Carbon Dioxide Rise May Alter Plant Life, Researchers Say

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Even within each of these broad classes, species respond differently. In a study led by Dr. Boyd Strain, a plant ecologist and physiologist at Duke University, two common Southern species of C3 trees, sweet gum and loblolly pine, were subjected to higher carbon dioxide levels. Loblolly is the South's most important timber crop, and sweet gum is a major competitor for resources in the ecosystem they share. The study found that sweet gum seedlings, largely because of their broad leaves, responded more dramatically than the pines.

Many scientists believe differences in species' response to enhanced carbon dioxide, and other problems some attribute to the enhancement, can be satisfactorily managed and minimized in agricultural settings where one crop predominates, and that higher carbon dioxide levels will be an agricultural boon.

"Agriculture has survived so many catastrophic events," said Dr. David T. Patterson, a plant physiologist for the Department of Agriculture associated with Dr. Strain's laboratory. "It's likely that this change will also be weathered."

But the price of this might be high, says Dr. Bazzaz, since crops do not benefit from higher carbon dioxide levels unless more fertilizer is applied and more pesticides are used to kill insects and, in the case of C4 crops, competitive C3 weeds. This would increase costs, and farmers in some development countries might not be able to afford it, he said.

Natural Ecosystems

The Impact On the Wild

Natural ecosystems cannot be managed like agricultural fields, Dr. Bazzaz said. Both Dr. Strain and Dr. Bazzaz, whose work deals mainly with natural ecosystems, say shifts in competitive advantage among plant species could produce far-reaching changes in the wild and even reduce the number of species.

In his laboratory at Harvard, Dr. Bazzaz has found that some annual plants do not do as well as others amid increased carbon dioxide. This, he said, suggests that annuals will leave fewer seeds when they die and that other species that do better in elevated carbon dioxide will become dominant the following year. Other experiments at Harvard have found that increased carbon dioxide altered the relative strength of five species of tropical trees.

While there is cause for concern on this score, Dr. Idso wrote in a 1989 review of research on the subject, it is possible that ecosystems could adjust much as forests did in the remote past, when carbon dioxide levels were higher than now. In those forests, he wrote, tree species came to co-exist rather than compete.

Humans also have little or no control over what Dr. Bazzaz and Dr. Strain say is a drop in the nutritional quality of natural vegetation that accompanies its jump in quantity at higher levels of carbon dioxide.

"Without fertilizing the soil," said Dr. Strain, "you pump more carbon into the plant and the ratio of carbon to nitrogen or phosphorus goes way up." He said this means insects and other plant-eaters have to eat more plant material to get enough protein.

In an experiment at Dr. Bazzaz's laboratory, Dr. Eric D. Fajer found that larvae of the buckeye butterfly ate 20 to 30 percent more vegetation from plants when they were grown in an atmosphere of doubled carbon dioxide, but that even so they developed more slowly and had higher mortality rates. Dr. Bazzaz suggests such effects could "cascade down the food chain" as fewer insects survive to provide food for predators. Dr. Idso, in his recent review, wrote that while some studies have found harmful repercussions for a number of insect species, they have not done so for others. "The final word on this matter is not yet in," he wrote.

Reduced nitrogen in plants could slow the decay of leaves and other plant litter, said Dr. Bazzaz, reducing soil fertility and producing a thick carpet of undecayed leaves and twigs that could hinder seed germination and, ultimately, the regeneration of forests. Dr. Idso says this could be offset by higher populations of litter-eating microorganisms that would be attracted to the larger root networks, and by an increase in earthworms.

While scientists struggle to learn how all these factors play out in nature, another question looms: If the global climate does warm substantially, how will this change the picture? Dr. Idso says the stress of high temperatures can be mitigated by carbon-dioxide enrichment. But studies at the University of Florida found that at both present and higher levels of carbon dioxide, grain yields decrease as temperature rises. A world 5 to 6 degrees warmer than now, as climatologists now predict by the end of the next century, "may not overpower the carbon dioxide effect, but we haven't run the numbers," said Dr. Hartwell Allen, a plant physiologist with the university and the Agriculture Department.

Sorting Out Mixed Effects Of a Profound Change

Scientists expect rising levels of atmospheric carbon dioxide to stimulate the growth of many kinds of plants. Some say this will bring about a global explosion in vegetation. But others say growth could be limited by stress and lack of nutrients. The net effect could be negative, some scientists say, especially on natural ecosystems.

NUTRITION VALUES MAY ALTER

Rising levels of carbon dioxide cause the nitrogen content of plants in nutrient-poor soils to decrease proportionally relative to the starch and sugar content. Consequently, some plant-eaters must consume more vegetation to get enough nitrogen-based protein.

SOILS MAY CHANGE

Leaves may not decompose as fast, some scientists say, slowing re-release of nutrients into soil and smothering some types of tree seedlings. Other scientists say the process could be offset by an increase in earthworms and soil microbes.

NEW FLOWERING PATTERNS

Phlox studied in Texas responded to higher levels of carbon dioxide by flowering earlier. The food supply for pollinators was no longer available when they expected and required it. Theoretically, this could lead to a reduction in pollinating insects.

Source: Dr. Fahkri Bazzaz

Drawings (pg. C1); Photo: Dr. Sherwood B. Idso with a three-year-old orange tree grown in high carbon dioxide levels at Agriculture Department laboratory, Phoenix. Such trees were found to be hardier in some respects. (Tim Koors for The New York Times) (pg. C9)

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