IMPACTS OF SPRING-SOWN
ZERO TILLAGE
ON UPLAND NESTING DUCKS

by
Jim R. Fisher

A Practicum Submitted in Partial Fulfillment
of the Requirements for the Degree
Master of Natural Resources Management

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"IMPACTS OF SPRING-SOWN ZERO-TILLAGE ON UPLAND NESTING DUCKS"

A practicum submitted to the Faculty of Graduate Studies of the University of Manitoba in partial fulfillment of the requirements of the degree of Master of Natural Resources Management.

By

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Abstract

The use of spring-sown zero tillage (SSZT) as a conservation practice in the Canadian Prairies has been widely supported by the North American Waterfowl Management Plan. However, the impact of SSZT practices on duck nesting effort and success is unclear. It was, therefore, the overall objective of this research to determine the impacts of such practices on nesting ducks.

Nest searches were conducted during the breeding seasons of 1990 to 1992 on SSZT fields and adjacent native uplands to determine nesting density and success. Fabricated nests were used to evaluate the extent of nest damage by implements used in SSZT. Crop residues were also evaluated in order to determine the effect of SSZT farming activities on stubble quantity as nesting cover.

Nesting density in SSZT ranged from 1.5 to 1.9/km^2 as compared to 15.5 and 43.3/km^2 found in adjacent native uplands. Mayfield nest success was 12.9% (n=13) in SSZT fields compared to 9.5% (n=66) in adjacent native uplands. Seed drills (Edwards HD 812 hoe drill and Flexi-coil 5000 air drill) left 40-42% of nests undisturbed, while the fertilizer applicators, Dutch Knives and Spoke Injector, left 58% and 86%, respectfully, of nests undisturbed. Various SSZT operations reduced ground stubble by only 7-23%, while standing stubble (nesting cover) was reduced by at least 50%.

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1.0 INTRODUCTION

North American duck populations, especially Mallards (*Anas platyrhynchos*) and Northern Pintails (*Anas acuta*), have declined since the 1970's (Reynolds 1987). Drought, habitat degradation and loss of nesting habitat are thought to be major contributors to the decline in populations (Hochbaum et al. 1987, Turner et al. 1987). Lack of breeding effort and high predation rates may also have contributed to the declines.

In an effort to increase waterfowl numbers, conservation agencies are examining techniques to improve the quantity and quality of upland nesting duck habitat. There are two general approaches to improving nesting cover (Nelson and Wishart 1988). One approach is intensive management, which is a short term practice designed to increase habitat quantity and quality in the immediate term. Dense nesting cover (Duebbert 1969, Duebbert et al. 1981) and predator fencing (Nelson and Wishart 1988) are examples of intensive management which have been implemented across prairie Canada. Another approach is extensive management which is a long term, farming program. Spring-sown zero tillage (SSZT) is an example of an extensive management practise which may increase both the quantity and quality of nesting habitat (Cowan 1982, Sugden 1985).

Several extensive management techniques have been implemented by the North American Waterfowl Management Plan (NAWMP) across prairie Canada. These practices include soil and water conservation initiatives, such as zero tillage, winter wheat and stubble mulching (NAWMP 1986, NAWMP 1990). Farmers are encouraged to zero till by the NAWMP and government agencies which provide specialized seed drills at low cost to farmers.

Spring-sown zero tillage, involves no "tillage" (cultivation, discing or plowing) throughout the year. Fertilizer and seed are placed into the soil with specialized equipment, minimizing soil disturbance. Soil susceptibility to erosion is reduced because crop residues remain from the previous year (Black and Siddoway 1979).

Farmer Benefits

SSZT offers many benefits to farmers in prairie Canada. Farmers may benefit from spring-sown zero tillage through reduced labour and reduced fuel consumption (Phillips and Phillips 1983). This reduction results from the elimination of tillage operations. These reduced inputs may save farmers money. Josephson (1992) found a $20/acre increase in net farm income by changing to zero tillage farming in southwestern Manitoba.

SSZT may benefit a farmer through water conservation. SSZT retains more residues than conventional tillage, resulting in increased water available due to reduced run off, reduced evaporation and cooler spring temperatures (Black and Siddoway 1979, Brun et al. 1986, Grevers et al.

1986, Nyborg and Malhi 1989). Increased water availability will increase yields in years of drought (Black and Siddoway 1979).

Increased soil organic matter may also result from zero tillage (Campbell et al. 1989, Chang and Lindwall 1989, however see Carter and Rennie 1982). If organic matter increases fertilizer costs may be reduced.

Yields in SSZT are similar to those in conventional tillage for most years (Tessier et al. 1990; however see Grevers et al. 1986, Nyborg and Mahli 1989) and potentially higher in years of drought or in areas of low annual precipitation (Black and Siddoway 1979, Malhi and O'Sullivan 1990). Yields in SSZT can be reduced, however, in years of low temperature (Malhi and O'Sullivan 1990).

Impacts of SSZT on Nesting Ducks

Spring-sown zero tillage may be beneficial to upland nesting ducks by increasing available nesting habitat in the form of stubble (Sugden 1985, Hill 1990). By increasing the amount of habitat available, nesting hens may distribute themselves over a larger area. An increased distribution may cause a reduction in predation rates which in turn may increase nest success and ultimately duck populations (Cowan 1982, Cowan 1985, Duncan 1987, Clark and Nudds 1991, Clark et al. 1991). Several studies have demonstrated increased nest success in areas where hens are widely distributed (see

Clark and Nudds 1991 for review).

Spring seeded zero till crops may, on the other hand, act as an ecological trap (Sugden and Beyersbergen 1982). An ecological trap occurs when a hen initiates a nest in a SSZT field (due to the cover provided by the stubble associated with SSZT fields) and it is later destroyed by farming operations. Field operations coincide with the nesting season and can cause considerable loss of nests in fields (Dzubin 1952, Milonski 1958a, Higgins 1977, Cowan 1982, Sugden and Beyersbergen 1985, Klett et al. 1988).

SSZT in the Minnedosa Area

In Minnedosa, Manitoba, farmers have been encouraged to try SSZT as an alternative to conventional tillage. The Province of Manitoba (Manitoba Dept. Agriculture), Agriculture Canada (PFRA), Ducks Unlimited Canada and The Prairie Farming Program (Delta Waterfowl Foundation) initiated a program in 1990 to encourage farmers in the Minnedosa area (Rural Municipalities of Saskatchewan, Harrison, Odanah, and Minto) to try zero tillage. Twenty-two farmers participated in the zero tillage program in 1990 (1100 ha), increasing to 42 (1900 ha) in 1991 and to 47 (2800 ha) in 1992. The main crops seeded with the zero tillage drills were wheat, barley, flax and canola.

This study measured some of the impacts of SSZT on duck nesting in order to determine whether SSZT was beneficial to upland nesting ducks.

1.1 Objectives

The purpose of this study was to determine the impact of spring-sown zero tillage on upland nesting ducks in the Minnedosa pothole region of Manitoba.

Specific objectives were:

1) To compare the density of upland nesting ducks in SSZT fields versus the adjacent native habitat.

2) To compare nesting success in SSZT fields versus the adjacent native habitat.

3) To determine and compare effects of various zero till seeding drills and fertilizing equipment used in the study area on simulated duck nests.

4) To quantify cover density with SSZT fields before and after farming operations.

5) To recommend ways to reduce nest loss from field operations and ways to increase duck use in fields (if desirable).

2.0 RELATED LITERATURE

2.1 Nesting Density

Nesting density is the number of nests per unit area (nests/km^2) for a habitat type in a particular year in a specific area. Upland duck nesting density varies greatly from year to year and area to area.

Several factors are believed to affect nesting density: local water conditions, population levels (pairs), homing rates, breeding effort, and habitat quality (Hansen and McKnight 1964, Smith 1970, Hochbaum and Bossenmaier 1972, Kantrud and Stewart 1977, Lokemoen et al. 1984, Hochbaum et al. 1987, Johnson and Grier 1988, Clark and Nudds 1991).

SSZT can provide nesting cover in the form of standing residue (stubble) from the previous year's crop or growing crop (Duebbert and Kantrud 1987).

Variable nest densities have been reported for stubble fields in the prairie pothole region. Stubble fields can be considered the same as SSZT fields prior to mechanical disturbance. Nesting densities have ranged from a low of 0.08 nests/km^2 to high of 14.71 nests/km^2 (Table 1). The low density found by Sugden and Beyersbergen (1985) in stubble fields may be due to the fact that all of the fields were searched only once and perhaps abnormally low breeding effort occurred during their study. Cowan's (1982) high nesting density found in SSZT fields may have been due to several factors: small area searched, limited adjacent habitat, excellent water conditions, and high breeding effort.

Table 1. Stubble field nesting densities from various locations in the prairies pothole region.

Source	Years	Area	ha	# nests	#/km²
Cowan (1982)	77,78	MB	136	20	14.71
Duebbert (in Cowan 1985)	?	ND	1620	135	8.33
Duebbert & Kantrud (1974)	71	SD	435	19	4.37
Higgins (1977)	69-74	ND	736	27	3.67
Milonski (1958a)	56,57	MB	8638	203	2.35
Sugden & Beyersbergen (1985)	80,81	SK	1201	1	0.08

Nesting density in SSZT is higher than in conventionally tilled fields (Cowan 1982, Cowardin et al. 1985, Milonski 1958a; however see Dzubin 1952) and lower than that found in native areas (Higgins 1977, Cowan 1982, Cowardin et al. 1985, Duncan 1987, Lokemoen et al. 1990). Near Shoal Lake, Manitoba, (R. E. Jones, Manitoba Habitat Heritage Corporation, pers. comm.) average nesting density in native areas was 24/km² from 1988 to 1992. Nesting density may be related to the cover density provided by both dead and growing cover.

After seeding and crop emergence a new type of cover is available for mid- to late-nesting ducks. Growing crops may be important to late nesting ducks. Higgins (1977) found a nesting density of 1.1 nests/km^2 in growing grain in North Dakota, including species not found in stubble alone. What attracts nesting hens to fields with growing crops is unknown; it may be either the stubble remaining, the growing crop, or some combination of the two.

2.2 Nesting Success

Nesting success is an estimate of the percentage of nests that survive until at least 1 egg hatches. A nesting success of at least 15% is needed for Mallard populations to remain stable in North Dakota (Cowardin et al. 1985). Nesting success in SSZT fields can be affected by predators, field operations (causing full or partial clutch loss), and timing of field operations.

Predation is a main factor reducing nesting success in the prairies (Cowardin and Johnson 1979, Greenwood 1986, Klett et al. 1988, Rondeau and Piehl 1989). Nests in SSZT may experience lower predation rates than nests in other cover types (Jones and Hungerford 1972). By spreading out nests over a large area (ie. crop fields compared to small native areas) nest loss to predators may be reduced due to decreased search intensity (Cowan 1982, Clark and Nudds

1991). Rodgers (1983) stated that stubble fields increase cover quantity, not quality, causing lower predation rates because nests are dispersed over a larger area.

Nests in spring-sown croplands are susceptible to field operations (see Milonski 1958a, Cowan 1982, Rodgers 1983, Klett et al. 1988) as well as predation. Destructive field operations include fertilizing, seeding and spraying. Nest destruction by farming equipment has been documented in conventionally tilled croplands (Dzubin 1952, Higgins 1977) and similar destruction may occur in SSZT since field operations coincide with the nesting season. Although some researchers have observed that individual nests do survive field operations (Cowardin et al. 1985, Higgins 1977, W. F. Cowan, Ducks Unlimited Canada, pers. comm.), the success rate is unknown. Field operations may also kill or injure incubating birds (Rodgers 1983), although this was not reported by Milonski (1958b) or Higgins (1977).

Predation and field operations reduce nest success for nests initiated prior to seeding. However, nests initiated after seeding may have a higher nest success rate (Higgins 1977, Sugden and Beyersbergen 1985). Timing of operations, therefore, can affect nest success. Nesting success increases when seeding is delayed long enough to allow early nests to hatch or when seeding is completed early thus providing cover for late nesting and renesting ducks (Higgins 1977, Sugden and Beyersbergen 1982). Early establishment of crops can result in successful nests for late nesting species and renesting ducks (Higgins 1977).

Nest success may also be influenced by egg destruction from field operations both prior to and after seeding. Partially destroyed nests may cause nest abandonment and increase predation. Rodgers (1983) found that 61% of artificial nests were disturbed after an undercutter operation. Unfortunately, no literature is available on egg destruction resulting from SSZT equipment.

Previous studies of SSZT and conventionally tilled fields report nesting success in the range of 7% to 17% (Milonski 1958a, Higgins 1977, Klett et al. 1988), while nesting success in native habitats range from 8% to 12% Mayfield estimates (Cowardin et al. 1985, Greenwood et al. 1987). Cowan's (1982) apparent nesting success of 60% in SSZT fields may not reflect a true value of success because he instructed farmers to avoid hitting nests with equipment. Other researchers also encouraged farmers to avoid nests (Milonski 1958a, Rodgers 1983, Haworth and Higgins 1990). Unfortunately, the extent to which these avoidance practices mirror actual farmer behaviour is unknown and therefore nest success may be exaggerated.

Nesting success in SSZT, overall, is not well documented and little understood. It may appear that SSZT offers additional nesting habitat while decreasing predation by allowing a dispersion of nests. On the other hand, field operations may decrease nest success.

2.3 Nesting Cover: Effect of Zero Till Equipment on Crop Residues

Nesting cover consists of dead and live vegetative matter which acts as visual obstruction to predators. Much of the NAWMP program in prairie Canada is based on increasing both the quantity and quality of upland nesting cover surrounding potholes.

The presence of standing crop residues in SSZT fields is thought to provide nesting cover (Haworth and Higgins 1990). There is more standing crop residue in SSZT than in conventionally tilled fields, as tillage reduces stubble quantity (Anderson 1961, Agriculture Canada 1982). SSZT, therefore, provides more cover for nesting ducks (Higgins 1977, Cowan 1982).

Although several natural factors alter the abundance of standing stubble and ground stubble (Tanaka 1986, Collins et al. 1990, Stott et al. 1990), field operations in SSZT can significantly decrease residue cover. Harrowing, fertilizing and seeding contribute to the reduction of cover density while spraying has little effect on stubble residues. Harrowing is not a common practice in SSZT and reduces stubble by only 10% (Troch et al. 1991).

Residue quantities may reduced significantly by fertilizing and seeding operations, however, little information is available on their effects. McNabb (1989) reported a 20% disturbance of the soil surface using Dutch Knives and the Edwards hoe press drill.

3.0 STUDY AREA AND METHODS

3.1 Study Area

The study was conducted within a 42 km radius of Minnedosa, Manitoba (50° 10′ N, 99° 47′ W) (Figures 1 and 2). This study area was chosen because of the use of SSZT, and its location in the prairie pothole region. The primary crops grown in the area are wheat, barley, canola and flax. The study area is described in detail in Evans et al. (1952) and in Kiel et al. (1972).

<u>History of SSZT in the Study Area</u>

In 1985 only 1 grower in the study area used zero tillage. By 1992 over 50 farmers had tried or have converted to zero tillage. Three factors were responsible for the increase in SSZT in the Minnedosa area (B. McNabb, area farmer, pers. comm.): 1) Zero tillage preserves more soil moisture, improving yields in dry or drought years; 2) High input costs (ex. fuel, labour, machinery maintenance, etc.) of conventional farming and the reduction of the cost of the herbicide Round-up (used extensively in SSZT); 3) Incentive programs from private and governmental agencies, including agencies involved in the NAWMP.

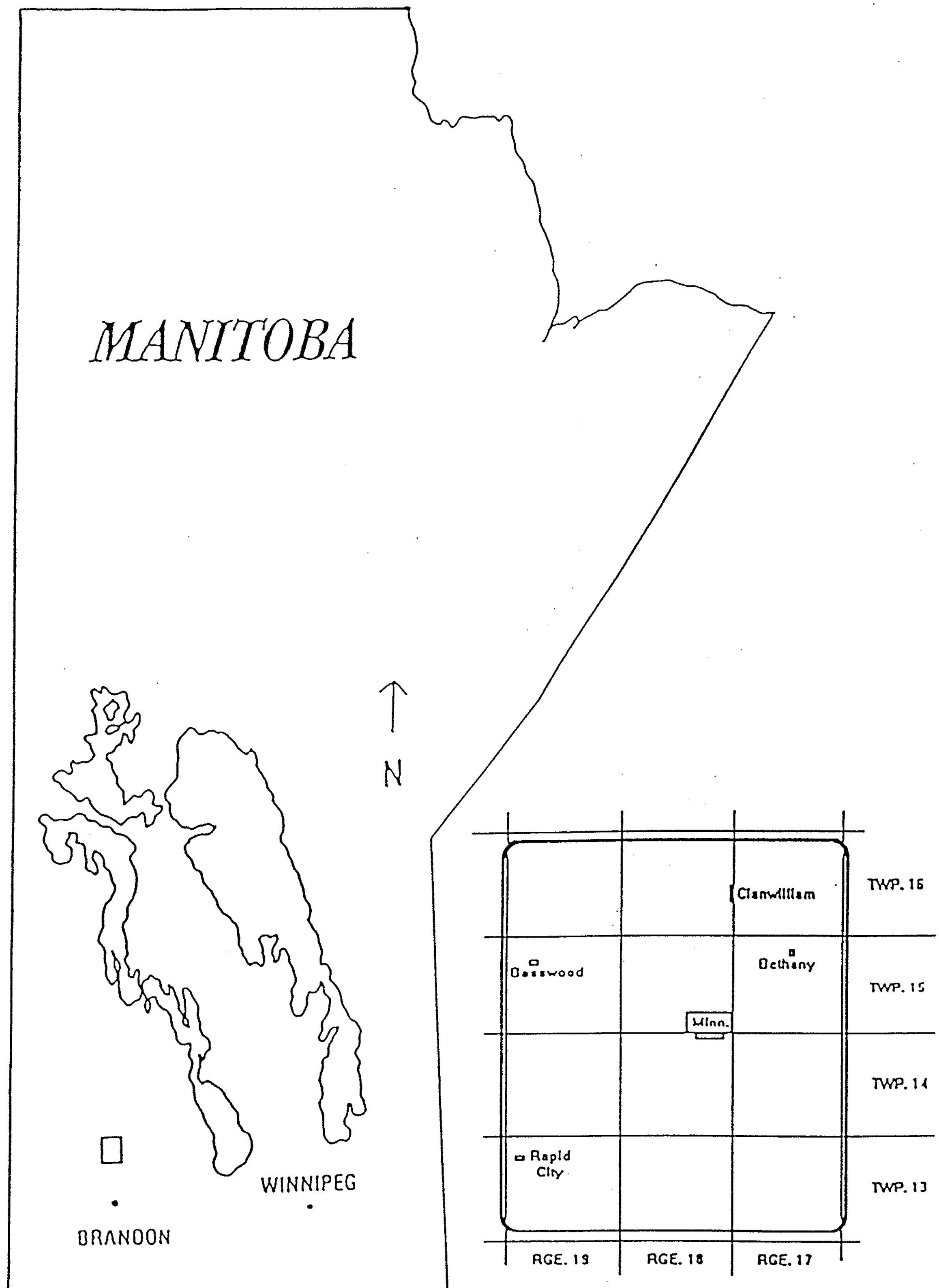

Figure 1. Study area in Southwestern Manitoba

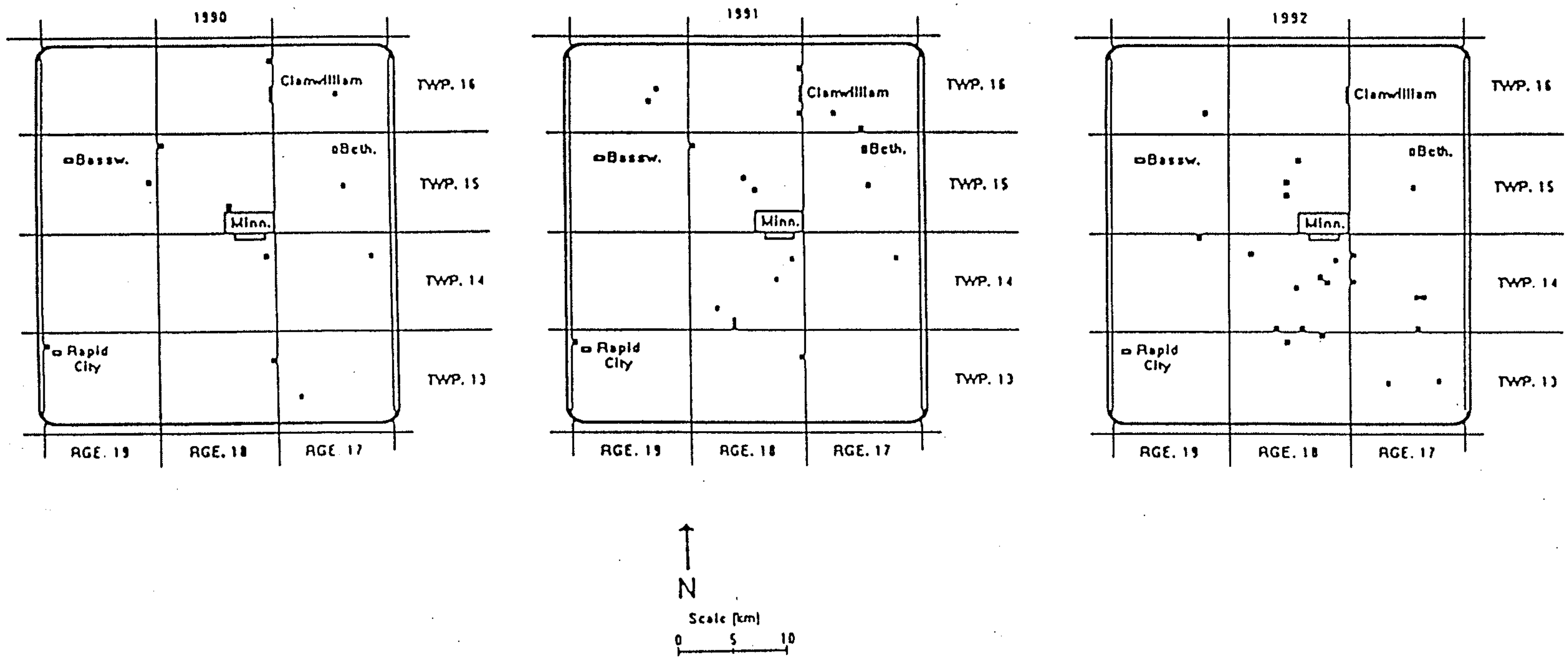

Figure 2. Areas searched near Minnedosa, during 1990, 1991 and 1992.

3.2 Methods

3.2.1. Evaluating Nesting Density

Nest searches were conducted throughout the nesting seasons of 1990, 1991 and 1992 to determine nest density on SSZT fields. Searches were carried out between 0600 hr and 1400 hr (Gloutney et al., in Press).

A modified rope (Lehmann 1941, Duebbert and Kantrud 1974), 90 metres long with rattling devices spaced at 1.5-metre intervals, was pulled between two all-terrain vehicles to flush female ducks from their nests. A cable chain drag (Higgins et al. 1969) was not used because of potential destruction of crop seedlings. The rope drag was used exclusively in 1991 and 1992 in both spring-sown zero tillage fields and native cover in order to maintain consistent results.

At each nest site the following variables were determined and recorded: hen species, clutch size, age of eggs (floatation method, Westerskov 1950), vegetation density (Robel pole, Robel et al. 1970), dominant vegetation type, date, and damage to the hen or eggs due to the search. All nest sites were marked with a 1m green cane (Piccozzi 1975) oriented toward a prominent land mark and stuck in the ground 10m away. This facilitated relocation of nests. Nests were revisited in 3 week intervals to determine their fate.

Fields and adjacent habitat were measured from aerial photographs using a Design CAD program (Design CAD 1989) to determine the total area searched.

In 1990, ten 16 to 28 ha blocks of SSZT fields of various stubble types were searched (see Appendix 1). Some of these fields had no adjacent wetlands while some had many.

In 1991 and 1992 the area searched was increased (see Appendices 2 and 3) because too few nests were found in 1990. Cereal stubble fields with one or more wetlands in or near the field were searched. Fields were not selected randomly due to the lack of fields with adjacent wetlands. Adjacent habitat was also searched to determine nest density and success, in order to make comparisons to SSZT.

In 1991, nest searches were completed on 5 selected intensive study areas. Each intensive area included a spring-sown zero tillage field and an associated "native" upland habitat in or adjacent to the field. All habitat was searched including woodlands, right-of-way and upland pond margins and lumped as "native" habitats for analysis.

Searches were conducted in 1991 on 13 additional stubble fields to increase the sample size of field nests. Fields with cereal stubble were given priority although one canola stubble field was searched.

In 1992, 22 areas, including cropland and adjacent habitats, were searched once: 12 before seeding (standing cereal stubble), and 10 after seeding (cereal stubble and the emerged crop). Woodlands were not searched in 1992 due to the intensive labour required.

3.2.2. Evaluating Nesting Success

Apparent and Mayfield 40% methods were used to calculate estimates for nesting success in all habitat types (Mayfield 1961, Mayfield 1975, Johnson 1979, Klett et al. 1986).

Farmers were not notified of the exact location of duck nests, unlike previous studies where nests were saved from farming operations by either moving or avoiding the nests (Cowan 1982, Milonski 1958a). This procedure provided unbiased nest success results that reflect actual farming operations.

Nest success in native areas was used to compare to that found in SSZT fields in order to determine if SSZT was beneficial to nesting ducks.

3.2.3. Effect of Zero Till Equipment on Simulated Nests

Fabricated nests were placed in fields prior to operation during 1992 to determine effects of 2 commonly used seeding drills and 2 fertilizing units. The equipment studied were the Edwards HD 812 hoe drill (Appendix 6), the Flexi-coil 5000 air drill (Appendix 7), the Dutch Knife fertilizer applicator with 2 rows of harrows (Appendix 8), and the Spoke Injector fertilizer applicator (Appendix 9).

Fifty nests, each containing 9 domestic chicken eggs, were placed randomly along a marked line in each field immediately prior to seeding or fertilizing. No egg destruction occurred prior to the trials. The chicken eggs were of similar size to Mallards. A scrape (depression) was made for each nest in order to mimic natural nests. These factors were recorded at each nest site following operations: number of eggs broken, number of eggs cracked, number of eggs intact, number of intact eggs ≥90% buried, and the greatest distance between intact eggs. Equipment coming in ground contact was measured (see Appendices 5-9). Tractor speed was approximately 8 km/hr for all trials.

3.2.4. Effect of the Zero Till Equipment on Crop Residues

Cover was analyzed once before farming operations commenced in the spring and once after fertilization and seeding had occurred (1 month) in 5 SSZT fields in 1992. Both ground and standing cover were measured at 10 sites in the fields (low spots and high spots were avoided). The following methods were used:

1) Ground Cover: A line transect method using a 15.2-metre long string stretched diagonally across the crop rows was used to evaluate ground cover (Richards et al. 1984). The string was marked every 15cm, totalling 100 marks. The number of ground sites (of the 100) which were covered by residue was recorded. Ten sites, each with 100 marks each

were used in each field analyzed.

2) Standing Cover: Standing cover was determined using the Daubenmire (1959) technique. Twenty samples were taken using a 25 by 40cm rectangular frame. All straw standing at 45 degrees or more were counted within the area of the rectangle and recorded for each site.

4.0 RESULTS

4.1 Nesting Density

A total of 17 nests were found from 1990 to 1992 in over 1600ha of SSZT and stubble fields (1200ha in SSZT and 400ha in stubble fields)(Table 2). In the intensive study areas, SSZT fields had a density of 1.5 to 1.9 nests/km^2 (Table 3). Nest density was much higher for adjacent native habitat (15-43 nests/km^2). Blue-winged Teal nests were the most prevalent and accounted for approximately one half of all nests (Table 4). Mallards, Northern Pintails, Northern Shovelers (Anas clypeata) also nested in fields but to a lesser extent. Gadwalls (Anas strepera) and Green-winged Teal (Anas crecca) were not found in fields.

A total of 20 nests were initiated in fields, however, only 2 were found in clean stubble. The majority of nests were found in either weed patches (n=8), growing crop (n=5), or weed patches and growing crop (n=3), un-spread straw and chaff (n=2). The 5 nests which were found in growing crop were initiated from 19 to 33 days after seeding. Four nests were found in one field alone which was overgrown with weeds (quackgrass Agropyron repens).

Table 2. Nesting density in SSZT fields in the Minnedosa pothole region of Manitoba from 1990 to 1992.

Year	Area searched (ha)	Nests found	Nests/km^2
1990	231	1	0.43
1991	695	5	0.72
1992	716	11	1.54

Table 3. Nesting density of intensive study sites near Minnedosa, Manitoba for 1991 and 1992.

Area (year)	No. searches	# Areas	Area searched (ha)	Nests found	Nests /km^2
SSZT fields (91)	3	5	161	3	1.9
Adjacent native (91)	4	5	67	29	43.3
SSZT fields (92)	1	22	716	11	1.5
Adjacent native (92)	1	22	251	39	15.5

Table 4. Species of duck nests found in SSZT fields and adjacent native cover near Minnedosa, Manitoba (1990-1992).

Species *	# in Field (%)	# in Native (%)
BWT	11 (55)	36 (50)
MAL	4 (20)	14 (19)
SHO	2 (10)	11 (15)
GAD	0	7 (10)
PIN	3 (15)	3 (4)
GWT	0	1 (1)
TOTAL	20	72

* BWT=Blue-winged Teal; MAL=Mallard; SHO=Northern Shoveler; GAD=Gadwall; PIN=Northern Pintail; GWT=Green-winged Teal.

4.2 Nesting Success

Mayfield nesting success was similar in SSZT and adjacent native habitat (Table 5). Because of the small sample for SSZT nests, data was pooled for all three years of the study.

Of the 19 nests found in fields; 5 were successful, 1 was abandoned, 7 were destroyed by predators, 2 were destroyed by SSZT equipment and 4 were either destroyed by predators or equipment not associated with SSZT. No nests survived field operations.

Thirteen nests were initiated in stubble fields prior to seeding, however, none were successful. Nests initiated after seeding (in growing crop) had a higher apparent nest success (5 of 6 nests were successful) than those initiated prior to seeding.

Table 5. Apparent and Mayfield nest success in SSZT fields and adjacent native habitats near Minnedosa, Manitoba.

Area	n	Apparent success %	Mayfield success % (SE)
SSZT fields (90,91,92)	13	38.5	12.9 (±9.3)
Adjacent native (91)	29	20.7	12.7 (±5.5)
Adjacent native (92)	37	13.5	7.3 (±3.4)
Adjacent native (91,92)	66	16.7	9.5 (±3.0)

4.3 Effect of Zero Till Equipment on Nests

Two active duck nests were checked immediately following seeding with an Edwards hoe press drill. In the first, a Blue-winged Teal had all 11 eggs buried, the hen was killed by a predator at the nest site by the next day and no eggs appeared to have been dug out. In the second case, a Mallard hen apparently abandoned a nest in which 4 of 9 eggs were broken and the remaining 5 were buried.

The amount of disturbance caused on simulated nests by various SSZT equipment varied. The Spoke Injector was the least destructive implement (Table 6). About 50% of the nests were left undisturbed and over 80% contained 5 or more of the original 9 eggs.

The Dutch Knife fertilizer applicator was more damaging to nests than the Spoke Injector. Over half of the nests had 5 or more eggs survive. The Dutch Knife applicator, however, displaced eggs farther than any other implement.

The two seed drills tested (Edwards hoe drill and Flexicoil air seeder) exhibited high disturbance rates. None of the nests remained undisturbed and less than half contained 5 or more undisturbed eggs after seeding.

Table 6. The disturbance of nests from 2 seeding and 2 fertilizing operations used in SSZT operations in Southwestern Manitoba, 1992.

			% nests undisturbed* (SE)			# of Nests with egg displacement (SE)					
Trial	n	# eggs OK/9	All eggs	≥5 eggs	No eggs	n	Avg. dist. (cm)	# ≥30 cm	%	# ≥100 cm	%
Dutch	48	4.0 (±.5)	0	58 (±7)	31 (±7)	30	161 (±29)	30	63 (±9)	21	44 (±9)
Spoke	51	7.1 (±.4)	51 (±7)	86 (±5)	10 (±4)	0	0	0	0	0	0
Edwds	50	2.4 (±.3)	0	40 (±6)	22 (±6)	23	82 (±12)	20	40 (±11)	7	14 (±8)
Flex.	52	1.9 (±.3)	0	42 (±7)	33 (±7)	28	62 (±7)	21	40 (±11)	6	12 (±7)

Undisturbed* means not broken, cracked or buried.

4.4 Effect of Zero Till Equipment on Crop Residues

Ground cover was affected very little by all operations while standing cover was highly reduced (Table 7). Only 6-22% of the standing stubble remained after both Dutch Knife (with harrows) and seeding operation occurred. In one situation where only the Edwards seeder was used, more standing stubble was retained than the other trials which were preceded by a fertilizing operation.

Table 7. Quantity of stubble residue remaining after field operations in SSZT fields. (D=Dutch Knives; E=Edwards seeder; F=Flexi-coil seeder; and S=Spoke Injector)

Trial	Percent ground covered			Avg. # of standing stems/M^2		
	Before	After	% left	Before	After	% left
D & E	89	75	84	346	35	10
D & E	94	72	77	294	66	22
D & F	98	82	84	365	22	6
S & F	98	87	89	317	102	32
E	89	83	93	335	164	49

5.0 DISCUSSION

5.1 Nesting Density

Nesting density in SSZT fields in the Minnedosa area was low (0.4 to 1.9/km^2), particularly when compared to adjacent uplands and previous studies of SSZT. Low numbers of nests found was in part due to reduced nest searching effort, as most fields were searched only once. Low nesting density in 1990 could be due to poor stubble quality (some flax and canola stubble fields were searched) and poor pothole association (fields were not chosen for their association with potholes). The higher nesting density in 1992 was influenced by one weed infested field which had 4 nests.

Although nesting density was relatively low in this study, the total number of nests could still be significant when considering the vast area of croplands in the prairie pothole region. In 1992 there was approximately 3.7 million, 12 million, and 7.2 million ha of seeded cropland in Manitoba, Saskatchewan and Alberta, respectively (Canadian Wheat Board 1992), for a total of 22.9 million ha. As of 1991, zero tillage comprised 212,000, 1,353,000, and 249,000 ha (Statistics Canada 1992a) or 5.0, 10.4 and 3.1% of total seeded cropland (Statistics Canada 1992b) in Manitoba, Saskatchewan, and Alberta, respectively. Therefore approximately 850,000 ha of SSZT existed in the prairie pothole region (using 1991 figures).

Nesting densities found in this study averaged 1 nest/km^2, however, most areas were searched only once, thus underestimating actual density (Klett et al. 1986). If we assume there are 2 nests/km^2 and extrapolate for the 3 prairie provinces there would be approximately 17,000 duck nests in SSZT fields in prairie Canada. Additionally SSZT will probably become more common given incentives from agriculture and wildlife agencies. This is evident in the Minnedosa region where about 18% of crops were zero tilled in 1992 (N. Galbraith, Manitoba Dept. Agr., pers. comm.). If this was increased to 20% for all 3 of the prairie provinces, Manitoba could potentially have over 3,600 duck nests in SSZT, while Saskatchewan and Alberta could have another 38,000 nests. Jenkins (1991) speculated that by the year 2000 there could be 8 million ha in SSZT which would result in 160,000 nests using similar extrapolations.

Even though as many as 160,000 duck nests may be found on SSZT fields in future years this is a small number (2.3%) compared to 6.7 million combined breeding pairs of Gadwalls, Mallards, Northern Pintails, Blue-winged Teal, and Northern Shovelers in the southern Canadian Prairies, the average for 1990 to 1992 (Caswell and Schuster 1991, Caswell and Schuster 1992, Caswell et al. 1993).

Nesting densities of SSZT may not be much higher than in some conventionally tilled and minimal (conservation) tillage fields. Considering cover in the form of crop residue, in early spring, SSZT fields are the same as conventionally tilled or minimally tilled fields until cultivated.

Factors influencing nesting density include the amount of crop residues, growing crop (Duebbert and Kantrud 1987), and weed patches.

Most of the nests found in SSZT fields prior to seeding were initiated in association with growing weed patches. This suggests that nest site selection may be due in part to the weeds. Perhaps the stubble was of less importance as nesting cover for those hens. Although no prior researchers found an association of duck nests with weeds, Misner and Dimmick (1988) noted an association between bobwhite quail (Colinus virginianus) nests and weeds in zero tillage fields.

Most of the nests found in SSZT fields which were initiated after seeding were initiated several days after crop emergence; once again showing the importance of a green growing component. Only 2 of 20 nests were associated with "clean" stubble and therefore 3 observations become evident. (1) Ducks can be discouraged from nesting in SSZT fields and fewer nests will be disturbed or destroyed by farming operations if fields are weedless prior to field operations in the spring. (2) Seeding early in the spring will cause less weed growth. Therefore fewer ducks will nest prior to seeding. Additionally, early seeding will provide relatively safe nesting cover for mid- to late-nesters. (3) In chemical fallow fields where field operations are few and relatively non-destructive (one spray) during the nesting season, weeds could be allowed to grow until just prior to seed set to allow for maximum nesting cover.

An aspect of ground stubble whcih could be important may be its use as nesting material. According to Johnsgard (1968) no waterfowl species carry nesting material in the bill, rather they reach out and pick up nesting material and drop it into their nests. Lack of ground stubble may limit nesting in fields with little or no stubble, as in conventional farming.

5.2 Nesting Success

Estimated nesting success in SSZT fields (12.9%, ±9.3 SE) was no different than that in native uplands (9.5%, ±3.0 SE), may be lower (not significantly) than the 15% needed to sustain duck (Mallard) populations (Cowardin et al. 1985). If further research reveals similar low nesting success, waterfowl managers must reconsider their involvement in SSZT. Perhaps managers should focus on methods used in SSZT which increase nesting success.

Nest success in SSZT fields was lower in this study than that found in earlier studies in which marked nests were avoided by farmers (Cowan 1982, Milonski 1958a). Under normal circumstances, farmers are not likely to avoid many nests, and nesting success would be reduced. Because potentially high nesting success in SSZT fields has been reported (Cowan 1982), future improvements in the implements used may lessen the damage to nests and therefore increase success.

Low nest success has been reported elsewhere for cropland nests (Milonski 1958b, Higgins 1977, Giroux 1981 in Cowan 1985). Mayfield nest success in Alberta chemical fallow fields was only 7%, the same as all other habitats combined (D. E. Hoffman, Alberta Fish Wildl., pers. comm.).

In this study, apparent nest success was high for nests initiated after seeding (when there was no longer an ecological trap), indicating potential for early seeding. Fall-sown crops such as zero till winter wheat reported a Mayfield nest success of 26-29% in North Dakota (Duebbert and Kantrud 1987).

5.3 Effect of SSZT Equipment On Simulated Nests

Field operations and the use of specific types of equipment can have a significant effect on nest damage. Implements such as the Spoke Injector applicator and an undercutter (Rodgers 1983) reduce impacts on nests compared to other equipment tested in this study. Seeders, such as the Edwards hoe press and the Flexi-coil air seeder, were much more damaging to nests.

Unfortunately, little is known about nest success when a clutch is partially disturbed by farming implements. Some eggs may be broken or cracked while others remain undisturbed. Whether a hen will abandon a nest with broken or displaced eggs or if she will recover displaced or buried eggs is unknown.

The disturbance by field operations which result in a partial clutch loss may cause reduced nesting success (see Choate 1967, Hall 1987). Armstrong (1986) found that all Blue-winged Teal abandoned nests when >65% of the eggs were removed and no abandonment occurred when <30% of the eggs were removed. If >50% of a Mallard clutch was removed, there was an abandonment rate of 63% (n=22) (Hall 1987). Additionally, partially destroyed clutches may increase predation rates, therefore lowering nesting success (Hammond and Forward 1956).

Disturbance by field operations may also result in displaced eggs. Literature on the fate of displaced duck eggs is limited. Bennett (1938) observed six Blue-winged Teal nests where one egg was found 8 to 91 cm from the nest; these eggs were often eaten by predators. Geese can move displaced eggs back to the nest by walking backward toward the nest, pulling the egg along with the underside of their bill (Skutch 1976). No literature was found indicating any of the ducks in the Genus Anas could roll eggs back to the nest. The Spoke Injector fertilizer applicator did not displace eggs, while the Dutch Knife fertilizer applicator (with harrows) moved eggs considerable distances.

If the assumption was made that ducks abandon nests at the rate mentioned above, even when broken eggs are present, and that all eggs which roll away from nests are retrieved, the impact of SSZT equipment studied would result in a loss or abandonment of about 50% of all nests per operation (for 3 of the 4 operations tested in this study). Any benefits from reduced predation in SSZT fields due to a spreading out of nests may be negated by the impacts of field operations.

5.4 Effect of Zero Till Equipment on Crop Residues (Nesting Cover)

The analysis of ground cover is used by agriculturalists to determine reduction of residues and the soil's susceptibility to erosion. However, while ground stubble may be important as nesting material, it may not be as important as standing cover to nesting ducks. Standing stubble was reduced more (51-94%) than ground cover (7-23%) by SSZT field operations. Reduction in ground stubble by the Dutch Knife applicator (with harrows) and the Edwards hoe press seed drill (16-23%) was similar to that found by McNabb (1989) who reported a reduction of 20%. Operations which used low impact equipment such as the Spoke Injector fertilizer applicator (which retained 32% of standing stubble) or operations which seeded and fertilized with 1 implement (which retained 49% of standing stubble) provide increased nesting cover.

Use of different seeding and fertilizing equipment may affect residue quantity. Wide row drills, such as 30 cm spacings, allows for greater stubble height (Lafond 1993a). Similar to studies elsewhere (Elsahookie 1978, Mohamed et al. 1990), Lafond (1993a,b) found yields of 4 common prairie crops to be no different in wide row spacings (30cm) compared to 20cm and 10cm spacings. These results contradicted the findings of other studies where yields increased when row spaces decreased (Bishnoi 1980, Reinertsen et al. 1984, Johnson et al. 1988). Narrow openers and packing wheels along with wide row spacing may retain more residue and destroy fewer nests.

The importance of retaining standing stubble would originally have seemed great, but few nests were initiated in clean stubble (no growing weeds or crop). The importance of stubble as nesting cover, should be further assessed if wildlife agencies are to continue spending money promoting SSZT.

6.0 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

6.1 Summary

Nest searches were conducted in the Minnedosa pothole region of Manitoba from 1990 to 1992 in order to determine the impact of spring-sown zero tillage on duck nesting. Twenty nests were found in SSZT fields throughout the 3 study years with an average nesting density of 1/km^2, much less than that found in the adjacent native areas.

No difference was found in nest success in SSZT fields compared to that of adjacent native habitat. Estimated nest success for both the SSZT fields (12.9%, ±9.3 SE) and the adjacent native areas (9.5%, ±3.0 SE) appeared to be below the 15% needed to sustain a population (Cowardin et al. 1985), but the difference was insignificant.

Spring-sown zero tillage acted as an ecological trap when ducks initiated nests prior to seeding as these nests were subjected to highly damaging farming operations. Because nests were associated with weed patches prior to seeding, ducks could be discouraged from nesting in fields by keeping them free of weeds.

A high apparent success rate (5 of 6 nests hatched) was observed for nests initiated after seeding and crop emergence. This indicates possible benefits to ducks of early seeded spring crops or fall sown crops.

All SSZT equipment had an impact on fabricated nests, but some was less destructive than others. The Spoke

Injector fertilizer applicator was the least destructive equipment tested. The 2 seeding drills (Edwards hoe press and Flexicoil air seeder) were highly destructive to nests.

While SSZT implements reduced ground cover minimally (7-23%), the standing cover was reduced significantly (51-94%). Standing cover was originally thought to be important as nesting cover. Because only 2 of 20 nests were found in association with stubble only, the role of a growing component (weeds or growing crop) along with the stubble seems more important than stubble alone.

6.2 Conclusions

The value of spring-sown zero tilled crops for duck nesting in the Minnedosa region of Manitoba was questionable. Four conclusions can be made based on the results of this study:

1) The nest densities in native uplands were higher than those in SSZT fields for both 1991 and 1992. While low densities of nests were found in SSZT fields, no difference in the nesting success between SSZT fields and adjacent native habitat could be detected. Therefore the promotion of SSZT by wildlife agencies is questionable.

2) The number of SSZT nests in prairie Canada will make up a very small percentage of the total breeding effort even if SSZT is applied to a substantial portion of the croplands.

3) SSZT can act as an ecological trap as nests initiated

prior to field operations are subject to destruction by farming equipment.

4) Given that SSZT will be used as a conservation farming practice, changes in SSZT equipment and practices could reduce cover loss and nest destruction.

6.3 Recommendations:

(1) The NAWMP may wish to consider the extent of their involvement with SSZT in the future until further research more accurately determines nesting success (with increased sample size) and the destruction of nests by various types of equipment.

(2) Because ducks nesting in SSZT fields were often associated with some growing plants, any chemical fallow program used as duck breeding habitat should avoid spraying weeds until the latest possible date, probably just prior to seed set. This will maximize growing cover, which nesting ducks seem to utilize.

(3) Nest-friendly equipment such as the Spoke Injector should be developed, tested and used in SSZT fields in order to reduce nest disturbance.

(4) Field operations which place both fertilizer and seed in one pass are recommended to reduce nest and cover loss.

(5) If fertilizer cannot be applied during the same operation as seed then fall fertilization is recommended to reduce nest destruction in spring.

(6) Farmers should avoid nests whenever possible to reduce nest disturbance by field operations.

(7) Further research should be conducted in 3 areas in order to monitor and understand the impacts of SSZT on nesting ducks:

A) Research on the nesting success in SSZT fields should be continued in order to increase the sample size, therefore more accurately determining nest success.

B) The effects of equipment on fabricated nests should be elaborated to test other equipment used in association with SSZT.

C) Further research on the impacts of SSZT equipment on crop residues should be conducted.

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8.0 Appendices

Appendix 1. Definitions

<u>Chemical Fallow</u>: A method where croplands are left idle for a year and uses herbicides to control weeds.

<u>Clean Stubble</u>: areas in croplands where only residues from past years' growth are present, and no growing weeds or crop are present.

<u>Ecological Trap</u>: the encouraging of an organism into a certain habitat which may cause harm to the organism.

<u>Native Habitat</u>: term used to descibe areas other than those used for agriculture, including woodlands, roadside ditches, grasslands, idle pastures, etc.

<u>Nest Site</u>: the exact location of a duck nest.

<u>Nest Success</u>: The percentage of nests that survive to hatch at least one egg.

<u>Spring-sown Zero Tillage</u>: Spring planting of annual crops with no prior tillage.

<u>Stubble Residue</u>: remains of plants not removed from the previous year's crop, including stems, chaff and leaves.

<u>Upland Nesting Ducks</u>: species of ducks which commonly nest on dry ground (mallard, gadwall, pintail, green-winged teal, blue-winged teal, american wigeon, northern shoveler and lesser scaup).

Appendix 2. Description of nest search areas and nests found, Minnedosa, 1990.

Legal descr.	Date	Drag method	Stubble type*	Crop type*	Field acres	Native acres	# field nests	# native nests
SW 15-16-17	7/5/90	1	F	-	40	-	0	-
	28/5/90	1	F	-	40	-	0	-
	22/6/90	2	F	W	40	-	0	-
NE 25-16-18	7/5/90	1	C	-	40	-	0	-
	22/6/90	2	C	B	70	-	1	-
N½ 15-15-17	8/5/90	1	W	-	80	-	0	-
	29/5/90	1	W	-	40	-	0	-
SW 17-13-17	9/5/90	1	W	-	40	-	0	-
SE 26-14-17	9/5/90	1	F	-	40	-	0	-
SE 25-13-18	9/5/90	1	F	-	40	-	0	-
	28/5/90	1	F	-	40	-	0	-
NW 10-15-18	10/5/90	1	B	-	40	-	0	-
	29/5/90	1	B	-	70	-	0	-
NW 30-13-19	10/5/90	1	O/M	-	40	-	0	-
S½ 24-15-19	10/5/90	1	W	-	80	-	0	-
	29/5/90	1	W	-	40	-	0	-

Appendix 2.

Legal descr.	Date	Drag Method	Stubble type*	Crop type*	Field acres	Native acres	# field nests	# native nests
SW 31-15-18	10/5/90	1	F	-	40	-	0	-
	29/5/90	1	F	-	40	-	0	-

* Crop types where F=flax, C=canola, W=wheat, B=barley, O=oats, M=millet, and R=rye.

Appendix 3. Description of nest search areas and nests found, Minnedosa, 1991.

Legal descr.	Date	Drag method	Stubble type	Crop type	Field acres	Native acres	# field nests	# native nests
SE 4-16-17	3/5/91	2	W	-	99	-	0	-
SE 25-13-18	8/5/91	2	W	-	118	32	0	1
	28/5/91	2	W	-	118	22	1	5
	31/5/91	2	-	-	-	10	-	0
	18/6/91	2	-	-	-	32	-	1
	20/6/91	2	W	C	118	-	0	-
	10/7/91	2	-	-	-	32	-	0
SE 26-14-17	9/5/91	2	W	-	158	12.5	0	0
	29/5/91	2	W	-	108	12.5	0	1
	19/6/91	2	-	-	-	12.5	-	0
	20/6/91	2	W	C	108	-	0	-
	15/7/91	2	-	-	-	12.5	-	0
NW 30-13-19	10/5/91	2	W	-	93	27	-	1
	30/5/91	2	W	-	60	-	1	-
	31/5/91	2	-	-	-	10	-	4
	3/6/91	2	-	-	-	17	-	1
	21/6/91	2	W	C	60	-	-	-
	24/6/91	2	-	-	-	27	-	0

Appendix 3.

Legal descr.	Date	Drag method	Stubble type	Crop type	Field acres	Native acres	# field nests	# native nests
NW 30-13-19	9/7/91	2	-	-	-	27	-	0
N½ 15-15-17	13/5/91	2	B	-	92	20	0	0
	3/6/91	2	-	-	-	20	-	0
	4/6/91	2	B	C	92	-	0	-
	21/6/91	2	B	C	92	-	1	1
	25/6/91	2	-	-	-	15	-	0
	26/6/91	2	-	-	-	5	-	0
	16/7/91	2	-	-	-	20	-	0
NW 12-16-18	15/5/91	2	W	-	154	-	0	-
SW 4-14-18	16/5/91	2	F/O	-	81	21	0	1
	17/5/91	2	-	-	-	21	-	1
	5/6/91	2	-	-	-	21	-	6
	7/6/91	2	-	-	-	15	-	2
	8/6/91	2	F	W	22	3	0	1
	9/6/91	2	O	W	17	3	0	1
	26/6/91	2	-	-	-	10	-	1
	27/6/91	2	-	-	-	16	-	2

Appendix 3.

Legal descr.	Date	Drag method	Stubble type	Crop type	Field acres	Native acres	# field nests	# native nests
SW 4-14-18	28/6/91	2	F/O	W	39	16	1	2
	12/7/91	2	-	-	-	21	-	1
	13/7/91	2	-	-	-	21	-	0
NW 4-14-18	17/5/91	2	W	-	107	-	0	-
S½ 8-14-18	18/5/91	2	W	-	196	-	0	-
SE 14-16-19	21/5/91	2	W	-	40	-	0	-
SW 11-16-19	27/5/91	2	W	-	30	-	0	-
SW 25-14-18	9/6/91	2	W	W	70	-	1	-
NW 23-14-18	10/6/91	2	C	W	55	-	1	-
NE 21-15-18	12/6/91	2	W	W	60	-	0	-
SW 31-15-18	12/6/91	2	W	W	79	-	1	-
SE 16-15-18	13/6/91	2	W	W	102	-	0	-
NE 21-15-18	14/6/91	2	R	F	140	-	0	-
N½ 15-15-18	14/6/91	2	B	C	75	-	0	-
NE 8-16-17	17/6/91	2	W	W	52	-	0	-

Appendix 4. Description of nest search areas and nests found, Minnedosa, 1992.

Legal descr.	Date	Drag method	Stubble type	Crop type	Field acres	Native acres	# field nests	# native nests
SW 21-14-17	18/5/92	2	W	-	99	38	0	1
SW 30-15-17	20/5/92	2	W	-	81	19	0	0
NE 3-14-17	23/5/92	2	W	-	81	28	4	3
SW 23-13-17	25/5/92	2	W	-	84	29	0	2
SE 19-14-17	26/5/92	2	W	-	80	10	0	1
	27/5/92	2	W	-	8	13	1	3
NW 29-14-18	28/5/92	2	W	-	119	19	1	1
NE 15-14-18	29/5/92	2	W	-	107	50	0	1
SE 23-14-18	30/5/92	2	W	-	72	34	0	3
	2/6/92	2	-	-	-	10	-	1
NE 3-14-18	1/6/92	2	W	-	103	27	1	1
SE 27-15-18	2/6/92	2	W	-	68	9	0	1
SW 20-14-17	5/6/92	2	W	-	35	17	0	2
	8/6/92	2	-	-	-	10	-	1
NW 11-16-19	9/6/92	2	W	-	94	14	2	1
SW 4-14-18	15/6/92	2	W	B	39	21	-	0
	17/6/92	2	-	-	-	21	-	9

Appendix 4.

Legal descr.	Date	Drag method	Stubble type	Crop type	Field acres	Native acres	# field nests	# native nests
NW 15-15-17	18/6/92	2	-	-	-	30	-	3
	20/6/92	2	W	W	80	-	2	-
NW 23-14-18	19/6/92	2	W	W	41	23	0	1
NW 35-14-19	23/6/92	2	W	W	80	21	0	0
NW 35-13-18	24/6/92	2	W	C	60	-	0	-
	25/6/92	2	-	-	-	44	-	2
SW 25-14-18	29/6/92	2	W	C	67	22	1	2
NE 17-13-17	30/6/92	2	W	C	97	20	0	0
	1/7/92	2	-	-	-	21	-	0
SE 33-13-18	4/7/92	2	W	F	61	28	0	1
SE 21-15-18	6/7/92	2	W	C	107	20	0	0
SE 16-15-18	8/7/92	2	-	-	-	21	-	0
	11/7/92	2	W	F	105	-	0	-

Appendix 5. Measurements of implement's features, which have ground contact, for equipment used in the egg disturbance trials where: 1) Edwards unit; 2) Flexi-coil unit; 3) Dutch Knives; and 4) Spoke Injector.

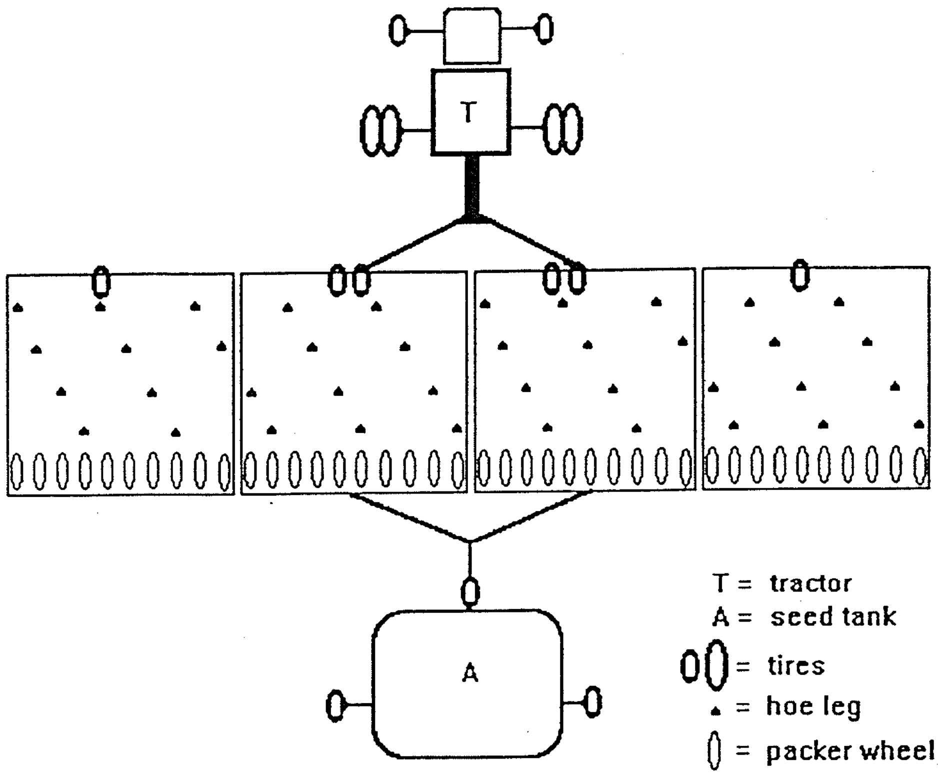
Exp	Width	Shanks/openers *			Packers/harrows *			
	(CM)	#	d	w	#	d	w	r
1	853	40	21	4	40	21	10	-
2	1006	40	25	6	40	25	6	-
3	518	17	30	2.5	61	8.5	1	2
4	1676	56	30	1.9	-	-	-	-

* #=number of objects on the implement; d=distance between each object; w=width of individual object; r=number of rows.

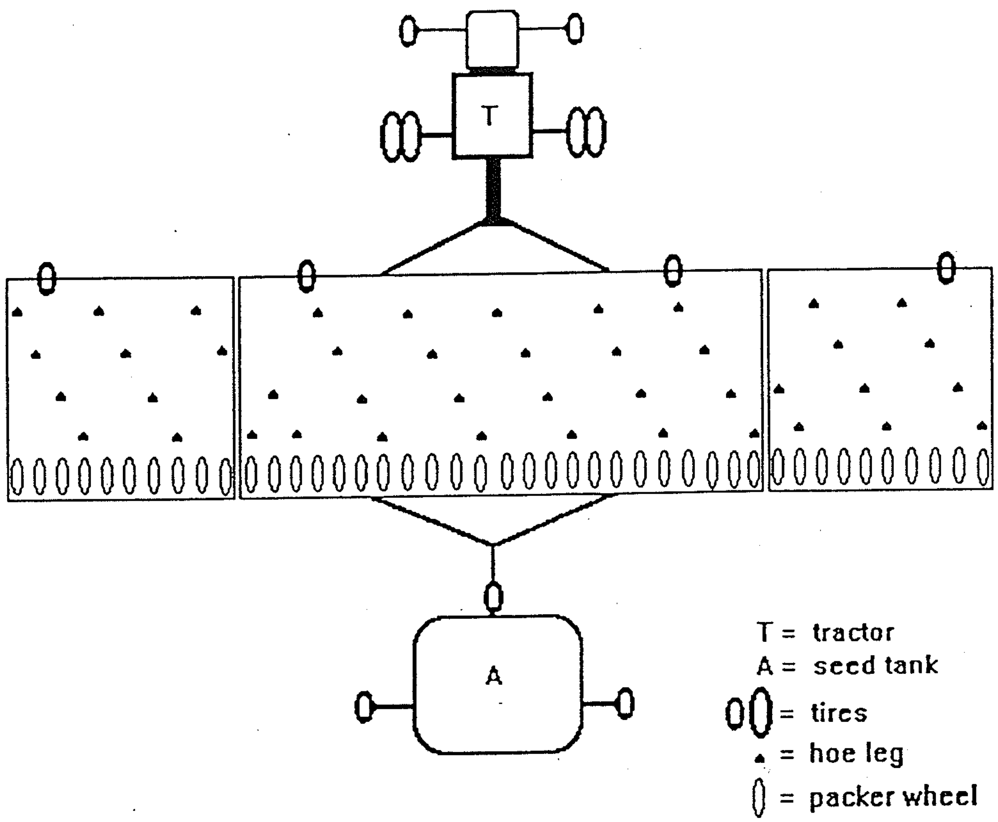
Appendix 6. Tire measurements of equipment used in the egg disturbance trials where: 1) Edwards unit; 2) Flexi-coil unit; 3) Dutch Knives; 4) Spoke Injector; A) Tractor; B) Supplement tank; and C) Implement.

Exp	Width (CM)	Duals (gap) (CM)	Tire width (CM) front	Tire width (CM) back	Centre gap (CM) front	Centre gap (CM) back	Area covered (CM) indiv.	Area covered (CM) Ttl.
1A		17	44	54	127	133	222	
1B		-	43	43	-	241	129	347
1C	853	14	24	-	143	162	144	41%
2A		16	43	53	152	145	212	
2B		-	32	43	-	254	118	356
2C	1006	-	27	-	363	249	108	35%
3A		12	25	51	134	139	209	
3B		-	25	25	180	180	50	209
3C	518	-	21	-	252	-	42	40%
4A		-	30	53	117	119	110	242
4C	1676	-	42	-	219	-	84	14%

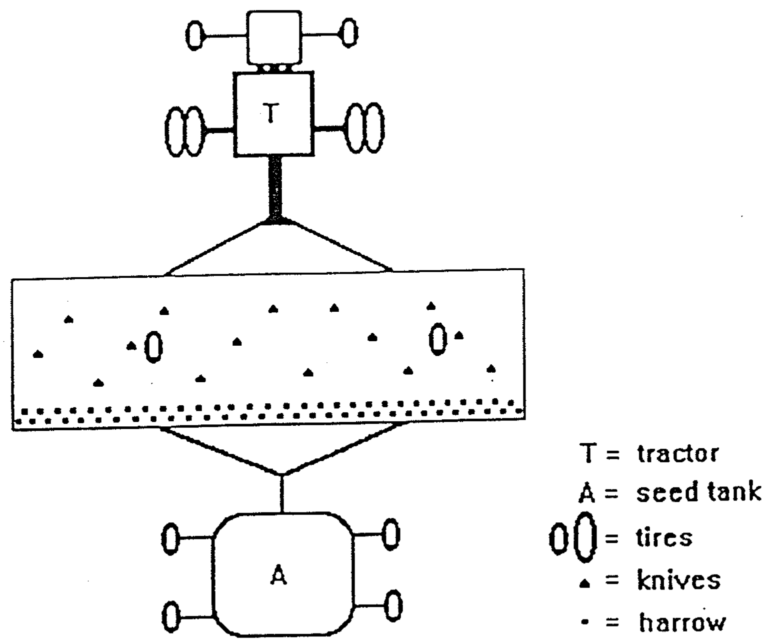
Appendix 7. Overhead view of the Edwards hoe press drill used in the egg disturbance trial.



Appendix 8. Overhead view of the Flexicoil air drill used in the egg disturbance trial.



Appendix 9. Overhead view of the Dutch knives fertilizer applicator used in the egg disturbance trial.



Appendix 10. Overhead view of the Spoke wheel fertilizer applicator used in the egg disturbance trial.