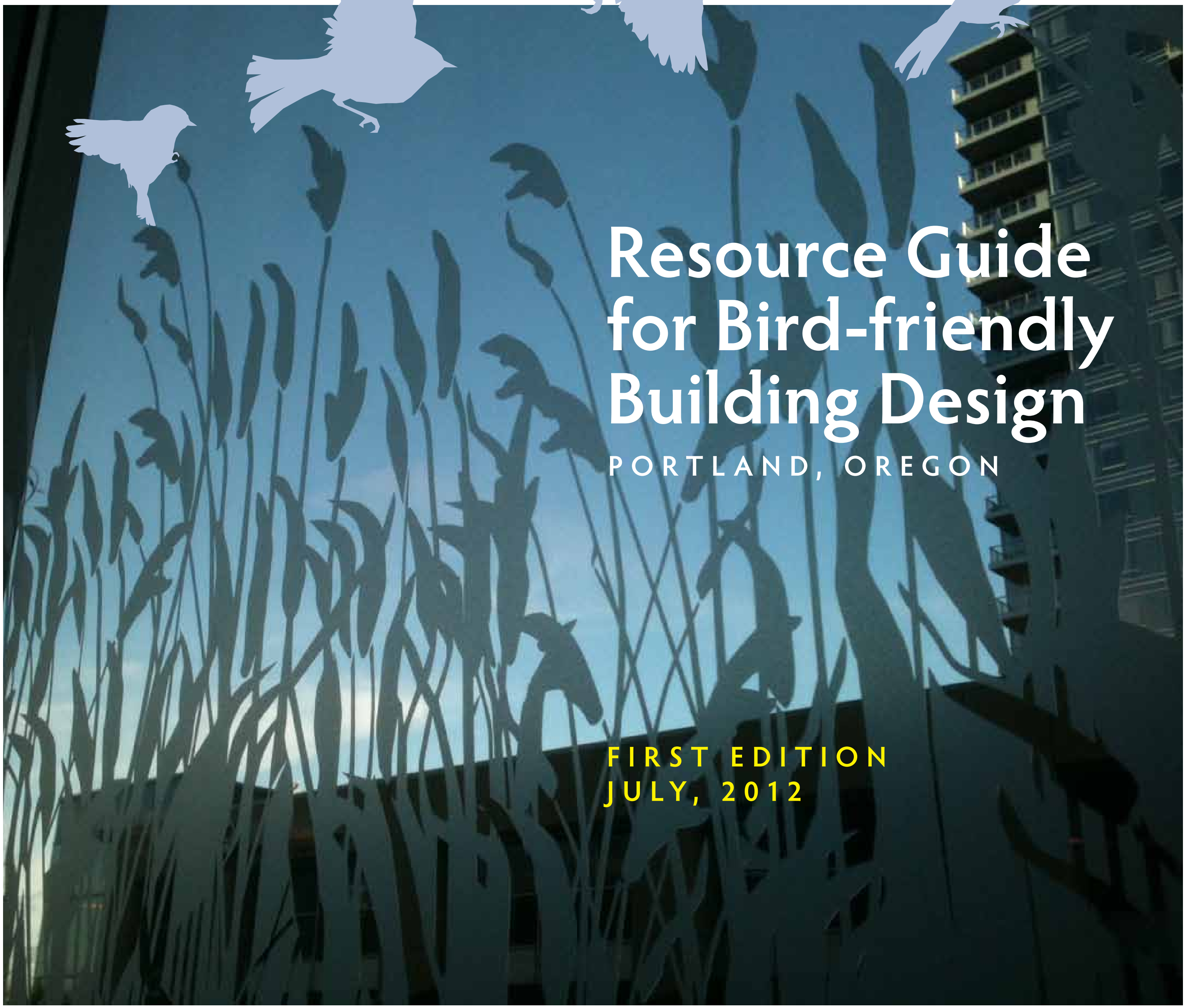

Resource Guide for Bird-friendly Building Design

PORTLAND, OREGON

FIRST EDITION
JULY, 2012

Audubon Society of Portland
Founded in 1902

AMERICAN BIRD CONSERVANCY

CITY OF PORTLAND, OREGON 1851

U.S. FISH & WILDLIFE SERVICE
DEPARTMENT OF THE INTERIOR

Together Green
act today, shape tomorrow

Right: Orange-crowned Warbler, a collision victim at the Atwater in South Waterfront. Photo: Mary Coolidge

Cover photo: Window films for branding and privacy, like this one designed by Heidi McBride and Megan Geer, can be beautiful, functional, and provide bird-friendly visual markers on windows. Photo: Mary Coolidge

Executive Summary

"Participation in the Urban Conservation Treaty for Migratory Birds demonstrates [Portland's] long term commitment to the protection and conservation of migratory birds. The program instills a sense of stewardship and responsibility…to ensure that [birds] remain an important element in the urban landscape." – USFWS Portland Urban Conservation Treaty, 2003

Window collisions are one of the top sources of mortality for birds, ranked second only to habitat destruction in terms of impact. Today, collisions are estimated to account for the death of up to one billion birds annually in the US alone.

In 2003, Mayor Vera Katz and City Commissioners pledged Portland's ongoing stewardship to our bird populations when we entered into the U.S. Fish and Wildlife Service (USFWS) Urban Conservation Treaty for Migratory Birds. In 2011, Portland Received a Challenge grant from the USFWS to develop local, voluntary Bird-friendly Building Guidelines.

Portland is a city characterized by its parks and natural areas, its bridge-nesting peregrines, its ecoroofs and naturescapes. Portlanders famously converge by the thousands on the Chapman Elementary School hill in September to witness the nightly spectacle of Vaux's Swifts taking to their chimney roost, and hundreds of homeowners have enrolled in the Backyard Habitat Certification Program to attract wildlife and improve their backyards' contribution to habitat connectivity through the city. We rely on birds to pollinate our plants, control our pests, disperse our seeds, generate recreation and tourism dollars, and capture our imaginations.

The Portland region hosts a remarkable 209 species of birds – everything from the Great Blue Heron to the Rufous Hummingbird. Some birds are year-round residents, well-adapted to city life. Some are just passing through, using the Pacific Flyway as they migrate northward or southward. Still others come for the winter, taking advantage of our mild Willamette Valley climate. They all contribute to Portland's identity as a green city.

Yet, birds face heightened hazards in the city, where they encounter deceptive and ubiquitous window glass, which they don't perceive as a barrier. Collision threats are exacerbated by unshielded overnight lighting, which draws migratory birds into urban areas at night, increasing their exposure to glass during the day. Research beginning in the late 1970's shows that window collisions are one of the top sources of mortality for birds, ranked second only to habitat destruction in terms of impact. Today, collisions are estimated to account for the death of up to 1 billion birds annually in the US alone. At a time when 1 in 4 bird species are showing precipitous population declines, anthropogenic threats to our bird populations with achievable, if incremental, solutions demand our attention. Surveys coordinated by Audubon Society of Portland have evaluated window collisions since fall 2009. While these surveys represent a small sampling effort, the data indicates that window glass undoubtedly poses a hazard to our urban bird populations. Downtown surveys catalogued a diverse array of native warblers, hummingbirds, flycatchers, and sparrows that fatally collided with buildings, 36 species to date.

Though most survey programs around the country focus primarily on commercial high-rises, window collisions are known to occur at both large and small buildings and residences. Mortality patterns are much more easily tracked in commercial districts, which results in amassing of more data about mortality patterns at high-rises than at homes. However, given the number of small commercial and residential buildings across the country, these structures represent a significant source of mortality. Challenges to surveying this type of development make it difficult to accurately quantify the true magnitude of strike mortality. However, Audubon Society of Portland has a unique source of valuable information about window strikes at homes and small buildings: collision intakes and phone calls received by the Wildlife Care Center increase our tracking capacity beyond targeted monitoring programs. What is clear is that all building types, large and small, residential and

41 Cooper Square in New York City, by Morphosis Architects, features a skin of perforated steel panels fronting a glass/aluminum window wall. The panels reduce heat gain in summer and add insulation in winter while also making the building safer for birds. Photo: Christine Sheppard, ABC

commercial, can pose a collision hazard where unmarked glass is used, and represent an opportunity for improved design.

Bird-Friendly Building Guidelines are an essential component of a comprehensive urban sustainability strategy. Cities such as San Francisco, New York, Toronto, Chicago and the state of Minnesota have already adopted Bird-Friendly Building Guidelines, some regulatory, some voluntary. Integrating Bird-friendly Building Guidelines into Portland's sustainability planning efforts will compliment other adopted strategies including: the Climate Change Action Plan; the Watershed Management Plan, the Urban Forest Action Plan, Grey to Green, Ecodistricts Initiative, and the Portland Bird Agenda.

In recent years, vast improvement in the energy-efficiency of glass has led to proliferation of glass curtain walls in architecture. Research into collision rates has shown the percentage of unmarked glass on a building to be the strongest predictor of bird mortality. And yet, there are already myriad examples of innovative designs which incorporate bird-friendliness into buildings, whether intentionally or incidentally, and many of these can help achieve multiple building objectives. Simply by understanding and avoiding collision hazards in building design, incorporating visual markers into the most predictably hazardous parts of a building, and identifying architectural approaches that elegantly layer bird-friendliness with energy conservation or other objectives, architects can begin to mold their designs toward bird-friendliness while remaining cost-neutral. For example, thoughtfully designed fritted windows can reduce solar heat gain, provide privacy, allow for light entry, and mark windows for birds. Audubon's voluntary Lights Out Portland program dovetails well with the city's Climate Action Plan goal of achieving 80% carbon reduction by 2050.

Evolution of the US Green Building Council's LEED standards to include a Bird Collision Deterrent Pilot Credit (Pilot Credit 55, introduced October 14, 2011) is strong evidence that leaders in the green building movement are committed to ensuring that green buildings are also safe for birds (see Appendix V). Great strides have been made in recent years to bring ecosystem-level considerations into play, with this new BCD Pilot Credit as well as the Light Pollution Reduction Pilot Credit 7, which predates it.

Simply by understanding and avoiding collision hazards in building design, incorporating visual markers into the most predictably hazardous parts of a building, and identifying architectural approaches that elegantly layer bird-friendliness with energy conservation, architects can begin to mold their designs toward bird-friendliness while remaining cost-neutral.

This resource guide is a customization of American Bird Conservancy's Bird-Friendly Building Design template, which was based on guidelines first developed by NYC Audubon Society. It aims to provide Portland architects, planners, designers, local authorities, and homeowners with a clear understanding of the nature and magnitude of the threat posed by unmarked glass to birds. Given Portland's projected growth by more than 100,000 households in the next 25 years, the development of this guide is well-timed to provide a resource for both the construction of new buildings and retrofits and remodels of existing buildings. Increased awareness among innovative designers about bird-friendly design options will yield thoughtful design of bird-friendly buildings that artfully achieve ecological, energetic, and aesthetic goals.

This edition includes an appendix on the science behind available solutions, examples of how these solutions can be applied to both new construction and existing buildings, and an explanation of the kind of information still needed. We hope it will spur imaginative incorporation of trend-setting bird-friendly designs into our local built landscape, and help illustrate the synergistic benefits that can weave together bird-friendliness with energy efficiency, aesthetics, branding, privacy, and other innovative design objectives.

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Willow Flycatcher
Photo: Jim Cruce

A Quick Look at Bird-friendly Building Design Recommendations

Cedar Waxwing
Photo: Jim Cruce

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- Glass on first 40' of a building
- Glass on first floor adjacent to an ecoroof or rooftop garden
- Windows at corners, on skybridges and in atria
- Freestanding glass around courtyards, ecoroofs, patios, and balconies

See page 13 for more information.

Window Treatment Options for High Risk Zones:

- Exterior frits, sandblasting, translucence, etching or screenprinting
- Exterior branding on glass for retail
- Exterior window films
- Exterior shades or shutters
- Glass block
- Exterior netting or screens
- Exterior framework, grilles, or trellises
- Awnings, overhangs, and deeply-recessed windows
- Louvers

See page 17 for more information.

Tips for Achieving Cost-effectiveness in New Construction and Retrofits:

- Have bird-friendly building design in mind from the start of project design.
- Plan to work within your project budget using bird-friendly design principles and materials—may or may not result in design modifications.
- Look for economies—unit costs go down as amount of materials increases.
- Seek opportunities to meet multiple project goals using bird-friendly design approaches (e.g. window treatments that provide privacy or branding or meet energy-reduction goals).

Lighting:

- Shield all outdoor lighting (full cut-off above 90 degrees)
- Properly design all outdoor lighting to be directed to minimize light spill
- Eliminate up-directed architectural vanity lighting
- Minimize down-directed architectural vanity lighting
- Design interior lights to minimize light spill
- Install or design for motion sensor lighting
- Design all non-exempt interior and exterior lighting to be off overnight (minimum: midnight to 6 am)
- Participate in Audubon's Lights Out Portland program

See page 32 for more information.

Other:

- Monitor bird mortality
- Distribute materials about birds and window collisons
- Report window collisions to Portland Audubon 503.292.6855

Song Sparrow
Photo: Jim Cruce

Introduction

Birds Matter

Birds have been important to humans throughout history, often used to symbolize cultural values such as peace, freedom, and fidelity.

In addition to the pleasure they can bring to people, we depend on them for critical ecological functions. Birds consume vast quantities of insects, and control rodent populations, reducing damage to crops and forests, and helping limit the transmission of diseases such as West Nile virus, dengue fever, and malaria. Birds play a vital role in regenerating habitats by pollinating plants and dispersing seeds.

Birds are also a vast economic resource. A 2009 USFWS study showed that bird watching is one of the fastest growing leisure activities in North America, and a multi-billion-dollar industry.

The 55,000 square foot mural on the mausoleum overlooking Oaks Bottom Wildlife Refuge features local birds. Photo: Bob Salllinger

The Legal Landscape

At the start of the 20th Century, following the extinction of the Passenger Pigeon and the near-extinction of other bird species due to unregulated hunting, laws were passed to protect bird populations. Among them was the Migratory Bird Treaty Act (MBTA), which made it illegal to kill a migratory bird. The scope of this law extends beyond hunting, such that anyone causing the death of a migratory bird, even if unintentionally, can be prosecuted if that death was foreseeable. This may include bird deaths due to collisions with glass, though there have yet to be any prosecutions in the United States for such incidents. Violations of the MBTA can result in fines of up to $1,500 per incident and up to six months in prison.

The Bald and Golden Eagle Protection Act (originally the Bald Eagle Protection Act of 1940), the Endangered Species Act (1973), and the Wild Bird Conservation Act (1992) provide further protections for birds that may be relevant to building collisions.

Recent legislation, primarily at the city and state level, has addressed the problem of mortality from building collisions and light pollution. Cook County, Illinois, San Francisco, California, Toronto, Canada, and the State of Minnesota have all passed laws or ordinances aimed at reducing bird kills, while other authorities have pushed for voluntary measures.

The International Dark Sky Association, an environmental organization whose mission is "to preserve and protect the nighttime environment" now actively supports legislation designed to restore the dark by curbing light emissions. Portland has joined 21 other North American Cities in establishing a voluntary Lights Out program.

Glass: The Invisible Threat

Glass can be invisible to both birds and humans. Humans learn to see glass through a combination of experience (many of us have

Introduction

The Varied Thrush is a common victim of window collisions in the Portland area. Photo: R. Michael Liskay

Warblers, such as this Yellow Warbler, are often killed by window collisions as they migrate. Photo: Eric Liskay

Most birds' first encounter with glass is fatal when they collide with it at full speed.

walked into a glass door or seen somebody do so), visual cues and context, but birds are unable to use these signals. Most birds' first encounter with glass is fatal when they collide with it at full speed.

No one knows exactly how many birds are killed by glass – the problem exists on too great a scale and many mortalities go undetected – but estimates range from 100 million to one billion birds each year in the United States. Despite the enormity of the problem, however, solutions are available that can reduce bird mortality while retaining the advantages of glass as a construction material, without sacrificing architectural standards.

Lighting: Exacerbating the Threat

Bird collisions with glass are greatly exacerbated by artificial light. Light escaping from building interiors or from exterior fixtures can attract birds, particularly during migration on foggy nights or when the cloud base is low. Strong beams of light can cause birds to circle in confusion and collide with structures, each other, or even the ground. Others may simply land in lighted areas and must then navigate an urban environment rife with other dangers, including glass. *(This is discussed further in the Problem: Lighting section, page 29)*

Birds and the Built Environment

Human population growth exerts real consequences on our wildlife populations in the form of habitat loss. Sprawling land use patterns and poorly planned and designed urbanization degrade both the quantity and quality of available habitat. The rate of sprawl in the US nearly quadrupled between 1954 and 2000. The tendency to build along waterways and shorelines means not only habitat depletion, but erection of potentially hazardous buildings along historic migratory pathways and in traditional stopover areas.

Great advancements in glass engineering have seen the evolution of buildings from relatively solid, blocky buildings to relatively transparent structures. The advent of mass-produced sheet glass in the early 1900's and the invention of float glass in the 1950's allowed mass production of flat glass for modern windows. In the 1980's, development of new production and construction technologies culminated in today's glass skyscrapers.

The amount of unmarked glass in a building is considered the strongest predictor of how dangerous it is to birds. However, even small areas of glass can be lethal. While bird kills at residential homes are estimated at one to ten birds per home per year, the large number of homes multiplies that loss to millions of birds per year in the United States.

Other factors can affect a building's potential impact, including the density and species composition of local bird populations, local geography, the location, and extent of landscaping and nearby habitat, weather, and patterns of migration through the area. All these factors will be considered in this document.

Impact of Collisions on Bird Populations

About 25% of species are now on the US Watchlist of Birds of Conservation Concern (http://library.fws.gov/pubs/mbd_watchlist.pdf). Forty years of Christmas Bird Count data indicate that even many common species are in decline (http://stateofthebirds.audubon.org/cbid/). Habitat destruction or alteration on both breeding and wintering grounds remains the most serious man-made problem, but collisions with buildings represent the largest known fatality threat. Nearly one third of the bird species found in the United States, over 258 species, are documented as victims of collisions. Over 78 species have been catalogued in Portland in 4 seasons of tracking collisions (2009-2011).

Unlike natural sources of mortality that predominantly kill weaker individuals, collisions kill some of the strongest, healthiest birds that would otherwise survive to produce offspring. This is both unsustainable and avoidable. Anthropogenic sources of mortality—like collision hazards—are both avoidable and mitigable: ***the goal of the Resource Guide for Bird-friendly Building Design is to provide avenues for incremental improvement in hazard reduction.***

The Impact of Trends in Modern Architecture

In recent decades, advances in glass technology and production have made it possible to construct buildings with all-glass curtain walls, and we have seen a significant increase in the amount of glass used in construction. Unfortunately, as the amount of glass increases, so does the incidence of bird collisions.

New trends in green development can potentially help reduce risk to birds in the built environment. The Green Building Council's (GBC) Leadership in Energy and Environmental Design, or LEED has recently begun to include language addressing the threat of glass to birds.

Their *Resource Guide*, starting with the 2009 edition, calls attention to parts of existing LEED credits that can be applied to reduce negative impacts on birds. Reducing light pollution, reducing disturbance to natural landscapes, and reducing energy use can all benefit birds. On October 14, 2011, GBC added Credit 55: Bird Collision Deterrence, to their Pilot Credit Library (http://www.usgbc.org/ShowFile.aspx?DocumentID=10402). Drafted by ABC, members of the Bird-safe Glass Foundation, and the GBC Site Subcommittee, the credit is open to both new construction and existing buildings.

Various materials have been evaluated to rate their threat level to birds. These threat factors are used to calculate an index representing the building's façade, and that index must stay below a standard value to earn the credit. The credit also requires adopting interior and exterior lighting plans as well as post-construction monitoring. Appendix I reviews the work underlying the assignment of threat factors.

Reflections of the sky and clouds on glass towers pose a danger to birds flying above treeline. Photo: Mary Coolidge

Unlike natural sources of mortality that predominantly kill weaker individuals, collisions kill some of the strongest, healthiest birds that would otherwise survive to produce offspring. This is both unsustainable and avoidable.

Introduction

The area of glass on a façade is the strongest predictor of threat to birds. The façade of Sauerbruch Hutton's Brandhorst Museum in Munich is a brilliant example of the creative use of non-glass materials. Photo: Tony Brady

Audubon Society of Portland has worked with ABC to become a registered provider of AIA Continuing Education on bird-friendly design and LEED Pilot Credit 55. Contact Audubon Society of Portland for more information: www.audubonportland.org.

Defining "Bird-friendly"

It is increasingly common to see the term "bird-friendly" used to demonstrate that a product, building, or legislation is not harmful to birds. However, this term lacks a clear definition and sound scientific foundation to underpin its use.

It is impossible to know exactly how many birds a building will kill before it is built, and so realistically, we cannot declare a building to be bird-friendly before it has been carefully monitored for several years. However, there are several factors that can help us predict whether a building will be harmful to birds or generally benign, and we can accordingly define simple "bird-smart standards" that, if followed, will ensure that a prospective building poses a minimal potential hazard to birds.

Boris Pena's Public Health Office building in Mallorca, Spain, sports a galvanized, electro-fused steel façade which deflects bird strikes. Photo: Boris Pena

ABC's Bird-friendly Building Standard

A bird-friendly building is one where:

- At least 90% of exposed façade material from ground level to 40 feet (the primary bird collision zone) has been demonstrated in controlled experiments[1] to deter 70% or more of bird collisions.
- At least 60% of exposed façade material above the collisions zone meets the above standard.
- There are no transparent passageways, corners, atria or courtyards that can trap birds.
- Outside lighting is appropriately shielded and directed to minimize attraction to night-migrating songbirds.[2]
- Interior lighting is turned off at night or designed to minimize light escaping through windows
- Landscaping is designed to keep birds away from the building's façade.[3]
- Actual bird mortality is monitored and compensated for (e.g., in the form of habitat preserved or created elsewhere, mortality from other sources reduced, etc.).

1. See the section Research: Deterring Bird Collisions in Appendix I for information on these controlled studies.
2. See the section Solutions: Lighting Design on page 34
3. See Landscaping and Vegetation, Appendix I on page 43

Red-tailed Hawk in downtown Portland. Photo: Bob Sallinger

The Hotel Puerta America in Mexico City was designed by Jean Nouvel, and features external shades. This is a flexible strategy for sun control, as well as preventing collisions; shades can be lowered selectively when and where needed. Photo: Ramon Duran

The large, unmarked panes of glass in this building reflect sky and trees. The building's proximity to the Willamette River and its greenroof with adjacent unmarked glass make it a potential collision hazard. Photo: Mary Coolidge

Problem: Glass

The Ever-changing Properties of Glass

Glass can appear very differently depending on a number of factors, including: the angle at which it is viewed; the difference between exterior and interior light levels; seasons; weather; and time of day. Combinations of these factors can cause glass to look like a mirror or dark passageway, or to be completely invisible. Humans do not actually "see" glass, but are cued by context such as window frames, roofs or doors. Birds, however, do not perceive architectural signals as indicators of obstacles or artificial environments.

Reflectivity

Viewed from outside, transparent glass on buildings is often highly reflective – even under Portland's often overcast skies. Almost every type of architectural glass, under the right conditions, reflects the sky, clouds, or nearby habitat familiar and attractive to birds. When birds try to fly to the reflected habitat, they hit the glass. Reflected vegetation is the most dangerous, but birds also attempt to fly past reflected buildings or through reflected passageways.

Transparency

Birds strike transparent windows as they attempt to access potential perches, plants, food or water sources, and other lures seen through the glass. Glass skywalks joining buildings, glass walls around planted atria, windows meeting at building corners, and exterior glass handrails or walkway dividers are dangerous because birds perceive an unobstructed route to the other side.

Passage Effect

Birds often fly through small gaps, such as spaces between leaves or branches, nest cavities, or other small openings. In some light, glass can appear black, creating the appearance of just such a cavity or "passage" through which birds try to fly.

The glass-walled towers of the Time-Warner Center in New York City appear to birds as just another piece of the sky. Photo: Christine Sheppard, ABC

Humans do not actually "see" glass, but are cued by context such as window frames, roofs or doors. Birds, however, do not perceive architectural signals as indicators of obstacles or artificial environments.

Transparent handrails are a dangerous trend for birds, especially when they are in front of vegetation. Photo: Mary Coolidge

Problem: Glass

The mirrored windows at Lewis and Clark were highly reflective on gray days as well sunny days. Photo: Mary Coolidge

Factors Affecting Collisions Rates for a Particular Building

Every site and every building can be characterized as a unique combination of risk factors for collisions. Some, particularly aspects of a building's design, are very structure-specific. Many hazardous design features can be readily countered, or, in new construction, avoided. Others, like a building's location and siting, relate to migration routes, regional ecology, and geography – factors that are difficult if not impossible to modify.

Overall Design

The relative threat posed by a particular building depends substantially on the amount of exposed glass, the type of glass used, and the presence of "design traps". Klem (2009) in a study based on data from Manhattan, found that a 10% increase in the area of reflective and transparent glass on a building façade correlated with a 19% increase in the number of fatal collisions in spring and a 32% increase in fall.

Type of Glass

The type of glass used in a building is a significant component of its danger to birds. Mirrored glass is often used to make a building "blend" into an area by reflecting its surroundings, which makes those buildings especially deadly to birds. Mirrored glass is reflective at all times of day, and birds mistake reflections of sky, trees, and other habitat features for reality. Non-mirrored glass can appear highly reflective or transparent, depending on time of day, weather, angle of view, and other variables. Tinted glass may reduce collisions, but only slightly. Low-reflection glass may be less hazardous in some situations but can create a "passage effect" – appearing as a dark void that could be flown through (see page 13).

Building Size

Unmarked glass on buildings of all sizes, residential and commercial alike, can pose a significant hazard to birds. Still, as building size increases, so usually does the amount of glass, making larger buildings a greater single threat. It is generally accepted that the lower stories of any type of building are the most dangerous because they reflect trees and other landscape features, which themselves are attractive to birds, and therefore the first 40' of a building should utilize bird-friendly features. However, monitoring programs which have access to setbacks and roofs of tall buildings have documented window collisions. Voluntary, internal reporting programs in Portland have documented collisions up to the 19th and 21st stories.

Orientation and Siting

Building orientation in relation to compass direction has not been implicated as a factor in collisions, but siting of a building with respect to surrounding habitat and landscaping can be an issue, especially if glass is positioned so that it reflects vegetation. Physical features such as outcrops or pathways that provide an open flight path through the landscape can channel birds towards or away from glass and should be considered early in the design phase.

Design Traps

Windowed courtyards can be death traps for birds, especially if they are heavily planted. Birds are attracted into such places, and then try to leave by flying directly towards reflections on the walls. Glass skywalks and outdoor handrails, and building corners where glass walls or windows are perpendicular are dangerous because birds can see through them to sky or habitat on the other side.

Reflected Vegetation

Glass that reflects shrubs and trees causes more collisions than glass that reflects pavement or grass (Gelb and Delecretaz, 2006).

Local Retrofit: Window Screen Installation at Lewis and Clark Law School. A multistory bank of mirrored windows (top photo) made the LRC building disappear into adjacent Tryon Creek State Park, and was the site of up to 50 documented collisions per season (spring/fall). Since the installation of screens (bottom photo), no fatalities have yet been documented at the LRC building (as of the date of this publication). Photos: Mary Coolidge

Problem: Glass

Planted, open courtyards lure birds then prove dangerous when they encounter reflections of vegetation on surrounding windows. Photo: Mary Coolidge

Studies have only quantified vegetation within 15 – 50 feet of a façade, but reflections can be visible at much greater distances. Vegetation around buildings will bring more birds into the vicinity of the building; the reflection of that vegetation brings more birds into the glass. Taller trees and shrubs correlate with more collisions. It should be kept in mind that vegetation on slopes near a building will reflect in windows above ground level. Studies with bird feeders (Klem *et al.*, 1991) have shown that fatal collisions result when birds fly towards glass from more than a few feet away.

Green Roofs, Gardens and Walls

Recent work shows that well designed green roofs and roof gardens can become functional ecosystems, providing food and nest sites for birds. However, green roofs bring habitat elements attractive to birds to higher levels, often near unmarked glass. Glass treatment around green roofs, green walls and rooftop gardens should be considered with features that prioritze protection for birds. Under the new LEED Bird Collision Deterrent Credit, glass on the first floor adjacent to a green roof is Zone 1, or high risk, and must meet a more stringent standard for bird-safety.

Unmarked glass adjacent to ecoroofs can be hazardous to birds that are attracted to available habitat. Photo by Tom Liptan

Windows Take their Toll on KGW-Audubon Raptor Cam Fledglings

Since 2007, people from around the world have tuned in to watch a pair of Red-tailed Hawks that have nested and raised young on a downtown Portland fire escape. The KGW-Audubon Raptor Cam has provided an intimate view into the lives of these urban hawks. One of the sad realities illuminated by Raptor Cam is the hazard posed by windows to young birds as they begin to explore the world around them. Of the eleven nestlings that have fledged from the Raptor Cam nest between 2007 and 2011, four have suffered serious collisions with windows. Fortunately three were able to be returned to the wild after treatment. Most birds are not so lucky...

Portland's Bridge-nesting Peregrines

The first Peregrine Falcon to fledge off Portland's Fremont Bridge collided with a window on East Burnside within a week of taking her first flight. She spent a month in captivity recovering from internal injuries before being released back to the wild. Window strikes have remained a significant cause of injury for both resident and migratory peregrine populations in Portland.

Solution: Glass

Numerous examples of bird-friendly buildings exist, which were primarily designed to be functional and attractive, and incidentally pair well with bird-friendly objectives. These buildings may have screens, latticework, grilles, or other visual noise either outside the glass or integrated into the glass that helps to reduce collisions.

Identifying glass treatments that eliminate or greatly reduce bird mortality while minimally obscuring the glass itself has been the goal of several researchers, including Martin Rössler, Dan Klem, and Christine Sheppard. Their research, discussed in detail in Appendix I, has focused primarily on the spacing, width, and orientation of lines marked on glass, and has shown that patterns covering as little as 5% of the total glass surface can deter 90% of strikes under experimental conditions. Most birds will not attempt to fly through horizontal spaces less than 2" high, nor through vertical spaces 4" wide or less. This concept has become known as the 2" x 4" Rule.

Research on human vision shows a striking ability to complete partial images in order to compensate for missing visual information. This linking of visual fragments and filling-in by our brains means it is possible to design patterns on windows that alert birds to a barrier while minimally impacting views out.

Designing a new structure to be bird friendly can be imaginative, innovative, sustainable and cost-neutral. Architects around the globe have created fascinating structures that incorporate little or no unmarked glass. Inspiration has been born out of functional needs, such as shading in many climatic zones, and/or aesthetics; being bird-friendly was often secondary or incidental. Retrofitting existing buildings can often be done by targeting areas where strikes are known to occur, rather than entire buildings.

Local Victories

Bird-friendly considerations are just beginning to gain traction in the Portland area. An exterior screening project at Lewis and Clark Law School *(pictured on page 15)* demonstrates a local commitment

View of fritted window pattern (above) at the OHSU Center for Health and Healing demonstrate how frit patterns can be designed to afford views out (Photo at left is a close-up). Frits can synergistically reduce solar heat gain, afford privacy, and provide visual cues to approaching birds. No collisions have been documented at this building in four seasons of monitoring. Photo: Mary Coolidge

Most birds will not attempt to fly through horizontal spaces less than 2" high, nor through vertical spaces 4" wide or less. This concept has become known as the **2" x 4" Rule**.

Solution: Glass

There are many ways to combine the benefits of glass with bird-safe or bird-friendly design by incorporating elements that minimize collisions without obscuring vision.

to reduce collisions at a problematic bank of windows on the south side of the Legal Research Center. Prototype screens will be incrementally installed campus-wide due to the true scope of the hazard. The Port of Vancouver has also recently undertaken to retrofit problem windows at its Administrative Offices, and has researched alternatives, evaluating effectiveness, affordability and aesthetics. Port staff also developed a memorandum on window collisions for tenants to help prevent and address window strikes. The University of Portland recently committed to designing all new buildings to comply with bird-friendly goals and standards.

Facades, netting, screens, grilles, shutters, exterior shades

There are many ways to combine the benefits of glass with bird-friendly design by incorporating elements that minimize collisions without obscuring vision. Some architects have designed decorative facades that wrap entire structures. Recessed windows can functionally reduce the amount of visible glass and thus the threat to birds. Netting, screens, grilles, shutters and exterior shades are commonly used elements that can make glass safe for birds. They can be used in retrofits or be an integral part of an original design, and can significantly reduce bird mortality.

Screens once protected birds in addition to their primary purpose of keeping bugs out. Screens and nets are still among the most cost-effective methods for protecting birds. Netting can often be installed so as to be nearly invisible, but must be installed several inches in front of the window, so impact does not carry birds into the glass.

Decorative grilles are also part of many architectural traditions, as are shutters and exterior shades, which have an additional advantage – they can be closed during high-risk seasons for birds, such as migration and fledging (see Appendix II).

Functional elements such as balconies and balustrades can act like a façade, protecting birds while providing an amenity for residents.

The façade of the New York Times building, by FX Fowle and Renzo Piano, is composed of ceramic rods, spaced to let occupants see out, while minimizing the extent of exposed glass. Photo: Christine Sheppard, ABC

External shades on Renzo Piano's California Academy of Sciences in San Francisco are lowered during migration seasons to eliminate collisions. Photo: Mo Flannery

Upper left: If designed densely enough, window films for branding and street activity can pair marketing with bird-friendliness. Photo: Mary Coolidge

Upper right: An exterior trellis on the new Edith Green Wendell Wyatt Federal building will shade the west aspect of the building, and may prove to be bird-friendly. Framework on the south and east aspects of the building does not meet the 2" x 4" rule, but will likely provide some visual cues to approaching birds. Photo: Mary Coolidge

Lower right: Etching patterns on glass at the Bird House at the National Zoo has worked to greatly reduce collision incidents. Photo: Bob Sallinger

Lower left: Fritted bike-themed design work on Whole Foods windows create interest and branding while helping to interrupt reflections. Fritting would be more effective on the outside of the window. Photo: Mary Coolidge

Solution: Glass

Some approaches that have been described as bird-friendly solutions in recent years need more critical consideration. Awnings, overhangs, tinting, UV patterns, and angled glass are not foolproof solutions, but must be carefully designed in order to be effective at eliminating reflections and reducing strike hazards.

Awnings and Overhangs

Overhangs may reduce collisions. However, they do not eliminate reflections, and only block glass from the view of birds flying above, and thus are of limited effectiveness.

UV Patterned Glass

Birds can see into the ultraviolet (UV) spectrum of light, a range largely invisible to humans *(see page 36)*. UV-reflective and/or absorbing patterns (transparent to humans but visible to birds) are frequently suggested as a solution for many bird collision problems. Progress in the search for bird-friendly UV glass has been slow due to the inherent technical complexities. Ornilux Mikado by Arnold Glass has been rated for use in LEED Pilot Credit 55 and is now available in the United States *(photo page 47)*. The cost for this product has already dropped 20% since early 2011. With the introduction of LEED Pilot Credit 55, development of Bird-friendly Building Guidelines in multiple cities, and increased awareness, demand will drive product development and availability.

Angled Glass

In a study (Klem et al., 2004) comparing bird collisions with vertical panes of glass to those tilted 20 degrees or 40 degrees, the angled glass resulted in fewer mortalities. While angled glass may be useful in special circumstances, the birds in the study were flying parallel to the ground from nearby feeders. However, birds approach glass from many angles. Therefore, angled glass is not considered a reliable strategy. The New York Times printing plant, pictured below, clearly illustrates angled glass reflecting nearby vegetation.

Tinting

Some colors and densities of tinted glass may reduce collisions, but these have not been sufficiently tested to determine the density necessary to achieve deterrence. Collisions have been documented on BirdSafe surveys at various Portland buildings with blue, green, and dark tints.

Overhangs block viewing of glass from some angles, but do not necessarily eliminate all reflections. Photo: Christine Sheppard, ABC

The angle on the New York Times printing plant facade is not sufficient to eliminate deceptive reflections of nearby vegetation. Photo: Christine Sheppard, ABC

Tinted windows at the State Building readily reflect vegetation. More testing on colors and density is needed. Photo: Mary Coolidge

Deeply recessed windows, such as these on Stephen Holl's Simmons Hall at MIT, can block viewing of glass from oblique angles. Photo: Dan Hill

Translucent glass panels on the Kunsthaus Bregenz in Austria, designed by Atelier Peter Zumthor, provide light and air to the building interior without dangerous reflections.
Photo : William Heltz

The glass facade of SUVA Haus in Basel, Switzerland, renovated by Herzog and de Meuron, is screen-printed on the outside with the name of the building owner. Photo: Miguel Marqués Ferrer

Patterns on Glass: Meeting Multiple Objectives

Patterns are often applied to glass to reduce the transmission of light and heat or to provide screening or branding. When designed according to the 2 x 4 rule, *(see page 17)* patterns on glass can also prevent bird strikes. External patterns on glass deter collisions effectively because they interrupt glass reflections. Ceramic dots or 'frits' and other materials can be screened, printed, or otherwise applied to the glass surface. This design element, useful primarily for new construction, is more common in Europe and Asia, but is increasingly available in the United States.

Patterns applied to an internal surface of double-paned windows may not be visible if the amount of light reflected from the frit is insufficient to overcome reflections on the glass' outside surface. Some internal frits may only help break up reflections when viewed from some angles and in certain light conditions. This is particularly true for large windows, but also depends on the density of the frit pattern. The internet company IAC's headquarters building in New York City, designed by Frank Gehry, is composed entirely of fritted glass, most of high density *(page 23)*. No collision mortalities have been reported at this building after two years of monitoring by Project Safe Flight. Current research is testing the relative effectiveness of different frit densities, configurations, and colors.

Opaque and Translucent Glass

Opaque, etched, stained, frosted glass, and glass block are excellent options to reduce or eliminate collisions, and many attractive architectural applications exist. They can be used in both retrofits and new construction.

Frosted glass is created by acid etching or sandblasting transparent glass. Frosted areas are translucent, but different finishes are available with different levels of light transmission. An entire surface can be frosted, or frosted patterns can be applied. Patterns should conform to the 2 x 4 rule described on page 17. For retrofits, glass can also be frosted by sandblasting on site.

The Studio Gang's Aqua Tower in Chicago was designed with birds in mind. Strategies include fritted glass and balcony balustrades. Photo: Tim Bloomquist

Galeo, part of a complex designed by Atelier Christian de Portzamparc in Issy les Moulineaux, France, has an external skin of printed glass scales which help to reduce reflections. Photo: Sipane

Renzo Piano's Hermes Building in Tokyo has a façade of glass block. Photo: Mariano Colantoni

The dramatic City Hall of Alphen aan den Rijn in the Netherlands, designed by Erick van Egeraat Associated Architects, features a façade of etched glass. Photo: Dik Naagtegal

External frit, as seen here on the Lile Museum of Fine Arts, by Ibos and Vitart, is more effective at breaking up reflections than patterns on the inside of the glass. Photo: G. Fessy

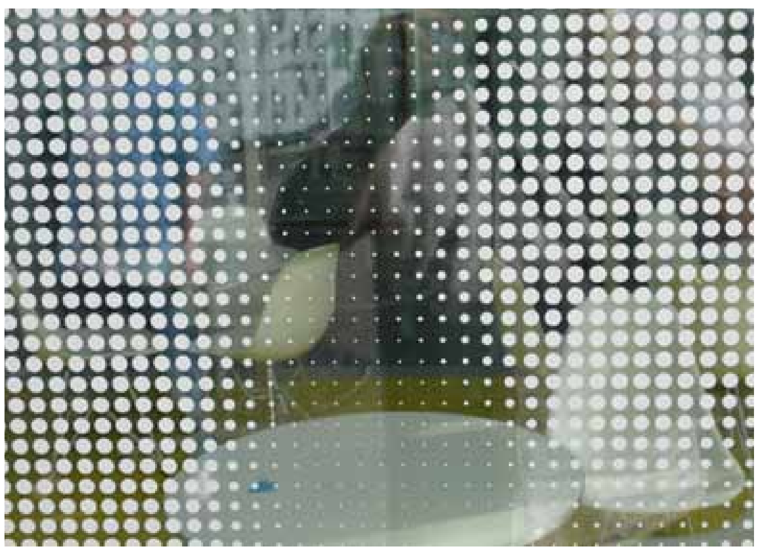
While some internal fritted glass patterns can be overcome by reflections, Frank Gehry's IAC Headquarters in Manhattan is so dense that the glass appears opaque. Photo: Christine Sheppard

Solution: Glass

Patterns are often applied to glass to reduce the transmission of heat or to provide screening or branding. When designed according to the 2" x 4" rule, patterns on glass can also prevent bird strikes.

Dense stripes of internal frit on University Hospital's Twinsburg Health Center in Cleveland, by Westlake, Reed, Leskosky will overcome virtually all reflections. Photo: Christine Sheppard, ABC

Privacy film on Mirabella windows preserves light entry and views out while marking the window for birds. Such film is more effective if applied to the exterior. Photo: Mary Coolidge



A detail of a pattern printed on glass at the Cottbus Media Centre in Germany. Photo: Evan Chakroff

Visual markers on the balcony glass at the Eliot Tower provide some privacy and decrease strike hazards. Photo: Mary Coolidge

The window at the Philadephia Zoo's Bear Country exhibit was the site of frequent bird collisions until this window film was applied. Collisions have been eliminated without obscuring views out. Photo: Philadephia Zoo.

Fritted glass photo panels on the Gibbs Street Pedestrian Bridge elevator in South Waterfront are part of a public art project made possible by the Regional Arts & Culture Council and the Portland Bureau of Transportation through the City's Percent for Art Program. Artist Anna Valentina Murch made the photographs of water, which were printed onto the glass panels by Peters Studios, thus marking the windows for birds. Photo by Jeanne Galick.

Solution: Glass

Photo : Dariusz Zdziebkowski

The American Bird Conservancy, with support from the Rusinow Family Foundation, has produced ABC BirdTape to make home windows safer for birds. This easy-to-apply tape lets birds see glass while letting you see out, is easily applied, and lasts up to four years. For more information, visit www.ABCBirdTape.org

Window Films

Currently, most patterned window films are intended for interior use as design elements or for privacy, but this is beginning to change. 3M™ Scotchcal™ Perforated Window Graphic Film, also known as CollidEscape, is a well-known external solution. It covers the entire surface of a window, appears opaque from the outside, and permits a view out from inside. Interior films, when applied correctly, have held up well in external applications, but this solution has not yet been tested over decades. A film with horizontal stripes has been effective at the Philadelphia Zoo's Bear Country exhibit (see photo on right) and the response of people has been positive.

Internal Shades, Blinds, and Curtains

Light colored shades do not effectively reduce reflections and are not visible from acute angles. Blinds have the same limitations, but when visible and partly open, can help to break up reflections.

Temporary Solutions

In some circumstances, especially for homes and small buildings, quick, low-cost, DIY solutions such as applications of tape or paint can be very effective. Such measures can be applied to problem windows and are most effective following the 2 x 4" rule. For more information, see Portland Audubon's Tips for Reducing Strikes at Home and a Birds and Windows Brochure at www.audubonportland.org/issues/metro/bsafe/tips.

Decals

Decals are probably the most popularized solution to collisions, but their effectiveness is dependant on density of application. Birds do not recognize raptor decals as predators, but simply as obstacles to try to fly around.

Decals are most effective if applied following the 2" x 4" rule, but even a few may reduce collisions.

Tape decals (Window Alert shown here) placed following the 2 x 4 rule can be effective at deterring collisions. Photo: Christine Sheppard, ABC

Reflections on home windows are a significant source of bird mortality. Partially opened vertical blinds may break up reflections enough to reduce the hazard to birds. Photo: Christine Sheppard, ABC

Residential and Small Building Collisions and Treatments

Though Bird-friendly Building Guidelines developed to date primarily address strike hazards, data, and solutions at the larger commercial scale, strikes can occur as readily at small-scale commercial and residential developments where unmarked glass is used. Research at large commercial buildings is far more common simply because of scope, access, and logistical limitations. High-rises in commercial districts tend to be geographically clustered and accessible to volunteers via sidewalk rights-of-way, thus lending themselves well to targeted observation, and resulting in a predominance of data from commercial districts.

Some research has endeavored to focus on residential construction. Dunn (1993) estimated that between 0.65 and 7.7 bird deaths per residential home occur every year in North America (described in Appendix 1: The Science of Bird Collisions). Therefore, though it may be tempting to implicate high-rise buildings in the majority of collisions, homes do contribute significantly to sources of collision risk and their distribution across the landscape in urban, exurban, and rural areas makes their cumulative impact undeniable. San Francisco's new Bird Safe Building Standards require residential buildings with "substantial glass façade" (those with a greater than 50% glass façade area) to incorporate glazing treatments such that 95% of all unbroken glass expanses 24 square feet or larger are treated.

Single and two-story homes occur largely within the highest risk zone of collisions, that is: within 40 feet of the ground. Homes often have vegetation near to and reflected in windows. Vegetation, bird-feeders, and birdbaths attract birds into yards, where they face deceptive reflections. Even small windows pose a hazard, because birds are accustomed to flying into small gaps in vegetation. Though the scale and budgets of residential and small commercial development may indeed call for unique, cost-effective approaches, the same principles of hazard-reduction apply. Architects and designers can mitigate hazardous features (such windows meeting

Silhouettes placed every 12 inches on the exterior of this residential window are spaced too far apart to reliably eliminate all strikes, but will likely reduce strike incidence.

Designwork on TriMet bus shelters has been shown to help to reduce vandalism and also marks the freestanding glass for birds. Photo: Mary Coolidge

Solution: Glass

When designing homes and small buildings with glass:

- Treat all glass on home or building, especially glass which meets at corners or allows view through another pane of glass to the outside
- Treat all freestanding glass around courtyards, patios, and balconies

Window design/ treatment options:

- Exterior screens
- Exterior framework, grilles, trellises or louvers; shades or shutters
- Awnings, overhangs, and deeply-recessed windows
- Glass: Exterior frits, sandblasting, translucence, UV patterns, glass block or screenprinting
- Consider exterior branding on glass for retail locations
- Exterior window films

at corners, unmarked glass expanses, glass balcony walls, or garden walls) by marking windows (with divided light panes, stained glass, UV patterns or frit patterns) or using exterior screening (screens, shades, or trellises) to reduce predictable collision threats. There is no single prescriptive one-size-fits all approach to designing bird-friendly buildings; solutions will be unique and innovative responses to a variety of variables and objectives. The exploration and development of more residentially-geared solutions will be addressed in updates of this document as they become available.

As reported in Appendix 1: the Science of Bird Collisions, Audubon's Wildlife Care Center (WCC) brought in 590 window strikes of 86 species in 2009, 2010, and 2011 combined, the majority from residential properties. Catalogued phone call reports tallied nearly 100 public reports per year during this same period, primarily from residential buildings in the Portland area, underscoring the vital importance of addressing both residential hazards and commercial-scale hazards.

Top left: Diamond leaded glass present on old English style houses in Portland adheres to the 2"x4" rule and effectively marks windows for birds.

Top right: Stained glass like this Frank Lloyd Wright reproduction by local designer Lisa Peterson can add aesthetic interest while effectively marking a window for birds.

Middle left: Close up of fritted glass residential entry provides privacy, reduces solar heat gain on this southern exposure, and still affords views in and out.

Middle right: Povey Brothers Glass Company produced extraordinary art glass in Portland at the turn of the century, and their windows are both beautiful and bird-friendly!

Bottom left: Ribbed glass used in a residential window retrofit provides privacy and effectively eliminates reflections.

Bottom Right: Window screens are still one of the most cost effective ways to reduce strike hazards while keeping insects out of building and home interiors.

Small-scale Retrofits to Prevent Window Strikes:

- Position bird feeders within 3 feet or more than 30 feet away from windows. At very close distance, birds have less momentum if they strike the window.
- Apply decals to the outside of the window, more densely than packaging suggests. Some decals will help reduce collision risk, but the best practice is still to adhere to the 2" x 4" rule. Available at Audubon's Nature Store, Backyard Bird Shops, and online.
- Apply tape horizontally, spaced ~2 inches apart to outside of window (www.abcbirdtape.org).
- Apply string, cord, mylar tape, raptor sillhouettes or other moving deterrents to the outside of the window (www.birdsavers.com/).
- Affix screen or mesh netting several inches in front of a window to cushion impact (www.birdbgone.com, www.birdscreen.com).
- Apply window film to the outside of a window (www.lfdcollidescape.com, www.thesunshieldpros.us).
- Participate in Lights Out Portland! Turn outside lights off and close drapes from August 25 through November 15 and March 15 through June 7 (migration season) to minimize the luring of migrants into cities.

There are many quick, easy, and cost-effective ways to deter collisions on a short term basis. Here, tape stripes, stenciled, and free hand patterns in tempera paint on home windows. Photo: Christine Sheppard, ABC

Waterproof, washable markers can be used in imaginative, fun, and cost-effective ways to deter collisions. This peacock window design offered a family-friendly activity and produced a beautiful image while marking the window for birds! Photo: Mary Coolidge

The view out of a window with horizontal tape spaced every 2 inches looks much like a view through miniblinds. Photos: Mary Coolidge

When birds encounter beams of light, especially in inclement weather, they tend to circle in the illuminated zone, appearing disoriented and unwilling or unable to leave. In this photo, each white speck is a bird trapped in the beams of light forming the *9/11 Tribute in Light* in New York City. Volunteers watch during the night and the lights are turned off briefly if large numbers of entrapped birds are observed.

Photo: Jason Napolitano

Problem: Lighting

Artificial light is increasingly recognized as a hazard for humans as well as wildlife. Rich and Longcore (2006) have gathered comprehensive reviews of the impact of "ecological light pollution" on the feeding, migrating and reproductive cycles of vertebrates, insects, and even plants.

Beacon Effect and Urban Glow

Light at night, especially during bad weather, creates conditions that are particularly hazardous for night-migrating birds which rely on celestial cues to navigate. Typically flying at altitudes over 500 feet, migrants often descend to lower altitudes during inclement weather, where they may encounter artificial light from buildings. Water vapor in fog or mist refracts light, forming an illuminated halo around light sources and can lead to catastrophic mortality events (see Appendix II).

Fatal Light Attraction

There is clear evidence that birds are attracted to and entrapped by light (Rich and Longcore, 2006; Poot et al., 2008; Gauthreaux and Belser, 2006). When birds encounter beams of light, especially in inclement weather, they tend to circle in the illuminated zone. This has been documented recently at the *9/11 Memorial in Lights*, where lights must be turned off intermittently when large numbers of birds become caught in the beams.

Significant mortality of migrating birds has been reported at oil platforms in the North Sea and the Gulf of Mexico. Van de Laar (2007) tested the impact on birds of lighting on an off-shore platform. When lights were switched on, birds were immediately attracted to the platform in significant numbers. Birds dispersed when lights were switched off. Once trapped, birds may collide with structures or fall to the ground from exhaustion, where they are at risk from predators.

While mass mortalities at very tall illuminated structures (such as skyscrapers) during fog or other inclement weather have received the most attention, mortality has also been associated with ground-level lighting during clear weather. Once birds land in lit areas overnight, they are at increased risk from colliding with nearby structures as they begin to forage for food in the vicinity the following day.

In addition to killing birds, overly-lit buildings waste electricity, and increase greenhouse gas emissions and air pollution levels. Poorly- designed or improperly-installed outdoor fixtures add over one billion dollars to electrical costs in the United States every year, according to the International Dark Sky Association. Recent studies estimate that over two thirds of the world's population can no longer see the Milky Way, just one of the nighttime wonders that connect people with nature. Together, the ecological, financial, and cultural impacts of excessive lighting are compelling reasons to reduce and refine light usage.

Unshielded lights in Elizabeth Caruthers Park in South Waterfront would benefit from full cutoff shielding to reduce contribution to ecological light pollution. Photo: Mary Coolidge

Light pollution has been shown to impact the Circadian rhythm of birds, fish, wildlife, and plants as well as humans.

Problem: Lighting

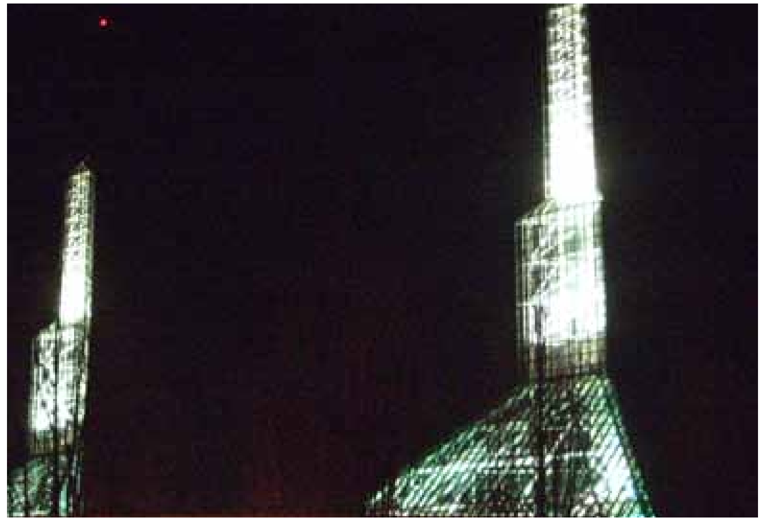
Overly lit buildings waste electricity, increase greenhouse gas emissions and air and light pollution levels as well as pose a threat to birds.

Floodlight at the base of the OHSU tram tower. Photo: Mary Coolidge

Unshielded, upward-directed floodlights at the base of the OHSU Tram Tower contribute directly to Portland's skyglow; existing fixtures which light the tram from above could instead be utilized as the primary lighting system. Photo: Mary Coolidge

Light spill is apparent from this stairwell in the Pearl District, and could be minimized by exterior shielding. Photo: Mary Coolidge

The height of the Wells Fargo Tower, coupled with its corner floodlights, make this building a potential collision hazard for migrants. Dimming or extinguishing exterior and rooftop lighting during migration season can help reduce collision hazards. Photo: Mary Coolidge



The iconic spires of the Oregon Convention Center feature unshielded light fixtures, rendering the spires visible for miles; though controversial, dimming or extinguishing these lights during migration season could reduce a potential collision hazard. Photo: Mary Coolidge

Though newer acorn-style light fixtures in South Waterfront have incorporated some shielding design, full cut-off improvements to the design of these fixtures would reduce contribution to light pollution. Photo: Mary Coolidge

Solution: Lighting Design

Poorly-designed or improperly-installed outdoor fixtures add over one billion dollars to electrical costs in the United States every year, according to the International Dark Sky Association.

Reducing exterior building and site lighting can:

- reduce mortality of night migrants
- reduce building energy costs
- decrease air pollution and
- decrease light pollution.

Efficient design of lighting systems and operational strategies to reduce light "trespass" from buildings are both important strategies. In addition, an increasing body of evidence shows that red lights and white light (which contains red wavelengths) particularly attract and confuse birds, while green and blue light have less impact.

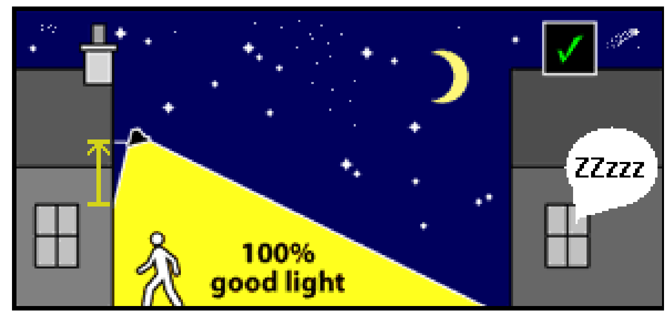
Light pollution is largely a result of inefficient exterior lighting, and improving lighting design usually produces savings greater than the cost of changes. For example, globe fixtures permit little control of light, which shines in all directions, resulting in a loss of as much as 50% of energy, as well as poor illumination. Cut-off shields can reduce lighting loss and permit use of lower wattage bulbs, resulting in lower costs.

Most "vanity lighting" is unnecessary. At minimum, building features should be illuminated using down-lighting rather than up-lighting. Spotlights and searchlights should not be used during bird migration.

Using automatic controls (timers, photo-sensors, and infrared and motion detectors) is more effective than reliance on people to turn off lights. These devices generally pay for themselves in energy savings in less than a year. The Center for Climate and Energy Solutions (www.c2es.org) Lighting Efficiency page cites that "some estimates suggest that occupancy sensors can reduce energy use by 45 percent, while other estimates are as high as 90 percent." Energy Trust of Oregon provides incentives to help offset up-front costs.

Workspace lighting should be installed where needed, rather than lighting large areas. In areas where indoor lights will be on at night, minimize perimeter lighting and/or draw shades after dark.

BADLY AIMED 500W HALOGEN FLOODLIGHT



WELL AIMED 100W FLOODLIGHT

Switching to daytime cleaning is a simple way to reduce lighting while also reducing costs.

Safety Concerns

Safety is a primary concern when designing exterior building lighting systems. Unshielded lighting that causes glare is problematic because it saturates rod cells in the eye (responsible for night-vision) and causes pupils to dilate, which reduces the amount of light that enters the eye. The result is temporary night-blindness, which may actually compromise a person's safety. Constant lighting can also allow intruders and prowlers to remain concealed in predictable shadows, which underscores the importance of well-shielded motion sensor lighting instead of constant-burning lights that produce a dazzling glare.

The Federal Bureau of Investigation's 2009 crime statistics actually indicate that over half of residential burglary crimes are known to have occurred during daylight hours, and less than 30% are known nighttime burglaries. In 2000, the Chicago Alley Lighting Project worked to increase both the number of alley streetlights and the wattage of bulbs (from 90 watt to 250 watt), with the goal of decreasing crime and increasing Chicagoans' sense of safety. Data analysis of pre- and post-installation of these alley lights revealed an increase of 21% in reported offenses occurring at night. Read more here: http://www.icjia.state.il.us/public/pdf/ResearchReports/Chicago%20Alley%20Lighting%20Project.pdf. Communities that have implemented programs to reduce light pollution have not found an increase in crime.

The International Dark Sky Association advocates for putting light where it is needed, during the time period it will be used, and at the levels that enhance visibility. Outdoor lighting directed usefully at the ground reduces dazzling glare, allows for use of lower wattage bulbs, and saves money, electricity, and birds.

Portland's light-pollution is visible in this satellite image of North America. Photo courtesy of NASA.

Shielded lights, such as those shown above, cut down on light pollution and are much safer for birds. Photo: Susan Harder

Cut-off shields can reduce lighting loss and permit use of lower wattage bulbs, resulting in lower costs. Shielded light fixtures are widely available in many different styles. Top photo: Susan Harder; bottom photo: Dariusz Zdziebkowski, ABC

Lights Out Programs

Birds evolved complex systems for navigation long before humans developed artificial light. Recent science has just begun to clarify how artificial light poses a threat to nocturnal migrants. Despite the complexity of this issue, there is one simple way to reduce mortality: turn lights off.

Across the United States and Canada, "Lights Out" programs encourage building owners and occupants to turn out lights visible from outside, at least during spring and fall migration. The first of these, Lights Out Chicago, began in 1995, followed by Toronto in 1997. There are over twenty programs as of mid-2011.

The programs themselves are diverse. They may be directed by environmental groups, by government departments, or by partnerships of organizations. Participation in some, such as Houston's, is voluntary. Minnesota mandates turning off lights

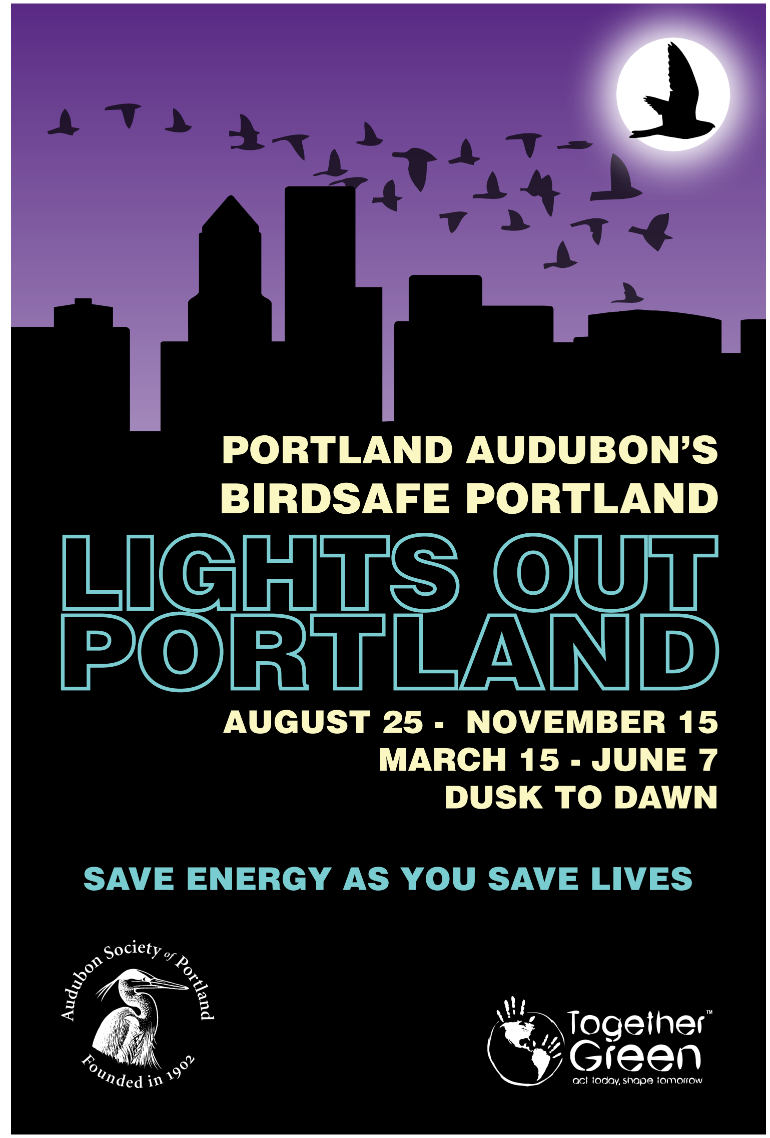
Lights Out map legend

- **Red:** state ordinance
- **Yellow:** cities in state-wide programs
- **Turquoise:** program in development
- **Blue:** local programs

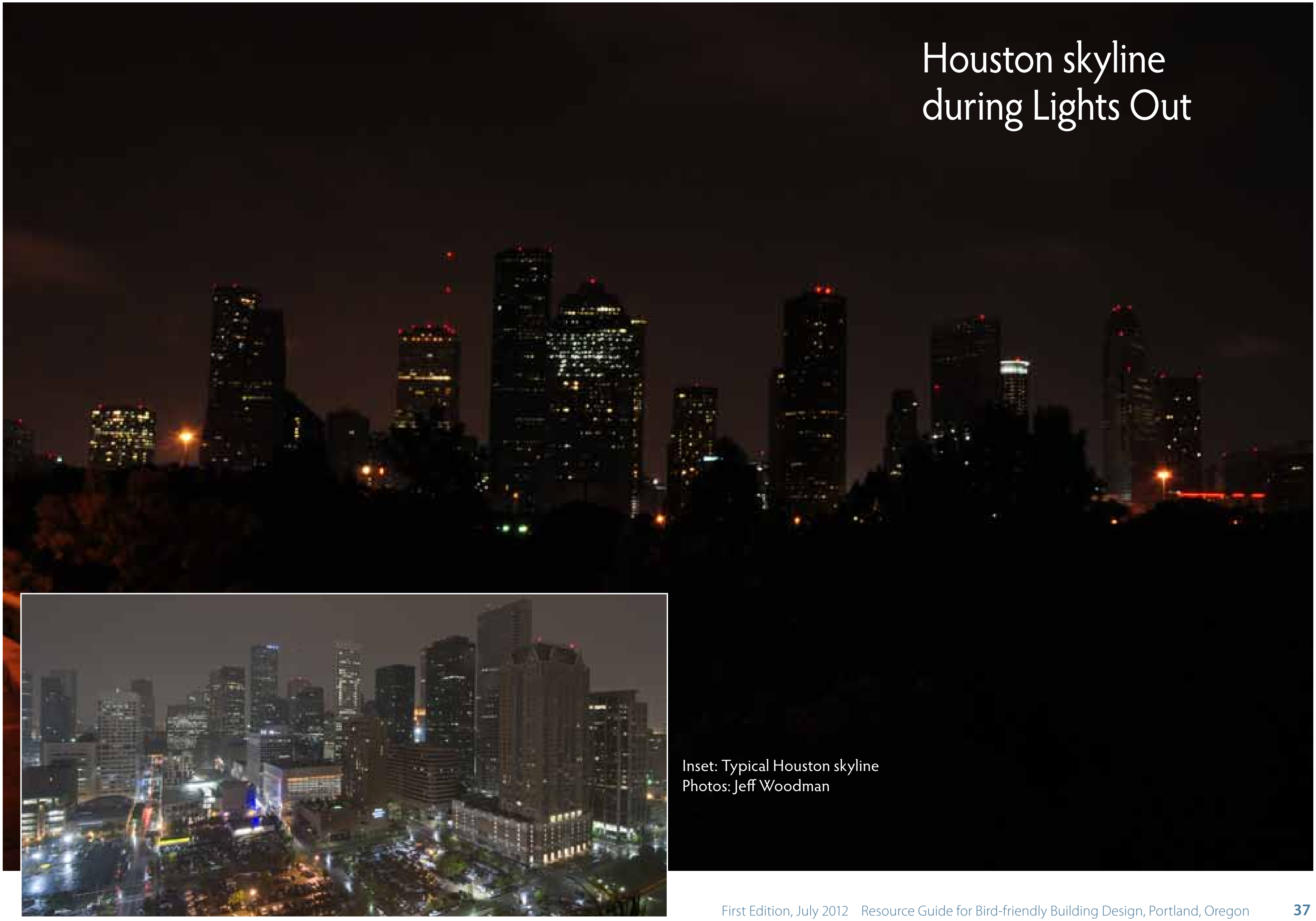
in state-owned and -leased buildings, while Michigan's governor proclaims Lights Out dates annually. Many jurisdictions have a monitoring component or work with local rehabilitation centers. Monitoring programs provide important information in addition to quantifying collision levels and documenting solutions. Toronto, for example, determined that short buildings emitting more light can be more dangerous to birds than tall building emitting less light.

Lights Out Portland

Coordinated by Audubon Society of Portland, Lights Out Portland asks buildings to turn off all unnecessary lighting from dusk to dawn between August 25th and November 15th (fall migration) and between March 15th and June 7th (spring migration). Lights Out provides for 3 levels of participation (silver, gold, platinum), affording some flexibility in the degree of participation. Visit www.audubonportland.org/issues/metro/birdsafe/lo for more information on enrollment, Energy Trust of Oregon incentives, and participating buildings.



Enrollment in Lights Out Portland is voluntary, seasonal and is a way to achieve multiple financial, environmental, and social benefits.



Houston skyline during Lights Out

Inset: Typical Houston skyline
Photos: Jeff Woodman

Hundreds of species of birds are killed by collisions. These birds were collected by monitors with FLAP in Toronto, Canada. Photo: Kenneth Herdy

Appendix 1: The Science of Bird Collisions

Magnitude of Collision Deaths

The number of birds killed by collisions with glass every year is astronomical. Klem (1990) estimated conservatively that each building in the United States kills one to ten birds per year. Using 1986 United States Census data, he combined numbers of homes, schools, and commercial buildings for a maximum total of 97,563,626 buildings. Dunn (1993) surveyed 5,500 homes with birdfeeders and recorded window collisions. She estimated 0.65 – 7.7 bird deaths per home per year for North America, supporting Klem's calculation. Therefore, given the number of homes across the landscape, they are considered a significant source of mortality. Attention cannot be solely focused on large buildings and highrises.

The number of buildings in the United States has increased significantly since 1986. Commercial buildings generally kill more than ten birds per year, as would be expected since they have large expanses of glass (Hager *et al.*, 2008; O'Connell, 2001). Thus, one billion annual fatalities is likely to be closer to reality, and possibly even too low.

Klem *et al.*, (2009a) used data from New York City Audubon's monitoring of seventy-three Manhattan building facades to estimate 0.5 collision deaths per acre per year in urban environments, for a total of about 34 million migratory birds annually colliding with city buildings in the United States.

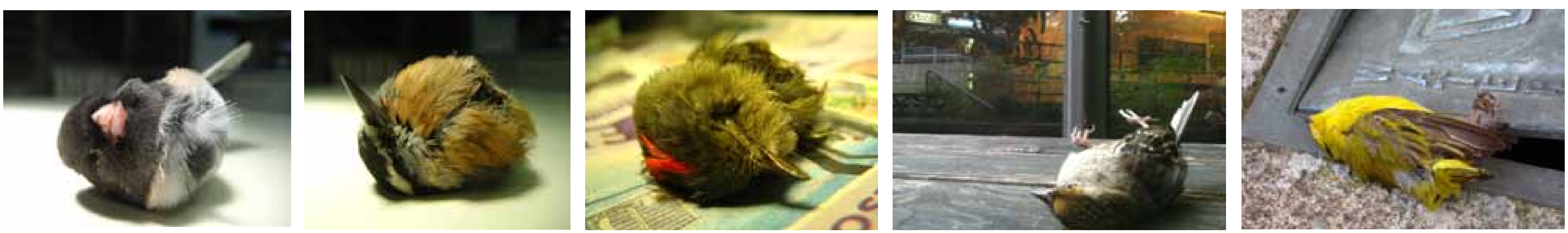
Patterns of Mortality

It is difficult to get a complete and accurate picture of avian mortality from collisions with glass. Collision deaths can occur at any time. Even intensive monitoring programs only cover a small sampling of buildings, are restricted to public rights of way, and often only occur during migration seasons.

Many city buildings have stepped roof setbacks that are inaccessible to monitoring teams. Recognizing these limitations to detection, some papers have focused on reports from homeowners on backyard birds (Klem, 1989; Dunn, 1993) or on mortality of migrants in an urban environment (Gelb and Delacretaz, 2009; Klem *et al.*, 2009a, Newton, 1999). Others have analyzed collision victims from single, catastrophic incidents (Sealy, 1985) or that have become part of museum collections (Snyder, 1946; Blem et al., 1998; Codoner, 1995).

There is general support for the fact that birds killed in collisions are not distinguished by age, sex, size, or health (for example: Blem and Willis, 1998; Codoner, 1995; Fink and French, 1971; Hager et al., 2008; Klem, 1989). Interestingly, species well adapted to and common in urban areas, such as the American Crow, House Sparrow and European Starling, are not prominent on lists of fatalities, and there is evidence that resident birds are less likely to die from collisions than migratory birds.

Given the sheer number of residential homes across the landscape, and their tendency to attract birds and reflect vegetation, these buildings are considered a significant source of window collision mortality.



A few collision victims documented by Portland Audubon's BirdSafe survey. Photos: Mary Coolidge

Appendix 1: The Science of Bird Collisions

BirdSafe Portland surveys found glass collisions were fatal for at least 36 native bird species (below):

- Anna's Hummingbird
- Black-capped Chickadee
- Bewick's Wren
- Black-throated Gray Warbler
- Cedar Waxwing
- Cooper's Hawk
- Common Yellowthroat
- Dark-eyed Junco
- Fox Sparrow
- Golden-crowned Kinglet
- Golden-crowned Sparrow
- Hammond's Flycatcher
- Hairy Woodpecker
- Hermit Thrush
- Lesser Goldfinch
- Lincoln's Sparrow
- MacGillivray's Warbler
- Mourning Dove
- Orange-crowned Warbler
- Pileated Woodpecker
- Pacific-slope Flycatcher
- Red-breasted Nuthatch
- Red-breasted Sapsucker
- Rufous Hummingbird
- Savannah Sparrow
- Song Sparrow
- Spotted Towhee
- Swainson's Thrush
- Townsend's Warbler
- Varied Thrush
- Warbling Vireo
- Western Tanager
- White-crowned Sparrow
- Willow Flycatcher
- Wilson's Warbler
- Yellow Warbler

Collision mortality appears to be a density-independent phenomenon. Hager *et al.* (2008) compared the number of species and individual birds killed at buildings at Augustana College in Illinois with the density and diversity of bird species in the surrounding area. The authors concluded that total window area, habitat immediately adjacent to windows, and behavioral differences among species were the best predictors of mortality patterns, rather than simply the size and composition of the local bird population.

From a Manhattan study of buildings, Klem *et al* (2009a) concluded that the expanse of glass on a building facade is the factor most predictive of mortality rates, calculating that every increase of 10% in the expanse of glass correlates to a 19% increase in bird mortality in spring, 32% in fall.

Collins and Horn (2008) studied collisions at Millikin University in Illinois, concluding that total glass area and the presence/absence of large expanses of glass predicted mortality level. Hager et al (2008) came to the same conclusion. Gelb and Delacretaz's (2009) work in New York City indicated that collisions are more likely to occur on windows that reflect vegetation.

Dr. Daniel Klem maintains species lists from collision events in countries around the world. This information can be found at: www.muhlenberg.edu/main/academics/biology/faculty/klem/aco/Country%20list.htm#World

He notes 859 species globally, with 258 from the United States. The intensity of monitoring and reporting programs varies widely from country to country, however. Hager (2009) noted that window strike mortality was reported for 45% of raptor species found frequently in urban areas of the United States, and represented the leading source of mortality for Sharp-shinned Hawks, Cooper's Hawks, Merlins, and Peregrine Falcons. See Portland's Urban Raptors and Collisions on page 16.

BirdSafe Portland Surveys

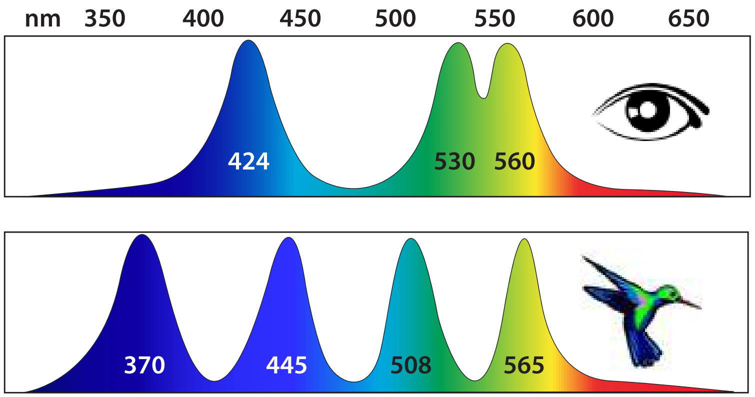
Window collision surveys are being conducted in numerous eastern and mid-western cities, but have been initiated in few west coast cities. San Francisco adopted Standards for Bird-Safe Buildings (July 2011). They have yet to conduct collision surveys, though they do identify monitoring as a goal in their standards, and coast-wide surveys at multiple cities along the Pacific Flyway would provide valuable information about which of our migrants are most at risk of colliding with windows.

In an effort to estimate the magnitude of collisions in the Portland area, Audubon Society of Portland has coordinated BirdSafe Portland surveys seasonally since fall 2009 (pilot season). Surveys have continued through fall 2011. During spring and fall migration, trained volunteers surveyed twenty-one buildings at dawn looking for evidence of strikes. Following low detection rates during the pilot season, building owners and managers, maintenance people, and tenants in each target building were solicited for collision reports. Detection rates increased as a result of increased reporting from areas outside of the right-of-way (courtyards, balconies, terraces, ecoroofs, etc). BirdSafe surveys catalogued up to 62 collisions per season on survey, and a cumulative total of 35 native species were detected. A list of these species can be found in far-left column.

While residential surveys using volunteers are virtually impossible due to private property limitations and staggering scope, much residential data can be gleaned from the Audubon Wildlife Care Center (WCC). As reported in the Residential and Small Building Collisions and Treatments section on page 26, Audubon's WCC brought in 590 window strikes of 86 native species in 2009, 2010, and 2011 combined, primarily from residential properties.

Additionally, Audubon catalogues about 100 calls per year reporting window strikes, most of which come from small buildings and residences.

Comparison of Human and Avian Vision



While human color vision relies on three types of sensors, birds have four and many birds can see into the ultraviolet spectrum. Illustration based on artwork by Sheri Williamson

Avian Vision and Collisions

Taking a "bird's-eye view" is much more complicated than it sounds. While human color vision relies on three types of sensors, birds have four. An array of color filters also allows them to see many more colors than people see (Varela *et al.*, 1993) (see chart below). Many birds, including most passerines (Ödeen and Håstad, 2003) also see into the ultraviolet spectrum. Ultraviolet can be a component of any color (Cuthill *et al.*, 2000). Where humans see red, yellow, or red + yellow, birds may see red + yellow, but also red + ultraviolet, yellow + ultraviolet, and red + yellow + ultraviolet. They can also see polarized light (Muheim *et al.*, 2006, 2011), and they process images faster than humans; where we see continuous motion in a movie, birds see flickering images (D'Eath, 1998; Greenwood *et al.*, 2004; Evans *et al.*, 2006). Birds also have two receptors that permit them to sense the earth's magnetic field, which they use for navigation (Wiltschko *et al.*, 2006).

Avian Orientation and the Earth's Magnetic Field

Thirty years ago, it was discovered that birds orient themselves relative to the Earth's magnetic field and locate themselves relative to their destination. They appear to use cues from the sun, polarized light, stars, the Earth's magnetic field, visual landmarks, and even odors to find their way. Exactly how this works is still being investigated, but there have been interesting discoveries that also shed light on light-related hazards to migrating birds.

Lines of magnetism between the north and south poles have gradients in three dimensions. Cells in three compartments of birds' upper beaks, or maxillae, contain the iron compounds maghemite and magnetite which probably allow birds to detect their "map" (Davila, 2003; Fleissner *et al.*, 2003, 2007). Other magnetism-detecting structures are found in the retina of the eye, and depend on light for activity. Light excites receptor molecules, setting off a chain reaction. The chain in cells that respond to blue wavelengths includes molecules that react to magnetism, producing magnetic directional cues as well as color signals. For a comprehensive review of the mechanisms involved in avian orientation, see Wiltschko and Wiltschko, 2009.

Birds and Light Pollution

The earliest reports of mass avian mortality caused by lights were from lighthouses, a source of mortality which essentially disappeared when steady-burning lights were replaced by rotating beams (Jones and Francis, 2003). Flashing beams apparently allow birds to continue to navigate. While mass collision events at tall buildings and towers have received most attention (Weir, 1976; Avery *et al.*, 1977; Avery *et al.*, 1978; Crawford, 1981a, 1981b; Newton, 2007), light from many sources, from urban sprawl to parking lots, can affect bird behavior and cause bird mortality (Gochfeld, 1973). Gochfeld (in Rich and Longcore, 2006) noted that bird hunters throughout the world have used lights to disorient and net birds on cloudy nights. In a review of the effects of artificial light on

House Finch Photo: Mike Houck

Anna's Hummingbird
Photo:R. Michael Liskay

Window strikes represent the leading source of mortality for urban Sharp-shinned Hawks (above), Cooper's Hawks, Merlins, and Peregrine Falcons. Photo: Jim Cruce

migrating birds, Gauthreaux and Belser (2006) report the use of car headlights to attract birds at night on safari.

Evans-Ogden (2002) showed that light emission levels of sixteen buildings ranging in height from eight to 72 floors correlated directly with bird mortality, and that the amount of light emitted by a structure was a better predictor of mortality level than building height, although height was a factor. Wiltschko *et al* (2007) showed that above intensity thresholds that decrease from green to UV, birds showed disorientation. Disorientation occurs at light levels that are relatively low, equivalent to less than half an hour before sunrise under clear sky. It is thus likely that light pollution causes continual, widespread, low-level mortality that collectively is a significant problem.

The mechanisms involved in both attraction to and disorientation by light are poorly understood and may differ for different light sources (see Gauthreaux and Belser (2006) and Herbert (1970) for reviews.) Haupt and Schillemeit described the paths of 213 birds flying through beams uplighting from several different outdoor

Steady-burning red and white lights are most dangerous to birds. Photo: Mike Parr, ABC

lighting schemes. Only 7.5% showed no change in behavior. Migrating birds are severely impacted, while resident species may show little or no effect. It is not known whether this is a result of physiological differences or simply familiarity with local habitat.

Light Color and Avian Orientation

In the 1940s, ceilometers came into use to measure the height of cloud cover and were thought to be associated with significant bird kills. Filtering out long (red) wavelengths and using the blue/ultraviolet range greatly reduced mortality. Later, replacement of fixed beam ceilometers with rotating beams essentially eliminated impact on migrating birds (Laskey, 1960).

A series of laboratory studies in the 1990s demonstrated that birds required light in order to sense the Earth's magnetic field. Birds could orient correctly under monochromatic blue or green light, but longer wavelengths (yellow and red) caused disorientation (Rappli et al., 2000; Wiltschko *et al.*, 1993, 2003, 2007). It was demonstrated that the magnetic receptor cells on the eye's retina are inside the type of cone cell responsible for processing blue and green light, but disorientation seems to involve a lack of directional information.

Poot *et al.* (2008) demonstrated that migrating birds exposed to different colored lights in the field respond the same way they do in the laboratory. Birds were strongly attracted to white and red light, and appeared disoriented by them, especially under overcast skies. Green light was less attractive and minimally disorienting; blue light attracted few birds and did not disorient those that it did attract (but see Evans *et al.*, 2007). Birds were not attracted to infrared light. This work was the basis for development of the Phillips "Clear Sky" bulb, which produces white light with minimal red wavelengths (Marquenie et al., 2008) and is now in use in Europe on oil rigs and at some electrical plants. According to Van de Laar et al. (2007), tests with this bulb on an oil platform during the 2007 fall migration produced a 50 – 90% reduction in birds

Fog increases the danger of light both by causing birds to fly lower and by refracting light so it is visible over a larger area. Photo: Christine Sheppard, ABC

circling and landing. Recently, Gehring et al. (2009) demonstrated that mortality at communication towers was greatly reduced if strobe lighting replaced steady-burning white, or especially, red lights. Replacement of steady-burning warning lights with intermittent lights is an excellent option for protecting birds, and possibly manipulating light color.

Weather Impact on Collisions

Weather has a significant and complex relationship with avian migration (Richardson, 1978), and large-scale, mass mortality of migratory birds at tall, lighted structures (including communication towers) has often correlated with fog or rain (Avery et al., 1977; Crawford, 1981b; Newton, 2007). The conjunction of bad weather and lighted structures during migration is a serious threat, presumably because visual cues for orientation are not available. However, not all collision events take place in bad weather. For example, in a report of mortality at a communications tower in North Dakota (Avery *et al.*, 1977), the weather was overcast, usually with drizzle, on four of the five nights with the largest mortality. However, on the fifth occasion, the weather was clear.

Landscaping and Vegetation

Gelb and Delacretaz (2006, 2009) evaluated data from collision mortality at Manhattan buildings. They found that sites where glass reflected extensive vegetation were associated with more collisions than glass reflecting little or no vegetation. Of the ten buildings

Lower floor windows are thought to be more dangerous to birds because they are more likely to reflect vegetation. Photo: Christine Sheppard, ABC

Birds are strongly attracted to white and red light, and appeared disoriented by them, especially under overcast skies. Replacement of steady-burning warning lights with intermittent lights is a viable option for protecting birds, and possibly manipulating light color.

Appendix 1: The Science of Bird Collisions

This security grille creates a pattern that will deter birds from flying to reflections. Photo: Christine Sheppard, ABC

responsible for the most collisions, four were "low-rise." Klem (2009) measured variables in the space immediately associated with building facades in Manhattan as risk factors for collisions.

Both increased height of trees and increased height of vegetation increased the risk of collisions in fall. Ten percent increases in tree height and the height of vegetation corresponded to 30% and 13% increases in collisions in fall. In spring, only tree height had a significant influence, with a 10% increase corresponding to a 22% increase in collisions. Presumably, vegetation increases risk both by attracting more birds to an area, and by being reflected in glass.

Research: Deterring Collisions

Systematic efforts to identify signals that make glass visible to birds began with the work of Klem in 1989. Testing glass panes in the field and using a dichotomous choice protocol in an aviary, Klem (1990) demonstrated that popular devices like "diving falcon" silhouettes were only effective if they were applied densely, spaced two to four inches apart. Owl decoys, blinking holiday lights, and pictures of vertebrate eyes were among items found to be ineffective.

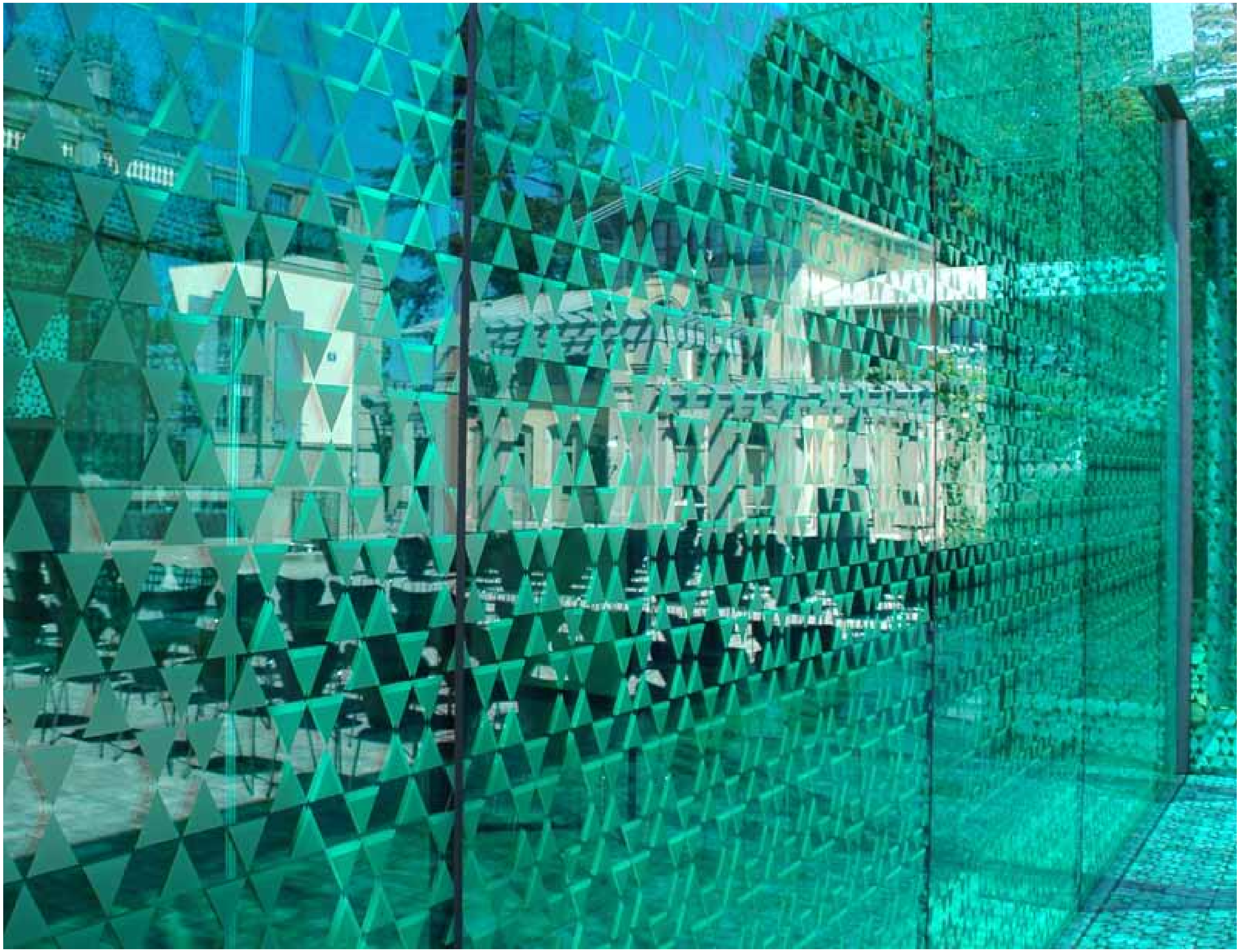
White grid and stripe patterns made from one inch wide material were tested at various spacing intervals. Only three were effective: a 3x4 inch grid, vertical stripes spaced four inches apart, and horizontal stripes spaced about an inch apart across the entire surface.

In further testing using the same protocols, Klem (2009) confirmed the effectiveness of 3MTMScotchcalTM Perforated Window Graphic Film (also known as CollidEscape), WindowAlert® decals, if spaced at the two- to four-inch rule, as above, and externally applied ceramic dots or "frits," (0.1 inch dots spaced 0.1 inches apart). Window films applied to the outside surface that rendered glass opaque or translucent were also effective. The most effective deterrents in this study were stripes of highly reflective 40% UV film (D. Klem, pers. comm., March 2011) alternating with high UV absorbing stripes.

Building on Klem's findings, Rössler developed a testing program in Austria starting in 2004 (Rössler and Zuna-Kratky, 2004; Rössler, 2005; Rössler, et al., 2007; Rössler and Laube, 2008; Rössler, 2009). Working at the banding center at the Hohenau Ringelsdorf Biological Station outside Vienna, Austria made possible a large

Patterns on the outside of glass, such as that shown above, are more effective than patterns on an inside surface. Photo: Hans Schmid

A pattern of narrow horizontal stripes has proven to be highly effective at deterring bird collisions, while covering only about 7% of the surface of the glass. Photo: Hans Schmid



This glass facade of a modern addition to the Reitberg Museum in Zürich, Germany, was designed by Grazioli and Krischanitz. It features a surface pattern formed of green enamel triangles, beautiful and also bird-friendly. Photo: Hans Schmidt

This Barn Swallow flying sideways through a barn door perfectly illustrates the 2″ x 4″ rule. Photo: Keith Ringland

Glass fritted in patterns conforming to the 2″ x 4″ rule scored well as deterrents.

sampling of birds for each test and permitted comparisons of a particular pattern under different intensities of lighting. This program has focused primarily on geometric patterns, evaluating the impact of different spacing, orientation, and dimensions. Birds are placed in a "tunnel," where they can view two pieces of glass: one unmodified, (the control) and the other with the pattern to be tested. Birds fly down the tunnel and are scored according to whether they try to exit through the control or the pattern. A mist net prevents the bird from hitting the glass and it is then released. The project focuses not only on finding patterns effective for deterring collisions, but also on effective patterns that cover a minimal part of the glass surface. To date, some patterns have been found to be highly effective while covering only 5% of the glass.

Building on Rössler's work, ABC has collaborated with the Wildlife Conservation Society and the Carnegie Museum to construct a tunnel at Carnegie's Powdermill Banding Station, primarily to test commercially available materials. This project has been supported by the Association of Zoos and Aquarium's Conservation Endowment Fund, the Colcom Foundation, and New York City Audubon. Results from the first season showed that an entirely UV-reflective surface was not effective at detering birds. UV materials seem to rely on contrast for effectiveness. Glass fritted in patterns conforming to the 2" x 4" rule scored well as deterrents.

Most clear glass made in the United States transmits about 96% of light falling perpendicular to the outside surface, and reflects about 4%. The amount of light reflected increases at sharper angles – clear glass reflects about 50% of incident light at angles over 70 degrees. Light on the inside of the glass is also partly reflected and partly transmitted. The relative intensities of light transmitted from the inside and reflected from the outside surfaces of glass, as well as the viewing angle, determine if the glass appears transparent or mirrors the surrounding environment.

ABC's Chris Sheppard testing a bird in the tunnel at the Carnegie Museum's Powdermill Banding Station in southwestern Pennsylvania. Photo: Susan Elbin, 2011

The tunnel – an apparatus for safely testing effectiveness of different materials and designs for deterring bird collisions. Photo: Christine Sheppard, ABC

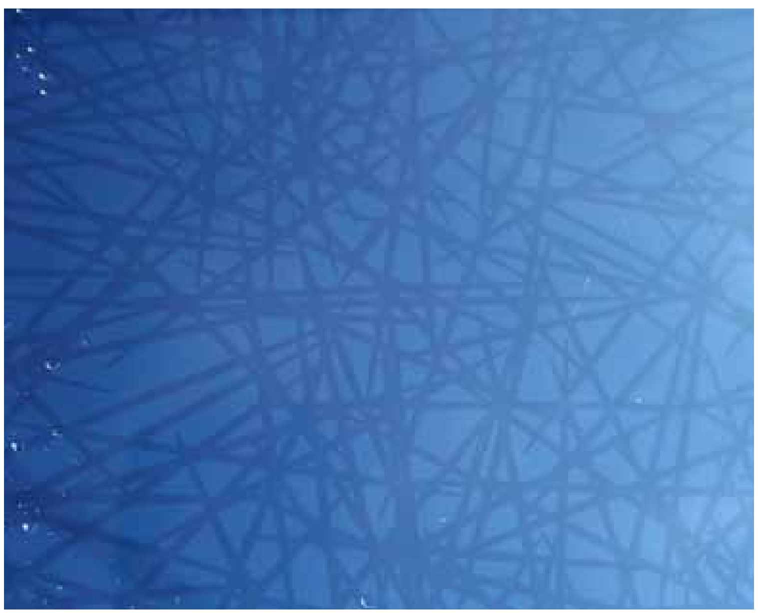
A bird's eye view of glass in the tunnel. Photo: Christine Sheppard, ABC

Patterns on the inside surfaces of glass and objects inside the glass may not always be visible. These optical properties emphasize the superiority of patterns applied to the outer surface of glass over patterns applied to the inner surface.

The majority of the work described here uses protocols that approximate a situation with free-standing glass – birds can see through glass to the environment on the other side, patterns tested are between the bird and the glass and patterns are primarily back-lit. While this is useful and relevant, it does not adequately model most glass installed in buildings. New protocols test materials whose effectiveness depends on the glass being primarily front-lit. This includes UV patterns and frit patterns on the inside surfaces of insulated glass. Window treatments and product testing are ongoing and data will continue to be shared as it becomes available.

A dense internal frit pattern on the glass of the Bike and Roll building, near Union Station in Washington D.C., makes it look almost opaque. Photo: Christine Sheppard, ABC

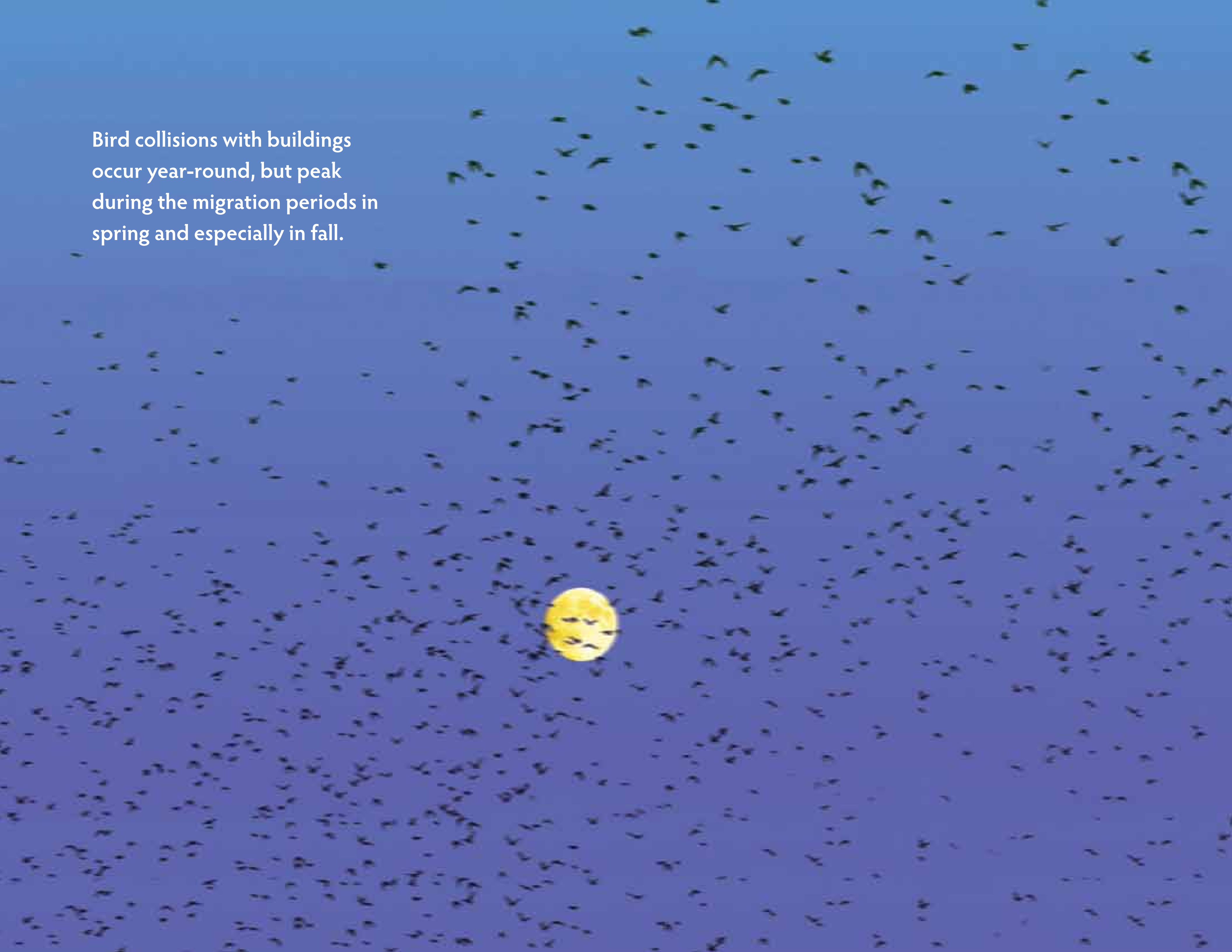
A panel of fritted glass, ready for testing. Photo: Christine Sheppard, ABC



Ornilux Mikado's pattern reflects UV wavelengths. The spiderweb effect is only visible to humans from very limited viewing angles. Photo: Arnold Glass

Patterns with more contrast and distinct spaces, such as the one shown on the left, are much more effective than repeating, all-over patterns like the one shown above. Photo: Christine Sheppard, ABC

Bird collisions with buildings occur year-round, but peak during the migration periods in spring and especially in fall.



Appendix II: Bird Migration

Portland sits along the Pacific Flyway, a primary north-south migration route on the West Coast of North America. Migrants generally follow natural geographical features such as valleys, shorelines, and mountain passes that concentrate migrants & may also provide them with clues to navigation. These features are known as leading lines. Portland's 209 species of birds are made up of both resident and migratory species. Our fall migration stretches from August 25 – November 15, and spring migration lasts from March 15 – June 7.

While bird collisions occur year-round, they peak during migration periods in spring and especially in fall when millions of adults and juvenile birds travel between breeding and wintering grounds, perhaps as far as Alaska and South America. Migration is a complex phenomenon, and hazards can vary depending on migration distances, immediate weather conditions, availability of food, and human-made obstacles encountered along the way.

Many species' migratory patterns alternate flight with stopovers to replenish their energy stores. Night-flying migrants, including many songbirds, generally take off within a few hours of sunset and land sometime between midnight and dawn (Kerlinger, 2009). Once birds land, they may remain for several days, feeding and waiting for appropriate weather to continue.

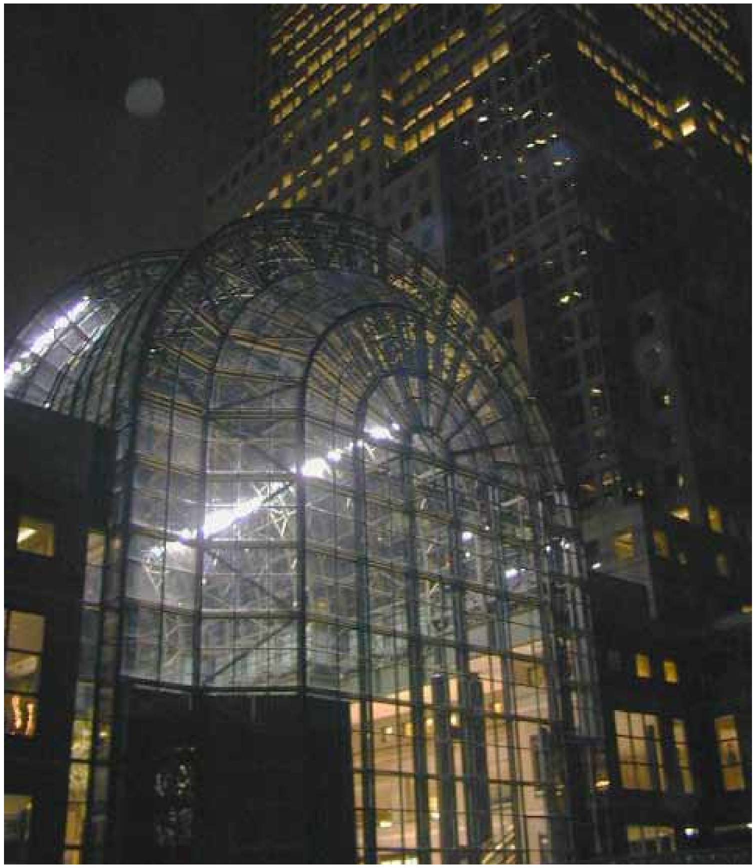
During that time, they travel around the local area, in search of good feeding sites. Almost anywhere they stop, they risk hitting glass. Like other cities, Portland's collision monitoring program involves searching near dawn for birds that have been killed or injured during the night *(see page 40)* for details on BirdSafe Portland surveys). Programs that monitor during the day continue to find birds that have collided with windows (Gelb and Delecretaz, 2009; Olson, pers. Comm.; Russell, pers. Comm.; Hager, 2008). These diurnal collisions are widespread, and represent the greatest number of bird deaths and the greatest threat to birds.

Birds moving between wintering grounds (usually to the south) and breeding grounds travel along the Pacific Flyway, a broad migration route that brings them through Oregon. Illustration courtesy of USFWS

Portland sits along the Pacific Flyway, a primary north-south migration route on the West Coast of North America. The Portland area regularly hosts 209 species of birds, a diversity composed of both resident and migratory species.

Appendix II: Bird Migration

Night-migrating songbirds, already imperiled by habitat loss, are at double the risk, threatened both by illuminated buildings at night and by glass reflections during the day.



The glass walls of this atrium, coupled with night-time illumination, create an extreme collision hazard for birds. Photo: NYC Audubon

Migrating Vaux's swifts roosting at Chapman Elementary School is a well-known phenomenon in Portland, with thousands of people gathering each September to see their nightly convergence down the chimney. Photo: Vern di Pietro

Diurnal Migrants

Daytime migration routes often follow land forms such as rivers, mountain ranges and coastlines. Birds tend to be concentrated along these routes or "flyways." Some songbird species such as American Robin, Horned Lark, and Rufous Hummingbird migrate during the day. Diurnal migrant flight altitudes are generally lower than those of nocturnal migrants, putting them at greater risk of collisions with tall buildings.

Nocturnal Migrants

Many songbirds migrate at night to avoid predators, to take advantage of cooler temperatures and less turbulent air, and in order to forage during daylight hours. Songbirds may fly as many as 200 miles in a night, and stop to rest and feed for one to three days, but these patterns are strongly impacted by weather, especially wind and temperature. Birds may delay departure, waiting for good weather. They generally fly at an altitude of about

2,000 feet, but may descend or curtail flight altogether if they encounter a cold front, rain, or fog. There can be a thousand-fold difference in the number of birds aloft from one night to the next. Concentrations of birds may develop in "staging areas", where birds prepare to cross large barriers such as the Great Lakes or Gulf of Mexico.

Night-migrating songbirds, already imperiled by habitat loss, are at double the risk, threatened both by illuminated buildings at night *(see Appendix I)* and by glass reflections during the day.

Millions are at risk as they ascend and descend, flying through or stopping in or near populated areas. City buildings are unseen obstacles by night and pose confusing reflections by day.

After landing, nocturnal migrants make short, low flights near dawn, searching for feeding areas and encountering glass in cities, suburbs and exurbs. When weather conditions cause night-fliers to descend into the range of lighted structures, catastrophic collision events can occur around tall buildings. Urban sprawl is creating large areas lit all night that may be causing less obvious, more dispersed bird mortality.

Local Movements

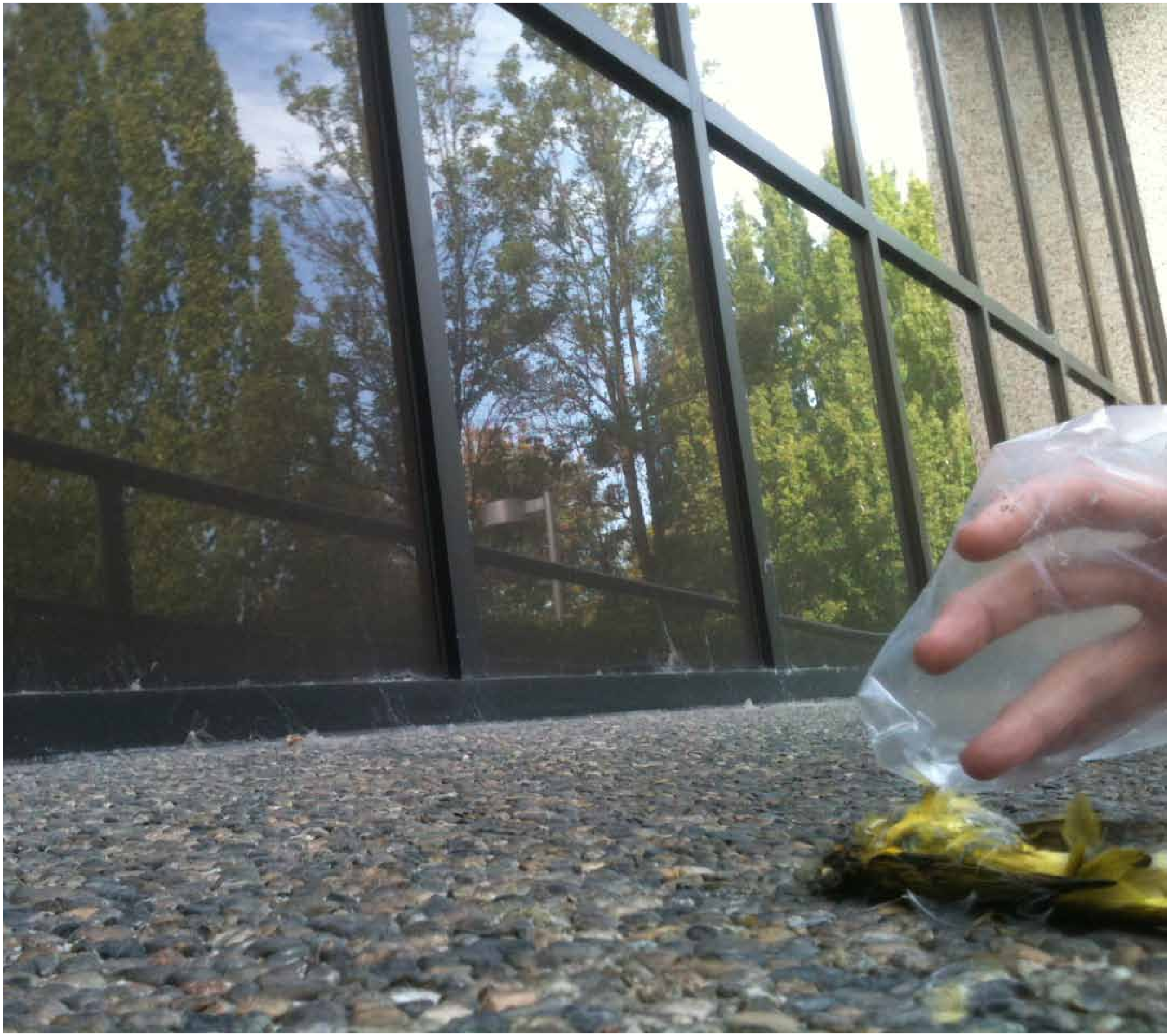
Glass collisions by migrating songbirds are by far the best known, but mortality of other groups of birds is not insignificant. Fatalities from collisions have been reported for 19 of 42 raptor species in both urban and non-urban environments. Collisions are the leading known cause of death for four raptor species in cities, including the Peregrine Falcon. Breeding birds encounter glass as they search for nest sites or food, patrol territories or home ranges, flee predators or pursue prey. Mortality increases as inexperienced fledglings leave the nest and begin to fly on their own.

Breeding birds encounter glass as they search for nest sites or food, patrol territories or home ranges, flee predators or pursue prey. Mortality increases as inexperienced fledglings leave the nest and begin to fly on their own.

The mirrored glass of this office building reflects nature so perfectly that it is easy to see how birds mistake reflection for reality. Photo: Christine Sheppard, ABC

Reflections of "urban canyons" between tall buildings can also deceive birds that attempt to fly through perceived passageways. Photo: Christine Sheppard, ABC

Swainson's Thrushes are common collision victims in Portland. Photo: Mary Coolidge



A volunteer with BirdSafe Portland picks up a Wilson's Warbler that had collided with the plate glass. Wilson's Warblers migrate through Portland and have been recorded in local collision surveys. Photo: Mary Coolidge

Appendix III: Evaluating Collision Problems – A Toolkit

Often, only part of a building is responsible for causing most of the collisions. Evaluation and documentation can help develop a program of remediation targeting that area. This can be almost as effective as modifying the entire building, as well as being less expensive.

Documentation of patterns of mortality and environmental features that may be contributing to collisions is essential. Operations personnel are often good sources of information as they may come across bird carcasses while performing regular maintenance activities. People who work near windows are often aware of birds hitting them. Regular monitoring documents mortality patterns and provides a baseline for demonstrating improvement. This monitoring is an internal effort by the building owner or manager, tenants, and staff. The data collected is a resource for internal use and evaluation. The following questions can help guide the evaluation and documentation process by identifying features likely to cause collisions.

Seasonal Timing

Are collisions happening mostly during migration or fledging periods, in winter, or year round? If collisions happen only during a short time period, it may be possible to apply inexpensive, temporary solutions during that time and remove them for the rest of the year.

Some birds will attack their own reflections, especially in spring. This is not a true collision. Territorial males, especially American Robins and Cardinals, perceive their reflection as a rival male. They are unlikely to injure themselves, but temporarily blocking the offending window from the outside should resolve the problem.

Diurnal Timing

Are collisions happening at a particular time of day? The appearance of glass can change significantly with different light levels, direct or indirect illumination, and sun angles. It may be possible to simply use shades or shutters during critical times *(see Appendix II)*.

External shades, as shown here on the Batson Building in Sacramento, California, designed by Sym Van der Ryn, are a simple and flexible strategy for reducing bird collisions, as well as controlling heat and light. Photo: MechoShade

Weather

Do collisions coincide with particular weather conditions, such as foggy or overcast days? Such collisions may be light-related. It may be possible to create an email notification system, asking building personnel to turn off lights when bad weather is forecast.

Location

Are there particular windows, groups of windows or building facades that account for most collisions? There are often particular windows or aspects of a building that account for most collisions; it may be cost-effective to modify only these problematic sections of glass.

Often, only part of a building is responsible for causing most of the collisions.


The American Goldfinch is a common resident in the Portland area. Photo: Jim Cruce

Vegetation

Is landscaping contributing to collisions? If so, landscaping may be more easily addressed and less costly to fix than glass modification or replacement. If there is an area where plants are visible through glass, moving plants away from windows may help to resolve a collision issue. If there is a clear pathway bordered by vegetation that directs birds toward windows, a trellis to shield the glass, reduce reflections, and divert flight paths may be considered. If fruit trees or berry bushes are attracting birds near to a glassy area, here again, a trellis or a screen may be less expensive than retrofits to the glass itself.

There may also be secondary factors contributing to collisions that are more easily addressed and less costly fixes than glass modification or replacement.

Evaluating Retrofit Options

In some cases, a collision problem on a building may be deemed sufficient to warrant a retrofit. When determining which material to use in retrofitting the area, there are many factors to consider. Seasonal, temporary solutions may be appropriate for on an interim basis to quickly address the collision issue while evaluating a long-term solution. Temporary solutions may include ABC Bird Tape *(see page 26)*, mylar tape, tempera paint, decals, or any of a myriad imaginative ways to create relatively effective, low cost, and easy to apply visual noise on a window.

Any retrofit approach may be evaluated by a number of factors, including: effectiveness, cost, ease of application or implementation, longevity, ease of maintenance, and potential to improve the energy performance of the building. Specific evaluation of approaches will vary widely based on details of product selection, but a general overview follows.

Netting: Fine mesh can be an effective, relatively low-cost, seasonal solution. This type of approach was used at the FBI's 10-story LEED Platinum office building in Chicago, where collisions were a concern. Netting requires installation prior to each spring and fall migration, but has little impact on the building's aesthetics.
Window Films: Films are available for use on the exterior surface of a window, where they are most effective. They can be quite effective and are easy to apply to small areas, and can carry an energy benefit, but some may decrease light entry and have a visible impact on window appearance, both from inside and outside.

Exterior Screens: Screens can effectively reduce visible reflections, provide insulation from strike impact, reduce solar heat gain, and are one of the less costly approaches to a retrofit. Screens installed at Lewis and Clark Law School have been very effective at reducing strike incidence, and seasonal removability makes them more acceptable to building occupants.

Shutters are a very effective strike deterrent, provide an energy efficiency benefit, may be aesthetically pleasing, and have reliable longevity. They can be useful for reducing seasonal strikes. Replacing glass with fritting or UV patterned glass is likely to be the most expensive retrofit option, but is one of the more attractive options, can increase the energy efficiency of the window, and requires no added maintenance.

Reglazing glass in place is an option for introducing visual noise while preserving the existing windows, and requires no additional product maintenance. Etching and sandblasting can create branding on retail glazing or can provide built-in privacy for other conditions.

Trellises that act as a green screen can be easily installed as a retrofit, can provide a shading or privacy benefit, are aesthetically pleasing, and can be a relatively low-cost fix. Careful plant selection can help offset potential maintenance demand.

Research

Research on songbirds, the most numerous victims of collisions, has shown that horizontal spaces must be 2” or narrower, to deter the majority of birds. Vertical spaces must be 4” or narrower. This difference presumably has to do with the shape of a flying bird with outstretched wings. Within these guidelines, however, considerable variation is possible when devising bird-friendly patterns. We recommend that lines be at least ¼” wide, but it is not necessary that they be only vertical or horizontal. Contrast between pattern and background is important, however, be aware that the background – building interior, sky, vegetation – may change in appearance throughout the day. Effective patterns on the exterior surface of glass will combat reflection, transparency and passage effect. In the case of handrails or other applications viewed from both sides, patterns should be applied to both surfaces if birds can approach from either side.

The white stripes on this glass wall are an easy way to make a very dangerous area safe for birds. Photo: Hans Schmid

Research on songbirds, the most numerous victims of collisions, has shown that horizontal spaces must be 2" or narrower, to deter the majority of birds. Vertical spaces must be 4" or narrower.

While patterns on the exterior surface of glass are most effective, blinds and curtains can help disrupt reflections. Partially open blinds, like those seen here, are most effective. Photo: Christine Sheppard, ABC

Patterns achieved with film or by etching glass can be beautiful as well as very effective in preventing bird collisions. Photo: Bob Sallinger


Peregrine Falcon and nest on the Interstate Bridge. Photo: Bob Sallinger

Appendix IV: Legislation

In recent years, efforts to standardize bird-friendly approaches have resulted in voluntary guidelines and/or legislation in a number of cities and states across the United States and Toronto. Cook County, Illinois, was the first to pass bird-friendly construction legislation, sponsored by then-assemblyman Mike Quigley. In 2006, Toronto, Canada, proposed a Green Development Standard, initially a set of voluntary guidelines to promote sustainable site and building design, including guidelines for bird-friendly construction. Development Guidelines became mandatory on January 1, 2011, but the process of translating guidelines into blueprints is still underway. San Francisco adopted Standards for Bird-safe Buildings in September, 2011.

Listed below are some examples of current and pending ordinances at levels from federal to municipal.

Federal (proposed): Illinois Congressman Mike Quigley (D-IL) introduced the Federal Bird-Safe Buildings Act of 2011 (HR 1643), which calls for each public building constructed, acquired, or altered by the General Services Administration (GSA) to incorporate, to the maximum extent possible, bird-safe building materials and design features. The legislation would require GSA to take similar actions on existing buildings, where practicable. Importantly, the bill has been deemed cost-neutral by the Congressional Budget Office. See http://thomas.loc.gov/cgi-bin/query/z?c112:H.R.1643.IH: Congressional Budget Office estimates are a matter of public record and can be found at http://www.cbo.gov/cost-estimates/

State: Minnesota (enacted): Chapter 101, Article 2, Section 54: Between March 15 and May 31, and between August 15 and October 31 each year, occupants of state-owned or state-leased buildings must attempt to reduce dangers posed to migrating birds by turning off building lights between midnight and dawn, to the extent turning off lights is compatible with the normal use of the buildings. The commissioner of administration may adopt policies to implement this requirement. See www.revisor.leg.state.mn.us/laws/?id=101&doctype=Chapter&year=2009&type=0

State: Minnesota (enacted; regulations pending): Beginning on July 1, 2010, all Minnesota State bonded projects – new and substantially renovated –that have not already started the schematic design phase on August 1, 2009 will be required to meet the Minnesota Sustainable Building 2030 (SB 2030) energy standards. See www.mn2030.umn.edu/

State: New York (pending): Bill S04204/A6342-A, the Bird-friendly Buildings Act, requires the use of bird-friendly building materials and design features in buildings. See http://assembly.state.ny.us/leg/?bn=S04204&term=2011

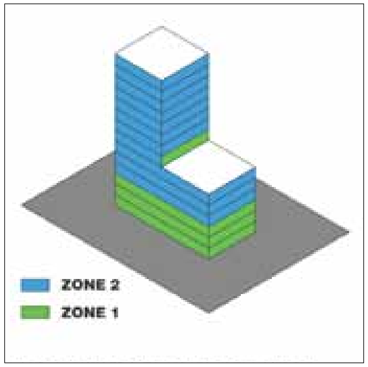
City: San Francisco (enacted): The city's Planning Department has developed the first set of objective standards in the nation, defining areas where the regulations are mandated and others where they are recommended, plus including criteria for ensuring that designs will be effective for protecting birds. See www.sf-planning.org/index.aspx?page=2506

City: Toronto: On October 27, 2009, the Toronto City Council passed a motion making parts of the Toronto Green Standard mandatory. The standard, which had previously been voluntary, applies to all new construction in the city, and incorporates specific Bird-Friendly Development Guidelines, designed to eliminate bird collisions with buildings both at night and in the daytime.Beginning January 31, 2010, all new, proposed low-rise, non-residential, and mid- to high-rise residential and industrial, commercial, and institutional development will be required under Tier 1 of the Standard, which applies to all residential apartment buildings and non-residential buildings that are four stories tall or higher. See www.toronto.ca/planning/environment/greendevelopment.htm

Voluntary Bird-friendly Building Guidelines: These guidelines, available in several jurisdictions, offer voluntary best practices resource guides for architects, developers, building managers, engineers, and the general public for the design and retrofitting of bird-friendly homes and buildings. Examples of guidelines include: New York City (www.nycaudubon.org/our-publications/bird-safe-buildings-guidelines); Minnesota (http://mn.audubon.org/guide-urban-bird-conservation/bird-building-collisions); and Chicago (www.birdsandbuildings.org/docs/ChicagoBirdSafeDesignGuide.pdf).

These legislative efforts promote bird-friendly design and the reduction of light pollution.

Appendix V: LEED Pilot Credits Addressing Ecosystem-level Considerations



Zone 1 includes the first 3 floors above ground level and the first floor above a green roof. Zone 2 includes all façade area above the 3rd floor. Zone 1 is considered twice as dangerous as Zone 2.

Pilot Credit 55: Bird Collision Deterrence

On October 14, 2011, The US Green Building Council introduced a pilot credit with the explicit intent of "reduc[ing] bird injury and mortality from in-flight collisions with buildings." The establishment of the Bird Collision Deterrence (BCD) credit demonstrates the USGBC's commitment to expanding the standards of its green building program to include ecosystem-level considerations in its rating system. Since collisions can occur due to a combination of factors, the credit addresses unmarked window glass as well as both interior and exterior lighting. The credit is available to both new construction and existing buildings.

For new construction, the building must comply with a building façade option, an interior lighting option, an exterior lighting option, and develop a 3-year post-construction monitoring plan.

Building Façade Requirement

Develop a façade design strategy to make the building visible as a physical barrier, and eliminate reflections. The BCD Pilot credit helps to direct architects and designers to window materials that have been tested & rated for their visibility to birds. Strategies for creating visual noise can include opacity, translucence, fritting, UV-patterns, exterior films, louvers, screening, netting, and shutters. A summary of Material Threat Factors allows a designer to calculate the overall Bird Collision Threat Rating (BCTR) for the building, which must score no higher than 15. All glazed corners or fly-through conditions (closely placed unmarked glass) must have a Threat Factor equal to or below 25. If all the materials used in the façade have a Threat Factor of <15, the project may submit a materials list in lieu of a BCTR calculation.

For more on BCD and BCTR Calculation:

An example of a proposed BCD project and its accompanying BCTR Calculation is available on page 10 of the LEED Pilot Credit Library materials http://www.usgbc.org/ShowFile.aspx?DocumentID=10402

Sampling of Material Threat Factor ratings:

- Opaque material, 0
- Exterior adhesive film, 2
- Interior patterned film 2" horiz. or 4" vert., 15
- Exterior louvers 2" horiz. or 4" vert., 5
- Glass Block 8" x 8" x 4", textured, 10
- Exterior white dot frit, 15
- Operable shutters, 10
- UV-patterned glass, 25

The building is first separated into two risk zones: Zone 1 (high risk) and Zone 2 (low risk). Zone 1 includes the first 3 floors above ground level and the first floor above a green roof. Zone 2 includes all façade area above the 3rd floor. Zone 1 is considered twice as dangerous as Zone 2.

For each zone, calculate the BCTR according to the formula:

1. [((Material Type 1 Threat Factor) x (Material Type Area)) + ((Material Type 2 Threat Factor) x (Material Type Area))…] / [Total Façade Zone Area = Façade Zone BCTR.

2. Then determine the total building Bird Collision Threat Rating by performing the following calculation with BCTRs for Zone 1 and Zone 2:
   [((Zone 1 BCTR) x 2) + (Zone 2 BCTR)] / 3 = Total Building BCTR

Lighting Requirement

In addition to a façade treatment and monitoring, the credit requires that overnight lighting be responsibly designed to minimize light spill from both interior spaces and exterior fixtures.

The new bird-safety credit addresses the hazard of light pollution by requiring properly-shielded fixtures, as well as establishment of manual or automatic shutoff programs from midnight to 6 am (safety lighting is exempted). The credit is synergistic with other LEED-spirited goals: it minimizes waste of electricity (and money!), helps to reduce carbon emissions, minimizes impacts to wildlife, and preserves our age-old cultural heritage of star-gazing.

Post-Construction Monitoring Plan

Submit a copy of the 3-year post-construction monitoring plan to routinely monitor for collision-prevention effectiveness. Include methods to identify and document strike locations, the number, date, and time of collisions, as well as the feature that may be contributing to collisions. The plan should include a process for correcting problem areas if any are discovered. Monitoring is not intended to be punitive, but rather, intended to provide data on the effectiveness of different design approaches.

Existing Building Operation & Maintenance

Lighting

For both interior and exterior lighting, the building must provide necessary reports, drawings, and descriptions of light fixtures, lighting systems, and operations as above to demonstrate compliance.

Post-Construction Monitoring Plan

Implement a 3-year façade monitoring Plan in NC, CS, Schools, Retail, Healthcare above. If a collision area is identified, consider a temporary or permanent retrofit. Implement interim retrofits within 120 days, and permanent retrofits within 2 years.

LEED Pilot Credit 7: Light Pollution Reduction

The US Green Building Council has rewritten the Light Pollution Reduction credit to make it easier to understand, more flexible for designers, and more applicable to different sources of light pollution. The Credit explicitly intends to “increase night sky access, improve nighttime visibility, and reduce development impacts on wildlife environments by reducing uplight (skyglow) and light trespass (glare).” The establishment of the Light Pollution Reduction credit is just one of the ways that the USGBC is demonstrating its commitment to include ecosystem-level considerations in its rating system.

For both the uplight and light trespass requirements, an optional path allows teams to demonstrate compliance by selecting luminaires with an appropriate BUG rating and placing them appropriately. No point-by-point calculation is required. The calculation path is simplified and requires calculations for fewer locations. Many projects can achieve the credit by simply complying with ASHRAE 90.1–2010 and selecting luminaires with an appropriate BUG rating.

The term *lighting boundary* has been introduced to indicate the nearest property line adjacent to the project site (modified in some cases). Light trespass requirements relate to the lighting boundary, rather than the LEED site boundary. Skyglow/Uplight requirements are still met based on all non-exempt exterior luminaires located within the LEED site boundary.

The credit is available for pilot testing in New Construction, Core & Shell, Schools, Retail, Healthcare, and EBOM.

Full text of the LEED Pilot Credit 55 language: http://www.usgbc.org/ShowFile.aspx?DocumentID=10402

Summary of Material Threat Factors: https://www.usgbc.org/ShowFile.aspx?DocumentID=10397

Full text of the LEED Pilot Credit 7 language: http://www.usgbc.org/ShowFile.aspx?DocumentID=8219

Bird-friendly practices often go hand-in-hand with energy efficiency improvements

Rufous Hummingbird.
Photo: Jim Cruce

Appendix VI: Cost Effectiveness – Considerations and Case Studies

> **Despite tremendous gains in the energy efficiency of glass, it is still far less energy efficient than solid walls, and is, in fact, the least energy efficient façade material available.**

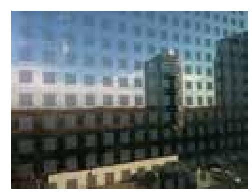
There are many approaches to designing a bird-friendly building. By far, the best way to realize cost-effectiveness is to incorporate bird-friendly design considerations into the initial concept, rather than addressing them as an afterthought. Capitalizing on potential opportunities to match bird-friendly approaches with other building objectives is an elegant approach that many designers have taken. There are numerous examples throughout this document of buildings that have achieved bird-friendliness while meeting other primary objectives. These may include energy efficiency, pure aesthetics, creation of privacy, or incorporation of branding into the building envelope. Case studies can begin to illustrate what the relative cost is for window treatment, but cost estimates are best formulated on a project-by-project basis, in light of other objectives in the building design, identifying where energy efficiency can be improved, and whether other objectives such as privacy or branding can be met.

Despite tremendous gains in the energy efficiency of glass, it is still far less energy efficient than solid walls, and is, in fact, the least energy efficient façade material available. An energy analysis by the University of Leeds, UK, indicated that energy efficiency decreases when window area exceeds 30% of an exterior wall. This is because R-values for a solid, insulated wall can be 5 to 30 times higher than glass. Scaling back on the percentage of glass as a building material is the best design strategy to maximize energy efficiency while reducing risk to birds. A recent article in *Environmental Building News*:19:7 entitled "Rethinking the All-glass Building" weighed the benefits of the all-glass building against the energetic and environmental operating costs, and concluded that an "overuse" of vision glass results in high energetic penalty. This is supported by research at the Pacific Northwest National Laboratory showing that high window-to-wall ratios (WWR) increase energy use in every climate zones studied (M. Rosenberg, pers. comm.). In San Francisco, a slight decrease in energy use occurred up to a 20% WWR, above which an energy penalty resulted. Where glass is used, adding patterns to glass (fritting or silk-screening) lowers the window's Solar Heat Gain Coefficient, which is a measure of the amount of solar heat transmitted. Long-term building costs are impacted by both the upfront costs of materials and installation, as well as the ongoing costs of operating a building over time.

The Federal Bird Safe Buildings Act of 2011 (HR 1643) proposes that all federal buildings constructed, acquired, or altered by the General Services Administration should incorporate bird safe materials and design features where practicable. A Congressional Budget Office analysis deemed the bill to be cost-neutral. In fact, many designers who have designed bird-friendly buildings have asserted that they do not see a significant increase in cost if these design approaches come into consideration from the start.

Case Study: Prendergast Laurel

Prendergast Laurel architects performed a cost analysis for a 12,625 square foot library, comparing the costs of conventional insulated glass to fritted or UV-patterned glass. For 3,084 square feet of glass, the total window cost (labor and materials) rose from $428,000 to $447,260 when upgrading all 3,084 square feet of façade glass to UV or fritted glass. The cost increase was $19,260, on an $11,350,000 building, which represents a 0.18% overall cost increase. Overall building costs increased by less than 1/2 a percent in this analysis.



Patterned glass at OHSU.
Photo: Mary Coolidge

Case Study: OHSU Center for Health and Healing

The new OHSU Center for Health and Healing in South Waterfront, designed by GBD Architects, uses vision glass on 40% of the building's skin, amounting to a total 78,105 square feet of glass façade. Of the total 78,105 square feet of glass skin, 9,092 square feet is fritted, or 12% of the vision glass. The skin of the building represented a cost of $10,443,794 of a total $145 million project cost, which represents 7.2% of total project cost. The net cost on the upgrade to fritted glass (a 50% upcharge to the cost of glass) on this building amounted to $45,460 in total, or a 0.03% increase in project cost for fritting, a treatment which in various places helped to create a sense of enclosure in the space, provided solar protection and glare control, and animated the façade as seen from a distance.

Retrofit Case Study: Lewis and Clark Law School

Mirrored windows on the Lewis and Clark Law School Legal Research Center have long been the site of fatal bird collisions. Students at the school developed a monitoring program to document fatalities, and when it was determined that hawk silhouettes were not effectively deterring collisions, the Law School administration hired Hennebery Eddy Architects to develop several retrofit test solutions. Test products included fixed exterior window screens, electronic roll-down window screens, and exterior window film. The approved project budget was $88,000, but ultimately, removable exterior screens designed by Steve Kem were installed on the LRC building for a fraction of the estimated cost, and have successfully reduced the collision hazard *(see page 15)*.

Madrid's Vallecas 51, designed by Somos Arquitectos, uses open-celled polycarbonate panels – a sustainable and recyclable skin that presents no threat to birds. Photo: Victor Tropchenko

Retrofit Case Study: Port of Vancouver

Highly reflective windows at the administrative building at the Port of Vancouver (PoV) have been the site of historic window collisions. PoV has initiated a pilot installation of roll-up solar shades to provide seasonal screening on 6 windows. Manufactured by Portland-based Suntek Solar Shades, the screens were supplied and installed by Integrity Window Coverings of Vancouver, WA, and cost $260 each, installed. Screens will be tested for effectiveness and acceptability by PoV staff, and will be coupled with a vegetation screening strategy. PoV also acts as a landlord to various industrial tenants, including two tenants who are undertaking new construction. Bird-Friendly Building flyers, produced by PoV, as well as additional resource materials have been provided to tenants to encourage consideration of bird-friendly design

Six reflective windows on the Port of Vancouver administrative building are slated for a pilot installation of roll-up solar shades, which will serve the dual purpose of softening incoming light and reducing strike hazards.
Top photo shows window with shades up and bottom shows the window with the shades down. Photo PoV.

Issues of cost prompted Hariri Pontarini Architects, in a joint venture with Robbie/Young + Wright Architects, to revise a planned glass and limestone façade on the School of Pharmacy building at the University of Waterloo, Canada. The new design incorporates watercolors of medicinal plants as photo murals. Photo: Anne H. Cheung

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Stunned Yellow Warbler after striking a window. Photo: Kate MacFarlane

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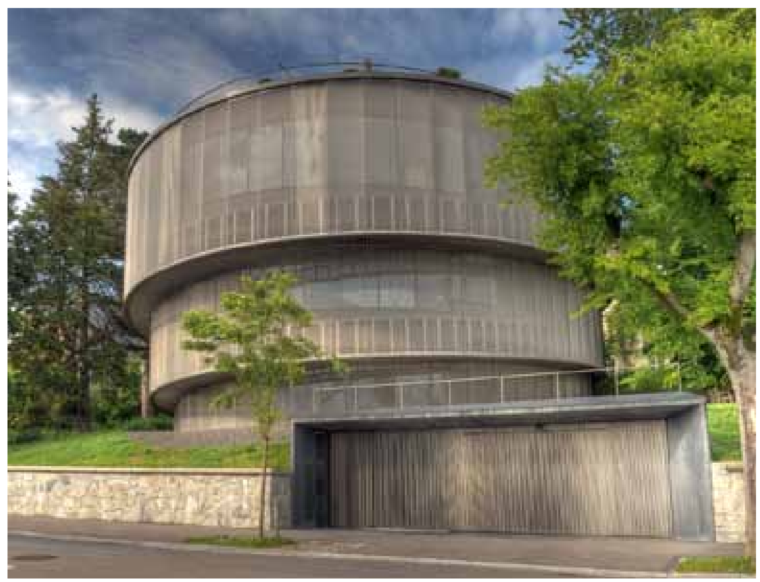

The steel mesh enveloping Zurich's Cocoon in Switzerland, designed by Camenzind Evolution Ltd, provides privacy and protects birds, but still permits occupants to see out. Photo: Anton Volgger

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The IIT Student Center in Chicago uses faceted glass, Panelite panels and a dot matrix pattern (above) in its facade. These elements create visual noise which is perceptible to birds.

The U.S. Census Complex in Suitland, Maryland, designed by Skidmore, Owings, Merrill, features a brise soleil that shades the curtain wall. Wavy vertical fins of marine-grade, white oak reduce sun glare while eliminating glass reflections. Photo: Esther Langan

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Great Blue Heron, designated as Portland's official city bird. Photo: Jim Cruce

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This is a working technical report and is subject to revision.

Snow and Canada Geese above Sauvie Island. Photo: Mike Houck

This Mourning Dove fatally hit a window hard enough to leave this ghostly image on the glass. Implementing bird-friendly design solutions can alleviate these types of collisions.

Photo: Jeanne Donaldson