ENVIRONMENTALLY SPEAKING Peter Schwartzman

Ozone: a very misunderstood gas

Here is an environmental question worth asking, "Is ozone good or bad?" Need more context? Okay. Has ozone been beneficial or detrimental to humans over the course of the past century? Unsure? Well read the following and decide. If you're not motivated to do so, consider that if ozone weren't part of the Earth, neither would we be, and, more immediately, if ozone levels aren't kept within certain narrow ranges in the future, the biosphere will suffer greatly.

What is ozone? Ozone is the gas in our atmosphere which has the chemical formula O_3, meaning that each of its molecules consists of three oxygen atoms. Although seemingly similar to the much more common diatomic oxygen, O_2, which we require consumption of in every breath, ozone is quite different. While our atmosphere consists of nearly 21 percent O_2, ozone is found in much, much smaller quantities, generally less than 1-part-per-million (that is, less than 0.0001 percent). Also, while O_2's concentration is equally distributed throughout the atmosphere (in terms of relative concentration), ozone has two distinct concentrations, that which resides near the surface (referred to as tropospheric ozone) and that which resides in the upper atmosphere (more than 10 miles up, referred to as stratospheric ozone). Ozone also has vastly different physical and chemical properties than O_2. While most animals require O_2 to survive, ozone is poisonous and very capable of destroying lungs, damaging immune systems and reducing crop production. Ozone also creates potential problems because it is a greenhouse gas and, thus, traps heat energy inside the earth's atmosphere which means it can result in "global warming" if levels become elevated. However, ozone isn't always "bad," it actually serves as a shield from dangerous light that comes from the sun. Ozone appears to have a schizophrenic influence on us, one worth contemplating more about.

Let's start in the upper atmosphere and work our way down to the surface. The stratosphere (that part of the atmosphere above the wispy clouds extending nearly thirty miles above the surface) contains about 97 percent of the ozone on the planet. This ozone is considered extremely beneficial and is, in fact, essential for life as we know it. Ozone has the very special property of absorbing the highly energetic ultraviolet (UV) rays that come from the sun. This partial absorption of UV light protects life from the complications that result when life forms are exposed to elevated levels of it. In humans, UV light might be desirous to someone attempting to get a tan, but it is very damaging to our eyes (via cataracts), contributes in the creation of cancerous skin cells, produces age spots, and stimulates wrinkles. (Despite the fact that our culture tends to admire tanned skin, the process of tanning is actually a sign of skin damage.) Many plants also show signs of reduced productivity when exposed to higher UV levels. Thus, stratospheric ozone is a blessing to all of life because of its ability to absorb (and therefore block) much of the UV light from reaching the earth's surface.

In the lower atmosphere, particularly near the surface, ozone isn't so beneficial. Often a primary ingredient in smog, ozone causes damage in lung when inhaled. The American Lung Association's website <http:/www.lungusa.org> contains many references to the problems associated with ozone. One of this association's studies claims "that ozone is linked to approximately 10,000 to 15,000 hospital admissions for total respiratory illnesses, asthma, pneumonia and chronic obstructive pulmonary disease, and an estimated 30,000 to 50,000 emergency room visits in 13 cities during the summer" in the U.S. alone. While there are natural sources for tropospheric ozone, human sources appear to be more important, particularly because humans push ambient levels above thresholds. Urban centers with heavy traffic and industry (such as Los Angeles and Denver) tend to have much higher levels than rural areas due to gaseous emissions from motor vehicles and factories in these locations. These emission sources do not release ozone into the atmosphere directly, but ozone is produced as a major byproduct when their gaseous effluents (i.e., nitrogen oxides and hydrocarbons) undergo photochemical (i.e., light-driven) reactions. Ozone near the surface can be dangerous to humans, the species largely responsible for its existence at dangerous levels in the first place.

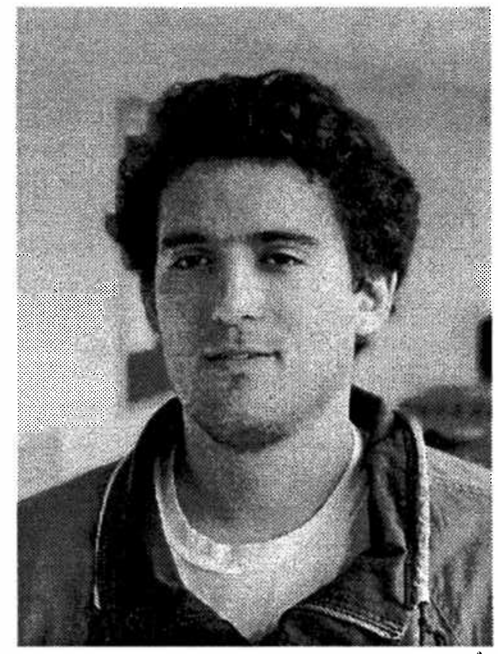
As can be seen, ozone has both positive and negative impacts, but you might ask, is there anything that can be done to minimize its negative impacts or increase its positive impacts? In fact, there are things humans have done to alter the effects of ozone and thus it is important to examine what the future holds regarding ozone and its impacts.

In the upper atmosphere, where ozone is a welcome absorber of UV light, humans have unfortunately reduced its concentration. However, the way this has been accomplished is a complex yet interesting story. It wasn't until the 1930s that scientists began to understand and properly describe the important role that stratospheric ozone played in shielding the lower reaches of the atmosphere and surface from dangerous levels of UV light.

The scientific community thought that the stratospheric ozone level was relatively constant and generally unaffected by human influence until the 1970s when a few scientists began to question the stability of ozone concentrations in the upper atmosphere. (Given the uniqueness of the conditions required for the breakdown of ozone by CFCs (chlorofluorocarbons) which requires among other things extremely cold ice clouds and sufficient levels of light — which usually destroy such clouds very quickly — it isn't surprising that it took so long for scientists to determine that CFCs might break down in the upper reaches of the atmosphere.) Two scientists, F. Sherwood Rowland and Mario Molina, who would later be awarded a Nobel Prize in 1995 for their work with ozone, were able to show that CFCs, a collection of large-molecule gases long thought to be stable, non-reactive and nonflammable, and thus perfect for use in refrigeration and aerosol cans, might cause ozone to break down because of the chlorine that CFCs release when they themselves break down in the upper atmosphere. This hypothesis took more than a decade before it was supported in 1985 by a study that confirmed a massive reduction in ozone concentrations above Antarctica. While reduced levels of stratospheric ozone were expected, the level of reductions observed was so large it came as a shock to the scientific community.

More recent observations suggest that ozone levels continue to be depleted, particularly in the polar regions of the globe where "the Antarctic ozone hole is spreading over wider areas and persisting longer" (Goudie). Also there is increasing evidence that high-flying aircraft might also be causing a reduction in stratospheric ozone due to the nature and whereabouts of their emissions. Since CFCs have no natural sources and were only first invented and produced in the 1920s, it is believed that the observed reduction in ozone concentrations has occurred over the past 70+ years.

The observed reductions in ozone were so large, and the potential dangers so ominous, the international community reacted very quickly to them. After a somewhat sluggish international discussion in the early 1980s about the extent to which CFCs needed to be reduced and to whom such responsibility would fall, the ozone measurements of the mid-1980s stimulated the quick adoption of an international agreement called the Montreal Protocol in 1987; the incredibly short period of time required being indicative of the perceived seriousness of the issue as well as the relatively weak political influence of the CFC production industry. Despite being a success, the Protocol, which required the rapid phasing out of several forms of these ozone-destroying gases, the black market for CFCs is still strong and CFCs often remain in the atmosphere destroying ozone for over one-hundred years. In 1999, a Texas man was arrested and charged with attempting to smuggle 75,000 pounds of CFC-12 (which is the preferred refrigerant in air-conditioning units of older cars) from Venezuela to the United States, where some will pay a substantial price for this illegal substance. Greater commitment to the precepts of the Montreal Protocol and its subsequent Amendments will be required to avoid further damage to our precious ozone layer.



Contrastingly, near the surface, ozone levels are increasing. The primary cause of this augmentation is the increased use of motor vehicles for transportation. Some areas, in particular the Los Angeles basin which has 14 million people and 23 million motor vehicles, has been successful in reducing ozone levels over the past 20-years via the enforcement of the world's toughest air-pollution control program. Yet despite the program, which among other things strongly encourages the sale and use of low- or zero-emission vehicles, air pollution is still severe in Los Angeles.

Other cities around the world — including Mexico City, Rio de Janeiro and Beijing — are also showing signs of enhanced ozone problems largely because of the increased use of vehicles that burn fossil fuels. Expanded utilization of public transportation and continued improvement in the technology of hybrid or fuel-cell vehicles appears to be an appropriate way to reduce the problems associated with tropospheric ozone. However, both of these programs undoubtedly require the full support of government agencies and members of the general public, who need to show their support with letters and phone calls to their representatives as well as through the purchase of these vehicles in order for positive steps to be made.

In summary, ozone is a multi-dimensional gas with its many influences on humanity and life in general. Some of its effects are considered essential while others are highly undesirable. Human-directed changes in the abundance of ozone, i.e., lower amounts in the upper atmosphere and higher amounts in the lower atmosphere, have created more problems for us and for our brethren — the other organisms on the planet. There are clearly things that humans can and are doing that can alleviate these problems. Perhaps ozone can now begin to be understood for the vital (yet dangerous) resource that it is.

References:

Goudie, Andrew. (2000) *The Human Impact on the Natural Environment.* Cambridge, MA: The MIT Press, 511 pp.

Philander, S. George. (1998) *Is the Temperature Rising.* Princeton, NJ: Princeton University Press, 262 pp.

Peter Schwartzman, a resident of Galesburg since 1998, is chair of the Environmental Studies Program at Knox College. He is a research climatologist with several peer-reviewed publications in the area of climate change and human population growth and he is currently writing two environmental books focused on bringing environmental understanding to a wider audience.