Twinkle, twinkle, little star. How I wonder *where* you are?

The stars in the nighttime sky are disappearing. One here, one there—a hardly noticeable process that began over large metropolitan areas and is now spreading to nearly every corner of civilization. Even remote areas are being exposed to increased illumination from "sky glow" that appears at night over urban areas and obscures our view of stars and other astronomic phenomena. Investigators predict that the most noticeable effects of light pollution will occur in those areas close to natural habitats (Longcore and Rich 2004). This may be near wilderness where summer getaways are built, along the expanding front of suburbanization, near wetlands and estuaries that are often the last open spaces in cities, or on the open ocean, where cruise ships, squid boats, and oil derricks light the night.

As faint celestial objects billions of miles away began to disappear from their telescopes, astronomers were the first to notice what we are stealing away from ourselves. Now other scientists, primarily ecologists, and citizens are realizing the effects of light pollution in deadly ways. The poster child for this issue is probably hatchling sea turtles, which are protected under

the Endangered Species Act of 1973. These baby reptiles generally break free of their shells under the cover of darkness and then waddle into the surf as soon as possible to avoid predation. Normally they orient themselves by scanning the horizon and heading for celestial lights such as the moon and stars reflecting off the sea. Artificial lighting on beaches and roadways near nesting areas, however, often confuses hatchlings and causes them to crawl inland instead (Schaar 2002). According to Kristen Nelson of the Florida Department of Environmental Protection, thousands of hatchlings are disoriented in this way every year. In 1998, for example, marine turtle permit holders reported 19,970 hatchlings as disoriented (Nelson 2000). Many hatchlings die from dehydration, are eaten by predators such as fire ants and ghost crabs, or are run over by cars if they wander onto nearby roadways. Those that do make it to the water may have a decreased chance for survival because of wasted energy resources.

In addition to causing disorientation, ecological light pollution has demonstrable effects on the behavior of most organisms in natural settings (e.g., insects, migrating toads and salamanders, birds, bats, and fish). Changed behaviors—orientation/disorientation and attraction/repulsion—in altered light environments may in turn affect foraging, reproduction, migration, and communication (Longcore and Rich 2004). Moreover, the cumulative effects of behavioral changes induced by artificial night lighting on competition and predation have the potential to disrupt key ecosystem functions (Longcore and Rich 2004). The consequence of ecological light pollution on aquatic invertebrates illustrates this point. Many aquatic invertebrates, such as zooplankton, move up and down within the water column during a 24-hour period. This regular vertical migration, called "diel vertical migration," presumably results from a need to avoid predation during lighted conditions; therefore, most zooplankton forage near water surfaces only during dark conditions (Gliwicz 1986). Artificial illumination decreases the magnitude of diel migrations, both in the range of vertical movement and the number of individuals migrating. Researchers hypothesize that this disruption of diel vertical migration may have substantial detrimental effects on ecosystem health. With less zooplankton migrating to the surface to graze, algae populations may increase. Such algal blooms would then have a series of adverse effects on water quality (Moore et al. 2000).

In *Management Policies 2001*, the National Park Service acknowledges the roles that light and dark periods and darkness play in natural processes, and in cooperation with park visitors, neighbors, and local governments, it strives to prevent loss of dark conditions and natural night skies. However, obstacles for the National Park Service include a lack of awareness of light pollution as a threat to wilderness values and cultural heritage, an absence of baseline formation about this resource, and inefficient facility lighting (Moore and Duriscoe 2002). Possibly conventional wisdom that light reduces crime also serves as a stumbling block. Most crime, however, actually occurs during the day, or inside buildings, and the paucity of data precludes any definitive statement regarding the relationship of lighting and crime (International Dark-Sky Association 1990). Furthermore, "dark campus" programs across the country have shown that darkness actually reduces crime, in particular vandalism, and saves money (e.g., decreased energy costs and reduced repairing and cleaning of damage) (International Dark-Sky Association 2000). On the other hand, studies indicate that lighting decreases the fear of crime; it makes us feel safe outside at night. Yet, the real task for resource and facility managers is to make visitors and staffs not just feel safe, but be safe, for example by providing good lighting for nighttime travelers around headquarters, housing areas, visitor centers, and entrance stations. Yet visitor and staff safety must be achieved while protecting the natural behaviors of wildlife and preserving natural night skies. This means that the National Park Service needs effective and efficient lighting in developed areas. Good visibility is the goal (not just wasting resources on lighting a vacant parking lot or perhaps lighting a criminal's way), and good lighting can help. Poor lighting compromises human safety, natural wildlife behaviors, and the natural night sky.

The International Dark-Sky Association (1996) provides some solutions that minimize light pollution without compromising safety or utility:

1. Use night lighting only when necessary. Turn off lights when they are not needed. Timers can be very effective. Use the correct amount of light for the need, not overkill.

2. Where light is needed, direct it downward. The use and effective placement of well-designed fixtures will achieve excellent lighting control. When possible, retrofit or replace all existing fixtures of poor quality. In all cases, the goal is to use fixtures that control the light well and minimize glare, light trespass, light pollution, and energy use.

3. Use low pressure sodium (LPS) light sources whenever possible. These are the best possible light sources to minimize adverse effects on astronomical activities and are the most energy efficient light sources that exist. Areas where LPS light sources are especially good include street lighting, parking lot lighting, security lighting, and any application where color rendering is not critical.

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4. Avoid development near existing observatories, and apply rigid controls on outdoor lighting when development is unavoidable. *—K. KellerLynn*

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