IOWA WATCH

THE CENTER FOR GLOBAL AND REGIONAL ENVIRONMENTAL RESEARCH

SPRING 1995

Songs of the Miner's Canary

A rise in atmospheric carbon dioxide concentrations; creation of an ozone hole over Antarctica; increasing greenhouse gases trapping ever more efficiently the sun's radiant heat. We all have heard of these environmental changes, as well as dire predictions about their probable results: more cataracts and skin cancer, melting ice caps, rising oceans and decreasing fresh water, agricultural systems collapsing in the sweltering heat.

Yet taking these predictions seriously is neither easy nor pleasant. Everything within us tempts us to proclaim the earth's systems protective and nurturing for the indefinite future. The thought that our own bodies and the earth's living communities can withstand the onslaught of rapid human-generated change without being scathed comforts us and lulls us into complacency. If we have no *proof* that crop yields will decline in the Midwest, or that our scantily-clad youngsters will suffer by playing outside in the summer's sun, it's much easier to continue to act in the traditional manner: to escape the heat by driving the kids to the swimming pool and returning to our air-conditioned homes to relax (all the while producing greenhouse gases, using ozone-depleting CFCs, and risking exposing our kids to UV radiation in the process). Advocating long-term sustainability rather than short-term consumption or profit simply isn't a popular suggestion, especially given the present political climate.

Yet that is just what a careful look at the earth's living systems seems to be telling us to do. Their reactions to invisible environmental alterations are difficult to detect and even more arduous to prove. But recent research confirms that the earth's complex ecosystems are indeed serving as our miner's canaries. Although natural ecosystems are exceedingly complex, and although many of their processes remain cryptic, they are exhibiting behaviors that demonstrate how human actions are affecting life on earth in a myriad of subtle ways. Consider as examples the three following discussions, each of which links ongoing research by CGRER members to a recently discovered, significant alteration of the earth's natural ecosystems.

#1. Greenhouse Gas Buildup and Alpine Plant Migration

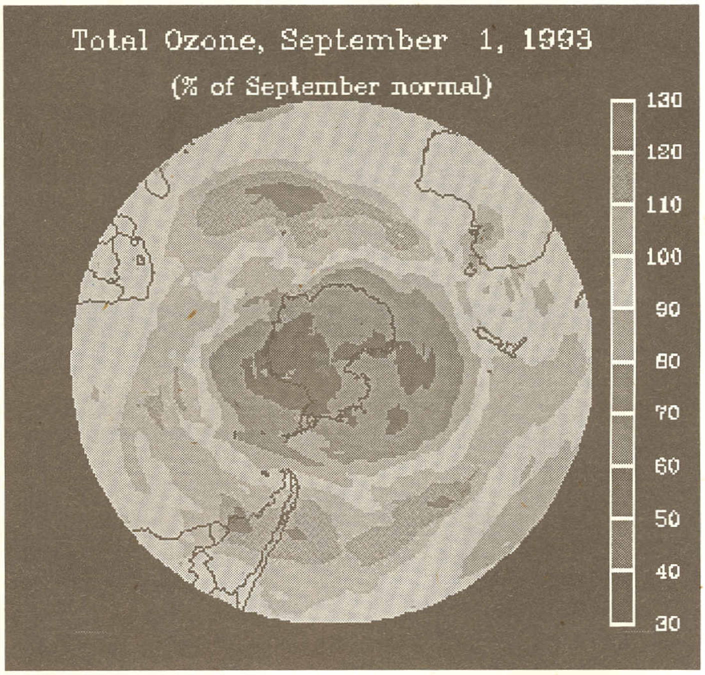
Greenhouse gases, which trap and hold the sun's radiant heat, play a vital role in maintaining the earth's surface temperature at livable levels. However since the

Industrial Revolution greenhouse gases have been poured ever more rapidly into the atmosphere, upsetting the ages-old balance between gas levels and the amount of radiant heat retained. The term *global warming* summarizes the fears of what might result: the sun's radiant heat, unable to escape the atmosphere, will cling to the earth's surface and eventually fry us all.

Gene Takle, a CGRER member and ISU atmospheric scientist, has been investigating fluctuations both in Iowa's mean temperatures and in climatic fluctuations. He is analyzing climatic data collected since 1900 in an attempt to determine whether significant temperature changes have already occurred in the Corn Belt. By feeding these data and expected alterations in atmospheric composition into his computer models, he also can spin out hypothetical midwestern climates of future years.

But even if temperatures warm a bit, what will this mean in terms of the earth's natural systems? While the human reaction might be to turn up the air conditioning, native species — plants as well as animals — would be forced to migrate to cooler climes. George Malanson, a geographer at The University of Iowa, is examining the potential future migration of midwestern trees by constructing computer simulations based on pollen data from the past 12,000 years. These data provide past rates of migration, which are then used to predict future movements across our modern fragmented landscape in hypothetical climates. He also is studying the response of treeline vegetation in the Rockies to climatic and geomorphic variables in an attempt to understand future upslope movement potentially stimulated by global warming.

Research published this past June provided the first evidence that such plant migrations are not just theoretical: they are already occurring among some of the earth's most sensitive predictors, the tiny tundra plants of the uppermost Alps. Comparisons of modern and early 1900s records revealed that certain plants are currently migrating upslope from 3 to 12 feet a decade. This movement corresponds with a warming of about 1.5° F, and demonstrates that even moderately warmer temperatures here are already playing a significant ecological role — potentially pushing the species in question upslope and off the mountain tops into extinction.



Antarctic ozone hole as measured by the TOMS instrument on the Nimbus-7 Satellite. The ozone hole forms each spring (in the southern hemisphere) as the result of heterogeneous reactions involving CFCs.

#2. Carbon Dioxide Enrichment and Tropical Forest Cycling

While atmospheric CO_2 concentrations remained below 300 ppm from ancient times until the Industrial Revolution, the burning of fossil fuels and cutting of the earth's forests have caused CO_2 to increase at an accelerating rate ever since. However not all CO_2 produced feeds directly into atmospheric increases. Some is absorbed by the oceans. Some is converted by photosynthesizing plants into more complex carbon-based molecules and then stored by the plant tissues. Soil microorganisms, like humans and all other animals, produce CO_2 during respiration. Plants also respire when they are not photosynthesizing. And all living tissues release CO_2 when they decompose. To further confuse the picture, CO_2 use and release is affected by temperature and chemical composition (for example of the ocean), and by the concentration of CO_2 itself.

These complex interactions all feed into predictions of future atmospheric CO_2 levels. CGRER botanist James Raich, along with Christopher Potter, have been attempting to better understand the CO_2 — soil emission link of the puzzle. Soil emissions vary significantly with seasonal moisture patterns, temperature, and land use patterns. Their model is the first to incorporate these important variables into calculations of soil CO_2 emissions on the global scale, and thus allow incorporation of soil CO_2 flux into more inclusive CO_2 models.

To derive a "global carbon budget," all of the complex CO_2 interactions need to be accurately fed into a computer model. CGRER members O-Yul Kwon and Jerry Schnoor have just published a model that integrates the oceanic, atmospheric, and soil interactions into a single model for the first time. Their model will aid persons who are analyzing atmospheric CO_2 changes and attempting to determine their probable results, and it will point out future research needs. Because of this new model's completeness, it also is being considered by the Intergovernmental Panel on Climate Change as a tool for guiding governmental restrictions on CO_2 emissions in the future.

But are all these efforts to model CO_2 changes worth the effort? True, CO_2 is the most abundant greenhouse gas, but global warming concerns aside, how do changes in CO_2 concentrations directly affect life on earth? Raising the levels of CO_2 in the laboratory has been shown to stimulate the growth of some plants, and recent research demonstrates that this growth enhancement may already be going on in nature. Tropical forests which are otherwise intact are displaying substantially higher rates of turnover — that is, higher death rates and faster recruitment of new individuals. Accelerating forest turnover rates, which have been detected around the world over the last 25 years, coincide with the buildup of atmospheric CO_2 over the same time period, and that CO_2 buildup is thought to be the causative factor. Speeding up the tropical forest turnover rate is significant: through selecting against slow-growing trees, it could decrease the biodiversity of these large, complex forests. Also, since the faster growers have less dense wood, the forests' CO_2 storage capability could decrease — which in turn would increase atmospheric CO_2 concentrations even more.

#3. Ozone Depletion and Amphibian Reproduction

Depletion of stratospheric ozone over Antarctica was first noted in the early 1980s. This decline was traced to CFCs, chemical compounds widely used in refrigerating systems, insulation, and elsewhere. The decline of ozone raised alarm because of ozone's importance as the primary filter for UV radiation from the sun. Without such a filter, the increased UV radiation at the earth's surface threatens to play havoc with exposed organisms. Humans, for example, could expect more cataracts, more skin cancer, and a depression of the skin's immune system. Effects on other animals could be similar or more severe, especially among species with the greatest exposure: those found at high altitudes, those with the thinnest and most vulnerable skin, and the like. Plant growth and consequently agricultural productivity also is negatively affected by increased UV radiation.

Tropical forests around the world are demonstrating a significantly accelerated turnover rate, which is thought to be caused by growth enhancement from climbing atmospheric CO_2 concentrations.

DID YOU KNOW:

The following statistics are taken from *The Earth as Transformed by Human Action**, the proceedings of a major symposium which documented human-induced alterations of the biosphere over the past 300 years. These statistics demonstrate the magnitude of human-induced change to which life on earth is being forced to respond.

About 6% of the earth's land surface has been radically transformed to structures such as settlements, roads, and reservoirs.

The net loss of forests through human activity is about 8 million km^2, approximately the size of the continental US; 3/4 of that amount has been cleared in the last 300 years. Much of this has been added to the 15 million km^2 now used for cropland.

The annual human withdrawal of water from natural circulation is about 3,600 km^3, an amount exceeding Lake Huron's volume.

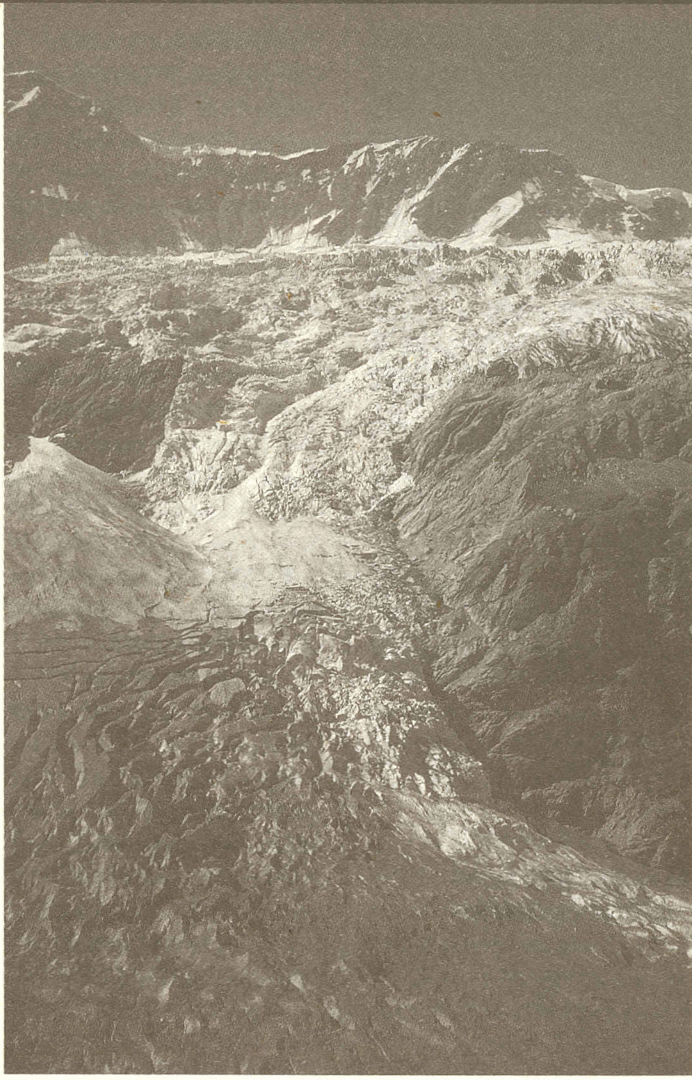
An area the size of France is submerged beneath the earth's artificial reservoirs.

* BL Turner, editor; 1990; Cambridge University Press with Clark University; Cambridge, England; 713 pp.

Ozone declines now have been documented around the globe, and researchers are attempting to determine the extent of depletion in various locations. The accuracy of their measurements is critical to this effort. CGRER astronomers Steve Spangler and Jack Fix are developing a technique to use radio telescopes to improve the vertical resolution of ozone measurements. By examining absorption as well as emission lines from ozone, they expect to fine tune our knowledge of the altitude profile of ozone distribution and better trace changing ozone abundance in the future.

A significant ozone depletion trend of a fraction of a percent annually already has been recorded for Iowa, as well as for much of the northern hemisphere. CGRER members Kevin Crist and Greg Carmichael have been using satellite and ground-based measurements to evaluate the ground-level changes in UV radiation resulting from this ozone decline. Their computer simulations show that rural Iowa is indeed experiencing increasing amounts of UV radiation. Persons need fear exposure particularly in the summer during the middle of the day, when the sun is directly overhead.

Beth Jurkiewicz, a graduate student working with CGRER member Garry Buettner, has demonstrated how increased UV radiation might affect human health. Using a mouse model, she showed that UV radiation hitting skin stimulates the formation of free radicals, reactive chemical species that are known to lead to photoaging and skin cancer.



The Grindelwald Glacier, a valley glacier in Switzerland's Alps, is melting at the speed of 2 cm. per year — an unprecedented rate in the last few thousand years. Glaciers worldwide are now melting due to the warm global climate.

Researchers have demonstrated that other detrimental responses to UV radiation are already occurring among amphibians. The severe decline of many frog and toad populations has alarmed herpetologists since 1990, when this drop was discovered to be occurring around the world. Several causes of the decrease have been suggested, such as acidification of waters where they lay their eggs and pollution of these waters. Research published in March showed that the decline, at least for high-altitude species that lay their eggs in the open, is likely caused by increases in UV-B radiation. This radiation alters the structure of the frogs' genetic code, preventing it from carrying out its tasks of protein production and self-replication during cell division. As a result, the sensitive gelatinous eggs of these amphibians do not hatch successfully, and the populations are cascading downward. Iowa's amphibian expert, Professor Jim Christiansen, has hypothesized that this process might explain the recent disappearance of the previously-abundant cricket frog in the northern tier of Iowa counties.

At times, the significance of individual bits of CGRER research may be viewed as inconsequential. We might wonder if a more accurate understanding of soil CO_2 emissions really matters. Or whether a few more free radicals in our skin will do much to us, or if programs to predict plant migrations are worth the cost. We might be lulled into skepticism concerning the worth of frog songs in the summer, or doubt the crashing slump of a tropical tree if no one is there to hear it.

But once these research bits are tied to the bigger picture, their significance looms overhead. For what other species are exposed to, so are we. The frogs and tundra plants that are now reacting to environmental changes probably differ from us humans in quantity of dose rather than quality of response. They are simply extremely sensitive detectors of atmospheric distortions. Heeding their canary songs now will bode us well in the future.

And even if we humans were never to react to certain environmental changes, we

will be affected by their perturbations. For each of nature's seemingly small reactions has the potential of cascading in ways that may never have been expected. As an example, consider the ongoing decline of migrant songbirds in temperate forests. Biologists had warned that populations of insects eaten by those birds could explode. But few expected the results of recent research, which demonstrated that a decrease in bird numbers also stresses forest productivity. Trees, in particular white oaks (which abundantly grace our Iowa woodlands), were shown to have twice as much insect damage to foliage when unprotected by songbirds, and they produced significantly fewer leaves in subsequent years. Thus a decline in songbird populations may assault the general health and integrity of our eastern forests and the strength of forest-based economies.

The need is greater than ever to collect the pieces of information that, when added together, create a complete picture of how we are changing our world. To bring researchers together in centers such as CGRER, where they can tie their ideas to those of others in related disciplines, linking cause to effect, and hoping that processes of change might also be discovered. To tie the atmospheric changes being measured by physical scientists and engineers to the rebounds of life on earth at all levels. These linkages of research and researchers endow CGRER with mission and point its direction. ✺

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Did You Know:

Global irrigated agriculture has jumped from 80,000 km^2 in 1800, to 2,200,000 km^2 in 1984; about half of all irrigated land is affected to some degree by secondary salination.The human population first reached 1 billion about 175 years ago. Since then each new billion has been added at shorter intervals: in 115 years, 35 years, 15 years, and 11-12 years.

The number of cities exceeding a million in population jumped from 16 in 1900, to about 400 today.

In the last 300 years, the human population has shifted from being almost totally rural, to over 40% living in urban areas.

In many categories — population growth, water withdrawals, and cumulative releases of sulfur, phosphorus, nitrogen, lead, and many organic chemicals — half of the totality of humankind's transformation of the earth has occurred since World War II.

15% of all plant species are believed to be threatened with extinction.

Student Focus

Editor's Note: From time to time, *IOWATCH* will replace the usual *Faculty Focus* column with a description of student activities. Training students in the interdisciplinary mode of thinking required for addressing global change issues remains a major goal at CGRER. Most of this effort is directed toward graduate and undergraduate students in the natural sciences and engineering. However, occasionally a younger student is enlisted in CGRER's ranks.

During the summer of 1994, intern Renee Hurtig performed library research in government policies dealing with greenhouse gases. Renee, newly graduated from City High in Iowa City, became interested in this field through high school debate. Now a freshman at Duke University, Renee plans to major in public policy. She summarized her internship investigations in the following article:

Imagine going into the greenhouse of your local plant store and permanently raising the temperature several degrees. Understandably, the owners would be furious — thousands of dollars of plants would wither, suffer, and die, and the owners' livelihood would be wiped out. The financial losses would hinder their ability to provide food and shelter for their families. Now translate that scenario into one involving billions of people and it's easy to see why many people are concerned about the potential for global warming.

Global warming is attributed to the magnification of a phenomenon known as the greenhouse effect. Like a greenhouse's glass panels, the Earth's atmosphere allows sunlight to filter through and heat the planet's surface. The Earth sends back much of that heat in the form of infrared radiation, yet not all of it escapes. Greenhouse gases, such as CO_2, water vapor, and ozone, trap some of this heat and send it back to the surface, adding to the warming effect of sunlight. Without this natural trapping effect, the average global temperature would drop approximately 60° F.

A continual rise in the concentration of CO_2 in the atmosphere since the start of the Industrial Revolution has magnified the greenhouse effect. Coincidentally, global temperatures have risen slightly, but the warming is within the annual variability that might be expected. Some scientists attribute that rise in temperature to the emission of CO_2 from increased burning of fossil fuels such as coal, combined with the destruction of forests and vegetation, which absorb some of the excess CO_2. Carbon dioxide emissions have more than tripled since 1950, while at the current rate of deforestation, the world's tropical rain forests, one of the largest known storers of CO_2, will all but disappear by midway into the 21st century. Some experts predict that CO_2 concentrations in the atmosphere will double by that time.

The United States is the world's largest CO_2 emitter, followed by China and Russia. In 1993, approximately 5,900 million tons of CO_2 were emitted by all countries from fossil fuel burning — 68% of which was from the industrial world and former Soviet Bloc, although those countries have only 22% of the world's population. The United States leads the world in per capita emissions of CO_2, with 5.4 metric tons of carbon, and Iowa ranks thirteenth among states in this category.

As a result of the magnification of the greenhouse effect, it has been estimated that global temperatures could rise 2 to 5° F. The Intergovernmental Panel on Climate Change estimated that global temperatures could rise as high as 19° C by 2050 if CO_2 concentrations double. The expected climate change would be of a magnitude similar to the difference between today's climate and that of the last Ice Age. In a worst-case scenario, this warming could lead to the melting of the polar ice caps, raising sea levels and dramatically altering coastlines, while also disrupting and potentially destroying the world's already-limited supply of fresh water. However, all of these predictions are highly uncertain.

It may be hard to believe that a few degrees of temperature change could have such dire consequences. Yet in Iowa, the possible impacts of global warming on crop production are grave enough to hit home. While average temperatures for the five-year period ending in March, 1991, increased by only a fraction of a degree over those of the mid-1950s, the average temperatures during the summer growing season were at record levels for the last three years in that period.

Using NASA's models, researchers at Michigan State University predicted that the average growing season temperature in Des Moines would be 6.3 to 14.4° F warmer if CO_2 levels are doubled, with no substantial change in the amount of precipitation. Crop failures and food shortages could become commonplace. Farmers would need to respond with different crop types and new farming techniques, and seed companies would need to develop new genetically adapted varieties.

To reverse this trend and stabilize CO_2 concentrations in the atmosphere, CO_2 emissions would have to be cut 60%.

The global implications of the greenhouse effect have attracted international attention. The Earth Summit, held in Rio de Janeiro in June, 1992, produced a number of agreements that dealt with global warming on some level. Agenda 21, a forty-chapter document of programs and cost estimates, outlined goals and an action plan for promoting environmentally and economically sustainable development, especially in industrializing countries. Individual chapters dealt with combating climate change and preventing deforestation.

Also accepted in conjunction with the Rio conference was the Convention on Climate Change. The goal of the convention was to "... achieve ... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner."[1] The convention requires industrialized countries to develop national emission standards and inventories and to report on their progress, but no specific targets or dates are included other than the aim of returning greenhouse gases to "earlier levels" by the year 2000.

Renee Hurtig

To fulfill the goals and requirements of the convention, President Bill Clinton and Vice President Al Gore proposed their Climate Change Action Plan in October, 1993. The Clinton-Gore plan intends to reduce U.S. greenhouse gas emissions to 1990 levels by the year 2000 through initiatives in all sectors of the economy — industry, transportation, homes, office buildings, forestry, and agriculture. Actions in each of these sectors are designed to increase the markets for greenhouse gas emission-reducing technology, including alternative energy sources such as wind and solar power, while protecting forests through increased recycling, better forest management, and more tree planting. Few of these plans were implemented as of the summer of 1994.

Currently, no national government laws or programs exist that intentionally and directly address greenhouse gas emissions in the United States. The Clean Air Act of 1990 focused mostly on urban smog, acid rain, and air quality. The act targets 189 pollutants, ranging from freon, used in refrigerators and air-conditioners, to hydrocarbon ethanol, a yeast by-product produced in large quantities by bread bakeries, whose emissions must be cut by 90%. It also sets regional air quality standards and emission levels and fees for many pollutants.

One section of the Clean Air Act that does address greenhouse gas emissions has a direct impact on Iowa. The act requires that the smoggiest areas of the country begin using cleaner-burning "reformulated" gasoline that is 2% oxygen by weight by 1995. On June 30, 1994, the U.S. Environmental Protection Agency ruled that 30% of the oxygenates added to the gasoline to meet the standard must be made from a renewable source. Ethanol, an oxygenate made from corn, is the only product that could meet the expected demand when the new gasoline hits the pumps. Iowa is the second largest producer of ethanol in the country, producing almost five times as much as the third largest producer, Indiana.

This requirement is controversial in two respects. First of all, conflicting reports about the environmental and economic benefits of ethanol, compared to its fossil fuel based alternative methanol, have been given by the U.S. Environmental Protection Agency and the U.S. Department of Agriculture. Second, the oil industry, the primary distributor of methanol in this country, is suing the government over this decision.

On the state government level, the Energy Efficiency Act of 1990 required Iowa utilities to spend 2% of their electric energy revenues and 1.5% of their natural gas energy revenues on energy efficiency programs. Iowans use more energy per capita than residents of forty other states, and most of this energy is generated by CO_2 producing methods such as burning fossil fuels. A 1989 study for the Iowa Utilities Board concluded that "the net benefit to Iowa on efficiency investments of $39 million to $52 million could range from $89 million to $205 million, making energy efficiency the most economically attractive source of energy supply."[2] The efficiency plans must include programs such as giving rebates on efficient appliances and light bulbs, and tree-planting.

Our behavior can affect ecosystems and climates from those of the small world of a local greenhouse to those of the Earth. Vice President Al Gore acknowledged the need for people to recognize the scope and impact of their actions when he wrote:

Human civilization is now the dominant cause of change in the global environment. Yet we resist this truth and find it hard to imagine that our effect on the earth must now be measured by the same yardstick used to calculate the strength of the moon's pull on the oceans or the force of the wind against the mountains. And if we are now capable of changing something so basic as the relationship between the earth and the sun, surely we must acknowledge a new responsibility to use that power wisely and with appropriate restraint.[3] ✹

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2. "Cutting Energy Bill Helps Economy, Environment," Nacy Lange, *Des Moines Register*, p. 13 (news), Oct. 18, 1993.
3. *Earth in the Balance*, Al Gore, 1993, Penguin Books.

Seeds

In August, 1994, CGRER awarded its fourth set of annual seed grants. These $15,000 grants are intended to finance the commencement of projects relating to global change, with the prospect that larger-scale funding then will be found to allow their continuation. The eight new grants cover research from September, 1994, through August, 1995. The deadline for grants for the fifth award period (commencing 9/95) is May, 1995.

R ARRITT (Agronomy, ISU) is evaluating the regional impact of potential climate changes resulting from the predicted doubling of atmospheric CO_2 by the middle of the coming century. By examining potential changes in large-scale patterns conducive to spring and summer precipitation in the Great Plains, he hopes to estimate precipitation changes and promote the evaluation of adaptive strategies.

T-C CHEN (Geological and Atmospheric Sciences, ISU) is looking at climatic changes and global air circulation patterns. Over the past 40 years, a deepening of the low pressure system over the North Pacific and amplification of the high pressure system over the California coast have intensified the channeling of cold air from Canada southward into the Midwest. Chen's research is among the first to examine the relationship between short and long-term changes in climate and global air circulation patterns as they affect the Midwest.

A ELDERING (Civil and Environmental Engineering, U of I) is investigating atmospheric aerosol particulates. Although little is known about their size, chemical composition, and transport in the Midwest, aerosols are important determinants of air quality. By scattering incoming radiation, they also could counteract global warming trends. Eldering trusts that her research will provide the baseline data needed to ascertain problem areas and trace future changes in aerosol levels.

B HELLAND and P ALVAREZ (Civil and Environmental Engineering, U of I) are looking at feasibility and specific design criteria for using elemental iron to transform chlorinated methane chemicals (such as carbon tetrachloride) into relatively innocuous compounds. Chlorinated methanes are hazardous both to humans and to the stratospheric ozone layer; thus methods to detoxify them are of great interest.

C PAVLIK and M ARMSTRONG (Geography, U of I), **D ZIMMERMAN** (Statistics and Actuarial Science, U of I) are evaluating which surface generating techniques most accurately interpolate and display various types of environmental data (such as measurements of acid rain deposition) collected at field stations. To do this, they are linking GIS software to a statistical programming environment to map out and visualize environmental data. Their research will also assist in siting field data collection stations.

F POTRA (Mathematics and Computer Science, U of I) and **G CARMICHAEL** (Chemical and Biochemical Engineering, U of I) are developing a sophisticated mathematical model to investigate the chemistry and transport of tropospheric contaminants. This computer model will allow faster and more precise simulations of atmospheric transport and chemistry processes, leading to a better understanding of the environmental effects of contaminants around the globe, both at present and in the future.

J SCHNOOR (Civil and Environmental Engineering, U of I) and **D FORKENBROCK** (Public Policy Center, U of I) are commencing a policy-oriented collaborative research effort with the Iowa Department of Natural Resources and the Midwest Transportation Center. They intend to inventory Iowa greenhouse gases, and then to integrate the strategies of increased energy efficiency and reforestation into an action plan for reducing greenhouse gases in Iowa. Transportation, residential, and agricultural policy alternatives will be analyzed.

US TIM (Agricultural and Biosystems Engineering, ISU) and **R JOLLY** (Economics, ISU) are concerned about the environmental and economic implications of global warming on rangeland ecosystems. They are attempting to integrate biophysical and economic models to estimate the impact of changes in climate on rangeland hydrology, forage production, and animal production. They also are using the integrated modeling system to examine the potential impact on regional economies. ✺

The University of Iowa's Center for Global and Regional Environmental Research (CGRER) promotes interdisciplinary efforts that focus on the multiple aspects of global environmental change, including its regional effects on natural ecosystems, environments, and resources, and on human health, culture, and social systems. Center membership is composed of interested faculty members at any of Iowa's colleges and universities.

Center goals are promoted by encouraging interdisciplinary research and dialogue among individuals whose disciplines touch upon any of the multifaceted aspects of global change. More specifically, the Center awards seed grants, fosters interdisciplinary courses, provides state-of-the-art research facilities and equipment, and holds seminars and symposia. The Center encourages students to broaden their studies and research through considering the multidisciplinary aspects of global and regional environmental problems. Through such activities, the Center attempts to assist Iowa's agencies, industries, and citizens as they prepare for accelerated environmental change that may accompany modern technologies.

Housed in the Iowa Advanced Technology Laboratory at The University of Iowa, the Center was established by the State Board of Regents in 1990 and received funding through the year 2001 from a public utility trust fund, as mandated by the State of Iowa's Energy Efficiency Act.

IOWATCH is published biannually for researchers, employees of state agencies and public utilities, members of citizen action groups, and other Midwesterners interested in environmental change and the actions of the center. Newsletter articles may be reprinted with proper citation. Comments, questions, and requests for additional copies are welcomed; please contact:

Jane Frank, Admin. Asst.
CGRER
The University of Iowa, 204 IATL
Iowa City, Iowa 52242
319-335-3333
FAX 319-335-3337

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