Wetland and Land Use Change in the Willamette Valley, Oregon: 1982 to 1994

Volume 1: Final Report

Prepared by:

Steve Daggett
Marc Boule'
Shapiro and Associates, Inc.

Joseph A. Bernert
Joseph M. Eilers
E&S Environmental Chemistry, Inc.

Elaine Blok
Dennis Peters
U.S. Fish and Wildlife Service

Janet C. Morlan
Oregon Division of State Lands

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Wetlands Program
Division of State Lands
775 Summer Street NE
Salem, OR 97310

503-378-3805

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1.0 INTRODUCTION AND OBJECTIVES

Oregon has a history of concern about the status of the state's wetland resource—a history reflected in the many programs and policies aimed at protecting the significant benefits that wetlands provide to Oregonians. The primary expression of concern was the Removal/Fill Law, first established in 1971 to halt the rapid loss of estuarine wetlands, and amended and strengthened over the years to include freshwater wetlands. The statewide land use planning program, established in 1973, recognized the importance of wetlands by including requirements for local governments to address wetland protection in three of the 19 statewide planning goals. Wetland legislation adopted in 1989 provided clear policies directed at maintaining the acreage and functions of the state's freshwater wetlands, and better integrated wetland protections into the statewide land use planning program. In addition, Oregon has developed an award-winning benchmark program that measures the progress and effectiveness of state programs (Oregon Progress Board, 1994). One of the benchmarks adopted for measuring Oregon's "livable environment" is to maintain 100% of the 1990 wetland resource base.

Despite the regulatory and policy attention focused on wetlands, there has been limited accounting of the outcome of these efforts. Kentula, et. al. (1992) found that the permit program has led to net losses of wetlands. The Oregon Division of State Lands (DSL), which implements the state Removal/Fill Law, conducted a field-based study of permitted wetland losses and associated compensatory mitigation for a significant number of projects in the Portland metropolitan area. The study found that the regulatory process led to a small net loss of wetlands and a permitted change from palustrine emergent to aquatic bed or open water ponds (Shaich and Franklin, 1995). Neither of these studies could address wetland losses or gains not captured by the permit process.

This study was 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 study was developed to establish a statistically valid estimate of wetland change from the mid-1980s to the mid-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. An additional objective was to identify the specific causes of mapped wetland losses and analyze how those losses were, or were not, addressed by wetland regulations and programs. This element will be completed as a phase II study.

The Willamette Valley was selected as a pilot region for a stratified sampling approach to estimating wetland losses throughout an ecoregion (Figure 1). The Willamette Valley was selected, in part, because of its importance to the economy of the state and because of the high degree of alteration it has experienced. Some of the most productive agricultural lands in the nation are found in the Willamette Valley, and the region is also

home to nearly 70% of Oregon's population and accounts for 75% of the state economy. The Willamette Valley has experienced, and will continue to experience, significant population growth. For this reason, the Willamette Valley has been the focus of a number of studies of the ecological effects of population growth and designs for alternative futures (EPA, 1995; Community Planning Workshop and Institute for a Sustainable Environment, 1994; Hulse, et. al., 1997).

Studies of the Willamette River channel through time show that the river system has been massively simplified by eliminating meander patterns and shortening the channel—the result of dam construction, channelization, drainage and other activities (Sedell and Froggatt, 1984; Benner and Sedell, 1994). Another study, an interagency effort between DSL, the Bureau of Land Management and The Nature Conservancy, has focused on the reconstruction of historic vegetation patterns of the Willamette Valley derived from General Land Office surveys of the 1850s to the 1880s. This study of wetland and land use change in the Willamette Valley complements the historic studies by focusing on recent wetland changes—changes that have occurred after implementation of many state and federal wetlands laws and programs.

MAP PAGE

2.0 METHODS

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

The main objective of the study was to examine land cover changes between 1982 and 1994 with an emphasis on wetland change. Based on this objective, a probability-based sample design was selected. Of the potential sample designs, the probability-based 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.

Many different sampling methods within the probability-based study design could have been used to select the specific areas to be surveyed. 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 the areas where wetland occurrence was most probable; and (2) perform detailed upland and wetland land cover mapping. The key elements of the sample design are listed and described below.

1. Select the study area: Willamette Valley Ecoregion (4,970 square mile sections).
2. Identify the population and create a sampling frame from readily available regional geographic information system (GIS) data sources.
3. Stratify the population (regional land use and soils databases).
4. Collect the Stage 1 sample (711 square mile sections).
5. Compare regional data sources (steps 2 and 3) to detailed data sources including the county soil surveys (i.e., verify soils and land uses).
6. Stratify verified soils and land uses (step 5) based on relative proportions of hydric soil.
7. Collect the Stage 2 sample (114 square mile sections).
8. Within each of the 114 sections, conduct aerial photographic interpretation of wetland and upland land cover in 1982 and any changes in 1994.
9. Digitize photointerpretation results in a GIS for statistical analyses and mapping.

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.

2. Identify population and create initial sampling frame

For the purposes of this study, it was decided that 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 within the boundaries of the Willamette Valley ecoregion (4,790 square mile sections).

3. Stratify the population

The initial sample 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.

4. Collect the Stage 1 sample

The number of samples were selected to minimize errors associated with the probability design. The minimum sample size in any of the 15 stratas 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.

5. 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) from the large-scale county soil survey photo map base.

6. 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 D, Volume 2).

7. Collect Stage 2 sample

Sampling 711 sections in the Willamette Valley ecoregion 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.

8. Aerial photographic interpretation and mapping conventions

Procedures and protocol for this study closely followed those used by the National Wetlands Inventory (NWI) for its periodic national status and trends of wetlands reports to Congress (FWS, 1994a). 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 aerial photography; new aerial photographs were not acquired.

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* (FWS, 1994a). The classification categories are described in Table 1 and defined in Technical Appendix I, Volume 2.

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	Agriculture	Crop Producing/Pasture
UB	Built/Urban	Cities and Towns
URD	Rural Development	Rural Building/Development
UFP	Forested Plantation	Christmas Tree Farms Cottonwood Plantations (drained)
UO	Other Uplands	Uplands not fitting other category

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. Each plot on the 1982 aerial photography was interpreted and delineated in full for wetlands, deepwater habitats, and uplands. Only the changes in land cover types were delineated on the 1994 aerial photography. Delineations on both sets of aerials went through a quality control review in the U.S. Fish and Wildlife Service (FWS) regional office to ensure accuracy and completeness of the photointerpretation. NWI regional staff conducted field review on more than 100 of the 114 plots in the study area.

National Wetlands Inventory Center staff in St. Petersburg, Florida, completed map production following *Cartographic Conventions for the National Wetlands Inventory* (FWS, 1994b). The 1982 delineated data and the change overlays were transferred from the aerial photographs to overlays on U.S. Geological Survey 1:24000 scale topographic maps. Using the 1980's maps and 1990's change maps, wetlands, deepwater habitats, and upland information and changes were digitized into a GIS.

9. 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

3.0 RESULTS AND INTERPRETATION

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

3.1 Willamette Valley Land Cover Status in 1982

Based on the statistical sampling and aerial photointerpretation in this study, wetlands comprised approximately 8.5% of the Willamette Valley ecoregion study area, deepwater habitats covered 5.3%, and 86.1% 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 1982 are shown in Table 2 and Figure 2. The study area is dominated by *upland agriculture*, which covered 50% of the study area and represented 58% of the *upland* land cover types. *Palustrine forested* was the most extensive wetland cover type, representing 3% of the study area and 34% of the wetland cover types. Other major wetland types were *palustrine emergent* and *palustrine farmed.*

Table 2. Estimate of Willamette Valley Wetlands, Deepwater Habitats, and Uplands in 1982

Land Cover Category	Land Cover Type	Willamette Valley Estimate (acres)	Standard Error (acres)	Willamette Valley Estimate (sq. miles)	% of Total	% of Category Sub-Total
Wetland	**PFO**	91,303	2,242	142.7	2.86	33.45
	PEM	79,252	2,186	123.8	2.48	29.04
	Pf	73,873	2,566	115.4	2.31	27.06
	PSS	16,300	481	25.5	0.51	5.97
	PUB	9,897	333	15.5	0.31	3.63
	PAB	2,145	108	3.4	0.07	0.79
	PUS	182	12	0.3	0.01	0.07
	Total	**272,952**	**7,928**	**426.6**	**8.54**	**100.00**
Deepwater	**RIV**	91,386	404	142.8	2.86	53.76
	LAC	78,593	5,337	122.8	2.46	46.24
	Total	**169,979**	**5,741**	**265.6**	**5.32**	**100.00**
Upland	**UA**	1,600,425	15,059	2,500.7	50.09	58.15
	UO	705,376	11,072	1,102.2	22.07	25.63
	UB	372,199	12,254	581.6	11.65	13.52
	URD	60,158	1,751	94.0	1.88	2.19
	UFP	14,302	821	22.3	0.45	0.52
	Total	**2,752,460**	**40,957**	**4,300.8**	**86.14**	**100.00**
Total		**3,195,391**	**54,626**	**4,993.0**	**100.00**	

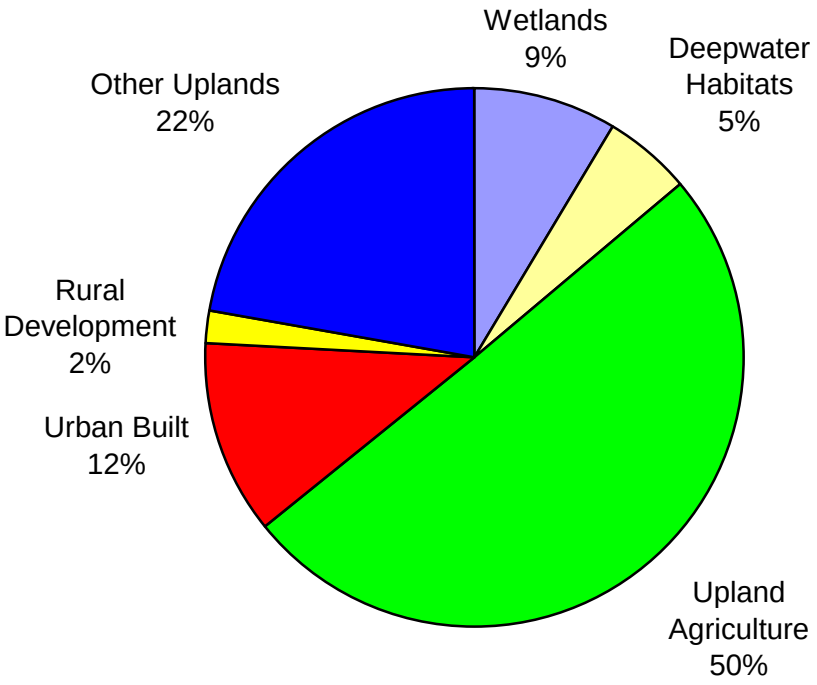


Figure 2. Willamette Valley Land Cover Types in 1982

Linear wetlands and deepwater habitats—those that were too narrow to be mapped in areal units—were mapped as linear features and measured in linear distances (miles). These were reported separately because of the uncertainty in determining their width (which would have allowed calculations of area). The extent of linear wetlands in 1982 is shown in Table 3. *Palustrine emergent* wetlands comprised the greatest linear wetland type. Most linear *palustrine emergent* wetlands in agricultural areas were ditches. A summary of 1982 areal and linear wetland coverage, by selected groupings, is shown in Table 4.

Table 3. Estimate of Willamette Valley Linear Extent of Wetlands and Deepwater Habitats in 1982

Land Cover Category	Land Cover Type	Estimate (miles)	Standard Error (miles)	% of Total	% of Sub-Total
Wetland	**PEM**	4,781	70	44.4	65.5
	Pf	1,475	52	13.7	20.2
	PSS	518	15	4.8	7.1
	PFO	504	18	4.7	6.9
	PUB	13	2	0.1	0.2
	PAB	8	2	0.1	0.1
	PUS	0	0	0.0	0.0
	Sub-Total	**7,299**	**159**	**67.8**	**100.0**
Deepwater	**RIV**	3,464	65	32.2	100.0
	Sub-Total	**3,464**	**65**	**32.2**	**100.0**
Total		**10,763**	**224**	**100.0**	NA

Table 4. Summary of Selected Groupings of Willamette Valley Wetland Cover Types in 1982

	Areal Wetlands			**Linear Wetlands**		
Wetland Types	**acres**	**% of Total Area**	**% of Wetland Area**	**miles**	**% of Total Linear Features**	**% of Linear Wetlands**
PEM	79,252	2.5	29.0	4,781	44.4	65.5
PFO+PSS	107,603	3.4	39.4	1,022	9.5	14.0
Oth. Pal.	86,097	2.7	31.5	1,496	13.9	20.5
Total	**272,952**	**8.5**	**100.0**	**7,299**	**67.8**	**100.0**

3.2 Land Cover Changes from 1982 to 1994

3.2.1 Summary of Willamette Valley Land Cover Changes

Six types of land cover change from 1982 to 1994 were examined:

1. Wetland loss (wetland to upland or deepwater habitat);
2. Wetland gain (upland or deepwater habitat to wetland);
3. Wetland 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 change (conversion from one upland type to another upland type).

As shown in Table 5, 4% of the study area (128,501 acres or 200.4 square miles) changed during the study period. Each of the six types of change are examined in detail in subsequent sections (Tables 6, 7, and 8).

Table 5. Summary of Willamette Valley Land Cover Change, 1982-1994

		acres	**sq. mis.**	**%**
Areal Land Cover	**Areal Change**[(1)]	128,501[(1)]	200.4[(1)]	4.0[(1)]
	No Change	3,066,829	4,791.9	96.0
	Total[(2)]	3,195,330[(2)]	4,992.3[(2)]	100.0
		miles		**%**
Linear Land Cover	**Linear Change**[(1)]	298[(1)]	NA	2.8[(1)]
	No Change	10,465	NA	97.2
	Total	10,763	NA	100.0

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 1982 estimates of study area land cover and the estimates of 1982-1994 changes, and rounding error.

Table 6. Expanded Summary of Willamette Valley Land Cover Change, 1982-1994

	Type of Change	Area Change (acres)	Area or Linear Change (sq. mi. or miles)	Change as % of Study Area[1] or Linear Total[2]	Change as % of Total Change Area[3] or Distance[4]	Change as % of Total 1982 Land Cover Type[5]
Wetland	**Wetland Loss**	9,412	14.4	0.29	7.32	3.45
	Wetland Gain	2,863	4.5	0.09	2.23	1.05
	Net Wetland Loss	**6,549**	**9.9**	**0.20**	**5.10**	**2.40**
	Wetland Change	17,206	26.7	0.54	13.39	6.30
Linear Wetland	**Linear Wetland Loss**	NA	80	0.74	26.85	1.10
	Linear Wetland Gain	NA	61	0.57	20.47	0.84
	Net Linear Wetland Loss	NA	**19**	**0.18**	**6.38**	**0.26**
	Linear Wetland Change	NA	142	1.32	47.65	1.95
Deepwater	**Deepwater Loss**	413	0.6	0.01	0.32	0.24
	Deepwater Gain	162	0.2	0.01	0.13	0.10
	Net Deepwater Loss	**251**	**0.4**	**0.01**	**0.20**	**0.15**
Linear Deepwater	**Linear Deepwater Loss**	NA	15	0.14	5.03	0.43
Upland	**Upland Loss**	2,545	4.0	0.08	1.98	0.09
	Upland Gain	9,345	14.6	0.29	7.27	0.34
	Net Upland Gain	**6,800**	**10.6**	**0.21%**	**5.29%**	**0.23**
	Upland Change	98,925	154.6	3.10	76.98	3.59

Notes:
[1] total study area: 3,195,391 acres
[2] total 1982 linear features: 10,763 miles
[3] total area with change: 128,501 acres
[4] total linear features with change: 298 miles
[5] total 1982 wetlands: 272,952 acres; total 1982 linear wetlands: 7,299 miles; total 1982 deepwater: 169,979 acres; total 1982 linear deepwater: 3,464 miles; total 1982 upland: 2,752,460 acres

Table 7. Details of Areal Land Cover Type Loss, Gain, Net Loss/Gain, and Wetland Type Change, 1982-1994

		1982 - 1994 Net Loss/Gain				Components of Net Loss/Gain					
Category	**Land Cover Type**	**1982 (acres)**	**1994 (acres)**	**Net Loss/Gain (acres)**	**% Net Loss/Gain**	**Total Loss (acres)**	**% Total Loss**	**Total Gain (acres)**	**% Total Gain**	**Net Change [1] (acres)**	**% Total Net Change**
Wetland	**PEM**	79,252	82,468	3,216	4.1	-5,188	41.9	702	5.7	7,702	6.6
	Sub-Total	**79,252**	**82,468**	**3,216**	**4.1**	**-5,188**	**41.9**	**702**	**5.7**	**7,702**	**6.6**
	PFO	91,303	87,606	-3,697	-4.0	-2,496	20.2	17	0.1	-1,218	-1.0
	PSS	16,300	17,445	1,145	7.0	-418	3.4	342	2.8	1,221	1.1
	Sub-Total	**107,603**	**105,051**	**-2,552**	**-2.4**	**-2,914**	**23.6**	**359**	**2.9**	**3**	**0.0**
	PAB	2,145	2,215	70	3.3	-82	0.7	52	0.4	100	0.1
	Pf	73,873	65,962	-7,911	-10.7	-613	5.0	667	5.4	-7,965	-6.9
	PUB	9,897	10,641	744	7.5	-499	4.0	1,083	8.8	160	0.1
	PUS	182	66	-116	-63.7	-116	0.9	0	0.0	0	0.0
	Sub-Total	**86,097**	**78,884**	**-7,213**	**-8.4**	**-1,310**	**10.6**	**1,802**	**14.6**	**-7,705**	**-6.6**
	Total	**272,952**	**266,403**	**-6,549**	**-2.4**	**-9,412**	**76.1**	**2,863**	**23.1**	**0**	**0.0**
Deepwater	**LAC**	78,593	78,531	-62	-0.1	-97	0.8	35	0.3	0	0.0
	RIV	91,386	91,197	-189	-0.2	-316	2.6	127	1.0	0	0.0
	Total	**169,979**	**169,728**	**-251**	**-0.1**	**-413**	**3.3**	**162**	**1.3**	**0**	**0.0**
Upland	**UA**	1,600,425	1,588,672	-11,753	-0.7	-2,147	17.4	6,510	52.6	-16,116	-13.9
	UB	372,199	423,501	51,302	13.8	0	0.0	576	4.7	50,726	43.7
	UFP	14,302	20,611	6,309	44.1	0	0.0	155	1.3	6,154	5.3
	UO	705,376	666,480	-38,896	-5.5	-389	3.1	1,086	8.8	-39,593	-34.1
	URD	60,158	59,996	-162	-0.3	-9	0.1	1,018	8.2	-1,171	-1.0
	Total	**2,752,460**	**2,759,260**	**6,800**	**0.2**	**-2,545**	**20.6**	**9,345**	**75.5**	**0**	**0.0**
Total		**3,195,391**	**3,195,391**	**0**	**0**	**-12,370**	**100.0**	**12,370**	**100.0**	**0[2]**	**100.0**

Note: [1] Net Change: net loss or gain of cover type resulting from change (e.g., change from one wetland type to another wetland type)
[2] Net Change total area is 116,131 acres: wetland 17,206 acres; upland 98,925 acres; deepwater 0 acres.

Table 8. Details of Willamette Valley Linear Feature Loss, Gain, Net Loss/Gain, and Wetland Type Change, 1982-1994

		1982 - 1994 Net Loss/Gain				Components of Net Loss/Gain					
Category	**Land Cover Type**	**1982 (miles)**	**1994 (miles)**	**Net Loss/Gain (miles)**	**% Loss/Gain**	**Total Loss (miles)**	**% Total Loss**	**Total Gain (miles)**	**% Total Gain**	**Net Change [1] (miles)**	**% Total Net Change**
Wetland	**PEM**	4,781	4,797	16	0.3	-55	57.9	16	26.2	55	38.7
	Sub-Total	**4,781**	**4,797**	**16**	**0.3**	**-55**	**57.9**	**16**	**26.2**	**55**	**38.7**
	PFO	504	437	-67	-13.3	0	0.0	0	0.0	-67	-47.2
	PSS	518	497	-21	-4.1	-24	25.3	0	0.0	3	2.1
	Sub-Total	**1,022**	**934**	**-88**	**-8.6**	**-24**	**25.3**	**0**	**0.0**	**-64**	**-45.1**
	PAB	8	45	37	462.5	0	0.0	37	60.7	0	0.0
	Pf	1,475	1,484	9	0.6	-1	1.1	1	1.6	9	6.3
	PUB	13	13	0	0.0	0	0.0	0	0.0	0	0.0
	PUS	0	7	7	NA	0	0.0	7	11.5	0	0.0
	Sub-Total	**1,496**	**1,549**	**53**	**3.5**	**-1**	**1.1**	**45**	**73.8**	**9**	**6.3**
	Total	**7,299**	**7,280**	**-19**	**-0.3**	**-80**	**84.2**	**61**	**100.0**	**0**	**0.0**
Deepwater	**RIV**	3,464	3,449	-15	-0.4	-15	15.8	0	0.0	0	0.0
	Total	**3,464**	**3,449**	**-15**	**-0.4**	**-15**	**15.8**	**0**	**0.0**	**0**	**0.0**
Total		**10,763**	**10,729**	**-34**	**-0.3**	**-95**	**100.0**	**61**	**100.0**	**0[2]**	**100.0**

Note: [1] Net Change: net loss or gain of cover type resulting from change (e.g., change from one wetland type to another wetland type)
[2] Net Change total area is 142 miles: wetland 142 miles; deepwater 0 miles

3.2.2 Willamette Valley Wetland Loss

In 1982, wetlands covered 8.5% (272,952 acres or 427 square miles) of the study area (Table 2). By 1994, 9,412 acres (14.4 square miles or 3.5% of the 1982 total) of these wetlands were converted to upland or deepwater habitat while 2,863 acres (4.5 square miles) of upland and deepwater habitat were converted to wetland, representing a net wetland loss of 6,549 acres (9.9 square miles or 2.4% of the 1982 total) of wetland from 1982 to 1994 (Tables 6 and 7). The details of the gross losses are shown in Table 9. The largest loss of wetland cover type occurred in *palustrine emergent* (5,188 acres or 55% of the total loss). Conversions to *upland agriculture* were accountable for the largest losses in *palustrine emergent* (39% of PEM loss) as well as the largest losses to all wetland cover types (69% of total wetland loss). Wetland conversion to urban land cover types (UB, URD and UO) accounted for 28% of the total wetland loss.

Similarly, net losses occurred with linear wetlands. In 1982, there were 7,299 miles of linear wetlands (Table 2). By 1994, there were losses of 80 miles and gains of 61 miles for a net loss of 19 miles (0.3% of the 1982 total, Tables 6 and 8). Many of the gains and losses associated with linear wetlands occurred in conjunction with gains and losses in areal wetlands. Table 10 details the gross linear losses. The largest loss was in linear *palustrine emergent* and conversions to *upland built* resulted in the largest loss of this wetland type. Conversions to *upland agriculture* and *upland built* were accountable for the majority of the losses (43% and 41% of the total linear loss, respectively).

3.2.3 Willamette Valley Wetland Gain

During the study period, 2,863 acres (4.5 square miles) of upland were converted to wetland (1% of the 1982 wetland area). Table 11 details the gains. The largest wetland increase was into *palustrine unconsolidated bottom* (38% of the total gain). This type of wetland is primarily farm ponds and stock ponds. *Upland agriculture* was the source for 75% of all gains. The gains observed in *palustrine unconsolidated bottom* were well distributed across the study area, occurring in 13 sections (11% of the study sites).

From 1982 to 1994, 61 miles of linear wetland were gained (1% of the 1980 linear wetland total). Table 12 details the linear gains. The major gain was in linear *palustrine aquatic bed* wetland. Conversions from *upland agriculture* were accountable for all of the gains in *palustrine aquatic bed* and 62% of the linear total gain.

Table 9. Details of Willamette Valley Areal Wetland Losses, 1982-1994

			To 1994																	
			Upland											Deep-water					Total	
			UA		UB		UFP		UO		URD		Total Loss	LAC		RIV		Total Loss		
			ac.	%	ac.	%	ac.	%	ac.	%	ac.	%	%	ac.	%	ac.	%	%	ac.	%
From 1982	**PEM**	**PEM**	3,677	39.1	255	2.7	150	1.6	591	6.3	515	5.5	55.1						**5,188**	**55.1**
		Total	**3,677**	**39.1**	**255**	**2.7**	**150**	**1.6**	**591**	**6.3**	**515**	**5.5**	**55.1**						**5,188**	**55.1**
	PFO + PSS	**PFO**	1,871	19.9	298	3.2	5	0.1	150	1.6	143	1.5	26.2			29	0.3	0.3	**2,496**	**26.5**
		PSS	346	3.7	13	0.1			12	0.1	1	<0.1	4.0	35	0.4	11	0.1	0.5	**418**	**4.4**
		Total	**2,217**	**23.6**	**311**	**3.3**	**5**	**0.1**	**162**	**1.7**	**144**	**1.5**	**30.2**	**35**	**0.4**	**40**	**0.4**	**0.8**	**2,914**	**31.0**
	Other Palus.	**PAB**							82	0.9			0.9						**82**	**0.9**
		Pf	605	6.4					8	0.1			6.5						**613**	**6.5**
		PUB	11	0.1					128	1.4	359	3.8	5.3			1	<0.1	<0.1	**499**	**5.3**
		PUS			10	0.1			106	1.1			1.2						**116**	**1.2**
		Total	**616**	**6.5**	**10**	**0.1**			**324**	**3.4**	**359**	**3.8**	**13.9**			**1**	**<0.1**	**<0.1**	**1,310**	**13.9**
	Total		**6,510**	**69.2**	**576**	**6.1**	**155**	**1.6**	**1,077**	**11.4**	**1,018**	**10.8**	**99.2**	**35**	**0.4**	**41**	**0.4**	**0.8**	**9,412**	**100**

Table 10. Details of Willamette Valley Linear Wetland Losses, 1982-1994

		To 1994									
		UA		UB		URD		UO		Total	
		mis.	(%)	mis.	(%)	mis.	(%)	mis.	(%)	mis.	(%)
From 1982	**PEM**	11	(13.8)	33	(41.3)	8	(10.0)	3	(3.8)	**55**	**(68.8)**
	PSS	22	(27.5)			2	(2.5)			**24**	**(30.0)**
	Pf	1	(1.3)							**1**	**(1.3)**
	Total	**34**	**(42.5)**	**33**	**(41.3)**	**10**	**(12.5)**	**3**	**(3.8)**	**80**	**(100.0)**

Table 11. Details of Willamette Valley Areal Wetland Gains from 1982 to 1994

			To 1994																	
			PEM		PEM + PSS						Oth. Pal.								TOT.	
			PEM (ac.)	(%)	PFO (ac.)	(%)	PSS (ac.)	(%)	Tot. (ac.)	(%)	PAB (ac.)	(%)	Pf (ac.)	(%)	PUB (ac.)	(%)	Tot. (ac.)	(%)	(ac.)	(%)
From 1982	**Upl.**	**UA**	469	16.4			38	1.3	38	1.3	49	1.7	663	23.2	928	32.4	57.3	1,640	**2,147**	**75.0**
		URD													9	0.3	0.3	9	**9**	**0.3**
		UO	96	3.4	17	0.6	37	1.3	54	1.9	3	0.1	4	0.1	146	5.1	5.3	153	**303**	**10.6**
		Tot.	565	**19.7**	17	**0.6**	75	**2.6**	92	**3.2**	52	**1.8**	667	**23.3**	1,083	**37.8**	**62.9**	1,802	**2,459**	**85.9**
	Deep-water	**LAC**	27	0.9			70	2.4	70	2.4									**97**	**3.4**
		RIV	110	3.8			197	6.9	197	6.9									**307**	**10.7**
		Tot.	137	**4.8**			267	**9.3**	267	**9.3**									**404**	**14.1**
	Total		**702**	**24.5**	**17**	**0.6**	**342**	**11.9**	**359**	**12.5**	**52**	**1.8**	**667**	**23.3**	**1,083**	**37.8**	**62.9**	**1,802**	**2,863**	**100.0**

Table 12. Details of Willamette Valley Linear Wetland Gains from 1982 to 1994

			To 1994											
			PEM		Other Pal.								TOTAL	
			PEM (mis.)	(%)	PAB (mis.)	(%)	Pf (mis.)	(%)	PUS (mis.)	(%)	Total (mis.)	(%)	(mis.)	(%)
From 1982	**Upland**	**UA**			37	(61)	1	(2)			38	(62)	**38**	**(62)**
		UO	12	(20)					7	(11)	7	(11)	**19**	**(31)**
		Total	12	(20)	37	(61)	1	(2)	7	(11)	45	(74)	**57**	**(93)**
	Deep-water	**RIV**	4	(7)									**4**	**(7)**
		Total	4	(7)									**4**	**(7)**
	TOTAL		**16**	**(26)**	**37**	**(61)**	**1**	**(2)**	**7**	**(11)**	**45**	**(74)**	**61**	**(100)**

3.2.4 Willamette Valley Wetland to Wetland Changes

From 1982 to 1994, 26.7 square miles of wetland (17,206 acres or 6.3% of the total 1982 wetlands) were converted from one type of wetland to another type of wetland. The changes are detailed in Table 13. The largest change was from *palustrine farmed* to *palustrine emergent* (8,708 acres or 51% of the total area converted). Two plots accounted for much of this change. One plot included a wetlands reserve program restoration project; the other captured an agricultural wetland converted to a wetland sewage treatment project. The relatively large change observed from *palustrine forested* to *palustrine emergent*, 2074 acres, was attributable to large changes in two of the sample sections. Also notable from a program perspective was the 260-acre change from *palustrine forested* and *palustrine scrub/shrub* to *palustrine farmed* which, though not large in acreage, indicates conversion of wooded wetlands to agricultural production. In contrast, the relatively large change from *palustrine emergent* to *palustrine scrub/shrub* (2,043 acres) may be largely due to plant community succession.

From 1982 to 1994, 142 miles of linear wetlands (2% of the 1982 total) were converted from one type to another. The linear wetland to wetland changes are shown in Table 14. The largest linear conversion was from *palustrine forested* to *palustrine emergent* (64 miles or 45% of the total linear conversions). *Palustrine emergent* to *palustrine emergent* conversions occurred in three sample sections where areal wetlands were converted to linear wetlands. These types of conversions were also accounted for in the areal losses.

Table 13. Willamette Valley Wetland to Wetland Conversions from 1982 to 1994

			To 1994																	
			PEM		PFO	+	PSS				Oth.	Pal.							Total	
			PEM (ac.)	(%)	PFO (ac.)	(%)	PSS (ac.)	(%)	Tot. (ac.)	(%)	PAB (ac.)	(%)	Pf (ac.)	(%)	PUB (ac.)	(%)	Tot. (ac.)	(%)	(ac.)	(%)
From 1982	**PEM**	**PEM**			294	1.7	2,043	11.9	2,337	13.6	12	0.1	719	4.2	334	1.9	1,065	6.2	**3,402**	**19.8**
		Tot.			**294**	**1.7**	**2,043**	**11.9**	**2,337**	**13.6**	**12**	**0.1**	**719**	**4.2**	**334**	**1.9**	**1,065**	**6.2**	**3,402**	**19.8**
	PFO + PSS	**PFO**	2,074	12.1			684	4.0	684	4.0			127	0.7	19	0.1	146	0.8	**2,904**	**16.9**
		PSS	219	1.3	1,392	8.1			1,392	8.1			133	0.8			133	0.8	**1,744**	**10.1**
		Tot.	**2,293**	**13.3**	**1,392**	**8.1**	**684**	**4.0**	**2,076**	**12.1**			**260**	**1.5**	**19**	**0.1**	**279**	**1.6**	**4,648**	**27.0**
	Oth. Pal.	**Pf**	8,708	50.6			217	1.3	217	1.3					19	0.1	19	0.1	**8,944**	**52.0**
		PUB	103	0.6			21	0.1	21	0.1	88	0.5					88	0.5	**212**	**1.2**
		Tot.	**8,811**	**51.2**			**238**	**1.4**	**238**	**1.4**	**88**	**0.5**			**19**	**0.1**	**107**	**0.6**	**9,156**	**53.2**
	Total		**11,104**	**64.5**	**1,686**	**9.8**	**2,965**	**17.2**	**4,651**	**27.0**	**100**	**0.6**	**979**	**5.7**	**372**	**2.2**	**1,451**	**8.4**	**17,206**	**100.0**

Table 14. Willamette Valley Linear Wetland to Wetland Conversions From 1982 to 1994

		To 1994							
		PEM miles	(%)	PSS miles	(%)	Pf miles	(%)	TOTAL miles	(%)
From 1982	**PEM**	17	(12)	25	(18)	7	(5)	**49**	**(35)**
	PFO	64	(45)			3	(2)	**67**	**(47)**
	PSS	19	(13)			3	(2)	**22**	**(15)**
	Pf	4	(3)					**4**	**(3)**
	Total	**104**	**(73)**	**25**	**(18)**	**13**	**(9)**	**142**	**(100)**

3.2.5 Willamette Valley Net Wetland Losses

Calculating the areal wetland losses and gains from 1982 to 1994 results in the net wetland loss of 6,877 acres to upland land cover types (2.5% of the total 1982 areal wetlands). Table 15 and Figure 3 show the sources of net wetland loss to upland land cover types. The primary cause of wetland loss was attributable to *upland agriculture* at 4,363 acres, or 64% of the total net wetland loss. There was a net wetland loss of 1,585 acres to *upland built* and *upland rural development*, together representing 23% of the loss to upland. *Upland other* and *upland forest plantation* accounted for 11% and 2%, respectively.

If net loss to deepwater habitat cover types is included, there was a net wetland loss during the study period of 6,549 acres or 2.4% of the total 1982 areal wetlands. Tables 6 and 7 show the corresponding losses, gains, and net changes. Table 15 groups the gains and losses by upland and deepwater cover types.

Table 15. Sources of Willamette Valley Net Areal Wetland Losses and Gains

		Net Loss or Gain (acres)	**(%)**	**Wetland Loss (acres)**	**(%)**	**Wetland Gain (acres)**	**(%)**
Net Loss To Upland	**UA**	-4,363	(66.6)	-6,510	(69.2)	2,147	(75.0)
	URD	-1,009	(15.4)	-1,018	(10.8)	9	(0.3)
	UO	-774	(11.8)	-1,077	(11.4)	303	(10.6)
	UB	-576	(8.8)	-576	(6.1)	0	(0.0)
	UFP	-155	(2.4)	-155	(1.6)	0	(0.0)
	Total	**-6,877**	**(105.0)**	**-9,336**	**(99.1)**	**2,459**	**(85.9)**
Net Gain From Deepw.	**LAC**	62	(-1.0)	-35	(0.4)	97	(3.4)
	RIV	266	(-4.1)	-41	(0.4)	307	(10.7)
	Total	**328**	**(-5.1)**	**-76**	**(0.8)**	**404**	**(14.1)**
TOTAL		**-6,549**	**(100.0)**	**-9,412**	**(100.0)**	**2,863**	**(100.0)**

For specific wetland cover types, net losses occurred in *palustrine forested* (4% net loss, 3,697 acres), *palustrine farmed* (11% net loss, 7,911 acres), and *palustrine unconsolidated shore* (64% net loss, 116 acres). All other wetland types had net gains (Table 7 and Figure 4).

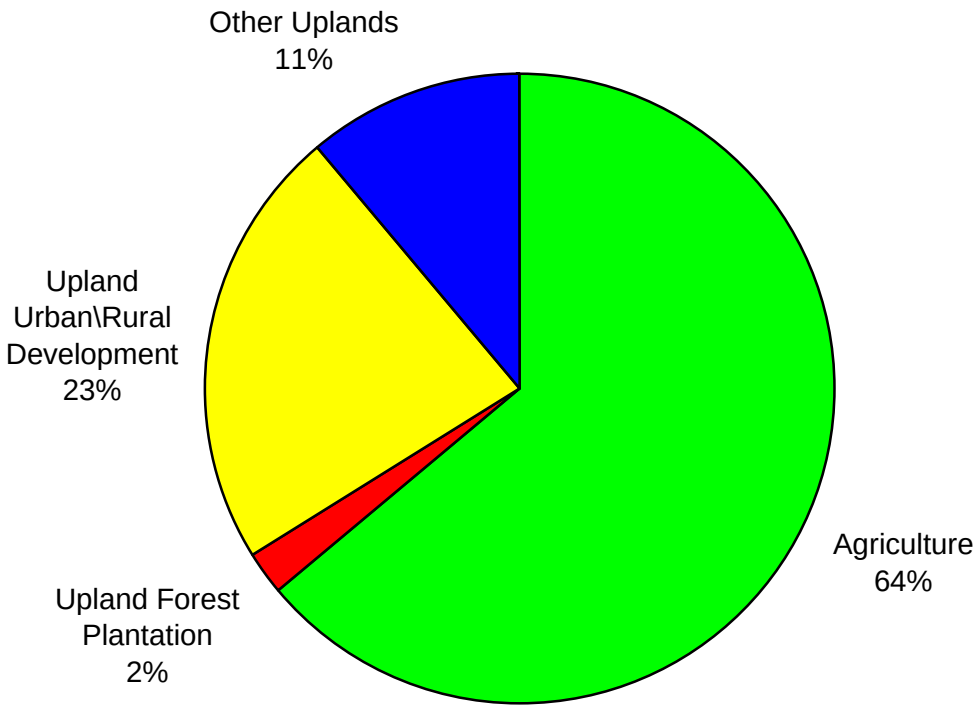


Figure 3. Causes of Willamette Valley Wetland Loss, 1982-1994

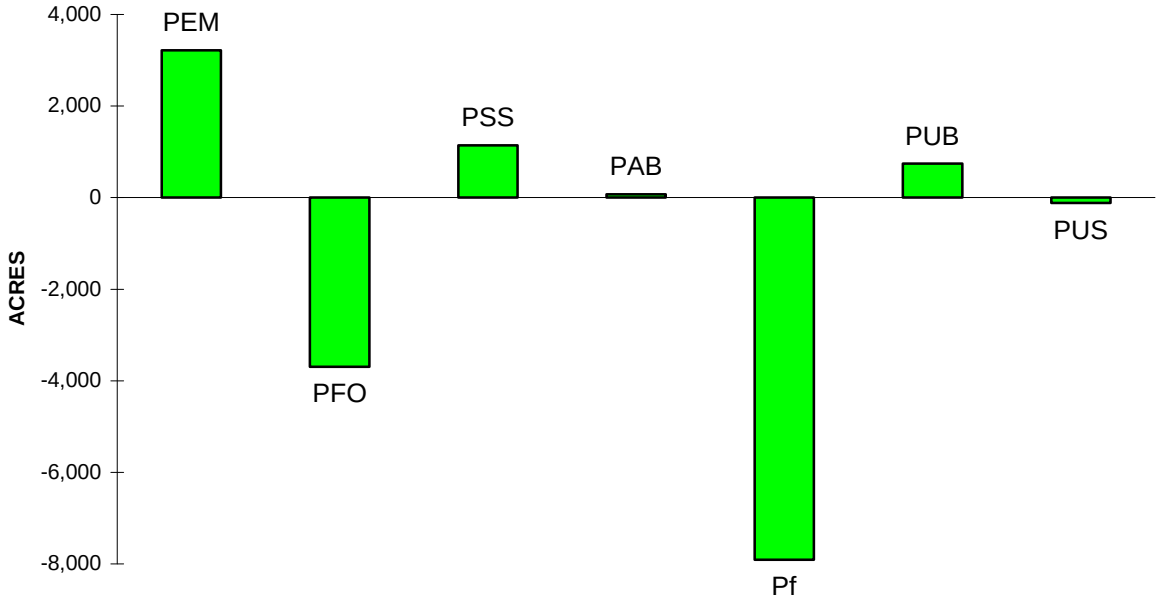


Figure 4. Wetland Loss or Gain by Wetland Type, 1982-1994

The causes of the net losses can be determined by examining Table 7 (detail table), Table 9 (loss), Table 11 (gain), and Table 13 (change). For example, *palustrine forested* had a 3,697 acre net loss resulting from loss of 2,496 acres to upland, a gain of 17 acres from upland, and a "loss" of 1,218 acres from wetland to wetland changes. The loss to upland was largely attributable to *upland agriculture* (1,871 acres or 75% of the 2,496 acre loss). The gain was attributable to *other upland* (100% of the 17 acre gain). The wetland to wetland change net "loss" was primarily attributable to a 1,780 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*. As mentioned previously, the relatively large change observed from *palustrine forested* to *palustrine emergent*, 2074 acres, was attributable to large changes in two of the sample sections that account for 75% of this estimated change.

The largest net gain (*palustrine emergent*, 3,216 acre net gain) and the largest net loss (*palustrine farmed*, 7,911 acre net loss) are directly related by the 8,708 acre change from *palustrine farmed* to *palustrine emergent*. The *palustrine emergent* net gain resulted from a loss of 5,188 acres, a gain of 702 acres, and a gain of 7,702 acres resulting from wetland to wetland changes. The loss was largely attributable to *upland* agriculture (3,677 acres or 71% of the 5,188 acre loss). The gain was also primarily attributable to *upland* agriculture (469 acres or 67% of the 702 acre gain). The wetland to wetland change net gain of 7,702 acres was largely the result of the 8,708 acre change from *palustrine farmed* to *palustrine emergent.*

There was a net loss of 19 miles of linear wetland from 1982 to 1994 (0.3% of the total 1982 linear wetlands). Examination of linear wetland loss, gain, and change data showed that net losses occurred in *palustrine emergent* and *palustrine scrub/shrub* wetland cover types. The causes of the net losses can be determined by examining Table 8 (summary table), Table 10 (loss), Table 12 (gain), and Table 14 (change). Table 16 shows the overall gains and losses attributed to the upland and deepwater cover types. The majority of the net loss was attributable to *upland built* (173% or 33 miles of the 19 mile net total).

Table 16. Sources of Willamette Valley Net Linear Wetland Losses and Gains

		Net Loss or Gain (miles)	(%)	Wetland Loss (miles)	(%)	Wetland Gain (miles)	(%)
Net Loss	**URD**	-10	(53)	-10	(13)	0	(0)
	UB	-33	(173)	-33	(41)	0	(0)
	Total	**-43**	**(226)**	**-43**	**(54)**	**0**	**(0)**
Net Gain	**UO**	16	(-84)	-3	(4)	19	(31)
	UA	4	(-21)	-34	(43)	38	(62)
	RIV	4	(-21)	0	(0)	4	(7)
	Total	**24**	**(-126)**	**-37**	**(47)**	61	(100)
TOTAL		**-19**	**(100)**	**-80**	**(100)**	**61**	**(100)**

3.2.6 Willamette Valley Deepwater Habitat Loss and Gain

From 1982 to 1994, 413 acres of deepwater habitat were lost while 162 acres were gained resulting in a net loss of 251 acres (0.15% of the 1982 total). The gains and losses are shown in Table 17. The net loss was primarily attributable to losses of *riverine* to *palustrine emergent* and *palustrine scrub/shrub*. No conversions from one deepwater type to another deepwater type occurred.

Table 17. Willamette Valley Deepwater Habitat Loss and Gain

			To 1994					
			PEM (ac.)	**PSS (ac.)**	**UO (ac.)**	**LAC (ac.)**	**RIV (ac.)**	**TOTAL (ac.)**
From 1982	**Deepwater Loss**	**LAC**	-27	-70				**-97**
		RIV	-110	-197	-9			**-316**
		Total	**-137**	**-267**	**-9**			**-413**
	Deepwater Gain	**PFO**					29	**29**
		PSS				35	11	**46**
		PUB					1	**1**
		UO					86	**86**
		Total				**35**	**127**	**162**
	Net Change		**-137**	**-267**	**-9**	**35**	**127**	**-251**

3.2.7 Willamette Valley Upland Loss, Gain and Change

From 1982 to 1994, there was a net upland gain of 6,800 acres (10.6 square miles or 0.23% of the 1982 upland area) resulting from a loss of 2,545 acres and a gain of 9,345 acres. Tables 6 and 7 summarize the gains, losses, and changes.

During the study period, 98,925 acres of upland (155 square miles or 3.6% of the 1982 upland area) were converted from one type of upland to another type. Table 18 shows the changes. The largest decrease was from *upland other* (48,426 acres or 49% of the change area) and the largest increase was to *upland built* (50,808 acres or 51% of the change area). The largest type of change (24,910 acres or 25% of the changes) was also from *upland other* to *upland built.* Conversion of *upland agriculture* to all other upland land uses was primarily to *upland forest plantation*, followed by conversion to *upland built* and *upland other* (Table 18 and Figure 5).

Examination of upland change (Table 18), wetland loss (Table 9), and wetland gain (Table 11) data show that *upland agriculture* sustained a net loss of 11,753 acres (0.7% decrease from 1982). As Table 18 shows, 33,405 acres of *upland agriculture* were converted to different upland uses (primarily *upland forested plantation*) while 17,289 acres of upland cover types were converted to *upland agriculture,* for a net loss of 16,116 acres of *upland agriculture* due to upland to upland conversions. As shown in Tables 9 (wetland loss) and 11 (wetland gain), 6,510 acres of *upland agriculture* were gained from wetland while 2,147 acres of *upland agriculture* were lost to wetland. The result was a net loss of 11,753 acres (0.73% of the total area of *upland agriculture* in 1982). (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.)

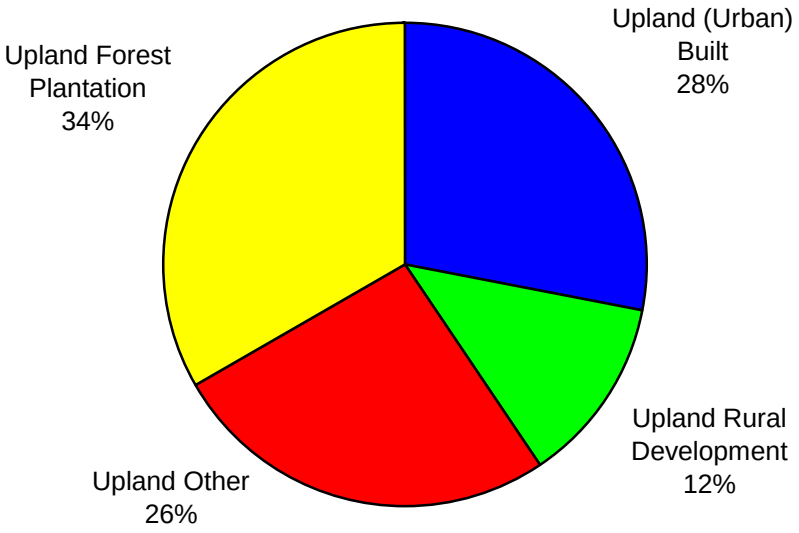
Similarly, *upland built* had a net gain of 51,302 acres (a 14% increase from 1982). The gains are primarily attributable to changes within upland types: a net gain of 24,878 acres from *upland other*, a gain of 10,751 acres from *upland rural development*, a net gain of 9,326 acres from *upland agriculture*, and a gain of 5,771 acres from *upland forest plantations*. There were also a gain of 576 acres from wetlands (primarily *palustrine forested* and *palustrine emergent*).

In comparison, a U.S. Forest Service study of land cover changes on non-federal lands in Western Oregon between 1971-74 and 1982 found a loss of 1% each in the land use classes of forest and agriculture, and gains of 1% each in low density urban and urban land use classes (Gedney and Hiserote, 1989).

Table 18. Willamette Valley Upland to Upland Changes from 1982 to 1994

		To 1994											
		UA acres	**(%)**	**UB acres**	**(%)**	**URD acres**	**(%)**	**UFP acres**	**(%)**	**UO acres**	**(%)**	**Total acres**	**Total (%)**
From 1982	**UA**	NA		9,376	(9.5)	4,139	(4.2)	11,089	(11.2)	8,801	(8.9)	**33,405**	**(33.8)**
	UB	50	(0.1)	NA						32	(<0.1)	**82**	**(0.1)**
	URD	130	(0.1)	10,751	(10.9)	NA						**10,881**	**(11.0)**
	UFP	360	(0.4)	5,771	(5.8)			NA				**6,131**	**(6.2)**
	UO	16,749	(16.9)	24,910	(25.2)	5,571	(5.6)	1,196	(1.2)	NA		**48,426**	**(49.0)**
	Total	**17,289**	**(17.5)**	**50,808**	**(51.4)**	**9,710**	**(9.8)**	**12,285**	**(12.4)**	**8,833**	**(8.9)**	**98,925**	**(100.0)**

Figure 5. Causes of Conversion From Upland Agriculture to Other Upland Land Uses, 1982-1994



3.3 Willamette Valley Wetland Change Pattern

As discussed in Section 3.2.1, there was a net wetland loss of approximately 6,549 acres (9.9 square miles) of wetland from 1982 to 1994. The net losses were evaluated to determine if losses in any wetland types were disproportionate to their relative presence on the landscape in 1982. Tables 19 and 20 address areal and linear losses, respectively, and show the coverage of each wetland type and its percent of the total in 1982, the proportional loss expected based on presence on the landscape in 1982 (% of total x 6,549 acres [net wetland loss]), the observed net loss (from Table 7), and the difference between the actual change and the predicted loss.

Evaluation of the net areal wetland losses showed that disproportionate losses occurred in the following three areal wetland types: *palustrine forested* (3,697 acres lost, 69% [1,506 acres] more than predicted), *palustrine farmed* (7,911 acres lost, 346% [6,139 acres] more than predicted), and *palustrine unconsolidated shore* (116 acres lost, 2,556% [112 acres] more than predicted. The *palustrine forested* loss has been discussed previously. The *palustrine farmed* loss was almost entirely attributable to conversion from *palustrine farmed* to *palustrine emergent*. The *palustrine unconsolidated shore* loss was attributable to loss to upland other. For the other cover types, net gains in acreage occurred (palustrine emergent, palustrine scrub/shrub, palustrine aquatic bed, and palustrine unconsolidated bottom).

Evaluation of the net linear wetland losses showed that disproportionate losses occurred in *palustrine forested* (67 miles lost, 5,000% [66 miles] more than predicted) and *palustrine scrub/shrub* (21 miles lost, 1,457% [20 miles] more than predicted). The *palustrine forested loss* was almost completely attributable to conversion from *palustrine forested* to *palustrine emergent*. The *palustrine scrub/shrub* loss was almost completely attributable to loss to *upland agriculture*.

Table 19. Predicted versus Actual Net Areal Wetland Losses in the Willamette Valley from 1982 to 1994

		Total Willamette Valley 1982 (acres)	(% Tot.)	Predicted Loss 1982-1994 (acres)	(% Tot.)	Actual Change 1982-1994 (acres)	(% Tot.)	Actual - Predicted Loss (acres)
Palustrine Emergent	**PEM**	79,252	(29.0)	-1,902	(29.0)	3216	(-49.1)	5118
	Total	79,252	(29.0)	-1,902	(29.0)	3216	(-49.1)	5118
Pal. Forested and Scrub/Shrub	**PFO**	**91,303**	**(33.5)**	**-2,191**	**(33.5)**	**-3697**	**(56.5)**	**-1506**
	PSS	16,300	(6.0)	-391	(6.0)	1145	(-17.5)	1536
	Total	107,603	(39.4)	-2,582	(39.4)	-2552	(39.0)	30
Other Palustrine	**PAB**	2,145	(0.8)	-51	(0.8)	70	(-1.1)	121
	Pf	**73,873**	**(27.1)**	**-1,772**	**(27.1)**	**-7911**	**(120.8)**	**-6139**
	PUB	9,897	(3.6)	-237	(3.6)	744	(-11.4)	981
	PUS	**182**	**(0.1)**	**-4**	**(0.1)**	**-116**	**(1.8)**	**-112**
	Total	86,097	(31.5)	-2,066	(31.5)	-7213	(110.1)	-5147
Total		**272,952**	**(100.0)**	**-6,549**	**(100.0)**	**-6549**	**(100.0)**	**-0**

Table 20. Predicted versus Observed Net Linear Wetland Losses in the Willamette Valley from 1982 to 1994

		Total Willamette Valley 1982 (miles)	(% Tot.)	Predicted Loss 1982-1994 (miles)	(% Tot.)	Actual Change 1982-1994 (miles)	(% Tot.)	Actual - Predicted Loss (miles)
Palustrine Emergent	**PEM**	4,781	(65.5)	-12	(65.5)	16	(-84.2)	28
	Sub-Total	4,781	(65.5)	-12	(65.5)	16	(-84.2)	28
Palustrine Forested and Scrub/Shrub	**PFO**	**504**	**(6.9)**	**-1**	**(6.9)**	**-67**	**(352.6)**	**-66**
	PSS	**518**	**(7.1)**	**-1**	**(7.1)**	**-21**	**(110.5)**	**-20**
	Sub-Total	1,022	(14.0)	-3	(14.0)	-88	(463.2)	-85
Other Palustrine	**PAB**	8	(0.1)	<1	(0.1)	37	(-194.7)	37
	PF	1,475	(20.2)	-4	(20.2)	9	(-47.4)	13
	PUB	13	(0.2)	<1	(0.2)	0	(0.0)	0
	PUS	0	(0.0)	0	(0.0)	7	(-36.8)	7
	Sub-Total	1,483	(20.5)	-4	(20.5)	53	(-278.9)	57
Total		7,299	(100.0)	-19	(100.0)	-19	(100.0)	0

4.0 CONCLUSIONS AND DISCUSSION

The primary purpose of this study was to examine recent (1982-1994) wetland trends in the Willamette Valley using a robust probability design. Wetlands and land uses were identified from 1:24,000 scale aerial photographs. The smallest possible area of wetland mappable at that scale is approximately 0.25 acre; therefore, the extent or losses of wetlands smaller than 0.25 acre were not captured in this study. The majority of all individually mapped changes observed in the sample sections (loss, gain, and change in wetland, deepwater, upland) were less than 25 acres in size. Individual changes greater than 25 acres were mapped in three occurrences of wetland change from *palustrine forested* to *palustrine emergent*, in one occurrence of wetland change from *palustrine* emergent to *upland* agriculture, and in 25 occurrences of upland changes. As noted in the discussion of wetland changes, large changes in two sample sections were responsible for 75% of the estimated change from *palustrine forested* to *palustrine emergent*.

For wetlands greater than 0.25 acre, of the 427 square miles of wetland present in 1982, there was a net loss of 9.9 square miles (6,549 acres) by 1994. This represents an average annual net loss of 546 acres. These figures represent the net loss of wetland to upland cover types offset by the net gain of wetland from deepwater habitats. The net loss was attributable to loss to *upland agriculture* (67%), *upland rural development* (15%), *other uplands* (12%), *upland built* (9%), and *upland forest plantation* (2%) and net gains from *lacustrine* (1%) and *riverine* (4%).

Considering only the wetland loss to upland land cover types, there was a net loss of 6,877 acres (2.5% of the wetlands present in 1982) attributable to *upland agriculture* (64%), *upland rural development* (15%), *other uplands* (11%), *upland built* (8%), and *upland forest plantation* (2%).

For individual wetland cover types, net losses (including wetland-to-wetland type changes) were sustained by *palustrine forested* (net loss of 3,697 acres, 4% decrease), *palustrine farmed* (net loss of 7,911 acres, 11% decrease), and *palustrine unconsolidated shore* (net loss of 116 acres, 64% decrease). The *palustrine forested* net loss was attributable to losses to *upland agriculture* and wetland to wetland changes (primarily *palustrine forested* to *palustrine emergent*). The *palustrine farmed* net loss was attributable to wetland to wetland changes (mostly *palustrine farmed* to *palustrine emergent*). The *palustrine unconsolidated shore* net loss was attributable to *upland other*. For other wetland cover types, net gains occurred.

Palustrine farmed and *palustrine forested* wetland cover types sustained the greatest net loss or wetland-to-wetland change over the study period and were lost in excess of their relative presence on the landscape. While *palustrine farmed* wetland represented only 27% of the wetland present in 1982, this type accounted for 121% of the net wetland loss to upland use or deepwater habitat. The net loss of the *palustrine farmed* wetland cover

type is almost entirely attributable to conversion to *palustrine emergent*. *Palustrine forested* wetland represented 34% of the wetland present in 1982 and this type accounted for 56% of the net wetland loss. The loss is primarily attributable to upland agriculture (51%) and wetland to wetland conversion (32%), primarily *palustrine forested* to *palustrine emergent*. It is also significant that there was a net conversion of 127 acres of *palustrine forested* to *palustrine farmed*. These results suggests that *palustrine forested* wetlands, especially within agricultural lands, were not effectively protected by regulations and programs in place during that time.

While there was an overall net wetland loss during the study period, approximately 2,863 acres of wetland not present in 1982 had developed by 1994. In this case, *upland agriculture* also was the primary source (75%) and *palustrine unconsolidated bottom* wetland (primarily farm ponds and stock ponds) had the largest gain (38% of total gain). Wetland gains can result from intentional actions aimed at restoring wetland or via neglect and abandonment of drainage systems in agricultural lands.

Some increase in individual wetland cover types occurred from 1982 to 1994. *Palustrine emergent* had a 4% increase resulting from wetland to wetland conversion (primarily *palustrine farmed* and *palustrine forested* to *palustrine emergent*). *Palustrine scrub/shrub*, *palustrine aquatic bed*, and *palustrine unconsolidated bottom* wetlands also had net gains.

There was a net gain of 6,800 acres of upland from 1982 to 1994. *Upland agriculture* had a net loss of 11,753, a decrease of 0.7%. *Upland built* had a net gain of 51,302 acres, an increase of 14%. By comparison, a U.S. Forest Service study of land cover changes on non-federal lands in Western Oregon between 1971-74 and 1982 found a loss of 1% each in the land use classes of forest and agriculture, and gains of 1% each in low density urban and urban land use classes (Gedney and Hiserote, 1989).

The main finding of this study is that wetland losses continue, at the average annual rate of approximately 546 acres per year, despite regulations, programs, and policies designed to curb wetland losses. It must be noted, however, that the time period covered by the study—the mid-1980s to the mid-1990s—was a period when many changes in state and federal wetland policies occurred. At the state level, Oregon passed a comprehensive wetland act in 1989 that strengthened wetland regulation under the existing Removal-Fill Law and established state policies and programs aimed at maintaining the state's wetland resource base. At the federal level, similar policies and programs addressing wetland loss were adopted, and perhaps most significantly, Congress enacted farm bill revisions aimed at reversing historic federal support for conversion of wetlands to crop land and implementing new wetland restoration incentive programs. A follow-up study covering the next decade (1994 to 2004) would provide additional insight into the effects of these programs and policies.

Another significant finding of this study, that agriculture is the main cause of recent wetland loss in the Willamette Valley, is consistent with the draft USFWS *National*

Status and Trends Survey (1997) which reported that 79% of wetland losses in the U.S. between 1985 and 1995 were attributable to agriculture. Additionally, the national study found that the total area of all palustrine wetlands was reduced by 1.2% with individual reductions in palustrine emergent and palustrine forested of 3.4% and 4.9%, respectively.

Change acres from the draft national study and the Willamette Valley study agree fairly well for all palustrine wetlands (national 1.2% loss; Willamette Valley 2.4% loss) and for *palustrine forested* (national 4.9% loss; Willamette Valley 4.0% loss). However, for *palustrine emergent* there is a large difference, with a national 3.4% loss and a Willamette Valley 4.1% gain. This is the result of a large gain in *palustrine emergent* from *palustrine farmed* in the Willamette Valley study.

While this report documents the aerial and linear wetland changes in the Willamette Valley, it does not address changes in quality of remaining wetlands. As urban and agricultural development increases, the quality of wetlands can be expected to deteriorate as a result of factors such as increased sedimentation, water pollution, hydrological alteration, and fragmentation unless adequate measures are taken to protect the quality, as well as the presence, of wetlands.

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