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# Rainwater Basin 2004 Wetland Vegetation Map

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## Abstract

The Rainwater Basin (RWB) wetland complex in south-central Nebraska provides crucial stopover habitat for over 7 million waterfowl and 500,000 shorebirds every spring. However, only 10% of the original RWB wetlands remain, which means less available habitat and forage for wetland-dependent birds. Conservation efforts are being employed to alleviate the loss of RWB wetlands. To aid conservation efforts, we created a vegetation map of all RWB wetlands, based on 2004 imagery. Field vegetation data were collected using the point intercept method along 50-m transects within distinct vegetation communities (e.g., moist-soil, mudflat, water) on public wetlands in 2003. A shapefile of RWB wetlands was then created and combined with a modified version of the Common Land Unit (CLU). This wetland-CLU shapefile was used in conjunction with 2004 August color infrared aerial imagery and 2004 July true color aerial imagery to create segments around similar imagery pixels using image object technology. Segments were then classified using a supervised classification, applying the field survey data as training data. All segments were manually verified twice, and an accuracy assessment was completed on the final vegetation map. The final map covered 198,178 ac of wetland, 80% of which was farmed. Of the remaining 20% of natural, hydophytic wetland area, 17% was dominated by upland grasses, 29% by invasive species, and 54% by beneficial early successional species. The accuracy of the final 2004 RWB wetland vegetation map was 81.8%.

## Introduction

The Rainwater Basin (RWB) wetland complex in south-central Nebraska includes over 11,000 historical wetlands across 21 counties. Those wetlands host over 7 million waterfowl and 500,000 shorebirds each spring migration. While in RWB wetlands, wetland-dependent birds replenish their nutrient and energy stores to continue migration and initiate nesting. Although RWB wetlands are important to migrating wetland-dependent birds, only 10% of the original wetlands remain (Schildman and Hurt 1984). The lack of functioning RWB wetlands can have significant impacts on multiple species of wetland-dependent birds. Most research has focused on waterfowl and suggests individuals that do not acquire sufficient nutrient reserves on the wintering grounds and migration staging areas are negatively impacted on the breeding grounds. These less-fit birds have lower lipid reserves and are more likely to delay nesting, lay smaller clutches, or forgo re-nesting if the initial clutch is lost (Krapu 1981, Dubovsky and Kaminski 1994, Devries et al. 2008).

To alleviate the loss of RWB wetlands, conservation efforts, such as wetland restoration and management, have been employed. Public conservation lands include state-owned Wildlife Management Areas (WMA) managed by the Nebraska Game and Parks Commission and federally owned Waterfowl Production Areas (WPA) managed by the U.S. Fish and Wildlife Service. The Natural Resources Conservation Service (NRCS) also holds Wetlands Reserve Program (WRP) easements for which private landowners have enrolled their wetlands in either a 10-year cost share agreement, a 30-year easement, or a permanent easement. The landowner retains the property ownership and is responsible for managing the site, but cannot cultivate or develop the property. The NRCS is responsible for wetland restoration, monitoring, and technical assistance. In 2004, 34 WMAs, 58 WPAs, 4 short-term (i.e., 10-year) WRP cost shares, and 56 long-term (i.e., 30-year and permanent) WRP easements existed on RWB wetlands.

Knowing what vegetation is present in wetlands can help focus conservation efforts and inform the allocation of financial and technical resources for conservation of RWB wetlands. To determine the vegetation, we created a vegetation map covering all historical RWB wetlands, based on 2004 aerial imagery. For example, this vegetation map has been used to calculate the forage produced for waterfowl by RWB wetlands in 2004 and annually since 2006 (Bishop et al., RWBJV, in review). It also serves as a baseline that can be compared to future vegetation to determine the changes in vegetation communities over time (Nugent et al. 2015). The objective of this article is to outline the method for creating the 2004 RWB vegetation map and summarize general results of the map.

## Methods

*Mapping Standards*

Before we could create the vegetation map, we first had to define the vegetation communities to be mapped. The vegetation communities were based on the National Vegetation Classification Standard (NVCS), a system adopted by federal agencies to ensure a consistent framework across agencies. The NVCS uses a hierarchical classification approach, with the highest class being the formation level that describes very broad vegetation communities, while the lowest classes include the alliance level for fine-scale plant species communities and, finally, the association level that describes dominant species in a specific habitat.

In the vegetation map, we used groups of alliances to form aggregate communities. Alliance groups included eight natural, hydrophytic groups and three farmed groups: (1) Water/Mudflat, (2) Moist-Soil (e.g., smartweed species [*Polygonum* spp.]), (3) Reed Canarygrass (*Phalaris arundinacea*), (4) River Bulrush (*Scirpus* spp.), (5) Cattail (*Typha* spp.), (6) Wet Meadow (e.g., sedges [*Carex* spp.]), (7) Grass (e.g., big bluestem [*Andropogon gerardii*]), (8) Trees (e.g., cottonwood [*Populus deltoides*]), (9) Irrigation reuse pits, (10) Stressed Agriculture (i.e., some wetland function), and (11) Agriculture (i.e., no wetland function). These alliance groups were chosen based on their impact, either positive or negative, on wildlife and wetland management.

*Training Data Collection*

To create training data for the supervised classification, we delineated vegetation communities on state WMA and federal WPA wetlands in 2003. A vegetation surveyor walked around vegetation communities while using a Global Positioning System (GPS) unit to create a digital polygon bounding the community. The surveyor then used a handheld computer to record attribute information. Delineated vegetation communities included Cattail, Moist-Soil, Mudflat, Reed Canarygrass, River Bulrush, Upland, Water, and Wet Meadow. Within communities, 50-m transects were established. The number of transects depended on the area of the community, with larger communities containing more transects. Each community contained at least two 50-m transects, and one additional transect was added for each 10 ac. We used the point intercept method to record the species present every 0.5 m along transects.

Data were entered into Microsoft Excel (Microsoft Corporation, Redmond, Washington), where each species was assigned an NVCS alliance (e.g., Pennsylvania smartweed was assigned Moist-Soil). Water and Mudflat were combined into one alliance of Water/Mudflat. The alliances present along each transect were summarized by percent cover.

To convert the transect data into a format usable for classification, transect lines were loaded as a shapefile in ArcMap (ESRI, Redlands, California). We then used the "feature to point" tool to convert each field-surveyed transect to its midpoint. The summarized transect field data were loaded to the midpoints shapefile.

*Image Acquisition and Processing*

Color infrared imagery covering a majority (92%) of the RWB wetland area was collected in August 2004 by Cornerstone Mapping (Lincoln, Nebraska). This timeframe was based on a 2003 flight that demonstrated the ability to differentiate wetland NVCS alliances during August because, due to plant phenology, plants are vigorously growing at that time. A Kodak 420 digital camera system modified for color infrared aerial photography was affixed to a Cessna 172 fixed-wing aircraft and was used to collect 1-$m^2$ resolution images of three spectral bands including red, green, and infrared. To create usable imagery, images were color balanced using ERDAS Leica Photogrammetry Suite (ERDAS, Inc., Norcross, Georgia) to remove streaking and variations, which created even color tone and hue across the region. We then orthorectified to a horizontal accuracy of 3–5 m and mosaicked images into a single dataset. Imagery was then degraded to 2 $m^2$ for segmentation. Lastly, from the Farm Service Agency (FSA) we acquired preprocessed true color imagery collected in July 2004 with 2-$m^2$ resolution.

*Historical Wetland Mask*

To create the wetland mask for analysis, we integrated historical wetlands with land use from the Common Land Unit (CLU). The wetland dataset was a shapefile containing all RWB wetlands derived from the United States Department of Agriculture Bureau of Soils and Bureau of Chemistry and Soils soil surveys (1910 – 1917), U.S. Fish and Wildlife Service's National Wetlands Inventory (Cowardin et al. 1979), and NRCS's Soil Survey Geographic Database (Bishop and Vrtiska 2008). The historical wetlands shapefile included over 11,000 individual RWB wetlands.

The CLU is a dataset created by the FSA to aid administration of agriculture commodity support and conservation programs. Each shapefile covers one county and contains property boundaries as well as the land use for each property, including the relevant land classes Agriculture (cropland), Range/Grass/Pasture, Conservation Reserve Program, and Non-Agriculture (e.g., rural developed). To create a seamless dataset, we merged the CLU shapefiles for all RWB counties together. Then, we validated the land classes based on aerial imagery, including 2003–2006 FSA true color imagery and fall 2003, spring 2004, fall 2004, and spring 2006 color infrared imagery collected by Cornerstone Mapping. The most recent imagery was used for validation, but older imagery was referenced if recent imagery was unclear. During validation, we also created the land class Stressed Agriculture and assigned it to all portions of cropped fields that contained hydric soils and appeared to have poor plant growth due to ponded water or saturated conditions. Other classes were also added to the CLU, but were not applicable to wetland areas (e.g., Riparian Corridor; Bishop and Vrtiska 2008).

The historical wetlands shapefile was combined with the modified CLU shapefile using an intersect overlay. The land classes in the modified CLU that covered RWB wetlands included Agriculture, Stressed Agriculture, and Hydrophytes, which was reclassified from the Range/Grass/Pasture class. We used the "dissolve" tool to merge polygons based on land class.

The wetland-CLU intersected shapefile was divided into two parts for analysis because the color infrared imagery did not cover the entire RWB. To divide the shapefile, we created a polygon defining the extent of the 2004 color infrared imagery. The wetland-CLU shapefile was clipped by the imagery boundary, leaving the wetlands that overlapped the infrared imagery, termed interior wetlands. The remainder of the wetlands that overlapped only the true color imagery and not infrared, termed exterior wetlands, did not include sufficient training data for supervised classification. To increase the amount of training data, we included the surveyed interior wetlands with the exterior wetlands for classification. To create the exterior wetlands shapefile, we first modified the imagery boundary shapefile by erasing the surveyed interior wetlands. We used the resulting shapefile to erase the interior non-surveyed wetlands from the wetland-CLU shapefile, leaving only exterior wetlands and interior surveyed wetlands.

*Segmentation and Classification*

We loaded the interior wetlands and the August infrared imagery into eCognition Developer (Trimble Germany GmbH, Munich, Germany). The interior wetlands shapefile was set as the thematic layer, using a chessboard segmentation, and the "assign class" tool was used to classify polygons as Agriculture, Stressed Agriculture, or Hydrophytes. Next, we conducted a multiresolution segmentation within the land classes to group pixels by the imagery's spectral and textural pixel characteristics (i.e., spectral signatures). By assigning land classes prior to segmentation, we supplemented the imagery's spectral signatures with thematic data, allowing eCognition to more effectively group pixels to delineate NVCS alliances.

The segments were exported from eCognition and imported into ArcMap, along with the field transect midpoint data. We conducted a spatial join to integrate the training data with the segments. If more than one training point fell within a segment, all the data associated with the points were used to describe the vegetation within that segment. Segments with field data were assigned their dominant NVCS alliance and its percent coverage. Segments that contained ≥75% of one alliance were selected for use as training and testing data.

To develop training and testing datasets, we used the “feature to point” tool to convert selected polygons to points. Of the points containing ≥75% of one alliance, 20 polygons of each alliance were randomly selected for use as testing data to be used in the accuracy assessment. The remaining points with ≥75% dominance were assigned training data to teach eCognition the spectral signatures of each alliance. The training data points were then given a coded value to reference the different map alliances and converted to a raster for use as a testing and training mask (TTA mask).

The TTA mask was loaded into our eCognition project, where we used it as training data for each alliance. In addition to the TTA mask, we also manually chose segments as samples to be used as training data, particularly for the Agriculture and Stressed Agriculture alliances, for which we did not have field data. Using the TTA mask and selected sample segments, we performed a nearest neighbor supervised classification. The result was polygons classified based on the training polygons’ pixel characteristics for each alliance, including the mean of each imagery band, standard deviation of each band, brightness, and texture.

We then created a new project in eCognition, in which we loaded the exterior wetlands, July true color imagery, and the previously created TTA mask. We again used the chessboard segmentation, “assign class,” and multiresolution segmentation to create segments within the three wetland land classes. Segments were manually selected as samples and used in conjunction with the TTA mask to perform the nearest neighbor supervised classification.

The classified interior and exterior polygons were exported from eCognition. In ArcMap, we deleted the surveyed interior areas used for training data from the exterior wetlands shapefile. The interior and exterior wetlands were then merged into a seamless dataset. The merged shapefile was imported into a geodatabase, in which we created a domain for the NVCS alliances in order to access dropdown lists for quick and easy editing in ArcMap. Polygons were manually verified twice for accuracy based on 2004 true color and color infrared imagery, and any misclassifications were fixed. During verification, the Water/Mudflat alliance was divided into Water/Mudflat and Irrigation Reuse Pit. Also, the Upland alliance was divided into Grasses and Trees. These subdivisions of Water and Upland were difficult for eCognition to classify separately, but easily identified during verification. Polygons were dissolved based on alliances, which created the final 2004 RWB wetland vegetation map.

*Accuracy Assessment*

We assessed the accuracy of the vegetation map by using the previously selected testing data. We did not have access to field-verified data to test the Agriculture and Stressed Agriculture alliances, because they only occur on private lands. Therefore, we used 2004 true color imagery provided by the FSA to determine the accuracy of those alliances. Overall map accuracy was calculated as the total area of correctly classified polygons divided by the total area of testing polygons. We then calculated producer accuracy for each alliance as the alliance’s correctly classified area divided by the alliance's field-verified testing area. Each alliance's user accuracy was determined by dividing the area correctly assigned to the alliance by the total area of testing polygons assigned to the alliance in the vegetation map. Overall alliance accuracy was assessed by averaging the alliance's producer and user accuracies.

Alliances are often grouped into habitat types for analysis. For example, habitat types are used to calculate the forage production for waterfowl and shorebirds in RWB wetlands (Rainwater Basin Joint Venture 2013*a*, Rainwater Basin Joint Venture 2013*b*). Because of the importance of habitat type, we also calculated overall map, overall habitat, producer, and user accuracies for each aggregated habitat type, including agriculture, early successional, grass, late successional, stressed agriculture, and trees habitats. The agriculture, grass, stressed agriculture, and trees habitats each consisted of their single, respective alliance. Late successional habitat was comprised of the invasive species alliances: Cattail, Reed Canarygrass, and River Bulrush. Early successional habitat included the remaining alliances of Moist-Soil, Water/Mudflat, and Wet Meadow.

## Results and Discussion

*Vegetation Map*

The 2004 RWB wetland vegetation map contained 34,321 polygons that covered 198,178 ac of wetland, of which 197,411 ac were within the RWB region while the remaining 767 ac were in nearby playa wetlands (Figure 1). The most common alliance was Agriculture, which covered 75% of RWB wetlands (Table 1). Stressed Agriculture covered 4% and Pits 1% of the vegetation map, for a total of 80% of wetland area being farmed. These data quantify the vast loss of RWB wetlands to drainage and other modifications to facilitate cultivation.

The Grass alliance is often in poorly functioning portions of the wetlands, which is evidenced by the dominance of upland species in this alliance. However, 17% of the natural hydrophytes (i.e., non-farmed alliances) were dominated by the Grass alliance, quantifying that a sixth of the natural vegetation is exhibiting more upland than wetland species. The presence of upland species is often attributed to the significant modification of watersheds, which reduces hydrologic function of RWB wetlands. Additionally, 29% of the natural, non-farmed alliances were dominated by invasive species (i.e., Cattail, Reed Canarygrass, and River Bulrush). The presence of these species is not surprising, due to their ability to establish and spread throughout wetlands and to form monocultures. Even with the presence of undesirable species, beneficial alliances, including Moist-Soil, Water/Mudflat, and Wet Meadow, still dominated a majority (54%) of the natural vegetation area. The prevalence of these beneficial, early successional alliances results from public habitat managers actively promoting these species through management actions; furthermore, privately owned wetlands are often incorporated into farming operations that disturb the vegetation, keeping it an early successional state.

Public wetland areas, including WMA and WPA properties, constitute 10% of the RWB wetland area. On public properties, Moist-Soil was the most common alliance, dominating 42% of public wetlands areas, followed by Grass and Reed Canarygrass (Table 2). Moist-Soil was predominant due to management actions on public lands to promote this alliance because of its benefit as high quality waterfowl and shorebird habitat.

On long-term (i.e., 30-year and permanent easements) WRP wetlands, Moist-Soil was again the most dominant alliance, followed by Wet Meadow and Agriculture. The commonness of Agriculture was due to recent acquisitions of WRP easements that had not yet been restored and were still cultivated. Invasive alliances were less common on WRP wetlands than on public wetlands because major disturbances caused by recent restorations promoted early successional species instead of invasive.

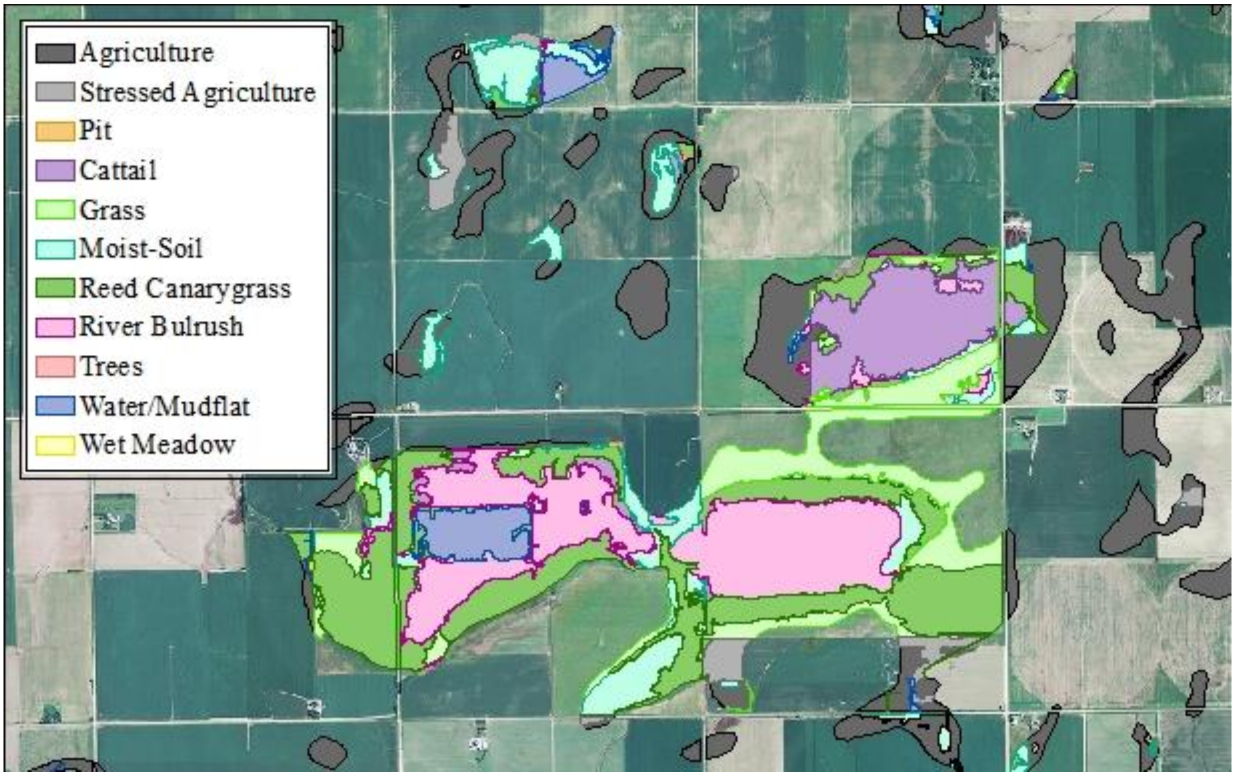


Figure 1. Wetlands in Fillmore County, Nebraska, representing a portion of the final 2004 vegetation map, including aerial imagery, of the Rainwater Basin.

Table 1. Area of each alliance in the final vegetation map of wetlands in the Rainwater Basin, Nebraska. Also included are the percentage of the area of the entire map covered by each map alliance and percentage of the area of natural hydrophytes (i.e., not Agriculture, Farmed Wetland, or Pit) covered by each of the non-farmed alliances.

| Alliance | Area (ac) | % of Entire Map | % of Natural Hydrophytes |
|---|---|---|---|
| Agriculture | 148,937.2 | 75.2 | --- |
| Cattail | 1,082.2 | 0.5 | 2.7 |
| Grass | 6,607.4 | 3.3 | 16.7 |
| Moist-Soil | 15,984.0 | 8.1 | 40.4 |
| Pit | 1,327.4 | 0.7 | --- |
| Reed Canarygrass | 6,433.2 | 3.2 | 16.3 |
| River Bulrush | 3,958.4 | 2.0 | 10.0 |
| Stressed Agriculture | 8,329.4 | 4.2 | --- |
| Trees | 216.2 | 0.1 | 0.5 |
| Water/Mudflat | 2,570.1 | 1.3 | 6.5 |
| Wet Meadow | 2,731.9 | 1.4 | 6.9 |

Table 2. Area of each vegetation alliance in acres and as a percentage of each area type: Wildlife Management Areas (WMA), Waterfowl Production Areas (WPA), long-term Wetlands Reserve Program sites (WRP), and all sites combined in the Rainwater Basin region of Nebraska.

| | WMA | | WPA | | WRP | | All | |
|---|---|---|---|---|---|---|---|---|
| | ac | % | ac | % | ac | % | ac | % |
| Agriculture | 92.3 | 1.6 | 62.0 | 0.5 | 295.2 | 12.5 | 449.6 | 2.1 |
| Cattail | 211.3 | 3.8 | 446.2 | 3.4 | 30.8 | 1.3 | 688.3 | 3.2 |
| Grass | 1,083.1 | 19.2 | 3,001.0 | 22.7 | 160.1 | 6.8 | 4,244.2 | 20.0 |
| Moist-Soil | 2,343.5 | 41.6 | 5,600.1 | 42.3 | 750.6 | 31.8 | 8,694.2 | 41.0 |
| Pit | 22.0 | 0.4 | 23.3 | 0.2 | 28.5 | 1.2 | 73.8 | 0.3 |
| Reed Canarygrass | 895.6 | 15.9 | 1,756.0 | 13.3 | 227.3 | 9.6 | 2,879.0 | 13.6 |
| River Bulrush | 376.3 | 6.7 | 1,339.2 | 10.1 | 88.9 | 3.8 | 1,804.4 | 8.5 |
| Stressed Agriculture | 7.9 | 0.1 | 5.3 | 0.0 | 226.1 | 9.6 | 239.4 | 1.1 |
| Trees | 0.9 | 0.0 | 91.6 | 0.7 | 0.0 | 0.0 | 92.4 | 0.4 |
| Water/Mudflat | 194.4 | 3.5 | 223.8 | 1.7 | 239.6 | 10.2 | 657.8 | 3.1 |
| Wet Meadow | 404.3 | 7.2 | 677.1 | 5.1 | 310.1 | 13.2 | 1,391.4 | 6.6 |

### *Accuracy Assessment*

The overall map accuracy was 81.8%, while overall alliance accuracies ranged from 69.1 to 99.6% (Table 3). The accuracy results were higher than average for the types of landcover used in the vegetation map (Congalton and Green 1999). Some of the error can be explained by RWB wetland vegetation community boundaries being indistinct and varying by year, and also by RWB wetlands' ephemeral nature. The field data were collected in 2003, while the imagery was collected in 2004, so alliance boundaries could have shifted slightly over that time. For example, an area mapped as water during public lands surveying could have been dry during imagery acquisition, which explains the lower user accuracy for the Water/Mudflat alliance (Table 4).

Also, moist-soil species can quickly establish after management activities or when ponded water recedes, helping to explain the relatively low producer accuracy of the Moist-Soil alliance. Agriculture and Stressed Agriculture were classified with high accuracy, which was likely due to the CLU being incorporated into the historical wetland mask that would have eliminated much of the errors between cultivated areas and native vegetation.

When NVCS alliances were grouped into larger habitats, the accuracy increased. The overall map accuracy when mapping habitats was 88.9%, with overall habitat accuracy ranging from 85.2% to 99.6% (Tables 5 and 6). The increased accuracy of habitats was logical, because as alliances were aggregated, errors between alliances within a habitat were negated. For example, 46 ac of testing data should have been classified as Moist-Soil but were actually classified as Water/Mudflat. Because Moist-Soil and Water/Mudflat alliances are both early successional habitat, those 46 ac were properly classified as early successional habitat.

Table 3. The producer, user, and overall alliance accuracies (%) of vegetation alliances in the 2004 wetland vegetation map of the Rainwater Basin, Nebraska. Producer accuracies represent the probability that a testing area was correctly classified. User accuracies represent the probability that a classification correctly denoted field conditions. Overall alliance accuracy denotes the mean of producer and user accuracies. Testing data were based on field vegetation surveys conducted in 2003.

| | Producer Accuracy | User Accuracy | Overall Alliance Accuracy |
|---|---|---|---|
| Agriculture | 99.9 | 99.2 | 99.6 |
| Cattail | 73.2 | 70.1 | 71.6 |
| Grass | 95.9 | 82.2 | 89.0 |
| Moist-Soil | 74.0 | 93.1 | 83.5 |
| Reed Canarygrass | 82.5 | 78.4 | 80.5 |
| River Bulrush | 90.3 | 64.1 | 77.2 |
| Stressed Agriculture | 99.0 | 95.0 | 97.0 |
| Trees | 84.0 | 99.8 | 91.9 |
| Water/Mudflat | 79.9 | 58.3 | 69.1 |
| Wet Meadow | 83.2 | 74.8 | 79.0 |

Table 4. The error matrix (ac) and producer and user accuracies (%) for vegetation alliances in a 2004 wetland vegetation map in the Rainwater Basin, Nebraska. Producer accuracies represent the probability a testing area was correctly classified. User accuracies represent the probability that a classification correctly denoted field conditions. Shaded cells are the area (ac) of each alliance that was classified correctly. Testing data were based on field vegetation surveys conducted in 2003.

| Vegetation Map Classification (ac) | Testing Data Classification (ac): Agriculture | Cattail | Grass | Moist-Soil | Reed Canarygrass | River Bulrush | Stressed Agriculture | Trees | Water/ Mudflat | Wet Meadow | Total | User Accuracy |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Agriculture | 239.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 0.0 | 0.0 | 241.5 | 99.2 |
| Cattail | 0.0 | 245.1 | 0.2 | 80.7 | 3.6 | 13.9 | 0.0 | 0.0 | 5.7 | 0.3 | 349.5 | 70.1 |
| Grass | 0.0 | 0.0 | 185.0 | 12.3 | 12.0 | 0.0 | 0.0 | 3.8 | 0.0 | 11.9 | 225.2 | 82.2 |
| Moist-Soil | 0.0 | 25.5 | 1.0 | 1,024.0 | 19.2 | 7.9 | 0.0 | 0.1 | 3.8 | 18.1 | 1,099.7 | 93.1 |
| Reed Canarygrass | 0.0 | 4.1 | 5.1 | 63.0 | 349.3 | 7.8 | 0.0 | 2.6 | 4.2 | 9.3 | 445.4 | 78.4 |
| River Bulrush | 0.0 | 55.5 | 1.5 | 77.8 | 17.1 | 292.5 | 0.0 | 0.0 | 10.9 | 1.1 | 456.3 | 64.1 |
| Stressed Agriculture | 0.0 | 0.0 | 0.0 | 9.4 | 0.0 | 0.0 | 177.3 | 0.0 | 0.0 | 0.0 | 186.6 | 95.0 |
| Trees | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 63.4 | 0.0 | 0.0 | 63.6 | 99.8 |
| Water/ Mudflat | 0.0 | 4.6 | 0.0 | 46.0 | 9.0 | 1.5 | 0.0 | 0.0 | 105.5 | 14.4 | 181.0 | 58.3 |
| Wet Meadow | 0.0 | 0.1 | 0.2 | 71.2 | 13.0 | 0.2 | 0.0 | 5.5 | 1.8 | 273.1 | 365.2 | 74.8 |
| Total | 239.8 | 335.0 | 193.0 | 1,384.3 | 423.3 | 323.8 | 179.1 | 75.5 | 132.0 | 328.2 | 3,614.1 | |
| Producer Accuracy | 99.9 | 73.2 | 95.9 | 74.0 | 82.5 | 90.3 | 99.0 | 84.0 | 79.9 | 83.2 | | |

Table 5. The producer, user, and overall habitat accuracies (%) of aggregated vegetation habitats in the 2004 wetland vegetation map of the Rainwater Basin, Nebraska. Producer accuracies represent the probability a testing area was correctly classified. User accuracies represent the probability that a classification correctly denoted field conditions. Overall habitat accuracy denotes the mean of producer and user accuracies. Testing data were based on field vegetation surveys conducted in 2003.

| | Producer Accuracy | User Accuracy | Overall Habitat Accuracy |
|---|---|---|---|
| Agriculture | 99.9 | 99.2 | 99.6 |
| Early Successional | 84.5 | 94.7 | 89.6 |
| Grass | 95.9 | 82.2 | 89.0 |
| Late Successional | 91.4 | 79.0 | 85.2 |
| Stressed Agriculture | 99.0 | 95.0 | 97.0 |
| Trees | 84.0 | 99.8 | 91.9 |

Table 6. The error matrix (ac) and producer and user accuracies (%) for aggregated vegetation habitats in a 2004 wetland vegetation map in the Rainwater Basin, Nebraska. Producer accuracies represent the probability a testing area was correctly classified. User accuracies represent the probability that a classification correctly denoted field conditions. Shaded cells are the area (ac) of each habitat that was classified correctly. Testing data were based on field vegetation surveys conducted in 2003.

| | | Testing Data Classification (ac) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Agriculture | Early Successional | Grass | Late Successional | Stressed Agriculture | Trees | Total | User Accuracy |
| Vegetation Map Classification (ac) | Agriculture | 239.6 | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 241.5 | 99.2 |
| | Early Successional | 0.0 | 1,558.0 | 1.2 | 81.2 | 0.0 | 5.6 | 1,646.0 | 94.7 |
| | Grass | 0.0 | 24.3 | 185.0 | 12.0 | 0.0 | 3.8 | 225.2 | 82.2 |
| | Late Successional | 0.0 | 252.9 | 6.8 | 988.9 | 0.0 | 2.7 | 1,251.2 | 79.0 |
| | Stressed Agriculture | 0.0 | 9.4 | 0.0 | 0.0 | 177.3 | 0.0 | 186.6 | 95.0 |
| | Trees | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 63.4 | 63.6 | 99.8 |
| | Total | 239.8 | 1,844.6 | 193.0 | 1,082.1 | 179.1 | 75.5 | 3,614.4 | |
| | Producer Accuracy | 99.9 | 84.5 | 95.9 | 91.4 | 99.0 | 84.0 | | |

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