

Reducing Ecological Impacts  
of Shale Development:  
RECOMMENDED PRACTICES  
FOR THE APPALACHIANS

# ARTIFICIAL LIGHTING



© Curt Weinhold

**A**rtificial lighting is a necessary component of oil and gas development to ensure the safety of workers, particularly around the well pad. However, this increase in light can also have adverse impacts on the surrounding ecosystem. The Appalachian region is host to vast stretches of interior forest that are naturally dark and have relatively few artificial light influences. This makes infrastructure lighting within these areas a concern for wildlife and recreation. As development expands, practices that reduce the amount, intensity and timing of artificial lighting can help to diminish these ecological impacts.



## STATE OF THE RESEARCH

The impact of artificial lighting on wildlife is a relatively new and poorly understood topic. Studies are few, and they have been primarily conducted in laboratory settings or limited to species of bats, insects, birds and sea turtles. However, based on the research that is available and the importance of ambient light to animal behavior and physiology, it is likely that artificial lighting can have significant impacts to wildlife.<sup>1-4</sup> Although impacts to aquatic organisms have primarily been studied in saltwater environments, studies suggest that artificial lighting can have an important effect on aquatic species' foraging and schooling behavior, migration and reproduction.<sup>5,6</sup>

Wildlife can be affected by artificial lighting in two main ways – disorientation

and attraction/repulsion.<sup>6-8</sup> The disorientation of sea turtles and the attraction of insects as a result of artificial lighting are common examples. Consequently, the addition of artificial lighting to an environment can alter foraging and reproductive behaviors, predator-prey interactions, habitat use, community structure and physiology.<sup>2,6,7,9-14</sup> For example, bats have been shown to change foraging behavior, flight routes and evening emergence times in response to artificial lighting.<sup>2,10,15-18</sup>

Effects are likely species-specific, based on the role ambient light plays in physiology and behavior, and might also depend on the type of lighting used.<sup>1,19</sup>

Of particular concern to conservation strategies in the Appalachian region is the lack of research in interior, naturally

**Artificial lighting** can affect foraging and reproductive behavior, biological clocks, predator-prey interactions, movement and dispersal patterns, community structure, and interactions among and within species.

For more information about light pollution, visit the International Dark-Sky Association (<http://darksky.org/>).

dark environments and on the broad range of taxonomic groups that occur there. Further research efforts to discover the impacts of artificial lighting are needed to help develop effective conservation practices.



Artificial lighting has been shown to affect bat foraging behavior, flight routes and evening emergence times; visual capabilities of many species; vulnerability of insects to predators; and the breeding behavior of bird, frog and insect species. © Elizabeth Berkowitz



## EVIDENCE OF IMPACT Effects on Orientation

The presence of artificial lighting can cause species to become disoriented or distracted from other essential behaviors (e.g., foraging, mating, migrating).<sup>7,8,12,19,20</sup> For example, some evidence suggests artificial lighting can distract amphibians from breeding sites.<sup>21</sup>

Rapid shifts in illumination (e.g., appearance of headlights) can temporarily blind animals, leading to injury or death.

Recovery of sight may only take several seconds, but studies conducted on nocturnal frogs revealed that recovery can take up to several hours.<sup>10,12</sup> Loss of visual capabilities can reduce foraging success as well as increase vulnerability to road mortality.<sup>12</sup>



The Appalachian region provides habitat for many migratory bird species, like the whip-poor-will pictured here, and the presence of artificial lighting can disrupt migratory routes. © Jacob W. Dingel

**Bird** mortality as a result of lighted structures is relatively well documented. Tall, lighted structures can result in high mortality rates, especially along migratory routes.<sup>7,19,20,22</sup>

**Insects** are ecologically important members of the food web and pollination process, and they are highly attracted to artificial lighting.<sup>13,14</sup> Attraction of artificial lighting can disrupt essential functions, including foraging opportunities, migration and reproduction, and can result in high mortality.<sup>13,14</sup> The impact from these widespread effects on population dynamics, as well as its cascading effects to the ecosystem is not well understood.<sup>13,14</sup>

## Shifts in Foraging and Predator-Prey Relationships

Artificial lighting can change predator-prey relationships in three main ways: (1) Shifting the timing of foraging activities; (2) Increasing the foraging efficiency of predators; (3) Interrupting natural camouflage and exposing predators and prey, potentially increasing mortality rates.<sup>1,10,16,23</sup>

Some species that are usually active during the day might continue to forage into the night as a result of higher ambient light levels. For example, toads and other predators may sit out during the night, foraging for insects attracted to artificial lights. Although this might



Artificial lighting can disrupt essential behaviors and result in high mortality rates for species of insects that are highly attracted to lights, like moths. © Janet Haas

result in higher levels of foraging, it also increases the risk of predation and competition.<sup>6,10,11</sup> For species that typically forage during periods of low light, the presence of artificial lighting might delay or prevent foraging activities.<sup>12</sup>

**Bats**, depending on the species, are either attracted to lights by the presence of insects or they avoid lighted areas. Artificial lighting increases the foraging efficiency of many bat species, but it might simultaneously increase their risk of predation.<sup>15-18</sup> Delays in the emergence of several bat species, which results in fewer foraging opportunities, have also been linked to the presence of artificial lights, and some studies show no evidence of habituation.<sup>2,16</sup>

**Insects** are not only attracted to lights, but they are also more susceptible to predation around lighted areas. Species of reptiles, amphibians, birds, bats and spiders have been shown to wait around artificial lights for prey.<sup>14</sup> Artificial lighting might also undermine the evasive and defensive tactics normally used by insects. For example, in the predator-prey relationship between bats and moths, moths have developed a sophisticated evasive system against bats. However, this system does not appear to work when moths are distracted by artificial lights.<sup>14</sup> Similarly, another way that moths avoid predators is by using cryptic coloration (i.e. camouflage), which can be less effective near lighted areas.<sup>14</sup>



Shale energy development near wetlands can artificially light habitat important to amphibians and reptiles, affecting behavior and mortality rates. © Mark Godfrey, TNC

## CONSERVATION PRACTICES AND SCIENTIFIC SUPPORT

Scientific literature supports practices that minimize and properly direct artificial lighting to lessen the effects of light pollution on wildlife. The following practices are derived from management and guidance [documents](#) developed by state agencies, scientific/conservation organizations and industry groups.

### Reduce Light Use and Spillage

**Scientific literature** suggests that the effects of lighting can be reduced by limiting times lights are on, choosing appropriate lamp types (low-pressure sodium lights are recommended), directing light only where it's needed to reduce the amount of light escaping outward into the sky and surrounding environment, and using vegetative screening or other methods to reduce light spillage.<sup>1,7,8,14,16,19,20,27,28</sup> In cases where birds have been attracted or disoriented by artificial lighting, simple practices – such as shielding lights and directing light downward or changing the type of bulb – have drastically decreased the mortality rates (up to 40 percent in one study).<sup>7,19,20,22</sup>

### Existing conservation practices

include properly shading and directing lights. Light spillage can be reduced by lighting necessary areas only, directing light downward and internally, and using light fixtures where the bulb is not visible from the fixture.



Artificial lighting can attract or repel bats, depending upon the species – affecting behavior, habitat use and survival. © John C. Abbott

### Behavioral Changes

Natural lighting drives an animals' circadian clock (i.e. the typical day-to-night activities of an animal). Artificial lighting can disrupt species' circadian clocks. This disruption can affect the way an animal eats, sleeps, reproduces and interacts with other wildlife, and it might result in physiological changes.<sup>10,12</sup> For example, artificial lighting can disrupt ambient light cues that tadpoles rely on for daily movement cycles that help in thermoregulation and predator avoidance.<sup>12</sup>

**Amphibians and reptiles** include many species that are nocturnal, making them especially susceptible to behavioral changes as a result of artificial lighting.<sup>11,12</sup> Moreover, because many species are reliant on a specific habitat (e.g., wetland, rocky outcrop) and have limited mobility, they might be less able to move in response to the presence of artificial lighting.<sup>12</sup> For example, lighting might increase predation along migration pathways and around amphibian breeding habitat. However, there is such a multitude of diversity in behavior, reproduction, and physiology among amphibians and reptiles that each species is likely to respond differently.

### Changes in Reproductive Behaviors

Artificial lighting can affect the mate selection and breeding behavior of some species.<sup>3,6,10</sup> For example, some male

frogs reduce their mating calls in the presence of artificial lighting.<sup>4,12</sup> Artificial lighting can also reduce the effectiveness of mating displays and communication.<sup>13,14</sup> For example, light signals used by fireflies to attract mates might be affected by the presence of artificial light rendering them less effective within a brighter environment.<sup>24</sup>

**Birds** have been shown to alter the timing of morning choruses and reproductive patterns in response to artificial lighting.<sup>3,9</sup> Some evidence suggests that artificial lights deter some bird species from establishing nests up to 300 meters away from an artificial light source.<sup>6</sup>

### Habitat Avoidance

Research suggests that species show preferences for particular light regimes – meaning that species might be either attracted to or repulsed by the presence of artificial lighting.<sup>10,11</sup>

**Mammals** have been shown to avoid lighted areas.<sup>10</sup> Mountain lions are one well-documented example.<sup>25</sup> Impacts to small mammals (e.g., shrews, moles, voles) are not well documented, but as a common prey species they are likely impacted.<sup>10,26</sup> Bat species that are typically associated with woodland habitats appear to be sensitive to artificial lighting and avoid lighted areas by changing flight routes and habitat use.<sup>15-17</sup>

## Avoid Areas and Times Important to Wildlife

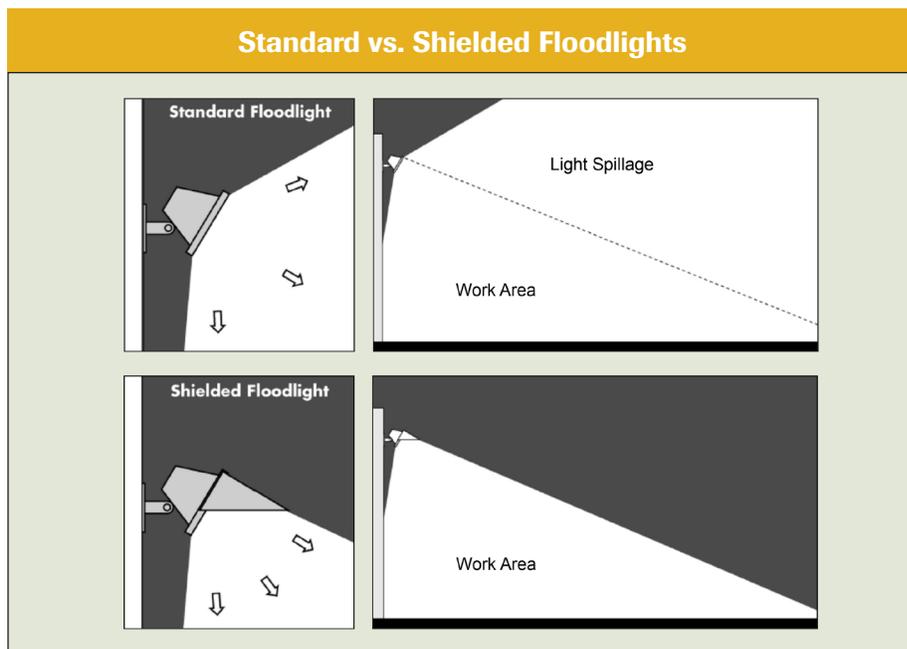
**Scientific literature** suggests reducing the impact of artificial lighting on wildlife by avoiding [times](#) and [areas](#) important to wildlife, including wetlands and other aquatic habitats, bat foraging and roosting areas, and where large numbers of birds concentrate to nest, feed roost, and within migration routes.<sup>1,6,14,15,28</sup> The use of external floodlights can be especially damaging during migration periods.<sup>1,7,27</sup>

**Existing conservation practices** include minimizing light pollution in sensitive and important wildlife areas, particularly during times when lighting could be especially disturbing to wildlife. Some organizations recommend minimizing exterior lights and light spillage within 750 feet of vernal pools.

## Monitor and Implement Adaptive Management

**Scientific literature** encourages monitoring protocols that include measurements on the timing and intensity of light pollution to aid in research and management strategies.<sup>6,12,28</sup>

**Existing conservation practices** include developing and implementing an adaptive management program, which includes monitoring, evaluation, and adjusting actions based on results and new information to make practices more effective.



When floodlights are necessary, shielding is recommended to direct light only onto necessary areas, reducing light spillage into other areas. Source: Adapted from International Dark-Sky Association

## TNC Recommended Conservation Practices

Based on scientific literature and existing practices, The Nature Conservancy recommends the following practices:

- ✓ **Reduce light spillage** by properly shading and directing light downward, diffusing light to reduce glare, using low-pressure sodium lamps, and avoiding and minimizing flaring (green completion).
- ✓ **Reduce the amount, intensity and timing of artificial lighting** particularly (a) during migration periods and other critical times for wildlife, and (b) near aquatic and sensitive habitats. In the Appalachian region, bird and bat migrations usually occur from April through May and August through October.
- ✓ **Monitor light levels** and support research on how artificial light affects wildlife – and actions that can reduce those impacts.

**These recommendations are part of a suite of recommended practices intended to avoid and reduce impacts of shale development on Appalachian habitats and wildlife.** These practices might need to be adapted to incorporate new information, consider operational feasibility, and comply with more stringent regulatory requirements that might exist.

➔ Visit [nature.org/shale-practices-refs](https://nature.org/shale-practices-refs) for a list of references used in this document