VOLUME 1: FINAL REPORT

Wetland and Land Use Change in the Willamette Valley, Oregon: 1994 to 2005

Oregon Department of State Lands
U.S. Fish and Wildlife Service

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Wetland and Land Use Change in the Willamette Valley, Oregon: 1994 to 2005

Volume 1: Final Report

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1.0 INTRODUCTION

Wetland status and trends information is important for managing Oregon's wetland resources and objectively assessing the effectiveness of the various state, federal and local programs and regulations aimed at protecting, managing or restoring wetlands. This study of wetland and land use change in Oregon's Willamette Valley, together with the previous study covering the period 1982-1994 (Daggett et. al., 1998; Bernert et. al., 1999; Morlan and Peters, 1999), provides quantitative information about wetland changes in the Willamette Valley over a period of 23 years. Together, these reports provide the first statistically valid information about changes in wetland acreage, by wetland type, and the land uses associated with wetland gains, losses and change in the Willamette Valley.

The concept of "no *net* loss" of wetland area as a public policy was first articulated by the National Wetlands Policy Forum (The Conservation Foundation, 1988) and was later adopted as federal policy by President George H.W. Bush. This policy has since been incorporated into many federal regulations, and in a 2004 speech President George W. Bush announced a policy objective to increase the overall quality and quantity of wetlands.

Oregon has adopted policies aimed at maintaining or increasing the state's wetland resource base, similar to the federal government's "no net loss" of wetlands policies. Although Oregon's wetland management and protection programs date back to the early 1970s, legislation passed in 1989 adopted clear policies directed at maintaining the acreage, functions and values of the state's wetlands. Oregon has also adopted no-net-loss of freshwater wetlands and net gain of estuarine wetlands goals as part of its Benchmark Program that sets public policy goals and measures the effectiveness of state programs (Oregon Progress Board, 1994).

The Oregon Department of State Lands (DSL), which administers the state Removal-Fill Law and issues permits for impacts to wetlands and other waters of the state, maintains a database of permitted activities. DSL generates information on wetland losses that result from permitted wetland fills, and offsetting gains from required compensatory mitigation (wetland creation or restoration), as well as voluntary wetland restoration projects that require a state permit. However, these data do not capture actual wetland changes and losses that are not subject to, or otherwise not captured by, the state permit process.

Jackson-Frazier Wetland, Corvallis

This study and the original study were proposed by DSL in order to provide an independent evaluation of the effectiveness of the state regulatory program and other state and federal programs that address wetlands. The first study was developed to establish a statistically valid estimate of wetland change from the mid-1980s to the mid-

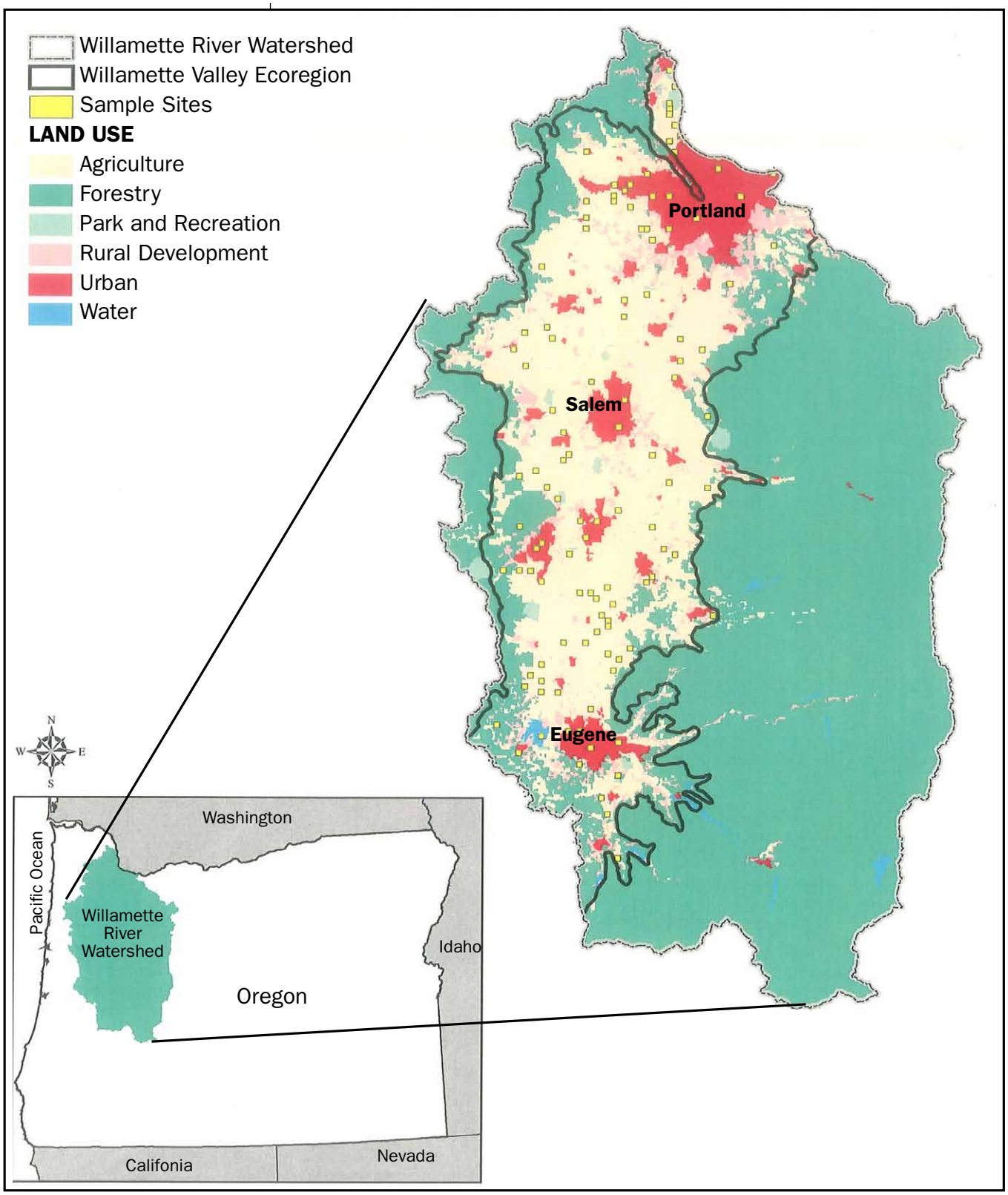


FIGURE 1
Location map showing the Willamette Valley Ecoregion Study Area and location of sample plots

Signature species of Willamette Valley wet prairies include tufted hairgrass (Deschampsia cespitosa), American slough grass (Bechmannia syzigachne) and one-sided sedge (Carex unilateralis)

1990s using aerial photographic interpretation. The primary objectives were to identify the nature of wetland changes, identify land uses associated with wetland loss, and identify wetland change dynamics over the last decade. This study uses the same sampling methodology (including the same sample plots) to extend the period of time from 1994 to 2005. This allows us to analyze not only wetland and land use changes over a longer period of time, but to evaluate differences between the two time periods (1982-1994; 1994-2005) and thus better assess trends. This is particularly important because, as noted in the conclusions and discussion in the original study report, the 1982 baseline predated most state and federal wetland protection and restoration programs.

The Willamette Valley was selected as a pilot region for a stratified sampling approach to estimate wetland losses throughout an ecoregion (Figure 1). This was done, in part, because of its importance to the economy of the state and because of the high degree of alteration it has experienced and continues to experience (see Section 2.0).

DSL entered into a cooperative agreement with the U.S. Fish and Wildlife Service (USFWS) to conduct the wetland and land use change aerial photo interpretation and change mapping for both studies. The USFWS has conducted wetland status and trends studies for the nation for more than 30 years, and reports the results of the studies periodically to Congress, as required by federal law. The collaboration with the USFWS ensured that the technical work would be conducted by experienced staff following USFWS photo interpretation and mapping conventions and standards. This allowed for quality control by the USFWS and also comparison of study results with national status and trends study results (Dahl, 2006).

The original study mapped all wetland and land use changes, classifying wetlands according to the "Cowardin" (Cowardin et al., 1979) classification and upland habitat types according to the USFWS wetland status and trends mapping conventions (see methods section). For this study, wetlands were also classified according to the hydrogeomorphic (HGM) classification developed for Oregon (Adamus, 2001). The USFWS status and trends studies and these two studies provide information on the acreages and types of wetland changes; they do not explicitly evaluate wetland condition, quality or functions. However, by using both classification systems, more information can be obtained about what types of wetlands are most common in the study area and what types have experienced the most loss, gain or change in type (wetland-to-wetland changes). While some conclusions may be made about the probable effect of these changes on wetland functions and values based upon the best professional judgment of wetland scientists, none of these studies address changes in wetland "quality." The Environmental Protection Agency 2011 National Wetland Condition Assessment (Scozzafava et.al., 2007), in the development phase as of the date of this report, will be the first attempt to fill that need.

2.0 STUDY AREA DESCRIPTION

The Willamette Valley ecoregion lies between the Coast Range on the west and the Cascade mountains on the east, and extends approximately 180 miles from the Columbia River to the south. The Willamette River runs north through the valley to its confluence with the Columbia River near Portland. The Willamette River—the 13th largest river in the conterminous United States in terms of stream flow—is a major tributary to the Columbia River (Hulse et al., 2002). The valley consists of nearly level to gently sloping broad alluvial floodplains of the Willamette River system, scattered low hills, and adjacent mountain foothills (Pater, 1998). Due to the maritime influence of the Pacific Ocean, the valley has a mild climate. Winters are cool and wet, and summers are warm and dry. Average annual precipitation is from 30 to 60 inches in much of the region. Snow is infrequent in the valley bottom, but is heavy in the Cascade mountains.

The Willamette Valley accounts for more than 70% of the state's population, the majority of its industry, and almost half of its farmland. Most of the state's major cities (Portland, Salem, Corvallis and Eugene) are in the Willamette Valley along the Interstate 5 corridor. Due to the long growing season and deep, fertile soils, the Willamette Valley is a major agricultural region. More than 50% of the valley bottom is in agricultural land use (Table 3). A little more than 50% of Oregon's $3 billion in agricultural sales are derived from the more than 100 commodities grown in the Willamette Valley (Oregon Progress Board, 2000).

As a result of the valley's importance as an economic and agricultural region, the Willamette Valley is the most altered region in the state (Oregon Progress Board, 2000). Human alterations began with Native Americans who regularly burned the valley to maintain open prairies that favored certain game species and native plants such as Camas that were a staple of their diet. When settlers arrived in the Willamette Valley, they found wide swaths of tall grass prairie dominated by tufted hairgrass *(Deschampsia cespitosa)*. Prior to the 1840s, the valley was a mosaic of wetland and upland prairies, oak savanna dominated by Oregon white oak *(Quercus garryana)*, extensive bottomland riparian forests with associations of Oregon ash *(Fraxinus latifolia)*, black cottonwood *(Populus trichocarpa)*, red alder *(Alnus rubra)*, bigleaf maple *(Acer macrophyllum)*, western red cedar *(Thuja plicata)*,

PHOTOGRAPH BY DANA FIELD

Willamette Valley wet prairie at Mud Slough Mitigation Bank west of Salem

Common Camas (Camassia quamash)

PHOTOGRAPH BY PETER SANZENBACHER

FIGURE 2
The Willamette Valley near Eugene, in winter

willows *(Salix)* and Douglas fir *(Pseudotsuga menziesii)*, numerous wetlands and sloughs, and Douglas fir forests on hilltops and better drained soils (Christy et. al., 1998; Hulse et. al. 1998; Pater, 1998). In winter, the Willamette River and its tributaries flooded the valley floor through numerous braided channels. This braided wetland pattern can still be seen in many areas in the winter despite conversion to agricultural use (Figure 2).

Early settlers drained the floodplain wetlands for agriculture, and flood control modifications have fundamentally altered the natural hydrologic dynamics of the river system and floodplain wetlands in the valley. The Corps of Engineers constructed 11 major water storage reservoirs on tributaries to the Willamette River between 1941 and 1969 (Hulse et. al, 2002). Dams, diversions, levees and similar alterations have largely disconnected the Willamette River from its braided channels, oxbows and sloughs (Oregon Progress Board, 2000); as a result, more than 50% of the channel length of the Willamette River has been lost (Hulse et. al, 1998).

Many acres of wetlands in the valley are used for a variety of purposes, such as this palustrine emergent pasture in Philomath

The Willamette Valley has lost approximately 57% of its original wetlands area (Morlan, 2000). Approximately 80% of the once abundant riparian, bottomland forest has been converted to agricultural and urban land uses (Oregon Progress Board, 2000). Today, the bottomland wet prairie is the rarest of the native plant communities, reduced by an estimated 99% (Christy et. al., 1998). Many wetland restoration strategies and efforts now focus on these heavily impacted wetland types.

3.0 METHODS

A summary of the methods is presented in this section. Complete descriptions of the methods are included in the Technical Appendices (Volume 2) on CD.

The main objectives of this study were to quantify land cover changes between 1994 and 2005, with an emphasis on wetland change, and compare the results of this study with the previous study covering the period 1982 to 1994. Based on these objectives, the same probabalistic sample design that was developed for *Wetland and Land Use Change in the Willamette Valley, Oregon: 1982 to 1994* (Daggett et.al., 1998) was used. However, due to improvements in technology, the 1994 baseline mapping first required some adjustment, as described in Section 3.10.

Of the potential sample designs, the probabalistic sample has multiple advantages, including:

- It is a reliable and repeatable method;
- Information collected at a few locations can be used to make estimates for the entire study area, thereby greatly reducing sampling and analytical costs;
- The statistical methods employed are easily transferable to other areas; and
- Uncertainty in the estimates can be tracked and quantified.

The most important aspect of the sample design is that it allows detailed information from a limited number of sites to be extrapolated, with known uncertainty, to the entire study area.

A stratified systematic sampling method was chosen for this project because it performs well for geographic data. The sampling method used a two-stage process: (1) identify areas where wetland occurrence was most probable; and (2) perform detailed upland and wetland land cover mapping for the selected sample plots. The key elements of the sample design, mapping and change analysis are described below.

PHOTOGRAPH BY JEVRA BROWN

Remnants of once-extensive Willamette River sloughs, like this one at Willamette Mission State Park north of Salem, are highly valued wetland types

3.1 Select and refine the study area

The study area was the Willamette Valley ecoregion (Clarke et al., 1991). This ecoregion is geographically restricted to the lowland areas of the Willamette River basin where the probability of wetlands is relatively high.

3.2 Identify population and create initial sampling frame

For the purposes of this study, it was decided that State Plane sections from the Public Land Survey System were the most easily identified land unit for the purpose of aerial photography interpretation; therefore, the population unit of interest was defined as all sections (generally 0.7 to 1.3 square miles) within the boundaries of the Willamette Valley ecoregion (4,790 square mile sections).

3.3 Stratify the population

The 1994 study stratified the valley using information from STATSGO—the statewide soils database (USDA, 1991) and from GAP—a regional land cover database (Kagan and Caicco, 1992), both at a scale of 1:250,000. The principal reason for stratifying the valley using the soils database was that wetlands are not randomly or uniformly distributed and represent a minority of land cover type throughout the state. By stratifying the study area using the soils data, the sampling could be focused on areas with potential for the presence of wetlands. This had the effect of increasing the precision of the estimates of wetland changes while maintaining the statistical rigor required to estimate wetland loss within the study area.

Land use strata were included in the sample design in order to ensure that adequate sample sizes were maintained within each major land use type. The Willamette River basin is dominated by forest and agricultural land uses, which account for 73 and 22 percent of the basin, respectively. Urban areas account for less than 5 percent of the entire basin. If land use strata had not been incorporated into the sampling design, the sample sizes would be approximately proportional to the areal coverage of the various land uses. This would have resulted in excessive representation of wetlands in forested areas and inadequate representation of wetlands in agricultural and urban areas.

3.4 Collect the Stage 1 sample

The number of samples was selected to minimize errors associated with the probability design. The minimum sample size in any of the 15 strata was 20 with a maximum of over 100 in agricultural land use. The margin of error was between 5% and 15%. This resulted in the selection of 711 sections for the sample.

3.5 Stratify verified soils and land use based on verified hydric soils

The second sample was stratified based only on the percentage of hydric soil units relative to non-hydric soil units, as verified with county soil surveys. Thirty percent of the high hydric soils units, 20% of the moderate, 10% of the low, and none of the 0% hydric soils units were resampled (see Technical Appendix A, Volume 2).

3.6 Verify the sample

Since the datasets used to stratify the study area (STATSGO and GAP) were regional- scale data and have inaccuracies, the 711 sections were verified by examining each selected section for the presence of hydric soils and land use category (agriculture, urban, forest, water) from the large-scale county soil survey photo map base.

3.7 Collect Stage 2 sample

Photointerpretation of 711 sections would be extremely costly and time consuming, so a subsample was selected. Areas with greater amounts of hydric soils were sampled more intensely than were areas with less hydric soil, since the probability of wetland occurrence was expected to be proportional to the amount of hydric soils verified on large scale soil survey maps. The resulting Stage 2

sample used for photographic interpretation consisted of 114 square mile plots, or 72,960 acres that compose the sample for this study. For a more detailed discussion of the sampling design, see Bernert et.al., 1999.

3.8 Aerial photographic interpretation and mapping conventions

Procedures and protocol for this study closely followed those used by the USFWS, National Wetlands Inventory (NWI), for its periodic national status and trends of wetlands reports to Congress (Dahl, 2004). The design of these procedures allows for future "continuous" analysis, at periodic intervals, of wetland change in the Willamette Valley. This study was based on interpretation of existing NAIP imagery.

The classification system used for this study includes wetlands, deepwater habitats, and uplands. Wetlands and deepwater habitats were identified and classified based on a modified version of the *Classification of Wetlands and Deepwater Habitats of the United States* (Cowardin, et al., 1979). The upland categories were identified and classified based on a modified version of the national status and trends classification system as defined in *Continuous Wetland Trend Analysis Project Specifications* (Dahl, 2004). The classification categories are described in Table 1 and defined in Technical Appendix B, Volume 2.

For this study, in addition to the classification of wetlands and deepwater habitats using Cowardin, we also classified wetlands according to the *Guidebook for Hydrogeomorphic (HGM) based Assessment of Oregon Wetland and Riparian Sites: Statewide Classification and Profiles* (Adamus, 2001). The hydrogeomorphic (HGM) classification is based upon a wetland's landscape position and hydrodynamics. Because these factors have been shown to exert a controlling influence on a wetland's ecological processes, wetlands of the same HGM classification in a particular ecoregion will likely support similar functions.

Table 1. Wetland, Deepwater and Upland Cover Types

Attribute	Wetland Types	Common Description
PFO	Palustrine Forested	Forested Wetlands
PSS	Palustrine Scrub Shrub	Shrub Wetlands
PEM	Palustrine Emergent	Marshes/Wet Pastures
PUS	Palustrine Unconsolidated Shore	Shallow/Unvegetated Ponds
PUB	Palustrine Unconsolidated Bottom	Open Water Ponds
PAB	Palustrine Aquatic Bed	Floating or Submerged Vegetation
Pf	Palustrine Farmed	Farmed Wetlands
WFP	Wet Forested Plantation	Planted Pine/Cottonwoods in Wetland Conditions
Attribute	**Deepwater Habitat Types**	**Common Description**
LAC	Lacustrine	Lakes/Reservoirs
RIV	Riverine	River Systems
Attribute	**Upland Land Use/Cover Types**	**Common Description**
UA	Upland Agriculture	Crop Producing/Pasture
UB	Upland Built (Urban)	Cities and Towns
URD	Upland Rural Development	Rural Building/Development
UFP	Upland Forested Plantation	Christmas Tree Farms; Cottonwood Plantations (drained)
UO	Upland Other	Uplands not fitting other category

The HGM classes and subclasses are described in Table 2 and defined in Technical Appendix B, Volume 2.

Table 2. Hydrogeomorphic Classification of Wetlands

HGM Code	HGM Class	HGM Subclass
DCNP	Depressional	Closed, Nonpermanently flooded
DCP	Depressional	Closed, Permanently flooded
DO	Depressional	Outflow (open)
F	Flats	None defined
LFV	Lacustrine Fringe	Valley
RFT	Riverine	Flowthrough
RI	Riverine	Impounding
SH	Slope	Headwater
SV	Slope	Valley

Photointerpretation followed the *Photointerpretation Conventions for the National Wetlands Inventory* (FWS, 1995). The minimum delineation unit for wetland polygons was approximately 0.25 acre. The minimum delineation unit for upland polygons was *5* acres. In some instances, it was important to delineate smaller upland units (e.g., small upland islands created in waterways) but areas smaller than 5 acres of one upland land use type surrounded by another upland land use type were not delineated. NWI regional staff conducted field review on 37 of the 114 plots in the study area, which represents 33% of the plots in the study area.

3.9 1982-1994 Geographic Information System (GIS) Data Input Methods

GIS databases were prepared in ARC/INFO according to the following steps:

1. Prepare maps
2. Digitize map coverages
3. Identify and correct digitizing errors
4. Define features and build topology
5. Identify and correct topological errors
6. Assign attributes to coverage features
7. Identify and correct attribute coding errors
8. Print final maps

3.10 1994 - 2005 GIS Data Input Methods

Despite the primary objective of replicating the original study plots and methods, in order to reveal long-term trends and make comparisons between the two study periods, we made two adjustments to the 1994 baseline data. These changes were necessary due to technological advances.

Originally, the 1982 delineated data and the change overlays were transferred from the aerial photographs to overlays on U.S. Geological Survey 1:24,000 scale topographic maps following Cartographic Conventions for the National Wetlands Inventory (FWS, 1994b). Using the 1982 maps and 1994 change maps, wetlands, deepwater habitats, and upland information and changes were digitized into a GIS database. This methodology created alignment issues for the update. Therefore, the first adjustment was to correct any major alignment errors on each 1994 plot before delineating the change polygons on the 2005 plots.

In the 1982 to 1994 study, narrow wetlands and deepwater habitats, those that were too narrow to be mapped in areal units (<33 feet), were mapped as linear features

Figure 3. Section of Plot #24 with adjusted 1994 line work and wetland and land cover type codes in red

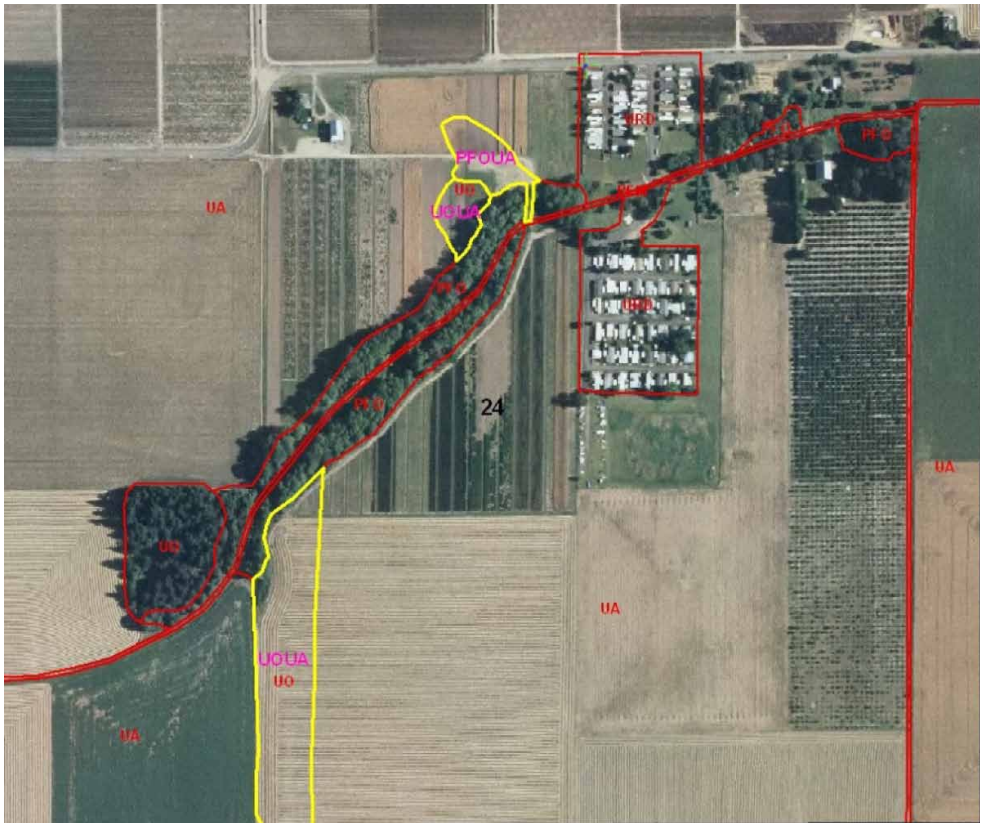


Figure 4. Section of Plot #24 with 2005 imagery showing changes in yellow. For example, in the yellow polygon at the top, the code PFOUA in pink indicates a change from palustrine forested to upland agriculture. In the bottom yellow polygon there was a change from upland other to upland agriculture

and measured in linear distance (miles). These were reported separately because of the uncertainty in determining their width (which would have allowed calculations of area). This study was completed without the use of hard-copy imagery and stereoscopic interpretation. Instead 1-meter digital imagery was used. This removed the limitations associated with scale from using 1:24 K aerial photographs in the first study. Therefore, the second adjustment was to convert all linear features to polygon features using a standard buffer of 2.5 meters. This is the buffer size used by the National Wetlands Inventory for NWI mapping in the west, creating a polygon width of 5 meters (~25 feet). In the previous study, palustrine emergent wetlands comprised the greatest linear wetland type. Most linear palustrine emergent wetlands in agricultural areas were ditches. Therefore, there is a small increase in palustrine emergent wetlands in the adjusted 1994 acreage numbers when compared to the original study (Table 3).

The adjustment of alignment and buffering of the linears created minor changes in the acreage and relative proportion of wetlands, deepwater, and upland habitats. Wetland acreage increased and upland acreage decreased as the buffered streams and wetlands occupy area that was previously counted as uplands. Table 3 shows the 1994 acreage numbers reported in the original report compared to the adjusted/edited acreage.

Table 3. Comparison of Land Cover Acreages after adjustments. Edited data were used as the baseline for this study

		1994		1994 after edits	
Category	Land Cover Type	acres	% of Total Area	acres	% of Total Area
Wetland	PEM	82,468	2.6%	89,245	2.8%
	PFO+PSS	105,051	3.3%	127,542	4.0%
	Oth. Pal.	78,884	2.5%	98,644	3.1%
	Total	266,403	8.3%	315,431	9.9%
Deepwater	RIV	91,197	2.9%	83,593	2.6%
	LAC	78,531	2.5%	64,934	2.0%
	Total	169,728	5.3%	148,527	4.6%
Upland	UA	1,588,672	49.7%	1,697,578	53.1%
	UB	423,501	13.3%	411,671	12.9%
	URD	59,996	1.9%	72,330	2.3%
	UO	666,480	20.9%	531,036	16.6%
	UFP	20,611	0.6%	18,818	0.6%
	Total	2,759,260	86.4%	2,731,433	85.5%
Total		3,195,391	100.0%	3,195,391	100.0%

Note: Total Willamette Valley Ecoregion area is 3,195,391 acres

The GIS data layers were brought into ArcInfo 9.2 and edited according to the following steps:

1. GIS data layers from the 1982 to 1994 study were brought into a geodatabase.

2. Major alignment issues were adjusted on the 1994 layer using 2005 NAIP imagery.

3. Linears were buffered into the polygon layer using a standard 2.5 meter buffer.

4. Areas where overlaps occur due to the buffering were corrected.

5. Topological errors were identified and corrected.

6. Change analysis was completed

4.0 RESULTS AND INTERPRETATION

The trends estimates have approximately 5% to 10% uncertainty. See Technical Appendix A, Volume 2 for a discussion of calculation of error estimates.

4.1 Willamette Valley Land Cover Status in 1994

Based on the statistical sampling and aerial photointerpretation in this study, wetlands comprised approximately 9.9% of the Willamette Valley ecoregion study area, deepwater habitats covered 4.6%, and 85.5 % of the study area was upland. The specific wetland, deepwater, and upland cover types and the extent of their coverage within the study area in 1994 are shown in Table 4 and Figure 5. The study area is dominated by *upland agriculture,* which accounted for 53% of the study area and represented 62% of the *upland* land cover types. *Palustrine forested* was the most extensive wetland cover type, representing 3.3% of the study area and 33.5% of the wetland cover types. Other major wetland types were *palustrine emergent* (2.8%) and *palustrine farmed* (2.6%) of the study area.

Table 4. Estimate of Willamette Valley Wetlands, Deepwater Habitats, and Uplands in 1994

Land Cover Category	Land Cover Type	Willamette Valley Estimate (acres)	Standard Error (acres)	% of Total	% of Category Sub-Total
Wetland	**PFO**	105741.2	2601.2	3.31	33.52
	PEM	89245.0	2463.2	2.79	28.29
	Pf	84505.2	2932.3	2.64	26.79
	PSS	21800.4	643.1	0.68	6.91
	PUB	9911.4	333.5	0.31	3.14
	PAB	4069.8	205.1	0.13	0.77
	PUS	157.9	10.4	0.00	0.05
	Total	**315430.8**	**9188.9**	**9.87**	**100.00**
Deepwater	**RIV**	83592.6	376.2	2.62	56.28
	LAC	64934.4	4409.0	2.03	43.72
	Total	**148527.0**	**4785.2**	**4.65**	**100.00**
Upland	**UA**	1697578.3	15974.2	53.13	62.15
	UO	531035.7	8335.7	16.62	19.44
	UB	411671.0	13544.0	12.88	15.07
	URD	72330.2	2104.8	2.26	2.65
	UFP	18818.0	1080.2	0.59	0.69
	Total	**2731433.2**	**41038.8**	**85.48**	**100.00**
Total		3195391.0	55012.9	100.00	

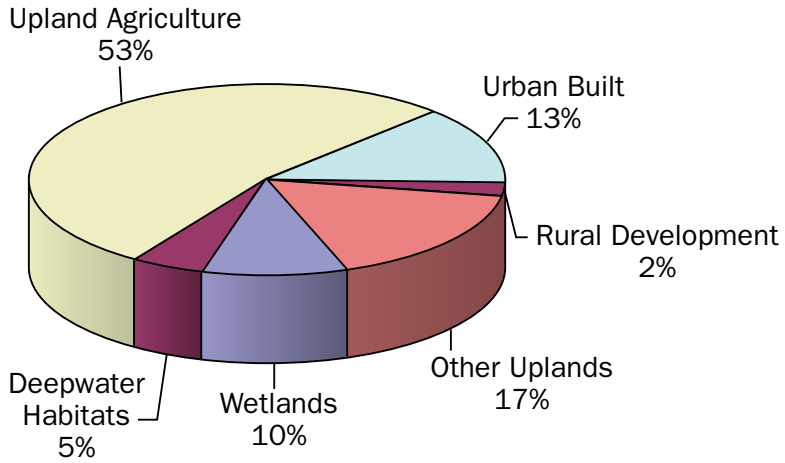


FIGURE 5
Willamette Valley Land Cover Types in 1994

4.2 Land Cover Changes from 1994 to 2005

4.2.1 Summary of Willamette Valley Land Cover Changes

Six types of land cover change from 1994 to 2005 were examined:

1. Wetland loss (wetland to upland or deepwater habitat);
2. Wetland gain (upland or deepwater habitat to wetland);
3. Wetland type change (conversion from one wetland type to another wetland type);
4. Deepwater habitat loss (deepwater habitat to wetland or upland);
5. Deepwater habitat gain (wetland or upland to deepwater habitat); and
6. Upland type change (conversion from one upland type to another upland type).

As shown in Table 5, just over 2% of the study area (77,009 acres) changed during the study period. Each of the six types of change are examined in detail in subsequent sections (Tables 6, 7, 8 and 9).

Table 5. Summary of Willamette Valley Land Cover Change, 1994-2005

		acres	%
Areal Land Cover	Areal Change [1]	77008.92	2.41
	No Change	3118382.08	97.59
	Total [2]	3195391.00	100

Notes:
[1] Does not equal sum of components shown in Table 6 (e.g., wetland losses were also counted as upland or deepwater gains in Table 6)
[2] Differences in totals listed here and in Table 2 are the result of small differences between the 1994 estimates of study area land cover and the estimates of 1994-2005 changes, and rounding.

Table 6. Expanded Summary of Willamette Valley Land Cover Change, 1994-2005

	Type of Change	Area Change (acres)	Change as % of Study Area	Change as % of Total Change	Change as % of Total 1994 Land Cover Type
Wetland	Wetland Loss	6212.55	0.19	6.65	1.97
	Wetland Gain	2252.92	0.07	2.41	0.71
	Net Wetland Loss	**3959.63**	**0.12**	**4.24**	**1.26**
	Wetland Change	6151.37	0.19	6.58	1.95
Deepwater	Deepwater Loss	288.88	0.01	0.31	0.19
	Deepwater Gain	348.44	0.01	0.37	0.23
	Net Deepwater Gain	**59.56**	**0.00**	**0.06**	**0.04**
Upland	Upland Loss	2033.46	0.06	2.18	0.07
	Upland Gain	5933.53	0.19	6.35	0.22
	Net Upland Gain	**3900.07**	**0.12**	**4.17**	**0.14**
	Upland Change	62299.38	1.95	66.67	2.28
Total			2.92	100.00	

Notes: total study area: 3,195,391 acres
total 1994 wetland: 315,442.3; total 1994 deepwater: 148,532.4; total 1994 upland: 2,731,433

Table 7. Details of Areal Land Cover Type loss, Gain, Net Loss/Gain, and Wetland Type Change, 1994-2005

		1994-2005 Net Loss/Gain				Components of Net Loss/Gain					
Category	Land Cover Type	1994 (acres)	2005 (acres)	Net Loss/Gain (acres)	% Net Loss/Gain	Total Loss (acres)	% Total Loss	Total Gain (acres)	% Total Gain	Net Change (acres)	% Total Net Change
Wetland	PEM	89245	88419	-826	-0.93	-1478.81	-17.33	1054.25	12.35	-401.34	-0.59
	Sub-Total	**89245**	**88419**	**-826**	**-0.93**	**-1478.81**	**-17.33**	**1054.25**	**12.35**	**-401.34**	**-0.59**
	PFO	105741	104266	-1475	-1.40	-405.96	-4.76	0.00	0.00	-1069.52	-1.56
	PSS	21800	21415	-386	-1.77	-846.77	-9.92	545.75	6.39	-84.49	-0.12
	Sub-Total	**127542**	**125681**	**-1861**	**-1.46**	**-1252.73**	**-14.68**	**545.75**	**6.39**	**-1154.01**	**-1.69**
	PAB	4070	4070	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Pf	84505	81714	-2791	-3.30	-3197.64	-37.47	34.11	0.40	372.19	0.54
	PUB	9911	11423	1512	15.25	-283.37	-3.32	618.81	7.25	1176.42	1.72
	PUS	158	166	8	5.33	0.00	0.00	0.00	0.00	8.41	0.01
	Sub-Total	**98644**	**97373**	**-1271**	**-1.29**	**-3481.01**	**-40.79**	**652.92**	**7.65**	**1557.03**	**2.27**
	TOTAL	**315431**	**311473**	**-3958**	**-1.25**	**-6212.55**	-72.79	**2252.92**	26.40	0.00	0.00
Deepwater	LAC	64934	64928	-7	-0.01	-6.64	-0.08	0.00	0.00	0.00	0.00
	RIV	83593	83659	66	0.08	-282.24	-3.31	348.44	4.08	0.00	0.00
	TOTAL	**148527**	**148587**	**60**	**0.04**	**-288.88**	-3.38	**348.44**	4.08	0.00	0.00
Upland	UA	1697578	1665982	-31596	-1.86	-1616.89	-18.94	2073.40	24.29	-32052.76	-46.83
	UB	411671	457729	46058	11.19	-59.87	-0.70	2758.02	32.31	43360.08	63.34
	UFP	18818	16974	-1844	-9.80	0.00	0.00	0.00	0.00	-1843.69	-2.69
	UO	531036	512374	-18661	-3.51	-333.38	-3.91	562.92	6.60	-18890.82	-27.60
	URD	72330	82272	9941	13.74	-23.31	-0.27	539.19	6.32	9425.52	13.77
	TOTAL	**2731433**	**2735332**	**3898**	**0.14**	**-2033.46**	-23.83	**5933.53**	69.52	0.00	0.00
Total		3195391	3195391	0	0.00	-8534.89	-100.00	8534.89	100.00	0.00	0.00

Note: Net Change: net loss or gain of cover type resulting from change (e.g., change from one wetland type to another wetland type).
Net Change total area is 68,450.75 acres: wetland 6151.37 acres; upland 62,299.38 acres; deepwater 0 acres.

4.2.2 Wetland Loss

In 1994, wetlands comprised 9.9% (315,431 acres) of the study area (Table 4). By 2005, an estimated 6,213 acres (2% of the 1994 total) of these wetlands were converted to upland or deepwater habitat while 2,253 acres of upland and deepwater habitat were converted to wetland, representing a net wetland loss of 3,960 acres (1.3% of the 1994 total, Tables 6 and 7). The details of the gross losses are shown in Table 8. The largest loss of wetland cover type occurred *in palustrine farmed* (3,198 acres or 52% of the total loss), followed by *palustrine emergent* (1,479 acres or 24% of the total loss).

Together, these two emergent wetland cover types comprised 75% of the total gross wetland loss. Conversions to *urban built* accounted for the largest losses in *palustrine farmed* (35% of Pf loss) as well as the largest losses to all wetland cover types (44% of total wetland loss). Conversions to *upland agriculture* were accountable for the largest losses in *palustrine emergent* (15% of PEM loss) as well as the second largest losses to all wetland cover types (33% of total wetland loss). Wetland conversion to other urban land cover types (URD and UO) accounted for 18% of the total wetland loss.

PHOTOGRAPH BY DAN CARY

Fill for urban development encroaching on pond

Palustrine scrub shrub wetland clearing to enlarge agricultural fields and improve drainage continues to contribute to wetland loss

Table 8. Details of Willamette Valley Areal Wetland Losses, 1994-2005. The data show the gross wetland losses to upland or deep water

		To 2005																	
		Upland											Deepwater					Total	
		UA		UB		UFP		UO		URD		Total Loss %	LAC		RIV		Total Loss %		
		acres	%	acres	%	acres	%	acres	%	acres	%		acres	%	acres	%		acres	%
From 1994	PEM	933.75	15.0	354.10	5.7	0.00	0.0	57.79	0.9	133.17	2.1	23.8	0.00	0.0	0.00	0.0	0.0	**1478.81**	**23.8**
	PFO	182.26	2.9	77.77	1.3	0.00	0.0	0.00	0.0	118.34	1.9	6.1	0.00	0.0	27.60	0.4	0.4	**405.96**	**6.5**
	PSS	518.26	8.3	24.16	0.4	0.00	0.0	5.30	0.1	28.92	0.5	9.3	0.00	0.0	270.12	4.3	4.3	**846.77**	**13.6**
	Pf	404.08	6.5	2174.74	35.0	0.00	0.0	493.02	7.9	125.80	2.0	51.5	0.00	0.0	0.00	0.0	0.0	**3197.64**	**51.5**
	PAB	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.00	0.0	0.00	0.0	0.0	**0.00**	**0.0**
	PUB	25.36	0.4	118.24	1.9	0.00	0.0	6.80	0.1	132.96	2.1	4.6	0.00	0.0	0.00	0.0	0.0	**283.37**	**4.6**
	PUS	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.00	0.0	0.00	0.0	0.0	**0.00**	**0.0**
Total		**2063.72**	**33.22**	**2749.00**	**44.25**	**0.00**	**0.00**	**562.92**	**9.06**	**539.19**	**8.68**	**95.21**	**0.00**	**0.00**	**297.72**	**4.79**	**4.79**	**6212.55**	**100.0**

Table 9. Details of Willamette Valley Areal Wetland Gains, 1994-2005. The data show the gross wetland gains from upland or deep water

			To 2005																			
					PFO + PSS						Other Palustrine											
			PEM		PFO		PSS		Total		Pf		PAB		PUB		PUS		Total		Total	
			acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%
From 1994	Upland	UA	1029.90	45.7	0.00	0.0	52.60	2.3	52.6	2.3	33.81	1.5	0.00	0.0	493.61	21.9	0.00	0.0	527.4	23.4	**1609.91**	**71.5**
		UB	2.85	0.1	0.00	0.0	57.02	2.5	57.0	2.5	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	**59.87**	**2.7**
		UFP	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	**0.00**	**0.0**
		UO	21.50	1.0	0.00	0.0	174.53	7.7	174.5	7.7	0.00	0.0	0.00	0.0	93.62	4.2	0.00	0.0	93.6	4.2	**289.64**	**12.9**
		URD	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	23.31	1.0	0.00	0.0	23.3	1.0	**23.31**	**1.0**
		Total	**1054.25**	**46.8**	**0.00**	**0.0**	**284.15**	**12.6**	**284.1**	**12.6**	**33.81**	**1.5**	**0.00**	**0.0**	**610.54**	**27.1**	**0.00**	**0.0**	**644.3**	**28.6**	**1982.74**	**88.0**
	Deep-water	LAC	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.0	0.0	**0.00**	**0.0**
		RIV	0.00	0.0	0.00	0.0	261.61	11.6	261.6	11.6	0.30	0.0	0.00	0.0	8.27	0.4	0.00	0.0	8.6	0.4	**270.18**	**12.0**
		Total	**0.00**	**0.0**	**0.00**	**0.0**	**261.61**	**11.6**	**261.6**	**11.6**	**0.30**	**0.0**	**0.00**	**0.0**	**8.27**	**0.4**	**0.00**	**0.0**	**8.6**	**0.4**	**270.18**	**12.0**
Total			**1054.25**	**46.8**	**0.00**	**0.0**	**545.75**	**24.2**	**545.8**	**24.2**	**34.11**	**1.5**	**0.00**	**0.0**	**618.81**	**27.5**	**0.00**	**0.0**	**680.4**	**30.2**	**2252.92**	**100.0**

4.2.3 Wetland Gain

During the study period, 1,983 acres of wetland were created from upland (0.5% of the 1994 wetland area). Table 9 details the gains. The largest wetland increase was a 1,054 acre gain in *palustrine emergent* accounting for 47% of the total gain. This was followed by *palustrine unconsolidated bottom* (27% of the total gain) mostly from creation of farm and stock ponds. *Upland agriculture* was the source for 72% of all gains.

4.2.4 Wetland to Wetland Type Changes

From 1994 to 2005, 6,151 acres (or 2% of the total 1994 wetlands) changed from one type of wetland to another type of wetland. The changes are detailed in Table 10. The largest change was from *palustrine emergent* to *palustrine unconsolidated bottom* (1,372 acres or 22 % of the total area converted). This shows a continued conversion of vegetated wetlands to ponds similar to what is occurring on a national level. This was followed by a change of 1,214 acres (20%) of *palustrine emergent* to *palustrine farmed* and a change of 1,028 acres of *palustrine farmed* to *palustrine emergent* (17%) which is only a net change of 187 acres or 3% of the total area converted. Some of these changes may be due to the dates of the imagery used, reflecting seasonal changes and annual differences in precipitation.

Another substantial change was from *palustrine forested* to *palustrine emergent* wetlands (694 acres or 11.3% of the total conversion) and to *palustrine farmed* (250 acres or 4.1% of the total conversion), which indicates a clearing of forested wetlands. The change from *palustrine scrub shrub* to *palustrine emergent* (610 acres) may also indicates clearing of shrub wetland; this is partially offset by change from *palustrine emergent to palustrine scrub shrub* (435 acres) that is most likely due to natural succession. There was relatively little net change in *palustrine scrub shrub* wetlands (net change of 84 acres).

Example of a Palustrine farmed wetland west of Salem. Where ponding duration results in crop failure, species such as western marsh cudweed (Gnaphalium palustre) and water foxtail (Alopecurus geniculatus) fill in.

Table 10. Willamette Valley Wetland to Wetland Conversions, 1994-2005

		To 2005															
		PEM		PFO		PSS		Pf		PAB		PUB		PUS		Total	
		acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%
From 1994	PEM			0.00	0.0	434.76	7.1	1214.22	19.7	0.00	0.0	1372.33	22.3	8.41	0.1	3029.73	49.3
	PFO	694.21	11.3			108.68	1.8	249.68	4.1	0.00	0.0	16.95	0.3	0.00	0.0	1069.52	17.4
	PSS	610.20	9.9	0.00	0.0			22.59	0.4	0.00	0.0	7.09	0.1	0.00	0.0	639.88	10.4
	Pf	1027.64	16.7	0.00	0.0	11.94	0.2			0.00	0.0	76.35	1.2	0.00	0.0	1115.94	18.1
	PAB	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0			0.00	0.0	0.00	0.0	0.00	0.0
	PUB	296.31	4.8	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0			0.00	0.0	296.31	4.8
	PUS	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0			0.00	0.0
Total		**2628.36**	**42.7**	**0.00**	**0.0**	**555.39**	**9.0**	**1486.48**	**24.2**	**0.00**	**0.0**	**1472.73**	**23.9**	**8.41**	**0.1**	**6151.37**	**100.0**

4.2.5 Net Wetland Losses and Gains

Wetland Loss to Upland or Deepwater Habitat

Calculating the areal wetland losses and gains from 1994 to 2005 results in an estimated net loss of 3,932 acres of wetland to upland (1.26% of the 1994 wetland acreage). Table 11 and Figure 6 show the sources of net wetland loss to upland land cover types. The primary cause of wetland loss was attributable to *upland built* at 2,689 acres, or 68% of the total net wetland loss. Combined with *upland rural development* the loss to development is 3,205 acres, or 81 % of the total net wetland loss. There was a net wetland loss of 454 acres to *upland agriculture* representing 11% of the loss to upland. *Upland other* accounted for 7%. There was no wetland loss to *upland forest plantation.*

When net loss to deepwater habitat cover types is included, there was an estimated 28 acre increase in the net wetland loss during the study period to 3,960 acres or 1.2% of the total 1994 wetland area. Tables 6 and 7 show the corresponding losses, gains, and net changes. Table 11 groups the gains and losses by upland and deepwater cover types.

Table 11. Sources of Willamette Valley Net Areal Wetland Losses and Gains

		Net Loss or Gain		Wetland Loss		Wetland Gain	
		acres	%	acres	%	acres	%
Upland	UA	-453.81	11.46	-2063.72	33.22	1609.91	71.5
	UB	-2689.13	67.91	-2749.00	44.25	59.87	2.7
	UFP	0.00	0.00	0.00	0.00	0.00	0.0
	UO	-273.27	6.90	-562.92	9.06	289.64	12.9
	URD	-515.88	13.03	-539.19	8.68	23.31	1.0
	Total	-3932.09	99.30	-5914.83	95.21	1982.74	88.0
Deep-water	LAC	0.00	0.00	0.00	0.00	0.00	0.0
	RIV	-27.54	0.70	-297.72	4.79	270.18	12.0
	Total	-27.54	0.70	-297.72	4.79	270.18	12.0
TOTAL		**-3959.63**	**100.00**	**-6212.55**	**100.00**	**2252.92**	**100.00**

Net Loss and Gain of Wetland Cover Types

For specific wetland cover types, net losses occurred in *palustrine farmed* (3.3 % net loss, 2,791 acres), *palustrine forested* (1.4% net loss, 1,475 acres), *palustrine emergent* (.9% net loss, 826 acres), and palustrine *scrub-shrub* (1.8% net loss, 386 acres). Only *palustrine unconsolidated bottom* and *palustrine unconsolidated shore* had net gains. (Table 7 and Figure 6).

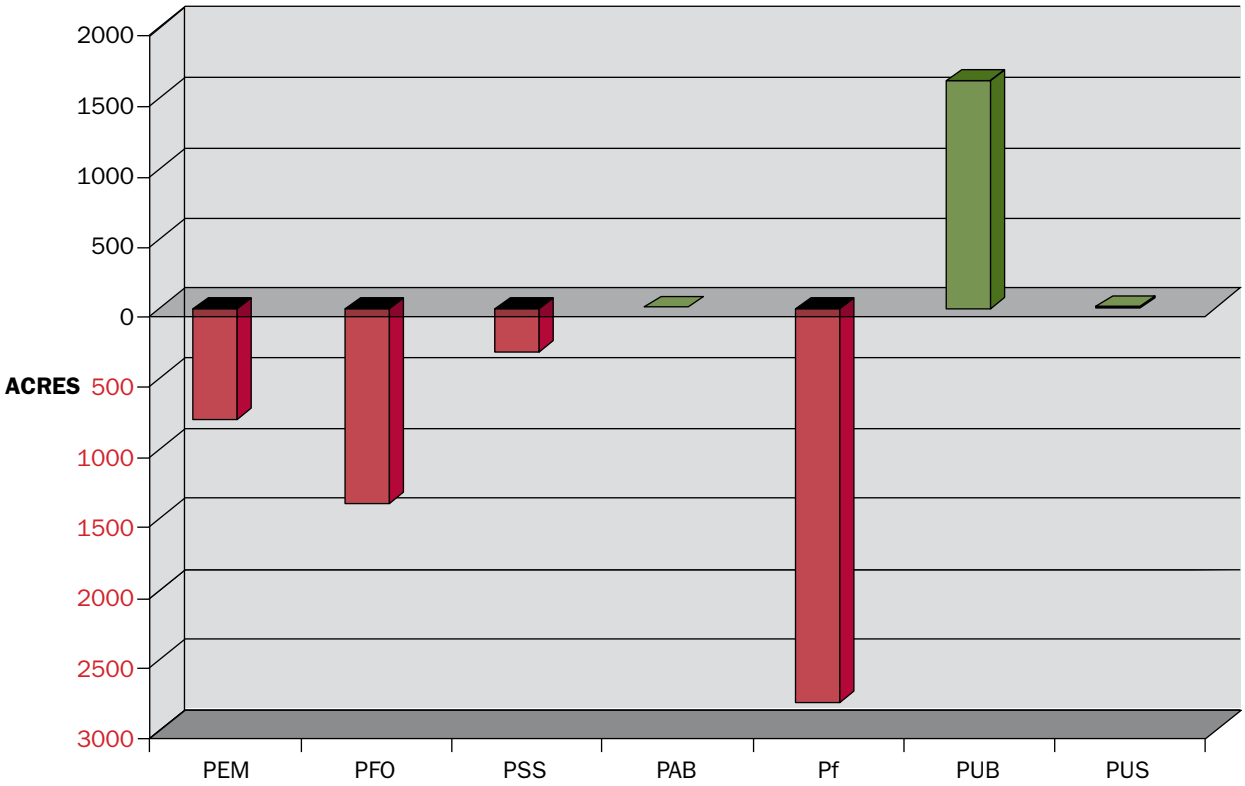


FIGURE 6. Wetland Loss or Gain by Wetland Types, 1994 - 2005

The primary causes of the net losses and net gains can be determined by examining Tables 7 through 10. For example, *palustrine forested* had a 1,475 acre net loss resulting from loss of 406 acres to upland and a "loss" of 1,069 acres from wetland to wetland changes. The loss to upland was equally attributable to *upland agriculture* (182 acres or 45% of the 1,475 acre loss) and a combined 196 acres of *upland built* and *upland rural development* (48% of the 406 acre loss). The wetland to wetland change net "loss" was primarily attributable to a 694 acre net "loss" from changes between *palustrine forested* and *palustrine emergent* that was offset by a net gain of 708 acres from changes between *palustrine forested* and *palustrine scrub/shrub*.

Palustrine unconsolidated bottom and *palustrine unconsolidated shore* were the only wetland types with a net gain. *Palustrine unconsolidated bottom* accounted for almost all of the net gain at 1,512 acres, or 15.3% net gain. This type of wetland is primarily freshwater ponds. Of the wetland to wetland type conversions, *palustrine emergent* was the source of 1,372 acres of *palustrine unconsolidated bottom*, followed by *palustrine farmed* at 76 acres. Of the upland cover types, *upland agriculture* was the largest source of *palustrine*

unconsolidated bottom gain (494 acres), suggesting that many of the *palustrine unconsolidated bottom* gains are due to construction of farm ponds. An analysis of all ponds gained from uplands shows that 55% of the gains were, in fact, farm ponds. *Upland rural development* accounted for 18% of ponds, *upland built* for 15%, and *upland other* for 12%.

4.2.6 Deepwater Habitat Losses and Gains

From 1994 to 2005, 289 acres of deepwater habitat were lost while 348 acres were gained resulting in a net gain of 60 acres (0.04% of the 1994 total). The gains and losses are shown in Table 12. The net gain was primarily attributable to conversion of *upland other* to *Riverine*, most likely caused by meandering of the river channel.

The largest losses (262 acres) and gains (270 acres) occurred in changes of p*alustrine scrub/shrub* to and from *Riverine* which results in a net gain of only 8 acres. This is most likely a natural gain and loss from channel movement. No conversions from one deepwater type to another deepwater type occurred.

Table 12. Willamette Valley Deepwater Habitat Losses and Gains

			To 2005							
			LAC	RIV	PSS	Pf	PUB	UA	UB	TOTAL
From 1994	Deepwater Loss	LAC			0.00	0.00	0.00	0.00	-6.64	-6.64
		RIV			-261.61	-0.30	-8.27	-9.68	-2.37	-282.24
		Total			**-261.61**	**-0.30**	**-8.27**	**-9.68**	**-9.01**	**-288.88**
	Deepwater Gain	PFO	0.00	27.60						
		PSS	0.00	270.12						
		UA	0.00	6.98						
		UO	0.00	43.73						
		Total	**0.00**	**348.44**						
	Net Change									**59.56**

4.2.7 Upland Losses, Gains and Type Change

From 1994 to 2005, there was a net upland gain of 3,900 acres (0.14% of the 1994 upland area) resulting from a loss of 2,033 acres and a gain of 5,934 acres. Tables 6 and 7 summarize the gains, losses, and changes.

During the study period, 62,299 acres of upland (2.3% of the 1994 upland area) were converted from one type of upland to another type. Table 13 shows the changes. The largest decrease was from *upland agriculture* (38,599 acres or 62% of the change area) and the largest increase was to *upland built* (43,354 acres or 70 % of the change area). The largest type of change (29,060 acres or 47% of the changes) was also from *upland agriculture* to *upland built.* Conversion of *upland agriculture* to all other upland land uses was primarily to *upland rural development,* followed by conversion to *upland other and upland forested plantation* (Table 13 and Figure 7).

Examination of upland change (Table 13), wetland loss (Table 8), and wetland gain (Table 9) data show that *upland agriculture* sustained a net loss of 4,706 acres (0.3% decrease from 1994). As Table 13 shows, 38,599 acres of *upland*

agriculture were converted to different upland uses (primarily *upland built)* while 6,593 acres of upland cover types were converted to *upland agriculture,* for a net loss of 5,160 acres of *upland agriculture* due to upland to upland conversions. As shown in Tables 8 (wetland loss) and 9 (wetland gain), 2,064 acres of *upland agriculture* were gained from wetland while 1,610 acres of *upland agriculture* were lost to wetland. The result was a net loss of 4,706 acres (0.28% of the total area of *upland agriculture* in 1994). (Upland losses and gains are the reverse of the wetland gains and losses, respectively, with the addition of deepwater *riverine* habitat factored into both the gains and losses.)

Similarly, *upland built* had a net gain of 46,058 acres (Table 7) (an 11% increase from 1994). The gains are primarily attributable to changes within upland types: a net gain of 13,440 acres from *upland other,* a gain of 445 acres from *upland rural development,* a significant net gain of 29,060 acres from *upland agriculture,* and a gain of 409 acres from *upland forest plantations.* There was also a gain of 2,689 acres from wetlands (primarily *palustrine farmed* and *palustrine emergent.* (Table 8 & 9).

Table 13. Willamette Valley Upland to Upland Changes, 1994 - 2005

		To 2005											
		UA		UB		UFP		UO		URD		Total	
		acres	%	acres	%	acres	%	acres	%	acres	%	acres	%
From 1994	UA			29059.90	46.65	94.48	0.15	2387.72	3.83	7057.23	11.33	38599.33	61.96
	UB	0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	UFP	1287.97	2.07	408.73	0.66			0.00	0.00	236.21	0.38	1932.91	3.10
	UO	5304.72	8.51	13439.70	21.57	0.00	0.00			2577.40	4.14	21321.82	34.22
	URD	0.00	0.00	445.32	0.71	0.00	0.00	0.00	0.00			445.32	0.71
	Total	**6592.69**	**10.58**	**43353.65**	**69.59**	**94.48**	**0.15**	**2387.72**	**3.83**	**9870.84**	**15.84**	**62299.38**	**100.00**

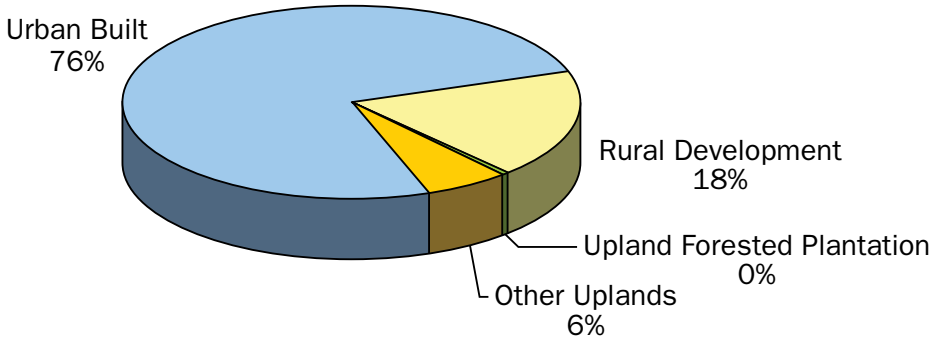


FIGURE 7
Causes of Conversion from Upland Agriculture to Other Upland Land Uses, 1994 – 2005

4.3 Wetland Changes by Hydrogeomorphic Class from 1994 to 2005

The hydrogeomorphic (HGM) classification is based upon a wetland's landscape position and hydrodynamics. Because these factors have been shown to exert a controlling influence on a wetland's ecological processes, wetlands of the same HGM classification in a particular ecoregion will likely support similar functions. Tracking wetland changes by HGM class may suggest general trends in relative functions, but cannot substitute for assessing wetland functions using a rapid wetland assessment method or by measuring actual changes in wetland functions (Adamus et. al., 2010). Assigning HGM class and subclass codes to wetlands requires landscape and topographic information in addition to aerial photo interpretation. Although topographic maps are used as ancillary information sources for status and trends mapping, their level of detail and accuracy is very limited. Light detection and ranging (LiDAR) technology, which is increasingly available, will greatly improve the accuracy for future projects.

4.3.1 Summary of Wetland Hydrogeomorphic Classes in 1994

Riverine wetlands, at 29.4% of the total wetland area, was the most extensive HGM class in 1994. *Slope valley* (SV) was the next most extensive class (21%) followed by *flats* (F) at 19% and lacustrine *fringe valley* (LFV) at 14%. The depressional wetland types (DCNP, DCP, DO) made up 15.4% of the wetlands. It is not surprising that *slope headwater* (SH) extent was relatively minor (0.7%) because the study area was confined to the valley bottomland.

Table 14. Estimate of Willamette Valley Wetlands by HGM class in 1994

HGM Category	HGM Type	Willamette Valley Estimate (acres)	% of Total	% of Category Sub-Total
Wetland	DCNP	16349.58	0.51	4.44
	DCP	6237.52	0.20	1.69
	DO	34447.25	1.08	9.34
	F	69385.17	2.17	18.82
	LFV	53054.72	1.66	14.39
	RFT	94676.57	2.96	25.68
	RI	13701.27	0.43	3.72
	SH	2516.06	0.08	0.68
	SV	78259.90	2.45	21.23
	Total	368628.05	11.54	100.00
Deepwater	N/A	95329.75	2.98	3.37
Upland	N/A	2731433.20	85.48	96.63
	Total	**2826762.95**	**88.46**	**100.00**
TOTAL		**3195391.00**	**100.00**	

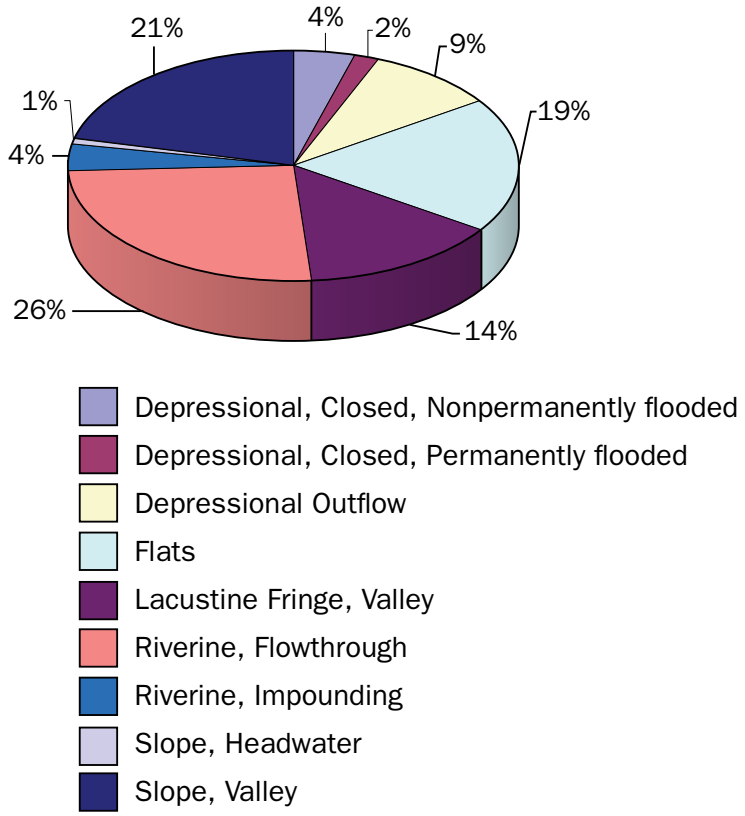


FIGURE 8
Willamette Valley Wetlands by Hydrogeomorphic Class in 1994

4.3.2 Wetland Losses and Gains by Hydrogeomorphic Class

Table 15 shows the details of the net loss or gain by HGM class. *Flats* experienced the most net loss at 3,742.6 acres (5.4% loss), followed by *slope valley* at 650.9 acres (0.8% loss). The only HGM classes with a net gain were each of the three depressional subclasses which combined for a net gain of 858.7 acres (4.8%). Other than a small net gain in *riverine impounding* (8 acres), the depressional class was the only HGM class with a net gain, similar to results by Cowardin cover type where only *palustrine unconsolidated bottom* and *palustrine unconsolidated shore* experienced a net gain (Table 7).

Table 15 Details of Aerial Wetland Loss and Gain by HGM Class

HGM Category	HGM Type	1994 (acres)	2005 (acres)	Net Loss/ Gain (acres)	% Net Loss/Gain	Total Loss (acres)	% Total Loss	Total Gain (acres)	% Total Gain	Net Change (acres)
Wetland	DCNP	**16349.582**	16610.39	260.81	1.60	-632.94	-10.67	721.62	35.49	172.13
	DCP	**6237.520**	6351.98	114.46	1.84	-283.37	-4.78	486.63	23.93	-88.80
	DO	**34447.250**	34930.68	483.43	1.40	-599.84	-10.11	294.37	14.48	788.89
	F	**69385.171**	65642.58	-3742.59	-5.39	**-3011.32**	-50.77	33.80	1.66	-765.07
	LFV	**53054.722**	53048.08	-6.64	-0.01	-6.64	-0.11		0.00	0.00
	RFT	**94676.574**	94320.79	-355.78	-0.38	**-579.96**	-9.78	183.18	9.01	41.00
	RI	**13701.268**	13709.37	8.10	0.06	-307.92	-5.19	313.86	15.43	2.16
	SH	**2516.065**	2507.65	-8.41	-0.33	0.00	0.00		0.00	-8.41
	SV	**78259.898**	77608.98	-650.92	-0.83	**-509.03**	-8.58		0.00	-141.89
	Total	368628.049	364730.49	-3897.56	-2.06	-5931.02	-100.00	2033.46	100.00	0.00

Table 16 Details of Wetland to Wetland Conversion by HGM class, 1994 - 2005

		To 2005																			
		DCNP		DCP		DO		F		LFV		RFT		RI		SH		SV		Total	
		acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%	acres	%
From 1994	DCNP			12.28	0.72	0.00	0.00	75.74	4.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	88.02	5.13
	DCP	260.15	15.15			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	260.15	15.15
	DO	0.00	0.00	71.56	4.17			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	71.56	4.17
	F	0.00	0.00	14.54	0.85	814.80	47.46			0.00	0.00	52.31	3.05	97.05	5.65	0.00	0.00	0.00	0.00	978.70	57.00
	LFV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	RFT	0.00	0.00	0.00	0.00	**4.54**	0.26	0.00	0.00	0.00	0.00			22.37	1.30	0.00	0.00	12.00	0.70	38.91	2.27
	RI	0.00	0.00	0.00	0.00	0.00	0.00	117.26	6.83	0.00	0.00	0.00	0.00			0.00	0.00	0.00	0.00	117.26	6.83
	SH	0.00	0.00	0.00	0.00	8.41	0.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00			0.00	0.00	8.41	0.49
	SV	0.00	0.00	**72.97**	4.25	**32.70**	1.90	**20.63**	1.20	0.00	0.00	**27.60**	1.61	0.00	0.00	0.00	0.00			153.89	8.96
	TOTAL	**260.15**	**15.15**	**171.35**	**9.98**	**860.45**	**50.12**	**213.63**	**12.44**	**0.00**	**0.00**	**79.91**	**4.65**	**119.42**	**6.96**	**0.00**	**0.00**	**12.00**	**0.70**	**1716.91**	**100.00**

	Net Change (acres)
DCNP	172.13
DCP	-88.80
DO	788.89
F	-765.07
LFV	0
RFT	41.00
RI	2.16
SH	-8.41
SV	-141.89
TOTAL	0.00

4.3.3 Wetland to Wetland Changes by Hydrogeomorphic Class

Wetland-to-wetland class changes by HGM classification between 1994 and 2005 are shown in Table 16. *Flats*, which accounted for 19% of the HGM class type in 1994, accounted for 57% of the wetland class loss by 2005. The net changes resulted in the loss of 765 acres of *flats* to other HGM classes; notably, 815 acres of *flats* were converted to *depressional outflow*. *Riverine flowthrough* gained 41 acres, but the most gain was in the *depressional* class with a combined gain of 872 acres.

A boardwalk at Jackson-Frazier Wetland provides access to this Benton County park, managed as a natural area to protect its forested, shrub and prairie wetland plant communities

PHOTOGRAPH BY JIM GOOD

Wetlands within National Wildlife Refuges in the Willamette Valley support millions of migratory species, like these Dunlin lifting off over the Ankeny National Wildlife Refuge

5.0 CONCLUSIONS AND DISCUSSION

From 1994 to 2005, the Willamette Valley continued to experience wetland losses. In 2005, there was an estimated 311,473 acres of wetlands in the Willamette Valley, which represents 9.7% of the total land area. Between 1994 and 2005, there was an estimated net loss of 3,960 acres of wetlands. This represents a change of 1.26% from the 1994 wetlands area in the valley (315,431 acres). The average net loss of wetlands between 1994 and 2005 was 357 acres per year.

Nearly all of the net wetland loss was to upland land use/cover types (3,932 acres). An additional 28 acres of wetland were lost to deepwater habitats (*riverine*). Of the 3,932 acres lost to upland, most (68%) was lost to *upland built*. This was followed by *upland rural development* (13%), *upland agriculture* (11%) and *other uplands* (7%). Collectively, development (combined rural and urban) accounted for an estimated 81% of all wetland losses to upland between 1994 and 2005 (Figure 9b).

The wetland type that experienced the most net loss (including from wetland-to wetland type changes) was *palustrine farmed* (2,791 acres). This was followed by *palustrine forested* at 1,475 acres. The only wetland types to experience net gains were *palustrine unconsolidated bottom* (1,512 acres) and *palustrine unconsolidated shore* (8 acres). Without these gains, primarily from ponds, there would be a net loss of 5,478 acres of vegetated wetlands. The importance of these changes is discussed below.

If we look at the gross loss of wetlands by wetland cover type (Cowardin class), 52% of the loss of wetland to all upland cover types was from *palustrine farmed*, mostly to *upland built*. *Palustrine emergent* followed with a 24% loss to all upland cover types, mostly to *upland agriculture*. Together, these emergent types accounted for 75% of the wetland losses to upland. The loss from *palustrine farmed* to *upland built* was 2,175 acres, and from *palustrine emergent* to *upland agriculture* was 934 acres.

Comparisons between the Two Willamette Valley Studies

As discussed in the introduction, one of the primary objectives of this study was to compare the findings with those from the original study that covered the time period 1982 to 1994. Although there were a few changes in methodology, the same sample plots and similar procedures were used.

In the conclusions of the original study report, we noted that the starting date of that study (1982) predated full development of most "modern" regulations and programs designed to curb wetland losses, including state and federal regulatory programs that require compensatory wetland mitigation for permitted wetland impacts, the U.S. Department of Agriculture Swampbuster program that discouraged conversion of wetlands to agricultural production, and various incentive programs for wetland restoration and protection. We suggested that a follow-up study would provide insight into the effects of these programs and policies.

What we find when comparing the two time periods is that wetland losses continue to occur in the Willamette Valley, though the rate of wetland loss is decreasing. From 1982 to 1994 (a period of 12 years), there was a net loss of

6,877 acres wetlands to uplands (2.5% of the 1982 wetland area), for an average loss of 573 acres per year. From 1994 to 2005 (a period of 11 years), there was an estimated net loss of 3,932 acres of wetlands to uplands (1.3% of the 1994 wetland area), for an average loss of 357 acres per year. The gain in ponds (*palustrine unconsolidated bottom*) was more than double the pond gain between 1982 and 1994.

The most striking difference between the two study periods is the nearly complete reversal of the source of most of the wetland loss (Figures 9a and 9b). Between 1982 and 1994, 67% of the wetland loss was to *upland agriculture*. In contrast, between 1994 and 2005, 68% of the wetland loss was to *upland built*. If we look just at *palustrine farmed*, most of the loss between 1982 and 1994 was to *upland agriculture*. However, between 1994 and 2005, 35% of the *palustrine farmed* loss was to *upland built*. *Palustrine farmed* accounted for 52% of the wetland loss to upland from 1994 to 2005. It is difficult to determine the specific causes without further investigation (see Shaich, 2000), but the 1994 to 2005 period was a period of substantial population and economic growth in the Willamette Valley.

Palustrine forested experienced a loss during both time periods, with less loss between 1994 and 2005 than in the earlier period. *Palustrine forested* experienced a 26% loss to upland between 1982 and 1994, mostly to *upland agriculture*. From 1994 to 2005, there was a 6% loss of *palustrine forested* to upland, again mostly to *upland agriculture*, followed by *upland rural development* (thus mostly to rural land uses). Looking at wetland-to-wetland type changes, conversion of *palustrine forested* to *palustrine emergent* was greater between 1982 and 1994 (2,074 acres) than between 1994 and 2005 (694 acres). Conversion of *palustrine forested* to *palustrine farmed* was not much different between the two time periods (127 acres and 250 acres).

The gains in *palustrine unconsolidated bottom* (ponds) between the two time periods were from different primary sources. Most of the gain from 1982 to 1994 was from *upland agriculture* (928 acres). There was also a wetland-to-wetland type gain of 334 acres of *palustrine unconsolidated bottom* from *palustrine emergent*. From 1994 to 2005, however, the largest *palustrine unconsolidated bottom* gain was a 1,372 acre gain from *palustrine emergent*; there was also a 494 acre gain from *upland agriculture*.

Conversion to urban land uses was the main cause of wetland loss between 1994 and 2005

Changes between *palustrine emergent* and *palustrine farmed* occur in both directions

and presumably include periodic, alternating changes in agricultural land management as fields are left fallow and later brought back into production. Some of the *palustrine emergent* to *palustrine farmed* change may represent bringing natural or abandoned wetland areas into production. Likewise, some of the *palustrine farmed* to *palustrine emergent* change may be attributed to wetland restoration and enhancement projects resulting from conservation incentive programs. From 1982 to 1994, there was a 719 acre change from *palustrine emergen*t to *palustrine farmed*, and an 8,708 acre change from *palustrine farmed* to *palustrine emergent*, for a net wetland-to-wetland *palustrine emergent* gain of 7,989 acres. Two plots accounted for much of this change, both related to wetland restorations projects. In contrast, between 1994 and 2005, the *palustrine emergent/palustrine farmed* changes very nearly balanced out with a 186 acre net loss of *palustrine emergent*.

FIGURE 9A

Causes of Willamette Valley Wetland Loss, 1982 - 1994

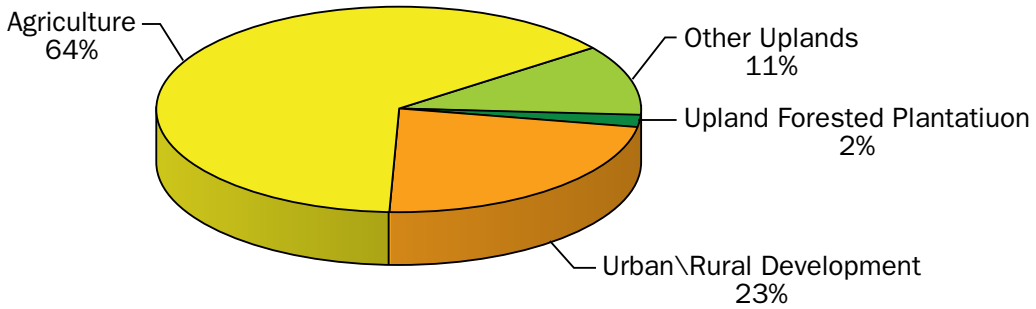
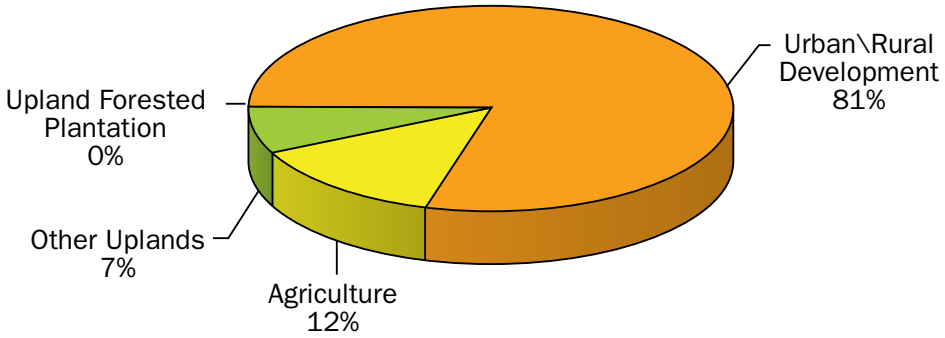


FIGURE 9B

Causes of Willamette Valley Wetland Loss, 1994 - 2005



Comparison with National Status and Trends Study

The U.S. Fish & Wildlife Service *Status and Trends of Wetlands in the Conterminous United States 1998 to 2004* (Dahl, 2006) covers a similar period of time, making some general comparisons possible. For comparison purposes, estuarine wetland types included in the U.S. Fish & Wildlife Service (USFWS) study were not considered. Also, the USFWS study does not differentiate *palustrine farmed* as a separate type *of palustrine emergent* wetland.

The most striking similarity between the two studies is that in both, the pond types of wetlands showed the most gain. The most striking difference between the two studies is that there was a net loss of wetlands in the Willamette Valley,

but there was a net gain of wetlands in the USFWS study. However, the national report notes that there would not have been a net gain without the significant (12.6%) gain in unvegetated ponds. The rate of vegetated wetland loss has declined nationally as well as in the Willamette Valley.

In both studies, urban and rural development accounted for most of the wetland loss. In the Willamette Valley, 81% of the net loss of wetland to upland was to *upland built* and *upland rural development*. Nationally, 61% of the wetland loss was to these two upland categories. In both studies, *palustrine forested* was the most extensive wetland type (33.5% in the Willamette Valley; 51% nationally). In the Willamette Valley, *palustrine forested* experienced a net loss, whereas nationally there was net gain in *palustrine forested*, attributed mostly to maturation of *palustrine scrub shrub*.

Increase in non-Vegetated Ponds

When the USFWS Status and Trends report for 1998 to 2004 (Dahl, 2006) was released, it reported a net gain in wetlands for the first time. However, without the 12.6% increase in freshwater pond acreage during that time period, wetland losses would have surpassed wetland gains. Because a great many of the ponds in the study are unvegetated (*palustrine unconsolidated bottom*) and include many artificially constructed ponds such as golf course ponds, stormwater retention ponds, and ponds built as amenities for subdivisions or commercial developments, there was an immediate expression of concern from wetland scientists and others that these features are functionally very different from naturally-occurring vegetated wetlands. Because peer reviewers had also raised this concern, Dahl addressed the subject, noting that scientists have inferred linkages between wetland structure and function, but also that the status and trends report methodology addresses quantitative, not qualitative, changes. Nonetheless, this increase in ponds is a substantial change and a potential trend to track.

Ponds constructed for aesthetic purposes account for much of the wetland and deepwater habitat gains in the Willamette Valley, as elsewhere in the United States

This Willamette Valley change study found similar results. Other than a minor amount (8 acres) of *palustrine unconsolidated shore*, *palustrine unconsolidated bottom* was the only wetland type to experience a net gain. Similarly, the three *depressional* HGM types accounted for nearly all of the net gain (859 acres) by HGM class. Also of potential concern is the wetland-to-wetland type conversion of 1,372

acres of *palustrine emergent* and 76 acres of *palustrine farmed* to *palustrine unconsolidated bottom* (ponds). Although not a part of this study, the tradeoffs in wetland functions and other potential impacts warrant future investigation (e.g., conversion of seasonal wetlands to permanent ponds can be detrimental to native amphibians) (Pearl et. al., 2005). Such investigations are particularly important if these wetland type conversions are conducted as wetland "enhancement" projects, whether voluntary or for compensatory mitigation.

Changes in Wetland Area and Assessing Wetland Condition

Most wetland status and trends studies, including this study, have primarily addressed wetland area losses and gains. Because of the large historical losses of wetlands in the United States, the primary concern has been to document changes in wetland area and the land cover/land use sources of wetland losses and gains (e.g., urban development or agriculture). This information is essential to reporting on federal and state no-net-loss or net-gain of wetlands policies, for evaluating program effectiveness, and for gaining insight into ways to halt or reverse wetland losses.

Based upon the results of this study, we have yet to achieve no-net-loss of wetland area in the Willamette Valley, though the rate of loss has declined. The Willamette Valley studies, like the USFWS wetland status and trends reports, do not provide information on changes in wetland condition or functions. Wetland functions are the ecological processes within wetlands, such as nitrate removal. Wetland condition is the health or "integrity" of the wetland, commonly determined by its vegetation composition and disturbances such as ditches or compaction of soils. Classifying wetlands and wetland changes by Cowardin class and HGM class provides some insight into changes in wetland condition and functions. For example, a change from palustrine forested to palustrine farmed signals a probable degradation of wetland condition, but also suggests changes in wetland functions (some decreasing and others increasing). However, such interpretation must be made cautiously, as these classification systems are not designed to be indicators of wetland condition or functions.

In more recent years, public policy has embraced the concept of assessing changes in the health, or condition, of wetlands in addition to tracking changes in area. In Oregon, the *Oregon State of the Environment Report 2000* (Oregon Progress Board, 2000) addressed the health of the state's natural resources, including freshwater wetlands (Morlan, 2000). At the national level, in 2004, then President George W. Bush called for an increase in the overall quality as well as quantity of wetlands. The 2011 National Wetland Condition Assessment (NWCA) effort will begin to address wetland condition at the national level (Scozzafava, 2007).

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