APPENDIX L

Ozone is one of the most ubiquitous pollutants which causes damage to vegetation. Forest ozone damage has been reported in California (Miller et al. 1996), New England (Treshow 1984), the southeastern US (Skelly et al. 1997), and Europe (Rennenberg et al. 1997). Ozone is formed from nitrogen oxides and volatile organic hydrocarbons (VOCs) in the presence of sunlight in source areas—cities, major transportation corridors, industrial sites and agricultural areas— and is transported via air masses to downwind forests where it is deposited. Ozone is a potent oxidant which invades tree foliage through stomatal pores and damages cell constituents responsible for normal physiological function (Heath and Taylor 1997).

Sierra Nevada forests receive ozone in plumes which originate from precursors in the urban centers, transit corridors, industrial and agricultural areas of the Central Valley and coast (Cahill et al. 1996). Air mass trajectories carry polluted air SSW through the Central Valley until deflected into the Sierra Nevada Mts. near Sequoia National Park by the transverse Tehachapi Range. Air masses with pollution from the Los Angeles area move eastward directly into the San Bernardino Mts. While ozone pollution in the urban areas of California has declined in general over the last 20 years, ozone pollution in remote natural areas has increased. In 1999 the National Park Service ranked Sequoia/Kings Canyon National Park (SEKI) the "worst ozone polluted park" of any National Park in the country.

Ponderosa pine is very sensitive to ozone pollution and has been studied extensively in relation to ozone damage. Ponderosa pine is the most abundant western conifer and is an important forest species in California, both economically and ecologically. Ozone impact on ponderosa and Jeffrey pine in the Sierra Nevada and San Bernardino Mts. has been monitored since the 1970's. The following symptoms have been observed and attributed to ozone exposure: visible chlorotic mottling; needle loss; loss of basal area; species replacement by forest species more tolerant of ozone, but less tolerant of fire; changes in forest physiology; changes in nutrient use (Pronos et al. 1978, Pronos and Vogler 1981, Miller 1973, Stolte and Bennet 1985, Miller and McBride 1988, Miller 1996).

Ozone injury has been well-documented in the San Bernardino Mts. downwind of Los Angeles (Miller et al. 1996, Grulke et al 1998, Grulke 1998, Grulke and Balduman 1999, Miller 1973, Stolte and Bennet 1985, Miller and McBride 1998, Miller 1996). At the 2 sites nearest L.A.,100% of measured trees had ozone injury. At the site most distant from L.A. 96% of trees measured had ozone injury. Forests of the Sierra Nevada Mts. in California are impacted by ozone as well (Miller and McBride 1988, Cahill et al. 1996, Miller 1996). Ozone injury was measured annually on 1700 ponderosa and Jeffrey pine at 11 different sites in the Sierra Nevada Mts. from 1990-1995. Ozone damage was observed at all sites measured. At the most damaged site, Sequoia National Park, 93% of ponderosa pine had ozone injury. The least damaged site, in Yosemite National Park, reported 39% ponderosa pine with ozone injury (Arbaugh et al. 1998).

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