# BARN SWALLOW (Hirundo rustica)



# AMERICAN ROBIN (Turdus migratorius)





# HOODED WARBLER (Setophaga cibrina)







# STAGE URBANIZED CITY



- Man-made structures
- Light pollution
- Noise pollution



BUI

## MAN - NADE STRUCTURS

- Varying Altitudes Reflective Windows
- source For Collisions



SOURCES FOR LOUD NOISE - Interferes With Auditory Cues



BRIGHT LIGHTS AT NIGHT

- Obstruct Vision
- Interferes with Navigation And Orientation



MORE BRIGHT LIGHTS - Albructs Birds and Increases Collisions

# LEVEL DESIGN



## MAN-MADE STRUCTURE



## IMPLEMENTATION

- Collisions can result in death when at low enough HP

- Complete Depletion = Transition Into Next Following Day / Towel or Rest Period

## LIGHT POLLUTION (ALAN)





## NOISE POLLUTION

## SCIENTIFIC CONCEPT

- → Increases risk of collision
   → A threat that builds upon danger of man-made structures.

## IMPLEMENTATION

- Brights lights will obstruct player's vision, making it more difficult to guide their bird through the terrain.

## SCIENTIFIC CONCEPT

## IMPLEMENTATION

Winni Wang Professor Jensen 25/SP-MSWI-270C-03 2 May 2025

#### The Effect of Urbanization on Migratory Birds

Amongst many harmful environmental impacts, global urbanization is largely responsible for loss of biodiversity. A group of species that is particularly impacted by the threats proposed by urbanization are migratory birds, who encounter many of these anthropogenic obstacles during the migratory journey. Anthropogenic threats brought about by the rapid globalization and urbanization significantly influence migration timing, physiological condition, and orientation and navigation, all of which are crucial for the success of the migratory journey and lifetime fitness. These threats include human-made structures and sensory pollutants, artificial light at night (also known as ALAN), and noise pollution.

Structures such as skyscrapers and other "human-made elements in the airspace have become an increasingly common barrier to migratory movements" as "birds [are colliding] with anthropogenic structures throughout the world's migration systems" (Nemes et al.). Varying altitudes and the increasing percentage of a building's surface area to be glass and window create a complicated maze of reflective obstacles that must be traversed. While some collisions are a source of instant mortality, many collisions result in nonlethal effects that instead contribute towards the reduction of the migrant's physical fitness. Traumatic brain injuries that emerge as a result of surviving a collision can lead to cognitive impairments in the form of "slowed reaction times, amnesia, balance impairment, and sleep and wake cycles" (Nemes et al.). Intracranial hemorrhaging, a medical condition in which there is internal bleeding in the skull, is a common

injury in birds that survive window strikes. Another common collision-related injury, ocular trauma, can "lead to infection or necrosis, causing vision impairments that leave birds vulnerable to predation and less efficient at foraging" (Nemes et al.). Collision survivors that manage to reach breeding grounds experience lowered reproductive success due to decreased physical fitness and broken or dislocated bones compared to birds that are uninjured.

Artificial light at night, also known as ALAN, is a threat induced by global urbanization that alters the nocturnal landscape for migratory birds during air travel. ALAN is capable of influencing the future survival and reproductive success of migrants by impacting their migration timing, physical condition, and orientation and navigation. ALAN is capable of increasing "migrating birds' risk of collisions with human-made structures, increasing the risk of immediate mortality" (Nemes et al.). As a nonlethal source, artificial light at night has the ability to "attract birds in flight (affecting orientation), which causes them to change direction and lengthen the distance traveled (affecting route), which leads to increased energy expenditure in flight (effecting condition)" (Nemes et al.). Artificial or natural, nocturnal migratory birds are evolutionarily attracted to light despite its source. Bright floodlights pointing upwards are capable of attracting nocturnal migrants and influencing them to "fall to their death from exhaustion" as they are unable to escape the light's influence on their orientation and navigation (Nemes et al.).

A rising concern for migratory birds, similarly emerging amidst rapid urbanization, is sensory pollution in the form of noise. Increased human development and activity in urbanized regions is "accompanied by noise from [various] sources such as transportation, construction, and energy production" (Nemes et al.). Although noise pollution has been studied to be one of the least mortality causing anthropogenic threats, it is capable of affecting "birds nonlethally by interacting with inter- and intraspecies communication" which "induces stress" and causes "birds to alter their behavior and habitat use" (Nemes et al.). Noise pollution can also "mask acoustic cues that birds use to detect predators or prey, " therefore " hindering their ability to escape or find food" (Nemes et al.). Birds in noisy urban environments must expend more energy to remain vigilant as a form of protection, therefore allotting less time and energy for the foraging of food.

The threats that urbanization imposes on migratory bird species is slowly leading to the decline in population of specialist bird species as they are slowly being replaced by generalist species, increasing similarity in phylogenetic traits to appear within bird communities. Scientists studying the large-scale negative impact of urban environments on the evolutionary uniqueness of birds found evidence that "bird communities in urban environments have lower average evolutionary distinctiveness [across] all countries" compared to bird communities present in predominantly rural regions (Morelli et al.).

Migratory birds with phylogenetic traits attributed to "larger clutch size, more generalist diets, and passage birds or species with more than one migration type" were found to be the most tolerant of urban spaces (Yang et al.). The terminology, clutch size, refers to the total amount of eggs laid by female birds in a single nesting attempt. Birds living in constantly changing environments have been studied to have larger clutch sizes, as the faster and increased reproduction rate is capable of overcoming the potential hazards of living in urban environments by increasing the chances of survival and reproduction (Yang et al.). Larger clutch sizes help account for the high mortality rate of migratory birds in urban settings and maintain a stable population, while fast reproduction rates allow quicker adaptation to environmental setbacks and obstacles through each generation of offspring.

In addition to larger clutch sizes, migratory birds with more generalist diets experience increased levels of survival traveling across urbanized regions. Generalist diets with less specialized restrictions help aid in the improvement of a migrant's performance when foraging for food and facing decreased options for nourishment due to human disturbance (Yang et al.). Omnivores, who eat a wider range of plant and animal-based foods, were advantaged in city settings. Birds with specialized feeding strategies" such as insectivores and granivores however, "were negatively associated with urbanization" (Callaghan et al.).

The method in which migrants acquired and foraged for food played an important role in the survival of the birds. Compared to waterside or canopy foragers, ground-foraging species were found to be at a disadvantage as human activity and disturbance were greatest at the ground level (Yang et al.). Increased human presence at the ground level increased chances of trampling as direct sources of mortality and obstruction of proper food when foraging.

Transitioning into my creative project, I have created a mockup of a video-game that highlights how anthropogenic threats related to urbanization such as structures and other human made elements, ALAN, and noise pollution negatively impacts migratory birds' success of the migratory journey and lifetime fitness for survival. The accumulating dangers present in urban settings pose a threat to avian biodiversity as generalist bird species slowly replace specialist migratory bird species. The three major creative processes that will enforce these scientific concepts and define the scope of my project include character design, stage design, and level design.

The threats posed by human urbanization is slowly leading to the decline of specialist bird species, eventually resulting in the increased similarity in phylogenetic genes present within rising bird communities. To properly portray the advantage some bird species have over others when traversing across highly urbanized regions, I have conducted research to decide upon three bird species available for player selection: the urban-tolerant barn swallow (*Hirundo rustica*), the moderate adaptor American Robin (*Turdus migratorius*), and the specialist Hooded Warbler (*Setophaga citrina*).

Character sheets detailing each of the birds' profiles have been created, each with a stat chart aiding in establishing each of the bird species' differences. In tandem with real phylogenetic traits present in migratory birds, the five statistical traits illustrated in the birds' stat charts are diet flexibility, nesting versatility, fear tolerance, mobility, and reproductive rate. A bird's diet flexibility, nesting versatility, and reproductive rate directly correlate with traits that are at the forefront in determining survival and reproductive success. Mobility directly translates to a bird's orientation and navigation, traits that if hindered can result in fatal mortalities through disorientation or collisions against structures. The fear tolerance stat is a reference to birds' tolerance in human presence as well as their ability to detect danger, a trait easily hindered by high levels of noise pollution, causing them to expend more energy to traverse and forage for food. These stats seek to define differences and similarities between the generalist barn swallow, the specialist Warbler, and the moderate adaptor American Robin.

A conceptual design sheet has been created for the game's stage design. The stage and setting consists of an industrialized cityscape. The design sheet helps provide a visual representation of the game's setting, and highlights areas and aspects of the city that pose potential threats to the migratory success and fitness of the birds. Sources for noise pollution and light pollution, two of the anthropogenic threats imposed by human urbanization, are highlighted in the conceptual design map.

The game's level design is detailed in a conceptual spread, where a combination of text and visuals aid in illustrating the mechanics and technicalities of the game. Formatted as a day-to-day survival, the player must survive twelve days and ultimately reach their final migratory destination in order to successfully complete the objective. Each day is divided into a travel period, in which the player focuses on successfully traversing the environment before them, and a rest period, in which the player must look for food and a place for rest until the following day. The player's user interface displays an hp bar and an energy bar. Complete depletion of the hp bar will result in a game over. Complete depletion of the energy bar will result in the closure of either the travel or rest period, and advance the player onto the next period or day depending on their current progress.

Man-made structures pose the most obvious threat to the player's migratory success. This appears more apparent in the game's first person point-of-view during play. Collisions and window strikes against structures are often direct sources of mortal fatality, or result in fatal injuries that are carried throughout the rest of the migratory journey. As such, players must avoid buildings, where collisions can result in hit points lost and permanent debuffs.

The anthropogenic threat of light pollution greatly affects the nocturnal landscape during air travel, thus it acts as a stage control effect that negatively affects the ease in which the player is able to traverse. ALAN is capable of affecting orientation by attracting birds during flight, leading to disorientation, increased probability of collision, death, and fatal injuries. The light pollution stage control effect is therefore most effective during nighttime, obfuscating vision to disorient the player's navigation and orientation.

The anthropogenic threat of noise pollution acts as a stage control effect that negatively affects the ease in which the player is able to rest. Noise pollution, although a threat that remains

nonlethal, is capable of masking acoustic cues utilized by birds to detect both predator and prey. In urban settings, migratory birds expend more energy both during the day and night to remain vigilant, hindering their ability to forage for food and rest. The stage control effect of noise pollution is therefore active during the rest period of each migratory day. Birds subjected to the noise pollution effect must expend more energy in order to find food and a resting location.

Each of these technicalities are detailed in the conceptual spread, with drawn visuals to help illustrate the mechanics, user interface, and stage control effects of the game.

The intended audience of my creative project is targeted towards teenagers aged 13 to 17 and young adults aged 18 to 25, who spend considerable time engaging with games and other interactive, immersive forms of media. These individuals often enjoy mentally stimulating activities, and seek a sense of visible progression through the problem-solving nature of many games. They are thus less likely to seek out information regarding the environmental concerns of Earth's modern environment in the form of books and articles. Adolescence and young adulthood comprise of the most impressionable stages of human development, where one's experiences and the knowledge they are exposed to can easily shape values and goals. By presenting information in the form of a simulated game, it aids in the direct engagement of such information in the form of online interactive media, helping to spread awareness and informing the views of the young and impressionable that are less likely to come across information regarding Earth's environmental concerns through other means.

#### Works Cited

Callaghan, C.T., Major, R.E., Wilshire, J.H., Martin, J.M., Kingsford, R.T. and Cornwell, W.K. (2019), Generalists are the most urban-tolerant of birds: a phylogenetically controlled analysis of ecological and life history traits using a novel continuous measure of bird responses to urbanization. Oikos, 128: 845-858. https://doi.org/10.1111/oik.06158 Factual

- Migratory birds with more generalized, phylogenetically controlled patterns such as larger clutch size were most urban-tolerant.
- Specialized feeding strategies, such as insectivores and granivores, displayed lower survival rates.

Elmqvist, T., Andersson, E., McPhearson, T. *et al.* Urbanization in and for the Anthropocene. *npj Urban Sustain* 1, 6 (2021). <u>https://doi.org/10.1038/s42949-021-00018-w</u>

#### Factual

- The Anthropocene is defined by rapid changes in the current biophysical conditions of the Earth, largely driven by the predominance and accelerating growth of human activity.
- Urbanization acts as a constant accelerating aspect of the Anthropocene.

Goudie, Andrew S. Human Impact on the Natural Environment: Past, Present and Future. 7th

ed., Blackwell Publishing, 2018. Google Scholar,

https://books.google.com/books?hl=en&lr=&id=YZVdDwAAQBAJ&oi=fnd&pg=PR11 &dq=human+actions+on+the+environment&ots=i2dld3vnzs&sig=P4Xh7R\_ag1U8ZrDF g-jd5Edotok#v=onepage&q=human%20actions%20on%20the%20environment&f=false

### Factual

- The 20th century is defined as a time of extraordinary change as the human population increased from 1.5 to 6 billion, the world's economy increased fifteenfold, the world's energy consumption thirteen to fourteen fold, freshwater use ninefold, and utilization of irrigated area fivefold.

Morelli, Federico, et al. "Evidence of Evolutionary Homogenization of Bird Communities in Urban Environments Across Europe." *Global Ecology and Biogeography*, vol. 25, no. 11, 2025, pp. 1284-1293. Wiley Online Library, <u>https://doi.org/10.1111/geb.12486</u>.
Factual

- Global urbanization is leading towards the culling of specialist species, and their replacement by generalist species, slowly increasing monogamy and similarity in traits amongst bird communities.
- Urban environments pose as a large-scale source negatively contributing to the evolutionary uniqueness of birds.
- Bird communities in urban environments display lower average evolutionary distinctiveness across all countries in comparison to bird communities that reside in rural areas.

Nemes, Claire E., et al. "More than Mortality: Consequences of Human Activity on Migrating Birds Extend Beyond Direct Mortality." *Ornithological Applications*, vol. 125, no. 3, 7 Aug. 2023, duad020, <u>https://doi.org/10.1093/ornithapp/duad020</u>.

### Factual

- Urbanization has caused the most drastic transformation to the landscape to date.

- Consequences of threats do not always materialize immediately at the source.
- The repeated combination and interaction of minor nonlethal threats can synergistically lower chances of survival.
- Anthropogenic threat types emerging from global urbanization include but are not limited to human-made structures, and sensory pollutants such as artificial light at night and noise pollution.
- Migration Timing
  - Appropriate timing of arrival to breeding, stopover, and nonbreeding sites are crucial for securing food resources, avoiding difficult weather, increasing reproductive ability, and seeking high-quality mates and territories.
- Physiological Condition
  - Migrants must find food, avoid predators, and seek potential mates upon arrival at their destination.
  - The health and energetic condition of migratory birds influences their subsequent survival and reproductive success.
- Orientation & Navigation
  - Migratory birds utilize an internal clock and compass mechanism combined with alertness to external cues to aid in orienting themselves when navigating to destinations.
- Anthropogenic Structures

- Human-made structures obstructing the airspace acts as a barrier to migratory movements, as birds are increasingly colliding against various anthropogenic structures throughout the world.
- Collisions are responsible for delayed mortality and the creation of nonlethal effects that impose fitness costs on migratory birds.
- Intracranial hemorrhaging is the most frequent injury in birds that survive collisions.
- Collision survivors that manage to reach breeding grounds with broken and dislocated bones experience lower reproductive success compared to their uninjured counterparts.
- Artificial Light
  - Artificial light at night influences future survival and the reproductive success of migratory birds.
  - Artificial light at night greatly alters the nocturnal landscape.
  - Artificial light at night increases risk of collision against human-made structures, increasing risk of immediate death.
  - Nocturnal migratory birds are attracted to light regardless if it is emitted by an artificial or natural source.
- Noise Pollution
  - Areas of high human activity and development create various sources for noise such as construction, transportation, and production of energy.
  - Noise pollution is amongst very few anthropogenic threats that are cause for immediate sources of direct mortality.

- Many migratory birds actively avoid noisy regions and habitats.

#### Conceptual

- Migration is the most dangerous period of the annual cycle for migratory birds as journeys are capable of spanning across several months and across various continents while navigating difficult, unfamiliar terrain.
- Migratory birds are adapted to overcome challenges posed by migration with ease, but human activity has greatly modified the environments birds must traverse en route.
- Direct and indirect anthropogenic sources of mortality can produce nonlethal effects in the form of delayed fitness costs, reducing migratory birds' probability for survival and ability to reproduce.
- Migration Timing
  - Anthropogenic threats encountered by migratory birds en route may delay their arrival to breeding sites, hindering reproductive ability and potential.
  - Delayed arrival to non breeding sites result in migratory birds spending the season in lower-quality habitats, and eventually delaying their departure in spring.
- Physiological Condition
  - Anthropogenic threats are capable of altering the physiological condition of migratory birds by reducing their energy level through an impairment to their ability to forage due to injury, illness, exhaustion, disturbance, and stress.

- Anthropogenic threats can reduce the fat stores of migratory birds, leading to potential costs in fitness through the delayed timing or hampering reproductive abilities upon arrival to areas for breeding.
- Orientation & Navigation
  - Although migratory birds have evolutionarily evolved to navigate with ease in the face of changing conditions en route, anthropogenic threats are capable of interfering with their ability to accurately perceive and interpret environmental cues for orientation and navigation purposes.
  - Disoriented migrants deplete their energy reserves quicker during flight,
     imposing harsh fitness costs due to reduced physiological condition,
     delayed migration timing, or complete failure to reach the destination.
- Anthropogenic Structures
  - Traumatic brain injuries resulting from collisions and window strikes cognitively impairs reaction time, balance, sleep wake disturbance, and causes amnesia.
  - Ocular trauma, a common collision-related injury, can result in infection and necrosis, eventually causing vision impairments that leave migratory birds vulnerable to predatory threats and decreased efficiency in foraging for food.
- Artificial Light
  - Artificial light affects the survival and reproductive success of migratory birds by altering their migration timing, physiological condition, and orientation and navigation.

- Artificial light affects the orientation or migratory birds by attracting their attention during flight, affects their route by causing changes in direction and length of flight, and affects condition by increasing the amount of energy expended.
- Flares and artificial lights from oil and gas drilling platforms are capable of attracting and disorienting birds before they die of exhaustion, inhalation of toxic compounds, or death by incineration.
- Birds that escape entrapment or burning often suffer exhaustion and injury, reducing their flight performance and hindering migratory birds' ability to successfully recover at an appropriate stopover site.
- Noise Pollution
  - Noise pollution affects migratory birds by interfering with inter- and intraspecies communication, causing birds to alter behavior and habitat use, and inducing stress.
  - Noise pollution is capable of masking acoustic cues that migratory birds utilize to aid in the detection of potential predators and prey, therefore hindering their ability to escape or forage for food.
  - Noise pollution in urban environments causes migratory birds to expend more energy to maintain vigilance against predators, leaving less time and energy for foraging for food.

Yang, Mengxia, Corey T. Callaghan, and Jiayu Wu. "How Do Birds with Different Traits Respond to Urbanization? A Phylogenetically Controlled Analysis Based on Citizen Science Data and a Diverse Urbanization Measurement." *Landscape and Urban* 

#### Planning, vol. 237, 2023, Article 104702. ScienceDirect,

https://www.sciencedirect.com/science/article/pii/S0169204623001202.

#### Factual

- Birds with larger clutch sizes and more diverse, generalist diets were found to be the most tolerant of urban environments and spaces.
- Omnivores displayed higher urban tolerance.
- Passage migrants with multiple migration types, larger clutch sizes, and more generalist diets were the most commonly found in urban environments and spaces.

### Conceptual

- Birds living in increasingly differing environments displayed larger clutch sizes, their fast and increased reproduction enabling them to overcome the hazards of living in urban spaces.
- Migratory birds with generalist diest display increased performance of foraging for food in the face of human disturbances.
- Unlike fast reproducing migratory bird species, migratory birds that reproduce slower and require specific resource requirements display decreased chances of survival and increased need for special protection strategies set in place by humans.
- Ground-foraging species are disadvantaged in urban spaces in comparison with waterside and canopy foragers, as increased human activity and disturbance at the

ground level are capable of trampling, destruction, and obstruction of potential sources of food and nourishment.