# CECB UPDATE

Boston University • Center for Ecology and Conservation Biology • Fall 2000

## GREETINGS FROM THE CECB DIRECTOR

*CECB Director, Tom Kunz*

Welcome to the 3rd edition of "CECB UPDATE." I am writing to tell you about some of the exciting things that have happened since our last newsletter in 1999. Friends of CECB have continued to support our educational and research programs, and we are most grateful for their valuable time and financial support. We continue to work closely with BU's Division of International Programs in offering a semester-long Tropical Ecology Program in Ecuador in both the Fall and Spring semesters. Students continue to rave about this truly unique opportunity and we are now exploring possibilities for more intense research opportunities for students in the summer following their participation.

In October 1999, CECB hosted a major conference at BU, in collaboration with the Humboldt Field Research Institute, to celebrate the 200th anniversary of Alexander von Humboldt's expedition to the American tropics. This two-day conference brought scholars and scientists from around the world to Boston University, where they shared their knowledge about one of the most influential scientist/explorers of the 18th Century. Chancellor Silber opened the conference with introductory remarks.

This past March, as in previous years, we hosted a 9-day excursion to the Tipituni Biodiversity Station in Ecuador. Participants on this trip included BU trustees, administrators, faculty, staff, and friends of CECB. This was an enjoyable trip for all who participated. Upon our return to Boston, we immediately began making plans for a return trip. We hope that some of you will consider joining us in March 2001.

An important highlight of our fund-raising efforts during the past year was the establishment of a CECB Graduate Fellowship Program. The inauguration of this program was made possible by the generous gifts of BU trustees and friends of CECB. Currently, we are supporting three graduate students who are conducting field research in Ecuador and Brazil. Finally, we are pleased to announce the addition of several new CECB Faculty Associates. Several of our faculty associates have begun new research projects and others have completed new books.

Again, I want to thank each of you for making this past year a great success. We look forward to your continued support.

Sincerely yours,

Thomas H. Kunz, Director

## RESEARCH ON LIZARDS SHOWS EVOLUTIONARY IMPORTANCE OF RAINFOREST EDGES

A recent study by CECB Associate Director, Christopher Schneider, is helping to dispel a long-standing belief that geographic isolation fosters species diversity in tropical rainforests. Published recently in the Proceedings of the National Academy of Science, his study of an Australian rainforest skink (a lizard), *Carlia rubrigularis*, demonstrates that ecological gradients, rather than geographic isolates, may be the engines that drive high species diversity in tropical rainforests.

The dominant view is that geographic isolation is critical to species formation because it allows populations to diverge and form new species. "Since perhaps the 1940s," Schneider says, "biologists have viewed gene flow, the exchange of genes between populations, as a force that tends to homogenize. If populations are exchanging a lot of genes, they're not going to diverge very much. The idea of geographic isolation is so attractive because it simply eliminates gene flow. Once you no longer have this exchange of genes that homogenize populations, they're free to diverge, whether in response to selection or through random changes in the genome." The importance of geographic isolation was first challenged by John Endler in the early 1980's. Endler argued that natural selection that acted across ecological gradients (e.g. rainfall gradients that result in different habitats) could cause populations to diverge to the point of becoming new species. Schneider's study adds to a mounting body of evidence that supports Endler's view and highlights the importance of natural selection in generating species richness regardless of the geographic context.

*Assistant Professor Chris Schneider*

Schneider, along with investigators from San Francisco State University and the University of Queensland, observed marked physical differences between skinks found deep in the Australian rainforest and those found on the forest edges. They found the ecotone skinks were generally smaller with shorter limbs and larger heads, and became sexually mature earlier than skinks in the deep rainforest. They also showed that predation on skinks by birds was more intense in the open forest and could be responsible for the physical and ecological differences among skink populations. *(continued on page 4).*

*Pothole wetlands near Minnedosa, Manitoba, Canada.*

## GLOBAL WARMING POSES THREAT TO POTHOLE WETLANDS AND WATERFOWL

CECB Faculty Associate, Dr. Lisa Sorenson recently led a study of the potential impacts of global warming on wetlands and ducks that breed in the prairie pothole region of the north-central United States and south-central Canada. Known as the continent's "duck factory," the prairie pothole region accounts for only 10% of North America's waterfowl breeding habitat but produces 50-80% of the continent's duck population. The region, characterized by gently rolling hills and millions of shallow ponds called "potholes," serves as a key breeding habitat for ducks as well as a crucial feeding and resting area for millions of migratory birds and waterfowl that breed farther north. These wetlands and the birds that use them may be at risk if predictions of future climate change are accurate.

Shallow pothole wetlands are vulnerable to drought, and droughts are precisely what computer models project will occur with greater frequency and severity in this region in the years ahead. A warmer climate increases evaporation and plant transpiration, reducing the amount of water in soils and ponds. Even if global warming brings more rainfall, it may not be enough to offset increases in evapotranspiration.

Sorenson and her research team assessed the impact of global warming on wetlands and duck numbers by comparing historical data on duck and pothole counts with the Palmer Drought Severity Index (PDSI), a rating of the wetness or dryness of an area compared with normal conditions. Sorenson found a strong correlation between the counts and the PDSI, indicating the utility of the PDSI as an index of climatic factors important to wetlands and ducks. Sorenson's team used these correlations in conjunction with projections from state-of-the-art climate models on future PDSI conditions to predict impacts on waterfowl and wetlands in a warmer world.

According to Sorenson, global warming could cause the number of prairie ponds in the north-central United States that hold water in the spring to drop from 1.3 million to just 0.6 to 0.8 million by the year 2060. During the same period, the loss of habitat could reduce the average number of ducks settling to breed in this region from 5 million birds to between 2.1 and 2.7 million. A second study by Sorenson and her colleagues on the Canadian portion of the region is still in progress, but findings for this area are similar to those for the United States. The new study projects significant reductions in wetland abundance and the numbers of ducks settling to breed in Prairie Canada by the middle of the next century.

Studies show that ducks breeding in the pothole region during drought years produce fewer surviving young. But Sorenson emphasizes that ducks are adapted to changing conditions. When severe drought hits the prairies, ducks typically move north to the parkland potholes of Canada, or even to boreal forest and tundra habitats. Even so, duck productivity may decline if birds move to northern areas with shorter breeding seasons. Sorenson's research shows that Canada's parkland potholes may be even more susceptible to drying in a warmer climate than are the prairie potholes. This finding suggests that the potential for ducks to find suitable alternative breeding areas in a drier future may be limited.

Global warming also may make it harder to balance agricultural and waterfowl needs in the region. "If drought increases," Sorenson wonders, "will there be pressure to bring more wetland habitat into agricultural production, or will farmland be abandoned? It's a big question."

*Nesting Canvasback duck in pothole wetlands.*

How can we protect waterfowl habitats from the potential effects of global warming? "It's important to emphasize that the prairie pothole region is unique," says Sorensen. "It's vast, and there's no single conservation action that will really have an effect on such a large area, but wetland conservation is key." She and her colleagues are identifying the least drought-sensitive areas of the prairie pothole region so that these sites can be placed on the priority list for protection.

Sorenson also recommends a redoubling of current efforts to conserve wetlands. "Wildlife and their habitats are already under threat from a wide variety of human-induced pressures," says Sorenson. "Global warming will only exacerbate the many problems that species face, as well as raise new ones."

*Research Assistant Professor Lisa Sorenson*

## PROFESSOR FRED WASSERMAN AND TRUSTEE WILLIAM MACAULEY VISIT TBS ON THE ANNUAL MARCH TRIP FOR ALUMNI AND FRIENDS OF CECB

In the February 1999 issue of *National Geographic*, Virginia Morell is quoted as saying, "I was in England, Kenya, South Africa, Costa Rica, Peru, the Philippines. I think it was 13 countries in all. I just tell people I went from Maine to Madagascar." Ms. Morell goes on to say that the most remarkable place she visited was Ecuador's Tiputini Biodiversity Station (TBS).

I had the pleasure of visiting TBS in March. Even though I have not traveled around the world, I can confidently state that Tiputini was the most remarkable place I have ever visited. Just getting there is an adventure! After arriving in Quito, Ecuador at 11:00 PM we arose early the next morning and rushed to the airport, took a 45 minute flight over the Andes, followed by a 2 1/2 hour boat ride on the Napo River, a 2 hour truck ride, and finally another 2 hour boat ride on the Tiputini River. It was a long, but most extraordinary, trip!

I have visited field stations in Costa Rica and Panama and expected similar accommodations at TBS. (Running water and a shower in our cabin was not what I remember in Costa Rica or Panama!) I had the good fortune to share my cabin with Bill Macauley, an avid birder and BU Trustee. The outdoor dining area offered an opportunity to share thoughts and experiences in a pleasant, relaxing atmosphere.

*Professor Fred Wasserman on the Tiputini River*

However, what makes TBS remarkable is not the adventure or the accommodations but the pristine environment that surrounds the field station. Surround seems as appropriate as any term, when I remember climbing the 120-foot canopy tower and looking out at the forest canopy for as far as the eye can see. I had the good fortune to be on top of the tower one afternoon when a troop of woolly monkeys leisurely made their way past the tower. They were almost as curious about me as I was about them. It gave me pleasure to share the experience with a group of BU undergraduates. Another afternoon we took a canoe ride up a black water river. Three male howler monkeys came within both sight and sound of our canoes. We realized that these animals most likely had never encountered humans. TBS is far from civilization as we know it and the animals around the field station have never been hunted.

Within fifteen minutes of our departure on a Tiputini river float we saw five species of primates along the banks of the river! For the next 90 minutes we slowed as we watched several of troops of spider, howler and squirrel monkeys moving in the trees along the river.

The birds were spectacular. Most interesting to me was the hoatzin, a bird that has been compared to the most ancient of all birds, *Archaeopteryx*. It nests over water and for the first few weeks of life it has claws on the tips of its wings. *No other bird that I know has this ancient characteristic.* It uses its claws to crawl back up a tree to its nest if it falls into the water. Its digestive system is also as unusual; it has bacteria that help digest its herbivorous diet. More like a cow than a bird! It was a short walk to the lagoon to see the hoatzin. The lagoon is also home to a rather large anaconda. Fortunately, the anaconda was too busy to make an appearance. It was possibly meeting for lunch with the jaguar, whose footprint was still fresh in the mud!

Our students return to BU each semester *raving* about TBS. I now know why: It is indeed a very special place.

*Professor Wasserman was a participant on the Annual CECB trip to Tiputini Biodiversity Station for Alumni and Friends of CECB. The trip is led annually by CECB Director Tom Kunz. For more information about this or similar trips please contact the CECB office at (617)353-6982 or email cecb@bu.edu.*

## SEEING IN THE DARK

CECB Director Thomas H. Kunz and colleague Jeff Frank (Indigo Systems, Inc.) spent 10 days in mid-July, on location in Belize, being filmed by a National Geographic film crew. This film highlights some of Kunz's research on the behavior of tropical bats using an advanced technology—in this case an infrared thermal camera. This camera, on loan from Indigo Systems, Inc., promises to make major advances in research on nocturnal animals. According to Kunz, who has reviewed segments of the film "Phantoms of the Night", to be aired on CNBC on November 19, 2000, "this film includes some absolutely amazing images of tropical bats in their natural environment."

In the total darkness deep within one of Belize's hundreds of caves, Kunz and Frank observed towering flowstone, diminutive as well as behemoth stalactites suspended from the ceiling above, massive stalagmites that stood as giant statues emerging from the mirror-like waters that filled the cave. Most importantly, on the rugged cave ceilings, carved by swirling waters of eons past, Kunz and Frank observed hundreds of "glowing," often fidgeting images of roosting bats. These surreal images appeared as if they were twinkling streetlights from small towns and cities that often can be seen from an airplane window when flying at night. As Kunz notes "Most of the images of bats moved ever so slightly; however, others swirled, danced and darted gracefully overhead as if they were choreographed by a symphonic orchestra. The sight was truly amazing! As we coursed through the pitch black chambers of the cavern, moving deftly by the skilled paddling of our guide, we observed bats engaged in assorted behaviors—some groomed themselves, others groomed one another, and females could be seen nursing their pups. With the aid of the infrared thermal camera, we were able to witness behaviors that no one has ever seen before in a natural setting!"

As Kunz's colleague, Jeff Frank notes, "infrared thermal technology has been under development and has been used for well over five decades—initially for military purposes, but more recently, with the development of advanced computer engineering and miniaturization of electronic components, this technology has become increasingly available to field researchers—with features that include high resolution, reliability, and most importantly—portability."

As Kunz notes, "because no illumination is required, this is one of the least intrusive technologies available for observing animals—especially at night. Instead of relying on dim, visible or near infrared light to detect images, infrared thermal cameras detect the heat energy that is emitted by animals during their normal daily activities. The images can be viewed on a liquid crystal display (LCD) mounted on a hand-held mini-DV recorder or on head-mounted goggles with a built-in LCD display. *(continued on page 6).*

## SCHNEIDER'S SKINK RESEARCH, CONTINUED...

Importantly, they found that populations within the rainforest that had been isolated for many million years by a geographic barrier did not differ significantly in morphology or ecology. These findings indicated that differences in natural selection across the ecotone were sufficient to cause population divergence while geographic isolation, even for millions of years, did not.

"Our research points to the fact that geographic isolation alone essentially does nothing," Schneider says. "The key, really, is divergent selective regimes; natural selection pushing populations in different directions. Geographic isolation is not even necessary, because we're seeing these populations diverging in response to natural selection even though there's gene exchange between them and neighboring populations. Selection is strong enough to overwhelm whatever homogenizing effects gene flow might have."

Studies of molecular systematics by Schneider and others have shown that most species of birds, small mammals, reptiles, and amphibians in the lowland rainforests of Australia, Africa, and South America are extremely old, on the order of tens of millions of years. But young species are concentrated in areas of geographic complexity such as the slopes of mountain ranges or transitions from rainforest to savanna.

"Selection that causes populations to adapt to new conditions and habitats in geographically complex areas seems to be driving the divergence of populations from their lowland rainforest ancestors," he says. "The rainforest proper is a reservoir of primarily ancient lineages, species that have stood the test of time. But it's new habitat and geographic complexity, mountain ranges and edges, that seem to be critically important for generating new diversity."

*skink (Carlia rubrigularis)*

This view of evolutionary processes that generate high species diversity in tropical rainforests has important implications for conservation in tropical regions. Conservation efforts often target current patterns of species diversity without considering vital evolutionary and ecological processes that generate and maintain the diversity. Schneider believes that long-term conservation efforts will only be effective if they preserve ecological and evolutionary processes that maintain the integrity of ecosystems. Schneider and others are working with scientists from the Jet Propulsion Laboratory and conservation organizations in South America and elsewhere to incorporate evolutionary processes into conservation planning.

"We're trying to see if we can identify geographic regions that are important for generating diversity," Schneider says. "If those regions can be remotely sensed, then we can target them for rapid assessment programs and try to incorporate them into reserve design."

The National Science Foundation has recognized the importance of this research with a $2.6 million grant to support a three-year study of biodiversity in tropical rainforests. This study involves scientists from the universities that produced the skink study (Boston Univerisity, San Fransisco State University and the University of Queensland) as well as UCLA, the Universidad San Francisco de Quito (Ecuador), the World Resources Institute, and NASA.

"This is a terrific opportunity to do some good work, and I'm very excited about it," Schneider says. "We've got a great opportunity to work with students and organizations in several countries, to develop resources there, and to improve conservation planning."

## TROPICAL ECOLOGY SCHOLARSHIP FUND

The Center for Ecology and Conservation Biology in collaboration with the Office of Development and Alumni Relations has recently initiated a fund-raising campaign to support scholarships for undergraduates, graduate students and post-doctoral fellows to conduct research in ecology and conservation biology.

We invite each of you to contribute to this worthy cause.

*Graduate students on the Tiputini River.*

**CECB wishes to acknowledge and thank the following individuals and organizations for their generous support during the past year.**

**Stratosphere Club (≥$50,000)**
Contributions at this level help us to acquire equipment as well as fund graduate and post-doctoral students.
•Lubee Foundation

**Ecosphere Club ($10,000 - 49,999)**
Two contributions of $10,000 support one graduate student to conduct research in the tropics for one full year.
•Richard Ablon, BU Trustee
•Chiles Foundation
•Dr. Annamarie Hayes-Eggert, CAS '47, GRS 48 SED '78
•William Macauley, BU Trustee, LAW '69
•New England Biolabs Foundation

**Canopy Club ($5,000 - $9,999)**
Gifts at this level will help us purchase equipment for research.

**Director's Club ($2,500 - $4,999)**
Director's Club gifts will help construct an extension to the canopy walkway the Tiputini Biodiversity Station.

**Rainforest Club ($1,000 - $2,499)**
These gifts will help upgrade computers and library resources at the Tiputini Biodiversity Station in Ecuador.
•Luci Baines Johnson
•Dr. David A.T. Donahue

**Friends of CECB (up tp $999)**
Friends of CECB provide general program support.
•Jean Dellert, CAS '41
•Agostio Galluzzo, COM '69
•Dr. James Hallett, CAS '72, GRS '74
•Nina and Jim Hanks, GRS '56
•Todd Klipp, BU General Council
•Roger Phelps, SSW '59
•Dr. John Rizzo, CAS '72
•Dr. Richard Sall, CAS '79, MED '83
•Scott Simpson

## RECENT BOOKS BY CECB FACULTY ASSOCIATES

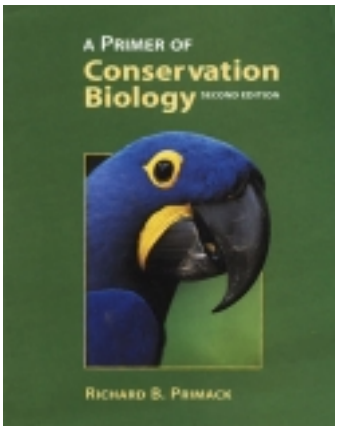
### Forgotten Waters: Freshwater and Marine Ecosystems in Africa


Shumway, C.A. 1999. Boston University, Boston, Massachusetts, 173 pp. $5 (to cover shipping). ISBN 87387-109-X (paperback). This book provides a primer on Africa's threatened aquatic biodiversity, along with lessons learned from successful and failed conservation projects, and options for biodiversity conservation. The report provides an overview of the value of Africa's aquatic biodiversity, identifies the biologically and socioeconomically most important sites, discusses threats, and recommends activities for urgent conservation action.

### Atlas of the State of Kuwait from Satellite Images

El-Baz, F. and Al-Sarawi, M. 2000. Kuwait Foundation for the Advancement of Sciences, Safat, Kuwait. 145 pp. $60. ISBN 99906-30-00-3 (hardcover). This Atlas provides a collection of satellite images and supporting data together with short articles by experts on the environmental characteristics on the State of Kuwait. The Atlas provides a brief background to satellite images, depicts the environment of Kuwait throughout recorded human occupation and classifies the geographic provinces of the State. The Atlas also provides material devoted to the environmental effects of the Gulf War, presenting a new understanding of the desert terrain and its fragility.

### A Primer of Conservation Biology (2nd edition)




Primack, R.P. 2000. Sinauer Associates, Inc., Sunderland, Massachusetts, 319 pp. $31.95. ISBN 0-87893-732-3 (paperback). This book introduces the key elements of the dynamic, multidisciplinary field of conservation biology. The new 2nd Edition incorporates background, theory, and examples in a lively and readable text that will appeal to a wide audience and stimulate interest in conservation biology. The book provides the most up-to-date perspective on high-profile issues in the field, such as sustainable development, the effectiveness of conservation laws and treaties, the design of conservation areas, classification of conservation threats, and strategies to save species on the verge of extinction.

## NEW CECB FACULTY ASSOCIATES

CECB is proud to welcome the recent addition of seven new Faculty Associates. These recent additions bring the total number of CECB Faculty Associates to 32.

Dr. Ben Campbell, Assistant Professor of Anthropology.
Human Population Biology, Reproductive Ecology.
Ph.D., Harvard University, 1990.

Dr. John Finnerty, Assistant Professor of Biology.
Evolution of Development.
Ph.D., University of Chicago, 1994.

Dr. Adrien Finzi, Assistant Professor of Biology.
Forest Ecology and Biogeochemistry.
Ph.D., University of Connecticut, 1996.

Dr. Mark Friedl, Assistant Professor of Geography and Associate Director, Center for Energy and Environmental Studies.
Remote Sensing, Climatology, Geographic Information Systems for the Analysis of Geophysical and Natural Systems.
Ph.D., University of California, Santa Barbara, 1993.

Dr. Laura Maclatchy, Assistant Professor of Anthropology.
Human and Primate Evolution, Functional Anatomy and Primate Locomotion.
Ph.D., Harvard University, 1995.

Dr. Ranga Myneni, Associate Professor of Geography.
Terrestrial Ecology, Biophysics, Biogeochemistry, Optical Remote Sensing, Transport Theory, Micrometeorology.
Ph.D., University of Antwerp, 1984.

Dr. Adjil Najam, Assistant Professor of International Relations.
Global Environmental Politics, Global Governance & Non-State Actors, International Negotiation, North-South Relations.
M.S., Massachusetts Institute of Technology, 1997

## NEW BU TEP SHIRTS AVAILABLE!

CECB has produced a new T-shirt to promote and commemorate the Tropical Ecology Program in Ecuador. T-shirts are currently on sale for $12.00. To order, please send a check (payable to CECB) to Cari Watkins, CECB, Boston University, 5 Cummington Street, Boston, MA 02215. Be sure to include the size that you would like to have (S, M, L, XL).

Boston University Tropical Ecology Program ECUADOR

A pocketsize image on the front is of a blue-footed booby, a bird endemic to the Galapagos Islands. The multifaceted image on the back (shown at left) depicts the four ecosystems in Ecuador where our students visit and study (the coast, Andes Mountains, Galapagos Islands, and Amazonian rainforest). Letters on the sleeves highlight the collaboration between Boston University (BU) and the Universidad San Francisco de Quito (USFQ).

## STUDENTS SUPPORTED BY CECB GRADUATE FELLOWSHIP PROGRAM

Jennifer Baldacci and Susan Murray, graduate students working under the direction of Dr. Thomas H. Kunz, recently began research funded by the Center for Ecology and Conservation Biology. Their research focuses on seed dispersal and roosting ecology of fruit-eating bats in a Brazilian Atlantic lowland rainforest. Brazil has the highest diversity and endemism of terrestrial and freshwater flora and fauna in the world. Much of this biodiversity is at risk, with the Brazilian Atlantic Rainforest biome listed among the world's five most threatened ecosystems. Continuing development and economic expansion along the Atlantic coast of Brazil has reduced the original Atlantic Rainforest habitat where only 5% remains intact. Despite deforestation, Brazilian forest fragments house 261 mammal species, one-third of which are bats. One of the largest fragments of Atlantic Rainforest remaining is located in Parque Estadual Intervales; a 490 $km^2$ protected forest.

*Graduate student Jennifer Baldacci slingshots a net hoist over a canopy branch.*

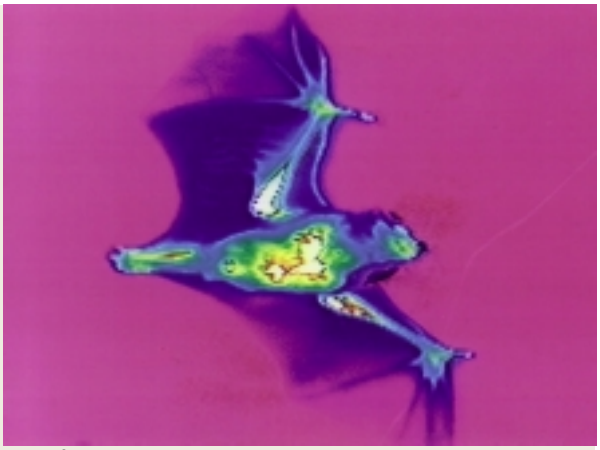
One major concern of conservation biologists is the extent of deforestation occurring worldwide. In Neotropical forests, nearly 100% of the shrubs and sub-canopy trees bear fruits adapted for animal consumption. The reproductive strategies of these plants rely on vertebrates for seed dispersal and bats are major dispersal agents; they are able to carry seeds long distances into areas, such as light gaps, that are not otherwise accessible by other dispersal mechanisms. Jennifer's research will focus on documenting seed dispersal by bats to establish the role they play in the reforestation of the Atlantic Rainforest. To accomplish this, she captures bats using mist-nets to discover which species of frugivorous bats are found in the area. She also uses seed traps to recover seeds as they are passed by bats in flight. From these data, she will be able to determine how far bats are dispersing seeds, and in what type of habitats the seeds are dispersed. With the collected seeds, Ms. Baldacci will conduct germination experiments to determine if seeds passed by bats have higher germination rates than seeds found in uneaten fruits.

Susan's research will examine the roosting ecology and mating system of the Jamaican fruit bat and the Large fruit bat. These two species represent the largest members of the genus *Artibeus*, and are considered generalists in their feeding and roosting strategies. They are mainly frugivorous, but are also known to eat leaves, insects, nectar and pollen. These bats roost in caves, unmodified foliage, tree cavities, and tents (leaves modified by the bats, which resemble tent-like structures). The Jamaican fruit bat has been reported to form harems in caves, in tree hollows and beneath leaves modified into tents. Harems usually consist of discrete groups of 4-20 females, and one male that defends the females and the roosting area.

Little is known about these bats in areas other than Central America, where most of the research on these species has been conducted. It is essential to document the roosting ecology of these important pollinating and seed dispersing bats to help develop management plans for the endangered Atlantic Rainforest. Susan will document where these bats roost and the mating system that occurs in different roost types. She captured bats with mist nets and attached small radio transmitters to their backs. Bats with transmitters are located during the day. The structure of the day-roost is noted and behavioral observations made on social cohesiveness and colony structure.

There has been little research on bats in the Brazilian Atlantic Rainforest, despite the fact that they are important in reforestation. The research conducted this past summer provides preliminary dissertation work for these two graduate students, but will also aid in developing conservation plans for the disappearing Atlantic Rainforest.

## SEEING IN THE DARK, CONTINUED...



As long as an animal is warmer than its environment, its image can be observed and recorded in remarkable detail. Our camera was able to detect differences in radiative temperatures as small as 0.02°C—yielding thermal images that can be displayed monochromatically or in rich rainbow colors."

The colorized image of a flying bat shown here illustrates that the tips of the wing and nose are cooler than other parts of the body. The coolest parts are black and the warmest parts are white. The warmest surfaces of a flying bat are underlain by muscles of the wing and parts of the head and shoulders, especially areas around the ears and ears that are used in navigation and for capturing prey in the dark. These metabolically active regions of the bat are only sparsely covered with insulating hair, and it is these surfaces from which most of the animal's metabolic heat is dissipated during periods of intense activity—such a flight. Using a camera with a built-in cursor, it is possible to thermally map the entire surface of a bat while it is roosting or while in flight. Kunz hopes to raise funds to purchase an infrared thermal camera that will help advance his research and that of his colleagues and students associated with CECB.

This infrared thermal camera also was used this past summer by Kunz, Frank, and Professor Cutler Cleveland, CECB faculty associate, and Director of Boston University's Center for Energy and Environmental Studies, and graduate student Jason Horn to investigate the economic impact of Mexican free-tailed bats on a Texas agroecosystem. From a grant funded by the National Science Foundation, they have used this camera to detect millions of bats as they disperse nightly from caves in south-central Texas to feed on insects. The thermal images that they recorded were fed directly into a computer where the data were stored digitally and are now being analyzed to determine the number of bats present—an important variable in their effort to assess the impact of these bats on insect pests that feed on agricultural crops such as corn and cotton.

**FOR MORE INFORMATION ABOUT ANY OF THE ITEMS IN THIS ISSUE. PLEASE CONTACT CECB.**
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