Rock Pigeons of Portland, Oregon: 10 Year Management Plan (2018-2028)

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Photo Credit: Kaiden J. Hill – 2017

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TABLE OF CONTENTS

EXECUTIVE SUMMARY

Rock pigeons (*Columba livia*) of the family *Columbidae* are urban exploiters with a worldwide distribution. Pigeons commonly present a management issue in urban areas due to their high density and opportunistic feeding habits. Rock pigeons are not protected under the Migratory Bird Treaty Act as they are non-migratory however, their versatile nature as wild, feral, and domestic stock tends to lead to their exclusion from hunting seasons and similar legislation. Property damage caused by pigeons in Portland is intensified in areas where the birds roost such as the site of a deconstruction grant program where roosting pigeons caused irreparable damage to over 66% of previously recoverable siding material. The view of pigeons as a nuisance by residents and the potential for disease transmission to people add to human-pigeon conflict within Portland. At its current trajectory, the rock pigeon population of Portland, Oregon will continue to rise above the social carrying capacity until it reaches the biological caring capacity. The goal of this management plan is to reduce human-pigeon conflict in Portland, Oregon. This goal requires a reduction in the population size of pigeons in the city, a reduction in pigeon related damages to public and private property, a decrease in disease transmission potential of the pigeon population, and offering a controlled opportunity for human pigeon interaction.

NATURAL HISTORY

Rock pigeons are distributed worldwide and live in grasslands, cities, and as domestic stock of breeders or pigeon fanciers. Urban pigeons, also known as feral pigeons or street pigeons, are not genetically distinct from other rock pigeons however, they do exhibit a distinctive natural history due to their integration into urban centers.

FOOD NEEDS

Urban rock pigeons are granivorous birds that may feed opportunistically in the urban areas where they reside or in agricultural fields surrounding the city (Johnston and Janiga 1995). Rock pigeons have idiosyncratic feeding habits and populations tend to express a foraging producer-scrounger system (Brown 1969, Giraldeau and Lefebvre 1986, Biedermann et al. 2012). Individuals require between 30 and 50 g of water intake a day and tend to adhere to a bimodal drinking schedule (Johnston and Janiga 1995). Diet composition varies with age, with hatchlings consuming protein and lipid rich crop milk in the first week of life, carbohydrate rich crop milk after the first week, and transitioning to grains post-fledge (Janiga 1991). Diet composition of pigeons tends to be high in protein and reflect the regional agriculture and varies with changes in agriculture production seasonality (Johnston and Janiga 1995). Urban pigeons get a portion of their diet from human feeding (Spennemann and Watson 2017) however, seasonally they tend to forage in recently harvested agricultural fields of maize, peas, or grains during the summer months, with a preference for oily seeds in fall and maize in the winter (Lawson 1979, Johnston and Janiga 1995). While pigeons have a strong preference for sunflower seeds and peas when present, individual diets, even within a single population, vary in composition (Biedermann et al. 2012, Spennemann and Watson 2017). In cities with shipping docks, pigeons can be found feeding on seeds year-round (Murton et al. 1972) and occur in high densities in areas of food spillage and organic waste are abundant (Spennemann and Watson 2017). During the winter months, urban populations of pigeons seek out grain elevators, locations of seed spillage, and factories where seeds are handled and become opportunistic and resort to eating garbage if snow cover is deep and persistent in early spring when seed availability is limited (Johnston and Janiga 1995).

Cover Needs

Rock pigeons as traditionally a grassland bird however, they are also an urban exploiter and a common resident of cities (Canole 2014). Individual pairs or large colonies seek out cave like dark openings in which to build their nest and once established become site attached (Johnston and Janiga 1995). Each year half of the juvenile population disperses from their home loft and become established elsewhere (Hetmanski 2007). Once established, sexually mature adults rarely relocate to a different loft or colony and in both daily activity and experimental displacements, pigeons have been found to use a combination of solar, magnetic, and visual cues to navigate back to their roost (Wiltschko and Wiltschko 2001, Hetmanski 2007). These nest sites serve as the roost site year-round and are commonly found in eves of buildings, air shafts, towers, abandoned buildings, or other man-made structures that provide a dark and wind shielded opening (Johnston and Janiga 1995). Peregrine falcons (*Falco peregrinus*) depredate pigeons, however tall buildings interfere with their maneuverability and can give pigeons the opportunity to out maneuver a falcon and escape to their roost site (Ellis et al. 2004).

Disease

Pigeons are host to and vectors for a wide variety of diseases that range in impact from mild irritation to flock wide mortality. Ectoparasites such as chewing lice are widespread in pigeons and are found at the base of feathers and are spread through contact and can persist in nesting material or roosting areas (Whiteman and Parker 2004, Galloway and Palma 2008). Lice cause limited irritation however a severe infestation can compromise an individual's immune system leading to weight loss and lethargy (Whiteman and Parker 2004, Galloway and Palma 2008). Viruses, internal parasites, and fecal diseases tend to result in impacts on population biology. Viruses including West Nile and Newcastle exhibit infrequent outbreaks in pigeon populations and is often fatal (Alexander 2000, Kilpatrick et al. 2007, Teske et al. 2013, Chancey et al. 2014). Columbid herpesvirus causes lesions in the digestive and respiratory tract reducing fitness of infected individuals (Aini et al. 1993, Woznaikowski et al. 2013). Trichomonad parasites are readily spread through shared food and water and feeding of young causing diphtheroid necrotic inflammation in adults and nest mortality in young (Cole 1997, Lennon et al. 2013). Ornithosis, a widespread fecal disease spread through feces and nasal discharge, tends to occur in wet weather in late fall and winter and has a mortality rate of 30 to 50% (Centers for Disease Control 1998).

Due to the scale of their movements and susceptibility to a wide variety of diseases, pigeons are host to several viruses that have implication on other wildlife and domestic livestock. High mortality is seen in falcons (*Falconidae*) that eat pigeons infected with Columbid herpesvirus, and in birds (*Aves*) and domestic horses (*Equus caballus*) that contract West Nile, a disease for which pigeons are a vector (Aini et al. 1993, Kilpatrick et al. 2007, Woznaikowski et al. 2013, Chancey et al. 2014). Domestic poultry are particularly prone to contracting Newcastle from pigeons if biosecurity measures are not in place (Alexander 2000, Teske et al. 2013). Biosecurity and regular cleaning of communal feeding areas for wild birds are important for control of these diseases.

Close proximity to people in urban areas also presents a high risk of transmission of diseases from pigeons to people. West Nile may cause severe illness or death in people however, generally the effects of pigeon vectored diseases are typically less severe than on wildlife and livestock (Kilpatrick et al. 2007, Chancey et al. 2014). Pigeon diseases that do commonly present problems for people are the fungal diseases Orithosis, Histoplasmosis, and Cryptococcosis that occur in buildups of feces and contaminated soil (Centers for Disease Control and Prevention 1998, Centers for Disease Control and Prevention 2015,

Centers for Disease Control and Prevention 2017). In people, Orithosis may cause pneumonia, Histoplasmosis may result in fatigue, and immunosuppressed individuals may experience effects from a Cryptococcosis infection (Centers for Disease Control and Prevention 1998, Centers for Disease Control and Prevention 2015, Centers for Disease Control and Prevention 2017). While outbreaks can cause significant harm to people in urban environments, outbreaks are infrequent and do not present a significant risk to people on a daily basis (Johnston and Janiga 1995).

POPULATION BIOLOGY

A population model of the Portland, Oregon rock pigeon population was developed using a stage-based model. A stage-based model allows for use of discrete life stages and varied survivorship of eggs, hatchling, fledglings, juveniles, and adults (figure 1). The stage-based model used assumes a 50:50 sex ratio which is exhibited by pigeons (AshrafulKabir 2014). Incubation of each clutch of 2 eggs typically takes 18 days (Johnston and Janiga 1995, Johnston 1998, Link 2005, Avery et al. 2008, Johnsgard 2009). In mild latitudes adult pigeons may breed year-round and have 10 to 12 clutches in a year however in latitudes similar to Oregon 5 clutches a year is more common (Johnston and Janiga 1995, Link 2005, Johnsgard 2009, Lowther and Johnston 2014). Around 4.5% of juveniles may also attempt to breed with low success, and do not significantly contribute to the population (Hetmanski 2004). Survivorship of eggs varies with an average of 77% of eggs successfully hatching (Johnston 1998, Lowther and Johnston 2014). An average of 56% of hatchlings survive to fledging (Johnston 1998, Lowther and Johnston 2014), which occurs around 30 days of life (Johnston and Janiga 1995, Johnston 1998, Johnsgard 2009). From fledgling to adult an average of 57% of individuals survive however, it is necessary to distinguish between fledgling a juvenile survival as survivorship is significantly higher for 6 to 11-month-old juveniles than for recently fledged individuals (Johnston and Janiga 1995, Hetmanski 2004, Lowther and Johnston 2014). In the closely related Eurasian collared-dove (*Streptopelia decaocto*) fledgling survivorship is 61%, largely due to predation (Eraud et al. 2011). Given that 61% of fledgling survive to become juveniles, that 57 % of initial fledglings survive to one year of age, and that post-fledging survivorship of mourning doves nears 99% 6 weeks post fledging, juvenile rock pigeons likely have a survivorship rate of 93% (Eraud et al. 2011, Lowther and Johnston 2014). Adult rock pigeons live an average of 2.4 years in the wild although it is not uncommon for pigeons to reach 5 years of age and have an average annual survival rate of 65.5% (Lowther and Johnston 2014). In 2017 1,878 rock pigeons were counted during a total of 288 party hours in Portland, Oregon during the December Christmas Bird Count (Christmas Bird Count 2017). Given that about 10% of the population would be juveniles and 90% adults, the population of rock pigeons in Portland, Oregon in 2017 can be estimated at 188 juveniles and 1,690 adults (Hetmanski 2004, Christmas Bird Count 2017). Given this input in the stage-based population model matrix, the pigeon population of Portland, Oregon will rise over the next 10 years (figure 2, *table 1 in appendix*). When analyzed for sensitivity and elasticity, the matrix indicates that hatchling and fledgling survivorship have the greatest influence on the population dynamics (*table 2 in appendix*).

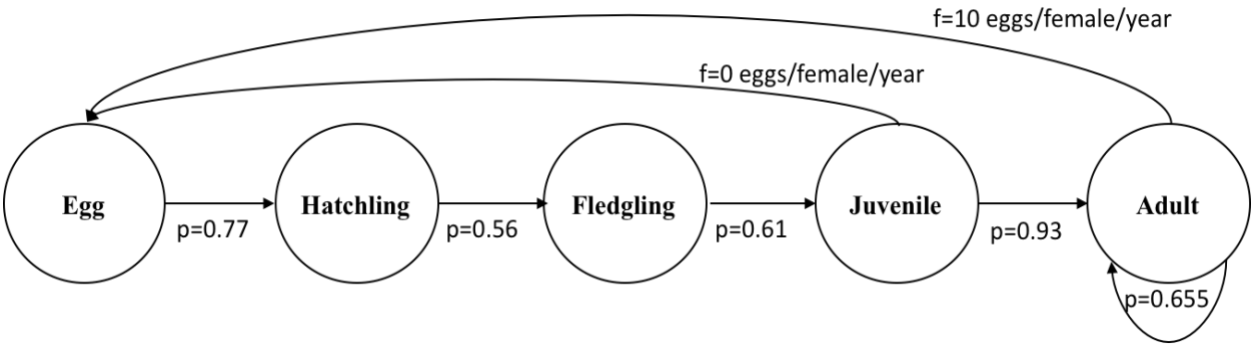

FIGURE 1. Stage-based population model visualization for rock pigeons of Portland, Oregon. Survivorship (p) is 77% for eggs [25][29], 56% for hatchlings [25] [29], 61% for fledglings [19], 93% for juveniles [19] [29], and 65.5% for adults [29]. The average lifespan for urban rock pigeons is 2.4 years although it is not uncommon for them to reach 5 years of age [29]. The stage-based model used assumes a 50:50 sex ratio which is exhibited by pigeons [3]. Incubation of each clutch of 2 eggs typically takes 18 days [4] [23] [24] [25] [28]. In mild latitudes adult pigeons may breed year-round and have 10 to 12 clutches in a year however in latitudes similar to Oregon 5 clutches a year is more common [23] [24] [28] [29].

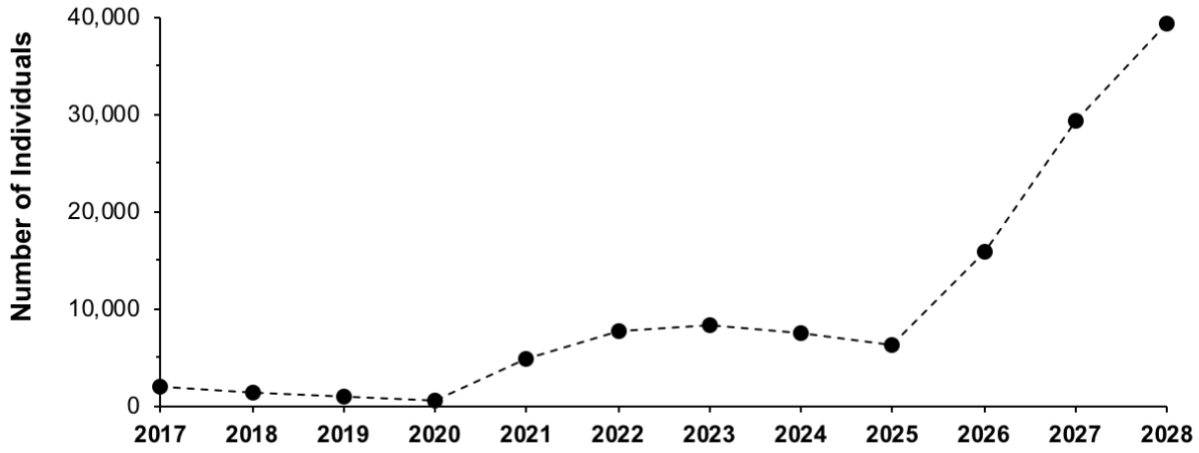

FIGURE 2. Stage-based population trajectory for the total population of adult rock pigeons of Portland, Oregon in December from 2017 to 2028 given a starting population of 188 juveniles, 1,690 adults, and without consideration for biological carrying capacity (Hetmanski 2004, Christmas Bird Count 2017).

STATEMENT OF NEED

Rock pigeons of Portland Oregon are in need of a comprehensive management plan. Pigeons are in conflict with the human population of Portland due to the economic and sociocultural issues they impose (Environmental Services 2005, Office of Management and Finance 2010, Bureau of Planning and Sustainability 2017).

Economic Issues

Invasive birds, including rock pigeons, cause economic damages to agriculture, human health and safety, and property more frequently than mammals or reptiles and amphibians (Bergman et al. 2000). Of 25 species of invasive birds, rock pigeons caused the second most in total damages at 12.7 million dollars, a majority of which was property damage, as reported to the Animal and Plant Health Inspection Service's Wildlife Services Program during the fiscal years 1990 to 1997 (Bergman et al. 2000). During this time, rock pigeons caused damages in all 50 states at an average of 1.6 million dollars a year (Bergman et al. 2000). In Portland, pest management services are contracted out and under the contract rock pigeons are explicitly included and qualify for emergency and special services provisions in the event that pigeons pose an urgent threat to health and safety (Office of Management and Finance 2010). Property damage caused by pigeons in Portland is intensified in areas where the birds roost such as the site of a deconstruction grant program where roosting pigeons caused irreparable damage to over 66% of previously recoverable siding material (Bureau of Planning and Sustainability 2017). Pigeons also congregate around grain processing sites and must be taken into consideration by facility operators and in planning for facility repurposing (Land Use Services 2013).

In Oregon, 14 of 35 state permitted wildlife control operators work with pigeon exclusion and removal (Oregon Department of Fish and Wildlife 2018). Wildlife control companies list pigeon nests, noise, and droppings as the main causes of damage and nuisance for which clients request their services for pigeon removal or exclusion (Premier Rodent and Bird Proofing 2015, Wildlife Control Services 2015, Bird Barrier 2018, Professional Wildlife Removal 2018). Nests can block gutters, drains, ventilation systems, and present a fire hazard and large numbers of pigeons can drive off customers from businesses and disturb sleeping residents (Premier Rodent and Bird Proofing 2015, Wildlife Control Services 2015, Bird Barrier 2018, Professional Wildlife Removal 2018). Droppings present additional potential for damage as a buildup of feces can collapse ceilings or roofs and even a small amount of feces can damage machinery, car finishes, transmit disease, and ruin products in warehouses (Premier Rodent and Bird Proofing 2015, Wildlife Control Services 2015, Bird Barrier 2018, Professional Wildlife Removal 2018). Hiring a wildlife control company to install exclusion measures to prevent pigeons from colonizing a home or warehouse and causing damage can range from a few hundred dollars to a few thousand dollars (Professional Wildlife Removal 2018).

Sociocultural Issues

Rock pigeons are a nonnative species in the United States however, it can be confused for being a native species due to it prevalence and long history in the country (Fitzwater 1988). Regardless of its long-standing residency, in 1988 71% of pest control customers identified pigeons of the family *Columbidae* as a nuisance (Fitzwater 1988). The perception of pigeons as a nuisance is likely due to accumulation of their droppings which are odoriferous, unsightly, can be slippery, erode metal or stonework, and commonly carry diseases (Fitzwater 1988). These diseases commonly found in the feces of pigeons include cryptococcus, histoplasmosis, ornithosis, and salmonellosis, (Fitzwater 1988, Link 2005). In 1990 pigeons were identified as the third most common nuisance animal for which pest control customers contacted a wildlife control company (Braband and Clark 1991). The following year, it was found that urban residents contacted a wildlife control agency for pigeon removal more often than suburban or rural residents (Braband and Clark 1991). The trend of pigeons as a nuisance has not disappeared in recent years, in 2016 a best management practices plan designed to avoid impacts on

nesting birds during vegetation and construction projects explicitly excluded rock pigeons from the plan (Environmental Services 2016). The plan goes on to indicate that a project activity should proceed as planned if a rock pigeon nest is discovered (Environmental Services 2016). Public perception of rock pigeons as a nuisance species sets social carrying capacity that is lower than the biological carrying capacity of the area.

POLICY

Oregon law does not consider rock pigeons a game species and current policy does not facilitate regulation of the species. OAR § 635.056.0020(30) exempts rock pigeons from OAR § 635.056 regulating game species because they are not "wild". Rock pigeons are also exempt from 41 ORS § 496.731 which concerns potentially habituated wildlife and rock pigeons are not a migratory bird under U.S. 50 CFR §10.13 commonly known as the Migratory Bird Treaty Act.
Policy in place regarding family *Columbidae* specifically names mourning doves (*Zenaida macroura*) and band tailed pigeons (*Patagioenas fasciata*) and does not extend to rock pigeons Under OAR§ 635.056.0070(2)(c) species in the family *Columbidae* are controlled game birds subject to OAR § 645.044.0540(1)(a) requiring a permit to propagate game birds for the *Columbidae* species mourning doves (*Zenaida macroura*) and band-tailed pigeons (*Patagioenas fasciata*). 41 ORS § 496.007(2) specifically names mourning doves and band tailed pigeons of the family *Columbidae* as game birds and both species have a migratory bird hunting season in Oregon (Oregon Fish and Wildlife 2017). These regulations allow for the management of mourning doves and band tailed pigeons as game birds and do not incorporate rock pigeons.

Policy that does encompass rock pigeons is limited in scope. Portland Code § 13.10.030 permits a state or federally agency to provide written permission to kill birds causing damage to private property. This is a reactive approach that can be interpreted subjectively with no formalize approach. The Oregon Department of Agriculture requires anyone transporting pigeons into Oregon to have a Certificate of Veterinary inspection (Oregon Department of Agriculture 2018). While this is a health regulation, the focus is on domestic pigeons and does not address the health of wild birds.

Policy in Oregon regarding the family *Columbidae* does not encourage proactive management of rock pigeons. Present regulations are limited in scope and do not consider rock pigeons to be "wild" despite the presence of wild populations.

BIOLOGY AND ECOLOGY

Originally occupying grassland habitat, rock pigeons exploit urban habitats with a great degree of success (Conole 2014). These colony birds were introduced from Europe in the 1600s and now make their nests on man-made structures, roofs, windowsills, gutters, and ventilation openings (Link 2005). Primarily feeding on seeds and grains, pigeons are opportunistic and will eat in open parks, near garbage dumps, around food loading facilities, around outdoor eating areas for people, and may consume scavenged food from people as well as fruits, insects, or vegetation (Link 2005). Populations of rock pigeons are fast growing and may breed year-round and have 10 to 12 clutches in a year however in latitudes similar to Oregon 5 clutches a year is more common (Johnston and Janiga 1995, Link 2005, Johnsgard 2009, Lowther and Johnston 2014). In addition to prolific reproduction, rock pigeons are highly competitive in Portland, outcompeting native species (Environmental Services 2005). In Portland peregrine falcons (*Falco peregrinus*) and even red-tailed hawks (*Buteo jamaicensis*) take advantage of

large pigeon populations and may nest within city limits (Environmental Services 2008). In Portland, rock pigeons comprise 20% of the birds observed within the city (Environmental Services 2015).

COURSE OF ACTION

Goal: Reduce human-pigeon conflict in Portland, Oregon.

Objective A: Decrease the population of rock pigeons within the City of Portland by 25% of the current population size (2018) within 10 years.

Action A1: Work with Oregon Department of Fish and Wildlife to increase the peregrine falcon population in and around Portland.

Peregrine falcons in and surrounding cities prey upon pigeons which can aid in reducing survivorship of fledglings, juveniles, and adults (Aini et al. 1993). Additionally, peregrine falcons are viewed favorably by residents and efforts to increase their population may increase resident support for wildlife management within the city. (City of Portland 2008). The 2008 management plan for the Columbia basin put forth by Oregon Department of Fish and Wildlife includes provisions for enhancing habitat for the benefit of raptor species (Oregon Department of Fish and Wildlife 2008).

Action A2: Administer contraception to adult pigeons via medicated grain stations within the city.

Feeding adult pigeons medicated food lowers their fecundity and may attract birds to designated areas away from areas of intense use by residents (Avery et al. 2008). Careful considerations are necessary to limit consumption by non-target birds and for the potential increased disease transmission at feeding stations (Avery et al. 2008, Aini et al. 1993).

Action A3: Work with farmers in Multnomah County to secure grain storage and encourage prompt cleanup of grain spillage.

Food access will be further limited during critical times putting greater food stress on adults during the winter and early spring, potentially decreasing survivorship (Janiga et al. 1990, Johnston and Janiga 1995).

Final Action: Complete actions A1, A2, and A3 to fulfill Objective A.

Action A1 and A3 target survivorship while action A2 targets fecundity, as high survivorship and fecundity contribute to the success of urban rock pigeon populations (Johnston and Janiga 1995, Link 2005, Johnsgard 2009, Lowther and Johnston 2014). While hatchlings and fledglings have significant influence on population dynamics (*table 2 in appendix*), it is difficult to access nests, and decreasing survivorship at these stages requires direct access to nests (Johnston and Janiga 1995). Decreasing survivorship of juveniles and adults by increasing the peregrine falcon population and limiting access to food requires less intensive efforts and greater long-term success than directly targeting nests and has the added benefit of improving ecosystem function (Johnston and Janiga 1995, Ellis et al. 2004). While fecundity does not influence population dynamics to the degree hatchling and fledgling survivorship does, contraceptive measures have been shown to be highly effective and are not cost prohibitive (Avery et al. 2008, MacDonald and Wolfe 2009).

Assessment Protocol: Assessment of population size is central to determining the success or failure of Objective A. As such, given that the current population model uses the Christmas Bird Count as a proxy for population size, it would be beneficial to establish a population estimate with higher accuracy. If funds are limited, however, the Christmas Bird Count may continue to be used as a proxy for population (Christmas Bird Count 2017). At 5 years out (2023), Objective A will be considered highly successful if the rock pigeon population has not increased from 2018. Moderate success is achieved if the population has increased by 100 or fewer individuals, and an increase of greater than 100 individuals from the 2018 population size constitutes failure of Objective A. At 10 years out (2028), objective A will be considered highly successful if the population of rock pigeons has been decreased by greater than 20%. Moderate success is achieved if the population is decreased by 1% or more, and failure to decrease the population constitutes a failure of Objective A. To achieve success of Objective A, it is necessary to meet additional criteria for the completion of actions A1, A2, and A3. For successful completion of action A1, the peregrine falcon population of Portland should be increased by 4 breeding pairs and an increase of 1 or more breeding pairs constitutes moderate success (Aini et al. 1993, Environmental Services 2008). Failure to increase the number of breeding pairs is a failure to complete action A1. For successful completion of action A2, 5 contraceptive feeding stations must be in place by 2021 with 2 contraceptive feeding stations resulting in moderate success (Avery et al. 2008). Failure to set up at least 2 feeding stations by 2021 is a failure to complete action A2. Successful completion of action A3 requires outreach to 3 or more farmers in Multnomah County with an onsite assessment the following year. If this is not possible, moderate success can be achieved with one outreach public forum held each year with voluntary participation in onsite assessments the following year. Failure to conduct outreach is failure to complete objective A3.

Objective B: Decrease damage to public and private property within the City of Portland by 25% of current rates (2018) within 10 years.

Action B1: Work with facilities within Portland that ship or store grain or other food products to secure stock and encourage prompt cleanup of spillage.

Grain shipping and storage facilities attract flocks of pigeons who feed on spilled grains and may cause damage to infrastructure, loss of product, and potentially contaminate the grain or storage facility (Murton et al. 1972).

Action B2: Work with architects and construction companies to design future instillations without dark cavities to exclude pigeons from roosting or nesting in the structures.

Pigeons use dark cavities to roost and nest and limiting the creation of these microhabitats in new construction excludes pigeons from becoming established there and causing damage to the building and presenting a health concern (Johnston and Janiga 1995).

Final Action: Complete actions B1 and B2 to fulfill Objective B.

Decreasing damage caused by pigeons to public and private property requires a combination of reactive and proactive measures.

Assessment Protocol: To be highly successful damage should be reduced by 25%. Given that there is not currently a comprehensive assessment of damage caused by pigeons in Portland, given funds it would be beneficial to establish total damage in monetary terms. In the event that damage cannot be reduced by 25% within the timeframe it is satisfactory to reduce damage by 10%. In completion of the 25% reduction, outreach to grain shipping and storage facilities in Portland should occur (Murton et al. 1972). Ideally all facilities will be reached by 2021 however outreach to a minimum of two facilities each year is also an option. Additionally, outreach to architect companies based in Portland should be completed by 2023. If this is not possible it is satisfactory to require all architects and contractors who submit bids to the city of Portland to limit creation of dark cavities.

Objective C: Determine what percentage of residents value the opportunity to feed the pigeons in Portland by 2022.

Action C1: Conduct a census survey of residents to determine what proportion of residents value the opportunity to feed the pigeons in Portland. For every 5% of residents who value this opportunity, create one designated feeding station.

If residents do not like feeding pigeons, there is no need to set up designated feeding areas. If residents do like to feed the pigeons designated feeding areas can be used to encourage the birds to frequent an area of infrequent use by residents and cleanly upkeep of these areas can reduce disease potential of congregations of birds (Alexander 2000, Teske et al. 2013).

Final Action: Complete actions C1 to fulfill Objective C.

Determining the potential need for designated feeding areas is necessary to balance social needs with overall population reduction and human health and safety.

Assessment Protocol: To be highly successful a public survey should be sent out by 2019 although if this is not met due to logistical constraints the survey should be distributed by 2020. Results of the survey should be made public by 2 years after the survey is distributed. For every 5% of residents who value feeding the pigeons one designated feeding are should be put in place by 2022 to accommodate safe pigeon feeding (Alexander 2000, Teske et al. 2013).

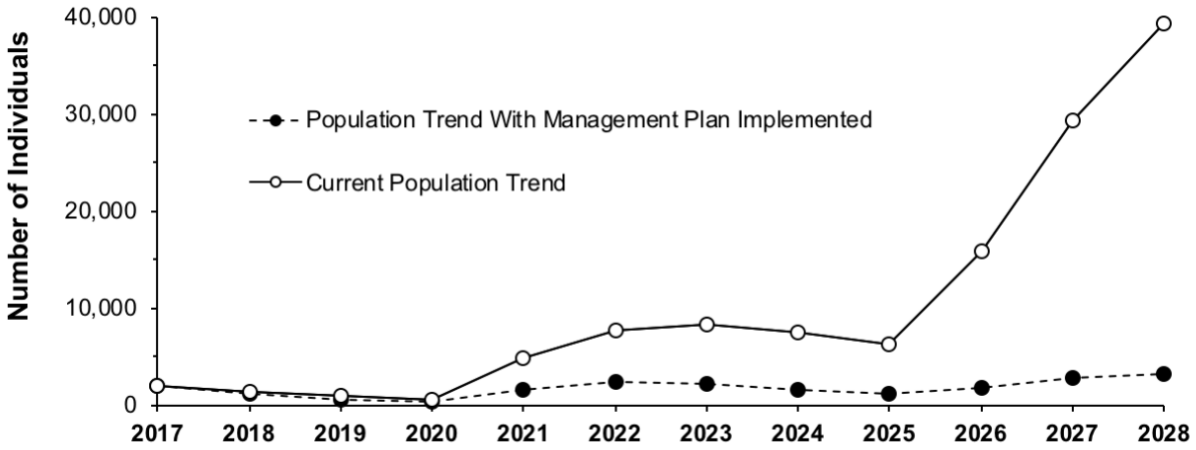

FIGURE X. Stage-based population trajectory for the total population of adult rock pigeons of Portland, Oregon in December from 2017 to 2028 given a starting population of 188 juveniles, 1,690 adults (Hetmanski 2004, Christmas Bird Count 2017). Current population trend represents the current trajectory without consideration for biological carrying capacity and the population trend with the management plan implemented represents the anticipated trend if all objectives are successfully completed (Avery et al. 2008).

CONCLUSION

This management plan calls for a combination of approaches to effectively reduce human-pigeon conflict in Portland. Successful completion of the objectives will require interagency cooperation between the City of Portland and Oregon Fish and Wildlife in addition to community support from residents, business owners, and farmers, and access to reliable funding. Long term success of pigeon management in Portland will require the continuation of a contraceptive program after 2028 to maintain low fecundity of adults (Avery et al. 2008). It is also necessary to continue limiting nesting and roosting locations within the city, limiting access to grain spillage, and monitoring the peregrine falcon population (Murton et al. 1972, Johnston 1998, Ellis et al. 2004). Failure to maintain these efforts may result in a return to pre-management conditions and a subsequent increasing in the rock pigeon population.

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APPENDIX

POPULATION BIOLOGY

TABLE 1. Stage-based population model matrix for the rock pigeon population of Portland, Oregon in December from 2017 to 2028 given a starting population of 188 juveniles, 1,690 adults, and without consideration for biological carrying capacity.

Stage-Structured Matrix Models								Initial
Five-stage matrix model Columbia livia								population
	F(e)	*F*(h)	*F*(f)	*F*(j)	*F*(a)			vector
	0	0	0	0	10			0
	0.77	0	0	0	0			0
	0	0.56	0	0	0			0
	0	0	0.61	0	0			188
	0	0	0	0.93	0.655			1690

TABLE 2. Sensitivity and elasticity matrix indicates that hatchling and fledgling survivorship have the greatest influence on the population dynamics.

	Sensitivity matrix				
	F(e)	*F*(h)	*F*(f)	*F*(j)	*F*(a)
Egg	0.2039	0.1028	0.0377	0.0151	0.0161
Hatchling	0.4044	0.2039	0.0748	0.0299	0.0319
Fledgling	1.1026	0.5560	0.2039	0.0815	0.0869
Juvenile	2.7600	1.3918	0.5104	0.2039	0.2175
Adult	2.3388	1.1794	0.4325	0.1728	0.1843

	Elasticity matrix				
	F(e)	*F*(h)	*F*(f)	*F*(j)	*F*(a)
Egg	0	0	0	0.0986748	0.1052475
Hatchling	0.2039223	0	0	0	0
Fledgling	0	0.2039223	0	0	0
Juvenile	0	0	0.2039223	0	0
Adult	0	0	0	0.1052475	0.0790634