IES Newsletter

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Director's Note

While the living components of ecosystems attract the most attention, non-living parts are just as important when we consider the "health" of the whole. Non-living components, including rocks, soil, water and air, constitute the physical environment, and from them come inorganic chemicals that are the nutrients required for life.

The nutrients that cycle through the ecosystem and sustain animals, plants and microbes include carbon, nitrogen, phosphorus, calcium and sulfur. My own research at the Hubbard Brook Experimental Forest in New Hampshire has demonstrated how imbalances in biogeochemical cycles can be harmful to the overall health of the system. This issue of the newsletter features the work of Dr. Louis Verchot, who has developed a way to measure and thereby understand some of the elusive components of the nitrogen cycle.

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Director: Gene E. Likens
Administrator: Joseph S. Warner
Head of Education: Alan R. Berkowitz
Newsletter editor: Jill Cadwallader

Address newsletter correspondence to the editor at:
Institute of Ecosystem Studies
Education Program, Box R
Millbrook NY 12545-0178
e-mail: CadwalladerJ@ecostudies.org

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Measuring the Impact of the Invisible

You're probably a reasonably observant person. Maybe you even fit the profile of the "keen observer". But no matter how hard you try to take in all that's going on around you, some things always will be invisible. And when these invisible things are linked to much bigger things — acid rain and global warming to name two — it's important to be able to make them if not visible at least measurable.

At the Institute of Ecosystem Studies, Dr. Louis Verchot is blending scientific creativity with technical ingenuity to make this possible. Dr. Verchot is measuring a process that produces nitrogen gases in the environment. As you will see, this is not so easy to do. But before we get into that, a little background may help explain the relevance of this work.

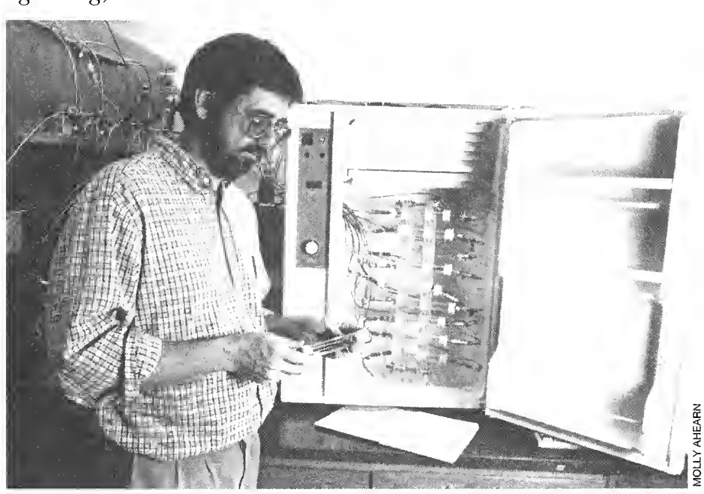
Invisible Elements

The nitrogen cycle is a biogeochemical cycle that has regulated ecosystems throughout Earth's history. Most of the materials contributing to biogeochemical cycles are invisible things, chemical elements circulating from environment to biological organisms and back again. You're surrounded by the tangible products of these cycles: the water you drink and the oxygen you breathe, the plants in the landscape ... not to mention what's on your dinner plate, and your own protoplasm, bones and teeth.

Bonded with other elements, nitrogen builds proteins, vitamins, hormones, enzymes and other compounds essential for life. To build these life-sustaining compounds, nitrogen gas, which makes up nearly 80% of the Earth's atmosphere, must be converted into a usable form, called nitrate. In nature, this conversion is accomplished through the effects of lightning, meteor trails and cosmic radiation in the atmosphere; by certain algae in aquatic ecosystems; and by nitrogen-fixing bacteria in soils and water, and in nodules on the roots of legumes such as peas, beans, clover and alfalfa. Industrial processes such as the manufacture of fertilizers also make nitrate.

Decomposition of fallen leaves, animal wastes and dead plants and animals returns nitrate to the system, at which point denitrifying bacteria in soils con-vert it back to nitrogen oxides — precursors for acid rain, ozone production and the greenhouse effect — as well as nitrogen gas. Denitrification, then, is the nitrogen cycle's equivalent of transporting recyclable products from the transfer station to the recycling center.

In a relatively recent development, human actions in some parts of the world are literally fertilizing forests. In the northeastern United States, for example, increased nitrogen mobilization comes from agricultural runoff, which carries with it nitrate from the escalating use of fertilizers, and from acid rain, of which nitric acid is a component. Whereas up to a point an additional input of nitrogen can boost plant growth, nitrogen satura-tion is a real problem — when forests can-not absorb any more nitrogen there may be a decline in productivity, an increase in plant disease from pests and pathogens, and pollution of surface water and groundwater. There are other dangers as well. Methemoglobinemia or blue-baby syndrome, for example, is a condition that results from nitrates in drinking water being converted in the intestinal tracts of infants to chemicals that oxidize hemoglobin in the blood. When hemoglobin can no longer transport oxygen, brain damage or death can follow.



MOLLY AHEARN

Dr. Verchot developed the apparatus he uses to measure denitrification. Here he holds one of the glass tubes in which soil samples are incubated.

Measurements Influence Policy

How do environmental managers and policy makers deter-mine how much nitro-gen is safe for an eco-system, thereby pre-venting or at least reducing the negative impacts? Frequently, they depend on ecolo-gists to tell them the "critical loads", above which the ecosystem degrades. And ecologists base their determinations on a

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Baltimore Ecosystem Study Going Strong at End of First Year

In October 1997, the Institute received funding through the National Science Foundation Long-Term Ecological Research (LTER) program to launch the Baltimore Ecosystem Study. This pioneering project, one of only two urban LTERs in the United States, was introduced to newsletter readers a year ago (Vol. 14, No. 6), and the past issue described some of the vegetation studies now under way. The first annual meeting of the Baltimore Ecosystem Study was held early in October, at the time of the project's first anniversary.

One of the strengths of the Baltimore Ecosystem Study (BES) is its extremely collaborative nature. The recent meeting provided the first formal opportunity to engage BES partners — city, county and state agencies; teachers; neighborhood associations and watershed associations — in dialog with project scientists, students and staff. Among the meeting's accomplishments, according to Dr. Steward Pickett, IES ecologist and BES Project Director, were development of a greater understanding of the multiplicity of interests among the group, and preparation of a list of questions for guiding watershed research.

MARY CADENASSO

The meeting was also a celebration of the completion and occupancy of new BES laboratory and office space in the Technology Research Center Building at the University of Maryland, Baltimore County. Speaker at the opening reception was Dr. Freeman Hrabowski, III, president of the university and a strong advocate for the Baltimore Ecosystem Study.

Dr. Hrabowski, center, with Ms. Jacqueline Carrera, Executive Director of the Parks and People Foundation and one of the BES principal investigators, and Dr. Pickett.

SEEDS for a New Generation of Ecologists

Eleven students from institutions participating in the Strategies for Ecology Education, Development and Sustainability (SEEDS) project attended the joint annual meetings of the American Institute of Biological Sciences and the Ecological Society of America (ESA), held in Baltimore in August. Among them were Tuskeegee University students Mr. M. Kamau R. Crawford and Ms. Zakiya Holmes, who met with U.S. Secretary of the Interior Bruce Babbitt following his ESA Plenary Address. Mr. Crawford and Ms. Holmes spent the summer at IES doing research with Drs. Peter Groffman and Louis Verchot in the Institute's Research Experiences for Undergraduates program.

SEEDS is a partnership formed in 1996 between the United Negro College Fund, the Ecological Society of America and IES. Its goal is to increase minority representation in the field of ecology through recruitment and curriculum development. Funding for the program comes from The Andrew W. Mellon Foundation, which recently not only renewed funding of the program through 2001, but also expanded its support so that 10 institutions, compared to five originally, will be able to participate. The ESA portion of the project is run by Dr. Alan R. Berkowitz, IES Head of Education and ESA Vice President for Education and Human Resources, and by Project Coordinator Stephanie Shoemaker, also at IES.

AIBS PHOTO

Left to right: IES Visiting Scientist Dr. Richard Pouyat, ESA Gender and Minority Affairs Committee Chairperson (and a BES principal investigator), Mr. Crawford, Ms. Holmes and Secretary Babbitt.

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"mass balance" approach, which is a kind of ecosystem accounting: What enters a system, what is stored and what leaves should add up. Unfortunately, if the measurements are inaccurate, the determinations and balance also are inaccurate.

The products of denitrification are gases, and nitrogen gases moving into an atmosphere that is predominantly nitrogen are extremely difficult to measure. Existing methods to determine how much nitrogen is released by denitrifying bacteria in forest soils have resulted in gross underestimation of nitrogen leaving the ecosystem. This in turn has led to inaccuracies in mass balance calculations and to potential errors in determining how much nitrogen we can tolerate in our forests without causing damage.

As an IES post-doctoral associate, Dr. Verchot took on the challenge of measuring these nitrogen gases, produced in parts per million but resulting in an estimated four to five pounds released per acre per year, and has developed and constructed a system to measure nitrogen flux in a nitrogen-free environment. The apparatus consists of glass tubes, metal piping and an incubator. Soil samples are put in the tubes and a mixture of inert argon gas and oxygen is piped through, purging nitrogen from the system. The system is then closed. Denitrifying bacteria present in the incubating soils convert nitrates to gases, which are sampled at intervals and injected into an instrument called a gas chromatograph. A print-out records the amounts of nitrogen gas and nitrous oxide — one of the gases

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Everything is Connected?

by Steward T.A. Pickett

A few years ago, one of the most important international scientific journals, *Science*, listed the "top 20" scientific ideas. Most of them were about physics, chemistry, physiology, or genetics and evolution. Only the last one was about ecology. As an ecologist, I hope that merely reflects the relative youth of ecology as a science, rather than some real expression of the value of our discipline. At least we made the list.

So, what was the big idea in ecology that made it onto that august list? "All life is connected." Sounds pretty good, and it is hard to argue with as it stands. But something is wrong with that idea as the sole portrait of ecology in a scientific hall of fame.

First, I must admit that there is some validity to the idea. Ecology as a science *is* about connections. Ecologists study the connections between organisms and their physical environments. For instance, connections can appear as the flow of energy in the food a predator eats, or the physical stresses that control where a plant can grow. Other kinds of connections include the interactions between organisms, like those behavioral interchanges that determine territorial boundaries, or breeding success. Interactions in ecology also include the subtle chemical transformations by microbes of the chemicals locked up in dead organic matter into nutrients that other organisms can use. All these kinds of interactions and transformations are connections.

There are other kinds of connections in ecology as well. Organisms, information encoded in genes, nutrients, toxins, and the whole roster of ecologically important things, can move from place to place. Sometimes, these movements are obvious, as when flocks of birds migrate south for the winter, or smoke transports some of the nutrients released in the process of combustion, or plumed seeds fly away on an autumn wind. In other cases, the movements are subtle, and knowable only by sophisticated techniques. Examples of such subtle connections are the movement of invisible pollutants in apparently clear air, or the transport of chemicals in ground water, or the concentration of a toxin in the fat of a voracious predator.

Yet another kind of connection in ecology is one that occurs through time. For example, the composition and physical structure of the forests of Dutchess County today reflect the way that farmers and settlers used the land decades and centuries ago. Whether land was grazed or plowed affects its capacity to support different kinds of trees or the rates at which those trees can grow. Over an even longer time, where the melting glaciers dumped coarse versus small sediments 12,000 years ago affects the moisture content and quality of our soils today.

So ecology *is* about connections. Connections are what make the world look and work the way it does. But still, there is something wrong with the surprisingly naive statement, by a journal whose editors ought to know better, that everything is connected to everything else.

If that statement were literally true, the world would be a fairly homogeneous smear. Uniform and instantaneous connection would mean that the world would offer everywhere very similar kinds and amounts of resources for plants and animals. It would mean that different places would be equally stressful or benign, and that they would be inhabited by the few species that would be able to use just that range of conditions and resources well.

This boring uniformity is clearly not the case. Ecology is an interesting science, and generates crucial knowledge for management and understanding the world, because things and places are not simply connected — they are *differentially* connected. Some of those fluxes of material, energy and organisms are stronger or faster than others. For instance, the mineral forms of nitrogen move more readily in moist soils than do the materials carrying phosphorus. Likewise, some places hold onto the materials or organisms that move into them better than others. For instance, the edges between forests and fields are hot spots for certain kinds of organisms. Differential connection also influences interactions through time. The echoes of different past events fade at different rates, so that the effects of even a very large snowstorm on forest tree populations may disappear over a few years, while the legacy of chemical pollution may take decades to centuries to fade to levels similar to those before the spill or dumping.

So the useful idea about ecological connection is not that connection is everywhere. The pervasiveness of connection is, in a sense, just a definition of ecology. Ecology can be defined as the science of the patterns and causes of connections — that is, interactions, fluxes, dynamics, and transformations — that the living world exhibits. Taken at that level of generality, ecology does of course suggest that an interaction or event at one place and a specific time may well have effects that appear elsewhere or at a later time. It is valuable to recognize this kind of "connectedness" in the world when we take individual, economic, or social actions. But expecting that everything literally affects everything else cheapens ecology, because, in fact, many events or processes have very little or virtually no effect on much of anything else. So the idea of connection doesn't mean that every event or process will strongly, directly, or immediately affect every other place and thing.

What is true about connections in the natural world is that they are often subtle, indirect, or slow. They often act over long distances, or their effects may take a long time to appear. This is what is interesting and challenging about ecology. It is the science that discovers how — how fast, how long, how distant — different connections occur. It is the science of ferreting out the unsuspected connections and the indirect links. Just because some connections are subtle doesn't mean they are trivial. Recall that the importance of DDT as a pollutant was missed because it doesn't have direct effects at the concentrations it typically reaches in a contaminated environment, but only after it has been concentrated in the fat of long-lived animals, or those that forage widely for their animal prey.

The metaphor that the journal *Science* assigned to represent ecology is quite misleading. Ecology isn't important because everything is connected to everything else. It is important because it discovers *how* things are connected, and exposes not only the strong and obvious connections, but also the hidden, slow, or distant ones as well. Different kinds and strengths of connections drive and shape the natural world, but not every connection equally.

Dr. Steward Pickett is a senior scientist at the Institute of Ecosystem Studies. In a follow-up article in the next issue of the newsletter, Dr. Pickett propose s an idea that might better represent the discipline of ecology in that "top 20" list.

INSTITUTE OF
ECOSYSTEM STUDIES
Education Program
Box R
Millbrook, New York 12545-0178

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responsible for air pollution — released. Using this apparatus in the IES laboratory, Dr. Verchot will be measuring denitrification in soils from forests around the Institute, at the Hubbard Brook Experimental Forest in New Hampshire and Bear Brook in Maine, and from sites in the Catskill Mountains, Massachusetts and Virginia.

Results from Dr. Verchot's research should help to bring the mass balance of nitrogen closer to reconciliation. Then, armed with more accurate data, ecologists will be better able to inform decision makers about safe amounts of nitrogen deposition to forest ecosystems.

* * * * *

Dr. Louis V. Verchot is an ecosystem ecologist with a doctoral degree in forest soil ecology from North Carolina State University. Prior to his arrival at the Institute in October 1997, Dr. Verchot had been a postdoctoral associate at the Woods Hole Research Center. During this period, he worked in Brazil, just south of the mouth of the Amazon River, studying the flux of greenhouse gases — carbon dioxide, methane, nitrous oxide and nitric oxide — from the soil to the atmosphere. His findings now are being used by scientists at NASA to estimate greenhouse gas emissions from soils in Amazonia. This work also is providing important information to the Brazilian government in its efforts to account for greenhouse gases emissions, as required by the Framework Convention on Climate Change. Dr. Verchot plans to continue his research in the Amazon, applying what he is learning at IES to further study of greenhouse gases. At IES, Dr. Verchot is collaborating with microbial ecologist Dr. Peter Groffman, as well as with Drs. Gary Lovett and Kathleen Weathers.

Calendar

CONTINUING EDUCATION

For a **winter-spring** catalogue and program information, call the Continuing Education office at 914/677-9643.

IES SEMINARS

Free **scientific seminars** are held each Friday at 11:00 a.m. at the IES Auditorium. A schedule for the winter-spring series, which begins January 15, was not available at press time. Call 914/677-5343 to request a copy, or find it on the IES Website (www.ecostudies.org) after January 8.

GREENHOUSE

The IES greenhouse, a year-round tropical plant paradise and a site for controlled environmental research, is open until 3:30 p.m. daily except public holidays. Self-guided Economic Botany Trail. Admission is by free permit (see "HOURS").

IES ECOLOGY SHOP

New in the Shop ... holiday candles ... blown glass paperweights ... 1999 calendars ... cotton throws ... **for children** ... new shipment of Folkmanis puppets ... lots of great books! ... **and in the Plant Room** ... glass vases in wonderful new colors ... kidskin gardening gloves ... copper planters.
Senior Citizens Days: 10% off on Wednesdays
January Sale: from January 1-20, 50% off holiday items, 20% off gifts, 10% off books
February Sale: 50% off all 1999 calendars
•• **Gift Certificates** are available ••

HOURS

Winter hours: October 1 - March 31
Public attractions are open Mon. - Sat., 9 a.m.-4 p.m. & Sun. 1-4 p.m., with a free permit*. (Note: The Greenhouse closes at 3:30 p.m. daily.) The **IES Ecology Shop** is open Mon.- Fri., 11a.m.-4 p.m., Sat. 9 a.m.-4 p.m. & Sun. 1-4 p.m. (The shop is closed weekdays from 1-1:30 p.m.)

Holiday Hours
The IES Ecology Shop closes at 3 p.m. on Dec. 24 and Dec. 31 and is closed on Christmas and New Year's Day. It is open as usual on the weekends of Dec. 26-27, and Jan. 2-3.
* *Free permits are required for visitors and are available at the IES Ecology Shop or the Education Program office daily until 3 p.m.*

VOLUNTEER OPPORTUNITIES

We have opportunities for volunteers in a number of areas. At present, there is special need for a one-day-a-week Volunteer Program coordinator, for an Education Program office assistant (either half-day or full-day on Fridays), and for weekday assistants in the IES Ecology Shop. For information on volunteering at IES, call Ms. Su Marcy at 914/677-5359.

MEMBERSHIP

Join the Institute of Ecosystem Studies. Benefits include subscription to the newsletter, member's rate for courses and excursions, a 10% discount on IES Ecology Shop purchases, and participation in a reciprocal admissions program. Individual membership: $30; family membership: $40. Call Ms. Janice Claiborne at 677-5343.

The Institute's Aldo Leopold Society
In addition to receiving the benefits listed above, members of The Aldo Leopold Society are invited guests at spring and fall IES science updates. Call Ms. Jan Mittan at 677-5343.

TO CONTACT IES ...

... for research, graduate opportunities, library and administration:
Institute of Ecosystem Studies
Box AB
Millbrook NY 12545-0129
Tel: 914/677-5343 • Fax: 914/677-5976
Street address: Plant Science Building, Route 44A, Millbrook, N.Y.

... for education, general information and the IES Ecology Shop:
Institute of Ecosystem Studies
Education Program, Box R
Millbrook NY 12545-0178
Tel: 914/677-5359 • Fax: 914/677-6455
IES Ecology Shop: 914/677-7649
Street address: Gifford House Visitor and Education Center, Route 44A, Millbrook, N.Y.

...IES website: www.ecostudies.org