

The Effectiveness of a Long-Term Canada Goose Relocation Program in Nevada

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Abstract: The resident Canada goose (*Branta canadensis*) population in Truckee Meadows (TM) increased in the 1980s from a few hundred to an estimated 1,200 by 1988. Concern arose after two incidents in which aircraft from Reno/Tahoe International Airport hit resident geese. As a result of a FAA mandate, a multi-agency task force led by USDA APHIS Wildlife Services was developed to address the problem. As a result of a recommendation from the task force, an annual Canada goose round-up with subsequent relocation was started in 1989 and has continued through 2001. Of the 7,954 geese initially captured, 3,081 (39%) were recovered (death, recapture, sighting) at a later date at least once. Of the 11,397 captures (newly banded and recaptured geese), 5,269 were released at the capture site and 6,128 were relocated. In addition, 347 geese were captured and released in TM in 1986-87 for a study conducted by the Nevada Division of Wildlife (NDOW). During the first few years of the program, juveniles and some adults captured in TM were relocated. Since 1997, all geese captured have been relocated. Of the geese released at the capture site prior to 2001, 59.6% of the adults and 40.6% of the juveniles were recovered at least once in TM. Comparatively, only 21.2% of the first-time relocated adults and 3.5% of the relocated juveniles have returned to TM, a significant difference for both ($P < .0001$). Second-time released and relocated adults were recovered a third time in TM at 68.5% and 32.8% ($P < .0001$). However, adults released or relocated 3 or more times have been recovered similarly in TM at 69.5% and 71.0% ($P = .846$). Relocated geese are subject to higher hunting mortality by about 8% ($P < .0001$); hunting as a management tool appears to have helped reduce the returning population. As a result of the relocation program, the population in TM has declined from a high of about 2,000 to 400 at the same 10 sites. The current population throughout TM is about 800. We conclude that the relocation program has been effective in reducing the Canada goose population in TM, except that relocating geese three or more times is not worthwhile.

Key Words: Canada geese, *Branta canadensis*, resident geese, nuisance geese, relocation, recapture, hunting mortality, Nevada

Proc. 20th Vertebr. Pest Conf. (R. M. Timm and R. H. Schmidt, Eds.)
Published at Univ. of Calif., Davis. 2002. Pp. 180-186.

INTRODUCTION

A "resident" or non-migratory Canada goose (*Branta canadensis*) population grew significantly during the mid- to late 1980s in the Reno-Sparks, Nevada greater metropolitan area known as Truckee Meadows (TM). Correspondingly, damage associated with Canada geese escalated rapidly in TM, where complaints rose 300% from 1986 to 1988 (Fairaizi 1992). The establishment of Canada goose populations has occurred throughout the United States, primarily from introduction and transplant programs (Oberheu 1973, Blandin and Heusmann 1974, Ankney 1996). Unfortunately, these programs were very successful and Canada geese established large "resident" populations in many urban centers, creating an increased number of conflicts between human interests and the geese (Conover and Chasko 1985, Hindman and Ferrigno 1990, Ankney 1996). The increased depredation complaints have primarily included damage to grass and flowerbeds at golf courses, parks, and residential and commercial properties; the nuisance of droppings at golf courses, on sidewalks, beaches, and lawns; and fecal contamination of lawns, swimming areas and ponds, and the associated potential for disease transmission to humans (Conover and Chasko 1985, Cooper and Keefe 1997). However, the biggest threat that Canada geese

pose is to aviation and the likelihood of a catastrophic bird-aircraft strike (Alge 1999, Dolbeer 2000). The mere presence of waterfowl on and around airports creates a threat to aviation and human safety. Waterfowl (geese and ducks) comprised 12% of all bird-aircraft strikes and 16% of bird-aircraft strikes where civil aircraft were damaged (Cleary et al. 1999). In 1995, a Boeing 707 AWACS jet taking off from Elmendorf Air Force Base in Alaska ingested geese into 2 engines and crashed, killing all 24 crew members and destroying the \$180-million aircraft. As a result, several metropolitan areas and airports began management programs to reduce problems associated with geese. The U.S. Department of Agriculture, Animal and Plant Health Inspection Service, Wildlife Services program (USDA APHIS WS) in a number of states has been involved in these programs.

A major concern about the growing population of Canada geese in TM arose following 11 airstrikes between 1986 and 1989 at Reno/Tahoe International Airport with damages exceeding \$250,000. Nine of the strikes occurred during the winter when migratory populations traditionally rise to between 5,000 and 20,000 geese. However, 2 strikes occurred in late spring and were a direct result of the sedentary resident goose population. The Federal Aviation Administration

required that action be taken to reduce the problem. As a result, a task force led by WS was launched in 1988 involving over 20 agencies, organizations, and individuals to address the Canada goose issue. The task force prepared a management plan. The winter population of Canada geese was dispersed from the airport using standard hazing techniques and exclusion at a major roosting lake (Fairaizl 1992). The "resident" population, which was estimated to be about 1,200 in 1988, was also addressed. The task force decided to conduct goose round-ups, with a primary intent of reducing the resident population over time and stabilizing it at a much lower number. This paper focuses on the effectiveness of the goose round-up program at reducing the population in TM.

METHODS

Goose round-ups began in 1989 and have been conducted annually through 2001 at several sites including parks, golf courses, and private grounds in TM. Geese captured during round-ups were either released on-site or relocated to refuges and wildlife management areas in Nevada, California, and Idaho. California and Idaho authorities took geese from 1989 to 1992 to bolster populations in specific areas of their states. In Nevada, U.S. Fish and Wildlife Service refuges took Canada geese from 1990 to 1997, but no longer accept them. However, the Nevada Division of Wildlife continues to take geese and place them on wildlife management areas under their waterfowl release plan (NDOW 2001).

From 1989 to 1996, all goslings and only a few adults captured during round-ups were relocated. It was widely believed that juveniles "home-in" to the site where they fledge and continue to nest in that area and not return. It was also believed that relocating adults was ineffective at reducing the population, because they would return to the capture site. Therefore, the majority of adults captured in TM were released on-site. However in 1997, it was decided that all geese would be relocated, even those recaptured, in hopes of having a more pronounced effect on the population. Even if the adults returned, the problems associated with them would be reduced while they were away. Most geese captured were banded with standard U.S. Fish and Wildlife Service bands, although 374 were released on site or relocated without bands in 1989 and 1992 (these are not included further or in the data analysis). In addition, alphanumeric coded black-on-white neck collars were put on many of the geese. Records from recovered (sighted, recaptured, or killed) geese have provided sufficient data to determine the effectiveness of the relocation program and if relocated juveniles and adults return to TM.

Prior to round-ups, Canada geese were surveyed at several sites in TM to determine the population, gosling production, and sites where round-ups needed to be conducted. The surveys were conducted mid-May to early June. From 1989 to 1996, an overall estimate of the population was made, but only gosling numbers were

recorded at the major nesting sites in TM. However, the number of goslings caught in round-ups typically exceeded the number recorded in the pre-round-up surveys. From 1997 to 2001, both adult and juvenile numbers were monitored. In 2001, all of TM was monitored before and after round-ups, including the previous unmonitored southwest portion, to get a more accurate estimate of the population in TM.

Canada geese were gathered annually from late May into July from 1989 to 2001 using a standard "drive-trap" (Addy 1956); a drive-trap consists of wire panels erected into pens (4 m² - 25 m², depending on the number of geese that were present), with two wings made of plastic fencing 1.5 m in height extending 20 m - 100 m in a 'V' from the pen. Geese were herded to the pen at each site by people on foot and in boats. Ropes were often stretched between boats or people to keep the geese moving towards the pen because geese would often breach spaces between people and boats to escape capture; this was especially true if they had been captured in a prior year. Geese were released on-site or transported in a holding trailer to a temporary holding facility or relocation site. Goslings, accompanied by a few adults, were transported separately from the adults to minimize trampling.

Canada goose relocation sites were selected by the various state game agencies. Geese captured in TM have been released at 5 sites in Idaho, 800-950 km away; 6 sites in California, 200-400 km away; 5 sites in northeast Nevada, 350-420 km away; 4 sites in southeast Nevada, 420-580 km away; 5 sites in central Nevada, 80-120 km away; and 3 sites in western Nevada, 30-50 km away. Currently, NDOW has 9 potential sites available for releasing the relocated geese (NDOW 2001).

Banding and band recovery information has been collected on site, from the National Biological Service Banding Laboratory records, and from periodic surveys of neck collars and bands on geese in and around TM (13,695 records). The information collected on a goose basically follows the Banding Lab's record format. The year for a goose follows the calendar year, so the year for new records begin in January. Recoveries have been recorded for recaptured, dead, or sighted geese, but recoveries have only been recorded once a year in the database unless a goose's status changed in the same year (e.g., if it changed 10-minute blocks¹ or died). There were 588 instances requiring a second recovery record in the same year, and 9 instances requiring a third record; 84% of the second or third records were deaths).

Two hypotheses were tested for this study. First, has relocating geese been effective at reducing the population of Canada geese in TM? To determine this, the probability of recapturing geese in TM between those released on-site and those relocated was analyzed. Secondly, has there been a difference in mortality rates

¹ Records are kept for birds by latitude and longitude at the degree/10 minute level (i.e., 39°30' lat., -119°50' long.).

for “resident” geese and relocated geese? To determine this, mortality recoveries were compared for geese released on site and those relocated. For the purposes of the analysis, recovery information was used from 1986-2001. However, banding data was used for geese captured for the first time from 1986-2000 (geese captured for the first time in 2001 were not used because these geese had not had a full year to be recovered). In addition, if a released on site goose was recovered in TM a following year (sighted or recaptured), a new cycle began for its second release, third release, and so on. If a goose was relocated for the first time and subsequently recovered in TM, this counted as a relocation cycle and the return of either a juvenile or adult. If this goose was sighted or released on site, and had a history of being released on site prior to its relocation, the cycles continued for being released on site. However, if the goose was relocated again, it became a second relocation cycle. The number of times it was relocated was counted as an additional relocation, regardless of prior locations where the goose was moved.

RESULTS

The goose population was estimated to be about 1,200 geese in 1988. However, this was likely a conservative estimate, because the population figures were based on surveys of high-profile sites, primarily 10 areas. The population was estimated to be about 2,000 from 1992 to 1994, again at the same 10 sites. The population began declining in 1995, but it declined more noticeably in 1998 following the relocation of all geese in

1997. Canada geese at the 10 primary round-up sites in north TM declined from about 1,100 to 400 birds between 1997 and 2001 (Figure 1), an 80% decline from the estimated population high of 2,000 in 1994. A more thorough search of TM in May and June 2001 found 788 geese, a population double the 400 at the 10 sites. The population in 2000 was estimated to be about 900 in TM based on surveys from most of the areas surveyed in 2001.

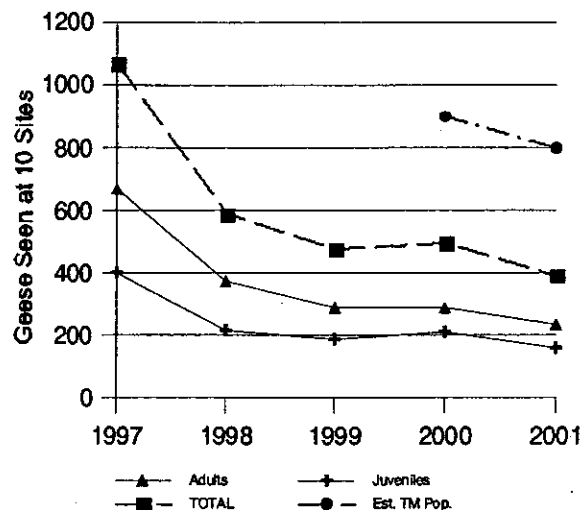


Figure 1. Canada geese seen during surveys at 10 sites in Reno, Nevada from 1997 to 2001 and estimated population in Truckee Meadows (TM) for 2000 and 2001.

Table 1. Canada geese banded and recaptured during annual goose round-ups in Truckee Meadows, Nevada.

| Year | Total Geese | Jun. Banded | % of Total | All Adults | % of Total | Adults Banded | % of Adults | Recap. Adults | % of Adults |
|-------|-------------|-------------|------------|------------|------------|---------------|-------------|---------------|-------------|
| 1986 | 79 | 43 | 54% | 36 | 46% | 36 | 100% | 0 | 0% |
| 1987 | 268 | 208 | 78% | 60 | 22% | 60 | 100% | 0 | 0% |
| 1988 | - | - | - | - | - | - | - | - | - |
| 1989 | 1,051 | 255 | 24% | 796 | 76% | 742 | 93% | 54 | 7% |
| 1990 | 1,459 | 477 | 33% | 982 | 67% | 653 | 66% | 329 | 34% |
| 1991 | 855 | 223 | 26% | 632 | 74% | 235 | 37% | 397 | 63% |
| 1992 | 767 | 383 | 50% | 384 | 50% | 92 | 24% | 292 | 76% |
| 1993 | 1,156 | 377 | 33% | 779 | 67% | 354 | 45% | 425 | 55% |
| 1994 | 1,265 | 485 | 38% | 780 | 62% | 296 | 38% | 484 | 62% |
| 1995 | 969 | 284 | 29% | 685 | 71% | 231 | 34% | 454 | 66% |
| 1996 | 941 | 467 | 50% | 474 | 50% | 120 | 25% | 354 | 75% |
| 1997 | 822 | 377 | 46% | 445 | 54% | 150 | 34% | 295 | 66% |
| 1998 | 456 | 221 | 48% | 235 | 52% | 104 | 44% | 131 | 56% |
| 1999 | 405 | 199 | 49% | 206 | 51% | 115 | 56% | 91 | 44% |
| 2000 | 432 | 253 | 59% | 179 | 41% | 111 | 62% | 68 | 38% |
| 2001 | 472 | 296 | 63% | 176 | 37% | 106 | 60% | 70 | 40% |
| Total | 11,397 | 4,548 | 40% | 6,849 | 60% | 3,405 | 50% | 3,444 | 50% |

*Includes initial foreign captures (geese initially banded by another bander, not in Truckee Meadows).

From 1989-2001, 11,050 Canada geese were banded or recaptured during round-ups (Table 1). In addition to these, 347 geese were captured and released on-site in TM for a study being conducted in 1986 and 1987 by NDOW and the University of Nevada (Table 1); data acquired from these geese is included in the analyses. Of these, 7,934 geese were banded for the first time under banding permits held by NDOW, the California and Idaho Departments of Fish and Game, and WS' National Wildlife Research Center. In addition, 19 "foreign captures" (geese banded by another bander, but not in TM) were caught during round-ups. The remaining 3,444 geese caught during the round-ups were recaptures from previous goose round-ups. Of the geese banded or recaptured, neck collars were placed on 4,752.

Of the geese banded between 1986 and 2000, 3,071 (39%) were recovered (sighted, died, or recaptured) at least once following their release through 2001. A total of 1,206 geese were recovered in 2 separate years; 663 recovered in 3 separate years, 368 in 4 years, 194 in 5 years, 97 in 6 years, 45 in 7 years, 14 in 8 years, 5 in 9 years, and 1 goose each in 10 and 11 years. Table 1 shows the percentage of geese caught that were recaptures during each year. Recaptures rose rapidly to 76% of the adults in 1992. Recapture rates remained high until 1997. However, in 1998, following the relocation of all geese, recapture rates began to decline. The percentage of recaptures fell to about 40% of the adults captured from 1999 to 2001. In 2001 during May and June, every band that could be seen or read was documented throughout TM during surveys (297 of 346 adults). Of the 297 adults whose legs were seen, 119 geese (40%) were banded, the same percentage of the adults captured during the round-ups. This drop was likely a direct result of the relocation of all adults in 1997. However, a variable that may have caused more unbanded geese to come to TM, and thereby, increasing the percentage of unbanded adults, has been drought. In early 1990s and again in 1999-2001, drought conditions dried up ponds and reduced lake water levels in rural areas, likely forcing geese to move from their normal breeding grounds to TM. This could also explain the drop in the percentage of banded adults in 1999-2001.

From 1989 to 2001, the goose surveys at the 10 sites determined where round-ups would be conducted, depending on the number of geese present; round-ups were not always conducted at all 10 sites. The number of geese captured at these same 10 sites annually during the round-ups has declined since 1994 (Figure 2). This indicates that round-ups have probably been successful at reducing the population at these sites. However, the actual number of sites where round-ups were conducted in TM increased in 2000 and 2001 because 8 new sites were added in TM as a result of new complaints; the new sites were in outlying areas, primarily in southwest TM. The inclusion of these areas increased the total number of geese captured in 2000 and 2001 over 1999. These new

areas were included because they were found to have high numbers of geese during surveys, and property owners wanted them taken. Of the geese captured at these sites, several had been banded in TM, but had not been seen for many years. In addition to the drought conditions discussed above, we believe that production from these outlying areas was keeping the population in TM at higher-than-desired levels and contributing to a slow decrease in the TM population.

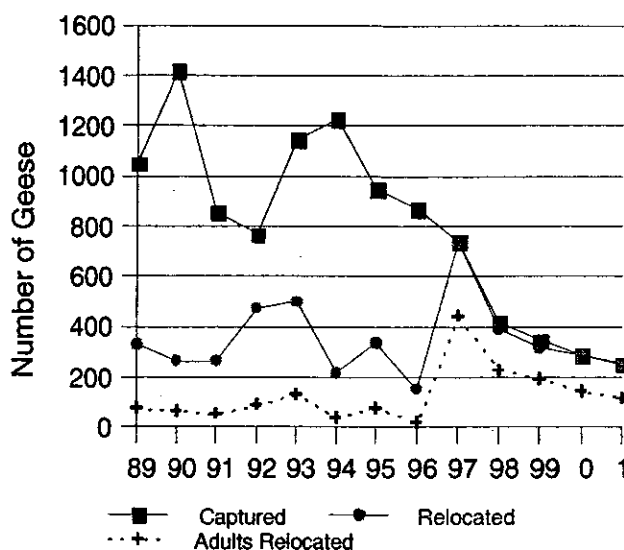


Figure 2. The total number of Canada geese banded and recaptured annually at 10 sites in north Truckee Meadows from 1989 to 2001, and the total number of geese and adults relocated to new sites.

Of the 11,397 Canada geese captured in TM from 1986 to 2001, 5,269 (4,959 adults plus 310 juveniles) were released on site, and 6,130 (1,892 adults, 4,238 juveniles) were relocated to other sites in Nevada (5,105), California (780), and Idaho (243). Subsequent records for these geese have provided a comparison of the recovery rates in TM for relocated and released on-site geese. Table 2 compares the recovery rates in TM for relocated geese from the various relocation sites with those geese released on-site in TM. The data used for releases and relocations only include those geese captured through 2000. However, the recovery rates include information gathered through October 2001.

Of the 7,953 geese initially captured in TM, 5,749 recoveries for these geese have been reported, but not only in TM. Of the recoveries, 3,505 (61%) were from recaptures, 1,447 (25%) from deaths, and 797 (14%) from visual sightings. Most of the recoveries (5,629) have been in the Pacific Flyway. Nevada had the most recoveries as expected with 5,140 (89.4%). Recoveries from surrounding states were 293 (5.1%) in California, 87 (1.5%) in Idaho, 43 (<1%) in Oregon, 39 (<1%) in

Table 2. Canada geese relocated from or released on-site in Truckee Meadows, Nevada during annual round-ups from 1986 to 2000 and recovery rates in Truckee Meadows from 1986 to 2001.

| Area | JUV | JUV R | % | ADU | ADU R | % | Ad1 | Ad2 | % | Ad3+ | R | % |
|--------------------------------|-------------|------------|------------|-------------|------------|-------------|------------|-----------|-------------|-----------|-----------|-------------|
| SE Nevada - 4 sites | 1280 | 12 | 0.9 | 573 | 53 | 9.3 | 93 | 15 | 16.1 | 7 | 4 | 57.1 |
| NE Nevada - 5 sites | 718 | 27 | 3.8 | 373 | 98 | 26.3 | 28 | 8 | 28.6 | 6 | 5 | 83.3 |
| Central Nevada - 5 sites | 925 | 64 | 6.9 | 262 | 98 | 37.4 | 64 | 36 | 56.3 | 18 | 13 | 72.2 |
| Western Nevada - 3 sites | 221 | 37 | 16.7 | 64 | 24 | 37.5 | 4 | 3 | 75.0 | - | - | - |
| Nevada Total - 17 sites | 3144 | 140 | 4.5 | 1272 | 273 | 21.5 | 189 | 62 | 32.8 | 31 | 22 | 71.0 |
| California - 6 sites | 588 | 5 | 0.9 | 192 | 38 | 19.8 | - | - | - | - | - | - |
| Idaho - 5 sites | 212 | 1 | 0.5 | 31 | 6 | 19.4 | - | - | - | - | - | - |
| Total Relocated Geese | 3944 | 146 | 3.7 | 1495 | 317 | 21.2 | 189 | 62 | 32.8 | 31 | 22 | 71.0 |
| Geese not Relocated | 308 | 125 | 40.6 | 2539 | 1514 | 59.6 | 1322 | 905 | 68.5 | 1480 | 1029 | 69.5 |

Ad1 - adult relocated/released once
Ad2 - adult relocated/released twice

Ad3+ - adult relocated/released three or more times;
R - recovered in TM

Table 3. Canada geese released on-site or relocated from Truckee Meadows and recoveries within the specified number of years in Truckee Meadows for juveniles and adults released/relocated anywhere once, twice, and three or more times.

| Return Year | NOT RELOCATED | | | RELOCATED | | |
|-------------|---------------|-------|-------|-----------|-------|-------|
| | Juv | JuvR | % | Juv | JuvR | % |
| All | 308 | 125 | 40.6% | 3944 | 141 | 3.5% |
| 1 | 308 | 48 | 15.6% | 3944 | 59 | 1.5% |
| 3 | 308 | 96 | 31.2% | 3492 | 103 | 2.9% |
| 5 | 308 | 120 | 39.0% | 2894 | 99 | 3.4% |
| | Ad1 | Ad1R | % | Ad1 | Ad1R | % |
| All | 2539 | 1514 | 59.6% | 1495 | 317 | 21.2% |
| 1 | 2539 | 924 | 36.4% | 1495 | 180 | 12.0% |
| 3 | 2487 | 1297 | 52.2% | 1220 | 208 | 17.0% |
| 5 | 2475 | 1435 | 58.0% | 648 | 170 | 26.2% |
| | Ad2 | Ad2R | % | Ad2 | Ad2R | % |
| All | 1322 | 905 | 68.5% | 189 | 62 | 32.8% |
| 1 | 1322 | 540 | 40.8% | 189 | 48 | 25.3% |
| 3 | 1294 | 810 | 62.6% | 104 | 17 | 16.3% |
| 4 | 1293 | 845 | 65.6% | 74 | 9 | 12.2% |
| | Ad3+ | Ad3+R | % | Ad3+ | Ad3+R | % |
| All | 1480 | 1029 | 69.5% | 31 | 22 | 71.0% |
| 1 | 1480 | 691 | 46.7% | 31 | 18 | 58.1% |

Ad1 - adult relocated/released once
Ad2 - adult relocated/released twice
Ad3+ - adult relocated/released three or more times
R - recovered in TM

Washington, 19 (<0.4%) in Utah, and 6 (0.1%) in Arizona. The Rocky Mountain Flyway had 33; the Central Flyway had 5; and the Atlantic Flyway had 2, with geese recovered as far away as North Carolina (1) and Maryland (1). Eighty geese (1.4%) were also recovered in Canada: 65 in Alberta, 13 in Saskatchewan, and 2 in British Columbia; this suggests that a molt migration occurs in non-breeding and subadult geese, similar to findings of other researchers (Rienecker 1987). Of recoveries due to death, 1,241 (21% of all recoveries) were from hunter harvest. The oldest goose, thus far, was 14½ years old when killed, but 2 other 14 year-old geese were relocated in 2001.

The probability of a recovery in TM was compared for geese released on site and relocated (Table 3). Of the 308 juvenile and 2,539 adult geese released in TM for the first time by the year 2000, the number of geese recovered anywhere was 165 juveniles (53.6%) and 1,759 adults (69.3%); the number recovered only in TM was 125 (40.6%) and 1,514 (59.6%), respectively. In comparison, the recoveries from all sites for the once-relocated 3,944 juvenile geese and 1,495 adult geese were 1,041 (26.4%) and 647 (43.3%), respectively; the number that returned to TM was only 141 juveniles (3.5%) and 317 adults (21.2%). This represented a significant reduction in geese returning to TM compared to geese released on site for both juveniles and adults ($P<.0001$). Adults recaptured and released a second time in TM were recovered more frequently in TM (905 of 1,322, or 68.5%) than those adults released on-site their first time (59.6%). Comparatively, geese relocated a second time that returned to TM increased to 32.8% (62 of 189), but again relocation resulted in a significant reduction in the number of geese returning ($P<.0001$). The percentage of geese released in TM and recovered in TM 3 or more times (1,029 of 1,480, or 69.5%) was much more similar to geese that were relocated 3 or more times and returned to TM (22 of 31, or 71%); there was no significant difference ($P>0.8$).

Since most geese released on site had more years to be recovered than those relocated, the probability of recovery in TM was also evaluated by the number of years between the release or relocation date to the recovery date in TM. Juveniles and adults released or relocated once were compared for 1, 2, 3, and 5 years (Table 3). A time period of 0.2 years (73 days, or about 2½ months) was added to the time of recovery for the yearly interval (i.e., 1.2 years, 2.2 years) to allow for differences in the annual round-up dates which could take place from early May into July. Of the geese released on site for a first time in TM, 48 of 308 juveniles (15.6%) and 924 of 2,539 adults (36.4%) were recovered within the first years following their release. Conversely, 59 of the 3,994 juveniles (1.5%) and 180 of the 1,495 adults (12.0%) relocated the first time were recovered in TM within 1.2 years, a significant difference from geese released on site ($P<.0001$). The recovery rates for all 4 groups increased similarly with the number of years

between time of release and recovery, and the probability remained the same. Geese released on site compared to those relocated twice were compared for returns in 1, 2, 3, and 4 years: 540 of 1,322 (40.8%) geese twice released on site vs. 48 of 189 (25.3%) twice-relocated adults were recovered in TM in their first year ($P<.0001$). Again, percentages increased similarly as the number of years increased and the probability of a difference remained the same ($P<.0001$). Adults released or relocated 3 or more times were compared for return rates only for the first year, because the majority of them were released in 2000. Of adult geese released on site 3+ times, 691 of 1,480 (46.7%) were recovered in TM, while 18 of 31 (58.1%) relocated 3+ times were recovered in TM within the first year ($P>0.2$), suggesting similar recovery rates in TM.

Geese in urban areas typically have exponential growth rates because they have much lower mortality rates as compared to geese that live in rural areas (Ankney 1996). However, a wider range of causes for mortality exists for released on-site (urban) geese such as hit by car, found dead, struck wires, and injured/euthanized compared to relocated (rural) geese. Hunting is allowed at the sites where geese have been relocated. Mortality was higher for relocated geese than for those released on-site in TM, as expected. Of the geese relocated before 2001, 1,032 of 5,438 (19.0%) were reported dead with 957 of 5,438 (17.6%) deaths attributed to hunting. However, for geese released on-site in TM, 405 of 2,845 (14.2%) were reported dead with only 280 of 2,845 (9.8%) due to hunting. This is a significant difference ($P<.0001$) in hunting-related mortality for relocated vs. non-relocated geese, representing almost an 8% increase in the number of geese shot by hunters. This additional mortality of relocated geese due to hunting likely helps stabilize the population at a lower level. In larger urban areas (Reno/Sparks is relatively small), it is likely that hunting mortality is even lower for urban geese.

DISCUSSION

The Canada goose relocation program that started in 1989 has been very successful in reducing the "resident" population at high profile sites in TM from a high of about 2,000 to 400, an 80% reduction. Throughout TM, the goose population was found to be about 800 in 2001. The entire TM Canada goose population will be monitored in the future to determine the effects of the relocation program over the larger area. Of the 5,438 birds relocated during the round-ups (Table 2), only 547 (about 10%) have returned. It is widely believed by wildlife biologists that relocation programs are very effective for goslings. This has been the case with the relocated goslings from TM, with a 10-fold difference in rate of return for relocated vs. non-relocated geese (4% vs. 40%). However, it has been thought that relocating adults was not effective because most would return to their capture site. However, we found a significant difference between the return rate of first- and second-

time-relocated adult geese vs. non-relocated geese ($P < .0001$). The return rate to TM was much less: 21% vs. 60% for relocated vs. released on site for first-time captured adults, and 33% vs. 69% for second-time captured adults— basically a 35-40% reduction in the number of birds that return. This has had a profound effect on the population in TM and has continued to reduce the numbers to a more desired level, as shown in Figures 1 and 2.

On the other hand, the relocation of adults more than 2 times had no effect on whether or not geese would be recovered in TM. Geese were recovered equally at 71% vs. 69.5% (relocated vs. not relocated), suggesting that geese should not be relocated more than 2 times. These geese have demonstrated their ability to “home-in” on TM and will likely continue to do so. In a program where the desired outcome is a reduced population, these geese may be euthanized rather than relocated. Euthanasia of local populations of geese has been done in many urban areas to reduce the population and damages associated with them.

The relocation of Canada geese has benefits and drawbacks. Relocation does increase recreational opportunities, primarily hunting, which can be used as a population management tool, as is reflected in our data. Unfortunately, in most states relocation is not an option because it is not allowed or may exacerbate problems elsewhere. In many states, especially in the East, urban centers would be relatively close to any potential relocation sites. The relocated geese, especially the adults, may not return to their capture site, but could turn up in new urban areas, where they could create a problem. This has been found to be true for relocation sites near urban centers in Nevada. In Nevada, relocated geese, most all adults, have been found in Las Vegas, Elko, and Ely, and these geese were from relocation sites near these areas. However, most of the relocation sites in Nevada are mostly remote and not located near any urban centers, making them ideal for relocation. One other drawback for relocation is that many urban areas in other states are struggling with a much more severe overpopulation of Canada geese than Nevada, and relocation may only add to the number of sites with problems. In Nevada, relocation appears to be a good management tool, and this strategy might be an alternative for reducing urban populations in other states.

Since the inception of the program, only 5 goose strikes have occurred at Reno/Tahoe International Airport, and only 2 of these (April 1992 and 1994) were a likely result of the resident geese. This is another indication that the relocation program has been effective, because no strikes have occurred since 1994, when the population was at its highest level and strikes were occurring at a rate of about 1 every 2 years. In addition, the number of complaints received by WS for resident geese in TM has also decreased.

Data analysis for the Canada goose relocation program has only just begun. Many questions could be

answered with the data. A few more years of data will also provide a better look at the return rates of adults relocated multiple times, because more adults previously relocated have been relocated each successive year. In 2001, one adult goose was relocated for the fifth time.

ACKNOWLEDGEMENTS

We thank the people, a couple hundred, especially WS and NDOW personnel in Nevada who participated in the annual goose round-up in Reno. Without the support of NDOW, the California and Idaho Departments of Fish & Game, and NWRC for the ability to band birds and track data, this paper would not have been possible. We also thank the Reno/Tahoe International Airport and other members of the Reno Goose Task Force for providing input, assistance with round-ups, and assuring that the goal of reducing strike hazards at the airport have been met.

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