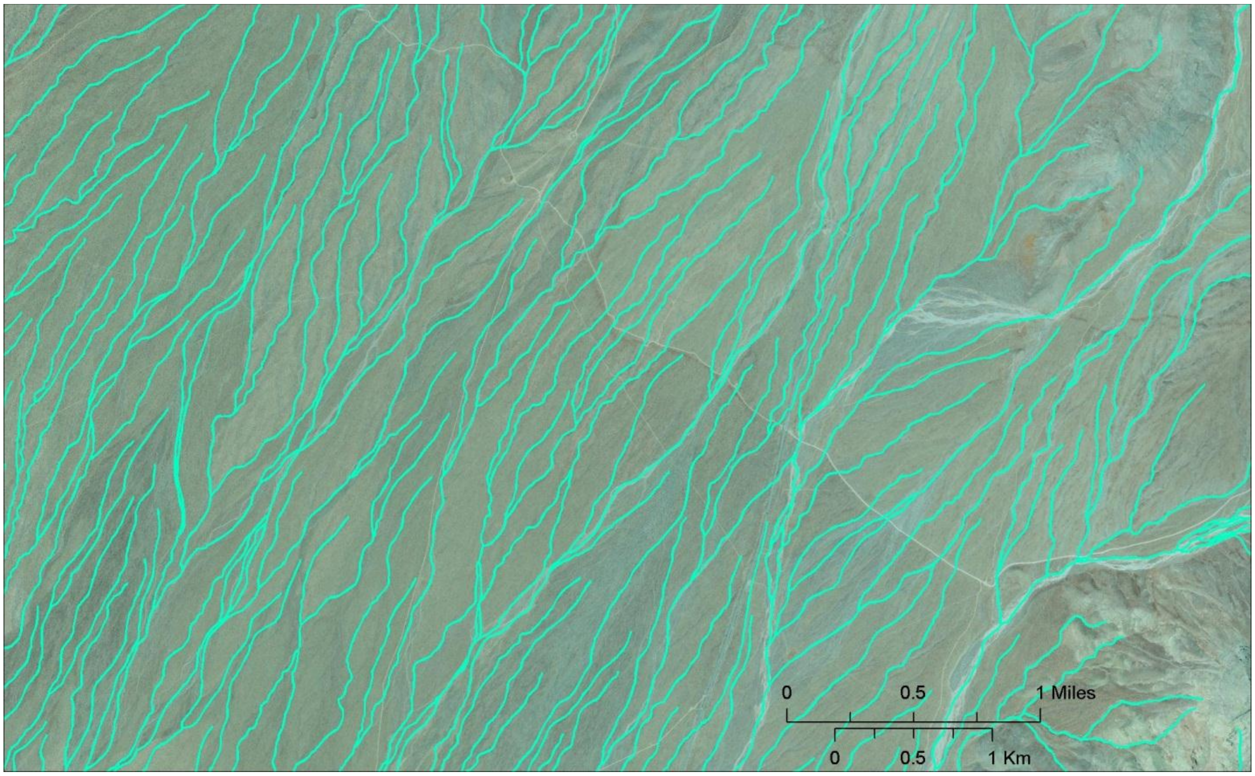

Figure 3.1. *This alluvial fan in southwestern Utah shows riverine wetlands erroneously buffered from NHD flow lines.*

two causes: errors in the original NWI data, or changes to the landscape. Landscape changes could be the result of fluctuating water levels near reservoirs or terminal lakes, or due to land management or land use changes.

3.2. Wetland Profiles

Developing a wetland landscape profile is a simple way to track changes in wetland abundance and distribution by type through time. The original intent of this project was to classify and provide detailed landscape profiles for the wetlands associated with Great Salt Lake. With the addition of a statewide reclassification, we also provide simple landscape profiles for watersheds in Utah where we had data for at least 50% of the watershed.

3.2.1. Great Salt Lake Wetland Landscape Profile

Figures 3.2.1 to 3.2.5 detail wetland profiles for Great Salt Lake. Distribution of the wetlands was determined by both type and elevation by extracting elevation values from a 10-meter DEM to the wetlands layer.

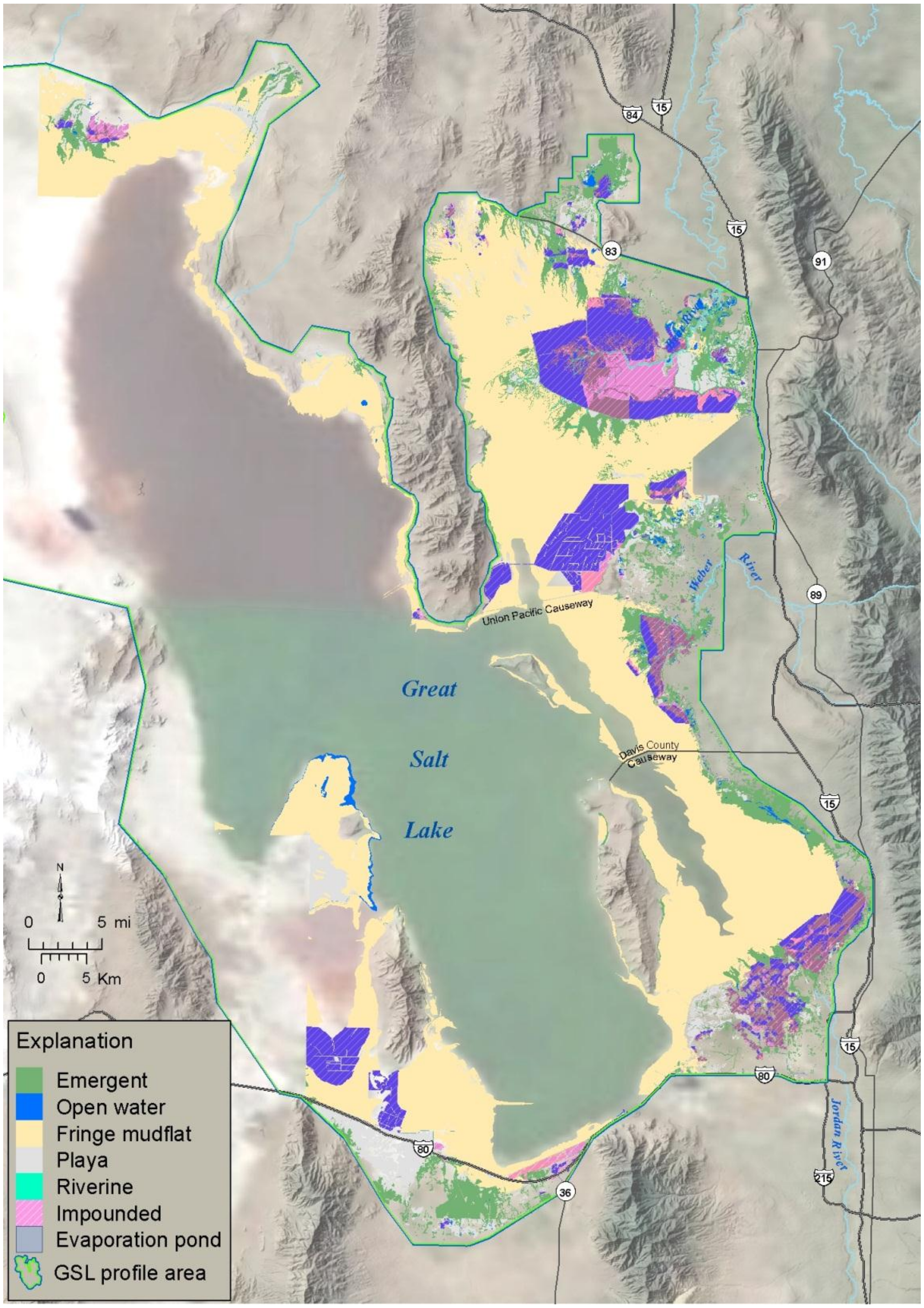

Figure 3.2.3. *Non-lacustrine wetlands associated with Great Salt lake were selected based on proximity and hydrologic connectivity to the lake.*

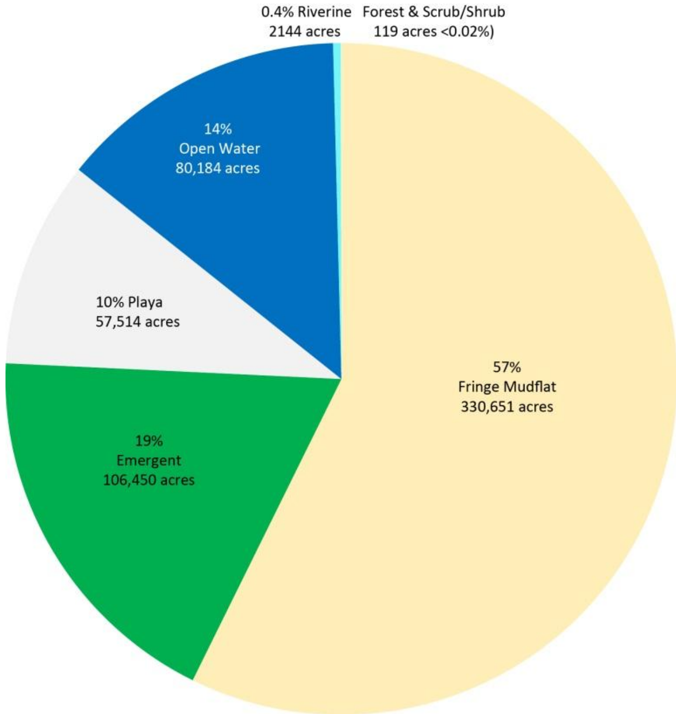

Figure 3.2.2. *Over half of the wetlands associated with Great Salt Lake are fringe mudflats. Most years these expansive flats are covered by shallow sheet flow in the spring and dry up sometime in the summer or fall, depending on water supply.*

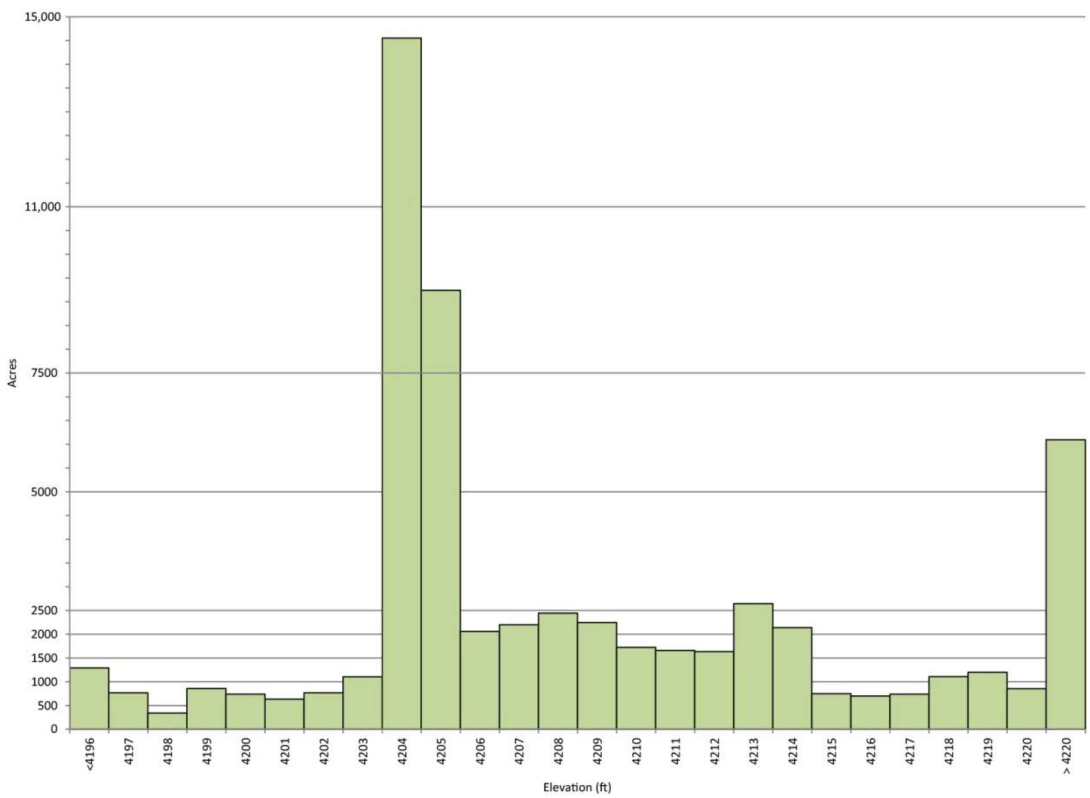

Figure 3.2.3. *Great Salt Lake wetlands range in elevation from 4193 to 4290 ft with 90% of the wetlands occurring below 4220 ft.*

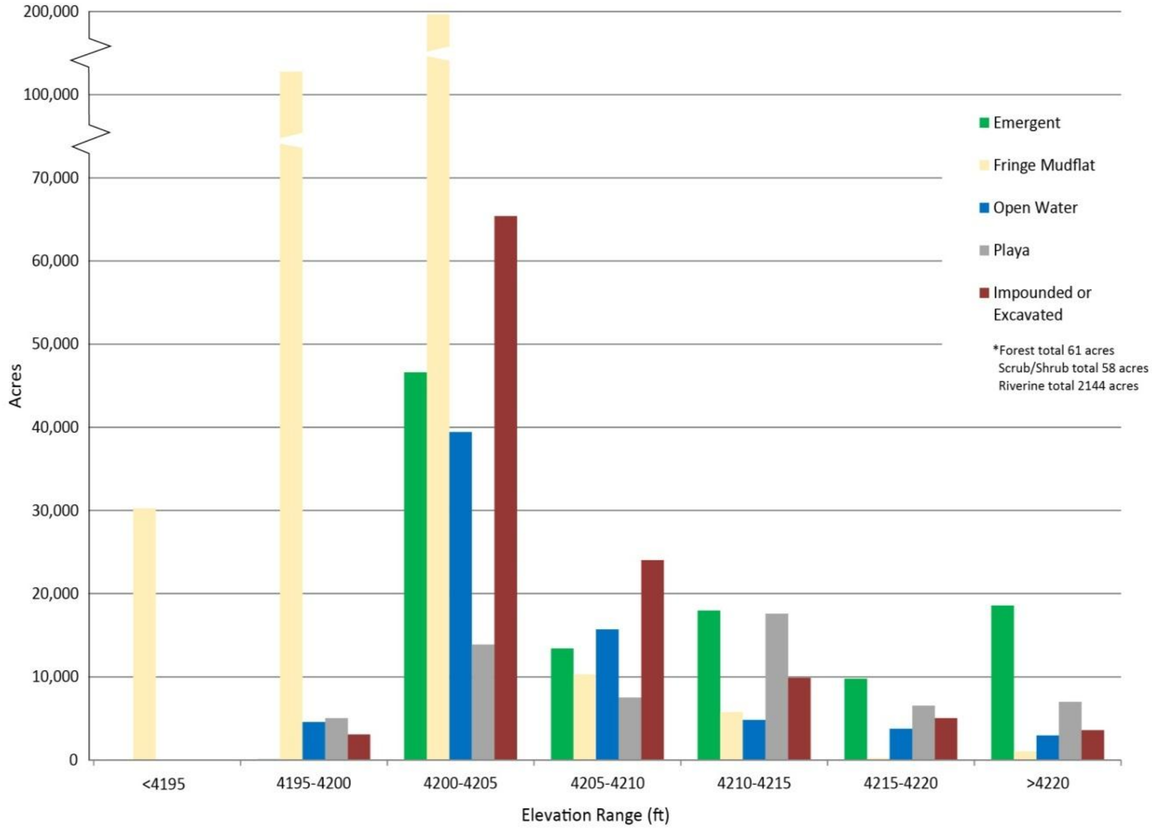

Figure 3.2.4. *Non-lacustrine wetlands around Great Salt Lake by wetland type and elevation range. Approximately 18% of Great Salt Lake's wetlands have been impounded.*

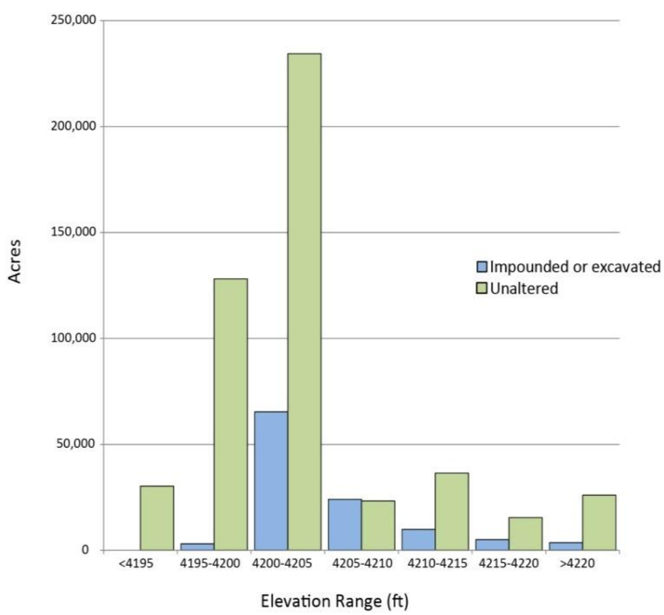

Figure 3.2.5. *Impounded wetlands around Great Salt Lake by elevation range. Note that there are more impounded wetlands between 4205 and 4210 ft than unaltered.*

3.2.2. Statewide Profile

In order to begin assessing the state's overall wetland condition as well as prioritizing mapping and other wetland projects, we conducted watershed profiles by summarizing wetland attributes by watershed. At the time of this report, the state of Utah has approximately 57% of its wetlands in a GIS format. This makes it impossible to conduct profiles across every watershed; however, nearly half (29/67) of Utah's HUC 8 watersheds are mapped to greater than 95% and 46/67 are mapped to greater than 50%. Table 3.2.2 summarize wetland profiles for the 46 watersheds, listed in order of percent mapped.

Table 3.2.2. *Wetland profiles by watershed with mapping completed over 50 percent.*

Watershed (% mapped)	Emergent	Forest	Fringe Mudflat	Open Water	Playa	Riverine	Scrub/ Shrub	Water-pocket
Ashley-Brush (100%)	64.8%	0.4%	0.8%	24.9%	1.0%	4.7%	3.4%	-
Blacks Fork (100%)	61.0%	<0.1%	0.2%	13.8%	0.2%	0.9%	23.9%	-
Central Bear (100%)	27.8%	-	-	68.6%	3.7%	-	-	-
Chinle (100%)	0.9%	0.7%	-	-	0.6%	6.1%	90.8%	0.9%
Colorado Headwaters-Plateau (100%)	0.8%	-	-	-	0.2%	93.4%	5.6%	-
Lower Dolores (100%)	19.1%	-	-	17.6%	1.0%	47.3%	15.0%	-
Lower Green - Diamond (100%)	26.5%	3.6%	1.2%	14.1%	9.4%	39.1%	6.2%	-
Lower Green-Desolation Canyon (100%)	18.2%	0.7%	<0.1%	3.1%	3.7%	65.6%	8.6%	-
Lower White (100%)	15.1%	0.2%	-	7.2%	5.2%	56.8%	15.4%	-
Upper Colorado-Kane Springs (100%)	7.4%	-	0.3%	13.1%	4.5%	71.1%	3.7%	-
Upper Dolores (100%)	59.4%	<0.1%	-	15.3%	5.1%	5.0%	15.1%	-
Upper Green-Flaming Gorge Reservoir (100%)	34.7%	<0.1%	0.3%	48.7%	0.8%	3.1%	12.4%	-
Upper Virgin (100%)	9.6%	0.2%	0.2%	23.4%	1.4%	63.8%	1.5%	<0.1%
Westwater Canyon (100%)	3.0%	0.2%	-	2.3%	3.4%	79.3%	11.8%	-
Willow (100%)	47.4%	0.4%	-	6.4%	1.4%	3.4%	41.0%	-
Lower Virgin (99.8%)	-	-	-	0.5%	-	99.5%	<0.1%	-
Kanab (99.3%)	0.4%	-	-	7.9%	<0.1%	91.6%	-	-
Lower Bear-Malad (99.1%)	32.3%	<0.1%	29.1%	22.7%	13.1%	2.7%	<0.1%	-
Duchesne (98.5%)	62.7%	1.1%	0.8%	15.9%	0.6%	4.5%	14.4%	-
Dirty Devil (97.8%)	2.7%	-	0.9%	32.3%	2.0%	61.6%	0.4%	-
Fort Pierce Wash (97.2%)	-	<0.1%	-	2.6%	-	97.4%	-	-
Fremont (89.2%)	66.7%	<0.1%	0.4%	16.6%	1.6%	11.7%	3.1%	-
Montezuma (88.7%)	11.9%	0.2%	<0.1%	11.9%	6.2%	32.0%	37.8%	-
Jordan (87%)	35.3%	<0.1%	24.6%	15.5%	22.8%	1.1%	0.6%	-
McElmo (85.2%)	2.6%	-	-	0.5%	<0.1%	32.8%	64.1%	-
Upper Lake Powell (84.8%)	0.3%	-	0.2%	96.2%	0.2%	3.0%	0.1%	-
Escalante Desert (81.3%)	1.5%	<0.1%	0.3%	16.3%	14.7%	67.1%	0.1%	-
Upper Sevier (80.3%)	9.7%	<0.1%	1.3%	22.1%	<0.1%	65.5%	1.3%	-
Price (79.6%)	56.9%	0.2%	0.6%	12.6%	5.9%	14.9%	8.9%	-
Lower Green (78.1%)	6.2%	<0.1%	-	0.9%	1.7%	84.4%	6.7%	-
Lower San Juan-Four Corners (75.5%)	2.7%	1.5%	-	3.2%	0.9%	39.1%	52.5%	<0.1%
Strawberry (69.8%)	18.6%	<0.1%	0.9%	65.8%	2.8%	1.2%	10.6%	-
Middle Bear (66.2%)	50.8%	0.6%	0.7%	34.8%	4.1%	4.1%	5.1%	-
Lower San Juan (62.1%)	<0.1%	-	-	48.2%	0.3%	30.5%	21.0%	<0.1%
Bear Lake (59.8%)	11.8%	0.1%	1.0%	84.8%	0.2%	1.5%	0.7%	-
Curlew Valley (59.8%)	9.5%	-	82.9%	1.2%	6.3%	<0.1%	-	-
Lower Weber (59.6%)	39.5%	0.5%	19.1%	31.8%	6.7%	1.4%	1.0%	-
Great Salt Lake (58.7%)	0.3%	-	32.7%	66.2%	0.9%	<0.1%	<0.1%	-
Paria (58.5%)	1.3%	-	-	4.5%	-	94.2%	-	-
East Fork Sevier (57.6%)	36.2%	-	1.6%	27.4%	1.6%	32.5%	0.7%	-

3.3. Products

An interactive wetland map for the state of Utah was produced using the new functional classification layer. In order to provide landowner information directly to personnel in the field this map is available on any portable device and includes detailed information regarding wildlife management areas, including federal, state, and privately managed parcels, such as duck clubs and wildlife cooperative management units. This map can be accessed from the Utah Department of Natural Resources mapping platform at http://utahdnr.maps.arcgis.com, or directly at http://utahdnr.maps.arcgis.com/home/webmap/viewer.html?webmap=b9056fec9100407797faea21561348cc.

The wetland GIS data may be accessed directly from the Utah Automated Geographic Reference Center (AGRC) through their ArcGIS SDE database connection (AGRC@SGID10.agrc.utah.sde\ SGID10.WATER.Wetlands), or downloaded in shapefile format at http://gis.utah.gov/data/water-data-services/wetlands.

4.0. Conclusion

This project demonstrates that a functional crosswalk from existing NWI data developed for Great Salt Lake is effective for the entire state of Utah. While the original scope of this project only included Great Salt Lake wetlands, minor modifications to the workflow and addition of classes to reflect wetland types not present near Great Salt Lake allowed us to reclassify the entire state during this project. While we found the NWI data to be obsolete in some areas, not reflecting current on-the-ground conditions, we found that the crosswalk accurately reclassified the data approximately 70% of the time. A long-term goal is to update all wetland maps in the state to NWI standards on a watershed-by-watershed basis. Currently there are multiple large-scale mapping projects underway in the state, including the Upper Bear River, Bear Lake, and Weber River watersheds. Additional mapping for the Wasatch Front including Great Salt Lake, the Jordan River, Utah Lake, and the Lower Provo River are recommended. High-resolution imagery and LiDAR will expedite efforts to create wetland maps in these areas. These datasets have the potential to streamline wetland classification and make it possible to generate highly accurate datasets quickly for large areas.

5.0. References

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