Nature disruption
http://www.sciencenews.org/articles/20020420/bob9.asp

Science News Online Week of April 20, 2002; Vol. 161, No. 16

Deprived of Darkness

The unnatural ecology of artificial light at night By Ben Harder

In 1988, physician and amateur moth enthusiast Kenneth D. Frank published a scientific paper that pulled together much of what researchers then knew about the consequences of artificial night-time lighting on moths. That paper is the closest thing the nascent field of artificial-light ecology has to a classic work. It didn't exactly trigger the response one might expect from a seminal study, however. The report has received precious little attention and stimulated no immediate cascade of follow-up research. Frank recently searched the scientific literature to count how many subsequent papers had made reference to his study, and found exactly one.

LONG SHADOWS. Even brief exposure to bright light can cause some nocturnal frogs to freeze for hours. Buchanan/Utica College

Nevertheless, Frank and a handful of other scientists are endeavoring to synthesize a coherent understanding of the ecological impacts of artificial light on a multitude of organisms. These efforts are gradually gaining momentum.

From anecdotal reports of little-studied phenomena, such as moths' tendency to perish, Icarus-style, in lamps and flames, researchers suspect that artificial night lighting disrupts the physiology and behavior of nocturnal animals. In many cases, scientists have few reliable data on which to rest conclusions, but every reason to be concerned.

Head for the water

Some of the best data on light pollution's effects on wildlife come from the coast of Florida, where sea turtles are struggling to survive the encroachment of urban development on their nesting sites. Michael Salmon of Florida Atlantic University in Boca Raton considers sea turtle conservation efforts "a lab" for studying measures that might protect other species. When turtle hatchlings emerge at night from their eggs and head for the ocean, lights from hotels and other sources can lead them off course. Sometimes the hatchlings get killed trekking in the wrong direction as they attempt to cross roads. If their long night's journey stretches into day, the turtles often die of exposure or fall victim to hungry predators.

Low-pressure sodium lamps, which produce light only at a specific yellow wavelength, mitigate the turtles' confusion. It seems that these animals don't see,or at least aren't distracted by, light at

that frequency, Salmon reported at a meeting of ecologists at the University of California, Los Angeles in February.

The Urban Wildlands Group, the L.A. based conservation think tank that organized the gathering, asked ecologists to share whatever information they had on artificial light's ecological effects. The conference's co-organizers Travis Longcore and Catherine Rich say they expect the knowledge swap to lead to new directions of research.

One theme arising from the meeting was that even when animals aren't exposed directly to artificial lights, illumination from urban areas that reflects off clouds can produce unnaturally bright conditions at night, an effect known as sky glow, that may have biological or behavioral effects.

Sky glow is already a recognized bane of astronomers, who have trouble identifying celestial objects against the background light near urban centers. Astronomers have created a movement, led by the International Dark-Sky Association in Tucson, Ariz., that advocates limiting light pollution to improve sky-viewing.

Dark skies, wet lands

Dark-Sky supporters favor, among other measures, broader use of low-pressure sodium lights, because astronomical equipment can relatively easily filter out their narrow spectra. "Astronomers would like [ecologists] to conclude that sodium lights are the most ecologically sound light sources," says Frank, whose work suggests that low-pressure sodium lamps are less harmful to moths than traditional streetlights are.

Unfortunately, sodium lights are no panacea, he says. Some animals, it turns out, fare no better with narrow-spectrum, yellow light than with any more traditional artificial lights. Some even seem to fare worse.

Frogs and salamanders are among these, says salamander researcher Sharon Wise of Utica College in Utica, N.Y. She and Bryant W. Buchanan, a frog researcher also at Utica, have found that sudden exposure to artificial light can cause nocturnal frogs to suspend normal feeding and reproductive behavior and sit motionless long after the light has been turned off.

Under yellow and red lights, salamanders can't navigate from one pond to the next. While they wander, they may fall prey to hungry nocturnal animals or die of exposure.

Wetlands, home to many frogs and salamanders, could be one of the first types of habitat to benefit from measures controlling light pollution. "Because wetlands are already afforded some protections, it would be relatively straightforward to add [artificial light] to the list of things they should be protected from," says Longcore. Some recent development proposals in California have run afoul of light-pollution concerns and been denied, he says.

Animals that dwell entirely in water are also susceptible to artificial lighting. Marianne V. Moore and Susan J. Kohler of Wellesley (Mass.) College have examined how artificial light affects small aquatic invertebrates in New England lakes and ponds. Their data show that the nighttime activity of these animals near the surface drops off in proportion to the amount of light reaching them. That could reduce the invertebrates' predation on algae at the surface, potentially leading to algal blooms and poor water quality.

Limited data also suggest that river ecosystems can be affected by artificial light at night. At the UCLA meeting, Barbara Nightingale of the University of Washington in Seattle described how several river-navigating fish species, including salmon, herring, and sand lance, gather under artificial lights that illuminate portions of their waterways. The unnatural concentration of fish, along with the illumination the lights provide, may facilitate hunting by bears and other predators and negatively affect vulnerable fish populations, Nightingale speculates.

Icarus redux

For more than a century, observers have reported that birds are attracted to towers with lights and, while circling or hovering in large numbers, often collide fatally with the structures or with each other. This tower kill can end the lives of thousands of birds in a single night and locale during peak migration periods.

Sidney A. Gauthreaux, a bird researcher at Clemson (S.C.) University, has studied factors that contribute to tower kill. In research he conducted in the late 1980s but is only now preparing for publication, Gauthreaux found that towers with red lights may be particularly dangerous for birds.

Gauthreaux and Carroll G. Belser monitored the number and behavior of birds at three different sites on 14 evenings during a fall migration season. Birds more often departed from direct flight paths near the two sites that featured artificially lit television towers than they did at a site without a tower. One of the two towers sported a white strobe light; the other had an array of steady red lights. Of the three sites, the red-lit tower showed the greatest concentration of birds in the air and presented the greatest avian collision risk, Gauthreaux said at the February meeting. "Birds' magnetic compasses seem to break down in red light," Gauthreaux notes, citing others' laboratory research. That effect, he suggests, could explain some of the disorientation that appears to occur when birds approach communication towers, whose numbers have mushroomed in recent years.

Richard Podolsky, an independent seabird researcher from Camden, Maine, has also observed how artificial light can be problematic. On the Hawaiian island of Kauai, he's been studying birds known as Newell's shearwaters.

The shearwaters nest on land, and fledglings depart on an autumn evening to make their first, critical flight to the sea. Urban development presents obstacles to these maiden flights, however, and many young birds crash into lit bridges and buildings, sometimes fatally.

A local citizens' group called Save Our Shearwaters, or SOS, has been rescuing these birds for more than a decade. Using data collected by SOS and their own field studies, Podolsky and his colleagues estimate that 10 percent of Newell's shearwater fledglings die each year and an additional 15 percent are injured from crashes attributable to artificial light. While this doesn't surpass the mortality that can be attributed to cats and other introduced species, it's contributing greatly to the birds' decline, the researchers reported in the 2001 volume of Studies in Avian Biology. However, restrictions on light pollution might help reverse the population's precipitous reduction, Podolsky says. Such restrictions are already in effect on the nearby island of Hawaii, which hosts several observatories.

Intriguingly, Podolsky notes, Newell's shearwater deaths have been consistently lower in years when the October full moon falls near the fledglings' midmonth exodus than in years when the

young birds take off on nights with little moonlight. Natural light's domination over urban lights during moonlit migration periods helps the shearwaters navigate, Podolsky suggests.

Light behavior

In addition to their noted tendency to fly perilously close to street lamps, moths and insects may respond to artificial light at night in maladaptive ways, Frank and other researchers have found. Moths typically go into erratic dives when they sense that they have been detected by nearby bats using echolocation. By exposing moths to simulated echolocation sounds, Jens Rydell of the University of Göteborg in Sweden and his colleagues have found that artificial light reduces moths' use of this defensive behavior, thereby interfering with their escape.

In other experiments, the researchers found that moths don't congregate around low-pressure sodium lights as they do around street lamps with broader light spectra.

Certain light spectra may also interfere with the behavior of fireflies, says James E. Lloyd of the University of Florida in Gainesville. These insects generate light that they use for sexual communication. Although there are few data on the effects of artificial light on fireflies, Lloyd suggests that because their chemiluminescence has similar spectra to incandescent light, fireflies in its presence may not court mates normally.

Even among animals that can adapt their behavior to cope with the influences of artificial light, there may still be a biological price to pay. Certain novel qualities may be favored under bright-night conditions that result in evolutionary selection of traits not adaptive under more natural conditions. Taken to its logical endpoint, such selective pressures could cause animal populations living near perpetually illuminated areas to evolve into species that are distinct from biological kin in darker wilderness. By reducing the effective size of populations that can interbreed, that process could increase the likelihood that both populations may go extinct.

Animals aren't the only organisms that may be adversely affected by artificial light. For example, nine different photoreceptors have been identified in a popular laboratory plant, the mustard Arabidopsis thaliana. These receptors play various roles in leaf and stem growth, the timing of flowering, fruit development, and other life processes, says botanist Winslow R. Briggs of the Carnegie Institution of Washington in Stanford, Calif.

Although there aren't rigorous scientific studies on plants' reactions to artificial light, anecdotal reports indicate that deciduous plants, which shed their leaves as days grow short in the fall, may be particularly affected by unnatural light, Briggs says.

A few trees that fail to show fall colors, or extra moths that become bat food aren't necessarily going to catalyze public opinion against light pollution. However, says Frank, when people consider that disturbing one component of an ecosystem may have ramifications for many other organisms, the case for reducing light pollution begins to look more compelling.

Local governments in Palm Beach, Fla., Malibu, Calif., and elsewhere in the United States have taken small steps in that direction. The Czech parliament has passed the world's first nationwide law designed to curtail light pollution. It takes effect June 1.

There are other signs that light pollution is entering public awareness. To commemorate the victims of the terrorist attacks, New York City beamed two pillars of light into the Manhattan sky from the former site of the World Trade Center. The memorial fomented some concern about its effects on spring bird migrations. Fortunately, the memorial's architects had taken ecological

effects into account. After consulting the city's Audubon Society about peak migration times, they scheduled it to shut off each night at 11 p.m. and to operate only through April 13.

Perhaps the wildlife impact of artificial light at night is finally dawning on public consciousness.

References:

Ainley, D.G., et al. 2001. The status and population of the Newell's Shearwater on Kaua'i: Insights from modeling. Studies in Avian Biology (No. 22):108-123. See http://www.cooper.org/cos/SAB.html.

Frank, K.D. 1988. Impact of outdoor lighting on moths: An assessment. Journal of the Lepidopterists' Society 42(No. 2):63-93.

Information about the Ecological Consequences of Artificial Night Lighting meeting, held Feb. 23-24 in Los Angeles, can be found at http://www.urbanwildlands.org/conference.html.

Further Readings:
Further information about artificial-light ecology is available at http://www.urbanwildlands.org/, http://www.darksky.org/, and http://www.towerkill.com/.

Sources:

Winslow R. Briggs
Department of Plant Biology
Carnegie Institution of Washington
260 Panama Street
Stanford, CA 94305

Bryant W. Buchanan
Department of Biology
Utica College of Syracuse University
1600 Burrstone Road
Utica, NY 13502

Kenneth D. Frank
2508 Pine Street
Philadelphia, PA 19103

Sidney A. Gauthreaux Jr.
Department of Biological Sciences
Clemson University
Clemson, SC 29634-0326

James E. Lloyd
Department of Entomology and Nematology
University of Florida
Box 970, Natural Area Road
Gainesville, FL 32611

Travis Longcore
The Urban Wildlands Group
P.O. Box 24020
Los Angeles, CA 90024-0020
Web site: http://www.urbanwildlands.org/

Marianne V. Moore
Department of Biological Sciences
Wellesley College
106 Central Street
Wellesley, MA 02481-8203

Barbara Nightingale
School of Aquatic and Fishery Sciences
University of Washington
1122 Boat Street, Box 35502
Seattle, WA 98195-5020

Richard Podolsky
Avian Systems
279 Melvin Eights Road
Camden, ME 04843

Jens Rydell
Department of Zoomorphology
Medicinaregatan 18
Box 463
405 30 Göteborg
Sweden

Michael Salmon
Department of Biological Sciences
Florida Atlantic University
Box 3091, 777 Glades Road
Boca Raton, FL 33431

Sharon Wise
Department of Biology
Utica College of Syracuse University
1600 Burrstone Road
Utica, NY 13502

http://www.sciencenews.org/articles/20020420/bob9.asp
From Science News, Vol. 161, No. 16, April 20, 2002, p. 248.