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INFLUENCE OF SKUNK REMOVAL ON NEST SUCCESS AND BREEDING POPULATIONS OF UPLAND NESTING DUCKS IN THE LOWER FLATHEAD VALLEY, MONTANA

By

Kurt J. Forman

B.S., South Dakota State University, 1990

Presented in partial fulfillment of the requirements

for the degree of

Master of Science

THE UNIVERSITY OF MONTANA

1993

Approved by:

Chairman, Board of Examiners

Dean, Graduate School

May 17, 1993

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ABSTRACT

Forman, Kurt J., M.S., Spring 1993 Wildlife Biology

Influence of skunk removal on nest success and breeding populations of upland nesting ducks in the lower Flathead Valley, Montana. (60 pp.).

Director: Dr. I.J. Ball

As part of an ongoing study, duck nest success, nest densities, and breeding pair numbers were studied during 1991 and 1992 on the Ninepipe skunk (Mephitis mephitis) removal area and Pablo National Wildlife Refuge (control area) in northwestern Montana. Results were compared with baseline data collected in 1986 and 1987 prior to skunk removal (Hall in prep.). Skunk trapping success (N captures/1000 trap-nights), in 1991 (5) and 1992 (3) was substantially lower than in 1988 (15), the first year of skunk removal (Pengeroth 1991), indicating that skunk densities had declined considerably during the removal period. Although Mayfield nest success varied substantially between years on both study areas, the 1991-92 average at Ninepipe was significantly higher than at Pablo (45% vs. 14%, $Z=4.24$, $P<0.005$). Conversely, nest site Visual Obstruction Readings (VORs) were significantly higher at Pablo than at Ninepipe in 1991 (3.9 dm vs. 3.2 dm, $t=3.19$, $P<0.005$) and 1992 (4.0 dm vs. 2.8 dm, $t=4.67$, $P<0.005$), suggesting that upland habitat conditions were not responsible for high nest success at Ninepipe. Apparent nest densities (nests/100 ha) at Ninepipe ranged from 8 in heavily grazed pasture to 175 in managed cover. Breeding pair densities (pairs/ha surface water) at Ninepipe in 1991 (13.9) and 1992 (11.9) were among the highest ever recorded in glaciated wetland habitats. Comparisons to baseline levels indicated that skunk removal was effective. With years combined, nest success at Ninepipe during this study was approximately double the pre-skunk-removal average of 1986-87, and 1992 nest densities in managed cover were over 4 times higher than in 1986. The number of dabbling duck pairs surveyed on standardized areas at Ninepipe by National Bison Range personnel increased from a 1982-88 average of 234 to 753 in 1992.

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Introduction

North American duck populations have declined for several decades and are currently near record lows (USFWS and CWS 1992). One hypothesis for this decline is that throughout much of the Prairie Pothole Region, which historically accounted for 50% of continental duck production (Smith et al. 1964), the effects of habitat fragmentation and current predator densities are suppressing recruitment rates below levels needed for population maintenance. Recent studies of nest success, a primary determinant of recruitment rates (Cowardin and Johnson 1979), support this contention. Most investigators in the Pothole Region are currently reporting Mayfield (1961) nest success rates below the 15% population maintenance threshold advanced by Cowardin et al. (1985) for mallards (Anas platyrhynchos) in central North Dakota. For example, Greenwood et al. (1987) reported average mallard nest success of 12% during 1982-85 on 17 study sites in Alberta, Saskatchewan, and Manitoba. Furthermore, Klett et al. (1988) summarized North Dakota data sets from 1966-84, and noted nest success rates of 7% for mallards, 8% for northern pintails (Anas acuta), and 13% for gadwalls (Anas strepera). Mammalian predation is the primary cause of nest failure in most contemporary nest success studies in the

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Pothole Region (e.g. Fleskes and Klass 1991, Higgins et al. 1992). Population modeling suggests that current predation levels, on both nesting hens and eggs, have created "sink" populations that can only be maintained by immigration. In the absence of immigration, it is believed that mallard populations would decline at an annual rate of 2% in North Dakota (Cowardin and Johnson 1979) and 13% in Iowa (Fleskes and Klass 1991). Documentation of sink populations is strongest for the mallard, primarily because detailed information on mallard survival rates are available. However, extremely low rates of nest success are known to occur in most duck species over enormous geographical regions. Many populations of prairie ducks (and probably other species of ground-nesting birds) have not realized their full recruitment potential for 2-3 decades. Similarly, recent studies have also implicated fragmentation of forest breeding habitat and subsequent high levels of nest predation and parasitism as contributing factors in the decline of neotropical migrant songbird populations (Andren et al. 1985, Wilcove 1985, Yahner and Scott 1988, Terborgh 1989).

A long-term study of the productivity of ground-nesting birds was initiated during 1986 in the glaciated pothole habitats of the lower Flathead (Mission) Valley of western Montana. Although obviously not part of the mid-continent prairies, the lower Flathead Valley is strikingly similar to

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the Prairie Pothole Region in terms of wetland densities, habitat fragmentation, high densities of small mammalian predators resulting from human influences, and low recruitment levels of ground-nesting birds. Baseline data collected in 1986 and 1987 indicated that nest success in the Ninepipe area was 23% for all duck species combined and 11% for mallards, and that predation by skunks (Mephitis mephitis) was the primary cause of nest failure (Hall in prep.). In 1988, an experimental reduction of skunk densities was initiated in the Ninepipe area in efforts to increase nest success, recruitment, and the local breeding population through philopatric homing of successful hens and their female progeny. After the initial year of skunk removal nest success remained unchanged (20%), but increased to 44% in 1989 and 60% in 1990 (Hall in prep.). Pablo National Wildlife Refuge (NWR) which served as an experimental control (nonremoval) area showed little change in nest success between 1986,88 and 1989-90 (Hall in prep.). In the present study, I continued skunk removal through 1992 and monitored nest success, nest densities, and breeding pair numbers. Study objectives were to:

1. monitor duck nest success and nest densities on control and removal areas;
2. assess the relative importance of skunk removal and the height-density component of nesting cover as determinants of nest densities and nest success;
3. quantify breeding pair densities on the removal area; and

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4. summarize and integrate my data with those from Hall (in prep.), and breeding duck surveys conducted from 1982-92 by personnel of the National Bison Range, to evaluate the influence of skunk removal on nest success and the size of local breeding populations.

Study Area(s)

The Ninepipe skunk removal area and the Pablo NWR (control area) were located in the lower Flathead Valley of western Montana, approximately 80 km north of Missoula (Fig. 1). The Valley was delineated by the Mission mountains to the east and the Flathead foothills to the west and has long been recognized as an important breeding and staging region for waterfowl (Girard 1941, Lokemoen 1966).

The climate was characterized by hot summers and cool to cold winters with highly variable snowfall amounts. The mean annual temperature recorded at St. Ignatius, 10 km southeast of Ninepipe, was 7.6 C with a January mean of -4.2 C and an August mean of 18.8 C (NOAA 1991-92). Average annual precipitation was 41 cm, with 30% occurring in May and June (NOAA 1991-92).

Primary nest predators in both study areas included skunk, coyote (Canis latrans), raccoon (Procyon lotor), black-billed magpie (Pica pica), and common raven (Corvus corax). Red fox (Vulpes vulpes) occurred at low densities in the Flathead Valley, but no sightings occurred in either study area during the two years of field work.

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Ninepipe skunk removal area

The skunk removal area consisted of 41 km^2 of federal, state, private, and Confederated Salish and Kootenai tribal lands approximately 8 km south of Ronan. Primary land uses were based upon cereal grain and livestock production. The United States Fish and Wildlife Service (USFWS) and the Montana Department of Fish, Wildlife and Parks owned 16.9 km^2 within the removal area. These state Wildlife Management Areas (WMAs) and federal Waterfowl Production Areas (WPAs) were managed for wildlife production, and nesting cover was enhanced primarily by seeding mixtures that included tall wheatgrass (Agropyron elongatum), intermediate wheatgrass (Agropyron intermedium), orchard grass (Dactylis glomerata), smooth brome (Bromus inermis), and alfalfa (Medicago sativa). Glaciated pothole wetlands occurred throughout the Ninepipe region at densities as high as 92/km^2 (Lokemoen 1962). Most of these basins were < 0.25 ha in size and often were vegetated with hardstem bullrush (Scirpus acutus) and cattails (Typha spp.).

Pablo NWR control area

Pablo NWR, approximately 10 km south of Polson served as an experimental control area. The refuge was comprised of the 750 ha Pablo irrigation reservoir and 280 ha of adjacent uplands. Although used extensively by breeding waterfowl, Pablo differed markedly from Ninepipe in terms of wetland and upland habitat types. While Ninepipe was

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generally comprised of small glaciated potholes with little woody cover in the adjacent uplands, Pablo, in contrast, was characterized by man-made impoundment wetlands and high densities of Russian Olive (Elaeagnus angustifolia) trees. Pastures at Pablo were generally comprised of smooth brome, quackgrass (Agropyron repens), and bluegrass (Poa spp.) with interspersed stands of Russian Olive.

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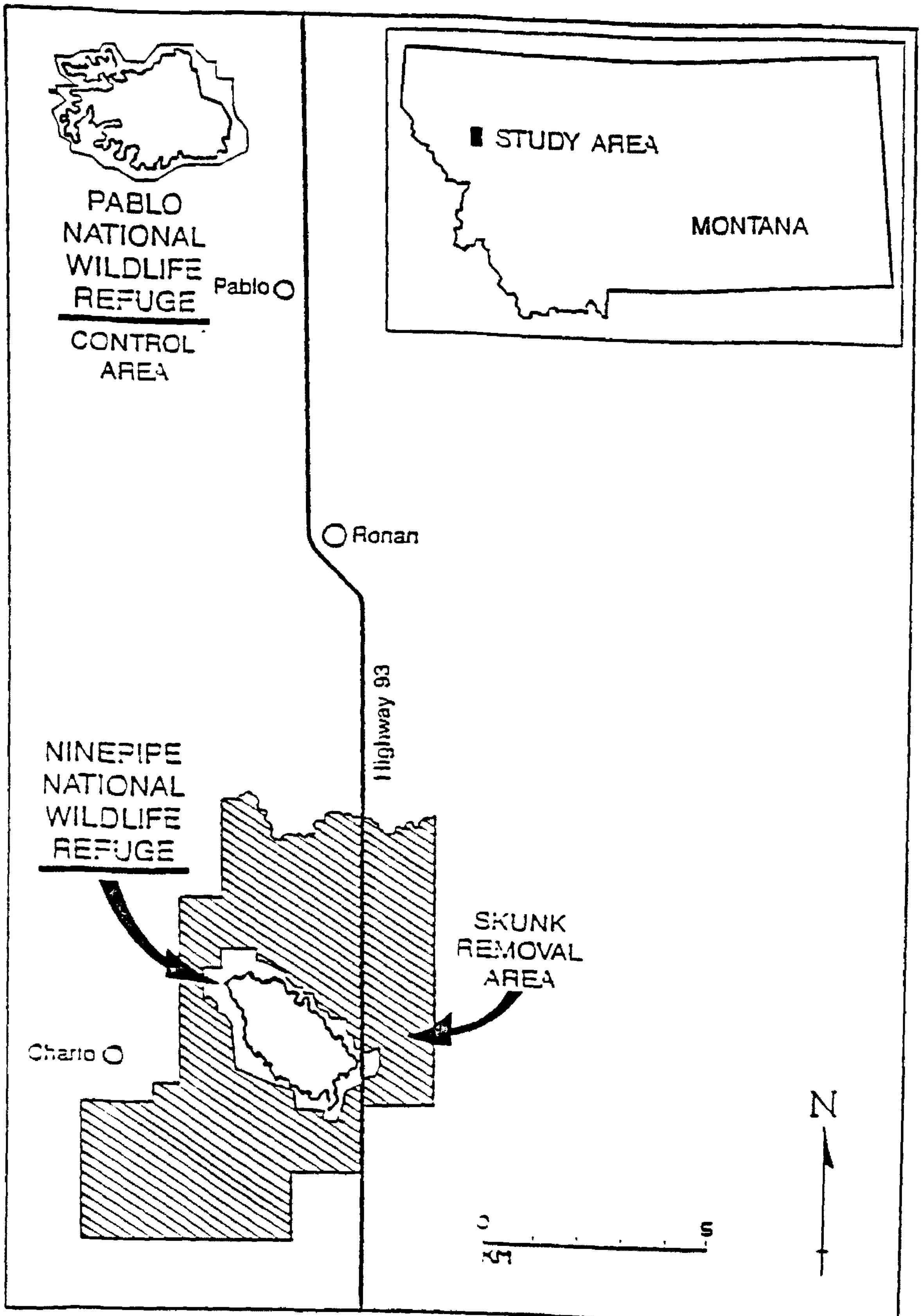

Fig. 1. The Lower Flathead Valley including the Ninepipe skunk removal area and Pablo NWR (control area).

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Methods

Weather and Wetland Conditions

Local weather data on monthly precipitation and temperatures was obtained from the National Oceanic and Atmospheric Administration (NOAA) monitoring station in St. Ignatius, Montana. The number of wetland basins containing surface water was monitored throughout the waterfowl breeding season.

Upland Habitat Evaluation

Visual Obstruction readings (VORs) modified from Robel et al. (1970) were systematically measured along permanent transects and were used to index the height-density component of vegetation within each study field. Transects were established in representative portions of each field and recording stations were spaced at 40m intervals. At each station, 4 readings, 1 from each cardinal direction, were recorded to the nearest 0.5 dm at 100% visual obstruction from a height of 1m and a distance of 4m. The VOR was the mean of the 4 readings. A mean VOR was calculated for each field and habitat type from the constituent station means. VORs were recorded twice in both 1991 and 1992. The first survey was conducted in late April and early May to index spring cover quality, primarily

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residual vegetation, and the second survey was conducted in early July during peak growth. All statistical comparisons of transect VORs were based on Friedman's repeated measures analysis (Conover 1980), and will be presented with the Friedman's X^2 test statistic (FX^2) and one degree of freedom. Statistical significance was established at $P<0.05$ for all analysis presented in this thesis.

Skunk Trapping

Skunks were removed from the Ninepipe area with Tomahawk live traps (primarily 23 x 23 x 66cm). Traps were baited with sardines and were set from 20 March through 2 July in 1991 and from 22 March through 8 June in 1992. Captured skunks were euthanized with sodium pentobarbital. Traps were selectively placed in fields with high densities of ground nesting birds and near sites of known or suspected skunk activity, such as dens, culverts, and irrigation headgates.

Breeding Duck Surveys

Breeding duck populations were surveyed each spring on the same 100 wetland basins on State, Federal, and Tribal land within the Ninepipe study area. The basins were selected from all those containing surface water in May 1990 aerial photographs. Wetland basin classification (Cowardin

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et al. 1979) was originally derived from National Wetland Inventory maps, but for ease of interpretation was translated to the Stewart and Kantrud (1971) classification system following guidelines presented by Cowardin et al. (1988). The observed pair/lone male ratio of breeding ducks observed on a 32 km roadside transect was used to determine the optimum survey period for each species. All 100 wetland basins were surveyed twice each spring; mallards and northern pintails were surveyed first and all the other species approximately 10 days later. Social groups were interpreted as by Dzubin (1969a). Observed pairs, lone males, and flocked males in flocks less than six were counted as indicated breeding pairs. Additionally, data from breeding waterfowl surveys conducted in the Ninepipe area from 1982-92 by USFWS National Bison Range personnel were used as an index to long-term changes in species composition and size of local breeding populations. These surveys were conducted on standardized areas each spring.

Nest Searching

The methods used for locating and monitoring duck nests generally followed the procedures and definitions presented by Klett et al. (1986). Nests were located during 3 systematic searches conducted at approximately 25-day intervals from late April through early July each year. Depending on field size, wetland densities, and topography,

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searches were conducted with a 53 m cable chain drag (Higgins et al. 1977), a 37 m cable chain drag, or a 30 m chain. The number of eggs, incubation stage (Weller 1956), species, and VOR at the nest site and 5m north of the nest (Holm 1984) were recorded when a nest was initially found. Each nest was identified by a numbered willow (Salix spp.) placed 4m to the north. Friedman's repeated measures analysis was used to detect significant differences between nest site VORs and VORs at adjacent sites (points 5m north of nest sites), while two-sample t procedures were used to evaluate nest site VORs by year, nest fate, and study area.

Nests were checked at 7-12 day intervals until fate was determined. Nests with at least one hatched egg were considered successful. Nests determined to have been abandoned on the day of discovery were considered to be influenced by search activities and were not used in calculating nest success. The number, location, and condition of eggshells, and the degree of nest bowl disturbance was noted at each depredated nest. Because nest destruction patterns even among a single predator species can be highly variable (Trevor et al. 1991), and nest site evidence commonly used to identify predators is often subjective (A. Sargeant, pers. commun.), I differentiated destroyed nests into 3 broad classes and did not attempt species-specific interpretation. Class I nests had crushed eggs or numerous fragments at the nest site and disturbance

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to > 50% of the nest material. Class II nests had no eggshells or fragments at the nest site and < 10% nest material disturbance. Class III nests were those not clearly meeting the criteria for the other two classes.

Nest Success and Density Calculations

Daily survival rates (DSRs) were calculated by the modified Mayfield method (Johnson 1979). DSRs were expressed as Mayfield nest success (after here referred to as nest success) where nest success = DSR^I and (I) is the average duration of laying + incubation, considered to be 35 days. Apparent nest densities (N nests found/100 ha) were based on slightly more nests than nest success estimates because nests that were abandoned due to investigator influence, damaged in search related activities, hatched when found, or were not relocated for nest checks were not used in calculating nest success. Z tests were used to detect significant differences in DSRs among study areas, years, and species (Johnson 1979). Simple linear regression was used to examine relationships between cover quality and nest density.

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Predator Community Assessment

Scent station methods (Roughton and Sweeny 1982, Conner et al. 1983) were used to index predator community composition and relative abundance. The control area was enlarged to include regions outside Pablo NWR. Four scent station transects were established along unpaved roadways in each study area. Each transect was 4.5 km long and consisted of 10 evenly spaced scent stations. Stations consisted of a 1 m diameter circle of sifted earth with a scent disk placed in the center. Scent stations were checked for signs of visitation (tracks) for 3 consecutive nights during the 2nd week of August each year. Chi-square tests were used to detect significant differences in the proportion of scent stations visited between study areas and years.

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Results

Weather and Wetland Conditions

Average monthly temperatures (Table 1) and monthly precipitation (Table 2) varied between years. Temperatures during the waterfowl breeding season were generally near normal in 1991 and above normal in 1992. Annual precipitation in 1991 was below normal, but the January-July subtotal in 1992 was above normal. Wetland conditions deteriorated substantially during the study, with the percentage of surveyed basins containing water during May declining from 91% in 1991 to 65% in 1992.

Table 1. Average[a] monthly temperatures (C) at St.Ignatius, Montana during the waterfowl breeding season, 1991-92. From NOAA (1991-92).

Month	1991	1992	Mean 1951-1980
March	2.3	5.8	2.1
April	7.5	9.1	7.2
May	11.4	13.8	11.8
June	14.4	18.2	15.7
July	19.7	17.7	19.3

[a]Based on the average maximum and minimum monthly temperatures

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Table 2. Monthly precipitation (cm) at St. Ignatius, Montana, 1991-92. From NOAA (1991-92).

Month	1991	1992	Mean 1951-1980
January	3.19	1.50	3.40
February	3.01	0.86	1.98
March	4.19	4.62	2.46
April	1.02	6.83	3.63
May	6.78	4.06	5.95
June	8.71	5.23	6.43
July	0.94	5.44	2.64
Jan.-July Subtotal	27.84	28.54	26.49
August	2.57		3.12
September	1.73		3.40
October	1.68		2.87
November	3.25		2.44
December	0.69		2.77
Annual	37.76		41.09

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Upland Habitat Evaluation

Ninepipe skunk removal area

Visual obstruction readings (VORs) varied substantially by habitat type, sampling period, and year (Table 3). Spring VORs within managed cover were significantly higher in 1992 than 1991 ($FX^2=98.45$, $P<0.005$). Spring 1992 VORs in pasture habitats were marginally greater than 1991 ($FX^2=3.56$, $P=0.06$), while spring VORs in alfalfa did not differ between years ($FX^2=0.50$, $P=0.48$). Summer VORs decreased significantly between 1991 and 1992 in all habitat types: managed cover ($FX^2=11.79$, $P<0.005$), alfalfa ($FX^2=4.50$, $P<0.05$), and pasture ($FX^2=9.97$, $P<0.005$).

Table 3. Visual Obstruction Readings (VORs) of three habitats on the Ninepipe skunk removal area. Based only on fields nest searched in both 1991 and 1992. All measurements in dm.

	1991				1992			
	Spring (20 Apr.-13 May)		Summer (2-10 July)		Spring (16-22 Apr.)		Summer (2-7 July)	
	VOR	SE[a]	VOR	SE	VOR	SE	VOR	SE
M.Cover[b]	0.51	0.04	3.42	0.15	1.48	0.07	2.83	0.11
Pasture[c]	0.27	0.01	0.50	0.05	0.31	0.01	0.35	0.03
Alfalfa[d]	0.67	0.09	6.64	0.66	0.68	0.15	2.49	0.42

[a]Standard Error

[b]Managed Cover: Primarily seeded to mixtures that include intermediate wheatgrass, tall wheatgrass, smooth brome, orchard grass, and alfalfa.

[c]Uncultivated land grazed by domestic livestock and vegetated with native and introduced grasses and forbs.

[d]Seedings dominated by alfalfa but interspersed with stands of grass: hayed once annually during late July.

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Pablo NWR control area

VORs at the Pablo NWR also varied by habitat, sampling period, and year (Table 4). Spring VORs did not change significantly between 1991 and 1992 in alfalfa fields ($FX^2=0.60$, $P=0.44$), but were marginally higher in 1992 in the north pasture ($FX^2=3.27$, $P=0.07$). Summer VORs decreased significantly between 1991 and 1992 in alfalfa fields ($FX^2=6.25$, $P<0.05$).

Table 4. Visual Obstruction Readings (VORs) of three fields nest searched at the Pablo NWR (control area) during 1991-92. All measurements in dm.

	1991				1992			
	Spring (22-24 April)		Summer (8-9 July)		Spring (22-23 April)		Summer (3-7 July)	
	VOR	SE[a]	VOR	SE	VOR	SE	VOR	SE
Alfalfa[b]	0.47	0.06	6.95	0.19	0.52	0.06	4.43	0.53
North Pasture[c]	0.30	0.01	0.55	0.06	0.44	0.05	0.75	0.09
South Pasture[c]			1.92	0.16	0.74	0.09	1.59	0.27

[a]Standard Error

[b]Land seeded to alfalfa but interspersed with stands of grass: hayed once annually during late July.

[c]Uncultivated land grazed by domestic livestock and vegetated primarily with smooth brome, quackgrass, and bluegrass, and interspersed with stands of Russian Olive trees.

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Skunk Trapping Summary

In 1991, 28 skunks (18M,10F) were removed from the Ninepipe study area from 18 March to 2 July during 6035 trap-nights, and 14 skunks (7M,7F) were removed from 22 March to 8 June 1992 during 4149 trap-nights. Fifty-seven percent of the 1991 captures and 93% of the 1992 captures occurred during the first 1500 trap-nights. Because of severely declining capture rates in 1992 (one skunk captured in 2649 trap-nights from 20 April to 8 June) the systematic trapping effort was ended approximately three weeks earlier than in previous years. Three additional female skunks were captured after 8 June 1992 as a result of incidental sightings. The 1991-92 data represents a decline in captures from 1988 to 1992: 109, 76, 34, 28, and 17. Trapping success (N captures/1000 trap-nights) during the systematic trapping effort also declined: 15, 10, 5, 5, and 3.

Breeding Pair Surveys

Of the 100 sampled basins, 17 were seasonal, 79 semi-permanent, and 4 permanent (Stewart and Kantrud 1971). Sixty-two of the basins were less than 0.2 ha and only 10 were greater than 0.4 ha in size. The proportion of basins containing water during May declined significantly from 1991

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to 1992 (91/100 vs. 65/100, X^2=19.70, df=1, P<0.005) with the majority of dry basins being less than 0.1 ha.

Temporal changes in the ratios of pairs, lone males, and flocked males observed along roadside transects at 5 day intervals indicated that the breeding chronology for all species was 2-3 weeks earlier in 1992 than 1991. Accordingly, breeding pair counts on the sampled basins were conducted from 4 May to 13 May 1992, approximately three weeks earlier than 1991. The number and species composition of breeding pairs surveyed varied between years, with the total number of pairs and pair density declining from 1991 to 1992 (Table 5). Although the total number of pairs declined between years, the numbers of mallards and northern shovelers (Anas clypeata) increased, and together represented 48% of the pairs surveyed in 1992. The proportion of mallards in the survey increased significantly from 1991 to 1992 (X^2=11.93, df=1, P<0.005).

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Table 5. Indicated pairs of ducks surveyed on 100 wetland basins in the Ninepipe skunk removal area, 1991-92.

	1991[a]			1992[b]		
Species	N	%	Density[c]	N	%	Density
Mallard	52	17	2.4	65	30	3.4
Gadwall	48	16	2.2	31	14	1.7
Cinnamon teal (*Anas cyanoptera*)	53	17	2.4	36	17	2.0
Northern shoveler	34	11	1.5	39	18	2.2
Redhead (*Aythya americana*)	48	16	2.2	18	8	1.0
Blue-winged teal (*Anas discors*)	21	7	0.9	1	<1	0.06
Green-winged teal (*Anas crecca*)	11	4	0.5	4	2	0.2
Wigeon (*Anas americana*)	20	7	0.9	7	3	0.4
Northern pintail	4	1	0.2	5	2	0.3
Lesser scaup (*Aythya affinis*)	10	3	0.5	11	5	0.6
Ruddy duck (*Oxyura jamaicenis*)	4	1	0.2	--	--	--
Barrow's Goldeneye (*Bucephala islandica*)	--	--	--	1	<1	0.06
Totals:						
All Species	305	100	13.9	218	100	11.9
Dabblers Only	243	80	11.0	188	86	10.3

[a]91/100 basins contained water when all species were surveyed.

[b]65/100 basins contained water when mallards and pintails were surveyed and 58/100 basins contained water when all other species were surveyed.

[c]Pairs per ha of surface water.

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Summary of Habitats Nest Searched

As a result of habitat management activities, the amount of land that could be nest searched on WPAs and WMAs (primarily managed cover) at Ninepipe varied between years. Three systematic nest searches were completed on 297 ha of WPA and WMA land in 1991 and 331 ha in 1992, 234 ha of this was searched both years. Eleven ha of alfalfa on WMA land, not included in the above totals, and 50 ha of tribally owned pasture were searched three times each year at Ninepipe. At Pablo, 65 ha of pasture were searched both years. Forty-three ha of alfalfa were searched in 1991 while only 35 ha of this was searched in 1992. Unless noted otherwise, all nest related data from each study area will be based on all nests found in all habitats.

Composition of Nesting Species

Ninepipe skunk removal area

The number of duck nests found during systematic searches at Ninepipe varied by species and year, with the total number found increasing from 305 in 1991 to 570 in 1992 (Table 6). Mallard, gadwall, and cinnamon teal (*Anas cyanoptera*) nests comprised 70% of the total in 1991 and 76% in 1992. Because we were unable to reliably identify hens flushing from the nest site, blue-winged teal (*Anas discors*) were included with cinnamon teal in all nest data. Long-

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term breeding pair data collected by National Bison Range personnel indicated that blue-winged teal are approximately 20% as numerous as cinnamon teal. The number of nests found in fields searched both years increased from 251 in 1991 to 360 in 1992, and the number of mallard nests found increased from 62 to 162. Accordingly, the proportion of mallard nests within these fields was significantly higher in 1992 than 1991 ($X^2=26.2$, df=1, $P<0.005$).

Pablo NWR control area

The number of duck nests found at Pablo declined from 56 in 1991 to 41 in 1992 (Table 7). With years combined, cinnamon teal and mallard nests were most numerous, comprising 64% of the total found at Pablo.

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Table 6. Species composition and number of nests found on the Ninepipe skunk removal area, 1991-92.

	All Fields			Fields Searched In Both 1991 and 1992		
	1991	1992	Combined	1991	1992	Combined
	N(%)	N(%)	N(%)	N(%)	N(%)	N(%)
Mallard	75(25)	265(47)	340(39)	62(25)	162(45)	224(37)
Cinnamon Teal[a]	81(27)	76(13)	157(18)	67(27)	49(14)	116(19)
Gadwall	56(18)	91(16)	147(17)	45(18)	63(17)	108(18)
Northern Shoveler	47(15)	71(12)	118(13)	38(15)	43(12)	81(13)
American Wigeon	18(6)	30(5)	48(5)	16(6)	20(6)	36(6)
Redhead	11(4)	20(4)	31(4)	9(4)	12(3)	21(3)
Green-winged Teal	11(4)	5(<1)	16(2)	10(4)	4(1)	14(2)
Northern Pintail	3(<1)	12(2)	15(2)	1(<1)	7(2)	8(1)
Lesser Scaup	3(<1)	----	3(<1)	3(<1)	----	3(<1)
Totals	305(100)	570(100)	875(100)	251(100)	360(100)	611(100)

[a]Includes ≈ 20% Blue-winged Teal

Table 7. Species composition and number of nests found on the Pablo NWR (control area), 1991-92.

	1991		1992		Combined	
Species	N	%	N	%	N	%
Cinnamon Teal[a]	27	48	12	29	39	40
Mallard	10	18	13	32	23	24
Gadwall	8	14	9	22	17	18
Green-winged Teal	6	11	2	5	8	8
Northern Shoveler	3	5	2	5	5	5
American Wigeon	1	2	3	7	4	4
Northern Pintail	1	2	0	0	1	1
Totals	56	100	41	100	97	100

[a]Includes ≈ 20% Blue-winged Teal

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Nest Density

Ninepipe skunk removal area

Apparent nest densities for all species combined increased between 1991 and 1992 in managed cover and pasture habitats, and declined in alfalfa (Table 8). Mallard nest density in managed cover nearly tripled from 1991 to 1992 and gadwall nest density doubled. Cinnamon teal nest densities declined in managed cover and alfalfa and increased in pasture habitats. Nest densities for all species combined were positively associated with height-density of residual vegetation, as indexed by spring transect VORs, in 1991 (R^2=0.64, $P<0.05$), and 1992 (R^2=0.48, $P<0.05$). As a result, nest densities in managed cover were 14 times higher than in pasture habitats in 1991 and 10 times higher in 1992.

Pablo NWR control area

Apparent nest densities for all species combined declined from 1991 to 1992 in all fields nest searched at Pablo (Table 9). Declines in cinnamon teal densities were most notable.

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Table 8. Apparent nest densities per 100 ha of three habitats nest searched in the Ninepipe skunk removal area. Based only on fields searched in both 1991 and 1992.

	1991			1992		
Species	Managed Cover	Alfalfa	Pasture	Managed Cover	Alfalfa	Pasture
Mallard	30	45	--	81	27	2
Cinnamon Teal[a]	28	9	2	22	--	10
Gadwall	14	27	6	29	45	2
N. Shoveler	19	27	--	22	9	2
G.W. Teal	5	--	--	1	--	2
A. Wigeon	7	9	--	10	9	--
Redhead	4	--	--	6	--	--
N. Pintail	1	--	--	4	--	--
Lesser Scaup	2	--	--	--	--	--
All Species	110	117	8	175	90	18

[a]Includes ≈ 20% Blue-winged Teal

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Table 9. Apparent nest densities per 100 ha of three fields nest searched at Pablo NWR (control area). Based only on fields searched in both 1991 and 1992.

	1991			1992		
Species	South Pasture	Alfalfa	North Pasture	South Pasture	Alfalfa	North Pasture
Mallard	7	17	--	16	17	--
Cinnamon Teal[a]	29	26	5	11	20	--
Gadwall	7	14	--	7	17	--
N. Shoveler	--	6	--	--	6	--
G.W. Teal	9	6	--	4	--	--
A. Wigeon	--	--	--	7	--	--
N. Pintail	--	3	--	--	--	--
All Species	52	72	5	45	60	--

[a]Includes ≈ 20% Blue-winged Teal

Nest Phenology

Ninepipe skunk removal area

Nest initiation dates at Ninepipe varied by species and year (Table 10). Mean nest initiation dates were significantly earlier in 1992 than 1991 for all species combined ($t=14.96$, $P<0.005$) and mallards only ($t=7.80$, $P<0.005$). Seventy-five percent of all nests were initiated by 5 June in 1991 and by 20 May in 1992.

Pablo NWR control area

The mean nest initiation date for all species combined at Pablo was marginally earlier in 1992 than 1991 (26 May vs. 1 June, $t=1.77$, $P=0.08$). Seventy-five percent of all nests were initiated by 10 June in 1991 and by 4 June in 1992.

Ninepipe skunk removal area vs. Pablo NWR control area

The mean nest initiation date for all species combined was significantly earlier at Ninepipe than at Pablo in both 1991 ($t=2.93$, $P<0.005$) and 1992 ($t=7.09$, $P<0.005$). Interspecific nesting chronologies in 1991 and 1992 at both study areas generally followed typical patterns (see Bellrose 1980), with northern pintails and mallards nesting earliest, gadwalls and American wigeon latest, and other species at intermediate dates.

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Table 10. Mean initiation dates of duck nests found within the Ninepipe skunk removal area, 1991-92.

	1991		1992	
Species	Mean (range)	SE[a]	Mean (range)	SE
N. Pintail	22 April (13 April-27 April)	4.4	21 April (2 April-11 May)	3.1
Mallard	16 May (4 April-15 June)	1.9	27 April (19 March-10 June)	1.1
N. Shoveler	21 May (27 April-17 June)	1.8	2 May (16 April-3 June)	1.5
Cinnamon Teal[b]	25 May (8 May-18 June)	1.1	13 May (26 April-11 June)	1.3
Redhead	28 May (2 May-15 June)	4.0	22 May (29 April-2 June)	3.1
G.W. Teal	5 June (22 May-21 June)	3.0	11 May (25 April-29 May)	5.4
Lesser Scaup	6 June (15 May-25 June)	11.9	-----------	
Gadwall	7 June (22 May-30 June)	1.5	22 May (24 April-12 June)	1.2
A. Wigeon	9 June (19 May-24 June)	2.9	18 May (30 April-4 June)	1.9
All Species	26 May (4 April-30 June)	0.9	5 May (19 March-12 June)	0.8

[a]Standard error in days

[b]Includes ≈ 20% Blue-winged Teal

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Nest Success

Ninepipe skunk removal area

With years combined, 818 of 875 (94%) of the nests found were suitable for calculating nest success. Seventy percent of the nests not used were either abandoned due to investigator influence or damaged by search related activities. Nest success (Table 11) was significantly higher in 1992 than 1991 for all species combined (61% vs. 22%, Z=7.85, P<0.005) and for mallards only (55% vs. 20%, Z=3.85, P<0.005). Mallard nest success was statistically similar to the nest success of all other species combined in 1991 (20% vs. 23%, Z=.59, P>0.50), but was marginally lower in 1992 (55% vs. 66%, Z=1.92, 0.10>P>0.05). With years combined, nest success in WMAs and WPAs was 47% (N=784, 95%CI= 43-52%), 16% in alfalfa (N=23, 95%CI= 6-44%) and 15% in pastures (N=11, 95%CI= 4-56%).

Pablo NWR control area

With years combined, 91 of 97 (94%) of the nests found were suitable for calculating nest success. Nest success at Pablo (Table 12) for all species combined improved markedly from 1991 to 1992 and the increase was nearly significant (10% vs. 27%, Z=1.93, 0.010>P>0.05). With years combined, nest success in pastures was 9% (N=42, 95%CI= 4-24%) and 19% in alfalfa (N=49, 95%CI= 11-37%).

Ninepipe skunk removal area vs. Pablo NWR control area

Nest success for all species combined was significantly higher at Ninepipe than Pablo in 1991 (Z=2.11, P<0.05), 1992 (Z=2.35, P<0.05), and years combined (Z=4.24, P<0.005).

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Table 11. Mayfield nest success of usable duck nests found within the Ninepipe skunk removal area, 1991-92.

	1991			1992			Combined		
Species	N	%[a]	95% CI[b]	N	%	95% CI	N	%	95% CI
Mallard	71	20	12-33	247	55	48-64	318	46	40-54
N. Shoveler	44	39	25-62	67	86	75-98	111	65	54-78
N. Pintail	3	8	0-100	11	42	18-99	14	33	13-81
Cinnamon Teal[c]	76	31	20-45	68	65	52-82	144	45	36-56
Gadwall	51	16	9-31	86	66	54-81	137	43	34-55
A. Wigeon	17	8	2-32	30	67	46-96	47	36	22-58
G.W. Teal	11	23	7-75	5	29	5-100	16	24	9-65
Redhead	11	6	1-41	17	32	14-71	28	20	9-44
Lesser Scaup	3	1	0-100	0	0	0	3	1	0-100
All Species	287	22	18-28	531	61	56-67	818	45	41-50

[a]Mayfield nest success

[b]95% confidence interval

[c]Includes ≈ 20% Blue-winged Teal

Table 12. Mayfield nest success of usable duck nests found within the Pablo NWR (control area), 1991-92.

	1991			1992			Combined		
Species	N	%[a]	95% CI[b]	N	%	95% CI	N	%	95% CI
Mallard	10	19	5-72	12	12	2-65	22	16	5-45
Cinnamon Teal[c]	26	7	2-22	11	22	5-97	37	9	3-34
Gadwall	8	23	6-84	9	52	20-100	17	34	15-76
G.W. Teal	6	4	0-86	2	100	0-100	8	14	2-95
A. Wigeon	1	0	0	2	25	1-100	3	16	1-100
N. Shoveler	1	0	0	2	14	0-100	3	4	0-100
N. Pintail	1	0	0	0	0	0	1	0	0
All Species	53	10	5-21	38	27	13-54	91	14	8-25

[a]Mayfield nest success

[b]95% confidence interval

[c]Includes ≈ 20% Blue-winged Teal

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Nest Site Selection Relative to Vegetation Density

Ninepipe skunk removal area

Nest site VORs at Ninepipe were higher than at adjacent sites for all species in both years, and the difference was significant in 15 of 19 comparisons (Table 13). Nest site VORs in managed cover searched both years varied by sampling period and year. Nest site VORs recorded during the initial nest search were lower in 1991 than 1992 (1.6 dm vs. 2.9 dm, $t=6.0$, $P<0.005$), but 1991 nest site VORs were higher during both the 2nd (3.4 dm vs. 2.7 dm, $t=3.9$, $P<0.005$) and 3rd nest searches (3.6 dm vs. 3.1 dm, $t=2.6$, $P<0.005$). Overall VORs at nest sites declined significantly from 1991 to 1992 for both mallards ($t=2.01$, $P<0.05$) and all species combined ($t=3.69$, $P<0.005$). VORs at successful and unsuccessful nests did not differ in 1991 (3.3 dm vs. 3.2 dm, $t=0.61$, $P=0.55$) or 1992 (2.8 dm vs. 2.9 dm, $t=0.73$, $P=0.47$).

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Pablo NWR control area

Nest site VORs at Pablo were significantly higher than at adjacent sites for all species combined in both 1991 (3.9 dm vs. 3.5 dm, $FX^2=9.68$, $P<0.005$) and 1992 (4.0 dm vs. 3.0 dm, $FX^2=11.92$, $P<0.005$). Nest site VORs did not change significantly between 1991 and 1992 ($t=0.23$, $P=0.82$). VORs at successful nests were higher than unsuccessful nests in both years, and the difference was nearly significant in 1991 (4.8 dm vs. 3.6 dm, $t=2.04$, $P=0.06$), but not in 1992 (4.4 dm vs. 3.9 dm, $t=0.88$, $P=0.39$).

Ninepipe skunk removal area vs. Pablo NWR control area

Nest site VORs for all species combined were significantly higher at Pablo than at Ninepipe in both 1991 ($t=3.19$, $P<0.005$) and 1992 ($t=4.67$, $P<0.005$).

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Table 13. Visual Obstruction Readings (VORs) at nest sites and at adjacent sites (points 5m north of nest sites), on the Ninepipe skunk removal area, 1991-92. All measurements in dm.

	1991					1992				
Species	N	Nest Site	Adja. Site[a]	Diff.[b]	Probability[c]	N	Nest Site	Adja. Site	Diff.	Probability
Mallard	72	3.4	2.3	1.1	<0.005	250	2.9	2.2	0.7	<0.005
Gadwall	54	4.4	3.2	1.2	<0.005	88	3.2	2.4	0.8	<0.005
N. Shoveler	47	2.4	1.7	0.7	<0.005	65	2.2	1.8	0.4	<0.005
A. Wigeon	17	4.1	2.6	1.5	<0.005	26	3.2	2.4	0.8	<0.005
Cinnamon Teal[d]	75	2.4	1.7	0.7	<0.005	67	2.2	1.7	0.5	<0.005
G.W. Teal	8	3.2	2.7	0.5	0.48	5	3.0	1.9	1.1	<0.05
Redhead	9	4.2	2.9	1.3	<0.05	17	3.5	2.4	1.1	<0.005
N. Pintail	3	1.0	0.6	0.4	0.08	8	2.5	2.0	0.5	0.48
Lesser Scaup	3	3.0	2.1	0.9	0.08					
All Species	288	3.2	2.2	1.0	<0.005	526	2.8	2.2	0.6	<0.005

[a]Adjacent sites

[b]Mean difference between nest sites and adjacent sites

[c]Friedman's repeated measures analysis

[d]Includes ≈ 20% Blue-winged Teal

Causes of Nest Failure

Ninepipe skunk removal area

The primary causes of nest failure at Ninepipe in both 1991 and 1992 were predation and abandonment. In 1991, 94% of the nest failures were a result of predation and 6% were abandoned. In 1992, 89% of the failed nests were depredated and 11% were abandoned. Nine hens (4 cinnamon teal, 2 gadwalls, 2 redheads, and 1 American wigeon) were killed at nest sites in 1991 but no hen mortality was noted in 1992. Nest destruction patterns varied between years (Table 14). Nest site VORs were not significantly different at class I vs. class II depredated nests in 1991 (3.2 dm vs. 3.0 dm, $t=0.82$, $P=0.41$) or 1992 (3.1 dm vs. 2.9 dm, $t=0.60$, $P=0.55$).

Pablo NWR control area

In 1991, 95% of the failed nests at Pablo were depredated and 5% were abandoned. In 1992, 93% of the nest failures resulted from predation and 7% were abandoned. No evidence of hen mortality was noted in 1991, but 1 mallard hen was killed at the nest in 1992. Nest destruction patterns at Pablo varied between years (Table 14).

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Table 14. Destruction patterns of depredated duck nests in the Ninepipe skunk removal area and Pablo NWR (control area), 1991-92.

		Ninepipe		Pablo	
Class	Description	1991 %	1992 %	1991 %	1992 %
I	Crushed eggs or numerous fragments, and >50% nest material disturbance.	39	58	58	23
II	No crushed eggshells or fragments, and <10% nest material disturbance.	48	25	33	54
III	Nests not clearly meeting criteria for class I or II.	13	17	9	23

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Predator Community Assessment

Ninepipe had a lower proportion of scent stations visited by skunks in both 1991 and 1992 than Pablo (Table 15). The difference was significant in 1991 (X^2=4.26, df=1, P<0.05), but not in 1992 (X^2=0.42, df=1, P=0.52), and marginally significant for years combined (X^2=3.88, df=1, P=0.050). The proportion of stations visited by skunks did not change between 1991 and 1992 at Ninepipe (X^2=0.18, df=1, P=0.68) or Pablo (X^2=1.11, df=1, P=0.29). With years combined, there was no significant difference between study areas in the proportion of stations visited by canids (X^2=0.47. df=1, P=0.49). With years combined, Pablo had a significantly higher proportion of stations visited by domestic cats than Ninepipe (X^2=10.21, df=1, P<0.005). Red fox tracks were not recorded at any stations and only two stations were visited by raccoons.

Table 15. Summary of scent station visits in the Lower Flathead Valley, 1991-92.

	[a]NINEPIPE AREA			[b]CONTROL AREA		
SPECIES	1991	1992	TOTAL	1991	1992	TOTAL
Skunk	3	4	7	10	6	16
Canids	9	12	21	12	13	25
Domestic Cat	9	11	20	20	23	43
Raccoon	1	0	1	0	1	1
Totals	22	27	49	42	43	85

[a]Based on 117 station-nights in 1991 and 114 in 1992

[b]Based on 113 station-nights in 1991 and 114 in 1992

Canids includes coyotes and domestic dogs.

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Discussion

Upland Habitat Conditions

Spring 1991 VORs in managed cover at Ninepipe ($\bar{X}$=0.51 dm) were considerably lower than in similar habitats throughout the Prairie Pothole Region, where spring VORs are generally > 1.0 dm (e.g. Higgins and Barker 1982, Lokemoen et al. 1990, Luttschwager 1991). A cyclic peak in microtine rodent (Microtus spp.) densities, and the effects of their grazing and tunneling on the cover were believed to be the primary factors in reducing spring 1991 nesting cover quality. Our subjective field observations and comments from local landowners indicated that microtine rodents reached high densities during the 1990-91 winter. Microtine populations cycle at 2-5 year intervals (Jones and Birney 1988), may reach densities > 600/ha (Jones et al. 1983), and at high densities can significantly reduce spring VORs in managed cover (Higgins and Barker 1982). Spring 1992 VORs in managed cover at Ninepipe improved to 1.48 dm and were 2-3X higher than 1991 in most fields surveyed. Minimal snowpack in the winter of 1991-92 also probably contributed to this increase. Summer VORs in managed cover at Ninepipe in 1991 ($\bar{X}$=3.42 dm) and 1992 ($\bar{X}$=2.83 dm) were generally lower than in similar habitats in the Prairie Pothole Region (Lokemoen et al. 1990, Luttschwager 1991). As within the

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Pothole Region, variations of VORs in managed cover at Ninepipe appeared to result from differences in seeding quality, soil type, management history, and stand age.

Skunk Populations

Declining capture rates, scent station data, landowner comments, and results from similar studies, all suggest that the trapping program effectively reduced skunk densities throughout the Ninepipe study area. Trapping success (N captures/1000 trap-nights) declined from 15 in 1988 to 3 in 1992. A widespread decimating factor such as disease does not appear to be a plausible explanation for the decline in trapping success. Scent station data, comments from local landowners, and trapping success rates from other areas of western Montana indicated that skunk densities remained high outside the Ninepipe area during the removal period. For example, during 1990 skunk trapping success was very high (36) at Lee Metcalf NWR, 100 km south of Ninepipe (N. Merz, pers. commun.), and high (20) at Blasdel WPA, 50 km north of Ninepipe (R. Washtak, pers. commun.). Pengeroth (1991) documented a decline in skunk densities based on total number of captured skunks at Ninepipe from 7.1/km^2 in 1988 to 2.2/km^2 in 1990, and concluded that the decline was best explained by the removal program. Results from 1991-92 strengthen that contention.

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Breeding Duck Populations

The apparent decline in the number of breeding pairs I counted on small wetlands around Ninepipe between 1991 and 1992 was likely a result of deteriorating wetland conditions and a subsequent shift of pairs to irrigation reservoirs and larger wetlands that I did not survey. In 1991, 91% of the basins I surveyed contained water versus only 65% in 1992. Correlations between wetland numbers and breeding duck populations have been widely documented in Saskatchewan (Stoudt 1969), Manitoba (Rogers 1964), North Dakota (Stewart and Kantrud 1974, Higgins et al. 1992), and South Dakota (Brewster et al. 1976). The apparent decline in blue-winged teal numbers at Ninepipe was most severe, which is in agreement with Ruwaldt et al. (1979) and Higgins et al. (1992) that blue-winged teal are very responsive to changes in wetland conditions.

Although the number of breeding pairs surveyed at Ninepipe declined between years, breeding pair densities (pairs/ha surface water) in 1991 (13.9) and 1992 (11.9) were higher than nearly all published records from glaciated wetland habitats. Stoudt (1969) summarized 1950-66 data sets from 5 of the most noted waterfowl breeding areas in the Prairie Pothole Region and reported peak densities of 9.9, 7.4, and 5.2 in Saskatchewan, 3.7 in Manitoba, and 2.0 in South Dakota. Mallard pair densities at Ninepipe in 1992 (3.4) were also higher than mallard densities reported by

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Stoudt (1969), who noted peak densities of 3.2, 2.9, and 1.4 in Saskatchewan, 0.6 in Manitoba, and 0.3 in South Dakota. High mallard pair densities of 5.4 (Smith 1971) and 2.2 (Duebbert et al. 1983) have been documented in Alberta and South Dakota. The highest breeding pair densities in glaciated habitats noted in the literature were recorded by Duebbert and Lokemoen (1980) on a South Dakota study area where all mammalian predators were controlled from 1969 through 1971. They reported peak dabbler densities in 1973 of 30.3 and mallard densities of 9.6 during a severe drought when 85% of the study area basins were dry, and ducks "crowded on the remaining water in dense aggregations." During other years of that study, dabbler densities ranged from 3.6 to 10.1 and mallard densities varied from 0.43 to 4.86.

Cowardin et al. (1988) summarized data from 6280 North Dakota basins surveyed during 1967-74 and noted average mallard pair densities of 0.24 on temporary basins, 0.21 on seasonal basins, and 0.15 on semi-permanent basins. These data were used to develop a model of mallard productivity in North Dakota, and probably best represent contemporary mallard pair densities throughout much of the Prairie Pothole Region. Dzubin (1969b) cautioned that correlations between wetland numbers and breeding pairs should be tempered with data on basin size, quality, and density. Other factors that may influence pothole use include

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invertebrate abundance (Murkin et al. 1982), and adjacent land use (Drewien and Springer 1969). Wetland basins at Ninepipe are generally smaller than basins in other glaciated habitats and thus may influence pair density comparisons with other areas. The average size of basins at Ninepipe is generally <0.25 ha, while Stoudt (1969) noted average sizes in 5 glaciated pothole habitats of 0.28 ha, 0.28 ha, and 0.53 ha in Saskatchewan, 0.36 ha in Manitoba, and 1.38 ha in South Dakota. Although my comparisons of breeding pair densities are based solely on surface water area, they nonetheless illustrate that densities observed at Ninepipe are among the highest recorded in glaciated wetland habitats.

Nesting Phenology

Above-normal spring temperatures appeared to be partly responsible for inducing the early nesting season observed in 1992. Many researchers have documented correlations between spring temperatures and the onset of the nesting season (see Hammond and Johnson 1984). Along with spring temperatures, nest success and subsequent renesting intensity also apparently contributed to the annual variation in mean nest initiation dates. Low nest success in 1991 promoted much renesting during June and July, and consequently, later mean nest initiation dates. Conversely, high nest success and poor wetland conditions in 1992 led to

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relatively few renesting attempts and to earlier mean nest initiation dates.

Annual Variation in Nest Success

The sharp decline in nest success at Ninepipe from 60% in 1990 (Hall in prep.) to 22% in 1991 appeared to result partly from a cyclic low in microtine rodents as buffer prey. Microtine rodents, which appeared to be at a cyclic high in 1990, were nearly absent from the Ninepipe area in 1991. Microtines are found in the diet of skunks (Crabtree and Wolfe 1988) and common ravens (Stiehl and Trautwein 1991), the two principal nest predators at Ninepipe. Byers (1974) and Weller (1979) documented an inverse relationship between predation on duck nests and populations of small mammals on an Iowa study area where skunks were the principal predator. Other nest predators at Ninepipe that also prey upon small mammals include black-billed magpies (Buitron 1988) and coyotes (Kantrud et al. 1989). The absence of alternate prey for coyotes provides a plausible explanation for the relatively high number of hens killed at nests in 1991 compared to 1992. Most of the hens were not consumed, or only partially consumed, which often is indicative of coyote predation (A. Sargeant, pers. commun.).

Another factor in the low 1991 nest success appeared to be the lack of residual nesting cover and an associated increase in the foraging efficiency of black-billed magpies and common ravens. Both species were seen carrying duck and

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pheasant (Phasianus colchicus) eggs regularly during 1991, but few such sightings occurred in 1992. Jones and Hungerford (1972) concluded that magpies were the most important nest predator on an Idaho study area, and Braun et al. (1978) suggested that common ravens were a major egg predator. Although results are mixed, most evidence suggests that cover quality is a primary factor in deterring nest predation by corvids. For example, Jones and Hungerford (1972) concluded that heavier cover lessened black-billed magpie predation, and Sullivan and Dinsmore (1990) noted that nests in low vegetation were most vulnerable to crows (Corvus brachyrhynchos). Changes in nest destruction patterns at Ninepipe between years (Table 14) further suggested that corvids were responsible for the majority of nest destruction in 1991, assuming class I represents nest destruction by mammals and class II by corvids.

Continued reduction of skunk densities, improved quality of residual nesting cover, and moderate microtine populations all probably contributed to the higher nest success at Ninepipe in 1992. Annual variations in nest success at Pablo also appeared to result from fluctuations in buffer prey densities and associated changes in residual nesting cover. As at Ninepipe, microtine rodents appeared to be nearly absent from Pablo in 1991 but occurred at moderate densities in 1992.

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Nest Success Relative To Other Studies

Despite poor nesting conditions in 1991, the mean 1991-92 nest success at Ninepipe (45%) was considerably higher than in similar habitats without predator removal. Higgins et al. (1992) reported a mean nest success of 16% from 1966-81 on a North Dakota study site. In South Dakota, nest success rates of 23% (Luttschwager 1991) and 20% (Kemner 1989) have been reported recently. Fleskes and Klass (1991) reported 12% nest success on a northern Iowa study area. Klett et al. (1988) summarized North Dakota, South Dakota, and Minnesota data sets from 1966-84 and noted nest success rates ranging from <5% to 36% and averaging <20%. These data probably best represent current nest success levels throughout much of the Prairie Pothole Region. In general, the only nest success rates noted in the Pothole Region that were comparable or higher than at Ninepipe occurred on islands, or when predators were removed or excluded from mainland sites. For example, Duebbert and Lokemoen (1980) reported mallard nest success of >75% for three consecutive years on a South Dakota site where attempts were made to remove all mammalian predators. Lokemoen et al. (1982) noted 65% nest success in North Dakota when electric fences were used as predator barriers. The mean nest success at Pablo in 1991 and 1992 (14%) was comparable to most rates currently being reported from similar habitats in the Pothole Region.

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Nest Success Relative to Nest Site Cover Quality

The relationship between cover quality and nest success is complex and is easily confounded with other environmental factors. Clark and Nudds (1991) reviewed 38 studies that provided enough information to examine this relationship, and concluded that the importance of concealment to nest success was dependent upon composition of the predator community. Nest success was enhanced by concealment if birds were the primary nest predators, but when mammals or both bird and mammal predators were involved, nest concealment was relatively unimportant to nest success. This interpretation is in general agreement with nest site VOR data recorded during my study. The predator communities at Ninepipe and Pablo are both comprised of avian and mammalian predators. Accordingly, nest concealment, at least on the scale indexed by nest site VORs, did not appear to be strongly associated with individual nest fate at either site. However, the relative importance of avian nest predation appeared to increase when residual cover conditions were extremely poor during 1991, and nest concealment was generally more important at Pablo than Ninepipe.

Nest Density

Nest densities (nests/100 ha) at Ninepipe in managed cover in 1991 (110) and 1992 (175) were generally higher

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than in similar habitats throughout much of the Pothole Region. Higgins et al. (1992) noted a mean nest density from 1966-81 of 82 in seeded grasslands on a North Dakota study site. In similar cover types, densities of 88 have been reported in Iowa (Fleskes 1986), and 75 in South Dakota (Luttschwager 1991). Nest densities at Ninepipe in 1991 and 1992 were positively related to the height-density of spring cover as indexed by transect VORs. As a result, nest densities in managed cover were substantially higher than in nearby pastures. Many other researchers have observed that managed cover contained higher nest densities than sparser cover types (e.g. Duebbert and Kantrud 1974, Duebbert and Lokemoen 1976, Higgins et al. 1992).

Nest Success, Nest Densities, and Breeding Populations Relative to Skunk Removal

With years combined, nest success at Ninepipe during my study was approximately double the pre-skunk-removal average noted by Hall (in prep.), and 1992 nest densities in managed cover were over 4 times higher than 1986 levels. In contrast, nest success at Pablo declined from 1986,1988 to 1991-1992 and nest densities which had been increasing previously, declined from 1991 to 1992. These results indicate that skunk removal was effective in increasing nest success and nest densities. Considering the high levels of nest success at Ninepipe, the increase in nest densities is

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best explained by philopatric homing of successful hens and their progeny (Sowls 1955, Lokemoen et al. 1990). Homing is partially a function of nest success, with successful hens homing at higher rates than unsuccessful nesters (Doty and Lee 1974). Consequently, high nest success should lead to local increases in population size, particularly in strongly philopatric species. Duebbert et al. (1983) suggested this as the mechanism responsible for creating extremely dense concentrations of duck nests on predator-free islands. Philopatric homing also appeared to contribute to the high breeding pair densities observed at Ninepipe. The number of dabbling duck pairs surveyed on standardized areas at Ninepipe by National Bison Range personnel increased from a 1982-88 average of 234 to 753 in 1992.

Differences in habitat conditions did not provide plausible explanations for the patterns observed. Wetland conditions at Ninepipe deteriorated steadily from 1990 to 1992. Cover conditions, as indexed by nest site VORs, were better at Pablo than Ninepipe during all years except 1986 (Hall in prep.), and fluctuations in microtine rodent densities appeared to be comparable between study areas.

Research Recommendations

Based on data presented by Hall (in prep.) and results from my study, skunk removal at Ninepipe effectively increased nest success and local breeding populations. I

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suggest that skunk removal be suspended at Ninepipe, and efforts initiated to increase nest success at Pablo. By switching "treatment" and "control" sites, the environmental variability that often confounds ecological research could be minimized, and the pertinent questions regarding duck nest predation could be more rigorously evaluated. For example: (1) Are populations of upland nesting ducks being held at low population levels because of excessive nest predation?, and if so, (2) Will a growing duck population stabilize at a higher level once predator removal is discontinued?

Techniques that could be used to increase nest success at Pablo include conditioned taste aversion (Dimmick and Nicolaus 1990, Conover 1990), nest structures (Doty and Lee 1974, Ball and Ball 1991), and skunk removal. Electric fence predator exclosures have increased nest success in the Prairie Pothole Region (Loekemoen et al. 1982), but may be less effective where avian nest predators are numerous. Once treatments are reversed, relative changes in nest success, nest density, breeding pair numbers, small mammal abundance, and habitat conditions should continue to be monitored.

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Appendix A. Mayfield nest success of useable duck nests found in the Ninepipe skunk removal area and Pablo NWR (control area), 1986-92. Data not collected at Pablo in 1987. All 1986-90 data provided by Hall (in prep.).

	All Species		Mallards Only	
Study Area/Year	N	Mayfield (95% CI)	N	Mayfield (95% CI)
Pablo				
1986	15	35(16-77)	2	45(9-100)
1988	18	10(2-45)	9	65(27-100)
1986,88	33	25(13-49)	11	57(26-100)
1989	28	29(15-56)	9	21(6-73)
1990	38	21(10-44)	6	32(6-100)
1991	53	10(5-21)	10	19(5-72)
1992	38	27(13-54)	12	12(2-65)
1989-92	157	18(13-27)	37	19(9-40)
Ninepipe				
1986	56	19(11-34)	12	13(3-59)
1987	85	28(18-42)	18	10(2-36)
1986-87	141	23(16-32)	30	11(4-30)
1988	115	20(13-31)	40	11(5-26)
1989	139	44(36-55)	45	39(26-61)
1990	253	60(52-69)	67	55(41-73)
1991	287	22(18-28)	71	20(12-33)
1992	531	61(56-67)	247	55(48-64)
1988-92	1325	44(41-48)	470	43(37-49)

STATISTICAL RESULTS

COMPARISON	Z	P
Pablo All Spp. 1986,88(25%) vs. 1989-92(18%)	0.44	>0.60
Ninepipe All Spp. 1986-87(23%) vs. 1988-92(44%)	3.79	<0.005
Ninepipe Mallards 1986-87(11%) vs. 1988-92(43%)	2.73	<0.05

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Appendix B. Number of hatched nests per 100 ha of WMA and WPA land on the Ninepipe skunk removal area, 1986-92. Based on two nest searches in 1986-90 and three searches in 1991-92. All 1986-90 data provided by Hall (in prep.).

Year	Number of Hatched Nests
1986	15
1987	16
1988	19
1989	32
1990	73
1991	40
1992	122

Appendix C. Nest site Visual Obstruction Readings (VORs) in the Ninepipe skunk removal area and Pablo NWR (control area), 1986-92. All 1986-90 data provided by Hall (in prep.). Data not collected at Pablo in 1987.

	Ninepipe			Pablo		
Year	N	Mean Nest	SE	N	Mean Nest	SE
1986	55	2.5	0.14	15	2.0	0.26
1987	82	2.5	0.11	--	--	--
1988	110	2.6	0.11	16	3.1	0.28
1989	134	2.4	0.10	25	3.8	0.22
1990	231	1.7	0.05	37	3.0	0.20
1991	288	3.2	0.10	53	3.9	0.21
1992	526	2.8	0.04	39	4.0	0.28

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Appendix D. Habitat types nest searched in the Ninepipe skunk removal area and Pablo NWR (control area), 1986-92.

	Ninepipe			Pablo		
	WPAs+WMAs[a]	Pasture	Alfalfa	WPAs+WMAs[a]	Pasture	Alfalfa
	HA(%)	HA(%)	HA(%)	HA(%)	HA(%)	HA(%)
1986	170(100)	----	----	----	121(100)	----
1987	273(100)	----	----	----	----	----
1988	273(100)	----	----	----	81(77)	24(23)
1989	273(100)	----	----	----	81(67)	40(33)
1990	273(100)	----	----	----	81(67)	40(33)
1991	297(83)	50(14)	11(3)	----	65(60)	43(40)
1992	331(84)	50(13)	11(3)	----	65(65)	35(35)

[a]Primarily managed cover

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Appendix E. Breeding duck pair counts on three Waterfowl Production Areas (WPAs) in the Ninepipe skunk removal area, and the adjacent Ninepipe National Wildlife Refuge, 1982-92. All data provided by the National Bison Range (USFWS).

SPECIES	YEAR 1982	83	84	85	86	87	88	89	90	91	92
Mallard	110	80	105	121	64	91	94	126	146	248	325
Gadwall	14	18	12	17	14	14	34	48	56	117	123
Cinnamon Teal	--	--	--	--	--	--	57	67	145	146	170
Blue-winged Teal	--	--	--	--	--	--	12	36	14	27	27
B.W.+ Cinnamon Teal	96	56	58	72	52	91	69	103	159	173	197
Northern Shoveler	17	23	36	19	29	38	31	63	74	75	72
American Wigeon	16	1	2	2	3	13	8	13	7	8	9
Green-winged Teal	13	16	8	3	5	9	8	9	13	8	12
Northern Pintail	23	3	2	2	5	13	5	10	6	9	15
All Dabbler Species	289	197	223	236	172	269	249	372	461	638	753
Redhead	55	70	71	28	63	59	43	66	78	106	76
All Species	344	267	294	264	235	328	292	438	539	744	829

STATISTICAL RESULTS: 1982-88 vs. 1989-92

COMPARISON	Mann-Whitney U	P
All Dabbler Species:	28	<0.05
Mallards Only:	28	<0.05