Wetlands of the Palouse prairie: Historical extent and plant composition

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This is a final report for our project on “Reference Conditions for Wetland Restoration in the Palouse Prairie.” The project was funded by the US Environmental Protection Agency Wetland Grants Program. The project was designed to support restoration efforts within the South Fork of the Palouse watershed (USGS 4th code Hydrologic Unit Code) by determining the extent and plant community composition of “pre-settlement” wetlands (that is, wetlands that existed prior to the arrival of substantial numbers of Euroamerican settlers). This project was originally funded for three years. We obtained a one-year no-cost extension in 2001.

After a brief introduction describing the need for the project and its objectives, the approach and accomplishments are described and synthesized in a brief discussion. A listing of products and activities follows.

Introduction

The Palouse Bioregion comprises the eastern portion of the Columbia Plateau in eastern Washington and adjacent northern Idaho (Caldwell 1961) (Figure 1). In this report, we focus on the region’s wetlands, especially those typical of places where water accumulates seasonally in topographic depressions with deep, well drained or moderately well drained soils. We do not address other types of wetlands that occurred in the Palouse Prairie, such as vernal pools or ponds. The seasonally moist or wet meadows we studied are a type of palustrine, emergent wetland (Cowardin et al. 1979, Smith et al. 1995) that was once widespread in the Palouse. They are also known as “camas meadows,” because they were dominated by common camas, *Camassia quamash* (or *qémes, keh-mes*). a liliaceous forb with edible corms.

The larger camas meadows were important food-gathering sites for native peoples. After Euroamerican missionaries and settlers arrived in the region, however, land was converted to a privately-owned commodity. This change in land ownership, combined with the results of farming (erosion, wetland drainage, and encroachment by exotic plant species), dramatically altered seasonally wet meadows. As settlers acquired more land, stands of camas gave way to croplands and pastures. Botanist John Leiberg described the result: “With the advance of settlements came the utilization of the camass fields as hay meadows. This ended the existence of the plant, except as a weed in the farmers’ fields” (Leiberg 1897:37-38). Water tables dropped and reed canarygrass (*Phalaris arundinacea*), an aggressive forage grass, displaced native plants. As a result, it became difficult for native people in the region to obtain this culturally important food. Today, sites that were once seasonally wet meadows are mostly fields. Many have been drained, while those that are still so wet in spring that farmers find them difficult to cultivate are dominated by invasive weeds. The few that remain are very small and isolated.

The loss of the camas meadows has prompted interest in restoring this ecologically and culturally important habitat. The Palouse region currently has one of the highest soil erosion rates in the country (U.S. Department of Agriculture 1978). Paradise Creek and 23 other streams in the Palouse River basin greatly exceed allowable total maximum daily loads (TMDLs) for sediment, nutrients, and water temperature under section 303(D) of the Clean Water Act (U.S. Environmental Protection Agency 1996; Idaho Division of Environmental Quality 1997). At the same time, city and county governments in both Idaho and Washington grapple with increases in the frequency and severity of recent flooding. Restored wetlands could provide “ecological sponges” to reduce sediment and nutrient loss, diminish hydrologic flashiness, and diversify agricultural landscapes by providing wildlife habitat. Restoration efforts are hampered, however, by a lack of information on appropriate reference conditions. It is difficult to find existing wetlands that can serve as benchmarks for monitoring the success of restoration efforts.

This project demonstrates a technique for mapping the former locations of seasonally wet meadows (and therefore many potential sites for wetland restoration) and provides information on their historical species composition. In addition, we have developed and disseminated educational materials about wetlands and their values.

Objectives

We have organized this report around our approach and findings for each of three objectives:

1) Develop and evaluate a technique for delineating the extent of wetlands prior to the advent of intensive agriculture in the late 1800s in order to provide information to evaluate potential sites for wetland restoration. We developed a model of the extent of pre-settlement seasonally wet meadows and compared the model with two sources of data on the pre-settlement distribution of these wetlands. The model used terrain analysis of 10-m and 30-m Digital Elevation Models to identify areas where flowing water would have accumulated on the landscape. The predictions of the model were compared to maps of hydric soils and soils with hydric inclusions (from soil surveys for Whitman County, Washington and Latah County, Idaho). Data on the extent of pre-settlement wetlands were also obtained from the original surveys conducted by the General Land Office.
2) Describe plant community composition of and soil deposition rates in historical wetlands. We searched herbarium records and early ecologists’ descriptions of plant communities, and qualitative information on sedimentation rates was obtained from soil cores at two locations. General information about the vegetation of the region was obtained by identifying pollen from two soil cores.
3) Implement an environmental education program on wetlands and wetland restoration in local schools and other public forums to involve and educate local people in wetland ecology, restoration, and mitigation. We developed a booklet, two videos, and a poster for Project Wild. A web site (www2.state.id.us/fishgame/info/info.htm) includes information on wetlands, including their current status, cultural and ecological values, and restoration projects. This site also includes depictions of the past, present, and possible future of three Palouse landscapes. In addition, in April 2002 we sponsored a symposium jointly with the Palouse Prairie Foundation that attracted diverse people from local communities across the Palouse. They learned a great deal about the history and future, including restoration, of the Palouse Prairie and its wetlands.

Research (Objectives 1 and 2)

Study Area

The Palouse Bioregion is characterized by rolling hills and deep, fertile, loessal soils. This region of productive farmland is drained by the Palouse River and its tributaries. Because precipitation falls mainly in autumn, winter, and spring and its upland soils are well drained, most of the region's streams are intermittent, so there is little surface water present in summer. However water accumulates in low-lying areas in winter and spring. Prior to widespread grazing and cultivation, the predominant native vegetation was meadow steppe in which perennial caespitose grasses were accompanied by herbaceous dicots and low shrubs (Weaver 1917; Daubenmire 1970). This type of vegetation is sometimes referred to as "Palouse Prairie." Our analysis was focused on two 4^{th}-code subwatersheds of the South Fork of the Palouse River: Paradise Creek and Missouri Flat Creek. These watersheds straddle the state border between Moscow, Idaho and Pullman, Washington (Figure 1).

Methods

We investigated the extent and the composition of historical wetlands in our study area. We used terrain analysis (Gessler et al. 1989, Gessler et al. 1995, Gallant and Wilson 1996) to model the extent of historical wetlands and compared the model to information from county soil surveys on the distributions of wet soils. In addition, we obtained data on the extent of historical wetlands from late-nineteenth century land surveys, and information on the composition of plant communities in historical wetlands was obtained from herbarium specimens and early botanical reports. Additional qualitative information on vegetation and sedimentations was obtained from soil cores at two sites.

Terrain analysis of hillslopes (Gessler et al. 1995) is a technique that can be used to map areas to which water would have been likely to flow on the historical landscape. Digital terrain analysis techniques allow systematic calculation of slope, aspect, and landform curvature and context (e.g. position on slope) on the basis of U.S. Geological Survey (USGS) 10-m and 30-m resolution Digital Elevation Models (DEMs). A DEM is a grid of elevation point values that may be derived from traditional contour maps, photogrammetry, or ground surveys conducted with survey instruments or Global Positioning Systems. Terrain analysis techniques have been used to map a broad range of soil-landscape properties and patterns (Moore et al. 1991, 1993; Gessler et al. 1995; 2000; McKenzie et al. 2000; Chamran et al. in press). Because terrain analysis enables us to characterize landform curvature and sites where water accumulation was likely, it can be used to identify the likely locations of historical wetlands prior to agricultural development and systematic wetland drainage in the Palouse.

We used two sources of DEM data: standard USGS 1:24 000, 30-m DEMs, which meet National Map Accuracy standards for horizontal and vertical accuracies, and the more recently developed National Elevation Data (NED), which use 10-m grid spacing. Individual DEMs for all the quadrangles in the study area were combined to create continuous 10-m and 30-m DEM mosaics for the study area. The resulting 10-m and 30-m DEM mosaics of the study area were analyzed using a deterministic flow-routing algorithm. Primary attributes (first surface derivatives) such as slope, aspect, plan or contour curvature (the across-slope curvature of the landscape), and profile curvature (the downslope curvature of the landscape) were calculated from both the 10-m and the 30-m DEMs.

Flow routing and flow accumulation were then calculated using ARC flow accumulation tools. This 8-direction deterministic method of routing flows first filled the sinks or pits within the DEM by using a local search window. Flow directions were computed using a 3-by-3 moving window algorithm, by routing flow between cells on the basis of the steepest drop from the center cell to surrounding cells. The algorithm sequentially moved across the entire input DEM to generate an output flow direction for each cell. Next, the flow direction grid was input to a flow-accumulation algorithm that integrated the routing of flow and provided an output grid with each cell containing a value for the number of cells contributing to that cell. The number of cells contributing to each cell was then multiplied by the cell area to provide a flow area for each grid cell. Recent research has pointed that this approach generates artificial zig-zag patterns of flow and cannot route flow to multiple downslope cells as may be appropriate over much of the landscape. Because of this limitation, we applied an alternative terrain analysis strategy, termed TauDEM, to the 10-m DEMs. This toolset uses a slope-weighted average to route flow to multiple downslope cells, so that the steepest drop accepts the largest percentage of the flow. Thus this algorithm can expand and contract flow routing on the basis of topography (Tarboton 1997).

A compound topographic index, CTI, often referred to as the steady-state wetness index, which integrates information on landform position and context, was used to identify areas of flow accumulation (AFAs). It is defined as

$$\mathrm{CTI} = \ln(A_s/\tan\beta)$$

where A_s is the specific catchment area (in m^2 per unit width orthogonal to the flow direction) and β is the slope angle. After A_s and β are calculated directly from DEMs, the CTI is derived using standard map algebra tools. Small CTI values generally indicate upper catenary or hillslope positions, and large values indicate lower catenary positions. This index has been used to predict the spatial distribution of variables such as soil depth, A horizon depth, net primary productivity, and soil carbon content.

Hydric soils develop “under sufficiently wet conditions to support the growth and regeneration of hydrophytic vegetation” (U.S. Department of Agriculture 1991:[1]). They are mapped at a scale of 1:20,000 and available in U.S. Department of Agriculture (USDA) county soil surveys produced by the National Cooperative Soil Survey. We used information on the distribution of hydric soils and soils that may have hydric inclusions from the soil surveys for Latah County, Idaho, and Whitman County, Washington (U.S. Department of Agriculture, Soil Conservation Service 1980, 1981) to identify AFAs with the greatest potential for supporting wetland vegetation. This was done by selecting map units in which the dominant component is either (1) a hydric (H) soil; that is, a soil listed on the Soil Conservation Service’s list of Hydric Soils of the United States (U.S. Department of Agriculture 1991) or (2) a soil that may have hydric inclusions (HI), which we defined as a soil described as having a water table within 2 feet of the soil surface for at least three months during the year or extending into May or June. The data on the distributions of H/HI soils in the two counties were aggregated and joined to provide digital coverage showing the distribution of H/HI soils for the study area. Figure 2 superimposes the distribution of H/HI soils over a hillshade of the 10-m DEM for the study area.

We used correlation analysis to compare areas that terrain analysis identified as areas of flow accumulation with the location and extent of soils that are hydric or have hydric inclusions. To evaluate the spatial correlation between H/HI soils and AFAs identified at different CTI thresholds, the coverage of hydric soil polygons, created from aggregated soil mapping units, was converted to a grid with a base grid cell size of 10 m. The watershed boundary polygon was used to cookie-cut out the hydric soils and CTI grids for the study area. The hydric soil grid was then converted to a binary grid showing H/HI soils and non-H/HI soils. Individual CTI grids for four thresholds (7, 8, 9, and 10) were converted to binary grids depicting those areas above the defined threshold and those below it. This made it possible to search for the CTI threshold that best matched the distribution of H/HI soils within the study area. The CTI threshold grids and binary H/HI soils grid were then compared on a cell-by-cell basis to develop statistics regarding the spatial correlation of these two variables. The correlation coefficient was calculated for each combination of H/HI soils and thresholded CTI grid.

To obtain qualitative information on sedimentation rates and past vegetation, we used a Giddings hydraulic soil probe to extract 2-to-3-m-long soil cores at two sites used for environmental education in our study area, the Phillips and Fosberg properties. Sites were selected on the basis of landowner cooperation. The depth to older surface horizons (A horizons, indicated by darker colors) buried by post-settlement sediments was noted. Cores were then sectioned into 5-cm intervals and sent to Tom Minkley and Cathy Whitlock at the University of Oregon for sample preparation and pollen analysis. Many sites that formerly supported wet meadow vegetation in the Palouse region have been drained, and those that remain are typically dominated by introduced forage grasses. Although it was difficult to find wetlands supporting the native species because of this situation, we collected 37 plant taxa from current wet meadow or streamside environments within our study (Appendix 1). Because we were collecting plants for a reference collection, we deliberately selected wetlands with relatively high plant diversity, so these sites are more rich in species than most current wetlands in the Palouse region.

We also examined the records of General Land Office surveys conducted from 1869 through 1875. Although early land surveyors made notes about vegetation, they included few references to wetland plants. One surveyor wrote of the area south of Moscow that “Portions of this country abound in camas affording fine food for swine.” However, surveyors were required to record places where section lines intersected “water objects,” including rivers, creeks, streams, and “intermittent watercourses, such as ravines” (U.S. Department of Interior, Bureau of Land Management 1973:101). The widths of stream beds but not ravines were usually recorded. Surveyors did not mention some of the streams they crossed. They gave widths for only the major lowlands crossed, such as Missouri Flat. To compensate for this omission, we estimated the bed widths of streams that were crossed but not specifically mentioned by the surveyors in our study area. These estimates were based on the width of similar streams in the area that were specifically mentioned. We also estimated the width of topographic depressions designated as “ravines” or “hollows” using topographic maps and our conservative judgment of the area of the ravine or hollow that was likely to have been wetland. These judgments were based on field experience in the study area as well as on the steepness of surrounding slopes and position in relation to ridge and hilltops as indicated on USGS topographic maps. We did not include springs unless they were specifically mentioned by the surveyors.

The vegetation of the camas-dominated plant communities on the plateaus above the Clearwater and Snake Rivers during the pre-settlement period was described by the German botanist Charles Geyer in the 1840s (Geyer 1845; 1846a,b,c; Hooker 1847a,b; Hooker 1848, 1850, 1852, 1853). To obtain information on the vegetation characteristic of topographic depressions in our specific study area, we had to rely on later records. In the early part of the twentieth century, accounts of the vegetation of the Palouse region were published by Piper and Beattie (1901) and by Weaver (1917). Although these works provide information on plants of wet meadow habitats in our study area, they have the disadvantage of being published after substantial settlement, along with changes in land use and the arrival of non-native species, had occurred.

These two types of historical accounts—Geyer's pre-settlement reports from the Palouse region and subsequent, post-settlement reports that included our study area—complement each other. To obtain more specific and detailed information on the vegetation of seasonally moist depressions in our specific study area, we consulted the collections of the Marion Ownbey Herbarium at Washington State University and the Stillinger Herbarium at the University of Idaho. The labels of species or subspecies that Geyer, Weaver, or Piper and Beattie considered important in wetlands associated with low, moist, or wet meadows, as well as species that we or experts whom we consulted considered likely to have occurred in camas meadow communities, were examined. We concluded that taxa that were collected in such habitats in our study area prior to 1917 were components of pre-settlement seasonal wet meadow communities in the Palouse watershed.

Results

CTIs for the study area are shown in Figures 3 and 4, and the distributions of H/HIs soils and CTI thresholds are overlaid in Figure 5. Values of *r* for the correlation between areas with H/HI soils and areas with high CTI were low (0.27 to 0.36) for all values of CTI, regardless of whether 10-m or 30-m DEMs were used (Figure 6). The best correlation coefficient, 0.36, was obtained with 30-m DEMs and a compound topographic threshold of 8 or with 10-m DEMs and a CTI of 9. Examples of the spatial correlation between the distribution of H/HI soils and CTI thresholds are shown in Figures 7 and 8. Gray and green indicate areas where the soil survey data and the terrain analysis are in agreement. Gray areas are below the CTI threshold and have soils that are not mapped as hydric or having hydric inclusions; both terrain analysis and soil survey data suggest that these areas were not wetland in the past. Green areas are above the CTI threshold and have H/HI soils; both terrain analysis and soil data suggest that these areas are likely to have supported wetlands in the past. Areas shown in blue fall below the CTI threshold but are mapped as having hydric soils or soils with hydric inclusions; terrain analysis suggests that they were unlikely to be wetlands in the past, but soil survey data suggest that they might have been. The reverse is true for orange areas; they are above the designated CTI threshold but do not have H/HI soils. Terrain analysis suggests that these areas may have been wetland in the past, although soil survey data do not identify them as such.

Estimates of the historical extent of wetlands derived from soil survey maps of H/HI soils and from compound topographic indices are compared in Table 1. In two instances the terrain analysis and soil survey data gave estimates that differed by no more than 10%: 10-m DEMs used with the Tarboton flow routing method and a CTI threshold of 9, and 10-m DEMs used with the 8-direction deterministic method and a threshold of 9. The estimates for the extent of wetlands generated by these two runs of the terrain analysis model were 12.3% and 13.3% of the study area respectively. Using lower CTI thresholds resulted in estimates that were substantially higher than the estimate derived from soil survey data, whereas using a higher threshold caused the terrain analysis estimate to be lower than the estimate derived from soil data. In most cases, 30-m DEMs generated higher estimates than 10-m DEMs.

Stream courses made up 0.3% of the surveyed section lines within the study area (2,960 ft streambed in 892,320 ft surveyed). When we included topographic depressions likely to support wetlands, the estimated proportion of the surveyed lines that intersected wetlands rose to 12.8%.

The soil cores revealed that dark A horizons were buried beneath 26 to 36 cm of recently-deposited sediments (Table 2) and contained pollen of both upland and wetland plant species. Pine (*Pinus* spp.) pollen made up 18-32% of all pollen in the samples. Pollen from the families Poaceae, Asteraceae (Liguliflorae), and the Chenopodiaceae-Amaranthaceae complex was also relatively abundant. American bistort, *Polygonum bistortoides*, a species of stream banks and moist to wet meadows, was particularly abundant; its pollen was present in 80% of the samples. The presence of abundant *Isoetes* pollen indicates that there were areas of wet ground or standing water within the area that contributed pollen. Pollen from plants in the Cyperaceae and Liliaceae was also common in the samples. These families include many plants of wet meadows, such as *Camassia quamash*, *Carex nebrascensis*, and *C. vesicaria*, but many upland species as well. The pollen assemblages are consistent with what would be expected for a region of meadow steppe vegetation bordering dry transition forest and containing some wet ground or areas of standing water. Although only 4 to 15% of the pollen grains in our samples were partially deteriorated, the pollen of some species may have broken down completely and not been detected.

Taxa that were considered by Weaver, Geyer, or Piper and Beattie to be important in wet meadows or camas meadows and that were also collected in the watershed of the South Fork of the Palouse River in wet or low-lying habitats prior to 1917 are listed in Table 3. It is likely that these plants were common in seasonally moist meadows of topographic depressions in Whitman or Latah Counties prior to 1917. Specimen data indicate that in addition to camas, these wet meadow communities were characterized by several graminoids, such as sedges (e.g. *Carex nebrascensis* and *C. vesicaria)*, tufted hairgrass (*Deschampsia cespitosa*), and members of the genera *Alopecurus*, *Agrostis*, and *Beckmannia*. A number of forbs were also collected in depressional wetlands. The lily family (Liliaceae), iris family (Iridaceae), smartweed family (Polygonaceae), parsley family (Apiaceae), and buttercup family (Ranunculaceae) were particularly well represented. Western blue flag (*Iris missouriensis*), American bistort (*Polygonum bistortoides*), and buttercups (*Ranunculus* spp.) were commonly found in wet meadows. Many forbs of upland meadow steppe also occurred in the wet meadows. For example, nine-leaf lomatium (*Lomatium triternatum*), northern mule's ears (*Wyethia amplexicaulis*), prairie gentian (*Gentiana affinis*), and western blue flag all occurred in wet meadows (Table 3) and also were common members of the Idaho fescue/common snowberry (*Festuca* *idahoensis*/*Symphoricarpos albus*) association typical of Palouse meadow steppe (Daubenmire 1970). Floodplains of small streams supported spike-rushes (*Eleocharis* spp.), rushes (*Juncus* spp.), sedges (*Carex* spp.) and field mint (*Mentha canadensis*). Broad-fruit mariposa (*Calochortus nitidus*), which is endemic to the Palouse and Canyon Grasslands of eastern Washington and northern Idaho (Weddell and Lichthardt 1998), was collected in "low ground" in Pullman in 1894 and in "flats" in Pullman in 1916, but it is now considered extirpated from Whitman County (Weddell 2002b). The U.S. Fish and Wildlife Service considers it a Species of Concern, and the Washington Natural Heritage Program lists it as threatened in Washington (Washington Natural Heritage Program 1997:7,16,A-2,C-4).

Reed canarygrass, which now forms virtually monolithic stands in stream channels and floodplains throughout the Palouse region, was not collected in the study area prior to 1917 and was not listed by Piper and Beattie as occurring in the region prior to 1901. This plant occurred in some parts of the West prior to white settlement, but the highly invasive form that now dominates moist meadows, streams, and streamside environments in the Intermountain West may be descended from a non-native cultivar or a hybrid between a cultivar and a native form (Merigliano and Lesica 1998). The earliest Latah or Whitman County specimen in the Stillinger or Ownbey herbaria was collected by R. Daubenmire in 1938 in a "muddy roadside ditch" 5 mi north of Moscow (WSU Ownbey Herbarium Spec. No. 261001) (Weddell 2002b).

Education (Objective 3)

We have developed two videos, a poster, and a workbook about wetlands. These environmental education materials are available throughout Idaho for use by teachers in Project Wild workshops and in classrooms. They can be used effectively at the elementary and high school levels. These materials complement existing educational materials.

Our web site explores the cultural as well as the ecological implications of the loss of camas meadows. Prior to settlement by Euroamericans, seasonally wet meadows were a critical resource for native peoples of the Palouse region (Weddell 2002a). These wetlands supported dense stands of camas and provided many important things to native people, including large quantities of a nutritious food, a stable source of food that could be stored for long periods of time, an economically valuable resource controlled by women, a place where people could gather in summer to socialize, and a valuable item for trade.

As a result of changes in land use, important camas gathering sites in the Palouse region were drastically altered. Camas grounds became rare, and those that remained were often privately owned or sprayed with pesticides or herbicides. These problems made it difficult to gather camas in the traditional way. In the mid-1960s, two thirds of 50 Nez Perce surveyed by Scrimsher (1967) indicated that they liked camas, but it had become difficult to obtain this food Harbinger (1964). Many aspects of native culture were undermined by the privatization of the Palouse landscape and the alteration of seasonally wet meadows. The network of social relationships that was grounded in traditional ways of using and managing natural resources began to unravel, and sometimes health problems developed when refined foods replaced the traditional diet. Yet the old ways did not completely die out, although it is difficult to follow those ways when the landscape that permitted them has been reorganized.

Recently, however, there has been a resurgence of interest in the pre-settlement landscape, and many people from the tribes, community organizations, universities, and government agencies of the Palouse have become interested in restoring parts of that landscape such as camas meadows and in reviving traditional ways of relating to the natural world. The web site produced by this project contributes to these efforts by using the information from our research to produce pictures of three landscapes depicting wetlands in Palouse landscapes at different points in time.

Discussion

Some areas identified by terrain analysis as areas of flow accumulation coincided with areas mapped as having soils that were hydric or had hydric inclusions (Figures 7 and 8), but overall the correlations between the results of terrain analysis using compound topographic index thresholds and maps of hydric soils or soils with hydric inclusions were low. There was not a great deal of variation in the relationship between hydric soils and CTI threshold. None of the scales, thresholds, or computation methods we used resulted in a strong correlation between hydric soil locations and terrain analysis. This may be a result of scale differences and other data quality factors.

Clearly, the accuracy of the method depends on the accuracy, resolution, and quality of the USGS DEM data and the USDA soil survey data. When soil survey data and the source DEMs are superimposed (Figure 2) some possible problems regarding data quality are evident. Hillshade and derivative maps of the CTI thresholds illustrate that significant differences exist in the quality of the DEM surfaces over the study area (Figures 3, 4, 7, and 8). Distinct boundaries appear between different blocks of the USGS quadrangles. Most of the quadrangles on the Idaho side of the study area along with a block of quadrangles in the southern portion of the study area in Washington appear to be of better quality than the block of quadrangles forming the northern portion of the study area (Figure 2). In addition, the source DEMs appear to be of variable quality. Although the 10-m DEMs are at a higher spatial resolution, they do not appear to be of better quality. The graphics suggest that the 10m DEMs were derived from the 30-m DEMs. Although there is some evidence that more sophisticated flow-routing techniques provide a better representation of reality (Gallant and Wilson 1996), in this study data quality issues may mask any potential improvements. Success would be improved if better quality DEMs existed for the study area. Application of existing methods of smoothing DEMs should be considered, along with careful matching of the DEMs at quadrangle borders.

A related problem resulted from the way hydric soils are mapped in the county soil surveys. Not all soil types mapped by soil surveys are unequivocally either hydric or non-hydric; some map units include areas of non-hydric soils as well as hydric soil inclusions. This lack of specificity results from the limitations of the surveys, which use cartography to integrate information from field work and aerial photographs. The National Cooperative Soil Survey specifies a minimum map unit size, which is influenced by the practicalities of mapping (the smaller the delineations, the more labor-intensive the survey process) and specifications relating to cartographic production (small delineations are difficult to show on maps and tend to make the map too complicated for general use). Because some map units include areas of both hydric and non-hydric soils, it is not always possible to determine from a soil survey whether a specific location had hydric soil at the time it was mapped. Furthermore, the soil surveys of Whitman County and

Latah County (U.S. Department of Agriculture, Soil Conservation Service 1980, 1981) differ in the ways that hydric/hydric-inclusion soils are mapped.

Our comparison of the results of terrain analysis with soil survey data at a 1:20,000 scale indicate some important differences. Terrain analysis has the capability to map landscape patterns in finer detail (Figure 5). This can be done for a large area in a consistent and objective manner, which can eliminate some of the apparent subjective differences that appear in the soil survey delineations of hydric soil characteristics. Unfortunately, logistical constraints prevented us from field testing the utility of either the terrain analysis model or the soil survey data for locating sites that supported seasonally wet meadows in the past but no longer do so. This should be done in order to clarify the advantages or disadvantages of either mapping technique. Ideally, the two approaches can be integrated with field sampling to develop a reliable technique for mapping locations of former wetlands. Further research could evaluate a broader range of potential multivariate combinations of terrain factors to model the distribution of historical wetlands. This would require additional funding to improve DEM quality or to produce better DEMs (e.g. LIDAR, Light Detection and Ranging) and to implement a field sampling program that could be stratified on the basis of existing hydric soil units and terrain analysis. Products derived from these methods could be used to implement field sampling to verify the distribution of historical wetlands with data from soil cores or other *in situ* methods. If strong correlation exists, the GIS analysis tools could be used to map likely sites of historical wetlands to support conservation planning and wetland restoration throughout the region.

The terrain analysis, soil survey data, and records of early land surveys suggest that seasonally moist meadows were formerly more widespread in the Palouse region, occupying approximately 13% of our study area. This is consistent with the historical accounts of extensive camas fields in those subwatersheds. Our research suggests these areas once supported many species of graminoids and forbs in addition to camas. However, again, we encountered limitations to the data sources we used. Because many early herbarium specimens lack habitat data, some species that probably occurred in seasonally wet meadows in the study area do not appear in Table 3. For example, Weaver, Piper, and Beattie considered California false hellebore (*Veratrum californicum*) a species of wet or moist meadows, but it was not possible to confirm this from the specimens we examined, because the labels of false hellebore plants collected in Pullman and Palouse City in the 1890s did not include any information about habitat. Our list of species historically present in seasonally wet meadows is therefore conservative.

At the sites we cored, older A horizons are now buried below 24 to 36 cm of sediment. These sediments probably originated from the nearby hillslopes. Sedimentation rates probably increased dramatically after the Palouse region was settled by Euroamericans, because farming removed native vegetation and caused increased soil erosion. Between 1910 and the 1930s, summer fallowing, stubble burning, and dry cropping of peas resulted in severe soil erosion (Kaiser 1961; Jennings et al. 1990). By 1935 a Soil Conservation Service scientist reported that erosion had caused dramatic downcutting of stream channels and that as a result the water table had receded, permitting “bottom lands and small meadows formerly considered too wet to farm . . . to be farmed” (Victor 1935:18). In meadows along the South Fork of the Palouse River, the conversion of wet meadows to cultivable land reportedly took only 10-12 years. Erosion was accompanied by high rates of siltation in streams and adjacent wetlands. By the late 1930s, many farmers were aware that soil loss was a serious problem, but erosion rates remained high. The estimated annual soil loss from Whitman County between 1939 and 1950 was 8.8 million tons (Kaiser 1961). One measure that farmers took to address this problem was to plant perennial grasses in within-field drainages (Jennings et al. 1990). This probably reduced the extent of native wetland species as the non-natives spread to other wetland areas. Although the soil erosion rates have declined, sedimentation loads remain high. The amount of sediment carried in Paradise Creek must be reduced by 75% to meet TMDLs established in 1999 by the Paradise Creek Watershed Advisory Group.

The information from this project will be useful to those involved in wetland restoration, enhancement, or creation who need reference information to monitor their success. Many efforts to restore, enhance, or create wetlands and shallow ponds are underway in the Palouse. Some are voluntary, while others are required to mitigate for causing wetland losses under Section 404 of the Clean Water Act or local ordinances such as those mandated by Washington's Growth Management Act. Federal and state programs also encourage landowners to participate in voluntary stream restoration efforts to stabilize streambanks, reduce erosion, improve stream water quality, and improve fish and wildlife habitat. Mitigation for adverse impacts to wetlands is especially critical in this region because it is within the watershed of the Snake River, and loss of wetlands is associated with increased runoff, declining water quality, and negative impacts on populations of anadromous fish.

This project combined with our extensive spatial information on land use history in the Palouse (Black et al. 1998a, b) will provide local people and state and county governments with historical perspectives on past and future changes that have occurred across the Palouse. The educational materials we have developed is being used to increase awareness of the functions and values of wetlands–such as providing wildlife habitat, improving water quality, and enhancing scenery–as well as their cultural importance. Thus, we anticipate a growing interest in wetland restoration as a result of this project. Local people and their governments are coming to recognize that wetlands are functionally important in watersheds and that restoring them can improve water quality and provide wildlife habitat. This project will contribute to the return of sustainable patterns of land use in this biologically and culturally rich region.

Partners

The Idaho Department of Fish and Game has coordinated this project. This agency has worked closely with the University of Idaho and Bertie Weddell of Draba Consulting. Other partners have included the U.S. Department of Agriculture Natural Resource Conservation Service, the Palouse Land Trust, and the Palouse Clearwater Environmental Institute. We collaborated with the newly established Palouse Prairie Foundation on the Palouse Prairie symposium, which took place on April 11 and 12, 2002. Members of the Nez Perce Tribe reviewed our work on the historical importance of wet meadows.

Products

This project has produced the following products:

Educational materials

Wild About Wetlands. An Educator's Guide. 2001. Idaho Fish and Game and Project Wild.

Wild About Wetlands, Video. 11 minutes.

Wild About Wetlands. Video. 14 minutes.

Wild About Wetlands. Poster.

Website materials

The Historical Significance of Camas Meadows for Native Peoples in Idaho (Appendix 2)

Other Materials for Idaho Fish and Game Wetlands Website (Appendix 3)

Draft reports

Weddell, B. J. 2002a. The causes and consequences of loss of a culturally significant resource: seasonally moist meadows in the Palouse region. (Appendix 4)

Weddell, B. J. 2002b. Historical vegetation of seasonally moist depressions in the South Fork of the Palouse River watershed. (Appendix 5)

The educational materials designed for this project include two videos, a poster, and an educator's guide. All are used in Project Wild workshops for teachers. Teachers have designed the hands-on activities included in the book. Lessons integrate Biology, Agriculture, Math, History, Geography, Language Arts, and Technology. These don't include specific information on wetland restoration in the Palouse, but some of the video was videotaped in the Palouse.

We have a web site (www2.state.id.us/fishgame/info/info.htm) with similar information. Students, teachers, researchers, and others interested wetlands and their restoration will find useful information there. In particular, the information on native plant species composition will be used in the Idaho Fish and Game Department's Habitat Improvement Program, by landowners (through the USDA Natural Resource Conservation Service and Agricultural Extension agents), and by nonprofit organizations (such as the Palouse Prairie Foundation, Palouse Land Trust, and the Palouse-Clearwater Environmental Institute) active in wetland restoration, conservation, and management.

For the wetlands web page, we produced representations of three landscapes representing the diverse conditions in the Palouse. These pictures of depict the landscapes historically, currently, and in the future. Our goal is to generate dialogue about future land use choices in the Palouse Prairie, particularly those that include some combination of restored prairie and wetlands and current land uses. These are accessible to the public and to state, tribal, and local governments.

We plan to submit two publications to refereed journals. One will focus on the loss of wetlands. In it, we will present the results of the variety of methods we used to reconstruct information on the location, extent, and composition of wetlands in the Palouse Prairie and the causes and consequences of the loss, as well as the implications for restoration of wetlands in the Palouse. The emphasis will be on how such information can be used by local state, tribal, and federal governments in establishing wetland restoration goals. It will be submitted to *The Geographical Journal*. The second manuscript will focus on the historical plant composition of the wetlands that were once widespread in the Palouse. We will synthesize the corroborating evidence for the extent of wetlands and their ecological and cultural importance and will emphasize the multiple lines of evidence necessary for establishing restoration goals for wetlands, such as those in the Palouse, that have long been lost from the landscape. This manuscript will be submitted to *Restoration Ecology*.

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Figure 1. Extent of the study area, within the Palouse Bioregion.

Figure 2. Hillshade of the study area showing distribution of soils that are hydric or have hydric inclusions. Blue hatching indicates areas with soils that are hydric or could have hydric inclusions. Orange line indicates buondary of study area and division between subwatersheds of Missouri Flat Creek and Paradise Creek.

Figure 3. Compound topographic indices for the study area. High CTIs correspond to low hillslope positions and vice versa.

Figure 4. Enlargement of area shown in Figure 3.

Figure 5. Comparison of the distributions of soils that are hydric or have hydric inclusions and compound topographic indices. Areas that have hydric soils or soils with hydric inclusions are shown in blue; terrain analysis predicts that areas shown in darker shades of orange are likely to have been wetlands in the past;.

Figure 6. Frequency distributions of correlation coefficients for spatial correlation between H/HI soils and compound topographic indices. Tarb = Tarboton method of routing flows; D8 = 8-direction deterministic method of routing flows.

Figure 7. Correlation between areas with soils that are hydric or have hydric inclusions and areas with a compound topographic index ≥ 9, derived from 10-m DEMs and Tarboton flow routing. Bel = CTI below the designated threshold of 9; non = non H/HI soils; hyd = H/HI soils; abv = CTI equal to or greater that 9.

Figure 8. Enlargement of area shown in Figure 7. Abbreviations as in Figure 7.

Table 1. Estimates of the proportion of the study area that historically supported wetlands. Underlined examples are cases where the estimates of wetland area derived from soil surveys and from terrain analysis differed by less than 10%.

			Method of estimating wetland area		
DEM	Method	Threshold	% of area in H/HI soils (A)	% of area above CTI threshold (B)	Ratio of A:B
10-m	Tarboton	7	13.5	30.1	0.45
10-m	Tarboton	8	13.6	18.0	0.75
10-m	Tarboton	9	13.6	12.3	1.11
10-m	Tarboton	10	13.9	9.8	1.42
10-m	D8	7	13.5	30.6	0.44
10-m	D8	8	13.6	19.0	0.71
10-m	D8	9	13.6	13.3	1.03
10-m	D8	10	13.7	10.4	1.31
30-m	D8	7	13.3	48.1	0.28
30-m	D8	8	13.5	25.6	0.53
30-m	D8	9	13.6	15.7	0.87
30-m	D8	10	13.7	10.4	1.31

Table 2. Depth to buried A horizon for two sites sampled in the study area.

Location	Sample number	Depth to buried A horizon	Current vegetation	Date
Virgil Phillips Farm	PF01	35 cm	Perennial grasses, (including timothy, Phleum spp., intermediate wheatgrass; Agropyron intermedium; reed canarygrass, Phalaris arundinacea), teasel, Dipsacus sylvestris. No bare ground	18 October 2000
	PF02	36 cm	Same, some ponderosa pine, *Pinus ponderosa*, saplings	18 October 2000
	PF03	24 cm	Same	18 October 2000
Fosberg's	FOSP	24 cm	Horse pasture, with timothy, intermediate wheatgrass	12 July 2000
	1FOSP, 26-33	26 cm	Same	12 July 2000
	2FOSP, 33-38	26 cm	Same	12 July 2000
	3FOSP, 38-43	26 cm	Same	12 July 2000
	4FOSP, 43-48	26 cm	Same	12 July 2000

Table 3. Taxa likely to have been common in seasonally moist meadows of topographic depressions in Whitman or Latah Counties prior to 1917. The taxa listed were considered by Weaver, Geyer, or Piper and Beattie to be important in moist, wet, or low meadows, topographic depressions, or floodplains or were collected in those habitats in Whitman Co, WA or Latah Co, ID prior to 1917. O = Ownbey Herbarium; S = Stillinger Herbarium.

				Specimens			
Family	**Genus and species**	**Common name**	**Reference**	**Collector and herbarium**	**Year**	**Habitat**	**Location**
Apiaceae	*Heracleum maximum*	cow-parsnip	Weaver	Hunt & Kimmel (O)	1906	near creek bottom	Pullman
Apiaceae	*Lomatium triternatum*	nine-leaf lomatium	Geyer	Piper (O) Aldrich (S)	1893 1910	low meadows low ground	Pullman Moscow
Apiaceae	*Perideridia gairdneri*	Gairdner's yampah	Piper and Beattie	Aldrich (S)	1907	low ground	Moscow
Asteraceae	*Senecio serra*	butterweed groundsel	Weaver	Piper (O)	1893	wet ground	Pullman
Asteraceae	*Wyethia amplexicaulis*	northern mule's ears	Weaver	Piper (O)	1893	wet ground	Pullman
Brassicaceae	*Rorippa curvisiliqua*	western yellowcress	Weaver	Hull (O) Pickett (O)	1892 1915	moist places wet soil along streams	Pullman Pullman
Caryophyllaceae	*Cerastium arvense*	field chickweed	Piper and Beattie	Elmer (O)	1897	very rich plots of ground in bottoms	Pullman
Cyperaceae	*Carex nebrascensis*	Nebraska sedge	Weaver	Henderson (O) Hunt (O)	1892 1906	wet meadows wet places near rr.	Union Flat Pullman
Cyperaceae	*Carex vesicaria*	inflated sedge	Weaver	Lake & Hull (O)	1892	edges of ponds	Pullman
Gentianaceae	*Eryngium articulatum*	beefthistle		Pickett (O)	1916	occasional in flats along streams	Pullman
Gentianaceae	*Gentiana affinis*	prairie gentian		Thomas (S)	1916	low meadow	Tomer's Butte
Iridaceae	*Iris missouriensis*	western blue flag	Geyer; Weaver	Pickett (O)	1916	flats	Pullman

Family	Genus and species	Common name	Reference	Specimens Collector and herbarium	Year	Habitat	Location
Iridaceae	*Sisyrinchium idahoense*	blue-eyed grass	Piper and Beattie	Piper (O)	1894	low meadows	Pullman
				Elmer (O)	1897	deep rich soil of bottomlands	Pullman
				Hunter (O)	1899	bottom land	Pullman
Liliaceae	*Allium geyeri*	Geyer's onion	Piper and Beattie	Henderson (O)	1894	moist ground, meadows, and along creeks	Moscow to Camas Prairie
				Thomas (S)	1916	low meadows	Moscow
Liliaceae	*Camassia quamash* and *Camassia quamash* ssp. *quamash*	common camas	Geyer; Weaver	Piper (O)	1893	wet meadow	Pullman
				Ransom (S)	1895	moist places	Moscow
				Elmer (O)	1896	moist places	Pullman
				Elmer (O)	1897	swales near streams	Pullman
				Hunter (O)	1899	wet lowland	Pullman
				Hunt & Kimmel (O)	1906	damp ground	Pullman
				Pickett (O)	1915	low flat	Pullman
				Pickett (O)	1916	low, moist flats	Pullman
				Dunkle (S)	1916	wet meadows	Genesee
Liliaceae	*Calochortus nitidus*	broad-fruit mariposa	Weaver; Piper and Beattie	Lake & Hull (O)	1892	low bottoms	Pullman
				Piper (O)	1893	low meadows	Pullman
				Piper (O)	1894	low ground	Pullman
				Hunter (O)	1899	bottomland	Pullman
				Pickett (O)	1916	flats	Pullman
Poaceae	*Agrostis exarata*	spike bentgrass	--	Piper (O)	1893	wet ground	Pullman
				Piper (O)	1894	low ground	Pullman
Poaceae	*Agrostis scabra*	winter bentgrass	Geyer	Piper (O)	1894	damp ground	Pullman
Poaceae	*Alopecurus geniculatus*	water foxtail	Geyer	Hunt (O)	1906	wet muddy bottom	Pullman
				Hunt (O)	1906	low places	Pullman

Family	Genus and species	Common name	Reference	Specimens: Collector and herbarium	Year	Habitat	Location
Poaceae	*Beckmannia syzigachne*	American sloughgrass	Geyer	Lake & Hull (O)	1892	wet ground	Union Flat
				Piper (O)	1893	edges of ponds	Pullman
				Hunt (O)	1906	wet places along railroad	Pullman
Poaceae	*Deschampsia cespitosa*	tufted hairgrass	Weaver	Piper (O)	1893	wet ground	Pullman
Poaceae	*Melica spectabilis*	showy oniongrass	Piper and Beattie	Elmer (O)	1897	small meadows of sloughs	Pullman
Polygonaceae	*Polygonum bistortoides*	American bistort	Geyer	Elmer (O)	1897	very low grassy marshes	near Moscow
Polygonaceae	*Polygonum polygaloides*	white-margined knotweed	Weaver	Piper (O)	1892	moist meadows	Pullman
Primulaceae	*Lysimachia ciliata*	fringed loosestrife		Aldrich (S)	1907	low, moist ground	Moscow
				Pickett (O)	1916	near a spring in pasture	Pullman
Ranunculaceae	*Clematis hirsutissima*	Douglas' clematis	Piper and Beattie	Pickett (O)	1915	flats	Pullman
Ranunculaceae	*Ranunculus orthorhynchus* and *R. orthorhynchus* var. *platyphyllus*	straightbeak buttercup	Weaver	Henderson (O)	1894	moist ground	near Moscow
				Piper (O)	1893	wet places	Pullman
				Piper (O)	1893	wet ground	Pullman
				Pickett (O)	1916	low, damp ground	Pullman
Scrophulariaceae	*Castilleja cusickii*	Cusick's paintbrush	Piper and Beattie	Lake & Hull (O)	1892	low ground	Pullman
				Piper (O)	1898	wet meadows	Pullman
				Piper (O)	1898	wet meadows	Collins, ID
				Aldrich (S)	1910	low ground	Moscow
Valerianaceae	*Valeriana edulis*	edible valerian	Geyer	Piper (O)	1893	low ground	Pullman
				Pickett (O)	1915	low, damp flats	Pullman

Appendix 1

Data on Vegetation of Wetlands in Whitman County, Washington and Latah County, Idaho in Summer 2000

Plant Taxa Collected

Agrostis scabra
Agrostis tenuis
Alopecurus aequalis
Alopecurus geniculatus
Alopecurus pratensis
Artemisia ludoviciana
Aster occidentalis var. intermedius
Beckmannia syzigachne
Camassia quamash
Carex athrostachya
Carex geyeri
Carex pachystachya
Carex pellita
Carex stipata
Deschampsia elongata
Eleocharis acicularis
Eleocharis palustris
Equisetum arvense
Iris missouriensis
Juncus balticus
Juncus bufonius
Juncus ensifolius
Juncus nevadensis
Juncus tenuis var. dudleyi
Panicum capillare
Phalaris arundinacea
Poa annua
Poa palustris
Polygonum bistortoides
Scirpus acutus
Scirpus microcarpus
Senecio serra
Sidalcea oregana
Wyethia amplexicaulis

Wet meadows

Wet meadow Location 1: Dumroese intermittent stream channel, Latah Co., ID, N 1/2 SW 1/4 and NW 1/4 SE 1/4, Sec. 5, T 38N, R 5W, 13 July 2000.

Estimated canopy coverage of vegetation in soil sampling area:

Alopecurus pratensis	80%
Juncus nevadensis	10%

Also present: Graminoids: *Carex athrostachya, Deschampsia elongata*, *Juncus ensifolius*, *J. tenuis*, *Koeleria nitida*, *Phalaris arundinacea*; Forbs: *Barbarea orthoceros*, *Epilobium ciliatum*, *Habenaria dilatata*, *Prunella vulgaris, Sidalcea oregana*

Wet meadow Location 2**:** Big Meadow, Latah Co., ID, SW 1/4, SW 1/4, Sec. 14, T 40N, R 4W15, July 2000.

Estimated canopy coverage of vegetation in sampling area:

Potentilla gracilis	25%
Carex pachystachya	20%
Agrostis tenuis	15%
Fragaria virginiana	12%
Phleum pratense	10%
Agrostis alba	8%
Juncus tenuis	5%
Equisetum arvense	5%
Achillea millefolium	5%
Heracleum lanatum	5%
Hypericum perforatum	5%

Also present: Trees: *Pinus ponderosa*, *P. contorta*; Shrubs: *Amelanchier alnifolia*, *Crataegus douglasii*, *Symphoricarpos albus*; Graminoids: *Carex densa*, *Danthonia intermedia*; *Antennaria rosea*, *Aster occidentalis*; Forbs: *Dipsacus sylvestris*, *Epilobium ciliatum*, *Gnaphalium palustre*, *Lotus purshiana*, *Penstemon rydbergii*, *Plantago lanceolata*, *Rumex acetosella*, *Verbascum thapsus*, *Veronica officinalis*, *Vicia* cf. *americana*

Wet meadow Location 3: Camas meadow at junction of Beulah and Randall Flat Roads, Latah Co., ID, SW 1/4, NE 1/4, Sec. 2, T 39N, R 4W, 25 July, 2000.

Estimated canopy coverage of vegetation in sampling area:

Perideridia gairdneri	50%
Poa pratensis	50%
Aster occidentalis var. *intermedius*	40%
Delphinium burkei	40%
Phleum pratense	30%
Potentilla gracilis	30%
Camassia quamash	20%
Achillea millefolium	10%
Bromus inermis	10%
Madia glomerata	5%
Senecio integerrimus	5%
Solidago canadensis	5%
Thermopsis montana	5%
Orthocarpus hispidus	3%

Also present: Graminoids: *Bromus japonicus;* Forbs: *Triteleia hyacinthina, Rumex salicifolius*

Floodplains

Flood plain Location 1: Fosberg's vernal pond, Latah Co., ID, Center, SW 1/4, Sec. 9, T 39N, R 5W, 19 July 2000.

Estimated canopy coverage of vegetation in sampling area:

Alopecurus geniculatus	65%
Eleocharis palustris	50%
Eleocharis acicularis	10%
Juncus nevadensis	10%
Agrostis alba	5%
Phalaris arundinacea	5%
Alopecurus pratensis	5%

Also present: Forbs: *Plantago major*, *Taraxacum officinale*, *Veronica anagallis-aquatica*

Flood plain Location 2: Union Flat, Whitman Co., WA - NE 1/4, SE 1/4, Sec. 36, T 15N, R 43E, 20 July 2000.

Estimated canopy coverage of vegetation in sampling area:

Eleocharis palustris	40%
E. acicularis	30%
Juncus bufonius	20%
Alopecurus geniculatus	7%
Alopecurus pratensis	5%
Deschampsia danthonioides	5%
Gnaphalium palustre	5%
Plagiobothrys scouleri	5%
Veronica peregrina	2%

Also present (not in immediate area but slightly "upstream"): Graminoids: *Agropyron repens*, *Bromus japonicus*, *Juncus tenuis* var. *dudleyi*, *Poa pratensis*, *Taeniatherum caput-medusae*, *Ventenata dubia*; Forbs: *Cichorium intybus*, *Dipsacus sylvestris*, *Hypericum perforatum*

Flood plain location #3: South shore Palouse River N of Palouse, Whitman Co., WA, NW 1/4, NE 1/4, Sec. 35, T 17N, R 46E, 5 August 2000.

Estimated canopy coverage of vegetation in sampling area:

Phalaris arundinacea	50%
Eleocharis palustris	40%
Scirpus microcarpus	30%
Juncus balticus	15%
Salix cf. amygdaloides (12-15" tall)	15%
Equisetum arvense	10%

Also present: Graminoids: *Carex pellita*, *C. stipata*, *Eleocharis acicularis*

Also present in general area: Trees: *Pinus ponderosa*; Shrubs: *Crataegus douglasii*, Graminoids: *Juncus bufonius*; Forbs: *Mentha arvensis*

Appendix 2

Website Materials on The Historical Significance of

Camas Meadows for Native Peoples in Idaho

Appendix 3

Other Materials for Idaho Fish and Game Wetlands Website

Historical Vegetation in Wetlands along the South Fork of the Palouse River, Latah County, Idaho.

Current Vegetation in Wetlands along the South Fork of the Palouse River, Latah County, Idaho.

Potential Future Vegetation in Wetlands along the South Fork of the Palouse River, Latah County, Idaho.

Historical Upland Vegetation Near Viola, Latah County, Idaho.

Current Upland Vegetation Near Viola, Latah County, Idaho.

Potential Future Upland Vegetation Near Viola, Latah County, Idaho.

Appendix 4

The Causes and Consequences of Loss of a Culturally Significant Resource: Seasonally Moist Meadows in the Palouse Region

Appendix 5

Historical Vegetation of Seasonally Moist Depressions in the South Fork of the Palouse River Watershed