

effects associated with changes in exposure to UV-B radiation mediated by changes in ground-level O<sub>3</sub> concentrations is being considered. As part of the O<sub>3</sub> Criteria Document, this information will be presented to CASAC and the public for review and comment. Based on the revised O<sub>3</sub> Criteria Document, and taking into account CASAC advice and public comments, EPA will consider the extent to which the available information provides an adequate basis for developing credible quantitative estimates of potential beneficial health effects of ground-level O<sub>3</sub>. All such relevant information will be considered in EPA's review of the primary O<sub>3</sub> NAAQS.

### III. Rationale for Final Response To Remand on the Secondary O<sub>3</sub> Standard

This notice also presents the Administrator's final response to the remand, reaffirming the 8-hour O<sub>3</sub> secondary standard promulgated in 1997, based on:

(1) Information from the 1997 criteria and standards review that served as the basis for the 1997 secondary O<sub>3</sub> standard, including the scientific information on welfare effects associated with direct exposures to O<sub>3</sub> in the ambient air, with a focus on vegetation effects, and assessments of vegetation exposure, risk, and economic values;

(2) A review of the scientific information in the record of the 1997 review (but not considered as part of the basis for the 1997 standard) on the welfare effects associated with changes in UV-B radiation, the association between changes in ground-level O<sub>3</sub> and changes in UV-B radiation, and predictions of changes in ground-level O<sub>3</sub> levels likely to result from attainment of alternative O<sub>3</sub> standards; and

(3) Consideration of the comments received on the proposed response.

#### A. Direct Adverse Welfare Effects

As discussed in the 1997 final rule, direct exposures to O<sub>3</sub> have been associated quantitatively and qualitatively with a wide range of vegetation effects such as visible foliar injury, growth reductions and yield loss in annual crops, growth reductions in tree seedlings and mature trees, and effects that can have impacts at the forest stand and ecosystem level. Visible foliar injury can represent a direct loss of the intended use of the plant, ranging from reduced yield and/or marketability for some agricultural species to impairment of the aesthetic value of urban ornamental species. On a larger scale, foliar injury is occurring on native

vegetation in national parks, forests, and wilderness areas, and may be degrading the aesthetic quality of the natural landscape, a resource important to public welfare. Growth and yield effects of O<sub>3</sub> have been well documented for numerous species, including commodity crops, fruits and vegetables, and seedlings of both coniferous and deciduous tree species. Although data from tree seedling studies could not be extrapolated to quantify responses to O<sub>3</sub> in mature trees, long-term observational studies of mature trees have shown growth reductions in the presence of elevated O<sub>3</sub> concentrations. Even where these growth reductions are not attributed to O<sub>3</sub> alone, it has been reported that O<sub>3</sub> is a significant contributor that potentially exacerbates the effects of other environmental stresses (e.g., pests). In addition, growth reductions can indicate that plant vigor is being compromised such that the plant can no longer compete effectively for essential nutrients, water, light, and space. When many O<sub>3</sub>-sensitive individuals make up a population, the whole population may be affected. Changes occurring within sensitive populations, or stands, if they are severe enough, ultimately can change community and ecosystem structure. Structural changes that alter the ecosystem functions of energy flow and nutrient cycling can alter ecosystem succession.

Based on key studies and other biological effects information reported in the Criteria Document and Staff Paper, it was recognized that peak O<sub>3</sub> concentrations equal to or greater than 0.10 ppm can be phytotoxic to a large number of plant species, and can produce acute foliar injury and reduced crop yield and biomass production. In addition, O<sub>3</sub> concentrations within the range of 0.05 to 0.10 ppm have the potential over a longer duration of creating chronic stress on vegetation that can result in reduced plant growth and yield, shifts in competitive advantages in mixed populations, decreased vigor leading to diminished resistance to pest and pathogens, and injury from other environmental stresses. Some sensitive species can experience foliar injury and growth and yield effects even when O<sub>3</sub> concentrations never exceed 0.08 ppm. Further, the available scientific information supports the conclusion that a cumulative seasonal exposure index is more biologically relevant than a single event or mean index.

To put judgments about these vegetation effects into a broader national perspective, the Administrator has taken into account the extent of exposure of

O<sub>3</sub>-sensitive species, potential risks of adverse effects to such species, and monetized and non-monetized categories of increased vegetation protection associated with reductions in O<sub>3</sub> exposures. In so doing, the Administrator recognized that markedly improved air quality, and thus significant reductions in O<sub>3</sub> exposures would result from attainment of the 0.08 ppm, 8-hour primary standard. In looking further at the incremental protection associated with attainment of a seasonal secondary standard, she recognized that areas that would likely be of most concern for effects on vegetation, as measured by the seasonal exposure index, would also be addressed by the 0.08 ppm, 8-hour primary standard.

#### B. Potential Indirect Beneficial Welfare Effects

This section is drawn from the limited information in the record of the 1997 review with regard to the effect of ground-level O<sub>3</sub> on the attenuation of UV-B radiation and potential associated welfare benefits.<sup>73</sup> While this information suggests the potential for effects on plants and aquatic organisms, EPA (1987, ES-40—ES-43) recognizes that relevant studies are limited and the uncertainties are great due in part to problems in study designs, such that quantitative conclusions cannot be drawn.

With regard to effects on vegetation, while some plant cultivars tested in the laboratory were determined to be sensitive to UV-B radiation exposure, these experiments have been shown to inadequately replicate effects in the field, such that they do not reflect the complex interactions between plants and their environment. The only long-term field studies of crops involved soybeans, producing suggestive evidence of reduced yields under conditions simulating changes in total column O<sub>3</sub> over an order of magnitude greater than those projected to occur as a result of changes in ground-level O<sub>3</sub> associated with attainment of the 1997 O<sub>3</sub> NAAQS. Beyond the limited studies of crops, EPA (1987, ES-41) notes that little or no data exist on UV-B radiation effects on trees and other types of natural vegetation, or on possible interactions with pathogens. While it is noted that changes in UV-B radiation levels could alter the results of competition in natural ecosystems, no evidence is available to evaluate this

<sup>73</sup> The information in this section is drawn primarily from the EPA document "Assessing the Risk of Trace Gases that Can Modify the Stratosphere" (U.S. EPA, 1987).