WILSON RIVER WATERSHED ASSESSMENT

Final Report

October, 2001

A Report by:

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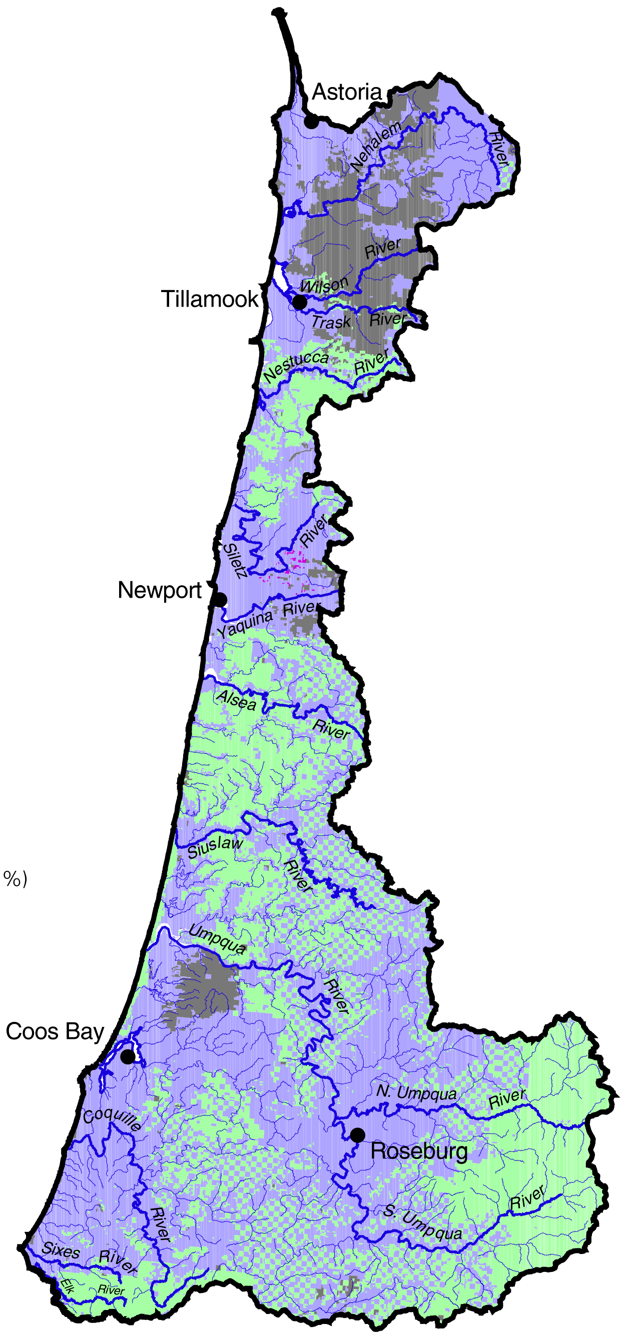
SALMONID ESUs

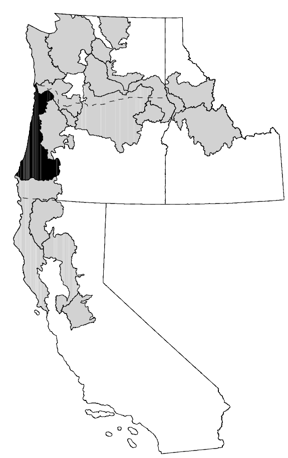
OREGON COAST
CHINOOK SALMON ESU



Land Ownership

- Federal (35%)
- Private (56%)
- State/Local (9%)
- Tribal (less than 1%)

Chinook Salmon ESUs



United States Department of Commerce
National Oceanic & Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
HABITAT CONSERVATION DIVISION
525 N.E. Oregon St., Suite 410
Portland , OR 97232
Tel (503) 231-2223

Scale:

10 0 10 20 30 40 Miles

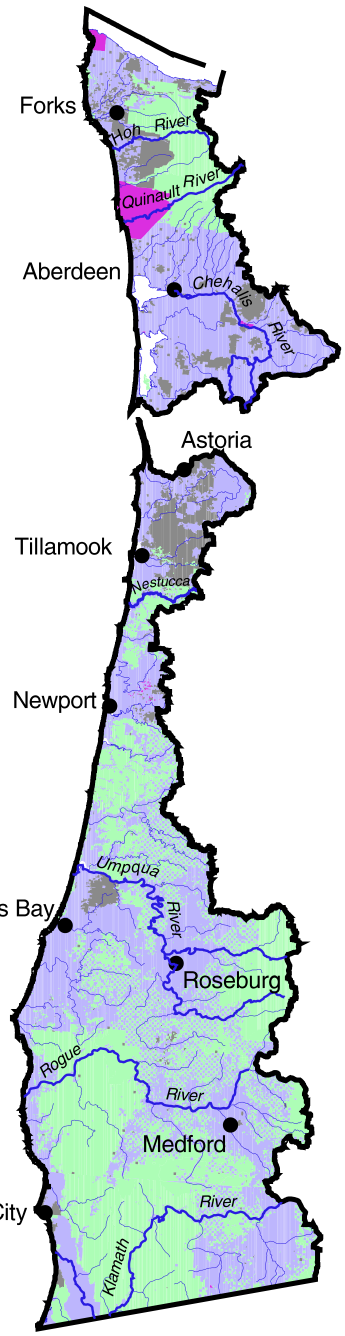
10 0 10 20 30 40 Kilometers

MAP DATE: 2/11/99

CREATED BY: D.H.
HCDGIS\RGN\WS\STONE\CHIN

Note: Map is for general reference only.

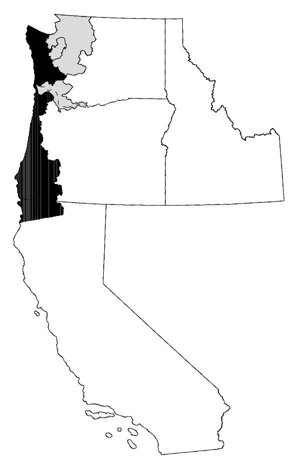
PACIFIC COAST
CHUM SALMON ESU



Land Ownership

- Federal (41%)
- Private (50%)
- State/Local (7%)
- Tribal (2%)

Chum Salmon ESUs



Note: Southern boundry of ESU uncertain.

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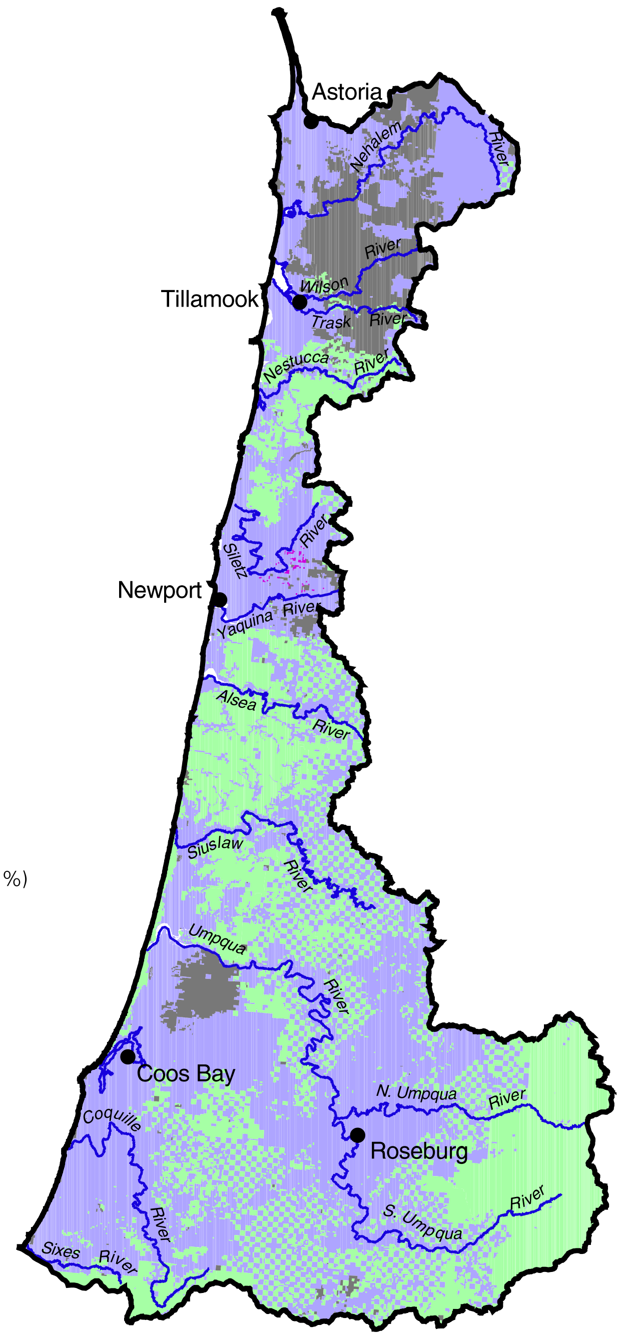
Scale:
25 0 25 50 75 Miles
25 0 25 50 75 Kilometers

MAP DATE: 2/11/99
CREATED BY: D.H.
HCDGIS\RGN\WS\STONE\CHIN

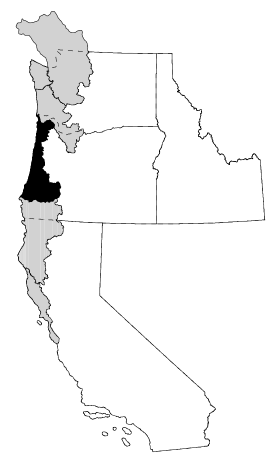
Note: Map is for general reference only.

OREGON COAST
COHO SALMON ESU



Land Ownership

- Federal (35%)
- Private (56%)
- State/Local (9%)
- Tribal (less than 1%)



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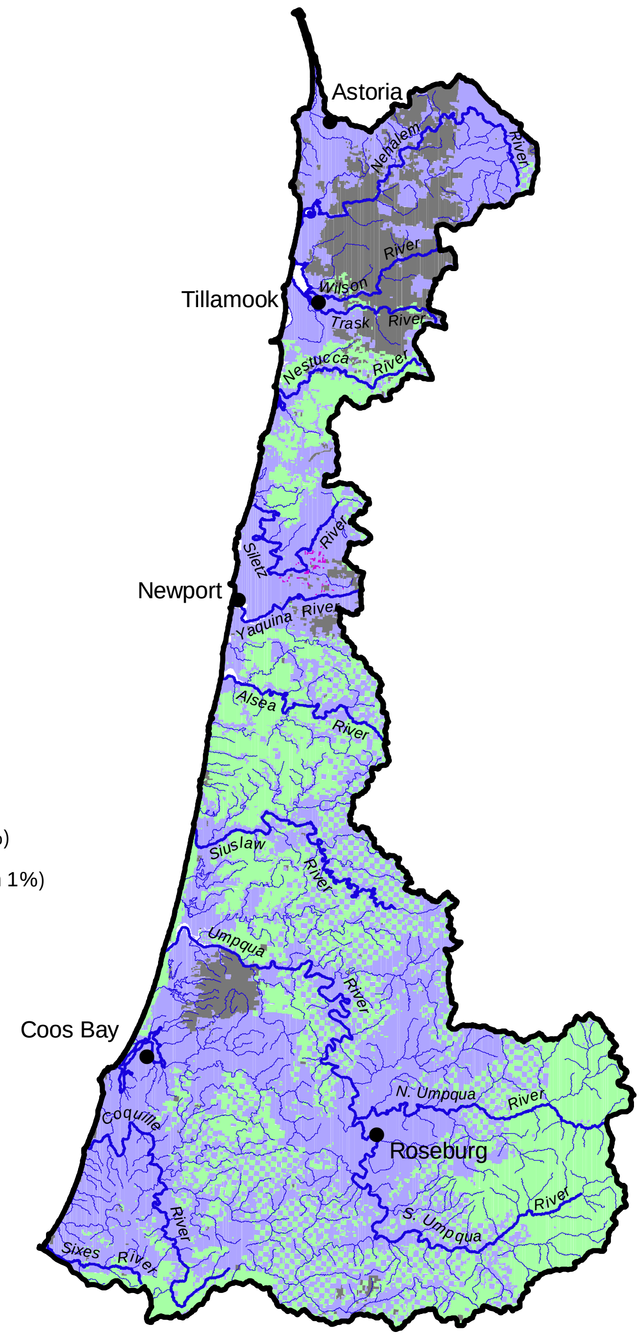
Scale:
10 0 10 20 30 40 Miles
10 0 10 20 30 40 Kilometers

MAP DATE: 2/11/99
CREATED BY: D.H.
HCDGIS\RGN\WS\STONE\CHIN

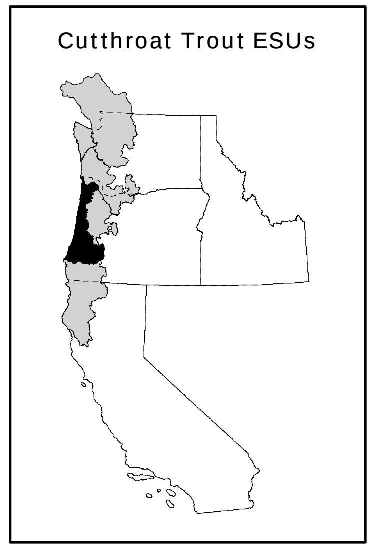
Note: This map is for general reference only.

OREGON COASTAL CUTTHROAT TROUT ESU



Land Ownership

- Federal (35%)
- Private (56%)
- State/Local (9%)
- Tribal (less than 1%)



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Scale:

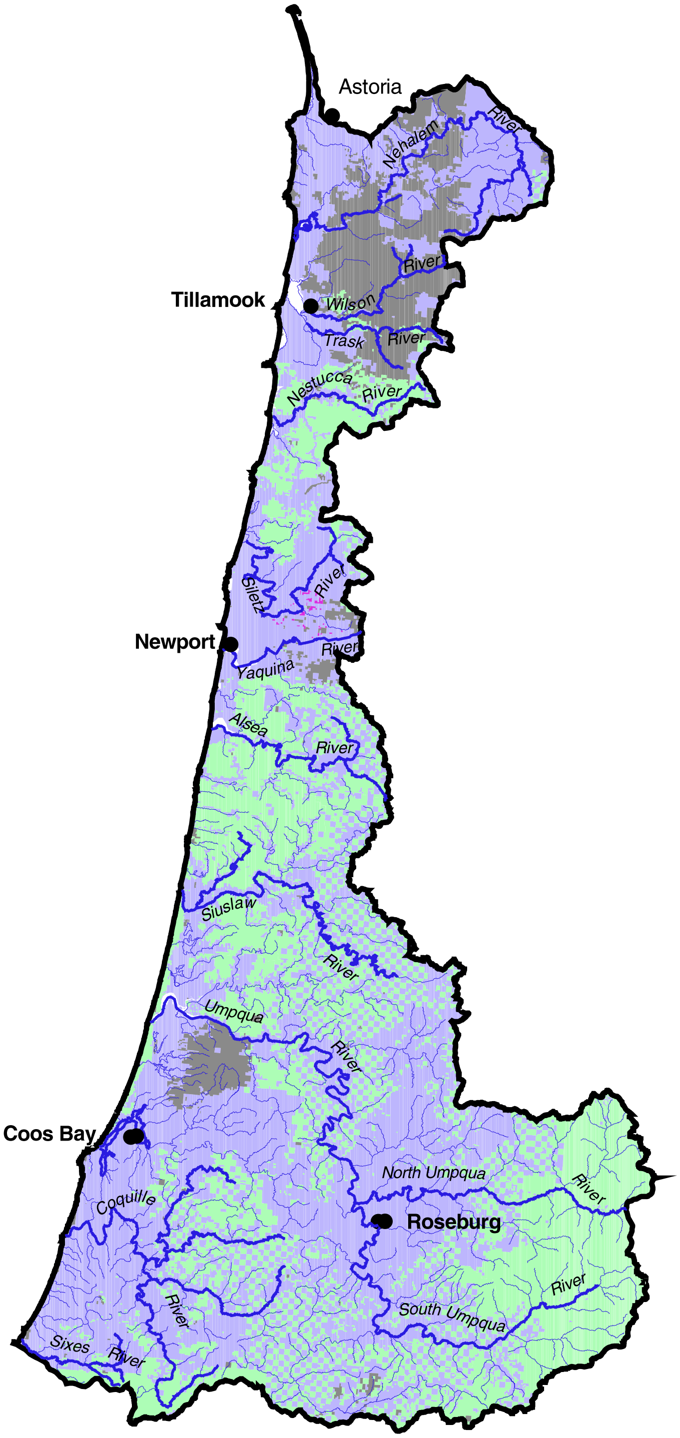
10 0 10 20 30 40 Miles

10 0 10 20 30 40 Kilometers

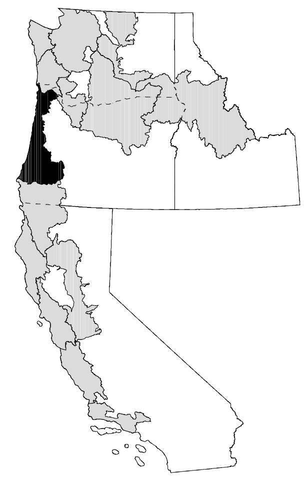
MAP DATE: 2/24/99
CREATED BY: D.H.
HCDGIS\RGN\WS\STONE\CUTTS\

Note: Map is for general reference only.

OREGON COAST STEELHEAD ESU



Steelhead ESUs



Land Ownership

- Federal (35%)
- Private (56%)
- State/Local (8%)
- Tribal (less than 1%)

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SCALE:
10 0 10 20 Miles
10 0 10 20 Kilometers

MAP DATE2/17/99

CREATED BY D.A.
HCDGIS\RGN\WS\STONE\STEEL

Note: Map is for general reference only.

APPENDIX B

WATER USE MODEL OUTPUTS

Table 1. Water availability					
Wilson River at Mouth					
Month	Natural Stream Flow	CU + Stor Prior to 1/1/93	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	1990.00	1.00	1989.00	450.00	0.05
2	1860.00	1.00	1859.00	450.00	0.05
3	1520.00	.98	1519.02	450.00	0.06
4	1040.00	1.02	1038.98	450.00	0.10
5	539.00	1.15	537.85	450.00	0.21
6	294.00	1.56	292.44	160.00	0.53
7	163.00	2.51	160.49	160.00	1.54
8	104.00	2.16	101.84	103.00	2.08
9	106.00	1.13	104.87	105.00	1.07
10	250.00	1.02	248.98	250.00	0.41
11	1440.00	.99	1439.01	520.00	0.07
12	2050.00	1.00	2049.00	520.00	0.05

Table 2. Consumptive Uses and Storages									
Wilson River at Mouth									
Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.02	.00	.00	.03	.00	.94	.01	.00	1.00
2	.01	.00	.00	.03	.00	.94	.01	.00	1.00
3	.00	.00	.00	.03	.00	.94	.01	.00	.98
4	.00	.04	.00	.03	.00	.94	.01	.00	1.02
5	.00	.17	.00	.03	.00	.94	.01	.00	1.15
6	.00	.58	.00	.03	.00	.94	.01	.00	1.56
7	.00	1.53	.00	.03	.00	.94	.01	.00	2.52
8	.00	1.18	.00	.03	.00	.94	.01	.00	2.16
9	.00	.15	.00	.03	.00	.94	.01	.00	1.13
10	.00	.04	.00	.03	.00	.94	.01	.00	1.02
11	.01	.00	.00	.03	.00	.94	.01	.00	.99
12	.02	.00	.00	.03	.00	.94	.01	.00	1.00

Table 3. Water availability

Little North Fork Wilson River at Mouth

Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	198.00	.00	198.00	160.00	0.00
2	187.00	.00	187.00	160.00	0.00
3	149.00	.00	149.00	149.00	0.00
4	90.00	.00	90.00	100.00	0.00
5	39.70	.00	39.70	80.00	0.00
6	24.60	.00	24.60	50.00	0.00
7	13.10	.00	13.10	20.00	0.00
8	7.66	.00	7.66	20.00	0.00
9	7.00	.00	7.00	20.00	0.00
10	16.90	.00	16.90	100.00	0.00
11	120.00	.00	120.00	130.00	0.00
12	197.00	.00	197.00	160.00	0.00

Table 4. Consumptive Uses and Storages

Little North Fork Wilson River at Mouth

Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00	.00
9	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	.00	.00	.00	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table 5. Water availability					
Wilson River ab Little North Fork Wilson					
Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1.00	1700.00	0.22	1699.78	320.00	0.01
2.00	1590.00	0.22	1589.78	320.00	0.01
3.00	1320.00	0.22	1319.78	320.00	0.02
4.00	922.00	0.22	921.78	320.00	0.02
5.00	490.00	0.23	489.77	320.00	0.05
6.00	258.00	0.25	257.75	97.00	0.10
7.00	141.00	0.30	140.70	97.00	0.21
8.00	90.00	0.28	89.72	90.10	0.31
9.00	93.70	0.23	93.47	93.80	0.25
10.00	223.00	0.22	222.78	223.00	0.10
11.00	1270.00	0.22	1269.78	320.00	0.02
12.00	1750.00	0.22	1749.78	320.00	0.01

Table 6. Consumptive Uses and Storages									
Wilson River ab Little North Fork Wilson									
Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.02	.00	.20	.00	.00	.22
2	.00	.00	.00	.02	.00	.20	.00	.00	.22
3	.00	.00	.00	.02	.00	.20	.00	.00	.22
4	.00	.00	.00	.02	.00	.20	.00	.00	.22
5	.00	.01	.00	.02	.00	.20	.00	.00	.23
6	.00	.03	.00	.02	.00	.20	.00	.00	.25
7	.00	.08	.00	.02	.00	.20	.00	.00	.30
8	.00	.06	.00	.02	.00	.20	.00	.00	.28
9	.00	.01	.00	.02	.00	.20	.00	.00	.23
10	.00	.00	.00	.02	.00	.20	.00	.00	.22
11	.00	.00	.00	.02	.00	.20	.00	.00	.22
12	.00	.00	.00	.02	.00	.20	.00	.00	.22

Table 7. Water availability

Wilson River ab Negro Jack Creek at 14301

Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	1690.00	0.15	1689.85	200.00	0.01
2	1580.00	0.15	1579.85	200.00	0.01
3	1310.00	0.15	1309.85	200.00	0.01
4	917.00	0.15	916.85	200.00	0.02
5	488.00	0.15	487.85	150.00	0.03
6	257.00	0.16	256.84	80.00	0.06
7	140.00	0.18	139.82	80.00	0.13
8	89.20	0.17	89.03	80.00	0.19
9	92.80	0.15	92.65	80.00	0.16
10	221.00	0.15	220.85	150.00	0.07
11	1260.00	0.15	1259.85	200.00	0.01
12	1740.00	0.15	1739.85	200.00	0.01

Table 8. Consumptive Uses and Storages

Wilson River ab Negro Jack Creek at 14301

Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.02	.00	.13	.00	.00	.15
2	.00	.00	.00	.02	.00	.13	.00	.00	.15
3	.00	.00	.00	.02	.00	.13	.00	.00	.15
4	.00	.00	.00	.02	.00	.13	.00	.00	.15
5	.00	.00	.00	.02	.00	.13	.00	.00	.15
6	.00	.01	.00	.02	.00	.13	.00	.00	.16
7	.00	.04	.00	.02	.00	.13	.00	.00	.18
8	.00	.03	.00	.02	.00	.13	.00	.00	.17
9	.00	.00	.00	.02	.00	.13	.00	.00	.15
10	.00	.00	.00	.02	.00	.13	.00	.00	.15
11	.00	.00	.00	.02	.00	.13	.00	.00	.15
12	.00	.00	.00	.02	.00	.13	.00	.00	.15

Table 9. Water availability

Fall Creek at Mouth

Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	37.40	0.00	37.40	17.00	0.00
2	35.70	0.00	35.70	17.00	0.00
3	29.90	0.00	29.90	17.00	0.00
4	19.40	0.00	19.40	17.00	0.00
5	9.60	0.00	9.60	9.60	0.00
6	5.80	0.00	5.80	5.83	0.00
7	3.42	0.00	3.42	3.46	0.00
8	2.19	0.00	2.19	2.22	0.00
9	2.33	0.00	2.33	2.37	0.00
10	5.27	0.00	5.27	5.30	0.00
11	26.00	0.00	26.00	17.00	0.00
12	36.30	0.00	36.30	17.00	0.00

Table 10. Consumptive Uses and Storages

Fall Creek at Mouth

Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00	.00
9	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	.00	.00	.00	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table 11. Water availability					
Jordan Creek at Mouth					
Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	253.00	.00	253.00	60.00	0.00
2	239.00	.00	239.00	60.00	0.00
3	203.00	.00	203.00	60.00	0.00
4	142.00	.00	142.00	60.00	0.00
5	76.20	.00	76.20	35.00	0.00
6	43.70	.00	43.70	23.00	0.00
7	24.50	.01	24.49	23.00	0.04
8	15.50	.01	15.49	15.50	0.06
9	16.00	.00	16.00	16.10	0.00
10	37.30	.00	37.30	37.50	0.00
11	195.00	.00	195.00	60.00	0.00
12	255.00	.00	255.00	60.00	0.00

Table 12. Consumptive Uses and Storages									
Jordan Creek at Mouth									
Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	.00	.00	.01
8	.00	.00	.00	.00	.00	.00	.00	.00	.01
9	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	.00	.00	.00	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table 13. Water availability

Wilson River ab Jordan Creek

Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	1130.00	0.05	1129.95	150.00	0.00
2	1060.00	0.05	1059.95	150.00	0.00
3	888.00	0.05	887.95	150.00	0.01
4	630.00	0.05	629.95	150.00	0.01
5	343.00	0.05	342.95	120.00	0.01
6	173.00	0.07	172.93	80.00	0.04
7	92.10	0.10	92.00	30.00	0.11
8	57.60	0.09	57.51	30.00	0.16
9	60.80	0.05	60.75	30.00	0.08
10	148.00	0.05	147.95	120.00	0.03
11	856.00	0.05	855.95	150.00	0.01
12	1170.00	0.05	1169.95	150.00	0.00

Table 14. Consumptive Uses and Storages

Wilson River ab Jordan Creek

Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.02	.00	.03	.00	.00	.05
2	.00	.00	.00	.02	.00	.03	.00	.00	.05
3	.00	.00	.00	.02	.00	.03	.00	.00	.05
4	.00	.00	.00	.02	.00	.03	.00	.00	.05
5	.00	.01	.00	.02	.00	.03	.00	.00	.05
6	.00	.02	.00	.02	.00	.03	.00	.00	.07
7	.00	.05	.00	.02	.00	.03	.00	.00	.10
8	.00	.04	.00	.02	.00	.03	.00	.00	.09
9	.00	.00	.00	.02	.00	.03	.00	.00	.05
10	.00	.00	.00	.02	.00	.03	.00	.00	.05
11	.00	.00	.00	.02	.00	.03	.00	.00	.05
12	.00	.00	.00	.02	.00	.03	.00	.00	.05

Table 15. Water availability					
Cedar Creek at Mouth					
Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	109.00	0.00	109.00	51.00	0.00
2	102.00	0.00	102.00	51.00	0.00
3	84.20	0.00	84.20	51.00	0.00
4	52.70	0.00	52.70	51.00	0.00
5	24.50	0.00	24.50	24.50	0.00
6	13.20	0.00	13.20	13.20	0.00
7	6.13	0.00	6.13	6.08	0.00
8	3.22	0.00	3.22	3.18	0.00
9	2.92	0.00	2.92	2.87	0.00
10	7.89	0.00	7.89	7.77	0.00
11	68.10	0.00	68.10	51.00	0.00
12	110.00	0.00	110.00	51.00	0.00

Table 16. Consumptive Uses and Storages									
Cedar Creek at Mouth									
Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00	.00
9	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	.00	.00	.00	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table 17. Water availability

North Fork Wilson River at Mouth

Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	370.00	0.02	369.98	130.00	0.01
2	344.00	0.02	343.98	130.00	0.01
3	295.00	0.02	294.98	130.00	0.01
4	207.00	0.02	206.98	130.00	0.01
5	112.00	0.02	111.98	112.00	0.02
6	60.70	0.02	60.68	42.00	0.03
7	30.30	0.02	30.28	30.00	0.07
8	17.30	0.02	17.28	17.10	0.12
9	17.20	0.02	17.18	16.90	0.12
10	47.30	0.02	47.28	80.00	0.04
11	326.00	0.02	325.98	130.00	0.01
12	386.00	0.02	385.98	130.00	0.01

Table 18. Consumptive Uses and Storages

North Fork Wilson River at Mouth

Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.02	.00	.00	.02
2	.00	.00	.00	.00	.00	.02	.00	.00	.02
3	.00	.00	.00	.00	.00	.02	.00	.00	.02
4	.00	.00	.00	.00	.00	.02	.00	.00	.02
5	.00	.00	.00	.00	.00	.02	.00	.00	.02
6	.00	.00	.00	.00	.00	.02	.00	.00	.02
7	.00	.00	.00	.00	.00	.02	.00	.00	.02
8	.00	.00	.00	.00	.00	.02	.00	.00	.02
9	.00	.00	.00	.00	.00	.02	.00	.00	.02
10	.00	.00	.00	.00	.00	.02	.00	.00	.02
11	.00	.00	.00	.00	.00	.02	.00	.00	.02
12	.00	.00	.00	.00	.00	.02	.00	.00	.02

Table 19. Water availability					
Elk Creek at Mouth					
Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	88.50	0.00	88.50	51.00	0.00
2	83.20	0.00	83.20	51.00	0.00
3	71.70	0.00	71.70	51.00	0.00
4	50.00	0.00	50.00	50.00	0.00
5	27.10	0.00	27.10	27.10	0.00
6	13.80	0.00	13.80	13.70	0.00
7	6.52	0.00	6.52	6.50	0.00
8	3.57	0.00	3.57	3.55	0.00
9	3.50	0.00	3.50	3.48	0.00
10	9.14	0.00	9.14	9.08	0.00
11	64.30	0.00	64.30	51.00	0.00
12	89.70	0.00	89.70	51.00	0.00

Table 20. Consumptive Uses and Storages									
Elk Creek at Mouth									
Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00	.00
9	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	.00	.00	.00	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table 21. Water availability

Devils Lake Fork at Mouth

Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	187.00	0.00	187.00	68.00	0.00
2	178.00	0.00	178.00	68.00	0.00
3	148.00	0.00	148.00	68.00	0.00
4	105.00	0.00	105.00	68.00	0.00
5	58.60	0.00	58.60	40.00	0.00
6	26.30	0.00	26.30	26.30	0.00
7	14.60	0.00	14.60	14.70	0.00
8	9.67	0.00	9.67	9.68	0.00
9	11.30	0.00	11.30	11.30	0.00
10	23.20	0.00	23.20	23.20	0.00
11	107.00	0.00	107.00	68.00	0.00
12	181.00	0.00	181.00	68.00	0.00

Table 22. Consumptive Uses and Storages

Devils Lake Fork at Mouth

Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	.00	.00	.00	.00
7	.00	.00	.00	.00	.00	.00	.00	.00	.00
8	.00	.00	.00	.00	.00	.00	.00	.00	.00
9	.00	.00	.00	.00	.00	.00	.00	.00	.00
10	.00	.00	.00	.00	.00	.00	.00	.00	.00
11	.00	.00	.00	.00	.00	.00	.00	.00	.00
12	.00	.00	.00	.00	.00	.00	.00	.00	.00

Table 23. Water availability

South Fork Wilson at Mouth

Month	Natural Stream Flow	CU + Stor	Expected Stream Flow	Instream Water Rights	% flow appropriated
1	124.00	0.01	123.99	110.00	0.01
2	118.00	0.01	117.99	110.00	0.01
3	102.00	0.01	101.99	102.00	0.01
4	75.10	0.01	75.09	75.10	0.01
5	44.10	0.01	44.09	44.10	0.02
6	23.90	0.01	23.89	24.00	0.04
7	14.50	0.01	14.49	14.60	0.07
8	9.91	0.01	9.90	10.00	0.10
9	11.20	0.01	11.19	11.40	0.09
10	22.20	0.01	22.19	22.50	0.05
11	87.90	0.01	87.89	88.40	0.01
12	121.00	0.01	120.99	110.00	0.01

Table 24. Consumptive Uses and Storages

South Fork Wilson at Mouth

Month	Storage	Irrigation	Munic	Ind/Man	Commer	Domest	Agricul	Other	Total
1	.00	.00	.00	.00	.00	.01	.00	.00	.01
2	.00	.00	.00	.00	.00	.01	.00	.00	.01
3	.00	.00	.00	.00	.00	.01	.00	.00	.01
4	.00	.00	.00	.00	.00	.01	.00	.00	.01
5	.00	.00	.00	.00	.00	.01	.00	.00	.01
6	.00	.00	.00	.00	.00	.01	.00	.00	.01
7	.00	.00	.00	.00	.00	.01	.00	.00	.01
8	.00	.00	.00	.00	.00	.01	.00	.00	.01
9	.00	.00	.00	.00	.00	.01	.00	.00	.01
10	.00	.00	.00	.00	.00	.01	.00	.00	.01
11	.00	.00	.00	.00	.00	.01	.00	.00	.01
12	.00	.00	.00	.00	.00	.01	.00	.00	.01

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CHAPTER 1. INTRODUCTION

1.1 Purpose and Scope

The purpose of this watershed assessment is to provide an inventory and characterization of watershed conditions in the Wilson River watershed and to provide recommendations that address the issues of water quality, fisheries and fish habitat, and watershed hydrology. This assessment was conducted by reviewing and synthesizing existing data sets and some new data collected by the watershed council, following the guidelines outlined in the Oregon Watershed Enhancement Board (OWEB) watershed assessment manual (WPN 1999).

It is important to note that many watershed processes cannot be characterized as either good or bad. Rather, these processes must be evaluated by their likely impact on valued resources such as salmonid habitat or water quantity and quality. By summarizing the existing conditions of the Wilson River watershed we hope to help natural resource managers and watershed council members to better understand the complex interactions that occur within the watershed. It is through this understanding that watersheds can be managed to protect the natural resources valued by local and national communities.

This assessment is diagnostic. It does not prescribe specific actions for specific stream segments. The intent of this assessment is to provide a decision-making framework for identifying areas of the watershed in need of protection and restoration. The assessment is conducted on a watershed level, recognizing that all parts of a watershed function as a whole and that alteration or loss of one watershed process or component can affect many other processes and components in the watershed.

The Tillamook Bay National Estuary Project (TBNEP) recently characterized many of the resources in the Tillamook Basin, providing good reference for current conditions in the Tillamook Bay watershed as a whole. Consequently, much of the material in this chapter has been taken directly from the Tillamook Bay Environmental Characterization report produced by the TBNEP.

1.1.1 The Decision Making Framework

A major product of the OWEB watershed assessment method is a set of wall-size maps (housed by the watershed council) to be used as a decision-making framework for selecting appropriate sites for on-the-ground restoration. The maps are organized so that they can be directly related to the U.S. Geological Survey (USGS) 1:24,000 quad sheets. Included on the maps are outlines of the quad sheet boundaries, township section, and range lines. These maps allow the information to be compiled by section (Public Land Survey System) and located. By compiling stream information by section, information can be used to make intelligent, science-based decisions regarding where restoration actions are most likely to be successful. All sites selected from the maps for restoration should be field checked before restoration or protection. Wall-size maps provided to the watershed council include anadromous fish distribution, channel habitat type, riparian conditions, and possible fish barrier locations. Additional data are provided in a digital format to the watershed council. This document supplements and expands on the information contained in the maps and the digital database. The maps in this document, by virtue of their scale, are only intended to provide summary visual representation of the data used in this assessment. They are not meant to provide site-specific information. The wall size maps and digital data should be used for identification of on-the-ground restoration opportunities.

1.1.2 Geographic Information Systems (GIS) Data Used in this Assessment

Geographic Information Systems (GIS) are widely used to store and analyze spatial environmental data for the purposes of evaluating watershed condition and guiding appropriate restoration activities. GIS data are only as accurate as their scale and source data. GIS data must be critically reviewed, and in many cases ground-truthed, to assure an accurate representation of on-the-ground conditions in a watershed. Key GIS data sets were evaluated for confidence in positional accuracy and in representing actual watershed conditions.

Major GIS data that were used in the development of this assessment are listed in Table 1.1. Following is a description of each of the data layers used in developing this watershed assessment.

Streams (1:24,000): Stream coverages were obtained from the State Service Center for GIS (SSCGIS) and are a part of the Baseline 97 data set. Streams were digitized from the 1:24,000 USGS quads. A visual check of the stream coverage demonstrated that they match the USGS quadrangles, although the positions of the streams were often slightly different from the streams on the aerial photos.

Channel Habitat Types (1:24,000): Stream channels were divided into distinct segments, based on topographic and geomorphic factors. The 1:24,000 stream coverage was attributed with gradient, side slope constraint, and stream-order, and classified into channel habitat type classes according to the protocol outlined in the OWEB manual (WPN 1999).

Land Use (1:24,000): The land use map was created by TCWRC/TCPP by combining the Western Oregon Land Ownership coverage (developed by OSU), a developed land coverage that was created by Alsea Geospatial for the TBNEP, and NWI wetlands.

Table 1.1 Primary GIS data used in developing this watershed assessment.

Coverage	Scale	Source	Notes
Streams	1:24,000	USGS	From topographic maps scanned by SCGGIS
Channel Habitat Types	1:24,000	E&S	Streams attributed by E&S
Land Use	1:24,000	TCWRC/TCPP	Created by combining data
Vegetation	30 meter	OSU, USFS, & ODFW	CLAMS 1995 LANDSAT
Aerial Photos	1 meter	USDA Farm Service Agency	1990 monochromatic
Watershed Boundaries	1:24,000	USGS, SSCGIS	USGS 4^{th} field watersheds combined with State of Oregon 5^{th} field watersheds
Roads	1:100,000	ODF	Updated DLG (Ad Hoc)
Digital Elevation Models	10 meter	Averstar	Created by TCWRC/TCPP
Riparian Vegetation	1:24,000	E&S	Attributed 1:24,000 streams from aerial photo interpretation
Riparian Shade	1:24,000	E&S	Attributed 1:24,000 streams from aerial photo interpretation
Salmonid Distribution	1:100,000	ODFW	From field surveys by fisheries biologists
ODFW Habitat Surveys	1:100,000	ODFW	Attributed 1:100,000 streams from field surveys
Diked Lands	1:24,000	TCWRC/TCPP	
Debris Flow Potential	1:24,000	ODF	
Points of Diversion	1:24,000	OWRD	Currently being updated

Ownership: Ownership was characterized by Oregon State University using the 1991 Atterbury Ownership maps. This coverage does not include land sales since 1991. It is our assumption that all more recent land sales in the watershed were sales that kept the land in the same category. For example, the sale of Cavenham lands to Willamette Industries kept the land in the Industrial Forest category.

Vegetation: The vegetation characterization was completed using a 1995 LANDSAT image from the Coastal Landscape Analysis and Modeling Study (CLAMS) being conducted jointly by the OSU, USFS Pacific Northwest Research Station, and ODF. The LANDSAT scene was characterized into broadleaf, mixed, and conifer-dominated stands, which were further delineated into four categories based on conifer size (small, medium, large and very large).

Aerial Photos: Monochromatic aerial photos were taken in 1990, and were obtained from the USDA Farm Service Agency. The scale of the photos was 1:7,920.

Watershed Boundaries (1:24,000): The watershed boundaries coverage originated from SSCGIS, and was created by adding fifth-field watersheds to the USGS fourth-field Hydrologic Unit Codes (HUCs). Fifth-field watersheds served as the basis for this assessment. The fifth-field watersheds were drainage basins delineated by the State of Oregon with an average size of approximately 50,000 acres, based on the USGS's hierarchical system of hydrological unit delineation. (For more information on USGS Hydrologic Unit Codes, see the USGS website at http://water.usgs.gov/GIS/huc.html).

Roads (1:100,000): Road data were obtained from the Oregon Department of Forestry (ODF). The road coverage utilized was the non-proprietary ODF transportation layer. Railroads and utility access roads were removed from this data set for the purpose of analysis. A more current road layer was created for ODF by a consultant, but at the time of this report the consultant retained rights to the coverage, so it was not available for analysis. An effort is underway by ODF to obtain the rights to this coverage.

Digital Elevation Models (DEMs; 10 m): The 10 m-resolution DEMs were obtained from the SSCGIS. Ten meter resolution refers to the cell size attributed with elevation data. Cell sizes in this coverage are 10 m by 10 m, or approximately 1,000 sq. ft. DEMs were mosaiced and sinks were filled.

Riparian Vegetation and Shade: The 1:24,000 stream coverage was attributed from aerial photo interpretation (see Aerial Photos above). Attributes include vegetation class and shade. Metadata have been provided with the digital data.

Salmonid Distribution (1:100,000): Salmonid distribution coverages were obtained from the Oregon Department of Fish and Wildlife (ODFW). ODFW mapped current salmonid distribution by attributing 1:100,000 stream coverages based on survey data and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. Theses coverages are dynamic data sets that are scheduled to be updated every two years. They are available on ODFW's website (*http://www.dfw.state.or.us*).

ODFW Fish Habitat Surveys (1:100,000): Field surveys of stream channel conditions by ODFW were attributed onto 1:100,000 scale stream layers. Two layers exist, including habitat units and reach level data. Reach level data generalize habitat unit data to give an overview of current habitat conditions. Reach level data can be used as a reference point for later comparative work or for the analysis of overall stream conditions. Habitat data include all of the unit data for the entire survey and provide a representation of the condition of the stream at the time of survey. These data change annually since streams are dynamic systems.

National Wetlands Inventory (1:24,000): The primary source for wetland information used in this assessment was the National Wetlands Inventory (NWI) maps created by the U.S. Fish and Wildlife Service (USFWS). Very few of the NWI quads had been digitized by USFWS for the Wilson River watershed, so information was generally derived from hard copy NWI maps. It is important to note that NWI wetland maps are based on aerial photo interpretation and not on ground-based inventories of wetlands. On-the-ground inventories of wetlands often find wetlands that are not included on the NWI maps and vice-versa.

Dikes: (1:24,000): The dikes coverage was created by the Watershed Ecosystem Team of the University of Washington. The data represents 1964 conditions, and has not been field-checked for current accuracy. It was based on the Soil Conservation Service soil survey.

Debris Flow Potential: The ODF created debris flow hazard maps based on underlying bedrock geology, slope steepness, historical landslide information, and stream channel confinement where applicable. Slope data were generated from 1:24,000 DEMs. These maps were created to show areas where on-the-ground investigation is prudent before conducting land management and development activities and could be impacted by debris flows. Further information was provided with the digital data.

Points of Diversion (1:24,000): Points of diversion were mapped by the Oregon Water Resources Department (OWRD) by digitizing individual water rights into a township coverage. Only permitted and certificated rights were digitized. All water rights should be up-to-date and maintained by OWRD. Links from points of diversion to actual water rights were found to be missing in this assessment, which was probably due to the database needing to be updated (Bob Harmon pers. comm.).

1.1.3 Data Confidence

GIS data vary in how well they represent actual on-the-ground conditions. Several of the data sets used to develop this assessment need to be evaluated and compared to on-the-ground conditions before restoration actions are taken or final conclusions are made about ecosystem processes. Data sets in need of further evaluation have been listed in the Recommendations section of this document. A few of these will be discussed here because they have characteristics that must be kept in mind while reading this document.

Land Use and Wetlands

The consistency of data quality is uneven for this layer because it is a composite from several sources. The base information was the Western Oregon Forest Ownership, which provides broad coverage, although it is somewhat out-of-date. The TBNEP land coverage layer and NWI wetlands layers that were merged into this coverage improve data quality in the lowland areas, but wetlands in the uplands are probably under-represented. Also, the TBNEP land development coverage was not originally created as a general land use layer, so less attention was given to undeveloped zones in the lowlands.

Roads

The roads coverage is a key coverage used to evaluate potential sediment sources and changes in watershed hydrology associated with road construction. However, it is not clear that the road coverage accurately represents on-the-ground conditions in this watershed. The road coverage was developed from the 1:100,000 USGS digital line graphs. These coverages were then updated on an ad-hoc basis from aerial photos and other information as it became available. A visual comparison of the data to aerial photos found the roads coverage to be fairly thorough. Although this coverage represents the best available data for roads, the data are nevertheless somewhat suspect. A study should be developed to determine the accuracy of the roads data.

Channel Habitat Types

Channel habitat types (CHTs) were determined for this assessment using GIS. Streams were divided into habitat types based on stream size, gradient, valley width, and ecoregion, according to OWEB protocols (WPN 1999). Minimum length of a habit type was 1,000 ft. CHTs provide an overall indication of the quality and distribution of various stream and associated riparian habitats throughout the watershed. Additional field-based assessment will be required for site-specific restoration activities.

Riparian Vegetation and Shade

Riparian conditions need to be further evaluated and ground-truthed before restoration actions occur. A visual comparison of field checks to the aerial photo interpretations found the data to be fairly consistent. After site selection using the GIS data, any stream reach identified for further action should be field-checked for actual on-the-ground conditions. A more rigorous analysis of the GIS data could also be performed (field data have been provided to the watershed council).

Overall, the confidence in the GIS data is moderate to good for watershed-level assessment purposes. Collection of field data is always recommended; however, field data collection is expensive, time consuming and often unfeasible for very large areas. Time can be saved by using the GIS data to select possible sites for restoration. Field verification can then define the exact conditions present. Used in this way, the GIS data can provide an extremely efficient decision-making framework to guide restoration activities.

1.2 Setting

Like most Pacific Northwest estuaries, Tillamook Bay is part of a coastal, temperate rainforest ecosystem. The Bay is surrounded by rich forests associated with the Oregon Coast Range. With mean annual precipitation around 90 inches (229 cm) per year in the lower elevations and close to 200 inches (510 cm) per year in the higher elevations, the watershed's coniferous forests — trees such as Douglas fir (*Pseudotsuga menziesii*), true fir (*Abies* spp.), Sitka spruce (*Picea sitchensis*), western red cedar *(Thuja plicata*), and western hemlock (*Tsuga heterophylla*) — cover about 89% of the total land area. Hardwood species such as red alder (*Alnus rubra*) and big leaf (*Acer macrophyllum*) and vine maple (*A. circinatum*) also grow throughout the region, especially as second growth in riparian areas. Most of the older trees have been lost to fire and timber harvest. Today, Douglas fir is the dominant tree species in the Tillamook Bay watershed. Foresters describe this environment as a highly productive ecosystem, from both biological and commodity perspectives (TBNEP 1998).

In the lower elevations of the watershed, forest gives way to rich alluvial plains used primarily for dairy farming and rural residential housing. Early settlers recognized the rich agricultural potential of the lowlands and drained the area with numerous dikes, levees, and ditches. Once characterized by meandering rivers and networks of wetlands and small channels that provided fish habitat, woody debris, and organic matter; today's 40 mi^2 (104 km^2) lowland supports about 28,600 dairy cattle (calculated in 1,000- pound units, including calves, heifers and dry stock; TBNEP 1998) and produces 95% of Oregon's cheese. Cattle also produce hundreds of thousands of tons of manure annually and much of the bacteria that washes into the estuary (TBNEP 1998).

The Wilson River watershed is one of five fifth-field watersheds that drain into Tillamook Bay (Figure 1.1). Fifth-field watersheds are drainage basins delineated by the State of Oregon with an average size of approximately 50,000 acres, based on the USGS's hierarchical system of hydrological unit delineation. The Wilson River drains approximately 194 sq. mi. of land and is the largest watershed of the Tillamook Bay drainage. The watershed is characterized by steep forested uplands and flat alluvial lowlands. Much of the higher elevations have been clear-cut for timber or were burned as a part of the Tillamook Burns. The lower Wilson River runs adjacent to the City of Tillamook and drains both agricultural and developed areas.

The boundaries of the various subwatersheds defined for this assessment and the stream network are shown in Figure 1.2. Where stream names are known, they were added to the figure for reference purposes. These subwatersheds and many of the individual streams are discussed at various locations in the report.

1.3 Ecoregions

The state of Oregon has been divided into ecoregions based on climate, geology, physiography, vegetation, land use, wildlife and hydrology. Each of these ecoregions has characteristic patterns of climate, geology, topography, and natural vegetation that shape and form the function of the watersheds. Dividing the state and the watersheds into different ecoregions permits regional characteristics to be identified. The Wilson River watershed spans portions of three ecoregions (Omernik 1987): the Coastal Lowlands, Coastal Uplands and Volcanics ecoregions.

The Coastal Lowland ecoregion occurs in the valley bottoms of the Oregon and Washington coast and is characterized by marine estuaries and terraces with low gradient meandering streams. Channelization and diking of these streams is common. Elevations in this ecoregion run from 0 to 300 ft and the land receives 60 to 85 in of annual rainfall. Potential natural vegetation includes Sitka spruce, western hemlock, western red cedar, Douglas-fir, grand fir (*Abies grandis*), red alder, and estuarine wetland plants (Franklin and Dyrness 1973).

Wilson River Watershed

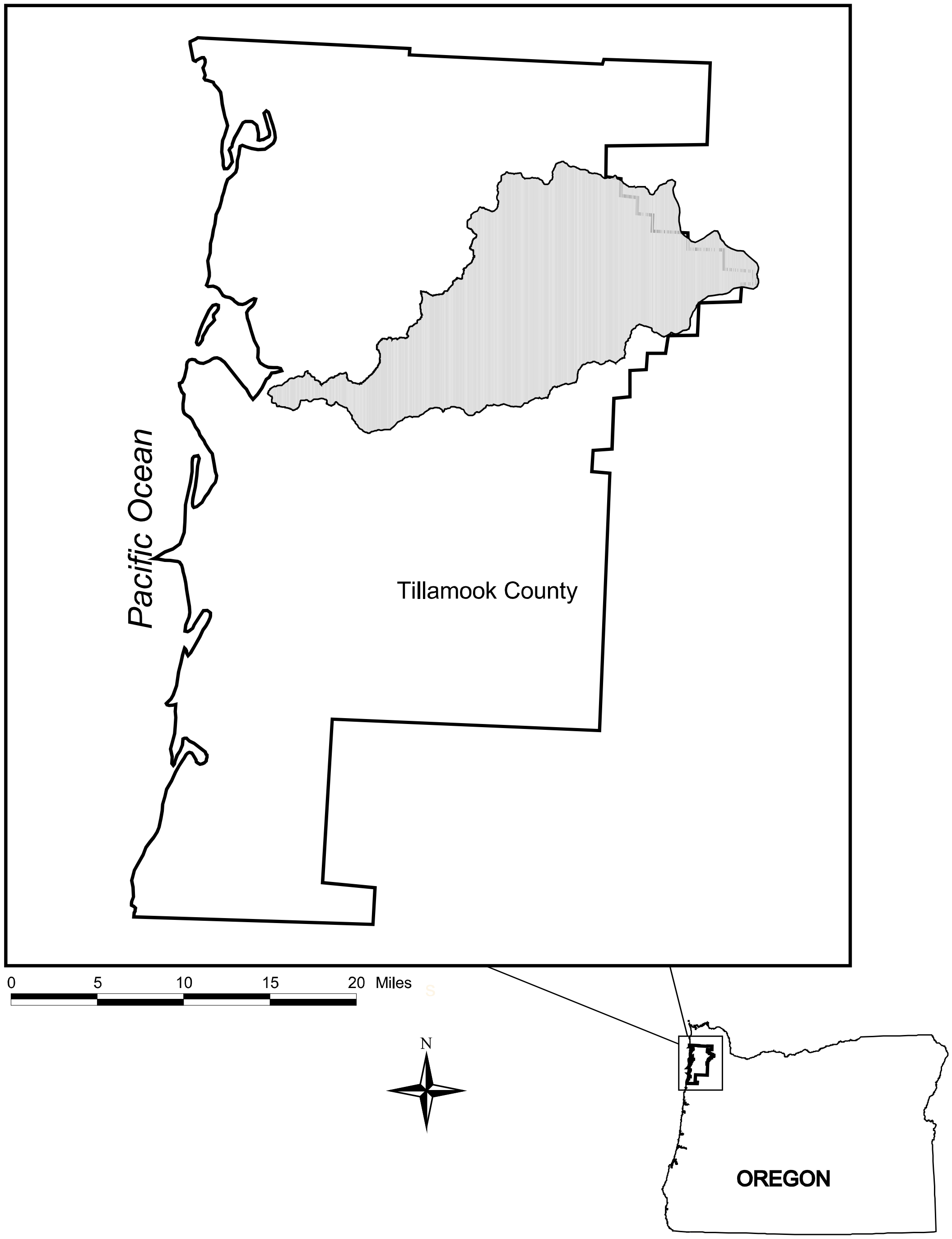

Figure 1.1. Physical location of the Wilson River watershed.

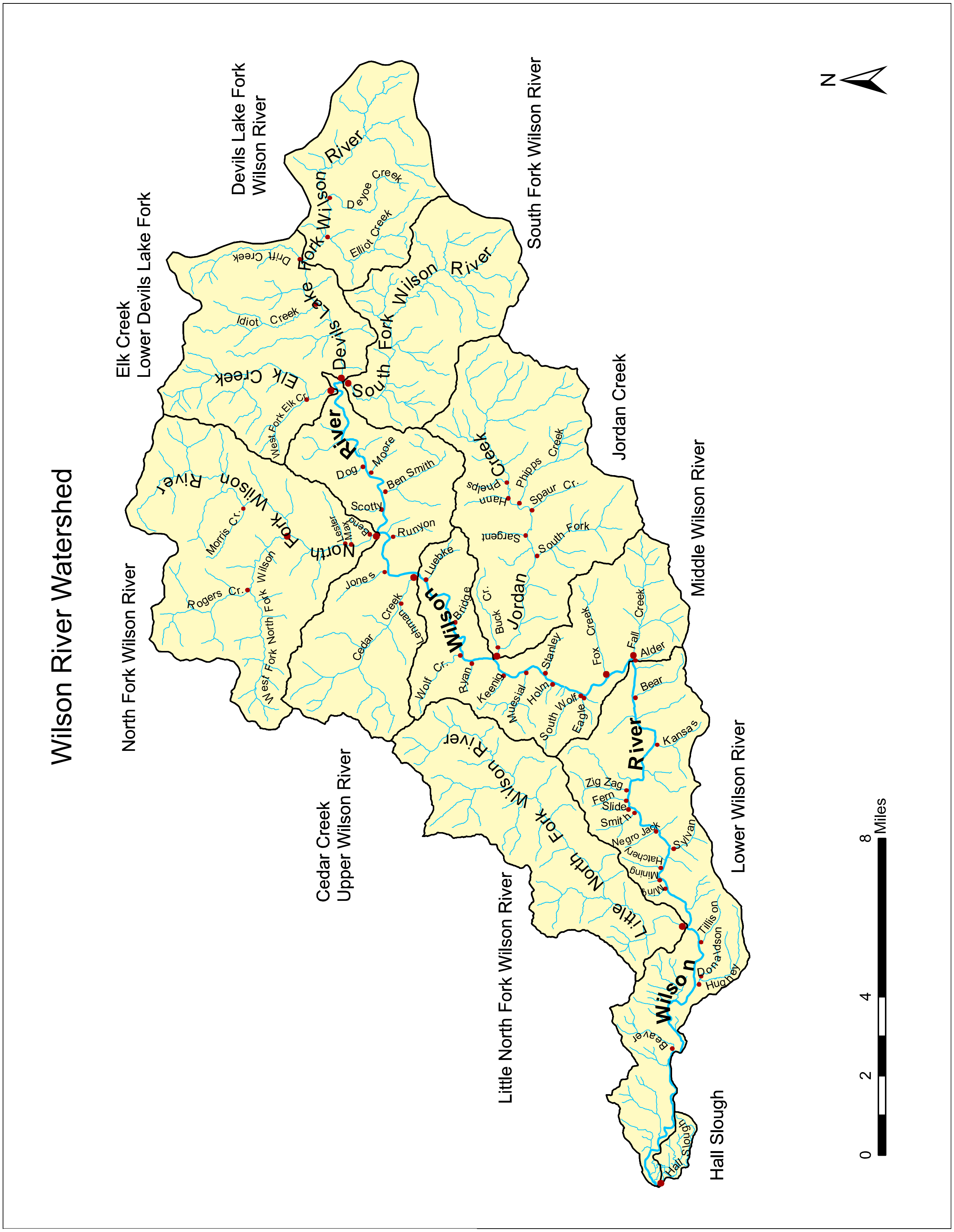

Figure 1.2. Map of watershed showing subwatershed boundaries and stream network, with names of streams indicated.

The Coastal Upland ecoregion extends along the Oregon and Washington coast and is typically associated with the upland areas that drain into the Coastal Lowland ecoregion. The Coastal Upland ecoregion is characterized by coastal upland and headland terraces with medium to high gradient streams. Elevations run from 0 to 500 ft and the land receives 70 to 125 in of precipitation. Potential natural vegetation includes Sitka spruce, western hemlock, western red cedar, Douglas-fir, grand fir, and red alder (Franklin and Dyrness 1973).

The Volcanics ecoregion extends from the upper extent of the Coastal Upland ecoregion to beyond the summit of the Coast Range mountains. The Volcanics ecoregion is characterized by steeply sloped mountains with high-gradient, cascading streams and rivers. Elevations range from 1,000 to 4,000 feet and the region receives 70 to 200 inches of precipitation annually. Potential natural vegetation includes Sitka spruce, western hemlock, western red cedar, Douglas-fir, grand fir, and red alder (Franklin and Dyrness 1973).

1.4 Population

Since 1950, the population of Oregon has doubled and Tillamook County's population has increased by approximately 20% (U.S. Bureau of Census 1990). The Tillamook County population declined in the 1960s and rose sharply between 1970 and 1980, largely as a result of fluctuations in the timber industry (Coulton et al. 1996). The County population stabilized during the 1980s and has risen steadily in the 1990s (Table 1.2). Population growth in Oregon, especially Tillamook County, historically depended on fluctuations in the natural resource industries. In recent years, population growth has been less a reaction to natural resource industries and more a function of living conditions and quality of life concerns (TBNEP 1998).

Although Tillamook County's population has continued to grow, birth rates have decreased and death rates have increased since 1990 (Center for Population Research and Census 1997). Population growth can be attributed primarily to in-migration, which is expected to continue to increase at a rate of 1.5–2% per year (TBNEP 1998).

1.5 Climate and Topography

Topography in the Wilson River watershed is typical of the Pacific Northwest coast where the terrain is characterized by steep upland slopes which provide sediment and organic material to the alluvial plain and estuary below. Much of the lowlands were historic floodplains and

Table 1.2. Population change in Oregon and Tillamook County since 1950 (TBNEP 1998).

Year	Oregon	Avg. Annual % Change	Tillamook County	Avg. Annual % Change
1950	1,521,341	N/A	18,606	N/A
1960	1,768,687	1.63	18,955	0.19
1970	2,091,385	1.82	18,034	-0.49
1980	2,633,156	2.59	21,164	1.74
1990	2,842,321	0.79	21,570	0.19
1995	3,132,000	1.94	23,300	1.53
2000	3,421,399	1.85	24,262	0.83

Source: U.S. Bureau of Census

wetlands that were drained and diked for agricultural and dairy purposes. Elevations in the watershed range from sea level at the ?mouth to 3,691 ft in the headwaters.

The Wilson River watershed experiences a coastal temperate climate strongly influenced by the Pacific Ocean and related weather patterns (Taylor and Hatton 1999). Climate in the Pacific Northwest usually includes an extended winter rainy season followed by a dry summer season. Precipitation patterns reflect a strong orographic effect in which precipitation increases with elevation as moist air masses rise over high terrain causing them to cool and drop more precipitation. Mean annual precipitation ranges from about 90 inches in the lowlands to about 200 inches in the highlands (Daly et al. 1994). Rainfall is the primary source of precipitation in the Wilson River watershed. From 1961 through 1990, The City of Tillamook averaged 90 inches (229 cm) of rain per year with 76% of total precipitation occurring from October through March. The highest precipitation and rainfall events occurred during November, December, and January. Tillamook County averaged more than 23 days per year in which precipitation exceeded 1 inch (2.54 cm). In 1996, however, 126 inches (320 cm) of lowland rain (and very heavy upland rain and snow) led to severe flooding throughout the watershed and caused significant economic and environmental damages.

The seasonal, episodic nature of precipitation defines the natural system. Fall chinook migrate upstream with the first heavy rains in late autumn. Big winter storms cause major landslides in the steeply sloped upland regions. Although heavy storms have characterized the natural system for thousands of years, human activities have exacerbated the impacts and consequences of high rainfall (Coulton et al. 1996). Westerly winds predominate and carry the temperature-moderating effects of the ocean over all of western Oregon. Summers are cool and dry; winters wet and moderate (USDA 1964). Winds blow nearly continuously throughout the year and often reach gale force in the winter. Prevailing winds come from the northwest during the summer and from the south and southwest during the winter (TBNEP 1998).

Temperatures in Tillamook County are moderate. The mean annual temperature is 50.4ºF (10.2ºC), with yearly mean maximum and mean minimum temperatures documented at 59.3ºF (15.1ºC) and 41.6ºF (5.4ºC), respectively. Those 30 years averaged less than one day per year with a temperature over 90ºF (32ºC). September had the greatest number of extreme temperatures while July and August recorded the highest temperature of 102ºF (38.89ºC; TBNEP 1998).

1.6 Geology

Tillamook Bay and its watershed are situated in typical Pacific Northwest coastal terrain. A relatively straight coastline consists of miles of sandy beaches punctuated with cliffs of igneous rock and small inlets such as the Bay. East of the Pacific Coast, the high, steep ridges of the Coast Range climb up to 3,500 feet (1,064 m). These upland areas consist mostly of volcanic basalt base material with overlying soils formed from basalt, shale, and sandstone material. Primarily an Astoria-Hembre association, moderately deep upland soils cover the gently sloping to very steep terrain of the forested uplands (TBNEP 1998).

In the Tillamook Bay Basin, five river valleys dissect the steep slopes of the uplands and bring sediment and organic material to the rich alluvial plain and estuary below. In this setting, a discontinuous coastal plain separates the coast and the mountains. Derived from basalt and sandstone-shale bedrock, these deep, level floodplain soils have been deposited over thousands of years by the streams and rivers. They range in width from a few hundred feet to more than a mile and can extend upstream up to seven miles along broad stream channels. Known as the Nehalem-Brenner-Coquille association, these are among the most fertile soils in the area, but require drainage for maximum productivity. Originally, these soils were almost all forested; but most have been cleared and are used for hay and pasture. Most farmers irrigate their soils in the dry summer months. Between the bottom-land floodplain and the forested regions, extensive alluvial terraces extend up to 80 feet (24 meters). Referred to as the Quillayute-Knappa-Hebo association, these soils have high to medium organic content, but are less fertile than soils on the bottom lands. Alluvial terrace soils make up about 50% of the Tillamook Basin's tillable lands (TBNEP 1998).

1.7 Vegetation

1.7.1 Potential Natural Vegetation

Human activities have greatly altered the vegetation of the Tillamook Bay Watershed. Since the 1850s, European-Americans have cleared and harvested trees, drained wetlands, and established pastures for dairy cattle. In addition, a series of human-caused forest fires beginning in the 1930s burned much of the natural vegetation of the upland forests. Today, most of the mixed conifer upland forests have been replanted in Douglas fir trees. But the natural, or potential vegetation of the Tillamook Basin is evenly distributed between the Sitka spruce and western hemlock vegetation zones. These two vegetation zones extend from British Columbia to Northern California, running roughly parallel to the coast with the hemlock zone also enclosing the Willamette Valley (Franklin and Dyrness 1973).

The spruce zone covers the lower regions of the watershed and normally occurs at elevations below 450 feet (150 meters). It is a wet zone with annual precipitation ranging between 118 inches (300 cm) and 78 inches (200 cm). The nearby ocean adds frequent summer fogs and moisture to otherwise dry months and distinguishes the spruce zone from the higher elevation hemlock zone. The temperature averages 51ºF (10.6ºC) annually with an average January minimum of 40ºF (4.7ºC) and a July maximum of 70ºF (20.6ºC) at Astoria. The soils are deep, fine textured, typically acid (pH 5.0 to 5.5) and high in organic matter (15–20%; TBNEP 1998).

Dense, tall stands of Sitka spruce, western hemlock, western red cedar, Douglas fir, and grand fir dominate the spruce zone. In dune areas close to the ocean, shore pine (*Pinus contorta contorta*) is locally common. Hardwood species occurring in the zone include red alder, bigleaf maple (*Acer macrophyllum*), and occasional California bay (*Umbellularia californica*) with red alder dominating recently disturbed sites and some riparian areas. Understory vegetation is generally composed of a dense growth of shrubs, herbs, ferns, and mossess. Common native species include sword fern (*Polystichum munitum*), wood sorrel (*Oxalis oregona*), red and evergreen huckleberry (*Vaccinium parvifolium* and *V. ovatum*), salal (*Gaultheria shallon*), red elderberry (*Sambucus racemosa*), and western rhododendron (*Rhododendron macrophyllum*; TBNEP 1998).

Successional patterns in the spruce zone following fire or logging are often dominated by a dense shrub community composed of salmonberry (*Rubus spectabilis*), sword fern, elderberry, and huckleberry, with the relative dominance varying with the site conditions. The shrub community can persist for quite some time due to the excellent growing conditions, but at some point it yields to one of two types of seral forest stand. The conifer type is a mixture of spruce, hemlock, and Douglas fir and the hardwood type is a monotypic, dense stand of red alder. Replacement of the alder stand can be very slow, due to the shade provided by the dense shrub understory. The resulting communities are either semipermanent brush fields, spruce stands, or red cedar and hemlock that grew on downed logs (TBNEP 1998).

The hemlock zone normally extends in elevation between 450 feet (150 meters) and the subalpine zone of the Coast Range. With less ocean influence and summer fog, the upland hemlock zone still receives heavy precipitation. In fact, the upland regions average up to 142 inches (360 cm) of rain each year with very little precipitation in the late spring to fall period. The zone temperature averages 50ºF (9.6ºC) annually with a January minimum of 30ºF (-0.7ºC) and a July maximum of 78ºF (25.6 ºC) at Valsetz. The soils are derived from sedimentary and basalt parent materials, of moderate depth and medium acidity, with a high infiltration rate.

In the hemlock zone, the dominant vegetation is dense conifer forest. Forest stands are dominated by Douglas fir, western hemlock, and western red cedar, with other conifers mixed in, such as grand fir, Sitka spruce, and Pacific yew (*Taxus brevifolia*). Hardwood species occurring in the hemlock zone include red alder, bigleaf maple, black cottonwood (*Populus trichocarpa*), and Oregon ash (*Fraxinus latifolia*). Understory vegetation varies with moisture regimes, but in the moist coastal portion of the hemlock zone, sword fern, wood sorrel, vine maple (*Acer circinatum*), and Oregon grape (*Mahonia nervosa*) are the most common species (TBNEP 1998).

Successional patterns in the hemlock zone following fire or clearcut logging bring the first year residual species and invading herbaceous species from the genera *Senecio* and *Epilobium*. This community is replaced during years two to five by one dominated by fireweed (*Epilobium angustifolium*), thistle (*Cirsium vulgare*), and bracken fern (*Pteridium aquilinum*). The next community is dominated by shrubs such as vine maple, Oregon grape, salal, and blackberry species (*Rubus* spp.). Eventually, the shrubs are overtopped by conifers such as Douglas fir (TBNEP 1998).

1.7.2 Historic Floodplain Vegetation

Historically, the Tillamook Valley floodplains were dominated by river bottom forest which consisted of a variety of trees, including black cottonwood, Sitka spruce, red alder, western hemlock, grand fir, big-leaf maple, and western red cedar **(**Figure 1.3**)**. Spruce trees up to 80 inches in diameter and hemlock 60 inches in diameter were used as bearing trees by the early surveyors. These forested floodplains provided woody debris to the lower river and Bay ecosystems, which added complexity to river patterns and nutrients to the rivers and helped to nurture and sustain fish populations. The forests slowed and regulated flooding across the valley floodplains, reduced erosion, and encouraged sediment deposition (Patricia Benner in: Coulton et al. 1996). These forested bottomlands have been replaced by large open pastures and developed lands with little or no woody vegetation in the riparian areas.

1.7.3 Current Vegetation

Vegetation cover in the Wilson River watershed was characterized using the 1995 CLAMS data (Figure 1.4**)**. CLAMS characterized the vegetation by classifying satellite imagery into 15 categories (Table 1.3). The satellite data were acquired in 1988 and updated in 1995. Garono and Brophy (1999) summarized CLAMS data for the Rock Creek watershed by combining these categories to describe the spatial patterns of conifers and open areas. We have used this same approach for the Wilson River watershed.

1.7.4 Large Conifers

Prior to European settlement, Oregon coastal forests were dominated by conifers (Franklin and Dyrness 1973). These forests were changed dramatically by human activities such as forest harvest and natural catastrophic events such as the Tillamook Burns, which changed both the age structure and species present in these forests (Garono and Brophy 1999; TBNEP 1998). Conifers, especially old growth, play an important role in ecosystem function in Oregon watersheds by providing shade and large woody debris to streams, slope stabilization, and habitat for wildlife (Naiman and Bilby 1998). Additionally, near-coast stands receive

Characterization of the Tillamook Bay Valley Historical Landscape Oregon, 1857

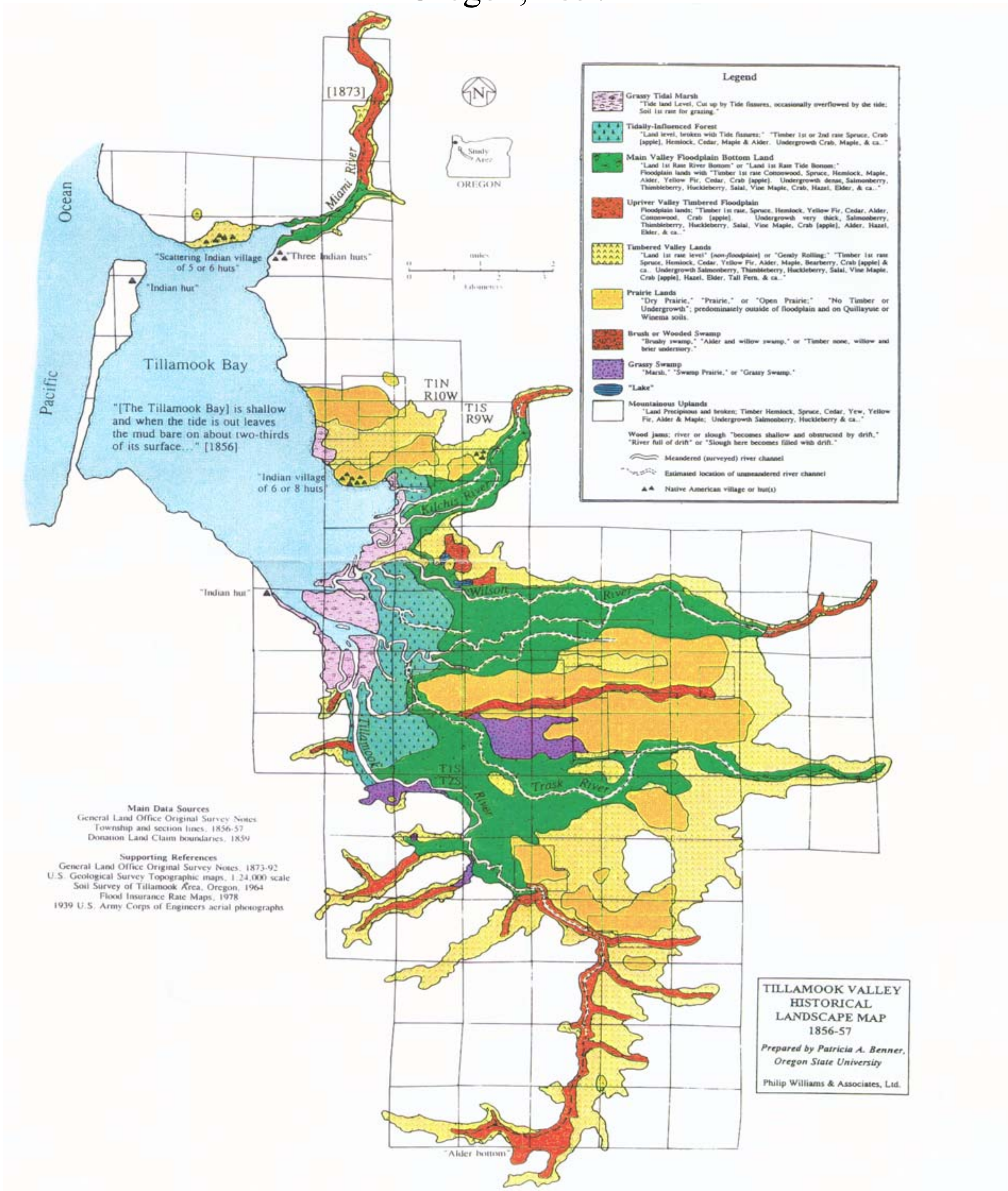

Figure 1.3. Characterization of the Tillamook Bay Valley Historical Landscape, Oregon, 1857 (Coulton et al. 1996).

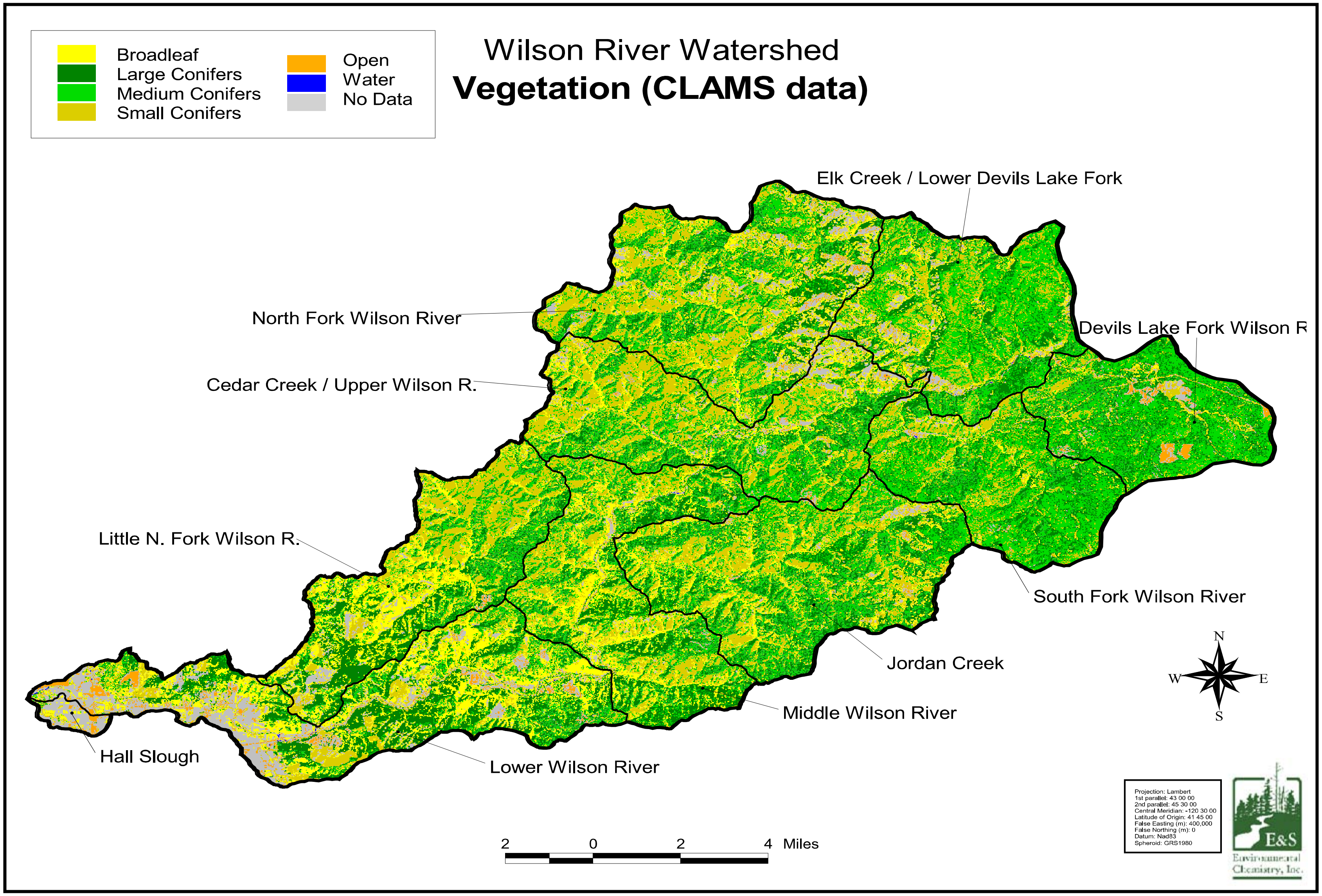

Figure 1.4 Vegetation cover in the Wilson River watershed. Vegetation was characterized using CLAMS data. Vegetation categories have been aggregated to show the relative distribution of conifers.

Table 1.3. Twelve categories of land cover present in the 1995 CLAMS data set. Categories 0 = background, 2=water, and 5= cloud are not shown (Garono and Brophy 1999). DBH is diameter at breast height.

Class	Cover type	Description
1	Shadow	Background (portions of the data file that do not contain image information)
3	Open	Open (0-40% vegetation cover)
4	Semi-closed	Semi-Closed (41-70% vegetation cover)
6	Broadleaf	Broadleaf (#70% broadleaf cover)
7	Mixed, small conifers	Mixed broadleaf/conifer: <70% broadleaf cover; small conifers (# 1 ft [25 cm] DBH)
8	Mixed, medium conifers	Mixed: <70% broadleaf cover; medium conifers (1-2 ft [26-50 cm] DBH)
9	Mixed, large conifers	Mixed: <70% broadleaf cover; large conifers (2-3 ft [51-75 cm] DBH)
10	Mixed, very large conifers	Mixed: <70% broadleaf cover; very large conifers (> 3 ft [75 cm] DBH)
11	Conifer, small	Conifer: >70% conifer cover, conifers small (#1 ft [25 cm] DBH)
12	Conifer, medium	Conifer: >70% conifer cover, conifers medium (1-2 ft [26-50 cm] DBH)
13	Conifer, large	Conifer: >70% conifer cover; conifers large (2-3 ft [51-75 cm] DBH)
14	Conifer, very large	Conifer: >70% conifer cover; conifers very large (>3 ft [75 cm] DBH)

precipitation in the form of fog drip. Old growth forests generate more fog drip precipitation than younger stands. Understanding the age and distribution of conifers within a watershed is essential for managing the system to maintain ecosystem function.

Following the methodology provided in Garono and Brophy (1999), we divided large conifer data into two distinct classes: Mixed Forest/Large Conifers (Classes 9+10+13+14) and Large Conifers (Classes 13+14). The Mixed Forest/Large Conifers class contains those areas that include large conifers, but may be dominated by a broadleaf forest while the Large Conifer Class is actually dominated by large conifers (>70 percent conifer cover). Large conifers are present in 25% of the watershed with the majority occurring in mixed stands (17%; Table 1.4).

Table 1.4. Vegetation cover in the Wilson River watershed, based on satellite imaging classification from the 1995 CLAMS study (OSU-Extension 1995).

Subwatershed	Total Area (sq. mi.)	Broadleaf (%)	Lg. conifers (%)	Mixed Lg. conifers (%)	Mixed - Very lg. conifers (%)	Very lg. conifers (%)	Med. conifers (%)	Mixed - Med. conifers (%)	Mixed - Sm. conifers (%)	Sm. conifers (%)	Open (%)	Other (%)
Cedar Creek / Upper Wilson R.	22.6	12.2	5.0	12.3	1.3	0.2	16.6	12.1	20.6	13.5	0.5	5.7
Devils Lake Fork Wilson R.	14.3	3.3	11.8	13.0	1.9	0.0	49.5	4.2	3.6	5.8	3.2	3.7
Elk Creek / Lower Devils Lake Fork	19.7	7.3	9.7	10.1	1.9	0.7	37.6	6.2	7.7	14.1	0.3	4.4
Hall Slough	1.1	13.8	0.0	1.4	0.0	0.0	0.2	1.4	5.8	0.9	11.0	65.4
Jordan Creek	25.2	12.1	7.9	17.9	2.1	0.2	17.6	13.3	18.4	8.7	0.2	1.6
Little N. Fork Wilson R.	20.0	24.4	5.4	15.9	4.8	1.1	7.3	10.0	18.6	8.8	0.2	3.6
Lower Wilson River	26.6	27.8	4.6	16.1	5.6	1.3	2.6	7.5	10.4	2.9	3.5	17.7
Middle Wilson River	21.1	20.2	4.3	20.9	2.6	0.2	8.0	14.5	20.7	6.1	0.3	2.2
North Fork Wilson River	27.2	14.1	7.3	10.7	2.4	0.8	13.6	8.9	18.8	15.1	0.6	7.6
South Fork Wilson River	16.0	4.7	10.0	11.5	1.2	0.1	44.2	7.7	8.1	10.5	0.3	1.6
Total	193.7	15.0	7.0	14.3	2.7	0.6	19.2	9.6	14.8	9.5	1.1	6.2

Semi-closed and water categories are not included in this table.

The Lower Wilson River and Little North Fork Wilson River subwatersheds have areas of very large conifer dominated stands (~1% of each subwatershed). These large conifer dominated stands probably represent rare old growth and warrant further identification and possible protection. Most of the vegetation in the Wilson River watershed is represented by small and medium conifers as a result of clear cutting activities and the Tillamook Burns. Although many of these areas have been replanted, they have not reached a state of maturity that would allow them to provide many of the watershed processes associated with old growth forests. Replanted stands rarely mimic natural vegetation communities and generally exhibit lower diversity in the overstory community than would be expected from a late-successional community.

1.7.5 Open Areas

Open areas within a watershed can indicate pastureland and meadows as well as recently harvested timberlands. Open areas can have a large influence on hydrology and slope failure (WPN 1999, Naiman and Bilby 1998, Binkley and Brown 1993). The CLAMS data were collected in 1995 and many of the open areas have most likely been replanted since that time. Consequently, these data represent the conditions as they existed in 1995, but not necessarily as they exist today. Pacific Northwest forest ecosystems are constantly in a state of flux, whereby open areas are replanted, and new open areas created through clearcutting or fire. Open areas represent a rather small proportion of the Wilson River watershed, accounting for approximately 1% of the total area (Table 1.4). Most of the open areas are associated with agricultural practices in the lowlands occurring in the Lower Wilson and Hall Slough subwatersheds. The Devils Lake Fork subwatershed is classified as 3% open area, which is rather high for a high elevation subwatershed. However, these open areas are mostly associated with wetlands which are considered natural open areas in the watershed.

1.8 Land Use

Watershed processes are often affected by land management practices which increase watershed disturbance. For example, management of forest land for timber harvest can influence watershed hydrology (increased peak flows) by increasing road densities and clearing vegetation (WPN 1999; Naiman and Bilby 1998). Wetlands are often drained for agriculture because of their rich organic soils, resulting in habitat loss and the disconnection of floodplains from the rivers. By understanding the land management activities and their associated economic values, land managers and watershed council members can better evaluate the effects of watershed disturbance on their watersheds and plan how to mitigate those impacts on natural ecosystem processes.

The dominant land use in the Wilson River watershed is State and Federal Forest, accounting for 81 percent of the watershed's total area (Table 1.5; Figure 1.5). The lowland

Table 1.5. Land use in the Wilson River watershed calculated from the refined land use coverage.

Subwatershed	Watershed Area	Agriculture	Wetland/ Agriculture	Wetland	Developed	Local Govt.	Other	State Forest	BLM Forest	Private Industrial Forest	Private Nonindustrial Forest	Rural Residential	Lowland Forest	Water
	mi^2	%	%	%	%	%	%	%	%	%	%			**%**
Cedar Creek / Upper Wilson R.	22.6	0.00	0.00	0.00	0.00	0.35	0.00	93.13	0.00	2.46	4.04	0.00	0.00	0.00
Devils Lake Fork Wilson R.	14.3	0.00	0.00	0.00	0.00	0.00	0.00	67.11	0.00	32.40	0.49	0.00	0.00	0.00
Elk Creek / Lower Devils Lake Fork	19.7	0.00	0.00	0.00	0.00	0.00	0.00	72.35	0.00	27.68	0.00	0.00	0.00	0.00
Hall Slough	1.1	56.89	26.55	0.07	12.35	0.00	0.00	0.00	0.00	0.00	0.06	2.22	0.00	1.89
Jordan Creek	25.2	0.00	0.00	0.00	0.00	0.00	0.00	85.72	0.00	14.28	0.00	0.00	0.00	0.00
Little N. Fork Wilson R.	20.0	0.00	0.00	0.00	0.00	0.00	0.00	81.86	13.79	4.08	0.21	0.00	0.00	0.06
Lower Wilson R.	26.6	9.11	0.92	0.49	0.13	2.36	0.39	52.56	10.22	4.08	14.82	3.65	0.01	1.27
Middle Wilson R.	21.1	0.00	0.00	0.00	0.00	0.00	0.17	96.21	0.00	0.28	3.35	0.00	0.00	0.00
North Fork Wilson R.	27.2	0.00	0.00	0.00	0.00	0.00	0.00	70.04	0.00	28.64	1.31	0.00	0.00	0.00
South Fork Wilson R.	16.0	0.00	0.00	0.00	0.00	0.00	0.00	96.78	1.97	1.27	0.00	0.00	0.00	0.00
Total	193.7	1.57	0.27	0.07	0.09	0.37	0.07	78.30	3.00	12.44	3.12	0.52	0.00	0.19

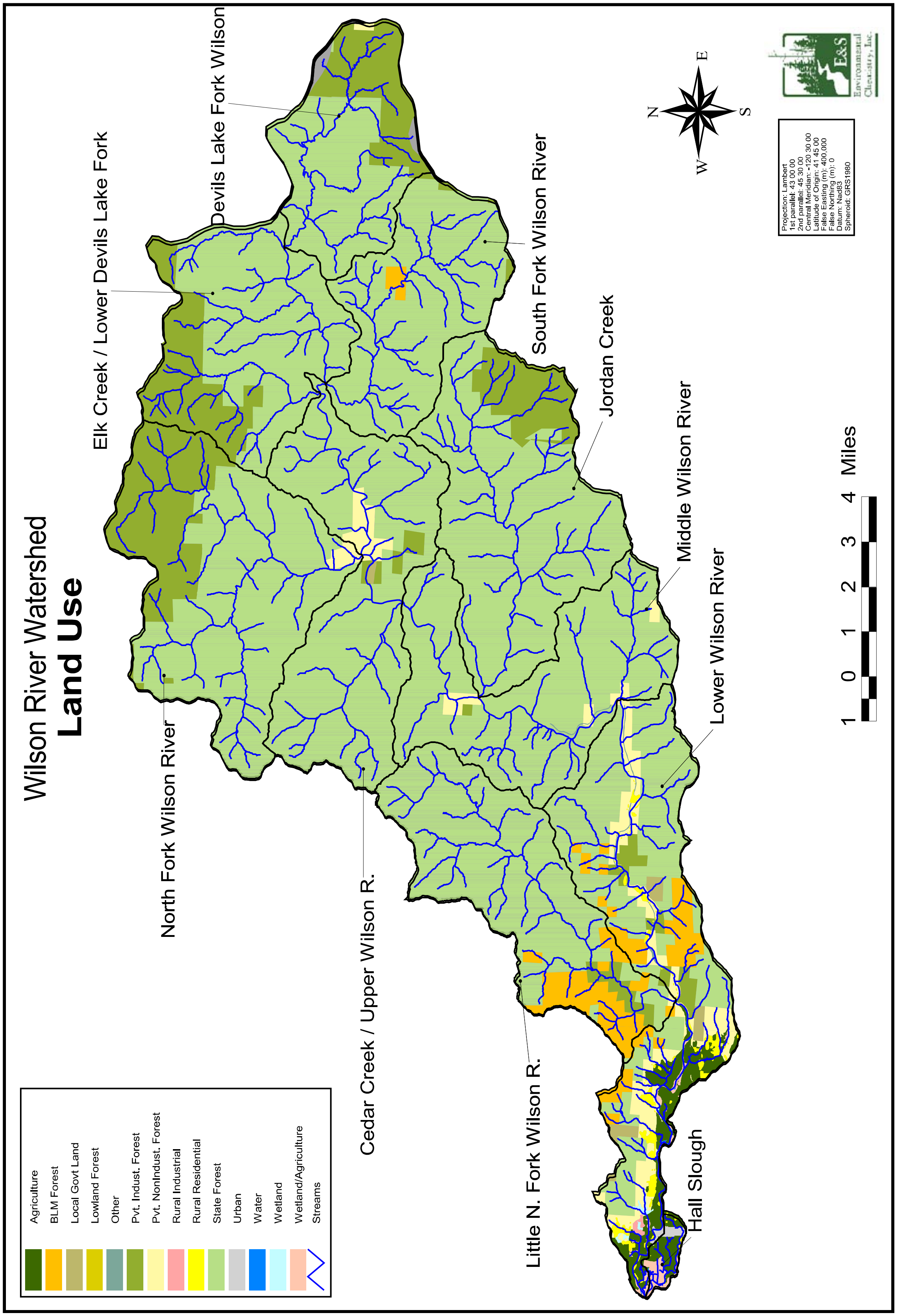

Figure 1.5. Land use in the Wilson River watershed. Data displayed is from the refined land use coverage.

areas of the watershed are dominated by dairy pastures. Development pressures from the City of Tillamook are also occurring in the lower portions of the watershed, where the Hall Slough and Lower Wilson subwatersheds are categorized as 12% and 1% developed, respectively. The Hall Slough subwatershed is predominantly pasture (agriculture) and developed areas. Watershed processes in the Wilson River watershed today are most likely affected by changes in forest management, increased development to accommodate population growth, and floodplain and wetland loss. Specific habitat and water quality related effects typically associated with land use activities are listed in Table 1.6.

1.9 Channel Habitat Types

Stream channels were separated into channel habitat type (CHT) categories using the OWEB protocol. Categories were based on stream geomorphic structure, including stream size, gradient, and side-slope constraint (Table 1.7). By identifying current channel forms in the watershed, we can better predict how land use activities may have affected the channel form as well as identify how different channels may respond to particular restoration efforts. Ultimately, changes in watershed processes will affect channel form and produce changes in fish habitat.

Channel responses to changes in ecosystem processes are strongly influenced by channel confinement and gradient (Naiman and Bilby 1998). For example, unconfined channels possess floodplains that mitigate peak flow effects and allow channel migration. In contrast, confined channels translate high flows into higher velocities with greater basal shear stress. Ultimately, these characteristics control stream conditions such as bedload material, sediment transport, and fish habitat quality. Generally, more confined, higher gradient streams demonstrate little response to watershed disturbances and restoration efforts (Figure 1.6). By grouping the channels into geomorphologic types (i.e., low-gradient confined, very steep headwater, alluvial fan, etc.), we can determine which channels are most responsive to disturbances in the watershed as well as those channels most likely to respond to restoration activities.

Table 1.6. Typical watershed issues organized by major land use activity (WPN 1999)

Land Use Category	Habitat-Related Effects	Water Quality Effects
Forestry	Channel modification Pool quantity and quality Large wood abundance Shade and canopy Substrate quality Flow alteration Passage barriers	Temperature Turbidity Fine sediments Pesticides and herbicides
Crop-land grazing	Channel modification Pool quantity and quality Large wood abundance Shade and canopy Substrate quality Flow alteration	Temperature Dissolved oxygen Turbidity Fine sediments Suspended sediments Nutrients, bacteria Pesticides and herbicides
Feedlots and dairies	Channel modification	Suspended sediments Nutrients Bacteria Pesticides and herbicides
Urban areas	Flow alteration Channel modification Pool quantity and quality Large wood abundance Shade and canopy Substrate quality Passage barriers	Temperature Dissolved oxygen Turbidity Suspended sediments Fine sediments Nutrients Organic and inorganic toxics Bacteria
Mining	Channel modification Pool quantity and quality Substrate quality	Turbidity Suspended sediments Fine sediments Nutrients Organic and inorganic toxics
Dams and irrigation works	Flow alteration Channel modification Pool quantity and quality Substrate quality Passage barriers	Temperature Dissolved oxygen Fine sediments
Road networks	Flow alteration Channel modification Pool quantity and quality Substrate quality Passage barriers	Turbidity Suspended sediments Fine sediments

Table 1.7. Channel habitat types and their associated channel geomorphologic conditions (WPN 1999)

Code	CHT Name	Channel Gradient	Channel Confinement	Channel Size
ES	Small Estuary	<1%	Unconfined to moderately confined	Small to medium
EL	Large Estuary	<1%	Unconfined to moderately confined	Large
FP1	Low Gradient Large Floodplain	<1%	Unconfined	Large
FP2	Low Gradient Medium Floodplain	<2%	Unconfined	Medium to large
FP3	Low Gradient Small Floodplain	<2%	Unconfined	Small to medium
AF	Alluvial Fan	1-5%	Variable	Small to medium
LM	Low Gradient Moderately Confined	<2%	Moderately confined	Variable
LC	Low Gradient Confined	<2%	Confined	Variable
MM	Moderate Gradient Moderately Confined	2-4%	Moderately confined	Variable
MC	Moderate Gradient Confined	2-4%	Confined	Variable
MH	Moderate Gradient Headwater	1-6%	Confined	Small
MV	Moderately Steep Narrow Valley	3-10%	Confined	Small to medium
BC	Bedrock Canyon	1 - >20%	Confined	Variable
SV	Steep Narrow Valley	8-16%	Confined	Small
VH	Very Steep Headwater	>16%	Confined	Small

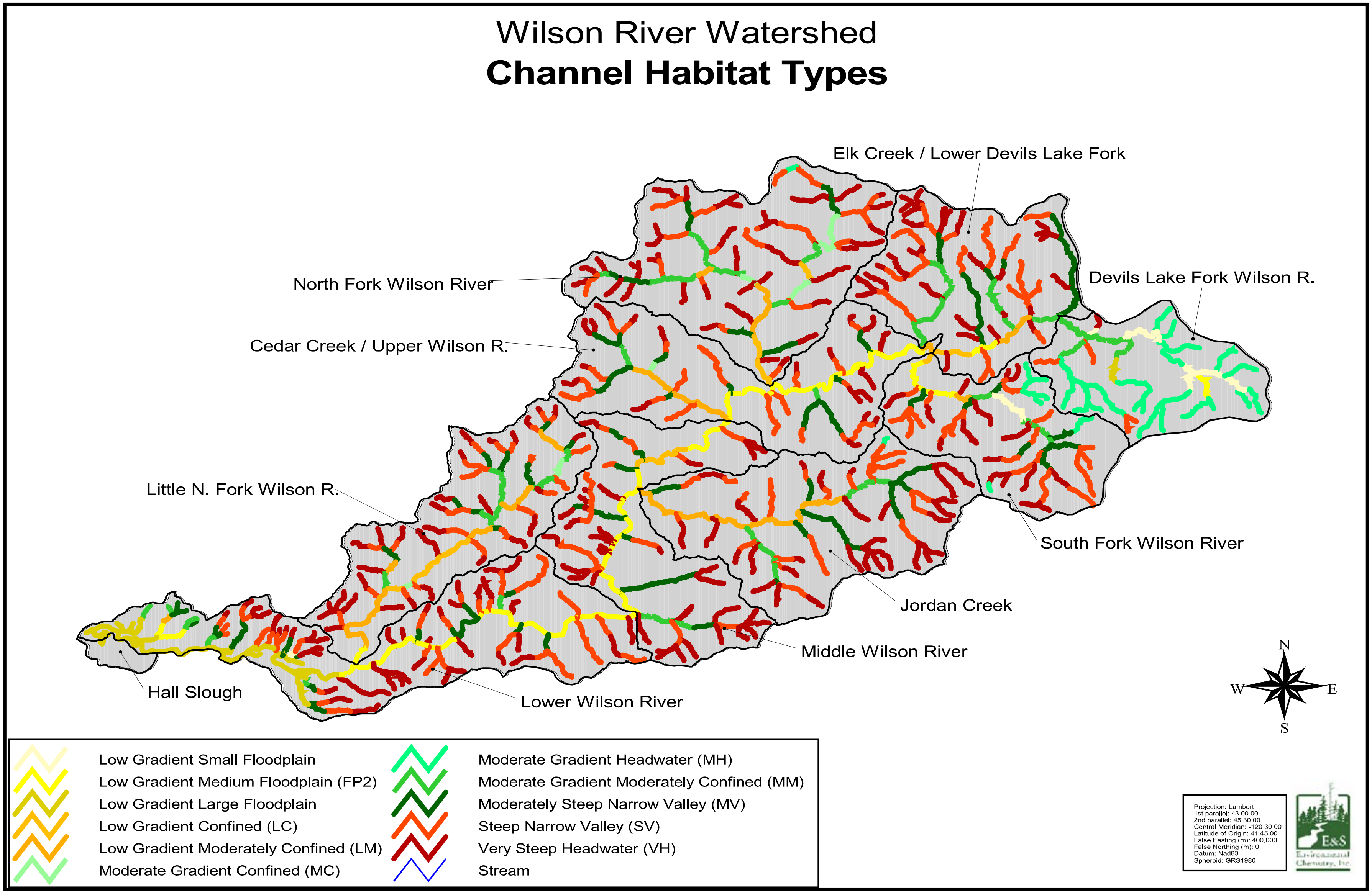

Figure 1.6. Channel habitat types in the Wilson River watershed. Stream reaches were classified by slope, size, and side-slope according to OWEB protocols (WPN 1999).

Topography in the Wilson River watershed is characterized by steep gradient uplands that move quickly into low gradient lowlands. Low gradient streams with extensive floodplains tend to be especially sensitive to the effects of watershed disturbance. However, only 25 percent of the channels in the Wilson River watershed are characterized as low gradient, high sensitivity streams (Figure 1.7; Table 1.8). The majority of the streams in the watershed are confined, high gradient streams (55%) that demonstrate a low sensitivity to restoration and watershed disturbance.

1.10 History

The history of a watershed is an important part of any watershed assessment because it provides information on how conditions have changed over time and provides a reference point for current conditions. The history of the Wilson River watershed has been compiled by the TBNEP (An Environmental History of the Tillamook Bay Estuary and Watershed) and is available through the Tillamook County Performance Partnership. The history section provides insight on issues that relate to landscape features such as aquatic/riparian habitat, fish populations, and water quality. Having information on these prior conditions will allow local stakeholders to develop appropriate reference conditions when conducting and evaluating restoration activities.

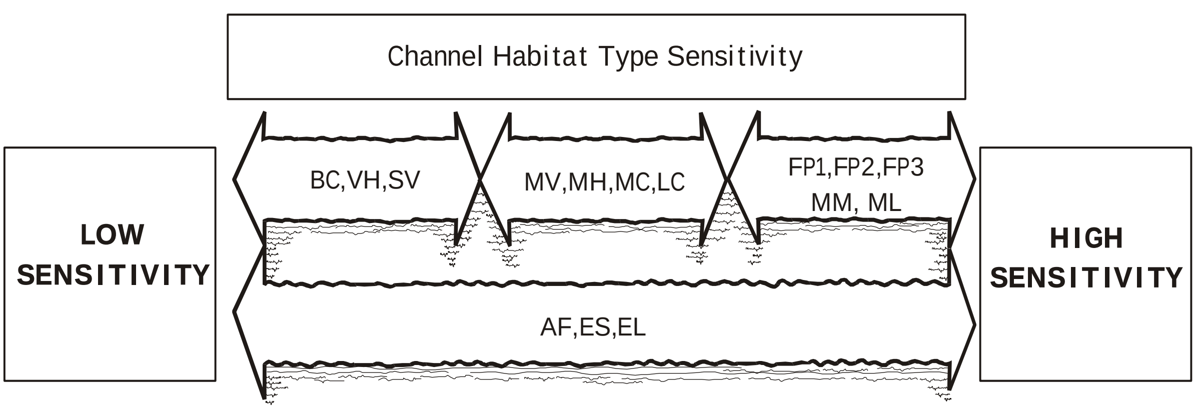

Figure 1.7. Different channel types respond differently to adjustment in channel pattern, location, width, depth, sediment storage, and bed roughness. Such changes may not only result in alteration of aquatic habitat, but the more responsive areas are most likely to exhibit physical changes from land management activities and restoration efforts. (WPN 1999)

Table 1.8. Channel habitat types in the Wilson River watershed. Channel habitat types are grouped by their sensitivity to watershed disturbance.

		PERCENT CHANNEL HABITAT TYPE										
Channel Sensitivity		Low		Moderate				High				
Subwatershed	Stream Length	% SV	% VH	% LC	% MC	% MH	% MV	% FP1	% FP2	% FP3	% LM	% MM
Cedar Creek / Upper Wilson R.	38.3	30.5	21.6	0.2	0.9	0.0	16.3	0.0	19.1	0.0	8.6	2.9
Devils Lake Fork Wilson R.	30.9	6.9	1.3	0.0	0.0	57.3	0.0	2.7	2.9	16.0	0.0	13.0
Elk Creek / Lower Devils Lake Fork	44.8	30.1	33.9	1.9	0.0	0.0	16.2	0.0	1.9	0.0	2.8	13.3
Hall Slough	0.2	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0
Jordan Creek	47.8	25.4	39.7	0.0	0.0	0.5	14.5	0.0	0.0	0.0	13.1	6.8
Little N. Fork Wilson R.	41.5	24.3	33.3	5.9	2.2	0.0	8.9	0.0	1.2	0.0	14.2	10.0
Lower Wilson R.	70.1	23.3	28.1	0.0	0.0	0.0	10.4	20.0	13.9	0.5	0.4	3.4
Middle Wilson R.	39.6	19.5	41.7	4.3	0.0	0.0	13.4	0.0	16.9	0.0	0.4	3.7
North Fork Wilson R.	49.0	22.7	41.4	4.4	6.1	0.6	9.5	0.0	0.2	0.0	4.5	10.6
South Fork Wilson R.	35.0	35.8	25.8	1.0	0.0	9.2	12.7	0.0	5.6	3.8	1.1	4.9
Total	397.1	24.5	30.8	1.9	1.1	5.4	11.5	3.8	7.1	1.7	5.0	7.4

1.11 Fire History

The Tillamook Burn, a series of human-caused forest fires from 1933–1951, profoundly affected the use of forest lands in the region. The fires killed most (about 200,000 acres) of the old-growth timber in the Wilson and Trask River watersheds, burning some areas repeatedly (TBNEP 1998). The fires were followed by road building for salvage logging, fire protection and replanting (Levesque 1985). Reforestation of the burned acreage began in 1949. Since salvage logging ended in 1959, timber harvest in the Tillamook Burn area, now the Tillamook State Forest, has been mainly commercial thinning. However, remaining private timber lands have been intensively clear-cut in recent years (TBNEP 1998).

CHAPTER 2. FISHERIES

2.1 Introduction

The OWEB assessment method focuses on watershed processes that affect salmonids and their associated habitats. Understanding the current condition of salmonid populations in a watershed is vital to identifying the effects of the spatial (across space) and temporal (across time, for example seasonal, year-to-year, etc.) distribution of key habitat areas. Additionally, salmonids are often used as indicator species under the assumption that they are the most sensitive species in a stream network (WPN 1999, Bottom et al. 1998, Tuchmann et al. 1996). Habitat conditions that are good for salmonids generally reflect good habitat conditions for other species of aquatic biota. Understanding the complex life cycles, spatial distribution, and current status of salmonids in a watershed is key to evaluating watershed management practices and their effects on watershed health.

2.2 Fish Presence

Anadromous salmonid species known to occur in the Tillamook Bay Watershed include chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), steelhead trout (*O. mykiss*), and sea-run cutthroat trout (*O. clarkii*). Although details of their life history and habitat requirements differ substantially, all spawn in fresh water, migrate through the estuary, and rear for varying lengths of time in the ocean before returning to their natal streams (where they hatched) to complete their life cycle. Resident cutthroat trout are also present throughout the Tillamook Bay watershed, including the Tillamook, Trask, Wilson, Kilchis, and Miami Rivers.

2.3 Species of Concern

The National Marine Fisheries Service (NMFS) has listed several anadromous fish species that do, or could potentially, exist in the watershed as threatened or as candidates for listing (Table 2.1). Coho salmon have been listed as threatened by NMFS. Coastal cutthroat and winter steelhead are candidates for listing. Listing for chum and chinook was not warranted as determined by NMFS. However, chum are locally depressed, and much of their historic habitat has been affected by human activities in the lower river (Michele Long, ODFW, pers. comm.)

Table 2.1. Status of anadromous fish occurring in the Wilson River watershed.

Fish	ESU	Status
Coho	Oregon Coast	Threatened
Coastal Cutthroat	Oregon Coast	Candidate
Chum	Pacific Coast	Not Warranted
Chinook	Oregon Coast	Not Warranted
Steelhead	Oregon Coast	Candidate

* An Evolutionarily Significant Unit or "ESU" is a distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout.

Listing occurs for an entire Evolutionarily Significant Unit (ESU) which is a distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout (Appendix A).

The Endangered Species Act requires that forests providing habitat for endangered species must be protected. Relationships between land cover and the decline of rare species have been established. For example, loss of late successional forests may be related to declines in threatened and endangered species such as the northern spotted owl, marbled murrelet, and coho salmon (Garono and Brophy 1999, Tuchmann et al. 1996). An understanding of the land patterns associated with the distribution of these species can lead to a better understanding of how to conserve them.

Private, federal, and state owned lands have their own mandates for the protection and conservation of the habitats related to these threatened and endangered species. Private timber practices are regulated by the Forest Practices Act, which was designed to help protect important habitats. The Oregon Department of Forestry (ODF) is developing an assessment and management plan to detail forest management practices within areas occupied by threatened species. Due to the complex interactions in watersheds, all of these practices must be considered on both public and private land in order to effectively manage the natural resources for the protection of the critical habitats associated with these species.

Background information on fisheries status is summarized below. Much of the following information was taken directly from ODFW's Biennial Report on the Status of Wild Fish in Oregon (ODFW 1995), from the NMFS website (*http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm*), or from the Tillamook Bay Environmental Characterization report (TBNEP 1998).

The Tillamook Bay National Estuary Project (TBNEP) found that data relating to numbers of adult spawners, numbers of fish harvested, and some rough estimates of the contribution of hatchery fish to the spawning runs are available for some, but not all of the runs. Information regarding the distribution and relative abundance of juvenile salmonids in tributary streams is only beginning to be developed and is not yet adequate to provide a comprehensive overview of status of juvenile salmonids in the watershed. Information on the estuarine distribution and abundance of juvenile salmonids is dated and incomplete. No information is available on smolt production.

Table 2.2 summarizes the findings relative to the general health and trends in abundance of the Tillamook Bay anadromous salmonid species and races. Health was considered poor if the naturally spawning population appeared to be heavily supported by hatchery fish and/or if the population is severely depressed compared with historic conditions. Of the five species present in the watershed, only fall chinook salmon appear to be healthy and relatively abundant. The

Table 2.2. Status and recent population trends of Tillamook Bay anadromous salmonids (TBNEP 1998, Nicholas and Hankin 1988).

Species/race	Status	Recent population trends
Chinook salmon		
fall	healthy	stable or increasing
spring	heavily supported by hatchery fish, depressed compared with historic abundance	possibly declining
Coho salmon	heavily influenced by hatchery fish, severely depressed compared with historic abundance	declining
Chum salmon	depressed compared with historic abundance	declining
Steelhead trout		
winter	heavily influenced by hatchery fish, numbers appear low	declining
summer	introduced, supported entirely by hatchery fish	declining
Sea-run cutthroat trout	depressed	possibly declining

rationale for the conclusions shown in Table 2.2 is described in the following species-by-species summaries of available information relating to status and trends for the Tillamook Bay salmonids.

The ODFW conducted monitoring of migration timing and abundance of salmonids in the Little North Fork Wilson River in 1998, 1999, and 2000, with funding from the TBNEP and ODF. Rotary screw juvenile traps were operated from March to July (Dalton 1999, 2000). To calibrate trap efficiency, and to expand catch statistics to estimates of total outmigration, up to 25 fish were marked each day by fin clipping and released upstream for recapture. Total outmigration was estimated, taking recapture percentages into consideration. Results are presented in Table 2.3, and discussed in the following sections on individual species.

Table 2.3. Estimated juvenile salmonid migrants by age and size class in the Little North Fork Wilson River, 1998-2000 (no estimate was made when <5 marked fish were recaptured but total number caught is given in parentheses; Source: Dalton 2000).

	Estimated Migrants		
	1998	1999	2000
Chinook Salmon			
fry (age 0+)	1,223,944	451,236	226,121
Chum Salmon			
fry (age 0+)	145,002	59,346	27,813
Coho Salmon			
fry (age 0+)	9,439	418	21,676
smolts (age 1+)	3,345	246	259
Unidentified Trout			
fry (age (0+)	77,823	60,918	41,936
Steelhead			
parr 60-89 mm	1,893	1,087	2,280
parr 90-119 mm	3,247	1,539	4,993
smolts $ 120 mm	13,885	3,524	4,194
Cutthroat Trout			
parr 60-89 mm	(4)	(8)	139
parr 90-119 mm	(31)	225	674
parr 120-159 mm	1,945	603	1,557
smolts $ 160 mm	524	420	670

2.4 Coho

2.4.1 Life History

The coho salmon (*Oncorhynchus kisutch*) is an anadromous species that rears for part of its life in the Pacific Ocean and returns to freshwater streams in North America to spawn. Coho may spend several weeks to several months in fresh water before spawning, depending on the distance they migrate to reach their spawning grounds. All adults die within two weeks after spawning. Juveniles normally spend one summer and one winter in fresh water, although they may remain for one or two extra years in the coldest rivers in their range. They migrate to the ocean in the spring, generally one year after emergence, as silvery smolts about four to five inches long. Most adults mature at 3 years of age (ODFW 1995).

2.4.2 Listing Status (Source: *http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm*).

Coho Salmon were listed as a threatened species on August 10, 1998 for the Oregon Coast ESU. The ESU includes all naturally spawned populations of coho salmon in Oregon coastal streams south of the Columbia River and north of Cape Blanco. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,606 square miles in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill.

2.4.3 Population Status

Coho salmon populations along the entire Oregon coast are now considered depressed. According to Hasselman (1995), Tillamook Bay coho abundance and adult spawning escapement have shown significant rates of decline not generally observed for other Oregon coastal river basins in the central and north coast (TBNEP 1998).

Historically, the Tillamook Bay Watershed was an important producer of coho salmon (TBNEP 1998). Coho were harvested intensively in the Bay with gill nets from the late 1800s through 1961 when the gill net fishery was permanently closed. The annual gill net catch during the 1930s ranged from 24,590 to 73,974 and averaged about 46,000 fish. After 1940, the gill net fishery declined while the ocean fishery increased. The decline in the gill net fishery may have been related, in part, to increased regulatory restrictions on the fishery. During the late 1980s, most of the harvest occurred in the ocean, off Oregon and California. The total combined harvest of naturally-produced Tillamook Bay coho in the ocean (commercial and sport fisheries), estuary (sport fishery), and fresh water (sport fishery) during the late 1980s was estimated to average 3,500 coho annually (Bodenmiller 1995).

The recreational catch of coho in Tillamook Bay and its tributaries has been estimated since 1975, based on angler salmon/steelhead reporting tag returns. Harvest rates averaged 1,785 fish annually and have shown wide interannual variation (TBNEP 1998). Note that the high catch in 1991 was an anomaly, in that relatively large numbers of non-Tillamook Bay coho were caught just inside the mouth of the Bay during the latter part of the summer. These fish may have temporarily entered the Bay due to localized abundance of prey species near the mouth of the Bay (TBNEP 1998).

Numbers of adult coho (mostly age 3) escaping to the spawning grounds have been indexed using the peak count method, which is based on repeated counts on the spawning grounds. Surveys have been conducted by ODFW since 1950 on Cedar Creek, a tributary to the Wilson River; and with the exception of five years (1974–1979), on the Devils Lake Fork of the Wilson River. Peak counts (expressed as number per mile of stream surveyed) were relatively low in the mid-1950s, relatively high from about 1960 through the mid-1970s and since about 1975 have remained low and variable (Figure 2.1). All-time lows were reached in the early 1990s. These data suggest that either the quality of freshwater habitat has seriously declined since about 1976 or that other factors (*e.g.*, poor ocean survival, over harvesting, influence of hatchery fish, or high estuarine mortality) are limiting the number of returning adults (TBNEP 1998).

ODFW outmigration estimates (Table 2.3) showed a dramatic increase in coho fry in the North Fork Wilson River in 2000, compared with 1998 and 1999. Similar findings were reported by ODFW elsewhere along the Oregon coast, but of the rivers studied, the Little North Fork Wilson River experienced one of the largest increases in coho salmon fry densities from 1998 to 2000, from one of the lowest to mid-range. However, the density of coho smolts in the Lower North Fork Wilson River in 2000 was again among the lowest along the coast (Dalton 2000).

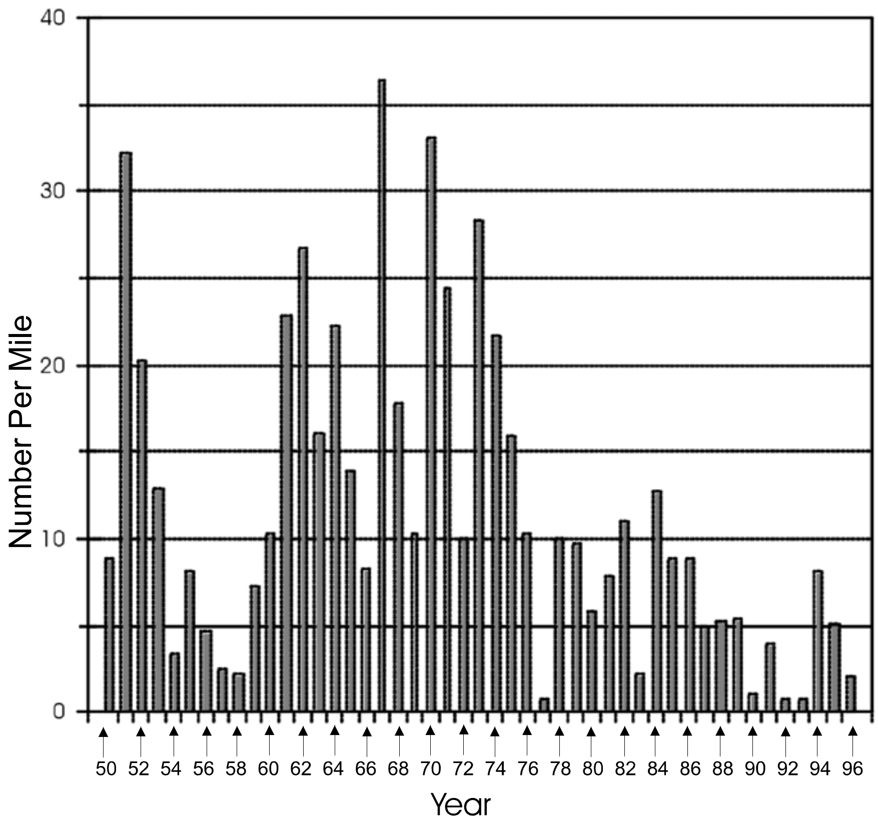

Figure 2.1 Tillamook Bay watershed peak count estimates for coho salmon. Source: TBNEP Environmental Characterization 1998.

2.4.4 Factors Responsible for Decline

A combination of factors, including rearing and spawning habitat degradation, reduction in summer streamflow, passage impacts at dams, decrease in ocean productivity, excessive fishing, and impacts caused by hatchery programs, have been implicated in most of the declines and extinctions of coho salmon populations in Oregon. There is little in the way of causal information available, however, that is specific to the Wilson River watershed. We assume that the observed decline of coho in this watershed has similar causes to the observed declines elsewhere.

Coho salmon evolved in freshwater ecosystems that were historically characterized by a high degree of structural complexity, including the presence of large wood, flood plains, braided channels, beaver ponds and, in some cases, lakes. Anthropogenic (human) activities, including timber harvest, mining, water withdrawals, livestock grazing, road construction, stream channelization, diking of wetlands, waste disposal, gravel removal, farming, urbanization, and splash dam logging have altered most freshwater ecosystems. In the last 15 years, the productivity of the marine environment used by Oregon coho also has declined. This decline in ocean productivity appears to be part of a long-term, apparently natural cycle in ocean conditions that is outside of management influence. These decreases in freshwater and marine habitat condition have coincided with several decades of increasing releases of hatchery coho salmon and sustained high harvest rates. Wild populations have declined, and the range of coho salmon in Oregon has contracted concurrent with these activities and processes (ODFW 1995).

In coastal rivers and lower Columbia Basin tributaries, low summer flows and the loss of complex instream structure, winter side channels, sloughs, and shade have been predominant problems. Timber harvest in the coastal temperate rain forest belt has contributed to winter habitat loss, particularly in the upper reaches of basins. Logging has caused the loss of large conifers from riparian areas that would have provided long-lasting instream structure when they fell into streams. Siltation from logging roads, road-failures, and loss of ground cover, along with reduction of water filtering and shade due to the removal of riparian vegetation, have reduced egg and juvenile survival. Historical logging practices also used splash dams that ripped spawning gravel and instream rearing structure out of streams when logs were flushed downstream as a form of transport. Agriculture, industrialization, and urbanization have degraded coho rearing habitat in the lower reaches and estuaries of many coastal streams through such actions as diverting water, channelizing streams, diking off-channel and estuary areas, and releasing effluents that elevate temperatures and reduce water quality (ODFW 1995). It is likely that all of these factors have played important roles in coho decline within the Wilson River watershed. The relative importance of each, and the segments of river most heavily impacted, are poorly known.

2.4.5 Species Distribution

ODFW mapped current coho distribution by attributing 1:100,000 stream coverages based on survey data, and best professional judgment of local fish biologists. The mappped distributions identified spawning, rearing and migration areas. These coverages are dynamic data sets that are scheduled to be updated every two years. They are available on ODFW's website (*ftp://ftp.dfw.state.or.us/pub/gis*).

Coho salmon utilize as habitat the entire Wilson River watershed, including all of the subwatersheds (Figure 2.2). Coho salmon were even identified above waterfalls in the Elk Creek and Jordan Creek subwatersheds. The Wilson River watershed provides a large proportion of the coho habitat in the Tillamook Basin and is currently extensively used by coho salmon (ODFW 1995).

2.4.6 Hatcheries

Hatchery coho were stocked in the Tillamook system, practically without interruption, from 1902 to the early 1990s. Returns of hatchery fish to the Trask River hatchery for the period 1985–1992 ranged from 1,245 to 10,174 with an average of 5,231 fish.

There is evidence to suggest that hatchery coho may have contributed to the decline of wild coho salmon. Hatchery programs supported historical harvest rates in mixed-stock fisheries that were excessive for sustained wild fish production (TBNEP 1998). Hatchery coho may have also strayed to spawn with wild fish, which may have reduced the fitness and therefore survival of the wild populations through outbreeding depression (c.f., Hemmingston et al. 1986; Flemming and Gross 1989, 1993; Hjort and Schreck 1982; Reisenbichler 1988), and which can lower effective population sizes (Ryman and Laikre 1991). Finally, hatcheries may have reduced survival of wild juveniles through increased competition for limited food in streams, bays, and the ocean in years of low ocean productivity, through attraction of predators during mass migrations, and through initiation or aggravation of disease problems (Nickelson et al. 1986).

The influence of hatchery fish on naturally-spawning populations is not known. However, it appears that spawning is now earlier than in the past, suggesting that hatchery fish may have had an influence (TBNEP 1995). Based on observations made during peak count spawning surveys, most Tillamook Basin coho spawned during December in the decades of the 1950s and 1960s. But by the late 1980s, peak spawning had apparently shifted to November. Until recently, it was the practice of hatcheries to take eggs from the first returning spawners. This practice selected for early spawners and over time has resulted in a shift toward earlier spawning runs of most coastal coho hatchery stocks, including the Trask River hatchery (ODFW 1995).

During the 1960s and 1970s, hatchery fish were released only into the Trask River and little change in spawn timing was noted. In the early 1980s, hatchery fish were released throughout

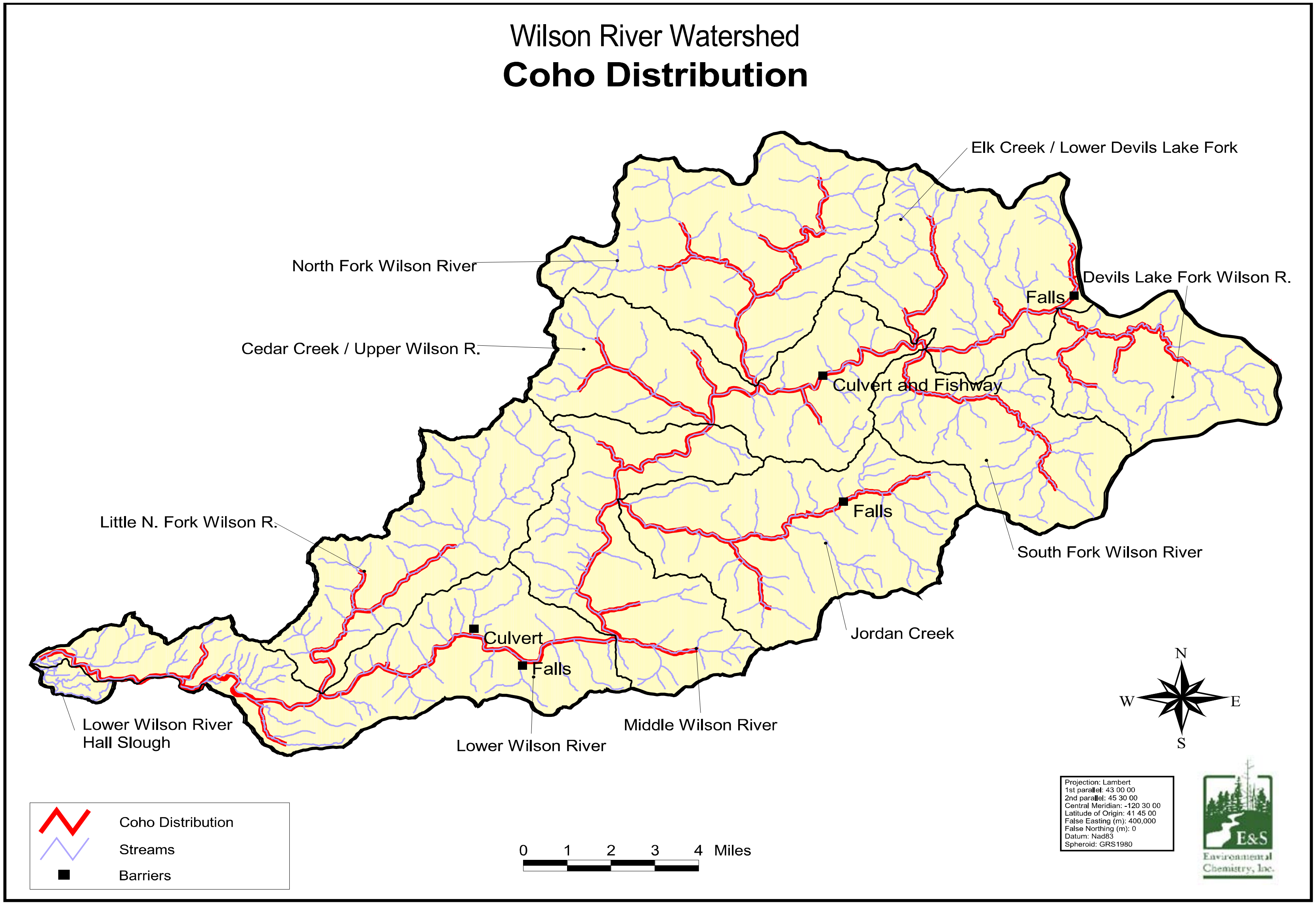

Figure 2.2. Coho distribution in the Wilson River watershed (ODFW 2000).

the Tillamook Basin (including the Miami, Kilchis, Wilson, and Tillamook Rivers). Chilcote and Lewis (1995) suggested that this practice was likely responsible for the shift in spawn timing among the natural spawners. However, they recommended additional studies before making definitive statements regarding cause and effect. Stocking of coho in the Tillamook basin was discontinued in 1992 (Keith Braun, ODFW, pers. comm., September, 2001). If hatchery stocks have largely displaced the wild, naturally spawning coho in the basin, the population could be in a very precarious situation. A shift to early spawning could increase mortality by subjecting more of the incubating embryos in the gravel to bedload movements caused by early winter storms. Reducing variability in the schedule of the coho life stages might also increase competition for food and habitat.

2.5 Chinook

2.5.1 Life History

Oregon chinook salmon populations exhibit a wider range of life history strategies than coho or chum salmon, with variation in the date, size and age at juvenile ocean entry; in ocean migration patterns; and in adult migration season, spawning habitat selection, age at maturity and size (Nicholas and Hankin 1989; Healey 1994). Generally, subyearling juveniles rear in coastal streams from three to six months and rear in estuaries from one week to five months. Nearly all Oregon coastal chinook salmon enter the ocean during their first summer or fall (ODFW 1995).

Both fall and spring chinook salmon are present in the Tillamook Bay Watershed. Mature fall chinook (2 to 6 years of age) return to all five of the major subbasins from early September through mid-February. Peak entry into the rivers occurs in mid-October. Tillamook Bay fall chinook spawn from October to January. Spring chinook salmon occur primarily in the Trask and Wilson Rivers, with a small population in the Kilchis River. Spring chinook enter Bay tributaries from April through June. River entrance probably peaks in May (Nicholas and Hankin 1988). Spawning begins as early as the first week in September and peaks during the last week of September or first week of October (TBNEP 1998).

2.5.2 Listing Status (Source: http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm).

On March 9, 1998, NMFS determined that listing was not warranted for the Oregon Coast ESU. The ESU includes all naturally spawned populations of chinook salmon in Oregon coastal basins north of, and including, the Elk River. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,604 square miles in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill.

2.5.3 Population Status

Chinook salmon were fished commercially by gillnetting in Tillamook Bay from about 1893 until 1961, when the fishery was permanently closed. As many as 28,000 spring and fall chinook salmon were packed annually on Tillamook Bay from 1893 through 1919. The packing of chinook salmon was very erratic during this period and was frequently less than 5,000 fish or not reported. From 1923 through 1946, commercial landings remained relatively stable ranging from 12,000 to 31,000 fish and averaged about 17,000 fish (Nicholas and Hankin 1988). The commercial catch declined from 1947 through 1961. The decline may have been related, at least in part, to increased regulatory restrictions on the fishery (TBNEP 1998).

The recreational catch of fall and spring chinook salmon has been estimated since 1969 from annual returns of salmon/steelhead punch cards (Nicholas and Hankin 1988, Nickelson *et al.* 1992, ODFW 1995, Kostow 1996). These catch estimates indicate a generally increasing trend from 1969 through 1993 (period of available data) for fall chinook salmon (TBNEP 1998). The recreational catch of fall chinook averaged about 15,900 fish between 1985 and 1993. When compared with the average annual commercial catch of about 17,000 for the period 1923–1946, the present level of harvest appears remarkably stable. Although hatchery fish contribute to the fall runs, it is believed that most fall chinook are produced from naturally spawning fish (Nicholas and Hankin 1988).

The recreational catch of spring chinook salmon has been relatively small compared to the fall chinook catch. However, the catch has remained relatively stable since about 1987. ODFW regards spring chinook salmon abundance as depressed when compared with commercial landings during May through July in the 1930s (Nicholas and Hankin 1988). Spring chinook runs are supplemented by hatchery fish produced at the Trask River and Whiskey Creek hatcheries (TBNEP 1998).

The only long-term direct counts of the number of adult chinook salmon reaching the spawning grounds (fish that have "escaped" the fishery) are "peak" count data collected on the spawning grounds. Peak counts are made during the spawning season by individuals who walk along the shore and count the number of spawners a number of times during the spawning season. The ODFW began peak counts of fall chinook on the Kilchis, Wilson, and Tillamook Rivers about 1950 and with a few exceptions has conducted them annually since.

It should be noted that the peak count method of estimating spawning escapement has some serious limitations (TBNEP 1998). Bodkin et al. (1995) reviewed the underlying assumptions in the peak count method, concluding that peak counts, as conducted by ODFW, are biased both in time and space and are often modified by a correction factor. One of the biggest problems with the peak count method was the selection of stream segments for monitoring. Instead of selecting stream segments randomly, the counts were routinely collected on those stream segments known to be more heavily utilized for spawning. Therefore, use of the peak count data for estimation of total numbers of spawners would result in an overestimation of the total numbers. The ODFW recognized the weakness in the peak count method, and since 1990 has randomized its sampling approach to spawning surveys. They have continued to collect peak count data at the standard survey reaches to allow comparison of the two methods.

ODFW outmigration data for chinook salmon show substantial declines in estimated fry abundance in the Little North Fork Wilson River from 1998 to 2000 (Table 3.2). The estimated number of migrants in 2000 was only 18% of 1998 estimates. Nevertheless, in 2000, as had been the case in 1998 and 1999, the Lower North Fork Wilson River had the highest chinook salmon fry density (8.11 fish per meter of stream) among the coastal streams monitored by ODFW (Dalton 2000).

2.5.4 Factors Responsible for Decline

The causes of declines of some chinook salmon populations vary substantially for different regions of the state, depending largely on human-related changes to each watershed, and also upon ocean migration routes used by different populations. Fall chinook in small south coast streams have declined due to loss or degradation of spawning habitat, elevation of summer water temperatures, and loss or degradation of estuarine rearing areas (ODFW 1995). These populations are also distributed into an area of ocean that was at a low productivity level during the early 1990s. Spring chinook populations in smaller coastal basins have been low for several decades due largely to loss or degradation of deep adult holding pools and elevation of summer water temperatures. Populations of far north-migrating wild fall chinook in north coastal rivers like the Wilson appear to be stable or increasing, largely due to their migration into an area where ocean conditions generally have been favorable for at least a decade, to improvements in mainstem spawning habitat, and to decreases in ocean harvest rates as a result of annually-negotiated fishing regimes under the Pacific Salmon Treaty between the United States and Canada.

There is little information available that is specific to the Wilson River watershed regarding environmental changes that may have adversely affected the quality of chinook habitat. General information regarding such issues is summarized below.

Spawning chinook salmon in Oregon's small coastal streams tend to concentrate in high densities on gravel bars in specific river reaches. Fall chinook adults may move directly to the spawning bars after river entry, but spring chinook adults require deep, cold holding pools reasonably near spawning areas where they hold and mature for four to six months prior to spawning. This holding period occurs during the summer when flows are naturally lowest and water temperatures are warmest. Fall chinook are more restricted by minor migration barriers such as culverts or berms than are coho or steelhead. Habitat alterations that affect the abundance, stability and accessibility of mainstem gravel bars impact all chinook. Habitat alterations that eliminate large holding pools in the area of spawning bars seriously impact spring chinook (ODFW 1995).

Coastal juvenile chinook salmon rear for several months during their first spring in lower river mainstems, using deep riffles, woody debris and shoreline riparian vegetation for cover and feeding areas. Juveniles move into estuaries generally by late June or July where they continue rearing through the summer. Most chinook juveniles in populations along the central coast enter the ocean in the fall. Lower basin habitat complexity, summer flows, and estuary productivity affect rearing chinook salmon.

Freshwater habitat alterations that have impacted chinook salmon along the mid- to north Oregon coast have primarily been associated with historical logging practices and, in the

Tillamook Bay Basin, with fires and storm-driven erosional events that deforested, channelized, scoured and destabilized mainstem spawning areas. Logging and agricultural practices, and urban development also decreased the complexity and productivity of lower mainstem reaches and estuaries. In many areas, impacts due to natural winter storm events have increased due to riparian deforestation, stream channelization, and bank destabilization.

Ownership of forested land along the mid- to north Oregon coast includes state and federal public forest lands, as well as private forest. The state lands are in Tillamook State Forest, which dominates the basins that drain into Tillamook Bay. This state forest was formed when private land holdings in the area were heavily impacted by a series of severe forest fires between 1918 and 1951, collectively called the "Tillamook Burn." The fires, and the extensive salvage logging that followed, deforested most of the Wilson and Trask basins, and impacted substantial portions of the Kilchis and Miami basins. The deforested basins were unprotected from subsequent winter storm events that destabilized streambanks, caused severe erosion and sedimentation, and scoured and channelized lower mainstem reaches. This area has been recovering since the 1960s and is now vegetated by young coniferous and red alder forest. Uplands, streambanks and stream channels are now stabilizing and conditions for fall chinook are improving. Spring chinook continue to be impacted by the loss of deep holding pools, which have not been reestablished (ODFW 1995).

Private lands have been extensively logged. Historical logging practices used splash dams to transport logs. This practice caused periodic migration blockages and deeply scoured mainstem rivers, removing gravel bars, filling holding pools, channelizing and destabilizing streambanks, and removing riparian vegetation and woody debris. This practice particularly impacted chinook salmon that depended on mainstem gravel bars and rearing areas. Splash dam logging was discontinued in the 1960s. More recent improvements in logging on private lands, associated with the adoption of Oregon's Forest Practices Act, can be expected to further improve riparian areas. Mainstem spawning habitat associated with forested lands along the coast have progressively improved for fall chinook over the last three decades although deep holding pools for spring chinook are still inadequate.

Much of the road construction in the Coast Range has been associated with logging, although major highways have also been constructed to provide access between the Willamette Valley and the coast. Major roads through the Coast Range have typically been placed along the relatively moderate gradients of river mainstems and have contributed to mainstem channelization. Roads in upland forestlands also contribute to erosion (ODFW 1995).

Agricultural and logging practices along low gradient river reaches in lower basins have greatly decreased the complexity and productivity of juvenile chinook rearing areas. Wetlands, marshes and braided channels have been straightened, channelized, diked, drained and deforested to create croplands and pastures. Summer flows and water quality have also decreased and summer water temperatures have increased in these areas.

The impacts in the lower basins continue downriver to the estuaries where agricultural and urban development are dominant land uses. Major urban areas, with associated agricultural land, are located on most of the major estuaries, including Tillamook Bay. Many wetlands adjacent to estuaries have been diked, filled or drained to provide land for development. Many of the estuaries associated with urban centers have also been dredged and jetties have been constructed to provide boat access. These activities have changed currents in the estuaries. Changes in estuary productivity are difficult to assess, but incidental observations made by some ODFW district staff suggest that fish species assemblages in some bays are becoming less diverse, which suggests that a decrease in productivity has occurred. Some estuaries, such as the Salmon River estuary, are being actively improved and estuarine wetlands are being reestablished. However, in general, impacts in the lower river basins and estuaries are increasing, particularly due to increased urbanization.

2.5.5 Species Distribution

ODFW mapped current chinook distribution by attributing 1:100,000 stream coverages based on survey data and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. These coverages are dynamic data sets that are scheduled to be updated every two years. They are available on ODFW's website (*ftp://ftp.dfw.state.or.us/pub/gis*).

Spring Chinook use the mainstem Wilson River into the headwaters and the lower portion of the Jordan Creek subwatershed (Figure 2.3). Fall chinook are found more extensively throughout the watershed including the Little North Fork, Cedar Creek and North Fork subwatersheds. Spring chinook remain in the larger streams where deep holding pools are more

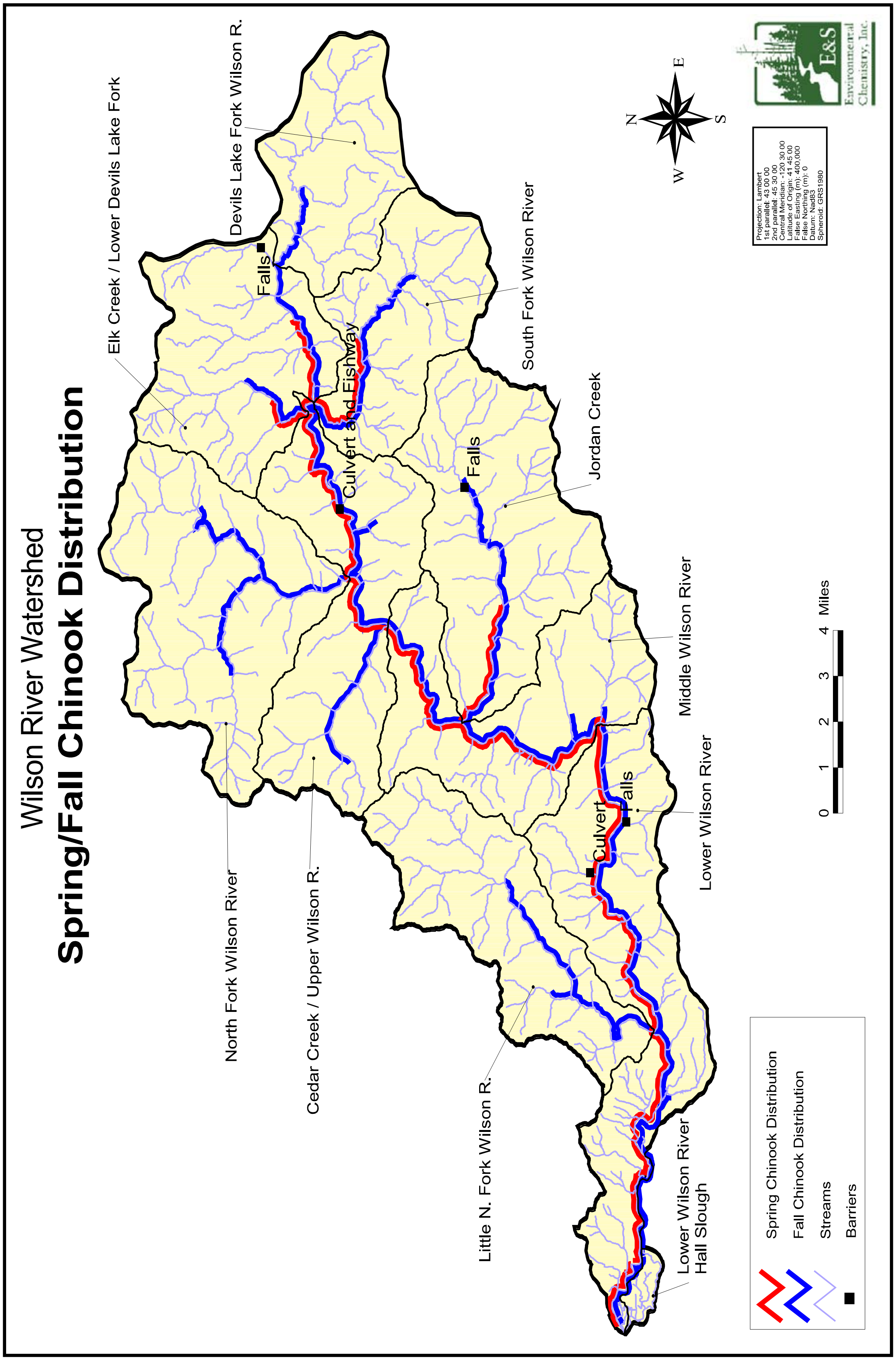

Figure 2.3. Spring and Fall chinook distribution in the Wilson River watershed. (ODFW 2000)

abundant. In contrast, fall chinook move directly to spawning areas, reducing the need for these large holding pools.

2.5.6 Hatcheries

The hatchery stocks used in the Kilchis, Wilson, and Nestucca Rivers were founded from the Trask River populations. Acclimation facilities are used on the Wilson and Nestucca Rivers. A statistical creel survey in Tillamook Bay during 1990 indicated that only 15% of the fall chinook in the catch were hatchery fish. The proportion of fall chinook hatchery fish on the spawning grounds in the Tillamook Basins is probably low since wild fish are currently abundant. The proportion of hatchery spring chinook on the spawning grounds in the bay area is unknown but may be significant, partly because the wild populations are relatively small (ODFW 1995).

Currently, about 136,000 spring chinook smolts are released annually in the Wilson River, mostly below Mills Bridge. Some are from the South Fork Project and some from the Whiskey Creek hatchery.

2.6 Coastal Cutthroat

2.6.1 Life History

Coastal cutthroat trout exhibit diverse patterns in life history and migration behaviors. Populations of coastal cutthroat trout show marked differences in their preferred rearing environments (river, lake, estuary, or ocean); size and age at migration; timing of migrations; age at maturity; and frequency of repeat spawning. Anadromous or sea-run populations migrate to the ocean (or estuary) for usually less than a year before returning to fresh water. Anadromous cutthroat trout either spawn during the first winter or spring after their return or undergo a second ocean migration before maturing and spawning in fresh water. Anadromous cutthroat are present in most coastal rivers. Nonmigratory (resident) forms of coastal cutthroat trout occur in small headwater streams and exhibit little instream movement. They generally are smaller, become sexually mature at a younger age, and may have a shorter life span than many migratory cutthroat trout populations. Resident cutthroat trout populations are often isolated and restricted above waterfall barriers, but may also coexist with other life history types.

2.6.2 Listing Status (Source: *http://www.nwr.noaa.gov/1salmon/ salmesa/inde3.htm*).

On April 5, 1999, NMFS determined that listing was not warranted for the Oregon Coast ESU. However, the ESU is designated as a candidate for listing due to concerns over specific risk factors. The ESU includes populations of coastal cutthroat trout in Oregon coastal streams south of the Columbia River and north of Cape Blanco (including the Umpqua River Basin, where cutthroat trout were listed as an endangered species in 1996). Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,606 square miles in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill.

2.6.3 Population Status

Less is known about the present status of sea-run cutthroat trout than about any of the other anadromous salmonid species in the Tillamook Bay watershed. Sea-run cutthroat trout, the smallest of the anadromous salmonids present in the watershed, have not been fished commercially. Although sea-run cutthroat trout are harvested in the recreational fishery, their numbers are not recorded on salmon/steelhead report tags. Therefore, determination of trends in abundance cannot be made on the basis of catch data. Beginning in 1997, sea-run cutthroat trout angling regulations were changed to “catch and release” only (TBNEP 1998). Cutthroat trout spawn in small headwater tributaries in late winter and early spring when water conditions are generally poor for viewing. Age at spawning is highly variable (2 to 10 years) and individual adults may spawn more than once during their lifetime (Emmett et al. 1991).

The only attempt to routinely count sea-run cutthroat has been resting pool counts made by ODFW staff since 1965 in conjunction with summer steelhead counts in the Wilson and Trask Rivers. Note that holding pool surveys were not conducted on the Wilson River in 1975 or 1978 or on the Trask River in 1975, 1977, or 1978. The resting hole count results are presented as average number of fish per hole to allow comparison from year to year due to differences in the number of holes surveyed (Figure 2.4). These data suggest that numbers of sea-run cutthroat trout in resting holes may have been somewhat higher before the mid-1970s than they have been since, particularly in the Wilson River. No further interpretation of the data is warranted.

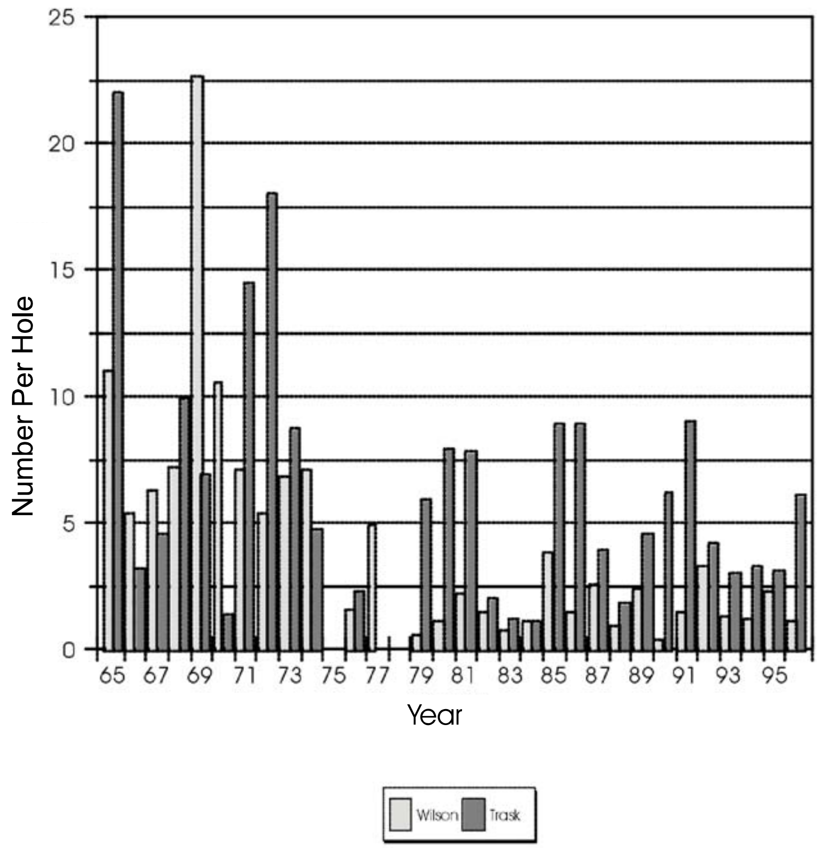

Figure 2.4. Resting pool counts of sea-run cutthroat trout for the Wilson and Trask Rivers. Source: TBNEP Environmental Characterization 1998.

2.6.4 Factors for Decline

Coastal cutthroat trout tend to spawn in very small (first and second order) tributaries. Young fry move into channel margin and backwater habitats during the first several weeks. During the winter, juvenile cutthroat trout use low velocity pools and side channels with complex habitat created by large wood. Specific information regarding habitat utilization in the Wilson River watershed, and changes over time in habitat, is not available.

Very little is known about the habitat requirements and preferences of sea-run cutthroat trout in estuarine environments. Juvenile and adult cutthroat trout spend considerable time in tidal rivers and low-gradient estuarine sloughs and tributaries during spawning and feeding migrations. Large wood likely is an important habitat component for cutthroat trout during their estuarine residence. They appear to remain near shore, probably near the mouth of their natal river, during their marine occupancy.

2.6.5 Species Distribution

Anadromous cutthroat trout have not been mapped by ODFW. However, ODFW identified populations that use the majority of the Wilson River watershed. Resident populations exist in almost all of the tributaries (ODFW 1995). Anadromous cutthroat populations were identified in the mainstem Wilson River to river mile 35 and the Devils Lake Fork subwatershed.

2.6.6 Species Interactions

Cutthroat trout populations with different life history patterns may co-occur in the same river. The level of genetic exchange between cutthroat trout of different life history types, for example, between sea-run and resident forms, is poorly understood (ODFW 1995). A single population may exhibit several life histories; or the life histories may form separate breeding populations through assortative mating, but still exchange low levels of gene flow; or the life history types may form completely reproductively isolated gene pools. Extensive genetic and life history surveys will be needed to clarify these relationships.

Habitat use by juvenile cutthroat trout is affected by interactions with other salmonids, although the extent of the effect is poorly understood. It is known, however, that whereas juveniles prefer to rear in pools, young-of-the-year cutthroat trout may be displaced into low gradient riffles, particularly by the more dominant coho salmon. The selection of small tributaries for spawning and early rearing may help to reduce competitive interactions between cutthroat trout and steelhead trout or coho salmon. Differential selection of spawning habitat also may help to minimize hybridization with rainbow/ steelhead trout (ODFW 1995).

2.7 Chum

2.7.1 Life History

The chum salmon is an anadromous species that rears in the Pacific and Arctic oceans and spawns in freshwater streams in North America. Most of the chum salmon life span is spent in a marine environment. Adults typically enter spawning streams ripe, promptly spawn, and die within two weeks of arrival. Most spawning runs are over a short distance, although exceptionally long runs occur in some watersheds in Asia and Alaska. Adults are strong swimmers, but poor jumpers and are restricted to spawning areas below barriers, including minor barriers that are easily passed by other anadromous species. Juveniles are intolerant of prolonged exposure to fresh water and migrate to estuarine waters promptly after emergence. A brief residence in an estuarine environment appears to be important for smoltification and for early feeding and growth. Movement offshore occurs when the juveniles reach full saltwater tolerance and have grown to a size that allows them to feed on larger organisms and avoid predators. Chum salmon mature at 2 to 6 years of age and may reach sizes over 40 pounds (ODFW 1995).

2.7.2 Listing Status (Source: *http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm*).

On March 10, 1998, NMFS determined that listing was not warranted for the Pacific Coast ESU. The ESU includes all naturally spawned populations of chum salmon from the Pacific coasts of California, Oregon, and Washington, west of the Elwha River on the Strait of Juan de Fuca. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,152 square miles in Oregon and Washington. The following counties lie partially or wholly within these basins: Oregon - Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill; Washington - Clallam, Cowlitz, Grays Harbor, Jefferson, Lewis, Mason, Pacific, Thurston, and Wahkiakum.

Although chum listing was not considered warranted for the entire Pacific Coast ESU, chum populations are locally depressed (Michele Long, ODFW, pers. comm., June, 2001).

2.7.3 Population Status

Tillamook Bay historically supported the Oregon Coast's largest chum salmon fishery (TBNEP 1998). During the 1930s and 1940s, catches of over 50,000 fish were not uncommon. Oregon is near the southern edge of chum salmon distribution which may, in part, account for the large interannual variability in run sizes that have been observed in Tillamook Bay streams over the years. The gill net fishery in Tillamook Bay held up longer than any of the other Oregon chum fisheries but was permanently closed in 1961.

Since chum salmon are not taken in the ocean troll fishery, the only recent catch data available for evaluating population trends are the estimates of recreational catch. The recreational catch of chum salmon has been estimated since 1969 based on salmon/steelhead reporting tag returns. Unfortunately, these data were not useful for estimating trends in the population because both fishing effort and regulations changed substantially over the period of record. Fishing for chum salmon with fly fishing equipment became popular in the 1980s on the lower Miami and Kilchis Rivers and fishing pressure increased greatly. In 1988, due to apparent declines in returning adults, the ODFW restricted chum salmon to catch and release on the Miami and Kilchis Rivers and closed all other streams to chum salmon fishing.

ODFW has collected peak counts of spawning chum salmon since 1948 in the Kilchis, Miami, and Wilson River watersheds (Figure 2.5). Peak counts (number per mile) were relatively high through about 1954. Since 1954, the peak counts appear to have declined somewhat and have shown high interannual variability. Due to the very low counts on the spawning grounds since about 1992, concern has been growing that the chum population is experiencing serious problems (TBNEP 1998).

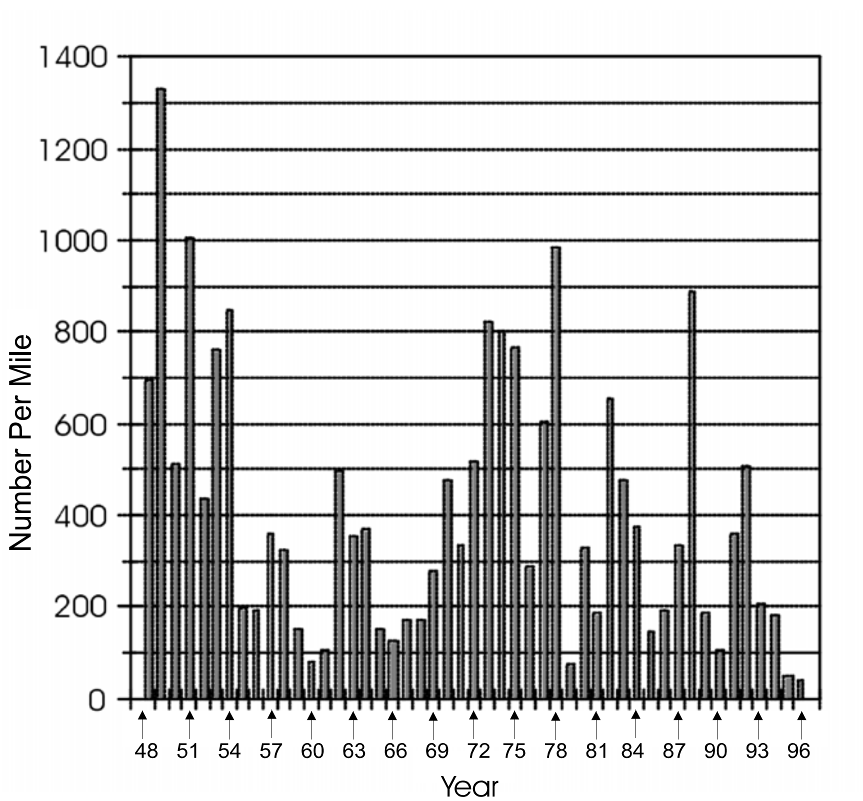

Figure 2.5. Tillamook Bay watershed peak count estimates for chum salmon. Source: TBNEP Environmental Characterization 1998.

Chum salmon outmigration estimates for the North Fork Wilson River show dramatic declines from 1998 to 2000. Estimated chum salmon fry abundance decreased to 18% of 1998 levels (Table 2.3; Dalton et al. 2000).

2.7.4 Factors Responsible for Decline

The observed decline in chum populations locally has been attributed to declines in the quantity and quality of spawning habitat and reduced egg survival (Michele Long, ODFW, pers. comm., June, 2001). Chum salmon spawning habitat has been impacted in Oregon (and presumably in the Wilson River watershed) by siltation, channelization and gravel extraction. Siltation of spawning gravels has resulted from road construction, road failures, and logging. Access to historical spawning areas has been blocked by structures that continue to be passable by other anadromous fish, including some tidegates, culverts, and gravel berms. Degradation of estuaries due to diking, water diversions, loss of marsh and cedar boglands, loss of estuary complexity, urbanization, and other actions have probably had severe effects on chum salmon. This species in Oregon requires typical low gradient, gravel-rich, barrier-free freshwater habitats and productive estuaries (ODFW 1995).

2.7.5 Species Distribution

ODFW mapped current chum distribution by attributing 1:100,000 stream coverages based on survey data and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. These coverages are dynamic data sets that are scheduled to be updated every two years. They are available on ODFW's website (*ftp://ftp.dfw.state.or.us/pub/gis*).

Historically, chum were dominant in the lower river, in the lowlands near tidewater, and up the Little North Fork Wilson River. Currently, chum salmon use only the lowest portions of the Wilson River watershed, never extending beyond the Lower Wilson or low elevations of the Little North Fork Wilson subwatersheds (Figure 2.6).

2.7.6 Hatcheries

Oregon has never had a large chum salmon hatchery program, and there are currently no state hatchery programs for the species. One private hatchery venture operated in the Nehalem

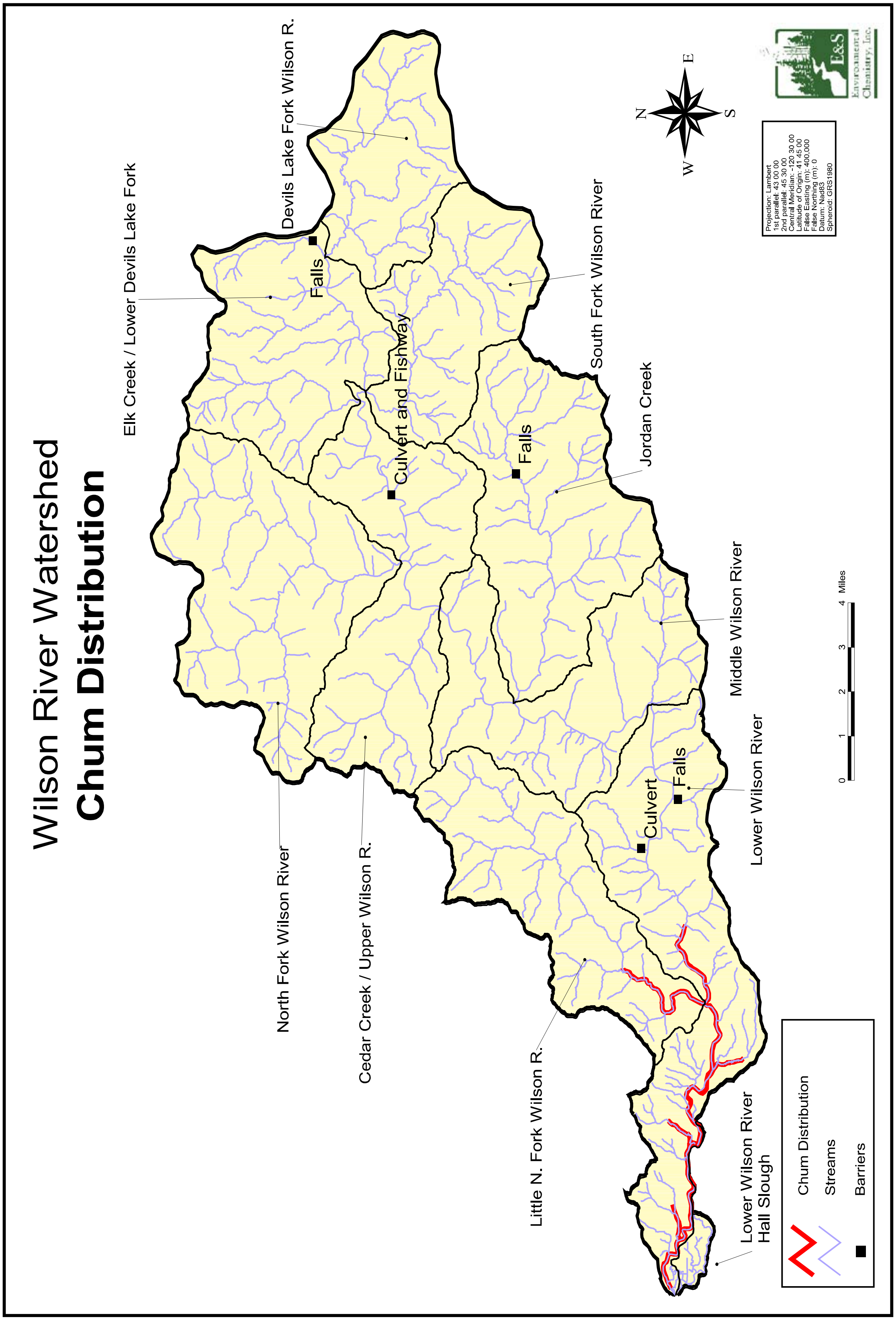

Figure 2.6. Chum distribution in the Wilson River watershed (ODFW 2000)

estuary for several years until approximately 1994. The objective at this hatchery was to collect all returning hatchery adults, although some straying occurred. Chum salmon are probably impacted by coho salmon hatchery programs that release large numbers of hatchery smolts into estuaries that are used by rearing juvenile chum. Coho salmon juveniles have been shown to be a major predator on chum juveniles in the Northwest (Hargreaves and LeBrasseur 1986). Juvenile chum salmon may also be affected by large releases of fall chinook salmon hatchery fish, particularly presmolts, since fall chinook juveniles also rear in estuaries and may compete with chum juveniles (ODFW 1995).

Chum salmon populations in the Tillamook Watershed have not been supplemented by hatchery fish. Chum adults return to spawn at ages 2 to 7 with most returning at ages 3 to 5 (Emmett et al. 1991). Most of the spawning occurs in the lower reaches of the main river channels or in small flood plain streams tributary to the lower river channels. Recent habitat trend information for these areas is not available (TBNEP 1998).

2.8 Steelhead

2.8.1 Life History

Most coastal steelhead in Oregon are winter-run fish and summer steelhead are present only in a few large watersheds, including the Wilson River watershed. The subspecies (*Oncorhynchus mykiss irideus*) includes a resident phenotype (rainbow trout) and an anadromous phenotype (coastal steelhead). Steelhead express a further array of life histories, including various freshwater and saltwater rearing strategies and various adult spawning migration strategies. Juvenile steelhead may rear one to four years in fresh water prior to their first migration to salt water. Saltwater residency may last one to three years. Adult steelhead may enter fresh water on spawning migrations year round if habitat is available for them, but generally spawn in the winter and spring. Adults that enter between May and October are called "summer-run" fish. These hold several months in fresh water prior to spawning. Adults that enter between November and April are called "winter-run" fish. These fish are more sexually mature upon freshwater entry and hold for a shorter time prior to spawning. Rainbow trout are thought to spawn at three to five years of age, generally in the winter or spring, although some populations vary from this pattern. Both rainbow and steelhead may spawn more than once. Steelhead return to salt water between spawning runs.

Two races of steelhead — "summer" and "winter" — live in the Tillamook Watershed. Winter steelhead are native to Tillamook Bay streams and are widely distributed throughout the Basin. Summer steelhead were introduced to the Basin in the early 1960s and are supported entirely by hatchery production (TBNEP 1998). Although summer steelhead have been observed in all five subbasins, most occur in the Wilson River and Trask River subbasins. Summer steelhead typically enter Tillamook Bay streams from April through July and hold in deep pools until they spawn the following winter. Very little, if any, natural production of summer steelhead occurs in the Wilson River (Michele Long, ODFW, pers. comm., April, 2001). Winter steelhead generally enter streams from November through March and spawn soon after entering freshwater. Age at the time of spawning ranges from 2 to 7 years with the majority returning at ages 4 and 5 (Emmett et al. 1991).

2.8.2 Listing Status (Source: http://www.nwr.noaa.gov/1salmon/salmesa/inde3.htm).

On March 19, 1998, NMFS determined that listing was not warranted for the Oregon Coast ESU. However, the ESU is designated as a candidate for listing due to the fact that hatchery fish heavily supplement many of the runs and that survival of both wild and hatchery fish has declined recently (Busby et al. 1996). The listing petition (ONRC et al. 1994) requested ESA protection for the winter runs of steelhead in the Miami, Kilchis, Wilson, and Trask Rivers. The ESU includes steelhead from Oregon coastal rivers between the Columbia River and Cape Blanco. Major river basins containing spawning and rearing habitat for this ESU comprise approximately 10,604 square miles in Oregon. The following counties lie partially or wholly within these basins: Benton, Clatsop, Columbia, Coos, Curry, Douglas, Jackson, Josephine, Lane, Lincoln, Polk, Tillamook, Washington, and Yamhill.

2.8.3 Population Status

No reliable information on the historic abundance of steelhead in Tillamook Bay streams is available. Steelhead were gillnetted commercially in Tillamook Bay from the late 1890s through the 1950s. However, harvest data for steelhead were not recorded in a reliable manner until after the fishery had been restricted to the early part of the steelhead run. Rough estimates of total coastwide steelhead run size made in 1972 and 1987 were similar (Sheppard 1972, Light 1987), suggesting that overall abundance remained relatively constant during that period. However, the proportion of hatchery fish in the run appeared to have increased between the two estimates. Light (1987) estimated total run size for the major stocks on the Oregon Coast (including areas south of Cape Blanco) for the early 1980s at 255,000 winter steelhead and 75,000 summer steelhead. With about 69% of winter and 61% of summer steelhead of hatchery origin, Light estimated that the naturally-produced runs totaled only 79,000 winter and 29,000 summer steelhead (note that most of the Oregon coastal summer steelhead are in the Umpqua and Rogue River systems; TBNEP 1998).

The only information available for assessing trends in the abundance of steelhead runs to Tillamook Bay streams is angler salmon/steelhead report tags and holding pool counts for summer steelhead. The combined recreational catch of winter steelhead for all five subbasins and Tillamook Bay shows a declining trend since the early 1970s (Figure 2.7). As indicated in Figure 2.7, the recreational catch has declined from a high of more than 20,000 in 1970 to fewer than 2,000 in 1993. The trend in the combined catch reflects the trends seen in each of the individual subbasins.

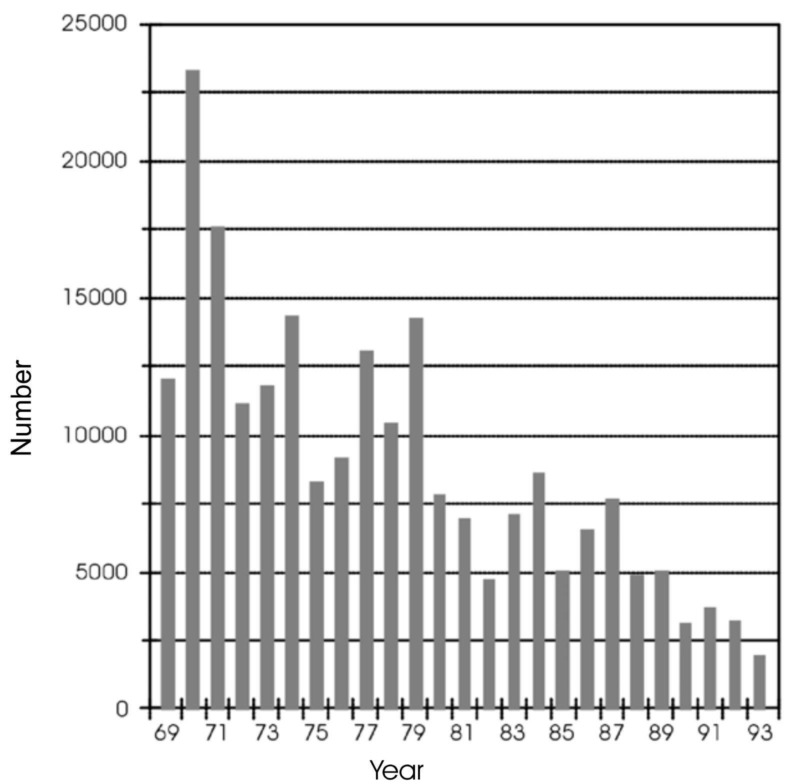

Figure 2.7. Tillamook Bay watershed sport catch of winter steelhead trout. Source: TBNEP Environmental Characterization 1998.

The combined recreational catch of summer steelhead for the five subbasins and Tillamook Bay is shown in Figure 2.8. Although numbers have varied considerably from year to year over the period of record, visual interpretation of the data suggests that there may be a declining trend in the catch, particularly since about 1980 (TBNEP 1998).

However, counts of summer steelhead in resting pools in the Wilson and Trask Rivers since 1965 (Figure 2.9) suggest that numbers of fish in resting pools were at least as high in the late 1980s as they were during much of the 1970s when catches were relatively higher. The resting pool counts can vary from year to year due to differences in viewing conditions, survey personnel, and viewing techniques. Therefore, caution should be used in interpreting resting pool counts for trend analysis (TBNEP 1998).

2.8.4 Factors Responsible for Decline

Coastal steelhead abundance follows a similar cycle in all populations from Puget Sound in Washington to California, indicating that factors common to all populations influence trends. The most probable factor responsible for this cycle is ocean condition. Ocean productivity is recognized to undergo long-term cycles that include periods that are relatively favorable or unfavorable to the survival of salmonids. This cycle appears to be a natural process that cannot be affected by management actions. The ocean productivity cycle appears to be unfavorable for steelhead currently and all steelhead population abundance trends are correspondingly low (ODFW 1995).

Steelhead and rainbow populations have also been affected by freshwater habitat degradation. Most coastal salmonid freshwater habitats were historically coniferous temperate rain forest ecosystems. Stream systems were structurally complex, with large instream wood, flood plains, beaver ponds, braided channels, and coastal marshes and bogs. Human activities have altered these ecosystems, particularly by reducing their complexity and removing components that were essential to steelhead and rainbow trout production. Logging and road construction in the Coast Range and Cascade Mountains has had the most widespread impact on coastal steelhead, and has affected most populations. Most habitat impacts are variable in different basins and are not well understood for the Wilson River specifically.

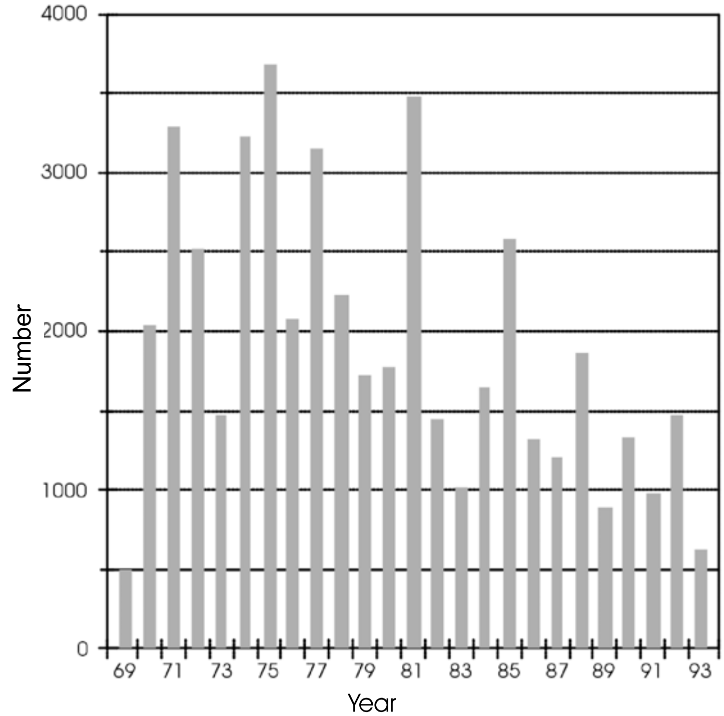

Figure 2.8. Tillamook Bay watershed sport catch of summer steelhead trout. Source: TBNEP Environmental Characterization 1998.

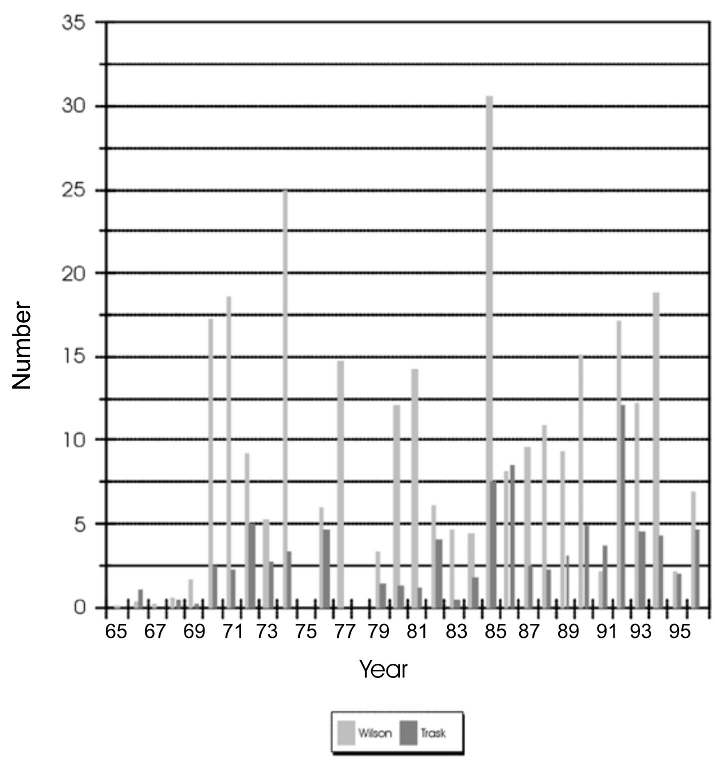

Figure 2.9. Resting pool counts of summer steelhead trout in the Wilson and Trask Rivers. Source: TBNEP Environmental Characterization 1998.

2.8.5 Species Distribution

ODFW mapped current steelhead distribution by attributing 1:100,000 stream coverages based on survey data, and best professional judgment of local fish biologists. Distributions identified spawning, rearing and migration areas. Theses coverages are scheduled to be updated every two years, and are available on ODFW's website (*ftp://ftp.dfw.state.or.us/pub/gis*).

Both winter and summer steelhead use the entire Wilson River watershed (Figure 2.10). Winter steelhead are found in more of the smaller tributaries than summer steelhead, including small tributaries in the Jordan Creek and Lower Wilson subwatersheds. Both summer and winter steelhead require structurally complex streams with large instream wood, flood plains, beaver ponds, braided channels, and coastal marshes and bogs.

2.8.6 Hatcheries

Coastal steelhead hatchery programs are present along the coast and in the lower Columbia and Willamette basins. These programs historically depended on two broodstocks. The Alsea winter steelhead hatchery stock was founded from wild steelhead in the Alsea River on the mid-coast. This stock has been outplanted into most coastal basins. In spite of this widespread outplanting of a single broodstock, Oregon's wild coastal steelhead populations have not been "homogenized" like those described by Reisenbichler and Phelps (1989) in Puget Sound. This is demonstrated by the high level of genetic variation that is still present among steelhead populations along the Oregon coast (Hatch 1990, Reisenbichler et al. 1992). Alsea steelhead are now being planted in fewer locations and local broodstocks are being developed in many of the basins (ODFW 1995).

ODFW has operated a winter steelhead broodstock program in the Wilson river since 1997. Participating anglers register with the ODFW office in Tillamook. Fish are collected by anglers and placed in the Hughey Creek acclimation pond; ODFW personnel then transport them to the Trask Hatchery. Fish collection is done between December 1 and April 30. From 1987 through 2000, 372 fish were collected by anglers and a trap on the South Fork Wilson River. Over 112,000 smolts were released in 1998, 1999, and 2000 (Memo from John Casteel, ODFW, Tillamook).

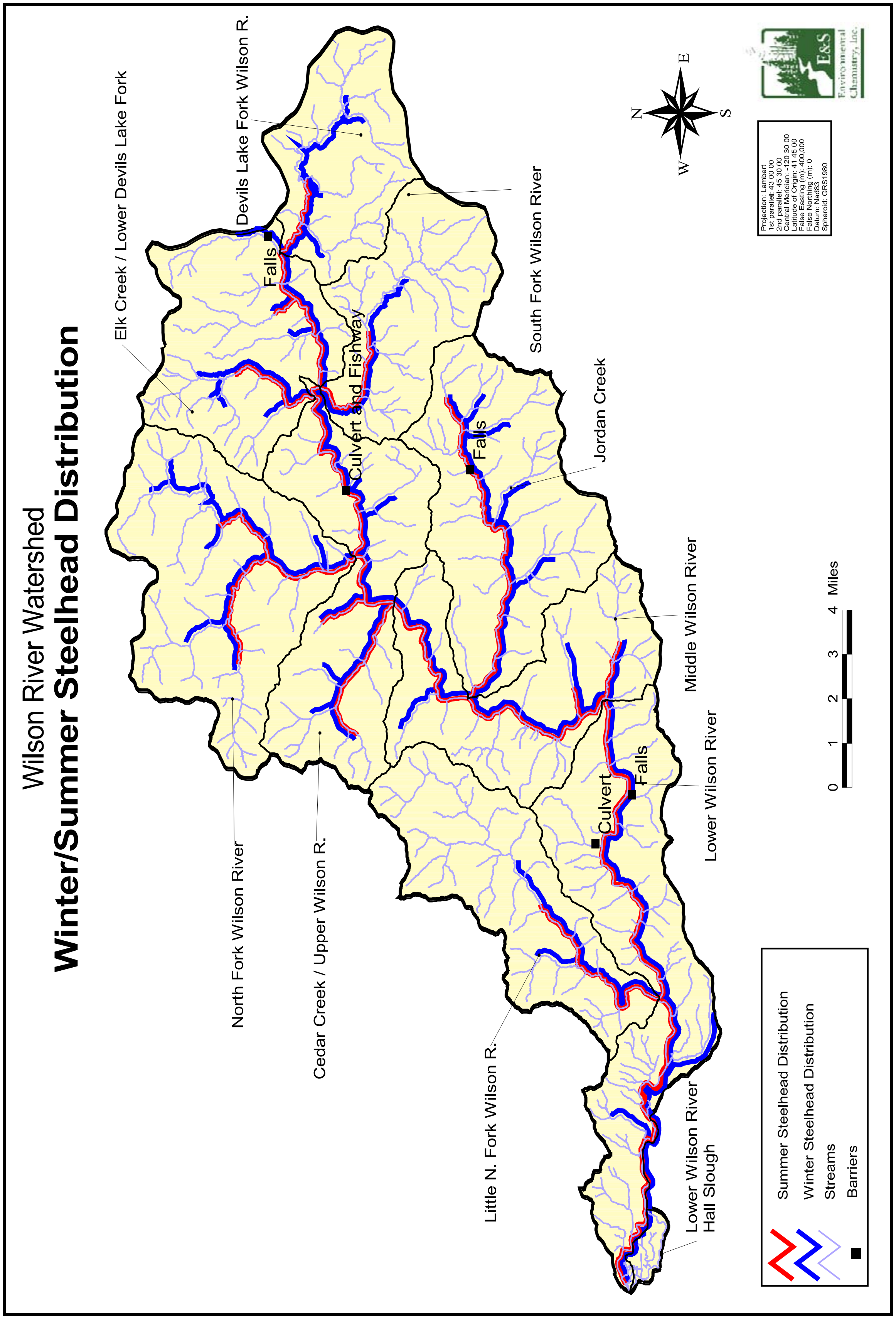

Figure 2.10. Summer and winter steelhead distribution in the Wilson River watershed. (ODFW 2000)

Despite years of hatchery releases of summer steelhead, there is little, if any, indication of successful spawning and naturalization (Michele Long, ODFW, pers. comm., June, 2001).

Currently, about 50,000 summer steelhead and 120,000 winter steelhead smolts are released annually into the Wilson River, mostly below Kansas Creek. The winter steelhead are derived from the Alsea stock (~ 70,000) and from Wilson River wild brood stock (~ 50,000; Keith Braun, ODFW, pers. comm., September, 2001).

CHAPTER 3. AQUATIC AND RIPARIAN HABITATS

3.1 Introduction

Distribution and abundance of salmonids within the watershed varies with habitat conditions such as substrate and pool frequency as well as biological factors such as food distribution (i.e. insects and algae). In addition, salmonids have complex life histories and use different portions of the watershed during different parts of their life cycle. For example, salmonids need gravel substrates for spawning, but may move to different stream segments during rearing. There are also differences among salmonid species in their timing and extent of habitat utilization. The interactions of these factors in space and time make it difficult to identify the specific watershed components that most strongly affect salmonid populations. Consequently, entire watersheds must be managed to maintain fish habitats, and not just individual components (Garono and Brophy 1999).

Understanding the spatial and temporal distribution of key aquatic habitat components is the first step in learning to maintain conditions suitable to sustain salmonid populations. These components must then be linked to larger scale watershed processes that may control them. For example, a stream that lacks sufficient large woody debris (LWD) often has poor LWD recruitment potential in the riparian areas of that stream. By identifying this linkage, riparian areas can be managed to include more conifers to increase LWD recruitment potential. Also, high stream temperatures can often be linked to lack of shade as a result of poorly vegetated riparian corridors. By linking actual conditions to current watershed-level processes, land managers can better understand how to manage the resources to maintain these key aquatic habitat components.

Healthy populations of anadromous salmonids are generally associated with the following freshwater habitat characteristics:

- cool, clean, well oxygenated water;
- unobstructed access to spawning grounds;
- clean, stable spawning gravel;
- winter refuge habitat for juveniles;
- complex stream channel structure with an appropriate mixture of riffles, pools, and glides;
- deep pools;
- stream channels with an abundant supply of large woody debris;

- abundant food supply;
- adequate summer stream flows; and
- diverse, well-established riparian community.

Many of these habitat elements as well as some additional species-specific habitat criteria have been evaluated in the Tillamook Basin during the last six years as part of the ODFW Aquatic Inventory Project. Although the project is not yet complete, these surveys provide the best source of information for assessing the present status of the freshwater habitat.

3.2 Aquatic Habitat Data

To assess current habitat conditions within the Wilson River watershed we have compiled fish habitat survey data collected according to the ODFW protocol (Moore et al. 1997). Stream survey data provide a snapshot in time of stream conditions. However, streams are dynamic and channel conditions may change drastically from year to year, depending on climatic conditions. Nevertheless, these data are useful in describing the current status or suggesting the existence of trends in habitat conditions that may be linked to larger watershed processes. Through development of an understanding of habitat distribution patterns, land managers can identify and address problem areas.

To interpret the habitat survey data, ODFW has established statewide benchmark values as guidelines for an initial evaluation of habitat quality (Table 3.1). The benchmarks rate conditions as desirable, moderate, or undesirable in relation to the natural regime of these streams. These values depend upon climate, geology, vegetation and disturbance history, and can help to identify patterns in habitat features that can lead to a better understanding of the effects of watershed processes on the current conditions of the stream channel.

Since 1996, 18 creeks and rivers have been surveyed in the Wilson River watershed, totaling approximately one-fifth (78 miles) of the entire stream network (Figure 3.1). The large flood event of 1996 altered LWD conditions in the watershed and probably introduced some new LWD to the stream network. High-velocity peak flows in 1998 and 1999 further altered LWD conditions in the watershed. However, stream channels still lack LWD in general. The condition of LWD in the system is dynamic, and while watershed-scale assessments can provide information useful for prioritizing restoration activities, all sites should be field- verified before specific restoration actions are planned.

Table 3.1. Stream channel habitat benchmarks. Source (except LWD Recruit. Potential): ODFW 1995a.

Parameter	Subfactor	Units	Good	Fair	Poor
Pool area		% of channel area	$35	>10 and <35	#10
Pool frequency		# of channel widths	#8	> 8 and <20	$20
Residual pool depth	gradient <3% or <7m wide	meters	$0.5	>0.2 and <0.5	#0.2
	gradient >3% or >7m wide	meters	$1.0	>0.5 and <1.0	#0.5
Riffle width/depth ratio	gradient <3%	ratio	#10	>10 and <30	$30
Silt/sand/organic matter		% of area	#10	>10 and <25	$25
Gravel available		% of area	$35	>15 and <35	#15
Shade	ACW <12m wide	% for reach	$70	>50 and <70	#50
	ACW >12m wide	% for reach	$60	>40 and < 60	#40
LWD pieces		# pieces/100m	$20	>10 and <20	#10
LWD volume		cubic m/100m	$30	>20 and <30	#20
LWD key (>50 m dia. and > ACW long)		# pieces/100m	$3	>1 and <3	#1
LWD recruit. potential* (Uses 3 subfactors)	1) age/size	cm diameter	old (>90 cm)	medium (< 50 cm)	Young (maj. small)
	2) density	% crown closure	dense (>67%)		sparse (67%)
	3) species	species	conifer (>70%)	mixed	deciduous (70%)

* Washington Forest Practices Board. 1993. Standard Methodology for Conducting Watershed Analysis. Version 2.0.

3.2.1 Stream Morphology and Substrates

Stream morphology describes the physical state of the stream, including features such as channel width and depth, pool frequency, and pool area (Garono and Brophy 1999). Pools are important features for salmonids, providing refugia and feeding areas. Substrate type is also an important channel feature since salmonids use gravel beds for spawning. These gravel beds can be buried by heavy sedimentation, resulting in loss of spawning areas as well as reduced invertebrate habitat. For streams that were surveyed, stream morphology and substrates were compared against ODFW benchmarks to evaluate current habitat conditions.

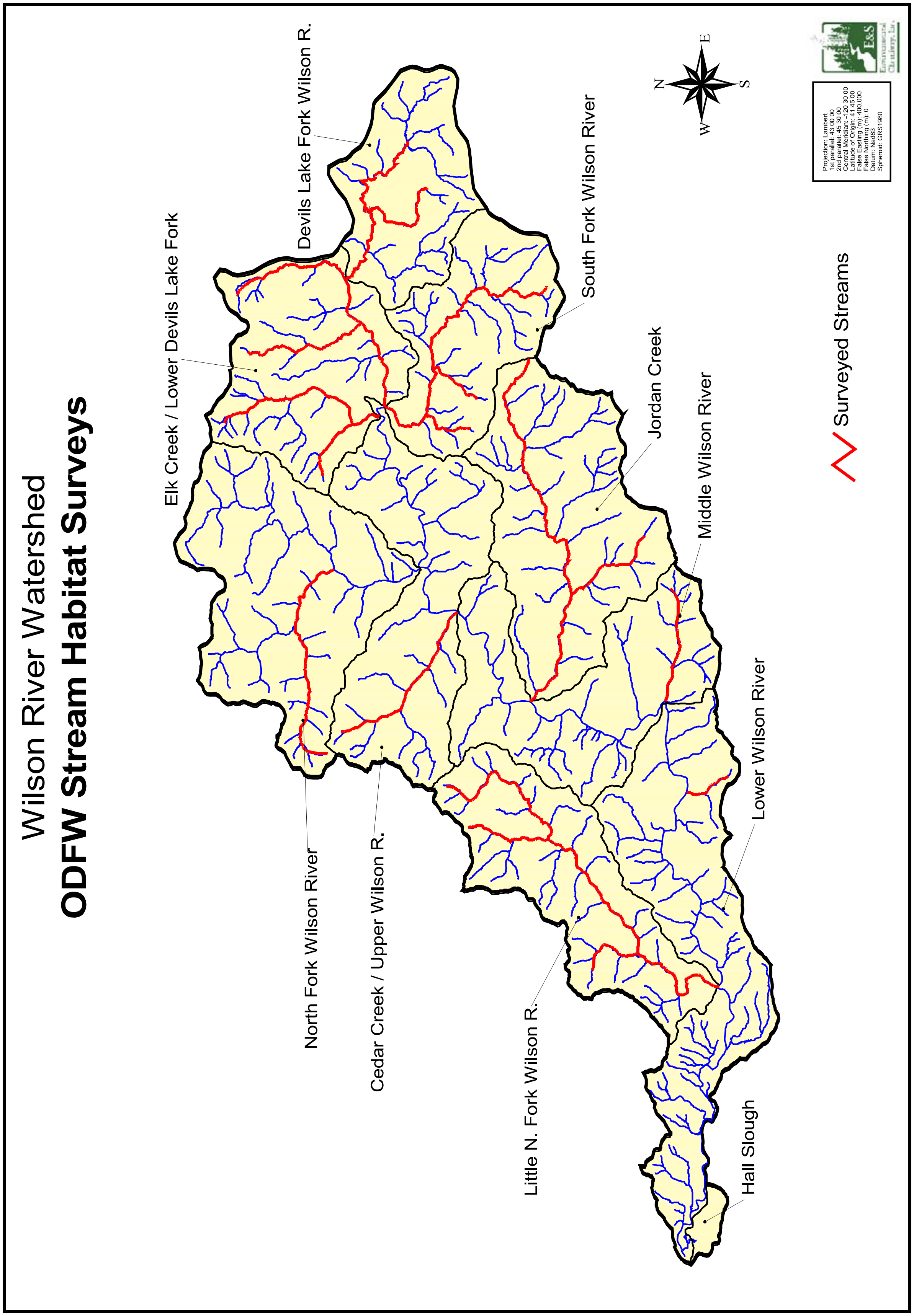

Figure 3.1 Streams surveyed for habitat conditions by ODFW.

In the streams surveyed, the pool frequency for the majority of the pools fell in the moderate category. Less than a quarter of the surveyed stream reaches were in the desirable or undesirable categories. The majority of the stream reaches were also in the moderate category based on the percent of area of the stream reach in pools. However, the percentage of undesirable streams was more than twice the percentage of desirable streams (Table 3.2). In general, the depth of pools was sufficient. Residual pool depth was desirable for approximately half of all stream reaches surveyed. Only 15% of surveyed streams had undesirable residual pool depths.

Table 3.2. Stream morphology and substrate conditions in the Wilson River watershed as compared to ODFW benchmark values. Benchmark values for stream habitat conditions have been provided in Table 3.1. Data were collected by ODFW.

Stream	Reach	Stream Miles	Gradient (%)	Pool Frequency (Channel Length Between Pools)	Percent Pools	Residual Pool Depth (m)	Gravel in Riffles (%area)
Berry Creek	1	1.0	3.7	7.8	19.5	0.7	33.0
	2	1.4	12.6	72.6	4.3	0.6	18.0
Cedar Creek	1	0.9	1.6	10.7	18.1	0.8	28.0
	2	1.7	1.8	10.4	20.9	0.8	28.0
	3	0.3	1.9	7.1	20.9	0.6	28.0
	4	0.4	2.7	10.2	15.7	0.5	31.0
	5	0.8	4.8	6.3	14.9	0.4	29.0
	6	0.8	23.0	15.9	7.5	0.1	30.0
Devils Lake Fork	1	1.0	6.5	4.6	24.0	0.5	25.0
	2	0.4	1.4	5.5	16.0	0.5	34.0
	3	1.4	2.2	6.8	31.0	0.6	28.0
	4	0.3	4.0	10.1	93.0	0.9	0.0
	5	0.5	3.7	3.1	29.0	0.4	32.0
	6	1.9	1.9	4.3	51.0	0.4	24.0
	7	1.7	1.5	7.5	43.0	0.5	17.0
	8	0.8	0.7	10.6	38.0	0.5	30.0
Deyoe Creek	1	0.9	3.9	27.2	8.2	0.6	25.0
	2	0.4	0.7	2.9	97.3	0.6	16.0
	3	0.2	2.2	47.4	9.5	0.3	24.0
	4	0.8	4.1	98.4	2.8	0.4	23.0
Drift Creek	1	3.0	7.9	21.8	6.5	0.4	66.0
Elk Creek	1	0.8	2.7	7.6	21.1	1.2	13.0
	2	2.3	3.9	18.9	10.8	1.1	16.0
	3	0.7	4.2	28.8	9.9	0.8	37.0
	4	1.5	12.8	98.0	4.5	0.8	53.0
Fall Creek	1	0.2	10.9	19.8	5.7	0.6	5.0
	2	1.7	6.0	14.3	6.4	0.3	44.0
	3	0.7	16.0	20.4	5.6	0.4	54.0
Idiot Creek	1	0.6	4.5	6.2	3.0	0.3	34.0
	2	2.8	8.7	8.3	20.1	0.4	47.0

Table 3.2. Continued.

Stream	Reach	Stream Miles	Gradient (%)	Pool Frequency (Channel Length Between Pools)	Percent Pools	Residual Pool Depth (m)	Gravel in Riffles (%area)
Jordan Creek	1	0.2	1.7	8.2	40.9	0.8	14.0
	2	1.5	1.6	4.9	34.3	1.0	14.0
	3	1.1	1.7	6.5	27.3	1.0	17.0
	4	2.3	2.4	7.1	43.8	1.3	16.0
	5	0.2	2.5	6.0	32.5	1.2	15.0
	6	1.4	3.3	6.6	28.5	1.0	12.0
	7	0.3	3.2	20.5	5.4	0.4	16.0
	8	0.4	3.3	4.8	32.1	0.7	13.0
	9	0.4	8.5	6.0	13.8	0.8	22.0
	10	0.1	6.4	0.0	0.0	0.0	0.0
	11	1.0	11.7	8.8	12.0	0.6	24.0
	12	1.0	23.4	40.3	4.5	0.5	37.0
Kansas Creek	1	0.5	6.3	8.4	20.6	0.4	44.0
	2	0.6	11.4	12.9	19.2	0.4	63.0
Little North Fork Wilson River	1	1.2	0.8	4.0	32.0	0.9	25.0
	2	1.4	1.0	0.0	49.7	0.8	23.0
	3	5.6	2.1	2.7	35.2	0.8	29.0
	4	1.1	4.2	3.1	20.7	0.8	63.0
	5	1.5	2.4	4.6	28.3	0.7	45.0
	6	0.8	9.2	32.7	7.8	0.5	38.0
South Fork Jordan Creek	1	0.7	3.5	24.8	6.8	0.5	25.0
	2	1.6	4.8	15.6	9.1	0.4	34.0
	3	0.7	12.5	171.6	0.7	0.4	43.0
South Fork Wilson River	1	2.6	1.4	7.2	36.0	0.9	21.0
	2	1.6	2.3	8.8	25.0	0.9	33.0
	3	1.6	3.4	12.7	9.6	0.7	22.0
	4	1.5	7.1	104.1	2.2	0.9	21.0
	5	0.6	23.1	0.0	0.0	0.0	35.0
	6	0.5	21.6	0.0	0.0	0.0	30.0
South Fork Wilson River Trib B	1	0.6	4.0	6.1	14.1	0.4	62.0
	2	0.7	13.2	26.1	4.2	0.4	75.0
South Fork Wilson River Trib C	1	0.5	6.5	10.4	12.8	0.4	29.0
	2	0.3	7.6	8.2	16.1	0.5	56.0
	3	0.3	8.2	7.7	18.3	0.5	47.0
	4	1.1	14.6	16.6	17.1	0.3	41.0
W. Fk of North Fk Wilson River	1	2.0	2.2	13.7	21.1	1.1	19.0
	2	1.7	2.8	11.7	25.2	0.6	19.0
	3	2.2	8.9	18.0	19.9	0.6	48.0
West Fork Elk Creek	1	1.1	8.3	33.9	4.3	0.9	30.0
	2	0.6	19.9	0.0	0.0	0.0	20.0
White Creek	1	2.0	5.5	15.8	24.8	0.6	36.0
	= Desirable		= Undesirable			= Moderate	

Gravel beds are important channel features since they provide spawning areas for salmonids. Gravel conditions in riffles demonstrated generally moderate to desirable conditions, although Jordan Creek showed undesirable conditions in 5 of 12 reaches surveyed (Table 3.2). The majority of reaches surveyed throughout the Wilson River watershed had moderate gravel conditions, suggesting a need for improvement.

3.2.2 Large Woody Debris

Large woody debris is an important feature that adds to the complexity of the stream channel. LWD in the stream provides cover, produces and maintains pool habitat, creates surface turbulence, and retains a small woody debris. Functionally, LWD dissipates stream energy, retains gravel and sediments, increases stream sinuosity and length, slows the nutrient cycling process, and provides diverse habitat for aquatic organisms (Bischoff et al. 2000; BLM 1996). LWD is most abundant in intermediate sized channels in third- and fourth-order streams. In fifth-order and larger streams, the channel width is generally wider than the length of a typical piece of LWD, and therefore, LWD is not likely to remain stable in the channel. In wide channels, LWD is more likely to be found along the edge of the channel.

In general, LWD conditions in the surveyed streams were less than desirable. In particular, the density of key pieces of LWD was predominantly rated as undesirable. In less than one-fifth of the surveyed stream reaches was the density of key pieces rated as desirable (Table 3.3). The volume of LWD was almost always rated either as desirable or undesirable, with very few stream reaches in the moderate category. LWD conditions in Deyoe Creek and South Fork of the Wilson were exceptionally good overall, having desirable LWD conditions in terms of the total number of pieces, the volume of the pieces, and the number of key pieces per 100 m of stream. For Devils Lake Fork, Elk Creek, Fall Creek, Idiot Creek, Jordan Creek and South Jordan Creek, all three LWD measures were undesirable. Riparian conditions almost uniformly demonstrated undesirable conditions, with nearly all streams lacking sufficient densities of conifers in the riparian zones (Table 3.4). Similarly, many of the streams showed poor LWD recruitment potential.

Table 3.3. Large woody debris conditions in the Wilson River watershed as compared to ODFW habitat benchmark values. Data were collected by ODFW.

Stream	Reach	Stream Miles	Gradient (%)	Woody Debris # Pieces/ 100m	Woody Debris Vol. (m^3/100m)	Woody Debris # Key Pieces / 100m
Berry Creek	1	1.0	3.7	15.1	28.9	0.50
	2	1.4	12.6	19.8	58.8	1.20
Cedar Creek	1	0.9	1.6	14.0	9.9	0.10
	2	1.7	1.8	12.9	12.4	0.10
	3	0.3	1.9	15.6	10.4	0.20
	4	0.4	2.7	36.1	27.3	0.00
	5	0.8	4.8	30.9	41.7	0.50
	6	0.8	23.0	61.9	115.3	3.00
Devils Lake Fork	1	1.0	6.5	5.0	14.4	0.00
	2	0.4	1.4	4.4	7.1	0.00
	3	1.4	2.2	5.5	15.2	0.00
	4	0.3	4.0	33.0	188.6	0.00
	5	0.5	3.7	3.7	10.8	0.00
	6	1.9	1.9	12.7	37.3	0.00
	7	1.7	1.5	2.1	7.9	0.00
	8	0.8	0.7	7.4	30.2	0.00
Deyoe Creek	1	0.9	3.9	35.4	144.1	6.20
	2	0.4	0.7	20.9	116.8	5.20
	3	0.2	2.2	33.5	153.2	8.90
	4	0.8	4.1	34.9	148.0	7.40
Drift Creek	1	3.0	7.9	24.4	21.3	0.20
Elk Creek	1	0.8	2.7	4.6	7.1	0.10
	2	2.3	3.9	2.2	3.1	0.00
	3	0.7	4.2	17.9	31.8	0.40
	4	1.5	12.8	32.7	62.1	2.10
Fall Creek	1	0.2	10.9	1.3	3.8	0.00
	2	1.7	6.0	1.1	2.9	0.10
	3	0.7	16.0	7.9	11.3	0.10
Idiot Creek	1	0.6	4.5	9.2	13.2	0.30
	2	2.8	8.7	9.2	9.7	0.20
Jordan Creek	1	0.2	1.7	3.2	2.8	0.00
	2	1.5	1.6	6.7	10.5	0.30
	3	1.1	1.7	12.4	15.6	0.30
	4	2.3	2.4	9.1	9.0	0.10
	5	0.2	2.5	7.8	11.2	0.30
	6	1.4	3.3	5.9	7.5	0.00
	7	0.3	3.2	20.6	29.1	0.70

Table 3.3. Continued.

Stream	Reach	Stream Miles	Gradient (%)	Woody Debris # Pieces/ 100m	Woody Debris Vol. (m^3/100m)	Woody Debris # Key Pieces / 100m
	8	0.4	3.3	5.2	6.1	0.50
	9	0.4	8.5	52.3	117.6	3.80
	10	0.1	6.4	3.4	5.1	0.60
	11	1.0	11.7	16.6	33.2	0.80
	12	1.0	23.4	38.3	105.1	4.60
Kansas Creek	1	0.5	6.3	2.2	1.3	0.00
	2	0.6	11.4	16.8	32.6	0.70
Little North Fork Wilson River	1	1.2	0.8	7.4	16.6	0.00
	2	1.4	1.0	9.2	33.4	0.00
	3	5.6	2.1	14.7	36.5	0.90
	4	1.1	4.2	40.5	68.4	1.00
	5	1.5	2.4	21.1	33.7	0.70
	6	0.8	9.2	22.1	28.6	0.00
South Fork Jordan Creek	1	0.7	3.5	2.9	2.3	0.00
	2	1.6	4.8	9.2	14.4	0.10
	3	0.7	12.5	8.3	17.3	0.20
South Fork Wilson River	1	2.6	1.4	4.4	6.8	0.30
	2	1.6	2.3	11.0	14.7	0.50
	3	1.6	3.4	28.9	92.6	3.80
	4	1.5	7.1	22.6	162.6	7.40
	5	0.6	23.1	77.2	594.2	25.10
	6	0.5	21.6	11.4	102.6	4.50
South Fork Wilson River Trib B	1	0.6	4.0	13.4	27.9	1.10
	2	0.7	13.2	31.7	65.3	2.40
South Fork Wilson River Trib C	1	0.5	6.5	8.3	11.6	0.60
	2	0.3	7.6	19.6	57.3	3.20
	3	0.3	8.2	24.2	73.7	3.80
	4	1.1	14.6	22.3	82.4	5.20
W. Fk of North Fk Wilson River	1	2.0	2.2	7.6	18.1	0.30
	2	1.7	2.8	24.1	47.1	0.50
	3	2.2	8.9	26.1	54.9	0.50
West Fork Elk Creek	1	1.1	8.3	43.8	92.4	1.90
	2	0.6	19.9	64.8	137.3	2.90
White Creek	1	2.0	5.5	14.6	33.1	1.60

Legend: light grey = Desirable; dark grey = Undesirable; white = Moderate

Table 3.4. Riparian conifer conditions in the Wilson River watershed as compared to ODFW habitat benchmark values. Benchmark values for stream habitat conditions have been provided in Table 3.1. Data were collected by ODFW.

Stream	Reach	Stream Miles	Gradient (%)	Width (m)	Shade (%)	# Conifers > 20" dbh per 1,000 ft stream length	# Conifers > 35" in dbh per 1,000 ft stream length
Berry Creek	1	1.0	3.7	4.8	94.0	0.0	0.0
	2	1.4	12.6	3.2	96.0	0.0	0.0
Cedar Creek	1	0.9	1.6	7.6	68.0	0.0	0.0
	2	1.7	1.8	6.9	59.0	12.0	12.0
	3	0.3	1.9	6.5	63.0	0.0	0.0
	4	0.4	2.7	4.1	63.0	0.0	0.0
	5	0.8	4.8	3.7	73.0	0.0	0.0
	6	0.8	23.0	2.3	77.0	0.0	0.0
Devils Lake Fork	1	1.0	6.5	7.9	69.0	0.0	0.0
	2	0.4	1.4	6.7	59.0	0.0	0.0
	3	1.4	2.2	6.7	79.0	0.0	0.0
	4	0.3	4.0	9.8	58.0	0.0	0.0
	5	0.5	3.7	5.0	74.0	0.0	0.0
	6	1.9	1.9	4.9	85.0	0.0	0.0
	7	1.7	1.5	4.4	68.0	0.0	0.0
	8	0.8	0.7	4.3	46.0	0.0	0.0
Deyoe Creek	1	0.9	3.9	3.5	88.0	61.0	61.0
	2	0.4	0.7	13.1	52.0	0.0	0.0
	3	0.2	2.2	2.4	91.0	0.0	0.0
	4	0.8	4.1	2.5	90.0	61.0	61.0
Drift Creek	1	3.0	7.9	4.5	88.0	69.0	69.0
Elk Creek	1	0.8	2.7	7.9	77.0	0.0	0.0
	2	2.3	3.9	6.3	81.0	0.0	0.0
	3	0.7	4.2	3.2	85.0	0.0	0.0
	4	1.5	12.8	2.0	83.0	0.0	0.0
Fall Creek	1	0.2	10.9	5.4	91.0	0.0	0.0
	2	1.7	6.0	5.0	99.0	0.0	0.0
	3	0.7	16.0	2.1	100.0	20.0	20.0
Idiot Creek	1	0.6	4.5	5.5	100.0	48.3	48.3
	2	2.8	8.7	3.4	99.0	60.3	54.3
Jordan Creek	1	0.2	1.7	8.3	76.0	0.0	0.0
	2	1.5	1.6	10.5	90.0	0.0	0.0
	3	1.1	1.7	9.7	81.0	0.0	0.0
	4	2.3	2.4	7.6	85.0	17.0	17.0
	5	0.2	2.5	9.0	97.0	61.0	61.0
	6	1.4	3.3	5.7	91.0	15.0	15.0
	7	0.3	3.2	4.4	87.0	0.0	0.0
	8	0.4	3.3	5.0	95.0	0.0	0.0

Table 3.4. Continued.

Stream	Reach	Stream Miles	Gradient (%)	Width (m)	Shade (%)	# Conifers > 20" dbh per 1,000 ft stream length	# Conifers > 35" in dbh per 1,000 ft stream length
	9	0.4	8.5	2.7	97.0	41.0	41.0
	10	0.1	6.4	3.2	92.0	0.0	0.0
	11	1.0	11.7	2.1	97.0	24.0	24.0
	12	1.0	23.4	1.1	95.0	98.0	98.0
Kansas Creek	1	0.5	6.3	3.3	100.0	0.0	0.0
	2	0.6	11.4	1.9	100.0	61.0	31.0
Little North Fork Wilson River	1	1.2	0.8	10.5	60.0	0.0	0.0
	2	1.4	1.0	11.6	69.0	0.0	0.0
	3	5.6	2.1	6.0	93.0	7.0	0.0
	4	1.1	4.2	4.0	96.0	0.0	0.0
	5	1.5	2.4	3.3	97.0	0.0	0.0
	6	0.8	9.2	3.0	100.0	0.0	0.0
South Fork Jordan Creek	1	0.7	3.5	4.0	95.0	30.0	30.0
	2	1.6	4.8	4.9	96.0	0.0	0.0
	3	0.7	12.5	3.1	99.0	30.0	30.0
South Fork Wilson River	1	2.6	1.4	7.9	77.0	0.0	0.0
	2	1.6	2.3	6.7	83.0	20.0	20.0
	3	1.6	3.4	5.2	90.0	20.0	20.0
	4	1.5	7.1	3.1	93.0	41.0	41.0
	5	0.6	23.1	2.3	89.0	122.0	122.0
	6	0.5	21.6	0.7	85.0	61.0	61.0
South Fork Wilson River Trib B	1	0.6	4.0	2.7	77.0	0.0	0.0
	2	0.7	13.2	2.0	84.0	102.0	102.0
South Fork Wilson River Trib C	1	0.5	6.5	3.4	100.0	0.0	0.0
	2	0.3	7.6	3.0	95.0	61.0	61.0
	3	0.3	8.2	3.3	97.0	0.0	0.0
	4	1.1	14.6	1.9	98.0	0.0	0.0
W. Fk of North Fk Wilson River	1	2.0	2.2	7.4	75.0	0.0	0.0
	2	1.7	2.8	4.2	84.0	91.0	0.0
	3	2.2	8.9	2.4	90.0	46.0	0.0
West Fork Elk Creek	1	1.1	8.3	2.5	85.0	0.0	0.0
	2	0.6	19.9	1.1	88.0	0.0	0.0
White Creek		2.0	5.5	3.7	75.0	46.0	0.0

(light grey) = Desirable; (dark grey) = Undesirable; (white) = Moderate

3.2.3 Shade

Shade conditions in the streams surveyed were generally rated as desirable. Only the Devils Lake Fork of the Wilson showed a significant proportion of less-than-desirable shade conditions (Table 3.4). However, ODEQ's latest reports, prepared in conjunction with the TMDL process, indicate shade to be deficient throughout the watershed. It is possible, perhaps likely, that shade conditions throughout the upland forest, not just within the riparian area, have a significant impact on stream temperature. In addition, riparian conifer conditions were undesirable in most reaches, suggesting that much of the shading is provided by hardwood species such as alder or maple. These relatively short-lived hardwoods do not contribute high quality LWD to the stream system.

3.3 Riparian Conditions

The riparian zone is the area along streams, rivers and other water bodies where there is direct interaction between the aquatic and terrestrial ecosystems. The riparian zone ecosystem is one of the most highly valued and highly threatened in the United States (Johnson and McCormick 1979, National Research Council 1995 in Kauffman et al. 1997). Riparian vegetation is an important element of a healthy stream system. It provides bank stability, controls erosion, moderates water temperature, provides food for aquatic organisms and large woody debris to increase aquatic habitat diversity, filters surface runoff to reduce the amount of sediments and pollutants that enter the stream, provides wildlife habitat, dissipates flow of energy, and stores water during floods (Bischoff et al. 2000). Natural and human degradation of riparian zones diminishes their ability to provide these critical ecosystem functions.

The USDA Farm Service Agency in Tillamook provided monochromatic aerial photos of the Wilson River watershed. The aerial photos were taken in 1990 at a scale of 1:7,920. Mylar overlays of the stream network were generated with the GIS. Riparian vegetation and shade conditions were interpreted from the photos, recorded on the overlays, and then digitized into the GIS.

Riparian vegetation frequently occurs in several zones parallel to the stream bank. For example, often a band of young hardwoods lines the stream bank, behind which is a zone of conifers. Consequently, riparian vegetation was assessed for two zones parallel to the stream bank, on both sides of the stream (Table 3.6). Zone RA1 included 50 feet on each side of the stream. Zone RA2 included from 50 to 100 feet on each side of the stream. Although LWD may theoretically reach the stream from a distance of a site potential tree height, the majority of functional wood has been found to come from within 100 feet on either side of the stream. The combined width of these two zones was therefore set at 200 feet (100 feet on each side), according to OWEB recommendations (McDade et al. 1990, WPN 1999).

3.3.1 Large Woody Debris Recruitment Potential

Riparian vegetation was categorized as having a high, moderate, or low potential for large woody debris recruitment. Vegetation classes defined as coniferous or mixed in the large class (>24 inch dbh) had a high potential for LWD recruitment. Coniferous or mixed vegetation in the medium size class (12-24 inch dbh), and hardwoods in the medium to large class, had moderate potential for LWD recruitment (Table 3.5).

Table 3.5 Descriptions of large woody debris recruitment potential classes. Vegetation is categorized by average stand density, tree size (DBH), and species composition (coniferous, hardwood, and mixed coniferous/hardwood.

Recruitment Potential	Stand Density*	Description
Low	Dense	Small trees of all species (<12" dbh)
	Sparse	Small trees of all species (<12" dbh), and sparse medium-sized hardwoods (12" - 24" dbh)
Moderate	Dense	Medium-sized conifers, hardwoods, and mixed conifers/hardwoods (12" - 24" dbh)
	Sparse	Large conifers and mixed large conifers/hardwoods (>24" dbh); Medium-sized conifers, mixed medium conifers/hardwoods (12" - 24")
High	Dense	Large conifers and mixed large conifers/hardwoods (>24" dbh**)

*Dense: <1/3 of ground exposed; sparse: > 1/3 of ground exposed
**Diameter breast-height

In general, the potential for LWD recruitment in the Wilson River watershed was poor (Figure 3.2). None of the riparian areas in the watershed demonstrated a high potential to contribute LWD to the stream channel. In seventy percent of the subwatersheds, the majority of LWD recruitment potential was low (Table 3.6). The lack of large conifers (>24" dbh) in this watershed is likely a result of the Tillamook Burn and historic vegetation removal along the riparian corridor.

Recruitment potential of LWD from the riparian zone was identified based on the size and species of trees in the riparian zone and their distance from the streambank, according to the

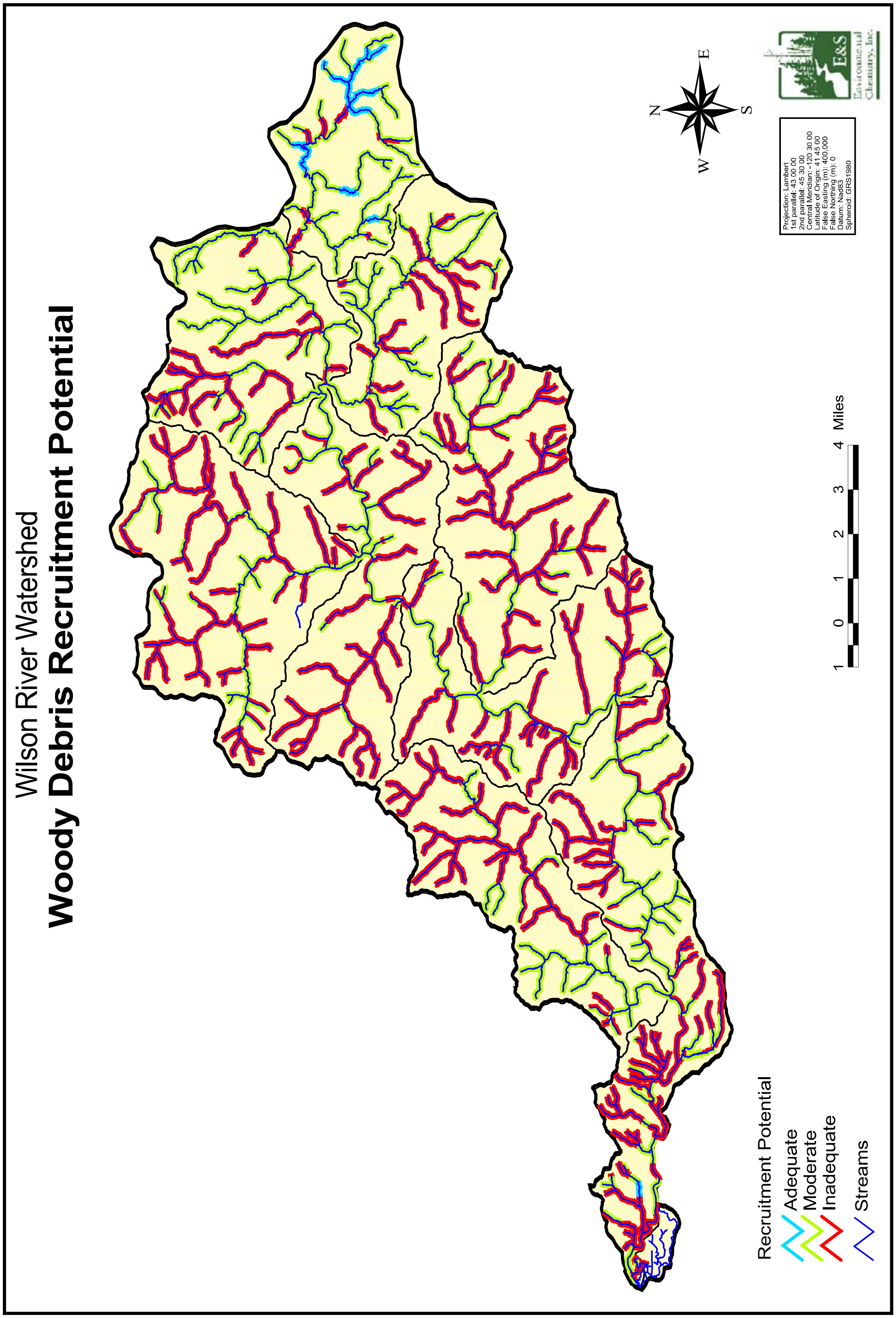

Figure 3.2 Woody debris recruitment potential in the Wilson River watershed. Data were developed from aerial photo interpretation conducted by E&S Environmental Chemistry, Inc..

Table 3.6 Large woody debris recruitment in the riparian zone. Large woody debris recruitment potential from two riparian zones (RA1 and RA2). RA1 extends 0-50 ft and RA2 extends 50-100 ft from the streambank.

Subwatershed	Stream Length (mi)	RA1 (%)			RA2 (%)			Overall Average (%)		
		Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Cedar Creek / Upper Wilson R.	38	72	28	0	50	50	0	61	39	0
Devils Lake Fork Wilson R.*	31	9	68	0	10	84	0	10	76	0
Elk Creek / Lower Devils Lake Fork	45	41	59	0	33	67	0	37	63	0
Hall Slough	6	100	0	0	100	0	0	100	0	0
Jordan Creek	48	75	25	0	67	33	0	71	29	0
Little N. Fork Wilson R.	42	62	38	0	62	38	0	62	38	0
Lower Wilson River	71	61	39	0	62	38	0	62	38	0
Middle Wilson River	40	70	30	0	57	43	0	63	37	0
North Fork Wilson River	49	72	28	0	55	45	0	64	37	0
South Fork Wilson River	35	39	61	0	32	68	0	35	65	0
Average for Wilson River Watershed		60	38	0	53	47	0	56	42	0

* Percentages do not add up to 100% due to non-forested areas.

OWEB methodology. It provides a coarse-screening of the overall condition of LWD recruitment potential throughout the watershed. However, it should be noted that not all areas would contribute large amounts of LWD to the stream system even if there was a high density of large conifers. In general, large streams (i.e. >4th-order) low in the watershed are not likely to contribute as much LWD as smaller streams in the middle portion of the watershed. This is because large streams often are in flat valley bottoms with wide gravel bars along the banks, whereas in the upper part of the watershed hillslopes are usually steeper, channels straighter, and banks narrower. LWD is less likely to stabilize in the lower reaches of the river system because the channel is often wider than the LWD pieces are long (WPN 1999). However, the lower river serves an important function in transporting LWD to the estuary, where it contributes to estuarine habitat complexity.

In the Wilson River watershed, LWD recruitment potential has been limited by extensive wood salvaging in the lower watershed and land management practices on private lands not affected by state forest practices regulations (Michele Long, ODFW, pers. comm., June, 2001).

The Devils Lake Fork of the Wilson River represents a unique situation. Much of the upper portion of this subwatershed was not heavily vegetated with coniferous forest, and slope gradients were relatively gentle. Based on aerial photo analysis, approximately 23% of the stream length was occupied by riparian wetlands (see Section 3.2). Although wetlands may or may not contribute LWD to the stream channel depending on the wetland type, they do provide several other important habitat features, such as back channels and cover for aquatic organisms.

3.3.2 Stream Shading

Riparian vegetation provides shade and insulation that helps moderate stream temperatures. While shade will not actually cool a stream, riparian vegetation blocks solar radiation before it reaches the stream and prevents the stream from heating (Bischoff et al. 2000, Beschta 1997, Boyd and Sturdevant 1997, Beschta et al. 1987). The shading ability of the riparian zone is determined by the quality and quantity of vegetation present. The wider the riparian zone and the taller and more dense the vegetation, the better the shading ability (Beschta 1997, Boyd and Sturdevant 1997). Current shade conditions for the Wilson River watershed were estimated from the aerial photo interpretation.

Results from our aerial photo analysis of stream shading yielded similar results to the stream reach surveys of ODFW. Stream shading conditions were generally high across the watershed (Table 3.7, Figure 3.3). Shade conditions were high for at least 80% of the stream length in 7 of the 11 subwatersheds. Hall Slough was the only subwatershed for which the

Table 3.7. Current stream shading conditions in the Wilson River watershed, based on aerial photo interpretation conducted by E&S.

Subwatershed	Total Stream mi.	% Low	% Medium	% High
Cedar Creek / Upper Wilson R.	38	2	18	80
Devils Lake Fork Wilson R.	31	22	9	69
Elk Creek / Lower Devils Lake Fork	45	3	7	90
Hall Slough	0.15	0	73	27
Jordan Creek	48	1	7	93
Little N. Fork Wilson R.	42	1	8	91
Lower Wilson River	70	22	14	64
Middle Wilson River	40	17	4	79
North Fork Wilson River	49	1	5	94
South Fork Wilson River	35	4	12	84
Grand Total	397	9	9	82

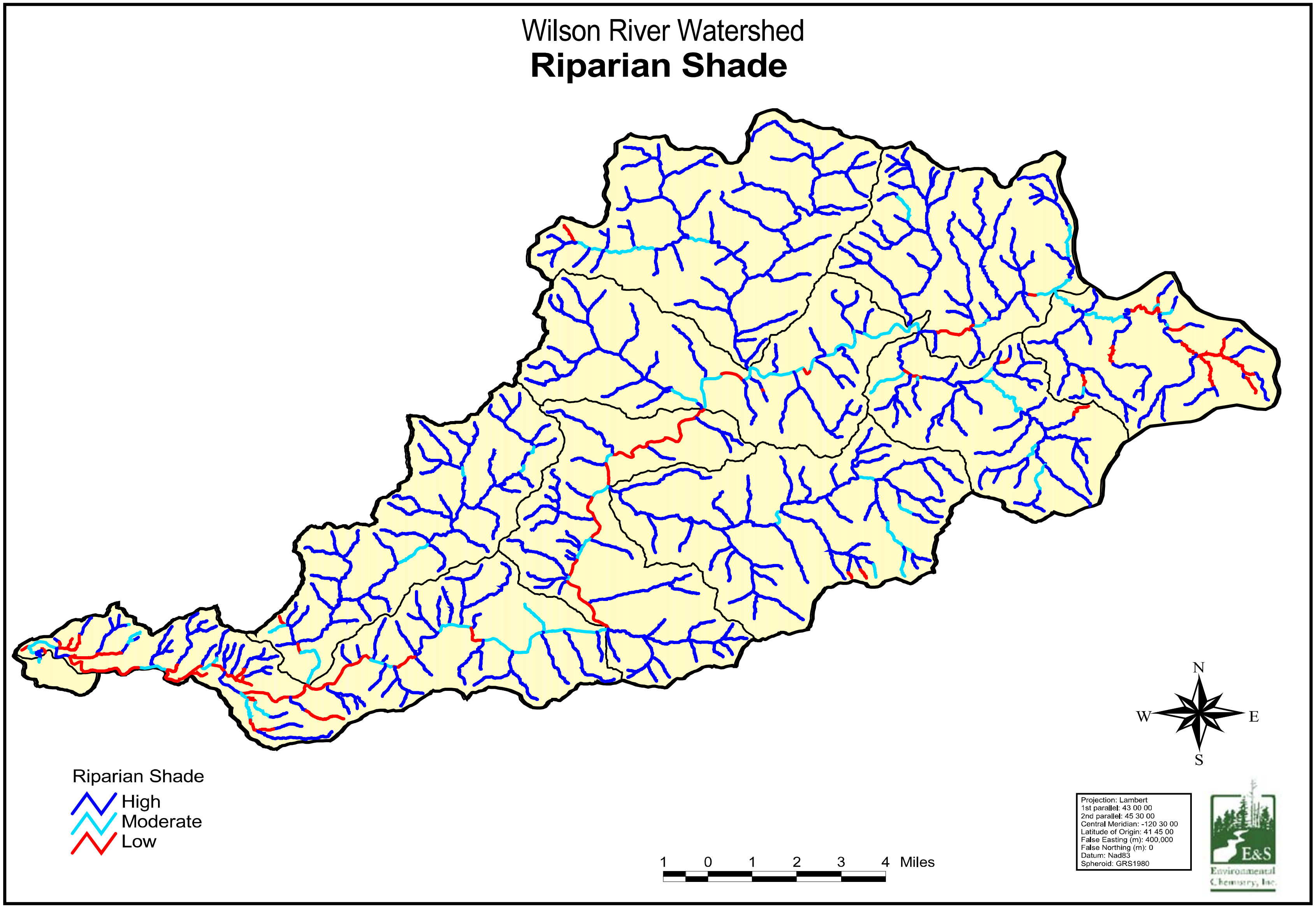

Figure 3.3 Riparian shade conditions in the Wilson River watershed. Data were developed from aerial photo interpretation conducted by E&S Environmental Chemistry, Inc.

majority of the stream was not in the high shade category. Wetlands can also provide some shade from vegetation although many of the wetlands in the watershed are diked and disconnected from the stream as a result of development and agriculture. The shading value of wetlands needs to be evaluated on a wetland by wetland basis.

3.4 Fish Passage Barriers

Stream channels are often blocked by natural barriers, such as waterfalls, or by human-caused barriers, especially poorly designed culverts at road crossings. This has resulted in significant loss of fish access to suitable habitat. Anadromous fish migrate upstream and downstream in search of food, habitat, shelter, spawning beds, and better water quality. Fish populations can be significantly limited if they lose access to key habitat areas. One study estimated the loss of fish habitat from forest roads to be 13% of total coho summer rearing habitat (Beechie et al. 1994). Another study reported that as many as 75% of culverts in some forested drainages are either impediments or outright blockages to fish passage, based on surveys completed in Washington state (Conroy, 1997). Surveys of county and state roads in Oregon have found hundreds of culverts that at least partially block fish passage. Potential effects from the loss of fish passage include loss of genetic diversity by isolation of reaches, loss of range for juvenile anadromous and resident fish, and loss of resident fish from extreme flood or drought events (prevents return).

3.4.1 Culverts

Culverts can pose several types of problems for fish passage, including excessive height above the downstream pool, excessive water velocity, insufficient water depth in culvert, disorienting flow patterns, and lack of resting pools between culverts. Culverts can also limit fish species only during certain parts of their life cycles. For example, a culvert may be passable to larger adult anadromous fish and not passable to juveniles. Culverts may also act as passage barriers only during particular environmental conditions, such as high flow or low flow events. Because of the variety of potential effects, it is important to understand the interactions of habitat conditions and life stage for anadromous fish.

In addition to limiting fish passage, culverts can also affect materials transport. In particular, culverts can limit the recruitment of gravel and LWD from upper to lower reaches. Over 211 culverts out of a total 436 road-stream crossings in the Wilson River watershed have been surveyed for potential fish passage barriers and 24% of those surveyed were judged to be impassable (Table 3.8, Figure 3.4). Culvert data were obtained from surveys conducted by ODOT, ODFW, and TCAA. The Wilson River watershed has an average stream crossing density of 2.3 stream crossings per square mile. Stream crossing densities were highest in the Hall Slough and Lower Wilson River subwatersheds (7.5 and 4.1 crossings/mi^2, respectively). These same two subwatersheds also contained the vast majority (84%) of the surveyed culverts that were judged to be impassable and the lowest subwatershed percentages judged to have high stream shading (Table 3.7). The only other subwatersheds found to contain impassable culverts were Cedar Creek/Upper Wilson River and Middle Wilson River (both < 10%). It should be noted, however, that culverts have not been surveyed in four of the subwatersheds.

Table 3.8. Culverts and road/stream crossings in the Wilson River watershed. Road/stream crossings were generated using GIS. Culvert data were provided by ODFW, ODOT, and TCAA.

Subwatershed	Area (sq. mi.)	Surveyed Culverts		Road-Stream Crossings	
		# Surveyed	# Impassable	#	#/mi^2
Cedar Creek/Upper Wilson R.	23	42	4	38	1.7
Devils Lake Fork Wilson R.	14	14	0	44	3.1
Elk Creek/Lower Devils Lake Fork	20	22	0	41	2.1
Hall Slough	1.1	25	13	8	7.5
Jordan Creek	25	0	0	53	2.1
Little N. Fork Wilson R.	20	0	0	11	0.5
Lower Wilson River	27	65	30	110	4.1
Middle Wilson River	21	43	4	46	2.2
North Fork of the Wilson River	27	0	0	27	1.0
South Fork of the Wilson River	16	0	0	58	3.6
TOTAL	194	211	51	436	2.3

3.4.2 Natural Barriers

Several natural fish passage barriers in the Wilson River watershed were identified by ODFW (Figure 3.4). There is a waterfall in the Lower Wilson subwatershed that blocks a small tributary stream. Two other falls occur in the Jordan Creek and Elk Creek subwatersheds, although coho have been found above these falls, suggesting they are not complete fish passage barriers.

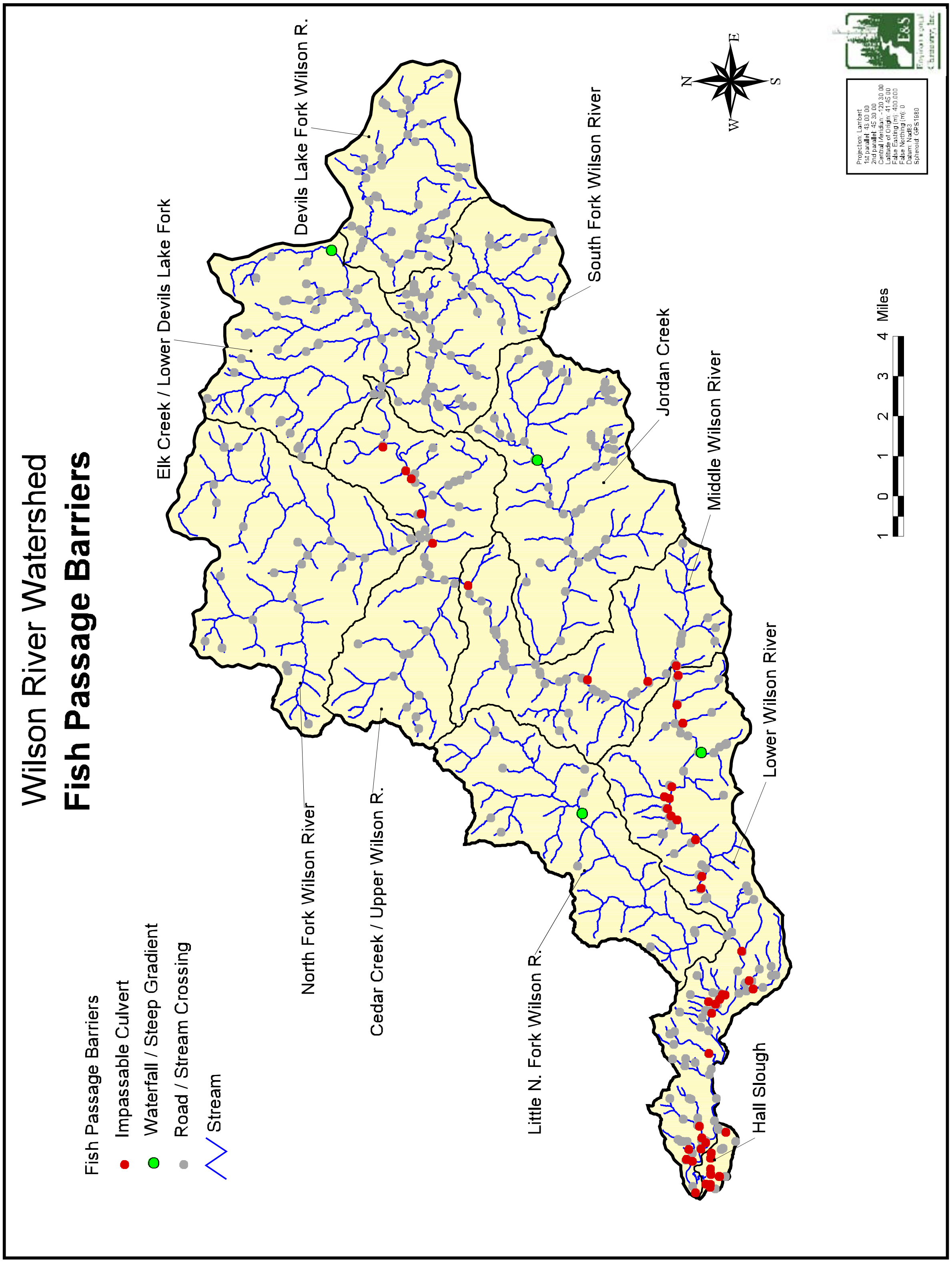

Figure 3.4. Road/stream crossings and known fish passage barriers in the Wilson River watershed. Road/stream crossings were generated using GIS. Culvert data were provided by ODFW, ODOT, and TCAA.

3.4.3 Tide Gates

There are numerous tide gates in the lower reaches of the Wilson, Trask, and Tillamook Rivers, in the southern portion of the Tillamook Basin, including six in the Wilson River watershed (Figure 3.4). Four of these have been identified as impediments to fish passage. An effort has been underway by the TCPP to replace them with fish-friendly tide gates. To date, one has been replaced, two are scheduled for replacement in 2001 (both on Blind Slough), and one is scheduled for replacement at a later date (midway between Blind Slough and the furthest end of the point in the bay). It is believed that, upon completion of this effort, all major tide gate impediments to fish passage in the Wilson River watershed will have been corrected (Don Reynolds, TCPP, pers. comm. 2001). However, additional information is needed to determine the extent to which fish access is improved.

3.5 Channel Modifications

In-channel structures and activities such as dams, dredging or filling can adversely affect aquatic organisms and their associated habitats by changing the physical character of the stream channel. These changes can ultimately alter community composition of in-stream aquatic biota. Identification of channel modification activities can help in the determination of the likely effects of anthropogenic channel disturbances on channel morphology, aquatic habitat, and hydrologic functioning.

The present condition of freshwater habitat in the Wilson River watershed has been heavily influenced by human activities and natural phenomena that have occurred over an extended period of time. Several events and practices have severely disturbed the watershed.

3.5.1 Channelization and Dredging

The Army Corps of Engineers (ACOE) was historically active in waterway modification projects in Tillamook Bay. From the mid-1890s to the mid-1970s, the ACOE performed maintenance dredging of the bay and snag clearing in the bay and lower river reaches for navigation purposes. Over time, changes in economic activity and improved ground transportation reduced the dependence of local commerce on water transportation and, in turn, the need for dredging. As early as 1949, "the people of Tillamook had ceased to think of the Tillamook as a navigable river" (Orcutt 1951).

There are special potential problems associated with dredging in estuaries and tidal river reaches. Waterway modifications in these areas may change local tidal currents or river flow patterns and, in turn, change sediment deposition, erosional processes (ABAG 1992), and vegetation communities. Damages from wave action may increase during storm events at high tides in deeper dredged waters, and the extent of the freshwater/saline water interface may shift in estuaries and river deltas, affecting agricultural or municipal water intakes, fisheries, and natural sedimentation processes (TBNEP 1998). Dredging can also simplify the physical estuary and river bed structure, thereby reducing microhabitat diversity. These impacts can include channelization, elimination of low flow channels, promotion of broader and shallower river cross sections, removal of LWD, and disruption of the riparian zone. In addition, direct impacts of dredging activity can include greatly elevated turbidity levels, increased biological oxygen demand, direct entrainment and mortality of benthic organisms, disruption of the gravel layer, and alteration and/or destruction of essential fish habitat and spawning areas. Direct and indirect impacts of dredging on salmonids can be significant due to clogging of gills, inducement of avoidance behaviors, decreased forage efficiency, reduced dissolved oxygen levels, loss of cover, increased water temperatures, disturbance of spawning gravels (in the case of chum salmon), and simplification of available habitat. The U.S. Army Corps of Engineers Feasibility Study and MIKE II modeling will address issues related to hydrologic conditions associated with dredging (A.D. Meyer, pers. comm., April, 2001).

3.5.2 Diking

Disconnecting the floodplain from the river can lead to reduced physical complexity and channel downcutting due to increased water velocities, resulting in deteriorated habitat conditions. Additionally, disconnection from the floodplain can lead to changes in the biotic structure of the aquatic ecosystem by limiting nutrient and organic material exchanges between the stream and floodplain.

One primary natural function of a floodplain is to store flood waters during high flow events. By impeding peak flood flows, natural floodplains tend to lower flood water elevations downstream and reduce downstream flood hazards and property destruction. As an example of this natural flood reduction benefit, an approximate 8-mile length of the floodplain along the Skykomish River in Washington State stores enough flood water to reduce flood flows by about 5% at downstream valley locations (Snohomish County Public Works 1996). In the Tillamook lowlands, considerable floodplain storage has been lost due to the construction of dikes and levees (Figure 3.5; TBNEP 1998). Many of these flood control structures, built to protect pasture lands from salt water inundation during tidal flooding, have also blocked the natural ability of the river floodplains to spread out flood waters, and thus the ability to slow and store flood waters flowing from the upland portions of the watersheds.

These attempts to control flooding have reduced the natural complexity of river channels and have separated the rivers from their floodplains. The loss of natural floodplain function due to diking has impacted other resources with economic value, such as the fish and shellfish industries, which attracted commercial and residential development to the floodplain (Coulton et al. 1996). To some degree the diking has increased streambank erosion by increasing water depth and flow velocity between the dikes (Leopold *et al*. 1992). In addition, the removal of large woody debris has made streambanks more vulnerable to this type of erosion process.

Dike construction has been extensive throughout the lower reaches of the Wilson river watershed (Figure 3.5). These dikes have had significant effects on flooding, hydrologic function, and fish access to estuarine wetlands.

The concept of working with the river's own natural functions to manage floods is replacing the concept of intervening in these processes to try to control floods (TBNEP 1998). Interest is growing in some areas in non-structural floodplain management methods, such as enforcing land use ordinances and restoring the floodplains.

3.5.3 Floodplain Development

Unaltered streams in natural lowland valley bottoms often meander through rich forested wetlands. These naturally meandering channels and adjacent wetlands typically have more frequent flooding, but lower flood peaks than human-altered streams and floodplains in similar geomorphic settings (Shields and Cooper 1994). Flood waves traveling through valley streams with natural riparian wetland floodplains have been observed to rise more gradually, reach lower peak elevations, and last longer than floods occurring on altered floodplains, which produced sharper, higher, and flashy flood conditions (Shields and Cooper 1994). Natural riparian wetlands help to distribute flood flows and store water for slower release.

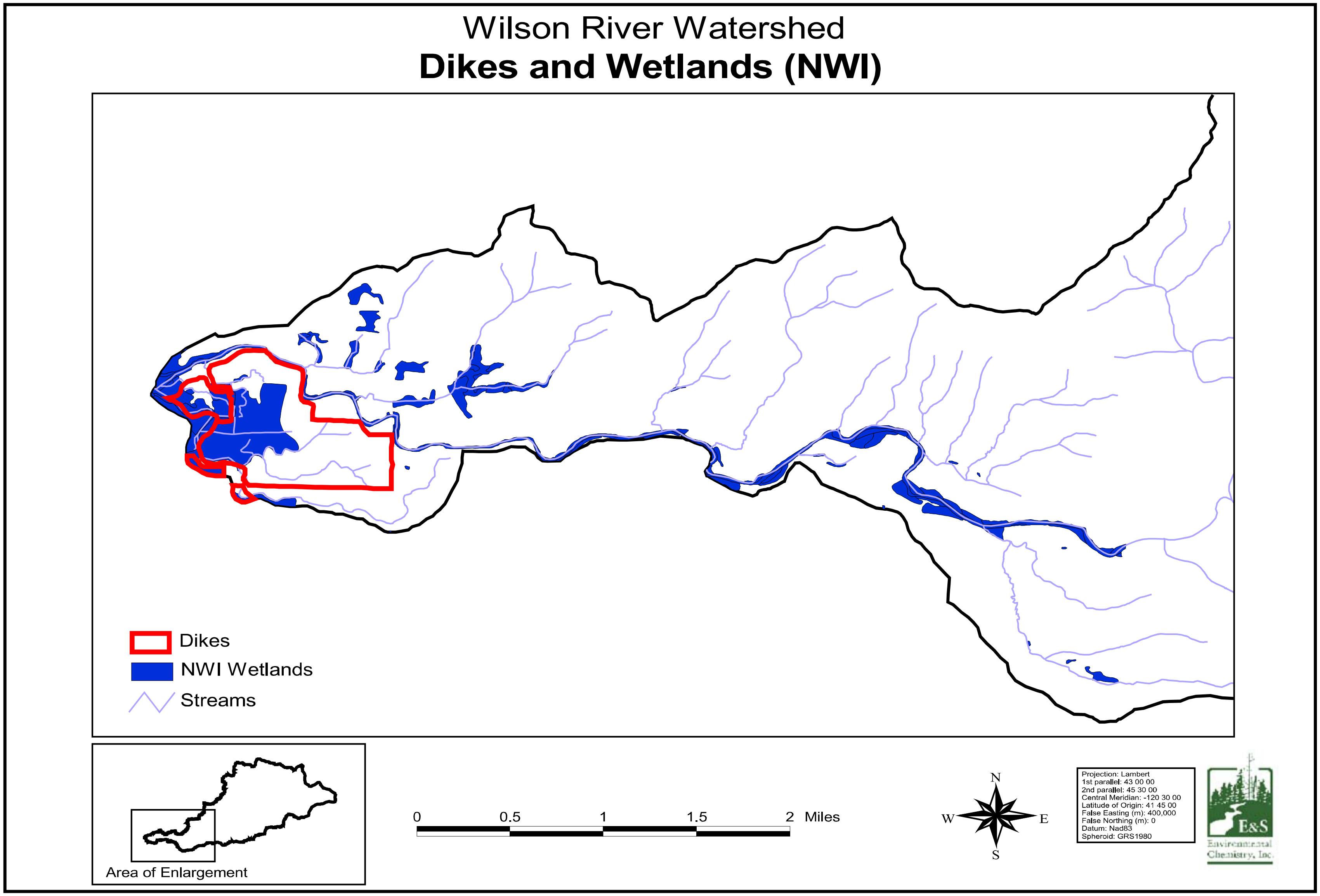

Figure 3.5 Location of dikes and wetlands in the Wilson River watershed. Dike data were provided by the TBNEP.

Historic mapping of the Tillamook Valley floodplains (See Chapter 1) and anecdotal accounts of flooding prior to Euro-American settlement indicate the historic floodplain landscape was much different than today. Historic valley landscapes were heavily forested bottom lands and wetlands which flooded often. These vegetative characteristics have been replaced by drained dairy pastures and urban or rural development. These changes have altered the ability of the floodplain to store and mitigate flood waters.

The reconnection of floodplain riparian areas and intertidal wetlands to the rivers in the Tillamook Bay valleys may help reduce erosion and flood hazards by reducing the height of flood waters currently constrained between levees and dikes. A recent ACOE study compared flood elevations along the Missouri River, determined from model simulations for three conditions: (1) the actual 1993 flood with existing levees (1993 computed), (2) levees lowered to provide protection only up to a 25-year flood (25-year levees); and, (3) levees removed (no levees) (ACOE 1995). The study determined that reducing the height of, or removing, levees lowers flood elevations. The on-going U.S. Army Corps of Engineers MIKE II modeling study for Tillamook Bay will help to determine if the modification or removal of levees and dikes would reduce flood elevations in this watershed.

3.5.4 Logging and Splash Damming

Historical logging in the Wilson River watershed has affected current stream conditions. Log drives during the late 1880s and early 1900s on the Wilson, Trask, and Tillamook Rivers caused long-term damage to the channels due to sluicing effect of the log drives and the clearing of obstacles in preparation for the drives (Sedell and Duval 1985). Logs were also stored in booms in the tidal portion of the river (Coulton et al. 1996).

3.5.5 Gravel Removal

Sand and gravel are two of the most important natural resources extracted from the earth, based on tonnage (Cooke and Doornkamp 1978). The sand and gravel industry in Oregon has prospered since the 1940s. Throughout this time Tillamook County rivers have provided a significant amount of this natural resource for local development interests. However, the in-channel extraction of sand and gravel has been scaled back in the county because of the assumed direct and cumulative impacts on the fisheries and shellfish resource industries which share the same ecosystem.

A 1992 Tillamook County Gravel Mediated Agreement was developed in response to state agency recommendations to protect fish habitat and spawning areas. Under the agreement, commercial in-stream (within the banks of a river) gravel removal above the heads of tide of the Kilchis, Miami, Wilson, Trask, and Tillamook Rivers was phased out by October 1, 1997. For the future, a Coordinated Resource Management Plan will control gravel removal from these rivers for non-commercial purposes and work to prevent unacceptable streambank erosion (Cleary 1996b). (ODSL and COE may consider applications for gravel extraction for flood control on Tillamook Bay rivers for tidal reaches of the rivers including "no less than all areas west of Highway 101" [Cleary 1996b]. However, applications are unlikely to get approval given EFH concerns and NMFS's 4(d) rules, unless the project can also be expected to improve fish habitat or restore ecosystem functions.)

Forecasts of aggregate use in Tillamook County show a mild increase in consumption to the year 2050 (TBNEP 1998). Total aggregate consumption for the County is estimated to be 28.9 million tons and virgin aggregate consumption will increase at a rate of 0.21% (Whelan 1995). Road construction will use up to 47% of the County's aggregate, and logging and forest roads will represent about 15% of the total consumption (Whelan 1995).

In 1996, Tillamook County took the necessary steps through the Goal 5 process to protect a number of upland aggregate sources. This action was prompted by an element of the Coordinated Resource Management Plan (CRMP) that phased out commercial gravel extraction from the Tillamook Bay rivers by October 1, 1997 (Cleary 1996b). Six upland sources have been identified as capable of yielding enough aggregate to meet the County's future aggregate needs (Tom Ascher, Tillamook County, pers. comm. 1997).

Research into the effects of gravel removal on river morphology is still limited, but findings have indicated some river channels have a certain amount of natural resiliency and may be capable of accommodating a degree of sediment removal. However, site-specific data should be obtained and physical responses should be carefully monitored.

These disruptions may result in downstream or upstream incision (down cutting) from the excavated area, as the river seeks dynamic equilibrium. In-stream gravel removal case studies reviewed by Collins and Dunne (1990) indicate channel degradation can extend several miles upstream from the removal site, if the extracted gravel volume exceeds the natural supply. Therefore, it is important to establish river sediment removal rates compatible with the sustainable yield of the river. Incision from gravel removal has been known to undermine river flood control works (Soil & Water 1985).

In-stream sand and gravel removal may also coarsen the bed sediments in streams, significantly impacting anadromous fish, because these fish require certain sizes of gravels for spawning (Allen 1969). Spawning fish have been observed to be capable of moving gravel up to a median size of approximately 10% of their body length (Kondolf and Wolman 1993). The removal of smaller gravels, of higher commercial value, may leave gravels too large for spawning fish to move. Other significant impacts to fisheries from in-stream dredging are the destruction of bottom-dwelling organisms and temporary water quality problems from turbidity (ABAG 1992).

3.6 Wetlands

Wetlands contribute critical functions to watershed health, including water quality improvement, filtration, flood attenuation, groundwater recharge and discharge, and fish and wildlife habitat. Because of the importance of these functions, wetlands are regulated by both state and federal agencies. Determining the location and extent of wetlands within a watershed is critical to understanding watershed structure and function.

3.6.1 National Wetlands Inventory

The primary source for wetland information used in this assessment was National Wetlands Inventory (NWI) maps created by the U.S. Fish and Wildlife Service. Very few of the NWI quads were digitized for the Wilson River watershed, so information was generally derived from hard copy NWI maps. NWI maps were created from interpretation of 1:58,000-scale aerial photos that were taken in August of 1981. It is important to note that NWI wetland maps are based on aerial photo interpretation and not on ground based inventories of wetlands. On-the-ground inventories of wetlands often identify extensive wetlands that are not on the NWI maps.

3.6.2 Wetland Extent and Types

Because digital NWI data were not available, wetland extent was not calculated for the Wilson River watershed. However, where NWI data were available, they were used to update the refined land use map. Hard copy NWI maps were used to evaluate wetland extent and types in the Wilson River watershed.

Wetlands are an important landscape feature in the Wilson River watershed. The predominant wetland type is palustrine wetlands with tidal salt marshes in the lower elevations. Palustrine wetlands are defined as all non-tidal wetlands dominated by trees, shrubs, and persistent emergents and all wetlands that occur in tidal areas with a salinity below 0.5 parts per thousand (Mitsch and Gosselink 1993, Cowardin et al. 1979). Palustrine wetlands are common along many of the stream corridors. However, many of these have been disconnected from the stream by dikes and flood protection efforts. The Devils Lake subwatershed, in particular, has a significant amount of higher elevation wetlands. Estuarine wetlands are defined as deepwater tidal habitats and adjacent tidal wetlands that are usually semiclosed by land but have open, partially obstructed, or sporadic access to the ocean and in which ocean saltwater is at least occasionally mixed with freshwater (Mitsch and Gosselink 1993, Cowardin et al. 1979). Prior to the 1970's, many estuarine wetlands were lost as a result of dikes and levees that removed the saltwater influence. Estuarine wetlands have since been protected, and losses minimized. However, many of the existing salt marshes have been recreated over the past 50 years and probably lack the diversity of habitats that the older salt marshes provided (Coulton ety al. 1996).

The Cowardin classification system is used by the NWI and others in classifying wetlands based on wetland type, vegetation or substrate type, and hydrology. The classification system is a hierarchical approach where the wetland is assigned to a system, subsystem, class, subclass, and water regime. Common types and characteristics of wetlands in the Wilson River watershed are shown in Table 3.9.

Table 3.9. Common NWI wetland types listed in the Wilson River watershed. Wetland codes are from the Cowardin Wetland Classification used by NWI (Cowardin 1979).

Code	System	Class	Water Regime
E2EMP	E=estuarine	EM=emergent	P=Irregularly Flooded
E2EMN	E=estuarine	EM=emergent	N=Regularly Flooded
E1UBL	E=estuarine	UB=Unconsolidated Bottom	L=Subtidal
E2FOP	E=estuarine	FO=Forested	P=Irregularly Flooded
PSSW	P= palustrine	SS=Scrub/Shrub	W=Intermittently Flooded
PSSC	P= palustrine	SS=Scrub/Shrub	C = Seasonally flooded

Table 3.9. Continued.			
Code	System	Class	Water Regime
PEMA	P= palustrine	EM=emergent	F= Semipermanently flooded
PEMB	P= palustrine	EM=emergent	B=Saturated
PEMC	P= palustrine	EM=emergent	C = Seasonally flooded
PEMCb	P= palustrine	EM=emergent	C = Seasonally flooded b=beaver
PEMCd	P= palustrine	EM=emergent	C = Seasonally flooded d = partially drained
PEMCh	P= palustrine	EM=emergent	C = Seasonally flooded h=Diked/impounded
PEMFb	P= palustrine	EM=emergent	F= Semipermanently flooded b= beaver
PFOA	P= palustrine	FO=Forested	A=Temporarily Flooded
PFOC	P= palustrine	FO=Forested	C = Seasonally Flooded
PSSC	P= palustrine	SS=Scrub/Shrub	C = Seasonally Flooded
PUBH	P= palustrine	UB=Unconsolidated Bottom	H=Permanently Flooded
PUBHh	P= palustrine	UB=Unconsolidated Bottom	H=Permanently Flooded h=Diked/impounded
PSSY	P= palustrine	SS=Scrub/Shrub	Y=Saturated/Semipermanent/ Seasonal
PFOW	P= palustrine	FO=Forested	W=Intermittently Flooded
PFOY	P= palustrine	FO=Forested	Y=Saturated/Semipermanent/ Seasonal
R1UBV	R=Riverine	UB=Unconsolidated Bottom	V = Permanent/Tidal
R2UBH	R=Riverine	UB=Unconsolidated Bottom	H=Permanently Flooded
R2USC	R=Riverine	US=Unconsolidated Shore	C = Seasonally Flooded

3.6.3 Wetlands and Salmonids

Wetlands play an important role in the life cycles of salmonids (Lebovitz 1992, Shreffler et al. 1992, MacDonald et al. 1987, Healey 1982, Simenstad et al. 1982). Estuarine wetlands provide holding and feeding areas for salmon smolts migrating out to the ocean. These estuarine wetlands also provide an acclimation area for smolts while they are adapting to marine environments. Riparian wetlands can reduce sediment loads by slowing down flood water, allowing sediments to fall out of the water column and accumulate (Mitsch and Gosselink 1993). Wetlands also provide cover and a food source in the form of a diverse aquatic invertebrate community. Backwater riparian wetlands also provide cover during high flow events, preventing juvenile salmon from being washed downstream.

Wetlands that intersect streams represent important salmonid habitats (WPN 1999, Lebovitz 1992). ODFW habitat surveys identified a general lack of off-channel refuge habitat such as alcoves, side channels, and connected wetland areas. These areas are particularly important in the over-winter survival of coho salmon and sea-run cutthroat trout and steelhead trout. Off-channel sites provide refuge from high sediment loads and high water velocities which occur in most larger stream channels during frequent winter rain events. Lack of off-channel refuge areas can be partially compensated for if in-channel refuge habitat (*e.g.*, root wads, debris jams, deep pools with complex cover) is abundant. However, as discussed previously, LWD is usually necessary for creation of such habitat in Coast Range streams.

According to the TBNEP environmental characterization report (TBNEP 1998), available information suggests that ample organic matter is available to supply animal populations in Northwest estuaries (Simenstad *et al.* 1984, Wissmar and Simenstad 1984, Wissmar 1986). However, in situations where populations are very abundant, local food resources may be limiting. It has been proposed that limited estuarine food resources may be partly responsible for declines in some natural salmon runs over the last century, as well as the lack of success of some hatchery stocks. When many juveniles reach the estuary at once (such as during a heavy natural outmigration or following release from a hatchery), they may dramatically reduce the size of the local invertebrate populations. Prey resources are further limited, and recovery of the prey population is protracted, in areas where shallow flats, marshes and quiet channel habitat have been removed by dredging and channelization. Simenstad *et al.* (1982) hypothesized that in this situation the salmon may spend less time in the estuary. As smaller outmigrants to the ocean, they would then be more susceptible to open water predators. This is probably not a problem in Tillamook Bay now but should be considered for future salmonid management (TBNEP 1998).

Table 3.10 summarizes the habitat types and juvenile residency information for the five salmonid species found in the Wilson River watershed. Of the five species, chinook salmon and chum salmon depend most on the estuary, followed by cutthroat trout. It is believed that most coho salmon and steelhead trout appear to use estuaries primarily as a migratory route and as a

Table 3.10. Primary estuarine habitats utilized by juvenile anadromous salmonids and approximate period of residency of individual fish (Healey 1982, Simenstad and Salo 1982, Iwamoto and Salo 1977).

SPECIES	PRIMARY HABITAT UTILIZED					RESIDENCY (approximate range for individual fish)
	Salt marsh	Eelgrass	Mud flat	Tidal channel	Open water	
Chinook	X	X	X	X	X	weeks to months
Chum	X	X		X		days to about 1 month
Coho			X(?)	X	X	days to months
Steelhead			X(?)	X	X	days to a few weeks
Sea-run cutthroat		X	X(?)	X	X	weeks to months

physiological transition zone for ocean residency. Additional research regarding fish utilization of estuaries is on-going.

The TBNEP (1998) determined that both tidally influenced wetland habitat and intertidal mud flat habitat have been substantially reduced since the mid-1880s. During the last 50 years, considerable new salt marsh habitat has been created in the south end of the bay due to delta formation associated with high sediment input from the watershed. Recent floods have probably accelerated this process. The new salt marsh does not replace the quantity of lost marsh and wetlands and probably provides lower quality habitat than the lost mature marsh. Some of these areas are accessible to cows for grazing. In general, the complexity of the estuarine habitat has been reduced. Complex structure provided by large woody debris and associated pools has been removed and the connections between river channels and their flood plains have been severed (except during periodic large floods) through the construction of dikes and levees. These losses are probably permanent unless restoration activities are actively pursued. Sediment from the watershed might be contributing to filling of the upper portion of the estuary and reducing the amount of pool habitat. This continues to be a topic for debate.

3.6.4 Filling and Diking of Wetlands

Wetlands have been one of the landscape features most impacted by human disturbance. In the Pacific Northwest, it is estimated that 75% of the original wetlands have been lost to human disturbances (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1990). Somewhere between 50 and 90% of tidal marshes in individual Oregon estuaries have been lost, most as a result of agricultural activities (Frenkel and Morlan 1991, Boule and Bierly 1987). Loss of wetlands that were connected to the stream system can lead to salmonid habitat loss and loss of flood attenuation.

It is clear that there have been substantial changes to riparian and wetlands ecosystems in the Tillamook Basin (Coulton et al. 1996). Extensive diking for flood protection has occurred in the Lower Wilson watershed (Figure 3.5). As a result of this practice, many wetlands have undergone significant changes and many have been lost or disconnected from the stream system. Many of these wetlands may have once been tidal estuarine wetlands that have been disconnected as a result of draining from tide gates and dike construction. These practices reduce or remove tidal influence, resulting in the loss of saltwater influences and leading to changes in the structure of the wetland.

Natural tidal marshes are sediment sinks. Dikes and levees constructed on tidal marsh lands have reduced the natural ability of estuary marshes to remove sediments by increasing the concentration of suspended riverine sediments transported directly into the bay. Sediments deposited in non-vegetated sloughs and mud flats are more likely to be resuspended by wind and wave action and transported into deeper navigable portions of the estuary than if they were deposited in vegetated tidal marshes. For estuaries experiencing a rising sea-level, restored tidal marshes can serve as long-term sediment sinks, keeping pace with the changing sea-level.

Many suitable tidal marsh restoration areas are former marshes that have subsided from soil compaction caused by dewatering. Removing levees and restoring tidal flows to these subsided land areas can result in significant short-term sediment deposition opportunities. For example, observations of California tidal marsh restoration projects under these conditions have shown deposition rates of up to 1.0 foot per year (TBNEP 1998). With 100 acres of tidal marsh restored, this may correspond to a first year deposition volume of 100 acre-feet or approximately 200,000 cubic yards of sediment. This amount of sediment is naturally removed from the total amount of recirculated estuarine sediment and can help reduce river sediment deposition to maintain desired flood conveyance and reduce the need for maintenance dredging. Ongoing investigations by the TBNEP into Tillamook Bay circulation patterns, sediment transport processes, and historic marsh characteristics will help to identify the most viable habitat restoration technique(s) for this particular ecosystem.

3.6.5 Wetlands and Future Development

Substantial development has occurred in the Wilson River floodplain, and it is likely to continue in association with increased population growth. Continued development has the potential to greatly impact wetlands within the urban growth boundary as well as rural residential areas, which may lead to the loss of important wetland functions. Wetlands are regulated so that any filling of wetlands must be mitigated by either wetland construction or restoration. However, it is unclear as to whether the mitigation wetland can replace the lost functions of a filled wetland. A local wetland inventory has been completed for the City of Tillamook to help identify important wetland resources that need to be protected.

3.7 Conclusions

Aquatic and riparian habitats have been substantially altered throughout the Wilson River watershed, especially in the lowland areas near the bay. Both habitat condition and access to habitat by biota, including anadromous fish, have been adversely impacted. Large woody debris (LWD) is generally lacking throughout the watershed. Although stream shading is rated as desirable in most subwatersheds, recent studies by ODEQ contradict this finding. In addition, potential future recruitment of LWD is poor, largely because large conifers have been replaced by smaller-diameter deciduous trees in many riparian areas.

Fish passage barriers are numerous; 24% of surveyed culverts were judged to constitute impediments to fish passage. This seriously limits the utilization of otherwise-suitable fish habitat. Tide gates have also blocked fish access to certain streams and estuarine wetland areas, but these have been, or soon will be, replaced by tide gates believed to be more fish-friendly. Monitoring is on-going. Channelization, diking, and dredging of lowland areas have simplified habitat structure in the lowlands, altered access to aquatic biota, and changed sedimentation and flooding regimes. All of these changes have adversely impacted habitat quality. Both the tidal-influenced wetland and intertidal mudflat habitat types have been reduced since the mid-1800s. The filling and diking of wetlands have removed, or cut off access to, important off-channel refugia and overwintering areas for salmonid fish.

Thus, the overall condition of aquatic and riparian habitats in the watershed has been dramatically changed. Habitat quality for salmonid fish and other biota has been reduced. On-going and future efforts to restore habitat quality include, in particular, replacement of culverts and tide gates that have blocked fish access to important habitat, improvement of LWD recruitment potential, and reconnection and restoration of wetlands and the floodplain. Specific locations for these activities should be determined in conjunction with development of an Action Plan for this watershed.

CHAPTER 4. HYDROLOGY

4.1 Introduction

Human activities in the watershed can alter the natural hydrologic cycle, potentially causing changes in water quality and the condition of aquatic habitats. Changes in the landscape can increase or decrease the volume, size, and timing of runoff events and affect low flows by changing groundwater recharge. Some examples of human activities that can affect watershed hydrology are timber harvesting, urbanization, conversion of forested land to agriculture, and construction of road networks. The focus of the hydrologic analysis component of this assessment is to evaluate the potential impacts from land and water use on the hydrology of the watershed (WPN 1999). It is important to note, however, that this assessment only provides a screening for potential hydrologic impacts based on current land use activities in the watershed. Identifying those activities that are most affecting the hydrology of the watershed, and quantifying those impacts would require a more in-depth analysis and is beyond the scope of this assessment.

4.2 Hydrologic Characterization

4.2.1 Watershed and Peak Flow Characterization

Peak Flow Processes

Peak flows occur as water moves from the landscape into surface waters. Peak flows occur in response to natural processes in the watershed and are characterized by the duration and volume of water during the rise and fall of a hydrograph. The primary peak flow generating process for the Coast Range and its associated ecoregions is rain events. The Coast Range generally develops very little snow pack. Snow pack that does develop in the coastal mountains is only on the highest peaks and is of short duration. Rain-on-snow events are infrequent in the Coast Range although these events have contributed to some of the major floods, including the floods of 1964 and 1996. These large floods are rare events, and we have no data to suggest that current land use practices have exacerbated the flooding effects from rain-on-snow events. Studies in the Coast Range found no appreciable increase in peak flows for the largest floods as a result of clearcutting (Rothacher 1971, 1973; Harr et al. 1975). Additionally, only two of the Wilson River subwatersheds have mean elevations above 2,000 ft in the rain-on-snow zone (based on measured snow accumulations; Table 4.1).

Table 4.1 Topographic features and precipitation amounts for the Wilson River watershed based on GIS calculations. Annual precipitation was estimated from the PRISM model (Daly et al. 1994).

Subwatershed	Subwatershed Area (mi^2)	Mean Elevation (ft)	Minimum Elevation (ft)	Maximum Elevation (ft)	Mean Annual Precipitation (in)
Cedar Creek/Upper Wilson R.	22.6	1371	472	3094	134
Devils Lake Fork Wilson R.	14.3	1841	1191	2756	86
Elk Creek/Lower Devils Lake Fork	19.7	2133	823	3530	109
Hall Slough	1.1	7	3	20	87
Jordan Creek	25.2	1749	348	3533	115
Little N. Fork Wilson R.	20.0	1155	39	2549	129
Lower Wilson R.	26.6	692	0	2293	108
Middle Wilson R.	21.1	1214	184	2930	120
North Fork Wilson R.	27.2	2005	554	3691	157
South Fork Wilson R.	16.0	2041	856	3533	102
Total	193.7		0	3691	120

Snow pack is monitored in the Wilson River watershed at Saddle Mountain and Seine Creek. The Saddle Mountain station is located at approximately 3,200 feet in elevation and has a mean snow water content of 6 inches (http://www.wrcc.wri.edu). The lower elevation site, Seine Creek, located at 2,000 feet, has a mean annual snow content of 2.5 inches and is periodic in nature. In contrast, Oregon Cascade Mountain snow water accumulation is typically 20 to 25 inches at 4,000 feet and snow pack begins to accumulate in December and generally remains at least through March. Only 25% of the Wilson River watershed is above 2,000 feet elevation and only 2% is above 3,000 feet, suggesting that snow contributions to flooding only occur in extreme snow accumulation years. This hydrologic analysis therefore focuses on the effects of land use practices on the hydrology of these subwatersheds using rain events as the primary hydrologic process.

Topography

Topography in the Wilson River watershed is characterized by steep headwaters that lead quickly into low gradient floodplains. Elevations in the watershed range from sea-level to 3,691 feet it its highest point. The Oregon Coast Range, including the Wilson River watershed, is characterized by a strong orographic effect on precipitation as demonstrated by the large differences between lowland and upland precipitation totals (Table 4.1).

Flooding

Flooding is a natural process that contributes to both the quality and impairment of local environmental conditions. Consequently, flood management attempts to reduce flood hazards and damage while protecting the beneficial effects of flooding on the natural resources of the system. Flooding causes, impacts, and management options are discussed in the Tillamook Bay environmental characterization report (TBNEP 1998).

River flooding tends to occur most commonly in December and January during periods of heavy rainfall or snowmelt, or a combination of both. River flooding combined with tidal flooding can extend the flood season from November to February. The lowland valleys are the most prone to flooding during these periods. Estimates of the floodplain acreage inundated during major floods and corresponding river watershed areas are provided in Table 4.2.

The Wilson River watershed has the largest floodplain area in the Tillamook Bay basin, at almost 5,000 acres (Table 4.2). One of the primary natural functions of the floodplain is to reduce the severity of peak flows, thereby reducing down-stream impacts and flood hazards. However, much of the floodplain area in the Wilson River watershed has been altered. The floodplain has been largely disconnected from the river and its tributaries through the construction of dikes and levees, reducing floodplain storage of flood waters. Impacts of floodplain loss are further discussed in Chapter 3, Aquatic Habitats.

Table 4.2. Watershed and lowland floodplain areas of the rivers that flow into Tillamook Bay. (Source: TBNEP 1998)

River	Watershed Area (acres)	Floodplain Area (acres)
Kilchis	41,620	660
Miami	23,390	125
Wilson	123,557	4,900
Trask	113,864	3,600
Tillamook	36,395	1,720

4.2.2 Stream Flow

The Wilson River has been monitored for discharge by the USGS from 1931 to the present (http://waterdata.usgs.gov/nwis-w/OR/index.cgi?statnum=14301500). The gage is located just downstream of the confluence with Jack Creek. The Wilson River demonstrates a typical coastal river discharge pattern with the majority of discharge occurring from November through April (Figure 4.1). Discharge during individual years sometimes deviates dramatically from the "average" pattern, however. Summer flows are low, averaging generally below 500 cfs. Flood events occur primarily in December through March. A discharge of 36,000 cfs (16.91 feet) was recorded on January 20, 1972. Also, on December 22, 1964, the gage height reached 20.26 feet resulting in one of the largest floods in Tillamook history. Average discharge for the period of record is 1,187 cfs.

4.3 Potential Land Use Impacts on Peak Flows

Increased peak flows can have deleterious effects on aquatic habitats by increasing streambank erosion and scouring (ODFW 1997). Furthermore, increased peak flows can cause downcutting of channels, resulting in a disconnection of the stream from the floodplain. Once a stream is disconnected from its floodplain, the downcutting can be further exacerbated by increased flow velocities as a result of channelization.

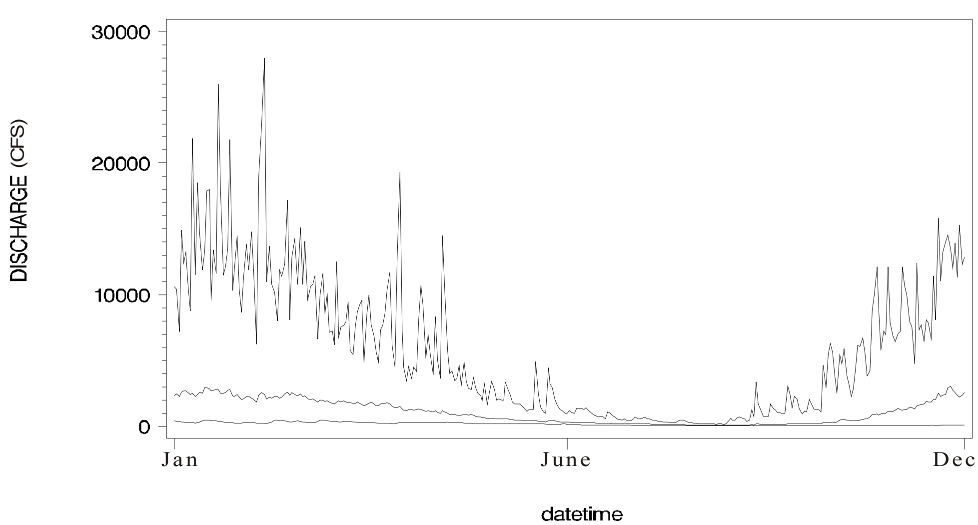

Figure 4.1. Wilson River discharge for the period of record (1993-present). The top line is the maximum mean daily flow; the center line is the mean daily flow; and the bottom is the minimum mean daily flow (Data from USGS)

All subwatersheds were screened for potential land use practices that may be influencing the hydrologic processes that contribute to increased peak flows and streambank erosion (WPN 1999). This screening process only deals with the most significant processes affected by land use (i.e runoff). There are four potential land use types that can affect the hydrology of a watershed: forestry, agriculture and rangeland, forest and rural roads, and urban or rural residential development.

4.3.1 Forestry

Forestry practices have the potential to influence the magnitude of flooding, but it is difficult to quantify such effects because of the large natural variability in discharge (Hirsch et al. 1990). This difficulty has contributed to over a century of debate in the United States concerning the role of forest conservation in flood protection (Naiman and Bilby 1998). Studies in the Oregon Coast range found no appreciable increase in peak flows for the largest floods that could be attributed to clearcutting (Rothacher 1971, 1973; Harr et al. 1975). Specific information is not available regarding changes in the hydrology of the Wilson River that might be attributable to forestry.

Although the largest floods are most important from a flood hazard standpoint, the effects of increases in smaller magnitude peak flows cannot be discounted from a stream channel or ecological standpoint (Naiman and Bilby 1998). High flows constitute a natural part of the stream flow regime and are largely responsible for transporting sediments and forming channels. Consequently, increases in the magnitude of moderate peak flows can lead to channel incision thorough bank building or erosion. Because forest harvest practices are common in the watershed, there may be effects of forestry on watershed hydrology. Current evidence suggests that elevated peak flows and "flashiness" can result from logging and road building activities, for small to moderate storm events. Effects might include reduced evapotranspiration, increased infiltration and subsurface flow, and increased overland flow (Naiman and Bilby 1998). Such changes may result in modified peak and low flow regimes and subsequent effects on in-stream aquatic habitat quality. They are difficult to quantify, however, and have not been determined for the Wilson River watershed.

4.3.2 Agriculture and Rangeland

The impacts of agriculture on river hydrology are dependent upon specific land use and management practices as well as the physical characteristics of the soil being farmed. Those management practices that change the infiltration rate of the soils are the most influential in changing the hydrologic regime (WPN 1999). Agriculture has the greatest impact in those areas where soils have naturally high infiltration rates.

The Natural Resources Conservation Service (NRCS) has mapped soils across the state of Oregon. As a part of this mapping process, soils were grouped into four hydrologic classes based on minimum infiltration rates. As a part of the NRCS method (USDA 1986), runoff curve numbers are assigned to areas based on soil type, land cover, and farming practice. These runoff curve numbers can be utilized to estimate runoff in small agricultural and rural watersheds. The estimated runoff can then be compared to estimated background conditions to identify likely changes in runoff as result of land management practices. Digital soils data for the Wilson River watershed were not yet available at the time of preparation of this assessment, however, and this kind of generalized analysis was not conducted.

Both the Lower Wilson and Hall Slough subwatersheds have relatively large areas of agricultural land use (9% and 57% receptively). Consequently, there is some potential for agricultural practices to change the infiltration rates of the soil in these areas. Additionally, land cover in the Tillamook bottomland has changed significantly since being settled in the early 1900's (Coulton et al. 1996). These factors suggest a potential for hydrologic impacts and warrant further investigation once digital soils data are available.

Other factors associated with agricultural land use that may have impacted the hydrology of the Wilson River watershed include draining and diking of wetlands and disconnection of the floodplain. Agricultural land use is concentrated in the lower elevations of the watershed, generally in the floodplains of the Wilson River. Historically, these floodplains were wetland areas that trapped sediments and accumulated plant material, resulting in rich fertile soils. Recognizing the economic value of these soils, the floodplains were drained and diked for agricultural purposes, mostly as dairy pastures. Disconnecting the floodplain from the river has resulted in the loss of flood attenuation capacity, increased peak flows, down-cutting of channels, and increased flow velocities. Further discussion of problems associated with disconnection of the floodplain and wetland loss can be found in Chapter 3 (Aquatic and Riparian Habitats).

4.3.3 Forest and Rural Roads

Road construction associated with timber harvest and rural development has been shown to increase wintertime peak flows of small to moderate floods in Oregon Coast Range watersheds (Harr 1983, Hicks 1990). This assessment uses a roaded area threshold of 8% to screen for potential impacts of roads on peak flows (discharge increase >20%; WPN 1999). Watersheds with a greater than 8% roaded area are considered to have a high potential for adverse hydrologic impact, 4 to 8% have a moderate potential, and less than 4% have a low potential.

According to GIS calculations from the ODF fire roads coverage, all of the subwatersheds in the Wilson River watershed were considered to have a low potential impact from the density of forest roads (Table 4.3). However, this GIS coverage may significantly under-estimate actual on-the-ground road conditions in the watershed. The GIS coverage was compared to a 1:24,000 road coverage for the area and it was determined that the results were fairly similar. In a study conducted in the Oregon Mid-Coast watersheds (Earth Design Consultants, Inc. 2000), 1:24,000 road coverages under-represented actual road densities by 1.7 times. However, even if we doubled the road densities in the subwatersheds, only two of the subwatersheds would change to a moderate potential for peak flow enhancement as a result of forest road densities.

Table 4.3 Forest road summary for the Wilson River watershed based on GIS calculations. The roads coverage data used for this analysis were obtained from the BLM (fire roads).

Subwatershed	Subwatershed Area (mi^2)	Area Forested (mi^2)	Forest Roads (mi)	Roaded Area (mi^2)*	Percent Forested Area in Roads	Relative Potential Impact
Cedar Creek / Upper Wilson R.	22.6	22.5	74	0.35	1.5	Low
Devils Lake Fork Wilson R.	14.3	14.3	84	0.39	2.8	Low
Elk Creek / Lower Devils Lake Fork	19.7	19.7	71	0.33	1.7	Low
Hall Slough	1.1	0.0	0	0.00	0.0	Low
Jordan Creek	25.2	25.2	92	0.43	1.7	Low
Little N. Fork Wilson R.	20.0	20.0	51	0.24	1.2	Low
Lower Wilson R.	26.6	21.7	74	0.35	1.6	Low
Middle Wilson R.	21.1	21.0	67	0.32	1.5	Low
North Fork Wilson R.	27.2	27.2	93	0.44	1.6	Low
South Fork Wilson R.	16.0	16.0	69	0.32	2.0	Low
Total	193.7	187.7	674	3.18	0.0	Low

* Width used to calculate roaded area was 25 ft.

4.3.4 Urban and Rural Residential Areas

According to GIS calculations from the ODF fire roads coverage, all of the subwatersheds in the Wilson River watershed were considered to have a low potential for adverse hydrologic impact from the density of rural roads (Table 4.4). Only the Lower Wilson subwatershed had a significant portion (2.8%) in roaded area, but that still represents a low potential for hydrologic impacts. Even if this road coverage significantly under-represents actual road conditions, there would still only be a moderate potential for hydrologic impacts in the Lower Wilson subwatershed.

Table 4.4 Rural road summary for the Wilson River watershed based on GIS calculations. The roads coverage data used for this analysis were obtained from the BLM (fire roads).

Subwatershed	Subwatershed Area (mi^2)	Rural Area (mi^2)	Rural Roads (mi)	Roaded Area (mi^2)*	Percent Rural Area in Roads	Relative Potential for Peak-Flow Enhancement
Cedar Creek / Upper Wilson R.	22.6	0.0	0	0.00		Low
Devils Lake Fork Wilson R.	14.3	0.0	0	0.00		Low
Elk Creek / Lower Devils Lake Fork	19.7	0.0	0	0.00		Low
Hall Slough	1.1	0.9	4	0.02	0.0	Low
Jordan Creek	25.2	0.0	0	0.00		Low
Little N. Fork Wilson R.	20.0	0.0	0	0.00	0.0	Low
Lower Wilson R.	26.6	3.6	22	0.10	2.8	Low
Middle Wilson R.	21.1	0.0	0	0.00		Low
North Fork Wilson R.	27.2	0.0	0	0.00		Low
South Fork Wilson R.	16.0	0.0	0	0.00		Low
Total	193.7	4.6	25	0.12	0.1	Low

* Width used to calculate roaded area was 25 ft.

4.3.5 Other Potential Hydrologic Impacts

Past fires changed the ability of the surface soils to store runoff from forested areas (c.f., Coulton et al. 1996). Burned areas, and especially areas of repetitive burns, typically show a reduced ability to store moisture in surface soils (TBNEP 1998). The Tillamook Burns of 1933, 1939, 1945, and 1956, and especially the repeated burns and construction of salvage logging roads, undoubtedly disrupted the infiltration and water storage capacity of the upland areas. The loss of this natural flood attenuation mechanism, combined with the steep slopes and impermeable soils, increased the frequency and quantity of runoff and sediment delivery from heavy rainfall events. Landslides from natural slope failures or induced by road and culvert construction added pulses of sediment to the river channels and changed the ability of the rivers to convey flood water (Coulton et al. 1996). We have no quantitative data, however, regarding these processes.

4.4 Conclusions

Screening for land management activities that may be affecting natural hydrologic conditions suggests that roads have little effect on current hydrologic regimes, but other hydrologic impacts may have occurred in response to the Tillamook Burns and/or agricultural practices (especially diking and draining of wetlands) in the valley bottoms. Loss of historical flood plain acreage and land cover (such as wetlands, forested valley bottoms) have likely had significant impacts on hydrologic conditions in the Wilson River watershed. Existing flood control features used to protect floodplain land uses have simplified natural streamflow processes in many places and reduced the complexity of in-stream habitats that support fish and aquatic organisms.

The documented sensitivity of valley flooding to upstream watershed conditions indicates the need for a strong management focus on restoring natural watershed functions throughout the watershed. Future flood management efforts in the valley floodplains may be obfuscated by the failure to adequately address upland watershed impacts that influence the flow rate and volume of flood waters. However, altered upland processes can be difficult to restore, especially where they are part of a significant disturbance regime such as the Tillamook Burns. There is a clear need for floodplain and wetland restoration to improve flood attenuation and storage.

CHAPTER 5. WATER USE

Under Oregon law, all water is publicly owned. Consequently, withdrawal of water from surface and some groundwater sources requires a permit, with a few exceptions. The Oregon Water Resources Department administers state water law through a permitting process that issues water rights to many private and public users (Bastasch 1998). In Oregon, water rights are issued as a 'first in time; first in right' permit, which means that older water rights have priority over newer rights. Water rights and water use were examined for each of the water availability watersheds (watersheds defined by the Oregon Water Resources Department for the assessment of flow modification).

Water that is withdrawn from the stream has the potential to affect in-stream habitats by dewatering that stream. Dewatering a stream refers to the permanent removal of water from the stream channel, thus lowering the natural in-stream flows. For example, a percentage of the water that is removed from the channel for irrigation is permanently lost from that watershed as a result of plant transpiration and evaporation. In-stream habitats can be altered as a result of this dewatering. Possible effects of stream dewatering include increased stream temperatures and the creation of fish passage barriers.

Water is appropriated at a rate of withdrawal that is usually measured in cubic feet per second (cfs). For example, a water right for 2 cfs of irrigation allows a farmer to withdraw water from the stream at a rate of 2 cfs. Typically, there are further restrictions put on these water rights, including a maximum withdrawal amount allowed and the months that the water right can be exercised. Identifying all of these limits is a time-consuming and difficult task, which is beyond the scope of this assessment. However, for subwatersheds identified as high priority basins, this should be the next step if water use is judged to pose a potential problem.

5.1 In-stream Water Rights

In-stream water rights were established by the Oregon Water Resources Department for the protection of fisheries, aquatic life, and pollution abatement; however, many remain junior to most other water rights in these watersheds.

Seven of the subwatersheds in the Wilson River watershed currently have in-stream water rights (Table 5.1; Appendix B). The Wilson River, Little North Fork Wilson, and the North Fork Wilson subwatersheds all have in-stream water rights established in 1973 for the protection of aquatic life. In 1991, ODFW established in-stream water rights for the protection of anadromous and resident fish. However, these water rights are junior to almost all of the other water rights in the Wilson River watershed. Developing in-stream water rights that are more senior than current in-stream water rights would aid in the protection of in-stream flows in the Wilson River watershed. This could be accomplished through water right trading and leasing through the Oregon Water Resources Department.

Table 5.1. In-stream water rights in the Wilson River watershed. Data were obtained from the Oregon Water Resources Department.

Water Availability Watershed	Priority	Purpose
Wilson River @ mouth	1991 1973	Anadromous and resident fish rearing Supporting Aquatic Life
Little N FK Wilson @ mouth	1991 1973	Anadromous and resident fish rearing Supporting Aquatic Life
Fall Cr. @ mouth	1991	Anadromous and resident fish rearing
S FK Wilson @ mouth	1991	Anadromous and resident fish rearing
Cedar Creek @ mouth	1991	Anadromous and resident fish rearing
N FK Wilson River @ mouth	1991 1973	Anadromous and resident fish rearing Supporting Aquatic Life
Elk Cr. @ mouth	1991	Anadromous and resident fish rearing
Devil Lake Fork @ mouth	1991	Anadromous and resident fish rearing
Jordan Cr. @ mouth	1991	Anadromous and resident fish rearing

5.2 Consumptive Water Use

5.2.1 Irrigation

The largest amount of water appropriated in the Wilson River watershed is for irrigation (Table 5.2). Most of this water is appropriated in the lower elevations of the Wilson River watershed (Wilson River @mouth subwatershed) and is most likely used for maintaining dairy pastures (Figure 5.1).

5.2.2 Municipal and Domestic Water Supply

Municipal and domestic water supplies can have a large impact on in-stream flows, especially during low flow months. The City of Tillamook, which resides adjacent to the Wilson

Table 5.2. Water use and storage in the Wilson River watershed. Numbers in parentheses are for water storage in acre-feet. Data were obtained from the Oregon Water Resources Department

Water Availability Basin	Irrigation (cfs)	Municipal (cfs)	Domestic (cfs)	Fish/ Wildlife (cfs)	Other (cfs)	Total (cfs)
Wilson River @ mouth	8.62 (2.62)	--	3.74 (0.61)	--	0.24	12.6
Wilson River above Little N FK Wilson	--	--	0.01	0.02	--	0.03
Little N FK Wilson @ mouth	--	--	--	--	--	0
Wilson River @14301500	0.18	--	0.60	--	0.08	0.86
Fall Cr. @ mouth	--	--	--	--	--	0
Wilson River above Jordan Cr.	0.26 (1.0)	--	0.01	--	--	0.27
S FK Wilson @ mouth	--	--	0.002	3	--	3.00
Wilson River above N FK Wilson River	--	--	0.04	--	--	0.04
Cedar Creek @ mouth	--	--	--	--	--	0
N FK Wilson River @ mouth	--	--	0.05	--	0.4 (15.5)	0.45
Elk Cr. @ mouth	--	--	--	--	--	0
Devil Lake Fork @ mouth	--	--	--	--	--	0
Jordan Cr. @ mouth	0.01	--	0.01	--	0.01	0.03

and Trask Rivers, draws the majority of its domestic water from the Tillamook River watershed (Fawcett and Killam Creeks; Tillamook Water Commission Master Plan). However, due to rural residential development on the outskirts of the city, there is a small amount of water appropriated from the Wilson River for domestic water use (3.74 cfs). During very dry seasons, domestic water used combined with irrigation withdrawals in the lower elevations of the Wilson River watershed may have deleterious effects on in-stream habitats by reducing in-stream flows. However, appropriated water represents only 12% of modeled in-stream flows (based on a 50% exceedance) suggesting that the impacts are most likely small and only occur during very dry years.

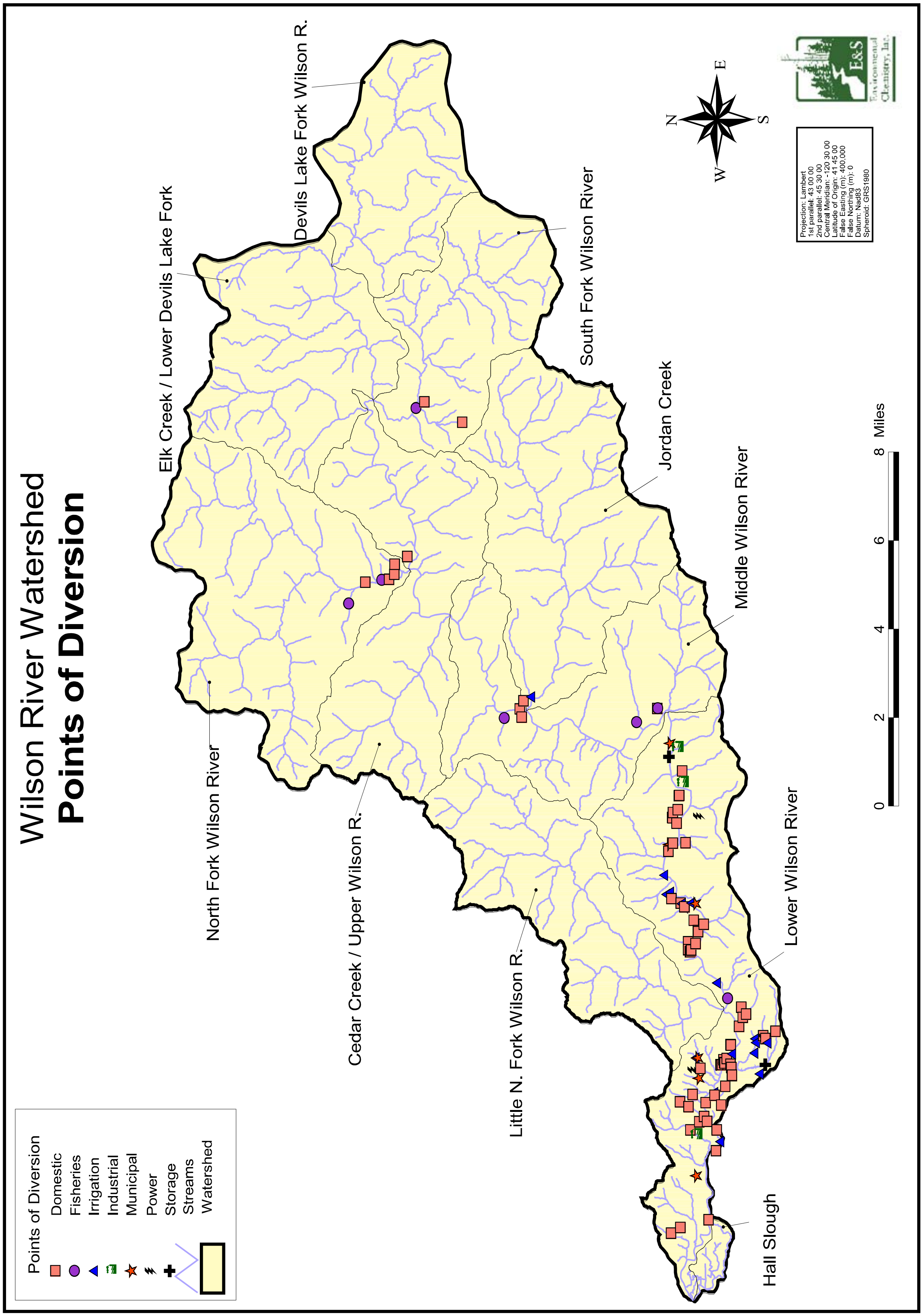

Figure 5.1 Water withdrawals in the Wilson River watershed. Data were obtained from the Oregon Water Resources Department.

5.3 Non-Consumptive Water Use

5.3.1 Fish and Wildlife

Very little water has been appropriated for fish and wildlife in the Wilson River watershed. In the South Fork Wilson River Subwatershed, 3 cfs has been appropriated for fish protection, and an additional 0.02 cfs has been appropriated in the Wilson River above Little North Fork subwatershed.

5.4 Water Availability

5.4.1 Water Availability Models

The Oregon Water Resources Department has developed models to assess the potential impacts of water withdrawals on stream flows (Robison 1991). These model outputs are available to the public on the OWRD website (http://www.wrd.state.or.us). They use predicted water loss based on the type of use for the appropriated water. Losses are then compared to predicted in-stream flows, based on a user- assigned exceedance level. We have chosen a 50% exceedance, which represents stream flows that would be expected at least 50% of the time. This exceedance level should provide a reasonable benchmark for evaluating the likelihood of adverse effects.

Based on current water availability model outputs for the 50% exceedence level, there is little concern for dewatering in the Wilson River watershedon average. None of the subwatersheds demonstrated water loss greater than 2% of the predicted in-stream flows (Table 5.3). Consequently, it is unlikely that water withdrawals from the Wilson River and its tributaries are having a large impact on current average in-stream flows. However, any time water is appropriated for out-of-stream use, there is a potential for some effects on the in-stream habitats to occur during periods of very low flow.

5.4.2 Low Flow History of the Wilson River

Although the model outputs suggested that in-stream flows would generally not be affected by appropriated water uses in the Wilson River watershed, there is some potential for low flow situations to deleteriously affect in-stream aquatic habitats. Using USGS stream flow data at the Wilson River gage for the period of 1931 to 1999, we established a frequency for the mean daily flows that were less than the established in-stream water right. We used the in-stream water

Table 5.3. Dewatering potential in the Wilson River watershed, based on a 50 percent exceedance*.

	Dewatering Potential (%)**					Overall Dewatering Potential	
Water Availability Watershed	Jun	Jul	Aug	Sep	Oct	Average Percent Withdrawal	Potential
Wilson River @ mouth	0.5	1.5	2.0	1.1	0.4	1.1	Low
Wilson River above Little N FK Wilson	0.1	0.2	0.3	0.3	0.1	0.2	Low
Little N FK Wilson @ mouth	0	0	0	0	0	0.0	Low
Wilson River @14301500	0.1	0.1	0.2	0.2	0.1	0.1	Low
Fall Cr. @ mouth	0	0	0	0	0	0.0	Low
Wilson River above Jordan Cr.	0	0.1	0.2	0.1	0	0.1	Low
S FK Wilson @ mouth	0	0.1	0.1	0.1	0.1	0.1	Low
Wilson River above N FK Wilson River						0.0	Low
Cedar Creek @ mouth	0	0	0	0	0	0.0	Low
N FK Wilson River @ mouth	0	0.1	0.1	0.1	0	0.1	Low
Elk Cr. @ mouth	0	0	0	0	0	0.0	Low
Devil Lake Fork @ mouth	0	0	0	0	0	0.0	Low
Jordan Cr. @ mouth	0	0	0.1	0	0	0.0	Low

* A 50% exceedance represents the amount of water than can be expected to be in the channel 50% of the time or one out of every two years.

** The dewatering potential is the percent of in-stream flows that are appropriated for consumptive use during the low flow months.

right as an indicator of in-stream flow conditions for salmonids, assuming that flows below the in-stream water right constituted poor conditions for salmonids and other aquatic biota.

During the low flow months (July through October), mean daily discharge was below the in-stream water right almost 50% of the time, with the highest percentage of occurrences in August through October (Table 5.4; Figure 5.2). Assuming that the in-stream water right is a good indicator of habitat conditions for salmonids, there is a potential for low flow conditions to have a deleterious effect on local salmonid populations. Consequently, any out-of-stream water use during these low flow situations will only exacerbate habitat problems. It is our

Table 5.4. Number of days that the mean daily flow was below the in-stream water right established for protection of anadromous fish. These data are for the Wilson River gage location for the period of 1931 to 1999.

Month	# of Days	Days below in-stream water right	
		Number	Percent
1	2108	16	0.8
2	1921	19	1.0
3	2108	17	0.8
4	2040	44	2.2
5	2108	407	19.3
6	2040	5	0.2
7	2108	214	10.2
8	2139	922	43.1
9	2070	1165	56.3
10	2108	1081	51.3
11	2040	241	11.8
12	2108	31	1.5

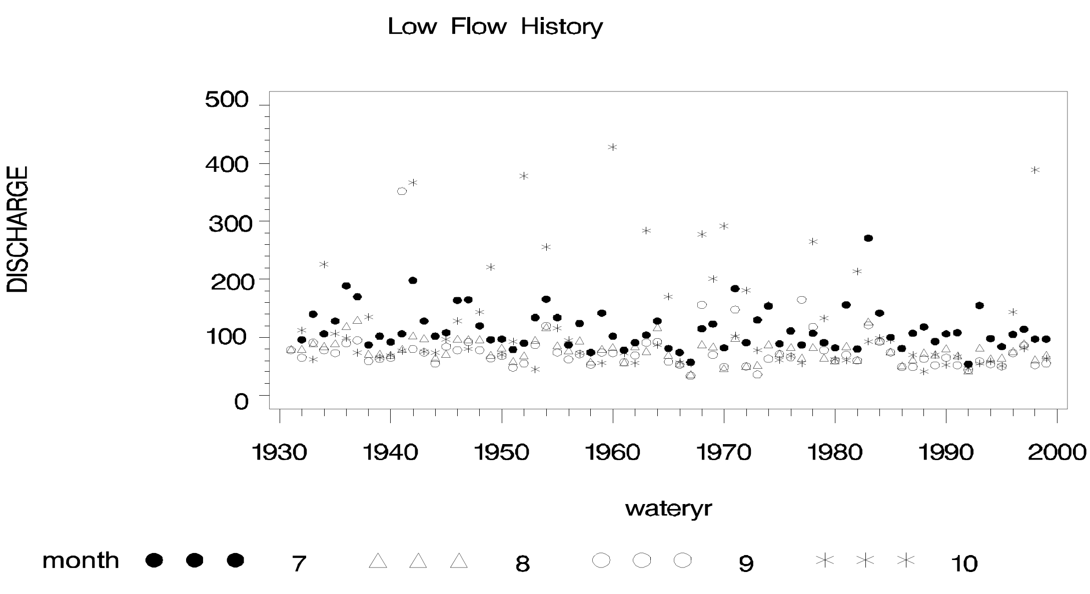

Figure 5.2. Minimum mean daily flow (cfs) for the summer low flow period (July through October) for the Wilson River gage. The in-stream water right represents the amount of water needed for anadromous fish rearing.

recommendation that in-stream water rights continue to be protected and in-stream flows monitored during very low flow conditions.

5.4.3 Flow Restoration Priorities under the Oregon Plan for Salmon

ODFW and OWRD prioritized coastal watersheds for recovery of anadromous salmonids based on in-stream flow conditions. Priorities were developed by season (spring , summer, fall,winter) and given a rating of low, moderate, high, or highest. The Wilson River watershed and all of its associated subwatersheds were given a moderate rating for flow restoration priority (Appendix B). Other watersheds in the Tillamook Basin received much higher ratings, including the Miami, Trask, and Tillamook River watersheds. None of the Wilson River subwatersheds is a State priority for streamflow restoration. The Oregon Plan website (www.oregon-plan.org/ AnnRept/2-implement/agency.reps/imp-odfw.pdf) describes some of the parameters that were used to rank subwatersheds for flow restoration. Some of these parameters include fish resources and habitat, risk factors, streamflow restoration optimism, water use, and endangered or threatened species.

5.5 Conclusions

Appropriated water in the Wilson River watershed represents only a small fraction of modeled in-stream flows. Consequently, it is expected that surface water withdrawals generally have little effect on current in-stream habitats during periods with average or higher flows. For some tributaries, this may not be the case. However, analysis of actual in-stream flows demonstrate that mean daily discharge is consistently (>50% of the time) below the in-stream water right value (used as an indicator of in-stream flow conditions for salmonid habitats) during the low flow months. This suggests a potential for habitat degradation as a result of insufficient stream flow during low flow periods. Consequently, any surface water withdrawals during very dry months can exacerbate existing streamflow deficiencies. In-stream flow requirements for salmonids needs to be further evaluated to determine actual impacts of surface water withdrawals on salmonid populations. Protection of in-stream flow for salmonid habitat is needed in the Wilson River watershed.

CHAPTER 6. SEDIMENT SOURCES

6.1 Introduction

Erosion is a natural watershed process in the Oregon Coast Range. The bedrock geology of much of the Oregon Coast is composed of weak, highly erosive rock types. However, most experts agree that land use practices have increased the rate of erosion in many coastal watersheds (WPN 1999, Naiman and Bilby 1998). High levels of sediment in rivers and streams is associated with loss of agricultural lands, the filling bays and estuaries. Sediment is also negatively impacting many aquatic organisms, including several species of salmon that are federally listed as threatened or endangered under the Endangered Species Act. Understanding the role of erosion and its interaction with other watershed processes is critical to maintaining a healthy ecosystem.

Issues regarding erosion in the Tillamook Bay Watershed have been the source of concern for several decades. Past studies were recently analyzed and summarized by the National Estuary Project (NEP). Much of the information in this section originated from NEP documents summarizing the condition of sediment in the Tillamook Bay Watershed.

Most Pacific Northwest estuaries, including Tillamook Bay, are depositional environments: they accumulate sediment (Komar 1997). Sediment in Tillamook Bay comes from marine sources, the five major rivers and numerous smaller streams which flow into Tillamook Bay, and from bayshore erosion (Glenn 1978). In recent decades the upper (southern) end of the Bay (bayhead delta) has become very shallow, leading to speculation that the uplands have been producing more sediment than the Bay can accommodate while retaining its historic dimensions (TBNEP 1998).

Upland processes that deliver sediment to the stream system include landslides and surface erosion. In lowland streams and rivers, erosion occurs principally as streambank erosion, which often causes significant losses of riparian agricultural land. Wildfires alter soil conditions, setting the stage for increased rates of erosion. The majority of sediment deposition into the stream system occurs during large storm events. The major floods of February, 1996 and minor floods of 1998 and 1999 focused attention on the sediment accumulating in Tillamook Bay, which is perceived to be blocking rivers and channels.

There were several assumptions made about the nature of sediment in this watershed (WPN 1999). First, sediment is a normal and critical component of stream habitat for fish and other aquatic organisms. Second, the more that sediment levels deviate (either up or down) from the natural pattern in a watershed, the more likely it is that aquatic habitat conditions will be significantly altered. Third, human-caused increases in sediment occur at a limited number of locations within the watershed that can be identified by a combination of site characteristics and land use practices. Finally, sediment movement is often episodic, with most erosion and downstream soil movement occurring during infrequent and intense runoff events.

Knowledge of current sources of sediment can provide a better understanding of the locations and conditions under which sediment is likely to be contributed in the future. These sources can then be evaluated and prioritized, in the process of developing the Action Plan, based on their potential effects on fish habitat and water quality to help maintain natural ecosystem functioning.

6.2 Screening for Potential Sediment Sources

OWEB has identified eight potential sediment sources that have a significant impact on watershed conditions (WPN 1999). Not all are present in every watershed, and they vary in influence depending on where and how often they occur. The potential sediment sources include slope instability, road instability, rural road runoff, urban area runoff, crop lands, range or pasture lands, burned areas, and other identified sources.

In this watershed, slope instability, road instability, and rural road runoff are the most significant sediment sources. Shallow landslides and deep-seated slumps are common in the Oregon Coast Range. Streamside landslides and slumps are major contributors of sediment to streams, and shallow landslides frequently initiate debris flows. Rural roads are a common feature of this watershed, and many are present on steep slopes. Washouts from rural roads contribute sediment to streams, and sometimes initiate debris flows. The density of rural roads, especially unpaved gravel and dirt roads, indicates a high potential for sediment contribution to the stream network.

Agricultural and pasture land runoff, as well as the history of fire in the Tillamook region are also contributing factors. However, agricultural and pastoral lands occupy a small portion of the watershed. Agricultural lands account for approximately 2 percent of this watershed, and are mostly located at the lower elevations of the watershed. Urban runoff is not a major contributor of sediment in this watershed. Developed lands occupy less than one percent of the Wilson River watershed.

6.3 Slope Instability

Landslides are the main source of sediment in the Wilson River watershed. A landslide is defined as "the movement of a mass of rock, debris, or earth down a slope" (National Research Council 1996). Often landslides gather large amounts of organic material, such as downed logs and woody debris, as they travel downslope. They are extremely variable in size and velocity, usually falling into two categories: "shallow-rapid" and "deep-seated" (Washington Forest Practices Board 1995). Shallow-rapid landslides are typical on steep forested hillslopes (Mills 1997). Shallow rapid landslides include rock slides, debris slides and debris flows. A small debris slide (generally occurring on steep slopes with shallow soils) becomes a debris flow if the sliding soil, moving downslope, scours and entrains additional soil and vegetation in its path. In areas with steep slopes, debris flows are the dominant erosional mechanism (Mills 1997). Deep-seated landslides are more commonly slow-moving and are also highly variable in size, although a very large, rapidly moving deep-seated landslide occurred along the Wilson River in 1991 (Mills 1997).

Under natural conditions, geology, topography, and climate interact to initiate landslides. With human intervention, natural conditions may be modified in ways that increase the likelihood of landslide initiation. Road-building often creates cuts and fills. In a slide-prone landscape, road-cuts may undercut slopes and concentrate runoff along roads, and road-fills on steep slopes may give way, initiating a landslide (NRC 1996). Vegetation removal, such as by logging or wildfire, may also increase the likelihood of landslide occurrence.

Landslides and debris flows can have positive and negative effects on fish in streams. A landslide from a forested hillside will contain soil, organic material, and a substantial amount of large woody debris. This mixture causes significant changes in the affected stream reach (Chesney 1982). In the short term, a debris flow can scour a channel or remove beneficial prey (benthic macroinvertebrates) and channel structures. Over the long-term, these events deliver woody debris, organic matter, and gravel that could result in the reestablishment of productive aquatic habitat and provide an important reset mechanism to the stream ecosystem.

There are few estimates of sediment yield from forest lands in the Tillamook region. To date, no comprehensive aerial photo or on-the-ground inventories of landslides have been conducted in the Wilson River. A 1978 study by the U.S. Department of Agriculture, prepared for the Tillamook Bay Task Force, estimated sediment yield for the entire Tillamook watershed. Upland erosion rates in Tillamook Bay's Watershed have increased due to human activities, but the exact amount of increase is unclear. The USDA (1978) report used the Universal Soil Loss Equation (USLE) to estimate sediment production for forested lands. Since this technique tends to overstate sheet and rill erosion on forest land — particularly where the soil has high infiltration rates typical of the volcanic soil areas in the Pacific Northwest — the upland erosion study results are not presented here.

One study in 1978 used false color infrared photographs to identify human-induced and natural landslides in the Tillamook area (Benoit 1978). Of the 4,680 landslides identified, 4,440 (95%) were classified as human-induced. Landslides were considered "human induced" if they occurred near roads, fire lines, or timber harvest or salvage activities. The liberal criteria for human impacts may tend to overstate the anthropogenic role, however. Other studies which used only aerial photos have reported more landslides in managed areas than in unmanaged areas, but not on the scale of Benoit's (1978) findings. An increase of 580% (6.8 fold) is typical (Amaranthus et al. 1985). Aerial photo studies like Amaranthus et al.'s (1985) and Benoit's (1978) have been shown to be biased due to the inability to identify landslides under forest canopy (Pyles and Froehlich 1987, Mills 1997); aerial photo surveys therefore under-estimate the number of landslides under forest canopy.

In 1999, the Oregon Department of Forestry compiled and mapped landslide information from state and federal agencies for all of western Oregon. This database recorded 133 landslides in the Wilson River Watershed. However, 99 of these were recorded in a portion of the North Fork of the Wilson subwatershed, in the only thorough survey of landslides in the watershed (ODF 1996). So, landslide density throughout the watershed is likely more similar to the density found in the North Fork of the Wilson than to the overall density based on all known landslide locations. The 1996 ODF study in the North Fork of the Wilson subwatershed examined landslides in a 4.5 square mile region. Fifty non-road landslides were identified, with a density of 11.1/sq. mi. Sixty-six percent (33 slides) delivered sediment to a stream channel. The average volume of sediment contributed by these slides was estimated to be $11.8 yd^3/ac$.

ODF created debris flow hazard maps in 1996 to characterize the future potential for landslide activity based on watershed features such as slope, soils, and geology. According to potential debris flow hazard maps created by ODF, more than three-quarters of the Wilson River watershed is in the debris flow activity zone (Figure 6.1). Nearly equal proportions of the watershed fall in the moderate and high-risk categories: 40% in moderate, and 38% in high-risk (Table 6.1). Little North Fork and North Fork of the Wilson subwatersheds are almost

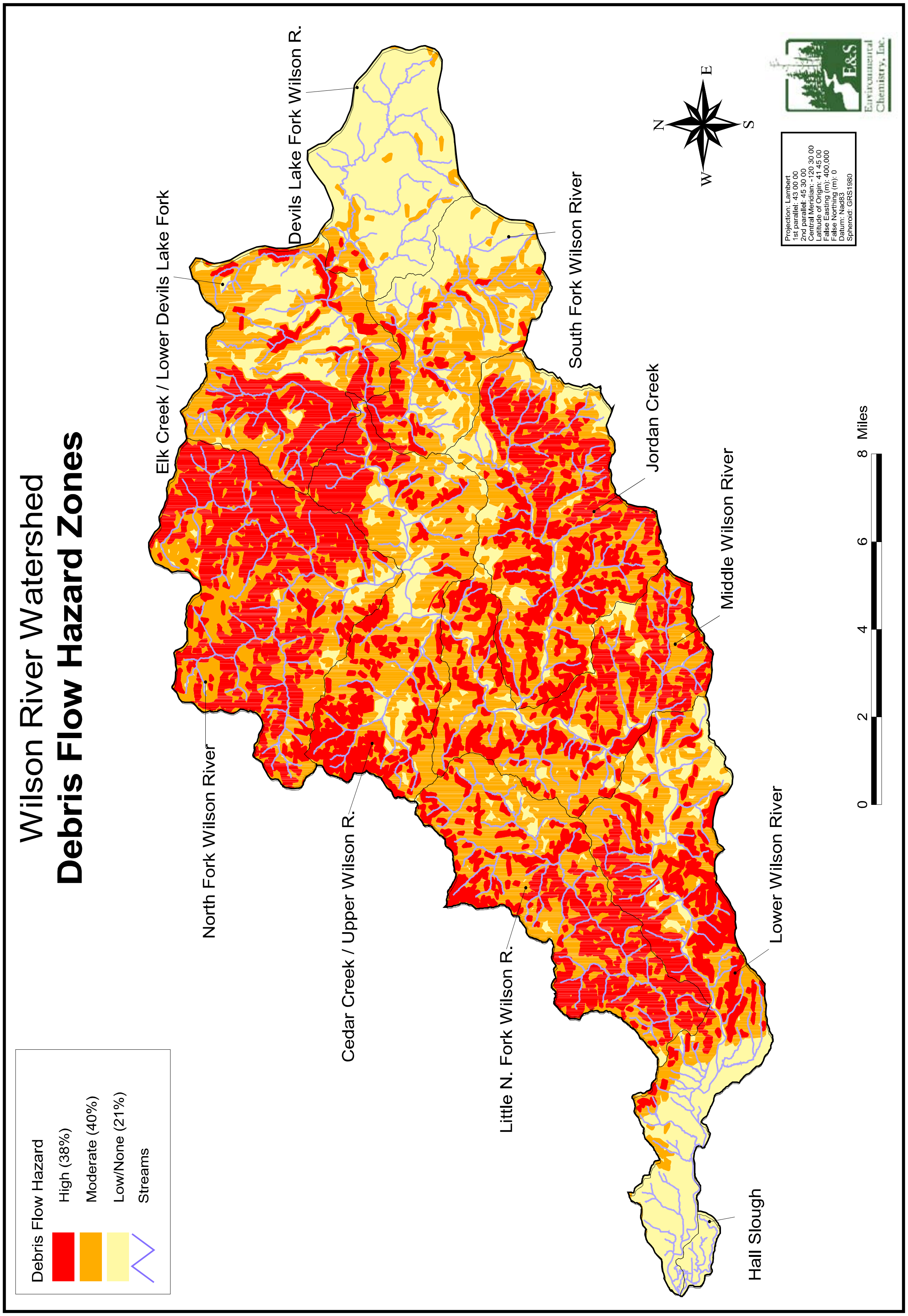

Figure 6.1 Debris flow hazard zones for the Wilson River watershed.

Table 6.1. Potential debris flow hazard zones in the Wilson River watershed.				
	Watershed Area (sq. mi.)	High (%)	Moderate (%)	High+Mod (%)
Cedar Creek / Upper Wilson R.	23	40	47	87
Devils Lake Fork Wilson R.	14	1.4	12	13
Elk Creek / Lower Devils Lake Fork	20	34	46	79
Hall Slough	1.1	0	0	0
Jordan Creek	25	49	41	90
Little N. Fork Wilson R.	20	50	48	97
Lower Wilson River	27	31	34	66
Middle Wilson River	21	45	49	93
North Fork of the Wilson River	27	62	35	97
South Fork of the Wilson River	16	12	46	59
TOTAL	194	38	40	78

completely in the debris flow risk zone (97% for both subwatersheds). Devils Lake Fork of the Wilson has very little area in the debris flow zone (13%). Hall Slough is the only subwatershed completely outside of the debris flow risk zone.

6.4 Road Instability

Roads constitute the primary source of increased sediment from forestry-related activities in the western United States (Mills 1997). Landslide frequency can be greatly accelerated by road building and management practices (Sidle et al. 1985). Road construction, especially on steep slopes, can lead to slope failure and result in increased landslide activity (WPN 1999, Sessions et al. 1987). Road stability is partially determined by the method of construction. For example, sidecast roads are built by using soil from the inside portion of a road to build up the outside, less stable portion of the road. Sidecast roads work well in moderately steep terrain, but in steep terrain the sidecast material frequently slides off the roadbed, initiating landslides or debris flows. Road crossings with poorly designed culverts can fail and wash out, create gullies, and deliver large pulses of sediment to the channel. Sediment delivery to streams depends on the percentage of the road drainage system which discharges directly to the channel; the proximity of non-stream discharges (*i.e.*, discharges across the hillside) to a channel; the volume of water involved and the potential for gully development (stream extension); and the volume of eroded material available (Mills 1997).

A recent source of information regarding road-related landslides in the Wilson River watershed is a 1996 ODF study, which examined a small portion of one subwatershed. The ODF study identified 12 road-associated landslides. The density of road slides was 2.7/sq. mi. Sixty percent of the road slides (5 events) delivered sediment to the stream channel.

ODF recently completed the fieldwork for a comprehensive road condition inventory, but the GIS layer was not complete at the time of this report, so detailed spatial analysis was not possible. However, we were able to conduct preliminary analyses at the scale of the Tillamook Bay watershed. In ODF lands throughout the Tillamook District, there are approximately 1,143 miles of road (Harrison, pers comm.). ODF surveyed over a thousand sidecast road sites. Of these, over half were determined by ODF to pose a moderate or high risk of contributing sediment to a stream if a road-related landslide were to occur. The overall density of these high-risk sites was approximately 1 site per every 2 miles of road. However, since these data were not specific to the Wilson Watershed, they only provide a region-wide sense of the potential for sediment contribution from roads on ODF lands.

We also conducted a GIS-based analysis of road-stream crossings. We found an average density of 2.3 crossings per square mile in the Wilson River Watershed. The highest density was in Hall Slough, with 7.5 crossings per square mile. However, it should be noted that Hall Slough is very atypical: it is the smallest subwatershed and covers a fairly developed lowland agricultural and urban area near the bottom of the watershed. The second highest density was in the Lower Wilson subwatershed, with 4.1 crossings/sq. mi. The lowest density was 0.5 crossings/sq. mi. in the Little N. Fork of the Wilson River subwatershed (Table 6.2).

6.5 Road Runoff

Water draining from roads can constitute a significant sediment source to streams. However, the amount of sediment potentially contained in road runoff is difficult to quantify, because road conditions and the frequency and timing of use can change rapidly. Poor road surfaces that are used primarily in dry weather may have a smaller impact on sediment production than roads with high quality surfaces that have higher traffic and are used primarily in the rainy season. Road data were used to assess potential sediment contribution from road runoff. Road density within 200 ft of a stream and on slopes greater than 50 percent was calculated using GIS.

Table 6.2. Stream/road crossings in the Wilson River watershed. Data were calculated using GIS.

	Watershed Area	Road-Stream Crossings	
Subwatershed	(sq. mi.)	(#)	(#/sq. mi)
Cedar Creek / Upper Wilson R.	23	38	1.7
Devils Lake Fork Wilson R.	14	44	3.1
Elk Creek / Lower Devils Lake Fork	20	41	2.1
Hall Slough	1.1	8	7.5
Jordan Creek	25	53	2.1
Little N. Fork Wilson R.	20	11	0.5
Lower Wilson River	27	110	4.1
Middle Wilson River	21	46	2.2
North Fork of the Wilson River	27	27	1.0
South Fork of the Wilson River	16	58	3.6
TOTAL	194	436	2.3

The density of roads within 200 ft of a stream was highest in the South Fork Wilson River subwatershed, at 0.41 miles of road per mile of stream, while the lowest was in the Little North Fork of the Wilson River, at 0.10 mi/mi. The most common road surface in the Wilson River Watershed is gravel, accounting for approximately two-thirds of all roads in the basin. Dirt roads account for nearly a third of all roads, while only 5% of roads are paved (Table 6.3).

Table 6.3. Current road conditions in the Wilson River watershed. The ODF fire roads coverage was used to calculate these numbers in GIS (see GIS data evaluation).

Subwatershed	Stream Length mi	Road Length mi	Gravel %	Dirt %	Paved %	Roads <200' from Stream (mi)	mi/mi*	Roads <200' from Stream and >50% Slope %
Cedar Creek / Upper Wilson R.	38	70	50	41	9	12.1	0.31	2.7
Devils Lake Fork Wilson R.	31	79	64	31	5	12.0	0.39	0.5
Elk Creek / Lower Devils Lake Fork	45	71	60	33	7	10.9	0.24	4.4
Hall Slough	6	5	67	22	11	2.1	0.33	-
Jordan Creek	48	92	69	31	0	15.1	0.32	4.2
Little N. Fork Wilson R.	42	51	70	30	0	4.3	0.10	2.4
Lower Wilson River	71	91	76	10	15	20.9	0.29	2.3
Middle Wilson River	40	61	44	42	13	11.8	0.30	3.6
North Fork Wilson River	49	93	62	38	0	14.8	0.30	4.4
South Fork Wilson River	35	66	62	38	0	14.4	0.41	3.7
Total	405	678	63	32	5	118.4	0.30	3.1

Very few roads in the Wilson River Watershed are both within 200 feet of a stream and on a slope gradient greater than 50%, based on GIS analysis. The South Fork Wilson River subwatershed was the only subwatershed that had any roads on very steep slopes, and these accounted for less than one percent of all roads (Table 6.3). It must be noted, however, that slope calculations based on Digital Elevation Models (DEMs) tend to under-represent slope steepness.

6.6 Streambank Erosion

Streambank erosion was identified as a critical issue in the lower reaches of Tillamook Bay's main tributary rivers twice in the 1970s (USDA 1978; SSWCC 1972). The conditions noted in both state reports, namely high bank erosion rates and resulting sediment deposition in the Bay, continue to the present day. The 1971–72 study conducted by the State Soil and Water Conservation Commission (SSWCC) identified five miles along the lower Wilson. However, the study was limited in time and funding, and therefore reflected only information readily available to Soil and Water Conservation District supervisors and local Soil Conservation Service staff. A later, more extensive study prepared for the Department of Environmental Quality (DEQ) by the SSWCC (1978) indicated severe bank erosion along 8 miles on the Wilson. These two studies indicate that streambank erosion in the Tillamook Bay floodplain has been a problem for many years, and has probably contributed greatly to the accumulation of sediment.

Erosion in agricultural lowlands typically takes two forms: streambank cutting, and sheet and rill erosion (Pedone 1995, as cited in Miller and Garono 1995). Streambank erosion is the more prevalent of the two types (USDA 1978). Significant streambank erosion typically takes place due to selective stratigraphic failure, soil saturation, and sloughing during high flow events (USDA 1978). Increased bank erosion is commonly associated with the removal of riparian vegetation. Cattle accessing streambanks can also increase erosion when their hooves break up the soil matrix and remove vegetation (USDA 1978). Sheet and rill erosion is most common along unvegetated road cuts and fills, but also occurs on construction sites and roadbeds, and can contribute significant amounts of sediment in localized areas.

Agricultural and urban lowlands occupy approximately 8% of the Tillamook Bay watershed (USDA 1978). USDA (1978) estimated that 60,613 tons (54,976 metric tons) of sediment enter Tillamook Bay annually. Of that total, 9,010 tons (8,172 metric), or 15%, were determined to be derived from agricultural lands. As in upland streams, non-organic sediment plays an important role in stream channel morphology. Organic sediment, including wood, contributes to channel structure, and to the aquatic habitat and food resources of the fluvial ecosystem. Human uses of the lowlands have affected the rate and character of lowland sedimentation through changes in flooding frequency and size, and by the diking of floodplains and tidal wetlands. In addition, channel modification, removal of LWD, and streamside grazing have increased streambank erosion. These changes have in turn affected the quantity and quality of riparian and aquatic habitat in the lowlands.

6.7 The Tillamook Burn

The Tillamook Burn fires of 1933, 1939, 1945, and 1956 affected sedimentation rates over a huge area for a few decades. Wood inputs and shading were drastically reduced and sedimentation increased by the fires and the subsequent logging and fire control practices that ensued. An earlier study concluded that this disturbance and its attendant increase in sediment production was within the range of natural variation of sedimentation rates through geologic time (LaFrance and McDonald 1995, as cited in Miller and Garono 1995). Active reforestation of the burned areas reduced sediment production rates, and probably has expedited the system's return to lower sediment production rates (LaFrance and McDonald 1995, as cited in Miller and Garono 1995). However, the intensive salvage logging operations which followed the burns, and especially the poor quality roads (now referred to as "legacy roads") built through the burned areas (*i.e.*, undersized culverts, log culverts, and extensive sidecasting of materials are examples of the poor techniques used), worsened the sedimentation which followed the fires (Coulton et al. 1996). The Federal Emergency Management Agency (FEMA) acknowledged in 1990 that many landslides which occurred that year originated from salvage roads built between 1940 and 1960 (Coulton et al. 1996).

6.8 Conclusions

Sediment in the rivers and streams of the Wilson River watershed has been an issue of great concern for many decades. The combination of the wet climate, steep slopes in the uplands, and very erosive soils results in naturally high levels of sediment in the rivers and streams. The historic wildfires in the watershed, as well as resource management practices over the past century are associated with an additional increase in sediment levels. High levels of sediment in the streams have been associated with increased rates of sedimentation in Tillamook Bay. Additionally, high sediment levels are associated with the declining health of salmonid populations. While naturally occurring sources of sediment in the watershed may be uncontrollable (and perhaps to some degree beneficial), the additional sediment contributed by human activity may have adverse effects on in-stream habitat quality.

Based on the landslide inventory conducted in the North Fork of the Wilson subwatershed, as well as studies conducted in nearby areas, landslide frequency in the Wilson River watershed appears to be very high. However, a comprehensive landslide inventory of the whole Wilson River watershed is lacking, so the specific locations of landslide activity are unknown. Previous assessments of sediment in the Tillamook Bay watershed have suggested that landslides and debris flows contribute the majority of the sediment in the watershed.

Roads are the primary source of sediment related to human activity. Contribution of sediment from roads is attributed to two processes: landslides originating from roads, and road runoff. Landslides coming from roads produce the largest proportion of road-associated sediment. The high density of stream-crossing culverts and sidecast dirt and gravel roads indicates that road-associated landslides are of significant concern in the Wilson River watershed. The ODF road inventory, when complete, will provide detailed road information on ODF lands, which constitute the majority of the gravel and dirt roads in the Wilson River watershed. Additionally, cooperation with private landowners to identify and improve sediment sources on private roads will further mitigate the impact of sediment in the watershed.

Lastly, streambank erosion is a concern in the Wilson River watershed. While the overall contribution of sediment from streambank erosion is less significant that other sources, erosion from the streambank is associated with a lack of riparian shade. Streambank erosion appears to be aggravated, indirectly and over the long-term, by gravel harvesting (Monte Pearson, pers. comm., 2000). Restoration of riparian vegetation and prevention of livestock grazing near streambanks will lessen sediment contribution from streambank erosion.

CHAPTER 7. WATER QUALITY

7.1 Introduction

The purpose of the water quality assessment, according to the OWEB manual (WPN 1999), is to complete a screening-level analysis of water quality. A screening-level analysis serves to identify obvious areas of water quality impairment by comparing selected measurements of water quality to certain evaluation criteria. The screening-level analysis uses existing data obtained from a variety of sources. This assessment does not include statistical evaluation of seasonal fluctuations or trends through time, and does not evaluate specific sources of pollution through upstream/downstream comparisons.

7.1.1 Assessment Overview

The water quality assessment proceeds in steps. The first step is to identify uses of the water that are sensitive to adverse changes in water quality, and identify potential sources of pollution in the watershed. The second step establishes the evaluation criteria. The third step examines the existing water quality data in light of the evaluation criteria. Conclusions can then be made about the presence of obvious water quality problems in the watershed, and whether or not additional studies are necessary.

Water quality is evaluated by comparing key indicators against evaluation criteria. Indicators are selected to represent pollution categories. Some aspects of water quality, such as fine sediment and temperature processes, are addressed in other sections of this watershed assessment. Although there are many constituents that contribute to the water quality of a stream, the watershed assessment is focused on seven that are most often measured, and that may have the most direct effect on aquatic organisms: temperature, dissolved oxygen, pH, nutrients, bacteria, turbidity, and chemical contaminants. Evaluation criteria, discussed in Section 7.4, have been determined based on values of these constituents that are generally protective of aquatic life.

7.1.2 Components of Water Quality

<u>Temperature</u>

Cool water temperatures are necessary for the survival and success of native salmon, trout, and other aquatic life. Excessively warm temperature can adversely affect the survival and growth of many native species. Although there is some debate about which specific temperatures should apply, and during which part of the year, standards have been set that can be used to determine if the waters in the stream are too warm. Because temperature in the stream varies throughout the day and among the seasons, multiple measurements throughout the day and in different seasons are needed to adequately assess water temperature conditions.

Dissolved oxygen

Aquatic organisms need oxygen to survive. Oxygen from the air dissolves in water in inverse proportion to the water temperature. Warmer water contains less dissolved oxygen at saturated conditions. Organisms adapted to cool water are also generally adapted to relatively high dissolved oxygen conditions. If the dissolved oxygen is too low, the growth and survival of the organisms is jeopardized. As with temperature, dissolved oxygen can vary throughout the day and among the seasons, so multiple measurements, both daily and seasonally, are required for an adequate analysis of water quality conditions.

pH

The pH is a measure of the acidity of water. The chemical form and availability of nutrients, as well as the toxicity of pollutants, can be strongly influenced by pH. Pollutants can contribute to changes in pH as can the growth of aquatic plants through photosynthesis. Excessively high or low pH can create conditions toxic to aquatic organisms.

Nutrients

Nitrogen and phosphorus, the most important plant nutrients in aquatic systems, can contribute to adverse water quality conditions if present in too great abundance. Abundant algae and aquatic plant growth that results from high nutrient concentration can result in excessively high pH and low dissolved oxygen, can interfere with recreational use of the water, and, in some cases, can produce toxins harmful to livestock and humans.

Bacteria

Bacterial contamination of water from mammalian or avian sources can cause the spread of disease through contaminated shellfish, contact recreation or ingestion of the water itself. Bacteria of the coliform group are used as an indicator of bacterial contamination.

Turbidity

Turbidity is a measure of the clarity of the water. High turbidity is associated with high suspended solids, and can be an indicator of erosion in the watershed. At high levels, the ability of salmonids to see their prey is impaired. As discussed elsewhere, high suspended sediment can have a number of adverse effects on fish and aquatic organisms.

Chemical contaminants

Synthetic organic compounds, pesticides, and metals can be toxic to aquatic organisms. The presence of such contaminants in the water suggests the presence of sources of pollution that could be having an adverse effect on the stream ecosystem.

7.2 Beneficial Uses

The Clean Water Act requires that water quality standards be set to protect the beneficial uses that are present in each water body. The Oregon Department of Environmental Quality (ODEQ) has established the beneficial uses applicable to the 18 major river basins in the State. The Wilson River watershed is in the North Coast Basin. The beneficial uses established for all streams and tributaries in the basin are (OAR 340-41-202):

Public domestic water supply[1]
Private domestic water supply[1]
Industrial water supply
Irrigation
Livestock watering
Anadromous fish passage
Salmonid fish rearing
Salmonid fish spawning
Resident fish and aquatic life
Wildlife and hunting
Fishing
Boating
Water contact recreation
Aesthetic quality

Estuaries and adjacent marine waters are considered to support the above beneficial uses as well, not including public or private water supply, irrigation, or livestock watering. Water quality must be managed so the beneficial uses are not impaired.

[1] With adequate pretreatment (filtration and disinfection) and natural quality to meet drinking water standards.

7.2.1 Water Uses Sensitive to Water Quality

Not all beneficial uses are equally sensitive to change in water quality. For example, use of the water body for domestic water supply would be impaired long before its use for commercial navigation. In general, water quality is managed to protect the most sensitive beneficial use. In the case of the Wilson River watershed, the most sensitive beneficial use is probably salmonid fish spawning. It is assumed that if the water quality is sufficient to support the most sensitive use, then all other less sensitive uses will also be supported.

7.3 Pollutant Sources

7.3.1 Point Sources

NPDES permitted discharges

The Clean Water Act prohibits discharge of waste to surface water. In order to discharge any waste, a facility must first obtain a permit from the State. ODEQ issues two primary types of discharge permit. Dischargers with Water Pollution Control Facility (WPCF) permits are not allowed to discharge to a water body. Most WPCF permits are issued for on-site sewage disposal systems. Holders of National Pollutant Discharge Elimination System (NPDES) permits are allowed to discharge wastes to waters of the state, directly or indirectly, but their discharge must meet certain quality standards as specified in their permits. Permits set limits on pollutants from industrial and municipal dischargers based on the ability of the receiving stream to absorb and dissipate the pollutants. Industries, municipal wastewater treatment facilities, fish hatcheries, and similar facilities typically have NPDES permits. General permits (GEN) are issued to certain categories of discharger rather than to individual facilities. The current discharge permits for the Wilson River watershed are listed in Table 7.1.

7.3.2 Non-point Sources

The largest current source of pollutants to Oregon's waters is not point sources such as factories and sewage treatment plants. The largest source of water pollution comes from surface water runoff, often called "non-point source" pollution. Rainwater, snowmelt, and irrigation water flowing over roofs, driveways, streets, lawns, agricultural lands, construction sites, and logging operations carries more pollution, such as nutrients, bacteria, and suspended solids, than discharges from industry.

Table 7.1. Permitted facilities that have discharges in the Wilson River watershed (ODEQ 2000).

Facility Name	Category	Type	River Mile
Alice's Country House	D	GEN56B	10.2
Churchill, George M.	D	WPCF-OS	2.6
Pacific Campground	D	NPDES	0.9
South Fork Forestry Camp	D	WPCF	33
Wilson River R V Park	D	WPCF	7.5
Tillamook Creamery	I	NPDES	1.7
Tillamook Creamery	I	GEN12Z	1.7

D = domestic, I = industrial, A = Agricultural, including fish hatcheries

Land use can have a strong influence on the quantity and quality of water flowing from a watershed. An undisturbed watershed with natural vegetation in and along streams and rivers and a diversity of habitats on the uplands provides clean water that supports the desirable beneficial uses of the waterway. As the watershed is affected by activities such as logging, agriculture, and urban development, the water quality in the waterways can become degraded. The percent of the land area of the Wilson River watershed affected by these land uses is shown in Table 7.2. Table 1.4 shows the distribution of all land use types in the watershed. Table 1.6 lists possible water quality effects from various types of land use.

Table 7.2. Percent area of the Wilson River watershed by selected land uses.

Land Use Type	Area (sq mi)	Percent of Total Area
State Forest	151.7	78.3
Private Industrial Forest	24.0	12.4
Agriculture	3.1	1.6
Developed	0.17	0.1
Other	14.7	7.6

The most prominent type of land use in the Wilson River watershed is forestry, with relatively little land in developed areas. This land use pattern suggests that water quality problems associated with toxic industrial chemicals may be of relatively little importance while problems associated with sediment, turbidity, temperature, and possibly bacteria are likely to be more important. To the extent that herbicides and pesticides are used in forestry and agriculture operations, these compounds may assume greater importance.

Water quality is affected by the introduction of organic matter to streams. The presence of organic matter increases biochemical oxygen demand, which means less dissolved oxygen is available for aquatic life. The introduction of untreated animal or human waste increases the possibility of bacterial contamination of water, increasing the risk of infection to swimmers and limiting its uses. Eutrophication is the process of enrichment of water with nutrients, mainly nitrogen and phosphorous compounds, which results in excessive growth of algae and nuisance aquatic plants. It increases the amount of organic matter in the water and also increases pollution as this matter grows and then decays. Through photosynthesis, algae and aquatic plants consume carbon dioxide (thus raising pH) and produce an abundance of oxygen. At night the algae and plants respire, depleting available dissolved oxygen. This results in large variations in water quality conditions that can be harmful to other aquatic life. While natural sources of nutrients can influence eutrophication, the introduction of nutrient pollution strengthens the process.

Sources of nutrients include wastewater treatment facility discharge and faulty septic systems, runoff from animal husbandry, fertilizer application, urban sources, and erosion. High water temperatures compound the decline in water quality by causing more oxygen to leave the water and by increasing the rate of eutrophication. Removal of streamside vegetation, among other factors, influences high stream temperature and, via erosion, increases sedimentation of streams.

7.3.3 Water Quality Limited Water Bodies

Sometimes, applying the best available treatment technology to all the point sources in a basin does not bring the stream into compliance with water quality standards. The combination of pollutants from all sources, point and non-point, within the watershed may contribute more pollution than the stream can handle. Under this circumstance, when a stream consistently fails to meet water quality standards for a particular pollutant, it is declared by ODEQ to be "water quality limited" as required by the Clean Water Act Section 303(d). Water bodies on the "303d List" must be analyzed to determine the total amount of pollutant that can be accommodated by the stream (the total maximum daily load – TMDL). This load is then allocated to all the dischargers, including non-point. Dischargers must then take the steps necessary to meet their allocated load. The water quality limited water bodies in the Wilson River watershed are listed in Table 7.3.

Table 7.3. Water quality limited water bodies in the Wilson River watershed (DEQ 1999).

Water Body	Segment	Parameter	Season
Wilson River	Mouth to Little North Fork Wilson River	Bacteria	Summer
Wilson River	Mouth to headwaters	Temperature	Summer

7.3.4 Oregon Water Quality Index

Although the 303(d) list identifies water bodies that are known not to meet current water quality standards, the list is not necessarily a complete indicator of water quality in a particular basin. For many stream reaches there is not enough data to make a determination. In addition, the 303(d) listing is tied to the total amount of monitoring done, which is influenced by the number of special monitoring studies completed by ODEQ. Because special studies are frequently concentrated where water quality degradation is a concern, the list is weighted toward poorer quality waters. Consequently the ODEQ has developed the Oregon Water Quality Index (OWQI) as a water quality benchmark that is keyed to indicator sites monitored regularly by ODEQ.

The OWQI integrates measurements of eight selected water quality parameters (temperature, dissolved oxygen, biochemical oxygen demand, pH, ammonia+nitrate nitrogen, total phosphates, total solids, fecal coliform bacteria) into a single index value that ranges from 10 (the worst) to 100 (the best). Land use, geology, hydrology, and water quality varies widely throughout the North Coast basin. Water quality data were collected by the ODEQ laboratory in 1985-1987 for the Tillamook Bay Tributaries special study, and regular quarterly ambient monitoring of all of the sites began in 1992. Comparing minimum seasonal Oregon Water Quality Index (OWQI) values (Table 7.4), water quality ranges from excellent at the upper Wilson River site to fair at the lower sites. Results show that the upstream site (Highway 6 Bridge) had a higher average OWQI score compared to the downstream site (Highway 101 Bridge). The increase in fecal coliforms and total solids from upstream to downstream led to a deterioration from excellent to fair water quality (Table 7.4).

Table 7.4. Seasonal Average OWQI Results for the North Coast Basin (WY 1986 -1995).

Site	STORET Number	River Mile	Summer Average	FWS Average	Minimum Seasonal Average
Miami R. @ Moss Ck. Rd.	412120	1.7	81	86	81
Wilson R. @ HWY 6 (Mill Bridge)	412133	8.5	91	90	90
Wilson R. @ HWY 101	412130	1.8	82	82	82

Summer: June - September; FWS (Fall, Winter, & Spring): October -May
Scores - Very Poor: 0-59, Poor: 60-79, Fair: 80-84, Good: 85-89, Excellent: 90-100

7.3.5 Data Sources

In order to assess more adequately the water quality conditions in the Wilson River watershed, we assembled available data from a variety of sources. Data were obtained from the EPA STORET[2] database for the period 1965 through 1999. In addition, a number of studies conducted and documents prepared under the auspices of the Tillamook Bay National Estuary Program (TBNEP) were reviewed to obtain water quality information for this assessment. They included the *Tillamook Bay Environmental Characterization* report (Hinzman and Nelson 1998), the *Tillamook Bay Comprehensive Conservation and Management Plan* (TBNEP 1999), *Results of Storm Sampling in the Tillamook Bay Watershed* (Sullivan et al. 1998b), *Oregon Coast Range Macroinvertebrate Analysis and Monitoring Status* (Canale 1999), *Water Quality Monitoring in the Tillamook Watershed* (Sullivan et al. 1998a), *Results of Bacteria Sampling in the Wilson River* (Bischoff and Sullivan 1999), and the Tillamook Bay TMDL analysis by ODEQ.

7.4 Evaluation Criteria

The evaluation criteria used for the watershed assessment are based on the Oregon Water Quality Standards for the North Coast Basin (ORS 340-41-205) and on literature values where there are no applicable standards, as for example, for nutrients (WPN 1999). They are not identical to the water quality standards in that not all seasonal variations are included. The evaluation criteria are used as indicators that a possible problem may exist. The evaluation criteria are listed in Table 7.5.

The water quality evaluation criteria are applied to the data by noting how many, if any, of the water quality data available for the assessment exceed the criteria. If sufficient data are available, a judgement is made based on the percent exceedence of the criteria as shown in Table 7.6. If insufficient, or no, data are available, it is noted as a data gap to be filled by future monitoring. If any water quality parameter is rated as “moderately impaired” or “impaired”, water quality in the stream reach in question is considered impaired. The condition that caused the impairment should be addressed through stream restoration activities.

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[2] STORET data are available on CD-ROM from Earth Info, Inc. 5541 Central Ave., Boulder, CO 80301; (303) 938-1788.

Table 7.5. Water quality criteria and evaluation indicators (WPN 1999).

Water Quality Attribute	Evaluation Criteria
Temperature	Daily maximum of 64° F (17.8° C) (7-day moving average)
Dissolved Oxygen	8.0 mg/L
pH	Between 6.5 to 8.5 units
Nutrients	
Total Phosphorus	0.05 mg/L
Total Nitrate	0.30 mg/L
Bacteria	Water-contact recreation 126 E. coli/100 mL (30-day log mean, 5 sample minimum) 406 E. coli/100 mL (single sample maximum) Marine water and shellfish areas 14 fecal coliform/100 mL (median) 43 fecal coliform/100 mL (not more than 10% of samples)
Turbidity	50 NTU maximum
Organic Contaminants	Any detectable amount
Metal Contaminants	
Arsenic	190 µg/L
Cadmium	0.4 µg/L
Chromium (hex)	11.0 µg/L
Copper	3.6 µg/L
Lead	0.5 µg/L
Mercury	0.012 µg/L
Zinc	32.7 µg/L

Table 7.6. Criteria for evaluating water quality impairment (WPN 1999).

Percent of Data Exceeding the Criterion	Impairment Category
Less than 15 percent	No impairment
15 to 50 percent	Moderately impaired
More than 50 percent	Impaired
Insufficient data	Unknown

7.5 Water Quality Data

7.5.1 STORET

Data were obtained from the EPA STORET database for the period 1965 through 1998. There were 354 sites in the USGS hydrologic unit 17100203, which includes the Wilson, Miami, and several other rivers in the ODEQ North Coast basin, that had water quality data in the STORET database. Of these 354 sites, 83 were from ambient stream stations in the Miami and Wilson Rivers. The remaining sites were from such locations as point discharges, wells, sewers, pump stations, and similar locations. The ambient water quality sites were distributed among the two watersheds as shown in Table 7.7.

Table 7.7. The distribution of applicable STORET ambient stream water quality sampling sites in the Oregon North Coast basin 1965-1999.

Description	Wilson River Watershed	Miami River Watershed
Total ambient sites	65	18
Number of sites sampled more than once	37	15
Number of sites sampled more than once since 1989	22	10

Sites sampled only once over a period of 30 years do not provide adequate data to make judgements about water quality. Likewise data from more than ten years ago may not be representative for current conditions. For these reasons only sites that had been sampled since 1989 and had been sampled multiple times were used in this analysis. This is consistent with the practice of ODEQ in establishing the Oregon Water Quality Index.

The ambient sites sampled more than once in the Wilson River watershed are listed in Table 7.8 and displayed in Figure 7.1.

Table 7.8. Ambient water quality sampling sites used for water quality assessment in the Wilson River watershed (EPA 2000).

Station Number	**North Latitude**	**West Longitude**	**Location**	**Number of Samples**	**Number of Analyses**
402246	45:28:49	123:50:58	Tillamook Creamery (TCCA) Outfall @ Wilson River	45	150
402596	45:28:48	123:51:08	Wilson River D/s of TCCA Outfall.	35	242
402597	45:28:42	123:50:49	Tillamook Creamery Outfall - Wilson River	97	761
405021	45:29:42	123:35:18	Fall Creek at Rm 0.7	5	85
405574	45:28:46	123:50:48	Wilson River Tributary U/s TCCA Outfall	2	6
405641	45:28:56	123:52:13	Wilson River @ Mouth	6	88
405642	45:28:49	123:50:58	Wilson River 20 Ft. U/s TCCA Outfall	6	79
405644	45:28:49	123:51:03	Wilson River 300 D/s of TCCA Outfall	6	79
405668	45:35:35	123:28:06	Wilson River So. Fk. 1 Mi. Up So. Fk. Rd	8	64
405669	45:35:40	123:28:06	Wilson River So. Fk. 7/8 Mi. Up So. Fk. Rd	16	124
405670	45:36:03	123:28:07	Wilson River So. Fk. @ 1st. Br. On So.fk. Rd.	8	60
405736	45:28:49	123:52:20	Hall Slough @ Mouth	2	34
405737	45:28:36	123:48:17	Beaver Creek at Mouth Wilson River Trib	2	30
405738	45:28:15	123:46:14	Donaldson Creek @ Mouth - Wilson Trib	2	30
405739	45:28:17	123:46:37	Wilson River at End of Donaldson Rd	2	30
412129	45:28:49	123:50:58	Wilson River Midchannel @ TCCA Outfall	47	614
412130	45:28:44	123:50:40	Wilson River at Hwy 101	243	3685
412132	45:28:40	123:48:24	Wilson River @ Powerline Crossing-rm 3.0	65	744
412133	45:28:21	123:44:06	Wilson River at Hwy 6 (River Mile 8.5)	231	4894
412223	45:28:00	123:52:00	Wilson River at Mankister Dock	27	255
412131	45:28:38	123:48:33	Wilson River at Sollie Smith Rd (Rm 3.5)	299	1744

7.5.2 ODEQ Sites

ODEQ currently maintains three sites in the Wilson River watershed as part of their ambient water quality monitoring network. The sites are 1) Wilson River at Hwy 101, 2) Wilson River at Hwy 6 (River Mile 8.5), and 3) Wilson River at Sollie Smith Rd (Rm 3.5). These three sites are the most frequently sampled, and are the STORET sites with the most recent data.

Table 7.9 shows a numerical summary of grouped data from all the STORET sites with more than one sample in the Wilson River for the parameters under consideration in this assessment.

Table 7.9. Numerical data summary for water quality parameters: Wilson River Watershed STORET sites.

Descriptors	Turbidity	Temperature	P-Tot	pH	NO_3-N	FCB[4]	*E. coli*	DO
No. of observations	218	936	366	780	229	780	55	398
Minimum	1	0	0.008	5.8	0	0	4	1.2
Maximum	218	25.4	21	8.8	18	130000	74000	13.6
Mean	5.94	13.55	0.28	7.02	0.47	3275	2813	10.60
Standard dev.	17.21	5.10	1.99	0.29	1.28	16731	12702	1.68
1st quartile[1]	1	8.75	0.02	6.8	0.2	30	22	9.6
Median[2]	2	14.5	0.027	7	0.31	91	48	11.2
3rd quartile[3]	4	18.3	0.05	7.2	0.49	362.5	272.5	11.8
Std dev of mean	1.17	0.17	0.10	0.01	0.08	599.10	1712.74	0.08

[1] 25 percent of values were less than or equal to the 1st quartile value
[2] 50 percent of values were less than or equal to the median value
[3] 75 percent of values were less than or equal to the 3rd quartile value
[4] FCB = fecal coliform bacteria

7.5.3 Other Data Sources

In a study of loading of water quality constituents to Tillamook Bay from the five major rivers, Sullivan et al. (1998) collected water quality at two sites on the Wilson River. The main site was on the lower river, river mile (RM) 3.5 (Sollie Smith bridge), the secondary site was near the interface between forest and agricultural land uses, at RM 14.1. The results of monitoring in 1997 in all five rivers entering Tillamook bay are presented in Table 7.10 (Sullivan et al. 1998).

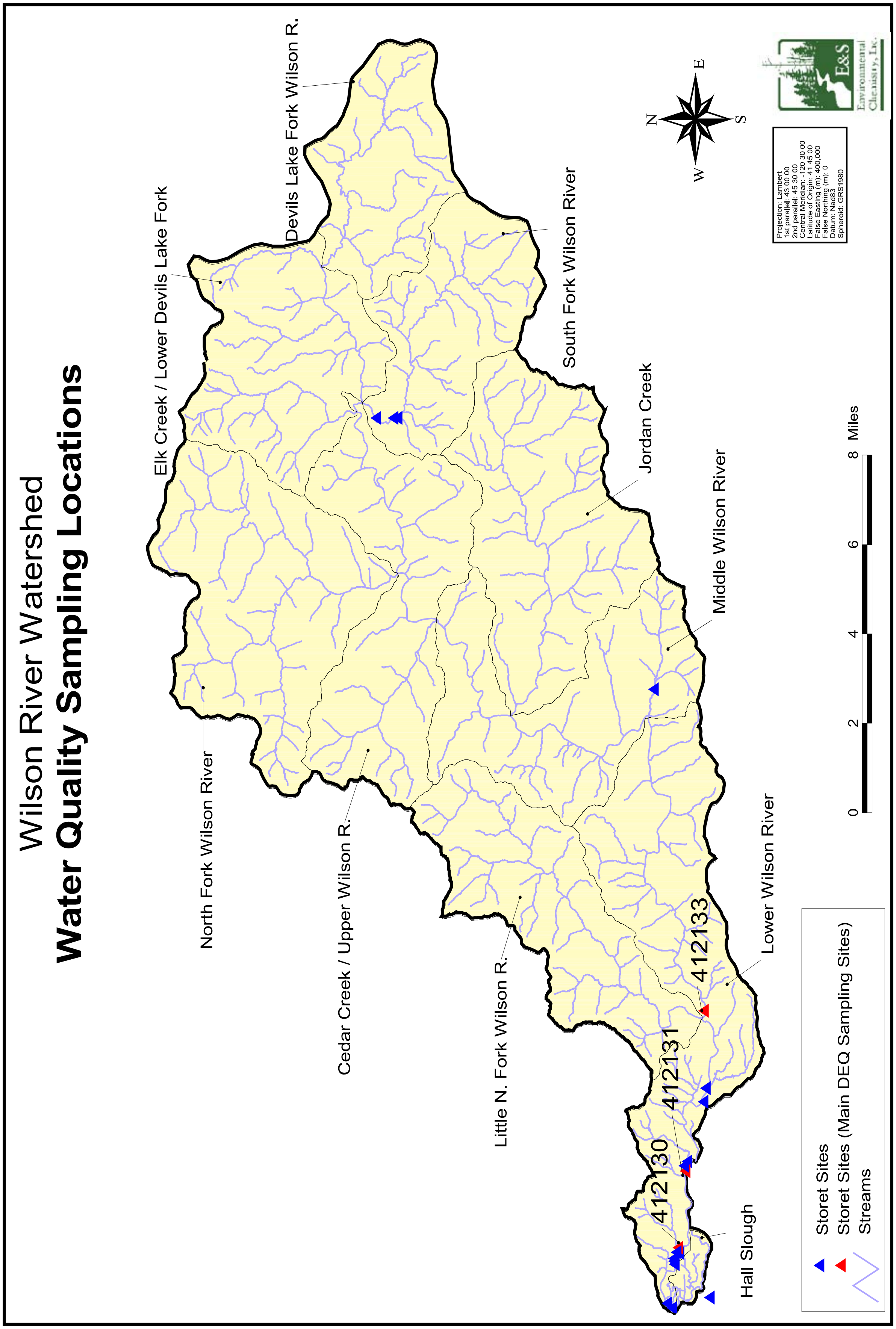

Figure 7.1. EPA STORET Sampling sites in the Wilson River watershed. Site descriptions are provided in Table 7.8.

Table 7.10. Flow-weighted average concentration of water quality parameters measured during 1997 at the lower watershed site on each of the five rivers (the number of samples is in parentheses).

Parameter	Flow Weighted Average Concentration				
	Tillamook[1]	Trask[1]	Wilson	Kilchis	Miami
Fecal Coliform Bacteria (cfu/100ml)	523(41)	169(26)	152(34)	36(32)	124(32)
NH_4-N (mg/L)	0.02(20)	0.02(18)	0.02(19)	0.02(20)	0.02(20)
NO_3-N (mg/L)	0.78(21)	0.82(19)	0.59(20)	0.73(21)	0.93(21)
Conductivity (µS/cm)	56(32)	66(13)	50(27)	44(24)	52(22)
pH	6.6(15)	7.0(22)	7.0(14)	6.9(15)	6.9(15)
TSS (mg/L)	38(24)	137(19)	253(23)	86(24)	60(24)
TKN (mg/L)	0.31(21)	0.25(19)	0.22(20)	0.24(21)	0.27(21)
TP (mg/L)	0.11(21)	0.25(4)	0.52(19)	0.22(20)	0.15(21)
Ca (mg/L)	3.1(4)	7.2(4)	7.8(4)	4.3(4)	3.97(4)
Mg (mg/L)	1.5(4)	4.3(4)	7.4(4)	2.8(4)	2.1(4)
Na (mg/L)	4.0(4)	3.9(4)	3.4(4)	2.9(4)	3.6(4)
K (mg/L)	0.614(4)	0.32(4)	0.47(4)	0.20(4)	0.27(4)
SO_4-S (mg/L)	0.62(4)	0.61(4)	0.49(4)	0.29(4)	0.35(4)
Cl (mg/L)	6.5(4)	3.2(4)	2.7(4)	3.3(4)	5.0(4)

[1] Data collected for the Tillamook and Trask Rivers during an intensively monitored storm even event in October, 1997 were excluded from this analysis because comparable data were not available for the other three rivers.

7.6 Water Quality Constituents

7.6.1 Temperature

Available temperature data are shown in Figure 7.2. Of the 663 available temperature measurements, 106 (13 percent) exceed 17.8° C, and 232 (38 percent) exceed 12.8° C. Sullivan et al. (1998) measured temperature on grab samples collected between October 1996 and January 1998. The temperature measured in the Wilson River was typically near 8° C during the winter, but began to increase in April and reached 20.4° C in August 1997.

The ODEQ (Boyd et al. 1999) conducted a detailed study of temperatures in the Wilson River basin as part of its TMDL for Tillamook Bay. ODEQ measured a total of twenty continuous monitoring sites for stream temperatures during summer months in both 1997 and

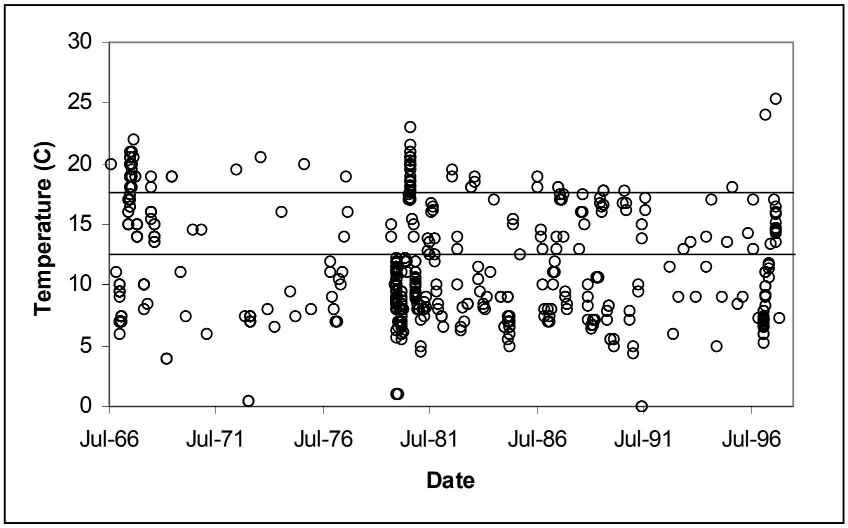

Figure 7.2. Temperature measurements taken in the Wilson River basin 1966- 1998. The horizontal lines mark the screening criteria of 12.8° C and 17.8° C. (Data from STORET)

1998. All major tributaries, as well as the Wilson River mainstem were sampled for temperature in either the 1997 or 1998 summertime monitoring season and continuous monitoring data have passed ODEQ quality control protocols. Data have been statistically processed to yield the 7-day average of the daily maximum temperatures (commonly referred to the *7-day statistic*). These 7-day statistics are used to specify if the sampled stream temperatures violate State water quality standards.

The TMDL established by ODEQ for temperature in the basin will set targets for shade development that should result in a reduction in water temperatures. To gauge progress, temperature monitoring stations have been established at eight sites. Spawning temperature recorders, which collect temperature data from May through October, occur at the South Fork at mouth, North Fork, Cedar Creek at mouth, and mainstem Wilson River near Cedar Creek. Migration and rearing temperature recorders, which collect data from June through September, occur at Devils Lake Fork, Wilson River at Lee's Camp Bridge, West Fork of North Fork at mouth, and Sollie Smith Bridge.

<u>Spatial Temperature Patterns</u>

Wilson River and tributary temperatures are generally warm. Of the twenty sites monitored for continuous temperature data, only Elk Creek, Idiot Creek and Cedar Creek have a 7-day statistic below 17.8ºC (64.0ºF). All other mainstem and tributary sites exceed the numeric criteria (17.8ºC). The data suggest that heating occurs in the upper watershed near the divide (headwaters). The mainstem Wilson continues warming to tidewater (Sollie Smith Bridge).

Upper watershed tributaries (North Fork Wilson River, South Fork Wilson River, and Devils Lake Fork Wilson River) allow rapid heating, relative to the short travel distances. Data collected indicate that much of the upper Wilson tributaries are temperature limited and pose an increased risk to salmonid fish populations.

The Wilson River mainstem is temperature limited throughout its entire stream length. In summer months the Wilson mainstem reaches stream temperatures greater than 20.3ºC (68.5ºF) and sometimes exceed 24.0ºC (75.2ºF) in the lower reaches. Lower watershed tributaries have little effect on mainstem temperatures. Cedar Creek is cooler than the mainstem, but offers little mainstem cooling because it has much less flow than the mainstem. Little North Fork Wilson River temperatures are warm when considering its relatively short perennial stream length. The Wilson River system in unique in that temperatures are warm throughout virtually all portions of the watershed. Wilson River and tributary temperatures continually heat in the downstream (longitudinal) direction. Significant stream heating was measured in the Wilson River throughout its entire length.

These data suggest that the Wilson River is impaired for temperature relative to salmonid rearing and growth.

7.6.2 Dissolved Oxygen

Dissolved oxygen data are presented in Figure 7.3. Of the 398 available dissolved oxygen measurements, 27 (7 percent) were below 8.0 mg/L, and 175 (44 percent) were below 11.0 mg/L. These data suggest that at least portions of the Wilson River are moderately impaired with respect to dissolved oxygen to support salmonid spawning and incubation.

7.6.3 pH

Data for pH are presented in Figure 7.4. Less than one percent of the measurements are outside the range of the screening criteria. Based on these data, there is no reason to suspect that water quality in the Wilson River is impaired for pH.

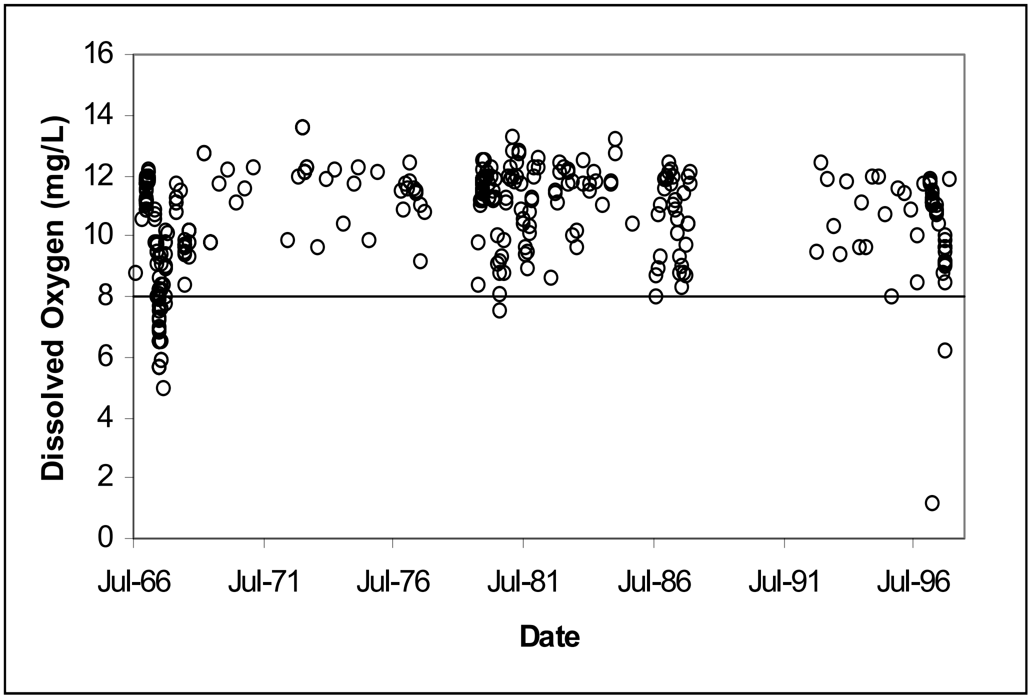

Figure 7.3. Dissolved oxygen measurements taken in the Wilson River basin, 1966-1998. The horizontal line marks the screening criterion of 8.0 mg/L. (Data from STORET)

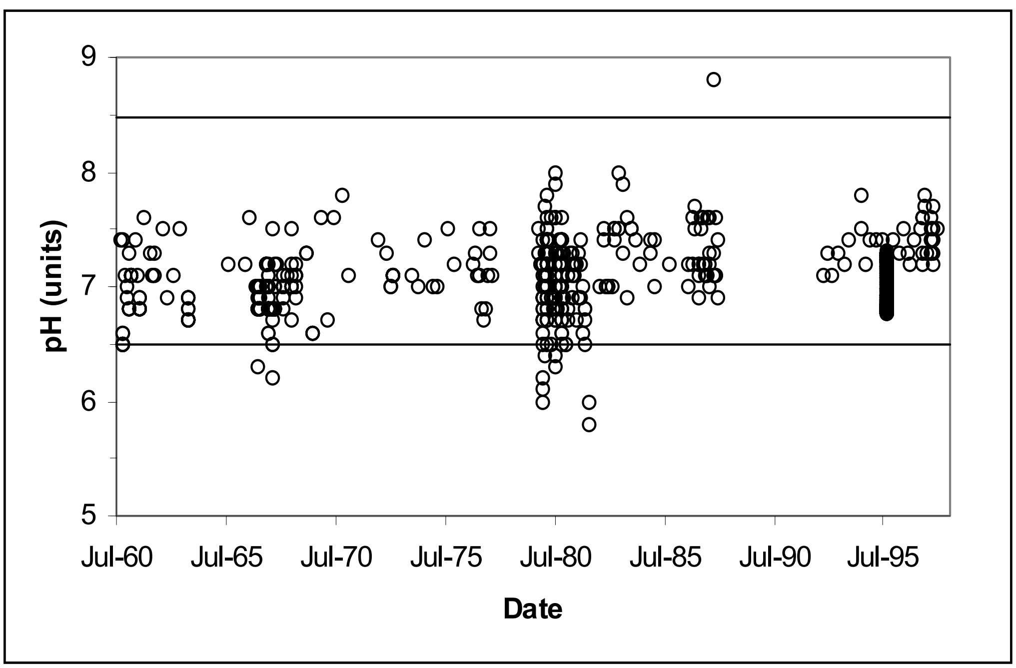

Figure 7.4 pH measurements taken in the Wilson River basin, 1960-1998. The horizontal lines mark the screening criteria of 6.5 and 8.5. (Data from STORET)

7.6.4 Nutrients

Phosphorus

Data for total phosphorus, measured at the STORET sites, are presented in Figure 7.5. Of the 336 measurements for total phosphorus, 66 (20 percent) are greater than the screening criterion of 0.05 mg/L. A seasonal analysis of the STORET data through 1995 conducted by DEQ (Hinzman and Nelson 1998) showed that total phosphorus concentration in the Wilson River did not vary much seasonally. Total phosphorus concentrations were generally rather low, with median values for all months not exceeding 0.05 mg/L.

Sullivan et al. (1998a) measured total phosphorus in the Wilson River during 1997. They found that total phosphorus (TP) concentrations were variable from river to river, with the highest concentrations consistently found in the Trask, Kilchis, and Wilson Rivers. Total phosphorus concentrations were typically less than about 0.1 to 0.2 mg/L, except during storms when the concentrations sometimes exceeded 0.5 mg/L. Total phosphorus at the forest/ agriculture interface exhibited similar patterns, although concentrations were often somewhat lower than at the lower watershed sites.

Total phosphorus is closely related to TSS concentration, which suggests that the phosphorus is bound to soil particles. It is likely that the sources of the total phosphorus and TSS are the same and that the phosphorus is geologic in origin. Additionally, paired sample analyses between RM 3.5 and the forest/agriculture interface site suggested that the contribution of total

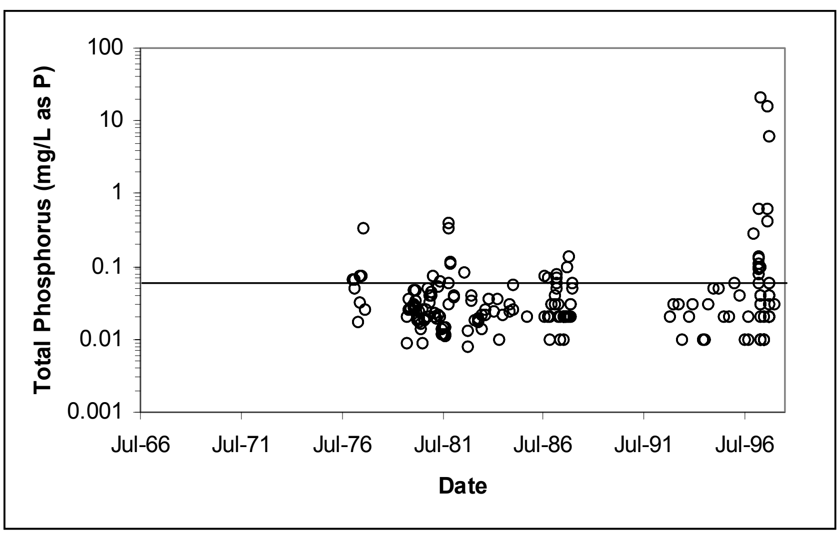

Figure 7.5. Total phosphorus measurements taken at all sites in the Wilson River basin 1966-1998. The horizontal line marks the screening criterion of 0.05 mg/L total phosphorus (as P). (Data from STORET)

phosphorus from the agricultural parts of the watershed was minimal and that total phosphorus was mostly generated in the forested part of the watershed where most of the sediment originates.

There was a general relationship between flow and the ratio of total nitrogen to total phosphorus. The growth of algae in the river appears to be limited by a relative lack of phosphorus compared to nitrogen (TN/TP>14) during low flow conditions. However, at flows greater than 5000 cfs plant growth in the river appears to become limited by a relative lack of nitrogen.

These data suggest that, although the screening criterion is exceeded by more than 15 percent of the samples, the seasonal pattern of concentration is such that the higher concentration of total phosphorus would not contribute to excess plant growth. It seems unlikely that the water quality of the Wilson River is impaired with respect to phosphorus.

Nitrogen

Data for total nitrate-nitrogen (NO_3-N) measured at the STORET sites are presented in Figure 7.6. Of 229 measurements, 125 (55 percent) exceed the screening criterion of 0.3 mg/L. A seasonal analysis of the STORET data through 1995 conducted by TBNEP (Hinzman and Nelson 1998) showed that nitrate-nitrogen concentration in the Wilson River varied seasonally. Nitrate-nitrogen was typically low, with median values less than 0.3mg/L, in the summer (June to August) with the highest concentrations occurring in November and December, at median values 0.65 and 0.75 mg/L respectively.

Sullivan et al. (1998a) found that total inorganic nitrogen concentrations (TIN=nitrate (NO_3-N) + ammonia (NH_4-N)) were generally near or below 1 mg/L (± 0.2 mg/L) in the Wilson River. TIN was typically composed of >95% NO_3^-, with a very small NH_4^+ component. Limited data from the forest/agriculture interface sites showed similar patterns. Paired sample analyses (samples taken within a few hours of each other) between the primary (downstream) and forest/agriculture interface sites showed there was relatively little contribution of TIN to the rivers from the lower agricultural portions of the watershed.

Concentrations of TIN were reduced during the summer time and were higher during the winter. This was likely due to greater biological demand for N in the aquatic and terrestrial systems during summer months. The greatest amount of seasonal variability in TIN loads occurred during the winter months, and may have been associated with the greater variability in winter flows. However, there was no clear relationship between TIN concentrations and flow.

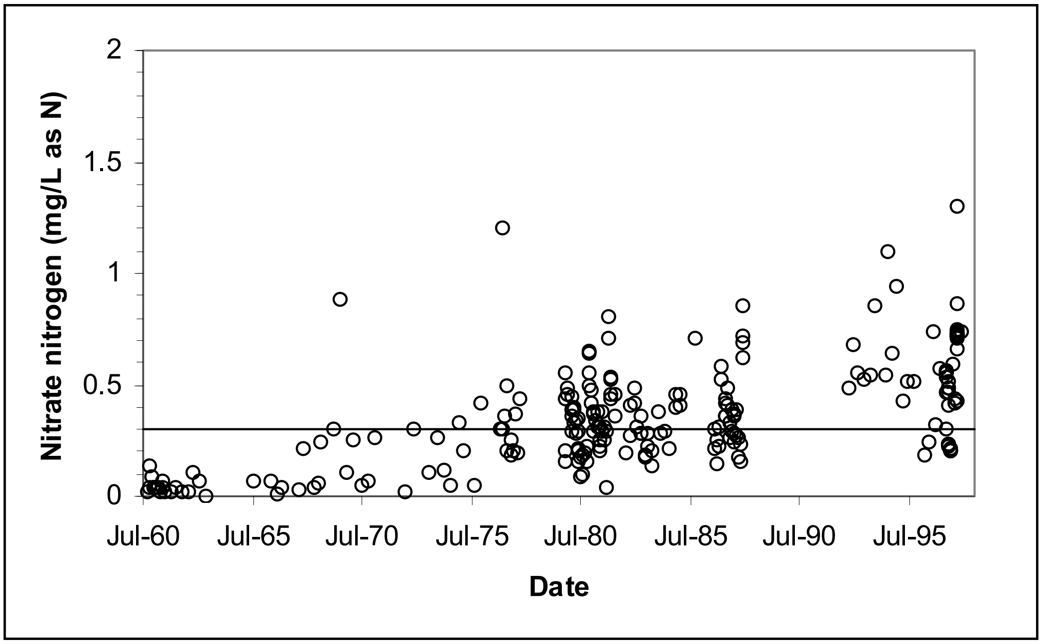

Figure 7.6. Nitrate nitrogen measurements taken at all sites in the Wilson River basin 1960-1998. The horizontal line marks the screening criterion of 0.3 mg/L nitrate nitrogen (as N). (Data from STORET)

Figure 7.6 suggests that nitrate nitrogen concentration may be increasing in the Wilson River, but the trend is not clear because all sample sites are plotted together. In Figure 7.7, the nitrate nitrogen concentration for the three most commonly sampled sites are shown separately. It appears from this plot that nitrate nitrogen concentration has been increasing over time, especially at site 412133, the Highway 6 bridge. The data are not sufficient to make a clear determination, but nitrate nitrogen may also be increasing at site 412130, Highway 101.

The cause of such an increase in nitrate nitrogen can not be determined from the available data. It is possible that nitrogen fixation in large alder stands in the Wilson River watershed may be contributing to higher nitrogen concentration in the river.

The available data suggest that the Wilson River water quality is impaired with respect to nitrogen.

7.6.5 Bacteria

Tillamook Bay has a long history of bacterial pollution problems (Blair and Michener 1962, Jackson and Glendening 1982, Musselman 1986), During the 1980's, major bacterial sources were identified and various measures were taken to decrease bacterial pollution. Important sources of fecal coliform bacteria have been identified as discharge from wastewater treatment

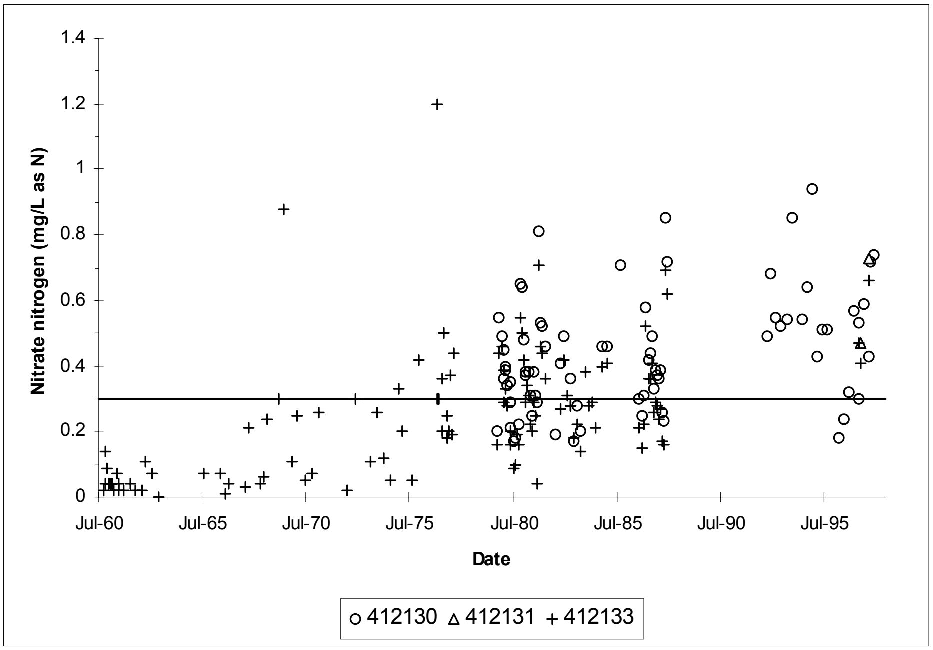

Figure 7.7. Nitrate nitrogen measurements taken at the three main ODEQ monitoring sites on the Wilson River: 412130 is at Highway 101, 412131 is at Sollie Smith Bridge (RM 3.5), 412133 is at Highway 6 bridge (RM 8.5). The horizontal line marks the screening criterion of 0.3 mg/L nitrate nitrogen (as N). (Data from STORET)

plants, runoff from agricultural areas, discharge from malfunctioning septic systems, and direct input from animals in the basin (Jackson and Glendening 1982). More recent reports on water quality in the Tillamook Basin have suggested that bacterial concentrations have decreased, although water quality violations still occur (Arnold et al. 1989). These data, however, were perceived to be biased due to sampling in different water years and later studies were performed to test for trends in the water quality data set. Statistical tests generally showed a reduction in fecal coliform concentrations (Dorsey-Kramer 1995) although the overall trend analysis was inconclusive (Wiltsey 1990). During this period, the number of dairy cows increased approximately 37% (Commodity Data Sheets 1980 and 1990), suggesting that implemented land use practices were partially effective in reducing fecal coliform contributions to surface waters of the Tillamook Basin.

Water quality standards for recreational contact and shellfish growing waters differ; but standards in both fresh water and the bay have long been violated in the Tillamook Watershed (Jackson and Glendening 1982). The bacteria standard for recreational contact applies to both fresh and saline waters and is intended to protect people in contact with water, such as swimmers. The shellfish standard is much more stringent, because it is designed to protect people from pathogens which might be consumed with raw shellfish. Oregon has adopted the water quality standards for bacteria and other pathogens in estuarine water set by the federal Food and Drug Administration (FDA) for interstate commerce (U.S. Dept. of Health and Human Services 1995). Bacterial concentrations in the bay have historically been high during the wet seasons of the year: fall, winter, and early spring.

Data for bacteria in the Wilson River are presented in Figures 7.8 (fecal coliform bacteria–FCB) and 7.9 (*E. coli*). In unimpaired bay waters, not more than 50 percent of the samples should exceed 14 fecal coliform bacteria per 100 mL, and not more than 10 percent should exceed 43 per 100 mL. For the available STORET data for fecal coliform bacteria, 82 percent of the measurements exceed 14 colony forming units (cfu/100 mL, and 61 percent exceed 43 cfu/100 mL. For *E. coli* 67 percent exceed the freshwater criteria for *E. coli* (26 cfu/100 mL) and 18 percent exceed the single sample maximum for freshwater of 406 cfu/100 mL. Particularly high bacteria concentrations have consistently been observed during small summer storm events and the first storms after the summer low flow season (Figure 3; Jackson and Glendening 1982). Concentrations observed at these times tend to be much higher than are typically observed during winter or spring storms. This pattern was attributed by Jackson and Glendening (1982) to dilution during winter and spring of a relatively constant source of fecal coliform bacteria.

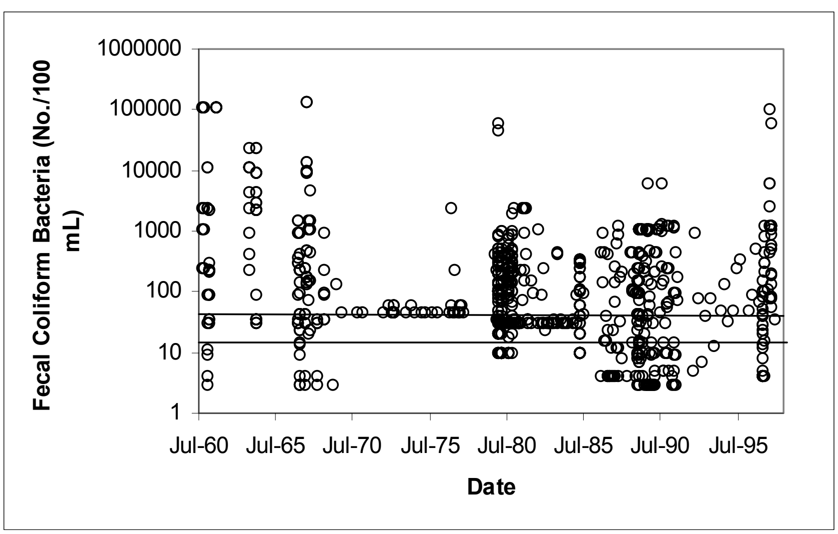

Figure 7.8. Fecal coliform bacteria measurements taken at all sites in the Wilson River basin, 1960-1998. The horizontal lines mark the screening criteria of 14 and 43 colony forming units per 100 mL. (Data from STORET)

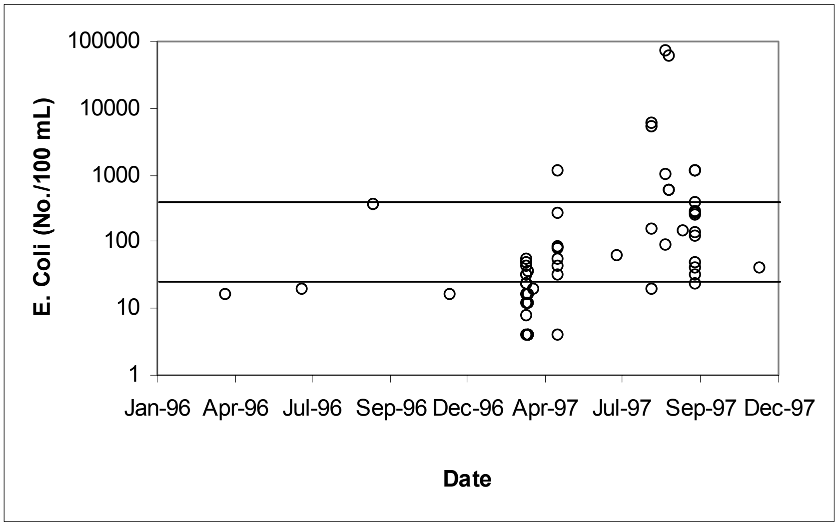

Figure 7.9. E. coli measurements taken at all sites in the Wilson River basin, 1996-1998. The horizontal lines mark the screening criteria of 26 and 406 cfu/mL. (Data from STORET)

Data on *E. coli* monitoring by the TCCA at nine Wilson River sites were provided by the TCPP as the geomean for the period October 1987 through October 1999. Values were lowest (10.4 colonies/100m) at site WR1, near the forest/agricultural interface and higher (generally 38 to 54 colonies/100 ml) in the lower portions of the watershed (sites WR4 to WR8).

The data collected by Sullivan et al. (1998) can only be used in a very limited fashion to examine whether or not the concentrations of fecal coliform bacteria have changed appreciably since the last major study of this type in 1979-1980 (Jackson and Glendening 1982). Although the available data are too limited to allow for a statistical evaluation, they are consistent with the belief that major changes in the extent of bacterial contamination of the rivers have not occurred in recent decades (Table 7.11).

Table 7.11. Comparison of fecal coliform bacteria results in the Wilson and Miami Rivers in 1979-1980 and 1996-1997.

River	Percent of samples exceeding criterion value (200 cfu/100 ml) (number of samples collected in parentheses)			
	December		October	
	1979[1]	1996-1997[2]	1980	1997
Wilson	25 (8)	22 (9)	67 (6)	100 (8)*
Miami	63 (8)	50 (10)	88 (8)	-

[1] 1979-1980 data from Jackson and Glendening (1982)
[2] 1996-1997 from Sullivan et al (1998a)

Based on the available data, water quality in the Wilson River is impaired with respect to bacteria.

7.6.6 Turbidity

Data for turbidity are presented in Figure 7.10. Only 3 of 218 measurements exceed the evaluation criterion of 50 NTU. This suggests that there is no impairment of water quality in regard to turbidity. However, it is likely that few of the samples considered in the assessment were taken during rainfall runoff events. It is probable, therefore that they do not represent the true range of values of turbidity. Additional sampling during rainfall events would be necessary to adequately evaluate water quality with regard to turbidity.

Sullivan et al. (1998b) sampled total suspended solids (TSS) in the Wilson River during 1997. Turbidity is often directly proportional to TSS. TSS concentrations were typically in the range of about 5 to 425 mg/L in the Wilson River, which had consistently higher TSS concentrations than the other rivers. Substantially higher TSS concentrations were observed during storm events than during baseflow.

There was a general relationship between TSS concentrations and flow, with greater flows resulting in increased TSS concentrations. TSS concentrations were consistently higher at RM 3.5 as compared with the forest/agriculture interface site, suggesting that the agricultural and residential portions of the watersheds do contribute sediment loads to the rivers. However, the

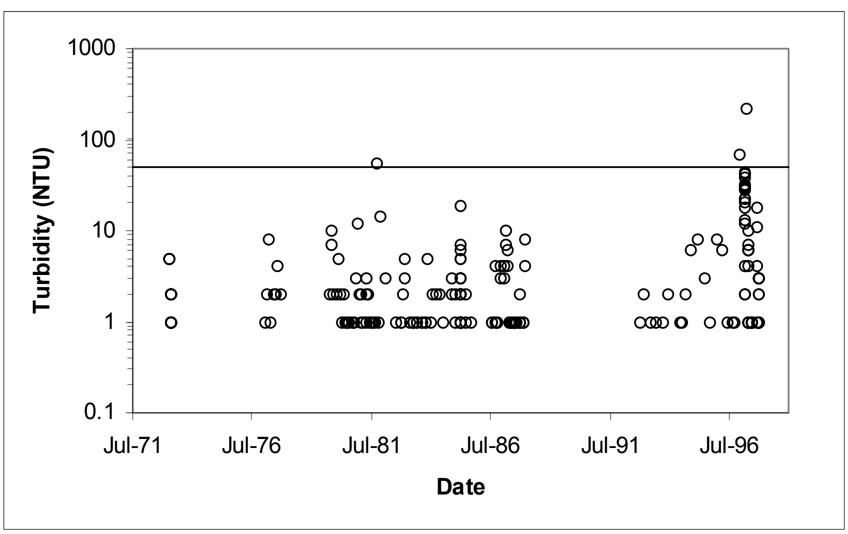

Figure 7.10. Turbidity measurements taken at all sites in the Wilson River, 1971-1998. The horizontal line marks the screening criterion of 50 NTU. (Data from STORET)

difference in measured TSS values at the paired sites was generally small, less than about 30 mg/L, even at relatively high TSS values (> 50 mg/L). This suggests that most of the TSS is derived from the forested uplands, but that some TSS is also derived from the agricultural lowlands. A more precise quantification of the relative contribution of sediment loads associated with different land uses would require calculation of storm loads at each location during several different storm events. This has been done for the lower watershed sites (Sullivan et al. 1998b), but not for the forest/agriculture interface on each of the rivers.

The available data indicate that the Wilson River is not impaired with respect to turbidity.

7.6.7 Contaminants

From 1979 to 1981 samples from two sites on the Wilson River (412130 at Highway 101, 3 samples, and 412133 at Highway 6, 8 samples) were collected and analyzed for trace metals. Of the 114 analyses, 11 had positive results greater than the detection limit and higher than the value for metals considered in our screening criteria. All of the positive results were from samples collected at RM 8.5, the Highway 6 bridge. The positive results are shown in Table 7.12. No data were available for organic contaminants.

Table 7.12. Positive results for trace metals obtained in the Wilson River at the Highway 6 bridge (412133; River Mile 8.5).

Element	Screening criterion (µg/L)	Analytical results[1] (µg/L)
Mercury (Hg)	0.12	0.6
Zinc (Zn)	32.7	12, 100
Copper (Cu)	3.6	5, 7, 10
Chromium (Cr), hexavalent	11.0	2, 5, 4
Cadmium (Cd)	0.4	2, 2

[1]Multiple results are separated by commas

These results do not indicate that the Wilson River is impaired for trace metals. There is insufficient data to determine the status for organic contaminants. This is a data gap that could be filled by further sampling and analysis.

7.7 Water Quality Conditions

At the screening level of this assessment, water quality in the major streams of the Wilson River watershed would be considered impaired because of the frequency of exceedence of the evaluation criteria for temperature, nitrogen, and bacteria. Dissolved oxygen may also be a problem in the lower reaches of the river near the mouth. There is no reason to suspect that the river suffers from impairment with respect to pH, total phosphorus concentration, turbidity, or trace metals. There is not sufficient data to make a determination with respect to organic contaminants.

Issues with regard to bacterial contamination are being addressed through implementation of a coordinated management plan. Temperature and dissolved oxygen issues can be addressed by stream and watershed restoration activities. In order to adequately address the causes of impairment with respect to nitrogen and organic contaminants, additional data should be obtained through a carefully designed water quality monitoring program.

CHAPTER 8. WATERSHED CONDITION SUMMARY

8.1 Introduction

Summarizing current conditions and data gaps within the watershed will help to identify how current and past resource management is impacting aquatic resources. Through this summarization, we have attempted to create a decision-making framework for identifying key restoration activities that will improve water quality and aquatic habitats. Following is a summary of key findings and data gaps derived from the primary components of this watershed assessment, including fisheries, fish habitat, hydrology, water use, sediment sources, and water quality.

8.2 Important Fisheries

Fisheries within the Wilson River watershed have undergone significant changes during the twentieth century. The types of fish present and their locations and abundance have been altered from historical conditions in the watershed. Arguably, the most significant activities to affect the fisheries during the last one hundred years have been habitat modifications, hatchery programs and harvest.

The National Marine Fisheries Service (NMFS) has listed as threatened, or is considering as candidates for listing, several anadromous fish species in the watershed (Table 8.1). Listing occurs for entire Evolutionarily Significant Units (ESU), defined as genetically or ecologically distinctive groups of Pacific salmon, steelhead, or sea-run cutthroat trout.

Tillamook basin coho salmon, chum salmon, steelhead trout, and sea-run cutthroat trout populations are depressed (TBNEP 1998). At least part of these species' decline can be attributed to recent changes in oceanic conditions that, since about 1975, have been less

Table 8.1. Status of anadromous fish occurring in the Wilson River watershed.

Fish	ESU	Status
Coho	Oregon Coast	Threatened
Coastal Cutthroat	Oregon Coast	Candidate
Chum	Pacific Coast	Not Warranted
Chinook	Oregon Coast	Not Warranted
Steelhead	Oregon Coast	Candidate

* An Evolutionarily Significant Unit or "ESU" is a distinctive group of Pacific salmon, steelhead, or sea-run cutthroat trout.

favorable for the survival of anadromous salmonids along the northern California, Oregon, and Washington coasts. Coho salmon have been particularly hard hit by the poor ocean conditions because they rear off the northern California and Oregon coasts and do not migrate into the more productive waters of the Gulf of Alaska. Overharvesting of coho salmon when ocean conditions were poor exacerbated the problem. Harvest management has been changed recently to adjust for the poor ocean conditions.

Hatchery fish spawning with wild fish may be causing significant problems for both coho salmon and steelhead trout in the Tillamook Basin. An observed shift in the spawning timing of naturally spawning coho salmon represents a potentially serious problem that could be contributing to the observed population decline. Although many contributors to the observed decline of anadromous fisheries are well known, the interactions among the various contributing factors are poorly understood. Information gaps for salmonids in the freshwater environment include:

- scientifically designed long-term monitoring programs to measure changes in key habitat variables through time;
- biological measures of habitat condition such as smolt production, density of juveniles per unit area of rearing habitat, and benthic macroinvertebrate abundance; and
- understanding of the amount of genetic mixing that has occurred between hatchery and wild stocks.

Information gaps for salmonids in the estuarine environment include:

- information on the quantity or quality of juvenile salmonid rearing habitat in the estuary;
- information on present use of various major estuarine habitats by juvenile salmonids; and
- long-term monitoring designed to evaluate effects of changes in watershed inputs of sediment, plant nutrients, large woody debris, and toxic substances on estuarine habitat conditions and estuarine biological communities.

The TBNEP (1998) found that very little of the existing information on fisheries populations was developed from statistically designed sampling programs. Inferences regarding population status were often based on potentially biased data. This can be a serious problem, particularly if management decisions such as harvest quotas are based on what may be inaccurate information. It is critical, therefore, that scientifically designed sampling schemes be built into any short-term or long-term sampling program used for the management of the valued resources of the Tillamook Basin.

In addition, reliable long-term monitoring data were not available for all of the valued resources. Without long-term data sets, it is impossible to evaluate trends through time or to separate out effects of natural phenomena from human-induced changes.

Finally, there have been no comprehensive studies relating the condition of the watershed to conditions in the estuary, especially with respect to important impacts on valued resources. We know that many of the changes that have taken place in the estuarine environment are caused by or related closely to disturbances in the watershed that have altered flow, sediment input rates, and water quality. Monitoring and research directed at linking conditions in the watershed to conditions in the estuary are lacking.

8.3 Hydrology and Water Use

8.3.1 Hydrology

Human activities in a watershed can alter the natural hydrologic cycle, potentially causing changes in water quality and aquatic habitats. These types of changes in the landscape can increase or decrease the volume, size, and timing of runoff events and affect low flows by changing groundwater recharge. Some examples of human activities that can impact watershed hydrology are timber harvesting, urbanization, conversion of forested land to agriculture, and construction of road networks. The focus of the hydrologic analysis component of this assessment was to evaluate the potential impacts from land and water use on the hydrology of this watershed (WPN 1999). It is important to note, however, that this assessment only provides a screen for potential hydrologic impacts based on current land use activities in the watershed. Identifying those activities that are actually affecting the hydrology of the watershed would require a more in-depth analysis and is beyond the scope of this assessment.

Screening for land management activities that may be affecting natural hydrologic conditions suggests that roads have little effect on current hydrologic regimes with regard to peak flows, but other hydrologic impacts may have occurred in response to the Tillamook Burns and/or agricultural practices (especially diking and draining of wetlands) in the valley bottoms. Loss of historical flood plain acreage and land cover (such as wetlands, forested valley bottoms) have likely had significant impacts on hydrologic conditions in the Wilson River watershed. Existing flood control features used to protect floodplain land uses have simplified natural streamflow processes in many places and reduced the complexity of in-stream habitats that support fish and aquatic organisms.

The documented sensitivity of valley flooding to upstream watershed conditions indicates the need for a strong management focus on restoring natural watershed functions. Future flood management efforts in the valley floodplains may be obfuscated by the failure to adequately address upland watershed impacts that influence the flow rate and volume of flood waters. However, altered upland processes can be difficult to restore, especially where they are part of a significant disturbance regime such as the Tillamook Burns. There is a clear need for floodplain and wetland restoration to improve flood attenuation and storage.

8.3.2 Water Use

Water is withdrawn from both surface and subsurface water supplies within almost all of the watersheds in Oregon. Much of this water is withdrawn for beneficial uses, such as irrigation, municipal water supply, and stock watering. When water is removed from these stores, a certain percentage is lost through processes such as evapotranspiration. Water that is "consumed " through these processes does not return to the stream or aquifer, resulting in reduced in-stream flows, which can adversely affect aquatic communities that are dependent upon this water. In fact, the dewatering of streams has often been cited as one of the major reasons for salmonid declines in the state of Oregon.

The largest amount of water appropriated in the Wilson River watershed is for irrigation. Most of this water is appropriated in the lower elevations of the watershed and is most likely used for maintaining dairy pastures. Due to rural residential development on the outskirts of the city, there is a also small amount of water appropriated from the Wilson River for domestic water use (3.74 cfs). During very dry seasons, domestic water use combined with irrigation withdrawals in the lower elevations of the watershed may have deleterious effects on in-stream habitats by reducing in-stream flows. However, appropriated water represents only 12% of modeled in-stream flows (based on a 50% exceedance) suggesting that the impacts are most likely small on average and only occur during dry periods.

Water availability was assessed by ranking subwatersheds according to their dewatering potential. All subwatersheds were judged to have low dewatering potential (Table 8.2), which is defined as the potential for large proportions of in-stream flows to be lost from the stream channel through consumptive use.

Table 8.2. Dewatering potential and associated beneficial uses of water in the Wilson River watershed.

Subwatershed	Fish Use	Average Percent withdrawn	Dominant Water Use	Dewatering Potential
Cedar Creek/Upper Wilson R.	C,WS,SS,FC,SC	0.0	--	Low
Devils Lake Fork Wilson R.	C,WS,SS,FC,SC	0.0	--	Low
Elk Creek/Lower Devils Lake Fork	C,WS,SS,FC,SC	0.0	--	Low
Hall Slough	C,WS,SS,FC,SC	--	--	Low
Jordan Creek	C,WS,SS,FC,SC	0.0	--	Low
Little N. Fork Wilson R.	C,WS,SS,FC,CH	0.0	--	Low
Lower Wilson R.	C,WS,SS,FC,SC,CH	1.1	Irrigation	Low
Middle Wilson R.	C,WS,SS,FC,SC	0.2	Fish	Low
North Fork Wilson R.	C,WS,SS,FC	0.1	Domestic	Low
South Fork Wilson R.	C,WS,SS,FC,SC	0.1	Fish	Low

[1] C=coho, FC=fall chinook, WS=winter steelhead
[2] Average of low flow months (June, July, August, September, October).
[3] Greater than 30% is high, 10 to 30% is moderate, and less than 10% is low.

Based on current water availability model outputs, there appears to be little concern for dewatering in the Wilson River watershed during average or above flows. None of the subwatersheds demonstrated water loss greater than 2% of the predicted in-stream flows. Consequently, it is unlikely that water withdrawals from the Wilson River and its tributaries are having a large impact on current average in-stream flows. However, any time water is appropriated for out-of-stream use, there is a potential for some effects on the in-stream habitats to occur during periods of low flow.

During the low flow months (July through October), mean daily discharge was below the in-stream water right almost 50% of the time, with the highest percentage of occurrences in August through October. Assuming that the in-stream water right is a good indicator of habitat conditions for salmonids, there is a potential for low flow conditions to have a deleterious effect on local salmonid populations. Consequently, any out-of-stream water use during these low flow situations will only exacerbate habitat problems. In-stream flow requirements for salmonids need to be further evaluated to determine actual impacts of surface water withdrawals on salmonid populations. It is our recommendation that in-stream water rights continue to be protected and in-stream flows monitored during low flow conditions.

8.4 Aquatic Habitats

Distribution and abundance of salmonids within a given watershed varies with habitat condition, such as substrate and pool frequency as well as biological factors such as food distribution (i.e. insects and algae). In addition, salmonids have complex life histories and use different areas of the watershed during different parts of their life cycle. For example, salmonids need gravel substrates for spawning but may move to different stream segments during rearing. The interactions of these factors in space and time make it difficult to determine specific factors affecting salmonid populations. Consequently, entire watersheds, not just individual components, must be managed to maintain fish habitats (Garono and Brophy 1999).

The Endangered Species Act requires that forests providing habitat for endangered species must be protected (Tuchmann et al. 1996). An understanding of the land patterns associated with the distribution of threatened and endangered species can lead to a better understanding of how to conserve these species. The OWEB process focuses primarily on salmonid habitat in the watershed. It is assumed, however, that other species will also benefit.

For some salmonid species such as coho salmon, which require specific overwinter rearing and refuge habitat, habitat conditions may be degraded. For other species, such as the fall chinook salmon, which spawn and rear in main stem and larger tributary habitat and do not spend long periods of time in the freshwater environment, habitat conditions appear to be satisfactory**.** One of the biggest habitat-related problems in the watershed is the general lack of LWD in the small- to medium-size tributary streams. The generally poor ratings for LWD recruitment from riparian areas indicate that recovery of habitat complexity in many areas will be a long process due to the lag time required to reestablish conifer communities in the riparian zone. Better management practices have eliminated a number of the man-caused disturbances that have contributed to the present condition of the freshwater habitat. A watershed approach to stream habitat restoration is needed to ensure continued recovery.

Other major problems identified were the general lack of channel complexity and off-channel habitat. Excessive fine sediment in the spawning gravel was identified as a persistent problem in many of the stream reaches surveyed.

To summarize, resource problems for anadromous salmonids include:

- general lack of LWD (and low LWD recruitment potential) and associated channel complexity;

- lack of off-channel habitat for winter refuge and rearing of coho salmon and cutthroat trout; and
- persistent sources of sediment loading.

8.4.1 Fish Passage

Culverts can pose several types of fish passage problems, including excessive height above the water, excessive water velocity, insufficient water depth in culvert, disorienting flow patterns, and lack of resting pools between culverts. In some cases, culverts limit fish passage during only certain parts of the species' life cycle. For example, a culvert may be passable to larger adult anadromous fish and not juveniles. Culverts may also act as passage barriers only during particular environmental conditions such as high flow or low flow events. Because of these variable effects, it is important to understand the interactions between habitat conditions and life stage for anadromous fish.

About one fourth of the culverts in the Wilson River watershed that have been surveyed were judged to pose fish passage barriers. These were most commonly found in the Lower Wilson River and Hall Slough subwatersheds (Table 8.3).

Table 8.3. Fish passage conditions in the Wilson River watershed based on ODFW data.

Subwatershed	Stream Length (mi)	Salmonid Use*	Miles Salmonid Use	# Surveyed	# Known Impassable Culverts	# Road/ Stream Crossings
Cedar Creek / Upper Wilson R.	38	C,WS,SS,FC,SC	14.3	42.0	4	38
Devils Lake Fork Wilson R.	31	C,WS,SS,FC,SC	8.5	14.0	0	44
Elk Creek / Lower Devils Lake Fork	45	C,WS,SS,FC,SC	10.7	22.0	0	41
Hall Slough	6		0	25	13	8
Jordan Creek	48	C,WS,SS,FC,SC	10.9	0.0	0	53
Little N. Fork Wilson R.	42	C,WS,SS,FC,CH	7.4	0.0	0	11
Lower Wilson River	71	C,WS,SS,FC,SC,CH	20.8	65.0	30	110
Middle Wilson River	40	C,WS,SS,FC,SC	12.5	43.0	4	46
North Fork of the Wilson River	49	C,WS,SS,FC	12.3	0.0	0	27
South Fork of the Wilson River	35	C,WS,SS,FC,SC	6.8	0.0	0	58
Total	405	C,WS,SS,FC,SC,CH	104	211	51	436

* C=coho, FC=fall chinook, WS=winter steelhead, SS=summer steelhead, SC=spring chinook, CH=chum

8.4.2 Fish Habitats

Understanding the spatial and temporal distribution of key aquatic habitat components is the first step in learning to maintain conditions suitable to sustain salmonid populations. These components must then be linked to larger scale watershed processes that may control them. For example, a stream that lacks sufficient LWD often has poor LWD recruitment potential in the riparian areas of that stream. By identifying this linkage, riparian areas can be managed to include more conifers to increase LWD recruitment potential. Also, high stream temperatures can often be linked to lack of shade as a result of poorly vegetated riparian areas. By linking actual conditions to current watershed-level processes, land mangers can better understand how to manage the resources to maintain these key aquatic habitat components.

Moore et al. (1995) suggested that Tillamook Basin habitat conditions, at least for coho salmon, may be at a low point. They contended that recovery will be a slow process because key elements for recovery, such as development of conifer communities in riparian zones, are only getting started. A number of positive management actions taken over the years are likely to improve anadromous fish habitat in the watershed over the long term. Some of the most important positive actions to date are listed below.

- Reforestation of the historic burned and logged areas of the watershed began in 1949 and was completed in 1970. This management measure is acknowledged as successfully improving hydrologic response in the burned areas and has significantly reduced soil loss from these areas (OWRD and USDA-SCS 1978)

- Unregulated timber harvest in the riparian zone of fish bearing streams ended in 1972 when the 1971 Oregon Forest Practices Act took effect. Forest practice rules have been modified over the years since that time to provide greater protection to streams and their riparian zones. It is anticipated that they will continue to be modified and improved in the future.

- Tillamook Basin has been identified as a priority area for implementation of the Oregon Plan, which succeeds the Governor's Coastal Salmon Restoration Initiative, developed in 1996.

<u>Stream Morphology</u>

Pools are important features for salmonids, providing refugia and feeding areas. Substrate is also an important channel feature since salmonids use gravel beds for spawning. Gravel beds can be buried by heavy sedimentation, resulting in loss of spawning areas as well as reduced invertebrate habitat quality. For streams that were surveyed, stream morphology and substrate were compared with ODFW benchmarks to evaluate current habitat conditions (Table 8.4).

Table 8.4 Stream morphologic conditions in the Wilson River watershed. Data were collected by ODFW (1990-1995).

Subwatershed	Stream Miles	Fish Use[1]	Miles Surveyed [2]	Pool Frequency[2]	Percent Pools[2]	Residual Pool Depth[2]	Gravel[2]
Cedar Creek / Upper Wilson R.	38	C,WS,SS,FC, SC	4.6 (6)	Moderate (4)	Moderate (5)	Good (3)	Moderate (6)
Devils Lake Fork Wilson R.	31	C,WS,SS,FC, SC	7.8 (12)	Moderate (6)	Good (5)	Moderate (10)	Moderate (11)
Elk Creek / Lower Devils Lake Fork	45	C,WS,SS,FC, SC	17.3 (9)	Moderate (4)	Moderate (3)	Good (5)	Moderate (4)
Hall Slough	6		0.0				
Jordan Creek	48	C,WS,SS,FC, SC	12.8 (10)	Moderate (8)	Moderate (9)	Good (9)	Moderate (7)
Little N. Fork Wilson R.	42	C,WS,SS,FC, CH	15.5	Moderate (6)	Moderate (5)	Good (8)	Moderate (5)
Lower Wilson River	71	C,WS,SS,FC, SC,CH	1.3 (2)	Moderate (2)	Moderate (2)	Moderate (2)	Poor (2)
Middle Wilson River	40	C,WS,SS,FC, SC	2.9 (3)	Moderate (2)	Poor (3)	Moderate (2)	Good (2)
North Fork of the Wilson River	49	C,WS,SS,FC	5.8	Moderate (3)	Moderate (3)	Good (3)	Moderate (2)
South Fork of the Wilson River	35	C,WS,SS,FC, SC	10.6(12)	Moderate (7)	Moderate (6)	Moderate (6)	Moderate (6)

1 C=coho, FC=fall chinook, WS=winter steelhead, SS=summer steelhead, SC=spring chinook, CH=chum
2 Subwatersheds were assigned categories (good, moderate, poor) based on the most prevalent category among all reaches surveyed in that subwatershed. The categories were based on how the data compared to ODFW habitat benchmarks. Number in parentheses is the number of reaches in that category.

Large Woody Debris

Large woody debris is an important feature that adds to the complexity of the stream channel. LWD in the stream provides cover, produces and maintains pool habitat, creates surface turbulence, and retains small woody debris. Functionally, LWD dissipates stream energy, retains gravel and sediments, increases stream sinuosity and length, slows the nutrient cycling process, and provides diverse habitat for aquatic organisms (Bischoff et al. 2000, BLM 1996). In-stream LWD conditions and LWD recruitment potential were generally poor to moderate (Table 8.5). Some subwatersheds showed better conditions, however, especially the South Fork of the Wilson River.

Table 8.5 Riparian and in-stream LWD conditions in the Wilson River watershed.

Subwatershed	Str Length (mi)	Salmonid Use	Miles Surveyed [2]	Riparian Recruitment	Riparian Shade	In-stream LWD Pieces	In-stream LWD Volume	In-stream LWD Key Pieces
Cedar Creek / Upper Wilson R.	38	C,WS,SS,FC,SC	4.6 (6)	Low	High	Moderate (3)	Poor (3)	Poor (5)
Devils Lake Fork Wilson R.	31	C,WS,SS,FC,SC	7.8 (12)	Moderate	High	Poor (6)	Good (7)	Poor (8)
Elk Creek / Lower Devils Lake Fork	45	C,WS,SS,FC,SC	17.3 (9)	Moderate	High	Moderate (1)	Moderate (1)	Poor (6)
Hall Slough	6		0.0	Low	Moderate			
Jordan Creek	48	C,WS,SS,FC,SC	12.8 (10)	Low	High	Poor (11)	Poor (11)	Poor (13)
Little N. Fork Wilson R.	42	C,WS,SS,FC,CH	15.5	Low	High	Moderate (4)	Good (6)	Moderate (6)
Lower Wilson River	71	C,WS,SS,FC,SC,CH	1.3 (2)	Low	High	Poor (1)	Poor (1)	Poor (2)
Middle Wilson River	40	C,WS,SS,FC,SC	2.9 (3)	Low	High	Poor (3)	Poor (3)	Poor (3)
North Fork of the Wilson River	49	C,WS,SS,FC	5.8	Low	High	Good (2)	Good (2)	Poor (3)
South Fork of the Wilson River	35	C,WS,SS,FC,SC	10.6(12)	Moderate	High	Good (6)	Good (8)	Good (7)

[1] C=coho, FC=fall chinook, WS=winter steelhead, SS=summer steelhead, SC=spring chinook, CH=chum
[2] From aerial photo interpretation conducted by E&S Environmental Chemistry, Inc.
[3] Subwatersheds were assigned categories (good, moderate, poor) based on the most prevalent category among all reaches surveyed in that subwatershed. The categories were based on how the data compared to ODFW habitat benchmarks. Number in parentheses is the number of reaches in that category.

Wetlands

Wetlands contribute critical functions to watershed health, such as water quality improvement, flood attenuation, groundwater recharge and discharge, and fish and wildlife habitat (Mitsch and Gosselink 1993). Because of the importance of these functions, wetlands are regulated by both State and Federal agencies. Additionally, wetlands play an important role in the life cycles of salmonids (Lebovitz 1992). Estuarine wetlands provide holding and feeding areas for salmon smolts migrating out to the ocean. These estuarine wetlands also provide an acclimation area for smolts while they are adapting to the marine environment. Riparian wetlands can reduce sediment loads by slowing down flood water, allowing sediments to fall out of the water column and accumulate. Wetlands provide cover and food in the form of a diverse aquatic invertebrate community. Backwater riparian wetlands also provide cover during high flow events, preventing juvenile salmon from being washed downstream. Wetlands need to be prioritized for restoration.

Estuarine wetlands were once common in the Tillamook Bay (Boulé and Bierly 1987). Many of these wetlands have been diked, disconnecting them from saltwater influences and changing the structure of the wetland. All existing estuarine wetlands currently accessible to salmonids should be protected or restored. Those estuarine wetlands disconnected by dikes should be evaluated for potential reconnection and restoration.

Palustrine wetlands are a dominant feature in the Wilson River watershed. Stream side wetlands should be protected, especially those that are within the current salmonid distribution. Streamside wetlands that have been disconnected due to diking or ditching should be evaluated for restoration opportunities. Other wetlands should be protected for their roles in maintaining water quality, flood attenuation, and habitat.

8.5 Sediment Sources

Sediment in the rivers and streams of the Wilson River watershed has been an issue of great concern for many decades. The combination of the wet climate, steep slopes in the uplands, and very erosive soils results in naturally high levels of sediment in the rivers and streams. The historic wildfires in the watershed, as well as resource management practices over the past century are associated with an additional increase in sediment levels. High levels of sediment in the streams have been associated with increased rates of sedimentation in Tillamook Bay. Additionally, high sediment levels are associated with the declining health of salmonid populations. While naturally occurring sources of sediment in the watershed may be uncontrollable (and perhaps to some degree beneficial), the additional sediment contributed by human activity may be preventable.

In this watershed, slope instability, road instability, and rural road runoff were determined to be the most significant sediment sources. Shallow landslides and deep-seated slumps are known to be common in the Oregon Coast Range. Streamside landslides and slumps can be major contributors of sediment to streams, and shallow landslides frequently initiate debris flows. Rural roads are a common feature of this watershed, and many are present on steep slopes. Washouts from rural roads contribute sediment to streams, and sometimes initiate debris flows. The density of rural roads, especially unpaved gravel and dirt roads, indicates a high potential for sediment contribution to the stream network.

Agricultural and pasture land runoff, as well as the history of fire in the Tillamook region are also contributing factors. However, agricultural and pastoral lands occupy only about 2% of this watershed, and are mostly located at the lower elevations of the watershed. Urban runoff is not a major contributor of sediment in this watershed. Developed lands occupy less than 1% of the Wilson River watershed.

Lastly, streambank erosion is a concern in the Wilson River watershed. While the overall contribution of sediment from streambank erosion is less significant that other sources, erosion from the streambank is associated with a lack of riparian shade. Restoration of riparian vegetation and prevention of livestock grazing near streambanks will lessen sediment contribution from streambank erosion.

8.6 Water Quality

Water quality is controlled by the interaction of natural and human processes in the watershed. Processes that occur on the hillslope can ultimately control in-stream water quality. Pollutants are mobilized through surface and subsurface runoff and can cause degradation of stream water quality for both human use and fish habitat. Consequently, many water quality parameters are highly episodic in nature and often associated with certain land use practices. The water quality assessment is based on a process that identifies the beneficial use of water, identifies the criteria that protect these benefits, and evaluates the current water quality conditions using these criteria as a rule set (WPN 1999).

The Wilson River mainstem is temperature limited throughout its entire length. In summer months, the Wilson mainstem reaches temperatures greater than 20.3ºC (68.5ºF) and sometimes exceeds 24.0ºC (75.2ºF) in the lower reaches. These data suggest that the Wilson River is impaired for temperature relative to salmonid rearing and growth.

Of the 398 available dissolved oxygen measurements, 27 (7%) were below 8.0 mg/L, and 175 (44%) were below 11.0 mg/L. These data suggest that at least portions of the Wilson River are moderately impaired with respect to dissolved oxygen to support salmonid spawning and incubation.

Available monitoring data suggest that nitrate concentrations have increased in the Wilson River since the 1960s. The cause of such an increase in nitrate cannot be determined from the available data. It is possible that nitrogen fixation in large alder stands in the Wilson River watershed may be contributing to higher nitrate concentration in the river. The available data suggest, however, that the Wilson River water quality may be impaired with respect to nitrogen.

Large changes in both loads and concentrations of fecal coliform bacteria are associated with storm events, especially during the fall season. Based on the available data, water quality in the Wilson River appears to be impaired with respect to bacteria. It has been suggested that prior moisture conditions and amount and intensity of rainfall play important roles in controlling the flux of fecal coliform bacteria into surface waters (Dorsey-Kramer 1995; Jackson and Glendening 1982). Particularly high concentrations have consistently been observed during small summer storm events and the first storms after the summer low flow season.

At the screening level of this assessment, water quality in the major streams of the Wilson River watershed would be considered impaired because of the frequency of exceedence of the evaluation criteria for temperature, nitrogen, and bacteria. Dissolved oxygen may also be a problem in the lower reaches of the river near the mouth. There is no reason to suspect that the river suffers from impairment with respect to pH, total phosphorus concentration, turbidity, or trace metals. There is not sufficient data to make a determination with respect to organic contaminants.

CHAPTER 9. RECOMMENDATIONS

General

- Prioritize restoration and watershed management activities based on information in this assessment and any other assessment work conducted in the watershed. One example is the in-stream habitat restoration guide developed by ODFW (ODFW 1997). Prioritize areas with known salmonid use for both spawning and rearing. Focus in-stream restoration work on areas with sufficient water quality for salmonids (low temperature, low turbidity) and areas with good stream channel characteristics (responsive channel habitat type, good geomorphologic conditions, good riparian shade and recruitment potential).

- Maintain relationships and contacts among the watershed council, Tillamook County Performance Partnership, Oregon Department of Forestry, the city of Tillamook, and private timber owners to keep up-to-date on data collection, further assessment, and restoration activities in the watershed. Update assessment data sets accordingly.

- Develop an understanding of the Forest Practices Act. This will provide a better understanding of regulations and mitigation actions necessary for timber harvest.

Data

- Use a standardized base map. As a part of this assessment, a series of 1:24,000 base map layers were developed. We recommend that these layers be used as a base map and additional data be maintained at a scale of 1:24,000 or larger (i.e. 1:12,000). All of these layers will relate directly to the USGS 7.5 minute quadrangles which can be used to develop additional data layers and find locations in the field.

- Georeference all field data at a scale of 1:24,000 or better. This can be accomplished by using GPS to record latitude and longitude or by marking the location on the USGS quadrangle maps.

- Maintain data in an accessible location and format. The Tillamook County Watershed Resource Center office would be the best place for this. Most data should be maintained in a GIS format and updated annually. Some coverages will be updated periodically by the agency that created the coverage (i.e. salmonid distribution data from ODFW). These data sets should be kept current in the database.

- Collect additional data in priority areas. The decision-making framework provided with this document allows the user to select strategic locations for data collection based on features such as channel habitat type, known salmonid distribution, and water quality conditions.

- Get expert advice on data collection and processing. Consult with the Technical Advisory Committee, federal and state agencies, and consultants to develop appropriate sampling collection, quality control, and data analysis protocols.

- Evaluate the GIS data layers. Several of the data sets used to develop this assessment need to be evaluated and compared to on-the-ground conditions before restoration actions are taken or final conclusions are made about ecosystem processes. Layers that need further evaluation or updating include:

  <u>Land Use and Wetlands</u>
  The land use was refined from a land use coverages provided by the TBNEP, zoning, National Wetlands Inventory (NWI), and ownership. NWI data were not available digitally for the entire area and so were used only in the areas of digital coverage. As NWI data become more readily available in digital format, the land use coverage should be updated. All land use categories should be field verified before restoration actions occur.

  <u>Roads</u>
  The roads coverage is a key coverage used to evaluate potential sediment sources and changes in watershed hydrology associated with road construction. However, the roads coverage may not accurately represent on-the-ground conditions in this watershed.

  <u>Channel Habitat Types</u>
  Channel habitat types were determined using GIS. Limited field verification of these data suggest that the data accurately represent actual on-the-ground conditions (through visual comparison). However, the channel habitat type should be further verified in the field before any restoration actions occur.

  <u>Riparian Vegetation and Shade</u>
  Riparian conditions need to be further evaluated before restoration actions occur. A visual comparison of field checks to the aerial photo interpretations found the data to be fairly consistent. After site selection using the GIS data, the stream reach identified should be field checked for actual on-the-ground conditions.

- Refine the land use layer. Continue to develop the land use layer to reflect changes in land use. Update the layer with digital NWI data as they become available.

Fisheries

- Develop and update a fish limits coverage, in cooperation with on-going activities by ODF.

- Efforts to inventory anadromous salmonid habitat throughout the watershed should continue.

- Work with ODFW to identify viable populations and distributions of sensitive species, particularly salmonids. These data are critical in developing watershed enhancement strategies.

- Identify and survey areas currently used by salmonids. Collect stream survey data according to ODFW protocols. These data will help identify habitat limitations and areas that may provide good habitat but are currently blocked by a barrier.

Aquatic Habitats

- Field verify the channel habitat type GIS data layer. Some data have already been collected and visually compared to the layers.

- Field verify the riparian GIS data layers. Some data have already been collected and visually compared to the layers.

- Areas of good habitat should be identified and protected. This should include an analysis of the watershed upstream from the good habitat to locate potential problems that could result in future degradation to the habitat.

- Where feasible, habitat should be improved through the creation of off-channel winter habitat and introduction of LWD. Efforts should focus first on locations where the target fish species are known to be present.

- Long-term monitoring in the watershed is needed to evaluate changes in habitat and system productivity for juvenile salmonids through time. One approach might be to select representative reaches in upper, mid, and lower sections of the major subwatersheds as monitoring sites. Parameters to monitor would need to be carefully selected to provide the most information with the least expenditure of time and money (TBNEP 1998).

- In the estuary, information is needed on the relative importance of major habitat types to the various anadromous salmonid species. This could be accomplished through focused sampling of specific habitat types when the various salmonid species are present (TBNEP 1998).

- Integrated long-term monitoring should be designed to provide the input needed to test hypotheses regarding the effects of changes in estuarine conditions on juvenile salmonid rearing habitat in the estuary (TBNEP 1998).

- Development of quantitative or semi-quantitative measures of estuarine habitat quality — similar to those used in the freshwater environment to classify stream habitat — would help us monitor long-term trends in habitat quality (TBNEP 1998).

- Eelgrass bed monitoring should continue, due to the importance of eelgrass as fish and wildlife habitat (TBNEP 1998).

- Prioritize stream reaches for restoration of riparian vegetation. Start in areas currently used by salmonids and lacking in LWD recruitment potential, good shade conditions, or in-stream LWD.

- Restore deep water pools.

- Plant riparian conifers and native species in areas lacking LWD recruitment potential. Start in areas of known salmonid use, and use the riparian vegetation map provided with this assessment and ODFW stream surveys to identify candidate reaches. Before any reaches are targeted for planting, they should be field verified for suitability and actual conditions. Vegetation planting should use only native species and mimic comparable undisturbed sites.

- Develop a riparian fencing strategy to maintain riparian vegetation.

- Complete a culvert survey of all culverts that have not been evaluated for fish passage. Data should be maintained in a GIS. The road/stream crossing coverage is a good place to start. The culvert survey should begin in priority subwatersheds at the mouth of each of the streams. Establish priorities for culvert replacement.

- Replace priority culverts identified in the culvert survey.

- Install fish passages at known fish passage barriers that are caused by human influences.

- Prioritize estuarine wetlands for restoration, creation, or maintenance based on their value to salmonids. Landowners with priority wetlands can then be contacted for possible wetland restoration.

- Prioritize for restoration, creation, or maintenance, palustrine wetlands that are connected to streams and provide back water rearing areas for salmonids. Start in areas with known salmonid rearing and spawning habitat.

- Create, restore, and maintain palustrine wetlands based on their prioritization.

- Establish acceptable criteria for floodplain restoration in conjunction with the Tillamook County Performance Partnership.

- Develop a comprehensive flood management plan.

- Identify and protect high-quality floodplain vegetative communities.

- Restore floodplain vegetation in priority lowland restoration areas.

- Evaluate the risks and benefits of removing and/or relocating existing dikes and setback levees to increase floodplain infiltration and improve wetland habitat connectedness (TBNEP 1998).

- Perform a feasibility study to identify opportunities for floodplain restoration. Evaluate findings from the TBNEP demonstration grant project assessing the feasibility of restoring estuarine wetlands by breaching dikes. Explore opportunities for floodplain restoration for flood hazard reduction in non-tidal portions of the river valleys (TBNEP 1998).

- Educate the public about the historic function of the rivers and their floodplains. Most people are not aware of the "way things were" before settlement in the Tillamook Bay river valleys. If the public understood the reasons why the floodplains are so fertile and how floods used to shape the landscape, floodplain management measures, such as relocation and restoration, might become more acceptable (TBNEP 1998).

Hydrology and Water Use

- Update and refine the roads layer. Keep in contact with ODF and other groups (private land owners) as the roads layer is updated to evaluate its accuracy.

- Develop an outreach program to encourage water conservation. Educate the public about dewatering effects and how water conservation will help salmonids in the watersheds.

- Identify water rights that are not currently in use and that may be available for in-stream water rights through leasing or conversion.

Sediment

- Identify roads that have not been surveyed for current conditions and fill these data gaps. Work with ODF to develop road survey methodologies.

- Map road failures in areas where data are lacking. Coordinate with watershed stakeholders that are currently collecting road data such as ODF and private timber companies. Develop a strategy to fill in the data gaps.

- Map culvert locations and conditions in conjunction with the culvert survey conducted for fish passage barriers. Check with ODF, ODFW, and local foresters for the best methodologies and data to collect.

- Map all debris flows and landslides. Begin in the areas most susceptible to landslide activity.

- Where possible, conduct road restoration activities such as road reconstruction, decommissioning, and obliteration.

- Replace undersized culverts that are at risk of washing out. Prioritize these culverts from the culvert surveys.

- Monitor sediment recruitment, for example using gravel traps.

Water Quality

- Continue on-going water quality monitoring efforts at Sollie Smith Bridge for fecal coliform bacteria, total suspended solids, and nutrients.

- Develop a systematic water quality monitoring program for areas with high priority for restoration activity. Focus the water quality monitoring on constituents that are important for the specific area being restored. Use the water quality data to refine the restoration plans.

- Develop or expand the continuous temperature monitoring network with monitors at strategically located points such as the mouths of tributary streams, locations of known spawning beds, at the interface between major land use types, or downstream of activities with the potential to influence water temperature.

- Include a plan for long-term monitoring in any restoration plan to measure the effects of the restoration activity.

- Begin to develop the capacity within the watershed council to conduct high quality, long term water quality monitoring to document the success of restoration activities.

- Locate and map potential sources of nitrogen, phosphorus, and bacteria in the watershed. An effort to identify source areas for bacteria in the lower watershed is on-going.

- Conduct all water quality monitoring activities according to established guidelines such as those published by the Oregon Plan for Salmon and Watersheds (OPSW 1999), or EPA (1997, 1993).

- Cooperate with DEQ and other agencies to share data and expertise. Coordinate the council's monitoring activities with those of the agencies, including DEQ's efforts to develop Total Maximum Daily Loads for water quality limited stream segments.

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