PROBLEM OF BIODIVERSITY IN THE CITY

(2) Almost 1,200 species of birds will face extinction in the next century. One of the most serious threats to the avian world is a loss of habitat. **(3)**Our ever-increasing need for space is continually growing our cities outwards and upwards while leaving little habitat behind. Ask why birds are important. Is it for our own benefit or theirs that we want them in the city? **(4)** There's no doubt humans appreciate wildlife and natural elements in the city and often times birds are the only connection to the natural world for many people on a daily basis. **(5)** Birds bring more than a connection to nature for humans, they are also a very important indicator of the general health of the environment. Additionally they consume many times their own weight of insects every day. **(6)**Think on this: birds provide ecosystem services such as pollination and pest control that equal upwards of 16 trillion dollars a year…and they do it all for free.

Birds in the city are excellent for education as well. Think about the Swifts at Chapman Elementary School in Portland, or Agate Hall in Eugene: in Portland thousands of people watch the swifts dive into the chimney during their three-week stay in Portland during migration. And right alongside the spectators is Audubon and other education groups.

BENEFIT OF ECO-ROOFS FOR WILDLIFE

(7) There are benefits to providing habitat in cities. Roofs are open, often unused real estate that is usually wasted. The rooftop offers certain opportunities for wildlife, space that is safe away from predators. Domestic cats kill millions of birds every year and can wipe out entire populations. Other urban predators such as raccoons and even humans also have no access to a rooftop.

WHY/GOALS

(8) I chose this project because I firmly believe wildlife should inhabit urban areas. I think it improves our standard of living by exposing us to the natural world when we might not otherwise be so. **(9)** It's important for everyone to have a daily link to the natural world to better understand our native neighbors so that we may be better global citizens.

One of my first goals of this project was to find a solution that would allow **(10)** *adapting the existing infrastructure* of the city without dramatic cost or change. There are dozens of ways we can incorporate habitat into the existing urban fabric and the most prominent and obvious answer is the rooftop. A second goal was to create a **(11)** *design that could be nearly universal* for all buildings, not just new construction so the design ideas could be used with a wide variety of developments. I also wanted to create a design that could be **(12)** *studied, monitored and analyzed* for further improvements and that lead me to a hypothesis driven design approach. I have written a series of hypotheses that you have in front of you about how I expect the design to perform. I will return to these in a few minutes.

SITE OVERVIEW/ANALYSIS

(13) The Portland Mausoleum is a great canvas for these goals because it is located in the city as it sits overlooking **(14)** Oaks Bottom Wildlife Refuge, **(15)** alongside the Willamette River and Ross Island. **(16)** Downtown Portland can be seen from the roof, while Interstate 5 runs along and across the river between downtown and the Mausoleum. To the east and south lay a residential neighborhood. The site is in an ideal, vegetated location.

(17) Oaks Bottom Wildlife Refuge includes a diversity of habitats and there are many native species such as **(18)** Oregon White Oak but also many invasive species as well such as Reed Canarygrass.

(19) Portland is also along an important migration route, the Pacific Flyway which carries millions of birds, over 350 species south to north and back every year.

(20) The first cornerstone of the Mausoleum was set in 1901 and in 1910 the building undertook a 70 year construction project. Another new wing was added in the 1990's and yet another as late as 2003. The highest section of building is 8 stories high and the entire property is as big as two and a half city blocks.

(21) The inside of the building is a series of rooms, hallways and corridors, each building section a different style and as a whole total several miles in length. Vaults line the walls in many sections while elsewhere glass-enclosed cases line a maze of hallways. In many corridors the light is provided by a series of skylights. **(22)** There are many marble sculptures and a couple of original Tiffany stained glass windows.

The building has recently been closed to the public and only families may now visit so the number of visitors is limited. **(23)** There are a number of views from the inside of roof top, most notable is the view from an oval staircase. **(24)** On the main entrance level are windows that look straight through to the roof deck from a recessed level. **(25)** These views make this section the most viewed, and one of the only sections viewable by visitors.

(26) The Mausoleum is slowly being turned into a huge canvas as a mural takes over the entire side of the building that faces Oaks Bottom. It will be the largest outdoor mural in North America.

(27) The entire building is extensive, but for this design this is the section that is focused on. The roof is divided into an upper level and a lower and each are accessible for maintenance. This portion of the roof is about an acre in size, just under 40,000 square feet. **(28)** The open face of the building faces **(29)** southeast and gets the hottest, **(30)** sunniest time of the day **(31)** bearing down straight on the roof. **(32)** There is some existing relief from the direct sun in the form of parapets and skylights.

(33) The upper roof levels nearly all have skylights with the exception of the tallest part of the building and the north east corner. **(34)** There are many trees that tower over the upper levels right up against the building. **(35)** There are significant changes in heights from the north end to **(36)** the south end and the last two levels are accessible by ladders. **(37)** Only one of these levels is viewable by visitors.

(38) There are less dramatic height changes **(39)** on the lower roof levels. **(40)** The southwest corner is the largest section of roof and has no skylights. **(41)** These are the

sections that are viewable from the inside. **(42)** All of the roof levels have various forms of exhaust vents that come up from the vaults in the building.

All About Birds

(43) This design explores prototypes for modifying roofs for urban wildlife habitat, particularly birds. I chose the Common Nighthawk for a couple reasons. First, they provide one of the previously mentioned ecosystem services: they consume a huge number of insects. The contents of two nighthawks stomachs were analyzed, one had 500 mosquitoes and the other had over 2,000 flying ants. Also, the Nighthawk was previously abundant in Portland and many individuals and organizations would like to see them back in the city again.

(44) The Common Nighthawk arrives in June and they stay in the northwest for three to four months out of each year. They start nesting very quickly and will tend to their eggs and chicks through August. Nighthawks feed on insects at dawn and dusk and the rest of the day is spent incubating or cooling the eggs, tending the chicks or roosting.

(45) Nighthawks nest in a variety of habitats including prairies, woodland clearings, rock outcrops and gravel building roofs. The common theme amongst all of their nesting sites is open ground with cover close by in the form of boulders, grass clumps or logs with a soil or gravel substrate on which they lay their eggs without a nest. Nighthawks will roll or drag their eggs during the day, presumably to areas with more shade, or a cooler substrate.

(46) In recent times they have started to vanish from the cities and there has been a general decline in nighthawk populations throughout North America. The foremost explanation for this is a change of roof construction from gravel to a rubberized surface. The rubberized surface is considerably too hot for eggs, which also roll around on the flat surface and there is no camouflage from predators.

(47) Common types of habitat are easy to replicate on a roof and many species can benefit from these habitat types in a variety of aspects of their lifecycle needs. Some of these

habitat types are prairies, rock outcrops, and brownfields. **(48)** Prairies are easy to replicate due to their natural growing conditions which are shallow, nutrient poor and dry soils. **(49)** Rock outcrops also have conditions that match growing conditions on a roof such as very shallow soils, direct sun and surrounding radiating heat. **(50)** Brownfields have extremely nutrient poor soils, gravel and little or no shade.

(51) Many species can benefit from these habitats and also from basic habitat elements that can be incorporated into the design such as branches or rocks for perching or shelter. The **(52)** Western Meadowlark roosts in thick grasses and uses perches to survey for danger and for feeding and **(53)** Sparrows often forage among boulders and in down logs.

Precedents

To understand how birds have been attracted to rooftops and what design elements are important I looked at two countries which have tackled this issue. **(55)** Switzerland has become the leader in creating biodiverse roofs with most of the work being done in Basel. One of the greatest Swiss design lessons is varying substrate depths, which is key to creating greater diversity. **(56)** They add rocks and timber on the top to add humidity for insects and plants and perching for birds. There has been however, a high chick mortality rate which is thought to be due to a lack of shelter, shade and water.

(57) In London, England they're taking these lessons and adapting them to their own needs, which is habitat for the Black Redstart, an endangered bird that nests on brownfield sites. Brownfields are abandoned industrial or commercial sites. These conditions are being replicated on roof tops incorporating reused debris such as crushed concrete and brick. Adding building material waste on top of the substrate or even mixed in creates a large amount of hiding places and increases moisture retention all of which add a microhabitat for insects.

Design Overview

(58) In this design there are four habitat types: **(59)** prairie, **(60)** rock outcrop, **(61)** brownfield and **(62)** sedum. Each of these habitat types are represented in multiple

locations on the roof. **(63)** Part of the reason for this is each habitat type will be in different microclimates on the roof and may perform differently based on that location. **(64)** For example sedum in the middle of a large area with no shade will perform differently than sedum on the upper level with shade created by parapets and skylights and shelter from wind. **(65)** This also gives the nighthawk multiple options for nesting. Because they may nest in any of the habitat types this layout gives equal distribution to all of the habitats in terms of shade, structure and microhabitats. **(66)** Having several habitats in one section such as brownfield and sedum, gives the nighthawks a variety of habitats easily accessible to roll their eggs to and from. **(67)** This diversity is important because we don't know exactly what they will prefer and this combination offers the opportunity for study, future replications and improvements of habitat design.

(68) The other overall design logic is based on the existing drainage of the roof. New drainage channels serve multiple purposes, first they create an aesthetic break between habitat types or large areas of one habitat. They also create a maintenance path throughout the entire roof and lastly they serve as overflow to move water away quickly during heavy storm events. The form of these gravel channels reflects the natural form of the perennial streams below in Oaks Bottom.

There are common elements in each of the habitats. **(69)** Each section contains wood in the form of logs, **(70)** branches or wood piles **(71)** and there are scattered boulders of various sizes. **(72)** In addition, each habitat has areas of bare ground with exposed substrate as well as patches of gravel or small rocks. **(73)** The larger elements are placed as the weight allows based on the structure of the building. The prairie, brownfield and sedum habitats have varying substrate depths including areas that are very shallow with pond liner and gravel or rocks to collect rain water. This gives wildlife access to water on the roof for a period of time.

(74) Local species are used for the woody debris and feather rock used for the boulders. **(75)** Feather rock is a volcanic glass that is lightweight, about 1/3 the weight of an average

boulder. It is also very porous which is beneficial for moisture retention and it could even allow plant growth to take hold onto the rock itself.

(76) Due to the lightweight and movable nature of some of the elements, particularly the woody debris, they will need to be tied down for safety. The wind could blow them off the roof or into a skylight. A metal grid frame provides a base to tie the branches and other materials to.

(77) The general construction of the roof consists of an asphalt waterproofing layer followed by a non-toxic root barrier. On top of that is a drainage layer with attached filter fabric. The drainage layer allows for uniform drainage following the existing roof slope once the water filters through the growing medium. The filter fabric prevents the growing medium from entering the drainage mat. **(78)** The growing medium is part air-filled pore space, part organic matter, part reused, waste or byproducts and part soil. The soil requires the right balance because clay clogs the filter fabric and sand dries out too quickly. Compost should be minimal because of compaction as it decays. Native, local soils could be mixed in, however along with the benefits of the local soil would also come the weed seed bank.

Design: Rock Outcrop

(79) Of the four habitat types the rock outcrop is the one with no precedent. Depending upon the building structure feather rock could be used by stacking boulders and bolting them together. The boulders are carved and lined with filter fabric to create planting pockets for plants while leaving some empty to gather rain water. **(80)** The stacked boulders create recesses that birds and insects can find shelter in. Additionally they may even create a space for bats to roost in. They are placed along walls due to the heavy nature of the material and the walls would help bear the load where the middle of the roof may not have the structure to support the weight. **(81)** Boulders can be found that are large enough to carve recessions deeper than the 4” the rest of the habitats maintain, which would benefit deeper rooting plants.

(82) Should feather rock prove to be too heavy there is an alternative. Replicate rock is often made from fiberglass or other materials and is often used for waterfalls, exhibits and even rock climbing walls. **(83)** It offers the same benefits as feather rock with shelter crevices, pockets for water collection and deeper pockets for plant growth. **(84)** It can be created from a mold and replicated in panels. The underside would be hollow therefore the weight would only be in the fiberglass panel, soil and plant materials.

Design: Prairie

(85) The proposed prairie habitat has mounded substrate depths of the greatest variation relative to the other habitats. **(86)** This creates a mounded topography. Depending on the weight and load bearing of the building's structure, these mounds are distributed accordingly with the deeper mounds over structurally appropriate areas. In other unsupportive locations, to create the topography without the added weight, recycled or reused plastics are mounded under the filter layer. The topography creates a diverse ecosystem with some plants preferring the mounds of deeper soil, while others prefer the low points where more water gathers. The mounds also create small microhabitats in the shady areas behind them.

Design: Brown Roof

(87) While the brown roofs in London were aimed at replacing brownfield habitat, there are elements to the brown roof that are common for many species that are associated with open areas and nutrient-poor, fast draining soils. **(88)** The brown roof habitat has the least amount of plant material and instead contains a large amount of open areas. This habitat also has the least amount of soil with small mounds and low points almost down to the filter fabric with gravel. The majority of the surface is only 2" of soil mixed with recycled materials such as crushed concrete or brick. These areas are ideal shelter for insects and in turn ideal foraging for birds. As with the other habitats, boulders and woody debris are scattered throughout the brown roof areas.

Design: Sedum

(89) The sedum habitat is for the most part the same as what is being constructed around the country. **(90)** The difference in this design is the varying substrate depths and addition of habitat elements. The reason a sedum habitat is part of the habitat diversity plan is that they offer many species with plentiful flowers. There is a variety of flowering sedum species that grow well in this region. Many of these species have been noted to attract bees and other pollinating insects. However, sedums need not be the only plant in this habitat as the goal is to attract insects, other plant species with flowers that attract insects are also incorporated.

Plants

(91) These are some of the plants that can be used in the various habitats. Many of them have not been grown on roofs before and may need to be experimented with before planting them in great numbers. Many of the plants can be used in multiple of the habitats such as the Wild Strawberry. The strawberry has many wildlife benefits such as providing fruit for birds and nectar for insects such as butterflies. The Roemer's Fescue provides wildlife benefits such as nesting or roosting for birds.

Phasing

(92) These two sections are the first phase. The City of Portland has an interest in seeing these two developed and they would be two of the easier sections to complete because there are no skylights. **(93)** The large lower section therefore incorporates all of the habitats in one section so they can be studied in depth. **(94)** The upper section is all sedum partly because it's more difficult to access for maintenance, and in part because it's a large area when covered with flowering sedums can quickly bring insect populations to the roof. Once established, these different habitats could be monitored for use. **(95)** These sections however are different from the rest of the roof because there are no parapets, walls and skylights and therefore no shade or protection from the wind. Because they're unlike the other sections they would not be a true indicator of how the habitat types would perform in the other locations on the roof. However, a study of this area will give a good indication of what habitat is preferred by plant, bird and insect species and a general insight to how each

habitat performs. It also would give a good indication of what technical aspects are working or not working and the overall plan could easily be adapted to correct problems. The lessons learned from the first phase would direct the decision of what order to install the following sections.

Conclusion

(96) The hypotheses highlight expectations about many aspects of the performance of the roof. The benefit is that after monitoring the roof, the hypotheses can be revisited and the design modified. For example the water availability hypothesis states: If elements are added to the design such as low points lined with plastic in the topography, pockets in the rock outcrops and materials that retain moisture such as logs and rocks then there should be adequate water available for the species on the roof such as insects, birds and their chicks. **(97)** Let's say that after the first year those elements are retaining no notable moisture during the hottest two months of the year, July and August. One way to modify the design might be to add a limited and selected drip irrigation system to run periodically in these key locations during those two months of the year.

(98) How were the initial goals achieved? The first goal was to adapt to the existing infrastructure and that was accomplished by creating a design that is built into an existing building with no major structural modifications. **(99)** The second goal was to create a universal design and that was achieved by designing a light-weight system averaging 20lbs per square foot that many buildings could sustain. **(100)** The final goal was to create a design that could be studied, monitored and analyzed and that was achieved with the set of hypotheses that highlight the expectations about how the roof is to perform.

(101) This design contains aspects that are tried and true as well as ideas that are new and untested. The set of hypotheses can lead to monitoring, studying and evaluation of this design and the results and subsequent future designs could lead the entire industry into a new direction. I hope it brings habitat to the forefront when thinking about eco-roofs. I see this design and what's already been done as just the beginning, with many more creative

and innovative ways to incorporate habitat into the urban fabric yet to come. Thank you for coming.