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Hubert A. Allen Jr.
Johns Hopkins School of Public Health, Baltimore, MD

David Sammons
University of Maryland, College Park, MD

Russell Brinsfield
Wye Research and Education Center, Queenstown, MD

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THE EFFECTS OF CANADA GOOSE GRAZING ON WINTER WHEAT: AN EXPERIMENTAL APPROACH

by Hubert A. Allen Jr. [1]
David Sammons [2]
Russell Brinsfield [3]
Roland Limpert [4]

Abstract: The effects of grazing winter wheat (Triticum aestivum) by Canada geese (Branta canadensis) was assessed in 3 fields during 2 years of experimentation at the Wye Research and Education Center, Queenstown, Maryland. Randomly placed wire enclosures prevented goose grazing on 11.1 m sq. control plots. Grazed plots were marked in each field soon after the geese migrated in March. Grazed plots had consistently lower yields than ungrazed plots with mean differences ranging from 0-13%. The differences were related to the intensity of grazing. Other parameters, including mean weight per seed, mean number of seeds per spike, mean number of spikes per plot, mean plant height and head date, were also measured. Statistically significant differences were found for many of these variables between grazed and ungrazed plots. The estimates of yield reduction were probably conservative in that the presence of control exclosures may have discouraged goose use of experimental fields compared to other fields in the vicinity.

INTRODUCTION

There is a need to assess the economic consequences of the use of winter grain fields by migratory waterfowl on the Atlantic Coast. The impact by waterfowl on agricultural fields includes grazing, trampling and manuring. Three of the largest species of wintering waterfowl, the tundra swan (Cygnus columbianus columbianus), Canada goose and greater snow goose (Anser caerulescens atlantica) are now frequently observed in agricultural fields in this region. The Canada goose has been known to use agricultural fields since at least the early 1950's (Stewart, 1962). However, there has been a dramatic increase in the use of these fields by the other two species in the last 20 years. Stotts (1983) observed a mass movement of tundra swans into fields during the cold winter of 1969 and Munro (1981) documented extensive field use during the early 1970's. Today, tundra swans can be seen using agricultural fields from Pennsylvania to North Carolina. The greater snow goose acquired this habit only during the late 1970's (Perry, 1984). Flocks of 10,000 snow geese may now be seen in agricultural fields of the Eastern Shore of Maryland.

Many hypotheses have been put forth to explain this dramatic change in feeding behavior. Foremost is that pollution has decreased the productivity of the Chesapeake Bay to the point where some species of waterfowl have been forced to change age old patterns of migration and feeding habits. Other suggestions are that the birds are simply taking advantage of a readily available food supply. Whatever the reasons, field feeding behavior is now well established in these species.

The annual cycle of migratory waterfowl overlaps considerably with the growing of winter grains on Maryland's Eastern Shore. Waterfowl begin to arrive in September and are resident through March of the following spring. Winter grains are planted, germinate and become established during the fall. Once sprouted the growing grain becomes available as a food source to waterfowl. As winter sets in the plants become dormant. In early

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[1] Department of Biostatistics, The Johns Hopkins School of Public Health, 615 North Wolfe St., Baltimore, MD 21205

[2] Department of Agronomy, University of Maryland, College Park, MD 27042

[3] Wye Research and Education Center, Queenstown, MD 21658

[4] The Wildfowl Trust of North America, P.O. Box 519, Grasonville, MD 21638

spring growth resumes, and continues until harvest time in late June and early July.

To the farmer the most important effect of waterfowl's use of winter wheat fields is on yield. This directly influences profitability of a crop. Because the profit margin for a farmer may be only a few percentage points of the initial investment, estimates of losses due to grazing and trampling, if they occur, need to be precise. Other variables of interest to agricultural concerns include straw production, seed quality, and date of maturity.

This study has been concerned with developing an experimental approach towards making such estimates. Results from two years of research, conducted on the Eastern Shore of Maryland, using winter wheat are presented.

Financial support for this research was provided by the Easton Waterfowl Festival during both years, the University of Maryland Agricultural Research Station at the Wye Research and Education Center, Queenstown, Maryland and the Department of Agronomy at The University of Maryland, College Park. Special thanks goes to The Old Mill Company, Savage, Maryland whose little elves made it possible for the project to use an automatic seed counter the second year and to the Wildfowl Trust of North America which served as an outpost for doing research on the Eastern Shore.

METHODS

Study Area

The Wye Research and Education Center (WREC) is a field agricultural station of the University of Maryland, Agricultural Experiment Station and is located near Queenstown, Maryland in Queen Anne's County. This county is renowned for the abundance of wintering waterfowl because of its proximity to the Chesapeake Bay. The fields of the WREC are known feeding and loafing areas for thousands of Canada geese (Smith, 1982). Because of its proximity to the Wye River much of the goose pressure on these fields is probably due to a flock of about 10,000 Canada geese that roost on the Wye River. Neither tundra swans or snow geese frequent these fields.

Experimental Design

Basic techniques of agricultural and ecological research were used to formulate an experimental design that would be flexible enough to cope with the unpredictable behavior of wild Canada geese. The exclosure method was borrowed from ecology (Quammen, 1981), while variables of interest, and how to measure them, were derived from agronomic procedures used to compare the performance of various strains of winter wheat (Sammons, 1982). Exclosures were randomly located within a field to prevent wild geese from grazing certain areas. In order for the treatment to be affected it was necessary for wild geese to enter the field and graze only the wheat outside of the exclosures. Grazed plots were randomly located and marked after the geese left on spring migration. Data on several variables were collected at harvest time from the grazed and ungrazed plots.

Fields

Data were collected from a 0.8 ha field during the winter of 1982-1983 (field 1) and fields of 1.6 ha and 0.4 ha during the winter of 1983-1984. The 0.8 ha and the 0.4 ha fields were seeded in November of 1982 and 1983 respectively at a rate of 100.8 kg/ha. However, the 1.6 ha field was seeded in November 1983 at two different rates in an alternating strip pattern. Each strip was 0.4 ha. For simplicity this large field will be treated as two different fields designated field 2 and field 3. Field 2 was seeded at 100.8 kg/ha (single seeded) and field 3 was seeded at 201.6 kg/ha (double seeded). Originally each strip contained 20 control exclosures.

Beginning in late November 1983, field 4 (0.4 ha) was under intense grazing pressure and almost all of the above ground biomass had been removed by late January 1984. This field was not originally part of the experiment but the opportunity arose to include it in the study. Therefore in late January a set of exclosures were randomly placed in the field to serve as controls against further grazing that might occur during February and early March.

Plot Size

Each plot was 11.1 m sq and contained 12 rows of wheat. Each row of wheat was 2.4 m long. Exclosures were made of 30.5 cm high wire fencing with a 9.5 mm mesh and were erected as open topped rectangles (2.4 x 4.6 m). All control exclosures were placed in early December (except in field 4) just as the wheat germinated but before any grazing had occurred. After geese left in late March grazed plots were randomly located and the exclosures were removed from the control plots. At this time three corners of each control and grazed plot were marked with colored flags while a 3 m length of steel reinforcement bar marked the fourth corner. The metal poles were color coded to indicate grazed or ungrazed plots.

Grazing Intensity

Kahl and Samson (1984) found that the amount of biomass removed by geese was a more reasonable description of grazing intensity than the more commonly reported goose days even in the controlled situation of their captive goose grazing trials. Because much of the grazing done by geese in the fields of the WREC was done at night it was decided not to use goose days; instead, weekly inspections of each field were made throughout the winter. A qualitative assessment of the reduction in biomass was made after each major grazing bout.

Harvest

A plot combine (Hege model 125 B) was used to harvest each plot. Grain was bagged and then weighed within two days. A 100 g subsample was taken from each bag of seed at the time of weighing and oven dried at 40 degrees C for 36 hours in order to determine moisture content.

Data on the other variables of interest were collected during the three days prior to harvest. Height was measured as the average height of a randomly selected group of tillers in each plot. A spike subsample was taken by randomly selecting a single spike and cutting it as well as the 19 spikes immediately subsequent to it in the same row. This procedure avoids the tendency to select larger spikes when selecting a sample completely at 'random'. Spikes were threshed, seeds were counted and weighed, and the average number of seeds per spike was determined. In 1984 this sample was increased to 30 spikes.

During May 1984 plots were also scored for the date of first heading (50% of the plants having emerged spikes). By May the plants had recovered to such an extent that grazing effects were not obvious. Scoring was done by technicians who did not know which plots were grazed or ungrazed.

Analysis was done using ANOVA and multiple comparisons were made using Duncan's multiple range test.

RESULTS

Goose behavior on the fields of the WREC was observed frequently throughout both years of the experiment by the senior author and the staff of the WREC. During this time several other fields at the WREC were also planted in winter wheat so that visual comparisons could be made of grazing intensity. The consensus among observers was that the geese seemed reluctant to use the fields having exclosures, although other nearby wheat fields received extensive grazing pressure from the time plants sprouted, in late November, through February. During both years, the weekly inspection of fields early in the season revealed that geese had fed in neighboring harvested corn (*Zea mays*) fields up to and even extending a few meters into the experimental fields of wheat.

On the nights of 27 and 28 January 1983, under the full moon, geese grazed field 1 heavily. Inspection on 29 January found that wheat in the control plots stood approximately 7 cm high while the rest of the field had been clipped to <1 cm. There was little subsequent grazing of this field during that winter.

Fields 2 and 3 were alternating single and double seeded strips of wheat with 20 control exclosures in each strip. By late January 1984 evidence of grazing was noted only at the very fringes of this area. It was decided that the density of exclosures was keeping the geese from using the fields. Accordingly, the 40 exclosures from the middle two sections were removed on 30 January 1984. During the subsequent three weeks grazing occured in these fields. The middle two sections were heavily grazed while the available sections of the fields that contained exclosures were grazed less heavily. Control plots were not grazed. A simple scoring of 0, 1, or 2, indicating ungrazed (control), moderately grazed and heavily grazed, respectively, is used to code the intensity of grazing.

Harvest occurred during the first 10 days of July of each year. Twenty ungrazed and 10 grazed plots were harvested in 1983. There were two ungrazed plots to a block and analysis of this data was based on the randomized blocks design.

Twenty ungrazed and 10 grazed plots were harvested from the strips of fields 2 and 3 that contained control plots. The grazed plots in these sections were scored as moderately grazed. The ten plots harvested from each of the two center sections were scored as being heavily grazed. Analysis of the 1983-84 fields was based on a completely randomized design.

One difficulty prevented all the plots harvested in fields 2 and 3 from being used in the analysis. As it turned out many of the control plots in Field 2 and 3 suffered because some rows of wheat had been drilled too deep and never came up. Several analytical attempts were made to compensate for this but the ultimate solution adopted was to drop all plots where less than nine rows of the intended 12 survived. The values from the affected plots were not weighted for the lost rows. Results are presented in Table 1.

The date of heading is an indicator of plant maturity. This is often but not always correlated with the optimal date of harvest. Highly significant differences indicate that in heavily grazed plots maturity was delayed 8 days; even in the lightly grazed plots maturity was delayed 6 days.

A comparison of the moisture content between grazed and ungrazed plots showed no significant differences. When yields were adjusted for moisture content results were the same as reported above. Therefore unadjusted values of yield have been used in Table 1.

The effect of grazing on yield was highly significant in field 1 and marginally significant in field 2. In each case yield was reduced by goose grazing. In field 3, the double seeded field, the heavily grazed plots did not significantly differ in yield from controls. Although, in absolute terms, there was an increase in yield for heavily grazed plots.

There were also statistically significant differences in plant height in every field planted the second year. Ungrazed plants were taller than grazed plants. There was no significant difference in height for field 1.

The subsamples of spikes of wheat provide data for determining yield components. The following equation shows the relationship between yield of the plot and yield components measured by the subsample (equations 1),

$$\frac{\text{grams}}{\text{seed}} \times \frac{\text{seeds}}{\text{spike}} \times \frac{\text{spikes}}{\text{plot}} = \frac{\text{grams}}{\text{plot}}$$

Analysis of these variables found significant differences in at least one yield component for each field although the direction of the relationship was not consistent. For example, in field 1 the weight per seed was greater in the grazed plots while in field 2 it was the seeds of the ungrazed plots that were heavier. Seed weight in field 3 was not significantly affected by grazing. The number of seed per spike also followed this inconsistent pattern. In fields 1 and 3 grazed plots had more seeds per spike than ungrazed plots there was no difference at all in field 2. The last component

Table 1. Mean values of yield, components of yield, head date and plant height in four winter wheat fields grazed by Canada geese.

FIELD #	Level of Grazing	Number of Plots	Yield Per Plot (g/11.1 m sq)		Components of Yield						Head Date	Plant Height (meters)	
					Weight Per Seed (grams)		Seeds Per Spike		Spikes Per Plot				
		N	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE	$\bar{X}$	SE		$\bar{X}$	SE
1982-1983													
1	0	20	2095.61	(32.25)**	0.0296	(0.0004)a	22.78	(0.53)*	3139.4	(81.22)**	______	0.97	(0.0086)
	2	10	1841.89	(58.53)	0.0315	(0.0004)	24.47	(0.79)	2416.7	(118.97)	______	0.95	(0.0170)
1983-1984													
2	0	17	2413.17	(83.83)a	0.0314	(0.0004)**	27.27	(0.55)	2820.3	(93.17)	May 12**	1.09	(0.0094)**
	1	10	2342.83	(72.34)	0.0304	(0.0007)	27.77	(0.92)	2807.3	(131.29)	May 18	1.05	(0.0108)
	2	9	2146.03	(57.46)	0.0279	(0.0008)	27.59	(0.93)	2831.9	(149.08)	May 20	0.98	(0.0118)
3	0	14	2195.36	(61.34)	0.0302	(0.0003)	23.05	(0.95)**	3236.4	(187.51)a	May 12**	1.04	(0.0130)**
	1	9	2132.64	(43.19)	0.0291	(0.0003)	23.87	(1.05)	3137.5	(202.32)	May 18	0.99	(0.0197)
	2	10	2227.72	(71.62)	0.0294	(0.0005)	28.54	(1.00)	2660.5	(66.15)	May 19	0.92	(0.0161)
4	1	7	2762.67	(80.07)**	0.0332	(0.0003)**	29.10	(0.78)*	2871.7	(133.46)	May 11**	1.12	(0.0102)*
	2	7	2407.34	(60.34)	0.0313	(0.0004)	26.20	(0.80)	2947.1	(118.50)	May 17	1.07	(0.0140)

a $0.05<P<0.10$ * $p<0.05$ ** $p<0.01$

Level of grazing coded as: 0=control, 1=moderately grazed, 2=heavily grazed of yield, the number of spikes per plot, can be estimated by rearranging equation 1, as follows(equation 2),

(gm/plot) / (gm/seed x seeds/spike)
= spikes/plot

This estimate is a measure of the tillering ability of the plant. In field 1 ungrazed plots tillered more than grazed plots. This was also true in field 3 while field 2 showed no significant difference.

The results from field 4 were analyzed separately because that field contained no ungrazed controls. The comparisons from this field were between plots which had been heavily grazed through January and plots which received the same grazing pressure plus additional grazing in February and March, also heavy. The yield from the early grazed plots were significantly greater than the yield from the plots which were continuously grazed from November through early March (Table 1). Seed weight was also significantly greater in the early grazed plots. as was the number of seeds per spike. However, greater tillering occurred in the continuously grazed plots than in the early grazed plots.

DISCUSSION

Results from two years of experimentation with wild Canada geese at the WREC suggest that, in general, there will be a loss of yield for fields of winter wheat that have been heavily grazed even if this is due to only one major episode of grazing. The timing of grazing in these experiments was confined to late January through February. The magnitude of loss in yield in the four fields varied from 0-13%. The effect of grazing extended beyond a simple loss of yield to include a delay in maturity and a reduction in plant height at harvest. Yield components (the weight per seed, number of seeds per spike, and spikes per plot) were also affected by grazing, although this relationship was more complex and variable than the response of the other variables.

Yield differences can be explained by the pattern of change in the components of yield. For example, in field 1 grazed plots had slightly heavier seeds and more seeds per spike than ungrazed plants. This may partly be due to a compensatory response by grazed plants. However, tillering was also reduced in the grazed plots so that the sample of spikes may consist of main tillers rather than branch tillers. Main tillers would be expected to have larger heads with heavier seeds.

In field 4 the early grazed plots had both heavier seed and more numerous seeds per spike. There was no difference in tillering. The net result was that the plots which had only been grazed from November through January had a larger yield.

Observations of goose behavior at the WREC indicated that the presence of control exclosures probably reduced the amount of goose grazing pressure these fields received when compared to other fields without exclosures. Therefore the estimates made here are probably conservative.

No consistent conclusions have emerged from previous studies on the effects of waterfowl on growing winter grains. These studies can be divided into two types, experiments that used wild geese and those that used captive flocks. Considering the diverse geographical sites of these studies, the effects of weather, timing of grazing, different varieties of grain used, and different intensities of grazing the failure to pinpoint the response may not seem unexpected. However, many of these studies suffered from methodological problems and may not adequately have tested the hypothesis.

For example, a study similar to the one presented here was conducted by the Maryland Department of Natural Resources in 1981 (Hindman, 1981). They selected a field that had been grazed by wild Canada geese and used a total of 40 plots, each 0.04 m sq. (0.0001 acres) in size, that were evenly divided between treatment and controls. No significant differences were found in yield. The report states that the sample size was too small to determine any significant differences. Strictly speaking it was not the number of plots that was inadequate but the plot size. Yield ranged from 21.4 g to 216.4 g. Also, exclosures were not put up until mid February, after some grazing had occurred.

In a study of the effects of grazing ryegrass by dusky Canada Geese (B.c. occidentalis), Clark and Jarvis (1978) found an increase in the yield of seed in two of eight fields, the rest showing no significant difference. Here again, plot size was small, 0.1 m sq, with yields ranging from 5.66 to 24.78 grams per plot. There was, however, a significant reduction in plant height for grazed plots in 7 of 10 fields. Stem density and percent cover did not vary by treatment.

During the early 1960's a series of experiments was undertaken by the Wildfowl Trust using a mixed flock of captive greylag geese (Anser anser) and pink-footed geese (Anser brachyrhynchus) (Kear, 1965). Plot size was larger than other studies reported (2.6 m x 9 m), and three replicates were made of grazing at several different times. Results showed no significant differences in the yield of wheat or straw production due to grazing. In this case it may be the small number of plots that prevents statistical significance since there was a consistent pattern of reduction for both yield and straw production in grazed plots.

The site at which our study was conducted is an area heavily used by Canada geese and one that has a history of farmer complaints of damage due to geese and other species of waterfowl. While this research would tend to substantiate these claims of yield reduction, it also points out the need for further research and better methods for estimating possible damage. Prior to 1980, Federal Crop Insurance had explicitly excluded coverage of damage done by migratory waterfowl (Ewing, 1983). Since then a new standard policy does not disqualify this source of loss to farmers. Thus a method of compensating farmers for their loss does exist today. However, losses of the magnitude documented here may be too small to allow coverage by standard actuarial procedures which use more general standards to estimate losses.

If many fields are available on a farm it may be better to focus waterfowl's use on one field, allowing heavy grazing pressure that will result in measurable losses, than to allow them to use many fields resulting in less pressure per field and an even, more subtle loss of yield.

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