CHANGE IN AVAILABILITY AND NUTRITIONAL QUALITY OF POST-HARVEST WASTE CORN ON WATERFOWL STAGING AREAS NEAR LONG POINT, ONTARIO

(Spine title: Dynamics of Waste Corn at Long Point, Ontario)

(Thesis format: manuscript)

by

Edward Sydney Barney

Graduate Program
In
Biology

Submitted in partial fulfillment
of the requirements of the degree of
Master of Science

School of Graduate and Postdoctoral Studies
The University of Western Ontario
London, Ontario
September 2008

THE UNIVERSITY OF WESTERN ONTARIO

SCHOOL OF GRADUATE AND POSTDOCTORAL STUDIES

CERTIFICATE OF EXAMINATION

Supervisors	Examining Board
______________	______________
Scott Petrie	Jeremy McNeil
______________	______________
Liana Zanette	Brent Sinclair

Supervisory Committee

____

Bob Scott

____

Jack Millar

The dissertation by

Edward Sydney Barney

Entitled

Change in Availability and Nutritional Quality of Post-harvest Waste Corn on
Waterfowl Staging Areas Near Long Point, Ontario

is accepted in partial fulfillment of the
requirements for the degree of
Master of Science

Date_________

____

Chair of the Examining Board

ABSTRACT

Increase in harvester efficiency has raised concern that there has been a decrease in the quantity of waste corn available for waterfowl staging in northern areas. I conducted this study to evaluate seasonal changes in waste corn availability and nutritional quality, as well as field use by waterfowl near Long Point, Ontario. I found significant decreases in both waste corn density and nutritional quality between fall (initial) and spring (final) sampling periods. Waterfowl use of fields was not related to initial waste corn abundance; birds used fields based on physical characteristics. Currently, waste corn densities are potentially limiting to waterfowl during spring migration, as average spring waste corn density (62 kg/ha) was similar to waterfowl selection thresholds (60 kg/ha) reported in other studies. No-till farming and the development of biofuels may ensure sufficient waste corn density for fall and spring staging waterfowl in northern regions of North America.

Key words: field-feeding, limiting, Long Point, no-till, staging, waste corn, waterfowl.

ACKNOWLEDGEMENTS

Funding for this research project was provided by the Long Point Waterfowl & Wetlands Research Fund, the Ontario Federation of Anglers and Hunters Zone J, Delta Waterfowl Foundation, the Long Point Waterfowlers Association, the Canadian Wildlife Service, the Ontario Ministry of Natural Resources, Ducks Unlimited Canada, and the Bluff's Hunting Club.

The help and support of the local farming community contributed to the success of my project. Their permission to sample corn fields allowed me to complete this study. I wish to thank all the local landowners and specifically, Martin Doerksen, Barry Hiebert, Paul Petker, Dennis Reimer, Gord Reimer, Dave Suderman, and Emile Vandommele for their logistical support and friendship.

I'd like to thank my committee members including my supervisor Dr. Scott Petrie, co-supervisor Dr. Liana Zanette and committee members Dr. Bob Scott and Dr. Jack Millar. This committee provided valuable comments and suggestions concerning this study throughout my time at UWO. I wish to thank my examining committee members, Dr. Jeremy McNeil, Dr. Jack Millar, and Dr. Brent Sinclair for their comments and final review of my thesis. Mary Dillon and Carol Curtis both helped considerably with making sure I completed all administrative tasks and provided answers to the many questions I had while being a student at UWO. A special thanks goes out to Dr. Bob Bailey for accepting me into the GHOST fold and providing this "Fund" student with a place to keep his stuff (and dog) and for being available to bounce ideas off when I needed someone to talk to. I have enjoyed the duck (and other) talks shared over the years with my fellow "Fund" and GHOST lab-mates at UWO. John Bailey, Michelle Marcus, Mike Schummer, Jeremy Stempka, Lindsay Ware and Adam Yates have all challenged my

ideas and provided support and friendship during my time as a student. I wish you all the best in your future research and academic endeavors.

I also wish to acknowledge the contributions of the LPWWRF scientific advisory committee members, Dr. Ken Abraham, Dr. Dave Ankney, Paul Ashley, Darrell Dennis, Dr. George Finney, Mike Gendron, Dr. Mark Gloutney, Dr. Dave Howerter, Garry McCullough, and Shawn Meyer.

I am forever indebted to my field assistant Ross Wood. Ross spent endless hours in the fields enduring all kinds of weather picking corn kernels and counting birds. His hard work, crazy stories and friendship kept our spirits up and ensured the work got done.

The staff of Bird Studies Canada has been very helpful during my field seasons. I wish to thank Anne Marie Ridout for her logistical and administrative support. Stu Mackenzie provided field assistance and always had the door open at “Old Cut” for some bird banding, barbecues, and late night card games. I would like to thank Ron Ridout for his patience with me and forgiveness of muddy and broken vehicles. Dr. Shannon Badzinski provided constructive criticism during the entire length of my research and has been a great friend and colleague during my time as a student. The conversations while hunting and fishing contributed immensely to the development of ideas, research design, and analysis of this research. I look forward to working, teaching, hunting and fishing with you at Long Point in the years to come.

I would like to thank my supervisor Dr. Scott Petrie for taking me from a “green-horn” high school co-op student to a “seasoned” waterfowl biologist. Scott has been a mentor to me for 10 years providing guidance, influence and direction along my career path in waterfowl research. I look forward to your continued mentorship as we work, teach and hunt together at Long Point.

I would like to acknowledge my parents Dr. Dave and Karen Barney for allowing me to explore the outdoors while growing up. Their passion for animals and academic influence has instilled in me the want to pursue a research career in wildlife. I can not thank them enough for the love, guidance and support during my time at UWO.

Finally, I would like to thank my best friend, partner and wife, Liza, for her endless love, support and encouragement over the last 4 years. Liza has been my rock during this time and I can not thank her enough for her support. She is also the mother to our son, Jaden, and has accepted the fact that “duck” is not such a bad first word! I can not wait to grow as a family and I look forward to the next path in our lives together.

Table of Contents

Certificate of Examination……………………………………………………………...ii

Abstract…………………………………………………………………………...iii

Acknowledgements……………………………………………………………….iv

Table of Contents…………………………………………………………...…vii

List of Tables…………………………………………………………………...…ix

List of Figures……………………………………………………………………..…x

Chapter 1. General Introduction……………………………………………….….1

1.1. Introduction…………………………………………………………………….1

1.2. Overall study objectives and predictions……..…………………………………….5

1.3. Study area…………………………………………………………………....5

1.4. Scope of the thesis………..…………………………………………………….7

1.5. Literature Cited……………………………………………………………...7

Chapter 2. Change in availability and nutritional quality of post-harvest waste corn on waterfowl staging areas near Long Point, Ontario………………………11

2.1. Introduction……………………………………………………………….11

2.2. Methods……………………………………………………………………...12

2.2.1. Study area………………………………………………………….……12

2.2.2. Study field selection and waste corn sampling methods……………….…….13

2.2.3. Waste corn nutritional quality………………………………………….....15

2.2.4. Terrestrial waterfowl surveys and field selection by field-feeding waterfowl…………………………………………………………....16

2.3. Statistical analysis……………………………………………………….....16

2.3.1. Waste corn availability……………………………………………………16

2.3.2. Waste corn nutritional quality………………………………………..17

2.3.3. Terrestrial waterfowl surveys and field selection by field-feeding waterfowl………………………………………………………….…...18

2.4. Results..18

2.4.1. Changes in waste corn availability……………………………….....18

2.4.2. Changes in waste corn nutritional quality……………………….…19

2.4.3. Waterfowl use of harvested corn fields……………………………..…21

2.5. Discussion…………………………………………………………...21

2.5.1 Effect of harvester efficiency and post-harvest tillage on waste corn availability ………………………………………………………………21

2.5.2 Effect of fall corn moisture content on spring nutritional quality……….27

2.5.3 Effect of waste corn abundance on waterfowl field use………………..…28

2.5.4. Management implications……………………………………………….30

2.6 Literature Cited…………………………………………………………..31

Chapter 3. General Discussion……………………………………………………..34

3.1. Discussion…………………………………………………………...34

3.2. Future research…………………………………………………………………36

3.3. Overall summary and conclusion ……………………………………...37

3.4. Literature cited………………………………………………………………38

Vita……………………………………………………………………………………40

LIST OF TABLES

Table 2.1. Multiple linear regression models used for analysis of absolute and proportional change in waste corn abundance for fields studied near Long Point, Ontario……20

Table 2.2. Study site comparison of initial corn densities (kg/ha; mean ± SE) and percent carbohydrates (percent; mean ± SE) of corn at harvest between southern Ontario, Texas, Nebraska, Illinois, Iowa, Missouri, and Kansas……25

LIST OF FIGURES

Figure 1.1. Map of the Great Lakes region and Long Point, Ontario with the arrow pointing to the 7,600 ha clay plain study site…………………………...6

Figure 2.1. Schematic of random transect method used to sample waste corn from study fields at Long Point, Ontario. Vertical lines represent main transects spaced at least 50 m apart. Horizontal lines represent perpendicular (sampling) transects with minimum length of 1 m and maximum length of 10 m……………………………………..…………………14

Figure 2.2. Correlation between initial fall 2005 waste corn abundance and total fall 2005 waterfowl-use-days (WUD) in cornfields near Long Point, Ontario..…………………………………………………………...22

Figure 2.3. Correlation between initial corn abundance and total abundance change during the (a) 2004/2005 and (b) 2005/2006 field seasons for fields studied near Long Point, Ontario...23

CHAPTER 1. GENERAL INTRODUCTION

1.1. INTRODUCTION

The proliferation of agriculture after European settlement in North America provided waterfowl new foraging opportunities and many species now rely heavily upon waste grains to meet energetic requirements of migration (Alisauskas and Ankney 1992, Petrie et al. 2002, Manley et al. 2004). While at staging areas, waterfowl store fat and protein which are essential for maintenance, migration and reproduction (Ankney 1984, Thompson and Raveling 1987, Stroud et al. 1990). Historic waterfowl field-feeding likely resulted from waterfowl learning that waste grains are a readily available and accessible food source (Bossenmaier and Marshall 1958). This behavior become more common and consistent after modern harvesting practices, such as windrowing and combining, became standard in the 1940s (Bossenmaier and Marshall 1958). Those farming practices also provided waterfowl with large areas of pre – and post-harvest grains on which to feed.

The lower Great Lakes (LGL) region continues to provide staging habitat for migrating waterfowl despite a basin-wide decline in wetland availability (Whillans 1982, Herdendorf 1987, 1992, Prince et al. 1992). Substantial populations of diving (Aythini), sea (Mergini), and dabbling ducks (Anatini), as well as geese (Anserini) and swans (Cygnini) use the LGL region during fall and spring migration (Bookout et al. 1989, Prince et al. 1992). Between three and four million waterfowl are estimated to migrate through the LGL region, making it continentally important for waterfowl populations and critical to waterfowl production in both the Atlantic and Mississippi flyways (Bookout et al. 1989, Prince et al. 1992). Thirteen of 36 waterfowl species that use the LGL depend on waste agricultural grains during migration (Bellrose 1976).

Patch selection by field-feeding waterfowl follows an abundance-availability hierarchy (Baldassarre and Bolen 1984). This selection method suggests that waterfowl switch between fields with high abundance of waste grain (absolute amount of waste grain in a field) and fields with high availability of waste grain (amount of waste grain accessible to waterfowl) depending on which field type is more prevalent in an area in an attempt to minimize foraging time (Baldassarre and Bolen 1984). Differences between fields with high abundance and high availability of waste grain are generally dictated by post-harvest treatments (i.e. disking and/or plowing) as such practices can decrease waste grain abundance, but increase accessibility (Baldassarre and Bolen 1984).

The marginal value theorem predicts that individual foragers use food density (energy within a patch) to select patches (Charnov 1976). Baldassarre and Bolen (1984) determined that the minimum density at which mallards (*Anas platyrhynchos*) on the Southern High Plains of Texas would select a corn (*Zea mays*) field in which to forage was 60 kg/ha (selection threshold) while they would no longer forage in fields with corn densities below 20 kg/ha (giving-up density). Other studies have identified comparable thresholds and suggest that waterfowl forage in fields until approximately 80% of the initial waste grain density has been depleted at which point it is no longer profitable to feed (Baldassarre and Bolen 1987, Clark and Greenwood 1987). Waste grain could potentially become limiting to waterfowl populations at the landscape level if harvesting practices result in grain densities below 60 kg/ha.

Agricultural economics have a large influence on the amount of waste grain remaining on harvested cropland (Pederson et al.1989). For instance, to increase profit margins, farmers strive to use the highest efficiency machinery available/affordable to reduce grain loss. Over time, farm machinery manufacturers have responded by designing more efficient harvesters, leaving less waste grain available for field-feeding waterfowl. Krapu et al. (2004) attributed a 50% decrease in waste corn available to staging waterfowl in Nebraska over the last 20 years to increased harvester efficiency. In addition, they reported a parallel long-term decrease in fat storage of field-feeding waterfowl staging in Nebraska and suggested that long-term declines in waste grain availability could drastically reduce waterfowl carrying capacities at northern staging areas. Consequently, long-term decreases in fat deposition during spring could negatively affect migration, reproduction and ultimately population size of several field-feeding waterfowl species using the LGL.

A second aspect to be considered is post-harvest treatment (i.e. disking and/or plowing), which may decrease the availability of waste grain to waterfowl (Warner et al. 1985). For example, disking and deep plowing can reduce waste grain availability by 77% and 97% respectively (Baldassarre et al. 1983, Warner et al. 1985). However, because autumn tillage practices can cause substantial soil losses through wind and water erosion, many farmers have responded by employing conservation - and no-till as primary approaches for soil conservation (Walker 1981). Conservation tillage retains crop residue on more than 30% of the soil surface, while no-till, results in no residue reduction (Little 1987). Conservation - and no-till maintain waste grain availability for field-feeding waterfowl by reducing the amount of waste grain buried within the soil (Baldassarre et al. 1983). Consequently, several conservation organizations in the LGL region, including The Long Point Region Conservation Authority and Ducks Unlimited Canada, advocate conservation – and no-tillage practices (Petrie 1998). Maintaining waste corn densities through conservation – and no-tillage may also offset higher rates of waste corn consumption by increasing waterfowl populations.

Milder winters leading to increased accessibility to waste grains because of reduced snow cover have resulted in waterfowl staging for longer periods in northern staging areas and shortstopping (overwintering) at higher latitudes (Davis et al. 1989, LeBlanc et al. 1991). Shortstopping occurs when waterfowl abandon use of traditional southern wintering areas and begin wintering further north (Davis et al. 1989, LeBlanc et al. 1997). Furthermore, increased numbers of waterfowl at northern staging areas during fall and winter could reduce the availability of waste grains for migrating waterfowl the subsequent spring when waste grains are important for migration and reproduction (Ankney 1982, Alisauskas and Ankney 1992). Anthropogenic sources of CO_2 are the leading cause of global warming (Alexiadis 2007). Global warming is predicted to continue and could potentially impact grain production and decomposition of waste materials (Dhakhwa et al. 1997, Okamoto et al. 1997, Aerts 2006). Increased annual temperatures could influence the nutritional quality of waste grain by increasing rates of decomposition. For example, Warner et al. (1989) found that despite no significant changes in caloric content of grains from fall to spring, energy values were more variable in spring. Variable spring values were possibly due to the periodic and somewhat prolonged thawing that would accelerate moisture related decay resulting in a decline in nutritional quality.

Substantial declines in waste corn availability have been reported on mid-west staging areas (Krapu et al. 2004), but has not been investigated within the LGL, or elsewhere throughout most northern staging and wintering areas. Since the LGL are important for staging and wintering waterfowl (Bookhout et al. 1989, Prince et al. 1992), it is necessary to assess the availability and depletion rates of waste corn during fall and spring. It is also important to assess the effects of changing harvester efficiency, post-harvest tillage and possible temperature change on waste corn availability and nutritional quality for staging waterfowl. Results of this study may be pertinent for waterfowl staging in other mid-latitude regions.

1.2. OVERALL STUDY OBJECTIVES AND PREDICTIONS

The objectives of this study were to: 1) determine the seasonal changes in availability of post-harvest waste corn, 2) determine the effects of harvester efficiency and post-harvest tillage on waste corn availability, 3) determine if there are seasonal changes in waste corn nutritional quality, and 4) determine the relationship between waste grain availability and field-feeding waterfowl density. I predicted that waste grain availability would decline between fall and spring and that most fields would have waste corn densities in spring that are below the giving up density (20 kg/ha) established for mallards (Baldassarre and Bolen 1984). Secondly, I predicted that newer harvesters would be more efficient and leave less waste corn available for staging waterfowl than older less efficient harvesters. Thirdly, I predicted that there would be a decline in the nutritional quality (percent carbohydrates) of post-harvest waste corn between fall and spring and that this decline would correlate with high initial moisture of waste corn. Lastly, I predicted that waterfowl use of harvested fields would correlate positively with initial (early fall) waste corn abundance during fall and spring.

1.3. STUDY AREA

Post-harvest waste corn sampling and terrestrial waterfowl surveys were conducted on agricultural fields situated on the 7,600-ha clay plain located at the base of Long Point, Ontario ($80^0$24’W, $42^0$38’N; Figure 1.1). A detailed description of Long Point and its associated agricultural uplands is given by Petrie (1998). Long Point’s clay

Figure 1.1. Map of the Great Lakes region and Long Point, Ontario with the arrow pointing to the 7,600 ha clay plain study site.

plain has heavy and poorly drained soils making it ideal for cereal grain production (Heathcote 1981), and the area is highly utilized by field-feeding waterfowl (Petrie 1998, Petrie et al. 2002).

1.4. SCOPE OF THE THESIS

This thesis is composed of three chapters. Chapter 1 is comprised of a general introduction to waterfowl field-feeding ecology and provides the ecological framework for this thesis. Management concerns over changes in waste grain availability and its impact on staging waterfowl in mid-latitude staging areas are also presented in Chapter 1. Chapter 1 includes my study objectives and predictions, as well as a general description of the study area. In Chapter 2, I assess the influence of harvester efficiency and post harvest tillage on waste corn availability for staging waterfowl, seasonal depletion rates, changes in nutritional quality and the seasonal interaction between waste corn availability and waterfowl-use-days of harvested corn fields. Chapter 2 is a manuscript style chapter that follows the “Checklist of Instructions to Authors” provided by The Wildlife Society and its journal, The Journal of Wildlife Management. Finally, in Chapter 3 I discuss the implications of my major conclusions in a broader management and ecological context and propose refined methods for future research in this field.

1.5. LITURATURE CITED

Aerts, R. 2006. The freezer defrosting: global warming and litter decomposition rates in cold biomes. Journal of Ecology 94:713-724.

Alexiadis, A. 2007. Global warming and human activity: a model for studying the potential instability of the carbon dioxide/temperature feedback mechanism. Ecological Modelling 203:243-256.

Alisauskas, R. T., and C. D. Ankney. 1992. Spring habitat use and diets of midcontinent adult lesser snow geese. Journal of Wildlife Management 56:43-54.

Ankney, C. D. 1982. Annual cycle of body weight in lesser snow geese. Wildlife Society

Bulletin 10:60-64.

Ankney, C. D. 1984. Nutrient reserve dynamics of breeding and molting brant. Auk 101:361-370.

Baldassarre, G. A., and E. G. Bolen. 1984. Field-feeding ecology of waterfowl wintering on the Southern High Plains of Texas. Journal of Wildlife Management 48:63-71.

Baldassarre, G. A., and E. G. Bolen. 1987. Management of waste corn for waterfowl wintering on the Texas High Plains. Department of Range and Wildlife Management Management Note 13, Lubbock, Texas, USA.

Baldassarre, G. A., R. J. White, E. J. Quinlan, and E. G. Bolen. 1983. Dynamics and quality of waste corn available to postbreeding waterfowl in Texas. Wildlife Society Bulletin 11:25-31.

Bellrose, F. C. 1976. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, Pennsylvania, USA.

Bookout, T. A., T. K. Bednarik, and R. Kroll. 1989. The Great Lake marshes. Pages 131-156 i*n* L. M. Smith, R. L. Pederson and R. M. Kaminski, editor. Habitat Management for Migrating and Wintering Waterfowl in North America. R.M. Lubbock, Texas and Texas Tech University Press.

Bossenmaier, E. F., and W. H. Marshall. 1958. Field-feeding by waterfowl in southwestern Manitoba. Wildlife Monographs 1:1-32.

Charnov, E. L. 1976. Optimal foraging: the marginal value theorem. Theoretical Population Biology 9:129-136.

Clark, R. G., and H. Greenwood. 1987. A circular “ring-angel” movement by field-feeding waterfowl. Wilson Bulletin 99:722-723.

Davis, S. E., E. E. Klass, and K. J. Koehler. 1989. Diurnal time-activity budgets and habitat use of lesser snow geese *Anser caerulescens* in the middle Missouri River valley during winter and spring. Wildfowl 40: 45-54.

Dhakhwa, G. B., C. L. Cambell, S. K. LeDuc, and E. J. Cooter. 1997. Maize growth: assessing the effects of global warming and CO_2 fertilization with crop models. Agricultural and Forest Meteorology 87:253-272.

Heathcote, I. W. 1981. Major physical features of Long Point Bay and its watershed. Journal of Great Lakes Research 7:89-95.

Herdendorf, C. E. 1987. The ecology of the costal marshes of western Lake Erie: a community profile. National Wetlands Research Center, Fish and Wildlife Service Report 85 (7a), Washington D.C., USA.

Herdendorf, C. E. 1992. Lake Erie costal wetlands: an overview. Journal of Great Lakes Research 18:533-551.

Krapu, G. L., D. A. Brandt, and R. R., Jr. Cox. 2004. Less waste corn, more land in soybeans, and the switch to genetically modified crops: trends with important implications for wildlife management. Wildlife Society Bulletin 32:127-136.

LeBlanc, A., D. J. Dudek, and L. F. Allegretti. 1991. Disappearing ducks: the effect of climate change on North Dakota's waterfowl. Environmental Defense Fund. New York, New York, USA.

Little, C. E. 1987. Green fields forever: the conservation tillage revolution in America. Island Press, Washington D.C., USA.

Manley, S. W., R. M. Kaminski, K. J. Reinecke, and P. D. Gerard. 2004. Waterbird foods in winter-managed ricefields in Mississippi. Journal of Wildlife Management 68:74-83.

Okamoto, K., H. Kawashima, and M. Fukuhara. 1997. Global prediction of area change of suitable regions for cereal cultivation caused by global warming. International Journal of Remote Sensing 18:3797-3810.

Pederson, R. L., D. G. Jorde, and S. G. Simpson. 1989. Northern Great Plains. Pages 281-310 i*n* Smith, L. M., R. L. Pederson, and R. M. Kaminski, editor. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press Lubbock, Texas, USA.

Petrie, S. A. 1998. Waterfowl and wetlands of Long Point and Old Norfolk County: present conditions and future options for conservation. Unpublished Norfolk Land Stewardship Council Report. Long Point Waterfowl and Wetlands Research Fund, Port Rowan, Ontario. 182 pp.

Petrie, S. A., S. S. Badzinski, and K. L. Wilcox. 2002. Population trends and habitat use of tundra swans staging at Long Point, Lake Erie. Waterbirds 25:143-149.

Prince, H. H., P. I. Padding, and R. W. Knapton. 1992. Waterfowl use of the Laurentian Great Lakes. Journal of Great Lakes Research 18:673-699.

Stroud, D. A., G. P. Mudge, and M. W. Pienkowski. 1990. Protecting internationally significant bird sites: a review of the EEC special protection area network in Great Britain. Nature Conservancy, Northminster House, Peterborough, U.K.

Thompson, S. C., and D. G. Raveling. 1987. Incubation behavior of emperor geese compared with other geese: interactions of predation, body size and energetics. Auk 104:707-716.

Walker, R. D. 1981. Conservation tillage: regional seminar 1981. Cooperative Extension Service. University of Illinois, Champaign-Urbana, USA.

Warner, R. E., S. P. Havera, and L. M. David. 1985. Effects of autumn tillage systems on corn and soybean harvest residues in Illinois. Journal of Wildlife Management 49:185-190.

Warner, R. E., S. P. Havera, L. M. David, and R. J. Siemers. 1989. Seasonal abundance of waste corn and soybeans in Illinois. Journal of Wildlife Management 53:142-148.

Whillans, T. 1982. Changes in marsh area along the Canadian shore of Lake Ontario. Journal of Great Lakes Research 8:570-577.

CHAPTER 2. CHANGE IN AVAILABLITY AND NUTRITIONAL QUALITY OF POST-HARVEST WASTE CORN ON WATERFOWL STAGING AREAS NEAR LONG POINT, ONTARIO

2.1. INTRODUCTION

The importance of staging areas to migratory waterfowl is well documented (Bellrose 1976, Baldassarre and Bolen 1994). Staging areas provide nutrients required for migration, maintenance and reproduction (Ankney 1984, Thompson and Raveling 1987, Stroud et al. 1990). Consequently, Richardson and Kaminski (1992) suggested that the conservation and management of staging areas for waterfowl nutrient acquisition is important to maintaining waterfowl populations.

Historically, the lower Great Lakes (LGL) region has provided staging habitat to millions of migratory waterfowl (Prince et al. 1992), including tundra swans (*Cygnus columbianas*), mallards (*Anas platyrhynchos*), and Canada geese (*Branta canadensis*; Petrie 1998). Thus, the LGL are continentally important to the production of waterfowl in the Atlantic and Mississippi flyways (Bookhout et al. 1989, Prince et al. 1992). Of 36 species of waterfowl that use the LGL, 13 use agricultural waste grain to meet nutrition requirements (Bellrose 1976, Baldassarre and Bolen 1994).

Declines in waste corn availability have been observed recently on mid-latitude staging areas and have been attributed to increased harvester efficiency rates and changes in crop type (Krapu et al. 2004). The decreases in food availability in spring resulted in reductions in fat storage that is essential for migration and egg formation (Alisauskas and Ankney 1992, Krapu et al. 2004). Agricultural practices in the LGL region are similar to other mid-continent regions, but little is know about the availability and nutritional quality of post-harvest waste corn in the LGL and the potential impact on waterfowl.

This study was conducted to determine the availability, depletion rate, and nutritional quality of post-harvest waste corn in the LGL as increase in harvester efficiency, increasing waterfowl populations and warmer winter temperatures may contribute to decrease waste corn density. I predicted that waste corn availability would decline between fall and spring and that most fields in spring would have waste corn densities below the giving-up density for foraging mallards (20 kg/ha; Baldassarre and Bolen 1984). Second, I predicted that newer, more efficient harvesters would leave less waste corn available for staging waterfowl than older less efficient harvesters. My third prediction was that the nutritional quality (percent carbohydrates) of post-harvest waste corn would decline between fall and spring and that this decline would be correlated to initial waste corn moisture. Lastly, I predicted that waterfowl use of harvested fields in fall and spring would correlate positively with initial (early fall) total waste corn abundance.

2.2. METHODS

2.2.1. Study area

I conducted this study on the 7,600-ha Norfolk clay plain located north of Long Point, Ontario ($80^0$24’W, $42^0$38’N; Figure 1.1). Long Point is a mid-continent staging area for waterfowl migrating through the Atlantic and Mississippi Flyways (Bookout et al. 1989, Prince et al. 2002). Many species of waterfowl staging at Long Point forage on the agricultural fields located on the Norfolk clay plain (Petrie 1998, Petrie et al. 2002). The Norfolk clay plain has heavy and poorly drained soils which make it ideal for cereal grain production (Heathcote 1981); corn (*Zea mays*), soybeans (*Glycine max*), winter wheat (*Triticum aestivum*) and vegetables (e.g. peppers, cucumbers, and squashes) are extensively farmed on the clay plain (Petrie et al. 2002).

2.2.2. Study field selection and waste corn sampling methods

I surveyed the entire study area during the first two weeks of September during 2004 and 2005 and recorded all crop types and locations on 1:10,000 ortho-photo maps. I also interviewed local landowners about their farming practices which allowed me to gather information on land-use history, tillage practices, yield, type and variety of grain, field size, and mechanical harvester type for most fields in the study area. The corn fields selected were harvested by new (model year 1990 and newer; 2004 and 2005 n = 7), as well as, older (model year 1990 and older; 2004 n = 5 and 2005 n = 6) mechanical harvesters, with a variety of post-harvest treatments (i.e. disking, plowing, conservation - and no-till) applied.

I sampled 42 separate corn fields in fall 2004/spring 2005 and 50 corn fields in fall 2005/spring 2006 to obtain an index of post-harvest waste corn availability and depletion rates. Study fields were sampled once immediately after fall harvest, after fall post-harvest tillage and once during spring immediately after departure of staging waterfowl. A random transect design (Figure 2.1) was used to sample all fields. I established main transects at the northeast corner of each field (at least 50 m apart) and transects were positioned north to south or east to west depending on row orientation (i.e. transects followed rows and did not run horizontally across rows) and were permanently assigned to each field. I used a random number table to select sampling locations along each main transect for each sampling period. The same number of samples were taken on each main transect. I used a random number table to determine the left or right direction of samples to be taken off of the main transect. A perpendicular transect at right angles

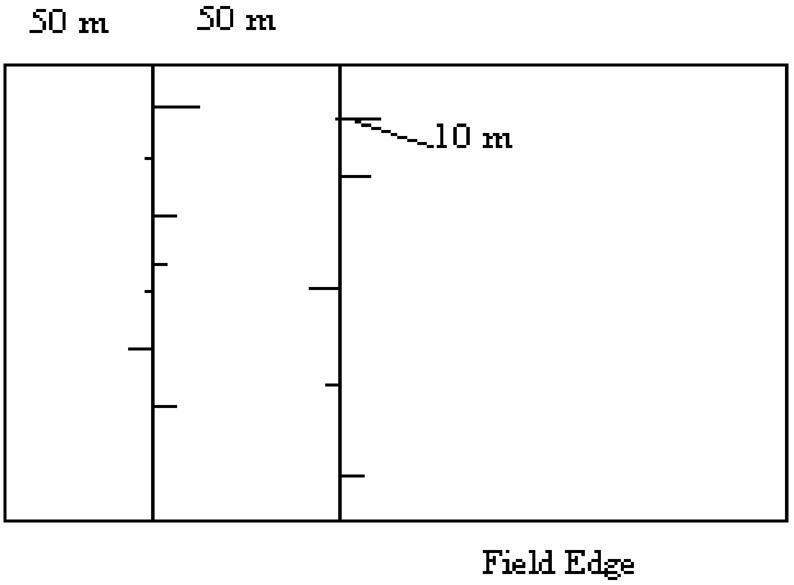


Figure 2.1. Schematic of random transect method used to sample waste corn from study fields at Long Point, Ontario. Vertical lines represent main transects spaced at least 50 m apart. Horizontal lines represent perpendicular (sampling) transects with minimum length of 1 m and maximum length of 10 m.

from the main transect (Figure 2.1) was sampled once direction (left or right) from main transect had been determined. I also used a random number table to determine how far down the perpendicular transect samples were taken (between 1 and 10 meters). Random sample selection was performed in this manner to ensure I distributed samples throughout the entire field and to minimize linear sampling. I also recorded locations of fall samples to ensure they were not re-sampled during spring.

I sampled waste corn using 1m x 1m removable quadrats at a frequency of 1 quadrat/0.4046 ha (1 quadrat/acre) for each field and all waste corn within each was collected, weighed and placed in marked plastic bags. Kernels (individual kernels and cobs with less than 10 kernels) and cobs (cobs with more than 10 kernels) were weighed separately (after kernels had been removed from cobs) and oven-dried for 48 hours at 60^0C (Baldassarre et al. 1983), then re-weighed to determine percent moisture content. I calculated an estimate of total waste corn (dry mass) available (kg) and density (kg/ha) within each field separately for kernels and cobs and combined weights (kernels + cobs) were used to determine total available waste corn (kg) and density (kg/ha) within each field during each sampling period. I conducted separate estimates of kernel and cob densities, as well as initial percent moisture in the 2005/2006 study year due to changes in sampling protocol and freezer malfunction in 2004/2005.

2.2.3. Waste corn nutritional quality

Proximate analysis (percent carbohydrates, protein, ash, and fat) were determined on corn samples following the methods of Harmon et al. (1969). Analyses were conducted on all fields sampled during fall and spring to identify seasonal changes in nutritional composition (Agri-Food Laboratories, Guelph, Ontario). All sub-samples within each field and sampling period were pooled for proximate analysis. A minimum sub-sample of 10 g was needed to conduct proximate analysis.

2.2.4. Terrestrial waterfowl surveys and field selection by field-feeding waterfowl

I conducted roadside waterfowl surveys of the entire study area every two days during fall and spring staging periods, except during March when surveys were conducted every day due to concentrated field use by spring staging waterfowl. I conducted a morning and afternoon survey (between 09:00-11:00 and 16:00-18:00 E.S.T.), and starting points (north versus south end of study area) were randomized daily. Fall waterfowl surveys (2004 n=62 and 2005 n=40) began in mid-October, the start of soybean and corn harvest and concluded 15 December. Spring surveys (2005 and 2006 n=40) were conducted between 1 March and 10 April (depending on timing of spring migrant waterfowl). I recorded total number of waterfowl, species composition, and field type used during surveys. I also recorded total numbers of other wildlife during surveys (e.g. white-tailed deer *Odocoileus virginianus*; wild turkey *Meleagris gallopavo*; black birds Icteridae; and gulls Laridae). I later converted total numbers of waterfowl to total waterfowl-use-days (WUD) by adding the total number of waterfowl observed in a field during each season (fall and spring). WUD were standardized for field size by dividing total WUD by total field size (ha) prior to analysis.

2.3. STATISTICAL ANALYSIS

2.3.1 Waste corn availability

Prior to analysis the proportional change in waste corn abundance was calculated for each study field as follows:

$$\exp(\ln(a + \min) - \ln(b + \min)) - 1$$

where exp = the natural logarithm raised to the power specified in the parentheses, ln = the natural logarithm, a = spring waste corn mass, b = fall waste corn mass, and min = the minimum observed value for the sampling period for either a or b in the data set. The minimum value (a) in the data set was added as a constant to both a and b because the natural logarithm of zero is undefined.

Linear regression was used to determine the effect of harvester age on initial waste corn densities and percentage of initial waste corn density comprised of whole cobs. Multiple linear regression was used to evaluate the seasonal total and percent change in total waste corn abundance (Zar 1999). The following model was used for analysis:

$$y = \text{Period} + \text{DBS} + \text{Dist} + \text{FSize} + \text{WUD} + \text{OUD}$$

where Period is the sample year (2004/2005 and 2005/2006), DBS is the number of days between initial and final waste corn samples, Dist is the distance (m) between the study field and Lake Erie, FSize is the study field size (ha), WUD is waterfowl-use-days (WUD/ha), and OUD are other wildlife-use-days (OUD/ha). Harvester age (proxy for efficiency) was not included in either model because there was no significant relationship found between harvester age and waste corn densities (see below). Significance levels for all tests and comparisons (see below) were set at $p<0.05$.

2.3.2. Waste corn nutritional quality

Percent carbohydrate was the only variable used for analysis of waste corn nutritional quality as carbohydrates constitutes approximately 80% of the dry weight of corn (Alisauskas et al. 1988). Between season differences in nutritional quality of waste corn were assessed using one-way analysis of variance. Linear regression was used to determine if waste corn quality decreased to a higher degree in fields with initially high moisture content.

2.3.3. Terrestrial waterfowl surveys and field selection by field-feeding waterfowl

Between season differences in total density of field-feeding waterfowl was made using one-way analysis of variance. Linear regression was used to identify the relationship between waterfowl density and total availability of waste corn.

2.4. RESULTS

2.4.1. Changes in waste corn availability

Mean initial waste corn density in fall 2004 was 152.86 ± 15.24 kg/ha. Study fields averaged 15.85 ± 2.14 ha in size and had a mean total initial waste corn abundance of 730.9 ± 88.39 kg; 15% percent of fields were below the field selection threshold (60 kg/ha) for mallards (Baldassarre and Bolen 1984). Waste corn densities decreased by spring 2005 to 46.26 ± 9.26 kg/ha and final average waste corn abundance dropped to 276.43 ±72.28 kg; 37% of fields sampled were below the selection threshold for foraging mallards. Initial waste corn densities in fall 2005 averaged 224.39 ± 59.57 kg/ha and mean field size of 13.38 ± 1.49 ha averaged an initial total waste corn abundance of 846.65 ± 141.62 kg; 34% of fields sampled were below the selection threshold for mallards. Waste corn densities decreased by spring 2006 to 77.60 ± 22.47 kg/ha and waste corn abundance decreased to 419.88 ± 96.10 kg; 68% of fields were below the selection threshold for mallards (Baldassarre and Bolen 1984).

No relationship was found between harvester age (proxy for harvester efficiency) and post-harvest waste corn density in either year of study (combined 2004 harvesters $\beta = 0.17$, $p = 0.95$ and combined 2005 harvesters $\beta = 14.21$, $p = 0.17$). There was also no effect of harvester age on the percentage of total waste corn density comprised of whole cobs in fall 2005 (combined 2005 harvesters $\beta = 0.09$, $p = 0.91$).

The model used to assess sources of variation in absolute change in waste corn abundance was found to be significant ($R^2 = 0.29$, $F = 4.97$, $p < 0.001$). Other wildlife-use-days and FSize were the two factors that contributed most to changes in absolute waste corn density (Table 2.1). Days Between Samples, WUD, Period, and Dist did not contribute to absolute change in waste corn density (Table 2.1).

The model representing proportional change in waste corn abundance was also significant ($R^2 = 0.20$, $F = 2.92$, $p = 0.013$). Other wildlife-use-days contributed most to proportional change in waste corn (Table 2.1). Field size, Dist, WUD, DBS, and period did not contribute to proportional change in waste corn abundance (Table 2.1).

Only 2 fields underwent post-harvest plowing in fall 2004, and only one field was plowed in 2005. As a result, changes in density for both years were combined and these fields were removed from analysis of absolute and proportional change in waste corn abundance. A 97% decrease in initial waste corn density from 163.02 ± 65.67 kg/ha to 4.65 ± 1.38 kg/ha was observed for both years. One corn field in fall 2005 was disked post-harvest and initial waste corn density decreased 95% from 61.18 kg/ha to 2.74 kg/ha.

2.4.2. Changes in waste corn nutritional quality

Two fall (2004) samples and 5 spring (2005) samples did not undergo proximate analysis due to lack of permission to sample in fall and spring samples being below the 10 g minimum respectively. Two fall samples from 2005 and 7 spring samples from 2006 also were not analyzed due to delay of fall harvest (fields were not harvested until late January) and spring samples being below the 10 g minimum respectively.

There was a difference ($F = 10.84$, d.f. = 1, 64, $p = 0.002$) in nutritional quality (%

Table 2.1. Multiple linear regression models used for analysis of absolute and proportional change in waste corn abundance for fields studied near Long Point, Ontario.

Model	R^2	Variable	Std. Error	t	p
TChange	0.29	Period	137.33	-0.71	0.48
		Waterfowl use days	0.94	-1.13	0.26
		Other wildlife use days	0.59	-3.3	0.002*
		Days between samples	4.44	-1.18	0.24
		Distance from Lake Erie	0.04	-0.34	0.74
		Field size	5.59	-3.7	<0.001**
%Change	0.2	Period	0.08	-0.19	0.85
		Waterfowl use days	0.001	-1.24	0.22
		Other wildlife use days	0.00	-2.09	0.04*
		Days between samples	0.003	-0.91	0.36
		Distance from Lake Erie	0.00	1.34	0.18
		Field size	0.003	1.55	0.13

*p<0.05
**p<0.001

carbohydrate) between fall 2004 and spring 2005 waste corn samples as carbohydrate percentage dropped from 84.47 ± 0.44% to 81.55 ± 0.77 %. However, no difference ($F = 2.79$, d.f. = 1, 80, $p = 0.10$) was found between fall 2005 and spring 2006 when carbohydrate percentage decreased from 79.51 ± 0.51 % to 77.90 ± 0.83%. There was no relationship ($\beta = -0.13$ $p = 0.32$) between fall 2005 initial waste corn moisture content and spring 2006 final waste corn quality.

2.4.3. Waterfowl use of harvested corn fields

Total waterfowl-use-days per ha (WUD) increased significantly ($F = 26.88$, d.f. = 1, 82, $p < 0.001$) from 7.12 ± 2.24 WUD during fall 2004 to 50.72 ± 8.11 WUD in spring 2005. Fall 2005 waterfowl-use-days of 7.11 ± 2.76 WUD were not different ($F = 0.77$, d.f. = 1, 98, $p = 0.383$) from the spring 2006 value of 16.65 ± 10.54 WUD. No relationship was detected between initial waste corn abundance and WUD in either fall 2004 ($\beta = 0.002$, $p = 0.7$) or spring 2005 ($\beta = -0.001$, $p = 0.97$). A positive correlation ($\beta = 0.005$, $p = 0.009$) was detected between initial waste corn abundance and WUD in fall 2005 (Figure 2.2). This relationship was strongly influenced by one outlier (Figure 2.2), as no significant relationship occurs when the outlier is removed ($\beta = 0.001$, $p = 0.64$). No effect ($\beta = 0.001$, $p = 0.955$) of initial waste corn density on spring 2006 WUD was detected. A positive relationship between total change in waste corn abundance and initial waste corn abundance was found in 2004/2005 ($\beta = 0.49$, $p<0.001$), and 2005/2006 ($\beta = 0.69$, $p<0.001$; Figure 2.3).

2.5. DISCUSSION

2.5.1. Effect of harvester efficiency and post-harvest tillage on waste corn availability

Agricultural waste grains provide field-feeding waterfowl with energy required for migration and reproduction (Alisauskas and Ankney 1992, Baldassarre and Bolen

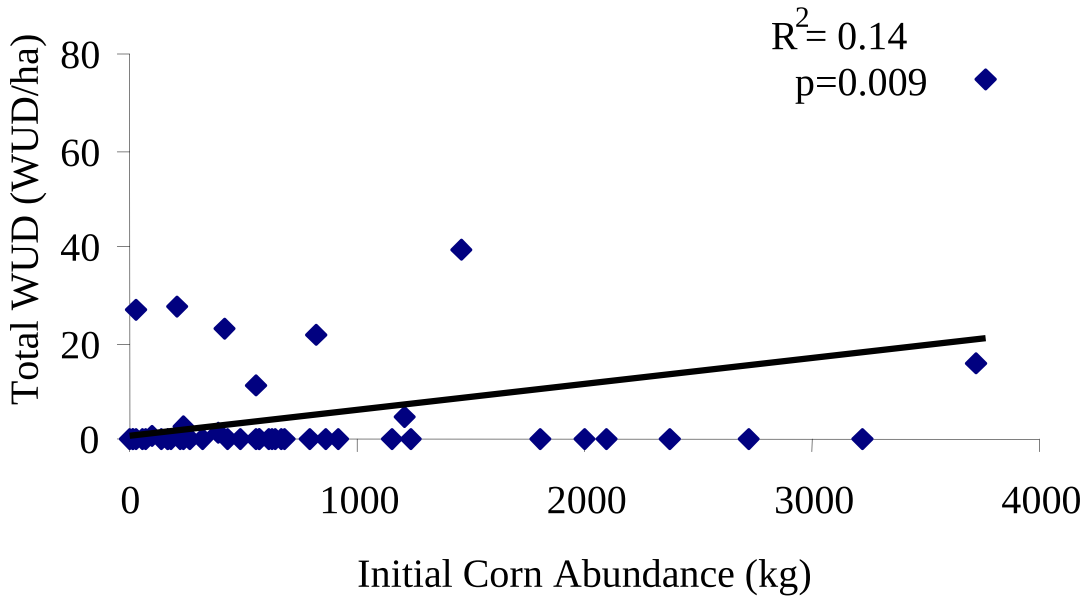
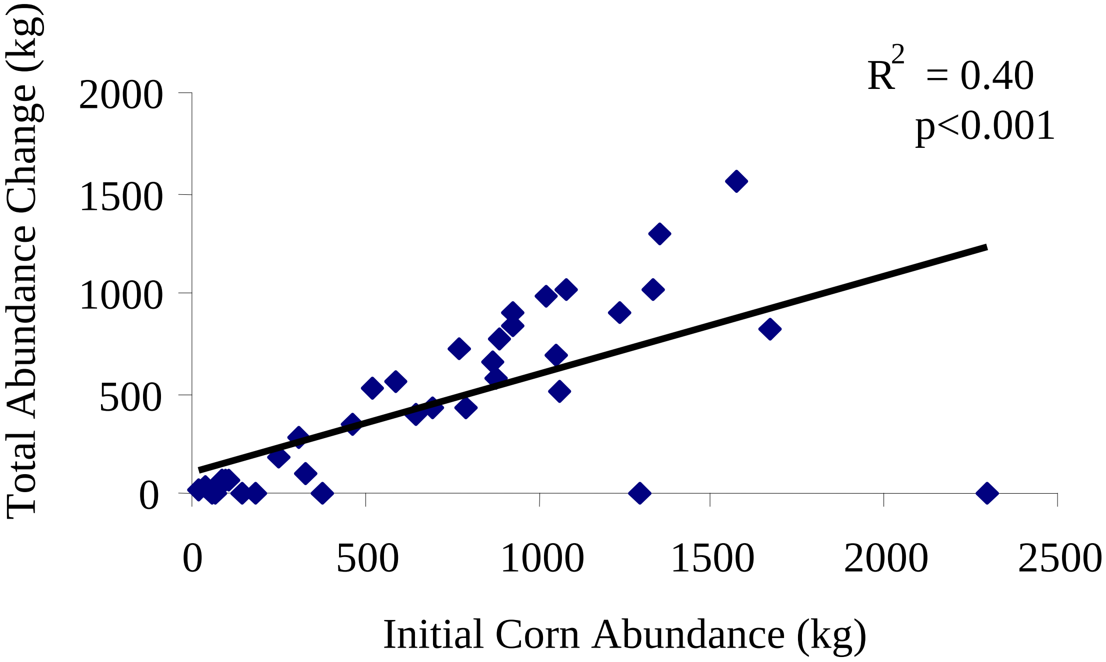
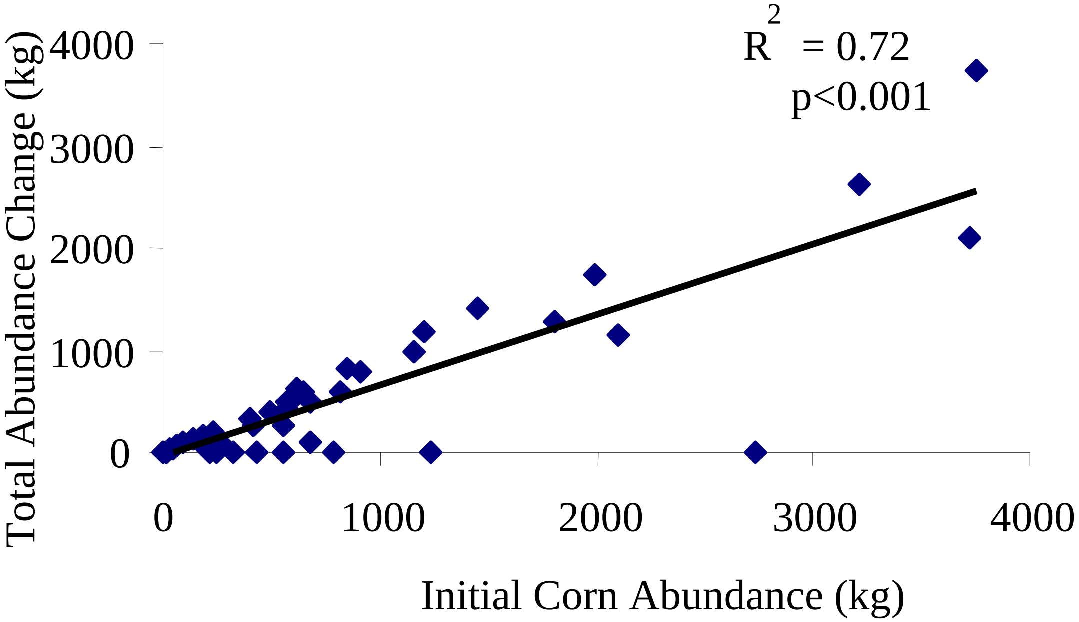


Figure 2.2. Correlation between initial fall 2005 waste corn abundance and total fall 2005 waterfowl-use-days (WUD) in cornfields near Long Point, Ontario.



a)



b)

Figure 2.3. Correlation between initial corn abundance and total abundance change during the (a) 2004/2005 and (b) 2005/2006 field seasons for fields studied near Long Point, Ontario.

1994). Possible limitations on food availability for field-feeding waterfowl due to long-term declines in waste grain availability have been identified (Krapu et al. 2004). Declines in waste grain densities have been attributed to increases in harvester efficiency rates over the last 20 years (Krapu et al. 2004). Initial waste corn densities in this study were comparable to those observed in other studies (Table 2.2; Baldassarre and Bolen 1984, Warner et al. 1985, Krapu et al. 2004), but effect of harvester age (efficiency) was detected.

A minimum waste corn density of 60 kg/ha is required for field-feeding mallards to select a corn field to forage within and mallards will give up foraging in fields with waste corn densities below 20 kg/ha (Baldassarre and Bolen 1984). Studies have also shown that waterfowl will forage in fields until approximately 80% of the initial waste grain has been consumed (Baldassarre and Bolen 1987, Clark and Greenwood 1987). Fifteen percent of fields in fall 2004 and 34% of fields in fall 2005 were below the 60 kg/ha selection threshold for mallards (Baldassarre and Bolen 1984). There was a considerable decline in waste corn availability from fall to spring, as 74% of fields at the end of spring 2005 and 68% of fields at the end of spring 2006 were below the 60 kg/ha selection threshold for mallards (Baldassarre and Bolen 1984). Of fields depleted below the selection threshold, 21 (66%) in spring 2005 and 25 (74%) in spring 2006 were below the 20 kg/ha giving-up density for mallards (Baldassarre and Bolen 1984). Therefore, based on initial fall densities and depletion rates, waste corn availability in this study was similar to other mid-latitude staging areas and could be potentially limiting to field-feeding waterfowl staging at Long Point, particularly during spring.

Table 2.2. Study site comparison of initial corn densities (kg/ha; mean ± SE) and percent carbohydrates (percent; mean ± SE) of corn at harvest between southern Ontario, Texas, Nebraska, Illinois, Iowa, Missouri, and Kansas.

Study Area	Initial Corn Densities (kg/ha)	Corn Quality (% Carbohydrates)
Long Point (2004)	152.86 ± 15.24	84.47 ± 0.44
Long Point (2005)	224.39 ± 59.57	79.51 ± 0.51
Texas (1984)[1, 2]	358 ± 38	82.10
Nebraska (1978)[3]	333 (261, 424)*	N/A
Nebraska (1998)[3]	177 (134, 233)*	N/A
Illinois (1981)[4]	430.50 (304, 606.5)*	N/A
Illinois (1982)[4]	273.70 (127, 588.4)*	N/A
Iowa (1988)[5]	N/A	80.40
Missouri (1988)[5]	N/A	80.40
Kansa (1988)[5]	N/A	80.40

[1] Baldassarre and Bolen (1984)
[2] Baldassarre et al. (1983)
[3] Krapu et al. (2004)
[4] Warner et al. (1985)
[5] Alisauskas et al. (1988)
* values in parentheses represent the lower and upper 95% confidence limits

Both the absolute and proportional change in waste corn abundance was reduced by the density of “other wildlife” feeding in corn fields. Black birds, white-tailed deer, wild turkeys and raccoons (*Procyon lotor*) have all been reported to impact grain yield before harvest, but little information is available on how much waste grain these animals remove (Blackwell and Dolbeer 2001, Tefft et al. 2005). Most of the “other wildlife” recorded consisted of black birds, as flocks consisting of thousands were recorded feeding on waste corn near Long Point. Over the staging periods in fall and spring these flocks likely consumed substantial amounts of waste corn which contributed to decrease the abundance of waste corn in fields. Few wild turkeys, white-tailed deer and no raccoons were recorded feeding in corn fields, possibly due to foraging behavior and timing of surveys. Wild turkeys often feed in fields closely associated with wood lots. Clean farming practices at Long Point have reduced bush cover and hedge rows within the study area (Petrie 1998) may have reduced wild turkeys field-feeding in the region. Both white-tailed deer and raccoons are nocturnal foragers and this behavior likely limited the number seen during surveys. More research is needed to better understand the relative importance of “other wildlife” and waterfowl to waste grain depletion rates.

Field size contributed significantly to waste corn abundance, as well as to absolute changes in waste corn abundance. Large corn fields had higher waste corn loss than smaller fields. This may be caused by larger fields having greater waste corn abundance and greater use of by waterfowl and other field-feeding wildlife compared to smaller corn fields. Newton and Campbell (1973) observed no relationship between waste grain availability and field use by geese in Scotland, concluding that physical attributes, such as field size, fields with close edges, and obstructions that reduced visibility were more important to feeding geese than food availability (Newton and Campbell 1973). Selection of large fields at Long Point was also possibly due to better visibility while feeding rather than high corn availability.

Effects of post-harvest tillage recorded at Long Point were comparable to studies conducted in Texas and Illinois (Baldassarre et al. 1983, Warner et al. 1985). Plowing and disking reduced waste corn density at Long Point by 97% and 95% respectively. Effects of plowing and disking observed in Texas and Illinois showed decreases in waste corn density by 99% and 90% respectively (Baldassarre et al. 1983, Warner et al. 1985). The lack of fields on the study area under such treatments (5% plowed in 2004, 2% plowed and 2% disked in 2005) undoubtedly increased the amount of waste corn available to field-feeding waterfowl. Between 1991 and 2006, no-till farming acreage in southern Ontario increased from 101,175 ha to 1.1 million ha (Statistics Canada 2006), and consequently has increased the amount of waste corn available to staging waterfowl and has likely increased or maintained the carrying capacity of southern Ontario staging areas. However, regional application of no-till farming in Ontario is variable. Long Point might be a “best-case scenario” as other regions throughout Ontario have limited application of no-till farming, potentially limiting the carrying capacity of those staging areas.

2.5.2. Effect of fall corn moisture content on spring nutritional quality

The percent carbohydrate content of fall collected waste corn was similar to that in other studies in North America (Table 2.2). Although only significant during 2004/2005, carbohydrate content decreased during both years of study (2004/2005 = 6.3%, 2005/2006 = 2.0%). Baldassarre et al. (1983) and Warner et al. (1989) did not identify a change in the carbohydrate content of waste corn throughout winter. However, Warner et al. (1989) did identify more variable carbohydrate levels in spring than fall waste corn. Harvest during fall 2004 occurred during much cooler and wetter conditions than fall 2005, and possibly led to the significant decrease in percent carbohydrates. Although I did identify a decline in carbohydrate content during winter, this is likely not as important a variable to field-feeding waterfowl as waste corn depletion.

2.5.3. Effect of waste corn abundance on waterfowl field use

The lack of relationship between WUD and the absolute or proportional change in waste corn abundance is surprising. Possible explanations to describe this result are numbers of waterfowl field-feeding at Long Point are currently not at a density high enough to contribute substantially to corn losses or that “other wildlife” have a stronger influence than waterfowl. Increasing field-feeding waterfowl populations and the increased frequency of shortstopping in the LGL could, in the future result in waterfowl having a greater influence on depletion of waste corn abundance.

The relationship between initial waste corn abundance and fall and spring waterfowl field use was highly variable. The significant relationship found in fall 2005 between initial waste corn abundance and WUD was influenced strongly by one outlier. There were numerous corn “spills” throughout this field and random sampling points fell on several of these spills. The large initial abundance and resulting WUD relationship had large leverage on the overall relationship. When this field was removed from analysis, no relationship was found. A positive correlation was detected between the total change in waste corn abundance and initial waste corn abundance in both study years. Larger total changes in abundance of waste corn in fields with high initial abundance suggest that fields with high initial abundance experience greater loss than fields with initially low abundance. This suggests that waterfowl and “other wildlife” probably select corn fields with high initial abundance over fields with initially low corn abundance.

Baldassarre and Bolen (1984) observed an abundance-availability hierarchy for field use of field-feeding waterfowl on the Southern High Plains of Texas. This selection pattern suggested that waterfowl used fields that had high abundance of waste corn (absolute amount of waste corn in a field) or fields with high availability of waste corn (amount of waste corn accessible) depending on which type of field was more prevalent in an area (Baldassarre and Bolen 1984). Field use in this study appears to be based on waste corn abundance (absolute amount of waste corn in fields) because there was little variation in waste corn accessibility due to little post-harvest tillage (5% of fields in 2004 and 4% of fields in 2005) and any environmental factors (i.e. snow cover) effecting corn accessibility would have been consistent over the entire study area.

Attempts to determine carrying capacities of major staging areas for water birds have been made (Alonso et al. 1994), but not at Long Point. If the average initial waste corn density determined for the study period was extrapolated to the approximate total acreage of waste corn in the study area, there would be approximately 1.9×10^9 kJ of energy available to staging waterfowl. If the same calculation was determined for average final spring waste corn densities there would be approximately 6.3×10^8 kJ of energy still available after staging waterfowl had left the area. The estimated daily energy requirement for a mallard is 1221 kJ (Drilling et al. 2002). If we assume that mallards staging at Long Point obtained their daily energy requirement completely from waste corn, then the amount of energy available in waste corn fields during the fall would provide 1.5 million duck-use-days of energy (i.e. 1.5 million mallards could find enough energy for 1 day). Left over spring waste corn would provide 515,873 additional duck-use-days of energy. The average peak number of mallards staging at Long Point in the fall during the study period was 12,215 and 1,806 mallards staged during spring (S. A. Petrie, Long Point Waterfowl & Wetlands Research Fund, unpublished data). Waste corn energy available at Long Point could support peak fall mallard populations for 127 days and remaining spring waste corn energy could continue to support staging mallards for an additional 285 days. These calculations suggest that waste corn is not currently at levels limiting the carrying capacity of the area for mallards. However, thousands of other field-feeding waterfowl (e.g. tundra swans and Canada geese), as well as “other wildlife” use waste corn to meet energetic demands and their foraging could contribute to depleting waste corn levels close to, or below the carrying capacity. This carrying capacity calculation is also an over estimate, as many of the fields in the study area were not used by field-feeding waterfowl (too small). If waste corn at Long Point is near or below carrying capacity, field-feeding waterfowl must acquire a proportion of their daily energy requirement from aquatic food sources, or make longer flights to feed in corn fields outside of the Norfolk clay plain.

2.5.4. MANAGEMENT IMPLICATIONS

Increases in the application of no – and conservation-tillage have substantially increased the capacity of the LGL to support staging and wintering waterfowl. However, waste corn appears to be potentially limiting at Long Point and possibly elsewhere throughout Ontario and the LGL. Further, continued increases in field-feeding waterfowl populations and other wildlife may result in a decreased carrying capacity for staging waterfowl in the future. Based on this, and the overall importance of waste corn to wildlife, managers should continue to promote no – and conservation-tillage farming in areas where post-harvest tillage practices are currently not being applied or in areas where corn acreage is declining. Ethanol production and volatile commodity markets could also impact corn production. Managers need to be aware of changing demands and markets for corn as commodity prices can substantially influence corn production.

2.6. LITURATURE CITED

Alisauskas, R. T., and C. D. Ankney. 1992. Spring habitat use and diets of midcontinent adult lesser snow geese. Journal of Wildlife Management 56:43-54.

Alisauskas, R. T., C. D. Ankney, and E. E. Klass. 1988. Winter diets and nutrition of midcontinental lesser snow geese. Journal of Wildlife Management 52:403-414.

Alonso, J. C., J. A. Alonso, and L. M. Bautista. 1994. Carrying capacity of staging areas and facultative migration extension in common cranes. Journal of Applied Ecology 31:212-222.

Ankney, C. D. 1984. Nutrient reserve dynamics of breeding and molting brant. Auk 101:361-370.

Baldassarre, G. A., and E. G. Bolen. 1984. Field-feeding ecology of waterfowl wintering on the Southern High Plains of Texas. Journal of Wildlife Management 48:63-71.

Baldassarre, G. A., and E. G. Bolen. 1987. Management of waste corn for waterfowl wintering on the Texas High Plains. Department of Range and Wildlife Management Management Note 13, Lubbock, Texas, USA.

Baldassarre, G. A., and E. G. Bolen. 1994. Waterfowl ecology and management. John Wiley & Sons, New York, New York, USA.

Baldassarre, G. A., R. J. White, E. J. Quinlan, and E. G. Bolen. 1983. Dynamics and quality of waste corn available to postbreeding waterfowl in Texas. Wildlife Society Bulletin 11:25-31.

Bellrose, F. C. 1976. Ducks geese and swans of North America. Stackpole Books, Harrisburg, Pennsylvania, USA.

Blackwell, B. F., and R. A. Dolbeer. 2001. Decline of the red-winged blackbird population in Ohio correlated to change in agriculture (1965 – 1996). Journal of Wildlife Management 65:661-667.

Bookout, T. A., T. K. Bednarik, and R. Kroll. 1989. The Great Lake marshes. Pages 131-156 i*n* L. M. Smith, R. L. Pederson and R. M. Kaminski, editor. Habitat Management for Migrating and Wintering Waterfowl in North America. R.M. Lubbock, Texas and Texas Tech University Press.

Clark, R. G., and H. Greenwood. 1987. A circular “ring-angel” movement by field-feeding waterfowl. Wilson Bulletin 99:722-723.

Davis, S. E., E. E. Klass, and K. J. Koehler. 1989. Diurnal time-activity budgets and habitat use of lesser snow geese *Anser caerulescens* in the middle Missouri River valley during winter and spring. Wildfowl 40: 45-54.

Drilling, N., R. Titman, and F. McKinney. 2002. Mallard (*Anas platyrhynchos*). No. 658 *in* A. Poole and F. Gill, editor The Birds of North America. Cornell Lab of Ornithology, Ithaca, New York, USA.

Harmon, B. G., D. E. Becker, A. H. Jensen, and D. H. Baker. 1969. Nutrient composition of corn and soybean meal. Journal of Animal Science 28:

Heathcote, I. W. 1981. Major physical features of Long Point Bay and its watershed. Journal of Great Lakes Research 7:89-95.

Krapu, G. L., D. A. Brandt, and R. R., Jr. Cox. 2004. Less waste corn, more land in soybeans, and the switch to genetically modified crops: trends with important implications for wildlife management. Wildlife Society Bulletin 32:127-136.

LeBlanc, A., D. J. Dudek, and L. F. Allegretti. 1991. Disappearing ducks: the effect of climate change on North Dakota’s waterfowl. Environmental Defense Fund. New York, New York, USA.

Newton, I., and C. R. G. Campbell. 1973. Feeding of geese on farmland in East-Central Scotland. Journal of Applied Ecology 10:781-801.

Pederson, R. L., D. G. Jorde, and S. G. Simpson. 1989. Northern Great Plains. Pages 281-310 i*n* Smith, L. M., R. L. Pederson, and R. M. Kaminski, editor. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press Lubbock, Texas, USA.

Petrie, S. A. 1998. Waterfowl and wetlands of Long Point and Old Norfolk County: present conditions and future options for conservation. Unpublished Norfolk Land Stewardship Council Report. Long Point Waterfowl and Wetlands Research Fund, Port Rowan, Ontario. 182 pp.

Petrie, S. A., S. S. Badzinski, and K. L. Wilcox. 2002. Population trends and habitat use of tundra swans staging at Long Point, Lake Erie. Waterbirds 25:143-149.

Prince, H. H., P. I. Padding, and R. W. Knapton. 1992. Waterfowl use of the Laurentian Great Lakes. Journal of Great Lakes Research 18:673-699.

Richardson, D. M., and R. M. Kaminski. 1992. Diet restriction, diet quality, and prebasic molt in female mallards. Journal of Wildlife Management 56:531-539.

Statistics Canada. 2006. 2006 Census of agriculture. Statistics Canada, Ottawa, ON., Canada.

Stroud, D. A., G. P. Mudge, and M. W. Pienkowski. 1990. Protecting internationally significant bird sites: a review of the EEC special protection area network in Great Britain. Nature Conservancy, Northminster House, Peterborough, U.K.

Tefft, B. C., M. A. Gregonis, and R. E. Eriksen. 2005. Assessment of crop depredation by wild turkeys in the United States and Ontario, Canada. Wildlife Society Bulletin 33:590-595.

Thompson, S. C., and D. G. Raveling. 1987. Incubation behavior of emperor geese compared with other geese: interactions of predation, body size and energetics. Auk 104:707-716.

Warner, R. E., S. P. Havera, and L. M. David. 1985. Effects of autumn tillage systems on corn and soybean harvest residues in Illinois. Journal of Wildlife Management 49:185-190.

Warner, R. E., S. P. Havera, L. M. David, and R. J. Siemers. 1989. Seasonal abundance of waste corn and soybeans in Illinois. Journal of Wildlife Management 53:142-148.

Zar, J. H. 1999. Biostatistical analysis. Fourth edition. Prentice Hall, Upper Saddle River, New Jersey, USA.

CHAPTER 3. GENERAL DISCUSSION

3.1. DISCUSSION

On a continental scale, waste grain availability can influence field-feeding waterfowl populations. For instance, waste grain has become a primary food source for numerous populations of waterfowl and directly influences survival and reproduction (McLandress and Raveling 1981, Jorde et al. 1983, Krapu et al. 2004). Waterfowl tend to winter and stage in concentrated areas (e.g. Long Point, Ontario and Central Platte River Valley, Nebraska; Petrie 1998, Krapu et al. 2004), and the availability of waste grains on these areas determines how much fat field-feeding waterfowl can acquire before migration and reproduction (Krapu et al. 2004). Decreases in waste grain availability has resulted in decreased fat acquisition in staging waterfowl (Krapu et al. 2004), which could limit reproductive output (Anteau and Afton 2004), and ultimately impact North American waterfowl populations.

Government subsidies and commodity prices can influence long-term trends in amount of waste grains remaining after harvest (Pederson et al. 1989) in part due to crop selection. For example, soybean production in the Midwest and Great Plains increased six fold during the last 50 years and represented 22% of the total cropland area during 2002 in the United States (United States Department of Agriculture 2002). Soybeans are not used by spring field-feeding waterfowl (Krapu et al. 2004) and shifting acreage away from corn can negatively impacts field-feeding waterfowl. The influence of government subsidies and commodity prices combined with decreases in waste corn availability on other northern staging areas (Krapu et al. 2004) have raised concern with managers over the future opportunities for field-feeding waterfowl to find adequate food resources. The increased production of biofuels may offset some of these concerns.

Biofuels have been suggested as a potential supplement or possible replacement to fossil fuels (Avery 2006, Nash 2007). Recently, increase demand for biofuels has more than doubled the price of corn, resulting in increased corn acreage planted throughout much of North America (Avery 2006). No doubt this increase in corn acreage has greatly increased food availability for field-feeding waterfowl, potentially increasing carrying capacities of major North American staging and wintering areas. Although there are obvious nutritional benefits for waterfowl, there are potential drawbacks that include, loss of breeding, wintering and staging habitat as a result of land clearing for biofuel production (Avery 2006, Nash 2007).

Global supply and demand for grain is the driving force behind the anthropogenic provision of food resources for waterfowl. Currently, supply to meet global demand is in question (Trostle 2008). As global human populations continue to increase, demand for grains for direct consumption (e.g. cereal grains), food production (livestock feed), and continued pressure for biofuels will continue to inflate commodity prices (Trostle 2008). These trends should ensure continued production of grains, making waste available to field-feeding waterfowl. However, costs of production are continually increasing (Trostle 2008) and there is potential for grain producers to switch to more profitable crops in the future, which may not provide a food resource to waterfowl. Krapu et al. (2004) discussed the switch in Nebraska from corn to soybean production and the negative effect it has had on field-feeding waterfowl. Waterfowl may be able to adjust to crop changes at a regional level (e.g. switch from corn to soybeans in Nebraska). However, if major staging and wintering areas were to suddenly switch to unsuitable crop types for waterfowl (e.g. California's Central Valley and the Mississippi Alluvial Valley switching from rice production to sugar cane) negative impacts on field-feeding waterfowl would occur. On regional scales, the potential for long-term waste grain availability for field-feeding waterfowl is uncertain. There will always be demand for cereal grain production, although the amount and type of grain produced may not benefit field-feeding waterfowl and the future food availability for continental waterfowl populations is unknown.

3.2. FUTURE RESEARCH

Results from this study have identified needs for future research that will advance our understanding of the dynamics of post-harvest waste corn. Krapu et al. (2004) have shown that there was a considerable decrease in waste corn availability over the past 20 years and attributed this decrease to greater harvester efficiency rates. Both environmental and mechanical factors can affect how much corn is left behind after harvest. Additional research into these factors in northern staging regions may help to answer questions about projected increases in harvester efficiency rates and their effect on waste corn availability to field-feeding waterfowl. Further research is required to better understand annual and regional variation in waste corn availability and how availability is influenced by physical factors (e.g. corn stock height, root strength and parasite load). Additional study is also required to further increase our knowledge of waste corn depletion rates by non-waterfowl wildlife, as they have been found to influence depletion rates more than field-feeding waterfowl.

Further research is needed also to identify the relationship between increased winter temperatures and changes in waste corn nutritional quality. Predicted increases in global temperature (Alexiadis 2007) could cause long-term declines in waste corn nutritional quality. Long-term research on changes in global temperature and changes in waste corn nutritional quality could provide insight into environmental impacts on waste corn and potential impacts on waterfowl.

3.3. OVERALL SUMMARY AND CONCLUSIONS

In conclusion, the results of this study supported some but not all of my predictions. I predicted that waste grain availability would decline between fall and spring and that fields would have waste corn densities below the giving up density (20 kg/ha) established for mallards. It was found that waste corn did decrease below the 20 kg/ha giving up density established for mallards in approximately half of fields studied. Secondly, it was predicted that newer harvesters would be more efficient and leave less waste corn available for staging waterfowl than older harvesters. I found that new and presumably more efficient harvesters did not leave less waste corn behind than did old harvesters. Thirdly, I predicted that there would be a decline in the nutritional quality (percent carbohydrates, protein, and fat) of post-harvest waste corn between fall and spring and that this decline would correlate with initial fall moisture level. A decrease in waste corn nutritional quality was found in both study years, but was only statistically significant in year one. Changes in waste corn quality did not relate to initial fall moisture levels as predicted. Lastly, the prediction that waterfowl use of harvested fields would correlate positively with initial (early fall) waste corn abundance was not supported. Waterfowl were found to select fields primarily based on physical attributes (e.g. field size), and not initial fall waste corn abundance.

Little is known about the ecology of staging waterfowl (Arzel et al. 2006), or the availability of post-harvest waste grains in northern staging areas (Krapu et al. 2004). This study provided the first information on waste corn availability for waterfowl at staging areas in southern Ontario. Conservation – and no-tillage practices may provide opportunities for staging waterfowl to forage in fields with waste corn densities above selection thresholds, and could be the main factor behind increasing or maintaining carrying capacities on northern staging areas. Although no effect of harvester age (and presumably efficiency) was observed, future changes to mechanical harvester efficiency are likely to occur, as technology continues to advance.

Overall, waste corn is potentially limiting to staging waterfowl at Long Point and quite possibly at other northern staging areas. Managers should continue to promote no-till farming in areas where large concentrations of migrating waterfowl occur and consume waste corn. Conserving this food may offset loss of wetland foraging opportunities and is important in spring when energy from waste grain is of critical importance to reproduction in several species of field-feeding waterfowl. However, fluctuating grain prices and volatile commodity markets could lead to long-term unpredictability in waste grain availability for field-feeding waterfowl on northern staging areas.

3.4. LITERATURE CITED

Alexiadis, A. 2007. Global warming and human activity: a model for stydying the potential instability of the carbon dioxide/temperature feedback mechanism. Ecological Modeling 203:243-256.

Anteau, M. J., and A. D. Afton. 2004. Nutrient reserves of lesser scaup (*Aythya affinis*) during spoirng migration in the Mississippi Flyway: a test of the spring condition hypothesis. Auk 121:917-929.

Arzel, C., J. Elmberg, and M. Guillemain. 2006. Ecology of spring-migrating Anatidae: a review. Journal of Ornithology 147:167-184.

Avery, D. 2006. Biofuels, food, or wildlife? The massive land costs of U.S. ethanol. Competitive Enterprise Institute No. 5.

Jorde, D. G., G. L. Krapu, and R. D. Crawford. 1983. Feeding ecology of mallards wintering in Nebraska. Journal of Wildlife Management 47:1044-1053.

Krapu, G. L., D. A. Brandt, and R. R., Jr. Cox. 2004. Less waste corn, more land in soybeans, and the switch to genetically modified crops: trends with important implications for wildlife management. Wildlife Society Bulletin 32:127-136.

McLandress, M. R., and D. G. Raveling. 1981. Changes in diet and body composition of Canada geese before spring migration. Auk 98:65-79.

Nash, S. 2007. Decrypting biofuel scenarios. An energy-food-environment maelstrom, and a prairie plan. BioScience 57:472-477.

Pederson, R. L., D. G. Jorde, and S. G. Simpson. 1989. Northern Great Plains. Pages 281-310 i*n* Smith, L. M., R. L. Pederson, and R. M. Kaminski, editor. Habitat management for migrating and wintering waterfowl in North America. Texas Tech University Press Lubbock, Texas, USA.

Petrie, S. A. 1998. Waterfowl and wetlands of Long Point and Old Norfolk County: present conditions and future options for conservation. Unpublished Norfolk Land Stewardship Council Report. Long Point Waterfowl and Wetlands Research Fund, Port Rowan, Ontario. 182 pp.

Trostle, R. 2008. Global agricultural supply and demand: factors contributing to the recent increase in food commodity prices. United States Department of Agriculture WRS-0801.

United States Department of Agriculture. 1950-2002. Agricultural statistics. National Agricultural Statistics Research Service, Washington, D. C., USA.

VITA

Name:	Edward Sydney Barney
Place of birth:	Etobicoke, Ontario, Canada
Post-secondary Education and Degrees:	The University of Western Ontario London, Ontario, Canada 2004-2008 M.Sc., Zoology
	University of Guelph Guelph, Ontario, Canada 2000-2004 B.Sc. Biology – Wildlife Biology
Honours and Awards:	Delta Waterfowl Foundation Student Research Grant 2005 ($6,500)
	The University of Western Ontario Special University Scholarship 2005-2006
Related Work Experience:	Biologist Long Point Waterfowl and Wetlands Research Fund 2006-Present
	Course Instructor of Wetland and Waterbird Ecology The University of Western Ontario 2006- Present (summer field course)
	Course Assistant of Wildlife Ecology and Management The University of Western Ontario 2007 - Present (winter term)
	Course Instructor of Animal Ecology The University of Western Ontario 2008 (winter term)
	Teaching Assistant of Wildlife Ecology and Management, Wetland and Waterbird Ecology, Scientific Methods in Biology, and Introductory Biology The University of Western Ontario 2004-2006
	Waterfowl Research Assistant Canadian Wildlife Service 2002 and 2003 (summer)

Costal Wetlands Ecologist
Ontario Ministry of Natural Resources
1999-2001 (summer)

Presented Papers:

Barney, T., and S. A. Petrie. 2006. Changes in availability and nutritional quality of post harvest waste corn for staging waterfowl near Long Point, Lake Erie. Fourth North American Duck Symposium, Bismarck, North Dakota.

Barney, T., and S. A. Petrie. 2005. Changes in availability and nutritional quality of post harvest waste corn for staging waterfowl near Long Point, Lake Erie. Delta Waterfowl Foundation Student Symposium, Delta Marsh, Manitoba.

Barney, T., and S. A. Petrie. 2005. Changes in availability and nutritional quality of waste grain for staging waterfowl near Long Point, Lake Erie. Environmental Research Western Colloquium, London, Ontario.

Barney, T., and S. A. Petrie. 2005. Changes in availability and nutritional quality of waste grain for staging waterfowl near Long Point, Lake Erie. Sixth Biennial Institute for Wetland and Waterfowl Research Student and Staff Symposium, Oak Hammock Marsh, Manitoba.

Barney, T., and T. D. Nudds. 2004. Grain yield and patch use: predicting foraging of Canada geese from corn yield. Great Lakes Waterfowl Symposium, London, Ontario.

Publications, Dissertations, and Theses:

Barney, E. S. 2008. Change in availability and nutritional quality of post-harvest waste corn on waterfowl staging areas near Long Point, Ontario. Unpublished M.Sc. thesis, The University of Western Ontario, London.