Comparison of Two Nesting Structures for Mallards in Pothole Habitat of Minnesota and Manitoba

By: Terry Kowalchuk

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

Natural Resources Institute
The University of Manitoba
Winnipeg, Manitoba
December 11, 1996

ISBN 0-612-16180-3

Name Terry Kowalchuk

Dissertation Abstracts International and *Masters Abstracts International* are arranged by broad, general subject categories. Please select the one subject which most nearly describes the content of your dissertation or thesis. Enter the corresponding four-digit code in the spaces provided.

SUBJECT TERM: Forestry and Wildlife

SUBJECT CODE: 0478

UMI

Subject Categories

THE HUMANITIES AND SOCIAL SCIENCES

COMMUNICATIONS AND THE ARTS

Architecture 0729
Art History 0377
Cinema 0900
Dance 0378
Design and Decorative Arts 0389
Fine Arts 0357
Information Science 0723
Journalism 0391
Landscape Architecture 0390
Library Science 0399
Mass Communications 0708
Music 0413
Speech Communication 0459
Theater 0465

EDUCATION

General 0515
Administration 0514
Adult and Continuing 0516
Agricultural 0517
Art 0273
Bilingual and Multicultural 0282
Business 0688
Community College 0275
Curriculum and Instruction 0727
Early Childhood 0518
Elementary 0524
Educational Psychology 0525
Finance 0277
Guidance and Counseling 0519
Health 0680
Higher 0745
History of 0520
Home Economics 0278
Industrial 0521
Language and Literature 0279
Mathematics 0280
Music 0522
Philosophy of 0998
Physical 0523
Reading 0535
Religious 0527
Sciences 0714
Secondary 0533
Social Sciences 0534
Sociology of 0340
Special 0529
Teacher Training 0530
Technology 0710
Tests and Measurements 0288
Vocational 0747

LANGUAGE, LITERATURE AND LINGUISTICS

Language
- General 0679
- Ancient 0289
- Linguistics 0290
- Modern 0291
- Rhetoric and Composition 0681

Literature
- General 0401
- Classical 0294
- Comparative 0295
- Medieval 0297
- Modern 0298
- African 0316
- American 0591
- Asian 0305
- Canadian (English) 0352
- Canadian (French) 0355
- Caribbean 0360
- English 0593
- Germanic 0311
- Latin American 0312
- Middle Eastern 0315
- Romance 0313
- Slavic and East European 0314

PHILOSOPHY, RELIGION AND THEOLOGY

Philosophy 0422
Religion
- General 0318
- Biblical Studies 0321
- Clergy 0319
- History of 0320
- Philosophy of 0322

Theology 0469

SOCIAL SCIENCES

American Studies 0323
Anthropology
- Archaeology 0324
- Cultural 0326
- Physical 0327

Business Administration
- General 0310
- Accounting 0272
- Banking 0770
- Management 0454
- Marketing 0338

Canadian Studies 0385
Economics
- General 0501
- Agricultural 0503
- Commerce-Business 0505
- Finance 0508
- History 0509
- Labor 0510
- Theory 0511

Folklore 0358
Geography 0366
Gerontology 0351
History
- General 0578
- Ancient 0579
- Medieval 0581
- Modern 0582
- Church 0330
- Black 0328
- African 0331
- Asia, Australia and Oceania 0332
- Canadian 0334
- European 0335
- Latin American 0336
- Middle Eastern 0333
- United States 0337

History of Science 0585
Law 0398
Political Science
- General 0615
- International Law and Relations 0616
- Public Administration 0617

Recreation 0814
Social Work 0452
Sociology
- General 0626
- Criminology and Penology 0627
- Demography 0938
- Ethnic and Racial Studies 0631
- Individual and Family Studies 0628
- Industrial and Labor Relations 0629
- Public and Social Welfare 0630
- Social Structure and Development 0700
- Theory and Methods 0344

Transportation 0709
Urban and Regional Planning 0999
Women's Studies 0453

THE SCIENCES AND ENGINEERING

BIOLOGICAL SCIENCES

Agriculture
- General 0473
- Agronomy 0285
- Animal Culture and Nutrition 0475
- Animal Pathology 0476
- Fisheries and Aquaculture 0792
- Food Science and Technology 0359
- Forestry and Wildlife 0478
- Plant Culture 0479
- Plant Pathology 0480
- Range Management 0777
- Soil Science 0481
- Wood Technology 0746

Biology
- General 0306
- Anatomy 0287
- Animal Physiology 0433
- Biostatistics 0308
- Botany 0309
- Cell 0379
- Ecology 0329
- Entomology 0353
- Genetics 0369
- Limnology 0793
- Microbiology 0410
- Molecular 0307
- Neuroscience 0317
- Oceanography 0416
- Plant Physiology 0817
- Veterinary Science 0778
- Zoology 0472

Biophysics
- General 0786
- Medical 0760

EARTH SCIENCES

Biogeochemistry 0425
Geochemistry 0996
Geodesy 0370
Geology 0372
Geophysics 0373
Hydrology 0388
Mineralogy 0411
Paleobotany 0345
Paleoecology 0426
Paleontology 0418
Paleozoology 0985
Palynology 0427
Physical Geography 0368
Physical Oceanography 0415

HEALTH AND ENVIRONMENTAL SCIENCES

Environmental Sciences 0768
Health Sciences
- General 0566
- Audiology 0300
- Dentistry 0567
- Education 0350
- Administration, Health Care 0769
- Human Development 0758
- Immunology 0982
- Medicine and Surgery 0564
- Mental Health 0347
- Nursing 0569
- Nutrition 0570
- Obstetrics and Gynecology 0380
- Occupational Health and Safety 0354
- Oncology 0992
- Ophthalmology 0381
- Pathology 0571
- Pharmacology 0419
- Pharmacy 0572
- Public Health 0573
- Radiology 0574
- Recreation 0575
- Rehabilitaion and Therapy 0382
- Speech Pathology 0460
- Toxicology 0383

Home Economics 0386

PHYSICAL SCIENCES

Pure Sciences

Chemistry
- General 0485
- Agricultural 0749
- Analytical 0486
- Biochemistry 0487
- Inorganic 0488
- Nuclear 0738
- Organic 0490
- Pharmaceutical 0491
- Physical 0494
- Polymer 0495
- Radiation 0754

Mathematics 0405
Physics
- General 0605
- Acoustics 0986
- Astronomy and Astrophysics 0606
- Atmospheric Science 0608
- Atomic 0748
- Condensed Matter 0611
- Electricity and Magnetism 0607
- Elementary Particles and High Energy 0798
- Fluid and Plasma 0759
- Molecular 0609
- Nuclear 0610
- Optics 0752
- Radiation 0756

Statistics 0463

Applied Sciences

Applied Mechanics 0346
Computer Science 0984

Engineering
- General 0537
- Aerospace 0538
- Agricultural 0539
- Automotive 0540
- Biomedical 0541
- Chemical 0542
- Civil 0543
- Electronics and Electrical 0544
- Environmental 0775
- Industrial 0546
- Marine and Ocean 0547
- Materials Science 0794
- Mechanical 0548
- Metallurgy 0743
- Mining 0551
- Nuclear 0552
- Packaging 0549
- Petroleum 0765
- Sanitary and Municipal 0554
- System Science 0790

Geotechnology 0428
Operations Research 0796
Plastics Technology 0795
Textile Technology 0994

PSYCHOLOGY

General 0621
Behavioral 0384
Clinical 0622
Cognitive 0633
Developmental 0620
Experimental 0623
Industrial 0624
Personality 0625
Physiological 0989
Psychobiology 0349
Psychometrics 0632
Social 0451

THE UNIVERSITY OF MANITOBA

FACULTY OF GRADUATE STUDIES

*****

COPYRIGHT PERMISSION PAGE

COMPARISON OF TWO NESTING STRUCTURES FOR MALLARDS IN POTHOLE HABITAT OF MINNESOTA AND MANITOBA

BY

TERRY KOWALCHUK

A Thesis/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

ABSTRACT

Nesting structures are a management tool used to increase nesting success rates of mallards (Anas platyrhynchos). Problems with nesting structures appear to arise because of maintenance considerations. I conducted a two year study to determine if a low maintenance fibreglass weave nesting structure was comparable to a flax-roll nesting structure in terms of occupancy, nesting success and preference in two different geographical areas (Minnesota and Manitoba). I also identified habitat within 1 km of structures that could influence the occupancy of structures.

The two year occupancy rate for flax-roll structures in Minnesota (37%) was significantly higher than fibreglass structures (22%). The two year occupancy rate for flax-roll structures in Manitoba was significantly higher (53%) than that of fibreglass structures (25%). No difference in nesting success rates between flax-roll (76%) and fibreglass structures (93%) was detected in Minnesota. No difference in nesting success rates between flax-roll (89%) and fibreglass structures (93%) was detected in Manitoba. A strong preference for flax-roll (72,76%) structures over fibreglass (29,24%) was observed in both Minnesota and Manitoba (respectively).

Habitats were finely classified into 14 categories, and mean amounts of each habitat type within 1 km of occupied and unoccupied were compared. No difference in any habitat type was detected. The habitat was also coarsely classified, and revealed a significant difference in the amount of treed area present within 1 km of structure locations that were occupied (6.1 ha) as

compared to those unoccupied (9.6 ha). All other coarsely classified habitat types were not significantly different.

Higher preference for flax-roll structures suggests that modifications be made to the flax-roll nesting structure in order to increase the life of the roll and make it more low-maintenance. The use of finer mesh wire in roll construction would prevent loss of roll material caused by hen activity and wind. Modification of roll construction to include an activity barrier sandwiched between flax layers, would also prevent hens from removing material from the roll. Use of long-strand flax fibre in roll construction would increase the life of the roll.

ACKNOWLEDGEMENTS

A project of this type is far from an individual effort. Many must be acknowledged for their effort starting with my advisor Rick Baydack, who took a raw student and rounded off a lot of rough edges. Much appreciation to my committee, whose comments and advice were only a small piece of the total experience.

Thanks to the landowners, whose co-operation was imperative in a project of this nature. These people are often overlooked in their importance in projects of this type.

Many "little people" played large roles and went far beyond the call of duty. Jude, Chris, Brenda and Karen, thanks for all the help and for solving the mystery of the fax machine. A special thanks to Larry and Chad who juggled their schedules to help me with nest checks. Your help made paddling the canoe and rowing the john-boat a lot easier.

When time was a factor and we needed to get structures placed, or maintenance completed in a hurry, many of you came to the rescue. Thanks to Miles, Srouch, Wiener, Warren, Iggy, Cabbage, Ian, Slim, Mel and Dad, whose work made my life both physically and mentally less stressful.

Thanks to all my fellow students at the Institute. Your ideas and comments interested and educated. Special thanks to the "Monty's Gang", who never let me stray too far from reality and helped me keep things in perspective.

Thanks to Mom and Dad for the support. You have always given me the opportunity to take on new challenges.

Finally to Kim, thank you for standing by me in the good times and the bad.

Dedicated to the memory of

Mary Kowalchuk

"You taught me more than you ever knew"

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 GENERAL INTRODUCTION

1.1 WATERFOWL POPULATIONS

Analysis of long term data reveals that a noticeable decline in North American waterfowl numbers began in the early 1970's (North American Waterfowl Management Plan 1990). To address the issue of population decline, an understanding of population dynamics is essential. Any population will grow if more are added than removed from a population. Recruitment to a population has been defined as young fledged to the fall population from adults present in the spring (Cowardin and Johnson 1979). The annual change in population size is a function of recruitment of young into the population and survival of existing members of the population (Cowardin and Johnson 1979), assuming that immigration and emigration are not significant.

Nesting success, the percentage of the total nests that hatch, is an important component in the recruitment equation, and the focus of much study in waterfowl management (Cowardin and Johnson 1979, Cowardin et al. 1985, Greenwood et al. 1995). Estimates of nesting success rates for ground nesting waterfowl ranged from 7 to 17% for the period 1982 to 1985 in the Canadian prairie pothole region (Greenwood et al. 1995). Klett (1988) found 11% nest success for all ground-nesting ducks in North Dakota. Untreated upland habitats produced 5% nest success rates in North Dakota (Greenwood et al. 1986).

These rates are of concern, as most are below that required to sustain present waterfowl populations. Through the use of simulation modelling which considers the factors that influence population change, it has been determined that 15% nesting success is required to maintain the population (Cowardin et al. 1985).

1.2 MORTALITY FACTORS

The causes of low nest success rates can be attributed to nest destruction by predators (Balser et al. 1968, Klett et al. 1988, Greenwood et al. 1995, Cowardin et al. 1985). Predation accounted for 77% of loss of all ducks and 82% of loss for mallards during the period 1966 to 1984 (Klett et al. 1988). The proportion of nests containing hatched eggs was markedly higher on active agricultural lands subjected to intensive predator reduction, providing evidence of the effect of predators on nesting success (Balser et al 1968, Duebbert and Kantrud 1974, Greenwood 1986). Lokemoen and Greenwood (1992) observed significantly higher nest success for mallards and gadwalls on islands with predator control than islands without. Nesting success rates in areas with predator removal were as high as 90% (Duebbert and Lokemoen 1980).

Several animals that depredate or parasitize nests of prairie nesting birds have recently increased in abundance in western Minnesota (Johnson and Temple 1990). Densities of red fox

(Vuples vulpes) have increased due to changes in agricultural practices and reductions of other canids (Johnson and Sergeant 1977). This increase in predator number and a shift to more waterfowl-specific canids are two of several reasons for low nest success.

Change in predator community structure is not the only reason for increased predation on waterfowl nests. A relationship between predator activity and upland vegetative conditions exists (Higgins 1977). Predation has an effect on nesting success, but the reason for this impact might be due to changing landscapes (Cowardin et al. 1985). In the prairie pothole region, where an estimated 63% of the North American duck population nests, 50% or more of the land is tilled annually (Higgins 1977). Farming has changed the number and location of potholes in some parts of the prairie, as thousands of potholes have been drained in the prairie pothole region (Smith et al. 1964, Melinchuk 1988). This wetland loss is assumed to have a negative effect on breeding population levels (Cowardin et al. 1985, Cowardin et al. 1988).

Poor nesting cover resulting from intensive land use practices, and nesting failure caused by farm machinery and predators, are the principal factors limiting nesting and production on these areas (Higgins 1977). Deterioration of upland cover has occurred in the prairie pothole area (Stoudt 1971, Krapu et al. 1979, Duebbert and Lokemoen 1980). More than 99% of the pre-settlement tall-grass prairie in Minnesota has been converted to agriculture and other uses (Johnson and Temple 1990). Farm efficiency caused the conversion of formerly uncultivated natural wetlands, grasslands, haylands and parkland into cropland (Higgins 1977). This conversion to monotypic small grain farming in this region has been stimulated by demands for more small grains from rising human populations and by greater farm economic pressures (Higgins 1977).

Rates of nest predation and brood parasitism on 5 bird species nesting in fragments of tall grass prairie in Minnesota were affected by both the size of the prairie fragment containing the nest and the distance from the nest to the wooded edge (Johnson and Temple 1990). Edges seemed to function as "ecological traps" by concentrating nests and thereby increasing density-dependent mortality (Gates and Gysel 1978). Clark and Nudds (1991) speculate that foraging efficiency of predators is reduced with increased patch size of nesting habitats because increased spatial heterogeneity or complexity enables birds to select better concealed sites.

1.3 NAWMP PROGRAM

In response to low waterfowl populations, public and private agencies in Canada and the United States began to design what was to become the most comprehensive land use and wildlife habitat program in the world - the North American Waterfowl Management Plan (North American Waterfowl Management Plan 1990, Clark and Nudds 1991). The goal of the plan is to employ management techniques to increase waterfowl numbers to a breeding population of 62 million ducks resulting in a fall flight of 100 million birds (Nelson et al. 1991). A combination of intensive and extensive programs have been proposed or implemented to achieve this objective (Clark and Nudds 1991).

The behaviour of mallards relating to nest site selection offers managers some unique management opportunities. Mallards are adept at locating the most secure nesting sites available (Drewien and Fredrickson 1970). Mallards are highly adaptable when it comes to selection of nest sites and have been known to take advantage of nest site locations that differ from those traditionally thought of as mallard nesting habitat (Bishop and Barratt 1970, Krapu et al. 1979, Cowardin et al. 1985).

The relatively high demand for ducks by hunters and the continuing reduction in suitable habitat has encouraged biologists to search for new methods of increasing breeding success (Bishop and Barratt 1970). The use of artificial nesting structures as a method to increase recruitment by increasing nesting success is one that has received considerable attention in the waterfowl management community. Success of nests in structures is much higher than for ground nests (Bishop and Barratt 1970).

I evaluated 2 different structures, to determine which was the most accepted in terms of occupancy and cost-effective in terms of maintenance. Determining the habitat characteristics of occupied structures was also addressed.

Co-operative funding by Delta Waterfowl Foundation, the United States Fish and Wildlife Service and their sponsors, and Ducks Unlimited have provided the opportunity to expand the information base pertaining to this management tool.

The next two chapters of the practicum have been written in a format that would allow ease of manuscript submission for journal publication. Each of the next two chapters begins with an introduction, followed by a methods section. Results are presented for each and are elaborated upon in the discussion section. A management implications section is also included. A final chapter provides the summary, conclusions, and recommendations for the entire project.

2.0 OCCUPANCY AND NESTING SUCCESS OF FLAX-ROLLED AND FIBREGLASS NESTING STRUCTURES

2.1 INTRODUCTION

Elevated nesting structures for waterfowl were used in St. James Park in London as early as 1665 (Doty et al. 1975). Pitcher-shaped wicker baskets and woven-reed wigwams were used in The Netherlands and Denmark, and were designs that sparked the first experiments in the United States and Canada (Burger and Webster 1964). Nesting tunnels were first designed and tested by Francis Uhler in 1956, at the Patuxent Wildlife Research Centre, Laurel, Maryland (Doty 1979, Jones unpublished 1993).

Initial studies attempted to determine the types of structures that were accepted by waterfowl. Work at Remington Farms in Maryland occurred in the early 1960's and found that a variety of nesting structures were selected by mallards (Burger and Webster 1964). Lee et al. (1968) performed some of the first evaluations of nesting structures in the Prairie Pothole region, and found that structures on prairie marshes showed high mallard occupancy and nesting success. This study revealed that basket-type nesting structures were preferred over a type of mailbox structure, and that baskets produced nesting success rates of 89%. The mailbox design consisting of a wood base with sheet aluminium arched over the top resembling a country mailbox, did not receive any occupancy and was only tested for one year (Lee et al. 1968). Others in north-central Iowa found nest success to be 87% for artificial nesting baskets over a six-year period, substantially higher than success rates found for ground-nesting ducks (Bishop and Barratt 1970) and much higher than the 15% thought necessary to maintain populations at current levels (Cowardin et al. 1985).

The value of nesting structures as management tools is limited if the structures experience long-term low occupancy rates. Initial studies of pole type structures were not promising, as only 14% were occupied (Doty 1979). Nest basket occupancy rates in North Dakota ranged from 44 to 69%, and tended to increase in subsequent years (Lee et al. 1968). Doty et al. (1975) found that 38% of nest baskets in the Prairie Pothole Region of North Dakota were occupied. Nesting structures in the states of Iowa and North Dakota had mallard occupancy rates of 53% and nesting success rates as high as 91% (Lee 1982). Mallards were the predominant species (98%) using structures, with incidental use by blue-winged teal (Anas discors), gadwall (A. strepera), pintails (A. acuta), and redheads (Aythya americana) (Doty et al. 1975).

Doty et al. (1975) and Doty (1979) found that avian predation increased annually in open topped baskets, but mammalian predation remained low. Mammalian predation of nesting baskets was believed to be limited to the raccoon (Procyon lotor) (Doty et al. 1975). Doty et al. (1975) concluded that duck nest success in structures was still substantially increased over ground nests.

Nest baskets were modified and re-evaluated to reduce predation. Nesting baskets fitted with covers to provide protection for nesting hens from avian predation had higher occupancy, but predation rates did not differ significantly due to small sample sizes (Doty 1979). Other structures have since been developed including baskets, both with and without covers, bales, cones, various cylinders, boxes, culverts, and a variety of floating rafts with combinations of cylinders and baskets (Lewis pers. comm. 1994).

A culvert structure used extensively in North Dakota has proven successful in terms of waterfowl production (Johnson pers. comm. 1994). The culvert structure is mounted in the wetland bottom usually when the wetland is dry. The structures are mounted in an upright fashion and filled with soil. Refilling culverts is usually necessary in the second year due to soil settling. Natural vegetation, or in some cases seeded vegetation, grows in the top of these culverts, providing cover for nesting waterfowl. The combined occupancy rates for mallards using culverts in North Dakota, South Dakota, and Montana in 1993 was 57% with a nesting success rate of 79% (Johnson pers. comm. 1994). Culvert occupancy ranged from 13 to 89% and nesting success rates ranged from 75 to 100% over the three states (Johnson pers. comm. 1994).

The flax-roll nesting structure consists of a tubular cylinder constructed from flax straw and wire framing (Figure 1). The rolls are 0.9 m long with an inside diameter of 0.3 m, and are mounted on a 1.5 m board that is 0.15 m wide and 2.5 cm thick, leaving a 0.3 m landing platform at each end of the cylinder. The wire framing used was 16 gauge, 2.5 cm by 5 cm stucco wire. Natural vegetation (Scolochloa sp., Carex sp.) is secured to the landing platforms and also used to line the bottom of the cylinder.

Flax-roll nesting structures have met with considerable success in southwestern Manitoba. This type of structure offers protection from avian as well as mammalian predators because the nest bowl and hen are concealed within the cylinder (Doty 1979).

Occupancy rates of the flax-roll structures was 83% in the Minnedosa and Shoal Lake regions of Manitoba, which is substantially greater than the 29% occupancy observed for baskets at the same time (Jones pers. comm. 1994) . Nesting success rates in flax-roll cylinders was 87%, with most nest losses due to abandonment rather than depredation (Jones pers. comm. 1994). An occupancy rate of 64% was observed in Manitoba in 1993 (Jones unpublished 1993). For areas with low mallard densities, occupancy rates were considerably lower (Jones pers. comm. 1994).

In central Saskatchewan, occupancy of flax-roll structures was 72%, with 92% nesting success (Eskowich et al. 1994). In west-central Minnesota, occupancy rates were 6 and 25% in 1993 and 1994, and nesting success was 67 and 100%, respectively (Lewis 1995). Occupancy of flax-roll cylinders increased from 50 to 92% in South Dakota from 1993 to 1995 and nesting success ranged from 84 to 100% (Vaa 1995).

Figure 1. 

Flax-roll nesting structure placed at wetland edge.

Culverts and flax rolls have successfully increased mallard production, but differ in construction, placement cost, and maintenance costs. Flax-rolled nesting structures cost $25 to $40 to build and install, but annual maintenance costs are high due to the life of the flax-roll. Maintenance includes annual cleaning and refilling of the structure with nesting material, straightening of support structures, and triennial replacement of the flax-roll (Doty 1979). The life of the flax-roll is approximately three years, but depends on the way the straw is combined and baled. Straw that is chopped and square baled results in short, physically damaged flax stalks. Conventional combining and round baling results in longer stalks that intertwine and tangle together within the roll and better withstand damage by weather and the hen (Bullion pers. comm. 1994). Maintenance requires considerable labour and limits the effectiveness of these structures in some areas.

For comparison, costs of initial placement of culvert structures average approximately $120 (Johnson pers. comm. 1994). Culverts occasionally need refilling and straightening but are otherwise virtually maintenance free. Culverts are limited to fairly shallow wetland basins as installation requires large equipment, and thus are impractical for individuals or sportsman's clubs.

Development of a high-success, low-initial-cost, low-maintenance structure would benefit waterfowl management efforts. A fibreglass cylinder model may fill this particular niche (Figure 2). The structure was constructed using a fibreglass weave that produced a cylinder with the dimensions of a flax-roll. The landing platforms and inside of the tunnel was lined with natural vegetation.

Figure 2. 

Fibreglass nesting structure placed at wetland edge.

In this study I compared fibreglass structures with flax to determine whether occupancy and nesting success of the low-maintenance structures make it a superior management technique.

Using the flax-roll as the standard (control) I specifically tested the following hypotheses:

1. nest occupancy rates of fibreglass and flax-roll structures did not differ

2. nesting success rates of fibreglass and flax-roll structures did not differ

3. preference rates of fibreglass and flax-roll structures did not differ

2.2 METHODS

2.2.1 Study area

The study was conducted from mid-April to mid-July 1994 to 1995 on two different study locations (Figure 3). I worked in west-central Minnesota on the Morris Wetland Management District, in Pope, Swift and Stevens counties. The Minnesota area topography ranges from granite outcrops of the Minnesota River bottoms to the rolling hills of Pope County, and is characterised by rolling agricultural land with remnant stands of hardwoods. Nearly 100% of native grasslands have been converted to cropland, and 60% of the wetlands have been drained. Semi-permanent and permanent wetlands are abundant [(3.5 wet ponds per square km) (Wetland Management District Report 1993)] throughout the farmland that is used mainly for corn, soybean, and wheat production. A more in-depth description of this area is provided in the Wetland Management District Report (1993).

The Manitoba location is near Minnedosa in the Prairie Parkland Region of southwestern Manitoba, in the municipalities of Odanah and Saskatchewan, and is characterised by slightly rolling agricultural lands, with an abundance of potholes and stands of hardwoods comprised of poplar (Populus sp.) and oak (Quercus macrocarpa) (Stoudt 1982). The land is intensively cultivated, with wheat, barley, flax, and canola, being the main crops produced. A more detailed description of the Minnedosa study area is presented in Kiel et al. (1972).

The Manitoba study area was chosen because prior work in this area has shown that flax-rolled structures have a high acceptance rate. Nest structures have been in southwestern Manitoba since 1992 (Jones pers. comm. 1994) and mallards have responded favourably to structures there. Existing structures are patchily distributed. The study site within the area offers the opportunity to test these structures in an area where structures were absent or scarce. These low densities will minimize the probability that birds using these structures had any prior experience nesting in structures. The study area in Minnesota was chosen because of the similarity of geographical features and accessibility of ponds, but flax-roll structures have not been evaluated in this area.

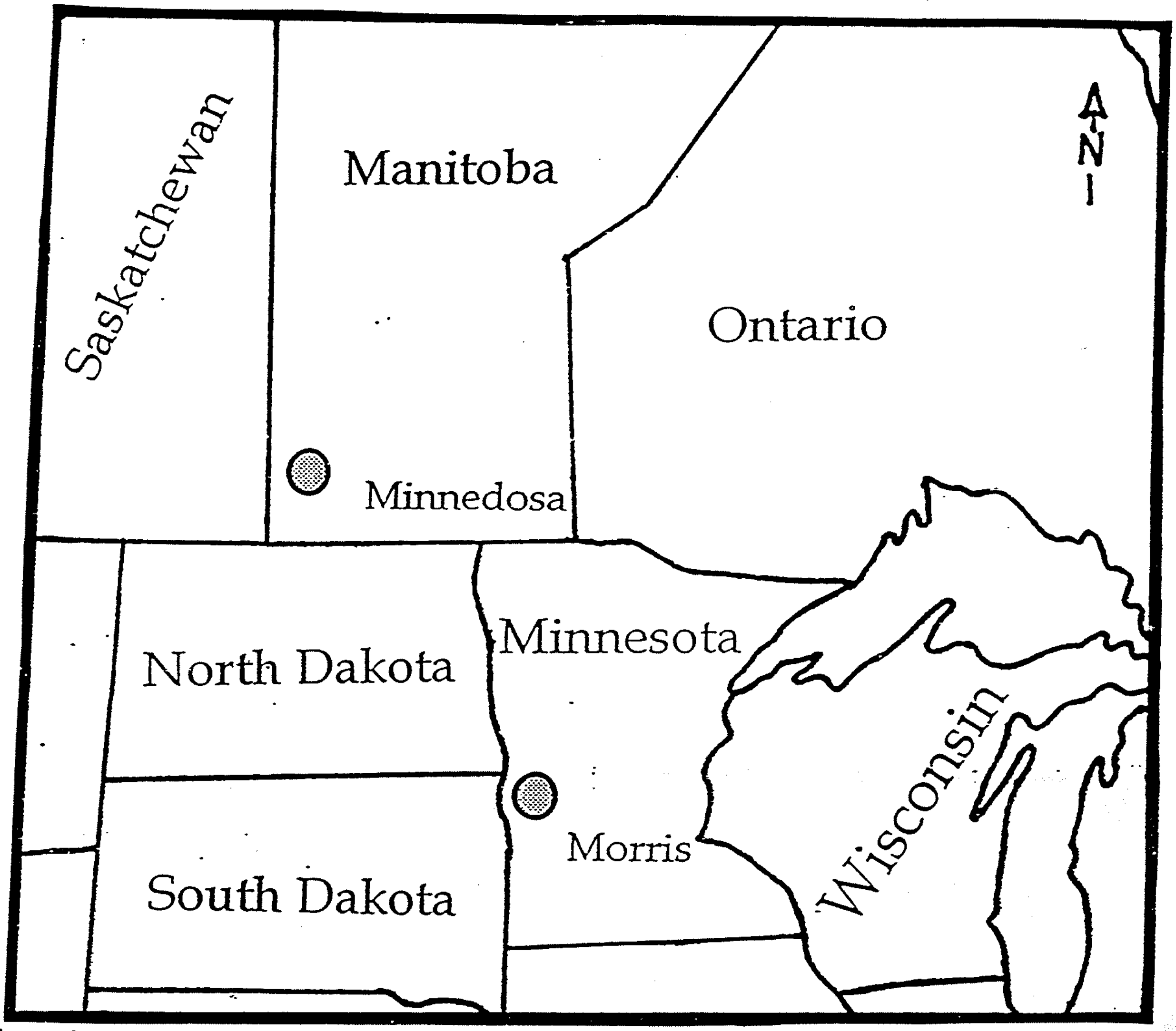

Figure 3.

Locations of study sites. The Morris Wetland Management District in west-central Minnesota and the Delta Waterfowl and Wetlands Research Minnedosa Sub-station in southwestern Manitoba.

2.2.2 Experimental design

2.2.2.1 Structure Placement

Structures were placed during February and March 1994 while ponds were frozen. Holes were drilled through the ice and (2.4 m) base poles were driven into the marsh bottom. Nesting cylinders mounted on insert pipes were then placed into the base poles and adjusted to the desired height (0.9 m) above ice level.

Structures were placed in a paired fashion with each pond receiving a fibreglass structure and a flax-roll structure. If structures were within visual contact of one another or within 90 m of each other on a single pond, an adjacent pond was used to complete the pairing, resulting in each adjacent pond receiving one structure. Selection of structure type at each site in the pairing was randomly determined by a coin toss.

Ponds in the Manitoba area were chosen at random from aerial photographs and had no existing nesting cylinders present. Ponds in the Minnesota area were chosen from aerial photographs of Waterfowl Production Areas that had no existing cylinder-style structures present; and if other nesting structures with previous nesting history were present they were removed. Ponds were semi-permanent or permanent based on classification outlined by the U.S. Fish and Wildlife Service and Canadian Wildlife Service (1977). Structures in these types of ponds receive higher usage than those in temporary or ephemeral ponds (Jones pers. comm. 1994).

The structures were positioned in openings on the edge of the emergent vegetation (e.g. cattails (Typha latifolia)), approximately 1 m above water (Doty et al. 1975), so that one end opened toward the nearest open water.

2.2.2.2 Structure inspections

Nest structure inspections occurred 3-4 times during the nesting season. The first scheduled inspection commenced after 20 April, upon observation of a lone-drake to paired-drake ratio of 1 to 1 based on roadside surveys (Sowls 1955). Nest inspections were spaced approximately 3 weeks apart. Nest checks included close examination of each nesting structure. There was little chance of nests being initiated and lost, so I calculated actual nesting success (Miller and Johnson 1978). When the nesting season proceeded past the last scheduled inspection, a fourth inspection was added.

I approached each structure and examined it for occupancy, flushing the hen if she was present. Structures were examined closely for the presence of a nest, including shell fragments, indications of a nest bowl, down or breast feathers, or any other indication of a nest that had been initiated but failed. Upon discovery of a nest I recorded species, number of eggs, clutch development, date, structure number, and other relevant observations. Clutch development was determined using field-candling (Weller 1956, Klett et al. 1986). I covered the clutch with down and breast feathers to minimize the egg exposure. Subsequent observations were used to determine nest fate based on nest bowl remains and evidence of predator activity such as scat.

2.2.3 Statistical analysis

Nest occupancy was defined as any evidence of a nest initiation by mallards (i.e. at least one egg was laid). Nesting success was the proportion of nests in structures that hatched. Preference was the proportion of each structure type in the pair that was occupied first. Repeat occupancy was the percentage of the structures occupied the first year that were occupied again in the second year. Contingency tables were used to test for independence between structure type and year for occupied structures (Zar 1984). The same test was performed for nests that were successful. Year effect in occupancy and success, preference rates, and repeat occupancy were analyzed by Z-tests. An alpha value of 0.05 was used for all tests.

2.3 RESULTS

Occupancy rates of flax-roll structures were significantly higher than fibreglass structures in both Minnesota ($p<0.005$) and Manitoba ($p<0.001$) (Table 1). A higher nesting success rate was detected in fibreglass structures over flax-rolls in Minnesota ($p<0.050$) but not in Manitoba ($p>0.750$) over the two years. Flax-roll structures were strongly preferred over fibreglass in Minnesota ($p=0.005$) and Manitoba ($p<0.005$). No significant difference was observed between repeat occupancy rates of flax-roll and fibreglass structures in either Minnesota ($p=0.897$) or Manitoba ($p=0.221$).

Occupancy rates of fibreglass and flax-roll structures in Minnesota (p=0.115) did not increase as a result of year effect from 1994 to 1995. Occupancy rates of fibreglass and flax-roll structures increased significantly from 1994 to 1995 in Manitoba (p<0.005). No significant difference in nesting success as a result of year effect was observed between structure types in Minnesota (p=0.599) and Manitoba (p=0.658).

Table 1. Mallard occupancy, actual nesting success of occupied nests, preference rates, and repeat occupancy for flax-roll and fibreglass nesting structures in Minnesota and Manitoba, 1994-95.

		Occupancy %		Success %		Preference %		Repeat Occupancy %
		1994	1995	1994	1995	1994	1995	1995
Minnesota	Flax-Roll	33	40	69	83	78	65	69
		n=48	n=45	n=16	n=18	n=18	n=23	n=16
	Fibreglass	14	29	100	85	22	35	71
		n=48	n=45	n=7	n=13	n=18	n=23	n=7
Manitoba	Flax-Roll	26	80	88	90	71	81	80
		n=97	n=90	n=25	n=72	n=31	n=78	n=25
	Fibreglass	10	39	100	86	29	19	60
		n=97	n=90	n=10	n=35	n=31	n=78	n=10

Abandonment and predation by mink was observed in 19 and 13% of the nests in flax-roll structures in Minnesota, respectively. In flax-roll structures, abandonment was observed in 4% of the nests in Manitoba and was mainly due to observer interference. Predation affected 8% of the nests in flax-rolls but the cause of predation was undetermined. No abandonment or predation occurred in fibreglass structures in either study area in 1994.

In Minnesota, predation was observed in 5.6 and 7.7% of the nests in the second year in flax-roll and fibreglass structures, respectively. Mink were the cause of predation in the flax-roll structures, but the cause of predation in fibreglass structures could not be determined. Abandonment occurred in 11.1 and 7.7% of the flax-roll and fibreglass structures respectively.

In Manitoba, predation was observed in 2.8% of the nests in flax-rolled and 5.7% in fibreglass structures. Avian predation accounted for half of the predation of nests in flax-rolls and mink accounted for half of the predation in fibreglass structures. Abandonment was observed in 6.9 and 8.6% for flax-roll and fibreglass structures, respectively.

The mean number of non-hatched eggs per nest in 1994 was 0.56 and 0.14 in Minnesota and 0.32 and 0.2 in Manitoba for flax-roll and fibreglass structures, respectively. The mean number of non-viable eggs in 1995 was 0.83 and 1.07 in Minnesota and 0.65 and 0.37 in flax-roll and fibreglass, respectively.

Incidental occupancy by wood ducks (Aix sponsa) (3), redheads (2), blackbirds (Agelaius sp.) (9), kingbirds (Tyrannus tyrannus) (2), grackles (Quiscalus sp.) (1) and swallows

(Tachycineta bicolor) (1) was observed. (Numbers in brackets represent total number of nests recorded in both years.)

Double occupancy, 2 nests in the same structure in the same year, was not observed in any structure in 1994, but occurred in 7 structures in 1995. All structures were initially occupied by mallards, with the second occupant being mallards (4 cases), redheads (2 cases) and a wood duck.

Seven nests had unusually large clutches. Clutch sizes ranged from 16 to 21 with evidence of nest parasitism in two cases. One of the seven had parasitic wood duck eggs, and a second nest was shared by two hens who were both flushed from the same nesting structure at the same time.

2.4 DISCUSSION

Occupancy was higher in Minnesota and Manitoba in the flax roll structures. Occupancy increased for both types of structures in Minnesota and Manitoba in the second year. This increase in occupancy follows the same trend that Lee et al. (1968) observed for mallards using baskets. Occupancy of flax-roll structures was higher than the 14% observed by Doty (1979) and may simply be a regional effect. In 1994 the flax-rolls had less than 60% occupancy, which was experienced by structures in southwestern Manitoba (MHHC Report unpublished 1993), but in 1994 occupancy was well above 60%. Variation in use at different areas indicate that some unidentified factors such as habitat characteristics, hen experience, structure placement, or duck numbers influence the use of structures (Bishop and Barratt 1970).

As in other studies of elevated nesting studies, nest success rates were high, ranging from 80-90% (Doty 1979, MHHC Report unpublished 1993). Nest success was more variable in year 1. Nesting success rates observed are high enough to ensure that nesting success would not limit the value of nesting structures as a management tool for mallards.

Predators destroyed a small percentage of nests (0-12.5%). High initial water levels in Minnesota provided mink the opportunity to access structures before water levels receded. Heavy localized losses (100%) were observed in areas where mink were identified as the predator. Newly erected structures are initially ignored by predators, but once predators became aware of the contents of these structures they continued to search out nesting structures (Burger and Webster 1964). One case of avian depredation was observed, but the species responsible was not identified. Avian depredation does not appear to limit the usefulness of either flax-roll or fibreglass nesting structures.

Abandonment rates ranged from 0 to 19%, with most abandonment caused by observer interference, consistent with Doty et al. (1975) who observed nest failure rates due to human interference ranging from 2 to 19%. Natural abandonment was minimal.

Double occupancy was low in this study, but occupancy of double cylinder type structures in west-central Minnesota in 1994 was 44% (Kirwin and Lewis 1994). Doty and Lee (1974) suggest that high occupancy and repeat use may be attributed to homing to areas with high successful nesting. Imprinting of young females to structures may explain the high occupancy (Bishop and Barratt 1970). Double occupancy occurred only in the second year, which may suggest that imprinted hens are homing back to structures. This study had no way to determine if the same hen returned the second year, however hens that nested successfully in the first season homed at a significantly higher rate than unsuccessful hens, which implies that returning related to the effect of breeding dominates over the influence of natal sites (Doty and Lee 1979, Majewski and Beszterda 1990), and may be one of the reasons for high repeat occupancy.

Unusually large number of eggs present in several nests suggests nest parasitism occurred at a low frequency. Hen mallards offered multiple nesting structures, interfered with activities of other hen mallards and abandonment greatly reduced nesting success (Burger and Webster 1964). Nest success was not reduced in any of the cases where dump nesting occurred; however, the proportion of non-viable eggs was above the proportion experienced for other nests that did not show evidence of dump nesting.

Egg viability has been a concern of managers that employ nesting structures. The traditional ground nest of mallards would have certain microclimatic properties such as temperature and humidity that would be a function of the substrate the nest was built upon. These microclimatic properties are thought to be different in nesting structures because the bowl is constructed in a different substrate (i.e. flax straw and wire mesh). These values presented indicate that the number of non-hatched eggs remaining in nesting structures is comparable to what is found in natural nests, and is not an area of concern. It must be noted that these values would be biased high, in comparison to natural nests because these data include nests that may have been parasitized, resulting in a large number of non-hatched eggs.

2.5 MANAGEMENT IMPLICATIONS

The development of a high occupancy, high nesting success, low-cost nesting structure would help increase recruitment in a localized area. Fibreglass nesting structures require less maintenance than the flax-roll nesting structure, however they are much less preferred. To maximize management resources, it may be more beneficial to modify existing flax-roll nesting structures to lower the annual maintenance costs than to employ fibreglass nesting structures. The use of finer mesh wire in roll construction (2.5 cm by 2.5 cm) might prevent loss of roll material caused by hen activity and wind. Modification of roll construction to include a barrier sandwiched between flax layers, might also prevent hens from removing material from the roll. Use of long-strand flax fibre in roll construction, might increase the life of the roll. Such modifications of flax-roll nesting structures would add minor costs while taking advantage of the high use rate of flax-roll structures.

3.0 HABITAT EVALUATION OF OCCUPIED AND UNOCCUPIED NESTING STRUCTURE SITES

3.1 INTRODUCTION

If resources are being spent on nesting structures, locations for placement that increase the probability of occupancy without decreasing the use of other nesting sites should be identified. Identification of these structure sites that increase occupancy would allow for more efficient allocation of management resources. The high nesting success that can be attained in nesting structures make them a valuable management tool, however occupancy may limit their effectiveness in increasing recruitment.

Much is known about the specific habitat characteristics of ground nest sites. These specifics include vegetative species composition, distance to water, and cover value just to mention a few. Little is known about the factors that influence structure occupancy. Determining the surrounding habitat factors, and the method of habitat classification that influence the occupancy rates of artificial nesting structures was the objective of the study.

The cost of nesting structures as a waterfowl management tool depends on the cost of construction or purchase, placement, and maintenance. Structure construction material, and placement costs may range from low cost nesting cylinders to high cost cement culverts. Maintenance costs on the other hand are inversely related to construction and placement cost. Cement culverts have low maintenance costs but cylinders require regular, costly maintenance. The combination of the three types of costs produces the annual cost of structures as a management tool. Use of structures for waterfowl management should be predetermined by acceptable cost efficiency.

Other management treatments on the landscape, such as dense nesting cover (DNC), idle pasture, and delayed haying all have costs associated with them as well as value to waterfowl production. Identification of factors that attract breeding hens would allow managers to reproduce these valuable habitats. Nesting habitat studies have been focused on nest site characteristics such as cover density, understory cover, and species richness (Crabtree et al. 1989) and have identified the structural characteristics of nest sites. It however is not enough just to produce nesting habitats with these structural characteristics without some understanding of how habitats relate to each other. Landscape features, vegetation, and presence of other animals are important factors determining habitat selection by waterfowl (Bengston 1970, James 1971). For waterfowl much remains to be learned concerning (1) proximate stimuli that cause a female to nest in a certain site and (2) how characteristics of selected habitats influence survival of nests (Hines and Mitchell 1983).

Cowardin et al. (1985) found that the most used mallard nesting habitat was grassland dominated by western snowberry (Symphorocarpus sp.), followed by wetland, odd area, right of way, hayland, and cropland. Haylands dominated by alfalfa were used later in the nesting season after the alfalfa reached about half of the mature height (Cowardin et al. 1985). This shift by mallards to alfalfa suggests that cover quality may be important in nest site selection. Lokemoen et al. (1990) found that cover types with high visual obstruction readings were preferred by mallards. When use of a habitat is greater than the availability of that habitat a preference for that habitat is exhibited (Johnson 1980) Cowardin et al. (1985) found that mallards preferred odd areas, with right-of-way, wetlands, hayland, grassland, and cropland making up the preferential ranking order. Nesting success was found to be highest in haylands, followed by grassland, odd area, and wetland (Cowardin et al. 1985). Klett et al. 1988 found similar results with a preference being exhibited for planted cover with odd areas, hayland and wetland being the nest most preferred. This preference for odd are was believed to be a result of lack of alternate habitats on the landscape (Cowardin et al. 1985, Greenwoood et al. 1995). The relationship between cover quality, habitat availability, and potential for nesting success are factors that must be considered when assessing nesting site selection

3.2 METHODS

3.2.1 Study area

The study location was near the Delta Waterfowl and Wetlands Research Substation (Minnedosa, Manitoba) in the Prairie Pothole Region of southwestern Manitoba, specifically in the municipalities of Odanah and Saskatchewan. This area is characterised by the slightly rolling agricultural lands, with an abundance of potholes and stands of hardwoods comprised of poplar and oak (Stoudt 1982). The land is intensively cultivated, with wheat, barley, flax and canola being the main crops.

The study area was chosen because prior work there has shown that flax-rolled structures have a high acceptance rate (Jones pers. comm. 1994). The existing structure distribution consisted of concentrations of structures in a patchy distribution. The study site within the area offers the opportunity to evaluate these structures where structures are absent or in insignificant densities.

3.2.2 Experimental design

Pairs consisting of one flax-rolled and one fibreglass nesting structure were placed in wetlands in the study area. The structures used in this study were also used in a comparison study between the two types to determine differences in occupancy, nesting success, and preference. The structures were installed in the wetlands in February and March 1994 in order to take advantage of the ease of access afforded by ice that was still present on the wetlands. Structures were placed at the water/vegetation interface. Each wetland had two structures, one fibreglass cylinder and one flax-roll, that were oriented with one end open toward the vegetation.

3.2.3 Nesting cover evaluation

Infrared spectral reflectance imagery was obtained in 1994 that categorized the habitat on the study area into 272 habitat classes. The resolution of the imagery was 30m by 30m block pixel size. The quadrant is represented by the dominant habitat type in the block. The imagery was reclassified into fine (appendix 1) and coarse (appendix 2) classification representing the major habitat categories on the landscape. These habitat categories could be easily recognized and evaluated by waterfowl managers to identify optimal structure placement sites.

With the aid of aerial photographs, structure locations were transposed onto each of the reclassified image with the aid of IDRISI™ geographical information system package. Each structure was centred in a 2 km diameter plot and the total area of each of the habitat categories on both the fine and coarse images were calculated. The size of the plot (314 ha) was selected in order to maximize the probability of including the territory and a large proportion of the home range. The mean home range of upland nesting mallard pairs was approximately 460 ha, but during the laying period it shrunk to less than one quarter of the size (Dwyer et al. 1979). One limitation of this method was that there was no way to determine the proportion of habitat within the plot that was within the actual territory and home range of the hen.

Structure numbers were randomly selected and categorized as occupied or unoccupied. All structures within 2 km from the selected structures were removed from the sample, and a subsequent selection was made. This process continued until all structures were either categorized or removed. This process eliminated the chance that areas of overlap, caused by closely located structures, supported both occupied and unoccupied arguments. This process produced 35 occupied structure plots and 71 unoccupied structure plots for the comparison of habitat characteristics of occupied and unoccupied structures.

3.2.4 Statistical analysis

The plots of occupied and unoccupied structures were compared by means discriminant function analysis. Analysis was the same for both fine and coarse classifications. This method detects differences between the communities which could be used as guidelines for structure placement. The analysis of the structure placement data allows an opportunity to detect individual habitat characteristics on the landscape that would increase the occupancy of structures. Detection of these individual characteristics would be easier than detection of communities comprised of habitat category combinations. A significance level of 0.05 was used in all tests.

3.3 RESULTS

No difference in mean amounts of each habitat type located within 1 km of nesting structures were detected in the fine scale classification analysis (Table 2). In the coarse scale classification, the mean amount of trees was significantly higher (p=0.02) in plots that were unoccupied, as compared to plots that were occupied (Table 3). No other coarse scale habitat classification was significantly different at the 0.05 level.

Table 2. Mean amount of each habitat classification located within 1 km of occupied and unoccupied nesting structures, fine classification, Manitoba, 1994

No.	Habitat classification	Occupied ha	Unoccupied ha
1	Open Fresh Water	1.2	1.2
2	Deep Marsh	11.2	11.7
3	Shallow Marsh	10.5	9.2
4	Wet Meadow	13.6	13.5
5	Fallow	36.8	49.3
6	Cultivated Stubble (low residue farmland)	116.1	96.3
7	Grass/Legume/Hayed Area (medium residue farmland)	17.7	13.0
8	Pasture/Grassland/Ditches/Dense Nesting Cover (high residue farmland)	83.3	91.9
9	Tame Hayland	17.8	19.8
10	Low Shrub	0.9	1.3
11	Deciduous Trees	5.0	7.9
12	Coniferous Trees	0.2	0.3

Table 3. Mean amount of each habitat classification located within 1 km of occupied and unoccupied nesting structures, coarse classification, Manitoba, 1994.

No.	Habitat classification	Occupied ha	Unoccupied ha
1	Water	36.4	35.6
2	Low Residue Cropland	152.9	145.5
3	Medium Residue Cropland	35.5	32.8
4	High Residue Cropland	83.3	91.9
5	Trees and Shrubs	6.1	9.6

3.4 DISCUSSION

Intensive management programs may increase substantially the local population of mallards because of the homing of successful hens and their progeny (Cowardin et al. 1988). With this in mind, it was hypothesised that nesting structures may increase local populations. To increase the local population with the least economic expenditure, structure placement locations that increase the probability of occupancy should be sought.

Placement of nesting structures has been tested to determine the best location that would increase occupancy within wetlands. Placement of structures in uplands, in wetlands of different types, and at different locations within wetlands, have produced information on structure location in wetlands that would increase the occupancy of the structure (Bishop and Barratt 1970). These studies attempted to assess preference of structure location for mallards. Knowing where to place structures in relation to wetland is only the first step. Determining the location on the landscape is the next step.

My study results indicated that there is no difference in the habitat within 1 km of structures that were occupied and those that were unoccupied, based on fine scale classification. My study results indicated however that structures that were unoccupied had a significantly greater number of treed ha within 1 km of the structure when a coarse scale classification was used. No other coarse classification category revealed a significant difference between occupied and unoccupied areas. The difference in treed area may be important, however caution should be taken before conclusions are drawn.

The amount of treed area within plots comprised less than 5% of the area. A significant difference in less than 5% of the area and no difference in the remaining 95+% indicate that the two communities tested are very similar and would probably not be detectable in a crude assessment, such as roadside observation, or inspection of aerial photographs.

The amount of treed area may play a role in the occupancy of structures, however the hypothesis is weak. Cowardin et al. (1985) suggests that occupancy in odd areas and shrubs associated with grasslands is due to the cover quality that these habitats offer to early nesting mallards. Areas with lower amounts of treed area that includes shrubs, received higher occupancy than areas with more treed area. The lack of quality nesting sites in an area may have an affect on the number of hens that nest in nesting structures.

The amount of treed area may be important however the means by which habitats are classified may have a more important role in the results of the study. The fine classification was one that separated the landscape based on structural and functional characteristics, such as cover quality, and water depth. The coarse classification amalgamated all functionally similar habitats, regardless of quality. The differences that are evident, or not evident between plots of occupied and unoccupied structures may be a result of actual differences in habitat, or may be a result of the way the date was categorized. This is no way suggests that the results of the study are invalid, but highlights the importance of proper classification.

Another point must be made that addresses the issue of scale. Habitat was assessed to a distance of 1 km. This value was used to increase the probability that the area evaluated would include the area that the hen assessed before she made a decision to nest. I may in fact be analyzing habitat that may not have been used in the decision making process if the hen only assessed the area within 500 m for example. This concept of scale is very important because it may or may not be a source of variability in the data.

Finally the factors that influence nest selection must be considered. The study evaluated the effects of fine and coarse habitat classifications on occupancy of nesting structures. It is unlikely that these two factors are the only ones that influence structure site selection by mallards.

Other factors such as number of wetlands, water temperature, proximity to alternate nest sites, alternate nest site quality or hen experience may have played a role in structure occupancy, and were not considered in this study. The role of habitat invariably plays a role in the nest site selection of mallards, however the influence of nest structures, and other behavioural and habitat factors has on this selection is still not understood.

3.5 MANAGEMENT IMPLICATIONS

The value of nesting structures as a management tool is a function of the occupancy and nesting success rates. Examination of the habitat within the immediate vicinity of a nesting structure may help to determine the best location for placing nesting structures. This study does not try to solve the nest site selection puzzle that exists, it is intended to provide managers with guidelines for the placement of structures, based on quantitative data. These guidelines are also intended to be macro level guidelines that will allow the manager to select areas that would receive high occupancy.

Based on the results of this study structure placement locations in areas lacking treed cover is suggested. This recommendation is given with some reservation, because of the lack of support by both the fine and coarse analysis. Areas lacking treed cover should be given extra consideration when placing nesting structures, but other suitable sites based on Jones' (1993) recommendations should not be overlooked. Placing structures in areas that would increase the probability of occupancy would increase the effectiveness by which waterfowl management resources are utilized.

4.0 SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

4.1 SUMMARY

Nesting structures are a successful management tool that can increase nesting success and recruitment (Cowardin et al. 1988). Flax-roll nesting structures work very well producing occupancy rates that range from 26 to 80%, and show a tendency to increase in occupancy in subsequent years (Jones pers. comm. 1994). The nesting success rates that can be expected in these structures range from 80 to 90%. A problem associated with these nesting structures is the high cost of maintenance. Low-maintenance fibreglass nesting structures experienced occupancy rates that ranged from 10 to 39%, which was significantly lower than that of flax-roll structures. Nesting success for fibreglass structures ranged from 80 to 90%, with most nest loss due to abandonment. A significant preference for flax-rolled structures was observed.

A significantly lower amount of treed area is present within 1 km of unoccupied structures than occupied structures based on coarse habitat classification. No difference in amount of each habitat type within 1 km of occupied and unoccupied structures based on fine habitat classification was detected.

4.2 CONCLUSIONS

In order to possibly increase the value of nesting structures as a management tool, modifications to the flax-roll or the design of another low-maintenance structure should be implemented. The maintenance drawback associated with flax-roll structures may be addressed through structure modification. Suggested modifications that may decrease maintenance include changing the type of processing that is associated with the flax straw, installing an activity barrier into the roll that would prevent the hen from pulling out straw, and using a finer wire mesh in roll construction . Nesting structures such as baskets experienced initial success in both occupancy rates and nesting success. Subsequent re-evaluation of the baskets revealed that depredation became a factor in the usefulness of nesting structures as a management tool. Continuing evaluation of the effects of depredation and modifications that may minimize the effects of depredation must be carried out.

The social component of management may have an effect on the value of nesting structures as a management tool. Placement of structures in wetlands changes the aesthetics of the wetland and, depending on the perspective, the change may be perceived as detrimental. One advantage that pole-type structures have over culverts and floating islands is that they are on the edge of vegetation and become camouflaged when vegetation regenerates each spring. This does not remove the structure, however it removes the emphasis of their presence. Culverts and islands that are situated in the open water zones of the wetland are visible throughout the year, and depending on the materials used in their construction, are less aesthetic.

Structures also have value beyond that of a nesting site. Structures have little impact on the physical landscape, and are often accepted by landowners who might not welcome other management treatments. The placement of structures into wetlands can be used as a tool to secure these wetlands and prevent further degradation of these habitats.

No matter what the structure type, ice movement can affect the operation of structures. Structures initially placed in "perfect" locations were knocked over by ice in years when water levels increased. Ice damage is a concern for all structures, and in some years can make up a large portion of annual maintenance.

Structures also have a role to play in management as an educational tool. The ease of construction of most structures make them projects that can be attempted by local wildlife clubs and organisations (Lee et al. 1968). This option is seldom available with other types of structures that require speciality materials and/or equipment or other types of management. These benefits surpass just the biological and include the efficient use of an under-utilized resource (i.e. person power), education, and increased awareness of waterfowl management problems.

4.3 MANAGEMENT AND RESEARCH RECOMMENDATIONS

Biological purists that believe that mallards should nest in "natural" sites may be justified in their concerns. Mallards that are produced in nesting structures may be less "wild" and more dependent upon nesting structures for nesting sites than birds produced in natural nests. The effect of several successive generations using nesting structures is not understood. Nesting structures are unusual nesting sites, that are intended to be safer from predators compared to natural sites. It has been well documented that mallards are opportunistic nesters, and by taking advantage of this nesting behaviour, managers have been able to develop successful structures.

Nesting cylinders, for the most part are restricted to use by mallards. This fact is realized and management by other treatments must continue in order to address other species needs.

One area of continued research should focus on substitutes for flax in roll construction in order to reduce the maintenance that is required, and increase the value of structures. Alternate roll materials that would provide a natural appearance may be an improvement and also should be further researched.

Biologically, research into the impacts that structures have on the nesting biology of mallards is an area of concern. It remains to be determined whether marsh-nesting mallards are a distinct sub-group, or if individuals nest interchangeably at marsh and upland sites, and whether imprinting is involved in the habitat selection process (Krapu et al. 1979). Mallards selecting these unusual nesting sites, do so in low numbers. Structures provide nesting sites for considerable proportions of the breeding hens, and may be creating high localized concentrations of hens that may be dependent on structures. The nesting behaviour in response to structure damage or destruction is not well understood. Additional work on the effects of imprinting of young produced in structures, and subsequent nest site selection, is required. The effects of dump-nesting of mallards into structures and the effect that dump-nesting has on nesting success is an area of concern. Continued investigation into the factors that effect nesting structure occupancy and the geographic scale that is relevant in habitat assessment, should be conducted.

Waterfowl managers must not only direct their efforts toward saving and restoring habitats, but also must implement new methods for producing more waterfowl on each acre of the habitats that they manage (Lee 1982). Structures are one of the methods that can be used to enhance these habitats. The keys to structure success are the use of inexpensive, readily available material, simplicity of construction, and ease of maintenance (Burger and Webster 1964). Managers should not however put all their eggs into one basket and expect nesting structures to restore population of mallards alone. Even if artificial nesting structures do succeed in doubling or tripling nesting success on local areas, many thousands of the devices would be needed to materially affect the continental waterfowl population (Lee et al. 1968).

LITERATURE CITED

Anden, H., P. Angelstam, E. Lindstrom, and P. Widen. 1985. Differences in predation pressure in relation to habitat fragmentation: an experiment. Oikos 45(2):273-277.

Balser, D. S., H. H. Dill, and H. K. Nelson. 1968. Effect of predator reduction on waterfowl nesting success. J. Wildl. Manage. 32(4):669-682.

Bengston, S. A. 1970. Location of nest-sites of ducks in Lake Myvtan area, north-east Iceland. Oikos. 21:218-229.

Bishop, R. A., and R. Barratt. 1970. Use of artificial nest baskets by mallards. J. Wildl. Manage. 34(4):734-738.

Burger, G. V., and C. G. Webster. 1964. Instant nesting habitat. in: J. P. Linduska. ed. Waterfowl Tomorrow. U.S. Gov. Printing Office, Washington, D.C. 770pp.

Clark, R. G., and T. D. Nudds. 1991. Habitat patch size and duck nesting success: the crucial experiments have not been performed. Wildl. Soc. Bull. 19(4):534-539.

Cowardin, L. W., D. S. Gilmer, and C. W. Shaiffer. 1985. Mallard recruitment in the agricultural environment of North Dakota. Wildl. Monog. 92. 37pp.

_____, and D. H. Johnson. 1979. Mathematics and mallard management. J. Wildl. Manage. 43(1) 18-35.

_____, _____, T. L. Shaffer, and D. W. Sparling. 1988. Applications of a simulation model to make decisions in mallard management. USF&WS Tech. Rep. 17. Washington, D.C.

Crabtree, R. L., L. S. Broome, and M. L. Wolfe. 1989. Effects of habitat characteristics on gadwall nest predation and nest site selection. J. Wildl. Manage. 53(1):129-137.

Doty, H. A. 1979. Duck nest structure evaluations in prairie wetlands. J. Wildl. Manage. 43(4):976-979.

_____, and F. B. Lee. 1974. Homing to nest baskets by wild female mallards. J. Wildl. Manage. 38(4):714-719.

______, ______, and A. D. Kruse. 1975. Use of elevated nest baskets by ducks. Wildl. Soc. Bull. 3(2):68-73.

Drewien, R. C., and L. F. Fredrickson. 1970. High density mallard nesting on a South Dakota island. Wilson Bull. 82:95-96.

Duebbert, H. F., and H. A. Kantrud. 1974. Upland duck nesting related to land use and predator reduction. J. Wildl. Manage. 38(2):257-265.

______, and J. T. Lokemoen. 1980. High duck nesting success in a predator-reduced environment. J. Wildl. Manage. 44(2):428-437.

Dwyer, T. J., G. L. Krapu, and D. M. Janke. 1979. Use of pothole habitat by breeding mallards. J. Wildl. Manage. 43(2):526-531.

Eskowich, K., D. McKinnon, G. Brewster, and K. Belcher. 1994. unpublished. An evaluation of nesting structure preference and use by mallards in Saskatchewan parkland. Nesting Structure Workshop, Yorkton, Sask.

Gates, J. E., and L. W. Gysel. 1978. Avian nest dispersion and fledging success in field-forest ecotones. Ecology 59(5):871-883.

Greenwood, R. J. 1986. Influence of striped skunk removal on upland duck nest success in North Dakota. Wildl. Soc. Bull. 14(1):6-11.

______, A. B. Sargeant, D. H. Johnson, L. M. Cowardin, T. L. Shaffer. 1995. Factors associated with duck nest success in the prairie pothole region of Canada. Wildl. Monog. No. 128.

Higgins, K. F. 1977. Duck nesting in intensively farmed areas of North Dakota. J. Wildl. Manage. 41(2)232-242.

Hines, J. E. and G. J. Mitchell. 1983. Gadwall nest-site selection and nesting success. J. Wildl. Manage. 47(4):1063-1071.

Hochbaum, H. A. 1944. The canvasback on a prairie marsh. University of Nebraska Press, Lincoln and London. 207pp.

James, F. C. 1971. Ordinations of habitat relationships among breeding birds. Wilson Bull. 83:215-236.

Johnson, D. H. 1980. The comparison of usage and availability measurements for evaluating resource preference. Ecology 61:65-71.

Johnson, D. H., and A. B. Sergeant. 1977. Impact of red fox predation on the sex ratio of prairie mallards. U.S. Fish Wildl. Serv., Wildl. Res. Rep. No. 6.

Johnson, R. G., and S. A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. J. Wildl. Manage. 54(1):106-111.

Jones, R. E. 1993. unpublished. The Manitoba nest structure program. Annual Report. Manitoba Habitat Heritage Corporation, Winnipeg, Manitoba. 13pp.

Kiel, W. H. Jr., A. S. Hawkins, and N. G. Perret. 1972. Waterfowl habitat trends in the aspen parkland of Manitoba. Canadian Wildlife Service report No. 18. Ottawa, On.

Kirwin, J. L., and L. E. Lewis. 1995. unpublished. An evaluation of two styles of pole type artificial nesting structures with multiple nest sites. Morris Wetland Management District Report. Morris, Minnesota. 8pp.

Klett, A. T., H. F. Duebbert, C. A. Faanes, and K. F Higgins. 1986. Techniques for studying nest success of ducks in upland habitats in the prairie pothole region. United States Fish and Wildlife Service Resource Publication 158. 24pp.

_____, T. L. Shaffer, and D. H. Johnson. 1988. Duck nest success in the prairie pothole region. J. Wildl. Manage. 52(3):431-440.

Krapu, G. L., L. G. Talent, and T. J. Dwyer. 1979. Marsh nesting by mallards. Wildl. Soc. Bull. 7(2):104-110.

Lee, F. B. 1982. Home-made nesting sites for mallards. North Dakota Outdoors Magazine. March 1982. pp 6-9.

_____, A. D. Kruse, and W. H. Thornsberry. 1968. New fashions for the duck marsh. Naturalist. Vol 19(1):27-32.

Lesser, C. A., H. L. Alexander, and T. Whittendale. 1974. Black duck imprinting and production in Delaware. Trans. N.E. Sect. Wildl. Soc. 31:73-81

Lewis, L. 1995. unpublished. Results of Morris wetland management district 1995 nesting structures field tests. Morris Wetland Management District annual report, Morris ` Minnesota.

Lokemoen, J. T., H. F. Duebbert, and D. E. Sharp. 1990. Homing and reproductive habits of mallards, gadwall and blue-winged teal. Wildl. Monog. No.106. 28pp.

______, and R. O. Greenwood. 1992. Nesting waterfowl and water birds on natural islands in the Dakotas and Montana. Wildl. Soc. Bull. 20(2):163-171.

Majewski, P., and P. Beszterda. 1990. Influence of nesting success on female homing in the mallard. J. Wildl. Manage. 54(3):459-462.

Melinchuk, R. 1988. Wetlands and waterfowl. in W. Nicholaichuk and H. Steppuhn eds. Proceedings of the symposium on the management affecting the wet-to-dry transition: planning at the margins. Water Studies Institute, University of Regina, Regina, Sk.

Miller, H. W., and D. H. Johnson. 1978. Interpreting the results of nesting studies. J. Wildl. Manage. 42(3):471-476.

Nelson, H. K., R. G. Streeter, and J. D. McCuaig. 1991. Accomplishments of the North American waterfowl management plan. Trans. 56th North American Wildl. and Nat. Resour. Conf. 56:449-451.

North American Waterfowl Management Plan. 1990. Prairie habitat joint venture, prairie habitat: a prospectus. Environ. Can. Edmonton, Alberta. 32pp.

Robel, R. J., and J. N. Briggs, A. D. Dayton and L. C. Hulbert. 1970. Relationship between visual obstruction measurements and weight of grassland vegetation. J. Range. Manage. 23:295-297.

Smith, A. G., J. H. Stoudt, and J. B. Gollop. 1964. Prairie potholes and marshes. in: J. P. Linduska. ed. Waterfowl Tomorrow. U.S. Gov. Printing Office, Washington, D.C. 770pp.

Sowls, L. K. 1955. Prairie Ducks: A study of their behaviour, ecology and management. Wildlife Management Institute, Washington, D.C. 193pp.

Stoudt, J. H., 1971. Ecological factors affecting waterfowl production in the Saskatchewan parklands. U.S. Dept. of the Inter. F&WS. Res. Publ. No. 99.

_____. 1982. Habitat use and production of canvasbacks in southwestern Manitoba, 1961-1972. U.S. Dept. of the Inter:, F&WS. Rep. No. 248. Washington, D.C.

United States Fish and Wildlife Service and the Canadian Wildlife Service. 1977. Standard operating procedures of aerial waterfowl breeding ground population and habitat surveys. United States Department of the Interior and Environment Canada. 78 pp.

Vaa, S. 1995. unpublished. South Dakota nest structure progress report. South Dakota Game, Fish and Park, Brookings S.D.

Weller, M. W. 1956. A simple field candler for waterfowl eggs. J. Wildl. Manage. 20(2):111-113.

Wetland Management District Report. 1993. Morris Wetlands Management District. Morris, Minnesota.

Zar, J. H. 1984. Biostatistical Analysis. 2nd edition. Prentice-Hall Inc., Englewood Cliffs N.J. 07632.

PERSONAL COMMUNICATIONS

Bullion, R. 1994. Biologist, Manitoba Habitat Heritage Corporation. Shoal Lake, Manitoba. March 1994.

Johnson, M. 1994. Waterfowl Biologist, North Dakota Department of Fish and Game. Bismarck, North Dakota. April 1994.

Jones, R. E. 1994. Biologist, Manitoba Department of Natural Resources. Winnipeg Manitoba. April 1994.

Lewis, L. 1994. Biologist, United States Fish and Wildlife Service. Morris Wetlands Management District. Morris, Minnesota. March 1994.

APPENDIX

Appendix 1

List of fine habitat classifications used in the evaluation of nesting structure sites.

Open Fresh Water
Deep Marsh
Shallow Marsh
Wet Meadow
Fallow
Cultivated Stubble (low residue farmland)
Grass/Legume/Hayed Area (medium residue farmland)
Pasture/Grassland/Ditches/Dense Nesting Cover (high residue farmland)
Tame Hayland
Low Shrub
Deciduous Trees
Coniferous Trees

Appendix 2

List of course habitat classifications used in the evaluation of nesting structure sites.

Water	(open fresh water, deep marsh, shallow marsh wet meadow)
Low Residue Farmland	(fallow, cultivated stubble)
Medium Residue Farmland	(grass, legume, hayland)
High Residue Farmland	(pasture, grassland, ditches, dense nesting cover)
Trees and Shrubs	(coniferous trees, deciduous trees, low shrubs)