APPENDIX I: FISH HABITAT AND WATER QUALITY

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INTRODUCTION

In most aquatic ecosystems in the Pacific Northwest, fire is a natural process that has occurred for at least the last 10,000 years (Walstad et al editor 1990), and in systems with adequate connectivity, and sufficient population numbers, fire would not have resulted in reduced persistence (Gresswell 1999). Historically, fire was one of the primary mechanisms affecting the delivery of instream fish habitat components as well as the primary contributor to changes in water quality. The effects of fire, combined with other factors such as flooding and natural soil movement events, served to provide organic and inorganic material to streams.

Woody material was consumed in high intensity fires, but the timeframe for recruitment was also accelerated due to increased overstory mortality of streamside trees, and increased potential for debris transport downslope (McMahon and deCalesta 1990; Young 1994). Water temperature can be significantly increased in headwater stream reaches after a high intensity fire due to the mortality to streamside vegetation and subsequent increase in insolation (Gresswell 1999). Amaranthus et al (1989) measured 3.3 to 10^{o} C increases in headwater streams after severe fires in southwestern Oregon, although these increases may become negligible in downstream reaches.

Sediment delivery rates, soil processes and erosion processes (surface erosion, mass wasting, channel erosion) were altered by fire (Beschta 1987). It is estimated that approximately 30% of the total sediment yield to Cascade Range streams is attributable to fire effects (Swanson 1981). Post-fire erosional events that might have appeared to have been catastrophic, may have be important factors affecting habitat complexity, and spawning and rearing habitat suitability, in some systems. High severity fire could have produced water repellent soils, accelerating erosion (Gresswell 1999).

Fire historically affected hydrologic processes in some cases by increasing water yield (Beschta 1987; Reiman and Clayton 1997) and sediment delivery rates (Helvey 1980; Swanson 1981). Hydrologic processes control channel morphology, sediment composition, and the distribution of large woody material.

It is likely that fire did not cause much direct mortality to fish. Recent studies have shown that the mortality of fish and aquatic invertebrates due to exposure to wildland fire is usually rare and the duration of mortality causing conditions is usually short-lived (Reiman et al. 1997). Death is caused by an increase in water temperature or chemical toxicity from ash (leaching of phosphorous from aerially deposited ash) or smoke (adsorption of smoke gasses into surface waters, increasing ammonium

levels) (Spencer and Hauer, 1991). Indirect mortality to both adult and juvenile fish through gill abrasion, reduced feeding success, increased water temperature (both due to direct water heating and loss of streamside shade providing vegetation), water chemical changes, etc, probably occurred. Fish likely moved downstream and relocated to adjacent unburned drainages, as they have been observed in the recent past. If habitat connectivity was maintained, then drainages depopulated of fish would have been reinvaded in less than 2 years (Reiman and Clayton 1997, Reiman et al. 1997).

Fire likely caused more mortality in the high severity, low frequency fire regime than in the other four fire regimes. The larger fires that occurred in this regime would likely have adversely affected most refugia habitat available to the fish. All other fire regimes would have likely retained some stream reaches where the fire would have burned at low or moderate intensity, and these reaches would have provided suitable refugia.

Anadromous fish species persevered in watersheds dominated by high severity, low frequency fire regime in part due to their life history, which increases the probability of persistence during periods of environmental fluctuation (Gresswell 1999). These fish have approximately 20% or less of the population spawning in any given year, and exhibit anadromy which results in the fish being absent from the forested environment for more than half its life cycle (ocean dwelling).

EXISTING CONDITION

In general, a present day fire in the project area would not have a significantly different effect on water quality and fish habitat than a historic fire. An exception might occur in the South Cascades Zone where it is dominated by the frequent, low intensity fire regime, but where fire suppression has caused an unnatural switch to fires which are less frequent and are of higher intensity. Historically, a fire in this zone would have retained suitable refugia areas for fish; rarely would a fire be of such magnitude to adversely affect water quality or fish habitat in such a manner that the fish would have to vacate their home drainage. Now, with an increasing risk of high intensity fire occurrence, the probability of adverse habitat modification is higher.

However, when effects are viewed cumulatively with other chronic effects in the project area, fire does have a different role than it did historically. Fire is now a minor component affecting water quality. Dams, roads, timber harvest, riparian area disturbance, agricultural, industrial, and urban pollutants are the primary causes of reduced water quality.

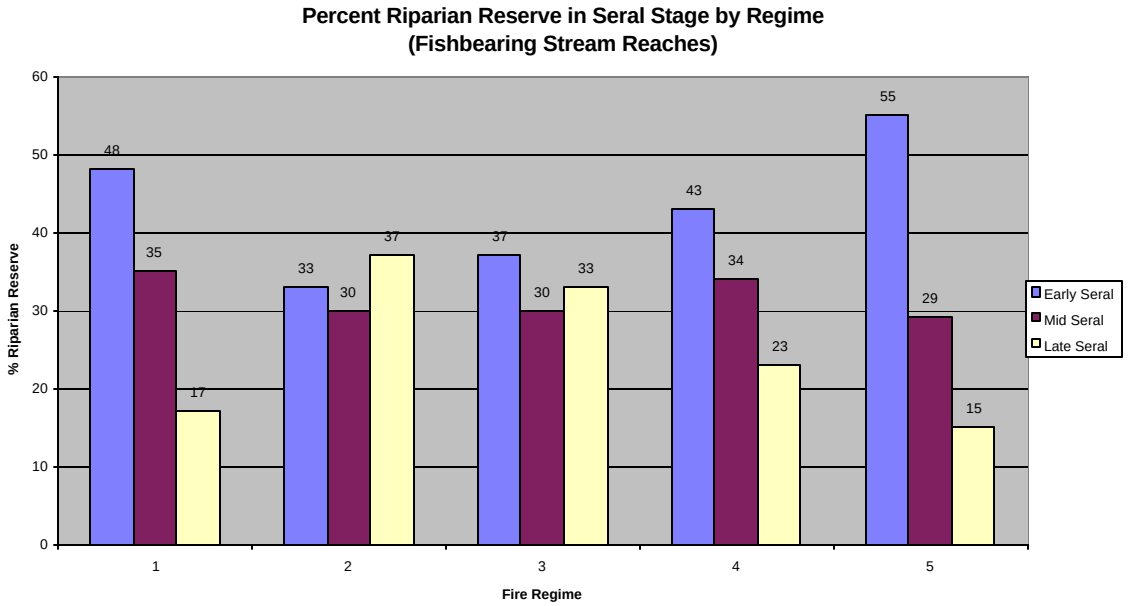
The significance of the fire caused impacts are greater due to many fewer fish being present now than there were historically, due to increased mortality of fish both in and downstream of the project area (harvest, ocean conditions, hatcheries). Population numbers for spring chinook

salmon, winter steelhead, and bull trout, three important fish species within the project area, are all at very low levels, and all have been listed as threatened species under the Endangered Species Act.

Also, the current spatial distribution of these species has been reduced from historic distribution. This limited distribution is due to habitat limitations such as barriers caused by dams or culverts, or adverse habitat modification due to land management. Fish now have a reduced opportunity to relocate to adjacent drainages during and after high intensity fire due to the lack of suitable habitat (refugia) in many of the drainages in the project area. Where the fish are forced to occupy less than suitable habitat, it results in reduced fitness, reduced spawning success, and fewer fish.

Also, the availability of riparian woody material, and the recruitment potential, is reduced from historic levels due to riparian timber harvest and road construction. Riparian reserves are fragmented, and many are in an early seral stage. Results of a query of the vegetation database for the Forest Service administered lands in the project area show that 33% to 55% of the overstory vegetation in the riparian reserves associated with fishbearing streams are in an early seral stage (see Figure I-1). Timber harvest and road construction within riparian reserves are the primary factor for this condition, and are in part replacing the ecological element historically provided by fire. The primary difference is that fire would have retained most large woody material on site, while timber harvest and road construction activities remove this material.

Figure I-1.



If fire exclusion from riparian reserves continues, the trend will be towards reserves with more stems, smaller size wood to streams, higher fuels, greater risk of high intensity fire, and a higher risk of insect infestation. This reduction in available woody material changes the overall effect of fire on the watershed. Historic fire would have likely resulted in a net increase in woody material available to the stream, while current fire would first consume more woody material due to suppression, and also standing overstory trees are no longer present, which would have been killed and available for recruitment. Additionally, fire "salvage" in recent history may have removed dead or dying trees from riparian areas, post-fire.

Stream temperatures are probably higher today than they were historically, in all fire regimes. Therefore, the buffer between water temperatures suitable for healthy fish habitat, and water temperatures leading to reduced fitness or mortality is narrowed. So, the effects of a fire-caused increase in water temperature may cause this threshold to be exceeded today, more so than it would have historically.

The greatest risk of increased stream temperature due to fire, outside of the normal range, exists in the South Cascade zone. The fires that burned here historically probably had little effect on stream temperature due to the moderate or low intensity, but currently, due to fire suppression activity, the probability of a higher intensity fire exists, and the magnitude of the effect on water temperature is probably higher.

Sediment delivery rates, soil processes and erosion processes (surface erosion, mass wasting, channel erosion) are altered after a fire, although road construction and timber harvest contribute much more sediment to streams than does fire (Rieman and Clayton 1997). The primary difference between the historical and current effects on these processes is that there are currently many more sources of accelerated soil erosion and sediment transport due to land management activities such as road construction and timber harvest, therefore the sediment "balance" may be nearing acceptable thresholds in some systems even before fire effects are realized. A fire-caused sediment increase that normally would be tolerated by fish or other aquatic organisms might now be enough to cause mortality, or make habitat unsuitable.

The primary change in how fire affects hydrologic processes might be most evident in the South Cascade zone where fire suppression has led to fires with increased magnitude and intensity, increasing the probability that there will be an increase in water yield, and potentially affecting timing of peak flows.

In fire regimes with non-frequent return intervals, there has likely not been many changes to water quality or fish habitat due to fire suppression, as enough time has not yet passed to complete a fire return interval cycle. However, continued suppression will ultimately lead to a situation where a large portion of the project area will be in a high risk situation and the extent of this stand replacing fire will likely be higher

than if we simply let naturally started fires burn without suppression. There is a risk that these large fires could potentially burn large watersheds, essentially leaving no refugia for fish, leading to local extinction in some cases. These fires would also potentially burn at higher intensity, leading to a higher level of adverse modification of habitat and water quality, and this affect would also be of longer duration.

DESIRED FUTURE CONDITION

Current direction discourages the use of prescribed fire in riparian reserves. Continued suppression of these fires will ultimately lead to suppressed stands at higher risk of high intensity fire and is slowly causing an adverse modification of instream habitat and water quality parameters in most fire regimes. Fire is a natural component of functioning watersheds, and should be returned as a component of the aquatic ecosystem. Simple vegetation manipulation through timber harvest or other mechanical fuels treatment techniques may not restore the complex ecological condition reached under natural fire (Reiman and Clayton 1997).

Care must be taken to analyze the effects of fire on local fish populations, due to the current limited population numbers. Specific protection measures should be in place to limit the extent, duration, and magnitude of any fire projects to limit the potential effects to water quality or fish habitat. Implementation guidelines should be developed that would result in low to moderate intensity fire in most riparian reserves. Monitoring of fuel consumption, soil/litter effects, and temperature effects should be considered a priority.

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