Urban avoidance by Golden Eagles in the Great Basin, U.S.A.

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Abstract

I am presenting the first documented attempt designed to track Golden Eagle (*Aquila chrysaetos*) movements in the Great Basin for evaluation of areas that they avoid. I hypothesize that Golden Eagles are eschewing urban population centers and associated built environments. Traditionally, Golden Eagle research has focused on understanding life-history traits, resource selection functions, and habitat requirements. Understanding the impacts of anthropogenic land-use changes on regional Golden Eagle populations has gained traction in the green energy sector, however, data on the effects of urban sprawl is sparse.

The primary goal of this project is to discern how Golden Eagles are responding to urbanization in the second largest metropolitan area within the northern portion of the Great Basin. We applied GPS-GSM transmitters to 12 Golden Eagles in the region of Reno and Sparks, Nevada. The transmitters update GPS coordinates every 15 minutes, allowing us to analyze movement data in relation to water-impervious built surfaces and human density. Preserving natural resources while humans increase their footprint across the landscape is a modern dilemma that can benefit from regional research within a framework capable of extrapolation.
Dedication

To my grandmother Phyllis, who made me promise to keep working with Eagles, and to my sister Elizabet, who made me promise I’d attend college. As you look down from the heavens and see me with Golden Eagles…. know that I am grateful to live this life.
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Chapter 1. Background

Golden Eagle Life History Traits

Eagles are classified as raptors, derived from the latin term *rapere*, which means to take by force. They are classified as birds of prey, which reflects their hunting prowess, talons, curved and sharp bill, all used to capture and dismantle food. Eagles have keen eyesight and are an apex predator. A Golden Eagle’s wingspan exceeds 2 meters which is only surpassed in North America by the Bald Eagle (*Haliaeetus leucocephalus*) and California Condor (*Gymnogyps californianus*) (Beedy 2013, Sibley 2001).

In the Reno and Sparks areas of Washoe County Nevada, eagle prey mainly consists of squirrels (*Sciuridae* spp.), rabbits (*Leporidae* spp.), marmot (*Marmota* spp.), pika (*Ochotona*), and the occasional bird (Beedy 2013). During the morning, Golden Eagles can be seen contour hunting along ridges and canyons as they descend into valleys. Working a varied topography, eagles ride thermal updrafts and gain orographic lift to climb in altitude and start the process over again (Katzner 2012). Golden Eagles perch on utility poles and other promontories. Although Golden Eagles cannot often gain the speed necessary to overtake avian prey from their perches, rabbits, squirrels and small mammals are still vulnerable to attack (Crossley 2013). Eagle hunting tactics vary, by and large, based on prey availability (Beedy 2013, Scott 1985). Despite having a full arsenal of weaponry, eagles are extremely wary of human (*Homo sapiens*) activity throughout their range (Beedy 2013, Bloom Pers. Communication 2018, Alcorn 1988, Scott 1985).
Golden Eagles are year-round residents in Nevada (Figure 1) and breed throughout the western United States (Beedy 2013, Lukas 2011, Floyd 2007, Chisolm 2002, Alcorn 1988, Ryser 1985). Eagle nests typically exceed five feet in width, occasionally weighing >2000 lbs., and generally are located in remote locations with commanding views of the surrounding area. The nests are often built on cliff ledges, and atypically, in large trees or rock outcroppings (Beedy 2013, Peters 2005, Alcorn 1988).

Golden Eagles reach sexual maturity in their fifth year of age. Adult eagles exhibit elaborate flight displays when courting a partner and defending their territory (Collopy 1984). This undulating flight is characterized by a series of U-shaped dives and is often used as a visual exhibition of power to either deter an intruder entering the eagle’s territory, or solicit a breeding partner (Collopy 1984). Eagles lock talons in the air with potential mates, and with intruders, to force a downward spiral. Golden Eagles are particularly vulnerable during breeding due to prolonged nesting seasons and variable reactions from humans (Scott 1985), as such, Pagel (2010) recommends a one-mile buffer around occupied nests from January through September.

Golden Eagle Research

Eagles primarily use vast tracks of open space, however, data on how eagles move through human dominated landscapes is sparse. Monitoring eagle movements and reproductive behavior is expensive and presents numerous logistical challenges regardless of the scale or extent of the research area.
Species level distributional interpretations have advanced recently at broad spatial scales as technology and innovative practices help to combat the high costs associated with Golden Eagle research (Wiens 2015). At local, finer grain scales, monitoring for eagles benefits from highly trained and certified biologists who are well skilled in locating eagles, their nests, and documenting their behaviors (Driscoll 2015). Nests are often difficult to find due to their remoteness, and novices typically find it hard to identify individual nests and nests clusters (Driscoll 2015). Wiens (2015) emphasized that research on Golden Eagles needs to account for imperfect detection and researchers need to be mindful of the spatial heterogeneity associated with abundance, site occupancy, and breeding success.

White et al. (2018) found no Golden Eagle nests within the city boundaries of Reno or Sparks, although a few were documented on the urban edge of the expanding metropolis. The continuation of urban sprawl in the greater Reno and Sparks areas will undoubtedly infringe upon these known nesting territories and continue to fragment eagle habitat. Golden Eagles can occupy territories for 10 years without producing offspring. Loss of habitat coupled with increased exposure to human activities is a perilous combination for Eagles.

The impacts on landscape connectivity lie in limitations of the Golden Eagle’s perceptual range, which may impose limitations for the dispersal of this species. For species with restricted dispersal, low perceptual range of the potentiality of suitable habitats could result in an ecological trap for the species through limited fitness in varied ecosystems. Phenotypic plasticity provides
species the opportunity for increasing their fitness within these shifts of available habitats. When certain environmental parameters align with spatially explicit needs, a bird’s adaptive capacity and evolutionary traits will either respond favorably to altered habitat, or they will seek more suitable areas. Modeling efforts and conservation strategies are hindered by limited understanding of species dynamics and variable perpetual ranges, and how to quantify them reliably (Lima 1996). Bloom (2011) showed that raptors who return to their natal birthplace for breeding, known as natal philopatry, have higher levels of success than raptors that breed elsewhere. In-depth understanding of regional Golden Eagle dispersal and breeding patterns can help guide research, local development, and conservation strategies pertaining to long-lived birds of prey.

Species-specific research methods at a fine resolution can be scaled up for meta-population analysis and predictions of species-level responses across a wide range of suitable habitats (Wiens 2015). Sub-adult eagles are expected to use landscapes differently than breeding adults, and different aged adults also exhibit varying behavior and landscape needs comparatively. Regional responses to environmental pressures at different locations, times of year, stages-of-life, and breeding phenology, vary with Golden Eagles and other taxa (Collopy 1984, Crandall 2015, Ellis 2013, Katzner 2012, Kochert 2002, LaSorte 2007, Olendorff 1975, Pagel 2010).

Neglecting to ascertain the regional differences in the presence or absence of species would most certainly fail to properly account for species-wide perceptual range, and therefore limit our understanding of habitat suitability.
Comprehensive research on the ecological, evolutionary, and conservation needs of taxa and their associated habitat needs pertaining to natal environments and dispersal, is limited (Fletcher 2015). Individual Golden Eagles may seek out habitats similar to those in their natal environment. Such preferences are often assumed to be important, in part, because settling in habitats similar to natal environments could confer several fitness benefits. Benefits can arise through a variety of mechanisms, such as habitat familiarity or more rapid settlement (Bloom 2011). Understanding the processes leading to natal habitat preferences by dispersing animals can be highly relevant for interpreting animal distribution, population structure, and conservation strategies (Fletcher 2015).

Human disturbance of raptors is a cost prohibitive topic to research at a large scale, and there is limited information available detailing the impacts on species movements. Anthropogenic activities have varying impacts throughout the animal kingdom. Understanding taxa response to regional, human-induced environmental variables is the predominant theme of this research. Analysis of regional data at different scales is fundamental for predicting eagle movements within human dominated landscapes.

The Importance of Biodiversity for Overall Ecosystem Health

Urban expansion directly effects biodiversity through complex interactions such as loss of habitat, lack of connectedness, and the spread of invasive species (McDonald 2018, Clucas 2012). These impacts produce the greatest
hardships for species with limited ranges and proximity to expanding urban areas (McDonald 2018). Reno’s geographical location along the Pacific Flyway designates the area as an important migratory corridor for birds of all sizes (Beedy 2013, USFWS 2018). Situated in the eastern foothills of the Sierra Nevada Mountain Range along the Truckee River, the Reno and Sparks areas attracts a wide variety of migratory and breeding birds (Ebird 2017c). The mosaic landscape pattern in the urban areas provide variable habitat types that offer potential microrefugia for species coping with contracting habitats during periods of climactic uncertainty and rampant development (Hylander 2015). Assessments of bird species richness have been used in adjacent watersheds as barometers of ecosystem health (Young 2013, USFWS 2018), thereby providing valuable data for those concerned with conservation, land management, and development. Continued research on the richness of bird species in Reno and Sparks will provide a barometer of ecosystem health that can be used to inform decisions, and better understand the enduring ecological consequences of human development patterns.

Biodiversity is rich and abundant along the eastern foothills of the Sierra Nevada as the landscape transitions into the high desert Great Basin (McIvor 2005). Multiple microhabitats exist throughout the region inclusive of natural landscapes and those influenced by anthropogenic land-use changes. Human responses to the changing climactic conditions coinciding with habitat-loss and urban sprawl represent the largest threats to biodiversity (McDonald 2018, Clucas 2012). Destruction and exotic species represent significant threats to any
ecosystem, with potential to create the homogenous landscape often found in urban cores lacking habitat connectivity (McDonald 2018). Stress on the regional flora and fauna is a limiting factor on biodiversity. Tolerance to stress is an overlooked and under-appreciated phenomenon, whether it is caused by a changing climate, increased exposure to perceived or realized threats, or an imposed alteration to optimal foraging strategies through land-use changes.

Understanding where the highest rates of biodiversity are, is paramount for land-managers and those seeking to institute conservation measures. It is essential for humans to maintain biodiversity as it provides us with ecosystem services (McDonald 2018). Humans benefit from the ecosystem services provided by a suite of raptor species inhabiting urban, suburban, rural, and exurban areas. The benefits are rodent and pest control in cities and areas with diverse raptor populations. For instance, a Barn Owl (Tyto alba) family with 3 offspring will consume upwards of 786 rodents annually (Wendt 2018). Barn Owls have the potential to produce multiple broods per year dependent upon weather conditions and prey availability. Cooper’s Hawks (Accipiter cooperii) and Peregrine Falcons (Falco peregrinus) are well known for their abilities to hunt pigeon and dove (Columbidae family) populations within urbanized areas (Estes 2003, Peters 2005). Red-Tailed Hawks (Buteo jamaicensis), a generalist species, can successfully hunt multiple species adjacent to the urban core, including, but not limited to marmots (Marmota sp.), shrews (Soricidae family), moles (Talpidae family), voles (Microtus sp.), mice (Heteromyidae family), rats (Heteromyidae family), who may or may not transmit hantavirus, and some are known vectors of
bubonic plaque (White 2018). Red-Shouldered Hawks (*Buteo lineatus*) are adept at catching smaller birds and mammals as they patrol riparian corridors (Dykstra 2001, Bloom 1996) which are a characteristic landscape throughout the City of Reno. The edges created along the riparian areas adjacent to varied habitat types allow for higher rates of biodiversity within ecotones. Swainson’s Hawks (*Buteo swainsoni*) are an open country bird, adapted to agriculture, that forages on ground mammals and other sage-steppe and agriculture obligate species (Beedy 2013, Crossley 2013, Peters 2005, Sibley 2001, Bloom 1996). Northern Harriers (*Circus cyaneus*) and Short-Eared Owls (*Asio flammeus*) need wet, open grasslands to thrive. Their populations are relatively unknown in this region but declines have been reported at migration sites (Personal comm. Allen Fish). Damonte Ranch, Swan Lake and at least one vacant lot in southeast Reno, have a small nesting contingent of Northern Harrier which makes a case for further research of the smaller mesic areas throughout this region. A male Harrier can reportedly sire multiple nests within his breeding territory when prey densities are high (Loughman 1994). This highlights the value of development projects that preserve native habitats while incorporating new habitat features without overcrowding or creating an urbanized monoculture.

Patchwork from the landscape mosaic in the greater Reno area, created by the assemblage of fragmented habitats, supports a diverse suite of raptor species (White 2018), but there is likely a threshold. This increased biodiversity resulting from edge effects associated with highly variable patches could be a temporary byproduct of anthropogenic influenced landscapes interwoven with
endemic habitat types. Observational data, personal commentary, agency personnel, local residents, citizens and scientists suggest growing American Crow (*Corvus brachyrhynchos*), Common Raven (*Corvus corax*), European Starling (*Sturnus vulgaris*), and Feral Pigeon (*Columba livia domestica*) populations in this region, which increases competition for limited local resources. These invasive species are well known as generalists capable of exploiting urban areas and displacing native species. The potential for a trophic cascade becomes viable with compounding exogenous stressors such as introduced species, and it will ultimately decrease biodiversity by way of homogenization.

**Anthropogenic Challenges Imposed on Golden Eagles**

The northern Great Basin has two major metropolitan areas, Salt Lake City, Utah and Reno, Nevada. Reno is the smaller of the two cities with a population of >337,539 (World Population Review 2018), and it is positioned along the Pacific Flyway, a major corridor for migratory birds. Both cities are projected to keep expanding, and are currently experiencing significant population increases. The rapid influx of humans has prompted urban sprawl. Open space in greater Reno is under siege by large housing lots dispersed along the urban edge and outwards towards exurban and rural areas. This type of development increases dependence on cars for transportation whilst increasing the infrastructure needed to link homes with offices and shopping areas (Clucas 2012, DeStefano 2003). The water-impervious surfaces throughout an urban
landscape create movement barriers for multiple species. Clucas and Marzluff (2012) note widespread development with low density is possibly the biggest threat to biodiversity.

In 2015 and 2016 (Figure 2), the southeast area of Reno averaged seven sightings of Golden Eagles. In 2017 (Figure 2), there was only one sighting according to publicly accessible Ebird records (Ebird 2017a). Comparatively, Red-tailed Hawk sightings in the same area and date ranges average <40 per year (Figure 3). These observational accounts, or lack thereof, are reason for concern and justification to increase monitoring. A thorough search of publicly available records pertaining to eagle mortality, similar to that performed by Pagel (2013) was unable to yield any results in the greater Reno area.

The City of Reno has recently finished construction of a 6-lane thoroughfare named the “Southeast Connector”. The roadway is one of many new projects in the area meant to expedite commute times as the city widens, east-west. The only publicly available information on displaced eagles pertains to a Bald Eagle pair that frequently utilized the Rosewood Lakes Golf Course, specifically, a tree that locals referred to as “The Eagle Tree” which has been removed (Damon 2015). There is no information readily available regarding mitigation efforts despite a loss of habitat so vast, it will not likely be suitable for Bald or Golden Eagles. Construction of the “Southeast Connector” was completed in 2018. Development of new homes in southeast Truckee Meadows region is expected to continue well into the future. Bald Eagles are atypical in urban environments and considered a rare sight around Reno. Golden Eagles
however, were more plentiful in previous years, especially throughout the southeastern foothills and canyons (Ebird 2017a).

Increased road density offers more opportunity for anthropogenic induced mortalities on Golden Eagles by way of vehicular collision and habitat loss. Commuters use the airport located in southeast Reno, which increases the opportunity for eagle fatalities. The rapid rise in human population intent on increasing their land-use in the quest for a certain quality of life is steadily depleting scarce natural resources. This over-exploitation is having profound impacts on raptors and their associated habitats (Satheesan 1996, Clucas 2012).

The current reality is the human population of greater Reno is growing, as is the infrastructure needed to support that growth. The demise of eagles, revered enough to share place names and be considered a national emblem, is not just a means to extirpation, it is a violation of established laws. In 1996, David Bird penned that “...progress, for better or worse, is here to stay”. It is increasingly important to expand our knowledge of which species can adapt to rapid environmental change in human dominated landscapes, and which species cannot (Bird 2007).

Residential and rural development along the foothills in the Sierra Nevada Mountain Range are fragmenting once-continuous habitat (Beedy 2013). Additionally, bird species are shifting their distributions in response to habitat reduction caused by a changing climate (Beedy 2013, LaSorte 2007). Local research has shown the greater Reno area as home to a robust Golden Eagle population on the urban edge (White 2017). Development and infrastructure
projects currently underway are positioned to severely limit habitat for these known nesting territories. The lack of nest location data and population estimates for the region can further confound conservation strategies.

Reno is home to several businesses that utilize “eagle” in their name. The commonality in which the term “eagle” is used, suggests there is familiarity with the species in this area. Eagle Canyon Drive, Eagle Place, Eagle Lane, Eagle Meadows Court, Eagle Falls Way, Eagle Creek Court, Eagle Springs Court, Eagle Bend Court, and Eagle Vista are just a few of the roads sharing a namesake (Google Maps Search 2017). The Golden Eagle Open Space area on the Carson River, The Golden Eagle Sports Complex and Golden Eagle Regional Parks in Sparks are located in areas that were once suitable habitat for Golden Eagles. As the Reno and Sparks areas continue to expand their footprint into Golden Eagle territory, it is reasonable to surmise that sightings of the bird will continue to diminish, and place names will serve as the reminder of what was lost.

The Impacts of Climate Change on Golden Eagles

Climate change and urbanization are quite possibly the biggest challenges of our time. Average annual temperatures are expected to rise 10-15% in the greater Reno area by 2070 (Ormsby 2014). Globally, urban areas are expected to grow by 120 million hectares by 2030. Throughout the course human history, the current decade is the fastest period of urban growth (McDonald 2018). How birds respond to habitat changes is important information for land-managers,
irrespective of the type of structure or cause of the habitat loss, it all has compounding effects on biodiversity (McDonald 2018). Urbanization poses its own distinct patterns of habitat transformation and fragmentation, with increased disturbance regimes inclusive of dense human populations. Green energy poses its own distinct patterns of habitat alteration, dependent upon the type of facility needed to gather and transport energy. Urbanization and green energy production offer unique opportunities for research with the potential to create overlapping mitigation measures that address human induced landscape changes.

Responses to environmental pressures emerge as humans and other species adapt. Sensitivity to changing climatic conditions is poorly understood for most species, including raptors. Poleward movements and expansion are expected by several species with colonization events occurring at the northern limits of their current range (LaSorte 2007). The shifts in movement are largely driven by anthropogenic-induced habitat alterations under the conditions of climactic uncertainty. LaSorte and Thompson (2007) concluded that regional drivers and responses to a changing climate will form new biogeographical patterns, which must be taken into account when conducting conservation assessments.

Conservation efforts and anthropogenic land-use patterns can coalesce under the right circumstances. Mosaic landscape patches can potentially offer “safe islands” as migratory corridors, stop-over sites and breeding habitats with increased biodiversity and resource availability commonly found in ecotones. If
we fail to assess and plan for the projected impacts of climate change within our
natural resource management strategies, we can plan to fall short of meeting
conservation objectives (Stralberg et al. 2009).

Unstable environmental conditions associated with species rarity can lead
to decreased species richness and potential extirpation of some species (Boyce
2015). Species dependent on stable resource conditions become more
vulnerable, and at risk, with frequent changes in resource availability. The
confounding effects of urbanization, climate change, species declines, invasive
species, and cascading ecological functions may be detected earlier by using
raptors as barometers of ecosystem health (Boyce 2015). Smaller, fine grain
studies designed to be extrapolated into coarser grain research rooted in
landscape ecological frameworks will help quantify ecological responses in a
spatiotemporal context.

The coming years will impose changes on the landscape, which will also
require those researching raptors to adapt. Interdisciplinary approaches and
collaborative efforts increase our abilities to garner the data necessary for
conservation (Boyce 2015). Raptors, and those who research them, are faced
with increasing frequency of environmental change. New impacts and mitigation
measures reveal a scope of conservation not limited to ecological functions, it
also includes political processes and socioeconomic factors. Communication
skills coupled with sound scientific inquiry need to work in unison for the
promulgation of conservation strategies (Bird 2007). Reliance on Federal laws as
being the primary mode of conservation strategies is not adequate for addressing
the complexity of ecosystem health.

**Laws to Protect Golden Eagles**

Eagles maintain a revered position in the history of America and are a
national emblem of the United States. Thus, special protections exist for these
iconic species. The Bald and Golden Eagle Protection Act (BGEPA), 16 U.S.C.
668-668c, is the main article of law meant to protect this national treasure.
BGEPA was enacted during 1940, and has since been amended multiple times.
The law prohibits anyone from “taking” eagles, their nests, their eggs, and any
part thereof. Within the BGEPA, there are provisions for criminal penalties
associated with violations such as; the sale of, offer of sale, purchase or barter,
export, import, alive or dead, whole or part of a Bald or Golden Eagle.
Essentially, it is illegal to harass, pursue, shoot at, wound, disturb or agitate an
eagle to the degree an injury is caused, breeding productivity is decreased, or
abandonment of its nest during the breeding season (USFWS 2013). The
BGEPA also address anthropogenic alterations to nesting locations when eagles
are not present, if those alterations disturb or interfere with normal breeding
activities, or causes injury. Violating BGEPA can result in fines up to $100,000 for
individuals and $200,000 for organizations. One year of imprisonment can be
added to the fine for first offenses. Violating the BGEPA a second time is a
felony, and fines substantially increase for additional offenses (USFWS 2013).
Within the lines of “take,” otherwise known as death, liability become blurred as causation becomes a problem of the commons. In the fringes of responsibility, vicarious liability comes into question as a plausible course of legal action. The burden of responsibility for “take” could perhaps be assigned as a secondary liability imposed on the governmental agencies, municipalities, and developers responsible for planning, zoning, and enforcing the BGEPA, Endangered Species Act (ESA), Migratory Bird Treaty Act (MBTA), and the National Environmental Policy Act (NEPA). Any person who had the right, duty, ability or foresight to control the actions or activities of the “take” violator, could be held liable for the tort committed (USFWS 2013, McLaren 2005).

The Reno and Sparks Local Area Population (LAP) of eagles may not have the adaptive capacity needed to sustain current land-use alterations. Knowing what laws have applicability to urban sprawl in conjunction with eagle conservation, and how those are enforced, will enable the public to have an active role in preserving this natural resource.

**Enforcement of Environmental Laws**

Defenders of Wildlife vs. EPA (1989) and Sierra Club vs. Yeutter (1991) are two cases in which vicarious liability has been applied to federal agencies. The Defenders case held the Environmental Protection Agency (EPA) liable for registering certain pesticides for permissible use that resulted in “takes”. The Yeutter court found the US Forest Service liable for approving a timber harvest plan that resulted in “takes”. A government agency does not have to exact the
“take” in order to be prosecuted under vicarious liability, however, they do have to approve actions that resulted in “take” (McLaren 2005). Although the “bird acts” exclude citizen suit provisions, a reasonable argument can be made for actions of vicarious liability regarding similar “take” definitions listed by the ESA, MBTA, NEPA and BGEPA.

The Department of Justice (DOJ) used the MBTA in November of 2013 to file the first criminal enforcement action against a wind energy company, Duke Energy Renewable. Duke was charged with 2 Class B misdemeanors for the deaths of 14 Golden Eagles. The United States Fish and Wildlife Service (USFWS) is looking into 17 additional mortalities. Selective enforcement of the “bird acts” could be a factor distinguished by “hard laws” versus “soft laws,” or it could relate to the ethos of the industry or agency in question. Regardless of the reasoning for selective enforcement of the “bird acts,” the laws exist, and enforcement becomes an obligation to the people knowledgeable of the violation(s).

Civil enforcement of illegal “take” or wounding an eagle is gaining traction in California. Civil penalties and settlements mandating research and development are being imposed for current and future protection of eagles. This “framework” is an “innovative solution to a tough conservation issue” (USFWS 2013). Debbie Love Shearwater filed a legal challenge in 2014, citing the USFWS was negligent in its actions to amend incidental take permit durations without a proper Environmental Impact Statement (EIS) or Environmental Assessment (EA) and should not have categorically excluded the process under
the NEPA. The court agreed with Shearwater and the USFWS was instructed to prepare the proper assessments.

**Perceived Gap of Law Enforcement**

The limits of our current conservation strategies lie within the perceptions that rely on biologists to provide data, and laws to enforce scientific understanding. Although the roots of conservation are embedded in biological processes, they are limited in breadth when failing to account for the influences and needs of humans. Unbridled industrialization trampled the environment in the early 20th century, which spawned the environmental movement as we know it (Engel 1996). The barriers between urban and environmental constituents creates friction when determining consumption of natural resources while attempting to preserve ecosystem health. The lack of interdependent environmental and development planning efforts, hampers the quest for a sustainable ecosystem (Engel 1996). Reexamination of the interactions between urban and environmental advocates is needed. The carrying capacity of species is not limited to physical and spatial biological patterns. Therefore, conservation objectives must account for human derived social carrying capacities to reconcile conflicts in conservation goals (Madden 2014).

Dependence upon laws alone, as the enforcement measure of conservation objectives, is outdated. The USFWS has stated that reliance on enforcement of the “bird laws”, as a stand-alone measure, is insufficient for preserving avian species (USFWS 2013). In the push for green energy, lies an
opportunity for enhancing our laws based on the needs of a growing population and the quest for sustainability. Urban planners need a better legal framework to operate from. Local and national policies that adequately and directly address urbanization while preserving biodiversity are long overdue. Human health, in conjunction with optimized ecosystems that do not pose economic disruption to the commons, can and should be a national goal. Overcoming economic and environmental hurdles is currently being attempted by our governing bodies and the green energy sector, and with other birds such as the Greater Sage-Grouse (NDOW 2010).

Green energy developments, and urbanization, demonstrate there has been a lack of policy focused on the integration of our natural resources and climate with energy needs and socioeconomics (Flatt 2014). However, the United States has recognized the need for eagle conservation in the renewable energy sector during the last few years. Subsequently, there have been multiple attempts to bridge the gaps between enforcement of environmental laws and those pertaining to green energy development. In an effort to address these needs, the USFWS developed the Eagle Conservation Plan Guidance (ECPG) document. It provides specific guidance to aid in the conservation of Bald and Golden Eagles during construction and operation of wind energy facilities. This guidance document supplements the agency’s Wind Energy Guidelines (WEG). The WEG serves the purpose of providing an overview for considerations of wildlife pertaining to wind energy producers. What the document does not do, is provide specific details on how to manage for eagles protected by the BGEPA,
and that is where the ECPG fits in. Both documents advise assessing wildlife interactions and completing site-specific surveys during pre-construction phases. Additionally, the ECPG suggests monitoring of the sites during construction and operations. Eagle fatalities are supposed to be reported to the USFWS, tribal, and state agencies, however, ECPG compliance is voluntary (USFWS 2013).

**Chance for Shared Governance of Eagles**

Accepting the anthropogenic toll imposed on avian species is where contention lies. Federal oversight is the norm for protecting eagles, but that is ultimately the shared responsibility of citizens, community leaders, and local policy-makers to ensure species and habitats are protected. Shared goals of conservation need to coalesce into city and county development plans, while adhering to established laws and policy to protect our natural resources. Section 101 of the National Environmental Policy Acts states a goal to; “preserve important historic, cultural, and natural aspects of our national heritage;… [and] achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life’s amenities” (Babcock 2008). Additionally, the NEPA is to “maintain, wherever possible, an environment which supports diversity, in cooperation with State and local governments” (Babcock 2008). Factual claims, empirical data, and rational arguments are not just idiosyncrasies; they are rudimentary in our law, in our culture, and in our belief systems. As one author puts it, “Equality, liberty, and fair process are agreed-
upon national goals such as economic growth, national defense, and public safety” (Freyfogle 2015).

Brunette et al. (2013) suggests using a “commons approach” as opposed to a “commodity approach” when dealing with regulated natural resources involving multiple stakeholders. Development does not have to conflict with wildlife preservation if we strive for a healthy ecosystem. Our current laws and conservation efforts inadequately address sustenance for the human population and preservation of natural resources (Engel 1996). The task of living responsibly within the natural systems of earth is plausible with a commons approach. Failure to do so can lead to a breakdown in the system, and cause societal upheaval (Brunette 2013).

Humans have a profound effect on wildlife through the modifications imposed on the environment, well beyond the direct interactions that influence behavior (Clucas 2012). Urbanization is increasing at a cost to nature, and that cost is being returned to us humans. The relationship between humans and nature has reciprocal feedback loops that demonstrate the need for better integration of socioeconomic factors, human behavior, and legislation, when managing for natural resource conservation (Clucas 2012). We can build on what’s been learned from the power industry in the quest for green energy. Setting our priorities and goals of natural resource management within a commons framework will allow for more meaningful collaborative efforts and cross-pollination from multiple sources, whereas, ideas can grow and blossom into fruitful conservation objectives. Empowered public participation through
citizen science, the commons framework, updated laws and policy, technology and science, are all tools that can benefit the Federal, State, and local authorities charged with managing our natural resources.

Albert Einstein noted, “The significant problems we face cannot be solved at the same level of thinking we were at when we created them” (Covey 1989). The Structure of Scientific Revolutions by Thomas Kuhn introduced the term paradigm shift (Kuhn 1962). A break from old ways of thinking, from tradition, from old paradigms, are how significant scientific breakthroughs happen (Kuhn 1962). New paradigms allow us to see the world through a different lens, which can reveal the changes we need to make in order to achieve different results (Covey 1989). With a paradigm shift in conservation happenings, the literal and metaphorical differences in our climate change, which entitles us a hopeful view that human and environmental rights may become synonymous concepts.

Our approach to valuing the environment and imposing laws that do not evolve to match contemporary values and the economic needs of a growing human population ultimately fail to protect natural resources. Humans are not distinct beings separate from nature and biology. The web-of-life is encompassing and includes humans as an integral part of the process, more in some areas than others. “The ways we think and talk about wilderness are well embedded in modern culture and the debates surrounding it have as much to do with meaning, values and human perception as they have to do with the ever-changing physical world” (Freyfogle 2015). Anthropogenic influence can either be a use of nature, or an abuse of nature. As stated by Aldo Leopold, “The oldest
task in human history: to live on a piece of land without spoiling it” (Leopold 1938).

As with the green energy recommendations imposed by the USFWS, an Eagle Conservation Plan (ECP) for areas adjacent to urban boundaries would be prudent prior to the encroachment on urban edge eagle territories, not just those in the way of energy developments. In 2009, the USFWS set the take limit for Golden Eagles at zero which means any loss must be equally offset through means of compensatory mitigation (USFWS 2013). When development projects move forward without assessing the impacts to eagles, we lose the opportunity to conserve the species and biodiversity. Additionally, we lose the chance to put mitigation measures in place, and project sponsors put themselves in a precarious position that can include fines and jail if laws are broken, and enforced.

Jackson et al. (2009) reminds us “however quickly a comprehensive research program can be implemented, ongoing and future rates of environmental change are likely to outstrip scientific capacity to predict ecological responses and societal capacity to adapt appropriately. Immediate actions to slow down the rates of global change will buy precious time to allow scientific understanding and mitigation strategies to catch up”. The USFWS cannot achieve bird conservation on its own. Collective and coordinated efforts of citizens and affiliated organizations are needed. It is the responsibility of the commons to act on behalf of birds, and put forth meaningful, tangible,
collaborative conservation objectives that also provide educational experiences for current and future generations (USFWS 2018).

Learning to live in a manner that respects the integrity of an ecosystemic ways and means is an age-old conflict for humans, and one where several notable cultures have failed. Degradation of nature resulting from human actions is ultimately what propels conservation efforts and the laws that substantiate those efforts. Now is the time to refocus our agenda of natural resource conservation happening as the result of law and policy, by making it a responsibility of the commons, for the people, by the people. The operations of Earth are complex and vast, and humans are tasked with an evolutionary charge to live in ways respectful, and in accordance with the planets processes (Freyfogle 2015). To resolve some of our land-use issues pertaining to development versus conservation, a paradigm shift must take place within our current policies.

It is paramount for researchers, land-managers, and policy-makers to understand how an apex predator such as the Golden Eagle, responds to increased human development of the landscape. Urban sprawl and human density restrict eagle population growth and represent a threat to breeding territories currently in use, and overall biodiversity in the region. The deficiency in reliable data sets pertaining to population movement patterns hampers efforts to protect species. Kelly (2015) raises awareness of the critical dilemmas of assessing impacts of human related activities on biodiversity, and the lack of primary data. This research addresses those dilemmas, in part with simplified
species-specific primary data that can aid decision-makers. Regional land-use changes influence eagle land-use patterns, and this research highlights some of those patterns.

This thesis project is meant to be a catalyst for an urban paradigm shift in the way development alters local ecosystem processes. Our data show that Golden Eagles from this region are eschewing urban areas and water-impervious built surfaces. Continued development will undoubtedly affect this apex avian predator and trophic cascade becomes feasible if eagles are extirpated.

**Chapter 2. Methods**

**Abstract**

Simply stated, urban growth affects biodiversity. The Reno and Sparks area of Nevada is currently experiencing rapid population growth. As such, housing and infrastructure development is increasing to meet the housing demand. Our research team surveyed the greater Reno and Sparks area for Golden Eagle nests and deployed 12 GPS (Global Positioning Satellites) GSM (Global System for Mobile communications) transmitters on seven male and five female, juvenile, sub-adult, and adult Golden Eagles. We compared the spatial distribution of eagle locations and nests against impervious surface layers with the North American Landscape Characterization Dataset. Resource Selection Functions (RSFs) were used to analyze GPS point distribution relative to urban areas, urban area proximity, percentage impervious and elevation. The vast majority of localities for eagles were closer to urban boundaries than expected at
random, but were less frequently within the urban boundary relative to a random expectation. Four occupied nests were located within the 1.6km buffer for development outlined in the USFWS Golden Eagle Monitoring Protocol and only one produced fledglings over a three-year period. This study uses GPS localities from Golden Eagles to evaluate their spatial distribution in an area experiencing rapid urbanization. Our research of this regional eagle population is meant to provide information on Golden Eagle habitat selection in the Reno and Sparks area, and has implications toward the use of habitat in other areas where the urban boundary encroaches on eagle habitat.

Introduction

Golden Eagle conservation grows more complex as humans expand their footprint across the landscape. Most eagle mortalities correspond to anthropogenic influences with urbanization, land-use issues, vehicle collisions, aircraft collisions, wind turbine collisions, and toxic lead levels composing some of the better-known threats (Hunt 2017, Washburn 2015, Pagel 2013, Katzner 2012, Kochert 2002). As human populations increase, anthropogenically influenced eagle mortalities are expected to rise. Eagle mortalities caused by collisions are well documented by researchers, and witnessed by the general public (Hunt 2017, Washburn 2015, Pagel 2013, Satheesan 1996). For example, throughout the range of Golden Eagles, collisions with aircraft are rising in urban and rural spaces, with an average cost of $103,000 per incident (Washburn 2015). Data from 386 eagles affixed with GPS transmitters showed 56% of eagle
deaths were human caused, 63% of which were adult eagles (USFWS 2013). Those mortality figures are suggestive of population losses outstripping productivity (USFWS 2013). Military and civilian airfields can potentially reduce these costly collisions, reduce eagle mortalities, and further ensure public safety with in-depth understanding of the movement patterns of Golden Eagles within the region.

The impacts of regional urban development on raptor populations is an area of research that has experienced considerable growth in recent decades. White et al. (2018) reported Reno and Sparks, Nevada, USA to have a robust, urbanized, population of Red-tailed Hawks with higher than average reproductive rates. Oliphant (1985) provided research on urban use by Merlins (Falco columbarius) in Canada. Palmer (1988) discussed urban inhabitance by American Kestrels (Falco sparverius) and Poole (1989) detailed changing habitat preferences by Osprey (Pandion haliaetus). In Berlin, Germany, the Northern Goshawk has been researched as an urban inhabitant for over ten years (Rutz 2006). Peregrine Falcons, Cooper’s Hawks and Red-shouldered Hawks have been well documented in urban environments (White, C.M. 2018, Bloom 2011, Peters 2005, Estes 2003, Dykstra 2001, Bird 1996, Bloom 1996, Cade 1988).

With advances in genetic research, Hull et al. (2008) described the western subspecies of Red-shouldered Hawk (B. l. elegans) as having recently experienced a genetic bottleneck that is likely associated with anthropogenic habitat alterations during the 19th and 20th centuries. Contemporary and traditional research methods have highlighted that Swainson’s Hawks show a
tendency to inhabit, and hunt in agricultural areas (James 1992, Bloom 1996, Bradbury 2009). These human induced landscape alterations have contributed to a change in migratory phenology of Swainson’s from the Central Valley of California, as they have adapted to the food subsidy provided by agricultural practices (James 1992, Bloom 1996, Bradbury 2009). While some raptors appear to acclimate well to human dominated landscapes in certain spatiotemporal contexts, there are other birds of prey that do not fare as well. Lincer and Bloom’s (2007) status account for Burrowing Owls (Athene cunicularia) in San Diego County, California, notes habitat reduction and human disturbance as contributing factors to the declining population.

While the field of urban raptor ecology is evolving, primary data on the impacts of human induced landscape changes on Golden Eagles remains sparse. In Bloom’s (1996) account of urban nesting Red-shouldered Hawks, he mentions Golden Eagles as being averse to urban environments that infrequently nest in proximity to urban areas. Scott (1985) details the impacts of human influence and urban encroachment on resident Golden Eagles in San Diego County, California, while Clouet and Barrau (2015) document the extirpation of a few Golden Eagles in Ethiopia resulting from increasing human disturbance. The impacts of urbanization on resident Golden Eagles remain understudied and the collective literature to date is too sparse to make well informed decisions regarding management and conservation.

The objective of this research is to analyze a regional Golden Eagle population as a function of human induced landscape alterations commonly
associated with urbanization. This research details spatiotemporal use of Golden Eagles in a region experiencing rapid population growth. Our aim is to provide insights that should be considered in other regions, and incorporated into larger scale assessments of Golden Eagle population dynamics. We also hope to highlight this understudied aspect of Golden Eagle habitat preference. Conservation strategies for this species will likely benefit from more research in this region, and other Golden Eagle occupied areas experiencing urban growth.

**Study Area**

*Nest Surveys*

The study area for Golden Eagle nests encompasses the urban footprint of Reno and Sparks, Nevada, USA and extended at least 1.6km into the surrounding landscape (Figure 4). The physiographic features of the study area are comprised of non-urbanized, conifer-bearing mountains to the north, west, and east and interconnecting valleys with a mixture of urbanized area, riparian corridor, and desert shrub-steppe habitat. The urban areas are expanding in all directions due to continuing growth of the human population in the area. The Reno and Sparks urban area is comprised of buildings ranging in size from 1-2 story residential and >1 story casinos, apartments, condominiums, and industrial complexes (White 2017) with clusters of high-rise buildings throughout the metropolitan area. The Truckee River flows from Lake Tahoe through Reno and Sparks from west to east, before heading north to its terminus in Pyramid Lake. In 2015, the Reno and Sparks city boundaries contained a population of 337,539
residents, and the total metropolitan area housed between 410,000-420,000 persons (White 2017). The regional plan expects a population growth of 100,000 residents from 2016-2036 which will continue to add more impervious built surfaces by means of housing and infrastructure developments (Truckee Meadows Regional Planning Agency 2017). The metropolitan region is expected to double in size by 2050 (Trammel 2011).

Methods for Nest Surveys

Nest location surveys were conducted from May 2014 through April 2015 as outlined by White et al. (2018). The study area was divided into one square kilometer cells and at least 1 linear km was surveyed in each cell. Collectively more than 8,000 km of linear tracks were investigated for potential nest locations, including all rock structures, cliffs, and large trees within 1.6km of urbanized landscapes. Surveys extended beyond the 1.6km buffer in areas where habitat was deemed suitable. Three Golden Eagle cliff nests, and one nest in a pine tree (Pinus spp.) were discovered at the peripheries of urban development. Aerial surveys were also conducted by experienced Golden Eagle biologists in a helicopter on May 27-28, 2015 (Figure 5) to confirm nest occupancy. The tree nest was not observable by aerial survey so a subsequent ground survey of the tree nest was conducted on May 29, 2015 (Figure 6). In 2016 and 2017, ground monitoring in accordance with recommendations from Pagel et al. (2010) was used to survey occupancy of the four Golden Eagle nests within the study area. Occupied nests were entered by an experienced biologist who applied Federal ID
bands to the tarsus of each eagle nestling (NV Scientific Collection Permit #504341 and USGS Bird Banding Permit #20431, Figure 7). We entered the nests when nestlings were approximately 5-6 weeks of age. GPS-GSM transmitters were applied to each of the two brood members from the tree nest clutch in 2017.

Methods for Capturing Golden Eagles

In November of 2015, three sites were used to deploy bait stations (Figure 8) with mule deer carcasses (*Ococoileus hemionus*). The carcasses were road-kill collected from Highway 395 north of Reno (CA Scientific Collecting Permit for Deer Carcass Transportation #SCP00021). Eight mega-pixel Bushnell TrphyCamHD trail cameras with night vision were used to monitor the mule deer carcasses for eagle presence. Trail camera photographs showed all three of the bait stations were actively used by multiple Golden Eagles (Figure 8). The active sites were just inside California, adjacent to Hallelujah Junction on Highway 395, near Red Rock Road and Turtle Mountain north along Highway 395. We set up remote fire bow-nets (Figure 9) as described by Bloom et al. (2015) to capture Golden Eagles for transmitter attachment. Six Golden Eagles were captured during the winter of 2015-2016, four eagles were captured during the winter of 2016-2017, and two nestlings were hand-captured from their nest in June of 2017. Federal ID bands and GPS-GSM transmitters were mounted (Figure 10) with the same techniques used by Miller et al. (2017). GPS movement data was recorded in 15 minute intervals and uploaded daily.
Methods for Locality Data Analysis

**Locality Data Study Area**

The study area extent for locality data was defined by GPS locations from 10 Golden Eagles affixed with transmitters (Figure 11a). The most northern point recorded was near McDermitt, NV. (N41.99090, W-117.704099) along the Oregon border. The eastern extent was adjacent to Tonopah, NV. (N38.099649, W-117.248229). Graeagle, CA. (N39.752457, W-120.645527) represented the westernmost point. The southern limit was near Olancha, CA. (N36.269787, W-118.001258). Of note, no eagle points were located on the western slope of the Sierra Nevada. A polygon was constructed from a union of the minimum convex polygons bounding GPS locations from each of the 10 eagles. The minimum convex polygon comprised the analysis region for Golden Eagles relative to a random expectation (null model) reflecting an area potentially occupied by the birds in this study (Figure 11b).

**Locality Covariate Data**

Covariates for the Resource Selection Function (RSFs) were acquired from two sources. The Elevation dataset (resolution 30 m) was acquired from the USGS National Elevation Dataset (NED 2018). Adjacent tiles were merged using GRASS GIS (v 7.4 Grass Development Team 2018). The Percent Impervious Surfaces dataset (resolution 30 m) was acquired from the USGS National Land Cover Dataset (NLCD 2011). Urban areas were defined as a binary calculation
where 0 = Percent Impervious <20, and 1 = Percent Impervious >=20. Distance to Urban was calculated as the distance to Urban Areas (distance function in raster package v 2.6-7 in R). Log Distance to Urban, and Log Percent Impermeable were calculated using the natural log + 1, to account cells with zero values.

Subsequent analyses were conducted in R Statistical Programming Language within RStudio 1.1.4. From the 12 eagles equipped with GPS trackers, we eliminated GPS data from one highly nomadic male sub-adult Golden Eagle and one eagle that died early in the study. RSFs using Generalized Linear Models (GLMs) were constructed to compare eagle locations against random locations relative to a suite of potential covariates (Table 1). A bootstrap analysis of 1000 iterations (N=1000) using five-hundred random points selected from each eagle’s GPS locations (totaling 5000) and 500 random points selected from within the study area polygon (using spsample, package sp v1.3-1) was performed. For each iteration, fifteen GLMs were run to evaluate the habitat attributes selected by eagles compared to random points from within the defined study area (Table 1). Covariates included – Elevation, the log of Impervious Surfaces (%), NLCD 2011, Urban Areas (calculated as impervious surfaces >20%, expressed as a binary 1,0), and the log of distances to Urban Areas.

Results of Nest Surveys

Four Golden Eagle breeding territories within 1.6km distance of urban development were surveyed for nest occupancy in 2015, 2016, and 2017.
One cliff nest cluster is in Damonte Canyon (Figure 5), one cluster in Hidden Valley (Figure 12), one cluster in Spanish Springs (Figure 7), and one tree nest was located in protected open space on Peavine Mountain (Figure 6). Two eagles fledged from each of the cliff nests in 2015 and three eagles fledged from the tree nest. In 2016 and 2017, the three cliff nest territories were unoccupied and development had encroached to within 0.5km of the previously occupied nests (White 2017). Two eagles fledged from the Peavine Mountain tree nest in 2016, and in 2017. Our surveys revealed increased development pressures coincided with vacancy of three previously successful Golden Eagle breeding territories.

Results of Locality Data Analysis

As determined by Akaike Information Criterion (AIC) values from the 1000 models run to evaluate the habitat attributes selected by eagles, three of the 15 models were repeatedly selected as the best models (Table 1). Each of these models had similar coefficients, and relationships with respect to selected habitat vs. random habitat (Table 2). The top model was Elevation by Distance to Urban in 568 of the 1000 runs (Table 1). This model showed eagles selecting locations closer to urban, and with lower impermeable percentage, and higher elevations than random locations. There was a negative association with distance to urban, indicating that eagles were at slightly higher elevations as they were closer to urban areas relative to random sites (Table 3). This is likely due to the location of urban areas within the study area being geographically located at valley bottoms.
The second best fit model was Distance by Impermeable in 358 of the 1000 runs (Table 1). This model showed a negative coefficient on distance to urban, where eagles selected locations closer to urban than expected at random, and with lower impervious values. Both of these trends are in the same direction as the higher selected model (Table 2). Random points tend to be located on areas of greater impermeability as compared to eagles (Table 4).

The final model, Urban by Distance to >10 percent impermeable was selected in 74 of 1000 runs (Table 1). This model similarly had a negative coefficient for distance to urban, where eagles selected locations closer to urban than expected at random, and a negative association with the binary urban variable where eagles selected points within urban areas significantly less often than expected at random (Table 2).

Collectively each of the three models indicated that eagles selected locations closer to urban areas, but were less often within an urban boundary (Table 2, Model 3), or within areas of increased impermeability (Table 2, Models 1 and 2). P-values for all three models were <.001. Averages for the 1000 iteration model runs also indicate Golden Eagle aversion to urban areas and impervious surface along with a preference for lower elevations (Table 3).

Discussion

Golden Eagles in this region use habitat in proximity to urban areas, however, they are not using urban areas. The proximity to urban is an important consideration (Figure 13) as there could be an edge effect that changes the
trophic structure of prey, and may offer prey resources that attract Golden Eagles. White et al. (2018) documented prey variability in nesting Red-tailed Hawks in Reno relative to urban density. The study showed a compositional change in the prey delivered to nests across an urban gradient. The closer Red-tailed Hawks were to the urban core, prey diversity decreased, mammalian prey deliveries decreased, while avian prey deliveries increased. This eludes to a threshold within urban areas for typical prey of Golden Eagles. Observations from nest surveys eluded to potentially overlapping populations of Cottontail (Sylvilagus spp.) and Black-tailed jackrabbits (Lepus californicus) on the urban edge. The limited scope of this project combined with the lack of Leporid data in this region did not afford the opportunity to research the topic further.

Since the cities are situated at lower elevations sloping from west to east, elevation has the potential to become less important for analysis in other regions. For example, if this study area encompassed Las Vegas, Nevada, the relationship between elevation and distance to impervious surface could be less significant due to an abundance of lower elevation habitat surrounding the greater Las Vegas region. Future research with a much larger spatial extent encompassing an area the size of the Great Basin, USA may find elevation to be less of a contributing factor to Golden Eagle presence.

White et al. (2018) documented Golden Eagles in the Reno and Sparks area as inhabiting the lowest urban density threshold of all recorded raptors. Of the four monitored nests in this study, only the tree nesting pair produced fledglings in all three years. It is also the only territory within protected open-
space. The other three cliff nest territories were vacant in the latter two years of this study. The vacancy of previously productive breeding territories coincided with development encroachment (Figure 14) within the widely accepted buffer outlined by Pagel et al. (2010). This research also gives credence to the work of Scott (1985) in San Diego, County, the findings of Clouet and Barrau (2015) in the Bale Mountains of Ethiopia, and the assertion by Bloom (1996) that Golden Eagles have low tolerance of anthropogenic activity, and their breeding attempts near the urban wildland interface are often temporary. The impacts of urbanization on Golden Eagle breeding behavior, prey availability, displacement, and locality, warrant’s future research.
References


Executive Summary

Golden Eagles in the Washoe Valley are avoiding urbanized areas. We deployed 12 GPS transmitters on Eagles in this region to document their movements during the course of 3 years, and 99% of the data is outside the urban boundary. Four occupied Golden Eagle nests on the urban edge were discovered in 2015. Three of those nests have failed to produce any young since, as development has encroached upon a widely accepted buffer. Our research found another 50 nests in outlying areas that were beyond the scope of this project.

As the greater metropolis of Reno and Sparks continues to grow in population, and size, it is reasonable to surmise that further impositions will be placed upon the local area population of Golden Eagles. Research has shown that widespread development with low density, is one of the biggest threats to biodiversity. The highest rates of mortality for Golden Eagles, are caused by human influences. Although there are federal laws that protect Eagles, enforcement on private lands is virtually non-existent. Preservation of this iconic natural resource, regionally, will have to come from a paradigm shift in the way local government balances the needs of an expanding human footprint against health of the ecosystem.

Adopting a “commons” based approach to development, as opposed to a “commodity” framework, has been suggested as a means of dealing with regulated natural resources involving multiple stakeholders. Development does not have to conflict with wildlife preservation if we strive for a healthy ecosystem.
Human and environmental rights can become synonymous concepts. Minnesota has incorporated bird-safe building codes that reduce hazards, conserve vital habitat, and protect natural resources. Several other cities, and states, have joined a program sponsored by the U.S. Fish and Wildlife Service, called the Urban Bird Treaty.

Public opinion surveys conducted by the Truckee Meadows Regional Planning Agency have shown that protection of natural resources, and quality of life, are top concerns. Indeed, this area boasts of natural splendor and access to a variety of outdoor recreational opportunities. Nature based tourism is the fastest growing segment of the travel industry. It is paramount in this time of Reno’s transition from a gambling destination to an outdoor recreation destination, we don’t lose sight of our most valuable resource, which is a healthy ecosystem.

Reno’s geographic location along the Pacific Flyway, designates the area as an important migratory corridor for birds of all sizes. Research has also shown higher rates of biodiversity within the city, compared to outlying areas. Working collaboratively with local and regional governments, NGO’s, and agencies, to develop partnerships that focus on conservation within the urban setting, is the commons based approach mentioned earlier. The Urban Bird Treaty program provides a framework and funding that support educational opportunities, restoration activities, and urban conservation strategies.

Taking a systems approach to conservation that is mindful of socioeconomic functions is holistic, and can be extrapolated into other regions,
as showcased by Minnesota, Wisconsin, and partners in the Urban Bird Treaty. Protections for Eagles and other birds already exist; however, they are not enforceable at the extent needed to preserve regional populations. Empowering local governments and citizenry to establish conservation objectives in concert with federal laws is what will make sustainable development a responsibility of the commons. We have partnered with the Lahontan Audubon Society, Truckee Meadows Parks Foundation, the Great Basin Bird Observatory, the Nevada Department of Wildlife, and others to work towards earning a designation as an Urban Bird Treaty City.

Please consider joining our coalition in taking responsibility for the protection of natural resources, quality of life, and economic growth, for the commons. Together, we can create the change we want to see, and ensure future generations of peoples and wildlife, continue cohabitating in this beautiful place we all call home.
## Tables

(Table 1. Model Rankings of 1000 iterations of bootstrap analyses of Resource Selection Functions.)

<table>
<thead>
<tr>
<th>Model</th>
<th>Number of Selections (from 1000 Bootstrap runs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevation * log(Distance to Urban) + log(Impervious Surfaces)</td>
<td>568</td>
</tr>
<tr>
<td>log(Distance to Urban) * log(Impervious Surfaces)</td>
<td>358</td>
</tr>
<tr>
<td>Urban + log(Distance to Urban)</td>
<td>74</td>
</tr>
<tr>
<td>Urban + Elevation</td>
<td>0</td>
</tr>
<tr>
<td>Urban * log(Distance to Urban)</td>
<td>0</td>
</tr>
<tr>
<td>Urban (binary 1,0)</td>
<td>0</td>
</tr>
<tr>
<td>log(Impervious Surfaces (% - continuous))</td>
<td>0</td>
</tr>
<tr>
<td>log(Distance to Urban) + log(Impervious Surfaces)</td>
<td>0</td>
</tr>
<tr>
<td>log(Distance to Urban)</td>
<td>0</td>
</tr>
<tr>
<td>Elevation + log(Impervious Surfaces)</td>
<td>0</td>
</tr>
<tr>
<td>Elevation + log(Distance to Urban)</td>
<td>0</td>
</tr>
<tr>
<td>Elevation * log(Impervious Surfaces)</td>
<td>0</td>
</tr>
<tr>
<td>Elevation * log(Distance to Urban)</td>
<td>0</td>
</tr>
<tr>
<td>Elevation</td>
<td>0</td>
</tr>
<tr>
<td>Intercept Only (null)</td>
<td>0</td>
</tr>
</tbody>
</table>
### Table 2. Average model coefficient. ***=p<.001

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1 coefficient</th>
<th>Model 2 coefficient</th>
<th>Model 3 coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>logDist2Urban</td>
<td>-0.05440 ns</td>
<td>-0.13221 ***</td>
<td>-0.13053 ***</td>
</tr>
<tr>
<td>logPct_Imperm</td>
<td>-1.06430 ***</td>
<td>-1.00602 ***</td>
<td>-</td>
</tr>
<tr>
<td>Elevation</td>
<td>0.00026 ***</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Elevation x logDist2Urban</td>
<td>-0.00004 ***</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Urban_101</td>
<td>-</td>
<td>-</td>
<td>-5.13912 ***</td>
</tr>
</tbody>
</table>

### Table 3. Average Values of 1000 iterations.

<table>
<thead>
<tr>
<th>Points</th>
<th>Points within an urban area</th>
<th>Average distance to urban in meters</th>
<th>Percent of Impervious Surface</th>
<th>Elevation meters</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 = random</td>
<td>0.7 %</td>
<td>3003</td>
<td>2 %</td>
<td>1768</td>
</tr>
<tr>
<td>1 = eagles</td>
<td>0.07 %</td>
<td>2141</td>
<td>0.2 %</td>
<td>1727</td>
</tr>
</tbody>
</table>

### Table 4. Example of percent impermeable comparison of randomly selected points within project extent and random eagle GPS points. 1 of 1000 iterations.

<table>
<thead>
<tr>
<th>Percent Impermeable</th>
<th>21</th>
<th>22</th>
<th>24</th>
<th>25-35</th>
<th>36-45</th>
<th>48-59</th>
<th>61-87</th>
</tr>
</thead>
<tbody>
<tr>
<td>random</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>10</td>
<td>9</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>eagle</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
(Figure 1. Nevada state map showing areas of Golden Eagle presence in dark purple, and presumed areas of eagle habitat in light purple.)
(Figure 2. eBird sightings of Golden Eagles in Reno and Sparks from 2015-17)
(Figure 3. eBird sightings of Red-tailed Hawks in Reno and Sparks from 2015-17)
(Figure 4. Project area extent of nests surveyed in Reno and Sparks Nevada)
Figure 5. Two nestlings from the Damonte Canyon cliff nest. Photograph was captured during aerial surveys for occupancy 28 May 2015.)
(Figure 6. This is the Peavine Mountain tree nest. This nest was not observable by aerial surveys on 28 May 2015. This photograph was taken during a ground survey to determine occupancy Federal ID bands were applied to three nestlings in 2015, two nestlings in 2016 and two nestlings in 2017. GPS-GSM transmitters were applied in 2017 to both nestlings)
(Figure 7. Two nestlings from the Spanish Springs nest in 2015. Photograph was captured by Joe Papp after he applied Federal ID bands.)
(Figure 8. Golden Eagle detected by trail camera at one of three deer carcass bait stations.)
(Figure 9. Pete Bloom about to remove two Golden Eagles from the remotely fired bow-net.)
(Figure 10. Pete Bloom and Zachary Ormsby affixing a Golden Eagle with a GPS-GSM transmitter with a backpack style mount.)
(Figure 11a. Project area extent as defined by eagle GPS points and configured with union of convex hulls from each eagle’s locality data. Figure 11b. Sample of 5000 random GPS points and 5000 randomly selected points from within the project area extent.)
(Figure 12. Hidden Valley cliff nest containing 2 nestlings. Photograph was captured from the ground in 2015 while Joe Papp entered the nest to apply Federal ID bands.)
Distributions of Locations Near Urban Areas

(Figure 13. Distribution of Golden Eagle Distance to Urban Areas)
(Figure 14. Photograph is from the ridge above the nest in Spanish Springs, 2015. Development has continued to encroach upon this breeding territory.)