8 Water Quality

8.1 Introduction

The 2001 Wilson River Watershed Assessment (E&S Environmental Chemistry 2001) provided an extensive analysis of water quality conditions in the Wilson River watershed. The purpose of this current effort is to briefly summarize the findings of the 2001 assessment to answer the OWEB critical questions, updating the existing information as appropriate with new data available from the intervening five years.

The primary focus of the current effort is to evaluate current and likely historic stream shading conditions along the principal streams within the Wilson River watershed, and to assess water temperatures within the forested portion of the basin. The effects of dispersed recreation upon water quality are discussed in the Recreation portion of this assessment.

8.2 Water Quality Criteria, Limited Sections, and Status

The conclusions of the 2001 Wilson River Watershed Assessment (E&S Environmental Chemistry 2001) were that, based on the frequency of exceedance of the evaluation criteria, water quality in the major streams of the Wilson River watershed would be considered impaired for temperature, nitrogen, bacteria, and (in the lower reaches of the river near the mouth) dissolved oxygen. The authors concluded that there was no reason to suspect impairment with respect to pH, total phosphorus concentration, turbidity, or trace metals; and that there was insufficient data to make a determination with respect to organic contaminants.

The federal Clean Water Act (CWA) requires that states maintain a list of water bodies that are "water quality limited," i.e., do not meet water quality standards. The listing of water quality limited streams is referred to as the "303(d) list." In Oregon, the Department of Environmental Quality (ODEQ) is responsible for maintaining the state's 303(d) list. The ODEQ periodically revises the 303(d) list.

Temperature and bacterial contamination issues have been addressed as part of the Tillamook Bay Watershed Total Maximum Daily Load (TMDL), completed by the Oregon Department of Environmental Quality (ODEQ 2001). Consequently, the stream segments identified on the 1998 303(d) list for temperature (the Wilson River mainstem from the mouth to the confluence with the South Fork), and bacteria (the Wilson River mainstem from the mouth to the confluence with Little North Fork) have been removed from the 303(d) list.

The 2002 303(d) list included the Wilson River from river mile 3.5 to 10.1 (Highway 101 to the confluence with Little North Fork) as water quality limited

for Dissolved Oxygen, for the September 15 - May 31 period, impacting salmonid fish spawning.

The latest iteration of the 303(d) list was prepared as part of ODEQ's 2004/2006 Integrated Report, which was approved by the U.S. Environmental Protection Agency (EPA) Region 10 office on February 26, 2007. Currently the Wilson River, RM 5.8 to 27.2 (approximately 4 miles downstream of the confluence with Little North Fork to Lee's Camp), is listed as water quality limited for dissolved oxygen for the period September 1 - June 15 (Table 55).

Table 55. Current 303(d) list status of streams within the Wilson River watershed. All records are for Dissolved Oxygen; all were added in 2004.

Location	Season	Criteria	Beneficial Uses	Status	Supporting Data
Wilson River, RM 0 to 3.5	Year Around	Estuarine: Not less than 6.5 mg/l	Estuarine water	Attaining some criteria/uses	ODEQ/ODA LASAR[71] database
Wilson River, RM 0 to 5.8	Year Around (Non-spawning)	Cold water: Not less than 8.0 mg/l or 90% of saturation	Cold-water aquatic life	Insufficient data	ODEQ/ODA LASAR database
Wilson River, RM 3.2 to 5.8	October 15 - May 15	Spawning: Not less than 11.0 mg/L or 95% of saturation	Salmon and steelhead spawning	Insufficient data	ODEQ/ODA LASAR database
Wilson River, RM 5.8 to 27.2	September 1 - June 15	Spawning: Not less than 11.0 mg/L or 95% of saturation	Salmon and steelhead spawning	Water quality limited, 303(d) list, TMDL needed	ODEQ/ODA LASAR database
Wilson River, RM 5.8 to 34.5	Year Around (Non-spawning)	Cold water: Not less than 8.0 mg/l or 90% of saturation	Cold-water aquatic life	Attaining some criteria/uses	ODEQ/ODA LASAR database
Wilson River, RM 27.2 to 34.5	October 15 - June 15	Spawning: Not less than 11.0 mg/L or 95% of saturation	Salmon and steelhead spawning	Insufficient data	ODEQ LASAR database

[71] Laboratory Analytical Storage and Retrieval (LASAR) database

8.3 Stream Shading

8.3.1 Distribution of Effective Shade

8.3.1.1 Methods

Stream shading was estimated as the combined function of riparian vegetation, topography, and active channel widths (i.e. *effective shade*) for the current and potential future conditions[72] (50- and 100- year scenarios). Our approach in estimating future effective shade levels assumed no management within riparian areas. Future riparian stand conditions (i.e., years 2056 and 2106) were modeled using the Pacific Coast variant of the Forest Vegetation Simulator (FVS) as described in section 6.2.1 above.

Effective shade values were estimated using the HeatSource version 7.0 temperature model (Boyd and Kasper 2003). Effective shade was estimated within a GIS using the ArcView 3.x TTools extension[73]. Input data is assembled within T-tools at sampling points located along a given stream. Sample data was assembled at a 100-meter interval along 12 principal streams in the Wilson River watershed. Location elevation, channel gradients, and topographic characteristics were calculated using the finest-resolution DEM available (i.e., 1/3 arc-second; ~7.3 meter)[74]. Active channel widths were associated with each shade sample point based on contributing drainage area, using the equations of Clarke and others (unpublished) and Lorensen and others (1994)[75].

The TTools extension was also used to sample riparian stand conditions, and assemble these data for evaluation within HeatSource. Several stand metrics are needed by HeatSource in calculating effective shade, these include stand height, canopy density, and canopy overhang. Values used for current (year 2006) and future (years 2056 and 2106) scenarios are given in Table 56. Values for all stand types were derived from SLI data (described in Chapter 6, section 6.1.3, Field Reconnaissance); with the exception of "unsampled forest" which were estimated using professional judgment.

[72] The development of the potential future conditions is described in the riparian vegetation section of the assessment.
[73] http://www.deq.state.or.us/wq/tmdls/tools.htm
[74] http://seamless.usgs.gov/
[75] Estimating active channel width is discussed in detail in the Hydrology section of this report.

Table 56. Riparian stand metrics used in estimating effective shade. Values are for current (2006) and modeled future (2056 and 2106) conditions.

Year	Land Cover Name (optional)	Code	Height (m)	Density (%)	Overhang (m)
2006	Hardwood	1	31.7	89%	2.0
	Mixed – Conifer	2	35.6	89%	2.5
	Hardwood	3	31.2	89%	2.2
	Mixed – Conifer	4	38.5	89%	3.3
	Hardwood	6	33.8	89%	2.6
	Hardwood	8	31.0	66%	2.1
	Hardwood	9	30.3	89%	2.4
	Conifer	26	36.3	89%	3.4
	Unsampled Forest	100	33.6	25%	2.6
	Non Forest	999	10.0	1%	0.5
	Non Forest with Trees	101	24.5	5%	1.2
2056	Hardwood	1	45.4	89%	2.6
	Mixed – Conifer	2	46.2	89%	3.3
	Hardwood	3	45.4	89%	2.9
	Mixed – Conifer	4	46.7	89%	4.3
	Hardwood	6	44.9	89%	3.0
	Hardwood	5	45.6	89%	2.5
	Hardwood	34	45.3	89%	2.9
	Unsampled Forest	100	33.6	25%	2.6
	Non Forest	999	10.0	1%	0.5
	Non Forest with Trees	101	24.5	5%	1.2
2106	Hardwood	1	51.0	89%	3.2
	Mixed – Conifer	2	50.7	82%	4.2
	Hardwood	3	50.7	89%	3.1
	Mixed – Conifer	4	50.4	73%	5.3
	Hardwood	6	50.5	80%	3.6
	Hardwood	8	50.5	77%	3.2
	Hardwood	34	50.8	89%	3.5
	HW Mix transition to Conifer	12	50.4	80%	3.9
	Unsampled Forest	100	33.6	25%	2.6
	Non Forest	999	10.0	1%	0.5
	Non Forest with Trees	101	24.5	5%	1.2

8.3.1.2 Results

Current and potential future shade levels for the principal streams in the Wilson River watershed are shown in Figure 37 and summarized in Table 57. With the exception of the Wilson River mainstem, the sampled streams had high levels (>90%) of effective shade for all modeling scenarios. Modeled effective shade generally increases from the current (2006) condition to 2056, but declines over the following 50-year period in most of the streams.

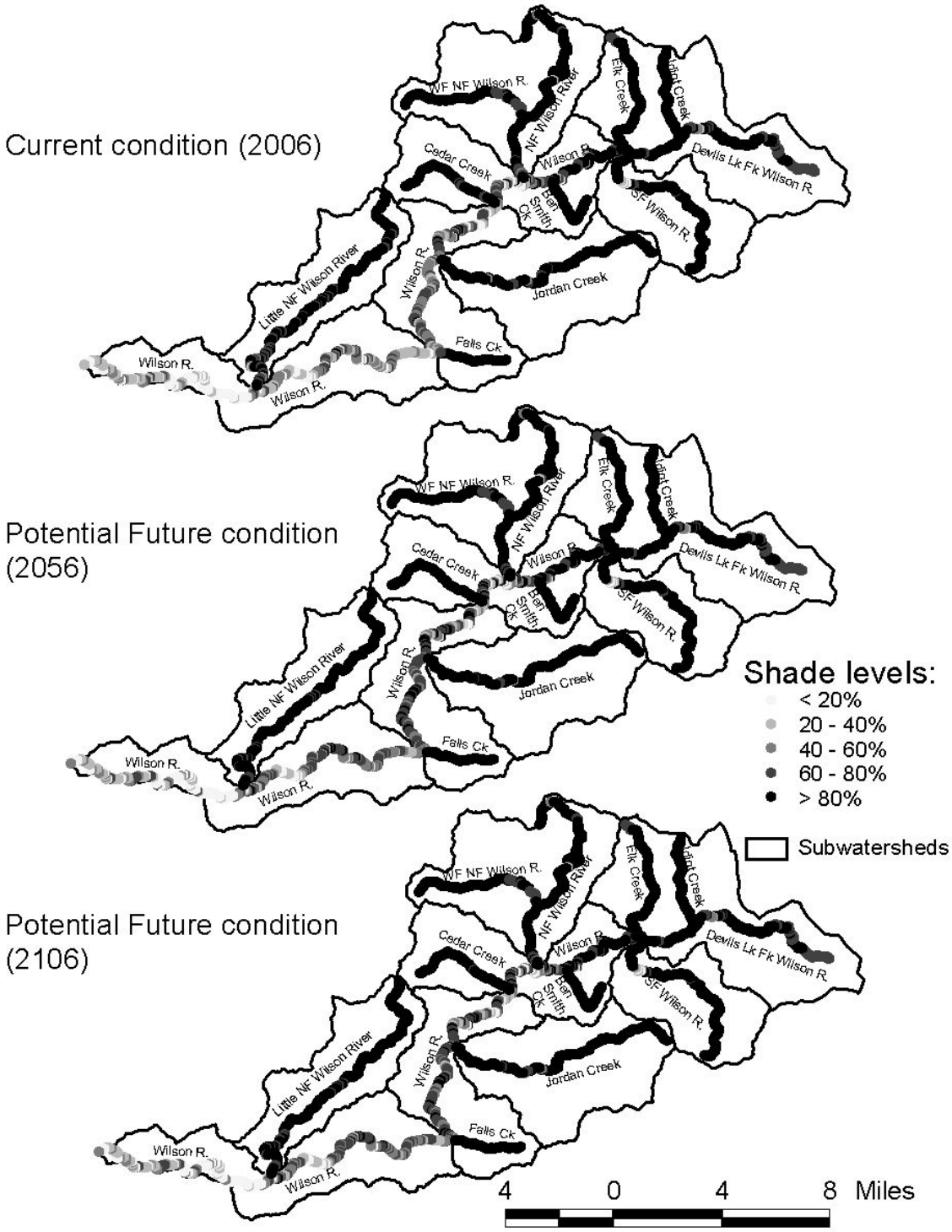

Figure 37. Current effective shade (top), and potential future shade conditions in 50 (middle) and 100 (bottom) years along principal streams, Wilson River watershed.

Table 57. Stream Shade Summary. Modeled average (minimum-maximum) effective shading (%) for 12 principal stream systems in the watershed in 2006 and projected 50 and 100 years in the future.

Stream	Current (2006)	Potential Future (2056)	Potential Future (2106)
Ben Smith	97% (95% - 98%)	98% (97% - 98%)	97% (96% - 98%)
Cedar	95% (69% - 98%)	97% (81% - 98%)	96% (80% - 98%)
Devils Lake Fork	86% (29% - 98%)	87% (29% - 98%)	86% (28% - 98%)
Elk	96% (68% - 98%)	96% (68% - 99%)	96% (68% - 98%)
Falls	96% (80% - 98%)	97% (96% - 98%)	97% (95% - 98%)
Idiot	97% (84% - 98%)	97% (85% - 99%)	97% (85% - 98%)
Jordan	95% (51% - 98%)	96% (54% - 98%)	96% (54% - 98%)
Little N. Fk. Wilson	90% (34% - 98%)	94% (63% - 98%)	93% (67% - 98%)
N. Fk. Wilson	94% (28% - 98%)	95% (28% - 98%)	95% (28% - 98%)
S. Fk. Wilson	93% (8% - 98%)	94% (8% - 98%)	94% (8% - 98%)
W. Fk. N. Fk. Wilson	91% (64% - 98%)	92% (65% - 98%)	91% (65% - 98%)
Wilson	47% (2% - 98%)	54% (2% - 98%)	55% (2% - 98%)

The largest and most widespread differences between current and potential shade scenarios were in the Wilson River mainstem. Overall, the Wilson River currently provides an average shade value of 47% as compared with 54% (2056) and 55% (2106) in the potential future conditions (Table 57). The largest differences occurred in the middle reaches (~RM 12-22); on ODF managed lands, the key opportunities for shade enhancement are between RM 20 and 30, approximately between the confluence of Jordan Creek and the North Fork Wilson River (Figure 37 and Figure 38).

Figure 38 illustrates the modeled changes in effective shade along the mainstem Wilson River. Values indicate the increases in effective shade that the potential future conditions would likely provide assuming no management. Areas with high values are likely areas for protection and passive restoration. Areas with no or only minor changes may be either fully functioning (in terms of shade), or have a natural or human-caused impediment to stand development; in either case they represent areas where enhancement opportunities could be investigated. Areas with negative or declining values represent areas where shade conditions are expected to deteriorate in the absence of active management.

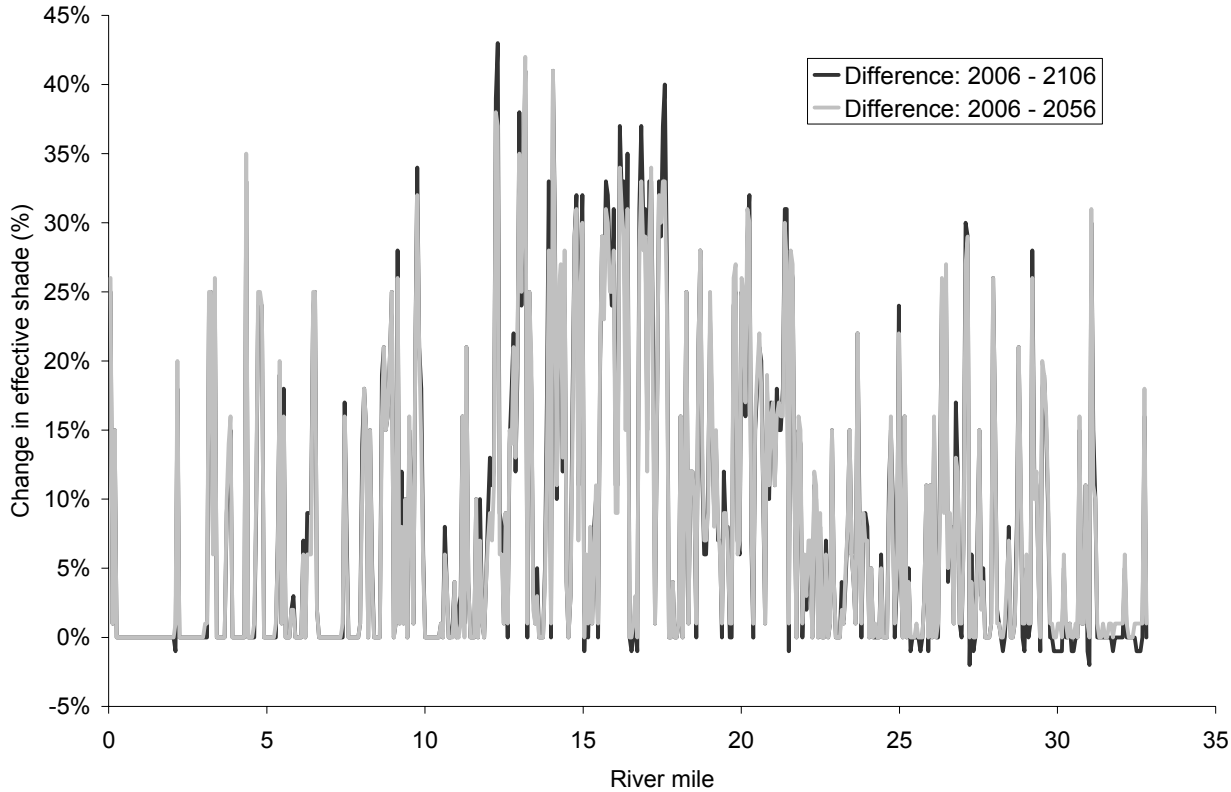

Figure 38. Changes in Effective Shade. The estimated changes in effective stream shading between the current (2006) and potential future (2056 and 2106) conditions for the Wilson River. Values indicate the increases in effective shade that the potential future conditions would likely provide assuming no management.

8.4 Stream Temperatures, Reasonable Achievable and Compared to Potential Levels

8.4.1 Methods

We conducted an analysis to evaluate what stream temperatures are reasonably achievable under natural conditions in the Wilson River watershed using empirical stream temperature data and site conditions for 24 monitoring sites in the Wilson River Watershed (Figure 39 and Table 58). Regression analysis was used to determine the relationship between the annual maximum seven-day moving average of the daily maximum water temperature ($\mathbf{T_{max}}$)[76] and the environmental variables most likely to affect water temperatures. The variables considered in the regression analysis were:

[76] OAR 340-04l-0006 (54) defines the numeric temperature criteria as the seven-day moving average of the daily maximum temperatures.

- ***Solar radiation.*** The seven-day moving average of total solar radiation received (in Langleys) at the Forest Grove Agrimet climate station[77] on the day of the annual $\mathbf{T_{max}}$.

- ***Streamflow index***. The flow exceedance percentile[78] (expressed as a decimal) for mean daily streamflow at the Wilson River USGS stream gage on the day of the annual $\mathbf{T_{max}}$.

- ***Air temperature***. The seven-day moving average of daily maximum air temperature (degrees F) at the Tillamook 1W weather station[79] on the day of the annual $\mathbf{T_{max}}$.

- ***Site elevation (E).*** The elevation at the stream temperature monitoring site (in units of feet; determined from digital elevation model data)

- ***Effective shade (S).*** Average 2006 effective shade levels (expressed as a decimal) for the entire stream upstream of the temperature monitoring site. Values for effective shade calculated for the current condition (as discussed in the previous section, Stream Shading) were used in developing the initial regression equations.

- ***Distance from watershed divide (D).*** The final variable used in the regression analysis was distance from watershed divide (in units of miles). Distance from the watershed divide provides an index of the time that water has been exposed to ambient air temperatures. The implication is that streams that have a shorter distance to the watershed divide would be expected to have lower water temperatures

[77] Data from the Forest Grove station were used because it is the only data set that covers the entire time period of stream temperature data. July and August total solar radiation values are well correlated (r^2 = 0.85; n=60, p<0.00001) with the short period of record available from the South Fork station which is located within the Wilson River watershed.
[78] Calculated using combined July and August mean daily flow values
[79] http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?or8494

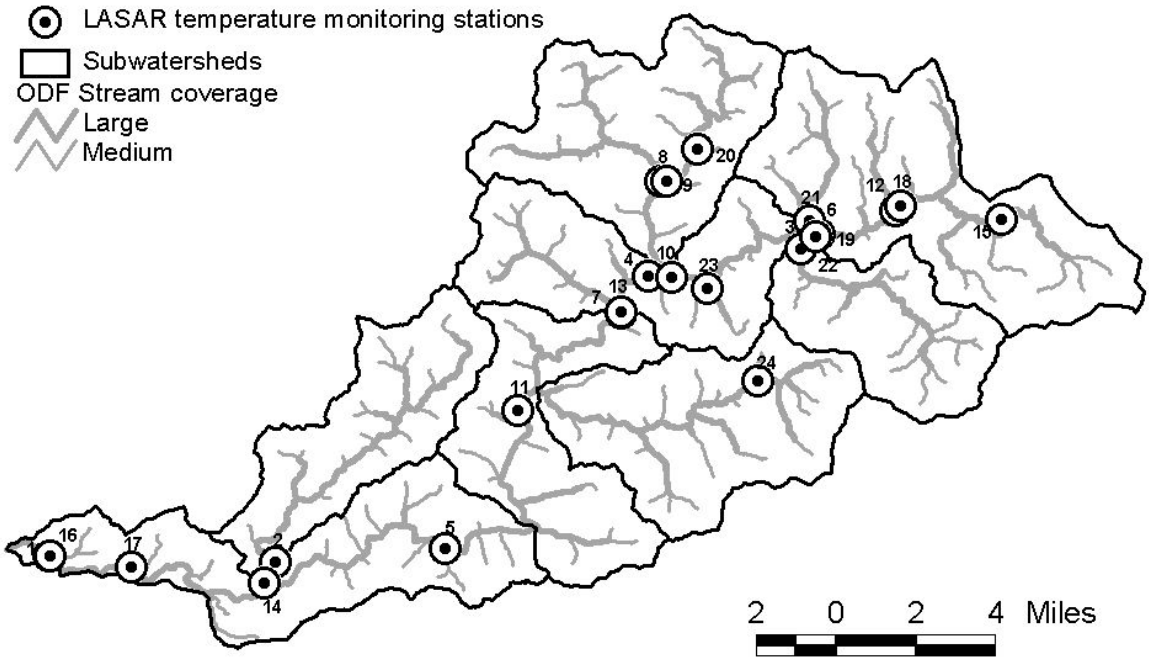

Figure 39. LASAR temperature stations within the Wilson River watershed.

Table 58. Site description and period of record for LASAR temperature monitoring stations in the Wilson River watershed.

Map ID	ODEQ ID	Description	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	10572	Tillamook Creamery (TCCA) outfall at Wilson River		a								
2	11845	Little North Fork Wilson River at River Mile 1.5			■							
3	12865	South Fork Wilson River at 1st bridge on South Fork	b									
4	12943	Wilson River downstream of North Fork Wilson River	■	■								
5	12944	Wilson River downstream of Kansas Creek	■									
6	12945	Wilson River downstream of Devils Lake Fork		■								
7	12946	Wilson River downstream of Cedar Creek	■	c		■						
8	12947	West Fork of North Fork Wilson River at mouth		■								■
9	12948	North Fork Wilson River upstream of West Fork Wilson		■								■
10	12951	Wilson River at Hwy 6 (Lee's Camp)	■	■		■						■
11	12952	Wilson River downstream of Jordan & Keening Creeks	■									
12	12954	Idiot Creek at mouth		■								
13	12956	Cedar Creek at mouth (to Wilson River)	■	■		■						
14	13027	Little North Fork Wilson River at mouth		■								
15	13102	Devils Lake Fork Wilson River at Saddle Mountain Rd		■								
16	13266	Wilson River Mid channel 100 feet upstream of TCCA		■								
17	13422	Wilson River at Sollie Smith Road (River Mile 3.5)		■								
18	20362	Devils Lake Fork Wilson River upstream of Idiot Cr		■								
19	20363	Devils Lake Fork Wilson River at mouth		■		■						■
20	20364	North Fork Wilson River 1.4 miles upstream of WFNF		■								
21	20365	Elk Creek upstream of Elk Creek Forest Park		■								
22	20366	South Fork Wilson River at mouth		■		■						
23	21811	Ben Smith Creek at River Mile 0.44			■	■	■	■		■	■	■
24	21812	Jordan Creek at River Mile 7.52			■			■				

a. Data not used; site is not a creek
b. Data not used; record didn't start until 9/2/1997
c. Data not used; record didn't start until 10/14/1998

8.4.2 Results

A stepwise approach was taken to eliminate those variable from the regression equation that were not statistically significant at the $p \leq 0.05$ level. Effective shade alone showed a significant ($p < 0.001$) relationship with maximum 7-day water temperature (Figure 40). Distance to watershed divide also showed a strong correlation with $\mathbf{T_{max}}$ (Figure 41). However, when effective shade and distance to watershed divide were both included as variables, distance to watershed divide was no longer significant, due to the high correlation between effective shade and distance to watershed divide (Figure 42). Site elevation was also dropped from the final equation. The final form of the regression included the following variables:

- *Effective shade,*
- *Solar radiation,*
- *Streamflow index,* and
- *Air temperature*

Regression statistics for the final equation are presented in Table 59.

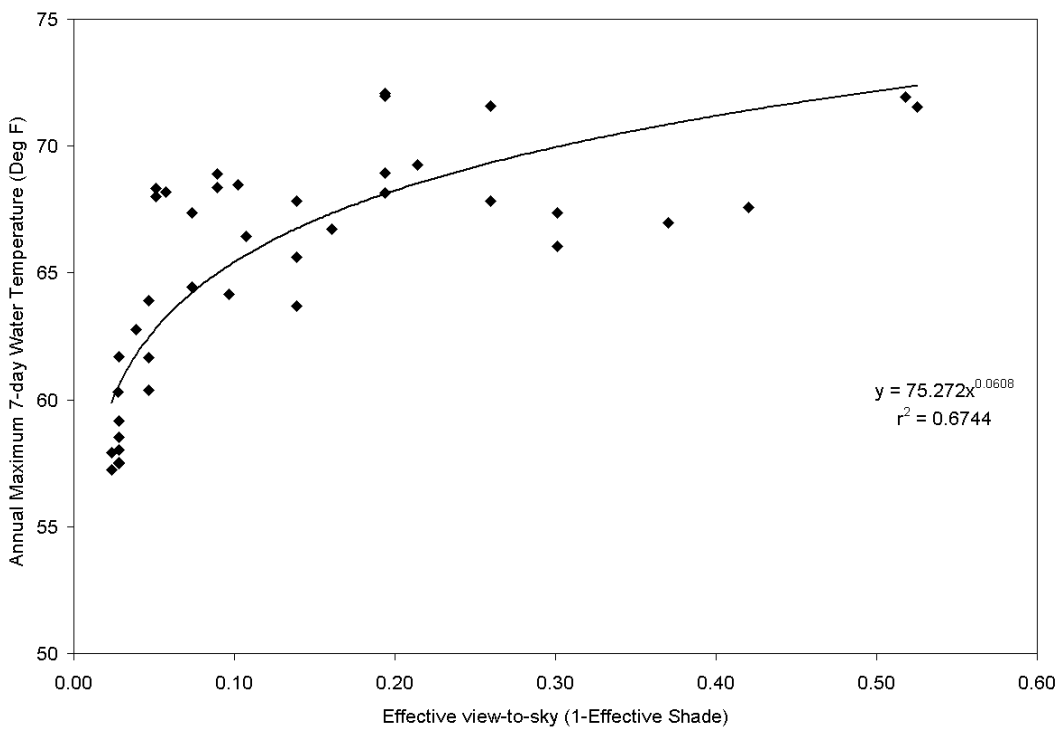

Figure 40. Relationship between annual maximum seven-day water temperature and effective shade. For this analysis effective shade was expressed as effective view to sky, which is 1 – effective shade.

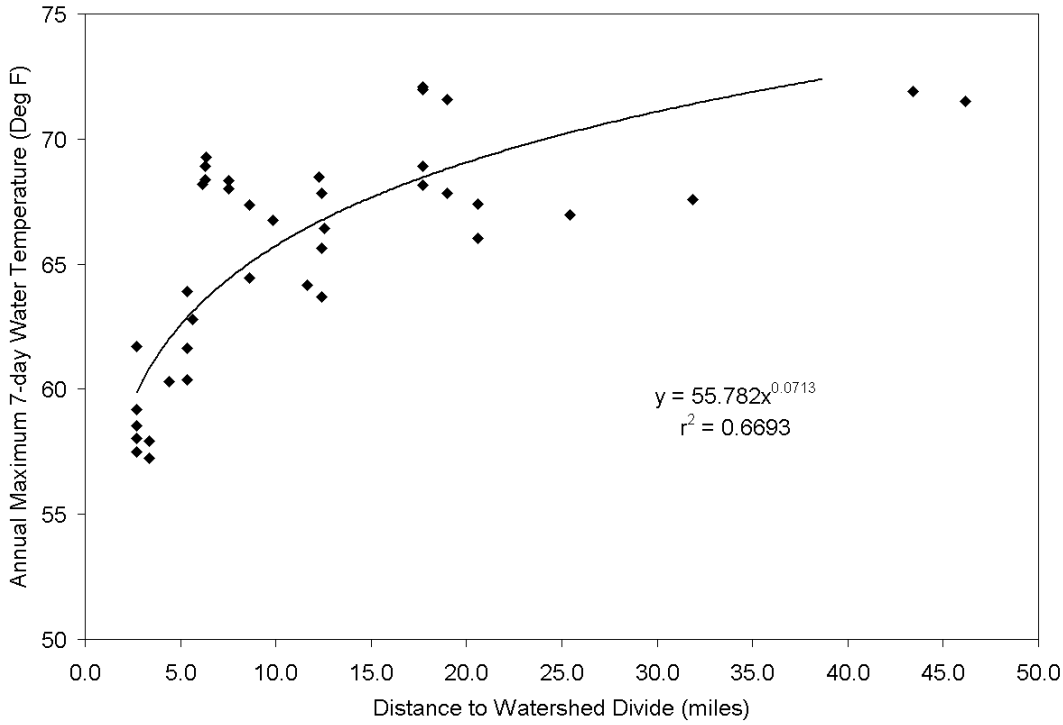

Figure 41. Relationship between annual maximum seven-day water temperature and distance to watershed divide.

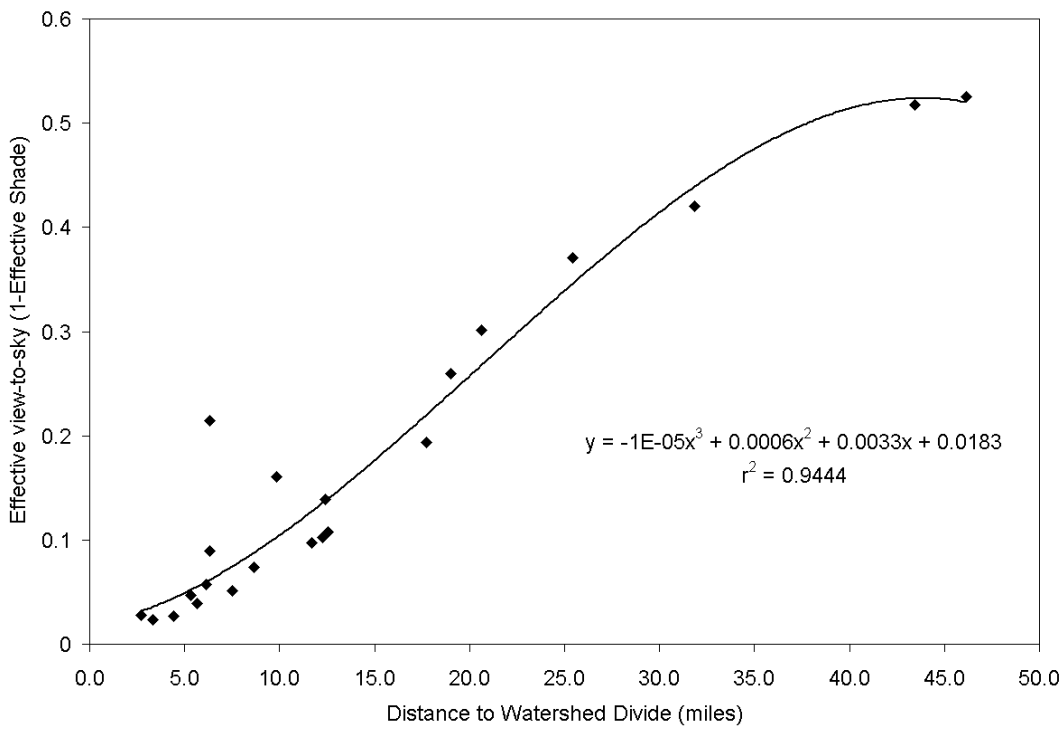

Figure 42. Correlation between distance to watershed divide and effective shade.

Table 59. Regression statistics for the Wilson River watershed temperature prediction equation.

Adjusted R Square		0.81067
Standard Error		1.99694
Observations		41
	Coefficients	P-value
Intercept	-370794.8517	4.575×10^{-13}
Effective shade (expressed as [1 – effective shade] $^{0.00001}$)	370809.4234	4.588×10^{-13}
7-day mean total solar radiation at Forest Grove	0.063000916	4.643×10^{-6}
Streamflow index	-13.47725843	0.000977
7-day average maximum air temperature	0.37536097	0.037709

We used the Wilson River temperature equation (Table 59) to evaluate the likelihood that stream temperatures and/or shade conditions are a limiting factor in the achievement of proper functioning condition among the principal streams found in the Wilson River watershed. Our approach was to estimate effective shade levels associated with current (2006) riparian conditions, and modeled conditions 50 and 100 years in the future (i.e., 2056 and 2106) while assuming no management within riparian areas. Only effective shade was varied among the modeling scenarios; values for solar radiation, streamflow and air temperature were held constant[80]. Effective shade values were estimated at 100-meter intervals along the principal streams. The Wilson River temperature equation was then used to estimate point $\mathbf{T_{max}}$ values along each principal stream.

Current and future $\mathbf{T_{max}}$ values were calculated at each 100-meter point along principal streams by substituting current and future effective shade values into the Wilson River temperature equation. Current and future $\mathbf{T_{max}}$ values for the mainstem Wilson River are shown in Figure 43 (top graph). Values are plotted from the river mouth upstream. Values for the mainstem Wilson River indicate a predicted ~ 1 degree Fahrenheit drop in temperature along the majority of the river from 2006 to 2056, with little expected change from 2056 to 2106. These scenarios assume no management of riparian stands. To better illustrate predicted changes in $\mathbf{T_{max}}$ values we also plotted the difference[81] between future and current values (Figure 43; bottom graph). The values in Figure 43 are typical for most streams; an overall decreasing trend in $\mathbf{T_{max}}$ values in an upstream

[80] Average values were used for the days of observed T_{max} at the temperature monitoring locations within the Wilson River watershed.
[81] Future (2056 and 2106) $\mathbf{T_{max}}$ values – current (2006) $\mathbf{T_{max}}$ values

direction. However, some streams (e.g., Ben Smith Creek; Figure 44) had their lowest predicted $\mathbf{T_{max}}$ values occur in the middle portions of the stream. Longitudinal $\mathbf{T_{max}}$ profiles for all principal streams are provided in Appendix V – Longitudinal T_{max} Profiles for all Principal Streams

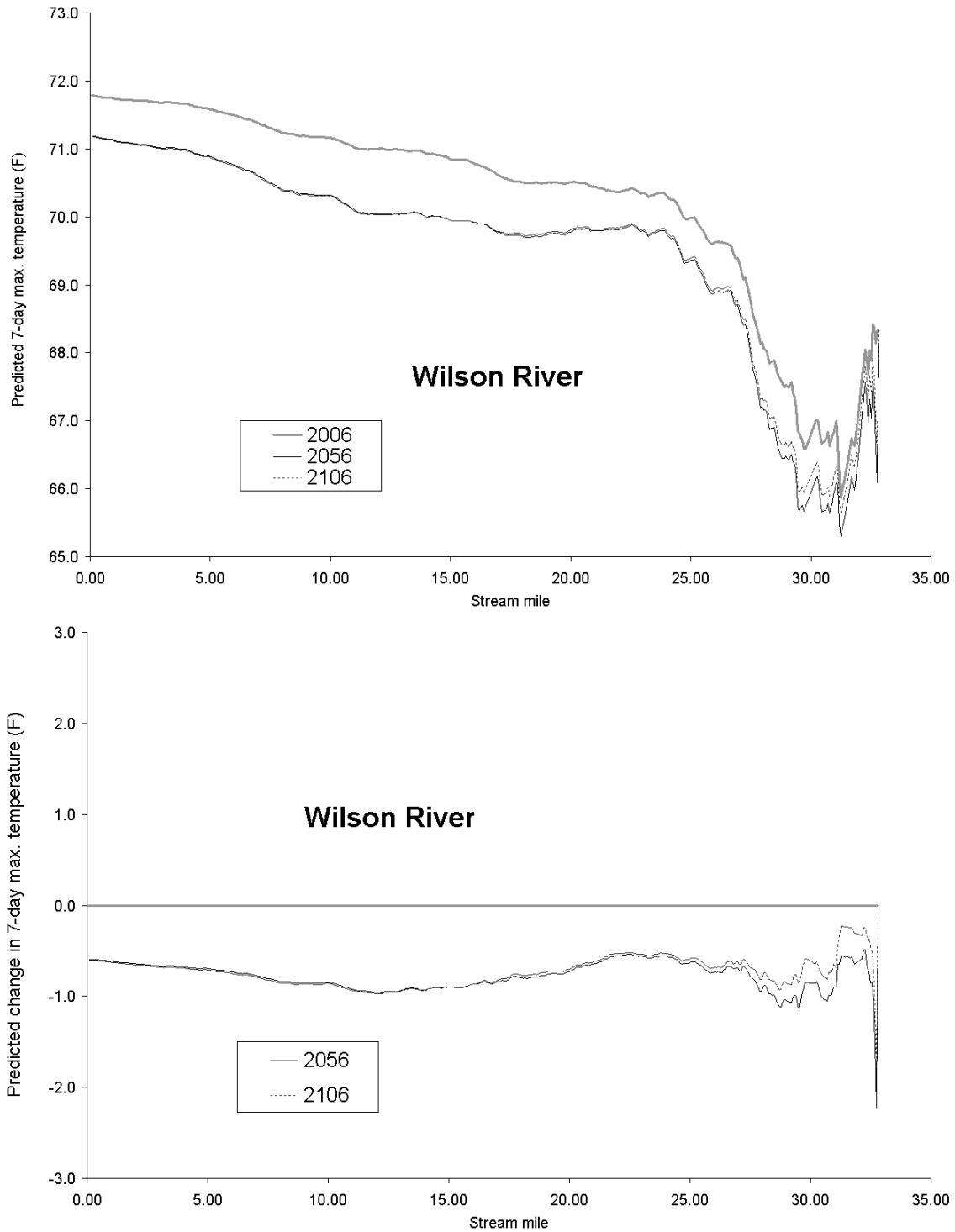

Figure 43. Longitudinal T_{max} profile, Wilson River mainstem. Top graphs shows predicted T_{max} values for current (2006) and future (2056 and 2106) scenarios. Bottom graphs shows difference between future and current scenarios.

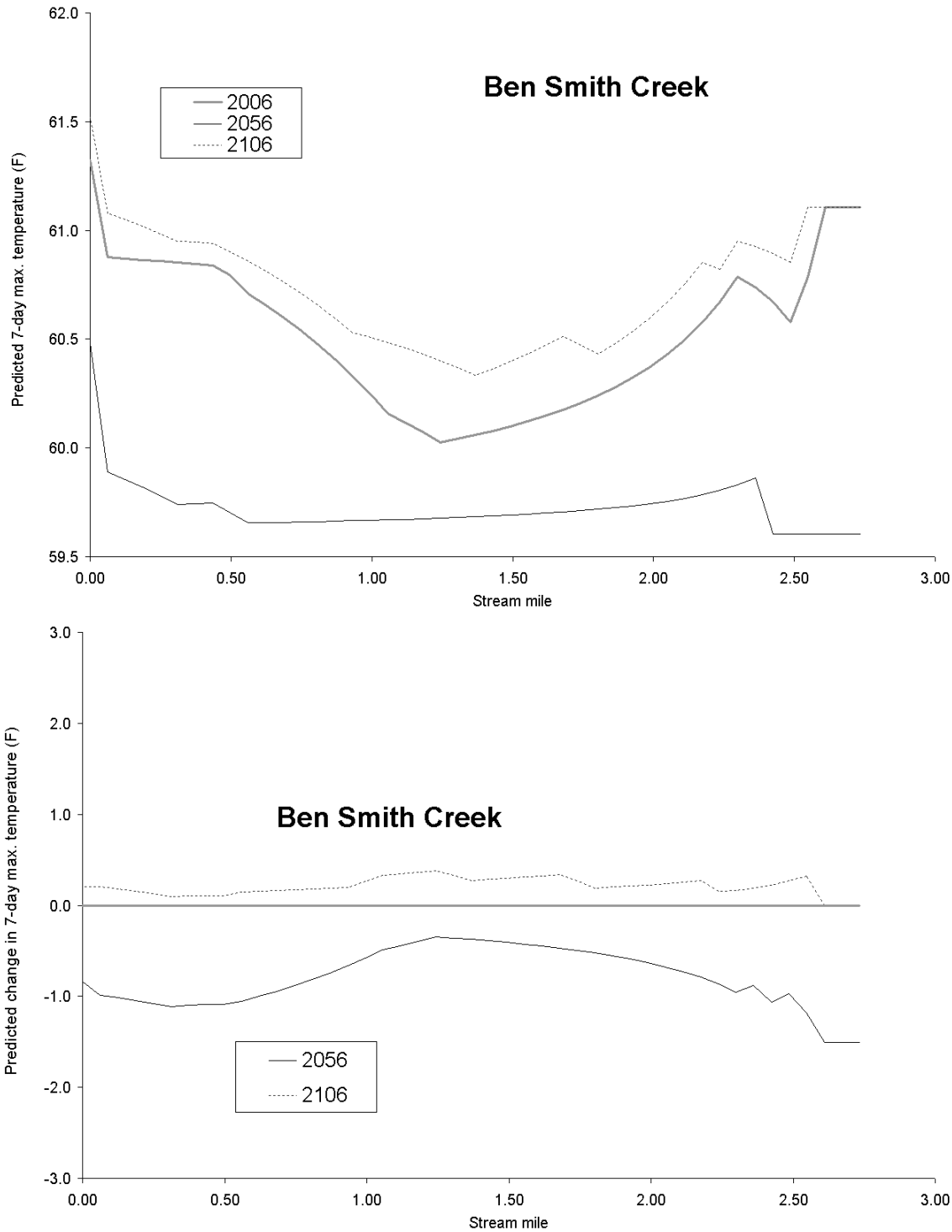

Figure 44. Longitudinal T_{max} profile, Bens Smith Creek. Top graphs shows predicted T_{max} values for current (2006) and future (2056 and 2106) scenarios. Bottom graphs shows difference between future and current scenarios.

Predicted changes between current and future $\mathbf{T_{max}}$ values are summarized in Table 60. Column one in Table 60 shows the average predicted change in $\mathbf{T_{max}}$ for the entire stream between 2006 and 2056; and column two shows the average predicted change between 2006 and 2106. Columns 3 and 4 in Table 60 show the largest point *decrease* in temperature for the two time scenarios within each stream (i.e., the largest at-a-point decrease in $\mathbf{T_{max}}$). Columns 5 and 6 show the largest point *increases* in temperature for the two time scenarios.

Table 60. Summary of predicted changes between current (2006) and future 2056 and 2106) T_{max} values..

	Mean T_{max} change for entire stream		Largest point decrease in T_{max} within stream		Largest point increase in T_{max} within stream	
Stream	**2006-2056**	**2006-2106**	**2006-2056**	**2006 - 2106**	**2006-2056**	**2006 - 2106**
Idiot Creek	-0.1	0.1	-0.2	0.0	0.0	1.5
WF NF Wilson	-0.5	0.6	-0.9	0.0	0.0	1.5
Ben Smith Cr	-0.8	0.2	-1.5	0.0	-0.3	0.4
Devils Lk Fk	-0.1	0.0	-0.1	0.0	0.0	0.0
Elk Creek	0.0	0.3	0.0	0.0	0.0	0.5
SF Wilson	-0.6	0.3	-1.3	-0.7	0.0	2.6
NF Wilson	-0.3	0.1	-0.9	-0.5	0.0	2.6
Cedar Cr	-0.7	0.1	-1.5	-1.0	0.0	1.5
Jordan Cr	-0.7	0.1	-1.4	-0.7	0.0	1.5
Falls Cr	-0.9	0.3	-1.5	-1.1	0.0	1.5
Little NF Wilson	-1.6	-1.2	-2.5	-2.3	0.0	0.3
Wilson River	-0.8	-0.7	-2.2	-1.8	-0.2	0.0

8.5 Stream Temperature Comparison with Adjacent Basins

8.5.1 Methods

We evaluated how water temperatures at sites in the Wilson River watershed compared to other nearby basins with similar flows climate and geology. The purpose of this assessment was to evaluate whether or not temperatures in the Wilson differ much from similar watersheds. Climate and geology are the two variables, independent of land use, that are most likely to affect summertime stream temperatures. We controlled for climate by limiting our comparisons to other watersheds in the North Coast area. We then identified watersheds in the

North Coast area that were similar to the Wilson River watershed in terms of underlying geology, and selected an area for comparison. Annual maximum 7-day temperatures were identified for each temperature site within the selected area, and distance to watershed divide was calculated for each site. Data were pooled with the Wilson data set, and annual maximum 7-day temperature as a function of distance to drainage divide was calculated for the pooled data set. Finally, residual variation in the data set was examined to see if results from the Wilson River watershed were similar to other North Coast sites.

8.5.2 Results and discussion

Geological information for the North Coast area was available from the USGS (Miller et al. 2003 [82] and Walker and MacLeod 1991). The principal lithologies for all fifth-field HUCs in the Wilson-Trask-Nestucca Basin were summarized (Figure 45). The adjacent Trask River watershed was most similar to the Wilson River watershed in terms of principal lithologies. The Trask watershed is also similar in size, and (given its adjacency to the Wilson) climate. Twenty temperature monitoring sites were identified in the Trask River watershed (Table 61 and Figure 46). Three sites had an insufficient record for three individual years, and were not used in the analysis.

[82] http://geopubs.wr.usgs.gov/open-file/of03-67/

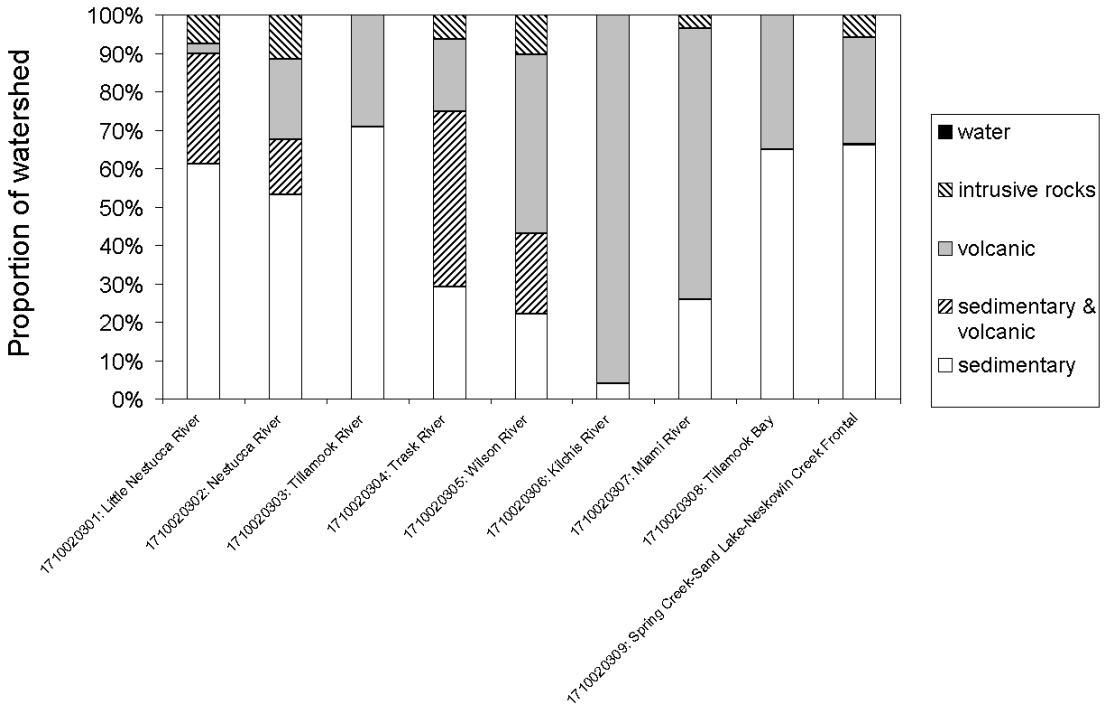

Figure 45. Summary of principal lithologic types for watersheds in the Wilson-Trask-Nestucca Basin. From Miller and others (2003).

Table 61. Site description and period of record for LASAR temperature monitoring stations in the Trask River watershed.

Map ID	Station ID	Description	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
1	12950	North Fork Trask River upstream of Bark Shanty Creek	a									
2	12957	Trask River at USGS Gage										
3	12958	Trask River at Trask River Fish Hatchery		b						c		
4	12959	Trask River at Lower Trask Boat Ramp										
5	12960	South Fork Trask River at mouth										
6	12961	South Fork Trask River downstream of Bill Creek										
7	12962	South Fork Trask River downstream of Edwards Creek										
8	12963	North Fork of North Fork Trask River at mouth										
9	12964	North Fork Trask River downstream of Clear Creek										
10	12965	North Fork Trask River upstream of North Fork of North Fork Trask										
11	12966	North Fork Trask River downstream of Bark Shanty Creek										
12	12967	Mill Creek at Pot RR Bridge (Trask River)										
13	12968	East Fork of South Fork Trask River downstream of Rock Creek										
14	12969	East Fork of South Fork Trask River downstream of Steampot Creek										
15	12970	Bark Shanty Creek at mouth (North Fork Trask River)										
16	13478	Trask River upstream of milepost 11										
17	13479	North Fork Trask River at Trask River Rd. bridge										
18	16987	East Fork of South Fork Trask River at mouth										
19	23819	Clear Creek at River Mile 0.72 (North Fork Trask River)										
20	25324	Laughlin Creek, Trask										

a. Data not used; record didn't start until 9/3/1997
b. Data not used; record didn't start until 10/14/1998
c. Data not used; record didn't start until 8/31/2004

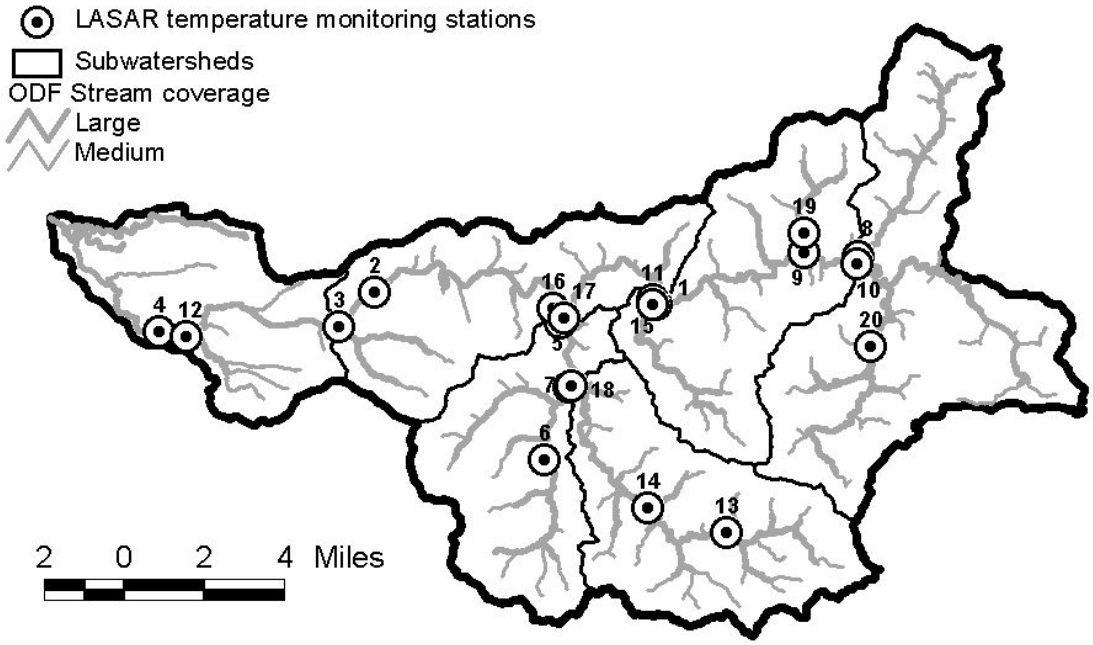

Figure 46. LASAR temperature monitoring sites within the Trask River watershed.

Figure 47 shows the relationship between distance to watershed divide and maximum 7- day water temperatures for the pooled Wilson River Trask River data sets. Distance from watershed divide accounts for approximately 2/3 of the observed variability in the data set. Figure 47 suggests that temperatures in the Trask watershed are lower than values in the Wilson watershed, at least up to approximately 20 miles from the drainage divide. This is also apparent in a plot of the residual variability (Figure 48). Results from a one-tailed t-test indicate that temperatures in the Trask are approximately 2 degrees F cooler than in the Wilson watershed ($p < 0.001$). Possible explanations for relatively lower temperatures in the Trask as compared to the Wilson include differences in riparian shading, due to more aggressive riparian harvest and/or greater riparian disturbance (e.g., flood damage); and cool-water reservoir releases (i.e., Barney Reservoir on the Middle Fork of the North Fork Trask).

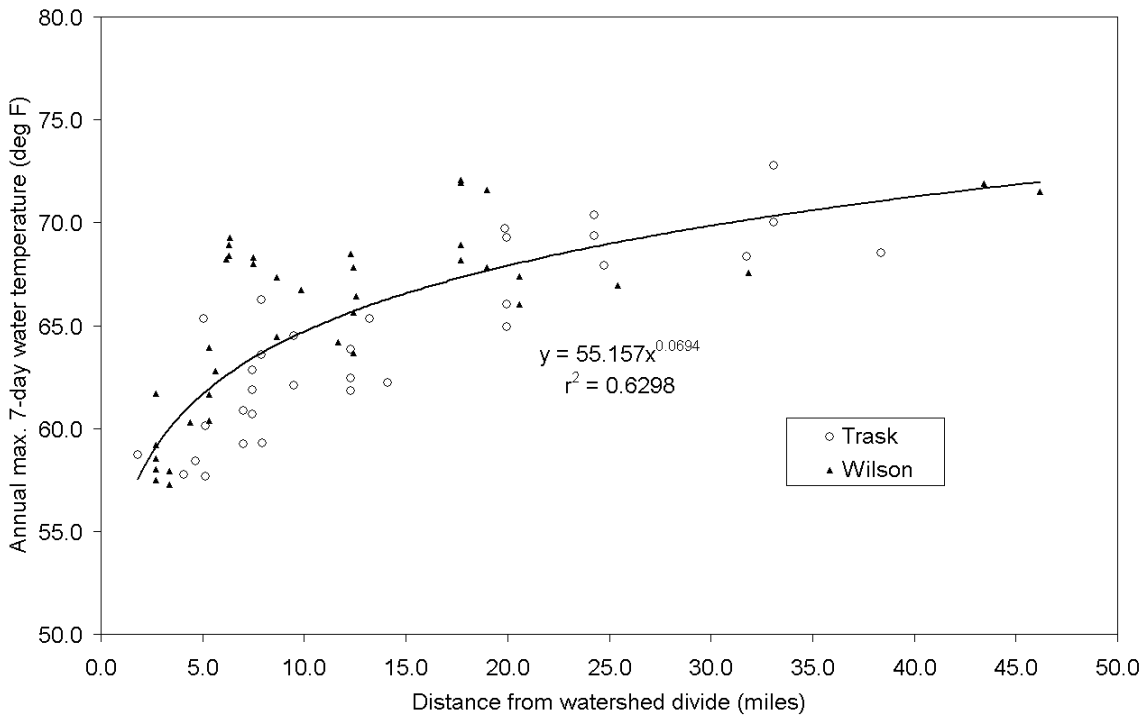

Figure 47. Relationship between annual maximum seven-day water temperature and distance to watershed divide for the pooled Wilson River / Trask River data sets.

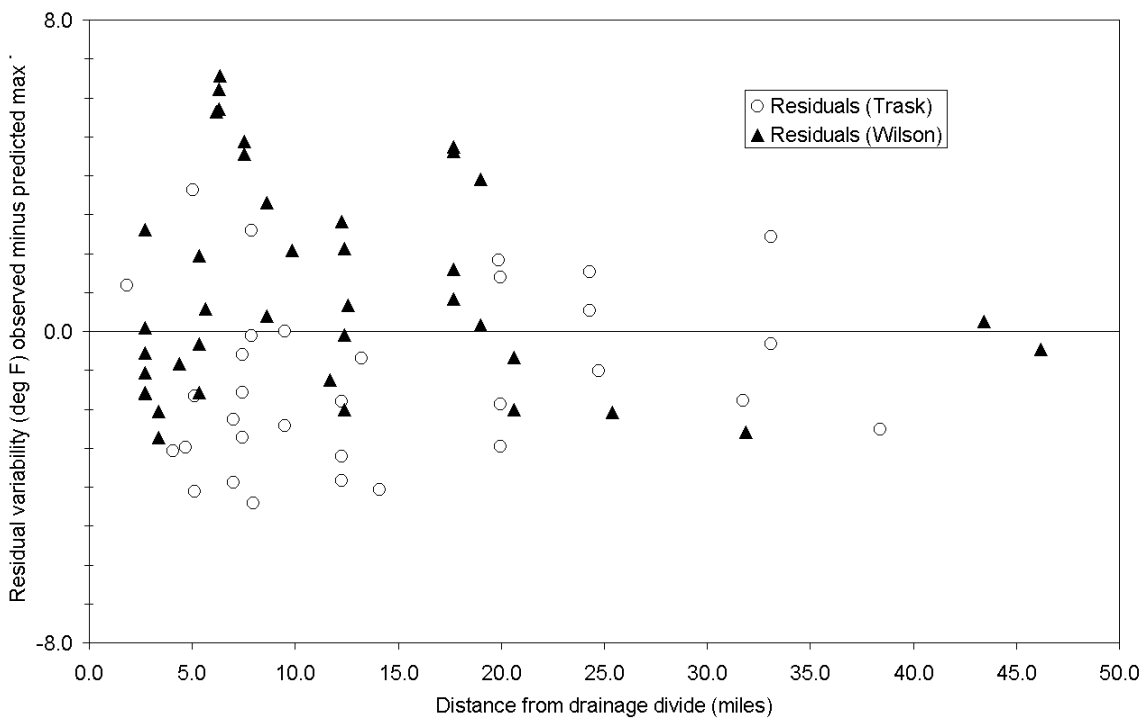

Figure 48. Residual variability from stream temperature regression model.

8.6 Limiting Factors

8.6.1 Stream Temperatures and Shade Conditions

We used the ODEQ "core cold water habitat use" criterion of T_{max} less than or equal to 60.8 degrees Fahrenheit (16.0 degrees Celsius)[83] as the metric to evaluate to what extent stream temperatures and/or shade conditions are limiting the achievement of properly functioning condition in the Wilson River watershed. All of the principal streams within the Wilson River watershed are designated as core cold water habitat[84]. Many of the principal streams are also designated as salmon and steelhead spawning use[85] as well, however, the seasons that this designation apply to are outside of the July and August time period considered for this analysis. We assigned impact ratings using the following approach:

- The proportion of total length for each principal stream that meets the ODEQ core cold water habitat criterion was calculated for each model scenario (i.e., 2006, 2056, 2106; Figure 49),
- Streams having less then 10% of their total length that meet the core cold water habitat criterion under <u>any</u> of the three model scenarios were assigned a "low" likelihood of posing a limitation to properly functioning condition. The reasoning behind this rating is that these streams are unlikely to meet the ODEQ criteria regardless of riparian management actions.
- Similarly, streams where the future proportion of stream length that meets the ODEQ criterion is greater than the current condition were assigned a "low" likelihood of posing a limitation to properly functioning condition (i.e., conditions are getting better).
- Streams where the future proportion of stream length that meets the ODEQ criterion is less then the current condition, but greater than 10%, were assigned a "moderate" likelihood of posing a limitation to properly functioning condition (i.e. worsening trend).
- Streams where the future proportion of stream length that meets the ODEQ criterion is less then the current condition, and less than 10%, were assigned a "high" likelihood of posing a limitation to properly functioning condition.

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[83] http://arcweb.sos.state.or.us/rules/OARs_300/OAR_340/340_041.html
[84] http://www.deq.state.or.us/wq/rules/div041/fufigures/figure230a.pdf
[85] http://www.deq.state.or.us/wq/rules/div041/fufigures/figure230b.pdf

Results are presented for two time periods; 0-50 years in the future, and 0-100 years.

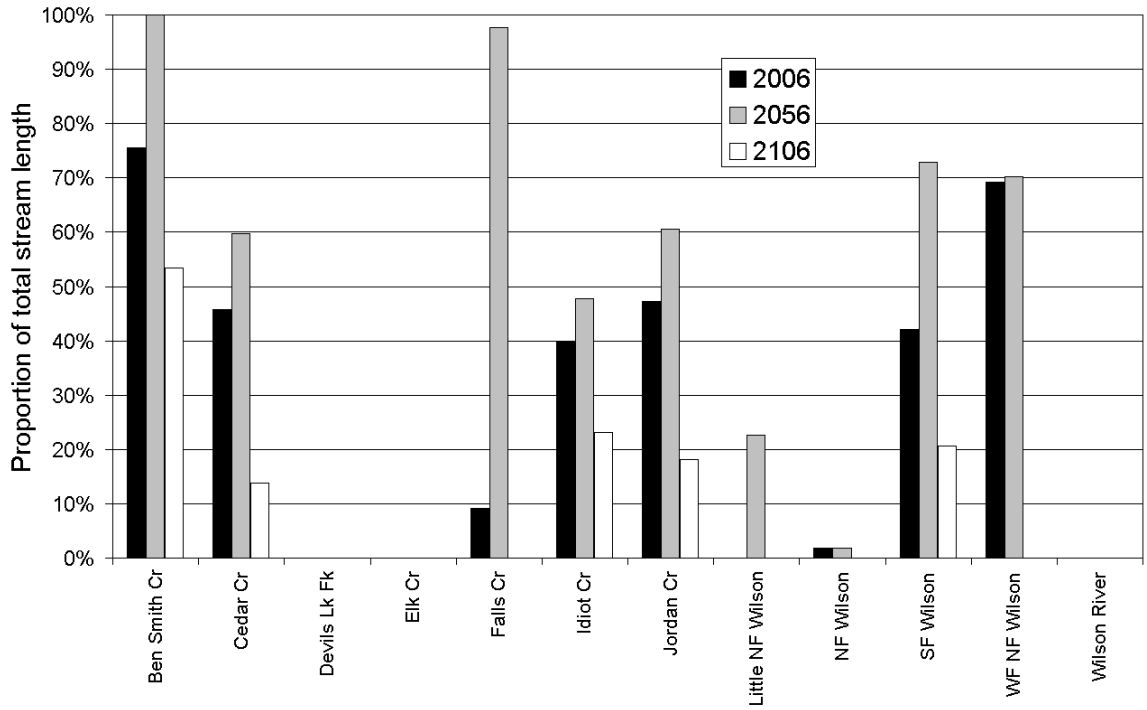

Figure 49. Proportion of total principal stream length that is estimated to achieve the ODEQ "core cold water habitat" criteria ODEQ "core cold water habitat use" criterion is T_{max} less than or equal to 60.8 degrees Fahrenheit. The absence of a bar means that 0% of the stream length is predicted to meet the criteria.

The results indicate that in the mid-term (i.e., 50-year time horizon) shade conditions, and associated stream temperatures, will experience an improving trend, as current stands mature, and riparian shade generally increases. However, over the longer term (0-100 years) we can expect to see shade conditions deteriorate, and temperatures increase, as stands break up and shade conditions decrease (see the discussion on lack of canopy recruitment in Chapter 6 Riparian and Wetlands, section 6.2 Potential Future Conditions).

Table 62. Likelihood that stream temperatures and/or shade conditions are a limiting factor for achieving properly functioning aquatic system. Results are provided by principal stream.

Principal stream	0-50 year time horizon	0-100 year time horizon
Ben Smith Cr	Low	Moderate
Cedar Cr	Low	Moderate
Devils Lk Fk	Low	Low
Elk Cr	Low	Low
Falls Cr	Low	High
Idiot Cr	Low	Moderate
Jordan Cr	Low	Moderate
Little NF Wilson	Low	Moderate
NF Wilson	Low	Low
SF Wilson	Low	Moderate
WF NF Wilson	Low	High
Wilson River	Low	Low

8.7 Confidence in the Assessment/Analysis

Confidence in the above analysis is moderate. The overall approach to estimating temperatures is robust, and follows a methodology similar to other recent state of the art efforts (e.g., Allen et al., 2007). However, the limited availability of recent temperature data from sites within the Wilson watershed limits the overall confidence. Given that stream temperature monitoring equipment is relatively cheap to deploy, and temperature data relatively easy to analyze, ODF is encouraged to increase its temperature monitoring efforts within the Wilson River watershed.

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