Evaluating Goose Grazing on Grass-seed Production: Developing Methods

Final Report, March 2002

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Introduction

Prior to the early 1980s, goose use of fields in the Lower Columbia and Willamette Valleys was not considered by area farmers to be a significant problem. In fact, light or non-repeated grazing of grass-type crops has been shown to be beneficial in past studies and practice. Since the early 1980s, goose use of grass-seed fields has become progressively more intense in the winter and spring. For the Lower Columbia and Willamette Valleys, historical overwintering goose populations were estimated at 20,000-25,000. By the mid-1980s, goose numbers were estimated at approximately 50,000 and today the population in this region is estimated in excess of 250,000. Population increases have been at least partly due to hunting restrictions that were imposed to protect the Cackler and Dusky subspecies. A shift of wintering grounds by the Cackler subspecies from California to this region has been a major factor in the increased populations for this region.

As numbers of wintering geese have increased, there has also been an increase in the economic impact to area farmers. Winter wheat, clover, peas, carrots, lettuce, barley, grass seed crops, lawns and golf courses are impacted throughout the Lower Columbia and Willamette Valleys. Impacts have been in various forms including yield reductions, replanting costs, dockage, hazing practices, and additional entries for fertilizer and chemical applications and for harvest due to delayed maturity.

The initial study (Phase I) was conducted on Sauvie Island winter wheat fields. Our primary research objective was to develop reliable methods that farmers can use (or contract out) to document the impact of grazing use on wheat yield and quality. The combination of yield maps generated by the GPS-equipped combine and image processing of both ground and aerial photos proved to be accurate and reliable for assessing goose impact on yield and quality of wheat.

Phase II has been conducted in the mid-Willamette Valley in perennial ryegrass and tall fescue grass-seed fields. Our primary research objective for this study has been to evaluate and adjust methods that farmers can use (or contract out) to document the impact of grazing use on grass seed yield. Methods to be evaluated and adjusted were initially developed for winter wheat during Phase I of the project. We have also estimated goose impact on grass-seed yield on specific fields during the research period.

To accomplish these objectives, we tested and modified several methods over the two years of the study. Methods included:

(1) GPS equipped commercial combines that provided yield maps of portions of five fields in 2000 and five fields again in 2001. Two of the fields used in 2001 replaced two fields sampled during 2000 and the three remaining fields were sampled again.

(2) Aerial photos were taken of large portions of fields, including paired exclosures and grazed plots used as reference areas.

(3) Fixed-height, ground-level photos (within paired plots and along transects) were taken to ground-truth aerial photos and to document whether or not geese had been grazing an area. Along with ground-level photos, we measured plant height and counted goose droppings when present. These photographs were converted to digital format and plant ground-cover (foliar) was measured.

The combination of seed-yield data generated by the yield-mapping-system equipped combine and image processing of photographs appears to be accurate and reliable for assessing goose impact on grass-seed yield. Aerial photography was not as effective for grass-seed fields as it had been for winter wheat for identifying areas of fields being grazed. Winter wheat started growth and produced more leaf area visible from the air earlier than did perennial ryegrass or tall fescue. It was the end of March before the grass-seed fields produced enough leaf area to show up on aerial photographs. Platform photography from about 6-feet height above ground, combined with measurements of plant height, counts of goose droppings (if present), and other documentation at each site, proved effective in documenting that goose grazing was or was not a factor for specified areas of fields.

Another major difference between winter wheat, Phase I, and grass seed, Phase II, was method of harvest. Winter wheat is harvested while standing, which provides a great deal of flexibility in maneuvering the combine through exclosures to obtain a measure of ungrazed yield. A grass-seed field is first swathed and allowed to dry before the yield-mapping-system equipped combine harvests the seed. It is still possible to make sure that swaths are included within areas that had been protected by exclosures, but it requires careful attention by the swather operators. After several days drying in windrows, the seed is harvested by combines.

If multiple combines are used in a field, and only some are equipped with yield-mapping systems, steps must be taken to ensure that the YMS equipped combines harvest the rows that run through exclosures. We used bicycle flags and paint to mark those rows. It occasionally resulted in a non-YMS equipped combine falling out of rotation until a YMS equipped combine was available to harvest a marked row.

Additional modifications may be needed, but we expect the research protocols and methods for documenting goose grazing impacts will apply to other grazing animals and other crops as well.

Methods

During September 1999, we mapped the perimeters of each of five fields included in year 1 of the study by using Global Positioning System (GPS) technology. One field was newly seeded perennial ryegrass (field Npr-00), and one was established perennial ryegrass (field Epr-00). One field was newly seeded tall fescue (field Ntf-00), two were established tall fescue (fields Etf-1-00 and Etf-2-00).

During September 2000, we again used GPS to map the perimeters of each of the five fields included in year 2 of the study. Two fields were established perennial ryegrass (fields Epr-1-01 and Epr-2-01), two were established tall fescue (Etf-1-01 and Etf-2-01), and one was newly seeded tall fescue (Ntf-01).

Three of the fields were included in both years: Npr-00 and Epr-1-01; Epr-00 and Epr-2-01; and Etf-1-00 and Etf-1-01.

Goose exclosures (6 m X 20 m) were placed in each of the fields during October 1999 and October 2000 (Table 1). In most of the fields, exclosures were placed so that all areas of a field had at least one exclosure. We attempted to place more exclosures in portions of fields where we expected more goose grazing activity. We waited until goose grazing had begun to place exclosures in field ntf-01 and concentrated exclosures in the area being grazed, so the entire field was not represented by exclosures.

We attempted to place exclosures to facilitate farming operations. Where feasible, we kept them along the same drill rows. This was intended to facilitate spraying, swathing, and harvesting activities. We attempted to keep enough distance between exclosures so that they would not interfere with geese landing in a field and would not create artificial barriers to normal movement (except within the exclosures themselves). Exclosures which were impacted by ponded water, or in which yield-mapping-system equipment was not functioning properly were excluded from yield analysis.

For the 1999-2000 field season, we conducted ground-level photography and data collection along transects within each field during 29 January – 4 February, 20 –23 March, and 24 – 29 April. We took aerial photographs from a camera mounted on a fixed-wing aircraft during December, January, March and April, while geese were present, and during July, between swathing and combining of the grass seed. In the newly seeded fields, grass had not yet grown sufficiently to show in the aerial photographs until March.

For the 2000-2001 field season, we conducted ground-level photography and data collection along transects within each field during the periods of 2-14 February, 19 – 30 March, and 17 April – 1 May.

Based on prior year results, we determined that aerial photographs were not particularly useful through the growing season until about the end of March. We elected to contract for one flight of higher-level photography with a camera designed for that purpose. We obtained high-quality aerial photographs of the study fields on April 24.

Ground level photographs along transects across the fields were taken to identify where grazing had been occurring, where flooding was a factor, and to detect any other potential impact. Other ground level photographs were taken of the paired exclosures and paired-plots that were subject to grazing. These corroborated grazing and flooding events throughout the growing season. The ground photos were taken of a 1 m X 1 m frame quadrat from a 1.8-m height. The camera was mounted on a bracket attached to the 1-m^2 quadrat to provide consistency.

Combines belonging to the grower were equipped with either John Deere® GreenStar® or Ag Leader® yield-mapping systems. These combines harvested major portions of the test fields and recorded real-time position, via Global Positioning Systems (GPS) technology, and grain yield.

Analysis

Yields within exclosures were compared to yields in paired plots subject to grazing (Table 2). One or more grazed plots were paired with each exclosure for comparison, depending on grazing pattern. An exclosure could serve as an ungrazed reference for nearby areas that were subjected to grazing during different periods. For analysis, exclosures and their paired plots were grouped according to when grazing occurred. For example, areas that were grazed through February, but not later, were grouped together; areas that were grazed through March, but not later, were grouped together; and areas that were grazed through April, but not later, were grouped together. For paired plots, analysis was by paired t-test.

Yield-mapping results are also presented for entire areas grazed at different times (as described immediately above) or not grazed (Table 3). Areas ‘not grazed’ included exclosures and areas of fields in which no evidence was found that geese had been grazing. We are not reporting statistical analysis for these comparisons. Numbers of observations are sufficiently high that all differences would be statistically significant.

Results

Paired-Plot Comparisons

Timing of grazing differed by grass type and by year for the fields we used in this study. Perennial ryegrass was grazed into April during 2000 but only into March in 2001. Tall fescue was grazed into March during 2000 but only into February during 2001. Part of the difference was due to hazing strategy by the farm. Tall fescue was a more valuable crop and received greater hazing pressure, which relieved grazing pressure, especially during 2001.

For established perennial ryegrass, early grazing (January in 2001 and March both years) generated variable results (Table 2). In the area grazed through March 2000, a 31 lb/acre yield increase was recorded ($P = 0.006$). In the area grazed through mid-April 2000, the difference between two exclosures and their paired plots was not statistically significant. A sample size of two is too small given the variability within the field. During 2001, yield reductions of 126, 183, and 187 lb/acre were recorded for areas grazed through January, in March only, and through March, respectively.

For a newly seeded perennial ryegrass field (year 2000 only), grazing into March did not result in a statistically significant yield reduction. However, grazing through mid-April did result in a nearly 300 lb/acre yield reduction that was statistically significant (Table 2).

Tall fescue field Etf-1-00 (-01) (an established field harvested during both 2000 and 2001) was long and narrow and very patchy due to ponded water throughout its length. We did not have enough exclosures to sufficiently capture the grazing patterns and the extreme variability within the field. Paired-plot comparisons were not possible within this field in either year, even though we increased the number of exclosures for 2001.

Tall fescue field Etf-2-00 (a 2^{nd} year established field harvested during 2000) did suffer a yield reduction due to grazing both in parts grazed only in March (123 lb/acre) and in parts grazed through March (225 lb/acre)(Table 2). In tall fescue field Etf-2-01 (an established field harvested in 2001), we recorded a 71 lb/acre reduction due to grazing through February, but only at a statistical significance of $P=0.13$ (Table 2).

We evaluated our methods in two newly-seeded tall fescue fields, one each in 2000 (Ntf-00) and 2001 (Ntf-01). During 2000, very light grazing occurred during March only and no yield difference was recorded (Table 2). During 2001, grazing occurred through February only, but a yield reduction of 138 lb/acre was recorded (Table 2).

Area Comparisons

In our single newly-seeded perennial ryegrass field, grazing through January and March did not appear to reduce seed yield. Grazing through January, but not later, may have helped increase seed yield. Grazing through April reduced seed yield (Table 3).

Results for established perennial ryegrass fields varied between the two years. Grazing did not appear to impact seed yield on the field evaluated during 2000 (Table 3). Grazing reduced seed yield in the field evaluated during 2001 in parts of the field grazed through January, in March only, and through March (Table 3).

In the newly seeded tall fescue field for 2000, grazing through January may have helped seed yield, but grazing through March appears to have reduced seed yields (Table 3). In the newly seeded tall fescue field for 2001, the results are not as clear. Exclosures were placed within the grazed area of the field and grazing through February appears to have reduced seed yield when compared to the seed yield within the exclosures. However, the outside area of the field, which had no exclosures, was not grazed and had seed yields similar to the interior of the field, which was grazed through February. Exclosures around the outside of the field would have helped clarify the results. It is possible that seed production potential is lower around the outside areas of the field, but we can't know that for sure without the exclosures. Therefore, the results for that field are not conclusive.

Results for established tall fescue fields were somewhat variable. Grazing on Etf-1-00 does not appear to have influenced seed yield (Table 3). On field Etf-2-00, grazing through February may have helped seed yield. However, grazing during March only and during January through March reduced seed yield (Table 3). Grazing on Etf-1-01 through March may have helped tall fescue seed production in that field. Grazing through April in the same field reduced yields (Table 3). In the other 2001 established tall fescue field (Etf-2-01), grazing through February reduced seed yield (Table 3).

Summary and Conclusions

Documenting goose-grazing impacts on grass-seed fields in Phase II proved more difficult than for winter wheat fields in Phase I. Different harvest techniques, more within-field variability, and a perennial crop with both newly planted and already established fields resulted in more challenges for documenting potential grazing impacts on grass-seed fields than on wheat fields. We also encountered equipment failure during the second year of Phase II that we had not encountered in the prior 3 years of study. Yield-mapping-system failures and possible operator errors resulted in substantial amounts of lost data that, in some cases, limited our ability to evaluate grazing impacts on seed yields. However, even with the additional complexity and problems encountered during Phase II, compared to Phase I, we were still able to document seed-yield differences between ungrazed exclosures and their paired plots that had been grazed, and among areas of fields that received grazing through different times of the crop year.

Results of paired-plot comparisons varied; including several cases of no difference due to grazing, a single case of a yield increase attributable to grazing, and several cases of yield reductions due to grazing. Non-statistical analyses comparing entire areas (as opposed to fixed-plot size) of fields with different timing of grazing to exclosures and to field areas not grazed also yielded variable results. Results included no apparent difference, possible increased yields due to grazing, and yield reductions due to grazing. Yield reductions tended to be associated with periods of later grazing, but there were exceptions. The participating farm continued to haze geese as part of their normal operations to reduce the potential for excessive damage to the crop.

Both exclosures and photography are essential components of any method used to verify goose-grazing impacts. The exclosures were very effective in providing ungrazed areas as comparisons to the grazing impacts around them.

Aerial photography was not as useful for the grass-seed fields as it was for the wheat fields. The dramatic differences in aerial photographs of grazed wheat fields were not apparent in grass fields. Later and slower growth of newly seeded grass fields compared to wheat fields resulted in little to no visible vegetation in aerial photographs until about mid-March. In established grass fields, grazing could significantly reduce leaf biomass, but dramatic bare ground increase was not as apparent because the crowns of the established plants were still in place.

Ground-level photography provided verification of goose grazing activity when and where it was occurring. Ground level photography provided a visual record of grazing. Ground-level photographs allowed us to identify when the various fields were being grazed and to verify cause and effect.

The yield mapping system developed for commercial combines proved to be an effective method for obtaining yield data. We were able to obtain yields for entire areas of a field. The flagging option allowed us to document yields in specific areas that could be compared to yields in comparison areas. For example, we were able to compare yields from within exclosures to paired plots outside the exclosures by turning on the exclosure flag when entering and turning it off when exiting an exclosure. The yield-mapping system allowed us to actually census a field, or part of a field, rather than subsample it. The differences were actual differences not subject to sampling error. Thus, statistical analysis was not necessary to determine whether or not differences were real.

During the second year of Phase II, we lost data for an entire field because of an apparent malfunction of the yield-mapping-system equipment. Yields recorded by the yield-mapping system were about half the actual weight recorded when the seed was independently weighed out of the field. In another field, either the flagging option was not properly set or the operators did not use the flagging option for exclosures. Substantial additional work was required to identify exclosure data. Important lessons learned were that calibration of the yield-mapping system is important, independently weighing seed out of the field is important for verification of yield-mapping-system recorded data, and the flagging option must be correctly set and used to facilitate data extraction, especially for exclosures.

Global Positioning System (GPS) data allowed us to tie together data collected during the growing season to yield data at specific locations on the ground. A specific location with standing water or goose grazing impact from a photograph earlier in the year could be tied to the yield at that same location. GPS data allowed us to identify cause-and-effect relationships.

The combination of exclosures to serve as ungrazed controls, photography, yield-mapping-system data collection, and global positioning system (GPS) technology has proven very effective in quantifying seed yield differences due to grazing and verifying cause-and-effect relationships.

Acknowledgements

Phase II of the ‘Goose Depredation Study’ was funded through U.S. Fish and Wildlife Service (USFWS) cooperative agreement # 1448-10136-99-J002 with the Oregon Agricultural Legal Foundation (OALF). USFWS funding does not imply USFWS concurrence or endorsement of conclusions, recommendations, or products. OALF contracted with the Agricultural Research Foundation to conduct the project through the Department of Rangeland Resources, Oregon State University. The Department of Rangeland Resources thanks the cooperating farm for facilitating conduct of the project. The farm was an excellent cooperator throughout the duration of the project.

Table 1. Field area and number of exclosures by field.

Field*	Area Hectares (acres)	Number of exclosures
Npr-00	97 (240)	18
Epr-00	75 (186)	7
Etf-1-00	24 (59)	2
Ntf-00	17 (41)	6
Etf-2-00	35 (87)	10
Epr-1-01	97 (240)	15
Epr-2-01	75 (186)	10
Etf-1-01	24 (59)	5
Ntf-01	78 (193)	5
Etf-2-01	35 (87)	8

* Field identification is as follows: Npr = newly seeded perennial ryegrass; Epr = established perennial ryegrass; Ntf = newly seeded tall fescue; Etf = established tall fescue; -00 = harvested during 2000; -01 = harvested during 2001.

Table 2. Paired plot comparisons (one-tail t-test) between exclosures and grazed paired plots.

Field*	Grazed period	Exclosure		Paired Plot		P
		Yield (lb/ac)	n	Yield (lb/ac)	n	
	Perennial ryegrass – 2000 harvest					
Npr-00	Through March	1794	7	1766	7	0.32
	mid-April	1712	5	1427	5	0.01
Epr-00	Through March	1973	4	2104	4	0.006
	mid-April	1861	2	1804	2	0.34
	Perennial ryegrass – 2001 harvest					
Epr-1-01	Through January	1545	3	1418	3	0.1
	March only	1602	3	1419	3	0.03
	Through March	1574	8	1387	8	0.003
	Tall fescue – 2000 harvest					
Etf-1-00	Insufficient comparisons for statistical analysis					
Etf-2-00	March only	1575	6	1452	6	0.008
	Through March	1647	7	1422	7	0.02
Ntf-00	March only – very light	1066	5	1078	6	0.45
	Tall fescue – 2001 harvest					
Etf-1-01	Insufficient comparisons for statistical analysis					
Etf-2-01	Through February	841	3	770	3	0.13
Ntf-01	Through February	1683	5	1545	5	0.09

* Field identification is as follows: Npr = newly seeded perennial ryegrass; Epr = established perennial ryegrass; Ntf = newly seeded tall fescue; Etf = established tall fescue; -00 = harvested during 2000; -01 = harvested during 2001.

Table 3. Yield-Mapping system data from areas of fields not grazed and grazed through different times. Information includes when grazed, areas by grazing treatment, number of observations by the yield-mapping system for each grazing treatment, yield, and standard deviation for each yield estimate.

Field*	Grazing	Area ha (ac)	# Obs.	Yield lb/ac	Std. Dev.
		Perennial ryegrass – 2000 harvest			
Npr-00	Exclosures	0.14 (0.36)	231	1758	261
	January	11.4 (28.3)	9994	1948	370
	March	60.6 (149.7)	53650	1753	395
	April	24.9 (61.5)	22996	1481	384
Epr-00	Exclosures	0.08 (0.21)	215	1921	277
	Other not grazed	45.9 (113.5)	67903	1846	333
	March	22.2 (54.9)	42901	1922	328
	April	7.9 (19.5)	11332	1911	331
		Perennial ryegrass – 2001 harvest			
Epr-1-01	Exclosures	0.2 (0.39)	305	1538	229
	January	20.2 (49.9)	43237	1405	290
	March only	14.3 (35.4)	31106	1441	299
	Through March	39.4 (97.3)	79604	1400	288
		Tall fescue – 2000 harvest			
Etf-1-00	Exclosures	0.02 (0.06)	33	1306	175
	Other not grazed	9.3 (23.1)	9784	1227	351
	March	9.3 (22.9)	6435	1379	350
	April	4.2 (10.5)	4083	1355	302
Etf-2-00	Exclosures	0.12 (0.3)	292	1744	359
	Other not grazed	13.5 (33.3)	17611	1798	350
	Through February	1.0 (2.5)	1055	1890	325
	March only	13.8 (34.0)	9858	1650	412
	January - March	6.3 (15.7)	5908	1532	336

Ntf-00	Exclosures	0.12 (0.29)	292	1744	359
	Other not grazed	13.5 (33.3)	17611	1798	350
	January-February	1.0 (2.5)	1055	1890	325
	March only	13.8 (34.0)	9858	1650	412
	January – March	6.3 (15.7)	5908	1532	336
		Tall fescue – 2001 harvest			
Etf-1-01	Exclosures	0.1 (0.15)	139	840	235
	Other not grazed	10.7 (26.4)	14040	982	374
	February	12.5 (30.9)	11889	933	316
	March	0.4 (1.0)	822	1048	290
	April	0.1 (0.3)	257	639	289
	February - March	3.1 (7.7)	3028	875	307
	Feburary - April	1.4 (3.3)	1935	639	281
Etf-2-01	Exclosures	0.1 (0.18)	133	808	160
	Other not grazed	24.5 (60.7)	37355	822	281
	January – February	11.8 (29.1)	16549	675	261
Ntf-01	Exclosures	0.1 (0.3)	103	1627	317
	Other not grazed	35.5 (87.7)	31438	1494	297
	January – February	39.5 (97.7)	37595	1473	279

* Field identification is as follows: Npr = newly seeded perennial ryegrass; Epr = established perennial ryegrass; Ntf = newly seeded tall fescue; Etf = established tall fescue; -00 = harvested during 2000; -01 = harvested during 2001.