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INTRODUCTION

The use of surfactants to reduce winter roosting blackbirds (Icteridae) and starlings *(Sturnus vulgaris)* in the southeastern United States attracted considerable attention several years ago. At that time concern was expressed that more research was required to ensure that the economic losses and health hazards attributed to the birds were real and that population reduction at winter roosts was a viable solution (Jackson 1976; Robertson et al. 1978). Subsequent research has shown that these concerns were justified. In a study of the winter roost at Milan, Tennessee, Dolbeer et al. (1978) found that the only serious agricultural problems were associated with starlings, a minor species in the roost and the one which would be least affected by surfactant spraying (Lustick and Joseph 1977). As well, from analyses of band recoveries for common grackles *(Quiscalus quiscula)* by Meanley (1976) and for red-winged blackbirds *(Agelaius phoeniceus) by* Dolbeer (1978), it was found that in any given winter roost there are birds from widely dispersed breeding populations. This led Dolbeer (1978) to conclude that killing blackbirds at a few winter roosts would not solve the problem of late summer agricultural damage in the breeding areas nor prevent the re-establishment in subsequent years of the winter roosts that were reduced.

Serious agricultural damage by blackbirds in the St. Lawrence Valley and the rapidly increasing red-winged blackbird population (Erskine 1978; Dolbeer and Stehn 1979) has led to demands by the agricultural community in this area for solutions to the problem. Not surprisingly, lethal control through surfactant spraying has been suggested as one possible alternative. This suggestion has some merit, because the factors that weigh against a widespread winter roost control program in the southeastern U.S. do not apply to the St. Lawrence Valley. Blackbirds returning to southern Quebec in late March and April form roosts prior to dispersing to breed in May. An analysis of band return data indicated that the birds in this region in April were predominantly from the breeding and early fall population (Weatherhead et al. 1980). This allows the possibility that the populations responsible for the crop damage could be reduced prior to the breeding season, thereby substantially reducing their fall population. Our aim in this paper is to examine the feasibility of surfactant spraying as a management technique in the St. Lawrence Valley of Quebec.

Factors that must be considered in a feasibility assessment fall into two general areas -- proximate and ultimate. Proximate factors include the number and size of spring roosts that can be sprayed, hazards to non-target species, meteorological constraints, and the logistics of surfactant spraying. Ultimate factors involve the prediction and assessment of the short-and long-term impact of a spray program on breeding and fall populations and the implications of that impact for the reduction of crop losses.

METHODS

Roost surveys

From mid-July through August 1977, a survey of blackbird roosts was carried out in the agricultural zone of the St. Lawrence Valley in Quebec (Figure 1). Roosts were located through questionnaires sent to farmers and by following flight lines leaving roosts in the morning or entering roosts in the evening. An attempt was made to search the entire study area. Each roost was counted at least once; and, for the majority of roosts, an estimate of species composition was made and the roost vegetation recorded.

In March and April 1978, all major roosts and a subsample of the smaller roosts found the previous fall were surveyed. When an active roost was found, a count was made, the vegetation recorded, and if sufficient personnel were available, an estimate of the species composition made. If the roost was inactive, a driven survey in the area was made to determine whether a roosting population was present but in a new location. Random searches also were made away from known fall roost sites, but we were unable to search the entire study area. The same information was recorded for roosts found using the latter two methods as for spring roosts active on fall sites.

Because the roost near Beauhrnois, Quebec (12 km south of Montreal Island) was the focus of a pilot surfactant application, the roost population was counted twice weekly, and periodic species composition estimates made from 25 March to 11 May. This was repeated in 1979 for the period 8 March to 2 May.

Meteorological constraints

Lustick (1975) has shown that, for surfactant wetting to be effective in killing red-winged blackbirds, ambient temperatures should be at least below 10°C and preferably below 5°C. This should be accompanied by precipitation, with the kill increasing in effectiveness the greater the amount of rain or snow. To determine how often suitable weather conditions could be expected during the spring roosting period, an analysis was made of the Montreal weather data between 15 March and 15 April for the years 1974 through 1978.

Spray logistics

Surfactant was sprayed on the Beauharnois roost on 18 April 1978 and 8 April 1979. Spraying was done by helicopter, and no artificial sources of "precipitation" were used. Although both attempts failed in their primary aim of providing a significant roost reduction for which a complete assessment could have been made, they did allow valuable insight into the logistics of the operation itself.

Breeding population

In order that the impact of a pilot surfactant application could be either predicted or assessed, it was necessary to determine the size, distribution, and breeding sex ratio of the breeding population in the study area. For this aspect of the research, the study area was expanded in 1978 to include Ontario east of 76° longitude, so as to incorporate the area likely to be affected by the pilot spray at the Beauharnois roost. The existing grid overlay on 1:250,000 topographic maps divided the study area into 455 100-km^2 blocks. One-hundred-fourteen blocks within the Quebec portion of the study area in 1977 and 117 blocks from the entire study area in 1978 were randomly selected. Five-kilometer, driven transects, beginning in the SW corner and proceeding NE (as existing roads, permitted) were driven between 10 May and 7 July 1978 to census breeding males, using the method of Hewitt (1967). The census included 75 metres on either side of the road, giving a per-route census area of 75 hectares. The breeding male density for the study area was computed as the mean of all routes.

In each of eight blocks chosen in the study area, an upland and marsh site were selected for the determination of breeding sex ratios. Each site had a minimum of six males and was visited at least four times during the breeding season. On each visit, territories were mapped, a thorough search made for new nests, and the status of nests found previously updated. Harem size was computed for each territory as the minimum number of females necessary to account for the maximum number of synchronously active nests in the territory at any time during the breeding season.

RESULTS

Roost surveys

Sixty-six fall roosts were located in 1977 (Figure 2) with the total roosting redwing population in the study area estimated to be 500,000 birds. Approximately one third of the roosts occurred in marsh (both *Typha* and *Phragmites)* with the remaining two-thirds occurring primarily in decidous upland sites. Only two roosts had more than 100,000 birds, while the majority had fewer than 10,000. It should be noted that a number of these roosts increase in size after August (Weatherhead and Bider 1979), but using only estimates prior to September improves the likelihood that the birds counted are those from local breeding populations (Dolbeer 1978).

Twenty-three 1977 fall roost sites were checked during the 1978 spring survey, of which 14 (61%) were active or had an active roost in close proximity to the fall site. Eight roosts were found in sites away from any known fall roost. In the roosts active both spring and fall, for which species composition estimates were made, red-winged blackbirds comprised 77% and 74% of the fall and spring populations, respectively. The other species in the roosts were starlings *(Sturnus vulgaris)*, common grackles *(Quiscalus quiscula)*, and brown-headed cowbirds *(Molothrus ater)*. In the same roosts, the total number of redwings decreased by 49.5% from fall to spring, a decline similar to that expected through overwinter mortality (Dolbeer, pers. comm.). While not conclusive, this result at least suggests that the same birds that occupied a roost in the fall return in the spring. This does not, of course, apply to roosts inactive in the spring. Roosts ranged in size from 130,000 bird to 700 birds, with the majority having fewer than 20,000.

Excluding the Beauharnois roost, which was by far the largest roost in fall and spring, there was no correlation between the size of roosts in fall and spring, ($r = 0.18$, $p>0.05$), nor were the larger fall roosts more likely to be active in the spring. This was in part due to a shift away from the use of marsh roost sites in the spring, with the only marsh roosts occuring in *Phragmites.* The use of *Typha* roosts appeared to be precluded by extensive snow accumulation.

Upland spring roost sites also differed from those used in the fall, with the majority occurring in coniferous or mixed coniferous-deciduous habitat. The lack of foliage in pure deciduous stands in the spring presumably makes them energetically suboptimal for roosting.

The Beauharnois roost had the largest population both spring and fall, and the birds used the same site in both seasons. Build-up of the roost began in March in both 1978 and 1979, with the peak population occurring in early April both years (Figure 3). Red-winged blackbirds accounted for approximately 80% of the roosting birds. Until mid-April these were almost exclusively males. From mid-April until the roost broke up, the proportion of females increased, and by the end of April females were predominant. This change in sex ratio coincided with males beginning to establish and remain on territories.

The arrival of large numbers of female red-winged blackbirds at the Beauharnois roost coincided with that of several species of swallows (Hirundinidae). Unlike blackbirds, swallows tend to leave the roost by first flying up until almost out of sight, thereby making it impossible to accurately count them. By late April, however, they were conservatively estimated to number in the tens of thousands. There appeared to be some spatial separation in the roost between blackbirds and swallows, but it was not complete.

Meteorological constraints

Between 15 March and 15 April one can expect few days when the temperature is not suitable or even ideal for a surfactant application to be effective killing birds (Table 1). Precipitation, however, is a limiting factor with greater than 13 mm falling on average only 2.2 days with temperature less than 10°C and 2.0 days with temperatures below 5°C. The uncertainty inherent in weather forecasting means that reliance on natural precipitation imparts considerable risk to the success of the application.

Spray logistics

The failure of the surfactant applications in 1978 and 1979 was due primarily to difficulties associated with having both a helicopter and pilot available on the night the weather conditions were most suitable. In Canada, Department of Transport regulations normally forbid commercial night flying of single-engine helicopters. In 1977, the best night for spraying was missed because of the time required to have those regulations waived. Because the regulations exist, few pilots have night-flying rating for helicopters. In 1978, the absence of the pilot employed the previous year and the inability to find a qualified replacement again resulted in our missing the best night. On the nights the spray was applied, no logistical problems were encountered.

Breeding population

The mean breeding male density for the study area was 21.6 (± S.D. 11.2) per 75 ha in 1977 and 18.6 (± S.D. 12.4) in 1978. The study area is 45,500 km^2, giving a breeding male population of 1.3 million birds in 1977 and 1.1 million birds in 1978. These values agree quite well with an independent estimate of 0.9 million breeding males in the Quebec corn belt (Erskine, pers. comm.).

The breeding sex ratio studies produced a mean female to male ratio of 2.0 in uplands and 2.9 in marshes. The latter value is similar to the value of 2.8 found in a marsh study in eastern Ontario (Weatherhead and Robertson 1977), and both values fall within the range of values given by Dolbeer (1976). Using an arbitrary ratio of 2.2, which gives greater weighting to the upland value because of the predominance of upland habitat (Dyer 1970), gives 2.2 females and 1.2 non-breeding males for each breeding male. The total red-winged blackbird population can therefore be estimated by multiplying the total breeding males by 4.4. This yields a population of 5.7 million birds in 1977 and 4.8 in 1978. These values are seriously overestimated, however, because of the bias introduced by restricting censuses to roadsides (Clark and Karr 1979; Weatherhead et al. in prep.). A more realistic estimate of the total red-winged blackbird population in our study area during the breeding season would be between two and three million birds.

DISCUSSION

Proximate factors

To determine the minimum roost size for which a surfactant application would be economically feasible requires knowing the net value per bird realized through population reduction. Without knowing this value, it seems nonetheless reasonable to assume that many of the small spring roosts would be precluded from a management scheme based on population reduction for economic reasons alone. Thus, the overall feasibility assessment can be reduced to a consideration of the merits of population control at a few sites.

Locating these sites would require roost surveys each spring, although the fall roost survey would be of some use if the changes in habitat preference from fall to spring are taken into consideration. It should also be noted that the increased use of upland sites in the spring reduces the likelihood that a roost could not be sprayed because of the danger to aquatic systems (U.S. Dept. of the Interior, unpublished draft of environmental statement of the use of PA-14, 1976).

The time available to apply surfactants is restricted both by the non-synchronous arrival and subsequent dispersal of the blackbirds in the spring and by the use of some roosts by non-target protected species. From the Beauharnois roost counts, the optimal period for spraying (maximum roost occupancy) could be considered to be at most two weeks in duration. Considering the meteorological constraints, it becomes unreasonable to expect more than one ideal opportunity to spray each spring. If precipitation can be supplied artifically by such means as pumper trucks or irrigation systems, the entire two weeks of maximum roost occupancy becomes suitable for spraying. This would in turn allow the same equipment and individuals to be employed for all spray operations.

The most serious logistic problem confronting a surfactant spray program in Quebec is the availability of pilots and helicopters capable of spraying a roost at night. The most viable solution to this problem may be to allocate sufficient funds to retain a night-rated pilot and properly equipped helicopter for the entire period in which the spray would be carried out. While this would increase costs substantially, our experience has shown that the shortage of such men and equipment jeopardizes the success of the program if one relies on their being available on the day(s) that conditions are optimal.

Ultimate factors

Given that there is some potential for reducing spring blackbird populations with surfactants, it is necessary to assess both the merit of such a program in ultimately reducing crop damage as well as its overall ecological impact. This could best be done by closely monitoring the effects of an experimental roost reduction. It should be possible, however, to make some predictions based on our knowledge of the breeding population.

Using a conservative population estimate of 2 million birds in the study area and a breeding sex ratio of 2.2 females per male, there would be approximately 450,000 breeding males and 550,000 non-breeding males. A spring roost reduction would have a far greater impact on males because of the late return of females. Therefore, considering the study region as a closed system, one could conceivably kill half a million males and still leave sufficient males to fill all existing territories. Productivity of the population would therefore not be affected, and the only advantage derived would be the reduction of fall roost populations by the number of birds killed in the spring.

The assumption made in the above argument is that the effect of a spring kill would be distributed evenly through the study region. Since the spring roosts are sites from which birds disperse to breed, however, it is more likely that most birds occupying a given spring roost will breed in the vicinity of that roost. In turn, they and their offspring would also comprise the early fall roost population. If these assumptions are valid, a population reduction at a spring roost would have a major impact on the initial size of the breeding population local to that roost, For this impact to result in the reduction of both their productivity and early fall population requires that the movements of non-breeding males elsewhere are not sufficient for them to fill the void left by the males that were killed. At present, the only means to determine if this would occur is through an experimental population reduction. The same is also true of how females arriving to breed would respond to the absence or paucity of males.

There remain several points that should be mentioned as requiring investigation should surfactant spraying be deemed feasible in its primary aim of reducing crop damage by red-winged blackbirds. The insectivorous diet of this species during the breeding season and the consumption of weed seeds at other times of the year are often cited as potentially providing some compensation for the damage done to crops. While a definitive answer is not yet available to the question of whether we derive some benefit this way, there is evidence that some economically important species of insects and weed seeds are eaten regularly by red-winged blackbirds in this region (Bendell, pers. comm.; McNicol, pers. comm.). Changes in the abundance of these species following population reduction of blackbirds should be monitored to assist with ongoing re-evaluation of a population reduction program. Similarly, the effect of the program on brown-headed cowbirds, common grackles and starlings should be monitored, lest the solving of one problem result in the creation of another (Dyer and Ward 1977).

SUMMARY

Population reduction of red-winged blackbirds through surfactant spraying of spring roosts has some potential for reducing crop damage in Quebec. This potential is proximately limited by the number of spring roosts with sufficient birds, the short duration of maximum roost occupancy, the use of some roosts by protected species later in the spring, and the limited occurrence of sufficient precipitation to make the surfactant effective in killing birds. Since males would be affected to a far greater extent than females, the feasibility may be ultimately limited by the ability of the surplus males in the population to replace those males killed. Finally, monitoring of pest insect and weed species eaten by the birds and of the cowbird, grackle and starling populations would be required, should a population reduction program be implemented, to ensure that current problems are not simply being replaced by new ones.

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TABLE 1. Temperature and precipitation between 15 March and 15 April from Montreal weather records.

temperature (°C)	precipitation (mm)	number of days 1974	1975	1976	1977	1978	mean
< 10	0	28	32	30	29	32	30.2
< 10	trace	19	12	9	16	15	14.2
< 10	trace-13	18	9	7	15	11	12.0
< 10	> 13	1	3	2	1	4	2.2
< 5	0	28	31	23	25	31	27.6
< 5	trace	19	11	7	11	14	12.4
< 5	trace-13	18	8	6	10	10	10.4
< 5	> 13	1	3	1	1	4	2.0

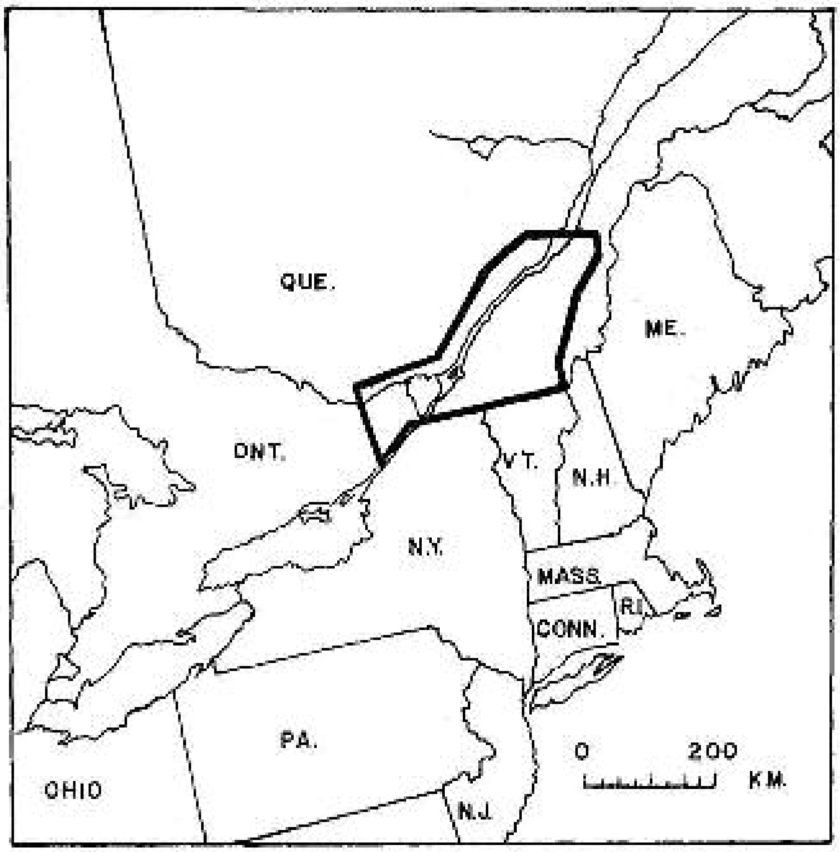

FIGURE 1. Map of the study area including the portion of eastern Ontario included in the 1978 breeding population survey.

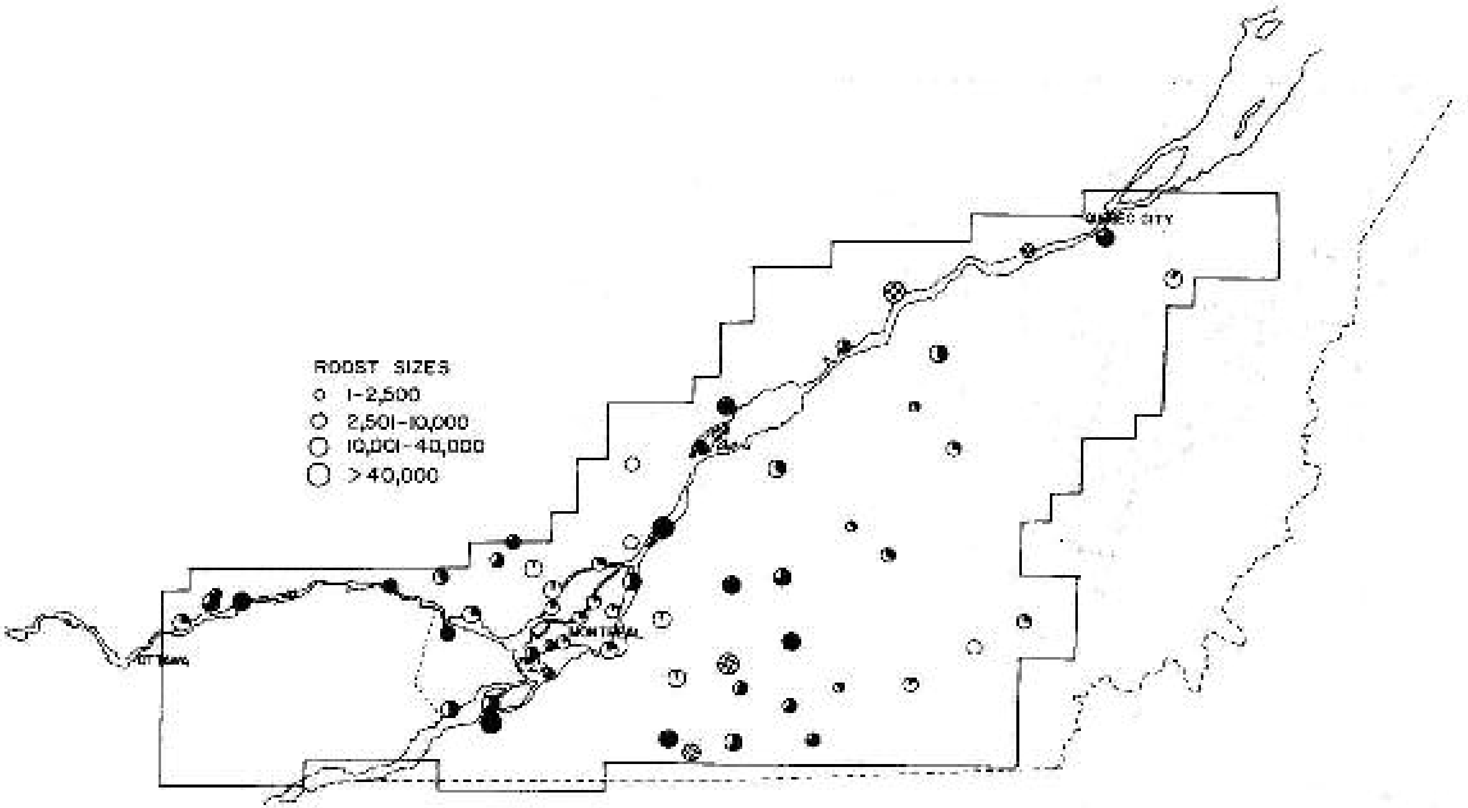

FIGURE 2. Size and location of fall roosts found in Quebec, 1977. The black portion of the circles indicates the percent red-winged blackbirds in a roost. Roosts for which a species composition estimate was not obtained are indicated by hatched circles.

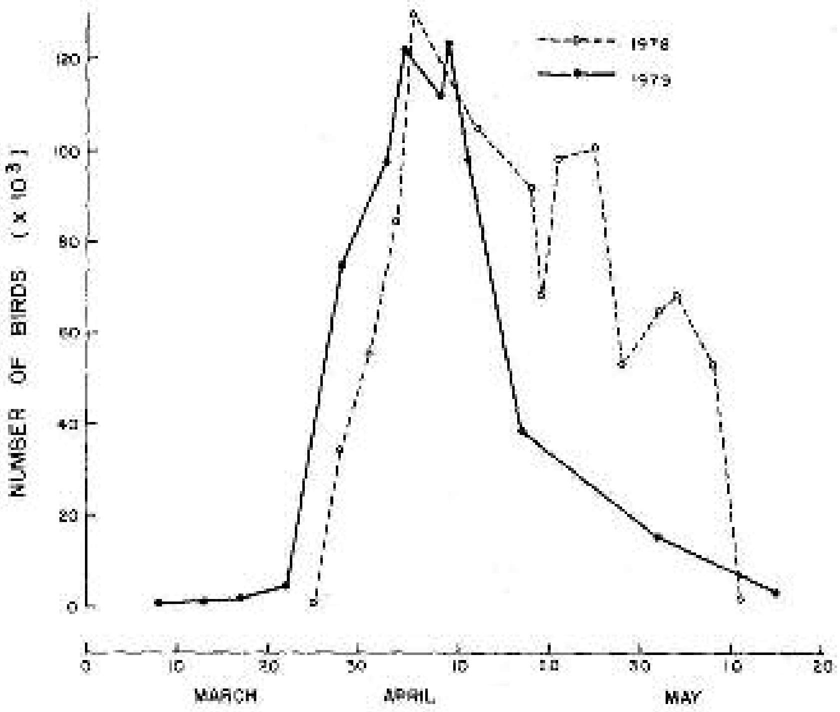

FIGURE 3. Spring population estimates at the Beauharnois roost, 1978 & 1979.