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Winter Term 2017 – Geography-560

February 26, 2017
Principles of GIS Mapping

Project Title: Socio-Ecological Characterization and Mapping of Willamette Valley, Oregon Wetgrass Prairie Recovery Using the Assistance of an Ecosystem-wide Conservation and Mitigation Banking Program.

1.0 Introduction

The purpose of this report is to outline the rationale and procedures used to plan and implement the above cited characterization and mapping project per partial fulfillment of my Geography-560 course requirements. The project on which this report is based borrows from a socio-economic systems approach and relies substantially on web technology for showcasing its deliverables.

The concept of a socio-ecological approach to the use of Geographic Information Systems (GIS) for the support of decision making has no doubt evolved from and is itself an integral part of applied geography. Both applied and research geographers have come to recognize the need to characterize and address solutions to target problems at the global/ecosystem level using multiple spatial and temporal scales crossing relevant human systems or knowledge domains (Reid 2006). The notion that solutions should embrace factors that support resilience and functionally sustainable systems is relatively recent in the mainstream thinking that faces increasingly complex world problems (Walker and Salt 2012). As modern and revolutionary as these concepts may seem, one could argue they are the logical result of a long history of cartographic representation by applied geographers (Slocum, McMaster, and Howard 2009).

A burgeoning conundrum looming in the field of natural resource management is how to effectively characterize and apply cumulative effects analyses, both direct and indirect. A socio-ecological GIS as described above can offer a framework that contributes to solving this problem (Reid 2006). One of the reasons it is so difficult to adequately address cumulative effects is related to a concept of historical loss informing some present-day assessment of a "baseline" condition. The Endangered Species Act (ESA) Section 7 Consultation Handbook (USFWS and NMFS 1998) defines the environmental baseline as:

> *"An analysis of the effects of the past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem within the action area. The environmental baseline is a snapshot of a species health at a specified point in time."*

The Council on Environmental Quality (CEQ 1997) lists eight principles of cumulative effects analysis:

1. Cumulative effects are caused by the aggregate of the past, present, and reasonably foreseeable future actions.

2. Cumulative effects are the total effect, including both direct and indirect effects, on a given resource, ecosystem, and human community of all actions taken, no matter who (federal, nonfederal, or private) has taken the actions.

3. Cumulative effects need to be analyzed in terms of the specific resource, ecosystem, and human community being affected.

4. It is not practical to analyze the cumulative effects on the universe; the list of environmental effects must focus on those that are truly meaningful.

5. Cumulative effects on a given resource, ecosystem, and human community are rarely aligned with political or administrative boundaries.

6. Cumulative effects may result from the accumulation of similar effects or the synergistic interaction of different effects.

7. Cumulative effects may last for many years beyond the life of the action that caused the effects.

8. Each affected resource, ecosystem, and human community must be analyzed in terms of its capacity to accommodate additional effects, based on its own time and space parameters (the long-term productivity or sustainability of the resource is ultimately of concern).

Using the foundation cumulative effects principles of existing Federal environmental laws (e.g., the Endangered Species Act and the National Environmental Policy Act), this project uses a socio-ecological approach to characterize the use of a mitigation and conservation banking program to assist in the partial recovery of a historically diminished resource type (wet prairie) in the Willamette Valley Ecoregion (Figure 1).

Close to 99% of the pre-European occupation wet grass prairie, generally classified as Palustrine Emergent Wetland (Cowardin 1979), in the Willamette Valley has been converted to pasture and other agricultural uses or urban development (Habeck 1961, Johannessen et al 1971, Christy and Alverson 2004). Additionally, displacement of aboriginal peoples and their cultural practices of prairie burning (Boss 2008, Pendergrass 1995, Alverson 2006, Alverson 2004) to drive game for hunting and maintaining native prairie food plants, such as camas, has led to an accelerated colonization by woody species and nonnative invasive weeds (largely transported and introduced by European settlers and their descendants) on the remaining 1% of the original prairie. These weedy species are overtaking and severely degrading the remaining prairie condition (Pendergrass 1995, Norman 2008, Pfeifer-Meister 2008), thereby limiting its capability to support already imperiled plant and wildlife species (Titus et al 1996).

Over a period of about 15 to 20-years, a mitigation and conservation banking program (ORS 196.668 – 196.622) has been steadily growing around the state of Oregon and 22 of those mitigation banks are established in the Willamette Valley Ecoregion. Many of these mitigation banks are targeting the recovery of Willamette Valley wet grass prairie as part of their over-arching management and long-term protection strategy. Recovery of historically diminished and presently rare resources is supported and encouraged by the State of Oregon's Conservation Strategy (ODFW 2006).

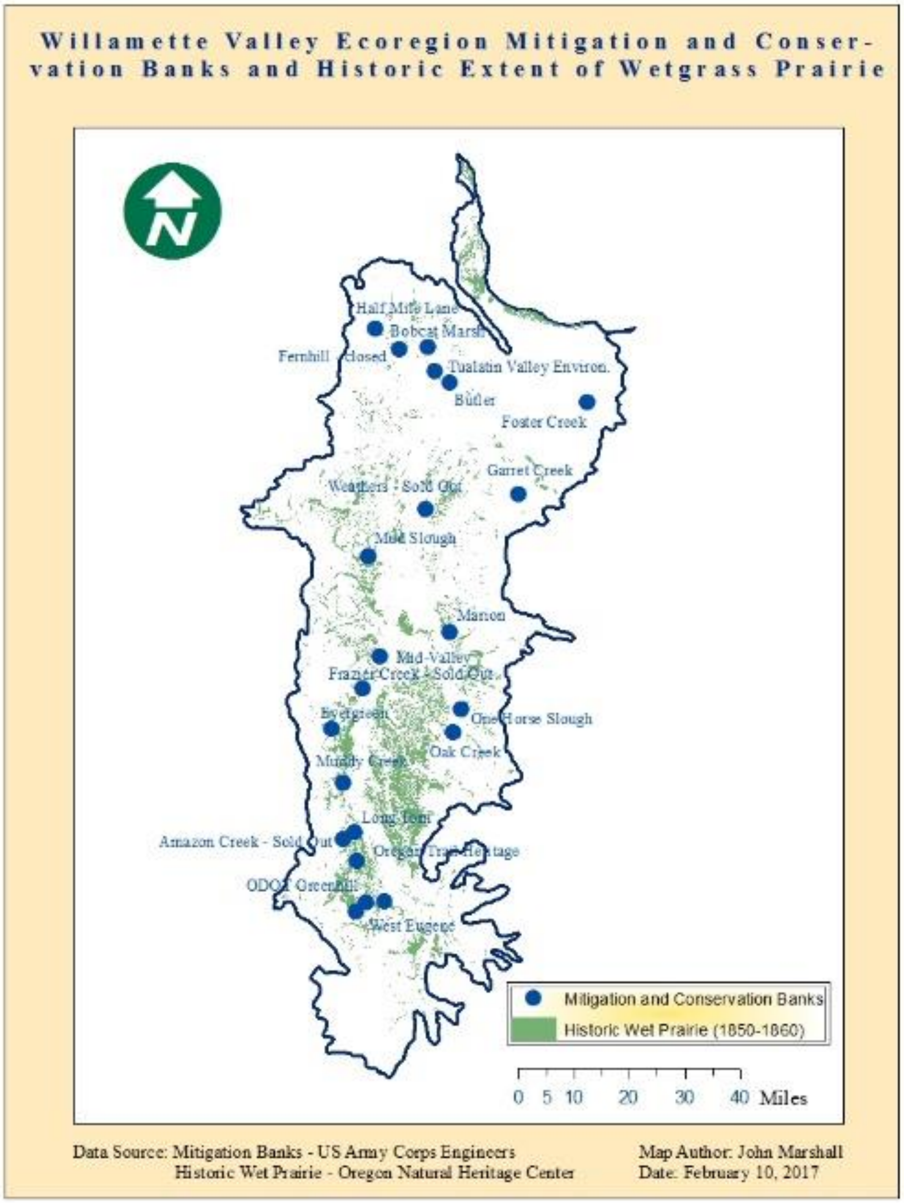


Figure 1. Willamette Valley Ecoregion Project Scale.

Multiple scales are used to characterize and map the role mitigation and conservation banks play in collectively contributing to wet prairie recovery (Figures 1, 2 and 3). A case study at the Muddy Creek Wetland Mitigation Bank illustrates specific details on Bank sponsor monitor-

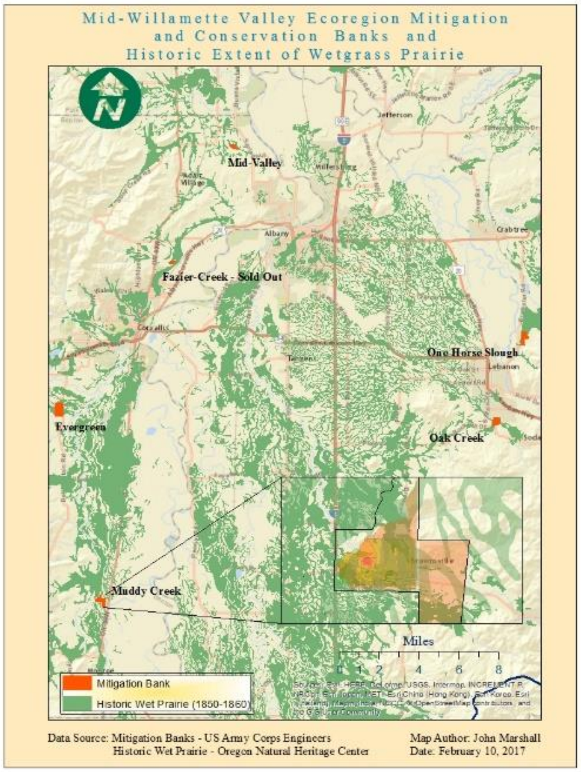


Figure 2. Land Parcel Scale.

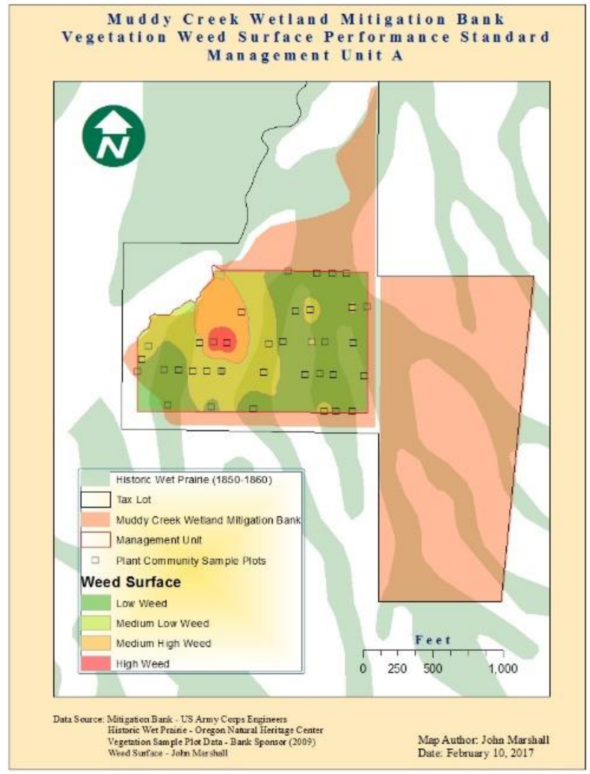


Figure 3. Management Unit / Sample Plot Scale.

ing and management of restored native wet prairie species and controlling nonnative invasive weeds.[1] The Muddy Creek Wetland Mitigation Bank was selected as a focal case study because its Mitigation Bank Instrument (Kiilsgaard and Reams) targets the recovery of historic Willamette Valley wet prairie species and performance conditions and the bank sponsors have georeferenced their 2008 plant community monitoring sample plot data (Arghangelsky 2009).

2.0 Design and Methods

Conceptual. The immediate goal of this project is to compare the historical loss of pre-European settlement wetgrass prairie in the Willamette Valley Ecoregion with the progress being made by an ecoregion-wide mitigation and conservation banking program targeting the recovery of wetgrass prairie in the Willamette Valley. A socio-ecological characterization and mapping framework (Table 1) is used as the operational construct for meeting the project objective. It recognizes the hierarchical spatial scale as: 1. ecosystem, 2. land parcel (site), 3. management unit, and 4. sample plots. The time scale ranges between pre-European settlement to the present. The primary human system/knowledge domains traversed include social, ecological, and economic foci.

[1] The performance monitoring assessment technique (weed index interpolation) discussed in this project is hypothetical for education purposes only and should not be considered a technique actively in use on any mitigation or conservation bank at this time.

Technical. A GIS is selected as a logical technology to create the necessary characterization model and conduct the analyses. The first step toward building the GIS is to inventory and acquire the GIS data required. Eight GIS data layers were identified and acquired (Table 2).

Table 1. A Socio-ecological Framework for Willamette Valley, Oregon Wetgrass Prairie Recovery Assisted by an Ecosystem-wide Mitigation and Conservation Banking Program.

Human Systems/ Scale	Social	Ecological	Economic
Ecoregion: (Willamette Valley, Oregon)	Native American Subsistence/Culture to European Domain	Extreme Habitat Loss and Loss of Species	Subsistence to Farm Based to Industrial to Post-Industrial
Land Parcel (Muddy Creek Wetland Mitigation Bank)	Alternative Lifestyle Regulation Adverse to Regulation Support	Land Restoration Habitat Recovery Species Recovery	Natural Resource Based Economy
Management Unit (Management Unit A)	Science Based Work Modern Social Role Soc./Cult. Shift	Natural Resource Accountability	Natural Resource Units Equate to Income
Sample Plot (Sample Plot 1 – 37)	Interdisciplinary Knowledge Applied /Community Shared	Ecological Performance Based Accountability	Income Tied to Ecological Performance

Table 2. Static and Web Map Application Data (see Appendices B and C).

Map Data Themes	DataType	Source	OriginalProj	ComProj Static	ComProj Web
Ecoregion Boundary	Polygon	Institute for Natural Resources	NAD_1983_Oregon_ Statewide_Lambert_ Feet_Intl'	NAD_1983_ UTM_Zone_ 10N	WGS 1984 Web Mercator
Historic Wetgrass Prairie	Polygon	Oregon Natural Heritage Information Center	NAD_1983_Lambert_ Conformal_Conic	NAD_1983_ UTM_Zone_ 10N	WGS 1984 Web Mercator
Willamette Valley Mitigation and Conservation Banks	Point	US Army Corps of Engineers (RIBITS)	WGS 1984	NAD_1983_ UTM_Zone_ 10N	WGS 1984 Web Mercator
Willamette Valley Mitigation and Conservation Banks	Polygon	US Army Corps of Engineers (RIBITS)	WGS 1984	NAD_1983_ UTM_Zone_ 10N	WGS 1984 Web Mercator
Muddy Creek Wetland Mitigation Bank Tax Lot	Polygon	Benton County, Oregon Assessor's Office	NAD_1983_HARN_ StatePlane_Oregon_ North_FIPS_3601_ Feet_Intl	NAD_1983_ UTM_Zone_ 10N	WGS 1984 Web Mercator
Muddy Creek Wetland Mitigation Bank Boundary	Polygon	US Army Corps of Engineers (RIBITS)	WGS 1984	NAD_1983_ UTM_Zone_ 10N	WGS 1984 Web Mercator
Muddy Creek Wetland Mitigation Bank Management Unit A	Polygon	Created by Project Author for This Report	NAD_1983_ UTM_Zone_ 10N	NAD_1983_ UTM_Zone_ 10N	WGS 1984 Web Mercator
Muddy Creek Wetland Mitigation Bank Management Unit A Sample Plots	Points	Arghangelsky 2009	WGS 1984	NAD_1983_ UTM_Zone_ 10N	WGS 1984 Web Mercator

Some of the original datasets were standalone downloads while others required various data editing and data preparation procedures before they could be used in this project. For example, the mitigation bank point and polygon data were downloaded from the US Army Corps of Engineers Regulatory In-Lieu-Fee and Bank Tracking System (RIBITS) web site as kmz files (USACOE 2017) which were converted to ESRI feature classes using the ArcGIS KML to Layer tool. Once data preparation procedures were completed, the datasets were imported into a file geodatabase feature dataset set to convert the different existing projections to a common NAD 1983 UTM Zone 10 projection. Each feature dataset contains one or more layers (Appendix B and C) of a common thematic type. Once the geodatabase was created it was added to an ArcMap project in ArcGIS desktop software. A SQL query was run to select by location all existing mitigation banks that intersect with historical wet prairie. The selected banks were exported to a separate feature class. A second SQL query was executed to further screen the exported banks by selecting by attribute the mitigation banks that have a wet prairie management unit. The statistics tool was then used to calculate the total acreage of the remaining banks (Figure 4). It was determined that over 1,476-acres was dedicated to helping recover wet grass

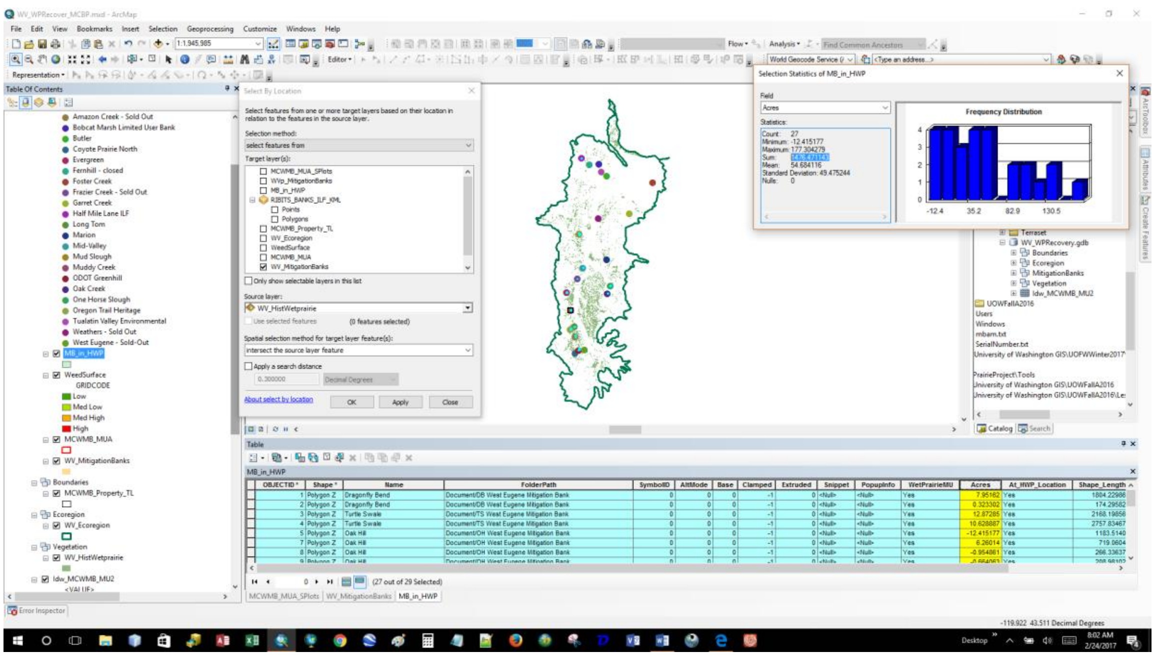


Figure 4. SQL Screening Queries Used to Estimate Wet Prairie Recovery Acreage by Mitigation Banks in the Willamette Valley Ecoregion.

prairie in the Willamette Valley ecoregion. However, since this estimate is based on total bank acreage and most banks have one or more management units that are not dedicated to restoring wet prairie but some other habitat type, it is judged to be an overestimate of the mitigation bank contribution to Willamette Valley wet prairie recovery. Visually we can discern that the recovery actions of these banks tend to be semi-evenly distributed throughout the entire Willamette Valley.

At a very coarse level we can say if a given bank is currently selling credits, it can be assumed that the management units on the banks are meeting their performance standard obligations. However, the reality is that on a case by case basis a given bank may or may not be meeting one or more of its performance standards over entire management units and / or may be only meeting its performance standards on some portion of a given management unit. And even if some credits are being temporarily withheld by the regulatory agencies, the bank can still show up on the ledger as being open for business. To illustrate this point, this project develops a hypothetical tool informed by field data to distinguish proportional performance on one performance metric, weeds, in a wet prairie management unit on the Muddy Creek Wetland Mitigation Bank in south Benton County, Oregon.

Vegetation sample plot data derived from the 2008 annual monitoring report for this Bank are assigned weed indexes (Marshall 2010).[2] If a plant is native it receives a weed score of 1, if nonnative but noninvasive it receives a weed score of 3, and if it is nonnative and invasive it receives a weed score of 5. A percent cover weighted average of all the plant species weed scores in each sample plot is used to derive a weed index score for the sample plot (Table 3).

Table 3. Example Sample Plot Weed Index Calculation.

Species	Percent Cover	Weed Index	Weighted Percent Cover	Weed Index for Sample Plot
Alopecurus geniculatus	63	3	189	375 / 189 = 1.98
Carex unilateralis	3	1	3	
Deschampsia cespitosa	15	1	15	
Juncus tenuis	15	1	15	
Rosa nutkana	15	1	15	
Mentha pulegium	15	5	75	
Eleocharis palustris	63	1	63	
Totals	189		375	

The sample plots were added to ArcMap as XY coordinates, rendered as an event in a WGS 1984 projection, and then exported to a shapefile and imported into the geodatabase Mitigation Bank feature dataset as a feature class projected in NAD 1983 UTM Zone 10. A field called Weed Index (WIndex) was added to the attribute table and each record for a sample plot was populated with a weed index for the sample plot based on the species nativity and percent cover attributes in the sample and using the arithmetic operations in Table 3 above. Next the Spatial Analyst Inverse Distance Weighting (IDW) tool was used to interpolate a raster weed surface (Figure 5) with a range between 1 (no weeds) and 5 (high weeds).

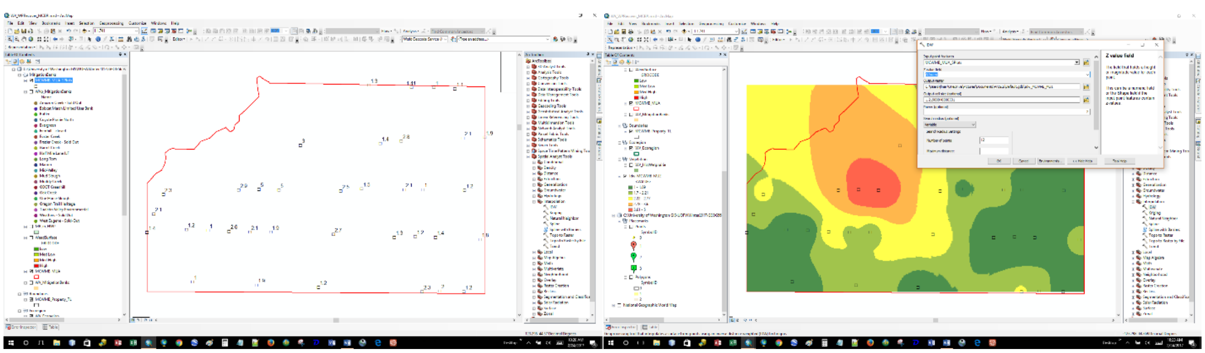


Figure 5. Plant Sample Plot Data Used to Interpolate a Weed Index Raster Surface.

The weed surface was divided into five classes using a natural breaks classification (Figure 6). To calculate an acreage measurement for each of the classes, the raster had to be converted into a polygon. However, before this procedure could be executed, a new raster was needed based on

[2] Similar indexes have been designed and used for documenting plant community moisture and salinity tolerances (Marshall 2010, Frenkel and Streatfield 1997, Marshall 2007, Marshall 1993).

the existing raster's cell values but altered from a continuous surface to a discrete surface. Each cell in the new raster needed to be given an integer value. To accomplish this, the int tool in the Math section of Spatial Analyst in ArcToolbox was used to create a new raster with integer cell values modeled from the existing raster's decimal values, but output as integers instead through truncation (Figure 7.) The truncation process eliminated one of the classes leaving four

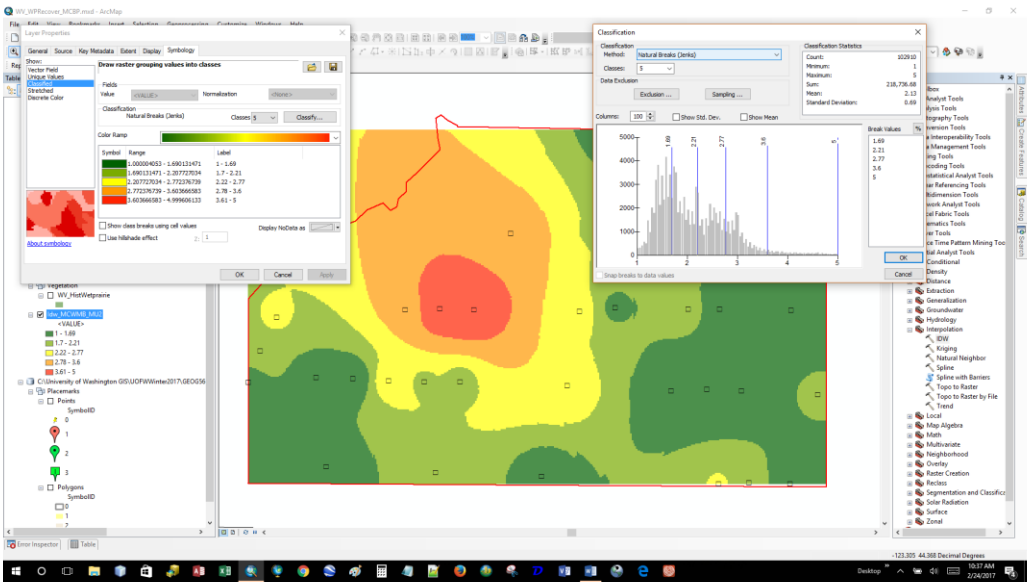


Figure 6. Weed Surface Classification (Continuous Surface).

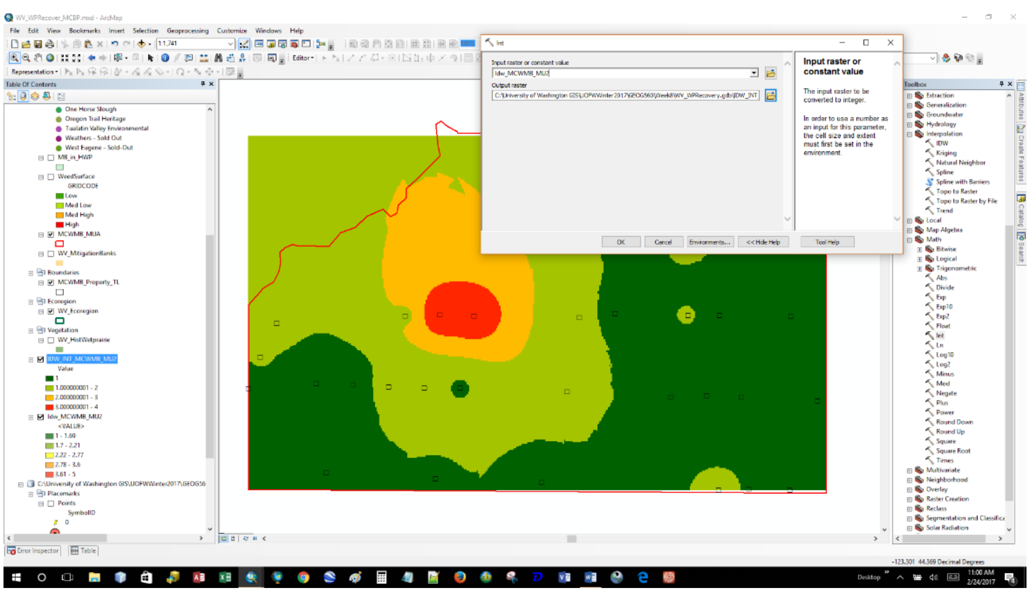


Figure 7. Weed Surface Classification (Discrete Surface).

weed index classes on the discrete surface output raster. The raster to polygon tool was then run on the discrete surface raster to produce a polygon with areal units with the same areal coverage by weed class as the discrete raster (Figure 8). This polygon was then imported into the geodatabase feature class for mitigation banks to give it the same coordinate system (NAD 1983 UTM Zone 10) as the other data in the geodatabase. The also served to give the polygon a projected coordinate system necessary to use the calculate geometry tool and determine the number of acres covered by the weed surface polygon (Figure 9). A SQL query is used to determine the proportional acreage of each weed class in the management unit (Figure 10).

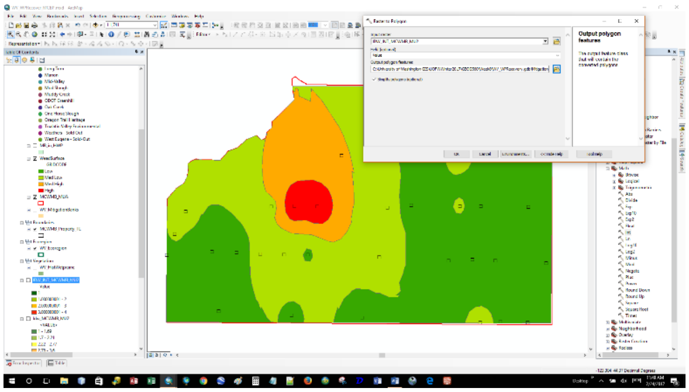


Figure 8. Polygon of Weed Surface Derived From the Discrete Raster.

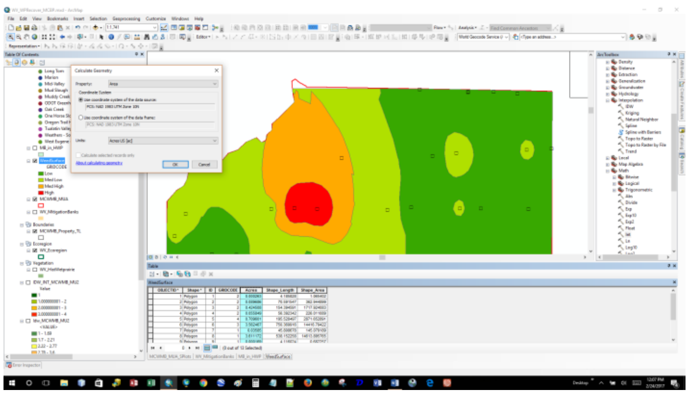


Figure 9. Use of Calculate Geometry Tool to Determine Weed Surface Acres Covered.

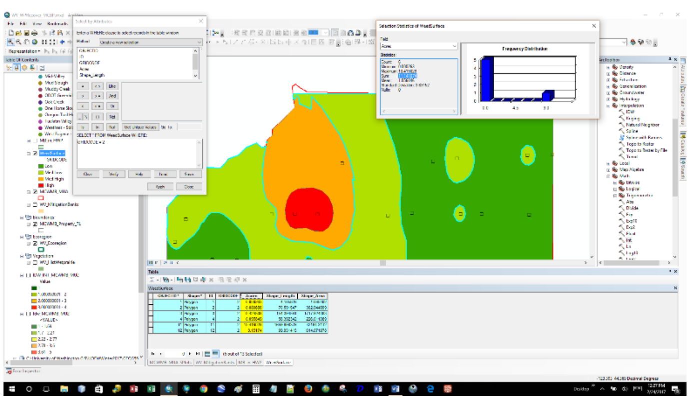


Figure 10. SQL Query is Used to Determine Acreage of Each Weed Class

These derived acreage values for four weed classes were then used to populate Table 4. And determine potential credits, penalty, available credit, and credit value.[3]

[3] Credit value based on the assumption that the price per credit is $75,000.00.

Table 4. Example Performance Based Credit Allotment and Value Calculation.

Weed Class	WindexRange	Acres	PotCredits[4]	Penalty[5]	AvailCredit[6]	CreditValue[7]
1	1 - 2	18.91	9.455	0	9.455	$709,125.00
2	2 - 3	11.14	5.57	0.25	4.1775	$313,312.50
3	3 - 4	3.56	1.78	0.50	0.89	$66,750.00
4	4 - 5	0.71	0.355	0.75	0.08875	$6,656.25
Total		34.32	17.16		14.61	$1,095,843.75

3.0 Results

A primary goal of this project was to compare the historical loss of pre-European settlement wet grass prairie in the Willamette Valley Ecoregion with the progress being made by an ecoregion-wide mitigation and conservation banking program targeting the recovery of wet grass prairie in the Willamette Valley. It was determined that the mitigation and conservation banks in the Willamette Valley ecoregion may be contributing as much as 1,476-acres of wet prairie recovery. Visually we can discern that the recovery actions of these banks tend to be semi-evenly distributed throughout the entire Willamette Valley (Figure 1 and 16).

Looking at the data from the Muddy Creek Wetland Mitigation Bank Management Unit A, it is possible to say that on this tract of land 87% of the land has a weed index of 3 or less which is successfully reflected in the output of this projects hypothetical method for assessing the bank's economic viability (85% of its potential credit is available for sale) proportional to it ecological performance.

Within the context of our socio-ecological characterization and mapping framework we have reasonable indication that at the ecosystem level, from pre-European settlement to present-day, there is a substantial trend toward semi-evenly distributed wet prairie acreage recovery. For one land parcel, management unit, and associated vegetation sample plots, we have reasonable indication (presuming the performance threshold is valid) that the prairie quality with respect to weeds is being adequately managed.

4.0 Discussion

The first observation should be that for prairie quality recovery, the sample size (n = 1) is much too small to make any broader inferences from. Another concern is that while the concentration on wet prairie is understandable given the nature of the regulatory program's tendency to focus on aquatic habitat and species (Marshall et al 1987, Gwin et al 1999), historically there was also a tremendous historical loss of native upland prairie (interdigitated with the wet prairie) resulting in its own set of associated imperiled species that this project completely ignores. Also, mitigation and conservation banking are not the only projects in the Willamette Valley engaged in wet prairie recovery activities. There are likely as many or more private lands and public lands projects both in the past and on-going that were not considered in this project. Finally,

[4] Potential credit based on an assumption of an acreage divider of 2 (e.g., 10-acres = 5-credits).

[5] Penalty is arbitrarily assigned for purposes of illustration and does not reflect actual penalties for low performance currently levied at mitigation banks.

[6] AvailCredit is derived using this formula: AvailCredit = PotCredits – (PotCredits x Penalty).

[7] CreditValue is derived using this formula: CreditValue = AvailCredit x $75,000.00.

there is no rationale or path laid out in this project to assess where the benchmark for the state of "successfully recovered" should be placed. Therefore, we cannot discern from the information used in this project where we are in the trajectory toward wet prairie recovery in the Willamette Valley, only that some progress appears to have been made.

From the socio-ecological perspective this project does provide some insight into spatial and temporal wet prairie loss and recovery across multiple scales, and it does offer room to speculate on the quantitative and qualitative nature of wet prairie across social, ecological, and economic aspects of human interactions with this resource. But mostly to the extent that it leaves more questions unanswered than it offers answers for and the sense that there is a lot of work remaining to be done.

5.0 Implementation

Constructing Optimal Project Information Reporting Interface. The reporting interface for this project is comprised of three major components: 1. A Hyper Text Markup Language (HTML) file functionally enabled by html, JavaScript (JS), and Cascade Style Sheets (CSS) code, 2. Hyperlinks to a series of static map jpg exports from ArcGIS Desktop, and 3. A URL connection to a project related web map application supported by ArcGIS On-Line University of Washington organizational account. Subcomponents include other hyperlinks embedded into the html file: 1. ESRI geodatabase diagrammer file, 2. ESRI geodatabase schema report file, and 3. kmz file supported for display by Google Earth software. As a prototype design, the html file is not now hosted as a web page with internet access and must be downloaded locally along with its supporting files in a common file folder for users to access it and connect with its contents. Notepad++ is the Integrated Development Environment (IDE) used to write code for this project and run it on various browsers.

HTML is the standard markup language for creating web pages and web applications. It semantically provides the web page structure (e.g., elements) for embedding different items including but not necessarily limited to text, URL links, other code languages such as CSS to inform web page appearance, and JS to create web page user interfaces and other functions. See an excerpt from this projects HTML code and a screenshot of how the code displays on the web browser in Appendix F.

CSS is a code language that serves to give various presentation options (e.g., color, size, fonts, etc.) to documents written in a markup language like HTML and XHTML. See an excerpt from this projects CSS code and a screenshot of how the code displays on the web browser in Appendix G.

JS is a code language that serves to add functionality to elements on web pages. See an excerpt from this projects js code and a screenshot of how the code displays on the web browser in Appendix H.

A central part of this project involved publishing a web map and a web map application (Appendices I and J). Static Maps were exported from ArcMap as jpg files, placed in the same file folder as the html file, and are rendered directly to the web page browser using the html code in conjunction with their respective file names. A Google Earth mitigation bank layer is made available to the web page using a mouse click event and a kmz file which is also sitting in the same folder as the html file (Figures 11 – 15).

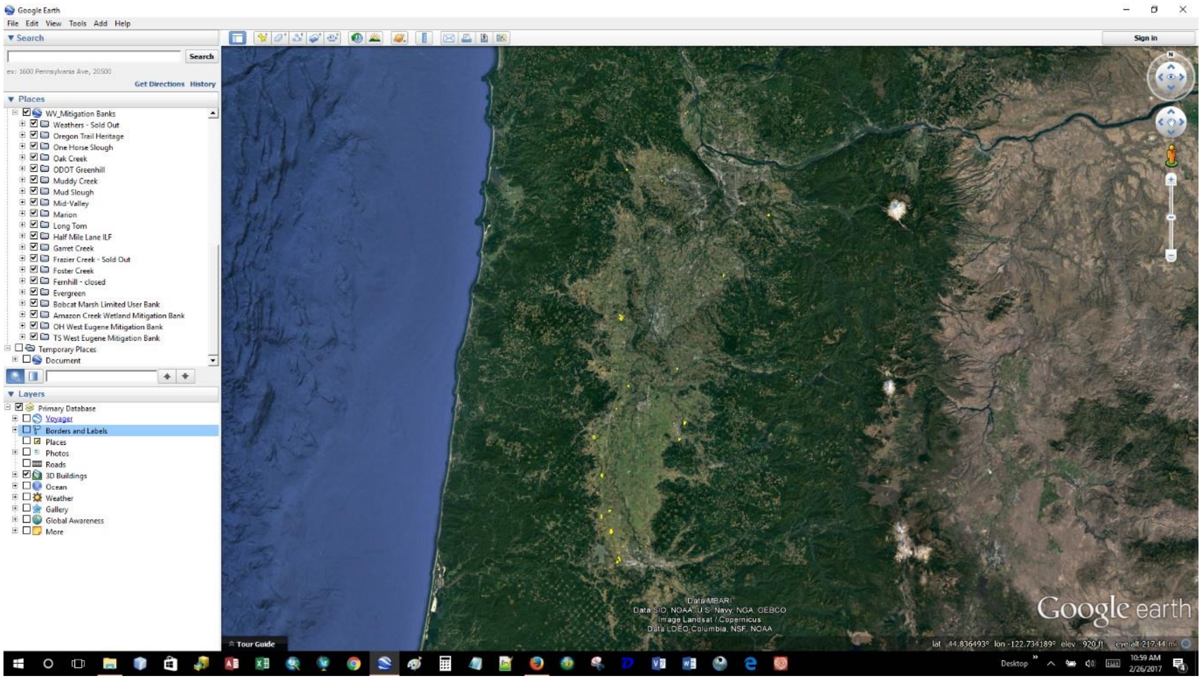


Figure 11. Willamette Valley Ecoregion Mitigation Banks (Ecoregion Scale / Google Earth).

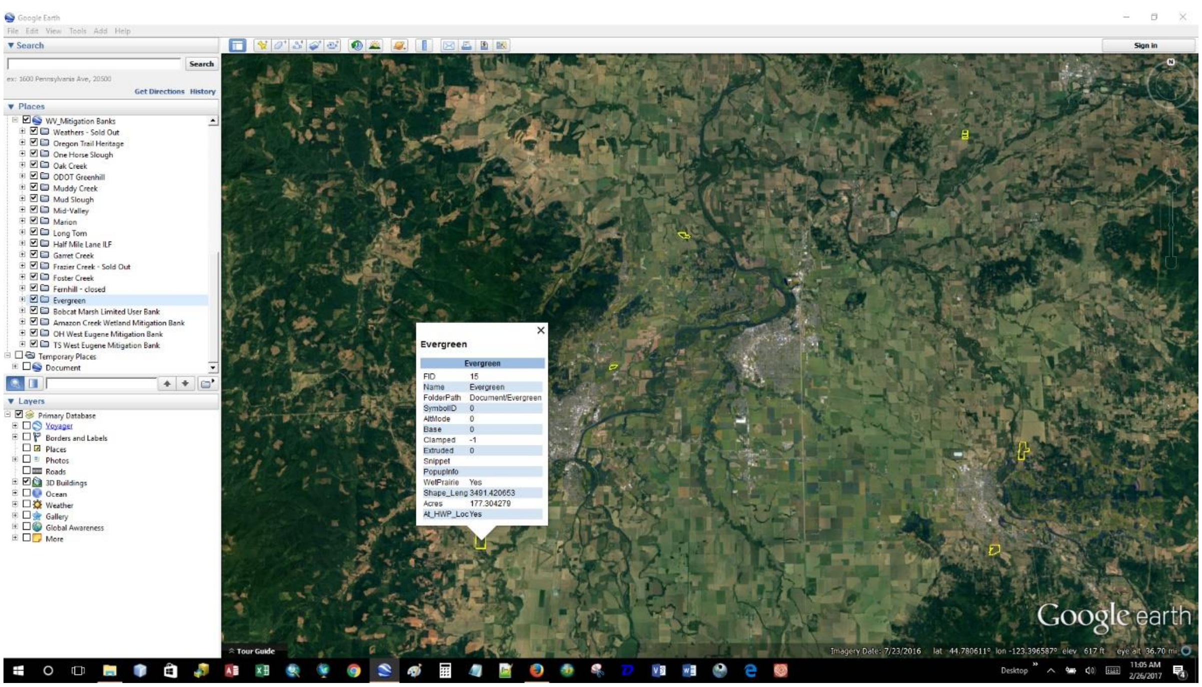


Figure 12. Willamette Valley Ecoregion Mitigation Banks (Mid-Valley Scale / Google Earth).

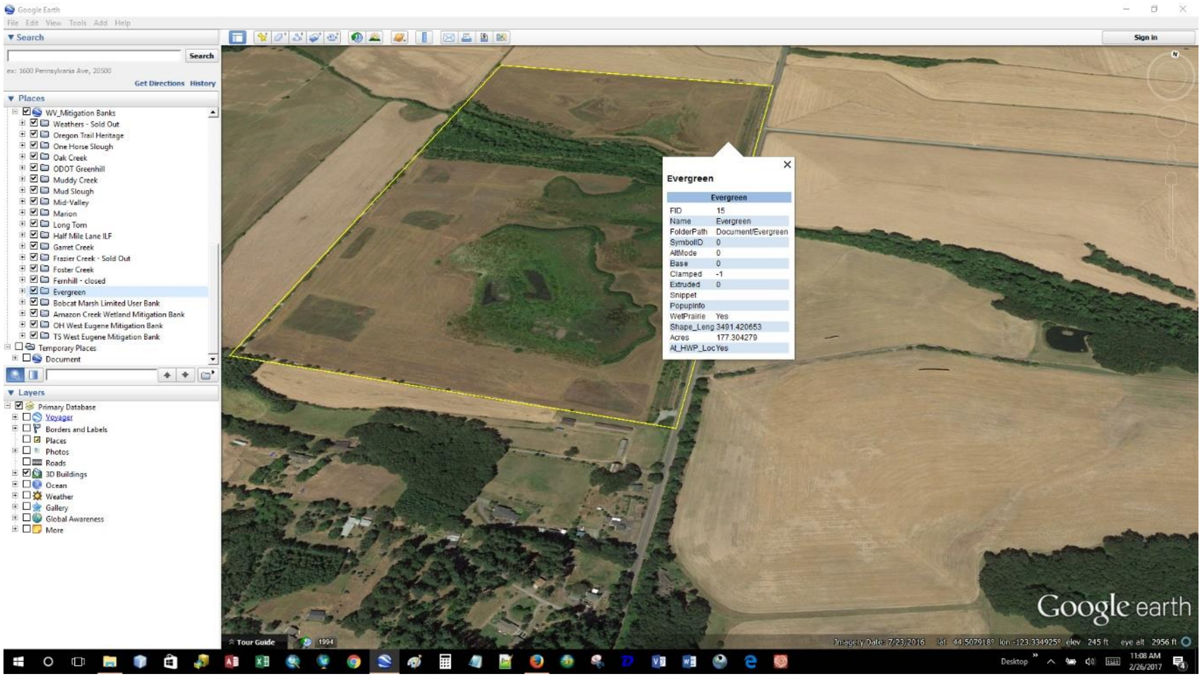


Figure 13. Evergreen Wetland Mitigation Bank (Site Scale / Google Earth).

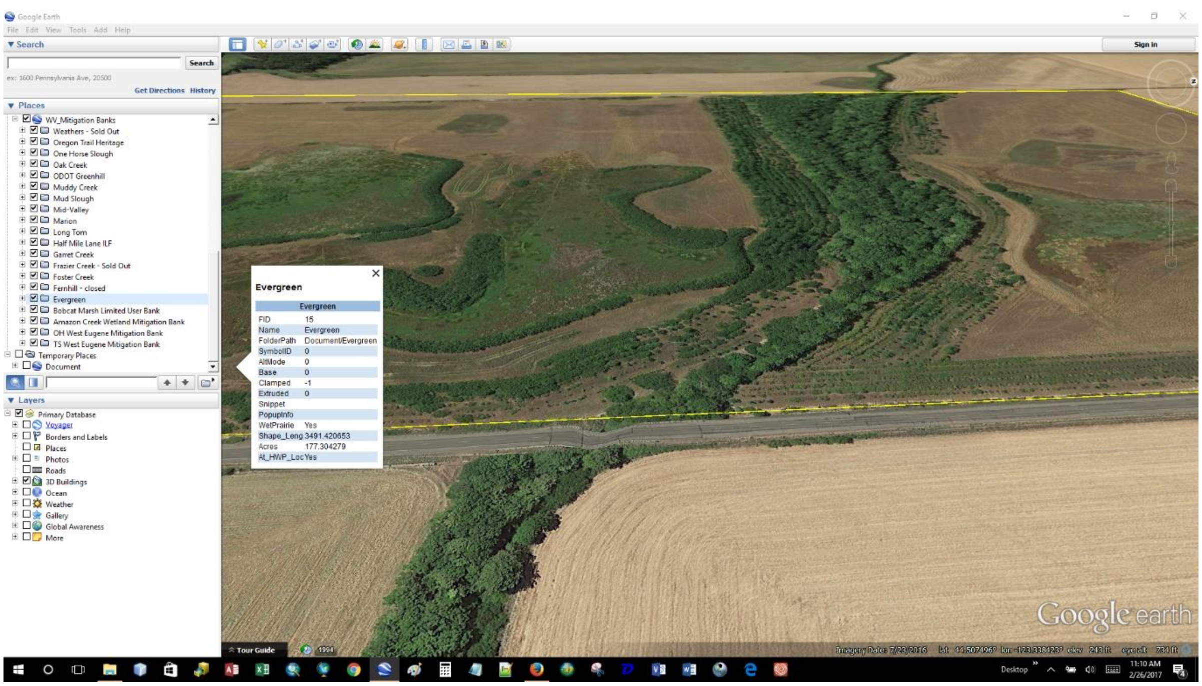


Figure 14. Evergreen Wetland Mitigation Bank (Management Unit Scale / Google Earth).

The same file geodatabase data (Table 2, Appendix B and C) was used to create the static maps and to publish the web map application. All maps were created following cartographic best practices described in Appendix D as a guide.

Figure 15. Evergreen Wetland Mitigation Bank (Ground View / Google Earth).

A web map application is made available on the web page using a mouse click event to access a URL (http://uw-geog.maps.arcgis.com/apps/View/index.html?appid=d64ab819a4544b3795aec2a381905855&extent=-123.3072,44.3676,-123.2958,44.3716) imbedded in the html code (Figures 16 - 21).

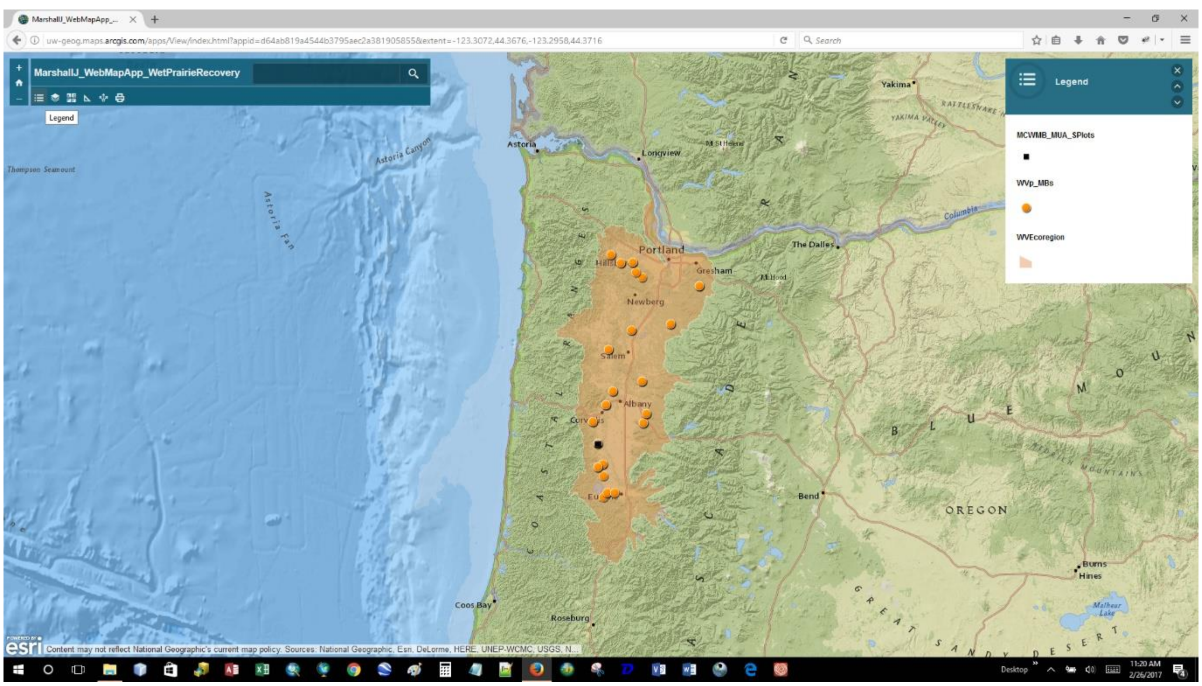


Figure 16. Willamette Valley Ecoregion Mitigation Banks (Ecoregion Scale / Web Map App).

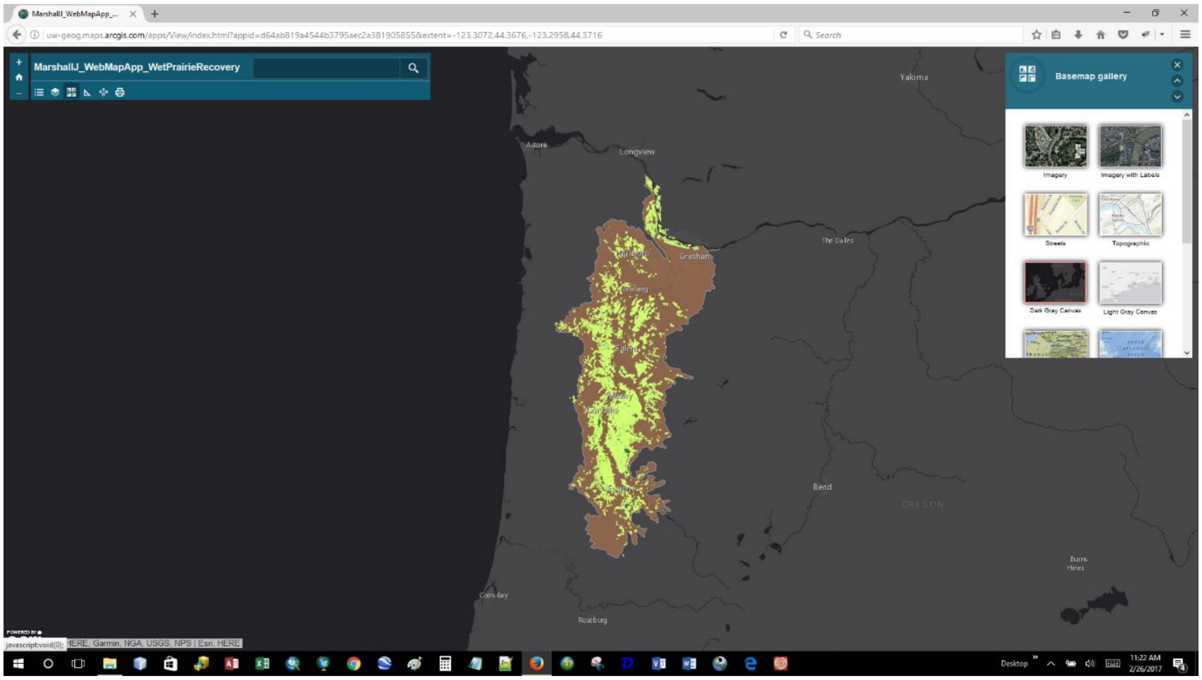


Figure 17. Willamette Valley Ecoregion Historic Wet Prairie (Ecoregion Scale / Web Map App).

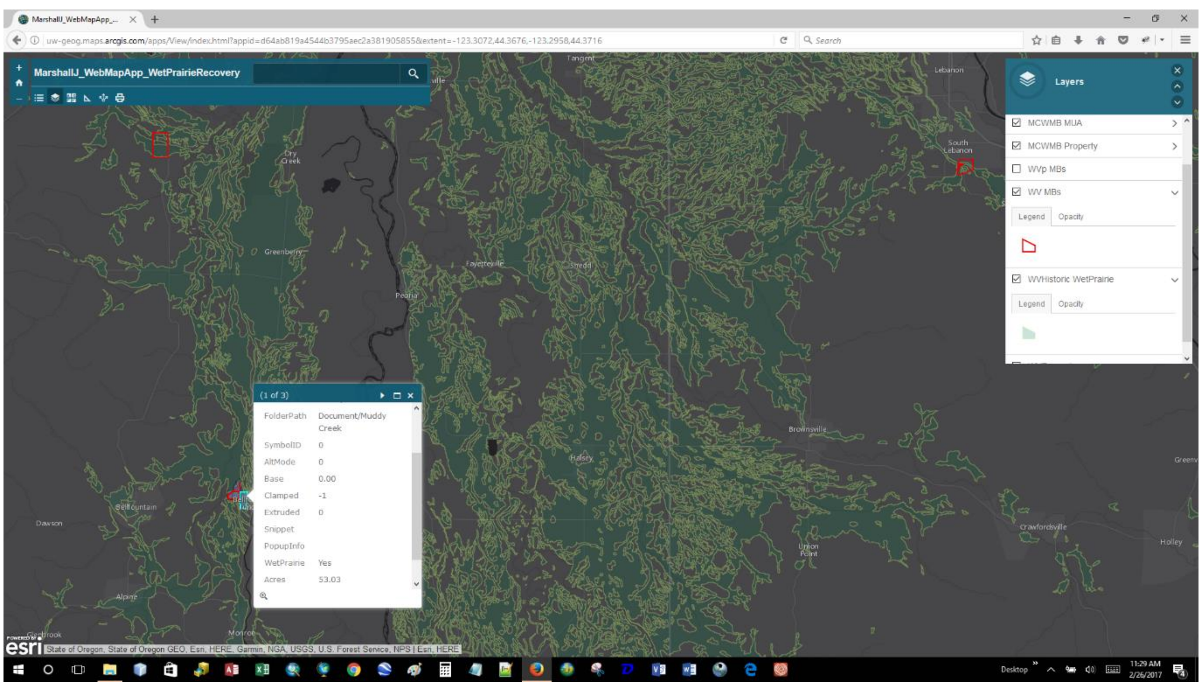


Figure 18. Willamette Valley Ecoregion Historic Wet Prairie and Mitigation Banks (Mid-Valley Scale / Web Map App).

While the entire GIS and mapping effort used in this project was designed to support the concept of a socio-ecological approach to characterize and address solutions (mitigation bank aided wet prairie recovery) to target problems (extensive historical loss of prairie across the entire Willamette Valley ecosystem), it should not be considered outside of the context of the information and functional tools coded into the web page containing the maps. The text is

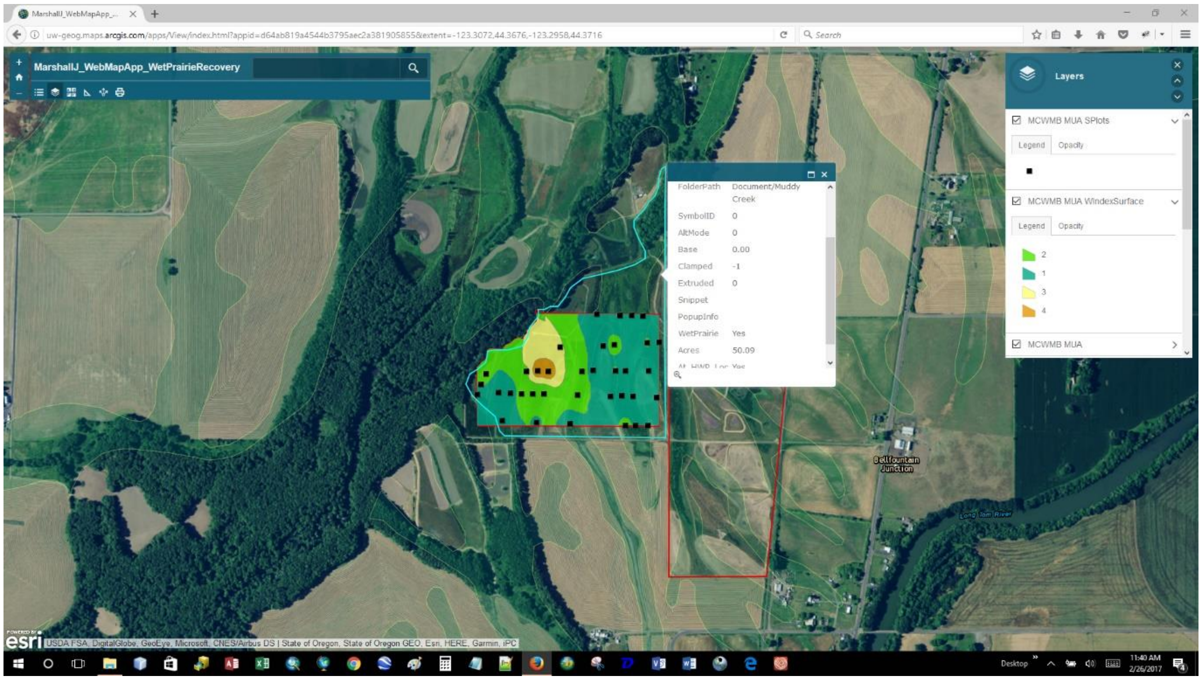


Figure 19. Muddy Creek Wetland Mitigation Bank Prairie Restoration Management Unit Weed Index Surface and Historic Wet Prairie (Site Scale / Web Map App).

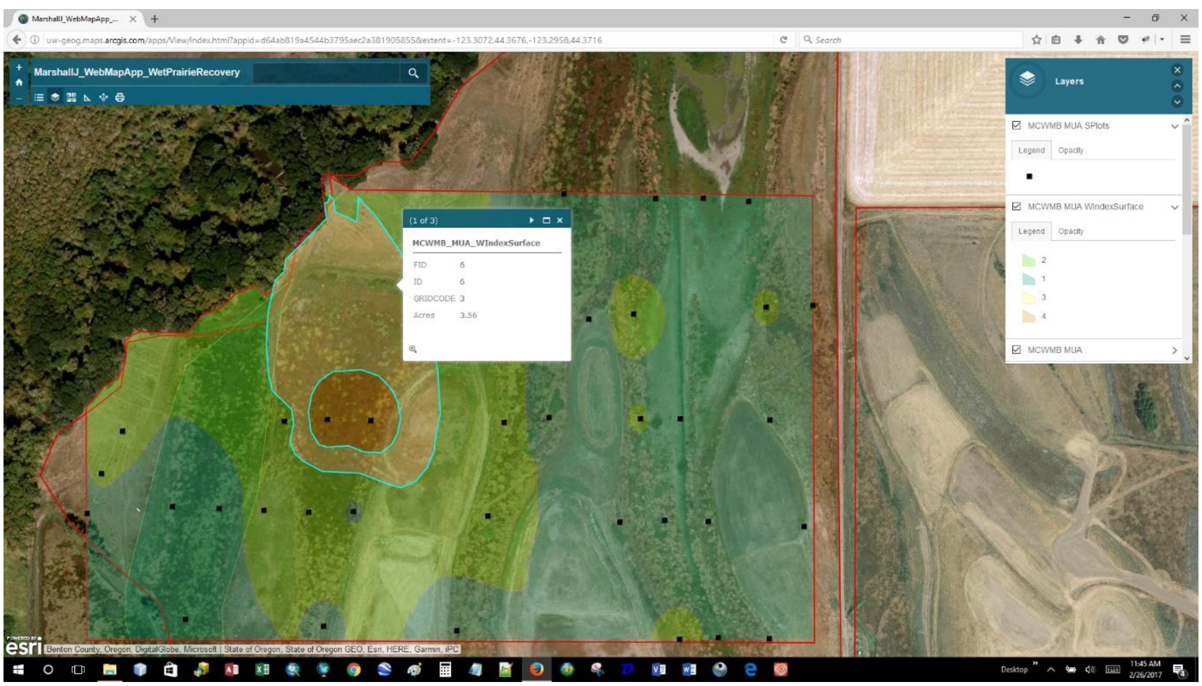


Figure 20. Muddy Creek Wetland Mitigation Bank Prairie Restoration Management Unit Weed Index Surface and Historic Wet Prairie (Management Unit Scale / Web Map App).

especially important in helping the user understand the meaning of the data displayed in the maps in a manner that bridges multiple spatial and temporal scales while crossing relevant human systems or knowledge domains (sociological, ecological, and economic). In fact, the html code (using fieldsets) visibly organizes the story (see excerpts from the web page story in

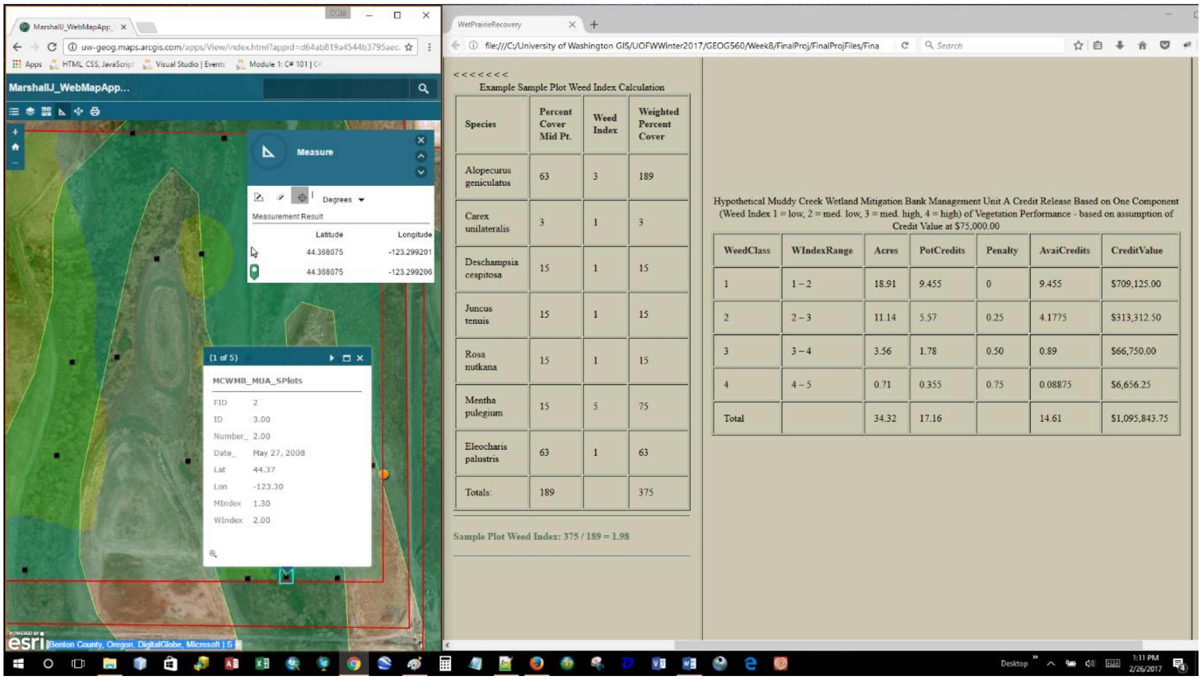


Figure 21. Muddy Creek Wetland Mitigation Bank Prairie Restoration Management Unit Weed Index Surface and Historic Wet Prairie (Sample Plot Scale / Web Map App – Web Page).

Table 5 below). The text provided in the web page under these three headings emphasizes and reinforces their importance to the focal issues of the project. The lines between these human systems / knowledge domains are not always distinct and often blend into one another.

Table 5. Socio-Ecological Context for Annotated Excerpts from Web Page Story Lines.

Ecological. *Historical losses subsequent to European settlement contribute to present conditions of rare habitat and species.*	*It is estimated that up to 99% of the original Willamette Valley wetgrass prairie may have been lost to agricultural conversion and urban development. Several plant and animal species that depend on the prairie for their survival are Federally listed as threatened or endangered.*
Economic. *Rare habitat and species become a source of income to landowners incentivizing their protection and restoration.*	*This helps give an economic incentive for mitigation bank sponsors to manage for high performance of public trust resources.*
Social. *Newspapers reflect changing societal values and new partnerships.*	*Wetland mitigation banks seem to strike a mutually beneficial balance between the needs of developers and the concerns of environmentalists.*

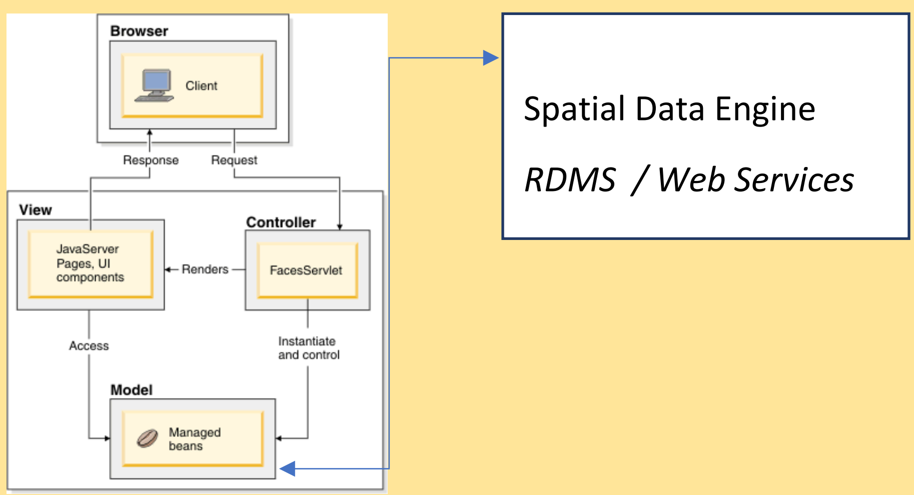
The entire project (web page, web map, static maps, etc.) comprises a socio-ecological characterization and mapping framework that is used as the operational construct for meeting the project objective. It recognizes the hierarchical spatial scales of ecoregion, mid-range ecoregion, land parcel or site, management unit, and sample plot and a time scale ranging between pre-European settlement to the present. The primary human system/knowledge domains traversed included social, ecological, and economic foci.

6.0 Logical Next Steps

This project currently uses several powerful technologies (e.g., a geodatabase, a web page, a web map application service, geographical information system mapping, geoprocessing, and analyses tools, etc.). But they are applied to a very small subset of the total data available and in a relatively very loosely connected manner. To effectively make use of the potential data management benefits these technologies offer, the entire complement of data associated with the ecoregion-wide mitigation and conservation banking program(s), along with nonregulatory wet prairie restoration efforts, needs to be entered onto a relational database management system (RDBMS) operating inside an enterprise spatial database engine that is accessible by a graphical user interface (GUI) in one or more web pages and capable of having supervised data entered and queried (e.g., customized stored procedures) from remote clients such as desktop computers, remote sensors, and hand held mobile devices with GPS functionality.

There are likely numerous organizational technical models that can be developed to achieve this goal, depending on such factors as hardware and software selection, vendors, budget, security needs, etc. But most of them will probably have the following primary features in common with the JAVA based system illustrated in Figure 22.

Model	Encapsulates the information (data) and the methods to operate on that information (business logic). Managed beans define the model of a JSF application. These Java™ beans typically interface with reusable business logic components or external systems, such as a mainframe or a **relational database management system**.
View	Presents the Model. JSPs / HTMLs make up the view of a JSF web application. These JSPs / HTMLs interact with JAVA code and use predefined and custom-made GUI components connecting to the Model.
Controller	Processes user events and drives Model and View updates. The Faces Servlet, which handles the request processing lifecycle defined by JSF, drives the application flow.



http://www.ibm.com/support/knowledgecenter/SSRTLW_9.5.0/com.ibm.etools.jsf.doc/topics/cmvc.html

Figure 22. Model / RDBMS, View, Controller Technology).

Literature Cited

Alverson, Edward R. 2006. Use of Prescribed Fire in Willamette Valley Native Prairies. The Nature Conservancy.

Alverson. 2004. Historic vegetation of Willamette Valley, Oregon, in the 1850's. Unpublished manuscript.

Arghangelsky 2009. VEMAData File. Muddy Creek Wetland Mitigation Bank.

Benton County, Oregon. 2010. Web site: County Assessors Tax Lot Boundaries, http://www.co.benton.or.us/maps/availdata.php?p=1&f=GISDataDownload/Assessment

Bosse, Charles. 2008. Fire in Wetland Prairie. HC 441: Willamette River Health Clark Honors College, University Christensen, Briggs 2008 Monitoring Report.

Council on Environmental Quality. 1997. Considering Cumulative Effects Under the National Environmental Policy Act, Executive Office of the President, Washington, D.C.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Office of Biological Services, Washington, D.C.

Frenkel, Robert E. and Rosemary Streatfield. 1997. Ecological Survey and Interpretation of the Willamette Floodplain Research Natural Area, W.L. Finley National Wildlife Refuge, Oregon, USA. Department of Geosciences, Oregon State University, Corvallis Oregon: In Natural Areas Journal, Volume 17(4), 1997.

Gwin, Stephanie E., Mary Kentula, and Paul Shaffer. 1999. Evaluating the effects of wetland regulation through the hydrogeomorphic classification and landscape profiles, Wetlands, Vol. 19, No. 3, The Society of Wetland Scientists, U.S. Environmental Protection Agency, Dynamic corporation Services, Corvallis, Oregon.

Habeck, J. R. 1961. The original vegetation of the mid-Willamette Valley, Oregon. Northwest Science 35:65-77.

Johannessen, C. L., W. A. Davenport, A. Millet, and S. McWilliams. 1971. The Vegetation of the Willamette Valley. Ann. Ass. Am. Geogr. 61:286-302.

Kiilsgaard ,Chris and Jeffery Reams. 2007. Memorandum of Agreement and Wetland Mitigation Bank Instrument (MOA): the establishment, use, operation, and maintenance of the Muddy Creek Mitigation Bank (Bank), U.S. Army Corps of Engineers (Corps), the Oregon Department of State Lands (DSL), the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (USFWS), and the Oregon Department of Fish and Wildlife (ODFW).

Marshall, John L. 2010. An Analysis of Plant Moisture Indexes and Potential Dependent Weed Indexes for Wetland Prairie Vegetation at the Muddy Creek Wetland Mitigation Bank, GIS Certificate Program, Geography 575-Digital Compilation and Database Design, Final Class Project, Term Paper, Portland State University, Portland, Oregon.

Marshall, John L. 2007. Draft Guidance for Vegetation Planning and Monitoring in Western Oregon Wetlands and Riparian Areas: Using Reference Sites to Help Plan and Evaluate Vegetation Performance of Mitigation Sites, U.S. Fish and Wildlife Service, Oregon Department of State Lands, Oregon Fish and Wildlife Office, Portland, Oregon.

Marshall, John L. 1993. Weighted Moisture and Salinity Tolerance Indexes at Astoria Airport Mitigation Bank. Draft Paper Submitted to Oregon Division of State Lands, Salem, Oregon.

Marshall, John, David S. Fox, Mark Barnes, and Hiller West. 1987. A Mitigation and Restoration Plan for the Columbia River Estuary, Columbia River Estuary Study Taskforce, Astoria, Oregon.

Norman, Katherine N. 2008. The Effects of Site Preparation on Native Forb Establishment in a Wet Prairie, Willamette Valley, Oregon. A Master's Thesis for the degree of Master of Science in Botany and Plant Pathology, Oregon State University, Corvallis, Oregon.

Oregon Department of Fish and Wildlife. 2006. Oregon Conservation Strategy. Oregon Department of Fish and Wildlife, Salem, Oregon.

Pendergrass, Kathy L. 1995. Vegetation Composition and Response to Fire of Native Willamette Valley Wetland Prairies. Master's Thesis, Oregon State University, Corvallis, Oregon.

Pfeifer-Meister, Laurel. 2008. Community and Ecosystem Dynamics in Remnant and Restored Prairies, PhD Dissertation, Department of Biology, Graduate School of the University of Oregon, Eugene, Oregon.

Reid, Walter V. 2006. Bridging Scales and Knowledge Systems: Concepts and Applications in Ecosystem Assessment. Millennium Ecosystem Assessment Program, Island Press, Washington D.C.

Schwindt, Rachel A. 2006. Plant Community Dynamics in Remnant and Restored Willamette Valley Wetland Prairies. Master s Thesis, Oregon State University, Corvallis, Oregon.

Slocum, Terry A, Robert B. McMaster, Fritz B. Kessler, and Hugh H. Howard 2009. Thematic Cartography and Visualization: Third Edition. Pearson Prentice Hall, Pearson Education Inc., Upper Saddle River, N.J. 07458.

Titus, Jonathan H., John A. Christy, Dick VanderSchaaf, James S. Kagan, and Edward R. Alverson. 1996. Native Wetland, Riparian, and Upland Plant Communities and their Biota in the Willamette Valley, Oregon, Phase I Project: Inventory and Assessment, Report to Environmental Protection Agency, Region X, Seattle, Washington Willamette Basin Geographic Initiative Program Oregon Natural Heritage Program, The Nature Conservancy, Portland, Oregon

U.S. Army Corps of Engineers 2017. Regulatory In-Lieu-Fee and Bank Tracking System (RIBITS), https://ribits.usace.army.mil/ribits_apex/f?p=107:2

U.S. Fish and Wildlife Service and National Marine Fisheries Service 1998. Endangered Species Act Consultation Handbook, Procedures for Conducting Section 7 Consultations and Conferences, Washington, D.C.

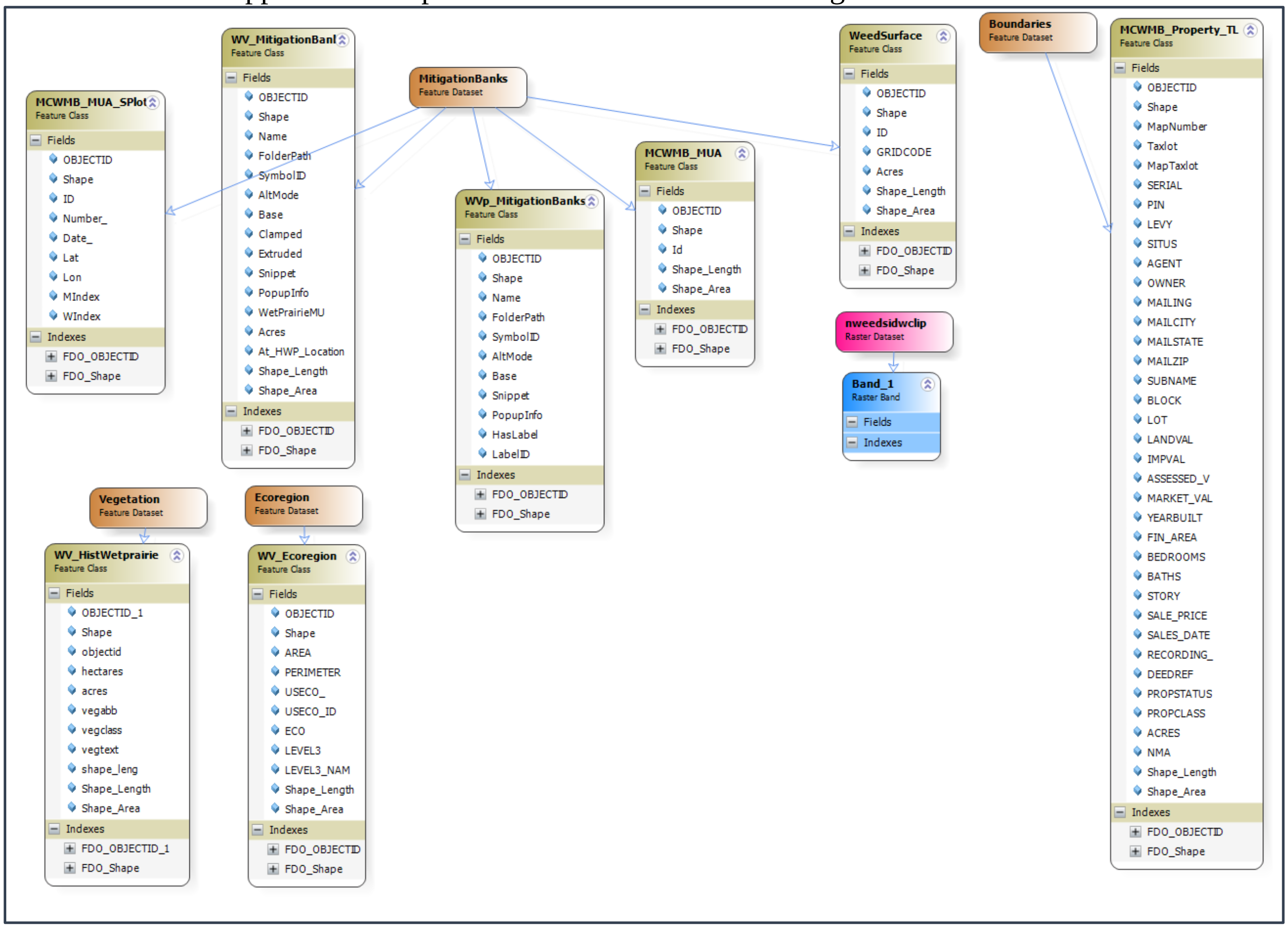
Walker, B. H. and David Salt 2012. Describing the System, in Resilience Practice: Building Capacity to Absorb Disturbance and Maintain Function, Island Press, Washington D.C. 35-53.

Appendix A – Project Design Framework

Title: Willamette Valley Ecoregion Wet-grass Prairie Recovery Using the Assistance of a Statewide Conservation and Mitigation Banking Program.

Human Systems / Scale	Social	Environmental	Economic
Ecoregion: (Willamette Valley, Oregon)	Native American Subsistence/Culture to European Domain	Extreme Habitat Loss and Loss of Species	Subsistence to Farm Based to Industrial to Post-Industrial
Land Parcel (Muddy Creek Wetland Mitigation Bank)	Alternative Lifestyle Regulation Adverse to Regulation Support	Land Restoration Habitat Recovery Species Recovery	Natural Resource Based Economy
Management Unit (Management Unit A)	Science Based Work Modern Social Role Soc./Cult. Shift	Natural Resource Accountability	Natural Resource Units Equate to Income
Sample Plot (Sample Plot 1 – 37)	Interdisciplinary Knowledge Applied / Community Shared	Environmental Performance Based Accountability	Income Tied to Environmental Performance

Appendix B – Spatial Data File Geodatabase Diagram



Dimension	Minimum	Precision
Boundaries		
X	-5120900	10000
Y	-9998100	
M	-100000	10000
Z	-100000	10000
Coordinate System Description PROJCS["NAD_1983_UTM_Zone_10N",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Transverse_Mercator"],PARAMETER["False_Easting",500000.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-123.0],PARAMETER["Scale_Factor",0.9996],PARAMETER["Latitude_Of_Origin",0.0],UNIT["Meter",1.0],AUTHORITY["EPSG",26910]]		
Ecoregion		
X	-5120900	10000
Y	-9998100	
M	-100000	10000
Z	-100000	10000
Coordinate System Description PROJCS["NAD_1983_UTM_Zone_10N",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Transverse_Mercator"],PARAMETER["False_Easting",500000.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-123.0],PARAMETER["Scale_Factor",0.9996],PARAMETER["Latitude_Of_Origin",0.0],UNIT["Meter",1.0],AUTHORITY["EPSG",26910]]		
MitigationBanks		
X	-5120900	10000
Y	-9998100	
M	-100000	10000
Z	-100000	10000
Coordinate System Description PROJCS["NAD_1983_UTM_Zone_10N",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Transverse_Mercator"],PARAMETER["False_Easting",500000.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-123.0],PARAMETER["Scale_Factor",0.9996],PARAMETER["Latitude_Of_Origin",0.0],UNIT["Meter",1.0],AUTHORITY["EPSG",26910]]		
Vegetation		
X	-5120900	10000
Y	-9998100	
M	-100000	10000
Z	-100000	10000
Coordinate System Description PROJCS["NAD_1983_UTM_Zone_10N",GEOGCS["GCS_North_American_1983",DATUM["D_North_American_1983",SPHEROID["GRS_1980",6378137.0,298.257222101]],PRIMEM["Greenwich",0.0],UNIT["Degree",0.0174532925199433]],PROJECTION["Transverse_Mercator"],PARAMETER["False_Easting",500000.0],PARAMETER["False_Northing",0.0],PARAMETER["Central_Meridian",-123.0],PARAMETER["Scale_Factor",0.9996],PARAMETER["Latitude_Of_Origin",0.0],UNIT["Meter",1.0],AUTHORITY["EPSG",26910]]		

ObjectClass Name	Type	Geometry	Subtype	
Boundaries				SR
MCWMB_Property_TL	Simple FeatureClass	Polygon	-	
Ecoregion				SR
WV_Ecoregion	Simple FeatureClass	Polygon	-	
MitigationBanks				SR
MCWMB_MUA	Simple FeatureClass	Polygon	-	
MCWMB_MUA_SPlots	Simple FeatureClass	Point	-	
WeedSurface	Simple FeatureClass	Polygon	-	
WV_MitigationBanks	Simple FeatureClass	Polygon	-	
WVp_MitigationBanks	Simple FeatureClass	Point	-	
Vegetation				SR
WV_HistWetprairie	Simple FeatureClass	Polygon	-	
Stand Alone ObjectClass(s)				

WV_Ecoregion

Alias	WV_Ecoregion	**Geometry:**Polygon
Dataset Type	FeatureClass	**Average Number of Points:**0 **Has M:**No
FeatureType	Simple	**Has Z:**No **Grid Size:**270000

Field Name	Alias Name	Model Name	Type	Precn.	Scale	Length	Null
OBJECTID		OBJECTID	OID	0	0	4	No
Shape		Shape	Geometry	0	0	0	Yes
AREA			Double	0	0	8	Yes
PERIMETER			Double	0	0	8	Yes
USECO_			Integer	0	0	4	Yes
USECO_ID			Integer	0	0	4	Yes
ECO			String	0	0	7	Yes
LEVEL3			Integer	0	0	4	Yes
LEVEL3_NAM			String	0	0	90	Yes
Shape_Length		Shape_Length	Double	0	0	8	Yes
Shape_Area		Shape_Area	Double	0	0	8	Yes

Subtype Name	Default Value	Domain

Index Name	Ascending	Unique	Fields
FDO_OBJECTID	Yes	Yes	OBJECTID
FDO_Shape	Yes	No	Shape

WV_HistWetprairie

Alias	WV_HistWetprairie	**Geometry:**Polygon
Dataset Type	FeatureClass	**Average Number of Points:**0 **Has M:**No
FeatureType	Simple	**Has Z:**No **Grid Size:**6000

Field Name	Alias Name	Model Name	Type	Precn.	Scale	Length	Null
OBJECTID_1		OBJECTID_1	OID	0	0	4	No
Shape		Shape	Geometry	0	0	0	Yes
objectid	objectid	objectid	Integer	0	0	4	Yes
hectares	hectares	hectares	Double	0	0	8	Yes
acres	acres	acres	Double	0	0	8	Yes
vegabb	vegabb	vegabb	String	0	0	16	Yes
vegclass	vegclass	vegclass	String	0	0	50	Yes
vegtext	vegtext	vegtext	String	0	0	254	Yes
shape_leng	shape_leng	shape_leng	Double	0	0	8	Yes
Shape_Length		Shape_Length	Double	0	0	8	Yes
Shape_Area		Shape_Area	Double	0	0	8	Yes

Subtype Name	Default Value	Domain

Index Name	Ascending	Unique	Fields
FDO_OBJECTID_1	Yes	Yes	OBJECTID_1
FDO_Shape	Yes	No	Shape

WVp_MitigationBanks

Alias	WVp_MitigationBanks	**Geometry:**Point
Dataset Type	FeatureClass	**Average Number of Points:**0
FeatureType	Simple	**Has M:**No **Has Z:**Yes **Grid Size:**17881.9408710857

Field Name	Alias Name	Model Name	Type	Precn.	Scale	Length	Null
OBJECTID		OBJECTID	OID	0	0	4	No
Shape		Shape	Geometry	0	0	0	Yes
Name	Name	Name	String	0	0	255	Yes
FolderPath	FolderPath	FolderPath	String	0	0	255	Yes
SymbolID	SymbolID	SymbolID	Integer	0	0	4	Yes
AltMode	AltMode	AltMode	Small Integer	0	0	2	Yes
Base	Base	Base	Double	0	0	8	Yes
Snippet	Snippet	Snippet	String	0	0	268435455	Yes
PopupInfo	PopupInfo	PopupInfo	String	0	0	268435455	Yes
HasLabel	HasLabel	HasLabel	Small Integer	0	0	2	Yes
LabelID	LabelID	LabelID	Integer	0	0	4	Yes

Subtype Name	Default Value	Domain

Index Name	Ascending	Unique	Fields
FDO_OBJECTID	Yes	Yes	OBJECTID
FDO_Shape	Yes	No	Shape

WV_MitigationBanks

Alias	WV_MitigationBanks	**Geometry:**Polygon
Dataset Type	FeatureClass	**Average Number of Points:**0
FeatureType	Simple	**Has M:**No **Has Z:**Yes **Grid Size:**1200

Field Name	Alias Name	Model Name	Type	Precn.	Scale	Length	Null
OBJECTID		OBJECTID	OID	0	0	4	No
Shape		Shape	Geometry	0	0	0	Yes
Name	Name	Name	String	0	0	255	Yes
FolderPath	FolderPath	FolderPath	String	0	0	255	Yes
SymbolID	SymbolID	SymbolID	Integer	0	0	4	Yes
AltMode	AltMode	AltMode	Small Integer	0	0	2	Yes
Base	Base	Base	Double	0	0	8	Yes
Clamped	Clamped	Clamped	Small Integer	0	0	2	Yes
Extruded	Extruded	Extruded	Small Integer	0	0	2	Yes
Snippet	Snippet	Snippet	String	0	0	268435455	Yes
PopupInfo	PopupInfo	PopupInfo	String	0	0	268435455	Yes
WetPrairieMU			String	0	0	5	Yes
Acres		Acres	Double	0	0	8	Yes
At_HWP_Location		At_HWP_Location	String	0	0	5	Yes
Shape_Length		Shape_Length	Double	0	0	8	Yes
Shape_Area		Shape_Area	Double	0	0	8	Yes

Subtype Name	Default Value	Domain

Index Name	Ascending	Unique	Fields
FDO_OBJECTID	Yes	Yes	OBJECTID
FDO_Shape	Yes	No	Shape

WeedSurface

Alias	WeedSurface	**Geometry:**Polygon
Dataset Type	FeatureClass	**Average Number of Points:**0
FeatureType	Simple	**Has M:**No **Has Z:**No **Grid Size:**320

Field Name	Alias Name	Model Name	Type	Precn.	Scale	Length	Null
OBJECTID			OID	0	0	4	No
Shape			Geometry	0	0	0	Yes
ID			Integer	0	0	4	Yes
GRIDCODE			Integer	0	0	4	Yes
Acres		Acres	Double	0	0	8	Yes
Shape_Length			Double	0	0	8	Yes
Shape_Area			Double	0	0	8	Yes

Subtype Name	Default Value	Domain

Index Name	Ascending	Unique	Fields
FDO_OBJECTID	Yes	Yes	OBJECTID
FDO_Shape	Yes	No	Shape

MCWMB_Property_TL

Alias	MCWMB_Property_TL	**Geometry:** Polygon
Dataset Type	FeatureClass	**Average Number of Points:** 0
FeatureType	Simple	**Has M:** No **Has Z:** No **Grid Size:** 1300

Field Name	Alias Name	Model Name	Type	Precn.	Scale	Length	Null
OBJECTID		OBJECTID	OID	0	0	4	No
Shape		Shape	Geometry	0	0	0	Yes
MapNumber			String	0	0	20	Yes
Taxlot			String	0	0	5	Yes
MapTaxlot			String	0	0	25	Yes
SERIAL			String	0	0	254	Yes
PIN			String	0	0	254	Yes
LEVY			Integer	0	0	4	Yes
SITUS			String	0	0	254	Yes
AGENT			String	0	0	254	Yes
OWNER			String	0	0	254	Yes
MAILING			String	0	0	254	Yes
MAILCITY			String	0	0	254	Yes
MAILSTATE			String	0	0	254	Yes
MAILZIP			String	0	0	254	Yes
SUBNAME			String	0	0	254	Yes
BLOCK			String	0	0	254	Yes
LOT			String	0	0	254	Yes
LANDVAL			Integer	0	0	4	Yes
IMPVAL			Integer	0	0	4	Yes
ASSESSED_V			Integer	0	0	4	Yes
MARKET_VAL			Integer	0	0	4	Yes
YEARBUILT			Small Integer	0	0	2	Yes
FIN_AREA			Integer	0	0	4	Yes
BEDROOMS			Small Integer	0	0	2	Yes
BATHS			Single	0	0	4	Yes
STORY			Single	0	0	4	Yes
SALE_PRICE			Double	0	0	8	Yes
SALES_DATE			Date	0	0	8	Yes
RECORDING_			Date	0	0	8	Yes
DEEDREF			String	0	0	254	Yes
PROPSTATUS			String	0	0	254	Yes
PROPCLASS			String	0	0	254	Yes
ACRES			Double	0	0	8	Yes
NMA			Small Integer	0	0	2	Yes
Shape_Length		Shape_Length	Double	0	0	8	Yes
Shape_Area		Shape_Area	Double	0	0	8	Yes

Subtype Name	Default Value	Domain

Index Name	Ascending	Unique	Fields
FDO_OBJECTID	Yes	Yes	OBJECTID
FDO_Shape	Yes	No	Shape

Appendix D – Cartographic Best Practices Worksheet

A fundamental principle to guide cartographic best practices is that maps are a means of communication and every effort should be made to support that communication. Also, simple representations are generally better at communicating information than complex representations. Traditional maps and web maps have different properties (Table 1) and therefore require separate cartographic best practices.

Table 1. Map Properties.

Traditional Maps	Web Maps
- Printed Map or Atlas	- Digital Media
- Static Perspective	- Dynamic Perspective
- Limited Audience	- Wide Audience
- Non-interactive	- Interactive/Smart Components

Five questions should be asked and answered to provide the information necessary for any map to be considered effective:

1. What is the map's purpose / message?
2. Who is the target audience?
3. Is the necessary content data available to support the stated purpose and message?
4. Is the necessary contextual data available to support the stated purpose and message?
5. What are the overarching design problems?

All map presentations can be classified as follows:

1. Infographic / Simple Maps
    a. Management / executive audience
    b. Fast and easy decision making
    c. Actionable information
    d. 2-second engagement
    e. Not always a map
    f. 1 - 2 colors

2. Narratives
    a. Public audience
    b. Designed to engage and excite
    c. 6-second engagement
    d. Up to 6 colors
    e. Strong visual hierarchy and grammar

3. Data Visualization
    a. Staff or expert audience
    b. Big-data visualization
    c. Knowledge sharing (multiple complex ideas)
    d. Minutes engagement
    e. Customized mapping conventions

Appendix D – Cartographic Best Practices Worksheet (Cont.)

All maps should provide easy to find and read documentation about the map data sources, map author, date map was published, and any relevant information about map data limitations and strengths. Maps that are designed well generally exhibit easily recognizable symbology and classification techniques that take into consideration such factors as color and symbol shape and / or size. Readable legends that correspond to the map symbols and classifications employed contribute to assuring the intended map message is understood. Visual variables that contribute to map readability and message conveyance include:

1. Visual hierarchy and weight (use to weight and prioritize the map's focal variables)
2. Visual contrast (relationship between foreground and background)
3. Colors are appropriately matched to the map themes

Summary

1. Map purpose is clear, relevant and unique
2. Map is for a specific audience whose needs are known
3. Information makes sense and is easily understood
4. TOC, popups, and metadata work as expected
5. Data is appropriate, enriched, current, and properly compiled
6. Color and symbology are appropriate and appealing
7. Scale dependency is logical
8. Map performance is good

Appendix E – Design Deliverables Checklist

1. Project design structure (see Appendix A). x
2. Geodatabase graphical representation and database schema (see Appendixes B and C); x
3. Cartographic best practices worksheet (see Appendix D); x
4. Final Project Research Paper 10 – 15 pages; x
5. Final project posted for review and grading:

   https://drive.google.com/drive/folders/0B4B9I8GgTZdeNS1fUWZDWFBoc2s X

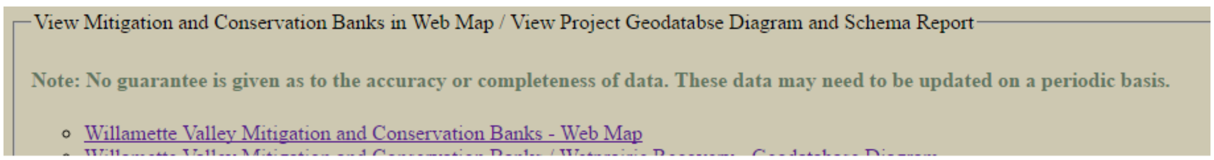
6. Fifteen to twenty-minute power point presentation of my project. x

Appendix F. HTML Code Example

```
<fieldset>  //Starts a partition for web display
        <legend> //Creates title for the fieldset partition
                View Mitigation and Conservation Banks in Web Map / View Project Geodatabse Diagram and
                Schema Report
        </legend>//Ends title for the fieldset partition
                <p><h4>//Starts paragraph and gives font size heading class 4 (1 is largest)
                        Note: No guarantee is given as to the accuracy or completeness of data. These data may
                        need to be updated on a periodic basis.
                </h4></p>//Ends paragraph and ends font size heading class 4 (1 is largest)

                        <ul><li>//Starts a list and a list item

                        <a href="http://uw-geog.maps.arcgis.com/apps/View/
                        index.html?appid=d64ab819a4544b3795aec2a381905855&extent=-123.3072,44.3676,-
                        123.2958,44.3716">Willamette Valley Mitigation and Conservation Banks - Web Map</a>
                        //hyperlinks html file to a web map application service hosted by ArcGIS online.
                        </li>// Ends list item
```



Appendix G. CSS Code Example

<head> *//denotes the start of code that is in the header portion of the html document [the portion of the document that contains code that serves functions]*

<title>WetPrairieRecovery</title> *//Assigns the browser page a title*

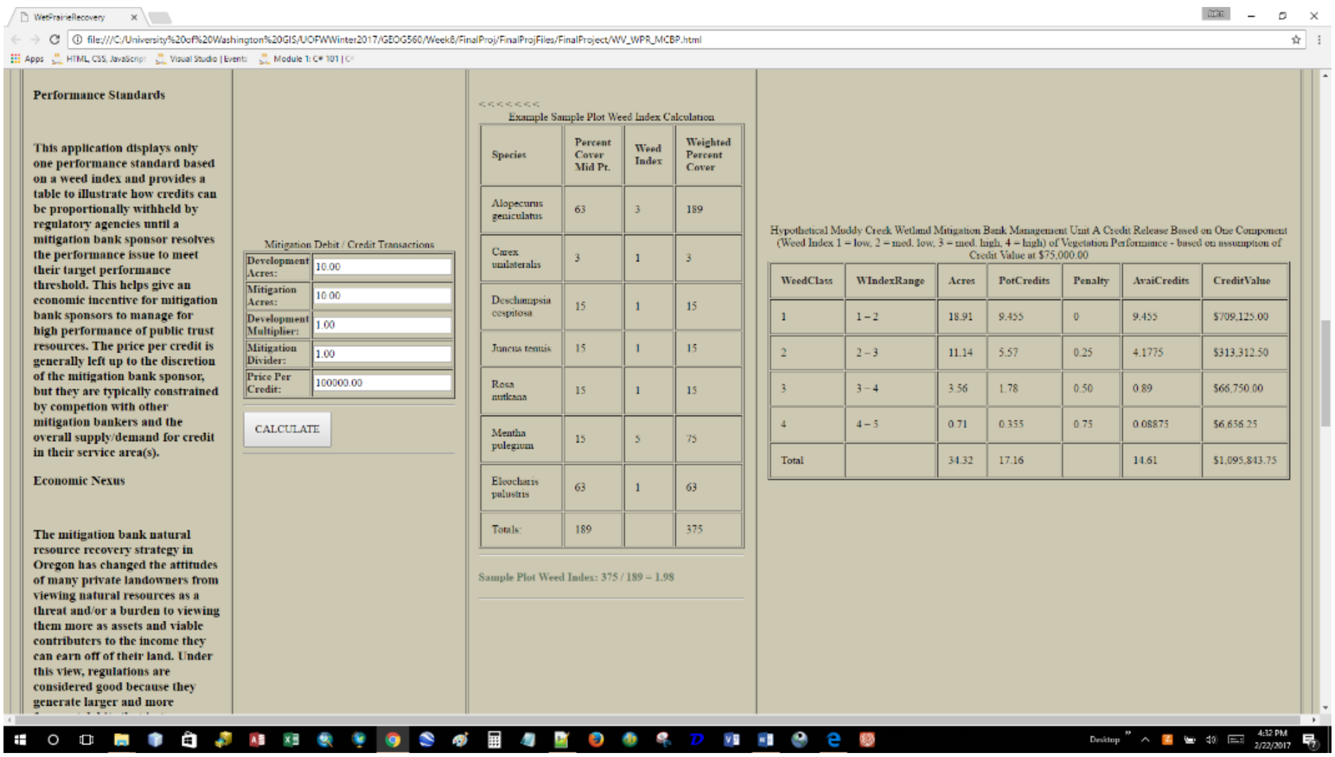
<style> *// denotes the start of css code where the labels to the left correspond to elements embedded in the html code and css code in curly braces to right are used to assign various appearance related values to those elements*

body{background-color: #CDC8B1} *//assigns the background color (corn silk 3) to the body of the web page*

</style> // denotes the end of css code

<body> *//start of code assigned a background color by the css code above*

</body> *//end of code assigned a background color by the css code above*



Appendix H. javaScript Code Example[8]

```
<script type="text/javascript"> //denotes the beginning of javaScript code

function clearOutput(target) //creates a function named clearOutput that takes one parameter called target
{
   document.getElementById(target).innerHTML = "";  //passes an empty string to a function named getElementbyID that inherits
inner HTML and is inherited by document.  Likely essentially clearing target elements when clearOutput function is called
}//end of function
function addOutput(target, text) //creates a function named addOutput that takes two parameters, target and text
{
   document.getElementById(target).innerHTML = document.getElementById(target).innerHTML + text; //adds text passed to this
                    function to target elements passed to this function and concatenates them when addOutput function is called
}//end of function
function getTransactionInput(transaction) //creates a function named getTransactionInput that takes one parameter named
          transaction which inherits all the user input data and likely converts it from text into double variables when
          GetTransactionInput function is called
{
   // takes user input for development acres as string called "transaction.dacres" and assigns it to a transaction.dacres double
variable
          transaction.dacres = document.getElementById("transaction.dacres").value;
 // takes user input for development acres as string called "transaction.macres" and assigns it to a transaction.macres double
variable
          transaction.macres = Number(document.getElementById("transaction.macres").value);
// takes user input for development acres as string called "transaction.multiplier" and assigns it to a transaction.multiplier double
variable
          transaction.multiplier = Number(document.getElementById("transaction.multiplier").value);
// takes user input for mitigation divider as string called "transaction.divider" and assigns it to a transaction.divider double variable
          transaction.divider = Number(document.getElementById("transaction.divider").value);
// takes user input for price per credit as string called "transaction.pricepercredit" and assigns it to a transaction.pricepercredit double
variable
          transaction.pricepercredit = Number(document.getElementById("transaction.pricepercredit").value);
}//end of function
function calculateTransactionDebitCredit(transaction)//Executes the calculator's arithmetic operations when function is called
{
 // declares a transaction.debit variable and assigns it the value from:  transaction.dacres x transaction.multiplier
          transaction.debit = transaction.dacres * transaction.multiplier;
// declares a transaction.credit variable and assigns it the value from:  transaction.macres / transaction.divider
          transaction.credit = transaction.macres / transaction.divider;
// declares a transaction.netcredit variable and assigns it the value from:  transaction.credit -  transaction.debit
          transaction.netcredit = transaction.credit - transaction.debit;
// declares a transaction.creditvalue variable and assigns it the value from:  transaction.pricepercredit x transaction.netcredit
          transaction.creditvalue = transaction.pricepercredit * transaction.netcredit;
}//end of function
function displayTransaction(transaction) //create a function named displayTransaction that takes one parameter transaction and
likely displays the results of the arithmetic calculations when the displayTransaction function is called
          {          clearOutput("result"); //call clearOutput function as applied to result parameter
```

[8] This my best interpretation of the javaScript code using my limited knowledge and training. The most perplexing thing to me about this code is there does not appear to be a creation of a transaction class with declared variables, a constructor, get / set properties for class encapsulation, and methods aka functions. There are obviously a number of functions written in the code and a transaction object does appear to be instantiated as well, taken as a parameter and passed as an argument in the functions while inheriting the variables used in the arithmetic calculation operations. Now there are libraries of template classes available to programmers and it may be that a library template class is providing the foundation for me to instantiate a transaction object here. So, I wrote this code in what is known as a "bat, cat, hat" strategy whereby I took existing code that was doing something close to what my calculator is now doing and tweaked it one step at a time until it did what it does now. I created the variables this code is using but in a way that is significantly different than the way I was trained to declare variables in my coding classes and one that I must admit I do not completely understand now. Because of this, it is also not clear to me how the code is converting text data types to the double data types necessary for using these arithmetic operators. In summary, my best guess is that there is a template library transaction class that contains counterparts (in a sense aliases) to my user informed variables (assigned double data types) and allows the instantiation of a transaction object which inherits the user informed variables and allows their user input values to be passed as numeric arguments in the code.

```
            addOutput("result","Net Credit is " + transaction.netcredit.toFixed(2) + "<br />"); //call addOutput function and
pass to it the net number of credits remaining fixed to 2 decimals
            addOutput("result","Credit Value"
            + " equals a total of $"
            + transaction.creditvalue.toFixed(2) + "<br />"); //call addOutput function and pass to it the output text
concatenated to credit dollar value fixed to 2 decimals and adds a break line
}//end of function
function calculate() //creates a function named calculate that calls the getTransactionInput and displayTransaction functions when
the calculate function is called
{
  var transaction = new Object(); //instantiate a new transaction object

  getTransactionInput(transaction); //calls getTransactionInput function and pass into it the transaction parameter
  calculateTransactionDebitCredit(transaction); //call calculateTransactionDebitCredit function and pass to it the transaction
parameter
  displayTransaction(transaction); //calls displayTransactionFunction and passes to it the transaction parameter
}//end of function

</script> //end of javaScript code
</head>//end of header section of html document
```

The code below this line is in the body of the html document

```
<td> <table border="1" align="center">//Start a single cell in an html table and assigns a table border
        <caption>Mitigation Debit / Credit Transactions</caption> //Creates html table caption
                <tbody> //Create organized structure to contain table rows
          <tr> //Start table row
            <th align="left">Development Acres:</th> //Column header contains heading
            <td><input id="transaction.dacres" value="10.00" type="text"></td> //Start single cell contains user input as text
                variable (default "10") assigns it to input id for retrieval by javaScript
          </tr>//End table row
          <tr> //Start table row
            <th align="left">Mitigation Acres:</th> //Column header contains heading
            <td><input id="transaction.macres" value="10.00" type="text"></td> //Start single cell contains user input as text
                variable (default "10") assigns it to input id for retrieval by javaScript
          </tr>//End table row
          <tr>//Start table row
            <th align="left">Development Multiplier:</th> //Column header contains heading
            <td><input id="transaction.multiplier" value="1.00" type="text"></td> //Start single cell contains user input as text
                variable (default "1.0") assigns it to input id for retrieval by javaScript
          </tr> //End table row
          <tr> //Start table row
            <th align="left">Mitigation Divider:</th> //Column header contains heading
            <td><input id="transaction.divider" value="1.00" type="text"></td> //Start single cell contains user input as text
                variable (default "1.0") assigns it to input id for retrieval by javaScript
          </tr>//End table row
          <tr> //Start table row
            <th align="left">Price Per Credit:</th> //Column header contains heading
            <td><input id="transaction.pricepercredit" value="100000.00" type="text"></td>//Start single cell contains user input
                as text variable (default "100000.00") assigns it to input id for retrieval by javaScript
          </tr>//End table row
        </tbody>//End organized structure to contain table rows

</tr>//End table row (associated with larger table that this table is inside of)
      </table>//End table row
<hr> //Creates a horizontal line
<input value="CALCULATE" onclick="calculate();" align="center" type="button" size="22"> //Create a button triggered by a mouse
click event which calls the calculate function in javaScript
 <hr> //Creates a horizontal line
<p id="result" align="center"></p> //display calculate output in string variable called result.
</td>//End a single cell in an html table
```

Mitigation Debit / Credit Transactions

Development Acres:	12.78
Mitigation Acres:	78.9
Development Multiplier:	2
Mitigation Divider:	1.5
Price Per Credit:	65899.92

CALCULATE

Net Credit is 27.04
Credit Value equals a total of $1781933.84

Appendix I. DEMO | PUBLISHING A MAP SERVICE IN NINE STEPS

1. Make sure that you have added and connected the UW Department of Geography AGO organizational account or “http://uw-geog.maps.arcgis.com” to your list of ArcGIS Portal Connections through ArcGIS Administrator under “Advanced Configuration … Manage Portal Connections.” After hitting “Add” you may need to hit “Connect” to confirm. 2. Open ArcGIS for Desktop and ArcCatalog. Locate the “GIS Servers” folder and click “Add ArcGIS Server”
GEOG 560 WINTER 2017 | PUBLISHING SERVICES TO THE UW DEPARTMENT OF GEOGRAPHY GIS SERVER

3. After opening “Add ArcGIS Server,” click “Publish GIS Services.”

GEOG 560 WINTER 2017 | PUBLISHING SERVICES TO THE UW DEPARTMENT OF GEOGRAPHY GIS SERVER

4. In General options, enter the “Server URL:” as http://geoggs01.geog.uw.edu:6080/arcgis This URL represents the UW Department of Geography’s GIS server. Keep the Server Type as “ArcGIS Server” and leave the Staging Folder location as it is. Enter your UW NetID credentials under “Authentication.”

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5. In ArcCatalog, you should now see the Dept.’s GIS server listed.

6. You are ready to publish your map service. See the steps in “Publishing a map service”. Make sure you are publishing your service to the Department of Geography’s GIS server (“geog-gs01.geog.uw.edu_6080”) under “Choose a connection.” Under “Service name” make sure to start the name of every service you publish with your last name, e.g., “{Your last name}_{Service name}”

GEOG 560 WINTER 2017 | PUBLISHING SERVICES TO THE UW DEPARTMENT OF GEOGRAPHY GIS SERVER

7. IMPORTANT: Select the “Use existing folder” and find the option “mgis560_wi17”. Do not publish to the “[root]” directory or create your own folder.

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8. Publish your mapping service using the Service Editor, using the appropriate service standard.

GEOG 560 WINTER 2017 | PUBLISHING SERVICES TO THE UW DEPARTMENT OF GEOGRAPHY GIS SERVER

Caching: Make sure to select a Tiling Scheme that produces a relatively small Estimated Cache Size. To take advantage of the ArcGIS Online base maps, select “ArcGIS Online / Bing Maps / Google Maps.”

Then, using the slider bars, choose the Levels of Detail carefully. Really think about how much detail (zooming in capability) your data needs to be available for. After selecting the Levels of Detail utilize the Calculate Cache Size feature to update the Estimated Cache Size. It is recommended to keep this number as small as possible, and under 50 MB. Avoid loading large vector and raster datasets that are unclipped.

9. Finally, make sure you share your service in your “My Content” folder and use it to author your ArcGIS web map from the AGO organizational account.

Special Notes: After you hit “Analyze” your map service, you may encounter Esri warnings. Many of these warnings can be ignored but check them anyway. Notice error code “20034.” You will be prompted to hit OK to datasets being packaged and copied to the server. Also, be patient depending on your web connection. After successfully publishing your Web Map Service you should receive the following result

Appendix J. GEOG 560 WINTER 2017 | WEB APPBUILDER

1. Go to the Esri Web AppBuilder page at http://doc.arcgis.com/en/web-appbuilder/ The only thing you need in order to the use the Web AppBuilder is an AGOL organizational account, so make sure to sign into our UW Geography AGOL
account.

2. Make your app: Especially for application developers, study the step-by-step tutorials on “Create Apps,” “Manage Apps,” and “Extend Apps.”

3. Step 1 under “Create Apps” explains how to initially access the Web AppBuilder from within our UW Geography AGOL account (e.g., see below).

4. You can share draft versions of your Web AppBuilder web mapping application in “GEOG560 Wi17 Mapping Exercise 6: Testing” within the UW Department of Geography ArcGIS online organizational account.