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THE POTENTIAL FOR MANAGING URBAN CANADA GEESE BY MODIFYING HABITAT

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ABSTRACT: Urban Canada goose (*Branta canadensis*) populations have grown rapidly during the past three decades. This paper reviews short-term and long-term urban goose management techniques, and using data for the Twin Cities of Minnesota, assesses the potential utility of habitat modification. Ninety-four percent of Twin Cities damage complaints occurred during the brood-rearing period, 5% in fall, and >1% in spring and winter. The potential for reducing goose damage by altering nest habitat is insignificant, brood-rearing habitat high but expensive, and fall and winter habitat low and also costly. Fences effectively thwart flightless geese but can entrap birds leading to starvation. Cost projections for programs limiting the Twin Cities summer population at 25,000 were \$125,000/year for relocation, \$325,000/year for processing for human consumption, \$12.3 million/25 years for wire fences, \$33.9 million for tall grass prairie, and \$1.8 billion for ground juniper (*Juniperus* spp.). Human preference for savanna and the fear of urban crime associated with dense vegetation may hamper implementation of goose habitat modification.

KEYWORDS: Canada goose, *Branta canadensis*, damage, urban management, habitat modification potential, effectiveness, cost estimates, crime

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INTRODUCTION

Many urban Canada goose populations have grown exponentially during the past three decades (Ankney 1996; Rusch et al. 1996; Zenner 1996; Cooper and Keefe 1997). Complaints of goose damage have been reported for Anchorage, Vancouver BC, Seattle, Denver, Kansas City, Chicago, Milwaukee, Winnipeg, Toronto, Boston, Washington DC, and other urban centers (Conover and Chasko 1985; Ankney 1996; Cooper and Keefe 1997). Damage complaints include: droppings on golf courses, docks and swimming beaches, playgrounds, athletic fields, park shorelines, residential yards, and commercial grounds (Conover and Chasko 1985; Cooper 1987; Cooper and Keefe 1997), water quality reduction (Manny et al. 1994), and highway (Cooper and Keefe 1997) and aircraft hazards (Cooper 1991; Dolbeer 1996).

Cooper and Keefe (1997) divided urban goose management approaches into short-term redistribution techniques and long-term population management procedures. Short-term methods prevent or reduce goose use of a specific site for a period of days to several weeks, forcing the birds to use alternative sites. Long-term approaches reduce the population by decreasing reproduction or survival, or by removal of the geese. Short-term, redistribution procedures include prohibition of artificial feeding, hazing using humans (Aguilera 1989), vehicles, dogs, swans, swan or dead goose decoys, and sounds (Mott and Timbrook 1988), erecting access barriers such as wire, rope, or bird-scare tape fences, and taste aversive chemicals (Conover 1985; Cummings et al. 1991; Belant et al. 1996; Gosser et al. 1997). Reproduction has been inhibited by embryocides (Baker et al. 1993; Christens et al. 1995), egg removal (Wright and Phillips 1991; Cooper and Keefe 1997), and vacsectomization (Converse 1985). Populations have been reduced by sport hunting, shooting (Cooper 1991; Cooper and Keefe 1997), capture and relocation of goslings and/or adults (Blandin and Heusmann 1974; Martz et al. 1983; Cooper 1987; Cooper and Keefe

1997), and capture and processing for human consumption (Cooper and Keefe 1997).

Habitat modification techniques can have both short- and long-term effects. For example, the replanting of upland grass with dense shrubs may eliminate goose use at a specific site. But, if the geese find adequate forage elsewhere, the effect would be short-term, whereas extensive turf conversion leading to insufficient forage and higher mortality, would have a long-term impact. While frequently mentioned as a potentially effective and environmentally sound approach (Gosser et al. 1997; Grandy and Hadidian 1997; Garner Lee Limited 1997), a comprehensive evaluation of the utility of habitat modification is lacking. Utilizing Twin Cities of Minnesota goose population, goose damage site, wetlands data (Cooper and Saylor 1974; Saylor 1978; Cooper 1987, 1991; and Cooper and Keefe 1997; Minnesota Department of Natural Resources unpubl.) and existing literature, this paper uses a "what if" approach to assess the potential biologic and economic efficacy, social acceptability, and application of landscape alterations as urban goose management tools.

TWIN CITIES GEESE AND GOOSE HABITAT

The Twin Cities Metropolitan Area (Metro), latitude 45° longitude 93°, is a 6,076 km² midwestern urban complex with 193 municipalities and 2.5 million human residents. Pleistocene glaciation left the area with a flat but diverse landscape of lakes, kettle ponds, wetlands, and small streams separated by low moraines and outwash plains. In spite of wetland drainage for development, the Metro presently contains 303 lakes and 2,800 type 3, 4, or 5 palustrine wetlands (Minnesota Department of Natural Resources unpubl.; Cowardin et al. 1979) larger than 1.1 ha. Wetlands cover 37% of the Twin Cities, three major rivers—the Mississippi, Minnesota, and St. Croix, and numerous small meandering streams flow through the Metro area, providing additional goose habitat.

There are no historical records, but based on the eight Metro area "Goose Lake" place names, breeding Canada geese were likely present prior to 18th century European settlement. No breeding wild geese were reported in the Twin Cities until the species was re-introduced in 1955 (Hawkins 1968). Once established, the goose population grew exponentially until population management was implemented in 1982 (Cooper and Keefe 1997). Ankeny (1996) reported similar growth of re-introduced Canada geese in Ontario, and Zenner's (1996) data for the Mississippi Flyway giant Canada geese are indicative of similar expansions in other midwestern re-introduced populations. Using breeding habitat as the limiting factor and conservative productivity indices, Cooper and Keefe (1997) estimated the summer Twin Cities goose carrying capacity at 1 million birds, 40 times that of the current population of 25,000.

GOOSE DAMAGE COMPLAINTS

Goose complaint site data have been recorded from 1982 to 1997. Wetlands where citizens have complained about goose damage have expanded from a total of one in 1982 to 451 in 1997. Sites were classified by season when the problem occurred (spring-breeding, summer-brood-rearing, summer and fall-flying, and winter) and predominate human use (park shorelines, swimming beach, residential, commercial, golf, airport, etc.). Summer brood-rearing period complaints are most common (94%), followed by fall (5%), spring (<1%), and winter (<1%). The two spring complaints were from golf courses. Summer complaints came from residential sites (52%), park shorelines (17%), golf courses (16%), swimming beaches (10%), and commercial grounds (6%). The 24 fall complaints came from golf courses (46%), residential (25%), athletic fields (12%), airports (12%), and commercial sites (5%). The three winter damage reports were from an airport and two golf courses.

MANAGING THE GOOSE POPULATIONS BY HABITAT MODIFICATION

Canada goose habitat use differs during breeding, brood-rearing, late summer and fall staging, and overwintering (Owen 1980); consequently, the potential for moderating or eliminating goose damage by changing the habitat differs by season.

Nest Habitat

Canada geese nest in a wide variety of situations. The most common sites are islands, muskrat or beaver lodges, and peninsulas (Hanson 1965; Williams 1967; Sherwood 1968; Hanson and Eberhardt 1971; Cooper 1978; Ogilvie 1978; Owen 1980; and others). Where preferred sites are limited or absent, birds utilize cliffs (Kondla 1973), abandoned eagle and heron nests (Craighead and Craighead 1949), and the flat roofs of buildings (Cooper unpubl.). When alternative sites are lacking, Canada geese nest in colonies on islands (Klopman 1958; Ewaschuk and Boag 1972). Canada geese also readily nest in man-made structures when provided (Dill and Lee 1970; Cooper 1978).

Potential alterations of Twin Cities nest habitat for either short-term or long-term goose management are

extremely limited. Drainage or filling of urban lakes and wetlands would control the geese, but would be costly, and have unacceptable impacts on other wetland wildlife species and diminish the landscape quality for humans (Ulrich 1983). Currently, all of Metro wetlands used by nesting geese are protected by Minnesota law. Nine percent of the Twin Cities 3,103 lakes and wetlands contain an average of two earthen islands. Because islands are favored by nesting geese and nest success is high on islands (Sherwood 1968; Ewaschuk and Boag 1972), removal of these sites would reduce local goose populations (e.g., at Lake of the Isles in Minneapolis where up to 60 pairs have nested). But islands are preferred breeding sites by other wildlife species, particularly ducks, herons, and egrets, thus island removal for goose management would significantly impact other species. The removal of man-made structures should be done at complaint sites; however, this would have minuscule effect on the Metro population. In the early 1970s, man-made sites were commonly provided at goose flock establishment locations; Saylor (1977) found 100 nests (30% of the total) in structures in 1973 to 1975, whereas presently, no structures currently exist at the 10 sites studied in the 1973 to 1975 period, and no structures were found at the 254 randomly surveyed wetlands in 1994 (see Cooper and Keefe 1997).

Brood-rearing Habitat

Because 94% of the Twin Cities goose damage complaints occurred during the brood-rearing period extending from mid-May to Mid-August, modifications during this interval would appear to have great promise. The high level on human/goose conflicts during brood-rearing is undoubtedly related to the restricted range (the adults are flightless for five weeks and the goslings for ten weeks), the bird's high forage demand, and the significantly higher human use of the landscape in summer, particularly shorelines for hiking, fishing, swimming, picnicing, etc.

Metro Canada goose broods hatch from April 30 to June 15 with a peak in mid-May (Saylor 1977). Pairs typically move their young to suitable nearby shoreline free of obstructing vegetation where they graze on forbs and grasses, particularly bluegrass (*Poa* spp.). If suitable shoreline is unavailable near the nest—in many cases even when it is—the goose families move to traditional brood-rearing sites within a week or two (Schultz et al. 1988). While most movements are less than 1 to 2 km and often along water courses and other greenway corridors, neckbanded Twin City pairs have traveled from 6 to 15 km from nest to brood-rearing site through city streets; in seven cases over fenced or sound-barriered, interstate highways where only arterial overpasses permitted passage.

Because the geese are traditional in their use of brood-rearing sites (Zicus 1981; Schultz et al. 1988), the wetlands used during this period are predictable, and likewise, so are the goose damage complaint locations. While many (62%) of the brood-rearing areas are along the shores of the large lakes, where parks, beaches, and suburban residential homes are concentrated, birds are also found on relatively small (<0.5 ha) golf course, apartment, townhouse, and residential ponds.

Alternatives to Managing Existing Turf

The apparent short-term solution in these cases is to discourage the geese by reducing the forage quality or availability, or by modifying the shoreline so that geese cannot move from the escape cover to the upland grazing area. Gosser et al. (1997) suggested that reduced lawn mowing or fertilization will discourage the geese. The recommendation appears sound, when present Metro geese concentrate on newly-laid, fertilized sod and consistently frequent lush mowed sections of wetland shoreline for grazing. However, there are cases of Metro geese rearing their young on unmowed, cool-season and tall prairie grasses when confined by fences. Until controlled by removal (Cooper 1991), Wood Lake Nature Center fledged 60 to 120 goslings on an area containing 11 ha of unmowed and unfertilized tall grass prairie. Similarly, the fenced 85 ha Mother Lake near the International Airport produced from 25 to 75 goslings without any management of the grass. Thus, the response to either not fertilizing or mowing is dependent upon the availability of an alternative site with suitable grass. In short, the birds will go elsewhere if an alternative is available, but will continue to use unfertilized and unmown grass if there is no other option.

Turf Replacement

Removing and replanting the upland grass with rough grasses (tall grass prairie, tall fescue, etc.), ivy, shrubs, or trees should force the birds to use alternative turf areas. However, there is a paucity of research in this area, and as the Wood Lake example illustrates, the degree to which rough grasses discourage geese is problematic if alternatives are absent. Alternative plant cover selection constraints include climatic suitability, tolerance to flooding (Metro wetland water levels vary as much as 3 m), palatability to geese, life form (i.e., dense enough to preclude goose movement to abutting grazing areas), and effect on the landscape quality to humans.

From a long-term management perspective, if sufficient shoreline was converted from grass to vegetation not used by geese, the population would become limited by available brood-rearing habitat. To assess the magnitude of habitat conversion necessary to limit the Twin Cities goose population at its present level (25,000 birds in summer), the amount of Metro shoreline in mowed grass (see Cooper and Keefe 1997), and the goose carrying capacity of a hectare of grass were estimated. Using areas of the 3,103 Metro wetlands and a shoreline development value of 1.5, Twin Cities has a minimum of 5,325 km of shoreline. Based on estimates of grass shoreline made at 227 wetlands in 1994, Cooper and Keefe (1997) found that one quarter (25.1%) of the Metro shoreline was in mowed grass or pasture. Thus 1,331 km of shoreline is currently in mowed grass or pasture. Because Metro geese have been observed leading broods through 70 m of dense cattail and woods and more than 200 m of grass to graze, it was assumed that broods would utilize at least a 100 m grass strip along the shoreline for grazing, thus the Metro contains 13,310 ha of preferred brood-rearing habitat. The literature lacks Canada goose brood carrying capacity data, consequently carrying capacity was estimated from the goose pasturing done in 1996 as part of a Metro food-shelf program

(Keefe 1996). Six hundred and fifty birds (500 Adult geese and 150 immatures) maintained normal weight growth on a 23 ha bluegrass pasture from August 1 to November 15, 1995. Thus, a hectare of unmanicured pasture grass may support a minimum of 28 geese. If this is representative of the capacity of fertilized and mowed urban lawns to support geese, then Twin Cities brood carrying capacity is 373,000 birds, and 93% of the existing lawns and pastures would have to be converted to limit the population to 25,000 geese.

Vegetative Barriers

Gosser et al. (1997) and Garner Lee Limited (1997) report that vegetative barriers such as trees and shrubs discourage goose transit. Grandy and Hadidian (1997) state that by "allowing grass and shrubs to grow as little as 18 inches high in a 10 foot band around a pond can act as a deterrent to geese as it will impede their access to grazing and block their view of predators." The author's observations of goose behavior in the Metro area over the past 20 years suggest that, while locations with good visibility (see Buchsbaum and Valiela 1987; Conover and Kania 1991) are selected for grazing, the species is capable of adapting to situations where dense shoreline vegetation exists and use it as escape cover. For example, Metro geese using corporate grounds with three wooded- and two mowed-grass-shoreline wetlands separated by up to 300 m by woodlands with dense shrub understories. These birds have consistently been found on all of the wetlands during brood-rearing and observed to travel through the woods to access them. In another case, geese using a 1 ha pond surrounded by robust tall grass prairie >1 m in height, moved 120 m to graze on a 20 m bluegrass strip surrounding a commercial building. This behavior has been observed for other Canada geese. Lebeda and Ratti (1983) working with Vancouver Canada geese (*B. c. fulva*) and Byrd and Woolington (1983) studying Aleutian Canada geese (*B. c. leucoparia*) reported extensive use of density vegetation for nesting, foraging, and escape cover during brood-rearing. In fact, Lebeda and Ratti (1983) report that dense forest was preferred to water as escape cover. Both studies were of island populations with either no (Byrd and Woolington 1983) or low densities (Lebeda and Ratti 1983) of mammalian goose predators typical of non-urban midwestern habitats, i.e., red fox (*Vulpes fulva*) and coyote (*Canis latrans*). Twin Cities urban goose habitat, particularly the highly developed zones containing most of the goose damage sites, support low densities of mammalian goose predators, and thus may present an ecological setting similar to that of islands. Thus, goose brood-rearing behavior appears adaptive and dense vegetation, when predators are uncommon or absent, may be used. This hypothesis would explain the author's observations that geese during the brood-rearing period readily move through dense vegetation when visually open pathways are unavailable. More research is needed on the goose barrier attributes of vegetation prior to investing in expensive (see below) changes.

Man-made Barriers

Man-made barriers blocking passage from wetlands to upland grazing locations, particular during the flightless

brood-rearing period in June and July, appear to be one of the most effective methods of limiting goose damage at specific locations. Barriers include electrified and non-electrified temporary (rope, wire, or bird-scare tape) and permanent wire or wooden fences, boulders, wooden boardwalks, construction vertical banks, and floating "bird" balls (Cooper and Keefe 1997; Garner Lee Limited 1997; Gosser et al. 1997; Smith and Craven, in press). Drawbacks to the enclosure approach included entrapment of goslings, potential impacts on other wildlife, interference with human activities, and landscape quality.

Cooper and Keefe (1997) found permanent and temporary fences to be an effective short-term technique. Because of the poor visual aesthetics of fences, Gosser et al. (1997) recommended, presumably to lessen the visual impact, that fences be placed in the water and screened with emergent vegetation; they also stated the "pond edges should be completely fenced." If the wetland contains breeding habitat and is surrounded by a permanent fence placed in this manner, available forage may be insufficient for goslings hatched within the enclosure, and they may starve. Two cases of entrapment were recorded in the Twin Cities in 1997. In one case, seven pairs of geese with 25 goslings were entrapped by homeowner-constructed fences. After 10 of the six-week old young were reported dead by a resident, the emaciated survivors were trapped and removed. In another case, 38 geese were entrapped in a newly constructed fountain basin with fences and vertical banks >1 m. When discovered, 3 of the 38, four-week old goslings were dead and the remainder emaciated. In order to assure humane use of barriers, sufficient grazing must be provided within the enclosure to accommodate the expected hatch.

Piling-supported or floating boardwalks are used at 17 Metro goose complaint sites. These structures appear to restrict goose brood travel during the first five weeks of brood-rearing when the goslings are too small to surmount them. But, based on the complaints received, once the broods can access them, boardwalks become preferred loafing sites and residents spend considerable time washing goose manure from the walks.

Like fences, abrupt shorelines (>0.5 m with >60° slope) thwart goose movement. Because of the flat Twin Cities topography, they are uncommon in the Twin Cities except on the east and southeast shorelines of the larger lakes where wind-driven waves cause flooding and erosion. Here wood, concrete, or rock rip rap is used to secure the soil. Because of the construction expense, the author suspects that these structures will not be used specifically as a goose deterrent. In addition, abrupt shorelines constitute a serious human drowning risk, particular to small children (U.S. Army Corps 1991).

FALL AND WINTER

Once flying in late summer, the geese cease using many of the small wetlands and concentrate on the larger marshes and lakes. From these staging locations, they frequently feed on the shorelines or fly to large open expanses of grass to forage. This explains the significantly lower number of complaints in fall compared to summer (94% vs. 5%), and the shift from residential sites, the most common brood-rearing period complaint type, to golf courses, athletic fields, and airports. Winter

reports are even lower (<1%), undoubtedly because most (>95%) of the birds migrate in late fall and the wetlands are frozen and snow-covered.

The birds' mobility combined with a preference for feeding sites where the existing landscape is essential for the intended human use, severely limits the potential for habitat modification. Gosser et al. (1997) recommended planting tall-growing trees to obstruct the birds' flight paths into problem sites. Indeed, the presence of trees surrounding many of the small wetlands used during the flightless period may be the reason that geese discontinue using small wetlands once they can fly. Trees conflict with human activities at airports, ball fields, and golf courses. Moreover, expanses of grass such as fairways and open water often serve as landing and take-off zones from which the birds walk or swim to the feed areas. Alternatives to goose-palatable grasses at airports have been investigated (Austin-Smith and Lewis 1970; Smith 1976), but no plant species have been identified that meet airport runway constraints: low height, low maintenance, relatively non-flammable, not attractive to other wildlife, etc. Overhead wire grids preventing geese from landing on a pond have successfully reduced use, but also precluded recreation such as fishing, swimming, boating, etc. (Lowney 1995) and impact non-target large birds such as herons, egrets, etc. Garner Lee Limited (1997) suggested that covering pond surfaces with floating "bird" balls could be highly effective, but also pointed to significant impacts on other wildlife.

LANDSCAPE MODIFICATION AND HUMAN BEHAVIOR

Human acceptance is a prerequisite to habitat modifications for goose redistribution or long-term control. Ironically, the open vista favored by geese is also a primary landscape component preferred by humans. Ulrich (1983) listed a moderate to high level of visual depth and a low or absent threat level as two of six primary attributes of landscapes favored by humans. Orians and Heerwagen (1992) contend that people "prefer environments in which exploration is easy and which signal the presence of resources necessary for survival," and where the likelihood of detecting danger in the form of "predators or unfriendly conspecifics" is high. Research on human landscape preference strongly indicates that savanna-like environments with water are consistently chosen over other environments (Balling and Falk 1982; Ulrich 1983, 1986; Orians and Heerwagen 1992), and that the preference was independent of age and cultural background, thus suggesting it may be innate (Orians and Heerwagen 1992). The decision to enter a landscape is also known to be high affective—emotionally based (Zajonc 1980; Ulrich 1983), and to be based on the level of apprehension (Orians and Heerwagen 1992). Clarke and Mayhew (1980), Bennett and Wright (1984), Michael and Hull (1994), and others investigated interrelationships between urban vegetation and crime, finding that surveillance, concealment, escape, and prospect were highly relevant components. Park areas with open visibility discourage criminals, whereas densely vegetated patches provide sites from which the perpetrator can scan undetected for victims, commit the crime, and escape. Michael and Hull (1994) recommended that

parks and residential areas be designed or altered to maintain open sight corridors by pruning or removing eye-level vegetation near paths, roads, parking lots, buildings, picnic grounds, etc. They pointed to "thin strips of tree and shrubs separated by grass or low vegetation" as a design that would minimize the "maze-like quality of dense plants that obstructs surveillance and hinders pursuit."

These findings suggest that proposals calling for the wide-scale replacement of expanses of mowed bluegrass lawns in the Metro would be met with strong public concern. While extensive reshaping of existing Twin Cities or other urban landscapes has not been undertaken for goose management, the outcome of a Minneapolis 1995 lawn mowing policy change elicited responses in agreement with Orians and Heerwagen's general hypotheses. In this case, in order to lower costs and sediment input to nearby lakes, the Minneapolis Park and Recreation Board reduced grass mowing on sections of several parks. Public reaction was strong and negative. The Minneapolis City Council threatened to cite the Park Board for violating the city's grass height restriction ordinance (Daiz 1995). A "Citizens For Mowing Our Parks" group was formed and lobbied for a change in the Minneapolis City Charter to give the City Council the power to direct the Park Board to cut the park grass. No changes were made in the Minneapolis Charter, but the mowing resumed and the proposal was shelved.

COSTS

The author estimated the cost for those habitat modification techniques with the potential for extensive application, i.e., replacement of blue grass on shorelines and fencing. To assess costs relative to budget, the City of Plymouth, a rapidly growing suburb of 57,000 residents located 9 km west of Minneapolis, was selected as a study case. Plymouth citizens have complained about goose damage at 19 individual wetlands or lakes, ranging in area from 5 to 432 ha. Aerial photos (Twin Cities Metropolitan Council, 1:800 scale, flown in 1997) were used to determine the expanse of shoreline that would need to be replanted to non-turf, the length of fence needed to enclose the complaint site wetlands, and extent of goose nest habitat within the wetlands. Existing wooded shorelines were assumed to be sufficiently dense to deter geese, and omitted from the revegetation calculations but not the fencing computations. Cost estimates were attained from local landscaping firms and include materials and installation but not design costs. Two alternative vegetations were included in the cost estimates, tall grass prairie and ground juniper. Tall grass prairie was selected because it is the native plant community most often re-established in the Twin Cities. Except in special cases (see above) it is not known to be used for grazing. Ground juniper, if planted at a minimum spacing of 1 m, would provide near 100% ground cover, and yet, remain low (<1 m) enough to provide human visibility without pruning. Fence height was set at 0.75 m and chain-link material with a pipe top crossbar were specified. This height will thwart flightless goose movement yet permit most humans to step over safely. Contractors projected a 25-year fence longevity if placed in the upland and more frequent replacement if

subjected to wave or ice damage, i.e., built below the high water level.

Plymouth goose complaint wetlands have 7 km² of open grass within 50 m of the shore and a total of 177 km of shoreline. Cost estimates ranged from \$0.54/m² for prairie, \$29/m² for juniper, and \$9.84/m for chain-link fencing; the total projected expenditures were \$3.7 million, \$203 million, and \$1.4 million, respectively. The 1997 City of Plymouth budget was \$15 million with \$10,000 allocated to goose management. Clearly, if Plymouth were to opt for the least expensive method—fencing—the city would have to spend 1/25th of total cost every year (\$56,000/year) to erect new or replace old fences. Also, the impacts on massive erections of low fences on other species of urban wildlife is unknown and needs study before such a program is undertaken. Expanses of cattail (*Typha* spp.) ranging from 0.009 to 1.1 km² were found in 74% of the 19 wetlands; thus, allowances for within-the-enclosure grazing would have to be done in order to avert gosling starvation.

If fencing were used to limit the Twin Cities brood-rearing carrying capacity to 25,000 geese, 93% of 1,331 km of shoreline currently in mowed grass or pasture would have to be enclosed at a cost of \$12.3 million. To replant this length of shoreline with prairie grass would cost \$33.9 million and for ground juniper \$1.8 billion. Using the population model for the Twin Cities (Cooper and Keefe 1997), 50% of the geese would have to be removed annually to attain population stability at 25,000. Goose removal costs are estimated at \$10/bird relocated and \$25/bird captured and processed for human consumption (Cooper and Keefe 1997); thus, expenditures from \$125,000 to \$312,500 per year would be necessary to control the population. Obviously, population management via direct removal is far less costly compared to the least expensive habitat modification.

SUMMARY

Canada goose populations and goose damage complaints are widespread in North American urban environments and growing. With a potential for impacting millions of human residents, and the ongoing conflicts over management approaches, urban geese present a major wildlife challenge. There is a critical need to evaluate promising techniques and integrate them into effective, comprehensive management programs. The control of goose damage by habitat modification, while potentially ecologically beneficial in urban settings, is biologically complex, expensive, and may be difficult to implement.

Because the species uses islands, muskrat lodges, man-made structures, and other elevated sites in semi-permanent and permanent wetlands for nesting, habitat modification options during the nesting period are limited to the simple, elimination of man-made nest structures, and the highly undesirable, filling or draining of the water bodies, and the elimination of islands.

Most (94%) goose damage complaints occur during the late spring and summer brood-rearing period when the birds are flightless; thus, habitat modification during this interval presents the greatest opportunity for limiting damage. Short-term applications where the objective is to reduce or eliminate goose use of specific property have

the most promise. Proposed methods include: not fertilizing and mowing grasses, replanting lawns with rough grasses, ivy, shrubs, trees, etc., planting shoreline barrier strips of vegetation, and the erection of fences. However, there is a paucity of research on the efficacy, acceptability, and cost of these techniques.

The Canada goose appears adaptive and will use unmanicured grasses if alternatives are lacking. The bird also readily traverses dense vegetation in island environments with low mammalian predator densities, and observations indicate that the bird may behave this way in urban settings. Research on human landscape preferences strongly suggests a predisposition, like that of the Canada goose, for savannas with water bodies. Studies of the relationships between urban crime and vegetation shows a clear correlation between visual depth and risk; that is, dense visibility-obscuring plantings are associated with higher crime rates. Because crime is a crucial urban issue, public acceptance of widespread removal of turf is unclear. In light of these concerns, habitat modification recommendations in recent publications (Gosser et al. 1997; Grandy and Hadidian 1997), while stated as uncomplicated solutions, ignore critical application constraints, do not address long-term population management needs, fail to consider the potential for inhumane flightless goose starvation, overlook potential impacts on other urban wildlife, and do not address economic constraints.

Clearly, if habitat modification that limits Canada geese damage in urban environments can be accomplished humanely, without compromising human safety or landscape quality or the management of other wildlife species, and within fiscal constraints, then such programs would indeed be beneficial. However, significantly more research is needed before currently proposed methods can be deemed effective and environmentally sound.

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