Potential Environmental Impacts of Artificial Lighting

at Saint Edward State Park:

A Literature Review

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Introduction:

Saint Edward State Park is located on Lake Washington in Kenmore, Washington (See Appendix 1: site map). Prior to its 1977 acquisition by the Washington State Parks and Recreation Commission (State Parks), the land was owned and developed by the Archdiocese of Seattle as a seminary. As part of the development, the seminarians cleared, filled and leveled a portion of the wetland west of the seminary to use as ball fields. Today the developed park includes ball fields; designed cultural features, including an apple orchard and picnic areas; parking for over 200 vehicles; and the seminary, with associated gymnasium and pool building. This developed footprint currently encompasses approximately 20 acres of the 316 acre park. Most of the remaining park is forested, with a network of trails.

The City of Kenmore has long expressed interest in improving the ball fields at Saint Edward to address the need for athletic fields for organized youth sports. In 2016, the City requested a long-term lease from State Parks to allow them to improve the fields. Proposed improvements include a drainage system, artificial turf, viewing stands, walkways and lighting. State Parks entered into a Memorandum of Agreement (MOA) with Kenmore to collaboratively conduct the environmental review for the project under the Washington State Environmental Policy Act (SEPA). As part of the early outreach for the proposal, State Parks and the City of Kenmore received public feedback about potential impacts to wildlife from the proposed artificial lighting.

Biodiversity Area and Corridor:

Saint Edward State Park is part of a Biodiversity Area and Corridor, a Priority Habitat, designated by Washington Department of Fish and Wildlife. A Biodiversity Area and Corridor is defined as “areas of habitat that are relatively important to various species of native fish and wildlife” (WDFW 2008). Specifically, Saint Edward qualifies for this designation because it is a large relatively undeveloped area, “within a city or an urban growth area (UGA) and contains habitat that is valuable to fish or wildlife and is mostly comprised of native vegetation. Relative to other vegetated areas in the same city or UGA, (it) supports a diverse community of species”. Saint Edward State Park is one of the few remaining relatively large forested areas in the Seattle/Bellevue urban area and contains a diversity of habitats including streams, riparian areas, shoreline, wetlands and older second growth forest.

Loss of habitat, habitat fragmentation, and interruption of corridors are critical concerns in managing for biodiversity, particularly within urban areas where habitat is already scarce and fragmented (WDFW 2009). Artificial lighting has the potential to impact the area's habitat values. The park is an island of relative dark within a sea of lights. It provides habitat that is not generally available in the surrounding lit environments, both for resident and migratory species. It is critical to assess the potential impacts of artificial lighting on species and their habitats at Saint Edward.

Literature Review:

To understand potential impacts of artificial lighting, State Parks conducted a literature review of the effects of artificial lighting on native ecosystems and species. There are many studies on the effects of artificial lighting on migratory birds, bats, and invertebrates. Fewer studies have looked at effects on songbirds, amphibians, plants, sea turtles and predatory mammals. Virtually no studies were found on most reptiles, other bird species (including owls) and most mammals. Also to be considered is the designation of the park as a Biodiversity Area and Corridor, essentially a large relatively undeveloped natural area within an urban setting.

In general artificial lights at dusk or night can alter the natural physiology, functions and behaviors of plants, invertebrates, amphibians, reptiles, birds and mammals, as well as predator-prey interactions (Rich and Longcore 2006; Longcore and Rich 2010; Longcore and Rich 2004; IDA 2008). However, impacts are species specific and dependent on the type of lighting, timing and seasonality.

Invertebrates

"Artificial light disrupts natural patterns of light and dark, disturbing invertebrate feeding, breeding and movement." (Bat Conservation Trust 2014; Bruce-White and Shardlow 2011; Rowse et al. 2016.). The effects of lighting on invertebrates is highly wavelength dependent. UV and green and blue light, which have short wavelengths and high frequencies, are seen by most insects and are highly attractive to them (Bruce-White and Shardlow2011). UV lighting is the most attractive to insects and deep-orange LPS lights are the least. Studies indicate that up to 30% of attracted invertebrates die as a result of the attraction. It also makes them much more vulnerable to predation. Artificial lighting disrupts normal life cycle cues, disorienting males and egg laying females and reducing reproduction (Bruce-White and Shardlow 2011; Esenbeis 2006).

Artificial light can attract insects away from other habitats, leaving some areas with reduced insect populations. This so called "vacuum effect" (Esenbeis 2006) draws invertebrates from varying distances but has been recorded for up to 500 m (1,640 feet or about 1/3 mile) away (Bruce-White and Shardlow 2011). Over time, this effect reduces populations in the general vicinity of the light (Esenbeis 2006). Invertebrates are a critical food source for a large number of animal species; hence reductions in their populations impact the viability (fitness) of their predator populations. Invertebrates provide a critical pollinating service for plants, so reductions in their populations can cascade to reduced reproduction in plants (Bennie et al. 2016). At Saint Edward, this impact could potentially extend through the entire forested wetland from the south edge of the ball field to the Water Tower Trail, a distance of 740-780 feet. It could also affect the wetland buffer along the eastern side of the field and the forested wetland area north of the road.

Dark landscapes were found to have much richer insect fauna than lighted areas (Esenbeis 2006). It is unclear what either the mechanism is for the reduction in numbers of species or the impact species loss has on native ecosystems.

Bats

Bats have low reproductive rates and high energy (food) requirements, which make their populations susceptible to disturbances (Voigt and Kingston 2016). Lactating females, in particular, have high energy needs, consuming more than their body weight in insects each night (Kurta and Teramino, 1992).

Some bat species are better adapted to living in urbanized landscapes than others. In general, habitat use by bats is significantly higher in natural landscapes than in either highly or intermediately urbanized landscapes (Voigt and Kingston, 2016; Kurta and Teramino, 1992). The diversity of bat species and the numbers of individuals is reduced in urban settings, and some species are not adapted to them at all (Kurta and Teramino, 1992; Hayes 2017). Big brown bats were found in urbanized parks, although in lower numbers than in rural settings, but other species may be absent or only occasionally found in urban parks. Initial studies appear to indicate that reproductive rates of big brown bats are lower in urban settings (Kurta and Teramino, 1992).

All bat species are highly sensitive to artificial light that falls on their roosts or roost exit points (Bat Conservation Trust 2014). Lighting of roosts or roost exit points inhibits emergence of bats and can cause them to abandon roost sites (Stone 2013).   Artificial lighting can cause a delay in bats emerging from their roosts to feed (Stone 2013). The abundance of insects is greatest at and shortly after dusk, so delay in emergence at that time can have critical effects on feeding (Rowse et al. 2016; Stone 2013). This impact is particularly important during reproduction in late spring through summer when females are rearing young. At Saint Edward, potential roosts include buildings, snags, trees and foliage. Studies to date indicate buildings are not being used.

Bats' sensitivity to artificial light away from the roost, for commuting or feeding, is species specific and depends on season and characteristics of the light. Fast-flying bat species (of which there are three at Saint Edward) tend to be light tolerant, while slow-flying species (of which there are four at Saint Edward) tend to be intolerant and avoid lights (Kuijper et al. 2008; BCT 2014; Stone et al. 2012). It is thought that slow-flying species are less able to avoid predators, so they avoid lights both in feeding and commuting (Kuijper et al. 2008; Stone et al. 2012).

Lighting of bat commute routes causes some bats to abandon or alter flight paths, which reduces habituated connections and efficiency in feeding (Kuijper et al. 2008; Rowse et al. 2016; Stone 2013; Stone et al. 2012). Connectivity of habitat and foraging areas to roosts is fundamental to the survival of many bat populations (Kuijper et al. 2008; Stone 2013.; Verboom and Huitema 1997; Hayes et al. 2017). Light disturbance can cut off some bat species from their foraging areas (Rowse et al. 2016). Slow-flying species often use linear features, such as forest edges or riparian corridors, for commute routes, which provide energy efficiency and protect from wind, rain and predators (Rowse et al. 2016; Stone 2013; Verboom and Huitema 1997). These corridors also provide en-route feeding. Avoidance of these routes can have an increased energy cost, reduced foraging time and increased predation. Lighting of commute routes, even at low levels, can act to fragment habitats (Stone et al. 2012).

Some bats feed around artificial lights and benefit from the concentrations of insects attracted to them (Stone 2013). Other bats avoid lights and cannot take advantage of the increased food resources at lights or in foraging areas affected by light (Kuijper et al. 2008; Rowse et al. 2016; Stone 2013). In general, fast-flying bat species will feed around artificial lights, whereas slow-flying species avoid lights (Rowse et al. 2016). The big brown bat, known to occur at Saint Edward State Park, is one of the species that will feed around lights; in one study doing so enabled them to reduce their foraging time and effort (Rowse et al. 2016). The four species of *Myotis* (mouse-eared bats) that occur at the park avoid light and would not be expected to take advantage of increased food concentration around lights. Light-avoiding species are shown to be negatively impacted by lights, through light avoidance, increased energy output to avoid them, and the need to find alternative food sources (Kuijper et al. 2008).

Bats hibernate during the winter when food resources are low (Stone 2013). Disturbance of roosts during hibernation can cause bats to break hibernation and deplete critical energy reserves threatening their survival (Hayes 2017). It is not clear whether artificial lighting can disrupt hibernation.

Other Mammals

Artificial night light has a variety of effects on crepuscular and nocturnal mammals. It can shift circadian rhythms and behaviors with as little as 15 minutes of light exposure (Beier 2006). Light affects hormones, particularly melatonin, which mediates physiological and behavioral functions. It can reduce foraging by light sensitive species and increase foraging success of predators. Sudden light can cause temporary blindness in animals that impedes function both in the lit environment and then in the unlit environment (Beier 2006).

Amphibians

Effects of artificial night lighting may differ for different species of amphibians. Studies indicate that artificial lighting can affect amphibians by altering photoperiods and hormones that regulate growth and metamorphosis (Wise 2007; Buchanan 2006; Perry et al. 2008). Three species of salamanders (Pacific giant salamander, Red-backed salamander and Ensatina) are recorded at Saint Edward State Park (Hallock 2007). Pacific giant salamander occurs in wetlands and red-backed salamander and Ensatina are forest dwellers. All three species were found in the drainage that flows out of the ball field. Additional species of amphibians may occur on site, but surveys have not been conducted.

Studies have found that artificial light reduces foraging by salamanders, which reduces growth and reproduction, survival during winter hibernation, and population size and distribution (Wise 2007).

Frogs and toads have a variety of reactions to artificial lighting. Some species are attracted and can take advantage of increased prey resources, while others are repelled by light (Buchanan 2006). Lighting can impact vision, making it difficult for frogs and toads to move back into unlit conditions. Lighting can also impact other visually mediated behaviors, such as mate selection, territorial interactions or detection and avoidance of predators. Tree frogs (*Hyla squirella*) are less likely to form or maintain chorus activity when artificial lights illuminate their breeding areas. They tend to move away from the lighted area and then call individually and are more easily disrupted from calling (Buchanan 2006).

Birds

Light is a critical environmental cue for birds for synchronizing seasonal changes in physiology and behavior, including singing and mating (Kay 2014; Rowse et al. 2016). It affects melatonin production, which guides their biological clocks controlling body function, growth and behavior. One study showed that artificial light can suppress estradiol and testosterone secretion affecting reproduction (Kay 2014; Schoech 2013).

Pileated woodpeckers, a state candidate species, use the forested wetland south of the ball field. There are numerous excavated cavities in the forested wetland made by pileated woodpeckers, and one was seen and heard by park staff working the trees. It is unclear what impacts there might be to pileated woodpeckers from lighting and extended use of the field.

Numerous studies have been done on the impacts of artificial light on migratory birds (Gauthreaux and Belser 2006; Poot et al. 2008). Wavelength, whether the light is static, flashing or strobe, height of the light, its orientation, and weather conditions all play a role in the degree of impact on migratory birds. Short wavelength lights appear to have the least effect on migratory birds, as do short pole heights and shielding so light does not project upwards or horizontally. These studies suggest that downward directed short wavelength lighting from poles at a height typical for recreational ball fields are unlikely to have negative effects as birds migrate through.

Plants

Artificial lighting at night can affect plant germination, growth, flowering, phototropism, tissue repair, leaf retention, bud break, susceptibility to disease and seasonal and daily cycles (Bennie et al. 2016; Chaney 2002). Effects are associated with specific light spectra and intensity. Wave lengths of LED lights affect cryptochromes, which are involved with regulation of circadian clocks in plants. Cryptochromes are also involved in germination, growth and development, shade avoidance and DNA repair. Studies have shown that some plants exposed to artificial light at night leaf-out, flower and drop their leaves at different times than those not exposed to artificial light (Bennie et al. 2016; ffrench-Constant 2016). Altered timing of bud break, flowering and leaf fall can lead to tissue damage and disconnect with pollinators and herbivores. Artificial night lighting effects on herbivores and pollinators can have cascading effects within ecosystems (Bennie et al. 2016).

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