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Introduction

Red-winged Blackbirds (*Agelaius phoeniceus*) in agricultural crops likely create the worst possible images in the minds of various segments of our society today. To some there is only repulsion, which results in desire for total annihilation of Red-wings (by many agriculturists); while to others there is only attraction, which results in desire to leave the situation absolutely alone (by conservancy minded purists). The great middle ground includes those who vascillate back and forth, between these extremes, those who are not cognizant of the problems, and those that do not care. This picture apparently is a common problem for our wildlife resources in America today when they come into conflict with man's interests. The problem often erupts in several different ways, but often pits the two most extreme sides against one another and squeezes governmental agencies given the responsibility of solving the problem into a nearly helpless position. However, these agencies are also partially responsible for the overall situation by not having obtained sufficient amounts of the right kind of information. The end result is a constant spiral of activities in time without solutions of the problem. In modern jargon, the entire situation is an endless "DØ LØØP" This is the best simile that I can provide at this time.

Whether there is an answer is really not known, but at least there is a possibility of progressing to a new level of scientific input by regarding the entire situation as a series of actions and interactions which, when put together in a new synthetic way, do provide new and significantly different outlooks. Such work is enormously complex and only a few individuals working on the problem cannot hope to provide the full analysis. This paper is then to be regarded as only a start in the direction of regarding blackbird and corn interactions where they come together in an agricultural situation. For the sake of simplicity, I have tried to reduce the problem to its basic elements by providing a Forrester flow diagram (Forrester, 1961) of the association. This is presented in Figure 1.

In Figure 1 the so-called State Variable 1 represents the corn crop biomass resulting from production of the corn kernels in any given agricultural area, and State Variable 2 represents the biomass of the Redwing population. The flow connecting the two state variables is represented by the process of "eating." In this example the flow rate is regulated by levels in each of the state variables and unspecified regulators 1 through n in the center "valve." The flow is corn biomass. In Figure 2 I have presented the same picture, but with one important addition, namely the construction of a feedback potential from the bird to the plant which eventually results in a changed condition in the level of corn seed production. This paper investigates the possibility of the existence of such feedback and discusses implications of this outcome.

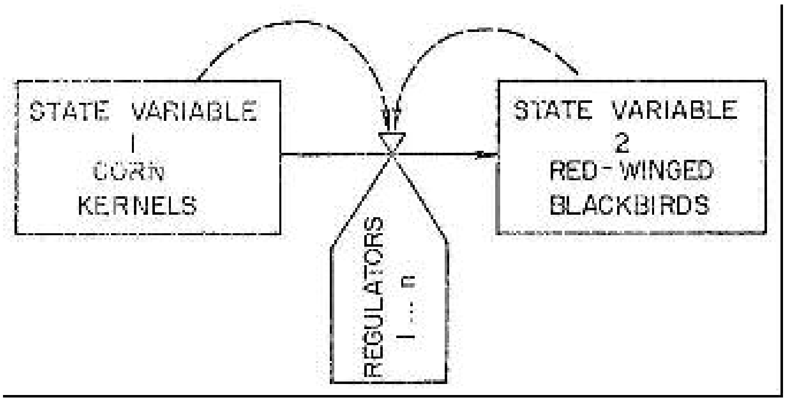

Figure 1. A basic Forrester diagram to show a low resolution evaluation of the association between an agricultural corn crop and the Red-winged Blackbird.

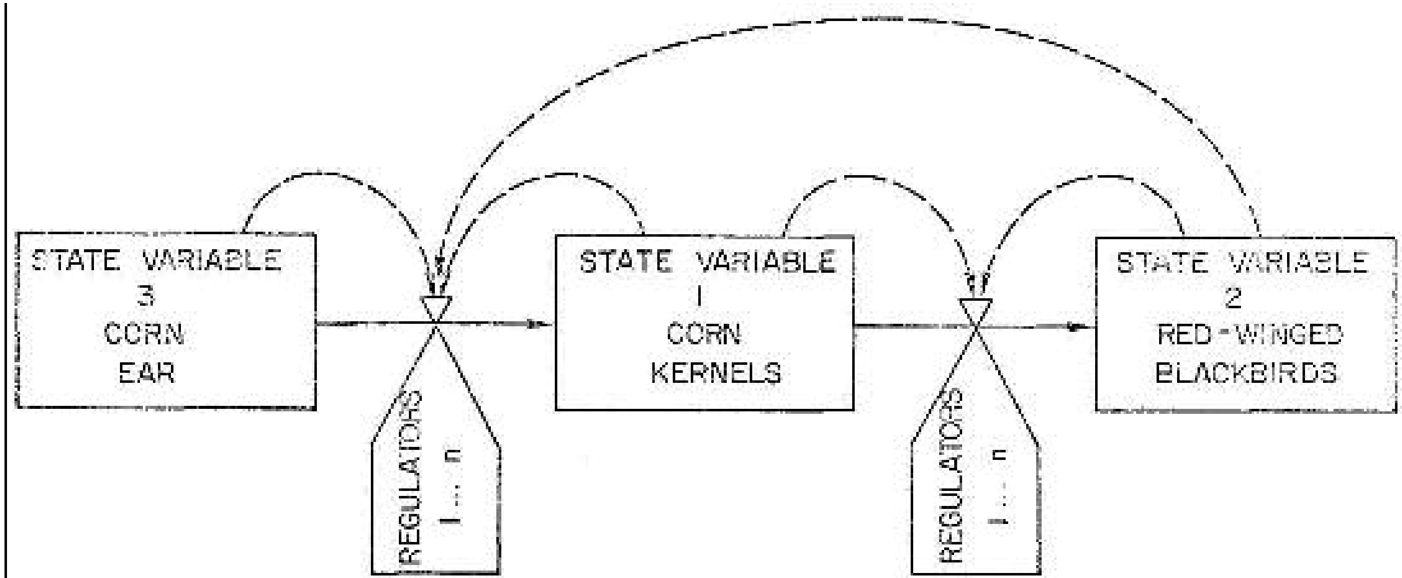

Figure 2. A first order modification of the Forrester diagram presented in Figure 1 to show a basic feedback potential from the Red-winged Blackbird to corn production.

Acknowledgements

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I have been helped with this work by Brian Hall, Jim Collins, Peter Albers, Robert Lewies, Robert Collins, and other students and staff at the University of Guelph. I am especially grateful to Messrs. Robert and David Bradley and Mr. Bert Dunlop of Chatham, Ontario, for their kind cooperation in providing the corn samples for the study.

Methods and Materials

Two fields were selected to provide intensive study on bird depredations to corn within Kent County, Ontario, through cooperative arrangements with two farm owners. One field, 17.5 acres in size, was located approximately 1/4 mile from an intensively used blackbird roost located in a marsh near Lake St. Clair. The second, 26.5 acres in size, was located approximately 9 air miles east of a second marsh roost.

The size of each field was measured into a scaled 10 x 10 grid and mapped accordingly. Twenty plots were selected from random numbers tables. From these plots 50 ears of corn were picked, sorted into damaged and undamaged categories, and bagged, and the bags were coded. The point of entering the plots was always from the southwest *corner,* and the ears were picked consecutively. The corn was taken to the University of Guelph Crop Sciences Department where it was dried to a constant weight (10% moisture content). Damage amounts on those ears attacked by blackbirds were measured using the method noted by DeGrazio *et al.* (1969) and Dyer (1967). The length of each ear was measured to the nearest half inch and weighed to the nearest 0.1 g. All ears were shelled and the shelled corn for each sample plot was weighed to the nearest gram on a Mettler balance. Total cob weight was also obtained for each class within each sample. Initial statistical analysis were made at the University of Guelph to determine the estimated level of bird damage to various lengths of corn ears. Subsequent analyses that contribute to the remainder of the paper were made at a later date. Two types of analyses are presented and identified where appropriate: (i) measurements of corn ear weights comprised of corn and cob weights and (ii) analysis of shelled corn weights for damaged and undamaged classes in each sample location.

Results and Discussion:

Distribution of Undamaged and Damaged Ears. In Figures 3 and 4 I have presented the frequency diagrams of the distribution of damaged and undamaged ears in each size class for the two study fields. Owing to several unidentified characteristics associated with the entire set of cultural conditions (such as soil fertility, variety of corn, time of planting, and undoubtedly others), the lenght classes are not the same for the two fields. It is also obvious that the entire distribution is skewed to the right, reflecting what is apparently an effort to obtain maximum yield per ear of corn and thus per plant.

What has not always been so obvious is the fact that there is a larger proportion of larger ears damaged than shorter ears. Both fields show this

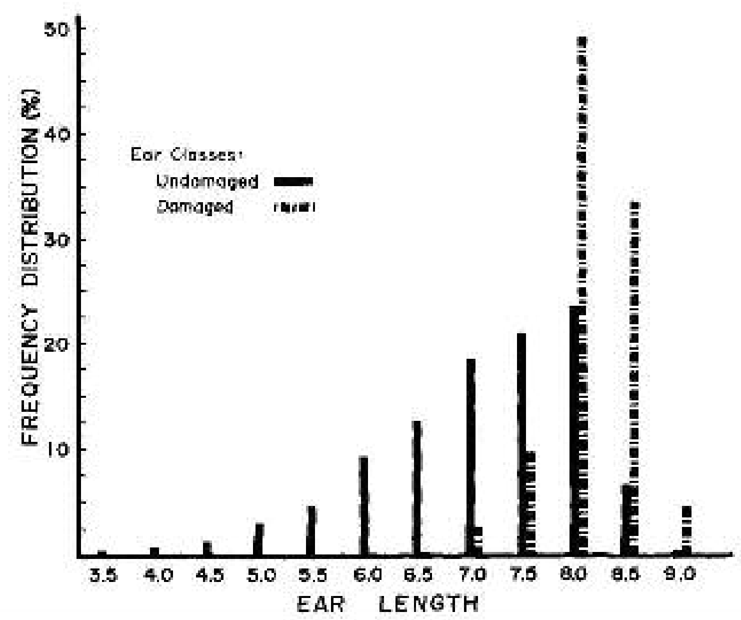

Figure 3. Frequency distribution for undamaged and damaged ears from Field 1, Ontario, 1966. The percent ears per length category are plotted.

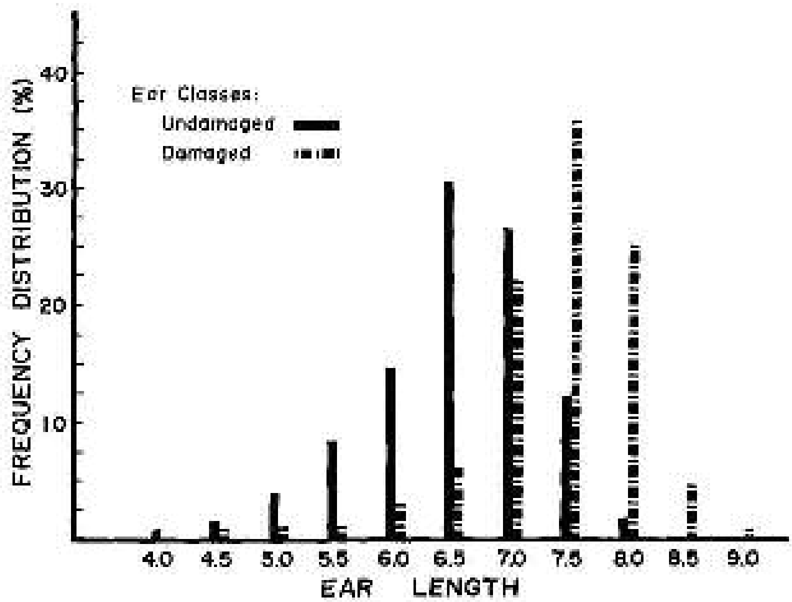

Figure 4. Frequency distribution for undamaged and damaged ears from Field 2, Ontario, 1966. The percent ears per length category are plotted.

relationship clearly, especially Field 1 which is nearest the marsh roost (Figure 3); there is also a larger proportion of longer ears in this field than in Field 2. Cardinell and Hayne (1945) noted a preference for longer ears, but DeGrazio *et al.* (1969) could not substantiate this finding. Instead they felt many other variables surrounding the relationship of blackbirds feeding on corn were responsible for contributing to the variation noted between damaged and undamaged frequencies more than ear length alone. Such a general statement is appropriate, but support for cause and effect is somewhat lacking at this time. This present study clearly indicates the relationship of size to damage frequency and supports the earlier claims made by Cardinell and Hayne (1945) for discriminant feeding functions, rather than those stated by DeGrazio *et al.* for indiscriminant feeding.

Also, the analysis made on flock feeding behavior by Dyer (1967) noted non-random behavior in selection of feeding areas which is consistent with discriminant feeding functions. It is quite possible that there is a relationship between definitive selection of feeding locations in the broad sense and the discriminant feeding behavior on individual ears of corn when the birds are finally located in their preferred foraging area. There is no definitive study relating these two functions to date, but it is likely they are part of the same behavioral repertory.

The mechanism or process involved in selection of the longer ears is not known exactly, but it seems reasonable to expect the birds to select the longer corn ears which are insufficiently covered with husks. Thus, the corn kernels are somewhat exposed at the outset of feeding, and it follows that the birds have learned to identify and select these ears.

The differences noted between the three studies cited previously are difficult to reconcile. However, it is worth noting that two (Cardinell and Hayne 1945 and this report) cover experiences in the midwest whereas the reports of DeGrazio *et al.* (1969) are from South Dakota. This one instance is not the only situation where experiences involved with blackbird biology are vastly different between the two regions (see Hintz and Dyer 1970 and Mott et *al.* 1972 for differences in summer diets).

Damage Levels. The number of ears damaged in each field was moderately high (53% in Field 1 and 31% in Field 2; Table 1) and compares closely with values reported previously from the region (Dyer 1967). The average weight of the shelled corn in the Field 1 was 191.7 g for the undamaged classes and 222.4 g. for the damaged classes. For Field 2 the weight of the shelled corn was 173.4 g for the undamaged classes and 210.2 g for the damaged classes. The differences indicate that the damaged classes are larger than undamaged classes by considerable proportions: 16.2% for Field 1 and 22.4% for Field 2. Recalling the discriminant feeding tendencies noted previously and shown in Figures 3 and 4, it is possible to understand why this should be so. Since the birds feed more heavily on the longer ears, any samples with significant proportions of long damaged ears, which weigh more to begin with, will of course be much heavier.

In an attempt to rid the analysis of this bias, Field 2 data were arranged so that only weights of ear classes where there were both damaged and undamaged classes were compared. For this analysis whole ear weights were examined, rather than shelled corn.

Table 1. Mean sizes and weights of corn from Fields 1 and 2, Ontario, 1966.

Field	Percent Damaged Ears	Undamaged Class			Damaged Class		
		Mean Length (inches)	Weight Shelled Corn[a]	Weight[b] Whole Ears	Mean Length (inches)	Weight Shelled Corn[a]	Weight[b] Whole Ears
1	53	6.57	191.7	NA[c]	7.39	222.4	NA
2	31	7.14	173.4	228.44	8.14	210.2	249.98

[a]Mean weight for all damaged and undamaged ear length classes; not corrected for damage equivalents.

[b]Mean weights expressed for conditions where there were damaged and undamaged ear length classes.

[c] NA = Not analyzed.

Table 2. Damage length and weight characteristics of damaged and undamaged corn ears from Field 2, Ontario, 1966 (data include kernels and cob). Only those size classes where there are both corresponding damaged and undamaged samples have been used for the analysis.

Characteristics	Length or Weight
a. Size:	
Mean length of undamaged ears	7.64 inches
Mean length of damaged ears	8.14 inches
b. Weight (Estimate 1):	
Mean weight per inch of undamaged ears	29.90 g
Mean weight per inch of damaged ears	30.61 g
Percent difference (damaged > undamaged)	2.64%
c. Weight (Estimate 2):	
Value for b plus estimated amount removed by birds added for damaged class	
Mean weight per inch for undamaged ears	29.90 g
Mean weight per inch for damaged ears	31.39 g
Percent difference (damaged > undamaged)	4.75%

Initial Check on Compensatory Assumptions. To some degree these Statements are somewhat speculative. I feel the empirical results are real, but the mechanisms producing such results are only conjectural. However, I have been able to conduct an early check on the compensatory growth hypothesis put forward here.

If the bird feeding behavior stimulates corn growth, there must be a minimum feeding level necessary to produce such a reaction. However, the birds are not simply pecking the corn kernels, but pecking and removing some of the biomass simultaneously. Therefore, there is an interaction developed where the corn ear could respond positively, but simultaneously be affected in a negative sense. Obviously there is a point beyond which the rate of corn removal exceeds the rate of compensation potential and the equation becomes negative. Since it has been well established that the amount of total potential damage in a field is a function of the feeding intensity measured in terms of damaged incidence to the field (Cardinell and Hayne 1945, Dyer 1967), it is possible to construct a model involving the feeding incidence as the independent factor. Graphically the reaction should look like the theoretical model presented in Figure 5. The main problem is to place values on the x and y axes.

By recomputing the 1966 Ontario data and by taking an independent set of unpublished data from northern Ohio obtained during an experiment with a chemical repellent, I have been able to obtain a description of the corn growth-bird damage reaction as observed in natural conditions (Figure 6).

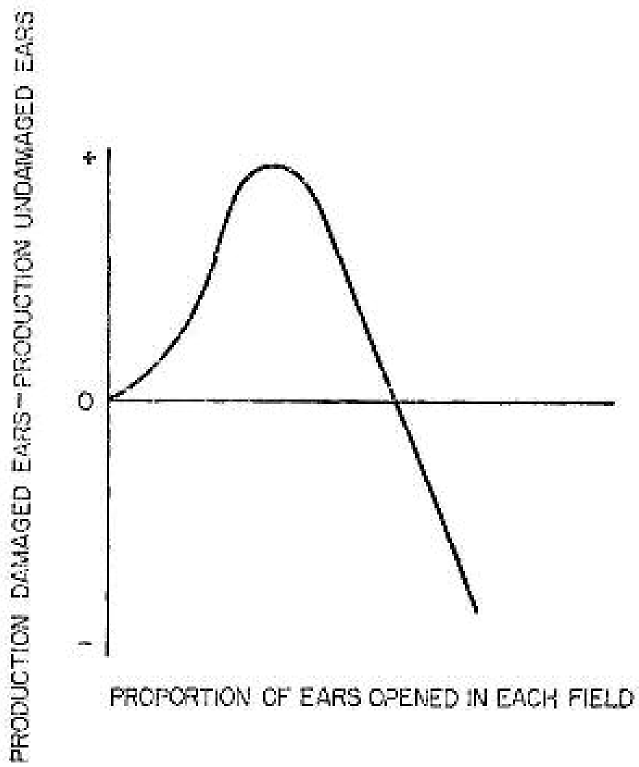

Figure 5. Theoretical curve to demonstrate plant compensatory growth in response to animal feeding activities. The hypothesis is that if there is plant compensatory growth the values can be demonstrated up to a certain level and after this point the rate of removal by the animal exceeds the rate of compensatory growth potential.

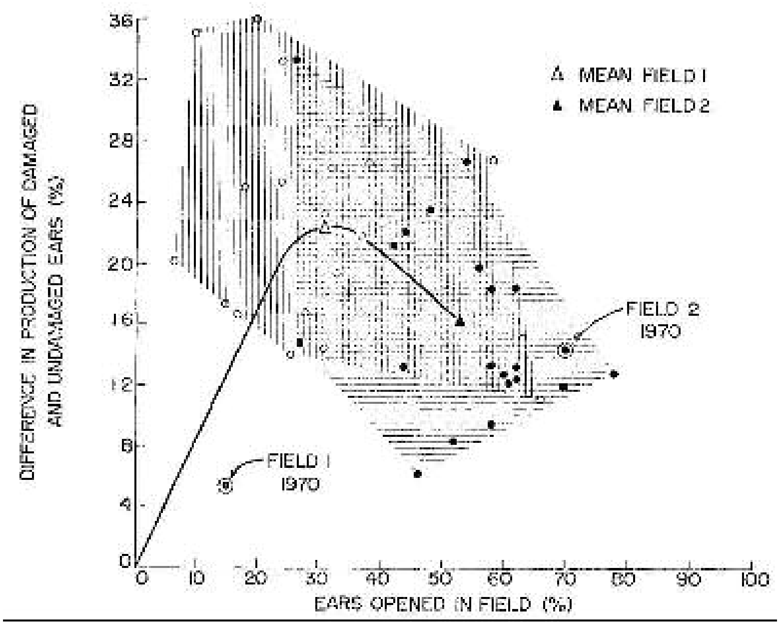

Figure 6. Field data from two sources (Ontario, 1966 and Ohio, 1970) showing difference in production of damaged and undamaged ears which suggests compensatory growth of corn due to blackbird feeding. The scatter distribution of each of the 1966 fields is presented in the shaded areas. The open circles with the vertical shadinq are the values from Field 2.

Since the reaction must pass through zero, this starting point is used. As can be seen, the four major field averages do follow the theoretical model in general shape. In addition to the four major field averages, I have plotted the means for the 20 plot samples from the two Ontario fields and have shaded in the perimeters of these two data sets. Again, the general distribution of the scatter diagram is believable, even though the points are widely despersed.

It is apparent that the few data presented here as an attempt to test the hypothesis do not create a regional, curve that can be used as a parameter. I suspect that upon rigorous testing of this hypothesis of corn growth compensation, the general appearance of the model curve will shift dramatically toward the left. However, it is noteworthy to point out that on the average in any bird damage situation which covers a large region, the damage incidence is less than 10% and closer to 3-5%. This is the precise region where, on the average, one should expect the greatest amount of compensatory growth potential.

Implications of Such an Hypothesis to Management Schemes. The serious regard of such a phenomenon creates a very interesting situation in respect to constructing and carrying out a control program. Foremost in such a move, of course, is making certain that the possibility is real and functions the way hypothesized here. Two other reports have hinted at the existence of this compensatory growth potential. *One* attempted to provide information about its effect in nature (Dawson 1970), but could not demonstrate any significant effect; and the second (Linehan 1967) simply stated the potential and provided no analytical insight.

If growth compensation is significant, management of Red-winged Blackbird populations, because they create a nuisance due to loss of corn crop through their eating habits alone, borders on the absurd. The levels of damage on a regional basis are relatively low and are probably well within the zone where compensatory growth is maximized. Thus, extensive control programs aimed at this one facet alone must be examined critically. However, there are other known side effects regarding bird feeding, and it is these problems that must be brought into focus. Secondary invasion from insects and microorganisms, mainly fungi, then becomes a greater potential threat to the corn crop than the primary invader, the redwing. Little is known about these relationships to date, and thus this is another region where research must be focused. The levels of potential loss are exacerbated by prolonged wet weather conditions that may reduce yield significantly. Associated with these topics is then the question of marketing practices of the corn. Too little is known about this entire subject in relation to the bird association with the corn crop. Such pronouncements have been made for a considerable time, but state and government officials responsible for activating such work have done apparently little to date about the situation. The matter is further complicated by the fact that experiments, to date unreported, indicate that the total protein yield of simulated-damaged corn ears is 5 to 10% higher than that for undamaged corn ears. Clearly there is an immense research potential in this one subject alone.

In light of these facts I suggest that the following steps are logical and necessary:

1. Examine more closely the relationship of bird-corn interactions in nature. Without such work, the association that has always purported to result in loss of production cannot be correctly evaluated.
2. Determine accurately the association of weather, insects, and micro-organismal growth with corn subsequent to feeding activities displayed by blackbirds.
3. Investigate thoroughly agricultural and marketing practices surrounding this entire animal-plant complex.

It is my opinion that a major overhaul of the research and management programs stripped of the political and emotional aspects now attached to the entire problem is a single best way to resolve the situation. Such work can only be done by regarding the entire complex, not just pieces here and there.

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