10 Synthesis

10.1 Watershed Condition

Overall, the Wilson River watershed appears to be in relatively reasonable functioning condition (i.e., functioning in an ecologically appropriate manner); the current conditions largely the result of the human-induced disturbances that have occurred over the last 100+ years. However, the watershed is largely recovering from these disturbances and is in an intermediate recovery phase. Although a few notable exceptions exist, current management activities are generally promoting this recovery. The ensuing discussion explores these ideas further.

Successful management of any watershed includes identifying factors (current and projected future) that limit riparian and aquatic resources and implementing management strategies that work to remove them. In the Wilson River watershed, the following features are not currently limiting factors:

- stream temperature and discharge,
- water use and withdrawal,
- sedimentation from landsliding, and
- hydrologic connectivity of roads.

The following watershed features are currently limiting (some aspect[s] of) riparian and/or aquatic resources:

- large pieces of instream wood (current),
- conifer large wood recruitment to streams,
- instream channel complexity (e.g., few pools, low percent gravel, low off-channel habitats, etc.). Additionally,
- highway fill is limiting channel migration and flood flows in some lower sections of the Wilson; see Map 20 and Table 7), and
- numerous stream crossings are currently acting as barriers (or potential barriers) to fish migration (adults and/or juveniles; see Table 38).

The following watershed features are considered potential (current) and/or future limiting factors:

- stream crossings rated as having a high washout potential (see Table 35),
- some dispersed camping and OHV recreation areas are acutely impacting riparian vegetation and sedimentation in some areas (projected to increase with increased OHV use; see sections 6.7 and 7.5), and
- stream temperatures and/or shade conditions are projected to become limiting in several principal streams in the Wilson (based on modeled results; see Table 62).

Since European settlement, the Wilson River watershed has experienced widespread natural and human-influenced disturbance. Although current timber harvest and riparian management practices adhere to widely-accepted standards (e.g., Forest Management Practices), much of the watershed has been heavily impacted by past management practices (e.g., timber harvesting, wildland fire activities, road building, conversion of lowlands to agricultural production, stream cleaning, etc.). While the Wilson is currently in a state of recovery, the combined effects of legacy and current practices are largely evident in:

- the young, even-aged riparian forest stands,
- the low potential for near- and long-term large wood recruitment to streams
- the low amounts of instream large wood,
- the low number of pools (including deep pools),
- the lack of instream diversity,
- the relatively high number of stream crossings that
    - exhibit a high washout potential and
    - are potentially blocking fish passage,
- and the quantity of road segments, trails, and dispersed recreation sites that are actively eroding to streams.

Although recovering, these legacy effects – particularly from the Tillamook Burns and subsequent road-building and logging activities – are still having a moderate to high impact on the Wilson. Furthermore, riparian and large wood recruitment modeling exercises indicate the legacy effects will continue to impact the Wilson into the foreseeable future (e.g., >100 years). Because there are no examples on which to base the recovery of a watershed after these kinds of large-

scale disturbance events, it is difficult to determine how far along in the recovery process the Wilson River watershed is.

Conversely, the negative effects of current management practices on overall watershed condition are considered relatively low. Effects on hydrology, for example, are currently considered negligible. There are, however, exceptions. For instance, we found that some recreational activities (e.g., dispersed camping near streams/wetlands, unrestricted OHV use of non-designated trails) are negatively influencing sedimentation, riparian vegetation, and washout risk in some areas.

Despite the relatively low impact of current management practices, there are distinct opportunities to adjust management activities to promote watershed recovery. Limiting recreational use and focusing restoration efforts on streamside areas will likely have a beneficial impact on the recovery of riparian areas. Fixing stream crossing with high washout potential and removing fish blockages will reduce sedimentation and open up additional areas for fish spawning, migration and rearing (although the degree to which this will aid in the recovery of a species is unclear). Additionally, tailoring riparian and upland silvicultural treatments for the enhancement/recruitment of large wood may help the aquatic habitat conditions recover at a faster rate.

In summary, while many basic biological and ecological requirements are largely being met by the current conditions in the Wilson, the lack of large wood (riparian and aquatic; especially conifers) is arguably having the largest impact on aquatic habitat complexity (e.g., lack of pools, deep pools, large wood accumulations, cover, low gravels, etc.) and large wood recruitment is projected to remain below target levels well into the next century.

10.2 Summary of Answers to Questions

Below is a list of Oregon Watershed Enhancement Board (OWEB) Critical and Oregon Department of Forestry (ODF) Key Supplemental historic and current condition questions. Questions are organized into resource categories (loosely corresponding to the primary chapters in this document) by their origin (i.e., OWEB or ODF) and abbreviated answers are provided below. Readers looking for more detailed discussions should refer back to the previous chapters/sections where individual topics are addressed.

10.2.1 Historical Condition Questions

OWEB Critical Question: What were the characteristics of the watershed's resources at the time of the European exploration/settlement?

The historical characteristics of Tillamook Bay (and the Wilson River watershed) prior to the mid-1800's are not well documented (refer to section 3.2.1 Early European Settlement) and our current understanding of the natural resources during exploration and settlement is limited to a handful of written accounts from early explorers and pioneers and to research into and accounts from Native American culture. What can be gleaned, however, is that the Tillamook Basin was rich in natural resources (e.g., fish, shellfish, crab, berries, roots big game, large timber, etc.), was subject to periodic natural and anthropogenic disturbances (e.g., fire, landsliding, etc.; refer to sections 3.4.1, 3.4.2, 3.4.3, and 3.5.2), and that the vegetative communities resembled what they are today (section 3.2.2).

OWEB Critical Question: What are the historical trends and locations of land use and other management impacts?

Historical land use and management impacts included periodic burning by Native Americans. European settlers cleared large sections of the lowlands and tidal areas, drained wetlands, and diked the rivers for agricultural use. Much of the uplands were heavily logged and/or burned over (both naturally- and human-influenced) and, with some exceptions, replanted primarily with one species of tree, the Douglas fir. Additionally, copious roads were installed in much of the watershed after the Tillamook Burns (refer to sections 3.3.1, 3.3.2, 3.4, and 3.5).

OWEB Critical Question: What are the historical accounts of fish populations and distributions?

Fish population accounts are relatively sparse. Early historic fish population data come primarily from gill-net fisheries but more detailed records, including spawning and redd counts were collected by ODFW starting around the middle of the last century (mid-1950's). Recent research into pre-European fish abundance, coupled with historic government agency abundances data, indicate many fish species/stocks had considerably larger populations compared to recent counts/estimates. Prior to the middle of the last century, almost no information exists pertaining to fish distributions. Furthermore, no known information exists pertaining to historic non-salmonid abundances and distributions. See sections 9.3, 9.5, and 9.7.

ODF Key Supplemental Question: What natural disturbances (floods, windstorms, fires) occurred in historic times? Discuss their impact on the aquatic ecosystem. Compare how these impacts have changed over time. In particular, note changes due to European settlement or changes in land management practices.

Periodic natural disturbances in the Wilson included fire, windstorms, and flooding. Fires frequency and severity have decline over the last 50+ years while relatively recent (e.g., <15 years) flooding and windstorm events have registered as some of the largest on record (with frequency in the last 20+ years) and peak flow discharge has increased in the last 40 years. Modeled landslide and debris-flow disturbances are also a natural part of the Wilson. See sections 3.4, 4.8, 5.3, 7.1.1, 7.2, and 7.3.

ODF Key Supplemental Question: What is the management history of the forestland in the watershed (e.g., salvage logging, replanting of burned areas)?

Early European settlers cleared large areas of timber in the lowlands near waterways, and, as technologies progressed, further up into the watershed. Early harvest operations were cut and burn and replanting after harvest didn't become commonplace until the mid-1900's. After the Tillamook Burns, huge tracts of land were salvage logged and replanted, usually with a single species (Douglas fir). See sections 3.3.1, 3.5.1, 3.5.2, and 3.5.3.

10.2.2 Current Condition Questions

10.2.2.1 Stream Channels

OWEB Critical Question: What is the distribution of channel habitat types throughout the watershed?

Because the channel habitat type classifications were not of primary interest, results from the analysis are presented in Appendix F – Classification of Stream Channel Habitat Types.

OWEB Critical Question: What is the location of channel habitat types that are likely to provide specific aquatic habitat features?

We developed a classification of stream channel habitat types and modeled the Habitat Intrinsic Potential (IP), habitat core areas, biological hotspots and channel disturbance areas. High coho IP areas occurs primarily in the lower South Fork Wilson and upper Devils Lake Fork subwatersheds, with a smaller amount in the Upper Wilson/Cedar Creek subwatershed. High steelhead IP areas occur throughout the Wilson but are generally relegated to the upper portions of the principal tributaries (e.g., 6th-field HUCs). Core steelhead areas occur throughout the Wilson in every subwatershed. Biological hotspot areas (>0.8) occur on approximately 14% of the fish-bearing network. See Maps 13-18 and sections 4.3, 4.4, and 4.5.

OWEB Critical Question: What is the location of areas that may be the most sensitive to changes in the watershed condition?

Sensitive channels in the Wilson occur primarily in headwater streams and are found throughout the subwatersheds with the highest concentration of channels found in the Little North Fork Wilson and the Cedar Creek portion of the Upper Wilson subwatersheds (see Map 19 and section 4.6).

ODF Key Supplemental Question: Where are channel modifications located?

Channel modifications have occurred throughout the Wilson but have been primarily restricted to the mainstem Wilson River corridor (along the highway; see Map 20 and section 4.7).

ODF Key Supplemental Question: Where are historic channel disturbances located (e.g., splash dams, stream cleaning)?

Historic channel disturbance (largely from previous reports) from log drives occurred as far upstream as the Lee's Camp area (~31 miles upstream). Log drives in the Wilson ended in 1908 and no splash-dams are known to have occurred in the Wilson. Historic records indicate that stream cleaning (e.g., removing log jams) occurred extensively in the Wilson at least until the early 1970's (end of records; see section 4.8).

ODF Key Supplemental Question: What channel habitat types have been impacted by channel modification?

The majority of channel habitat types in the Wilson impacted by channel modification occur off of ODF lands. Where they do occur on ODF lands, they occur primarily in less-responsive, steep and/or confined segments and are found in the North Fork Wilson and Jordan Creek subwatersheds (Table 8; see section 4.9).

ODF Key Supplemental Question: What are the types and relative magnitude of the past and current channel modification?

Answers to this question are found within the various sections that discuss channel modifications (see sections 4.7, 4.8, and 4.9).

10.2.2.2 Hydrology and Water Use

OWEB Critical Question: What land uses are present in your watershed?

Land uses were previously discussed in sections 3.3.1, 3.3.2, and 3.5.

OWEB Critical Question: What is the flood history in your watershed?

Periodic flooding is relatively commonplace in the Tillamook Basin. The largest recorded peak flow event occurred on November 6th, 2006. Since stream gage records were first kept in the Wilson, seven of the nine annual events that had recurrence intervals of 10 years or greater have occurred since 1970 (see sections 3.4.2 and 5.2).

OWEB Critical Question: Is there a probability that land uses in the basin have a significant effect on peak flows?

Results from the Distributed Hydrology Soil Vegetation Model (DHSVM) indicate that land use has affected peak flows in some streams in the Wilson River watershed, especially after the Tillamook Burns (e.g., 6.4% increases in total discharge). Neither changes in vegetation or roads, however, appear to have a significant effect on modeled changes in peak flows (see section 5.3).

OWEB Critical Question: Is there a probability that land uses in the basin have a significant effect on low flows?

Results from the DHSVM modeling exercise indicate that current vegetation conditions and roads have had little effect on mean low flows in the Wilson River watershed. While many of the smaller drainages show large percent increases (e.g., the Little North Fork), the magnitude of change is very small (hundredths of a cfs; see section 5.3).

OWEB Critical Question: For what beneficial use is water primarily used in your watershed?

Only four new water rights have been applied since publication of the 2001 Wilson River Watershed Assessment. Three are for manufacturing-related use of water, and the fourth (from a well) is for irrigation. Collectively these new application are for less than 0.01% of the total instantaneous withdrawal rate already allocated. Consequently, the values reported in the 2001 Wilson River Watershed Assessment are not modified from what was originally reported. The majority (~70%) of water is appropriated in the Lower Wilson River watershed, is used for irrigation, and is removed from the Wilson below the confluence with the Little North Fork (i.e., very low in the system). The second largest use for appropriated water (~30%) is for municipal and domestic water supplies, which is also withdrawn primarily in the Lower Wilson River subwatershed (see section 5.2.2).

OWEB Critical Question: Is water derived from a groundwater or surface water source?

The majority (> 90%) of appropriated waters are from surface, rather than groundwater, sources (see section 5.2.2).

OWEB Critical Question: What type of storage has been constructed in the basin?

No significant water storage has been constructed in the watershed (see section 5.5.2.2).

OWEB Critical Question: Are there any withdrawals of water for use in another basin (inter-basin transfer) or is water being imported for use in the basin?

No inter-basin transfer occurs, beyond the application of water withdrawn from the Wilson River to irrigated lands in the adjacent Trask River watershed and no water is being imported for use in the basin (see section 5.5.2.2).

OWEB Critical Question: Are there any un-permitted uses of water occurring in the basin?

It is not known to what extent (if at all) un-permitted uses of water are occurring in the basin (see section 5.5.2.2).

OWEB Critical Question: Do water uses in the basin have an effect on peak or low flows?

Consumptive water use does not exceed the estimated volume of natural stream flow in any month, either in average (50% exceedance flows) or dry (80% exceedance flows) years. Consumptive use of water is far below the amount available in all months. When the instream water right is added to consumptive uses, however, there is insufficient flow to meet all uses during the months of August – October in average years, and in May, July – October in dry years. Instream flow rights, although they have a late priority date, should be adequate in maintaining ample flows needed by salmonids and other aquatic species (see section 5.5.2.3).

ODF Key Supplemental Question(s): The OWEB Critical Questions sufficiently address ODF's concerns. Therefore, there are no ODF Key Supplemental Questions relating to hydrology and water use.

10.2.2.3 Riparian and Wetlands

OWEB Critical Question: What are the current conditions of the riparian areas in the watershed?

In terms of species composition, approximately two-thirds of the watershed riparian zones are dominated by mixed conifer-hardwood species. This "Mixed" forest type is characterized as a stand having ≤80% of the observed basal area in a single species, and is typified by the Douglas-fir and red alder community type in shifting proportions of co-dominance. Hardwood-dominated sites occur throughout the watershed, representing ~22% of all riparian acres, and 24% of ODF riparian zones. Conifer-dominated stands were less prevalent, representing only 13% of the riparian land area in the watershed (see section 6.1.5 – Riparian Vegetation Current Conditions).

OWEB Critical Question: How do the current conditions compare to those potentially present or typically present for this Ecoregion?

The majority of the riparian vegetation of the Wilson River watershed is in an early-mid successional state, with a mixed hardwood-conifer forest composition in varying degrees of co-dominance. The series of stand-replacement fires followed by multiple salvage logging events ending in the 1950s defined the current vegetation to a near complete stand-replacement in the uplands and riparian zones for the watershed as a whole.

The potential vegetation types of the Wilson River will likely include a mosaic of even-aged stands for many years, as the current stand structure matures, and mortality due to self-thinning (stem exclusion phase) carries through to the next growth cycle (10-30 years). These stand types differ from others that are characteristic of this Ecoregion for the primary reason that the large-scale disturbances were so complete in removal of older, established trees. The diversity of vertical structures is dramatically reduced in the current condition from the potentially multi-layered stand structure that existed prior to Euro-American settlement. See sections 3.2.2 – Vegetation and 6.1.5 – Riparian Vegetation Current Conditions.

OWEB Critical Question: How can the current riparian areas be grouped within the watershed to increase our understanding of what areas need protection and what the appropriate restoration/enhancement opportunities might be?

The current mapping efforts for the riparian zones followed a similar classification scheme for mapping upland vegetation, using a series of vegetation codes to estimate species mix, size class and stem density. These units were typically 1,500 feet long and 100 foot wide, and contained a range of patch diversity over a shifting longitudinal stream profile. The results indicated that this form of classification did not provide enough resolution for determining adequate placement for field sample sites to determine statistically sound and accurate stand composition and structure inventory data. As such, the classification scheme was beneficial for a watershed-level assessment to evaluate

stand compositional dynamics, shade, and LW recruitment at the broad scale. Additionally, the vegetation classifications – when overlayed with landslide/debris flow hazards – identified coarse-scale areas where large wood development/recruitment may benefit from stand treatments and where it may not.

In 2008, ODF will acquire high-resolution LiDAR data of the Wilson River watershed (and others), which contains a minimum of the bare earth and canopy height elevations for the watershed. These data can be used to further identify manageable units, suitable for site-specific treatments to enhance (at a minimum) conifer growth and establishment and increasing the potentials for LW recruitment in the time period beginning in ~2050 – 2100. These manageable units will likely be small in size (~1-2 acres) and should contain elements of topography (terraces, benches, usable slopes, etc), canopy characteristics, and vegetative composition in the mapping effort. This form of riparian mapping and management is different from traditional forestry mapping and operations at large scales, but allows for traditional on-the-ground patch-level treatment prescriptions and operations. See section 6.3.2 – Pathways for Management Action.

OWEB Critical Question: Where are the wetlands, ponds, and lakes in this watershed?

The highest concentration of wetlands is located in the Lower Wilson River subwatershed (~570 acres) located off of ODF Lands (see section 6.4 and Map 40).

OWEB Critical Question: What are the general characteristics of wetlands, ponds, and lakes in the watershed?

The major wetland types on ODF lands included freshwater forested and emergent wetland types. The overall condition of the wetlands and ponds within ODF lands is generally good; road influence may cause increased siltation in some areas, though there appears to be relatively intact riparian buffers available to slow sediment delivery. In areas where management has occurred near wetland areas, standing tree buffer areas appear to be present on ODF lands (see section 6.4).

OWEB Critical Question: What opportunities exist to restore wetlands in the watershed?

As part of a Best Management Practice, it is important to evaluate areas of potential emergent wetland environments and provide mechanisms of buffer enhancement to increase the success of wetland establishment. This is especially

true for lower gradient systems where beaver activity is observed. Accommodation of natural disturbance processes, such as beaver activity, provides the mechanisms necessary to create patch diversity of wetland communities. Minimizing recreational and other land-use impacts in these areas would increase the potential for wetland diversity in the watershed (see section 6.4).

ODF Key Supplemental Question: What are the current riparian vegetation characteristics on state forests lands within the watershed?

At the subwatershed scale (Figure 9 and Table 19), the distribution of ODF-managed riparian zones is highly biased toward mixed conifer/ hardwood types; mixed types ranged between ~48% and 73% of each subwatershed riparian areas. Hardwood dominated types were abundant (~20 – 49%) in all subwatersheds except Devils Lake Fork (7%) and the SF Wilson (16%) subwatersheds, where conifers were more prevalent (28 and 22% conifers, respectively). See section 6.1 – Riparian Composition and Structure.

ODF Key Supplemental Question: Which riparian areas currently have high, moderate, and low large wood input potential for key conifer pieces (>24-inch conifer)?

Because the riparian structure and composition is currently following an early-mid successional trend toward a stem-exclusion phase, a pulse of instream large wood (LW) is expected to be generated in the next 50 years from self-thinning mortality. This material is mostly hardwood, with few large pieces (>24 inches). In addition, the data suggest there are progressively fewer conifer trees that will be recruited to the canopy through time, and with a notable decline in conifer tree mortality (and recruitment to the stream channel) through time. Overall, the Wilson River riparian zones are not projected to provide key conifer wood that meets >24 inch standards under a non-managed scenario. The Devils Lake Fork and South Fork Wilson River subwatersheds are expected to attain the highest large conifer densities per 1,000 feet of stream channel, though these numbers are expected to remain under current ODFW benchmarks. See section 6.2 Potential Future Conditions.

ODF Key Supplemental Question: Which riparian areas will provide high large wood input potential for key conifer pieces under 50- and 100-year scenarios? Map these areas. Additionally, map areas of low and moderate wood input for each scenario.

The models run as part of this analysis and field observation suggest the canopy dynamics are currently in a 'stem exclusion' phase, where the overstory canopy is represented by small diameter trees in a period of growth stagnation from

competing canopy pressures. The long-term outlooks suggest a decline in the number of trees entering the canopy strata through time, and more importantly, the rate by which trees will enter the canopy strata. The latter is of particular importance as it indicates a long-term trend of current trees getting larger in diameter (an ODF priority), but less replacement of those larger trees from the younger size classes of today. Hence, as the fewer, larger trees die, there does not appear to be a replacement cohort for those large-diameter trees in the future. These combined observations strongly suggest the trajectory of the riparian zones in all subwatersheds will not meet the definitions of "mature forest conditions" (see section 6.2 Potential Future Conditions).

ODF Key Supplemental Question: Are there known concentrations of noxious weeds in the riparian areas? Where do these problem areas exist?

The presence of Scotch broom (*Cytisus scoparius*), garlic mustard (*Alliaria petiolata*) and Japanese knotweed (*Polygonium cuspidatum*), are of growing concern to the health of the watershed. Invasion vectors for these species include recreation, equipment use, roads, and imported material from infested areas (e.g., road fill). See section 6.5 – Noxious and Non-native Weed Species.

ODF Key Supplemental Question: To what extent do recreational activities impact riparian vegetation?

Results based on ODF's dispersed campsite database indicate that OHV impacts and unrestricted use of riparian areas have significant impacts on riparian vegetation. The two most frequently reported impacts were tree damage and soil compaction – both of which have direct and indirect impacts on riparian vegetation health (see section 6.7 – Recreational Impacts on Riparian Vegetation – Direct and Indirect Effects).

10.2.2.4 Sediment Sources

Sediment sources questions and answers have been broken down into four distinct categories: general questions, non-road-related questions, road-related questions, and recreation-related questions.

10.2.2.1.1 General Questions

OWEB Critical Question: What are the current sediment sources in the watershed and their relative significance?

The primary sources of sediment in the watershed are shallow-rapid landslides, debris flows triggered by shallow-rapid landslides, roads, and off-highway-vehicle trails. The effects and significance of these sources differ with process. Landslides and debris flows are natural events important to ecological processes

in the watershed, but management-related increases in landslide rate and reductions in large wood available for recruitment to channels by landslides and debris flows have severe and cumulative detrimental effects to the watershed ecosystem. The watershed is recovering from increased rates of landsliding and reduced rates of landslide-carried wood delivery following extensive fires, salvages logging, and timber harvest in landslide-prone areas over the past century. The slow rate of tree growth will cause landslide and debris-flow delivery of large wood to channels to be persistently reduced from natural rates well beyond the next century. Roads and off-highway-vehicle trails are not natural features: both contribute fine sediment and roads are a source of landslides. Although site-specific inputs have significant local effects, overall these are not significant sources of sediment in the watershed.

OWEB Critical Question: Are any new sources of sediment anticipated in the watershed?

No.

OWEB Critical Question: Where are erosion problems most severe and qualify as high priority for remedying conditions in the watershed?

The lack of large wood in debris flow source areas and runout corridors poses the most severe problem associated with erosional processes in this basin.

10.2.2.1.2 Non-Road-Related Questions

ODF Key Supplemental Question: What is the distribution of slopes prone to shallow, rapidly moving landslides on state forest lands within the watershed?

All slopes in this basin exceeding 60% are subject to shallow, rapidly moving landslides. They are ubiquitous, but less common in the eastern portion of the basin, in the eastern Lower Devils Lake Fork and the South Fork of the Wilson. These are discussed in Chapter 7 and shown in Map 33.

ODF Key Supplemental Question: What is the distribution of debris flow-prone channels on state forest lands within the watershed?

All Type N channels with upslope debris flow source areas are debris-flow prone. They are ubiquitous throughout the watershed, although found in lesser quantities in the eastern portion of Lower Devils Lake Fork and the South Fork Wilson. Debris-flow-prone Type N channels are identified and ranked in Map 29 (section 7.2.2.1) and the Type F channels that receive these debris flows are identified in Map 26 (section 7.2.2.2). Debris flows may also contribute to formation of destructive debris-laden floods through Type F channels; channels

most likely to experience debris-laden floods are identified in Map 28 (section 7.2.2.3).

ODF Key Supplemental Question: Are there locations with gullies or other active surface erosion areas in the watershed?

Gullies and extensive surface erosion do not form under typical conditions in the watershed. Activities that compact soil or processes that reduce soil permeability, such as wild fire, can trigger development of gullies and active surface erosion.

ODF Key Supplemental Question: Are there deep-seated, actively or recently actively moving landslides?

Small to moderate deep-seated landslides do occur in the watershed (on steep and planar slopes) and do contribute to road damage and production of sediment to stream channels. There have been an insufficient number of these landslides to characterize their sensitivity to management activities, but their deeper depth suggests that loss of root strength from forest cover is not a contributing factor. At times, these landslides can be major sources of sediment to channels and valley floors.. At present they are unpredictable and should be considered part of the natural (background) disturbance regime (see section 7.3 – Deep-seated Landslides).

ODF Key Supplemental Question: Are there any unusually erosion prone soils on steep slopes in the watershed?

Surface erosion in undisturbed (i.e., non compacted) forested soils is negligible because soil infiltration capacity typically exceeds precipitation intensity (Harr 1977) and soil compaction is minimal outside of roads and landings.

10.2.2.1.3 Road-Related Questions

ODF Key Supplemental Question: What portion of the road network is located in critical locations?

Approximately 20% of the road network is found in locations classified as "critical" (see section 7.4 – Road-Related Issues).

ODF Key Supplemental Question: What is the washout risk of roads within the watershed? Are road washouts present?

Along open roads ~46% of stream crossings are considered Low Washout potential; ~44% Moderate; and ~10% High. Along blocked roads ~42% of stream crossings are considered Low Washout Potential; ~16% Moderate: 15% High; and ~27% were washed out (see section 7.4.6.2 – Washout Risks).

ODF Key Supplemental Question: What proportion of the road system is hydrologically connected to streams?

Approximately 16% of the open road system is hydrologically connected while ~10% of the blocked roads are hydrologically connected (see sections 7.4.3 – Hydrologic Connectivity and 7.4.7 – Reducing Hydrologic Connectivity at Stream Crossings). However, the December 2007 storm event likely changed the hydrologic connectivity of some roads. A census of some of the areas we identified as suspect could help determine what proportion the hydrologic connectivity status of the road system has changed, if any.

ODF Key Supplemental Question: What are the surface drainage conditions of the roads?

Surface drainage is best reported in conjunction with hydrologic connectivity and prism stability to determine short term risk to the watershed. We found that 30 miles, or ~5% of the total roads in the Wilson River watershed, are actively delivering sediment to streams. Of those 30 miles, 16 miles, or 53% of the delivering total originates from blocked roads, while 14 miles, or 47% originates from open roads (see sections 7.4.3 through 7.4.11).

ODF Key Supplemental Question: What is the condition of the road prism?

Prism ratings categorize the extent to which a landslide or erosion is affecting a road prism. Approximately 10.5% of the open roads have significant blocking by landslides or erosion (Prism Stability Codes 1-3). Blocked roads have nearly 23% of the total rated as Stability Code 1-3 (see section 7.4.5 – Prism Stability).

10.2.2.1.4 Recreation-Related Questions

ODF Key Supplemental Question: To what extent do OHV trails and other recreational activities impact stream sedimentation?

Sedimentation is most acute where eroding trails intersect adjacent streams or road drainage systems linked to streams. Results from a field survey indicate that approximately 2.0 acres per mile are disturbed and 1,157 cubic yards of soil loss per mile of OHV trail. Where ODF has placed and maintained drainage features on designated trails, the sediment is successfully being diverted to the forest, but on unmaintained hydrologically connected trails, sediments can/are flowing directly into road drainage systems and streams (see section 7.5 – Recreation-Related Issues).

ODF Key Supplemental Question: What portion of the recreational trail network is located next to streams?

Of the OHV trails surveyed (42.7 total miles or about 28% of the total trail system), 2.1% ran parallel to streams. Data were unavailable for determining the percentage of other unsurveyed user-created trails that were parallel to streams. More accurate figures, therefore, were not available (see sections 7.5.1 – Off-Highway Vehicle Trails and 7.5.4 – Hydrologically Connected Trails). Because the exact number of OHV trails in the basin are unknown, this may not be a representative sample of the whole designated and undesignated trail network.

ODF Key Supplemental Question: What is the washout risk of recreational trails within the watershed? Are trail washouts present?

Of the trail-stream intersections that have no mitigating trail drainage engineering, bridging, and/or that exhibit trail grade/slope alignment in excess of trail standard maximums, almost half (of the surveyed trail-stream crossings) were found to have "high" or "moderate" washout potential. Additionally, 3.11 miles of sampled trails were found to have Prism Stability Priority Codes of 1-3 (Map 56; see section 7.5.7 – Recreational Trail Washout Risk).

ODF Key Supplemental Question: What proportion of the trail system is hydrologically connected to streams?

Of the OHV trails surveyed (42.7 miles; ~28% of the total trail system), 2.1% are hydrologically connected, indicating that about 7.3% of the total trail system (an estimated 150 total trail miles) is hydrologically connected (Map 55). Data were unavailable for determining the percentage of other unsurveyed user-created trails that were connected to streams. More accurate figures, therefore, are not available (see sections 7.5.1 – Off-Highway Vehicle Trails and 7.5.4 – Hydrologically Connected Trails). Because the exact number of OHV trails in the basin are unknown, this may not be a representative sample of the whole designated and undesignated trail network.

ODF Key Supplemental Question: What is the erosion condition of the trails?

Sedimentation is most acute where eroding trails intersect adjacent streams or road drainage systems linked to streams. Results from a field survey indicate that approximately 2.0 acres per mile are disturbed and 1,157 cubic yards of soil loss per mile of OHV trail. Where ODF has placed and maintained drainage features on designated trails, the sediment is successfully being diverted to the forest, but on unmaintained hydrologically connected trails, sediments can/are flowing into drainages (see sections 7.5.5 and 7.5.7). Additionally, the field assessment of trails found more highly eroding and hydrologically connected trails than were identified by the Duck Creek Associates survey, suggesting a greater degree of erosion than what was indicated in the road condition survey (see section 7.5.5 – Trail Erosion Condition).

10.2.2.5 Water Quality

OWEB Critical Question: What are the water quality criteria that apply to the stream reaches?

Dissolved Oxygen limited from river mile 3.5 to 10.1 (Highway 101 to the confluence with Little North Fork) from September 15 - May 31 and from river mile 5.8 to 27.2 (approximately 4 miles downstream of the confluence with Little North Fork up to Lee's Camp) from September 1 - June 15 (Table 55; see section 8.2 – Water Quality Criteria, Limited Sections, and Status).

OWEB Critical Question: Are the stream reaches identified as water quality limited segments on the 303(d) list by the state?

Yes. From river mile 3.5 to 10.1 was listed in 2002 and from river mile 5.8 to 27.2 was listed in 2006 (Table 55; see section 8.2 – Water Quality Criteria, Limited Sections, and Status).

OWEB Critical Question: Do water quality studies or evaluations indicate that water quality has been degraded or is limiting the beneficial uses?

Since 2001, water quality in the Wilson has improved for the temperature, nitrogen, and bacteria criteria while the dissolved oxygen criteria was extended further upstream between the 2002 and 2006 water quality assessments. Temperature and bacterial contamination issues were addressed as part of the Tillamook Bay Watershed Total Maximum Daily Load (TMDL), completed by the Oregon Department of Environmental Quality (ODEQ 2001; see section 8.2 – Water Quality Criteria, Limited Sections, and Status).

ODF Key Supplemental Question: What stream temperatures are reasonably achievable under natural conditions, given climatic and geologic constraints?

The final model for predicting reasonably achievable stream temperatures included the following variables: effective shade, solar radiation, streamflow index, and air temperature. Modeled stream temperatures are presented in section 8.4 – Stream Temperatures, Reasonable Achievable and Compared to Potential Levels and Appendix V – Longitudinal T_{max} Profiles for all Principal Streams.

ODF Key Supplemental Question: How do the current shade levels along streams compare to historic levels by sub-watershed and stream size?

Current shade levels are predicted to increase for approximately the next 50 years, followed by a decrease that mirrors the projected decrease in riparian canopy cover (see sections 8.3 – Stream Shading and 6.2 – Potential Future Conditions).

ODF Key Supplemental Question: How do the current stream temperature levels compare to historic levels by sub-watershed and stream size?

The riparian shade and water temperature analysis conducted as part of this project focused on current and projected future conditions. However, given that past (pre-fire) riparian conditions likely included mature conifer stands (see discussion above), it is likely that current stream temperatures are elevated above historic levels (see section 8.4 – Stream Temperatures, Reasonable Achievable and Compared to Potential Levels).

ODF Key Supplemental Question: How do water temperatures compare to other nearby basins with similar flows and geology?

The only other nearby river basin with similar flow and geology is the Trask River watershed. Results from a one-tailed t-test comparing temperatures in the Trask and Wilson rivers indicate that temperatures in the Trask River are approximately 2 degrees Fahrenheit cooler than in the Wilson ($p < 0.001$; see section 8.5 – Stream Temperature Comparison with Adjacent Basins).

ODF Key Supplemental Question: Which specific dispersed recreation sites adversely affect water quality?

Results from 1) an analysis of ODF's dispersed campsite inventory and 2) an additional field sample of sites indicate that 33 dispersed recreation sites are located within 25 feet of a stream and 19 sites were rated as producing streamside damage (Table 25 in section 6.7.2.1 – Dispersed Campsite Inventory Data). Of the 18 sites visited during a field assessment, 13 were located within 10 feet of the high water mark of a stream, 3 were within 20-50 feet of a stream and observations of human impacts included direct erosion to the stream channel or wetlands, site-level tree mortality, severe compaction, and multiple user-defined trails to the stream channel (see Table 26 in section 6.7.2.2 – Field Sample of Dispersed Campsites; also see Appendix B – Photographic Plates, plate numbers 9-13, and sections 7.5.10 – High Priority Dispersed Camping Sites and 7.5.12.4 – Dispersed campsite upgrades).

10.2.2.6 Fish and Fish Habitat

OWEB Critical Question: What fish species are documented in the watershed? Are any of these currently state- or federally listed as endangered, threatened or candidate species? Are there any fish species that historically occurred in the watershed that no longer occur there?

Six salmonids (steelhead trout, cutthroat trout, Chinook, chum, pink[103] and coho salmon), three species of lamprey (Pacific, river, Western brook lamprey), two species of sturgeon (Green and White sturgeon), and several species of non-game fish have either been documented in, or – where records are lacking – are presumed to inhabit[104] the Wilson River watershed. No species are currently Federally- or State- listed as *Threatened* or *Endangered* (several are, however, Federally-listed as *Species of Concern* or State-listed as *Sensitive* and *Critical* or *Vulnerable*; see Table 63 in section 9.2 – Species, Listings, and Extinctions). There are no species that historically occurred in the Wilson River watershed but are no longer found there

OWEB Critical Question: What is the distribution, relative abundance and population status of salmonid species in the watershed?

Salmonids are distributed throughout each of the Wilson River subwatersheds. In general, cutthroat trout have the largest distribution while chum salmon have the narrowest. Additionally, there is substantial intra-annual variation in their distributions, based largely upon respective life history differences. Adult abundance (spawner) estimates have fluctuated considerably in the years since records were first kept and, with the exception of fall Chinook salmon, have exhibited declines. The salmonid population status' have not changed since the 2001 assessment (E&S Environmental Chemistry) but the recent population trends (e.g., <15 years) has. Refer to sections 9.5 through 9.9.

OWEB Critical Question: Which salmonid species are native to the watershed, and which have been introduced to the watershed?

With the exception of summer steelhead, all salmonids found in the Wilson River watershed are native to it (see section 9.3 – Native and Introduced Salmonids).

OWEB Critical Question: Are there potential interactions between native and introduced species?

Summer steelhead trout are currently the only introduced salmonid known to inhabit the watershed. They are, however, reportedly not naturally reproducing (see footnote #89). Given their presence in the system and the similarity of their habitat/food preferences to other native salmonids, it is likely that summer steelhead are negatively interacting with native salmonids (e.g., occupying habitat, consuming food resources, behavioral interactions) but the extent and severity is unknown (see section 9.4 – Native/Introduced Species Interactions).

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[103] Juvenile pink salmon were documented in a smolt trap on the Little North Fork Wilson in 2003. Dave Plawman (ODFW-Tillamook Fish Biologist), personal communication, July 12, 2007.
[104] Based upon geographic species distributions and/or documented presence in nearby river systems.

OWEB Critical Question: What is the condition of the fish habitat in the watershed (by subwatershed) in relation to Proper Functioning Condition targets or baselines?

Subwatersheds were rated relative to the condition in ODFW-established "reference/benchmark" reaches. Of the eight subwatersheds in the Wilson River, one was rated as being in GOOD condition (Little North Fork Wilson), three were rated as being in MODERATE condition (Middle Wilson, Upper Wilson/Cedar Creek, South Fork Wilson), two were rated as being in POOR condition (Devils Lake Fork and North Fork Wilson), one was rated as being in VERY POOR condition (Jordan Creek) and one was not rated (Lower Wilson) due to sample size issues with the data (see section 9.10 – Fish Habitat Condition).

ODF Key Supplemental Question: What are the levels of in-channel key pieces of large wood (>24-inch conifer) in the watershed?

Levels of instream key pieces of large wood in Wilson River subwatersheds are generally very LOW (<0.5 pieces/mile); 47% of the total stream reaches surveyed had a LOW number of key pieces of instream large wood. Only the Jordan Creek and South Fork Wilson subwatersheds had any reaches that had a HIGH (>3.0 pieces/mile; 1 and 7 reaches, respectively) number of key pieces of instream large wood (8% of the total stream reaches surveyed; see section 9.11 – Instream Large Wood).

ODF Key Supplemental Question: If splash-damming occurred in this watershed, are the effects still apparent?

Splash-damming is not known to have occurred in the Wilson River watershed. Log drives, however, were known to occur. The effects, however, have not been well mapped and, to a large degree, are likely to have recovered or in the process of recovery (see section 4.8 – Historic Channel Disturbances and 9.12 – Splash-Damming and Effects).

ODF Key Supplemental Question: What is the distribution of fish species, by life stage, in the watershed?

Existing data layers for the Wilson River do not specify the distribution of salmonids by life stage. Rather, they specify whether a particular species use is for 1) spawning and migration or 2) rearing and migration. The vast majority of each species distributions within the Wilson fall into the spawning and rearing use category (see Maps 5-8 and section 9.6 – Current Salmonid Distributions).

ODF Key Supplemental Question: What is the estimated historical fish presence?

Information pertaining to their distribution at the time of European settlement through the early 1900's, however, is virtually non-existent. Recognizing this, the Oregon Department of Fish and Wildlife (ODFW) conducted an analysis to identify areas above current fish distributions that could have potentially supported salmon/steelhead in the past (Kavanagh et al. 2005). Although somewhat speculative in nature, the results indicate that historic salmon distributions may have been similar to their present distributions[105] (see section 9.5 – Historic Salmonid Distribution).

ODF Key Supplemental Question: How many miles of fish-bearing or potentially fish-bearing streams are blocked by culverts, and where are these blockages?

There are an estimated 24.6 miles (or 7.8% of the total miles [313] of designated fish habitat in the Wilson) of *potential* fish habitat that are blocked by impassable culverts (see Table 78 in section 9.13 – Fish Passage Barriers). Of the total percent blocked by culverts(7.8%), 4.6% are effective adult salmonid barriers and 3.3% are only barriers to juvenile salmonid movement. For a detailed list of the road location of these barriers, refer to Appendix Q – Fish Barriers).

10.3 Management Considerations

10.3.1 General

The Wilson River watershed is prone to periodic, large-scale disturbances. Large storm events lead to flooding and landsliding, resulting in debris-flows and torrents. Historic catastrophic fires with long fire-return intervals, combined with periodic storm events, historically recruited large wood and sediments to the system creating a rich, diverse freshwater habitat. Since European settlement, the watershed has been exposed to a variety of human-influenced events including frequent forest fires, creation of a dense network of forest roads, increasing forest recreation use and intense timber harvest.

It is important to consider that the riparian ecosystem has essentially been reset to an early-successional, even-aged, hardwood-dominated forest which modeling exercises predict, in the absence of management, is likely to persist for 100+ years. Furthermore, the Wilson has abundant steep, landslide-prone slopes and steep, mainstem channels that often confined and highly sensitive to management activities. For example, road building on steep slopes may lead to road failure

[105] See maps 17 and 18 in Kavanagh et al. 2005.

and increased sedimentation to fish-bearing streams. Additionally, dispersed recreational trails on erosion-prone steep slopes that are hydrologically connected can dramatically increase sediment loading. While landsliding and debris-flows deliver sediments and large wood that is beneficial as aquatic habitat, increased fine sediments can inhibit survival of salmonid eggs and decrease the amount of available spawning gravel. Given that salmonid populations are depressed compared to historic levels and recent return rates are highly variable, management actions influencing these areas should be carefully considered.

While the road system in the Wilson is dense and some human-influenced barriers to fish movement exist, improvements to the existing infrastructure and well-designed new roads have largely eliminated sedimentation and fish passage issues. ODF-managed lands in the Wilson are currently being (or are attempting to be) managed to effectively address key issues influencing water quality and aquatic life. Additionally, continuation of current projects that address sedimentation and fish passage issues will help the watershed (e.g., speed up) continue its process of recovery.

Hydrologically, the Wilson has recovered from the Tillamook Burns evidenced by modeled low and peak flows that are ≤3% of baseline flows. Water quality issues (e.g., low dissolved oxygen, high stream temperatures, localized sedimentation), however, are still present during some portions of the year and streamside roads, chronic recreation-related impacts, and projected decreases in shade (under a "no management" scenario) are likely to continue to degrade water quality.

Sedimentation in the Wilson has been of considerable concern, especially after the Tillamook Burns and subsequent logging and road-building activities. However, current sediment sources from landsliding and debris flows should be considered at or near (e.g., slightly elevated) background levels as aerial and field surveys indicate that these types of disturbances were occurring in the Wilson prior to European settlement. This watershed analysis, however, has identified road segments that are actively eroding to streams that might increase sedimentation above background levels.

Riparian areas in the Wilson were essentially "reset" during the Tillamook Burns and are in an early seral stage (early recovery). This is evidenced by a general lack of large diameter trees and a relatively uniform age structure. Additionally, modeling results indicate that in the absence of active management, current riparian conditions are likely to persist into the foreseeable future (e.g., >100 years). Furthermore, few trees are projected to recruit to the larger diameter size classes, resulting in a lack of large wood recruiting to streams. Silvicultural prescriptions designed to encourage the production and recruitment of large

conifers may help speed the recovery of both riparian and aquatic habitat condition.

Recreational activities in the Wilson have been occurring since settlement but large-scale activities (e.g., OHV riding and camping) are relatively recent and increasing at a rapid rate. Sedimentation and streamside shading impacts are of the greatest concern and are severe in some areas. The extent to which these activities are occurring throughout the watershed is not fully known but year-round use levels are considered chronic (as opposed to episodic) and will likely remain high.

From an aquatic habitat standpoint, the Wilson is still largely experiencing the legacy effects of past management practices evidenced by the lack of instream large wood, pools (including deep pools) and relatively low channel habitat complexity. While aquatic habitat conditions in the Wilson are recovering, three of the eight subwatersheds received a MODERATE to GOOD proper functioning condition rating but four of the subwatersheds are in POOR or VERY POOR condition. Even though modeling exercises predict large wood will recruitment to the streams at very low levels over the next 100+ years, accumulations of wood (and gravels) from natural landsliding and debris flows may help the system recover aquatic habitat complexity faster than predicted.

For specific management recommendations, refer to sections 10.3 – 10.8, below.

10.3.2 Data

The current riparian dataset for the watershed provides a broad and detailed view of the composition and structural attributes organized at the subwatershed scale. However, it does not provide the level of detail required to design or organize *site-specific* silvicultural prescriptions. This is primarily due to the inherently patchy nature of the riparian zones and extreme heterogeneity within riparian stands. Despite this, the combined field-collected and photo-interpreted stand data provide a basis for identifying candidate stands for silvicultural treatments that produce large wood. The best resource for assessing any given stand for both large-wood potential and the best silvicultural approach is the field forester. We have identified areas that appear to have a high potential (at the coarse scale) for developing large wood (Map 63). These areas can be considered a “list” of potential sites that require evaluation by a professional forester.

The current road dataset provides a comprehensive and detailed snapshot of current conditions in the Wilson (winter 2006). Additionally, it is a robust dataset that may be analyzed to identify the number and location of stream crossings that have a high potential for washing out and blocking fish passage. The dataset also provides information on the location of roads that actively erode sediment to

streams. Storm events can change conditions on the ground, so managers should inspect stream crossings and areas of high erosion potential after such events.

Although ODF has some current recreation data which was used for general site condition summaries, it is insufficient to draw strong conclusions about the overall condition or priority status of recreational sites in the Wilson. We recommend that future surveys include current and established recreational assessment methodologies, such as the US Forest Service campsite and trail condition assessment protocols (as outlined in section 7.5.12.1 General Recommendations) based on current standards (e.g., Glidden 2005, Marion 2004, Cole 1989). Additionally, we recommend that ODF conduct a comprehensive survey of all recreational trails (including undesignated trails) in the Wilson as it would allow managers to better identify problem areas.

NetMap, utilized extensively in this watershed analysis, is a computer software program consisting of a set of analysis tools used to address the type, abundance, and spatial distribution of riverine habitats, degree of habitat diversity and disturbance potential, sources of erosion and sedimentation and sensitivity to land uses. Although this analysis was comprehensive, one of the drawbacks was the use of coarse 10-m DEMs to conduct all of the topographical and slope-stability analyses. A NetMap-based analysis using LiDAR data would allow for finer-scale analyses thereby increasing the confidence and conclusions of the overall assessment. Additionally, the DHSVM hydrology model used for this analysis is robust and well-established, the use of LiDAR data would also allow for finer-scale analyses at the watershed level.

Using recent fish abundance data coupled with modeled habitat predictions (using NetMap) allowed us to prioritize stream segments for protection and restoration. However, only one year of fish abundance data was available at the time of this analysis. Using data from multiple years would allow for more reliable ranking of key stream reaches. Additionally, given the lack of historic abundance data (e.g., pre-1930), estimates are somewhat speculative in nature. While salmonids are often the species of interest, non-salmonids also play a key role in the proper functioning of aquatic ecosystems. However, no data pertaining to non-salmonid species distributions and abundance exists.

10.3.3 Stream Channel and Channel Modification

Few human-caused channel modifications exist on ODF lands within the Wilson River watershed, and those that are present are due to legacy practices. Management recommendations for ODF lands should include inspecting the few existing areas of canyon and channel fill that have been identified from the road surveys to determine if vacating these road segments is feasible. Additionally,

ODF should continue the current trend of locating roads away from channels and channel migration zones.

10.3.4 Hydrology and Water Use

Post-fire restoration of upland and riparian stands within the Wilson River watershed, combined with the inherent resiliency of rain-dominated forests to vegetation-related hydrologic change, results in few concerns over management-related impacts to either peak or base flows within the area. Road drainage networks are for the most part disconnected from the stream network, further reducing the likelihood of management-related flow impacts. Hydrology-related management recommendations for ODF lands include continuing to add cross-drain filters to further limit hydrologic connectivity to streams. The DHSVM (or similar model) could be run at the sixth-field subwatershed scale to evaluate the effects of proposed management actions if necessary.

The relatively low levels of water withdrawals within the Wilson River watershed have resulted in little concern that present consumptive uses significantly impact aquatic species on ODF lands. Potential future increases in population and urban development could, through restrictions on water uses, alter ODF's management practices.

10.3.5 Riparian and Wetlands

10.3.5.1 Riparian Enhancement Opportunities

10.3.5.1.1 Changes to Successional Dynamics: Large Wood and Shade Enhancement

Given the majority of the riparian zones exhibit high proportions of hardwood species, and that the successional changes predicted in the 100-year time frame do not indicate any substantial shifts in species composition through time, the riparian zones are likely to remain predominantly hardwood dominated for the foreseeable future. At the subwatershed scale, the current trajectories indicate a pulse of tree mortality, followed by a lag where mortality declines and mid-sized trees are not recruited to the canopy. This lag period trajectory appears to extend beyond the 100-year timeframe, assuming a no-management scenario. This has direct implications that limit the potential for instream LW recruitment and stream shading.

While the data were insufficient for writing site-specific prescriptions, the vegetation classification – when overlayed with landslide/debris flow hazards in a GIS – allowed coarse-scale areas to be identified where treatments encourage the development of large wood and conifers. Additionally, the incoming LiDAR information will make it possible to create a finer-scale map of 'manageable units', or areas where patch-level treatments can be made to maximize benefit to

the stream system (shade and LW). The current trajectory benchmarks presented in the Riparian Vegetation Dynamics: "No Management" Scenario section (6.2.1) can be used as a basis for comparison to design site-level treatments and evaluate the effects to LW recruitment and shade (using additional modeling tools) as well as provide the site-level metrics for monitoring the effectiveness of the treatments. Future *Action Plan* treatments should focus on improving regeneration and recruitment to the canopy (≥14 inches DBH), favoring conifers where appropriate at the site-level, focusing on areas of the riparian zone that have high potentials for interaction with the stream channel, and where silvicultural operations will have the lowest impact, identifying terraces as primary locations, and using LiDAR data and ground-truthing. Future *Action Plans* should also include selecting treatment sizes that take advantage of the patch sizes inherent in the riparian zones. Treatments should be distributed along reaches to monitor the *reach-level* responses to LW and stream shading and incorporate enough land area to observe responses and provide the desired number of trees to engage the stream channel through time. We also recommend that ODF pair treatment reaches with similar reference reaches in the watershed (e.g., similar hydrology and morphologies, stand successional projections (no-management), and fisheries potentials) and monitor and evaluate treatment trajectories with reference trajectories using growth modeling tools, mortality estimates, projected LW recruitment, and stream shading potentials (as presented in this analysis). Finally, ODF should compare and contrast trajectories of each reach to evaluate if benchmarks are being met, and if the successional dynamics are improving toward the desired future condition.

10.3.5.1.2 Abatement of Invasive Weed Species

Perhaps the most critical and immediate action item for riparian areas in the Wilson River watershed is the immediate treatment and isolation of the Japanese knotweed at the Idiot Creek bridge. The positioning of this patch at the upper reaches of the watershed is of major concern, as knotweed propagates downstream following scouring and hydrologic disturbance patterns (pulses and floods). Treatment options to consider include pruning and chemical applications that target the rhizome system. Often multiple applications/ treatments over multiple years are required for success. Ground disturbances should be minimized to avoid spreading rhizomes to other reaches.

It is highly recommended that monitoring for weed species be incorporated into road surveys, stream surveys, and as stand-alone exercises to identify, map and eradicate non-native plant species from the system. Monitoring and treatment of the garlic mustard infestation in Gales Creek (outside the watershed) will minimize the chances that garlic mustard spread to the watershed.

To be effective, eradication of knotweed and other non-native species requires collaboration with other agencies and landowners. Development of BMPs with recreation groups and users can be effective in limiting the spread of weed species. Installation of wash stations at trailheads and outreach with the user groups to ensure their equipment does not act as vectors for spread, as well as limiting the ground disturbance by OHVs in and around infected areas are methods that can minimize the spread of these weed species.

10.3.5.1.3 Wetland Enhancement

Recreational impacts on the wetland environment, including OHV use and dispersed campsites, are potential avenues for decline in wetland abundance, water quality, size, and health. Development of BMPs that restrict uses in the near-wetland environment (within ~100 ft) will likely result in improved wetland buffer health. A 100 foot buffer area is recommended, as this corresponds to an approximate tree height; compaction and soil disturbance from OHVs and camping outside of this area will likely not contribute to buffer decline.

Though beaver activity can cause problems for certain forms of infrastructure, their presence is vital in the creation of new wetland areas, especially in the low-gradient systems found in Devils Lake Fork subwatershed. Allowing beaver to persist will likely result in increased wetland areas in many areas of the watershed, providing water storage capacity and improved fisheries habitats.

10.3.5.2 Recreation-related Effects

OHVs and dispersed campsite users present a high risk of introducing and spreading invasive species (e.g., plants, fungi, pathogens), especially where use is concentrated in the flood zone (e.g., where garlic mustard and knotweed are at the highest risk of spreading).

Tree removal, damage and loss of reproductive capacity in inner riparian zones from recreational impacts on shade, tree canopy and large wood (LW) recruitment are localized and occur at relatively small scales. Long-term implications, however, need to be assessed as they have the potential to become even more of a problem for ODF if user behavior and expectations of tolerance of current impacts keep shaping attitudes to resources.

Although relatively localized, human waste, garbage and other camp related impacts on water quality need to be addressed while the costs of camp closure, restoration, cleanup and upgrading need to be recovered from the users, probably through an overnight fee/permit program.

OHV and recreational impacts to wetlands areas are growing concern and the 25 foot buffer rule (e.g., exclusion) has not been consistently applied. Therefore, we

recommend that recreational sites be set back from wetlands between 100-200 feet, consistent with the distances established in the literature. Additionally, at sites where instream large wood recruitment is limited (or limiting), ODF may want to consider relocating/moving campsites in these areas to beyond 100 feet from the stream.

A user education/involvement program will need to be applied in conjunction with an array of alternative solutions to eliminate or curtail the negative impacts identified in this study. ODF has begun this effort along a tributary of the Wilson at Browns Camp by posting signs. Such information needs to be included in all communications with users (camp hosts, event registration, websites and trail head sign boards, etc). However, heavy duty barriers, trail and camp relocation and revegetation actions need signs to improve user understanding. Unfortunately, a significant number of users disregard signs or circumnavigate barriers unless they are both robust and well maintained.

10.3.6 Instream Large Wood Recruitment, Debris Flows and Landsliding

The topography and climate of the Wilson Basin drive an erosion regime characterized by punctuated, storm-driven episodes of sediment production and transport. Shallow, rapid landslides are the primary mechanism for movement of sediment from hillslopes to stream channels. Landslides into small, headwater channels form deposits that restrict fluvial (water carried) transport, so that these small channels serve as storage reservoirs for sediment and wood, until scoured by a long-runout debris flow that can carry material to fish-bearing channels downstream.

Several factors link these processes of sediment production and transport to forest cover in the basin: landslide susceptibility is increased for a period of a decade or more after loss of forest cover, the volume of sediment stored in headwater channels is affected by the size and abundance of woody material in these channels, and incorporation of large wood into debris flows may limit runout length. Hence, management actions that alter the spatial distribution of stand types and the subsequent recruitment of large wood to headwater channels can alter the rate and location of sediment production and delivery within the basin. Strategic use of upslope leave areas in landslide source zones and riparian buffers on Type N channels may work to minimize management influences on rates of sediment production by landsliding. We have used empirical models of landslide initiation and debris-flow runout to identify and rank likely source areas for landslides and debris flows that will affect fish-bearing streams. These maps and GIS data files can be used to distinguish sites where leave areas and buffers are and are not likely to aid in reducing management impacts to the fish-bearing channel network.

Because they are subject to increased rates of blowdown, which may also contribute to shallow landsliding, the effectiveness of leave areas and buffers in mitigating management-related increases in landslide rate is not fully determined. It is important to recognize, however, that both serve other important functions: in particular, they can ensure a source of large wood to small headwater channels that act both to restrict fluvial transport of sediment and to provide a source of debris-flow-transported wood to downstream fish-bearing channels. Debris-flow deposits in fish-bearing channels are an important component of the Wilson River channel and riparian environment, and the ecological benefits provided by these deposits are heavily dependent on inclusion of large wood. Upslope leave areas and riparian buffers on debris-flow-prone Type N channels can be placed to ensure that debris flows delivering to reaches with high habitat value carry large woody material. We have ranked Type F channels in terms of current and potential future habitat value and identified the landslide source areas and debris-flow-prone Type N channels that serve as debris flow corridors to these channels.

Disturbance history in the basin has left the majority of riparian stands along Type F channels in predominantly early and mid seral vegetation types. Hence, these channels, for the most part, lack riparian sources of large wood, with key pieces (> 24 in diameter) in particularly short supply. Debris flows may serve as a primary source of large wood to many Type F channels well into the next century, assuming large wood sources exist in debris-flow source areas. Efforts to protect and enhance the growth of large conifer trees in these upslope and Type N source areas will increase availability of large wood to these reaches. Conversely, debris-flow delivered sediment and wood also poses a serious risk to downstream resources, particularly for channels large enough for flood flows to transport these materials. Topography and climate render channels throughout this basin sensitive to landsliding triggered by storm events. This is a natural process, and it is essential that management planning identify sites subject to destructive debris flows and debris-laden floods. At the same time, these processes are integral to creation of habitat features to which the ecosystem of this basin is adapted; to protect the fisheries and other resources provided by this ecosystem it is equally essential that management planning seek to minimize alterations of natural sediment and wood delivery rates. The analyses presented here provide guidelines to direct the location and type of conservation and restoration actions that should be effective, but it is also important to recognize that predictions of future occurrences (e.g., where landslides will occur) are hypotheses waiting to be tested.

10.3.7 Sediment Sources

10.3.7.1 Non-Road Related

The Wilson River is, overall, a system sensitive to disturbance. It has abundant steep, landslide-prone slopes and steep, often confined mainstem channels. The uniform stand structure across the basin, with a very low abundance of large trees, exacerbates this condition: sources of large wood that would aid recovery from disturbance don't exist. Streams subject to debris-laden floods generally also have low riparian wood recruitment and high value for fish. A big storm could hit these hard (as happened in 1996 and December 2007) no matter what management actions occur. Efforts to reduce upstream debris flow occurrence to these reaches could be beneficial, but pretty much involve the entire watershed. Most beneficial may be efforts to ensure opportunities for recovery; i.e., maintain and enhance riparian and upslope sources of wood through the sensitive reaches.

10.3.7.2 Road Related

Roads in the watershed are performing well in terms of limiting hydrologic connectivity, prism stability, and limiting the length of roads on critical locations like steep slopes and those with cut and fill slope slides. Even though hydrologic connection is low compared to other watersheds, problems exist in terms of active sediment loading to creeks. This is most pronounced on blocked roads that are not routinely maintained.

Many stream crossings pose a short-term risk to the watershed's aquatic resources and have been identified as having a high washout potential. When stream crossings fail and are washed-out, fine sediments may be loaded into creeks imperiling critical salmon habitat. In light of the storms that swept through the Oregon coastal regions in 2006 and 2007, and the number of wash-outs that occurred as a result of those storms, the stream crossings that have a high washout potential are now considered extremely vulnerable and have been prioritized for inspection and repair. Similarly, many stream crossings were also identified as being potential blocks to fish passages. Although the number of stream miles cut-off by these potential blocks is relatively small compared to the overall amount of fish habitat, it remains extremely important to inspect and repair these potential blocks.

As stated previously, hydrologic connectivity is relatively low in the watershed. This fact is primarily a result of proper road engineering. The State has done an excellent job of installing cross drains that divert sediments to the forest floor where they filter out before entering streams. However, there are significant segments of hydrologically connected roads that are currently eroding directly to streams. These segments pose a longer-term risk to the watershed and should be

inspected and repaired simultaneously with potentially failing stream crossings if they are in close proximity to one another. Otherwise, these longer-term hydrologically connected and eroding roads should be inspected after the high washout potential crossings and fish blocks have been inspected and repaired.

The issue of opening blocked roads to repair eroding segments remains problematic because of their isolation and access constraints. Many of these blocked roads may have been closed for some time and are alder- choked making access nearly impossible. Other may have eroded prisms that are now far too narrow to access with vehicles even if they were opened. In spite of these obstacles, this analysis has identified roads that are actively eroding to streams and are on blocked segments. It will be up to district engineers to determine which of these roads are feasible to repair and which are not.

The longest-term risk to aquatic resources are those roads located on steep slopes and adjacent to streams. These roads have been identified and as managers "catch-up" on inspecting and repairing the highest priority roads identified in this analysis, they could potentially turn their attention to these critically located long-term risk roads.

Short term risks at stream crossings are the most important and highest priority for manager to consider. Table 35 and Table 36 list roads crossings that are rated as having a high potential for washout. Table 38 lists stream crossings that may act as fish blocks. Appendix X – List of Priority Inspection Roads lists road with segments that are actively eroding.

10.3.7.3 Recreation-related effects

Steep terrain, heavy rainfall and soil types not well-suited for OHV use present challenges to recreational use in the Wilson River watershed. Some of the hydrologically connected trail segments are on legacy roads and skid trails adopted by OHV users. Furthermore, existing recreational use pressures are likely too high to be sustained but the lack of a complete trail census does not allow for a complete picture to be drawn. Additionally, poor trail design, location and lack of adequate maintenance has produced serious, although localized, levels of vegetation loss and sedimentation (e.g., 2 acres/1,157 cubic yards of aggregate soil loss per mile; considerably high compared to values presented in the literature that typically report measures in the low hundreds of cubic yards; see Marion and Cole 1996 and Glidden 2005 for some examples).

Current OHV trail data for the Wilson does not allow for a thorough identification of all trail segments at risk of a washout. Additionally, the lack of a complete trail inventory (which includes undesignated, user-created/braided trails) does not allow an estimation of how many stream crossings and

hydrologically connected trail segments may be impacting aquatic habitats. Field samples of both designated and undesignated trails, however, clearly indicate problems do exist and that some impacts are serious (e.g., sediment delivery directly to streams).

Incorporation of key washout risk indicators in future field inventories will help inform ODF of trail conditions and identify high priority trails for corrective action(s). This action need not wait for a full scale forest-wide trail inventory, rather it can commence when any trail work repair priorities are being assessed. We recommend that ODF continue to develop and refine sustainable trail designs and Best Management Practices (BMP) based on updated recreational standards (e.g., Marion 2007, IMBA 2004, Steinholtz & Vachowski 2001, Wernex 1994). In addition, ODF should increase measures to reduce user pressure (events, season of use, trail closures) and designate 100 foot buffer zones designed to minimize watershed impacts. Finally, more rigorous enforcement and a monitoring system needs to be added to ODF's OHV and dispersed campsite management programs.

10.3.8 Water Quality

Current water quality limitations identified by the Oregon Department of Environmental Quality are due to dissolved oxygen for the period September 1 - June 15 in the Wilson River mainstem. Dissolved oxygen limitations are related to high water temperatures, which are in turn influenced by riparian shade.

Restoration opportunities are limited along the mainstem Wilson River for political as well as physical reasons. The dynamic nature of much of the Wilson River mainstem is a physical constraint to restoration activities. Fragmented ownership and small lot size in many areas, along with the desire of some homeowners for "river views" and to have structures in close proximity to the river, limit restoration opportunities. Opportunities for restoration on these small private parcels (either through acquisition, easements, or cooperation) may best be handled through the Tillamook Bay Watershed Council or other organizations (e.g., Nature Conservancy). Newly acquired State Park land along the highway 6 corridor are an example or additional public lands that may be available for restoration.

Modeled shade levels are generally predicted to increase along the principal streams over the 0-50 year time horizon, but decrease over the 0-100 year time horizon as stands mature and canopy conditions begin to break up. Channel widening, associated with debris flows also contribute to loss of effective shade. Recreation-related impacts to shade, temperature and other water-quality concerns (primarily sediment inputs) appear to be causing significant localized impacts, but probably represent a minor impact at the subwatershed scale.

Road-parallel streams (discussed above) also represent significant long-term limitations to stream shading. Stream parallel roads were identified as part of the recent ODF road assessment in the Wilson River (see Appendix M – ODF Roads Protocol for protocol). This information can be used in conjunction with the temperature limiting factors results (section 5.6 – Limiting Factors) to prioritize road segments for restoration. High-priority candidates include segments along the south bank of the West Fork North Fork Wilson, segments along Ben Smith Creek, Cedar Creek, Idiot Creek, Jordan Creek, Little NF Wilson, and South Fork Wilson River.

10.3.9 Fish and Fish Habitat

As of December 2007, none of the anadromous salmonid species inhabiting the Wilson River watershed are currently listed as *Threatened* or *Endangered* under the federal Endangered Species Act (ESA). Oregon coastal coho, however, are likely to be re-listed by NOAA Fisheries in early 2008 as *Threatened*. Additionally, numerous species/stocks are listed by the State as *Threatened* or *Sensitive* and/or *Vulnerable*. Since fish abundance survey data indicate general declines and high variability in peak abundance over the last 50+ years, we recommend using extreme caution when interpreting the effectiveness of restoration activities, especially over the short-term. Additionally, the effectiveness of restoration projects should be repeatedly assessed over the course of several years and even decades. Furthermore, long-term monitoring activities should be included when calculating future projects' associated costs.

Although the Tillamook Bay estuary may well be the conduit for potential introduced species invasions, introductions may also occur on ODF lands. Because some invasions can have far-reaching and catastrophic effects on local, native populations, we recommend that ODF maintain a close working relationship with the ODFW and Tillamook Estuaries Partnership to identify (early) potential outbreaks of invasive species.

Human-caused disturbances have drastically altered the condition of aquatic habitats within the Wilson River watershed. The Tillamook Burn fires, subsequent road-building and associated timber harvest activities (e.g., legacy effects) have significantly altered the types and availability of high-quality aquatic habitats present in the Wilson. From a hydrologic standpoint, the Wilson has largely recovered from these past activities. However, perhaps the most significant legacy effect was the removal of large wood from the system, both from the streams ("stream-cleaning") and from the riparian zone (fires and subsequent harvest). The lack of large instream wood pieces (and the lack of large wood recruitment in the riparian; see section 6.2 Potential Future Conditions) is having a substantial and persistent detrimental effect on the overwintering abilities of juvenile salmonids and on the accumulation of gravels,

increases in pool frequency and presence of deep pools. This is especially evident in the Jordan Creek subwatershed where 80% of the surveyed stream reaches exhibited low percent gravel, high percent bedrock and low percent pools (although this may also be a relic of historic log drives). Therefore, silvicultural treatments that encourage the production and recruitment of large instream wood may well have a substantially positive impact on long-term aquatic habitat conditions (see section 6.3 Riparian Enhancement Opportunities and Map 63).

Current aquatic habitat data in the Wilson are often negatively skewed compared to ODFW's Aquatic Inventories Project (AIP) reference reach data. When considered collectively, however, (e.g., at the subwatershed scale) the data suggest that aquatic habitat conditions in the Wilson River are still exhibiting a reasonable level of functionality. For example, aquatic habitat conditions in the Little North Fork Wilson subwatershed are fairly evenly distributed among the LOW, MODERATE and HIGH categories (28.7%, 54%, and 21.3%, respectively), indicating that aquatic habitat conditions within this subwatershed are likely functioning in a manner similar to other coastal watersheds that have experienced relatively little human disturbance. Indeed, fish numbers in this subwatershed generally reflect this. Therefore, we recommend that ODF take actions that maintain the current conditions in this subwatershed.

Key habitat attribute data from the Jordan Creek subwatershed, on the other hand, are skewed relatively heavily toward LOW categories (48% LOW, 37% MODERATE, 15% HIGH), indicating that aquatic habitat conditions in this subwatershed are compromised compared to reference conditions. Indeed, steelhead and coho numbers generally reflect this. Because this subwatershed contains high habitat intrinsic potential but low fish numbers, ODF should consider restoration actions in this subwatershed that are geared toward steelhead and coho recovery and improvement of overall aquatic habitat complexity (e.g., increase the number of pools, percent gravel, and instream large wood).

Aquatic habitat conditions in the Upper Wilson/Cedar Creek and the Little North Fork Wilson, on the other hand were rated as being in MODERATE and GOOD condition (respectively), the subwatersheds contain high IP for coho and steelhead, areas of high core habitat for coho and steelhead, and contribute large numbers of coho, steelhead and cutthroat trout. Few restoration efforts, therefore, may be needed here and ODF should take actions that maintain the current conditions. Conversely, aquatic habitat conditions in the Devils Lake Fork and the South Fork Wilson were rated as being in POOR and MODERATE condition (respectively), yet the subwatersheds contain areas of high IP and core habitats for coho and steelhead, contribute large numbers of coho salmon and cutthroat trout but do not produce many steelhead. Therefore, restoration efforts in these subwatersheds could be focused on improving aquatic habitat conditions (e.g.,

increasing the number of pools, percent gravel, and large wood) for 1) steelhead (low numbers) and 2) coho (likely to be re-listed as *Threatened*).

Additionally, while apparently not a large issue in the Wilson, historic road-building activities have reduced the connectivity of stream reaches to each other, blocking the movements of fish. Although some fish blockages still exist (e.g., improperly sized culverts, steep gradients, too high steps at the mouth, etc.), current road-building and road-restoration practices have largely eliminated fish passage issues. Yet, the stream crossing washout potential and sedimentation issues identified in this assessment still have the ability to negatively impact aquatic habitats and, given the recent frequency of large storm events, should be immediately repaired or replaced. Furthermore, this assessment identified numerous recreational trails and dispersed recreation sites that were 1) hydrologically connected, 2) actively eroding, and 3) damaging riparian vegetation. To reduce sedimentation and increase riparian shade at these sites, ODF should 1) restrict their recreational use or close them altogether, 2) repair damaged areas, and 3) work to educate recreational users about the negative ecological, biological, and socio-economic effects from improper use.

In general, the Wilson River watershed is recovering and appears to be in relatively moderate shape given the high degree of disturbance it has experienced in the last 100+ years. While many basic biological and ecological requirements are largely being met by the current conditions in the Wilson, the lack of large wood (upslope, riparian and aquatic) is arguably having the largest impact on aquatic habitat complexity (e.g., lack of pools, deep pools, large wood accumulations, cover, low gravels, etc.) and large wood recruitment is projected to remain below target levels well into the next century. Tailoring riparian and upland silvicultural treatments for the enhancement/recruitment of large wood may help the aquatic habitat conditions recover at a faster rate. Indeed, as key pieces of large wood begin to recruit to the waterways, we would expect to see an increase in pool frequency, decreases in the number of habitats where bedrock dominates, increases in gravels, and increases in aquatic cover associated with wood accumulations.

10.3.10 Recreation

Historical conditions, physical characteristics and social pressures combine to present considerable challenge to preventing and repairing impacts on the watershed from recreational use. However, ODF has established an internal capacity to tackle these challenges and an array of partnerships, relationships and programs to pull in users to assist in their efforts. The focus of the recreation impact analysis was to try to gauge the extent and intensity of recreation impacts in the context of a larger watershed analysis. The tools, data and experience in

doing this are not well developed and have few precedents in the region or nation.

Within those limitations, the results of this analysis do provide a picture of watershed impacts associated with recreation and direction for tackling those impacts and the data needs for managing and monitoring recreational use. Findings show that OHV and dispersed camping impacts occur throughout the watershed, across all seasons and produce some locally intense erosion and sedimentation. High rainfall, steep terrain and storm events exacerbate the effects of high levels of OHV use in a trail system that is not yet under full management control. Given the quantity of soil loss measured along a sample of trails, high priority needs to be given to assessing the extent to which this occurs in the rest of the trail system. The field work also assessed sample trail segments for washout risk indicators such as fall line alignment, steep grades and hydrologic connectivity and found significant occurrence of these indicators on all trail types, but particularly on undesignated and user-created trails. ODF has made considerable progress in rerouting, repairing and maintaining designated trails, and now all of these trails feature bridges or culverts at stream crossings.

Impacts on riparian areas are of particular concern and recreation (OHVs and dispersed camping) represents a potential vector for the spread of invasive species. Garlic mustard and Japanese knotweed are two new highly invasive species that were assessed by this study and both have a habit of invading flood plains in association with human disturbance, floods and recreation activity. In addition, the study revealed long term impacts of recreational use of inner riparian areas, including soil loss, site hardening, tree mortality and loss of vigor, vegetation loss and sedimentation. Where recreation sites a clustered and impacts are high, impacts can be expected on riparian vegetation, canopy tree health and long term large wood recruitment into streams.

With only 88 acres of wetlands in the watershed it will also be important to prevent further encroachment and impact from recreation along hydrologically connected trails and campsites. While ODF has successfully buffered streams from campsites within the formally designated campgrounds in the watershed, a majority of dispersed campsites are still within the stream bank and inner riparian zones (<100 ft from water). Highest priority should be given to high impact sites within 25 feet of streams identified in this report from ODF inventory data. This same inventory recorded but did not enter data that would identify sites within the inner riparian zone (25-100ft). Field assessment results show that sites in this category should also receive management attention.

However, dispersed camps are attractive because they are close to water, free, isolated and rustic which many locals prefer over designated and developed fee campgrounds closer to high activity areas. ODF must weigh the resource impacts

and social implications of continuing to allow users to occupy sensitive riparian sites. Statewide trends indicate more people will be recreating closer to home as travel costs increase, and as fees increase for developed sites, more people will be seeking alternatives. Restricting access to inner riparian areas, or upgrading sites to contain impacts will be necessary actions to reduce impacts on riparian function and water quality.

ODF staff reports and field assessment work reinforce the need for placing a combination of very robust physical barriers, revegetation and explanatory signage to combat OHV and dispersed camp impacts. In addition, a more effective enforcement program is needed to set expectations of compliance and the consequences of non-compliance. Demand for recreation across the forest is projected to increase, particularly among motorized recreation uses. ODF has developed a skilled and talented staff that has applied considerable resources to establishing high quality recreation facilities and opportunities within the watershed. However, demand and the constraints of terrain, rainfall and historic patterns of use make it difficult to bring all trails and sites up to standard and maintain the ones already there.

The new round of recreation planning anticipated for the Tillamook State Forest will benefit from a thorough inventory of all trails like the one done by ODF for dispersed campsites. However, it will be important to design survey tools to gather information on impacts that reflect state of the art recreation monitoring protocols and that provide indicators that feed directly into long term monitoring programs. At this point we know impacts are occurring and a good indication of where to look or what to look for in prioritizing management actions. What is needed next is monitoring with effective tools and more quantifiable measures to gauge the rate of site deterioration and the relative impacts of management actions design to reverse those problems.

Recent advances in trail related research has produced much more specific guidelines and a greater understanding of trail design principles. This has in turn fostered the development of better resources, design standards and best management practice guidelines for improving user experiences, minimizing resource impacts and reducing management inputs. The time is right to incorporate these into the next round of recreation planning for Tillamook State Forest.

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