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Title: Characterizing Patterns of Wetland Occurrence in Oregon Using an Interactive Geodatabase: A Method for Conservation Planning

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Several state and federal agencies have identified Oregon's coastal wetlands as priority areas for conservation, and in some cases have specifically singled out nontidal (mostly palustrine) wetlands as a major concern. Recent research has highlighted the need to study and manage wetlands from a regional perspective that considers the distribution of wetlands within the framework of watersheds and ecoregions. Public planning and awareness of coastal palustrine wetlands has been limited by their small size and the lack of digital National Wetlands Inventory (NWI) coverage in the upper reaches of coastal watersheds where many are located.

This research was designed to test hypotheses about physiographic and derived topographic variables associated with mapped palustrine wetlands. The study assumed that certain variables were more significant than others in characterizing these wetlands, and sought to identify relationships among variables that were indicative of wetland distributions across watersheds and ecoregions. A three phase approach was demonstrated for characterizing palustrine wetland size and degree of isolation that included designing an enhanced NWI geodatabase of palustrine wetland polygons, creating watershed profiles and wetland demographic statistics, and analyzing the data using exploratory data analysis in the form of decision tree modeling. This study confirmed the ability to provide information on the geographical distributions and relationships existing among environmental variables and mapped wetland polygons. An enhanced understanding of these characteristics has applications for conservation planning including sustainable wetland creation and restoration.

Characterizing Patterns of Wetland Occurrence in Oregon Using an Interactive Geodatabase: A Method for Conservation Planning

by

Jennifer Larsen

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Chair of the Department of Geosciences

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

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Jennifer Larsen, Author

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CHAPTER ONE: INTRODUCTION

Background

Tidal and nontidal wetlands in Oregon's coastal watersheds have been altered extensively due to diking, filling, ditching, road construction, logging, and many other factors (Moore et al. 1991a, Oregon Wetlands Joint Venture 1994). This is a concern because wetlands are often considered ecological "hotspots" within watersheds and play a large role in maintaining the biodiversity and ecological integrity of coastal watersheds (Good and Sawyer 1998, Good et al. 1998). Wetlands are of statewide conservation interest because of their decline in all Oregon ecoregions and a lack of comprehensive inventory and mapping (Defenders of Wildlife 1998).

Several state and federal agencies have identified Oregon's coastal wetlands as priority areas for conservation, and in some cases have specifically singled out nontidal (mostly palustrine) wetlands as a major concern (Kjelstrom and Williams 2003, Oregon Parks and Recreation Department 2003). These wetlands are important to society partly because of their large contribution to coastal wildlife and plant biodiversity (Kjelstrom and Williams 2003). In particular, streamside or off-channel palustrine wetlands located adjacent to estuaries may provide key habitat and habitat linkages for anadromous fish and terrestrial wildlife (Good and Sawyer 1998, Adamus 2001).

Located anywhere from shoreline dune environments to the upper reaches of coastal watersheds (Figure 1), Oregon's coastal nontidal palustrine wetlands include freshwater marshes, riparian and floodplain wetlands, swamps and backwater sloughs,

Figure 1: Coastal nontidal palustrine wetlands on the Oregon coast.

sphagnum bogs, interdunal marshes, and slope wetlands (Akins and Jefferson 1973b). Smaller and more scattered in distribution than tidal wetlands, many of these wetlands are at high risk from both direct and indirect impacts of some coastal land uses.

A recent study analyzing the effectiveness of national coastal zone management programs found that within coastal zones, nontidal wetlands generally receive less protection and management priority than tidal wetlands (Good and Sawyer 1998). This is true for Oregon, where state planning requirements and zoning ordinances provide substantial protection for tidal wetlands but offer considerably less protection for coastal nontidal wetlands (Oregon Wetlands Joint Venture 1994, Good and Sawyer 1998, Oregon Parks and Recreation Department 2003). Wetlands in general are underrepresented in state watershed programs such as those of the Oregon Watershed Enhancement Board (OWEB), which has focused mainly on the protection and restoration of stream channels, their riparian zones, and associated uplands. Although Oregon is considered a leader in developing and implementing wetland protection programs, incremental losses of nontidal wetlands are still occurring, particularly among palustrine types (Good and Sawyer 1998). These varying degrees of protection are particularly surprising given the fact that nontidal wetlands account for 84 percent of all wetlands within the study area (Figure 2).

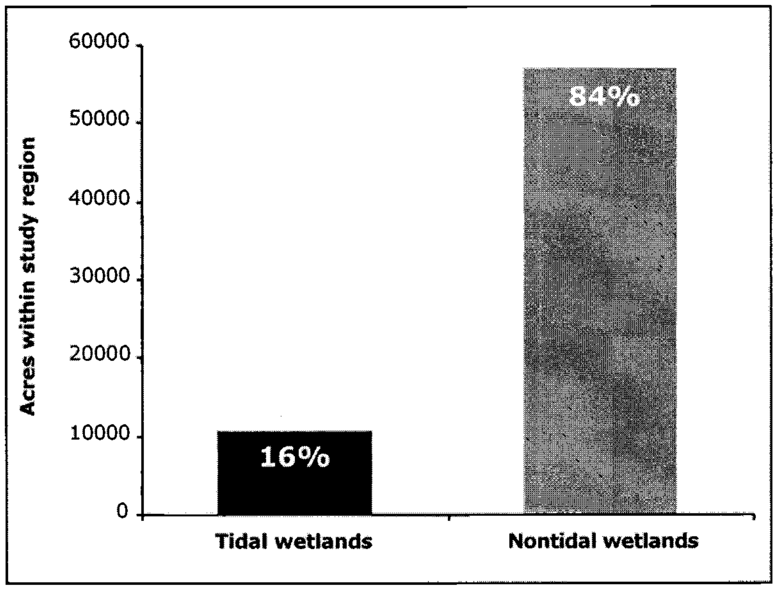

Figure 2: Proportion of tidal versus nontidal wetland acreage within the study area.

Palustrine Wetlands

The 'Classification of Wetlands and Deepwater Habitats', also known as the Cowardin classification, was adopted by the U.S. Fish and Wildlife Service in 1979 and is the most widely recognized classification system for wetlands in the United States (Cowardin et al. 1979). The *system* is the highest level of classification, grouping wetlands based on similar hydrologic, geomorphologic, chemical, and biological factors (Mitsch and Gosselink 2000a). The U.S. Fish and Wildlife Service defines the palustrine system as nontidal wetlands dominated by trees, shrubs, or persistent emergent or herbaceous vegetation. It also includes open-water bodies less than 20 acres in size provided they contain water less than 6.6 feet in depth and are not riverine (Cowardin et al. 1979).

The palustrine wetland system encompasses a great number of wetland types that occur across a range of landscape settings. In Oregon, the steep topography of the Coast Range extends directly to the shores of the Pacific Ocean in several places, presenting a limited range of conditions in which wetlands can form. In this landscape, palustrine wetlands are generally found in areas of sediment accumulation at the mouths of rivers, within steep-sided stream valleys, in depressions among sand dunes, and as small, scattered depressions at higher elevations within the mountains (Akins and Jefferson 1973a, Kjelstrom and Williams 2000). The spatial signatures exhibited by palustrine wetlands can vary dramatically, reflecting the diverse range of conditions in which they occur within the Coast Range (Figure 3).

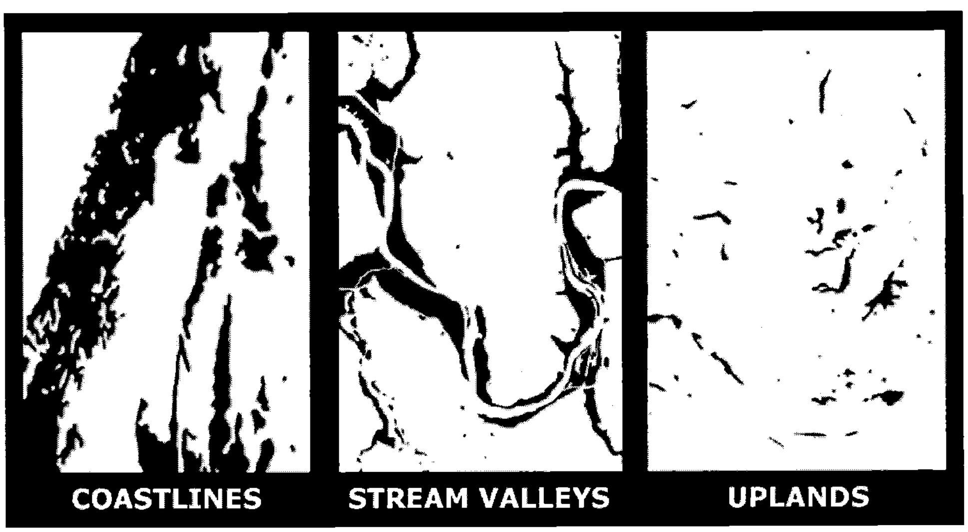

Figure 3: Spatial signatures of palustrine wetlands within the study area.

The National Wetlands Inventory

The National Wetlands Inventory (NWI) is a major mapping effort conducted by the U.S. Fish and Wildlife Service that produces quadrangle maps of wetlands in both paper and digital formats at scales ranging from 1:24,000 to 1:100,000 (Mitsch and Gosselink 2000a). These maps provide general locations, but their resolution is too coarse to aid in jurisdictional wetland delineations. The entire state of Oregon has been mapped, but only about 20 percent of these maps are available in digital form (Good and Sawyer 1998). Large data gaps exist along much of the coast, particularly in the upper portions of watersheds.

Each unit mapped by NWI is assigned a code that reflects the hierarchical structure of the Cowardin classification system (Figure 4). *Classes* are designated by

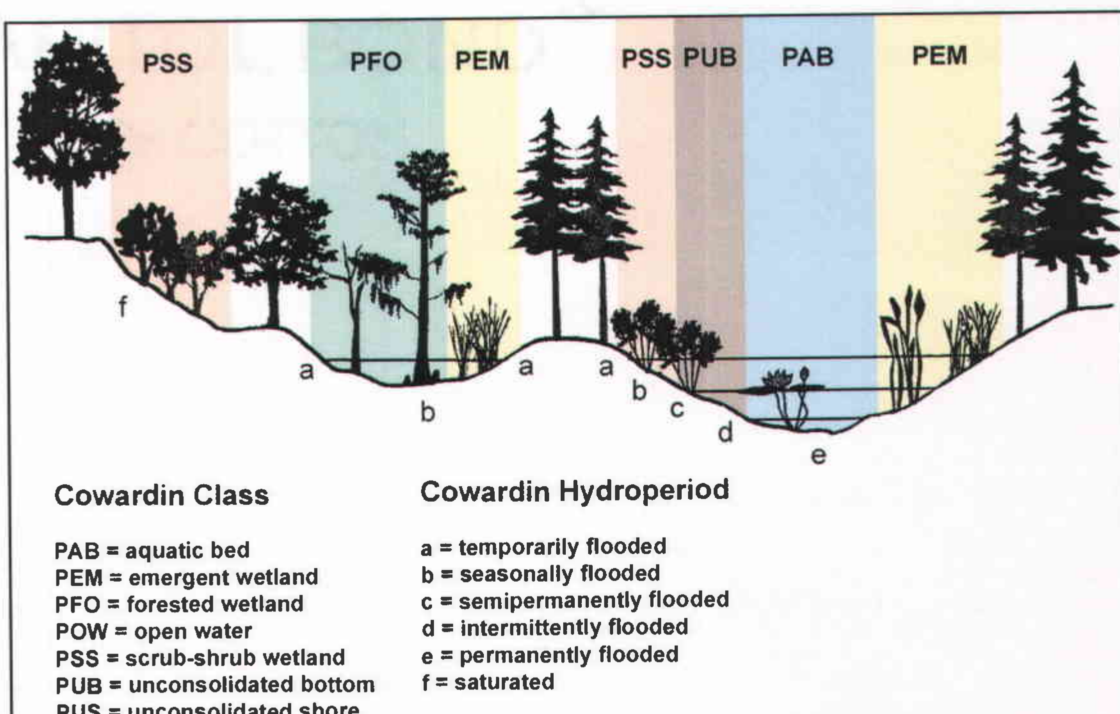

Figure 4: The Cowardin classification system used by the National Wetlands Inventory (adapted from Mitsch and Gosselink 2000b).

a two-letter code that reflects vegetation structure in the wetland, followed by a single-letter hydroperiod designation and an additional single-letter designation that denotes any special modifiers used to describe the condition of the wetland (i.e. farmed, excavated). For example, a wetland designated PEMC is part of the palustrine system, has persistent emergent vegetation, and is seasonally flooded. Some examples of Cowardin classes found within the study area are displayed in Figure 5. Each NWI-mapped unit does not necessarily represent a whole wetland in the geomorphic sense. For this study, the internal boundaries of contiguous NWI polygons were dissolved in order to create true wetland polygons.

Figure 5: Examples of palustrine wetlands of the Oregon coast with their corresponding Cowardin classification code.

Synthesizing watersheds and ecoregions

This research utilizes a comprehensive digital database compiled in association with the Oregon Tidal Wetlands Hydrogeomorphic Assessment Project directed by Paul Adamus (Adamus and Carter 2003). This database is a merged layer of all digital NWI layers for watersheds located in western Oregon that drain to the ocean. For this research, it was necessary to identify a subset of the database for analysis. The Coast

Range Ecoregion (Omernik 1987) was chosen as an initial way to partition the database into a smaller subset. Fifth-field watersheds were then superimposed on the Ecoregion to delineate smaller geographic units in the database. Each watershed located in the Coast Range Ecoregion was then examined and ones containing complete NWI data coverage were selected. A 2,900 square mile complex of watersheds located south of Florence and north of Bandon provided a contiguous block of watersheds with complete NWI coverage in which watershed boundaries coincide with the ecoregion boundary. This region was selected as the study area for this research. In contrast, large data gaps are clearly evident along the northern coast (Figure 06). There is much discussion in the literature concerning which unit of delineation, the watershed or the ecoregion, provides the best spatial framework within which features such as wetlands should be analyzed (Clarke et al. 1991, Bedford 1996, Omernik and Bailey 1997, Good and Sawyer 1998, Bryce and Woods 2000, NRC 2001). Watersheds have traditionally been considered the primary spatial framework that best defines the physical setting of hydrologic features. Watershed structure determines the amount and timing of water and nutrient flow through the landscape, and the relationship between hydrological processes and wetland position within the watershed contributes greatly to the structural and functional expressions of that wetland (NRC 2001).

The concept of the ecoregion as envisioned by Omernik (1987) is based on the idea that ecosystems and their associated landscape components form relatively homogenous regional patterns that are expressed in terms of land surface form, soils,

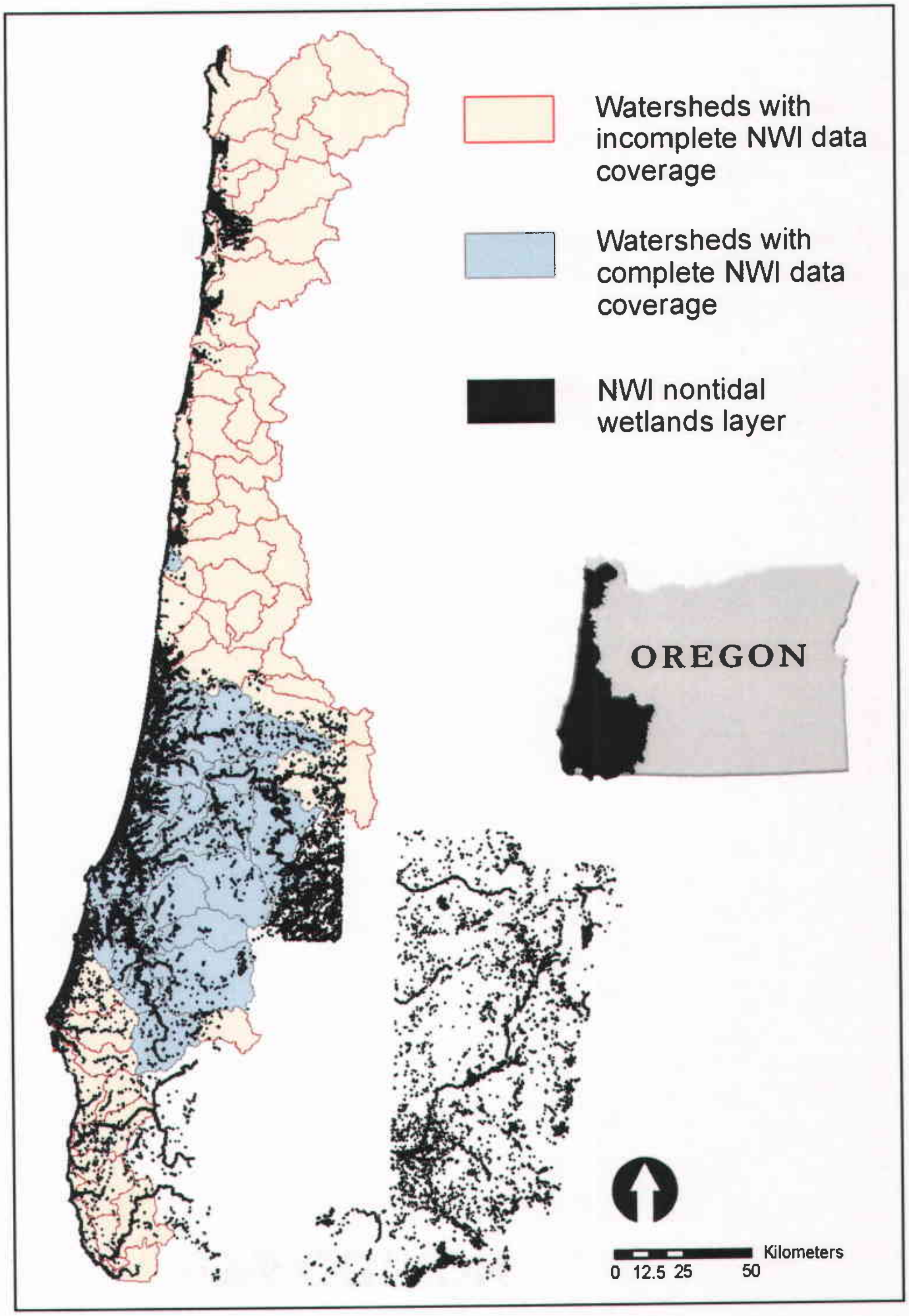

Figure 6: NWI digital data coverage for watersheds in the Coast Range Ecoregion.

climate, and vegetation. The contribution of each element to the resulting ecosystem varies regionally, and this spatial variability is captured in the designation of subregions (Bryce and Woods 2000). Ecoregions are complexes of landscapes possessing similar attributes and are thus expected to support similar patterns of wetland occurrence (Johnson 2004).

Along the Oregon Coast, areas of small, flat coastal lowlands exist in sharp contrast to the steep terrain of the surrounding uplands. These regional differences in landform are responsible for the diverse array of palustrine wetlands that exist within the study area (see Appendix 1 for detailed descriptions of these Level III and Level IV ecoregions). Ecoregions represent a holistic approach to conservation planning that considers multiple coarse-scale processes at work in the landscape (Omernik and Bailey 1997, Defenders of Wildlife 1998).

Despite the differences in scale between watersheds and ecoregions, some argue that they can be complementary tools for watershed management and regional conservation planning (Bedford 1996, Good and Sawyer 1998, Johnson 2004). For example, managers should consider a watershed framework when determining reference conditions for wetlands, while recognizing the ecoregions within which these wetlands occur to provide a framework that considers the regional similarities and distributions of these elements (Omernik and Bailey 1997, NRC 2001). Wetlands occur in a diverse range of physical settings. Generating data to characterize them in a geographic information system requires a synthesis of scales within a single study area. Simultaneously considering a wetland in terms of both watershed and ecoregion identity (Figure 7) enables us to acquire information about the location of a wetland in relation to finer scale gradients of hydrologic processes and in relation to coarser scale gradients of landscape processes such as climate and physiography.

Study Area

The study area selected for this research contains a broad representation of palustrine wetland polygons from the NWI database. Palustrine wetlands occupy 2% of the land area. The region encompasses 18 fifth-field watersheds, all of which drain to the ocean. They have been grouped into 5 larger watershed complexes to simplify

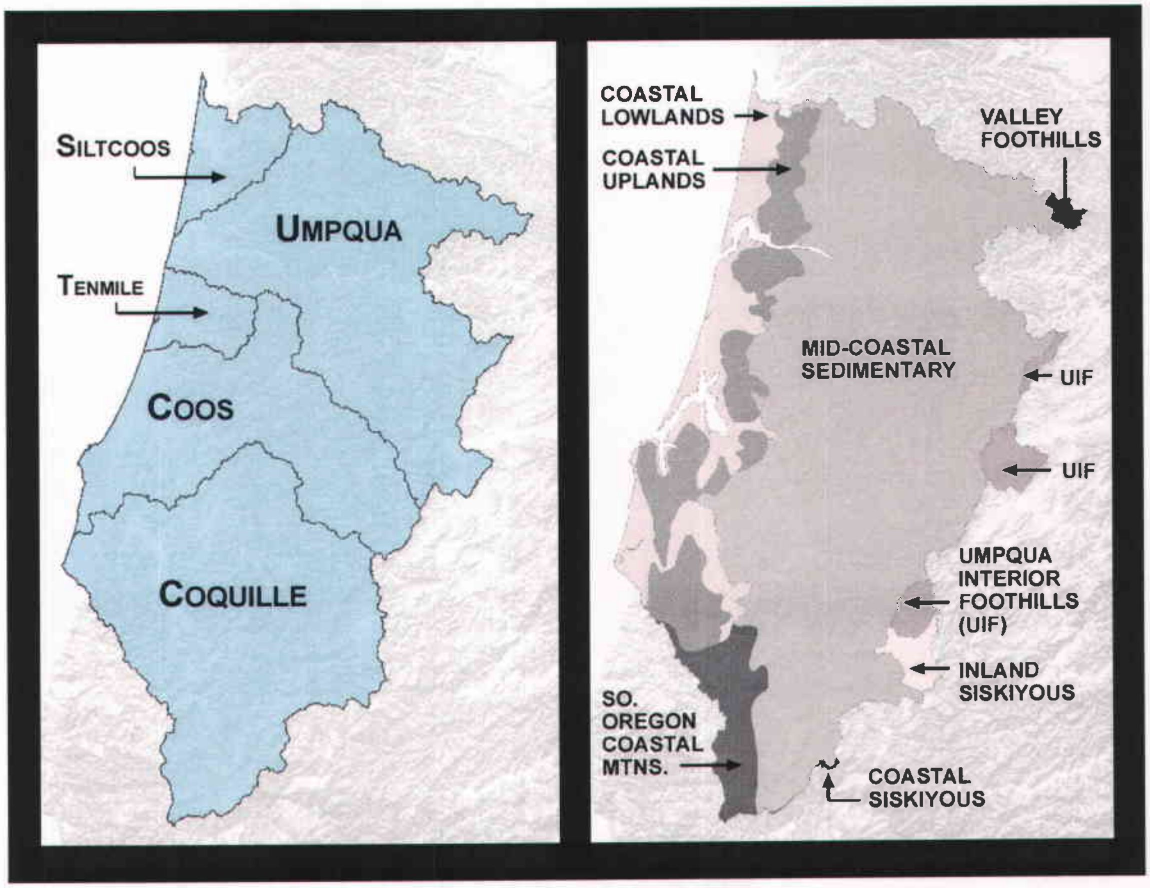

Figure 7: Watersheds (left) and ecoregions (right) located within study area boundaries.

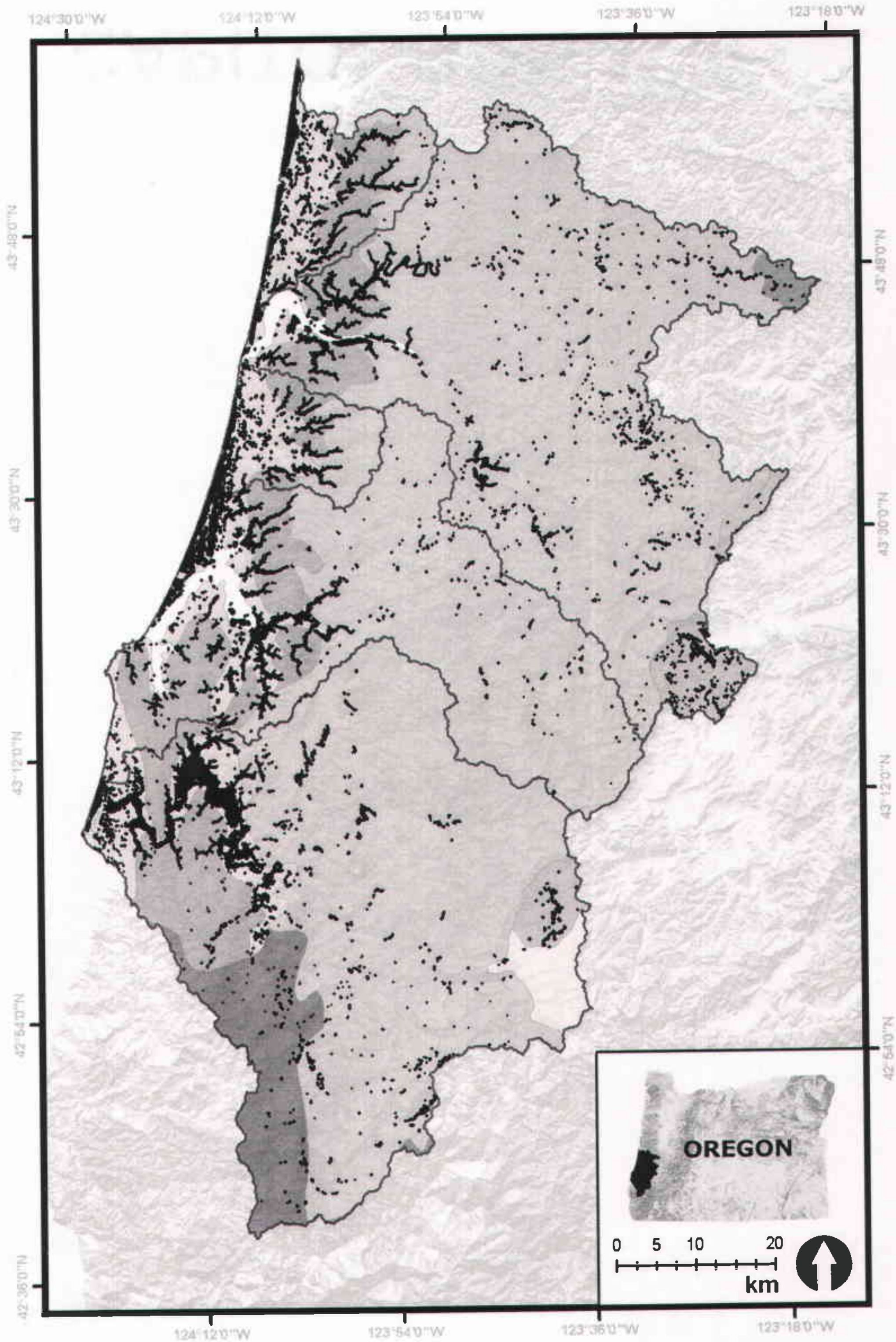

Figure 8: The study area shown with palustrine wetland polygons, watershed boundaries, and ecoregion boundaries.

analysis (Figure 8). The study area is located almost entirely within the Coast Range Ecoregion, with smaller areas in the upper portions of the watersheds overlapping the Klamath Mountain and Willamette Valley ecoregions.

Palustrine wetlands selected from the NWI database represent 71% of all NWI types located within the study area (Figure 9). Within the palustrine system, PEM (palustrine emergent) wetlands represent 61% of all NWI classes. Palustrine wetlands are distributed throughout every ecoregion, with the highest numbers occurring in the Coastal Lowlands, Coastal Uplands, and Mid-Coastal Sedimentary ecoregions.

Creating an Enhanced NWI Geodatabase

The database used for this research is a digital layer of NWI polygons classified using the Cowardin code administered by the U.S. Fish and Wildlife Service (Cowardin et al. 1979). The NWI digital wetland layer provides polygons delineating wetland locations along with the corresponding Cowardin code, but provides little else in terms of physiographic or contextual information about the wetland.

However, enhanced NWI databases can be created with a geographic information system (GIS) by adding various environmental attributes to the original polygons (Good and Sawyer 1998, Wooten et al. 1998, Tiner 2003a). For this study, an enhanced NWI database was created for the study area by subdividing the original wetland polygons into numerous smaller polygons according to variations in soil type. This enables the database to more closely approximate the spatial variability found in wetlands (Stolt et al. 2001).

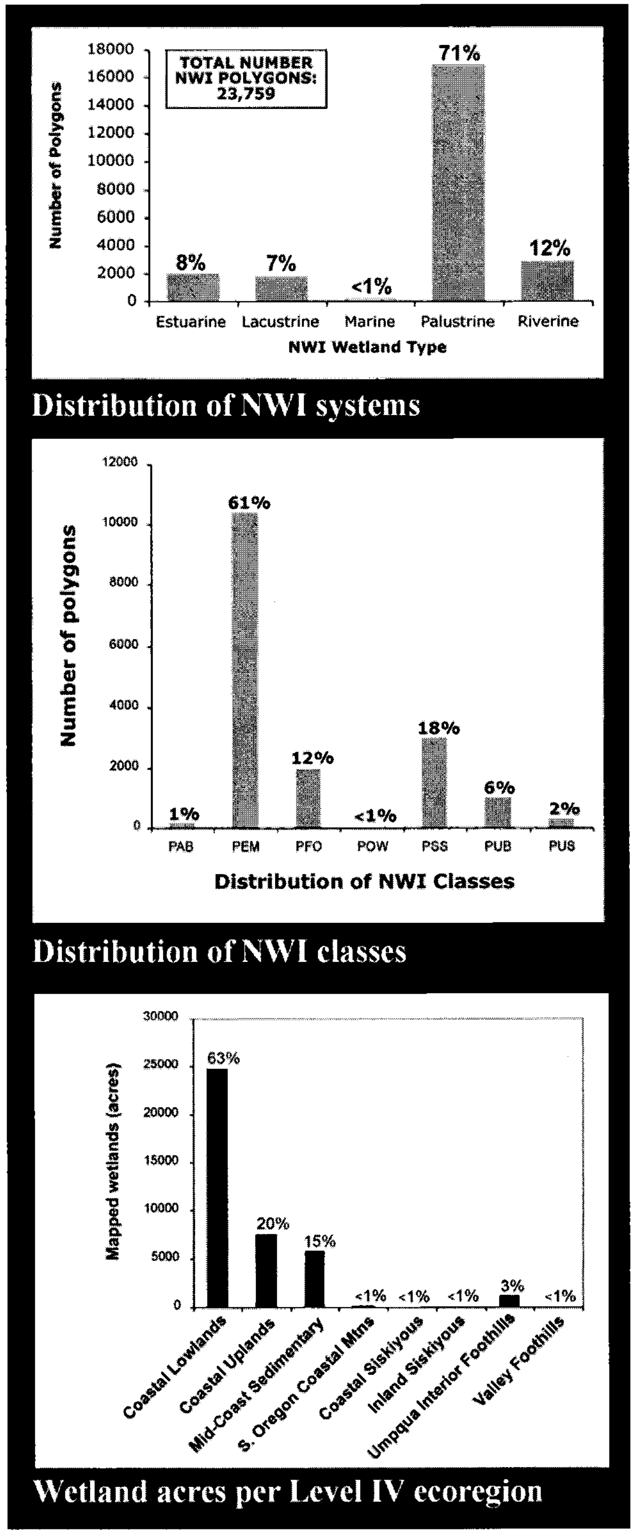

Figure 9: Study region statistics generated using watershed profiles.

Problem Statement

Public planning and awareness of coastal palustrine wetlands has been limited by their small size and the lack of digital National Wetlands Inventory (NWI) coverage in the upper reaches of coastal watersheds where many are located (Akins and Jefferson 1973b, Adamus 2001). Comprehensive regional maps of these wetlands are lacking in Oregon, and recent research has highlighted the need to study and manage wetlands from a regional perspective that considers the distribution of wetlands within the framework of watersheds and ecoregions (Whigham et al. 1988, Omernik and Bailey 1997, Bedford 1999, Palik et al. 2000, Adamus 2001).

Site-specific approaches to wetland management often overlook changes occurring at the scale of broader landscapes. The spatial configuration of wetlands within this larger framework is easily degraded by a loss of connectivity and increasing geographic isolation (Bedford 1999, Gwin et al. 1999a, Shaffer et al. 1999, Leibowitz 2003, Leibowitz and Nadeau 2003). Accurately assessing landscape-scale impacts to coastal palustrine wetlands will involve the ability to identify the environmental variables that influence their occurrence (Moore et al. 1991a, Tiner 2003a). If more information is known about the conditions that control wetland distributions at a landscape scale, these data can be used in wetland management and conservation planning.

The combination of digital NWI wetland layers and the analysis capabilities of a GIS represent a tremendous resource available to managers and planners. Enhanced NWI databases are valuable for their ability to organize information on the wetland demographics of a study area (Bedford 1996, 1999, Tiner 2003a) such as percentages of wetland types, distributions within ecoregions, and dominance of certain NWI classes within watersheds. However, even though enhanced NWI databases are powerful in their ability to catalog numerous environmental variables occurring within mapped wetland polygons, they are limited in their ability to translate information about statistical relationships among variables. In order to move beyond a descriptive analysis of these wetlands, this study will use exploratory data analysis in the form of decision tree models (Moore et al. 1991a, De'ath and Fabricius 2000) to identify key relationships among variables and how they are expressed in the landscape in terms of wetland characteristics and distributions. Additionally, this method will be used to test for threshold values of some variables. It has been suggested that the identification of threshold values associated with the occurrence of natural features may have greater ecological value than statistical parameters such as means and standard deviations (Moore et al. 1991a).

Research Questions

This research was designed to test hypotheses about physiographic and derived topographic variables (Moore et al. 1991b) associated with mapped palustrine wetlands. It was assumed that certain variables were more significant than others in characterizing these wetlands, and sought to identify relationships among variables that were indicative of wetland distributions within watersheds and among ecoregions. Building on geographic techniques developed in previous wetland studies (Moore et al. 1991a, Bedford 1996, Adamus 2001, Tiner et al. 2002, Palik et al. 2003, Tiner 2003a), this research proposes to develop an interactive method of characterizing palustrine wetland occurrence using decision tree analysis with an enhanced NWI geodatabase. Additionally, it will demonstrate the applicability of this process to conservation planning and wetland management. Specific research questions addressed by this study are as follows:

1. Can this methodology be used to identify geographic patterns of occurrence among NWI palustrine wetland polygons in the study area?

2. Can this methodology be used to predict environmental variables associated with the size and degree of isolation of NWI palustrine wetland polygons?

3. Do threshold values exist for environmental variables that predict or characterize the size and degree of isolation of NWI palustrine wetland polygons?

CHAPTER TWO: LITERATURE REVIEW

The vast majority of published research on coastal wetlands in the United States has focused largely on the Southeast, Northeast, and Midwest. Research on coastal Pacific Northwest wetlands is generally lacking in the literature, particularly regarding coastal palustrine systems. This study attempts to fill this gap by contributing to an understanding of the relationships among environmental variables that characterize these wetlands in selected coastal watersheds of the Oregon coast.

Wetland Classification Techniques

Inventory and classification are key aspects leading to a better understanding of wetlands, and thus complement wetland research (Lett 2002). Classification frameworks are typically based on either vegetative (Cowardin et al. 1979) or hydrogeomorphic qualities (Brinson 1993b). Vegetation is relatively easy to observe and map, whereas water is usually visible only seasonally or is present underground. The Cowardin system provides information on the dominant vegetation form present within a wetland along with a hydroperiod designation, which categorizes the approximate duration of flooding. The source of water that sustains a wetland is not reflected in the Cowardin classification, whereas the hydrogeomorphic (HGM) classification (Brinson 1993b) attempts to characterize this while providing little information on vegetation. The hydrogeomorphic classification relies on three factors—location in the landscape, dominant water source, and hydrodynamics—to characterize wetlands (Brinson 1993b, Smith et al. 1995). This national-scale classification is meant to serve as a general template for development of versions specific to particular regions (Brinson 1993b, Smith et al. 1995), and this has been done in Oregon (Adamus 2001). By assigning wetlands to HGM classes within a landscape framework, inference can be made regarding the functional processes responsible for forming and sustaining wetlands within a region (Shaffer et al. 1999, Adamus 2001).

Landscape Level Controls on Wetland Occurrence

Wetlands are complex natural systems that exhibit a great amount of spatial variability in terms of their biological, chemical, and physical structure. Wetlands also display a wide range of variability in the way they are distributed across and positioned within the landscape (Stolt et al. 2001). The geomorphic setting of a wetland is an important factor to consider when analyzing these regional patterns. Some wetlands existing in close geographic proximity to each other may support completely different biological communities, consistent with the concept that multiple attributes of the basin play a large role in determining the structure and function of a wetland (Keough et al. 1999, Stolt et al. 2001, Euliss et al. 2004).

Landscape hierarchy theory states that coarse-scale ecosystem characteristics and processes control the development of finer-scale, nested ecosystems (Allen and Starr 1982). Recent studies have applied this idea to the study of wetlands, arguing that landscape-scale processes, rather than site-specific relationships, may be primarily responsible for determining the formation of particular wetland types (Bedford 1996, 1999, Palik et al. 2000, Palik et al. 2003). The hierarchical structure of landscapes can thus enable predictions to be made concerning the relationships among geomorphology, soil types, and vegetation. Palik et al. (2003) found that hierarchical constraints such as regional physiography, glacial landform, and soil type were important factors determining the abundance of seasonal wetlands in an upland forest.

The geomorphic setting in which a wetland is positioned reflects the physical surface of the landscape and the manner in which water either flows across or collects within certain locations (Brinson 1993a). Additionally, the abundance and diversity of wetland types in a region are related to the physical setting of the landscapes in which they occur (Johnson 2004). Landforms and other physical properties of a landscape are comparatively easier to observe and quantify than ecological processes (Swanson et al. 1988). Wetlands predominately occur in topographic depressions or in areas of low slope gradient, but can also be found at higher elevations on steeper slopes or near ridgelines (Winter 1988). The elevation, slope, shape, and geology of landforms are all variables related to wetland position in the landscape and can be represented digitally in an enhanced NWI database (Wilson and Gallant 2000).

Wetland Demographics

Landscape scale interactions of hydrogeomorphic variables influencing the formation and sustainability of specific wetland types are generally referred to as *wetland templates* (Bedford 1996, 1999). Templates represent the array of settings existing in a landscape that are conducive to the formation of particular wetlands, and are thus landscape-specific and must be developed for specific geographic regions (Bedford 1999). Several studies have used *landscape profiles* to describe the spatial distribution of wetland templates across the landscape (Bedford 1996, 1999, Gwin et al. 1999b, Johnson 2004). Detailing the types, numbers, and abundance of wetlands, profiles provide information on 'wetland demographics' and can reveal the cumulative effects of management decisions on wetlands at a landscape scale and potentially influence conservation policies (Bedford 1996, 1999, Shaffer et al. 1999, Leibowitz and Nadeau 2003, Johnson 2004).

Wetland demographics and landscape profiles can also be used in conservation planning at a watershed scale by identifying rare or regionally unique wetland types and large assemblages of wetlands that represent the diversity of wetlands in a given area (Tiner 2003a). Using wetland templates, Bedford identified a downward shift in the proportion of wetland types that occur within a landscape as a function of current approaches to wetland mitigation and restoration (1999). At least two regional studies found mitigation wetlands often have hydrologic regimes differing from the naturally occurring wetlands they are designed to replace, causing mitigation failure and changing water regimes on a landscape scale (Cole et al. 1997, Gwin et al. 1999b, Shaffer et al. 1999). Additionally, Bedford (1996 and 1999) demonstrated that the homogenization of wetlands, which results from a loss of both hydrologic function and biodiversity, could be avoided by making mitigation decisions within a landscape scale framework. Bedford (1999) noted that proper placement in the landscape is necessary for wetlands to be self-maintaining and this could be accomplished by using wetland templates to correctly predict the occurrence and size of wetlands.

Isolated Wetlands

Many coastal palustrine wetlands, such as bogs, interdunal marshes, and seepage slopes, are small and more geographically isolated than tidal wetlands, which often form over large contiguous areas (Akins and Jefferson 1973b, Tiner 2003b). However, the spatial distribution of small and scattered wetlands is not well understood, despite the growing body of knowledge concerning isolated wetlands (Gibbs 1993, Semlitsch and Bodie 1998, Leibowitz 2003, Leibowitz and Nadeau 2003, Merot et al. 2003, Tiner 2003b, Whigham and Jordan 2003, Winter and LaBaugh 2003, Zedler 2003).

There is much debate over definitions of isolation in regards to wetlands. Geographic isolation refers to wetlands that are completely surrounded by uplands and are spatially isolated from other wetlands (Leibowitz 2003, Leibowitz and Nadeau 2003). Hydrologic isolation refers to wetlands that are not connected to streams or other surface-water bodies. However, isolated wetlands are occasionally linked during periods of high precipitation and rising water levels (Winter and LaBaugh 2003). Also, some wetlands that appear to lack a connection via surface water may nonetheless be connected by a persistently high groundwater table.

Gibbs (1993) found the size and distribution of small wetlands to be important for the persistence of metapopulations of certain animals. Other studies indicate that isolated wetlands can contribute to regional biodiversity, metapopulation dynamics, and biological landscape connectivity (Gibbs 1993, Semlitsch and Bodie 1998, Leibowitz 2003, Leibowitz and Nadeau 2003). Landscape scale functions of isolated wetlands need further study, particularly regarding the environmental characteristics that influence function. Palik et al. (2003) propose that the development of management policies for small, seasonal, or isolated wetlands depends on the ability to effectively predict the distribution and abundance of these ecosystems in the landscape. However, neither the NWI nor the HGM classifications distinguish isolated from non-isolated wetlands (Leibowitz and Nadeau 2003).

In the famous case Solid Waste Agency of Northern Cook County (SWANCC) v. U.S. Army Corps of Engineers the Supreme Court ruled that isolated, non-navigable waters could not be protected under the Clean Water Act based solely on their use by migratory birds. This decision was interpreted by some to mean that isolated wetlands should not be protected for any reason, and in the years since the decision was rendered, hundreds of wetlands have been altered (usually illegally) as a result of such misinterpretation. This highlights the importance of compiling basic information on the numbers and distributions of isolated wetlands (NRC 2001). Data are needed that quantify the number, area, and function of isolated wetlands to use in wetland monitoring and conservation planning of this limited resource (Leibowitz and Nadeau 2003).

To address the need for such data, the U.S. Fish and Wildlife Service initiated a study to identify the extent of isolated wetlands in a few study areas around the country. The Coquille watershed was one of the areas selected, and coincidentally is part of the study area for the analysis described in this thesis. The Service chose to define isolation in terms of landscape position where wetlands had no apparent connection to surface water, perennial rivers or streams, estuaries, or the ocean (Tiner et al. 2002). Using digital NWI data in a geographic information system, the Service found that isolated wetlands represent a significant amount of the wetlands within their study areas. This finding is significant in terms of the SWANCC decision, which would leave most of these wetlands without legislative protection. The Service defined isolation in terms of three scenarios—wetlands not connected to a 40-meter buffer of a river or stream, wetlands within a 20- to 40-meter buffer, and a scenario that included all road-fragmented wetlands.

Enhanced NWI Databases

A GIS enables users to synthesize information in a database with the spatial expression of these data in the landscape at multiple scales (Ji et al. 1992, Good and Sawyer 1998, Wooten et al. 1998, Lyon 2001, Tiner et al. 2002, Tiner 2003a, Johnson 2004). Digital NWI layers can serve as a foundation dataset for wetland analysis using GIS. The NWI data use Cowardin classification codes to characterize wetland polygons with regard to vegetation, hydroperiod, water chemistry, and special modifiers indicating human use. Although this is useful for some purposes, it provides little in terms of physiographic or topographic information about the wetland and its context within the larger landscape. Physiographic variables include landscape-scale data such as geology and precipitation patterns. Topographic information can describe more localized characteristics of a wetland such as landscape position or landform conditions such as elevation and slope (Moore et al. 1991a).

To compensate for the lack of information, it is possible to create an enhanced NWI database by adding other spatial attributes to the wetland polygons. This creates an extremely valuable resource with many applications in watershed management, conservation planning, and functional assessments (Good and Sawyer 1998, Wooten et al. 1998, Tiner 2003a). Tiner et al. (2003a) used an enhanced NWI database to conduct a preliminary assessment of wetland functions for one watershed in the northeastern United States. The study sought to develop correlations between wetland characteristics represented in the database and the functions various wetland types perform. Another study (Wooten et al. 1998) added digital terrain variables to an NWI database in order to assess the extent of wetlands in an upper montane area of Washington. A 30-meter digital elevation model was used to create variables describing slope, curvature, and hydrologic accumulation, which were combined to create a wetland probability surface.

Derived Topographic Variables and Terrain Modeling

Variables representing the spatial distribution of wetlands in the landscape are important to include in an enhanced NWI database. Geomorphology is considered to be a primary control on wetland formation, which thus influences the patterns of wetland occurrence across a landscape (Merot et al. 2003).

Geomorphic variables determine how wetlands function at both a site-specific and landscape scale. Many studies have focused on how the geomorphic setting of a wetland influences hydrology, which is believed to be of primary importance in determining the formation and functions of wetlands (Winter 1988, Moore et al. 1991a, Brinson 1993a, b, Doss 1995, Bedford 1996, Brinson and Rheinhardt 1996, Mitsch and Wilson 1996, Cole et al. 1997, Shaffer et al. 1999, Mitsch and Gosselink 2000b). Complex interactions of topography, hydrology, and soil attributes influence wetland occurrence and position within a landscape and define the functional significance of particular wetland types. In his description of the physical framework within which palustrine wetlands form, Winter (1988) stressed that understanding wetland function and occurrence patterns requires knowledge of the variable physiographic and hydrologic environments that support wetland formation.

Wetland geomorphology is expressed partly in terms of topographic variability. Variables such as slope, aspect, and basin curvature are all localized expressions of topography, which controls both the movement of water with the landscape and where it will collect (Moore et al. 1991b, Stein et al. 2004). The geomorphic heterogeneity of a landscape is thus a function of various combinations of topographic variables (Nichols et al. 1998). Capturing this heterogeneity in an enhanced NWI database requires the ability to model the three-dimensional nature of the landscape in a way that allows for easy extraction and transferability of data values (Moore et al. 1991b, Rodhe and Seibert 1999).

A digital elevation model (DEM) is a data format used extensively for terrain modeling applications that are used to represent the three-dimensional surface of the landscape in a digital format (Moore et al. 1991b, Wilson and Gallant 2000). A DEM is a grid comprised of pixels containing an average elevation value sampled over the area of the pixel. Resolution is determined by the size of the pixel. For example, a 30-meter DEM contains pixels that are 30-meters on a side. A 30-meter DEM samples elevation over a larger area than a 10-meter DEM, and thus has a coarser resolution with less accuracy.

Derived topographic variables are those that are obtained by terrain modeling applications performed on a DEM, and are represented as either primary or secondary topographic attributes (Moore et al. 1991b, Wilson and Gallant 2000). Primary topographic attributes are those that are calculated directly from a DEM and include variables such as elevation, slope, aspect, curvature, and flow direction. Secondary topographic attributes are calculated by using a specific algorithm to combine two or more primary attributes and are used to describe the spatial variability of specific processes at work in the landscapes. Examples of secondary topographic attributes include various soil wetness indices. All derived topographic attributes are modeled surfaces, and thus some inherent inaccuracies must be expected when estimating spatial patterns in the landscape (Wilson and Gallant 2000).

A secondary topographic attribute that has received attention for its applicability to wetland prediction studies is the compound topographic index (CTI). Numerous studies have examined the degree to which the CTI can be used as an approximation of soil moisture content (Moore et al. 1991b, Gessler et al. 1995, Rodhe and Seibert 1999, Gessler et al. 2000, Wilson and Gallant 2000, Merot et al. 2003), especially as related to wetland occurrence. The CTI is used to model the influence of topography on the location and extent of areas of saturated soil by considering local slope and drainage area parameters. Large CTI values indicate areas of increasing concavity and flow accumulation and are most often found along drainage paths and other zones of moisture accumulation, although large CTI values may also be found along slopes disconnected from river networks (Gessler et al. 2000, Merot et al. 2003).

Several studies have used either physiographic or derived topographic attributes as variables to characterize patterns of wetland occurrence and distribution (Moore et al. 1991a, Halsey et al. 1997, Toner and Keddy 1997, DeSteven and Toner 2004, Stein et al. 2004). Halsey et al. (1997) studied climatic and physiographic controls on wetlands in Manitoba and found that climatic variables and geology were the most significant determinants of wetland type. Palik et al. (2000) tested an approach to predict plant communities in order to prioritize restoration efforts and found that ecosystem identity was predicted with high accuracy using only geomorphic and soil variables. They believe this was because upper hierarchical levels such as ecosystem identity control the development of lower levels such as vegetation. These results indicate that geomorphic and soil attributes may be significant indicators of wetland characteristics, which are expressed in terms of lower hierarchical levels such as vegetation (Cowardin et al. 1979).

Decision Tree Analysis

Enhanced NWI databases are powerful in their ability to catalog numerous environmental variables occurring within mapped wetland polygons, but are limited in their ability to translate information about statistical relationships among variables. A type of exploratory data analysis is needed in order to identify key relationships among variables and how they are expressed in the landscape in terms of wetland characteristics and distributions.

Decision tree analysis, such as classification and regression tree analysis (CART), is a form of data exploration that can be used to identify relationships among variables (Breiman et al. 1984, De'ath and Fabricius 2000, ANGOSS 2001). Decision trees are the graphic outputs of conventional statistical tests that illustrate rules of statistical association among variables in a dataset (Moore et al. 1991a, ANGOSS 2001). This type of modeling is particularly suited for analyzing ecological data because it requires few assumptions about frequency distributions, is fairly insensitive to outliers or missing data, and accommodates both categorical and continuous variables (Moore et al. 1991a, De'ath and Fabricius 2000).

Palik et al. (2003) used one form of decision tree analysis, CART, to generate rules describing the distribution of small seasonal wetlands in an upland matrix. They demonstrated that there is a significant degree of spatial variation in seasonal wetland densities across a landscape and related wetland occurrence to larger-scale constraining variables. Although CART explained only 11.6% of variation in wetland density, it identified the most significant variables related to differences in density. Using such an approach, the authors suggested that natural resource managers could estimate the likelihood of wetland occurrence without the expense of inventories using aerial photography (Palik et al. 2003).

Moore et al. (1991) used decision tree models to predict forest community distributions using topographical and geological attributes inventoried in a GIS database. This research demonstrated the utility of using a geographic database in conjunction with decision tree modeling to reveal processes and relationships found among variables. In their study, variables that operated at large scales were used as rule-splitting criteria early in the model, while more localized variables influenced the rules near the terminal nodes. This reflects the ability of decision tree models to represent complex ecological systems composed of a hierarchy of interacting variables. The study also suggests that the specification of threshold values of occurrence may have more ecological validity than descriptions based solely on parameters such as means and standard deviations (Moore et al. 1991a). Results of other studies indicate that decision tree models may be effective at distinguishing among variables at multiple scales that are related to the occurrence of wetlands, which are entities regulated by a hierarchy of ecosystem constraints (Palik et al. 2003).

CHAPTER THREE: METHODOLOGY

The research described here was designed to test hypotheses about physiographic and derived topographic variables associated with palustrine wetlands as mapped by the NWI. The study attempted to identify relationships among variables that are indicative of wetland distributions within watersheds and among ecoregions. This research also sought to demonstrate an approach for characterizing palustrine wetland size and degree of isolation using decision tree analysis and an enhanced NWI geodatabase. The questions that were addressed are re-stated as follows:

1. What are the geographic patterns of occurrence among NWI palustrine wetland polygons in the study area?

2. Which environmental variables are associated most closely with the size and degree of isolation of NWI palustrine wetland polygons?

3. Do threshold values exist for environmental variables that could be used to predict the sizes of NWI palustrine wetland polygons and their degree of isolation?

This project involved two major phases—designing an enhanced NWI geodatabase of palustrine wetland polygons and using the geodatabase to answer specific queries. This approach was structured as follows:

- Designing an enhanced NWI geodatabase
- Using the geodatabase
    - Creating watershed profiles and wetland demographics
    - Using exploratory data analysis in the form of decision tree modeling
    - Visualizing model results

An important point to emphasize is that this research seeks to develop models used to characterize variables associated with *mapped NWI wetland polygons*. Any inferences or predictions made about the data are only true within the boundaries of these polygons. For purposes of this project, these maps are assumed to show wetlands with 100% accuracy and completeness within the area analyzed. Predictions concerning the occurrence of wetlands at points in the landscape outside the mapped polygons could be made if non-wetland sample points were included in the analysis, but this was beyond the scope of this project.

Designing an Enhanced NWI Geodatabase

For this phase of the methodology, an enhanced NWI database was created with ArcGIS using digital NWI data. Only wetlands with a palustrine designation located within study area boundaries were selected for analysis. Contiguous NWI polygons were first merged ("dissolved") to create whole-wetland polygons, and these were subsequently re-divided into numerous smaller polygons by merging with SUURGO soil data layers whenever soil map units were present within the polygon boundary (Figure 10). This enabled the database to more closely approximate the natural spatial variability found in wetlands (Stolt et al. 2001). Within the study area boundary, 16,941 of these polygons have palustrine labels. Dissolving the palustrine polygons that were contiguous reduced this number to 6,002 individual wetland polygons (Table 1).

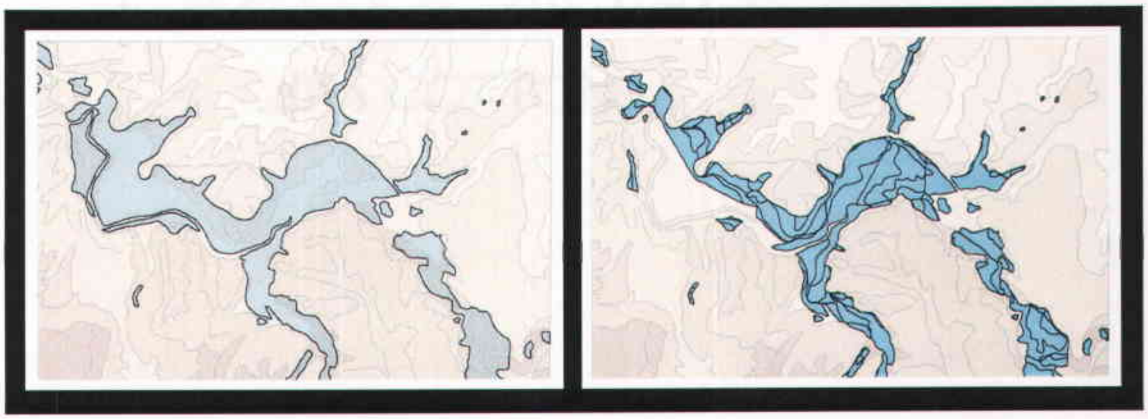

Figure 10: The process of merging soil data layers with NWI polygons. This image shows an original NWI polygon (left), and the same polygon after it has been merged into many smaller polygons according to variations in soil type (right).

Table 1: Study area statistics.

Study Area Statistics	
Surface area	2,900 miles^2 / 7,500 km^2
Number of watershed complexes	5
Number of individual watersheds	18
Total # of NWI polygons	16,941 polygons
Total NWI polygon acreage	40,627 acres

The ability to successfully characterize wetland occurrence is largely dependent on the types of variables that are added to the database and analyzed (Figure 11). Each wetland polygon has a Cowardin classification code, but little else is known about the physiographic or geomorphic context of that wetland within the landscape. In considering which environmental variables should be added to the database, it was important to consider three factors—data availability, ease of generation, and the potential significance of that variable to wetland size and degree of isolation.

Selected variables can generally be considered either physiographic or derived topographic variables. Physiographic variables are those that occur at a broad scale and have the potential to influence the physical characteristics of a wetland. These variables included (for example) geology, proximity to floodplain, average annual precipitation, and ecoregion identity. Not all physiographic variables were used in the decision tree analysis; some serve as selection criteria (pre-classifiers) when analyzing wetlands among isolation categories. Derived topographic variables occur at more

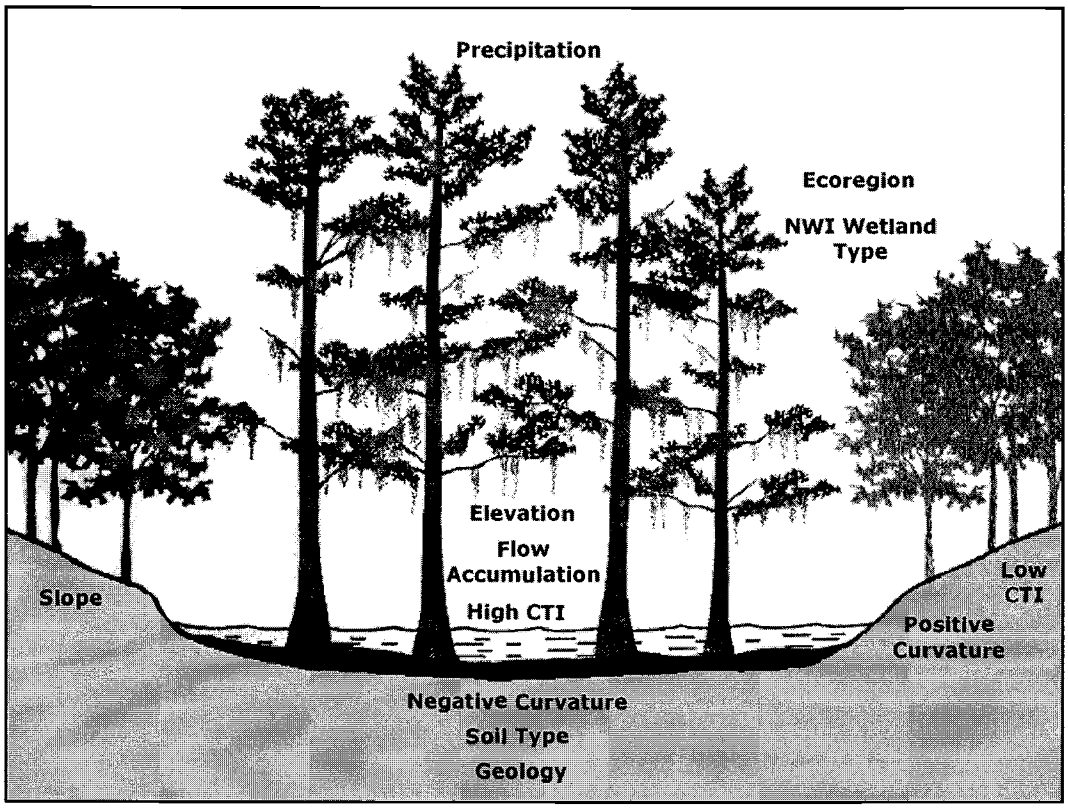

Figure 11: The spatial distribution of environmental variables used in the enhanced NWI geodatabase (image adapted from Mitsch and Gosselink 2000b).

localized scales and influence the geomorphology or landform characteristics of a wetland. All derived topographic variables were generated from a 10-meter DEM and include (for example) elevation, slope, curvature, and flow accumulation.

Physiographic Variables

Physiographic variables used in this analysis were all categorical in nature—they are either categories such as geologic type or binary values such as yes/no designations for hydric soil intersection (Table 2). This simplified the process of converting these data layers into attributes that could be included in the geodatabase. Categorical data cannot be averaged over an area, so a custom script was written that

Table 2: Environmental variables added to the geodatabase.

PHYSIOGRAPHIC VARIABLES	
Variable	**Data Source**
Wetland type	NWI Cowardin classification
Ecoregion	EPA Ecoregions
Soil type	SUURGO
100-year floodplain	FEMA
Geology – fine scale	USGS
Precipitation – avg. annual	PRISM
Stream intersection	CLAMS
Road intersection	TIGER
DERIVED TOPOGRAPHIC VARIABLES	
Variable	**Data Source**
Elevation	10-meter DEM
Slope	10-meter DEM
Curvature	10-meter DEM
Plan curvature	10-meter DEM
Flow direction	10-meter DEM
Flow accumulation	10-meter DEM
Compound topographic index	10-meter DEM

uses the centerpoint of a wetland polygon to extract a data value. However, in some instances it may not be logical to extract data in this manner.

Binary physiographic variables that rely on spatial intersections of the wetland polygon with a physical feature such as a stream or FEMA floodplain require the use of a special dissolved polygon layer. Each individual wetland polygon has been subdivided into numerous smaller components based on soil type. As a result, if a normal spatial query is performed with ArcGIS to find all wetland polygons that intersect a stream, there is the potential to select only a portion of the NWI polygon (Figure 12). In reality, if one part of a wetland intersects a stream, the entire wetland

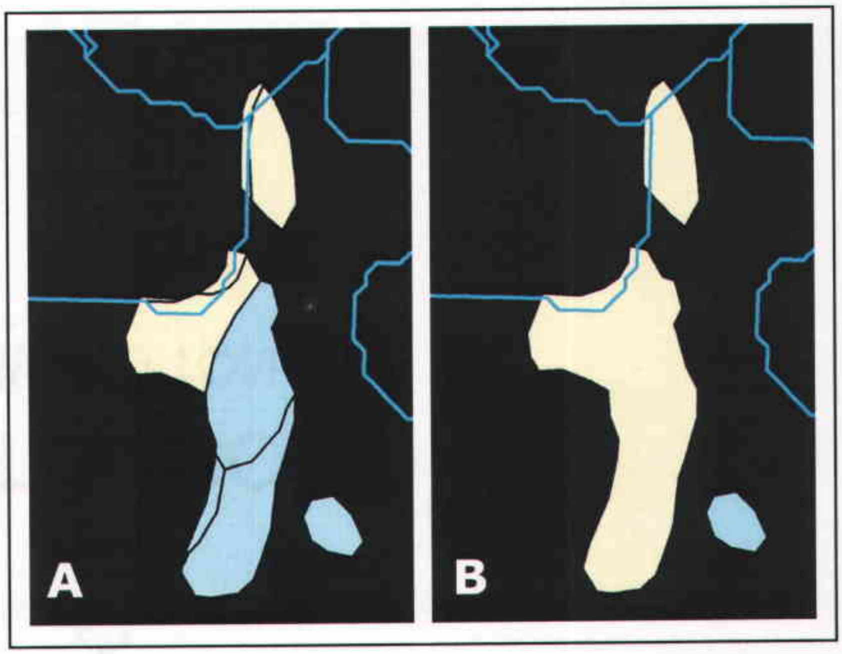

Figure 12: Demonstration of the need to use a dissolved polygon layer for spatial queries. 'A' represents the problem encountered when selecting wetlands that intersect streams—only polygons adjacent to the stream will be selected; 'B' represents how the problem is alleviated by the use of dissolved wetland polygons that enable an entire wetland to be selected when it intersects a stream.

should be considered to potentially be influenced by surface water inputs from that intersection. Each NWI-mapped polygon does not necessarily represent a whole wetland in the geomorphic sense. To avoid this inconsistency, the NWI palustrine layer was dissolved so that all internal polygons (whether a result of adjacent NWI wetland types or different soil types) were erased. The product is a layer containing 6,002 polygons outlining the complete boundaries of contiguous wetlands. Once spatial queries are made and the desired wetland boundaries are selected, another spatial query can be performed on the original un-dissolved palustrine database layer that will select all of the component polygons contained within those boundaries.

Derived Topographic Variables

Topographic variables are all derived from an input DEM and are thus comprised of either continuous or floating-point data values (Table 2). Extracting data values from the grids required the use of zonal statistics, a utility in ArcToolbox that calculates certain statistical parameters such as mean or standard deviation values within a specified polygon (ESRI 2005). For this study, the zonal statistics utility was used to derive the mean value of each derived topographic variable. The zonal statistics utility has the potential to oversimplify the characteristics of a wetland if the mean is being computed over a large area. However, the palustrine database is subdivided into numerous smaller polygons based on soil type, which enables multiple samples of a topographic variable to be taken within a single NWI wetland polygon. This means that the variability of landform within a single wetland can be represented more accurately within the database.

A series of 10-meter DEMs was used to derive all topographic variables. Two DEM layers overlap within the study area and a mosaic image was created to form a seamless surface that extended beyond the boundaries of the study area. All terrain modeling operations were performed on the seamless mosaic to avoid edge effects and maintain flow paths around the study area boundaries.

The ArcHydro extension of ArcGIS was used to perform all terrain modeling operations. Hydrological and geomorphological processes at work in the landscape are directly related to variations in topography. Terrain modeling provides a way to represent the land surface in three dimensions and enables the creation of indices that can quantify these landforms for use in a geodatabase (Moore et al. 1991b).

Table 3: Definitions of environmental variables added to the geodatabase.

Primary Topographic Attributes (adapted from Moore et al. 1991)	
Variable	**Description and indications**
Elevation	A measure of altitude; influences microclimate and vegetation; can indicate landscape position
Slope	The rate of maximum change in *z* value from a cell; the means by which gravity influences the flow of water through the landscape
Curvature	Indicates whether a surface is upwardly concave or convex; indicates converging/diverging flow
Plan curvature	Curvature of the surface perpendicular to slope direction; indicates converging/diverging flow
Flow direction	Indicates the direction of steepest descent; indicates flow paths
Secondary Topographic Attributes	
Variable	**Description and indications**
Flow accumulation	Derived from flow direction grid; indicates areas of concentrated flow or local topographic highs
Compound topographic index	Derived from slope, flow direction, and flow accumulation grids; indicates zones of saturation

An important first step in the terrain modeling process is to create a depressionless DEM surface to use for analysis. When DEMs are re-projected, slight irregularities can develop in the grid spacing that result in artificial sinks, or cells with no defined drainage direction. These sinks have the potential to disturb drainage pathways, which can be avoided by numerically 'filling' the sinks and creating a depressionless surface.

The derived topographic variables generated by ArcHydro are listed in Table 3. Two variations of curvature were created to test (in the decision tree models) which variable was a more significant predictor of wetland size and isolation. Aspect, which consists of 8 direction categories, was not added to the database because of the inherent difficulty of averaging a categorical value within a wetland polygon. Using the centerpoint of the polygon to select one aspect value to represent the whole wetland was not judged to be a valid choice due to the large potential for error and misrepresentation of the true aspect of the wetland.

The compound topographic index (CTI) is a secondary topographic index that has been used widely to approximate soil moisture content in various physical environments (Moore et al. 1991b, Gessler et al. 1995, Rodhe and Seibert 1999, Gessler et al. 2000, Wilson and Gallant 2000, Merot et al. 2003). This index quantifies the effects of topography on both the location and size of zones of saturated areas in the landscape, and assumes uniform soil properties (Wilson and Gallant 2000). The CTI, or steady-state wetness index, provides a relative value index with low values indicating higher topographic position and drier soils and high values indicating increasing concavity and flow accumulation (Gessler et al. 2000).

A valuable application of this index is the ability to reclassify a watershed into saturated and unsaturated zones, although it is unclear which values form the boundaries between these conditions. In this portion of the study, decision tree analysis was used to identify threshold values for the CTI index within the study area. Another application of the CTI model is the ability to visually identify saturated zones that are disconnected from river networks, which may be a component variable in the identification of geographically isolated wetlands.

Merot et al. (2003) found that a topographic wetness index, when used in conjunction with climate data, can be a significant predictor of wetland distribution.

These findings suggest that the ability of the CTI to predict wetland occurrence may be increased when used with other physiographic or derived topographic variables. Rodhe and Seibert (1999) also tested the ability of the CTI to indicate areas of moisture associated with wetland occurrence. However, their study was inconclusive due to the use of rather coarse 50-meter resolution DEM layers.

The CTI is derived from a formula utilizing three other grid surfaces—slope, flow direction, and flow accumulation (Figure 13). The significance of these variables in relation to wetland occurrence will be tested against the CTI with decision tree models. The algorithm used for this research is as follows:

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

$$CTI = ln\ ((flow\ accumulation + 1)/(tan\ (slope + 1)))$$

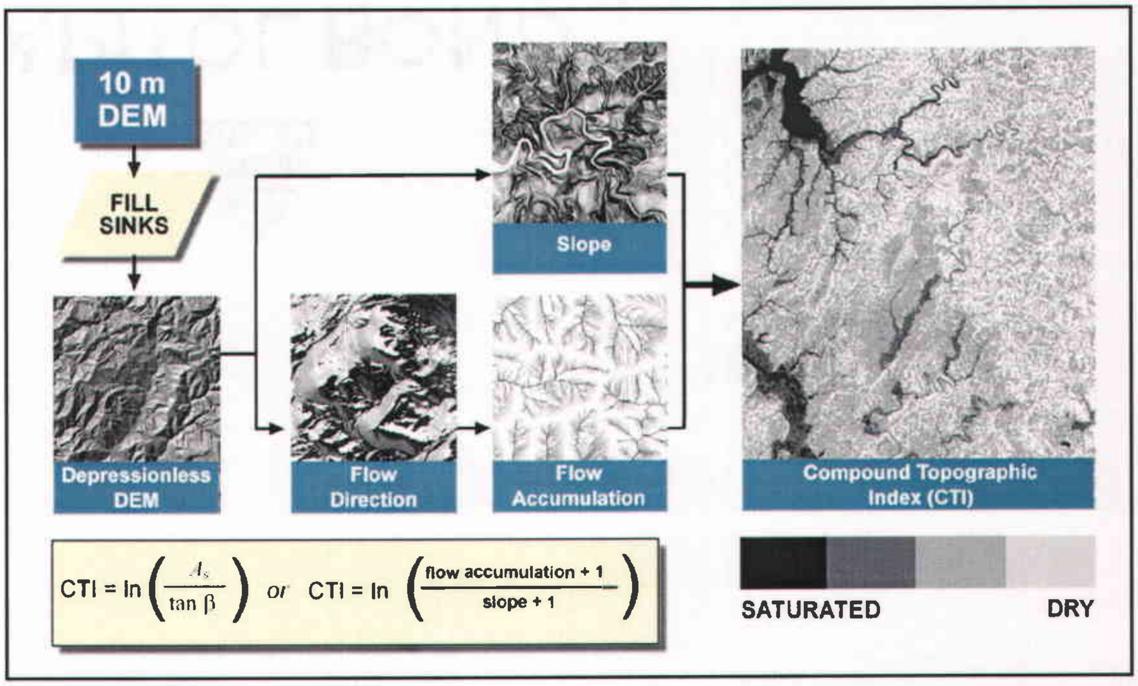

Figure 13: Calculating the compound topographic index.

Data Uncertainty and Variable Correlation

There is an inherent amount of uncertainty associated with geospatial data. The major uncertainties associated with this research are related to boundary accuracy and resolution, conflicting scales, and issues of correlation among variables. An NWI wetland polygon layer is the foundation of the geodatabase, and any inaccuracies in these polygons have the potential to influence analysis results (see the Palustrine Database metadata in the Appendix for detailed information on NWI mapping accuracy). Boundary accuracy is an issue that is difficult and sometimes impossible to resolve without extensive efforts at field verification. Scale differences can also introduce sources of inconsistency in spatial data. Wetland polygons and watersheds are generally mapped at a scale of 1:24,000 while data layers such as ecoregions have a scale of 1:250,000 and the DEM for Oregon has a pixel resolution of ten meters. These differences in scale have the potential to influence the accuracy by which boundaries coincide. In future research, it would probably be beneficial to derive watershed boundaries directly from a DEM, helping to ensure that variables such as catchments, streams, and slope values are spatially related to each other in an internally consistent manner.

DEM accuracy is dependent on data source selection, sampling method, and interpolation scheme (Erskine et al. 2004). Using a single DEM to generate variables such as streams, slope, and compound topographic index raises questions of variable correlation and compounding error in the geodatabase. Any errors inherent to the original DEM will be present or possibly enhanced in related variables.

Wetland Isolation Categories

For the purposes of this study, isolation refers to wetlands that are geographically isolated from apparent surface water connections. Operationally, two categories of isolation were defined, one based on proximities to streams, hydric soils, floodplains, and other wetlands, and another based solely on varying proximities to stream buffers (Table 4). Binary fields assigning wetlands to these isolation categories are included in the database. The dissolved polygon selection layer was used to develop the spatial queries in order to ensure wetland polygons were assigned to only one category.

Isolation categories A-C represent a series of increasingly restrictive isolation scenarios. The categories attempt to identify wetlands lacking physical surface connections to hydrologic features such as streams, floodplains, and hydric soils. An alternative classification system was used to define isolation categories S1-S3, with rules similar to those developed by the U.S. Fish and Wildlife Service and used in their study of geographically isolated wetlands (Tiner et al. 2002). Tiner et al. (2002) included road-fragmented wetlands in one of the scenarios, but were unsure whether the wetlands were truly isolated or were connected to non-isolated wetlands by culverts. For the purposes of this research, road crossings alone were not considered sufficient to fragment wetlands. Road-crossed wetlands were considered fragmented only if mapped by NWI as separate polygons. Road fragmentation was considered an important variable related to wetland size, and was thus used in the statistical analysis.

Table 4: Definitions of isolation scenarios for wetland polygons.

Isolation Scenarios A,B,C, and X	
Scenario	**Description**
Isolation 'A'	Not intersected by mapped stream and not within 10m horizontally of another mapped NWI polygon
Isolation 'B'	'A', and not intersected by hydric soil or water as defined by SUURGO and not intersecting the FEMA floodplain
Isolation 'C'	'B', and not within 10m horizontally of a stream, floodplain, or hydric soil
Isolation 'X'	None of the above (not isolated)
Isolation Scenarios S1, S2, S3, and X	
Scenario	**Description**
Isolation 'S1'	Does not intersect a 40m stream buffer
Isolation 'S2'	Intersects a 40m buffer but not a 20m buffer
Isolation 'S3'	Intersects the 40m and 20m buffer but not a 10m buffer
Isolation 'X'	None of the above (not isolated)

Using the Enhanced NWI Geodatabase

Once all variables were added to the palustrine database, the shapefile was integrated into an ArcGIS geodatabase containing database tables and selected shapefiles in one concise package (Figure 14). The benefits of geodatabases over separately managed shapefiles and database tables are numerous (Zeiler 1999). They can easily manage large amounts of data, which is important since the palustrine database contains nearly 17,000 individual records. Geodatabases are portable, meaning multiple database tables and shapefiles are stored within one file that can be exported and shared with other users. Geodatabases are very interactive and are easily updated as new information becomes available. For example, once the palustrine geodatabase is initialized, it is extremely easy to add new data fields. A watershed manager could theoretically create a smaller geodatabase particular to a specific watershed and add new field-sampled data to the model as they become available. Geodatabases also possess a structured method of data organization that can allow a user to separate physiographic and derived topographic variables into separate tables that reference the same spatial polygon layer. This increases efficiency by reducing processing time when queries or other applications are run on the data. Once a geodatabase is complete, summary statistics can be generated in the form of watershed profiles and wetland demographics, showing the range of values observed within mapped wetland polygons. Mean observed values for continuous variables are easy to

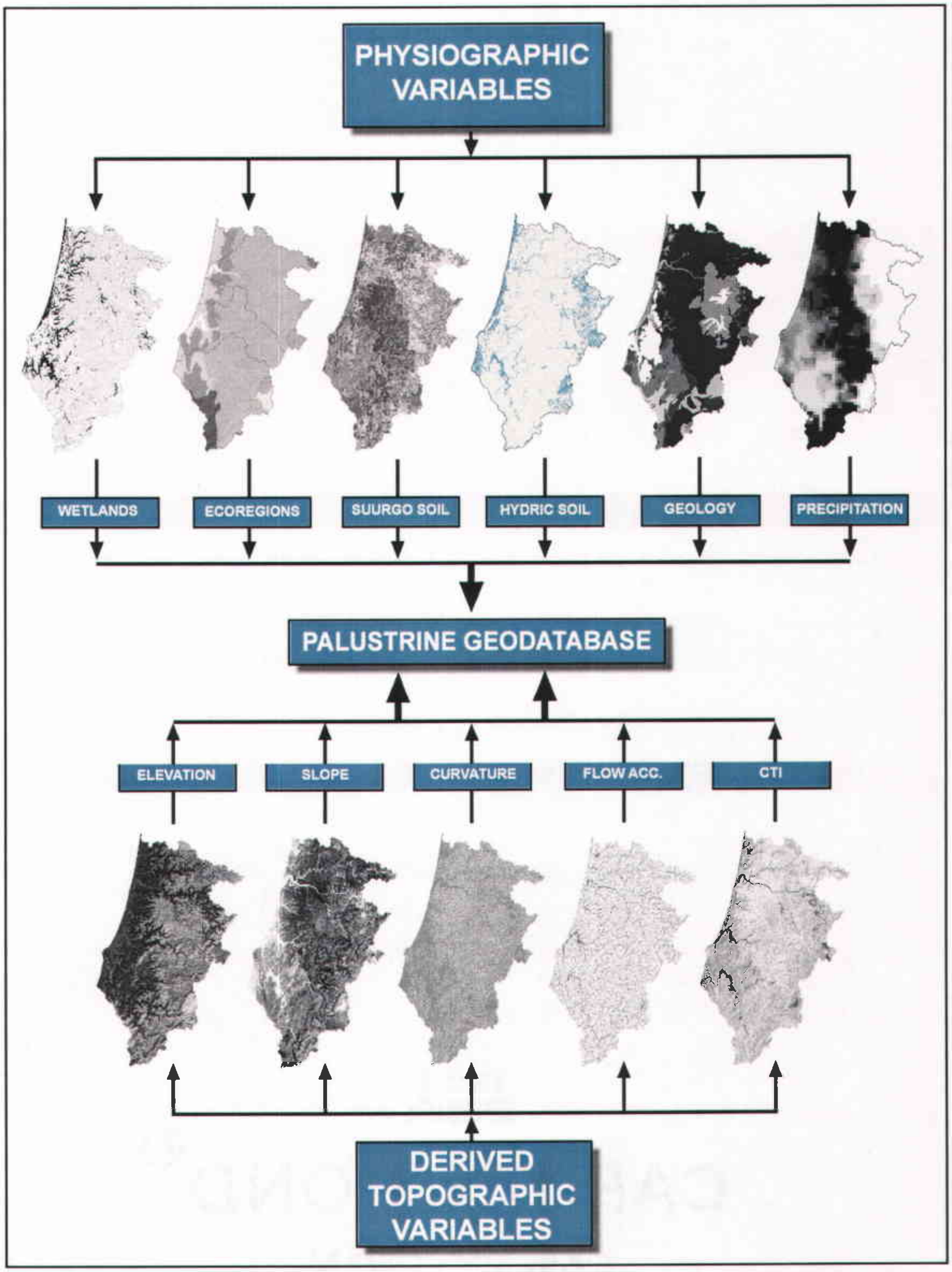

Figure 14: Examples of physiographic and derived topographic variables included in the enhanced NWI geodatabase.

produce and provide an initial snapshot of the characteristics of the wetlands in the database.

Exploratory Data Analysis

After the geodatabase was constructed and watershed profiles developed, these were used to characterize the wetland demographics of the study area. The information from these demographics was used to formulate a group of models to test using decision tree analysis. These models can be grouped into three broad categories of inquiry—variables associated with isolated wetlands, variables associated with the occurrence of hydric soils, and variables associated with PEMC (palustrine, emergent vegetation, seasonally flooded) wetland types. These groups represent only a small sample of the types of inquiries that could be constructed with the database.

Decision tree analysis (DTA) was applied to selected variables in the geodatabase. A binary field that identified each polygon as being (or not being) an isolated wetland, having hydric soil, or having PEMC as the type of wetland present served as the dependent variable. A series of models were produced that attempted to predict each of these dependent variables, and the resulting models varied in complexity and accuracy. For each prediction, alternative models were ranked according to their accuracy ratings.

DTA uses various statistical techniques to infer a set of rules from a dataset. The rules describe associations between a dependent variable and any number of independent variables, either categorical or continuous (ANGOSS 2001). Unlike regression models which only identify significant variables, decision trees can illustrate contingent relationships and thresholds among variables. Chi-Square

Automatic Interaction Detection (CHAID) software was used to create decision tree models for this research (ANGOSS 2001). Similar to Classification and Regression Tree (CART) software, CHAID uses chi-square tests rather than regression to determine splitting rules for the models, and has the additional advantage of allowing more than 2 splits at each node in a tree, wherever such splits are supported by the underlying statistical tests.

Decision tree models are developed by repeatedly splitting the data according to a rule based on the independent variables (Figure 15). At each split, data are partitioned into two or more mutually exclusive groups (or nodes) that are as homogeneous as possible. This splitting procedure is applied to each node separately to determine which combinations of variables best explain the dependent variable. Terminal nodes are created when no other significant splits exist for that node. Split reports are generated that list variables in rank order according to their degree of significance in explaining the dependent variable. The split report also lists a p-value and either an F-statistic or chi-square value for each variable, making ancillary ANOVA or regression tests for variables unnecessary. It is also possible to generate rules reports for selected nodes of interest that provide a verbal description of the splitting criteria.

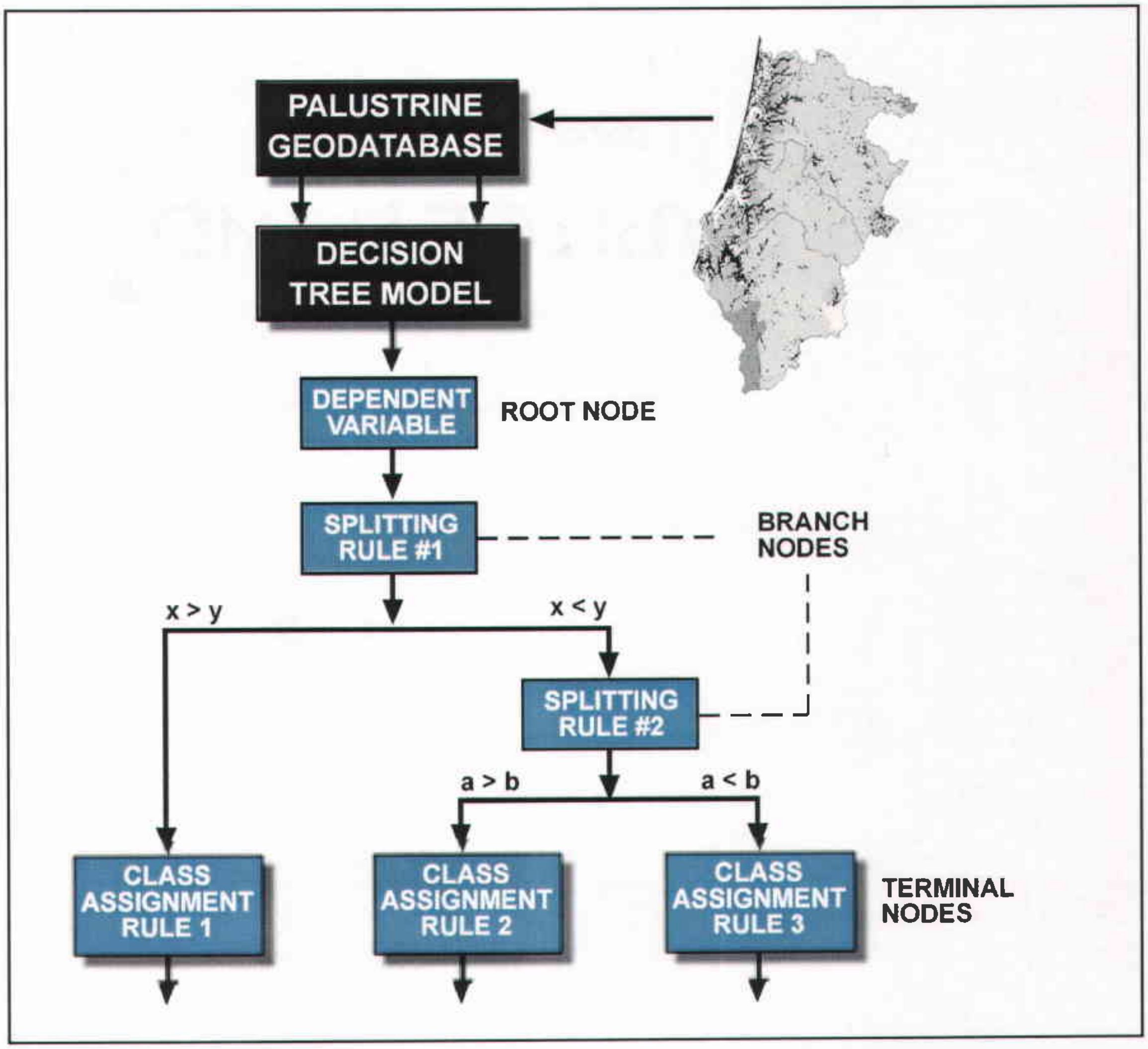

Figure 15: The decision tree modeling process.

When binary fields are used as the dependent variable it is relatively easy to identify the nodes that best answer a question of interest (Figure 16). Each node is divided into two colors representing the binary field (0's and 1's). If one color occupies more than 50% of the node box, then the splitting rule has found variables that are most associated with the binary variable corresponding to that color. For the

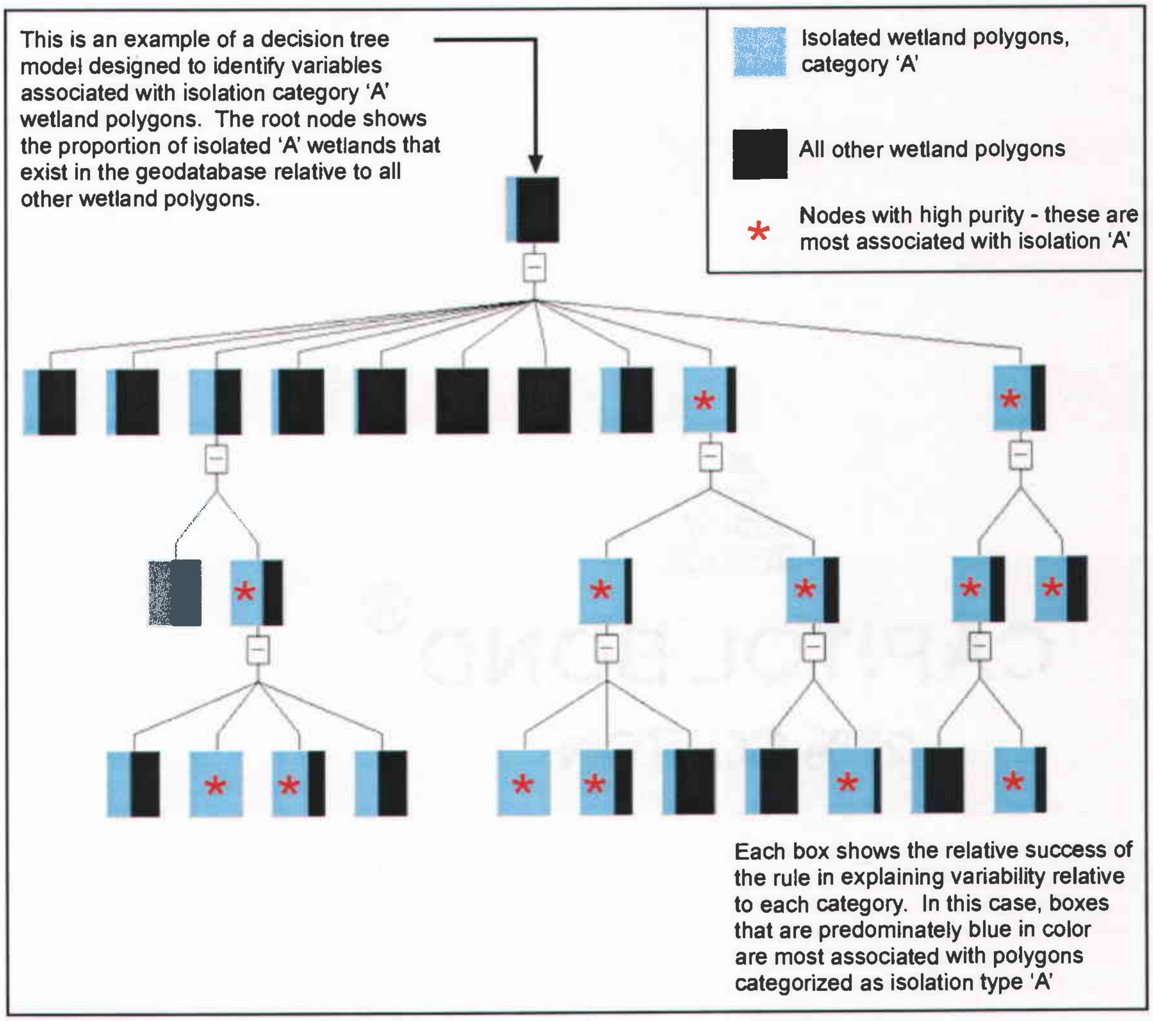

Figure 16: Interpreting decision tree diagrams.

purposes of this study only results for nodes that best answer the question of interest will be reported, although the accuracy rating of the model will always be stated.

To ensure each model was initiated and reported in an identical manner, a standard process was developed and followed when modeling the isolation, hydric soil, and PEMC variables (Table 5).

Table 5: The standard modeling process used for each application.

1	State specific question to be addressed by a FULL model
2	Run the FULL model (all physiographic and topographic variables are included)
3	Record accuracy rating of the model
4	Record significant variables and associated p-values
5	Identify nodes with lowest impurity percentages (most homogeneous)
6	Record rules report for nodes related to specific questions
7	State specific question to be addressed by a PARTIAL model
8	Run PARTIAL model on selected significant variables (identified by the full model)
9	Record accuracy rating of the model
10	Identify any threshold values

Employing a process such as this that incorporates both decision trees and a geodatabase creates a unique interactive environment for data exploration. The geodatabase is used to catalog data and provide summary statistics that are then used to formulate inquiries. These inquiries are modeled using decision trees, which produce a set of rules about relationships among variables. The geodatabase can then be used again to graphically display these rules in a spatial context. The coupling of these two methodologies thus provides a powerful tool for use in conservation planning and management.

Despite the flexibility of the modeling process, there are inherent limitations. Accuracy ratings are influenced by the spatial resolution of the DEM's and the mapping accuracy of the NWI polygons. It has been suggested that NWI maps may underestimate the extend of wetlands (Tiner et al. 2002). Another limitation is that although the methodology can be replicated in any watershed, the specific rules generated by the models cannot be extrapolated to other regions—results are specific to the study area only.

CHAPTER FOUR: MODEL RESULTS

This project consisted of two major phases—designing an enhanced NWI geodatabase of palustrine wetland polygons, and then using the geodatabase to create watershed profiles and wetland demographic statistics and for exploratory data analysis in the form of decision tree modeling. It is important to re-emphasize that this research attempted to develop models to characterize variables associated with *mapped NWI wetland polygons*. Any inferences or predictions made about the data are only true within the boundaries of these polygons and cannot be inferred to other points in the landscape.

The Palustrine Geodatabase

The histograms of mean observed values (Figure 17) indicate that on average, the larger nontidal palustrine wetlands in the study area are located in areas receiving higher amounts of precipitation and are found primarily at lower elevations on flat to slightly concave surfaces. Additionally, the larger palustrine wetlands are located on flat to gently sloping land and their soil moisture as predicted by the CTI may be moderate to high. These results were expected. The profiling also showed the larger palustrine wetlands to exhibit low to moderate flow accumulation values, which seemed counterintuitive. The observed values from the histograms do not provide information at a detail sufficient to characterize the wetlands in any of the three applications—isolated wetlands, hydric soil presence, or PEMC wetland types.

To provide an initial screening of independent variables associated with these groups, the mean and standard deviation values were extracted from the database

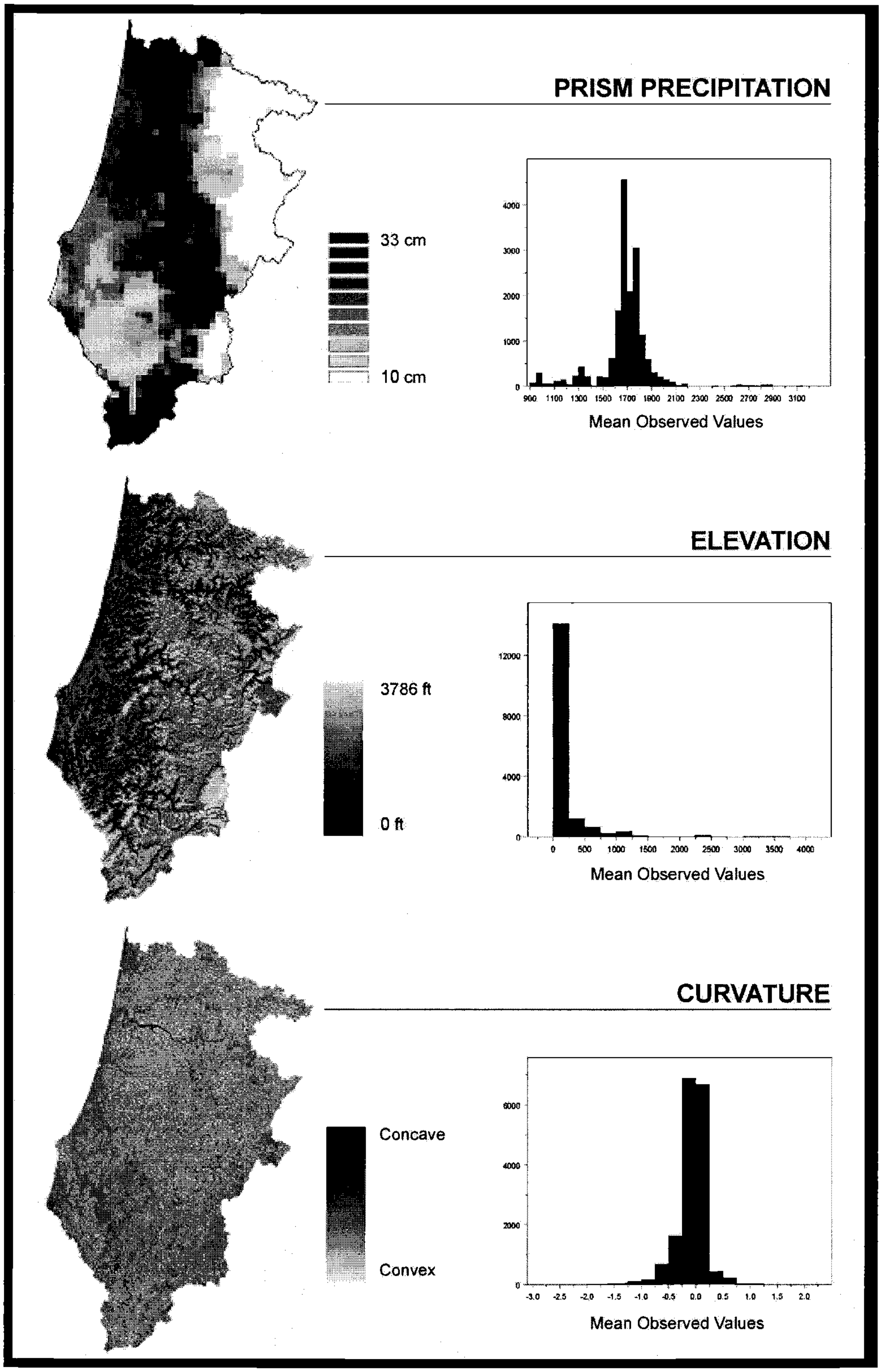

Figure 17: Histograms of mean observed values for selected variables.

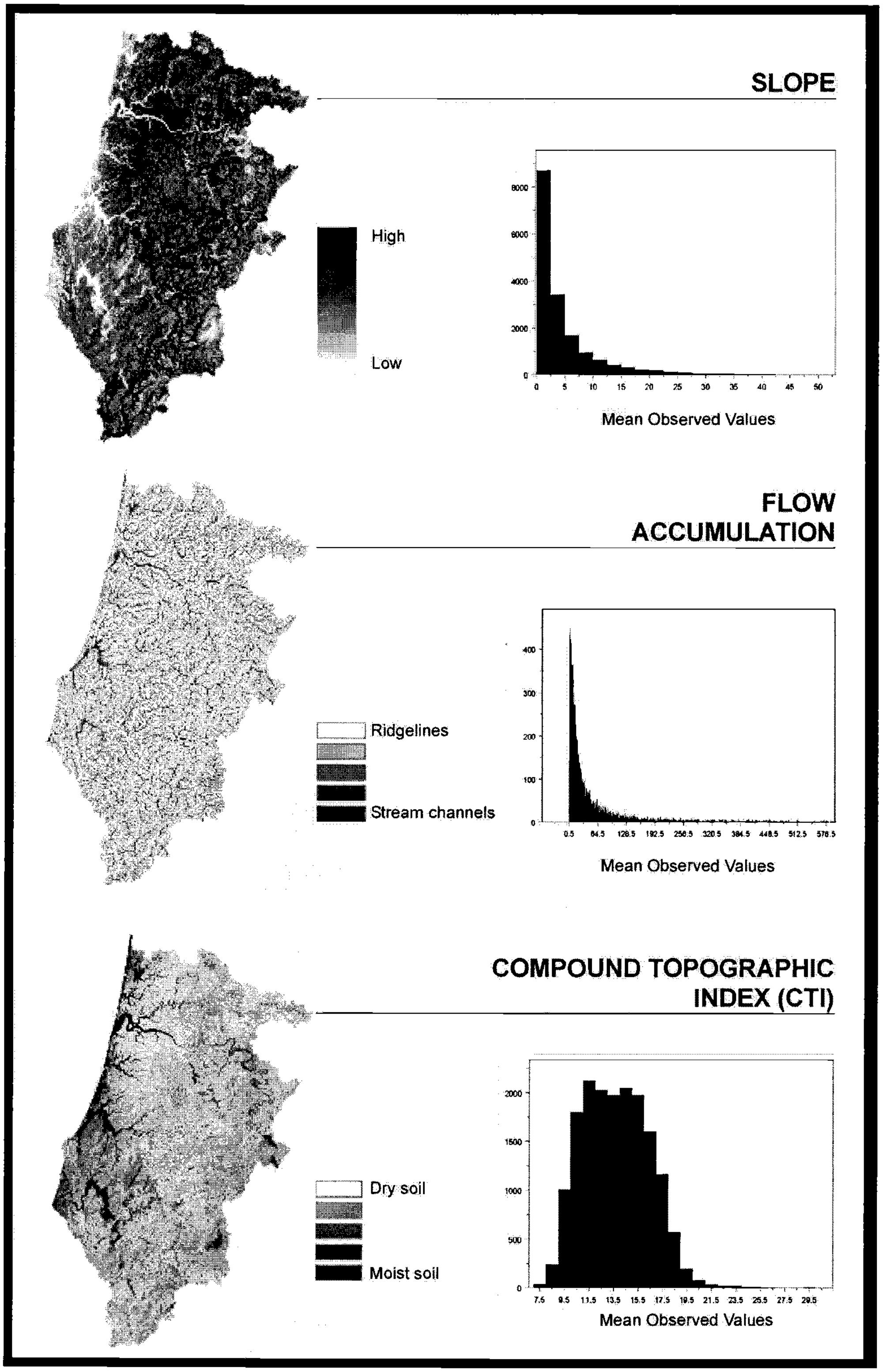

Figure 17 (Continued): Histograms of mean observed values for selected variables.

(Table 6). By comparing these values to the mean values of all other palustrine wetland polygons in the database, it is possible to identify differences that can be explored in more detail with decision tree analysis. For example, wetland polygons in isolation categories A-C represent increasingly restrictive definitions of isolation. Mean values indicate that increased isolation is associated with increased elevation and slope. For example, wetlands in scenario 'C' have a mean elevation of 841 feet compared to a mean of 150 feet for all non-isolated wetlands. Flow accumulation values are significantly less than non-isolated wetlands, and decrease dramatically with increasing isolation. This seems reasonable based on the criteria used to

Table 6: Mean and standard deviation values for selected variables associated with isolated wetland polygons.

DERIVED TOPOGRAPHIC VARIABLES	ISOLATION CATEGORIES							
	A		B		C		X	
	MEAN	STD DEV	MEAN	STD DEV	MEAN	STD DEV	MEAN	STD DEV
CTI	13.38	2.42	11.30	1.57	11.31	1.54	13.82	2.79
Curvature	-0.02	0.19	-0.04	0.25	-0.03	0.25	-0.09	0.27
Elevation	271.74	485.17	834.25	896.13	841.46	885.10	149.27	373.86
Flow Accumulation	8535.47	170249.00	4118.75	83766.50	33.71	51.78	37980.87	470563.16
Plan Curvature	0.00	0.08	-0.01	0.12	-0.01	0.13	0.00	0.10
PRISM	1607.00	264.80	1708.90	338.32	1698.57	340.28	1704.63	212.51
Slope	3.63	4.71	8.78	6.10	8.58	5.88	4.64	6.23

VARIABLES	ISOLATION CATEGORIES							
	S1		S2		S3		X	
	MEAN	STD DEV	MEAN	STD DEV	MEAN	STD DEV	MEAN	STD DEV
CTI	13.85	2.47	13.72	2.51	13.67	2.53	13.74	2.78
Curvature	-0.02	0.19	-0.02	0.19	-0.02	0.20	-0.09	0.27
Elevation	215.78	430.30	227.06	444.54	229.71	446.80	158.36	387.16
Flow Accumulation	5875.02	164031.03	8995.02	177870.37	12889.40	239614.64	37610.99	468044.24
Plan Curvature	0.00	0.08	0.00	0.08	0.00	0.08	0.00	0.10
PRISM	1618.39	236.88	1619.37	245.55	1618.33	248.20	1704.45	217.52
Slope	2.88	4.05	3.17	4.41	3.28	4.54	4.78	6.29

categorize isolated wetland polygons. Wetlands in isolation scenarios S1-S3 follow similar patterns. To provide more detailed information on the relationships between these variables and wetland characteristics it was necessary to explore the database using decision tree models.

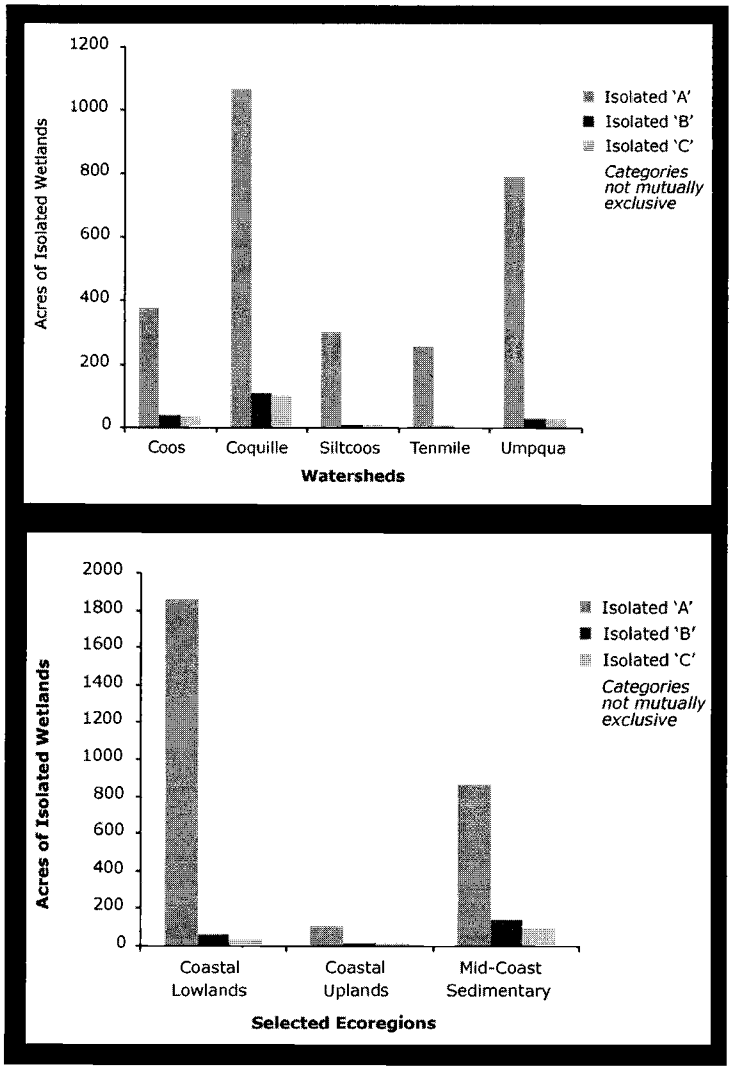

Figure 18: Example of wetland demographic information extracted from the watershed profiles.

Watershed Profiles and Wetland Demographics

Information in the palustrine geodatabase was used to develop profiles for each of the five watershed complexes with the study area. These profiles provide summary statistics on the wetland demographics within each watershed (see Appendices 7-15). As noted previously, demographics reveal the number of wetlands that populate a watershed, how they are distributed among ecoregions, the dominant and least represented wetland types, the proportion of isolated versus non-isolated wetlands, the degree to which isolated wetlands are distributed among watersheds and ecoregions (Figure 18), the proportion of wetlands occurring on hydric soils, the number of wetland fragmented by roads, and much more. Watershed profiles are summaries of these wetland characteristics for wetlands in a given watershed. The watershed profiles were used to generate most of the graphs for this study, and information from the profiles can be used to create maps that highlight certain spatial relationships to be explored further by decision tree analysis.

The demographics indicated that wetlands in the broadest isolation scenario 'A' represented 20% of all wetlands in the database. When these wetlands were highlighted in a map it was evident that these wetlands occur in linear bands along the coastline and as smaller scattered wetlands higher in the watersheds (Figure 19). While mapped wetlands are predominately associated with the occurrence of hydric soil, a small percentage of wetlands are associated with non-hydric soils. Instances of wetland association with non-hydric soil include interdunal wetlands located in depressions between coastal sand dunes and wetlands associated with beaver

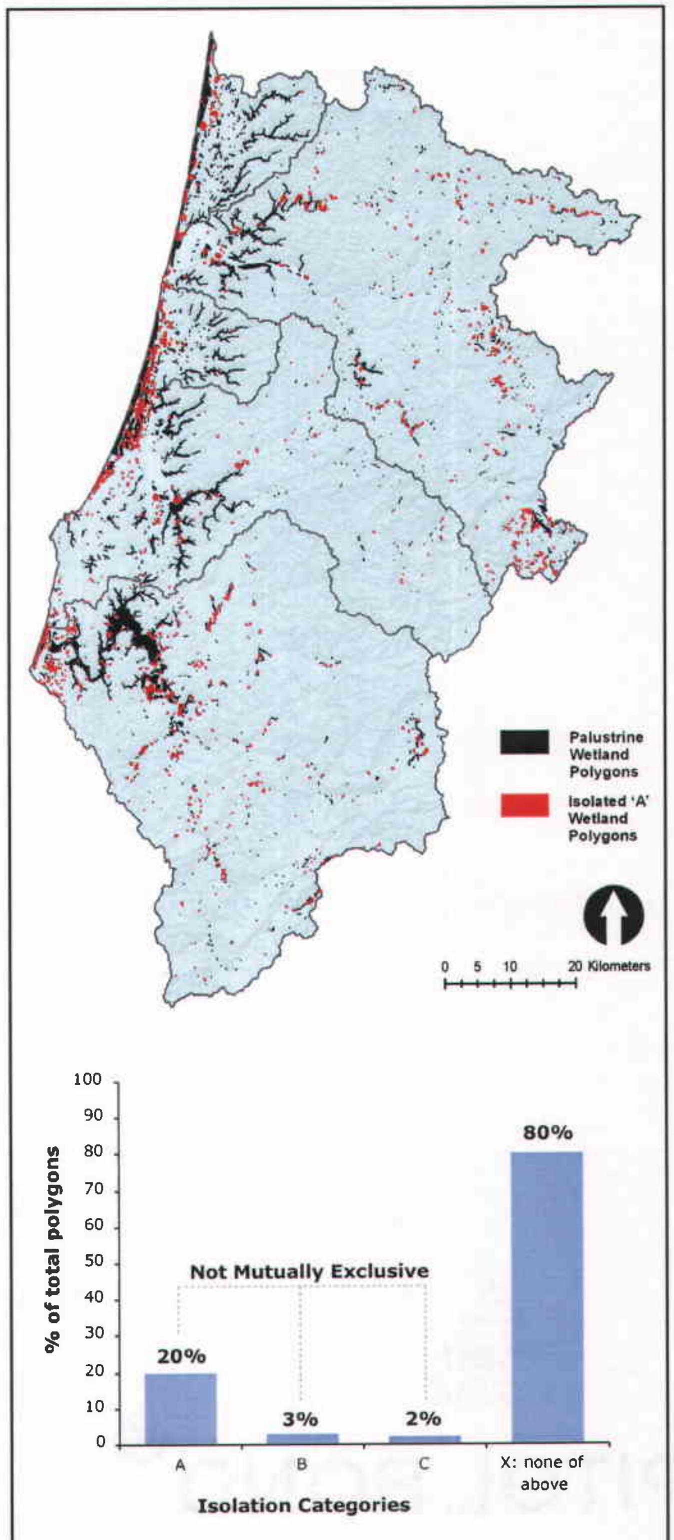

Figure 19: Distribution of isolated 'A' wetland polygons.

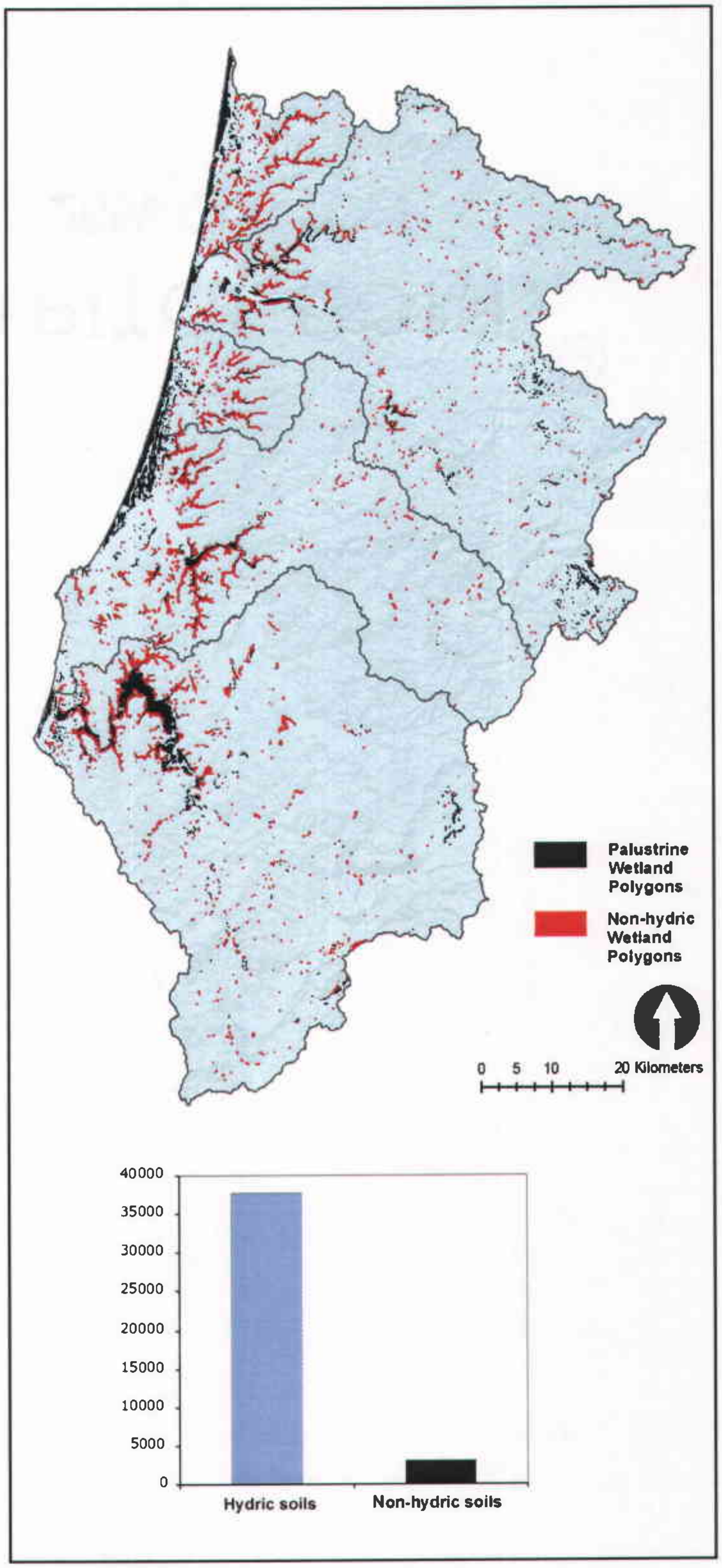

Figure 20: Distribution of wetland polygons with hydric soils.

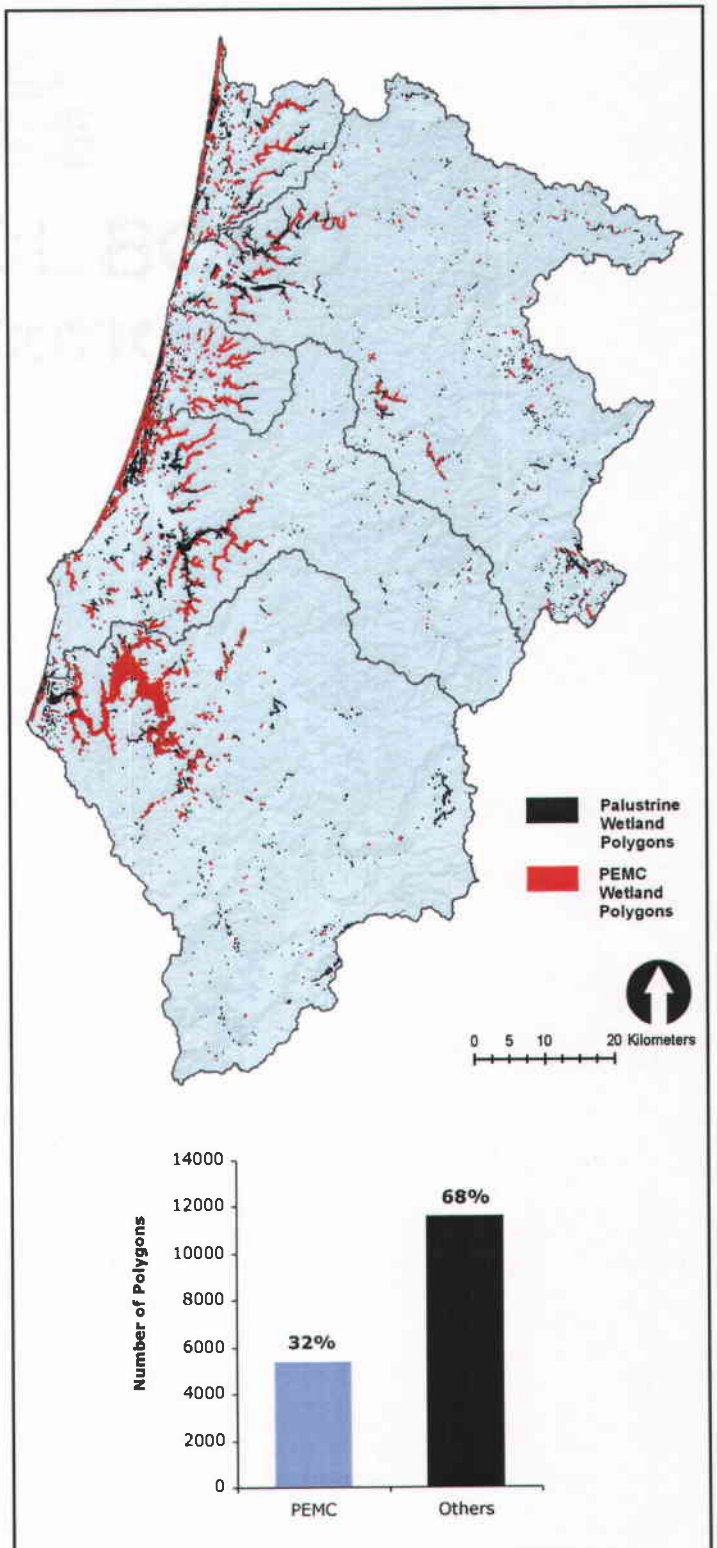

Figure 21: Distribution of PEMC-type wetland polygons.

impoundments. When this relationship is displayed graphically, it appears that most of the wetlands associated with non-hydric soils occur adjacent to wetlands on hydric soils (Figure 20). This may suggest spatial imprecision in existing digital layers that delimit boundaries of the soil units or the wetlands. Additionally, the profiles show that PEMC wetlands account for almost a third of all mapped wetlands in the database. Spatially, these wetlands appear to be distributed primarily in bands near the coastline or along the upper reaches of coastal river channels (Figure 21).

Although information extracted from the watershed profiles allows only limited inferences to be made about causes of wetland distributions, it is valuable for its ability to show broad wetland distributions and abundances within the study area. This demographic information is useful in developing and refining avenues of inquiry to be explored through decision tree analysis.

Decision Tree Analysis Models

Decision tree models are complex representations of relationships that exist between a particular subset of wetlands (the dependent variable) and all possible combinations of physiographic and derived topographic variables (the independent variables). It is impractical to report all of the relationship rules that were generated by each model (Figure 22). A total of 18 models were generated among the three applications. A comparison of the accuracy ratings of these models are provided, followed by a detailed look at results from each of the applications—isolated wetlands, wetlands with hydric soil occurrence, and PEMC wetlands.

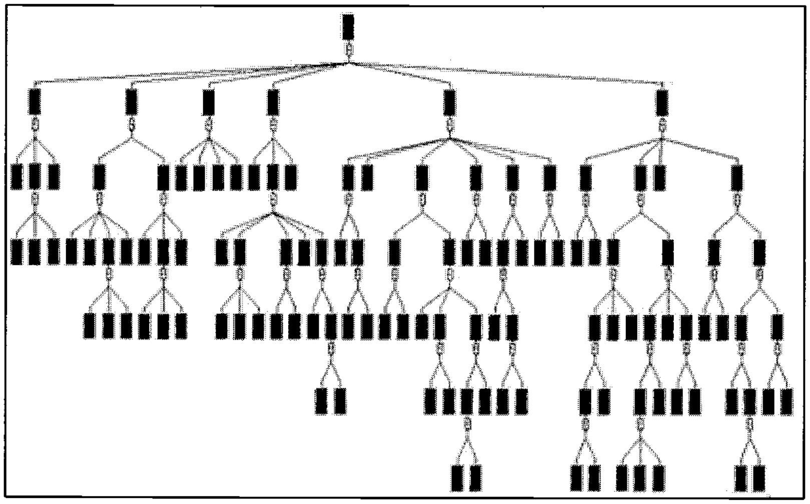

Figure 22: The complexity of decision tree model output.

For each application, both full and partial models were produced. Full models were run using all available variables, and accuracy ratings and split reports are provided (Table 7). Partial models were run using only a selected set of variables identified as significant by the full model, and additional details on rules reports and probability tables are provided.

Eighteen models were produced for this study (Table 7). Accuracy ratings indicate the percentage of data correctly predicted by a model. Accuracy ranged from 68% to 97%, with an average accuracy of 82.43%.

Table 7: Misclassification rate comparison among all models.

Model Category and Dependent Variables	Model Type	Misclassification Rate / Accuracy Rating
ISOLATION (binary)		
Scenario 'A'	Full	0.14, 86.34 n=3,624
'A' plus road int.	Full	0.12, 87.67 n=3,624
Scenario 'B'	Full	0.02, 98.22 n=426
Scenario 'C'	Full	0.02, 98.37 n=385
'A' and ecoregions	Partial	0.18, 81.40 n=3,624
'A' and watersheds	Partial	0.13, 86.60 n=3,624
'A' and hydric soils	Partial	0.19, 80.66 n=3,624
'A' and derived topographic variables	Partial	0.18, 81.91 n=3,624
'A' and physiographic variables	Partial	0.17, 83.00 n=3,624
Scenario 'S1'	Full	0.11, 88.35 n=3,319
Scenario 'S2'	Full	0.13, 86.75 n=3,825
Scenario 'S3'	Full	0.15, 85.52 n=4,063
ISOLATION (area)		
Scenario 'A'	Full	* 0.75, 25.35
HYDRIC SOILS (binary)		
Hydric soils	Full	0.19, 80.93 n=11,182
Hydric soils and NWI Attribute	Partial	0.25, 75.25 n=11,182
Hydric soils and CTI	Partial	0.32, 67.88 n=11,182
PEMC type (binary)		
PEMC type	Full	0.26, 75.35 n=5,382
PEMC and ecoregion	Partial	0.30, 70.21 n=5,382
PEMC and watershed	Partial	0.27, 72.95 n=5,382
PEMC type (area)		
PEMC type	Full	* 0.75, 24.6
* Measured as relative error and variance explained		

Decision tree analysis is an interactive form of modeling where different strategies can produce different accuracy ratings. Growing a complex tree will usually yield higher accuracy ratings, but some of the results may not make sense from an ecological standpoint. Pruning a tree to a more manageable size by merging adjacent nodes is a way to reduce the complexity of the tree while maintaining high accuracy ratings. An alternative is to run the full model to identify which variables are the most significant. A partial model can then be run with the selected variables to generate a simpler model. The accuracy rating may drop slightly, but the clarity of the model has been improved. The model results included in this report are the result of multiple test runs that attempted to find logical models that also had high accuracy ratings.

Wetland Attribute Application: Isolated Wetlands

The percentage of total NWI acres for isolation categories S1-S3 paralleled those reported by Tiner (2002) for the same general area, despite the fact that this study treated road-fragmented wetlands somewhat differently than did Tiner (Table 8). For comparison, Tiner reported 8.4% of NWI wetlands were isolated for a scenario similar to S1, 8.4% for a scenario similar to S2, and 9.6% for a scenario similar to S3. Table 8 illustrates that isolated wetlands may constitute a significant proportion of mapped wetlands, with the exact proportion varying depending on the specific scenario used to define isolation.

Table 8: Comparison of isolation scenarios by acreage and number of polygons.

ISOLATION SCENARIOS	SCENARIO DESCRIPTIONS	# ACRES	% TOTAL NWI ACRES	# POLY	% TOTAL POLY	MODEL ACCURACY
GEOGRAPHIC ISOLATION						
Isolation 'A'	Mapped wetland not intersected by a mapped stream and not within 10m (horizontal) of another NWI polygon	3347	8.24%	3624	21%	87.66
Isolation 'B'	A, and not intersected by hydric soil or water according to SUURGO and not within the FEMA floodplain	191.96	0.47%	426	2.51%	98.22
Isolation 'C'	B, and not within 10m of a stream channel or 10m of the FEMA floodplain	177.20	0.44%	385	2.27%	98.37
Isolation 'X'	None of the above	37280	92%	13317	79%	---
STREAM ISOLATION (Data: CLAMS modeled stream network)						
Isolation 'S1'	Mapped wetland does not intersect 40m buffer of modeled streams	3797	9%	3319	20%	88.35
Isolation 'S2'	Mapped wetland intersects a 40m buffer but not a 20m buffer	4264	10%	3825	23%	86.74
Isolation 'S3'	Mapped wetland intersects a 40m and 20m buffer, but not a 10m buffer	4500	11%	4063	24%	85.52
Isolation 'X'	None of the above	36127	89%	12878	76%	---

QUESTION: With which variables are isolated wetlands most closely associated under various categorical scenarios?

Table 9a describes a full model generated with isolated wetlands 'A' as the dependent binary variable. The split report lists the most significant independent variables in order of importance, but does not illustrate their contingent relationships, which are addressed by the decision trees. The appendix contains definitions for each variable listed in the split reports (see Appendix 16).

Table 9a: Split report generated for polygons in isolation scenario 'A'.

Dependent Variable = Isolation Scenario 'A' presence/absence				
Root Node: 'A' = 3,624 polygons (21.39% of database) All other wetlands = 13,317 polygons (78.61% of database)				
Type of Model = FULL				
Accuracy Rating = 86.33%				
SPLIT REPORT				
Rank	**Variable Name**	**df**	**Chi2**	**P-value**
1	NWI Attribute	9	1959.23	< 0.001
2	Soil type	9	1866.32	< 0.001
3	Geology	6	1619.46	< 0.001
4	Flow accumulation	6	1227.49	< 0.001
5	Elevation	7	1180.01	< 0.001
6	Precipitation	7	1040.83	< 0.001
7	NWI Class	4	991.37	< 0.001
8	Ecoregion	3	767.22	< 0.001
9	NWI Hydroperiod	4	733.77	< 0.001
10	Curvature	4	403.36	< 0.001
11	Hydric soils	1	249.00	< 0.001
12	CTI	4	155.75	< 0.001
13	Slope	4	99.41	< 0.001
14	Plan curvature	5	84.90	< 0.001

QUESTION: With which variables are isolated wetland polygons associated most strongly within particular ecoregions and watersheds?

The model presented in Table 9b exemplifies the use of decision tree analysis to answer a more detailed query of the geodatabase. Both NWI attribute and Ecoregion were significant variables identified by the full model. In this partial model, NWI Attribute is used as a 'force-split'. This means that wetlands are automatically classified according to the variable before associations with other variables are explored within each of the splits (classes). Once split categories are created based on NWI attributes, Ecoregion is used to force-split those groups to identify if any associations exist between particular NWI attributes and ecoregions. From that point, the find-split command is used to find the next best variable that is most associated with the split groups.

Table 9b represents a selected set of rules generated by the tree model. The table is to be read like a horizontal version of the tree model, from left to right, with the right-most entries representing terminal nodes in the tree. In this example, PUSA (palustrine unconsolidated shore temporarily flooded) and PUSC (palustrine unconsolidated shore seasonally flooded) have a similar predictive influence and thus form one split group in the tree model. The first table entry would be read as follows: 'If a wetland polygon has either a PUSA or PUSC attribute designation and it is located within the Coastal Lowlands Ecoregion between elevations of 20 feet and 430 feet then there is a 77.5% chance that the polygon is in the Isolated 'A' scenario. If a wetland polygon has either a PUSA or PUSC attribute designation and it is located within the Coastal Lowlands Ecoregion between elevations of 0 and 20 feet then there is a 22.4% chance that the polygon is in the Isolation 'A' scenario.' If a polygon has a PUSA or PUSC designation and is located in the Coastal Uplands Ecoregion there is a 100% chance that the polygon is in the Isolation 'A' scenario. However, this particular sample includes just two polygons and is thus slightly suspect. The table represents a sample of rules generated by the tree. Additional results can be found in the Appendix (see Appendices 2-6).

Table 9b: Sample model results for polygons in isolation scenario 'A' (complete model results can be found in Appendices 2-6).

Dependent Variable = Isolation Scenario 'A' presence/absence				
Root Node: 'A' = 3,624 polygons (21.39% of database) All other wetlands = 13,317 polygons (78.61% of database)				
Type of Model = PARTIAL				
Accuracy Rating = 86.33%				
IF	**THEN...**		**AND...**	
ATTRIBUTE (force split)=	**VARIABLE: ECOREGION (force split)=**		**VARIABLE x (find split)=**	
PUSA PUSC **72.22% n=270**	Type	Probability	**Elevation**	
			Range	Probability
	Coastal Lowlands	71.76%, n=262	0 - 20	26.67%, n=30
			20 - 430	77.59%, n=232
	Coastal Uplands	100.00%, n=2	---	---
	Mid-Coastal Sed.	83.33%, n=6	---	---
PABH PEM1Ad PEM5C PEMB PUBFh **50.67% n=975**	Coastal Lowlands	56.73%, n=104	**Flow accumulation**	
			Range	Probability
			0 -12	88.00%, n=25
			12 - 62	52.63%, n=88
			62 - 143	100.00%, n=8
			143 - 2.6 e7	27.27%, n=33
	Coastal Uplands	69.23%, n=26	**NWI Attribute**	
			Type	Probability
			PABH, PUBFh	0.00%, n=8
			PEMB	100.00%, n=18
	Inland Siskiyous	80.00%, n=5	---	---
	Mid-Coastal Sed.	47.51%, n=442	**Flow accumulation**	
			Range	Probability
			2.85 - 33	67.40%, n=181

The next example shows how the model was used to examine the relationships between isolation 'A' polygons and watersheds. A full model was run to test whether watersheds were a significant variable related to isolated wetland polygons (see Appendices 2-6). While significant, it did not rate as high as Ecoregions. The model received an accuracy rating of 86.61%, which is only slightly higher than the original full model rating from Table 9a. Table 9c displays model results when watersheds are added as a force-split variable.

Table 9c: Sample model results for polygons in isolation scenario 'A' (complete model results can be found in the Appendix).

Dependent Variable = Isolation Scenario 'A' presence/absence					
Root Node: 'A' = 3,624 polygons (21.39% of database) All other wetlands = 13,317 polygons (78.61% of database)					
Type of Model = PARTIAL					
Accuracy Rating = 81.44%					
IF **ATTRIBUTE (force split)=**	**THEN...** **VARIABLE: WATERSHED (force split)=**		**AND...** **VARIABLE x (find split)=**		
	Type	**Probability**	**Variable x**	**Range**	**Probability**
PUSA **PUSC** **72.22%** **n=270**	Coos	52.83%, n=53	**Flow accumulation**	---	---
	Coquille	63.41%, n=205	**Flow accumulation**	0 -33	80.19%, n=106
				33 - 546	56.96%, n=79
				546 - 2.66 e^7	0.00%, n=20
	Siltcoos	72.73%, n=33	**Elevation**	16 - 26 34 - 40	100.00%, n=17
				70 - 140	43.75%, n=16
	Tenmile	45.83%, n=24	**Plan curvature**	-1.577 - 0.02	0.00%, n=9
				-0.005 - 1.52	73.33%, n =15

An example of a rule from this table is 'if a polygon has a PUSA or PUSC attribute designation and is located within the Coquille watershed with a flow accumulation between 0 to 33 then there is an 80% chance that the polygon is in the Isolation 'A' scenario'. For the PUSA/PUSC wetland polygons in the Coquille watershed it appears that a threshold exists for flow accumulation values. Polygons associated with a flow accumulation value of 546 or less have a greater probability of being isolated. This seems reasonable, because the lower the flow accumulation value, the further an object is located from a stream channel or other area of concentrated flow. It is interesting to note that each watershed is associated with a different variable that is most predictive of isolated wetland presence. This highlights the value of using decision tree analysis rather than conventional regression analysis. Additional results from this model can be found in Appendices 2-6.

QUESTION: Under which conditions are isolated wetland polygons associated with non-hydric soils?

The next model is designed to find relationships between isolated wetland polygons and the occurrence of either hydric or non-hydric soils (Table 9d). The force split command was used to create split groups based on NWI Attribute, and then another force split command was issued on each of those groups to determine the probability of isolation based on hydric soil presence or absence.

Table 9d: Sample model results for polygons in isolation scenario 'A' (complete model results can be found in the Appendices 2-6). Binary classification fields labeled '1' represent the number of polygons considered isolated, and binary classification fields labeled '9'represent all other palustrine wetlands.

Dependent Variable = Isolation Scenario 'A' presence/absence				
Root Node: 'A' = 3,624 polygons (21.39% of database) All other wetlands = 13,317 polygons (78.61% of database)				
Type of Model = PARTIAL				
Accuracy Rating = 80.66%				
IF	**THEN...**		**AND...**	
ATTRIBUTE (force split)=	**VARIABLE: HYDRIC INTERSECTION (force split)=**		**VARIABLE *x* (find split)=**	
PUSA PUSC 72.22% n=270	**Binary**	**Probability**	**Elevation**	
			Range	**Probability**
	1	72.52%, n=262	0 - 20	26.67%, n=30
			20 - 430	78.45%, n=232
	9	62.50%, n=8	---	---
PABH PEM1Ad PEM5C PEMB PUBFh 50.67% n=975	1	48.19%, n=801	**NWI Attribute**	
			Type	**Probability**
			---	---
	9	62.07%, n=174	PABH	47.22%, n=36
			PEM5C	100.00%, n=4
			PEMB	68.14%, n=113
			PUBFh	47.62%, n=21

An example of a rule generated by the above model is 'if a polygon has a PABH (palustrine aquatic bottom permanently flooded) or PEMB (palustrine emergent saturated) attribute designation and is located on hydric soil then there is a 48% chance that the polygon is associated with Isolation scenario 'A'; or 'if a polygon has a PEMB attribute designation and is located on non-hydric soil then there is a 68% chance that the polygon is associated with Isolation scenario 'A''. For these wetland attributes it appears the presence/absence of hydric soil is significantly related to isolation status. For PUSA and PUSC wetlands, the presence of hydric soils in relation to a particular elevation range is significantly related to isolation status. Additional results from this model can be found in the Appendices 2-6.

QUESTION: What is the degree to which physiographic and derived topographic variables separately explain the occurrence of isolated wetland polygons?

Two additional full models were generated to explore the degree to which physiographic (Table 9e) and derived topographic variables (Table 9f) are successful in separately explaining the association of wetland polygons with isolation scenario 'A' (De'ath and Fabricius 2000). For the original full model, physiographic variables appeared to dominate in the split report.

Table 9e: Split report generated for physiographic variables associated with polygons in isolation scenario 'A'.

PHYSIOGRAPHIC VARIABLES				
Dependent Variable = Isolation Scenario 'A' presence/absence				
Root Node: 'A' = 3,624 polygons (21.39% of database) All other wetlands = 13,317 polygons (78.61% of database)				
Type of Model = FULL				
Accuracy Rating = 83.00%				
SPLIT REPORT				
Rank	**Variable Name**	**df**	**Chi2**	**P-value**
1	NWI Attribute	9	1959.24	< 0.001
2	Geology	6	1619.46	< 0.001
3	Precipitation	7	1040.83	< 0.001
4	Ecoregion	3	767.22	< 0.001

Table 9f: Split report generated for derived topographic variables associated with polygons in isolation scenario 'A'.

DERIVED TOPOGRAPHIC VARIABLES				
Dependent Variable = Isolation Scenario 'A' presence/absence				
Root Node: 'A' = 3,624 polygons (21.39% of database) All other wetlands = 13,317 polygons (78.61% of database)				
Type of Model = FULL				
Accuracy Rating = 81.91%				
SPLIT REPORT				
Rank	**Variable Name**	**df**	**Chi2**	**P-value**
1	Flow accumulation	6	1227.50	< 0.001
2	Elevation	7	1180.01	< 0.001
3	Curvature	4	403.36	< 0.001
4	CTI	4	155.75	< 0.001
5	Slope	4	99.40	< 0.001
6	Plan curvature	5	84.90	< 0.001

The original full model run where physiographic and derived topographic variables were combined received an accuracy rating of 86.34%. Individual full models of physiographic and derived topographic variables received ratings of 83% and 81.91% respectively. Although the accuracy decreased slightly, these full models are useful for the information they provide about individual variables.

Physiographic variables were more successful overall at explaining the association of polygons with isolation. The three top ranking variables in this group were NWI attribute, Geology, and average annual precipitation. This model indicates that vegetation and hydroperiod, bedrock and soil parent material, and rainfall amounts together best explain the relationship with isolation 'A'.

The three top ranking derived topographic variables were flow accumulation, elevation, and curvature. This indicates that location relative to stream channels or ridgelines, altitude within the watershed, and localized landform concavity or convexity together best explain the relationship with isolation 'A'. It is surprising that flow accumulation ranks first overall, higher even than the CTI of which it is a component. The significance of flow accumulation will be explored further in other models.

Generalized Wetland Attribute Application: Hydric Soil Presence

For this application, the presence of hydric soils within wetland polygons is the dependent variable. A full model indicates that overall, derived topographic variables are ranked highest in significance, in contrast to the importance of physiographic variables in explaining isolated wetland occurrence (Table 10a). Another interesting result is that the CTI ranked higher in significance than flow accumulation for hydric soil presence, whereas the opposite was true for isolation.

A two-sample t-test was performed on slope, elevation, and CTI to evaluate whether a difference in mean values existed between wetland polygons with hydric soils or polygons with non-hydric soils. Results indicated that on average, hydric soils were located at lower elevations and on flatter slopes than non-hydric soils within mapped wetlands. Additionally, polygons with hydric soils had a higher mean CTI value than polygons with non-hydric soils. Decision tree analysis was used to identify threshold values for these variables in order to better describe these conditions.

Moore et al. (1991) used decision tree analysis to predict vegetation community distributions in a forested landscape. They argued that defining threshold values associated with community boundaries may have greater ecological utility than predictions based primarily on parameters such as means and standard deviations.

To see if any clear thresholds exist within variables that may indicate the presence of hydric soils within wetland polygons, force split commands were issued for each variable individually (Table 10b).

Table 10a: Split report generated based on hydric soil presence or absence within polygons.

Dependent Variable = Hydric soil presence/absence within polygons				
Root Node: Polygons with **hydric soil** = 11,182 polygons (66% of database) Polygons with **non-hydric soil** = 5,759 polygons (34% of database)				
Type of Model = FULL				
Accuracy Rating = 80.92%				
SPLIT REPORT				
Rank	**Variable Name**	**df**	**Chi2**	**P-value**
1	Slope	9	3575.03	< 0.001
2	CTI	3	2732.50	< 0.001
3	Curvature	9	2538.05	< 0.001
4	Geology	7	2455.99	< 0.001
5	Plan Curvature	9	2161.16	< 0.001
6	Ecoregion	4	1205.16	< 0.001
7	Elevation	3	1051.53	< 0.001
8	Flow Accumulation	5	787.52	< 0.001
9	NWI Attribute	6	618.56	< 0.001
10	Precipitation	7	497.98	< 0.001
11	NWI Hydroperiod	5	188.03	< 0.001
12	NWI Class	3	154.08	< 0.001

Table 10b: Threshold values for selected variables indicating hydric soil presence or absence within polygons.

THRESHOLD VALUES DERIVED FROM FULL MODEL			
Variable	**Model Accuracy**	**Threshold Value**	**P-value**
Slope	73.98%	Hydrics < 4.798	< 0.001
CTI	72.63%	Hydrics > 11.12	< 0.001
Curvature	70.91%	Hydrics > -0.15	< 0.001
Plan Curvature	70.58%	Hydrics: -0.04 to 0.02	< 0.001
Elevation	66.76%	Non-hydrics: 40' – 70'	< 0.001
Flow Accumulation	66.01%	No threshold apparent	< 0.001
Precipitation	66.01%	No threshold apparent	< 0.001

In Table 10b, slope received the highest accuracy rating. Results indicated that wetland polygons on slopes less than 4.79 degrees were most associated with hydric soils. This threshold can be represented spatially by reclassifying the slope grid (Figure 23). CTI values were most strongly associated with hydric soil presence above values of 11.12. This threshold can also be represented spatially by

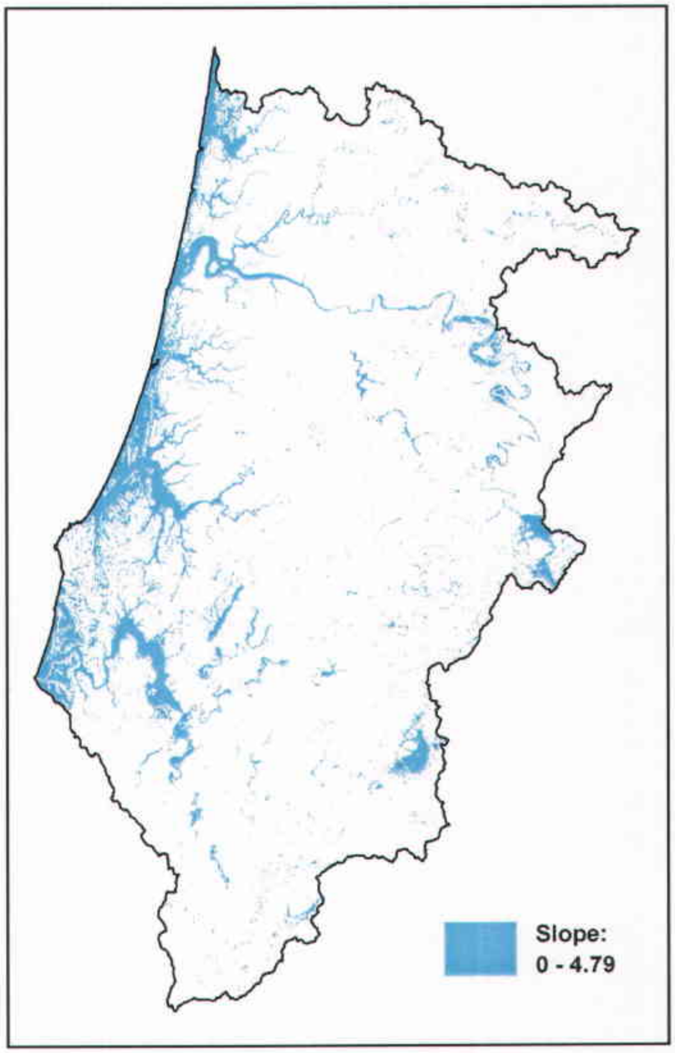

Figure 23: Threshold grid displaying geographic areas with slopes less than the threshold value.

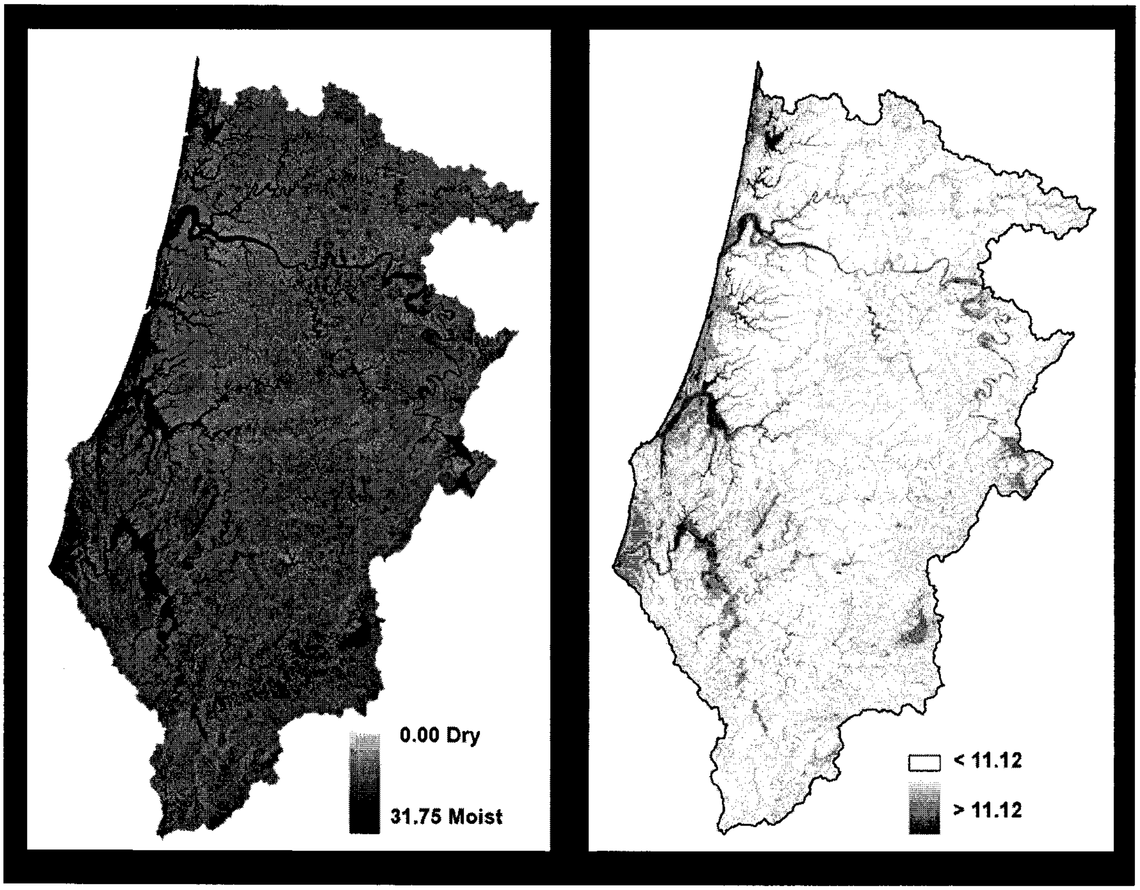

Figure 24: Comparison between the threshold grid of CTI values (right) and the original CTI grid (left).

reclassifying the CTI grid (Figure 24). Another test will be run to evaluate how consistent this CTI threshold is when analyzed in combination with slope and elevation, and among watersheds and ecoregions (Table 10c). Additional model results can be found in the Appendices 2-6.

Table 10c: CTI threshold values for polygons under various geographic and physiographic scenarios.

Dependent Variable = Hydric soil presence/absence within polygons			
Root Node: Polygons with **hydric soil** = 11,182 polygons (66% of database) Polygons with **non-hydric soil** = 5,759 polygons (34% of database)			
Variable (force split)	**Accuracy Rating**	**CTI threshold for Hydric Soil Presence**	**P-value**
Slope	**74.48%**		
0 - 7.37		H >13.14 (average)	< 0.001
7.37 - 50.00		No association with hydric soils	< 0.001
Watershed	**74.32%**		
Coos		H > 12.78	< 0.001
Coquille		H > 11.93	< 0.001
Siltcoos		H > 11.12	< 0.001
Tenmile		H > 11.12	< 0.001
Umpqua		H > 10.27	< 0.001
Ecoregion	**73.63%**		
Coastal Lowlands		H > 11.12	< 0.001
Coastal Uplands		H > 12.78	< 0.001
Inland Siskiyous		CTI not significant	0.131
Mid-Coastal Sedimentary		H > 11.12	< 0.001
So. Oregon Coastal Mtns.		CTI not significant	0.106
Umqua Interior Foothills		No threshold exists (always associated with hydric soil)	< 0.001
Valley Foothills		CTI not significant	0.563
Elevation	**73.15%**		
0 - 16		No threshold exists (always associated with hydric soil)	< 0.001
16 - 26		H > 12.78	< 0.001
26 - 40		H > 11.12	< 0.001
40 - 140		H > 11.12	< 0.001
140 - 3786		H > 11.12	< 0.001

Specific Wetland Attribute Application: PEMC Wetlands

QUESTION: With which variables are PEMC wetlands most closely associated?

This series of models demonstrated how specific queries could be generated and tested with the methodology. The table below describes a full model generated with PEMC (palustrine emergent seasonally flooded) wetland polygons as the dependent variable. The model indicates that physiographic variables are ranked highest in significance (Table 11a). These results are similar to the isolated wetlands application, in which isolated wetlands were also closely associated with physiographic variables, but contrasts with the hydric soil application in which wetlands found on hydric soils were closely associated with derived topographic variables.

Table 11a: Split report generated for polygons associated with a PEMC Cowardin classification code.

Dependent Variable = Wetlands with a PEMC label				
Root Node: Polygons with **PEMC** labels = 5,382 polygons (31.77% of database) All other wetland polygons = 11.559 polygons (68.23% of database)				
Type of Model = FULL				
Accuracy Rating = 75.07%				
SPLIT REPORT				
Rank	**Variable Name**	**df**	**Chi2**	**P-value**
1	Soil type	8	1075.82	< 0.001
2	Elevation	6	779.14	< 0.001
3	Ecoregion	4	663.65	< 0.001
4	Precipitation	6	554.81	< 0.001
5	Watershed	3	515.9862	< 0.001
6	Geology	5	397.92	< 0.001
7	Road intersection	1	241.16	< 0.001
8	Slope	2	191.13	< 0.001
9	Plan curvature	2	139.49	< 0.001
10	CTI	1	83.80	< 0.001
11	Curvature	3	79.12	< 0.001
12	Hydric soil presence/absence	1	32.01	< 0.001
13	Flow accumulation	1	22.90	< 0.001

QUESTION: What are the relationships between Soil Type, Elevation, Ecoregion and PEMC wetland polygons?

This application demonstrated ways in which the geodatabase could be used to explore relationships among variables and specific wetland types. In this partial model, an "automatic-grow" command was issued using only the three highest-ranking variables. This is identical to running a full model on a selected subset of variables instead of the entire set. When full models are run on subsets of variables, the accuracy rating of the model decreases because the model is being simplified, regardless of how significant the variables are as predictors. Table 11b represents a

Table 11b: Sample model results for polygons associated with a PEMC Cowardin classification code (Soil Group1: 01138f, 01140, 01141, 01146e, 01154d, 01160d, 01162).

<table>
<tr><th colspan="7">Dependent Variable = Wetlands with a PEMC label</th></tr>
<tr><td colspan="7">Root Node:
Polygons with PEMC labels = 5,382 polygons (31.77% of database)
All other wetland polygons = 11.559 polygons (68.23% of database)</td></tr>
<tr><td colspan="7">Type of Model = FULL</td></tr>
<tr><td colspan="7">Accuracy Rating = 67.88%</td></tr>
<tr><th>IF</th><th colspan="2">THEN...</th><th colspan="2">AND...</th><th colspan="2">AND...</th></tr>
<tr><th rowspan="2">SOIL TYPE =</th><th colspan="2">VARIABLE: ELEVATION</th><th colspan="2">VARIABLE: ECOREGION</th><th colspan="2">VARIABLE: SOIL TYPE</th></tr>
<tr><th>Range</th><th>Prob.</th><th>Ecoregion</th><th>Prob.</th><th>Type</th><th>Prob.</th></tr>
<tr><td rowspan="5">Soil Group 1

51.88%
n=2,053</td><td>0 - 70</td><td>54.71%
n=1,824</td><td>---</td><td>---</td><td>---</td><td>---</td></tr>
<tr><td rowspan="3">70 - 430</td><td rowspan="3">34.25%
n=181</td><td rowspan="2">Coastal Lowlands and Coastal Uplands</td><td rowspan="2">56.56%
n=76</td><td>01138F
01146E
01162</td><td>80.00%
n=35</td></tr>
<tr><td>01140
01141
01154D</td><td>36.59%
n=41</td></tr>
<tr><td>Mid-Coastal Sedimentary</td><td>18.10%
n=105</td><td>---</td><td>---</td></tr>
<tr><td>430 - 3786</td><td>10.42%
n=48</td><td>---</td><td>---</td><td>---</td><td>---</td></tr>
</table>

selected set of rules generated by the tree model. In this example, soil types represented by Soil Group 1 have a similar predictive influence and thus form one split group in the tree model.

An example of a rule from this table is 'if a wetland polygon has a soil type included in Soil Group 1 and is located at elevations between 0 and 70 feet then there is a 55% chance that the polygon is labeled PEMC'. Polygons associated with Soil Group 1 that occur at elevation higher than 70 feet have a much lower probability of being labeled PEMC, with one exception. If a wetland polygon has a specific soil type of 01138F, 01146E, or 01162 and is located at elevations between 70 and 430 feet within the Coastal Lowlands or Coastal Uplands Ecoregion, there is an 80% chance that the polygon is labeled PEMC. Additional model results can be found in the Appendices 2-6.

QUESTION: Which relationships influence the distribution of PEMC types among ecoregions?

Additionally, the geodatabase was used to explore relationships among variables, geographic location, and specific wetland types. This application shows how a model was used to find relationships associated with PEMC labels within particular ecoregions, a variable that ranked third in significance in the initial split report (Table 11c). PEMC wetlands are distributed across all ecoregions in the study area.

Table 11c: Sample model results for polygons associated with a PEMC Cowardin classification code (complete model results can be found in Appendices 2-6).

Dependent Variable = Wetlands with a PEMC label		
Root Node: Polygons with **PEMC** labels = 5,382 polygons (31.77% of database) All other wetland polygons = 11.559 polygons (68.23% of database)		
Type of Model = PARTIAL		
Accuracy Rating = 70.21%		
IF	**THEN...**	
Ecoregion (force split)=	**VARIABLE: SOIL TYPE (find significant split)**	
	Type	**Probability**
Coastal Lowlands 35.04% n=6,971	01117B 01134 01138F 01141 01148 01152E 01154D 01160D 01162	51.59%, n=1,479
	01139F 01140 01146F 01151E 0119	62.84%, n=662
	Type	**Probability**
Coastal Uplands 42.26% n=3,190	01138F 01139F	80.00%, n=264
	01146E 01146F 01152E	68.94%, n=132
Mid-Coastal Sedimentary	Cannot distinguish (there are no splits)	
So. Oregon Coastal Mtns.	Cannot distinguish (there are no splits)	
Umpqua Interior Foothills	Cannot distinguish (there are no splits)	
Valley Foothills	Cannot distinguish (there are no splits)	

In this example, a force-split command was issued using the ecoregion variable that resulted in six splits. A find-split command was then issued on each of these six splits to find the variable most closely associated with PEMC wetlands within ecoregions. Wetlands of the PEMC type in the Coastal Lowlands and Coastal Uplands ecoregions were closely associated with soil type, while PEMC wetlands in all other ecoregions displayed no relationship with any other variable and did not split further within this model. An example of a rule from this model is 'if a wetland polygon is located in the Coastal Uplands ecoregion and has a soil type of 01138F or 01139F then there is an 80% chance that the polygon is labeled PEMC'. Additional model results can be found in Appendices 2-6.

QUESTION: Which relationships influence the distribution of PEMC types among both watersheds and ecoregions?

In this application, a force-split command was issued using the watershed variable. For each resulting split, another force-split command was issued using the ecoregion variable. The find-split command was then used to explore which other variables were significant and whether the type of variable differed depending on specific watershed/ecoregion combinations (Table 11d).

The table indicates that only two combinations of watersheds and ecoregions result in significant relationships. If a wetland polygon is located in the Coos watershed complex within the Coastal Uplands ecoregion, there is a 52% chance that the polygon has a PEMC label. If a wetland polygon is located in the Tenmile watershed complex within the Coastal Uplands ecoregion, there is a 67% chance that the polygon has a PEMC label.

However, other variables were found that provide more detail about the watershed/ecoregion relationships. The previous example can be modified to read as follows: 'if a wetland polygon is located in the Tenmile watershed complex within the Coastal Uplands ecoregion and is located on non-hydric soils (binary code '9') then there is a 77% chance that the polygon has a PEMC label'. If the same wetland polygons are located on hydric soils (binary code '1') there is a decreased, yet still significant, probability of 56% that the polygons will have a PEMC label.

Some watershed/ecoregion relationships that display low probability levels (less than 50%) can display significant probability levels (greater than 50%) with the addition of variables from the find-split command. For example, if a wetland polygon is located in the Coos watershed complex within the Mid-Coastal Sedimentary ecoregion, there is only a 35% chance that the polygon will have a PEMC label. However, if the polygons are also located at elevations between 0 and 26 feet the probability increases to 61%.

The results presented in Tables 11c and 11d suggest a high degree of variability in the types of significant variables associated with watershed/ecoregion combinations. Within the Coos watershed complex, PEMC polygons within the Coastal Lowlands ecoregion are most closely associated with soil type; PEMC polygons within the Coastal Uplands ecoregion are most closely associated with geologic type; and PEMC polygons within the Mid-Coastal Sedimentary ecoregion are most closely associated with elevation. The detailed relationships displayed by the tree model would not have been possible to elucidate with ordinary regression models.

Table 11d: Sample model results for polygons associated with a PEMC Cowardin classification code (complete results can be found in the Appendices 2-6).

Dependent Variable = Wetlands with a PEMC label

Root Node:

Polygons with **PEMC** labels = 5,382 polygons (31.77% of database)

All other wetland polygons = 11.559 polygons (68.23% of database)

Type of Model = FULL

Accuracy Rating = 72.95%

IF WATERSHED (force split)=	THEN... VARIABLE: ECOREGION (force split)=		AND... VARIABLE *x* (find split)=		
	Ecoregion	**Probability**			
Coos 34.45% n=4,044	Coastal Lowlands	28.55% n=2,718	**Soil Type**	**Type**	**Probability**
				Soil Group 1	65.38%, n=182
	Coastal Uplands	52.25% n=890	**Geology**	**Type**	**Probability**
				Qal	90.91%, n=22
				Tm Tsr Tt	64.27%, n=431
	Mid-Coastal Sed.	34.86% n=436	**Elevation**	**Range**	**Probability**
				0 - 26	61.29%, n=124
				34 - 70	65.22%, n=46
Coquille 39.17% n=4,552	Coastal Lowlands	49.45% n=2,718	**Soil Type**	**Type**	**Probability**
				Soil Group 2	56.30%, n=675
				Soil Group 3	64.80%, n=804
	Coastal Uplands	41.78% n=438	**Elevation**	**Range**	**Probability**
				0 – 26	54.93%, n=71
				70 – 140	58.02%, n=81
Siltcoos 29.56% n=2,635	Coastal Uplands	46.09% n=677	**Soil Type**	**Type**	**Probability**
				637112G	59.03%, n=432
Tenmile 40.62% n=1,652	Coastal Lowlands	37.15% n=1,249	**Road intersection**	**Range**	**Probability**
				=1	53.30%, n=621
	Coastal Uplands	66.80% n=266	**Hydric Soils**	**Range**	**Probability**
				= 1	55.77%, n=104
				= 9	77.16%, n=162

CHAPTER FIVE: DISCUSSION

The distribution of various wetland types across the landscape is influenced by complex interactions of physiography, topography, and climate. As a result, wetland occurrence is associated with geographic, physiographic, and derived topographic variables. An enhanced NWI geodatabase used in conjunction with decision tree modeling provides an interactive means of revealing associations among these variables and wetland polygons that can be used at varying scales to identify wetlands with attributes ranging from general (hydric soils) to specific (NWI class). The geodatabase facilitates the creation of summary statistics that help formulate specific queries, while the tree models provide a graphic representation of query results. In some instances, it is then possible to create spatial data layers of results using the geodatabase (i.e. threshold grids or distribution maps).

In this study, watershed profiles and wetland demographics were generated to assess the geographic patterns of occurrence among palustrine wetland polygons mapped by the NWI. These profiles were of great assistance in identifying the proportions of various wetland types existing within individual watersheds and across the entire study area. The profiles can indicate broad patterns of abundances and distributions of wetland polygons (see Figures 18-20). However, these profiles only provide limited information from which inferences can be made concerning causal factors for wetland formation. For example, the spatial distribution of isolated wetlands is poorly understood and the watershed profiles were used to compile basic information on the number and area of isolated wetlands in each watershed based on various categorical scenarios. Proportions of isolated wetlands closely matched estimates produced by the study mentioned previously near the Coquille River (Tiner et al. 2002).

Decision tree analysis successfully identified variables closely associated with isolated wetlands. Different variables tend to dominate at certain levels of the model, a pattern that was repeated in various iterations of the modeling process. The most significant variables were predominately physiographic, with the exception of flow accumulation, which ranked fourth highest. Derived topographic variables, although significant, generally received the lowest rankings (see Table 10a). This pattern was also observed in split reports generated for all of the other isolation scenarios. These results parallel findings suggesting that variables operating at broad scales (such as physiographic variables) often generate splits early in the model, while more site-specific or localized variables (such as derived topographic variables), tend to form splits nearer the terminal nodes (Moore et al. 1991a). This pattern is consistent with the idea that wetlands are regulated by a hierarchy of environmental constraints (Palik et al. 2003), such that landscape-scale physiographic variables influence finer-scale derived topographic variables that determine patterns of wetland occurrence.

The tree models were also successful at developing rules that identified particular NWI attributes closely associated with isolated wetland polygons based on the ecoregion or watershed in which they were found (see Table 10b). Force-split commands were used on the NWI attribute variable because it was the highest ranked significant variable and offered a logical grouping mechanism to provide a spatial context for the results. In some instances, the dependent variable was not positively associated with a particular ecoregion (probability less than 50%), but positive associations were achieved when analyzed in conjunction with other variables (probability greater than 50%). In find-split searches there was a high degree of variation in the types of variables determined significant. For example, there was a 47.51% probability that PABH wetlands are associated with the Mid-Coastal Sedimentary ecoregion. However, the probability increased to 67.40% for the same ecoregion if flow accumulation values for the polygons are between 2.85 and 33.

Flow accumulation was frequently identified as a significant variable in find-split searches. The highest probabilities were associated with lower flow accumulation values, indicating a relationship between isolated wetland polygons and higher topographic positions. Flow accumulation ranked higher than the CTI in the isolated wetland model split report (see Table 10a). This is particularly interesting because flow accumulation is a part of the algorithm used to calculate the CTI. These results indicate that flow accumulation may be a better indicator of wetland polygon isolation than the CTI. The reason for this is unknown, and warrants further research. High flow accumulation values indicate areas of concentrated flow, with low values signifying local topographic highs or ridges. The zonal statistics utility was used to calculate the mean flow accumulation values for polygons of all NWI Classes located within the study area (Figure 25). Mean flow accumulation values for palustrine wetlands are significantly lower than those of riverine and estuarine wetlands.

Results from tree models using the presence of hydric soils within wetland polygons as the dependent variable indicate that derived topographic variables ranked highest in significance for this attribute. These models also indicated that the CTI ranked well above flow accumulation as a significant explanatory variable for hydric

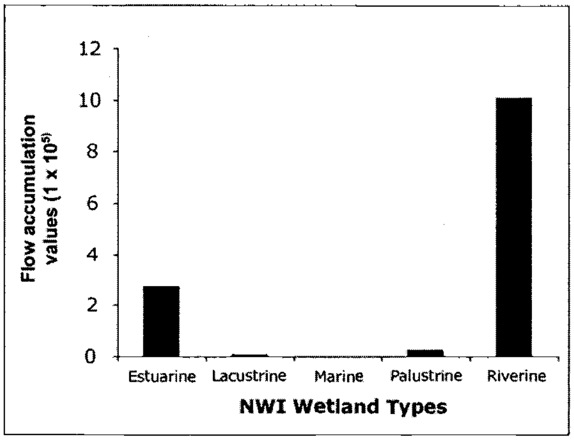

Figure 25: Mean flow accumulation values for each NWI type.

soils, which may mean that the CTI is more effective as an indicator of soil properties than of wetland occurrence. Clear thresholds exist for values of slope, CTI, and curvature. A study that used decision tree analysis to predict the distribution of forest communities found that the specification of threshold values might be more informative than results based purely on statistical parameters (Moore et al. 1991a). For example, wetland polygons are most associated with hydric soils if they have CTI values greater than 11.12. The CTI threshold appears to be consistent across watersheds, ecoregions, and elevations. A threshold CTI grid was created by reclassifying the original CTI modeled surface into saturated and unsaturated zones based on the numeric threshold value. Threshold grids provide a spatial representation of the conditions associated with hydric soil presence within wetland polygons. It is important to note that the threshold grids cannot be used to make predictions about areas outside mapped NWI polygons; they can only be used as a reference when the polygons are used as an overlay. Despite these limitations, threshold grids provide a way to visualize model results in a way that would not be possible without the use of a spatially-explicit geodatabase. The creation of threshold grids illustrates the unique iterative nature of the methodology outlined by this research.

Results from tree models using PEMC wetland polygons as the dependent variable are similar to those from the isolated wetland application in that physiographic variables ranked highest in significance and derived topographic variables ranked lowest. Although flow accumulation is significant, it ranks last in the split report. When models were run to determine relationships influencing the distribution of PEMC types among ecoregions, no clear associations were evident. However, significant relationships existed between PEMC types, ecoregions, and the variable for soil type when a find-split command was issued. Modeling PEMC types with combinations of ecoregions and watersheds resulted in a high degree of variability in the types of significant variables reported.

Overall, physiographic variables appear to be most closely associated with both isolated and PEMC type wetland polygons, while derived topographic variables are associated strongly with polygons that have hydric soil designations. This may indicate that landscape-scale factors exert more of an influence on the occurrence of particular types of wetlands, and localized or finer-scale factors may influence the characteristics found within a wetland (such as soil saturation). Additionally, physiographic variables tend to be expressed at higher stages of the tree models while derived topographic variables are usually expressed near the terminal nodes. This may demonstrate a hierarchical influence of variables associated with the distribution and characteristics of mapped wetland polygons.

Future Research Opportunities

There are many opportunities for future research that expand on the methodology outlined in this report. Adding variables from remote sensing imagery such as NDVI or tasseled cap greenness may improve the accuracy of some tree models. If the study area were limited to a single watershed, watershed managers or other researchers could input field sampling data to test whether the level of detail expressed by the models could be increased. The watershed profiles would then contain detailed information on biological and hydrological characteristics of sampled wetland polygons, and the tree models could potentially increase efficiency in sampling site selection and prioritization of fieldwork locations. Enhanced NWI data has been used to generate information on wetland functions and cumulative impacts analysis (Tiner 2003a, Johnson 2004). The addition of more specific data on the geomorphic or hydrologic conditions associated with wetlands could enable this methodology to be used in preliminary HGM assessment models.

There is also the potential for watershed profiles and tree models to be used in the development of wetland management policies related to biodiversity conservation. Information in detailed watershed profiles could be used to identify wetlands that represent the range of natural diversity of wetlands in a watershed. With the addition of vegetation data, profiles could be used to identify naturally diverse wetland complexes, regionally unique wetland types, or other wetlands that may be significant for biodiversity conservation (Tiner 2003a).

The methodology outlined in this report provides a foundation for the creation of predictive models based on decision tree analysis techniques. Predictions concerning the occurrence of wetlands at points in the landscape outside the mapped polygons could be made if non-wetland sample points were included in the geodatabase. Before decision trees were created, the geodatabase would need to be partitioned into at least two subsets—one used to develop the decision tree models and the other to serve as a means of testing and validating the models. Predictive modeling represents one of the most powerful applications of the enhanced NWI geodatabase.

Sustainable Wetland Creation

Many studies have detailed the problems with current approaches to wetland mitigation. In Oregon, wetland compensatory mitigation often fails to address the important functional aspects of wetlands in favor of mitigation aimed solely at a policy of "no net loss" of wetland acreage. Highly diverse arrays of wetlands are frequently replaced by the standard version of a mitigation wetland featuring standing water and fringing marsh vegetation. The appropriate acreage of wetlands may have been mitigated, but all of the functional qualities of the other diverse wetland types have often been lost. The cumulative effect of this type of mitigation is a broad scale homogenization of wetlands resulting in a gradual reduction in the overall landscape diversity of wetland types and functions (Good and Sawyer 1998).

Brinson and Rheinhardt (1996) suggest that mitigation projects should be designed according to existing ecosystem characteristics instead of being driven by design standards that rarely focus on specific wetland types. Mitigation or restoration that is sensitive to naturally occurring hydrogeomorphic properties is likely to be more successful in re-establishing wetland functions (Shaffer et al. 1999). Stanley (2004) has developed a method to recommend suitable sites for constructed wetlands in Washington, but a similar approach has yet to be performed for Oregon mitigation or restoration projects.

Watershed profiles and decision tree modeling have the potential to be valuable tools in the assessment of potential sites for sustainable wetland creation. A goal of wetland restoration is to improve the health of former or degraded wetlands to return them to self-regulating ecosystems that are successfully integrated within a larger landscape context. Proper placement is necessary for wetlands to be self-maintaining (Good and Sawyer 1998, Bedford 1999). The methodology outlined in this thesis could be applied to these efforts. Although model rules only apply to mapped wetland polygons, the process can identify the landscape characteristics associated with particular NWI wetland types and the range of conditions under which these wetlands occur. It can also be used to identify physiographic differences within a single NWI type and the topographic conditions that influence their distributions within watersheds and among ecoregions. The predictive capabilities of the tree models could be enhanced by the addition of non-wetland sample points to the geodatabase. This would enable the creation of rules that apply to points in the landscape outside mapped wetland polygons. In this way, it may be possible to identify areas of the landscape that would be suitable for sustainable wetland creation.

CHAPTER SIX: CONCLUSION

This project consisted of two major phases—designing an enhanced NWI geodatabase of palustrine wetland polygons, and then using the geodatabase to create watershed profiles and for exploratory data analysis in the form of decision tree modeling. This research was designed to test hypotheses about physiographic and derived topographic variables associated with palustrine wetlands as mapped by the NWI. Among isolated wetland polygons, physiographic variables were more significant than derived topographic variables. NWI attribute, soil type, and geology were the three variables most closely associated with isolated wetland polygons. The high ranking of flow accumulation is a surprising result and warrants further research. For wetland polygons with hydric soil designations, associations between hydric soils and derived topographic variables were more significant than associations with physiographic variables. Slope, CTI, and curvature were the variables most closely related to polygons with hydric soils, with clear threshold values existing for each one. The CTI threshold of 11.12 was consistent across ecoregions, watersheds, and elevation. On average, wetland polygons with hydric soils have a mean CTI value that is higher than polygons with non-hydric designations. For polygons labeled PEMC, associations between this NWI class and physiographic variables were more significant than those with derived topographic variables, a result similar to that of isolated wetlands. Soil type, elevation, and ecoregion were the three variables most closely associated with PEMC polygons.

This research demonstrated a unique and exciting approach for characterizing wetlands by their attributes using an interactive combination of an enhanced NWI geodatabase and decision tree analysis. This study confirms the utility of this methodology to provide information on the geographical distributions and relationships existing among environmental variables and mapped wetland polygons.

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APPENDIX

Appendix 1:
Level III and Level IV Ecoregion Descriptions
(Bryce and Woods 2000)

LEVEL III: COAST RANGE ECOREGION

Low mountains covered by highly productive, rain-drenched coniferous forests. Sitka spruce forests originally dominated the fog-shrouded coast, while a mosaic of western red cedar, western hemlock, and seral Douglas-fir blanketed inland areas. Today Douglas-fir plantations are prevalent on the intensively logged and managed landscape.

- **Coastal Lowlands**
  The Coastal Lowlands ecoregion encompasses estuarine marshes, freshwater lakes, black-water streams, marine terraces, and sand dune areas. Elevations range from sea level to 300 feet. Channelization and diking have converted many of its wetlands into dairy pastures; associated stream quality degradation has occurred.

- **Coastal Uplands**
  The Coastal Uplands ecoregion extends to an elevation of about 500 feet. The climate is marine-influenced and is characterized by an extended winter rainy season, sufficient fog during the summer dry season to reduce vegetal moisture stress, and a lack of seasonal temperature extremes. The ecoregion roughly corresponds with the historic distribution of Sitka spruce. The extent of the original forest has been greatly reduced by logging.

- **Mid-Coastal Sedimentary**
  Massive beds of siltstone and sandstone commonly underlie this ecoregion. Its dissected, forested mountains are rugged and prone to mass movement when the vegetal cover is removed. Stream gradients and fluvial erosion rates can be high.

- **Southern Oregon Coastal Mountains**
  A mountainous ecoregion with an ocean-modified climate, it is a transitional area between the Siskiyou Mountains and the Coast Range and is underlain by Jurassic sandstone, metamorphosed sediments, granite, and serpentine. Overall, the geology is complex, like that of the Siskiyou Mountains, but its mountains are lower and are not as dissected. The distributions of northern and southern vegetation blend together here and species diversity is high.

LEVEL III: KLAMATH MOUNTAINS ECOREGION

This ecoregion is physically and biologically diverse. Highly dissected, folded mountains, foothills, terraces, and floodplains occur and are underlain by igneous, sedimentary, and some metamorphic rock. The mild, subhumid climate of the Klamath Mountains Ecoregion is characterized by a lengthy summer drought. It supports a vegetal mix of northern Californian and Pacific Northwest conifers.

- **Umpqua Interior Foothills**
  This ecoregion is an intermingling of narrow valleys, terraces, and foothills. It contrasts with the terrain of the more mountainous Inland Siskiyous. A mix of oak woodlands, Douglas-fir, ponderosa pine, and madrone intermingle with pastureland, vineyards, orchards, and row crops. The vegetation and land use are similar to those of ecoregions 78a and 78b. Summers are hot and dry and, although the climate is transitional to both the Willamette and Rogue valleys, it is most similar to the Rogue valley.

- **Inland Siskiyous**
  This ecoregion is mountainous. Granitic and sedimentary rock underlies the ecoregion and distinguishes it from the volcanic mountains of the Cascades. Greater fire frequency, less annual precipitation, longer summer droughts, and a lack of tanoak differentiate if from the Coastal Siskiyous.

- **Coastal Siskiyous**
  This ecoregion has a wetter and milder maritime climate than elsewhere in the Klamath Mountains. Productive forests composed of tanoak, Douglas-fir, and some Port Orford cedar cover the dissected, mountainous landscape.

LEVEL III: WILLAMETTE VALLEY ECOREGION

Rolling prairies, deciduous/coniferous forests, and extensive wetlands characterized the pre-settlement landscape of this broad, lowland valley. This ecoregion is distinguished from the adjacent Coast Range Ecoregion by lower precipitation, less relief, and a different mosaic of vegetation. Landforms consist of terraces and floodplains that are interlaced and surrounded by rolling hills.

- **Valley Foothills**
  The Valley Foothills ecoregion is a transitional zone between the Willamette Valley, the Cascade Range, and the Coast Range. It has less rainfall than adjacent, more mountainous ecoregions and, consequently, its potential natural vegetation is distinct. Oregon white oak and Douglas-fir were originally dominant.

Appendix 2:
Additional Decision Tree Model Results for the Isolated Wetlands Application

QUESTION: With which variables are isolated wetlands most closely associated under various categorical scenarios?

Appendix Table 2a: Full model split report for Isolation "A" wetland polygons with the inclusion of watersheds as a variable.

Dependent Variable = Isolation Category 'A' presence/absence				
Root Node: 'A' = 3,624 polygons (21.39% of database) All other wetlands = 13,317 polygons (78.61% of database)				
Type of Model = FULL				
Accuracy Rating = 86.61%				
SPLIT REPORT				
Rank	**Variable Name**	**df**	**Chi2**	**P-value**
1	NWI Attribute	9	1959.23	< 0.001
2	Soil type	9	1866.32	< 0.001
3	Geology	6	1619.46	< 0.001
4	Flow accumulation	6	1227.50	< 0.001
5	Elevation	7	1180.01	< 0.001
6	Precipitation	7	1040.83	< 0.001
7	NWI Class	4	991.37	< 0.001
8	Ecoregion	3	767.22	< 0.001
9	NWI Hydroperiod	4	733.77	< 0.001
10	Curvature	4	403.36	< 0.001
11	Hydric soil presence	1	249.00	< 0.001
12	Watershed	3	177.91	< 0.001
13	CTI	4	155.75	< 0.001
14	Slope	4	99.40	< 0.001
15	Plan curvature	5	84.90	< 0.001

Appendix Table 2b: Full model split report for Isolation "A" wetland polygons with the inclusion of road intersection as a variable.

Dependent Variable = Isolation Category 'A' presence/absence				
Root Node: 'A' = 3,624 polygons (21.39% of database) All other wetlands = 13,317 polygons (78.61% of database)				
Type of Model = FULL				
Accuracy Rating = 87.66%				
SPLIT REPORT				
Rank	**Variable Name**	**df**	**Chi2**	**P-value**
1	**Road intersection**	**1**	**2970.38**	< 0.001
2	NWI Attribute	9	1959.23	< 0.001
3	Soil type	9	1866.32	< 0.001
4	Geology	6	1619.46	< 0.001
5	Flow accumulation	6	1227.49	< 0.001
6	Elevation	7	1180.01	< 0.001
7	Precipitation	7	1040.83	< 0.001
8	NWI Class	4	991.37	< 0.001
9	Ecoregion	3	767.22	< 0.001
10	NWI Hydroperiod	4	733.77	< 0.001
11	Curvature	4	403.36	< 0.001
12	Hydric soils	1	249.00	< 0.001
13	CTI	4	155.75	< 0.001
14	Slope	4	99.41	< 0.001
15	Plan curvature	5	84.90	< 0.001

Appendix Table 2c: Full model split report for Isolation "B" wetland polygons.

Dependent Variable = Isolation Category 'B' presence/absence				
Root Node: 'B' = 426 polygons (2.51% of database) All other wetlands = 16,515 polygons (97.49% of database)				
Type of Model = FULL				
Accuracy Rating = 98.22%				
SPLIT REPORT				
Rank	**Variable Name**	**df**	**Chi2**	**P-value**
1	Elevation	5	**1027.22**	< 0.001
2	Geology	6	1033.12	< 0.001
3	Ecoregion	3	920.86	< 0.001
4	Attribute	5	675.21	< 0.001
5	NWI Hydroperiod	4	551.57	< 0.001
6	Slope	5	451.72	< 0.001
7	CTI	4	446.80	< 0.001
8	Soil type	4	528.14	< 0.001
9	NWI Class	3	305.51	< 0.001
10	Watershed	3	268.28	< 0.001
11	Precipitation	5	249.19	< 0.001
12	Plan curvature	5	246.22	< 0.001
13	Flow accumulation	3	146.43	< 0.001
14	Curvature	4	120.14	< 0.001

Appendix Table 2d: Full model split report for Isolation "C" wetland polygons.

Dependent Variable = Isolation Category 'C' presence/absence				
Root Node: 'C' = 385 polygons (2.27% of database) All other wetlands = 16,556 polygons (97.73% of database)				
Type of Model = FULL				
Accuracy Rating = 98.37%				
SPLIT REPORT				
Rank	**Variable Name**	**df**	**Chi2**	**P-value**
1	Geology	6	1042.70	< 0.001
2	Elevation	4	975.15	< 0.001
3	Ecoregion	3	825.58	< 0.001
4	NWI Attribute	5	627.80	< 0.001
5	NWI Hydroperiod	4	524.48	< 0.001
6	CTI	4	400.78	< 0.001
7	Slope	4	385.51	< 0.001
8	Soil type	4	476.46	< 0.001
9	NWI Class	2	258.79	< 0.001
10	Watershed	3	239.64	< 0.001
11	Precipitation	4	224.23	< 0.001
12	Plan curvature	5	212.74	< 0.001
13	Flow accumulation	3	148.26	< 0.001
14	Curvature	4	111.13	< 0.001

Appendix Table 2e: Full model split report for Isolation "S1" wetland polygons.

Dependent Variable = Isolation Category 'S1' presence/absence				
Root Node: 'S1' = 3,319 polygons (19.59% of database) All other wetlands = 13,622 polygons (80.41% of database)				
Type of Model = FULL				
Accuracy Rating = 88.36%				
SPLIT REPORT				
Rank	**Variable Name**	**df**	**Chi2**	**P-value**
1	Road intersection	1	**2399.64**	< 0.001
2	Soil type	9	2320.48	< 0.001
3	Geology	5	2274.88	< 0.001
4	NWI Attribute	8	1433.16	< 0.001
5	Flow accumulation	7	1116.57	< 0.001
6	Precipitation	8	987.97	< 0.001
7	Ecoregion	3	798.72	< 0.001
8	NWI Class	4	765.76	< 0.001
9	Curvature	4	513.91	< 0.001
10	Elevation	7	478.95	< 0.001
11	Slope	5	338.41	< 0.001
12	NWI Hydroperiod	4	352.55	< 0.001
13	Plan curvature	3	232.22	< 0.001
14	CTI	3	86.42	< 0.001

Appendix Table 2f: Additional model results for Isolation "S1" polygons.

<table>
<tr><th colspan="5">Dependent Variable = Isolation Category 'S1' presence/absence</th></tr>
<tr><td colspan="5">Root Node:
'S1' = 3,319 polygons (19.59% of database)
All other wetlands = 13,622 polygons (80.41%% of database)</td></tr>
<tr><td colspan="5">Type of Model = PARTIAL</td></tr>
<tr><td colspan="5">Accuracy Rating = 88.36%</td></tr>
<tr><th>IF</th><th colspan="2">THEN...</th><th colspan="2">AND...</th></tr>
<tr><th>ATTRIBUTE (force split)=</th><th colspan="2">VARIABLE: ELEVATION (find split)=</th><th colspan="2">VARIABLE x (find split)=</th></tr>
<tr><td rowspan="11">PUBFx
PUBHx
PUBKx
PUSA
PUSC

72.00%
n=489</td><td rowspan="2">Range</td><td rowspan="2">Probability</td><td colspan="2">Flow Accumulation</td></tr>
<tr><td>Range</td><td>Probability</td></tr>
<tr><td>0 - 11</td><td>22.22%
n=18</td><td>---</td><td>---</td></tr>
<tr><td rowspan="2">11 - 40</td><td rowspan="2">64.37%
n=174</td><td>0 – 546.3</td><td>67.27%, n=165</td></tr>
<tr><td>546.3 – 2.6 e7</td><td>11.11%, n=9</td></tr>
<tr><td rowspan="5">40 – 3786</td><td rowspan="5">79.46%
n=297</td><td colspan="2">Slope</td></tr>
<tr><td>Range</td><td>Probability</td></tr>
<tr><td>0 – 2.54</td><td>90.23%, n=174</td></tr>
<tr><td>2.54 – 4.80</td><td>75.00%, n=52</td></tr>
<tr><td>4.80 – 50.00</td><td>56.34%, n=71</td></tr>
</table>

Appendix Table 2g: Full model split report for Isolation "S2" wetland polygons.

Dependent Variable = Isolation Category 'S2' presence/absence

Root Node:
'S2' = 3,825 polygons (22.58% of database)
All other wetlands = 13,116 polygons (77.42% of database)

Type of Model = FULL

Accuracy Rating = 86.74%

SPLIT REPORT

Rank	Variable Name	df	Chi2	P-value
1	Soil type	9	**2330.65**	< 0.001
2	Geology	4	2274.94	< 0.001
3	NWI Attribute	9	1539.74	< 0.001
4	Flow accumulation	6	1280.90	< 0.001
5	Precipitation	8	1001.31	< 0.001
6	Ecoregion	4	837.32	< 0.001
7	NWI Class	4	783.49	< 0.001
8	Elevation	7	605.78	< 0.001
9	Curvature	3	500.96	< 0.001
10	Hydric soil presence	1	415.25	< 0.001
11	NWI Hydroperiod	6	463.74	< 0.001
12	Slope	5	249.39	< 0.001
13	Plan curvature	4	184.07	< 0.001
14	CTI	2	59.72	< 0.001

Appendix Table 2h: Additional model results for Isolation "S2" wetland polygons.

Dependent Variable = Isolation Category 'S2' presence/absence		
Root Node: 'S2' = 3,825 polygons (22.58% of database) All other wetlands = 13,116 polygons (77.42% of database)		
Type of Model = PARTIAL		
Accuracy Rating = 86.74%		
IF	**THEN...**	
ATTRIBUTE (force split)=	**VARIABLE: ELEVATION (find split)=**	
PUBFx PUSA PUSC 72.00% n=489	**Range**	**Probability**
	0 -11	12.50%, n=16
	11 - 40	71.23%, n=146
	40 - 140	84.11%, n=107
	140 - 3786	58.82%, n=17
ATTRIBUTE (force split)=	**VARIABLE: GEOLOGY (find split)=**	
PUBHx PUBKx PUSCx 81.19% n=218	KJds, OW, Qls, Qt, Ti, Tss, Ty	96.03%, n=151
	Qal, Tmsc, Tmsm, Tmss, Tsr, Tt	47.76%, n=67

Appendix Table 2i: Full model split report for Isolation "S3" wetland polygons.

Dependent Variable = Isolation Category 'S3' presence/absence				
Root Node: 'S3' = 4,063 polygons (23.98% of database) All other wetlands = 12,878 polygons (76.02% of database)				
Type of Model = FULL				
Accuracy Rating = 85.52%				
SPLIT REPORT				
Rank	**Variable Name**	**df**	**Chi2**	**P-value**
1	Soil type	9	**2345.42**	< 0.001
2	Geology	6	2297.53	< 0.001
3	NWI Attribute	11	1580.63	< 0.001
4	Flow accumulation	6	1332.60	< 0.001
5	Precipitation	8	1061.66	< 0.001
6	Ecoregion	5	860.81	< 0.001
7	NWI Class	4	766.80	< 0.001
8	Elevation	7	646.16	< 0.001
9	Curvature	4	526.72	< 0.001

Appendix Table 2j: Additional model results for Isolation "S3" wetland polygons.

<table>
<tr><th colspan="3">Dependent Variable = Isolation Category 'S3' presence/absence</th></tr>
<tr><td colspan="3">Root Node:
'S3' = 4,063 polygons (23.98% of database)
All other wetlands = 12,878 polygons (76.02% of database)</td></tr>
<tr><td colspan="3">Type of Model = FULL</td></tr>
<tr><td colspan="3">Accuracy Rating = 85.52%</td></tr>
<tr><th>IF</th><th colspan="2">THEN...</th></tr>
<tr><th>ATTRIBUTE (force split)=</th><th colspan="2">VARIABLE: ELEVATION (find split)=</th></tr>
<tr><td rowspan="6">PUBFx
PUSA
PUSC

74.13%
n=286</td><th>Range</th><th>Probability</th></tr>
<tr><td>0 -11</td><td>12.50%, n=16</td></tr>
<tr><td>11 - 40</td><td>72.60%, n=146</td></tr>
<tr><td>40 - 140</td><td>85.98%, n=107</td></tr>
<tr><td>140 - 430</td><td>54.55%, n=11</td></tr>
<tr><td>430 - 3786</td><td>100%, n=6</td></tr>
<tr><th>ATTRIBUTE (force split)=</th><th colspan="2">VARIABLE: GEOLOGY (find split)=</th></tr>
<tr><td rowspan="2">PUBHx
PUBKx
PUSCx

83.03%
n=218</td><td>KJds
OW
Qls
Qt
Ti
Tss
Ty</td><td>96.03%, n=151</td></tr>
<tr><td>Qal
Tmsc
Tmsm
Tmss
Tsr
Tt</td><td>53.73%, n=67</td></tr>
</table>

Appendix 3:
Additional Decision Tree Model Results for the Isolated Wetlands Application

QUESTION: With which variables are isolated wetland polygons associated most strongly within particular ecoregions and watersheds?

Appendix Table 3a: Additional model results for Isolation "A" wetland polygons associated with ecoregions (see Table 9b).

Dependent Variable = Isolation Category 'A' presence/absence
Root Node: 'A' = 3,624 polygons (21.39% of database) All other wetlands = 13,317 polygons (78.61% of database)
Type of Model = PARTIAL
Accuracy Rating = 86.33%

IF ATTRIBUTE (force split)=	THEN... VARIABLE: ECOREGION (force split)=		AND... VARIABLE *x* (find split)=	
			Geology	
			Type	**Probability**
PUBFx PUBHx PUBKx PUSCx 83.33% n=234	Coastal Lowlands	88.76%, n=169	OW Qt	96.45%, n=129
			Qal Tss	69.23%, n=26
			Tmss Tt	35.71%, n=14
	Coastal Uplands	62.50%, n=8	---	---
	Mid-Coastal Sed.	67.39%, n=46	---	---
	So. Oregon Coastal Mtns.	100.00%, n=5	---	---
	Umpqua Interior	66.67%, n=6	---	---

Appendix Table 3b: Additional model results for Isolation "A" wetland polygons and watersheds (see Table 9c).

<table>
<tr><th colspan="5">Dependent Variable = Isolation Category 'A' presence/absence</th></tr>
<tr><td colspan="5">Root Node:
'A' = 3,624 polygons (21.39% of database)
All other wetlands = 13,317 polygons (78.61% of database)</td></tr>
<tr><td colspan="5">Type of Model = PARTIAL</td></tr>
<tr><td colspan="5">Accuracy Rating = 81.44%</td></tr>
<tr><th>IF</th><th colspan="2">THEN...</th><th colspan="2">AND...</th></tr>
<tr><th>ATTRIBUTE (force split)=</th><th colspan="2">VARIABLE: WATERSHED (force split)=</th><th colspan="2">VARIABLE x (find split)=</th></tr>
<tr><td rowspan="14">PUBFx
PUBHx
PUBKx
PUSCx

83.33%
n=234</td><td rowspan="4">Coos</td><td rowspan="4">82.83%, n=41</td><td colspan="2">Flow accumulation</td></tr>
<tr><td>Range</td><td>Prob.</td></tr>
<tr><td>0 - 143</td><td>93.94%, n=33</td></tr>
<tr><td>143 - 2.66 e7</td><td>37.50%, n=8</td></tr>
<tr><td rowspan="4">Coquille</td><td rowspan="4">88.24%,
n=153</td><td colspan="2">Geology</td></tr>
<tr><td>Range</td><td>Prob.</td></tr>
<tr><td>KJds
Qt
Tmsc</td><td>100.00%,
n=113</td></tr>
<tr><td>Qal
Tmsm
Tmss
Tss</td><td>55.00%, n=40</td></tr>
<tr><td>Siltcoos</td><td>100.00%, n=1</td><td>---</td><td>---</td></tr>
<tr><td>Tenmile</td><td>100.00%, n=4</td><td>---</td><td>---</td></tr>
<tr><td rowspan="4">Umpqua</td><td rowspan="4">60.00%, n=35</td><td colspan="2">Elevation</td></tr>
<tr><td>Range</td><td>Prob.</td></tr>
<tr><td>34 - 430</td><td>33.33%, n=18</td></tr>
<tr><td>430 - 3786</td><td>88.24%, n=17</td></tr>
</table>

Appendix Table 3b (Continued): Additional model results for Isolation "A" wetland polygons and watersheds (see Table 9c).

PABH PEM1Ad PEM5C PEMB PUBFh 50.67% n=975	Coos	52.83%, n=53	**Flow accumulation**	
			Range	**Prob.**
			---	---
	Coquille	63.41%, n=205	0 -33	80.19%, n=106
			33 - 546	56.96%, n=79
			546 - 2.66 e7	0.00%, n=20
	Siltcoos	72.73%, n=33	**Elevation**	
			Range	**Prob.**
			16 - 26 34 - 40	100.00%, n=17
			70 - 140	43.75%, n=16
	Tenmile	45.83%, n=24	**Plan curvature**	
			Range	**Prob.**
			-1.57 - -0.01	0.00%, n=9
			-0.005 - 1.52	73.33%, n=15
	Umpqua	45.61%, n=660	**Flow accumulation**	
			Range	**Prob.**
			0 - 33	65.43%, n=480

Appendix 4:
Additional Decision Tree Model Results for the Isolated Wetlands Application

QUESTION: Under which conditions are isolated wetland polygons associated with non-hydric soils?

Appendix Table 4a: Additional model results for Isolation "A" wetland polygons and hydric soils (see Table 9d). Binary classification fields labeled '1' represent the number of polygons considered isolated. Binary classification fields labeled '9'represent all other palustrine wetlands in the database

Dependent Variable = Isolation Category 'A' presence/absence				
Root Node: 'A' = 3,624 polygons (21.39% of database) All other wetlands = 13,317 polygons (78.61% of database)				
Type of Model = PARTIAL				
Accuracy Rating = 80.66%				
IF **ATTRIBUTE (force split)=**	**THEN...** **VARIABLE: HYDRIC INTERSECTION (force split)=**		**AND...** **VARIABLE *x* (find split)=**	
PUBFx **PUBHx** **PUBKx** **PUSCx** **83.33%** **n=234**	1	86.26%, n=182	**Geology**	
			Type	**Prob.**
			OW Qt Tmsc	100.00%, n=127
			Qal Tmsm Tss Ty	67.57%, n=37
			Tmss Tt	27.78%, n=18
	9	73.08%, n=52	**Curvature**	
			Range	**Prob.**
			-3.34 - 0.15	30.77%, n=13
			-0.15 - 2.11	87.18%, n=39

Appendix 5:
Additional Decision Tree Model Results for the Hydric Soil Application

Appendix Table 5a: Additional model results for wetland polygons associated with hydric or non-hydric soils (this particular model sought to find relationships between NWI Attributes wetland polygons with hydric soils).

IF	THEN...		OR...	
NWI ATTRIBUTES (force split)=	**VARIABLE: SLOPE (find split)**		**VARIABLE: ELEVATION (force split)**	
PSSB Group [1] **51.88% n=1,226**	**Range**	**Probability**	**Range**	**Probability**
	0 – 1.80	Hydric > 50%	0 – 16 feet	Hydric > 50%
	1.80 - 50.08	Non-hydric > 50%	16 – 3786 feet	Non-hydric > 50%
PUBH Group [2] **65.63% n=288**	**Range**	**Probability**	**Range**	**Probability**
	0 – 3.50	36% chance non-hydric	0 – 26 feet	Hydric > 50%
	3.50 – 50.00	76.3% chance non-hydric	26 – 3786 feet	Non-hydric > 50%

[1] ***PSSB Group:*** *PABHh, PEMCh, PEMFb, PEMHh, PFO1A, PFOCh, PSSB, PSSCh, PUBHh, and PUSCx*

[2] ***PUBH Group:*** *PEMCb, PEMFh, PFO/SSC, PSSCb, and PUBF*

Appendix 6:
Additional Decision Tree Model Results for the PEMC Wetlands Application

QUESTION: What are the relationships between Soil Type, Elevation, Ecoregion and PEMC wetland polygons?

Appendix Table 6a: Additional model results for PEMC wetland polygons and the top three ranked variables (see Table 11b).

Dependent Variable = Wetlands with a PEMC label				
Root Node: Polygons with **PEMC** labels = 5,382 polygons (31.77% of database) All other wetland polygons = 11.559 polygons (68.23% of database)				
Type of Model = FULL				
Accuracy Rating = 67.88%				
IF SOIL TYPE =	**THEN... VARIABLE: ELEVATION**		**AND... VARIABLE: SOIL TYPE**	
	Range	**Probability**	**Type**	**Probability**
Soil Group [2] **59.15% n=590**	0 - 11	75.00%, n=52	---	---
	11 - 70	60.17%, n=477	---	---
	70 - 3786	37.70%, n=61	0155E	58.62%, n=29
			01152E 0119	18.75%, n=32

***Soil Group [2]:** 01138f, 01140, 01141, 01146e, 01154d, 01160d, 01162*

Appendix 7: Watershed Profile for NWI Classes.

NWI Totals: All Complete Watersheds

Number of watersheds:	**18**				
Total # NWI polygons:	**16941**				
Total area (acres):	**1854784.56**				
Total NWI area (acres):	**40626.69**				
Ecoregions included:	**Acres**	**% area**			
Coastal Lowlands	187425.55	1106.34			
Coastal Uplands	208900.58	1233.11			
Mid-Coast Sedimentary	1262929.06	7454.87			
S. Oregon Coastal Mtns	83707.98	494.11			
Coastal Siskiyous (KM)	1590.79	9.39			
Inland Siskiyous (KM)	23006.45	135.80			
Umpqua Interior Foothills (KM)	50648.54	298.97			
Valley Foothills (WV)	7843.33	46.30			
% of HUC with NWI data:	**Acres**	**%**	**w/ soils**		
	1854784.56	2.19	100%		
WETLAND TOTALS					
NWI Class	**Class**	**Acres**	**% NWI area**	**# polygons**	**% polygons**
	PAB	176.76	0.44	193	1.14
	PEM	29601.64	72.86	10409	61.44
	PFO	3502.73	8.62	1984	11.71
	POW	18.74	0.05	16	0.09
	PSS	6435.65	15.84	2989	17.64
	PUB	586.01	1.44	1046	6.17
	PUS	300.40	0.74	302	1.78

Appendix 8: Watershed Profile for NWI Subclasses.

NWI Totals: All Complete Watersheds (page 1 of 2)

Watershed HUC code:			
Number of watersheds:	**18**		
Total # NWI polygons:	**16941**		
Total area (acres):	**1854784.56**		
Total NWI area (acres):	**40626.69**		
Ecoregions included:	**Acres**	**% area**	
Coastal Lowlands	187425.55	1106.34	
Coastal Uplands	208900.58	1233.11	
Mid-Coast Sedimentary	1262929.06	7454.87	
S. Oregon Coastal Mtns	83707.98	494.11	
Coastal Siskiyous (KM)	1590.79	9.39	
Inland Siskiyous (KM)	23006.45	135.80	
Umpqua Interior Foothills (KM)	50648.54	298.97	
Valley Foothills (WV)	7843.33	46.30	
% of HUC with NWI data:	**Acres**	**%**	**w/ soils**
	1854784.56	2.19	100%

WETLAND TOTALS (NWI Type and Acres)

PEMC	17093.77	PFO/SSC	138.14
PSSC	5591.20	PEMH	131.33
PEMA	4787.52	PUSA	128.48
PEMCh	4161.12	PEMFh	122.93
PFOC	1458.21	PFOS	108.96
PFOA	1042.43	PFO1A	108.54
PEMB	1035.81	PABH	96.70
PEMR	592.77	PEM5C	81.59
PSSA	480.69	PUBHx	72.98
PEMF	383.15	PSSCh	43.45
PFO1C	374.66	PSSB	41.58
PEMHh	229.93	PEMFb	34.88
PUBH	228.38	PUBKx	33.46
PUBHh	218.40	PSSCb	33.41
PEMT	214.17	PSS/EM1C	32.94
PEMAh	199.96	PABF	29.98
PFOR	193.36	PEM/ABC	27.80
PEMAd	170.65	PFOCH	25.32
PUSC	159.09	PFO1J	25.08
PSSR	149.43	PEM5Bd	24.98
PEMCd	144.51	PEMTh	23.96

NWI Totals: All Complete Watersheds (page 2 of 2)

WETLAND TOTALS (NWI Type and Acres)

PABHx	23.30	PEM5/AB7Fh	1.36
PEM/SSA	22.77	PEM1Af	1.22
PEM1Ad	20.81	PABFh	1.09
PEM5Ad	20.73	PUSCh	1.06
PFOB	20.35	PEM5F	0.89
PSSF	17.31	PEM5A	0.84
PEMCb	16.05	PEMS	0.74
PEM5E	14.74	PSSAd	0.72
PSS1C	12.96	PEMAx	0.71
PEMN	12.86	PABFx	0.55
PUBFh	12.74	PFO4	0.49
PSS/FOC	12.60	PABGb	0.46
PABHh	11.26	PUBKh	0.30
POWFx	9.44	PUSAX	0.23
PEMFx	7.76		
PUSR	7.40		
PFO/SS1C	7.19		
PEMKh	6.59		
PSS1/EM5C	6.08		
PUBF	6.08		
PSSS	5.54		
PEM1A	5.45		
PEMCx	5.15		
PUBHb	4.90		
POWFh	4.20		
PAB7/OWFx	4.19		
PUSCx	4.14		
PAB7/OWFh	4.08		
PUBFx	3.83		
PABKx	3.55		
POWHhx	3.28		
PSSFb	3.14		
PUBGx	2.61		
PUBFb	2.33		
PSSAH	2.30		
PSSCx	2.30		
PEM5B	2.14		
POWF	1.82		
PABHb	1.60		

Appendix 9: Watershed Profile for All Watersheds with Complete NWI Data.

All Watersheds with Complete NWI Data (page 1 of 4)

Number of watersheds:	**18**						
Total # NWI polygons:	**16941**						
Total area (acres):	**1854784.56**						
Total NWI area (acres):	**40626.69**						
Ecoregions included:	**Acres**	**% area**					
Coastal Lowlands	187425.55	10.10					
Coastal Uplands	208900.58	11.26					
Mid-Coast Sedimentary	1262929.06	68.09					
S. Oregon Coastal Mtns	83707.98	4.51					
Coastal Siskiyous (KM)	1590.79	0.09					
Inland Siskiyous (KM)	23006.45	1.24					
Umpqua Interior Foothills (KM)	50648.54	2.73					
Valley Foothills (WV)	7843.33	0.42					
% of HUC with NWI data:	**Acres**	**%**	**w/ soils**	**Quad %**			
	1854784.56	2.19	100%	100.00%			
TOTALS							
	Acres	**% NWI AREA**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
NWI intersect. by hydrics	39095.63	96.23	14219	83.93	<1	503.4	2.74
NWI not intersect. w/ hydrics	1531.06	3.77	2722	16.07	<1	58.06	0.577
	Acres	**% AREA W/ DATA**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
Hydrics not intersect. w/ NWI	117735.66	100	3154	18.62%	<1	1094.21	37.3

All Watersheds with Complete NWI Data (page 2 of 4)

	Acres	% NWI AREA	# poly	% poly	MIN	MAX	MEAN
ISOLATION							
Isolation A	3346.78	8.24	3624	21.39%	<1	58.10	0.92
Isolation B	191.96	0.47	426	2.51%	<1	6.73	0.45
Isolation C	177.20	0.44	385	2.27%	<1	6.73	0.46
Isolation D: none of above	37279.90	91.76	13317	78.61%	<1	503.42	2.8
RIVER ISOLATION: CLAMS	Acres	% NWI AREA	# poly	% poly	MIN	MAX	MEAN
Isolation C1: not w/in 40m	3797.00	9.35	3319	19.59%	<1	89.61	1.11
Isolation C2: not w/in 20-40m	4264.34	10.50	3825	22.58%	<1	89.61	1.11
Isolation C3: not w/in 10-20m	4499.17	11.07	4063	23.98%	<1	89.61	1.11
Isolation C4: none of above	36127.51	88.93	12878	76.02%	<1	503.42	2.8
RIVER ISOLATION	Acres	% NWI AREA	# poly	% poly	MIN	MAX	MEAN
Isolation S1: not w/in 40m	11463.34	28.22	7356	43.42%	<1	503.40	1.55
Isolation S2: not w/in 20-40m	11951.00	29.42	7772	45.88%	<1	503.40	1.54
Isolation S3: not w/in 20m	12142.28	29.89	7960	46.99%	<1	503.4	1.52
ROAD ISOLATION	Acres	% NWI AREA	# poly	% poly	MIN	MAX	MEAN
Road isolation (X)	8639.26	21.26	6630	39.14%	<1	255.3	1.3
Road isolation (Y): not X	31987.43	78.74	10311	60.86%	<1	503.4	3.1

All Watersheds with Complete NWI Data (page 3 of 4)

ECOREGIONS	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Coastal Lowlands	24776.53	60.99	8465	49.97%	<1	503.4	2.92
Coastal Uplands	7554.80	18.60	3190	18.83%	<1	115.64	2.36
Mid-Coast Sedimentary	5738.25	14.12	3824	22.57%	<1	163.37	1.5
S. Oregon Coastal Mtns	95.54	0.24	187	1.10%	<1	11.18	0.5
Coastal Siskiyous (KM)	0.00	0.00	0	0.00%	0	0	0
Inland Siskiyous (KM)	18.86	0.05	18	0.11%	0.01	3.94	1.04
Umpqua Interior Foothills (KM)	1136.70	2.80	710	4.19%	<1	162.09	1.6
Valley Foothills (WV)	30.72	0.08	41	0.24%	<1	4.53	0.75
FEMA ZONES	**Acres**	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
Zone A	30722.02	75.62	9105	53.75%	<1	454.62	3.37
Zones D, X500	30755.63	75.70	9134	53.92%	<1	454.62	3.37
ELEVATION ZONE	**Acres**	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
0-15 ft	14837.50	36.52	4376	25.83%	<1	349.34	3.4
16-35 ft	16245.94	39.99	5241	30.94%	<1	503.41	3.09
36-170 ft	5831.93	14.35	4260	25.15%	<1	113.93	1.36
171-3800 ft	3711.32	9.14	3064	18.09%	<1	162.09	1.2

All Watersheds with Complete NWI Data (page 4 of 4)

SLOPE CATEGORY	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
(-1.0)-2.5%	32358.67	79.65	8728	51.52%	<1	503.42	3.7
2.51-6.5 %	5992.00	14.75	4543	26.82%	<1	113.93	1.32
6.51-12.5 %	1507.57	3.71	2133	12.59%	<1	16.46	0.71
12.51-22.5 %	638.61	1.57	1133	6.69%	<1	15.98	0.56
22.51-50.5 %	129.84	0.32	404	2.38%	<1	3.38	0.32

AVG. ANNUAL PRECIP.	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
900-1250 mm	1146.41	2.82	810	4.78%	<1	162.09	1.41
1251-1500 mm	1101.29	2.71	1119	6.61%	<1	35.25	0.98
1501-1750 mm	26198.74	64.49	9195	54.28%	<1	454.61	2.85
1751-2250 mm	11927.49	29.36	5603	33.07%	<1	503.4	2.13
2251-3150 mm	252.75	0.62	214	1.26%	<1	15.52	1.18

Appendix 10: Watershed Profile for Isolated Wetlands

Isolated Wetlands: All Watersheds with Complete NWI Data (page 1 of 2)

ISOLATION

	Acres	% NWI AREA	# poly	% poly	MIN	MAX	MEAN
Isolation A	3346.78	8.24	3624	21.39%	<1	58.10	0.92
Isolation B	191.96	0.47	426	2.51%	<1	6.73	0.45
Isolation C	177.20	0.44	385	2.27%	<1	6.73	0.46
Isolation D: none of above	37279.90	91.76	13317	78.61%	<1	503.42	2.8
	Acres	% NWI AREA	# poly	% poly	MIN	MAX	MEAN
Road isolation (X)	8639.26	21.26	6630	39.14%	<1	255.3	1.3
Road isolation (Y): not X	31987.43	78.74	10311	60.86%	<1	503.4	3.1

ECOREGIONS

	Iso A	% A	Iso B	% B	Iso C	% C	Iso D	% D
Coastal Lowlands	1854.65	55.42	58.02	30.23	33.40	18.85	22921.89	61.49
Coastal Uplands	110.36	3.30	21.94	11.43	15.20	8.58	7444.44	19.97
Mid-Coast Sedimentary	869.14	25.97	144.80	75.43	97.02	54.75	4869.11	13.06
S. Oregon Coastal Mtns	38.64	1.15	16.64	8.67	13.27	7.49	56.91	0.15
Coastal Siskiyous (KM)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Inland Siskiyous (KM)	5.46	0.16	1.52	0.79	0.80	0.45	13.40	0.04
Umpqua Interior Foothills (KM)	202.78	6.06	8.00	4.17	4.67	2.64	933.91	2.51
Valley Foothills (WV)	3.63	0.11	1.61	0.84	0.00	0.00	27.09	0.07

FEMA ZONES

	Iso A	% A	Iso B	% B	Iso C	% C	Iso D	% D
Zone A	1409.87	42.13	0	0.00	0	0.00	29312.14	78.63
Zones D, X500	1434.89	42.87	0	0.00	0	0.00	29320.75	78.65

Isolated Wetlands:
All Watersheds with Complete NWI Data (page 2 of 2)

ELEVATION ZONE	Iso A	% A	Iso B	% B	Iso C	% C	Iso D	% D
0-15 ft	595.43	17.79	252.43	131.50	0.8	0.45	14242.07	38.20
16-35 ft	1017.85	30.41	10.17	5.30	2.81	1.59	15228.08	40.85
36-170 ft	962.47	28.76	73.33	38.20	34.6	19.53	4869.46	13.06
171-3800 ft	771.03	23.04	167.85	87.44	126.84	71.58	2940.3	7.89
SLOPE CATEGORY								
	Iso A	**% A**	**Iso B**	**% B**	**Iso C**	**% C**	**Iso D**	**% D**
(-1.0)-2.5%	2623.16	78.38	62.23	32.42	34.00	19.19	29735.51	79.76
2.51-6.5 %	508.29	15.19	87.27	45.46	55.41	31.27	5483.71	14.71
6.51-12.5 %	161.12	4.81	74.89	39.01	53.61	30.25	1346.45	3.61
12.51-22.5 %	43.24	1.29	22.00	11.46	18.37	10.37	595.37	1.60
22.51-50.5 %	10.97	0.33	7.12	3.71	3.65	2.06	118.86	0.32
AVG. ANNUAL PRECIP.								
	Iso A	**% A**	**Iso B**	**% B**	**Iso C**	**% C**	**Iso D**	**% D**
900-1250 mm	218.28	6.52	7.47	3.89	4.55	2.57	928.13	2.49
1251-1500 mm	327.17	9.78	44.03	22.94	23.34	13.17	774.12	2.08
1501-1750 mm	2172	64.90	143.54	74.78	96.79	54.62	24026.75	64.45
1751-2250 mm	597.65	17.86	43.74	22.79	26.82	15.14	11329.84	30.39
2251-3150 mm	31.68	0.95	14.74	7.68	13.54	7.64	221.06	0.59

Appendix 11: Coos Watershed Profile

Coos Watershed Complex (page 1 of 3)							
Number of watersheds:	**3**						
Total # NWI polygons:	**16941**						
Total # NWI this watershed:	**4044**						
Polygon % of Total:	**23.87**						
Total area (acres):	**406593.75**						
Total NWI area (acres):	**10192.07**						
Ecoregions included:	**Acres**	**% area**					
Coastal Lowlands	56367.79	13.86					
Coastal Uplands	71004.75	17.46					
Mid-Coast Sedimentary	262675.34	64.60					
Umpqua Interior Foothills (KM)	1.10	<1					
% of HUC with NWI data:	**Acres**	**%**	**w/ soils**	**Quad %**			
	406593.75	2.51	100.00	100.00			
TOTALS							
	Acres	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
NWI intersect. by hydrics	9697.83	95.15	3426.00	84.72	<1	196.70	2.83
NWI not intersect. w/ hydrics	494.23	4.85	618.00	15.28	<1	58.06	0.80
	Acres	**% AREA W/ DATA**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
Hydrics not intersect. w/ NWI	19058.60	100	521.00	12.88	0.56	816.38	36.58
ISOLATION							
	Acres	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
Isolation A	377.01	3.70	795.00	19.66	<1	23.50	0.47
Isolation B	39.35	0.39	92.00	2.27	<1	2.96	0.43
Isolation C	35.06	0.34	82.00	2.03	<1	2.96	0.43
Isolation D: none of above	9260.46	90.86	3249.00	80.34	<1	196.74	2.85

Coos Watershed Complex (page 2 of 3)

RIVER ISOLATION: CLAMS

	Acres	% NWI AREA	# poly	% poly	MIN	MAX	MEAN
Isolation C1: not w/in 40m	1442.43	14.15	965	23.86%	<1	58.06	1.5
Isolation C2: not w/in 20-40m	1512.16	14.84	1032	25.52%	<1	58.06	1.5
Isolation C3: not w/in 10-20m	1526.42	14.98	1052	26.01%	<1	58.06	1.5
Isolation C4: none of above	8665.64	85.02	2992	73.99%	<1	196.74	2.89

RIVER ISOLATION

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Isolation S1: not w/in 40m	3465.70	34.00	1786.00	44.16	<1	196.70	1.94
Isolation S2: not w/in 20-40m	3604.04	35.36	1886.00	46.64	<1	196.70	1.91
Isolation S3: not w/in 20m	3613.35	35.45	1905.00	47.11	<1	196.70	1.89

ROAD ISOLATION

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Road isolation (X)	1856.71	18.22	1349.00	33.36	<1	57.95	1.37
Road isolation (Y): not X	8335.35	81.78	2695.00	66.64	<1	196.74	3.09

ECOREGIONS

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Coastal Lowlands	6677.06	65.51	2539	62.78	<1	196.75	2.63
Coastal Uplands	2032.40	19.94	890	22.01	<1	113.90	2.28
Mid-Coast Sedimentary	848.97	8.33	436	10.78	<1	163.37	1.95
Umpqua Interior Foothills (KM)	0.00	0.00	0	0.00	0.00	0.00	0.00

FEMA ZONES

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Zone A	8762.31	85.97	2836.00	70.13	<1	196.74	3.10
Zones D, X500	8783.96	86.18	2845.00	70.35	<1	196.74	3.10

Coos Watershed Complex (page 2 of 3)

ELEVATION ZONE	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
0-15 ft	5023.95	49.29	1391.00	34.40	<1	191.16	3.61
16-35 ft	4050.20	39.74	1758.00	43.47	<1	196.70	2.30
36-170 ft	904.29	8.87	674.00	16.67	<1	113.90	1.34
171-3800 ft	213.61	2.10	221.00	5.46	<1	15.98	0.96
SLOPE CATEGORY							
	Acres	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
(-1.0)-2.5%	8796.85	86.31	2347.00	58.04	<1	196.74	3.75
2.51-6.5 %	1015.40	9.96	1041.00	25.74	<1	113.93	0.97
6.51-12.5 %	239.50	2.35	397.00	9.82	<1	11.78	0.60
12.51-22.5 %	111.67	1.10	200.00	4.95	<1	15.98	0.56
22.51-50.5 %	28.63	0.28	59.00	1.46	<1	3.38	0.48
AVG. ANNUAL PRECIP.							
	Acres	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
900-1250 mm	8.57	0.08	9	0.22	0.009	3.32	0.95
1251-1500 mm	11.58	0.11	13	0.32	0.002	3.25	0.89
1501-1750 mm	8764.48	85.99	3358	83.04	<1	196.7	2.61
1751-2250 mm	1407.42	13.81	664	16.42	<1	121.2	2.12
2251-3150 mm	0.00	0.00	0	0.00	<1	0	0

Appendix 12: Coquille Watershed Profile

Coquille Watershed Complex (page 1 of 3)

Number of watersheds:	**7**						
Total # NWI polygons:	**16941**						
Total # NWI this watershed:	**4552**						
Polygon % of Total:	**26.87**						
Total area (acres):	**676741.83**						
Total NWI area (acres):	**14712.60**						
Ecoregions included:	**Acres**	**% area**					
Coastal Lowlands	57323.52	8.47					
Coastal Uplands	62977.23	9.31					
Mid-Coast Sedimentary	430241.00	63.58					
S. Oregon Coastal Mtns	83707.98	12.37					
Coastal Siskiyous (KM)	1590.80	0.24					
Inland Siskiyous (KM)	23006.45	3.40					
Umpqua Interior Foothills (KM)	17299.81	2.56					
% of HUC with NWI data:	**Acres**	**%**	**w/ soils**	**Quad %**			
	676741.83	2.17		100.00			

TOTALS

	Acres	% NWI	# poly	% poly	MIN	MAX	MED
NWI intersect. by hydrics	14262.65	96.94	3748.00	82.34	<1	349.34	3.80
NWI not intersect. w/ hydrics	449.95	3.06	804.00	17.66	<1	13.44	0.56
	Acres	**% AREA W/ DATA**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
Hydrics not intersect. w/ NWI	33123.79	100.00	730.00	16.04	0.22	1094.20	45.38

ISOLATION

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Isolation A	1064.30	7.23	1226.00	26.93	<1	22.41	0.86
Isolation B	109.12	0.74	254.00	5.58	<1	6.73	0.43
Isolation C	100.37	0.68	229.00	5.03	<1	6.73	0.43

Coquille Watershed Complex (page 2 of 3)

RIVER ISOLATION: CLAMS

	Acres	% NWI AREA	# poly	% poly	MIN	MAX	MEAN
Isolation C1: not w/in 40m	867.93	5.90	922	20.25%	<1	22.41	0.95
Isolation C2: not w/in 20-40m	1019.26	6.93	1114	24.47%	<1	22.41	0.95
Isolation C3: not w/in 10-20m	1069.15	7.27	1187	26.08%	<1	22.41	0.95
Isolation C4: none of above	13643.45	92.73	3365	73.92%	<1	349.34	4.05

RIVER ISOLATION

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Isolation S1: not w/in 40m	1800.28	12.24	1805.00	39.65	<1	49.78	0.99
Isolation S2: not w/in 20-40m	1947.55	13.24	1932.00	42.44	<1	49.78	1.00
Isolation S3: not w/in 20m	2008.42	13.65	1994.00	43.80	<1	49.78	1.00

ROAD ISOLATION

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Road isolation (X)	2324.67	15.80	1800.00	39.54	<1	78.38	1.29
Road isolation (Y): not X	12387.93	84.20	2752.00	60.46	<1	349.34	4.50

ECOREGIONS

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Coastal Lowlands	11932.80	81.11	2717	59.69	<1	349.34	4.39
Coastal Uplands	799.50	5.43	438	9.62	<1	68.94	1.83
Mid-Coast Sedimentary	1481.37	10.07	1048	23.02	<1	42.60	1.41
S. Oregon Coastal Mtns	95.55	0.65	187	4.11	<1	11.18	0.51
Coastal Siskiyous (KM)	0.00	0.00	0	0.00	0.00	0.00	0.00
Inland Siskiyous (KM)	18.86	0.13	18	0.40	<1	3.94	1.05
Umpqua Interior Foothills (KM)	384.48	2.61	143	3.14	<1	22.36	2.70

FEMA ZONES

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Zone A	13206.38	89.76	3029.00	66.54	<1	349.34	4.36
Zones D, X500	13206.38	89.76	3029.00	66.54	<1	349.34	4.36

Coquille Watershed Complex (page 3 of 3)

ELEVATION ZONE	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
0-15 ft	7411.07	50.37	1214.00	26.67	<1	349.34	6.10
16-35 ft	4578.85	31.12	1265.00	27.79	<1	163.19	3.62
36-170 ft	1565.97	10.64	1124.00	24.69	<1	62.50	1.40
171-3800 ft	1156.70	7.86	949.00	20.85	<1	22.36	1.22
SLOPE CATEGORY	**Acres**	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
(-1.0)-2.5%	12905.43	87.72	2656.00	58.35	<1	349.34	4.85
2.51-6.5 %	1396.50	9.49	1218.00	26.76	<1	62.50	1.15
6.51-12.5 %	304.74	2.07	496.00	10.90	<1	13.45	0.61
12.51-22.5 %	97.75	0.66	154.00	3.38	<1	10.30	0.64
22.51-50.5 %	8.19	0.06	28.00	0.62	<1	1.70	0.30
AVG. ANNUAL PRECIP.	**Acres**	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
900-1250 mm	262.86	1.79	93.00	2.04	<1	22.36	2.83
1251-1500 mm	287.35	1.95	212.00	4.66	<1	35.25	1.35
1501-1750 mm	13794.70	93.76	3924.00	86.20	<1	349.34	3.51
1751-2250 mm	115.68	0.79	110.00	2.42	<1	9.34	1.05
2251-3150 mm	252.00	1.71	213.00	4.68	<1	15.52	1.19

Appendix 13: Siltcoos Watershed Profile

Siltcoos Watershed Complex (page 1 of 3)

Number of watersheds:	**1**						
Total # NWI polygons:	**16941**						
Total # NWI this watershed:	**2635**						
Polygon % of Total:	**15.55**						
Total area (acres):	**83181.23**						
Total NWI area (acres):	**5096.98**						
Ecoregions included:	**Acres**	**% area**					
Coastal Lowlands	37319.88	44.87					
Coastal Uplands	26369.87	31.70					
Mid-Coast Sedimentary	18354.07	22.07					
% of HUC with NWI data:	**Acres**	**%**	**w/ soils**	**Quad %**			
	83181.23	6.13	100.00	100.00			
TOTALS							
	Acres	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
NWI intersect. by hydrics	4936.63	96.85	2233	84.74	<1	503.42	2.21
NWI not intersect. w/ hydrics	160.35	3.15	402	15.26	<1	9.66	0.40
	Acres	**% AREA W/ DATA**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
Hydrics not intersect. w/ NWI	3940.15	77.30	192	7.29	0.03	155.95	20.52
ISOLATION							
	Acres	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
Isolation A	303.85	5.96	383	14.54	<1	13.83	0.80
Isolation B	9.06	0.18	13	0.49	<1	2.92	0.70
Isolation C	9.06	0.18	13	0.49	<1	2.92	0.70
Isolation D: none of above	4793.13	94.04	2252	85.46	<1	503.42	2.13

Siltcoos Watershed Complex (page 2 of 3)

RIVER ISOLATION: CLAMS

	Acres	% NWI AREA	# poly	% poly	MIN	MAX	MEAN
Isolation C1: not w/in 40m	634.09	12.44	472	17.91%	<1	89.61	1.34
Isolation C2: not w/in 20-40m	671.87	13.18	535	20.30%	<1	89.61	1.25
Isolation C3: not w/in 10-20m	749.72	14.71	576	21.86%	<1	89.61	1.3
Isolation C4: none of above	4347.26	85.29	2059	78.14%	<1	503.42	2.11

RIVER ISOLATION

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Isolation S1: not w/in 40m	2251.14	44.17	995	37.76	<1	503.42	2.26
Isolation S2: not w/in 20-40m	2270.05	44.54	1006	38.18	<1	503.42	2.26
Isolation S3: not w/in 20m	2342.20	45.95	1046	39.70	<1	503.42	2.24

ROAD ISOLATION

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Road isolation (X)	991.78	19.46	776	29.45		107.18	1.28
Road isolation (Y): not X	4105.21	80.54	1859	70.55		503.42	2.21

ECOREGIONS

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Coastal Lowlands	3093.14	60.69	1669	63.34	<1	503.41	1.85
Coastal Uplands	1535.34	30.12	677	25.69	<1	73.07	2.27
Mid-Coast Sedimentary	268.06	5.26	180	6.83	<1	22.20	1.49

FEMA ZONES

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Zone A	1611.91	31.62	701	26.60	<1	89.61	2.30
Zones D, X500	1611.91	31.62	701	26.60	<1	89.61	2.30

Siltcoos Watershed Complex (page 3 of 3)

ELEVATION ZONE	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
0-15 ft	348.59	6.84	461.00	17.50	<1	29.83	0.76
16-35 ft	3383.67	66.39	1060.00	40.23	<1	503.42	3.19
36-170 ft	1357.23	26.63	1097.00	41.63	<1	34.77	1.24
171-3800 ft	7.49	0.15	17.00	0.65	0.17	1.14	0.44

SLOPE CATEGORY	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
(-1.0)-2.5%	3572.36	70.09	1295.00	49.15	<1	503.42	2.75
2.51-6.5 %	1025.83	20.13	613.00	23.26	<1	34.92	1.67
6.51-12.5 %	349.30	6.85	374.00	14.19	<1	16.46	0.94
12.51-22.5 %	115.67	2.27	249.00	9.45	<1	3.67	0.46
22.51-50.5 %	33.82	0.66	104.00	3.95	<1	3.05	0.33

AVG. ANNUAL PRECIP.	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
900-1250 mm	0.00	0.00	0	0.00	0	0	0
1251-1500 mm	0.00	0.00	0	0.00	0	0	0
1501-1750 mm	972.32	19.08	657	24.93	<1	107.18	1.5
1751-2250 mm	4124.66	80.92	1978	75.07	<1	503.42	2.09
2251-3150 mm	0.00	0.00	0	0.00	0	0	0

Appendix 14: Tenmile Watershed Profile

Tenmile Watershed Complex (page 1 of 3)

Number of watersheds:	**1**						
Total # NWI polygons:	**16941**						
Total # NWI this watershed:	**1652**						
Polygon % of Total:	**9.75**						
Total area (acres):	**64819.75**						
Total NWI area (acres):	**3375.80**						
Ecoregions included:	**Acres**	**% area**					
Coastal Lowlands	29369.20	45.31					
Coastal Uplands	12734.47	19.65					
Mid-Coast Sedimentary	22421.21	34.59					
% of HUC with NWI data:	**Acres**	**%**	**w/ soils**	**Quad %**			
	64819.75	5.21	100.00	100.00			
TOTALS							
	Acres	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
NWI intersect. by hydrics	3321.67	98.40	1446	87.53	<1	454.62	2.30
NWI not intersect. w/ hydrics	54.13	1.60	206	12.47	<1	7.36	0.26
	Acres	**% AREA W/ DATA**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
Hydrics not intersect. w/ NWI	1183.14	100.00	42	2.54	2.49	163.01	28.17
ISOLATION							
	Acres	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
Isolation A	259.98	7.70	297	17.98	<1	16.21	0.87
Isolation B	3.73	0.11	5	0.30	<1	3.73	0.75
Isolation C	3.52	0.10	3	0.18	<1	2.85	1.17
Isolation D: none of above	3115.82	92.30	1355	82.02	<1	454.62	2.30

Tenmile Watershed Complex (page 2 of 3)

RIVER ISOLATION: CLAMS	Acres	% NWI AREA	# poly	% poly	MIN	MAX	MEAN
Isolation C1: not w/in 40m	249.71	7.40	269	16.28%	<1	14.73	0.93
Isolation C2: not w/in 20-40m	294.94	8.74	306	18.52%	<1	20.02	0.96
Isolation C3: not w/in 10-20m	299.61	8.88	314	19.01%	<1	20.02	0.96
Isolation C4: none of above	3076.18	91.12	1338	80.99%	<1	454.62	2.3

RIVER ISOLATION	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Isolation S1: not w/in 40m	1549.07	45.89	735	44.49	<1	454.62	2.11
Isolation S2: not w/in 20-40m	1591.05	47.13	782	47.34	<1	454.62	2.03
Isolation S3: not w/in 20m	1597.82	47.33	787	47.64	<1	454.62	2.03

ROAD ISOLATION	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Road isolation (X)	992.58	29.40	642	38.86	<1	255.30	1.55
Road isolation (Y): not X	2383.22	70.60	1010	61.14	<1	454.62	2.36

ECOREGIONS	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Coastal Lowlands	2393.30	70.90	1249	75.61	<1	454.62	1.92
Coastal Uplands	710.75	21.05	266	16.10	<1	74.15	2.67
Mid-Coast Sedimentary	271.75	8.05	137	8.29	<1	32.28	1.98

FEMA ZONES	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Zone A	2596.64	76.92	863.00	52.24	<1	454.62	3.01
Zones D, X500	2596.64	76.92	863.00	52.24	<1	454.62	3.01

Tenmile Watershed Complex (page 3 of 3)

ELEVATION ZONE	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
0-15 ft	261.85	7.76	413.00	25.00	<1	40.80	0.63
16-35 ft	1685.20	49.92	397.00	24.03	<1	454.62	4.24
36-170 ft	1390.43	41.19	803.00	48.61	<1	74.15	1.73
171-3800 ft	38.31	1.13	39.00	2.36	<1	10.86	0.98

SLOPE CATEGORY	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
(-1.0)-2.5%	2548.52	75.49	859.00	52.00	<1	454.62	2.96
2.51-6.5 %	650.60	19.27	381.00	23.06	<1	74.12	1.70
6.51-12.5 %	124.52	3.69	221.00	13.38	<1	13.24	0.56
12.51-22.5 %	43.55	1.29	149.00	9.02	<1	3.68	0.30
22.51-50.5 %	8.60	0.25	42.00	2.54	<1	1.13	0.21

AVG. ANNUAL PRECIP.	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
900-1250 mm	0.00	0.00	0	0.00	0	0	0
1251-1500 mm	0.00	0.00	0	0.00	0	0	0
1501-1750 mm	1516.11	44.91	607	36.74	<1	454.62	2.5
1751-2250 mm	1859.69	55.09	1045	63.26	<1	120.77	1.78
2251-3150 mm	0.00	0.00	0	0.00	0	0	0

Appendix 15: Umpqua Watershed Profile

Umpqua Watershed Complex (page 1 of 3)

Number of watersheds:	**6**						
Total # NWI polygons:	**16941**						
Total # NWI this watershed:	**4058**						
Polygon % of Total:	**23.95**						
Total area (acres):	**623448.00**						
Total NWI area (acres):	**7249.25**						
Ecoregions* included:	**Acres**	**% area**					
Coastal Lowlands	7045.16	1.13					
Coastal Uplands	35814.24	5.74					
Mid-Coast Sedimentary	529237.11	84.89					
Umpqua Interior Foothills (KM)	33347.63	5.35					
Valley Foothills (WV)	7843.33	1.26					
% of HUC with NWI data:	**Acres**	**%**	**w/ soils**	**Quad %**			
	623448.00	1.16	100.00	100.00			
TOTALS							
	Acres	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
NWI intersect. by hydrics	6876.83	94.86	3365	82.92	<1	162.09	2.04
NWI not intersect. w/ hydrics	372.42	5.14	693	17.08	<1	7.66	0.54
	Acres	**% AREA W/ DATA**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
Hydrics not intersect. w/ NWI	64579.63	100.00	1714	42.24	0.02	997.24	37.67
ISOLATION							
	Acres	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
Isolation A	787.05	10.86	923	22.75	<1	27.42	0.85
Isolation B	30.69	0.42	62	1.53	<1	2.71	0.50
Isolation C	30.69	0.42	62	1.53	<1	2.71	0.50
Isolation D: none of above	6462.20	89.14	3135	77.25	<1	162.09	2.06

Umpqua Watershed Complex (page 2 of 3)

RIVER ISOLATION: CLAMS	Acres	% NWI AREA	# poly	% poly	MIN	MAX	MEAN
Isolation C1: not w/in 40m	602.84	8.32	691	17.03%	<1	40.96	0.87
Isolation C2: not w/in 20-40m	766.11	10.57	838	20.65%	<1	40.96	0.91
Isolation C3: not w/in 10-20m	854.26	11.78	934	23.02%	<1	40.96	0.91
Isolation C4: none of above	6395.00	88.22	3124	76.98%	<1	162.09	2.05

RIVER ISOLATION	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Isolation S1: not w/in 40m	2397.14	33.07	2035	50.15	<1	121.50	1.18
Isolation S2: not w/in 20-40m	2538.32	35.01	2166	53.38	<1	121.50	1.18
Isolation S3: not w/in 20m	2580.50	35.60	2228	54.90	<1	121.50	1.16

ROAD ISOLATION	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Road isolation (X)	2473.53	34.12	2063.00	50.84	<1	121.50	1.20
Road isolation (Y): not X	4775.73	65.88	1995.00	49.16	<1	162.09	2.40

ECOREGIONS	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Coastal Lowlands	680.26	9.38	291	7.17	<1	121.51	2.34
Coastal Uplands	2476.82	34.17	919	22.65	<1	115.64	2.70
Mid-Coast Sedimentary	2868.10	39.56	2023	49.85	<1	67.96	1.42

FEMA ZONES	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
Zone A	4544.77	62.69	1676.00	41.30	<1	162.10	2.71
Zones D, X500	4556.74	62.86	1696.00	41.79	<1	162.10	2.70

Umpqua Watershed Complex (page 3 of 3)

	Acres	% NWI	# poly	% poly	MIN	MAX	MEAN
ELEVATION ZONE							
0-15 ft	1792.03	24.72	897.00	22.10	<1	121.50	2.00
16-35 ft	2548.00	35.15	761.00	18.75	<1	81.55	3.35
36-170 ft	614.01	8.47	562.00	13.85	<1	32.55	1.09
171-3800 ft	2295.21	31.66	1838.00	45.29	<1	162.09	1.25
SLOPE CATEGORY	**Acres**	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
(-1.0)-2.5%	4535.52	62.57	1571.00	38.71	<1	162.09	2.89
2.51-6.5 %	1903.67	26.26	1290.00	31.79	<1	69.81	1.47
6.51-12.5 %	489.52	6.75	645.00	15.89	<1	12.00	0.76
12.51-22.5 %	269.96	3.72	381.00	9.39	<1	9.57	0.71
22.51-50.5 %	50.57	0.70	171.00	4.21	<1	2.70	0.30
AVG. ANNUAL PRECIP.	**Acres**	**% NWI**	**# poly**	**% poly**	**MIN**	**MAX**	**MEAN**
900-1250 mm	874.98	12.07	708	17.45	<1	162.09	1.24
1251-1500 mm	802.35	11.07	894	22.03	<1	11.02	0.9
1501-1750 mm	1151.12	15.88	649	15.99	<1	121.51	1.77
1751-2250 mm	4420.05	60.97	1806	44.50	<1	115.64	2.45
2251-3150 mm	0.75	0.01	1	0.02	<1	0.75	0.75

Appendix 16: Palustrine Database Metadata in Standard ArcGIS Format

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Palustrine_Database

Metadata:

- Identification_Information
- Data_Quality_Information
- Spatial_Data_Organization_Information
- Spatial_Reference_Information
- Entity_and_Attribute_Information
- Distribution_Information
- Metadata_Reference_Information

Identification_Information:
Citation:
Citation_Information:
Originator: Jennifer Larsen - Oregon State University
Publication_Date: August 2005
Title:
Palustrine_Database
Geospatial_Data_Presentation_Form: vector digital data
Online_Linkage: \\WILK204-PC2\TerraCognita2\larsjenn\thesis\wetlands_database\Palustrine_Database.shp
Description:
Abstract:
The author developed a GIS shapefile of palustrine wetland occurrence for a selected portion of the Oregon Coast for use in an enhanced National Wetlands Inventory (NWI) geodatabase. The study was designed to test hypotheses about physiographic and derived topographic variables associated with mapped palustrine wetlands. A three phase methodology was developed for characterizing palustrine wetland size and degree of isolation that included designing an enhanced NWI geodatabase, creating watershed profiles and wetland demographic statistics, and analyzing the data using decision tree modeling.
Purpose:
To catalog palustrine wetland polygons and associated environmental attributes in an enhanced NWI geodatabase.
Time_Period_of_Content:
Time_Period_Information:
Single_Date/Time:
Calendar_Date: August 2005

Currentness_Reference:
publication date
Status:
Progress: Complete
Maintenance_and_Update_Frequency: Unknown
Spatial_Domain:
Bounding_Coordinates:
West_Bounding_Coordinate: -124.485069
East_Bounding_Coordinate: -123.276377
North_Bounding_Coordinate: 44.026434
South_Bounding_Coordinate: 42.685418
Keywords:
Theme:
Theme_Keyword: wetlands
Theme_Keyword: GIS
Theme_Keyword: decision tree analysis
Theme_Keyword: geodatabase
Theme_Keyword: palustrine
Theme_Keyword: National Wetlands Inventory
Point_of_Contact:
Contact_Information:
Contact_Person_Primary:
Contact_Person: Jennifer Larsen
Contact_Organization: Oregon State University, Department of Geosciences
Contact_Position: Graduate Student
Contact_Address:
Address_Type: mailing and physical address
Address:
Oregon State University
Address:
Department of Geosciences
Address:
143 Wilkinson Hall
City: Corvallis
State_or_Province: OR
Postal_Code: 97331
Native_Data_Set_Environment:
Microsoft Windows 2000 Version 5.0 (Build 2195) Service Pack 4; ESRI ArcCatalog 9.0.0.535

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Data_Quality_Information:
Attribute_Accuracy:
Attribute_Accuracy_Report:
The attribute accuracy is tested by manual comparison of the source with hard copy printouts and/or symbolized display of the digital wetlands data on an

interactive computer graphic system. In addition, quality control verification software (USFWS-NWI) tests the attributes against a master set of valid wetland attributes.

Logical_Consistency_Report:

Taken from National Wetlands Inventory (NWI) Metadata (http://www.nwi.fws.gov/other/metadata/nwi_meta.txt): "Polygons intersecting the neatline are closed along the border. Segments making up the outer and inner boundaries of a polygon tie end-to-end to completely enclose the area. Line segments are a set of sequentially numbered coordinate pairs. No duplicate features exist nor duplicate points in a data string. Intersecting lines are separated into individual line segments at the point of intersection. Point data are represented by two sets of coordinate pairs, each with the same coordinate values. All nodes are represented by a single coordinate pair which indicates the beginning or end of a line segment. The neatline is generated by connecting the four corners of the digital file, as established during initialization of the digital file. All data crossing the neatline are clipped to the neatline and data within a specified tolerance of the neatline are snapped to the neatline. Tests for logical consistency are performed by quality control verification software (USFWS-NWI)."

Completeness_Report:

Taken from National Wetlands Inventory (NWI) Metadata (http://www.nwi.fws.gov/other/metadata/nwi_meta.txt): "NWI maps do not show all wetlands, but attempt to show most photointerpretable wetlands given considerations of map/photo scale and wetland delineation practices. A target mapping unit (tmu) is an estimate of the size class of the smallest group of wetlands that NWI attempts to map consistently; it is not the smallest wetland mapped. Recognize that some wetland types are conspicuous and readily mapped (e.g., marshes and ponds) and smaller ones may be mapped. Drier wetlands and forested wetlands (especially evergreen) are more difficult to photointerpret and larger ones may be missed. The tmu also varies with photo scale; in forested regions, the tmu may be 3-5 acres (1:80K photos), 1-3 acres (1:58K), or 1 acre (1:40K). NWI maps should show most wetlands larger than the tmu. In the treeless prairies, a 1/4 acre tmu is possible due to the openness of terrain and occurrence of wetlands in distinct depressions. Take notice of the hoto scale/type used to make the maps (see legend) and realize that black and white photos tend to yield more onservative interpretations than color infrared film. Most farmed wetlands (e.g., mucklands) are usually not mapped, except for pothole-type wetlands, cranberry bogs, and diked former tidelands (Sacramento Valley). Partly drained wetlands are conservatively mapped due to photointerpretation limitations. No attempt was made to identify regulated wetlands from other wetlands. Recognize that maps produced through photointerpretation are not as accurate as one prepared from on-the-ground surveys, so NWI boundaries are generalized."

Lineage:

Source_Information:

Source_Citation:

Citation_Information:
Originator: U.S. Fish and Wildlife Service, National Wetlands Inventory
Publication_Date: Ranges from October 1981 to present
Publication_Time: Unknown
Title:
National Wetlands Inventory
Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publication_Place: St. Petersburg, Florida
Publisher: U.S. Fish and Wildlife Service, National Wetlands Inventory
Online_Linkage: http://wetlands.fws.gov/
Source_Scale_Denominator: Ranges from 1:20,000 to 1:65,000. Information for this element varies for each 7.5' quad.
Type_of_Source_Media: online
Source_Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:
Beginning_Date: 1981
Ending_Date: Present
Source_Currentness_Reference:
publication date
Source_Citation_Abbreviation:
National Wetlands Inventory
Source_Contribution:
Source material used to identify palustrine wetland polygons.
Source_Information:
Source_Citation:
Citation_Information:
Originator: Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture
Publication_Date: 20040830
Publication_Time: Unknown
Title:
Soil Survey Geographic (SSURGO) Database for
Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publication_Place: Fort Worth, Texas
Publisher: Natural Resources Conservation Service, United States Department of Agriculture
Online_Linkage: http://soildatamart.nrcs.usda.gov
Source_Scale_Denominator: 1:12,000 to 1:63,360
Type_of_Source_Media: online
Source_Citation_Abbreviation:
SSURGO soil data
Source_Contribution:

Source material used to identify soil type (MUID, MUNAME, and whether the soil is hydric).
Source_Information:
Source_Citation:
Citation_Information:
Originator: The Oregon Natural Heritage Program following EPA guidelines
Publication_Date: Unpublished Material
Publication_Time: Unknown
Title:
EPA Ecoregions
Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publisher: The Oregon Natural Heritage Program
Online_Linkage: http://www.gis.state.or.us/data/alphalist.html
Source_Scale_Denominator: 1:250,000
Type_of_Source_Media: online
Source_Citation_Abbreviation:
EPA Ecoregions
Source_Contribution:
Source material used to delineate ecoregion boundaries.
Source_Information:
Source_Citation:
Citation_Information:
Originator: Oregon GAP Analysis
Publication_Date: Unpublished Material
Publication_Time: Unknown
Title:
Land Cover for Oregon
Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publication_Place: Corvallis, Oregon
Publisher: Northwest Habitat Institute
Online_Linkage: http://www.gis.state.or.us/data/alphalist.html
Source_Scale_Denominator: 1:100,000
Type_of_Source_Media: online
Source_Citation_Abbreviation:
Oregon GAP Vegetation
Source_Contribution:
Source material used to identify land cover and vegetation type.
Source_Information:
Source_Citation:
Citation_Information:
Originator: Claudine Tobalske (Oregon Natural Heritage Program)
Publication_Date: June 2002
Publication_Time: Unknown
Title:

Historic Vegetation 2002
Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publication_Place: Portland, OR
Publisher: Oregon Natural Heritage Program
Online_Linkage: http://www.gis.state.or.us/data/alphalist.html
Source_Scale_Denominator: 1:100,000
Type_of_Source_Media: online
Source_Citation_Abbreviation:
Historic Vegetation 2002
Source_Contribution:
Source material used to identify historic vegetation types.
Source_Information:
Source_Citation:
Citation_Information:
Originator: Federal Emergency Management Agency (FEMA)
Publication_Date: 1996
Publication_Time: Unknown
Title:
FEMA Floodplains
Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publication_Place: Washington, D.C.
Publisher: Federal Emergency Management Agency
Online_Linkage:
http://libweb.uoregon.edu/map/map_section/fema_data/map_fema_index.html
Source_Scale_Denominator: 1:24,000
Type_of_Source_Media: online
Source_Citation_Abbreviation:
Federal Emergency Management Agency (FEMA) floodplains
Source_Contribution:
Source material used to delineate 100-year and 500-year floodplains.
Source_Information:
Source_Citation:
Citation_Information:
Originator: U.S. Geological Survey
Publication_Date: 1991
Publication_Time: Unknown
Title:
Oregon Lithology (fine scale)
Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publication_Place: Unknown
Publisher: Unknown
Online_Linkage: http://www.gis.state.or.us/data/alphalist.html
Source_Scale_Denominator: 1:500,000

Type_of_Source_Media: online
Source_Citation_Abbreviation:
Oregon Lithology (fine scale)
Source_Contribution:
Source material used to identify fine scale geologic features.
Source_Information:
Source_Scale_Denominator: 1:2,000,000
Type_of_Source_Media: online
Source_Citation_Abbreviation:
Oregon Lithology (coarse scale)
Source_Information:
Source_Citation:
Citation_Information:
Originator: Unknown
Publication_Date: Unknown
Publication_Time: Unknown
Title:
Oregon Lithology (coarse scale)
Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publication_Place: Unknown
Publisher: Unknown
Online_Linkage: http://www.gis.state.or.us/data/alphalist.html
Source_Scale_Denominator: 1:2,000,000
Type_of_Source_Media: online
Source_Citation_Abbreviation:
Oregon Lithology (coarse scale)
Source_Contribution:
Source material used to identify coarse-scale geologic features.
Source_Information:
Source_Citation:
Citation_Information:
Originator: Chris Daly of Oregon State University and George Taylor of the Oregon Climate Service at Oregon State University
Publication_Date: April 1998
Title:
Oregon Average Monthly or Annual Precipitation, 1961-1990
Geospatial_Data_Presentation_Form: raster digital data
Publication_Information:
Publication_Place: Portland, OR
Publisher: Water and Climate Center of the Natural Resources Conservation Service
Online_Linkage: http://www.ocs.orst.edu/prism/
Source_Scale_Denominator: Pixel resolution: 2 km
Type_of_Source_Media: online
Source_Citation_Abbreviation:

Oregon Average Monthly or Annual Precipitation, 1961-1990
Source_Contribution:
Source material used to obtain average annual precipation amounts.
Source_Information:
Source_Citation:
Citation_Information:
Originator: Dr. Dan Miller, Kelly Burnett, and Kelly Christiansen
Publication_Date: 20010216
Title:
CLAMS Modeled Stream Network
Geospatial_Data_Presentation_Form: vector digital data
Online_Linkage: \\trillium.fsl.orst.edu\swamp\streams\all4hastreams tml
Source_Scale_Denominator: Unknown
Type_of_Source_Media: online
Source_Citation_Abbreviation:
CLAMS Modeled Stream Network
Source_Contribution:
Source material delineating a modeled stream network for coastal Oregon.
Source_Information:
Source_Citation:
Citation_Information:
Originator: U.S. Department of Commerce, U.S. Census Bureau, Geography Division
Publication_Date: 2004
Title:
TIGER Roads
Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publication_Place: Washington, D.C.
Publisher: U.S. Department of Commerce, U.S. Census Bureau, Geography Division
Online_Linkage: http://www.census.gov/geo/www/tiger
Source_Scale_Denominator: Unknown
Type_of_Source_Media: online
Source_Citation_Abbreviation:
TIGER Roads
Source_Contribution:
Source material used to delineate road networks.
Source_Information:
Source_Citation:
Citation_Information:
Originator: Reno Field Office/WMR/USGS
Publication_Date: Unknown
Publication_Time: Unknown
Title:
Faults

Geospatial_Data_Presentation_Form: vector digital data
Publication_Information:
Publisher: Reno Field Office/WMR/USGS
Online_Linkage: http://www.gis.state.or.us/data/alphalist.html
Source_Scale_Denominator: 1:500,000
Type_of_Source_Media: paper
Source_Citation_Abbreviation:
Faults
Source_Contribution:
Source material used to identify fault lines.
Source_Information:
Source_Citation:
Citation_Information:
Originator: USGS, EROS
Publication_Date: 1999
Title:
Oregon 10m DEM
Geospatial_Data_Presentation_Form: raster digital data
Publication_Information:
Publication_Place: Sioux Falls, SD
Publisher: USGS
Online_Linkage: http://buccaneer.geo.orst.edu/dem/data/dem10oregon.html
Source_Scale_Denominator: Pixel resolution: 10 meters
Type_of_Source_Media: online
Source_Citation_Abbreviation:
Oregon 10m DEM
Source_Contribution:
Source material used to provide a digital elevation model of coastal Oregon.

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Spatial_Data_Organization_Information:
Direct_Spatial_Reference_Method: Vector
Point_and_Vector_Object_Information:
SDTS_Terms_Description:
SDTS_Point_and_Vector_Object_Type: G-polygon
Point_and_Vector_Object_Count: 16941

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Spatial_Reference_Information:
Horizontal_Coordinate_System_Definition:
Planar:
Map_Projection:
Map_Projection_Name: Lambert Conformal Conic
Lambert_Conformal_Conic:
Standard_Parallel: 43.000000
Standard_Parallel: 45.500000

Longitude_of_Central_Meridian: -120.500000
Latitude_of_Projection_Origin: 41.750000
False_Easting: 1312336.000000
False_Northing: 0.000000
Planar_Coordinate_Information:
Planar_Coordinate_Encoding_Method: coordinate pair
Coordinate_Representation:
Abscissa_Resolution: 0.001024
Ordinate_Resolution: 0.001024
Planar_Distance_Units: User_Defined_Unit
Geodetic_Model:
Horizontal_Datum_Name: North American Datum of 1983
Ellipsoid_Name: Geodetic Reference System 80
Semi-major_Axis: 6378137.000000
Denominator_of_Flattening_Ratio: 298.257222

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Entity_and_Attribute_Information:
Detailed_Description:
Entity_Type:
Entity_Type_Label: Palustrine_Database
Attribute:
Attribute_Label: FID
Attribute_Definition:
Internal feature number.
Attribute_Definition_Source:
ESRI
Attribute_Domain_Values:
Unrepresentable_Domain:
Sequential unique whole numbers that are automatically generated.
Attribute:
Attribute_Label: Shape
Attribute_Definition:
Feature geometry.
Attribute_Definition_Source:
ESRI
Attribute_Domain_Values:
Unrepresentable_Domain:
Coordinates defining the features.
Attribute:
Attribute_Label: ATTRIBUTE
Attribute_Definition:
NWI Cowardin classification code
Attribute_Definition_Source:
National Wetlands Inventory
Attribute:

Attribute_Label: MUID
Attribute_Definition:
Map unit ID for soil type
Attribute_Definition_Source:
SSURGO soil layers
Attribute:
Attribute_Label: MUNAME
Attribute_Definition:
Map unit name for soil type
Attribute_Definition_Source:
SSURGO soil data
Attribute:
Attribute_Label: X_COORD
Attribute_Definition:
'X' coordinate location
Attribute:
Attribute_Label: Y_COORD
Attribute_Definition:
'Y' coordinate location
Attribute:
Attribute_Label: WATERSHED_
Attribute_Definition:
Watershed name
Attribute:
Attribute_Label: AREA
Attribute:
Attribute_Label: PERIMETER
Attribute:
Attribute_Label: ACRES
Attribute:
Attribute_Label: HECTARES
Attribute:
Attribute_Label: ECO_NAME
Attribute_Definition:
Ecoregion name
Attribute_Definition_Source:
EPA Ecoregions data
Attribute:
Attribute_Label: UNIQUE_ID
Attribute_Definition:
A number unique to each polygon
Attribute:
Attribute_Label: UNIQUE_STR
Attribute_Definition:
A number unique to each polygon
Attribute:

Attribute_Label: GAP_VEG
Attribute_Definition:
GAP vegetation type
Attribute_Definition_Source:
Idaho Fish & Wildlife GAP vegetation data
Attribute:
Attribute_Label: GAP_NAME
Attribute_Definition:
GAP vegetation type
Attribute_Definition_Source:
Idaho Fish & Wildlife GAP vegetation data
Attribute:
Attribute_Label: HIST_VEG
Attribute_Definition:
Historic vegetation
Attribute_Definition_Source:
Oregon Natural Heritage Program data
Attribute:
Attribute_Label: FEMA_A
Attribute_Definition:
"1" = polygon intersects the FEMA floodplain zone 'A'; "0" = polygon does not intersect the floodplain
Attribute_Definition_Source:
FEMA floodplain data
Attribute:
Attribute_Label: FEMA_ALL
Attribute_Definition:
"1" = polygon intersects any FEMA floodplain zone; "0" = polygon does not intersect any floodplain zones
Attribute_Definition_Source:
FEMA floodplain data
Attribute:
Attribute_Label: GEOL_F
Attribute_Definition:
Geology - fine scale
Attribute_Definition_Source:
USGS data
Attribute:
Attribute_Label: GEOL_C
Attribute_Definition:
Geology - coarse scale
Attribute_Definition_Source:
USGS data
Attribute:
Attribute_Label: PRISM_01
Attribute_Definition:

Average PRISM precipitation - January
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: PRISM_02
Attribute_Definition:
Average PRISM precipitation - February
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: PRISM_03
Attribute_Definition:
Average PRISM precipitation - March
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: PRISM_04
Attribute_Definition:
Average PRISM precipitation - April
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: PRISM_05
Attribute_Definition:
Average PRISM precipitation - May
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: PRISM_06
Attribute_Definition:
Average PRISM precipitation - June
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: PRISM_07
Attribute_Definition:
Average PRISM precipitation - July
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: PRISM_08
Attribute_Definition:
Average PRISM precipitation - August
Attribute_Definition_Source:
PRISM precipitation data
Attribute:

Attribute_Label: PRISM_09
Attribute_Definition:
Average PRISM precipitation - September
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: PRISM_10
Attribute_Definition:
Average PRISM precipitation - October
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: PRISM_11
Attribute_Definition:
Average PRISM precipitation - November
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: PRISM_12
Attribute_Definition:
Average PRISM precipitation - December
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: PRISM_13
Attribute_Definition:
Average PRISM precipitation - Annual
Attribute_Definition_Source:
PRISM precipitation data
Attribute:
Attribute_Label: INT_STREAM
Attribute_Definition:
"1" = polygon intersects stream; "0" = polygon does not intersect stream
Attribute_Definition_Source:
CLAMS modeled stream data
Attribute:
Attribute_Label: INT_ROAD
Attribute_Definition:
"1" = polygon intersects a road; "0" = polygon does not intersect a road
Attribute_Definition_Source:
TIGER road data
Attribute:
Attribute_Label: ISO_ROAD
Attribute_Definition:
"1" = polygon intersects a 10m road buffer; "0" = polygon does not intersect a 10m road buffer

Attribute_Definition_Source:
TIGER road data
Attribute:
Attribute_Label: ISO_RIVER
Attribute_Definition:
"1" = polygon does not intersect a 40m stream buffer; "2" = polygon intersects a 40m stream buffer; "3" = polygon intersects a 20m stream buffer
Attribute_Definition_Source:
CLAMS modeled stream data
Attribute:
Attribute_Label: HYDRICS
Attribute_Definition:
"1" = polygon contains hydric soils; "0" = polygon does not contain hydric soils
Attribute_Definition_Source:
SSURGO soil data
Attribute:
Attribute_Label: ISO_NWI
Attribute_Definition:
"1" = polygon is within 10m horizontally of another NWI polygon; "0" = polygon is not within 10m of another NWI polygon
Attribute_Definition_Source:
National Wetlands Inventory data
Attribute:
Attribute_Label: CLAMS_STR
Attribute_Definition:
"1" = polygon intersects a stream; "0" = polygon does not intersect a stream
Attribute_Definition_Source:
CLAMS modeled stream data
Attribute:
Attribute_Label: CLAMS_BUF
Attribute_Definition:
"1" = polygon intersects a 10m stream buffer; "0" = polygon does not intersect a 10m stream buffer
Attribute_Definition_Source:
CLAMS modeled stream data
Attribute:
Attribute_Label: FEMA_BUF
Attribute_Definition:
"1" = polygon intersects a 10m buffer of the FEMA floodplain; "0" = the polygon does not interesect a 10m buffer of the FEMA floodplain
Attribute_Definition_Source:
FEMA floodplain data
Attribute:
Attribute_Label: HYDRIC_BUF
Attribute_Definition:

"1" = polygon intersects a 10m buffer of hydric soil; "0" = polygon does not intersect a 10m buffer of hydric soil
Attribute_Definition_Source:
SSURGO soil data
Attribute:
Attribute_Label: SLOPE_ZONE
Attribute_Definition:
Mean slope value for a given polygon; measured in degrees
Attribute_Definition_Source:
DEM derived grid surface
Attribute:
Attribute_Label: ASPECT_ZON
Attribute:
Attribute_Label: INT_HYDRIC
Attribute_Definition:
"1" = polygon intersects hydric soil; "0" = polygon does not intersect hydric soil
Attribute_Definition_Source:
SSURGO soil data
Attribute:
Attribute_Label: CURV_ZONE
Attribute_Definition:
Mean curvature value for a given polygon. Positive curvature indicates the surface is upwardly convex. Negative curvature indicates the survace is upwardly concave.
Attribute_Definition_Source:
DEM derived grid surface
Attribute:
Attribute_Label: PLAN_ZONE
Attribute_Definition:
Mean plan curvature value for a given polygon. Positive curvature indicates the surface is upwardly convex, negative plan curvature indicates the surface is upwardly concave.
Attribute_Definition_Source:
DEM derived grid surface
Attribute:
Attribute_Label: FAC_ZONE
Attribute_Definition:
Mean flow accumulation value for a given polygon. High flow accumulation values indicate areas of concentrated flow. Low flow accumulation values indicate areas of local topographic highs or ridgelines.
Attribute_Definition_Source:
DEM derived grid surface
Attribute:
Attribute_Label: INT_FAULTS
Attribute_Definition:

"1" = polygon intersects a geologic fault; "0" = polygon does not intersect a geologic fault
Attribute_Definition_Source:
USGS
Attribute:
Attribute_Label: FAULTS_BUF
Attribute_Definition:
"1" = polygon intersects a 10m buffer of a geologic fault; "0" = polygon does not interset a 10m buffer of a geologic fault
Attribute_Definition_Source:
USGS
Attribute:
Attribute_Label: CLAMS_40M
Attribute_Definition:
"1" = polygon intersects a 40m buffer of a stream; "0" = polygon does not intersect a 40m buffer of a stream
Attribute_Definition_Source:
CLAMS modeled stream data
Attribute:
Attribute_Label: CLAMS_20M
Attribute_Definition:
"1" = polygon intersects a 20m buffer of a stream; "0" = polygon does not intersect a 20m buffer of a stream
Attribute_Definition_Source:
CLAMS modeled stream data
Attribute:
Attribute_Label: CTI_TAN
Attribute_Definition:
Mean compound topographic index value for a polygon. High CTI values indicate areas of high soil saturation. Low CTI values indicate areas of low soil saturation.
Attribute_Definition_Source:
DEM derived grid surface
Attribute:
Attribute_Label: ISO_A
Attribute_Definition:
"1" = polygon is not intersected by a mapped stream an not within 10m horizontally of another mapped NWI polygon; "0" = none of the above
Attribute:
Attribute_Label: ISO_B
Attribute_Definition:
"1" = 'A', and polygon is not intersected by hydric soil or water as defined by SSURGO and not intersected by the FEMA floodplain; "0" = none of the above
Attribute:
Attribute_Label: ISO_C

Attribute_Definition:
"1" = 'B', and polygon is not within 10m horizontally of a stream, floodplain, or hydric soil; "0" = none of the above
Attribute:
Attribute_Label: ISO_D
Attribute_Definition:
"1" = polygon meets none of the isolation category requirements (not isolated)
Attribute:
Attribute_Label: ISO_C1
Attribute_Definition:
"1" = polygon does not intersect a 40m stream buffer; "0" = polygon does intersect the buffer
Attribute:
Attribute_Label: ISO_C2
Attribute_Definition:
"1" = polygon intersects a 40m stream buffer but not a 20m stream buffer
Attribute:
Attribute_Label: ISO_C3
Attribute_Definition:
"1" = polygon intersects the 40m and 20m stream buffers, but not a 10m stream buffer
Attribute:
Attribute_Label: ISO_C4
Attribute_Definition:
"1" = polygon does not meet any of the other isolation requirements (not isolated)
Attribute:
Attribute_Label: OVER_100
Attribute_Definition:
"1" = polygon is over 100 acres in size; "0" = polygon is under 100 acres in size
Attribute:
Attribute_Label: UNDER_100
Attribute_Definition:
"1" = polygon is under 100 acres in size; "0" = polygon is over 100 acres in size
Attribute:
Attribute_Label: ELEV_MEAN
Attribute_Definition:
Mean elevation value for a given polygon (measured in feet)
Attribute_Definition_Source:
DEM
Attribute:
Attribute_Label: DISS_ID
Attribute_Definition:

An identification value indicating with which dissolved wetland polygon a given polygon is associated
Attribute:
Attribute_Label: WATERSHED
Attribute_Definition:
Watershed name
Attribute:
Attribute_Label: HYDRIC_SOI
Attribute_Definition:
"1" = polygon is located on hydric soil; "0" = polygon is not located on hydric soil
Attribute_Definition_Source:
SSURGO soil data
Attribute:
Attribute_Label: HYDROPERIO
Attribute_Definition:
Cowardin hydroperiod designator
Attribute_Definition_Source:
National Wetlands Inventory
Attribute:
Attribute_Label: PAB
Attribute_Definition:
"1" = polygon is associated with this Cowardin class designator; "0" = polygon does not have this Cowardin class designator
Attribute_Definition_Source:
National Wetlands Inventory
Attribute:
Attribute_Label: PEM
Attribute_Definition:
"1" = polygon is associated with this Cowardin class designator; "0" = polygon does not have this Cowardin class designator
Attribute_Definition_Source:
National Wetlands Inventory
Attribute:
Attribute_Label: PFO
Attribute_Definition:
"1" = polygon is associated with this Cowardin class designator; "0" = polygon does not have this Cowardin class designator
Attribute_Definition_Source:
National Wetlands Inventory
Attribute:
Attribute_Label: POW
Attribute_Definition:
"1" = polygon is associated with this Cowardin class designator; "0" = polygon does not have this Cowardin class designator
Attribute_Definition_Source:

National Wetlands Inventory
Attribute:
Attribute_Label: PSS
Attribute_Definition:
"1" = polygon is associated with this Cowardin class designator; "0" = polygon does not have this Cowardin class designator
Attribute_Definition_Source:
National Wetlands Inventory
Attribute:
Attribute_Label: PUB
Attribute_Definition:
"1" = polygon is associated with this Cowardin class designator; "0" = polygon does not have this Cowardin class designator
Attribute_Definition_Source:
National Wetlands Inventory
Attribute:
Attribute_Label: PUS
Attribute_Definition:
"1" = polygon is associated with this Cowardin class designator; "0" = polygon does not have this Cowardin class designator
Attribute_Definition_Source:
National Wetlands Inventory
Attribute:
Attribute_Label: CLASS
Attribute_Definition:
Cowardin class designator
Attribute_Definition_Source:
National Wetlands Inventory

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Distribution_Information:
Resource_Description: Downloadable Data
Standard_Order_Process:
Digital_Form:
Digital_Transfer_Information:
Transfer_Size: 7.659

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Metadata_Reference_Information:
Metadata_Date: 20050818
Metadata_Contact:
Contact_Information:
Contact_Organization_Primary:
Contact_Organization: Oregon State University, Department of Geosciences
Contact_Person: Jennifer Larsen
Contact_Position: Graduate Student

Contact_Address:
Address_Type: mailing and physical address
Address:
Oregon State University
Address:
Department of Geosciences
Address:
143 Wilkinson Hall
City: Corvallis
State_or_Province: OR
Postal_Code: 97331
Contact_Voice_Telephone: NA
Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Standard_Version: FGDC-STD-001-1998
Metadata_Time_Convention: local time
Metadata_Extensions:
Online_Linkage: http://www.esri.com/metadata/esriprof80.html
Profile_Name: ESRI Metadata Profile