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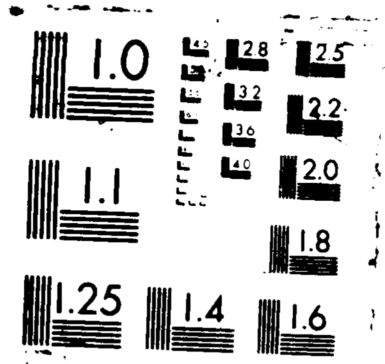
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This report provides a descriptive survey of conflicts and problems that birds have caused man, identifies the state of the art methodologies in bird management and control, and examines potential disease risks to humans.

Bird problems are related to one or more of the following categories: (1) damages and economic losses, (2) human health and safety, (3) aesthetics, (4) inconveniences, and (5) competition with native species and brood parasitism. Pigeons, starlings, and house sparrows, all introduced from Europe, and several species of native blackbirds--usually (Cont'd)

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in excessive numbers--are responsible for most problems in the United States. Most of the research on bird management has been directed to agricultural and feedlot depredations, winter blackbird-starling roosts, and safety hazards to aircraft; urban bird management strategies have not been adequately researched. Large-scale control measures include habitat modifications, repellents, frightening devices, and wetting agents. Exclusion, toxic baits, toxic perches, live-trapping, repellents, and frightening devices are all used for controlling small-scale or local bird damage problems.

Birds represent a potential, although low, health or disease risk for humans. Most avian pathogens or parasites only affect other birds and host specificity is often high. Pets, poultry, game species, and aviary specimens have been affected in epidemics. The most important human diseases associated with birds in the United States are histoplasmosis, encephalitis, chlamydiosis, and cryptococcosis. All four of these diseases are potential health hazards at Civil Works Projects because of the bird species present and site/habitat characteristics.

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PREFACE

The study reported here was authorized by Headquarters, U.S. Army Corps of Engineers (HQUSACE), under Civil Works Research Work Unit 32333, "Control of Roosting Birds and Bird Waste," for which Dr. Anthony J. Krzysik is Principal Investigator. Funds for this work were provided through the Repair, Evaluation, Maintenance, and Rehabilitation (REMR) Research Program, Research Area, "Miscellaneous Maintenance and Repair of Hydraulic Structures and Equipment." Mr. James E. Crews (CECW-O-M) is the REMR Technical Monitor for this work.

Mr. Jesse A. Pfeiffer, Jr., CERD-C, is the REMR Coordinator at the Directorate of Research and Development, HQUSACE; Mr. James E. Crews, Dr. Tony C. Liu (CEEC-ED), and Mr. Bruce L. McCartney (CECW-HD) serve as the REMR Overview Committee; Mr. William F. McCleese (CEWES-SC-A), U.S. Army Waterways Experiment Station (WES), is the REMR Program Manager; Dr. Ashok Kumar (CECER-EM) is Problem Area Leader for the Electrical and Mechanical Problem Area.

Special thanks to Mr. Robert Whiting (St. Paul District), Mr. Carl Cable (North Central Division), Mr. Harold Lawson (Detroit District), Mr. Gerard Mick (Omaha District), Dr. Donald Mott (Department of Agriculture), and Mr. Ronald Ogden (Department of Agriculture) for their excellent review of the earlier draft of this report. Their comments appreciably improved the clarity and organization of the report, as well as provided insight into novel avian management strategies. Mr. Chester Martin (CEWES-ER-W) helped to clarify the final report.

This work was conducted by the U.S. Army Construction Engineering Research Laboratory (USA-CERL) during the period November 1984 to September 1985 under the general supervision of Dr. R. K. Jain, Chief of the Environmental Division. COL Norman C. Hintz is Commander and Director of USA-CERL, and Dr. L. R. Shaffer is Technical Director.

CONTENTS

A REVIEW OF BIRD PESTS AND THEIR MANAGEMENT

PART I: INTRODUCTION

Background

1. Bird control is a sensitive public and political issue since people possess a strong appreciation and affection for birds. The public does not want to see dead birds, even when the birds are present in excessive numbers, or are the known cause for specific health problems or economic losses. There is increasing concern over the humane treatment of animals, and public attitude may remain unswayed even with ecologically based arguments aimed at controlling pest species.

2. Public response is more favorable toward the use of repellents, frightening devices, exclusions, or live-trapping and transplanting. However, these methods are often impractical or ineffective. The informed public is more tolerant of control measures directed at introduced nongame species (e.g., pigeons, starlings, house [English] sparrows, and monk parakeets) as contrasted to targeting native birds. If toxicants are employed, they should be slow acting in order for the birds to disperse before succumbing.

3. There are no Federal regulations for controlling exotic nongame species. Although migratory species are protected by Federal law, a U.S. Fish and Wildlife permit can be obtained to control birds doing economic damage. Blackbirds, grackles, cowbirds, crows, and magpies can be taken without a U.S. Fish and Wildlife permit when they are committing or about to commit agricultural damage. However, State regulations vary. Additionally, the use of chemicals for repelling or killing birds is regulated by Federal and State Environmental Protection Agencies.

4. The social, scientific, and economic importance of birds, and their visibility and popularity with the public must be thoroughly understood, considered, and realistically appraised whenever a bird management program is planned and implemented. This is especially apparent at Civil Works facilities, where the public and the Army Corps of Engineers interface. Additionally, potential environmental impacts should

be thoroughly assessed during the planning stages of any bird control or management program. This is particularly important for habitat modifications, or when using chemicals or toxins whose environmental fate is unknown.

5. Most problem birds in the United States are either imported "weedy species" or represent native populations which have grown excessively as a direct consequence of deforestation, extensive agricultural monocultures, and other man-made habitat changes in the landscape. Starlings and house sparrows (imported species), combined with huge population increases in several native species of blackbirds, have been a detriment to many native bird populations. Numerous native species are becoming uncommon or rare because of strong competition (or brood parasitism) with their numerically abundant and more aggressive neighbors. Of course, contrary to blackbird and "edge" species, many native bird species have been deleteriously affected by landscape changes, particularly forest fragmentation (Forman et al. 1976, Whitcomb et al. 1981). Additionally, the recent extreme deforestation in the New World Tropics may be having serious impacts on overwintering neotropical migrants (Aldrich and Robbins 1970).

6. Since the common names of birds are well known and consistently used through the country by both the public and biologists, only common names will be used in this report. Scientific names of most species discussed are given in Appendix A. Scientific names can also be found in any of the commonly available field guides.

Objectives

7. This report represents the first phase of research addressing bird problems at U.S. Army Corps of Engineers Civil Works Projects. There were four objectives in this phase:

a. Provide a review of bird problems.

b. Discuss current methods and State of the art technologies in bird management.

c. Provide a perspective of birds in society and science.

d. Provide extensive and diverse references for background information, as a bibliography for problem solving, and as a foundation for initiating specific research objectives. A more extensive list of references is available in a more detailed and comprehensive report (Krzysik 1987).

Approach

8. For this phase of work, an extensive literature survey was made, which included a computer search (Dialog Information Services - Biosis Previews, National Technical Information Service). Particular attention was addressed to conference proceedings dealing with bird management and wildlife damage control. Part II provides a brief background and perspective on the social, economic, and scientific values of birds. Parts III and IV summarize the problems, economic damages, and potential diseases caused by bird pests. Parts V and VI used in conjunction provide specific management recommendations or guidelines for species specific bird problems. Part VII is the conclusion.

PART II: BIRD BENEFITS TO MAN

Social

9. Nonconsumptive wildlife recreation has become one of the most popular and important recreational activities in this country in terms of the number of participants as well as dollar expenditures. Birds are undoubtedly the single most important component of nonconsumptive wildlife recreation. Additionally, birds play the central role in State, U.S. Fish and Wildlife Service, U.S. Forest Service, and other Federal nongame wildlife programs. Enthusiastic members of the numerous local chapters of the National Audubon Society, scattered throughout all 50 states, attest to the popularity of bird watching as a hobby or avocation. Bird watchers also form a strong core within other environmentally aware and oriented organizations such as the National Wildlife Federation, Nature Conservancy, Sierra Club, and Wilderness Society. The strong public grass-roots support within these organizations has provided substantial economic and political motivations for environmental legislation, as well as public participation in the processes and issues involving Environmental Impact Statements and the National Environmental Policy Act (NEPA).

10. The strong public attraction to birds is attributable to many factors. Unlike most other animals, birds are highly conspicuous both visually and vocally; flight has always intrigued man, and birds are active, abundant, diverse, and widely distributed, being found in all conceivable habitats. Birds are regarded as a vital component of "the outdoor experience" by hikers, campers, fishermen, hunters, canoeists, picknickers, and backyard barbecuers.

Economic

11. Enjoyment and appreciation of birds is widespread and not restricted to those who regularly participate in outdoor recreation. This is reflected in the increased sales of bird seed, feeders, and houses. About 20 to 30 percent of U.S. households feed birds (More 1979).

Supplies of wild bird seed are widely available. Nonconsumptive wildlife recreation (e.g., feeding, observing, photographing, and nature study, centering mainly around birds, was engaged in by more people (94.6 million) than fishing (53.9 million) and hunting (19.4 million) combined (U.S. Department of the Interior 1982). Nonconsumptive wildlife recreation, therefore, possess a firm economic basis. Products used by participants include: photography equipment, binoculars, field guides and other books, outdoor equipment and clothing, and the numerous and diverse products and services associated with travel and lodging.

12. An important economic benefit of birds, including pest species, is their enormous appetite for insects. Red-winged blackbirds consume corn borers, rootworm beetles, cutworms, and earworms, all serious pests of corn. McAtee (1920) listed 70 instances of local exterminations of insects and other pests by birds. Woodpeckers controlled an outbreak of bark beetles in Colorado (Olson 1953). At some localities 75 percent of the beetles were consumed, and 90 percent of the stomach contents of several woodpeckers consisted of bark beetles. Starlings are primarily insect foragers, having a significant impact on lawn and garden pests. They feed heavily on Japanese beetles, cutworms, grasshoppers, and lawn grubs, and are the most effective control for clover weevils. Additionally, some bird species consume large quantities of weed seeds (e.g., cowbirds and red-winged blackbirds).

13. Hawks and owls feed heavily on rodents and are an important check in regulating population numbers in these pests. These predators are particularly effective population regulators when rodent population cycles are at their low point. Kestrels (sparrow hawks) show a high preference for grasshoppers and locusts when they are available. Peregrin falcons are important predators of pigeons when their eyries are located on urban buildings.

14. Another, not widely acknowledged, asset of some avian species (e.g., hummingbirds in the United States) is their role in flower pollination. Pollinators are known as keystone species, since their importance in the structure and function of communities is far greater than their biomass or energy flow indicates.

Scientific

15. Scientifically, birds have been among the most intensively studied groups of organisms. Taxonomically, birds represent the best known class in the animal kingdom. Birds also respresent the best studied group of animals by non-professional biologists. The seasonal Christmas and breeding bird censuses (published in American Birds) are only one important example of the numerous contributions made by bird enthusiasts.

16. Birds have been the prime subjects in both empirical and theoretical ecological research. In addition to practicality and aesthetics, birds are of high ecological interest for several critical reasons. Birds display a broad diversity of ecological roles (niches). Not only are birds abundant, but a large number of species can be found in the same habitat, many of them possessing very similar ecologies. Therefore, they make excellent candidates for research dealing with resource partitioning, competitive interactions, foraging strategies, and behavior. Studying and quantifying these components is easier and more practical with birds than with other animal groups, since birds can be observed foraging, nest building, feeding nestlings, and socially interacting during daylight hours. Most mammals, reptiles, and amphibians are nocturnal or spend much of their time underground. Fish and invertebrates are difficult to study since there are usually serious observational problems.

17. There is an increasing enthusiasm for wildlife research, inventory, and management in urban/suburban environments, with a strong emphasis on birds (Guthrie 1974, Vale and Vale 1976, Leedy et al. 1978, Lancaster and Rees 1979, Leedy 1979, Leedy and Adams 1984).

18. Recently the U.S. Forest Service (Department of Agriculture) has recognized the importance of nongame bird species, not only as a natural resource in themselves but as valuable indicators of timber, range, and watershed management practices.

19. A more comprehensive account of this section, including detailed references, is available (Krzysik 1987).

PART III: BIRD PROBLEMS AND CONFLICTS WITH MAN

Introduction

20. Despite all their benefits, birds have also created problems for society. These problems are usually related to one or more of the following categories: (a) damages and economic losses, (b) public health and safety, (c) aesthetics--visual and acoustic, and (d) inconveniences. Competition with native species, particularly for nesting cavities, and brood parasitism can also be included as important ecological problems.

21. Generally, bird problems are of a highly local nature and only a few bird species are usually responsible. Three introduced species closely associated with man and his urban landscape are responsible for the majority of local problems--common pigeon or rock dove, European starling, and the house or English sparrow. (See Appendix A for the scientific names of most bird species cited in this report.)

22. Two native species, the common grackle and the red-winged blackbird,* have dramatically increased their populations and distributions in modern times. This is most likely attributable to deforestation, the increase in ecotones (edges), and the large-scale habitat changes man has made in the landscape, particularly the increase of grain crops. These birds find an almost infinite supply of grain in agricultural fields (including ones already harvested) and livestock feeding pens. These feeding areas, especially livestock pens, are particularly necessary during severe winter weather. The availability of

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*Taxonomically, blackbirds are a subfamily of birds (Icterinae) that includes bobolinks, meadowlarks, orioles, grackles, cowbirds, and blackbirds. Other species with blackbird in their common name in addition to the red-winged are: Brewer's, rusty, yellow-headed, and tricolored. Of these five species, the red-wing is by a great margin the most abundant and widely distributed. It is also the most abundant species of icterinid (Meanley and Royall 1976). The red-wing along with the common grackle, brown-headed cowbird, and European starling (Sturnidae) usually comprise 95 to 99 percent of the infamous winter roosting flocks that often contain over a million individuals. The use of the term blackbird in this report will collectively refer to three species: red-winged blackbird, common grackle, and brown-headed cowbird.

adequate and predictable winter food resources may have been the limiting factor on blackbird populations in the past. Decreases in the predators and competitors of blackbirds may also be attributable to man-dominated landscapes and may in part also contribute to their newly achieved success.

23. Brown-headed cowbirds have also benefited from modern land-use patterns since they are an edge species. Cowbirds feed heavily on weed seeds and have not been implicated in economic losses as frequently as other blackbirds. However, cowbirds are brood parasites and they may do severe damage to song bird populations since forest fragmentation encourages parasitism to forest interior bird species.

Specific Species

Pigeons, Starlings, and House Sparrows

24. The common pigeon or rock dove, the European starling, and the house or English sparrow are three species introduced from Europe that are responsible for the majority of local nuisance bird problems. All three species are abundant, familiar, and closely associated with man throughout the United States. Even in the inhospitable Mojave Desert, starlings and house sparrows can be found, but only in close association with man and his modified environment. The Rock dove was the first bird to be domesticated (4500 BC) and has been distributed worldwide (Zeuner 1963). The house sparrow has filled the avian urban niche and can be found in all settled areas of the world with the exception of China and Japan (Campbell and Lack 1985). The starling's original range was Europe and western Asia, but it has become abundant when introduced into temperate and Mediterranean regions (e.g.,the United States, southern Canada, southern Africa, southern Australia, New Zealand, and numerous islands) (Feare 1984). Although these species cause problems mainly in the urban environment or with man-made structures, starlings are also responsible for depredations at livestock and poultry feedlots and damage to newly sprouted wheat. Since these species usually contribute to similar problems for man, they will be discussed together.

25. Urban Settings. Most people are quite familiar with the visual effects of pigeons, starlings, and house sparrows on buildings, automobiles, and virtually all structures associated with the urban landscape. Superficially, the problem is aesthetic, but more serious is the economic damage caused by their acidic excrement. Metal and concrete surfaces, paints and coatings, limestone, marble, and electrical components are only a few examples that are susceptible to severe damage or decay. Structural damage, equipment failure, and slippery ledges or walkways are potential safety hazards resulting from bird excrement. Additionally, bird droppings may pose serious health hazards, especially for histoplasmosis and chlamydiosis (see Birds as Potential Disease Vectors, page 24).

26. Starlings and house sparrows are cavity nesters, and a common problem concerns their nests constructed in undesirable places such as air vents, inlets, or breathers; rain spouts; under awning edges; cracks or crevices in walls and around windows or doors; under eaves; and in electrical, hydraulic, or mechanical equipment. Usually the nest itself is the problem, but excrement or noisy birds may be a more serious consideration since these species are often colonial.

27. Buildings. Pigeons, starlings, and house sparrows often nest within large buildings such as warehouses, boathouses, and airplane hangars. Severe and costly damage from their excrement occurs in hangars since cockpits are opened and engines, electrical/electronic components, and hydraulic systems are being maintained or repaired out in the open (Will 1985). Occasionally planes must be repainted because of corrosion or chipping paint. A small Air Force fighter plane requires over $1,000 in paint and supplies and about 800 manhours to paint. Occasionally the birds build nests among mechanical, electrical, or hydraulic components when equipment is being maintained or the cockpit is open. The nests interfere with moving parts and create a fire hazard. (See Urban Settings in the previous section for additional problems caused by bird excrement and nests.)

28. Starlings often nest within fiberglass or styrofoam insulation, causing extensive damage within building roofs and walls (Hall 1985).

29. Birds, their nestlings, as well as nests usually carry large numbers of ectoparasites (Krzysik 1987). Thousands of workers in an Air Force hangar in Oklahoma were affected by bird mites (Will 1985). Pigeons were the most abundant pest species, but starlings and house sparrows were also present. Similarly, personnel entering the boathouse at Dale Hollow Lake, Tennessee (Nashville District, COE) were covered by bird mites from resident nesting starlings (James Hunter, personal communication). Bird mites are irritating and some people show an allergic reaction, but members of the family Sarcoptidae (itch or scaly-leg mites) can be skin parasites of dogs and man (Terres 1980).

30. Bridges. Pigeons are commonly associated with bridges. Their natural roosting and nesting places were high rugged cliff faces with abundant flat ledges in otherwise open habitat. Pigeons will not use round perches and they avoid dense vegetation. The flat perches of the structural components and girders of bridges along with completely open surroundings represent optimal pigeon habitat in man-modified environments. Since the structural integrity of bridges is of prime concern, but aesthetics is also important, excessive bird excrement may be a serious economic problem. Sandblasting, primering, and painting bridge structures is very costly because of the difficulty and safety risks involved.

31. Dam and Lock Complexes. Locks, dams, powerhouses, and all their associated structures provide an unusually rich source of nesting and roosting sites for pigeons, starlings, and house sparrows. Pigeons need flat surfaces in open areas. Since pigeons are large birds and usually abundant around these structures, their excrement may create serious aesthetic, health, safety, and corrosion/deterioration problems.

32. Starlings and sparrows are cavity nesters and therefore find an unlimited source of nooks and crevices at these installations. The typical problems of starlings and sparrows at locks, dams, and cranes is that their nests or associated excrement may impair or contribute to the failure of mechanical (movable parts) and electrical or hydraulic equipment. Therefore, they may create safety or fire hazards. The earlier sections Urban Settings, Buildings, and Bridges also discuss relevant information for lock and dam bird problems.

Gulls

33. Over the past 50 years, ring-billed and California gulls have greatly increased their population sizes, including the proliferation of breeding colonies, throughout western United States (Conover 1983). Similar increases have taken place in ring-billed gull populations around the Great Lakes region (Blokpoel 1977, Blokpoel and Tessier 1984). Both of these species breed inland and apparently have prospered from the increased food supply provided by garbage dumps (including rodent populations) and agricultural crop land (especially grain fields and the associated insect and rodent fauna) as well as an increase in breeding habitat on islands formed by man-made reservoirs.

34. Farmers derive a great deal of benefit from gulls since both of the above species actively feed on insect and rodent populations in their fields (Greenhalgh 1952, Behle 1958, Vermeer 1970, Jarvis and Southern 1976). Conover (1983) concluded that any further increases in gull populations should be encouraged, whenever local conditions permit, because they feed on agricultural pests and have aesthetic value.

35. However, gulls can be a nuisance in urban settings. The chief complaint about urban ring-billed gulls is the nuisance caused by extensive unsightly and smelly defecation and their noisy and aggressive behavior; food-begging, stealing, and frightening people (Blokpoel 1983). Their defecation contaminates areas such as swimming pools, dining tables, benches, sidewalks, windows, vehicles, food, and water supplies. Gulls have also been implicated in eating the eggs and nestlings of waterfowl; damaging cherry orchards, tomatoes, and vegetable shoots; defecating on commercial products; and removing insulation from buildings (Krzysik 1987). Gulls are the major species involved in bird-aircraft strikes in eastern North America (Blokpoel 1976).

Canada Geese

36. Canada geese have been intensely managed in the United States as a highly desirable game species. Over the past decade their populations have dramatically increased and they have become tame permanent residents of natural as well as manmade impoundments where they graze on short grass and persistently beg for handouts, particularly around picnic areas.

37. The excrement from the large birds is extensive and causes severe aesthetic and littering problems, potential health hazards, turf damage, and aquatic eutrophication at parks, picnic areas, campgrounds, beaches, athletic fields, golf courses, lawns, and other public-use areas (Hawkins 1970, Laycock 1982, Conover and Chasko 1985). The littering problem may be of such magnitude that recreational facilities have been abandoned. The Canada geese problem may become more serious in the coming decades. Canada geese and other waterfowl have also been implicated in agricultural damage, primarily to newly sprouting wheat (Besser 1985).

Swallows

38. There are eight species of swallows in North America, but only two of the species, barn and cliff swallows, build mud nests which may be closely associated with man-made structures. As in the case of pigeons, the construction of anthropic structures which satisfy the species ecological requirements, particularly nest sites in association with foraging sites, have enabled barn and cliff swallows not only to increase their population sizes but to expand their ranges. Highway bridges crossing streams, rivers, lakes, bays, and reservoirs have been the predominant factor in the success of these two species. This has been particularly dramatic with the spread of cliff swallows (originally a western species) eastward in the last decade (Grant and Quay 1977, Weeks 1984a, personal observation).

39. Cliff swallows probably come into conflict with man more than barn swallows since the former nest in large colonies. One to two thousand in single colonies have been reported (Terres 1980). Barn swallows form small colonies or are solitary nesters.

40. Cliff swallows prefer to attach their gourd-shaped, enclosed nests on overhanging surfaces of cliffs, vertical rock, or concrete or wood surfaces, although rough metal surfaces have been used. The nest has a tubular round entrance near its lower end. Barn swallow nests are open at the top and attached to flat horizontal as well as vertical surfaces. Swallow colonies of these two species--especially large ones--have four requirements for their habitat: (1) an appropriate and large site for nest attachment, (2) mud of the appropriate composition for their nests,

(3) fresh drinking water, and (4) an open foraging site with an abundance of insects. Reservoirs and dams represent highly desirable habitats since they fulfill all of these requirements. Extensive areas of open water are ideal since aquatic insects' productivity (especially midges) is generally very high.

41. The mud nests generally cause no problems, and swallows are highly beneficial to man since they consume large quantities of insect pests, including mosquitoes. However, when colonies of cliff swallows are large, there may be aesthetic, safety, corrosion/deterioration, or equipment damage problems caused by excessive excrement. The large numbers of ectoparasites associated with colonial birds may also be a nuisance or health hazard for man.

Woodpeckers

42. Woodpeckers are only involved in occasional localized damage to wooden buildings or structures such as billboards or telephone poles in suburban or rural settings. Generally the damage is minor since only one or a few birds are involved. However, in vacant summer cottages their drilling may go undetected and serious damage may occur in siding, eaves, or shutters. Cedar and redwood siding are highly preferred (Marsh 1983). Acorn, Lewis', and red-headed woodpeckers (especially the former) cache stores of acorns and nuts (even insects) in the cracks (natural and drilled) of trees, utility poles, and fence posts. An acorn woodpecker cached 50,000 acorns in a large ponderosa pine (Dawson 1923). In some regions, weakened utility poles must be frequently replaced (Jorgensen et al. 1957). Marsh (1983) predicts that woodpeckers may become involved in new damage problems as more plastic materials, such as rooftop solar panels, are being used for energy-efficient heating and hot-water systems.

43. Another complaint about woodpeckers is their drumming on utility poles or houses, including the sheet metal on gutters or roofs. Contrary to popular belief, the birds are not usually searching for insects, which they detect by sound, but are communicating with each other. Their drumming is analogous to singing in other bird species and is used by males for advertising territorial claims and attracting females

during courtship. Woodpeckers select hollow limbs or other appropriate sites, such as galvanized gutters, as druming posts to maximize sound resonance or attenuation. This creates a noise problem as well as aesthetic and potential structural damage.

44. Sapsuckers bore rows of closely spaced holes in the bark of trees and remove the sap with their tongues. They generally select a few trees to feed from, and their persistence may damage the cambium layer or make the tree susceptible to pathogens or insect pests.

45. Occasionally woodpeckers cause damage to nut orchards, particularly pecan crops in the southern states. The acorn woodpecker feeds on walnuts and almonds (Koehler 1962).

Crows, Ravens, Magpies, and Jays

46. Crows, ravens, magpies, and jays (Corvidae) cause local damage to agricultural crops. All may be scavengers, especially the raven, which often feeds on garbage.

47. Crows, magpies, and especially jays cause serious damage to nut crops (e.g., pecans, walnuts, almonds, pistachios, and filberts). The American crow prefers English walnuts, while scrub jays prefer almonds (Neff 1937). Pecans are fed on more heavily by birds than any other commercial nut, about a $10 million loss nationally in an average year (Hall 1984). Crows and blue jays along with woodpeckers are the primary culprits.

48. Crows may cause serious local damage to sprouting corn seedlings.

Eagles, Hawks, and Owls

49. Raptors are highly beneficial since they primarily feed on rodents. The smaller raptors feed heavily on insects when they are abundant. The peregrin falcon is an effective predator of pigeons. Accipiters* and falcons** may consume some game or song birds but these

*Accipiters--Goshawk, Cooper's hawk, and Sharp-shinned hawk.
**Falcon--Peregrin falcon (formerly duck hawk), prairie falcon, kestrel, and merlin are common examples.

species are uncommon and their impact is minimal. Although kestrels (our smallest falcon) are common, they mostly feed on insects, small rodents, and lizards.

50. Bald eagles are mainly carrion and fish-eaters, although they sometimes feed on waterfowl (usually crippled or sick), other birds, rabbits, squirrels, and muskrats. They occasionally rob ospreys and other hawks of their catches. Ospreys feed almost exclusively on fish, mainly species of low comercial or sport value.

51. Golden eagles feed primarily on rabbits, marmots, and ground squirrels, but also on small rodents, reptiles, and occasionally birds. They also eat carrion, but not to the same extent as bald eagles. Golden eagles rarely attack healthy large mammals. Much of their reputation as livestock predators can be attributed to carrion feeding, although yearling lambs and kids are occasionally taken.

52. Owls feed almost exclusively on rodents. The great-horned owl is a large and powerful raptor that possesses an extremely broad diet. Besides rodents it also feeds on rabbits, squirrels, woodchucks, skunks, and has even attacked porcupines. A wide variety of large and small birds, including hawks and owls, reptiles, amphibians, insects, and occasionally scorpions and fish have all been included in their diets. Decapitated bird carcasses generally mean owl predation (Hawthorne 1980). A flock of wild turkeys (16 birds) with every individual decapitated but not damaged in any other way was found in Pennsylvania, presumably the work of a great-horned owl (personal observation). Great-horned owl predation represents the greatest impediment to the successful establishment of newly released peregrin falcons at some of their historical nesting localities (Barclay and Cade 1983).

Bird Roosts

53. Large flocks of common grackles, red-winged blackbirds, brown-headed cowbirds, and starlings form winter roosts, primarily in southcentral and southeastern United States, which can contain 1 to 10 million or more birds (Webb and Royall 1970, Meanley 1971, Meanley and Royall 1976). Conflicts with man and these roosting flocks have been

extensive and controversial (McAtee 1926, Meanley 1971, Free 1975, U.S. Army 1975, Graham 1976, 1978, Dolbeer et al. 1978). Although all four species are common in winter roosts, the relative abundance of each species is variable. Grackles are usually the most abundant species, especially in Tennessee and Kentucky, but starlings or cowbirds may be the dominant species (D. Mott, personal communication). In a detailed study of a major winter roost in southwestern Tennessee over a three-year period common grackles comprised 68-80 percent of the population, red-wings 10-20 percent, starlings usually less than 10 percent and brown-headed cowbirds about 1-2 percent (White et al. 1985).

54. These roosts are responsible for two major problems in addition to their obvious aesthetic impacts of excessive bird waste and noise, and habitat damage. Serious depradations to agricultural grain crops and livestock feed lots have been reported near large roosts, and winter roosts have been implicated in harboring *Histoplasma capsulatum*, the fungus that causes histoplasmosis, a respiratory infection in man and other mammals.

55. The flocks select rather specific roosting sites that possess dense canopy stands of immature trees, often evergreens. Such an environment provides an optimal microclimate for winter roosts with regards to air temperature, wind velocity, air circulation, and the radiant environment (Francis 1976, Lustick 1981). This environment minimizes radiative and convective heat losses by the birds, a critical condition during the winter for small animals possessing a high body temperature. Roosting sites have also been reported in mature deciduous or conifer stands, and cattail or reed marshes (Krzysik 1987).

Agriculture

56. Bird damage to agricultural crops in the United States costs growers more than $100 million annually (Besser 1985). Blackbird (red-wings and grackles) depredation on field corn was estimated at $34.8 million in 1981 (Kelly and Dolbeer 1984), and Besser and DeGrazio (1985) reported that this is the number one agricultural bird damage problem in the United States. Blackbirds have also been implicated in serious

depredations on sprouting and ripening rice, ripening sunflowers, sweet corn, and grain sorghum. Starlings may feed extensively on sprouting wheat.

57. Birds are also responsible for serious damage to fruit crops. Crase et al. (1976) reported that bird damage to grapes in the United States was at least $4.4 million in 1972, with the California loss representing over $3.7 million. The birds responsible in California were the house finch and starling. Along the southern Lake Erie shore in Ohio, 28.3 percent of the diet of summer-fall starlings consisted of grapes (Williams 1976). Additionally, sparrows, robins, bluebirds, waxwings, and 23 other species have been reported to damage grapes (Besser 1985). Conover (1982) reported that about 50 percent of the total blueberry crop was destroyed each week in Connecticut farms when left unprotected. The primary culprits were starlings, blue jays, mockingbirds, robins, northern orioles, and brown thrashers. Mott and Stone (1973) reported that starlings, robins, and grackles cause the most damage to highbush and lowbush blueberries. Besser (1985) lists an additional 16 species that feed on highbush blueberries. Blueberries have been found in the stomach of at least 93 species of United States birds (McAtee 1942). Cherries are also severely impacted by bird depredations. Sweet cherries are damaged more than tart cherries because of their longer period of vulnerability and their higher sugar content. Starlings, robins, orioles, and house finches are the primary culprits that damage cherries, but grosbeaks, catbirds, waxwings, grackles, blue jays, and woodpeckers are also involved (Besser 1985).

58. American and lesser goldfinches remove strawberry seeds causing decay of the fruit.

59. Jays, crows, and magpies cause serious damage to nut orchards (see Crows, Ravens, Magpies, and Jays, page 17).

60. Although blackbirds and starlings are involved in the major portion of agricultural damage in the United States, game birds have also been implicated (pheasants feeding on sprouting corn and Canada geese and ducks on sprouting wheat). For over a century the house finch and horned lark were implicated as the severest pests to California crops (Clark 1976). The house finch feeds on the buds of fruit and nut trees,

embryonic and mature fruits and nuts, small grains, and vegetable and flower seeds. The primary damage by horned larks and white-crowned and golden-crowned sparrows is on newly planted seeds and sprouts/seedlings of vegetable and flower crops. American and lesser goldfinches feed on the mature seeds from flower and vegetable crops produced by commercial seed growers. A more comprehensive account of agricultural damage by birds, including detailed references, can be found in Krzysik (1987).

61. Because of the high population levels at fall and winter roosts, roosting birds have generally been blamed for extensive agricultural losses during the fall and early spring, particularly in the southern states. Louisiana, Mississippi, and Arkansas harbored 43 percent of the 137 major roosts of a million or more birds in the United States (Meanley and Royall 1976). Although local damage to grain crops may occasionally be severe at farms located near major blackbird-starling roosts, studies initiated in Kentucky and Tennessee to evaluate the effects of roosting flocks on sprouting and ripening corn and sprouting wheat concluded that the total bird damage to these resources was minor compared to damage from insects or weather. Williams (1976) reported that only 0.27 percent of the corn yield for three Ohio counties was consumed by roosting birds (primarily red-winged blackbirds) during the summer-fall flocking season. Dolbeer (1981) and Mott (1984) concluded that overall agricultural losses around the country are generally less than 1 percent of the total crop. These losses are negligible contrasted to damages caused by insects, other pathogens, and the weather. Jugenheimer (1976), Pimentel (1976), and McEwen (1978) estimated that for Midwestern corn the combined losses caused by insects, disease, fungi, and weeds was greater than 20 percent of the total harvest and an additional 5 percent of the potential harvest remained on the field as crop residue (Jugenheimer 1976). White et al. (1985) similarly concluded from a detailed study of a major blackbird-starling roost in Tennessee that the overall agricultural impact was negligible since most of the corn consumed came from fields already harvested. Interestingly, corn damage in western Ohio did not correlate with the relative population sizes of breeding red-winged blackbirds over a 9-year period (Stehn and deBecker 1982). Dyer (1975,

1976a, 1976b) found that bird damage to maturing corn increased the yield in some cases.

Feedlots

62. Blackbirds and particularly starlings have been implicated in economic losses at cattle and swine feedlots and dairy and chicken farms (Besser et al. 1968, Stickley 1979, Glahn 1983). The main problem was the consumption or spoiling of livestock feed, but the birds may be vectors in the spread of TGE (transmissible gastro-enteritis, baby pig disease). Hobson and Geuder (1976) surveyed 2051 randomly selected farmers in Tennessee and reported a loss of $4.2 million from consumed or spoiled feed. In a randomly selected sample of 287 Tennessee dairy, beef, and swine feedlots, Glahn (1983) concluded that 25.8 percent had more than negligible problems, including 6.3 percent with significant damage.

63. White et al. (1985), in a detailed study of the feeding ecology of a large (> 1 million birds) Tennessee winter roost of blackbirds and starlings, found that the overall losses of corn at all feedlots in the foraging range of the roost were about 1 percent (0.25 percent in swine feedlots). However, a few scattered feedlots received significant losses in midwinter after snow-falls when grackles foraged in large numbers. Although cowbirds foraged almost exclusively in feedlots, they primarily consumed weed seeds (74 percent of diet). Starlings used feedlots frequently and accounted for 75 percent of all birds in swine feedlots. This was the species most frequently observed in the feed troughs. Grackles only came into feedlots during severe winter weather when snow cover exceeded 2.5 cm. Red-winged blackbirds were uncommon in feedlots.

Safety Hazards

64. Research and reports dealing with the safety hazards associated with birds have generally been limited to aircraft collisions. Probably the most dramatic case was the 1960 collision of an Electra turboprop with a large flock of starlings at Boston's Logan Airport when 62 people were killed. The birds were sucked into three of the four engines continuously

for several seconds during the critical takeoff period. In the United States about 200 people have been killed in bird-strike accidents (Murton and Westwood 1976). The annual cost to repair aircraft damage resulting from bird-strikes exceeds $1 billion worldwide and $10 million in the United States (Lefebvre and Mott 1983).

65. Aircraft collisions with birds occur at a rate of one to three collisions per 10,000 takeoffs and landings, generally without damage to the aircraft (Terres 1980). Seventy-five percent of all bird-strikes occur at or near airports (Solman 1971). During 1984 there were 331 bird-strikes with Naval aircraft for every 100,000 hours of flight time (Walker and Bennett 1985).

66. Gulls are the number one aircraft bird hazards in eastern North America. They are involved in half of all bird-aircraft strikes in Canada (Blokpoel 1976).

67. The Air Force has developed an extensive awareness and research and development program to directly assist military bases in reducing bird-aircraft collisions (Will 1983). The BASH (Bird-Aircraft Strike Hazard) Team has been dealing with the problem for over a decade, and Air Force bird-strike rates have gradually decreased as the program has progressed (Kull 1983). Four Naval air stations implementing BASH procedures in 1984 reported 57 to 78 percent fewer collisions with birds than in 1983 (Walker and Bennett 1985).

68. Other safety hazards, such as equipment failure or the fall of a worker from scaffolding, ladders, or walkways because of slippery bird excrement, or being startled by a flushed or attacking bird, have not been researched.

PART IV: BIRDS AS POTENTIAL DISEASE VECTORS

Introduction

69. Birds possess an unusually large number and wide variety of external and internal parasites. Additionally, they are subjected to a wide variety of protozoan, bacterial, viral, and fungal infections. Most of these pathogens or parasites can only affect other birds. Sometimes an infection is highly host specific and restricted to a particular species or a certain family or order of birds. Humans and other mammals are not typically affected with avian parasites or pathogens. However, wild (free-living as well as captive) and domestic bird populations have often infected one another in epidemic proportions. These have included poultry, pigeons, game species, nongame species, and expensive exotics such as pets, aviary populations, and zoo specimens. See Krzysik (1987) for further details concerning avian ectoparasites, including blood-feeding arthropods.

Encephalitis

70. Blood-feeding arthropods (insects, ticks, mites) represent disease vectors that possess the potential to spread protozoan, nematode, bacterial, and viral infections among vertebrates. Despite the large variety and number of these blood-suckers that feed on adult and nestling birds, they are not usually considered as being serious threats to human health, with one exception. Encephalitis, an inflamation of central nervous system membranes, especially the brain, is caused by arboviruses (togaviruses) and can be fatal. An arbovirus is a virus found in the blood stream of infected vertebrates and is spread among other vertebrates by blood-feeding arthropods (e.g., mosquitos, blackflies, louse flies, ticks, mites). Arthropods are carriers and the disease can only be transmitted through the blood stream. Encephalitis has been reported in mammals (including man), birds, and reptiles (Johnson 1960).

71. Four major encephalitis arboviruses are found in the United States: eastern equine encephalitis (EEE), western equine encephalitis

(WEE), St. Louis encephalitis (SLE), and LaCrosse encephalitis (LAC) (Gordon 1983). Other strains have been reported from various parts of the world. These viruses use mosquitos as vectors and vertebrate reservior hosts. The usual hosts for the first three arboviruses are wild birds, while the latter strain primarily infects squirrels. EEE and WEE are named because of their geographical distribution in the United States, and are the forms best known (Kissling 1965, Karstad 1971). WEE has also been isolated from brown-headed cowbirds and house sparrows in New Jersey (Scherer 1963, Karstad 1971). Both of these arboviruses cause encephalomyelitis in horses and humans. Natural and experimental infections of EEE have been reported in 51 species of wild birds (Stamm 1963). Encephalitis does not appear to harm native bird species, which may, therefore, be a reservoir (Terres 1980, Campbell and Lack 1985). However, fatal infections have been reported in some imported species (e.g., chukar partridge, ring-necked pheasant, Pekin duck, and house sparrow) (Herman 1962, Terres 1980).

72. The prominent species implicated for transmitting EEE is Culiseta melanura, which breeds in swamps from the Gulf of Mexico to Canada, and is particularly fond of birds (Karstad 1971). Several Aedes species have also proven to be vectors (Terres 1980). The prominent transmitter for WEE and SLE is Culex tarsalis, which readily feeds on both mammals and birds and readily invades houses (Matheson 1944). This is a widespread species, abundant in the semiarid regions of western North America and also found in North and South Dakota, Texas, Illinois, Michigan, and western Florida. A potentially serious epidemic of WEE was prevented in Minnesota by an extensive mosquito control effort directed at Culex tarsalis (Gordon 1983). Karstad (1971) believes that birds do not carry virulent forms of WEE over long periods because of their strong and persistent antibody response.

73. Gordon (1983) has summarized the extent of encephalitis infections in the United States for the calendar year 1983 (as of 4 November). EEE infected 120 horses and 12 humans, with three human fatalities. WEE infected 101 horses and 13 humans, with one human fatality (6 of these cases occurred just across the border in Manitoba, Canada). SLE infected 10 humans. A major epidemic of this strain

occurred in 1975, which resulted in 1,815 cases nationwide, including 416 (29 fatal) from the northcentral states.

Chlamydiosis (Parrot Fever)

74. The average person is probably more familiar with "parrot fever" than with any other disease transmitted by birds. Parrot fever is the vernacular for psittacosis, also known as ornithosis. Page (1966, 1968) has suggested the name chlamydiosis to clarify the terminology, since psittacosis falsely implies that psittacine birds (parrot family) are the primary or only disease transmitters. In actuality, over 140 bird species in 17 orders have been implicated (Burkhart and Page 1971, Campbell and Lack 1985). The birds most frequently infected with chlamydiosis are pigeons, psittacines, ducks, geese, gulls, petrels, and shorebirds, but the disease appears in domestic and wild birds and mammals throughout the world. The most common and consistent source of infections are feral pigeons (Burkhart and Page 1971). Two-thirds of the pigeons in Paris were estimated to be infected with chlamydiosis (Welty 1979). In a 1944 Chicago epidemic of the disease in humans, 45 percent of the pigeons in the city were estimated to be infected (Welty 1979).

75. Chlamydiosis is a bacterial (Chlamydia) infection, often resembling pneumonia in man. It is characterized by fever, headaches, and muscle pain, with or without respiratory symptoms. Although it is usually fatal in untreated birds, human mortality is low, especially with tetracycline treatment (Terres 1980). About 150 cases are reported annually in the United States (U.S. Army 1985). Infected birds need not show symptoms but can still transmit the disease (Schacter and Dawson 1978). The bacteria are transmitted to man by (1) airborne inhalation, (2) inadvertent ingestion of infected bird excrement or nasal discharges, (3) skin-piercing bites by infected birds, or (4) blood-sucking arthropod vectors. The disease is most prevalent among breeders of pigeons or poultry and workers processing poultry (Boyd 1958, Meyer 1965). Bird-banders, wildlife specialists, and aviary workers are often exposed to infected birds and contract the disease (Wobeser and Brand 1982). Worth et al. (1957) reported that native North American bird species neither

constitute a health hazard for man, nor are they a significant reservoir for the bacteria. Nevertheless, the fact that bird species frequently infected by chlamydiosis represent the common avian fauna (pigeons, ducks, geese, gulls, shorebirds) around Civil Works facilities implies a potential human health risk.

Histoplasmosis

76. Histoplasmosis is a relatively common lung disease caused by airborne spores (actually microconidia) of the fungus *Histoplasma capsulatum*. Until the late 1960's and early 1970's it was commonly misdiagnosed as tuberculosis (Stickley and Weeks 1985). Clinical cases fall into three major categories, acute pulmonary, chronic pulmonary, and disseminated, reflecting the relative severity of the infection (Weeks and Stickley 1984, Stickley and Weeks 1985). Acute pulmonary histoplasmosis is the most common form and is usually mild, requiring no treatment. Pulmonary lesions are detectable by chest x-rays. Chills, fever, muscle pains, and a cough accompany the disease. Chronic pulmonary histoplasmosis results in cavitation in the upper parts of the lungs and is characterized by a cough, sputum containing pus, anorexia, weakness, and fatigue. It may continue for months or years, and unless treated, it can be fatal, usually from associated complications. Disseminated histoplasmosis results from the spread of the fungus throughout the body by the bloodstream. This form of the disease is characterized by an enlarged liver and spleen, paucity of leukocytes in the blood, anemia, high fever, and ulcerated lesions in the mouth. This form is usually fatal if untreated. Recovery in treated patients is about 80 percent.

77. Histoplasmosis is considered a relatively benign disease, accounting for only about 50 human fatalities a year (Weeks and Stickley 1984). An Army report (U.S. Army 1985) estimates that annually there are 500,000 infections, 5,000 individuals hospitalized, and 800 deaths in the United States due to histoplasmosis. About 90 percent of the people infected with the spores (register positive antigen serological tests) show no discernible symptoms; the other 10 percent develop cold or allergy-like symptoms which clear up without treatment. The severity of

the infection appears to be proportional to the amount of spores inhaled (Tosh et al. 1966a, Powell et al. 1973). More than 30 million Americans and 95 percent of the population of central Kentucky are estimated to test histo-positive (Monroe and Cronholm 1976).

78. The most serious threat of airborne infections by H. capsulatum spores occur when contaminated dry soil is disturbed, producing dusty conditions. Histoplasmosis can also result from contact with items exposed to the spores. Infections have occurred among family members of roost workers whose field clothes were contaminated or laboratory technicians processing infected soil samples (Stickley and Weeks 1985) but cases of this nature are unusual.

79. H. capsulatum is a widespread soil organism which has been postulated to thrive in all the world's river valleys in temperate and tropical regions, generally between 45° north and 45° south latitude (Furcolow 1960). However, it is rare or absent in arid regions like the Middle East (Selby 1975). The greatest infections in the United States have been reported for rural central states, especially the Ohio-Mississippi Valley regions (Ajello 1967, Weeks and Stickley 1984). A good review of the historical aspects of histoplasmosis can be found in Rogers (1966). An in-depth authoritative review is provided by Weeks and Stickley (1984) or Stickley and Weeks (1985), and a brief introduction suitable for the public is Weeks' (1984b) publication.

80. Histoplasmosis is usually implicated with roosting birds, predominantly blackbird-starling winter roosts (Furcolow et al. 1961, Ajello 1964, d'Alessio et al. 1965, Tosh et al. 1970). Histoplasmosis infections have also been associated with chicken feathers, sawdust, decaying wood, and coal dust (summary in Selby 1975) and soils enriched with droppings from chickens (Furcolow 1965, Stickley and Weeks 1985), pigeons (Grayston and Furcolow 1953), ring-billed gulls (Waldman et al. 1983), and oilbirds (Ajello et al. 1962). Cave explorers have contracted the disease from bat guano deposits (Furcolow 1965, Hasenclever et al. 1967). Since bat guano deposits may be very extensive and deep, spore production may be very high, leading to severe infections.

81. The soil at bird roosts (see Bird Roosts, page 18) is often infected with histoplasmosis (Furcolow et al. 1961, Powell et al. 1973,

Latham et al. 1980). A third of the 70 roost sites examined by Chick et al. (1981) in Kentucky harbored H. capsulatum, and human populations living near these positive sites had a significantly higher positive histo-reaction than those living near negative sites. Other studies have shown strong positive correlations between incidences of human histoplasmosis and distance from H. capsulatum infected sites (Furcolow 1961, Tosh et al. 1966b, Chin et al. 1970). However, living near a positive site does not necessarily mean that infections will be acquired (Menges et al. 1967). Mott (1984) discusses some unpublished reports on the ecology of H. capsulatum and concludes that temperature, humidity, and pH regulate the geographical distribution and growth of the fungus. Spore formation is inhibited at temperatures above 40°C or below 15°C, pH < 6.6, and low relative humidity. However, the spores can tolerate temperatures below 0°C and above 40°C for extended periods (Goodman and Larsh 1967) and survive within a pH range of 5 to 10 (Stickley and Weeks 1985). Histoplasmosis is detectable in soil around roosts generally after they have been in use at least 3 years (Chin et al. 1970). The high levels of nitrogen, phosphorus, and organic matter associated with older roosts apparently promote rapid growth of the fungus, and it takes this length of time and nutrient levels for H. capsulatum to compete successfully with other soil organisms (McDonough 1963). However, once established in the soil it becomes very presistent (Smith et al. 1964, Brandsburg et al. 1969). The fungus generally grows in the upper 2 to 12 cm of soil, but has been found as deep as 37 cm (Smith et al. 1966). Although H. capsulatum needs moisture for growth, the spores can survive many years in dry soil (Goodman and Larsh 1967).

82. Histoplasmosis has frequently been reported in dogs, cats, and wildlife, but it is not a contagious disease and animals (especially birds) are neither carriers of the fungi nor help disseminate it but are infected, like man, from a source of fungal spores (Selby 1975, Stickley and Weeks 1985). However, there is some evidence that bats may aid in spore dissemination (Zamora 1977). Birds appear to be immune to histoplasmosis, because their high body temperature (around 42°C for typical songbirds) prevents fungal development (Menges and Habermann 1955).

Cryptococcosis

83. Pigeon droppings are probably the most important source of the fungus *Cryptococcus neoformans* (U.S. Army 1985). The fungus has been found in 84 percent of samples taken from old pigeon roosting areas. The infection is acquired by inhaling the airborne yeast-like vegetative cells of the organism. Clinical symptoms are not characteristic and may be absent, but the infection may lead to cryptococcal meningitis, an inflamation of the brain and spinal cord membranes. It is difficult to diagnose and is fatal if not properly treated. Between 1969 and 1978 the annual death rate averaged 126 in the United States, but this is an unreported disease and the actual number is greater (U.S. Army 1985).

PART V: BIRD MANAGEMENT STRATEGIES

Introduction

84. This section summarizes the wide variety of approaches that have been used to control bird pests. Specific references should be consulted if more details are required. Lefebvre and Mott (1983), Timm (1983a), and Besser (1985) are particularly excellent references and they also contain a rich bibliography. Another good source of references is U.S. Fish and Wildlife Service (1984). Conference proceedings dealing with wildlife damage control are also a good source of information and references (e.g., Bird Control Seminar, Bowling Green State University, Bowling Green, OH; Vertebrate Pest Conference, University of California, Davis, CA; Great Plains Wildlife Damage Control Workshop, University of Nebraska, Lincoln, NE; Eastern Wildlife Damage Control Conference, North Carolina State University, Raleigh, NC).

85. This section should be used in conjunction with Part VI, Specific Problem Management. Although small or local problems may be resolved using some of the methods discussed here (e.g., exclusion, porcupine wire, sticky repellents), large or persistent problems and especially the use of toxins should be handled by experienced animal damage control professionals. The initial contact should be with the state agency involved with wildlife or animal damage. The Departments of Conservation, Natural Resources, or Fish and Game in your state will know who to contact. Also, the Federal Animal Damage Control Program has numerous research stations throughout the country. Many of these stations are administered from the Animal Damage Control Division, U.S. Department of Agriculture, Denver Wildlife Research Center, Building 16, Denver Federal Center, Denver CO, 80225-0266. This division was formerly with the U.S. Fish and Wildlife Service. Although there are many reliable private pest control firms that deal with bird problems, some may jeopardize environmental considerations and safety for assured bird kills, profit, or time/man-power savings.

Architecture/Structure Considerations

86. Most architectural/structural considerations are "after the fact"; the design criteria are inflexible or modifications are impractical. Nevertheless, the insight of an experienced animal damage control consultant during the planning/design stages of buildings, lock and dam complexes, and aircraft hangars could save problems and money for the entire lifetime of the project after it is completed. All types of ledges, beams, nooks or crannies, decorative or ornamental architecture, open vents or breathers, and irregular surfaces are potential nesting or roosting sites. Building ledges and beams could be constructed on a 45° angle. Although the girder design of bridge structures cannot be compromised, some structural beams or girders could possibly be designed at a 45° angle. Pigeons prefer to perch on flat surfaces or occasionally surfaces with gentle or moderate pitches. Openings and crevices could be kept to a minimum. All of these considerations are common sense approaches. Of course, aesthetics or specific contemporary designs or constraints will take precedence over potential bird problems. However, there are numerous facilities where aesthetics is secondary to serious bird management (e.g., large warehouses and aircraft hangars). It would be more economical to conceal internal beams in the design stages than to do it after the structure is completed. This is also the case with crevices, openings, or potential openings where birds can gain access into structures. Concrete surfaces should be constructed as smooth as possible.

Habitat Modifications

87. Birds are well known to select specific features of the habitat for their environmental needs in providing nesting, feeding, shelter, and roosting requirements. Some species (e.g., Kirtland's warbler, golden-cheeked warbler, black-capped vireo, and ovenbird) have various restrictive habitat requirements, and therefore are very susceptable to habitat manipulations or fragmentation. Unfortunately, most pest bird species are not only generalists but respond very favorably to most of

man's landscape changes. Probably the best example of habitat modification to effectively discourage bird pests is the thinning or pruning of trees and shrubs to control roosting blackbirds and starlings or birds around airports (see Bird Roosts, page 18).

88. Habitat/environmental manipulations to control bird pests require site as well as species specific knowledge concerning food and water availability, nesting sites, resting places, and shelter. An experienced animal damage control expert, after a period of observations, can usually recommend environmental manipulations. Sometimes a minimal effort is highly beneficial such as minor landscape changes, reductions in grass mowing, or improved garbage management. However, major environmental manipulations may be unfeasible or uneconomical, particularly if continual maintenance is required.

89. Environmental considerations at airports provide the most experience for evaluating the effectiveness of controlling bird pests with habitat modifications. Since bird-aircraft strikes present potentially high human safety risks, a great deal of effort has been made to manage birds in the vicinity of airports (Seubert 1966, Canadian Wildlife Service 1971, Blokpoel 1976, Harrison 1976, Lefebvre and Mott 1983, Will 1983, Walker and Bennett 1985). Blokpoel and Lefebvre and Mott's publications are particularly informative sources for the use of habitat manipulations in bird management strategies.

90. Gulls are the bird species most frequently involved in bird-aircraft collisions (Blokpoel 1976). Therefore, garbage dumps should be located beyond 3,000 m of jet aircraft runways and 1,500 m for propeller powered aircraft (Federal Aviation Administration 1974). A European-Mediterranean Regional Air Navigation Meeting recommended that garbage dumps should be located beyond 8 km of airports (International Civil Aviation Organization 1978).

91. Land-use planning in the vicinity of airports should be a strong priority (Harrison 1976). Golf courses, grain agriculture or storage, fruit and nut orchards, lakes, ponds, and marshes are all sites that attract large bird populations.

92. Lakes, ponds, marshes, and temporary standing water, regardless of size, water depth, or permanence are generally eliminated since these

attract waterfowl, both shore and wading birds, in addition to large numbers and varieties of song birds. Shallow water is much more attractive to most birds than deep water. Gulls, ducks, geese, swans, herons/egrets, cormorants/anhingas, ibises, storks, cranes/rails, kingfishers, and a variety of shorebirds (sandpipers, plovers, etc.) are mostly large birds strongly attracted to wetland sites and hazardous to aircraft (Seubert 1966, Canadian Wildlife Service 1971, Blokpoel 1976). Depressions in the vicinity of runways are leveled off since they collect runoff or rain water.

93. Birds can be excluded from ponds by the use of overhead stainless steel wire, nylon monofilament line, or netting (see Exclusion, page 35 and Monofilament Line, page 36).

94. Another major bird control strategy at airports is the management of grass height (Lefebvre and Mott 1983). Short grass (5 to 10 cm) is favored by Canada geese, gulls, shore and wading birds, crows, pigeons, and starlings. Geese prefer to graze on short lawns, which are also ideal for starlings probing for lawn grubs. All these species require open habitats to visually monitor approaching predators.

95. Long grass (15 to 40 cm) attracts pheasants, some quail species, ducks, meadowlarks, bobolinks, dickcissels, and grassland sparrows. Even the presence of only a few shrubs that provide perching or nesting sites above the grass layer and/or weeds encourage a much broader diversity of song birds. Tall grass provides suitable habitat for many small mammals (e.g., deer and harvest mice, voles, cotton rats, rabbits, shrews, and moles). Short grass mainly attracts ground squirrels and sometimes moles. These small mammals attract hawks and owls, especially just after tall grass or weeds are mowed. Hawks are known to follow harvesters, combines, or mowing equipment to forage on the disturbed insects, mammals, and birds. Tall grass also harbors dense insect populatons, including grasshoppers. Grasshoppers are a prime prey item for kestrels, gulls, herons, and egrets. Insects and earthworms are often controlled at airports by insectides, and small mammals by trapping or the use of toxins (Lefebvre and Mott 1983).

96. Specific recommendations for grass height vary geographically. The United Kingdom, Canada, and the Air Force have each

found different heights to be optimal (Lefebvre and Mott 1983). U.S. Fish and Wildlife Service recommendations are to maintain grass at 15 to 25 cm in height where gulls and small birds are a problem and 13 cm or less where these species are not a problem (Lefebvre and Mott 1983).

97. Fruit bearing trees, shrubs, and vines attract a wide varity of birds, sometimes in large flocks. Common fruit-eating species include starlings, robins, catbirds, cardinals, orioles, thrashers, mockingbirds, thrushes, finches, grackles, and waxwings.

Exclusion

98. Mechanical exclusion, generally by hardware cloth, poultry screening, or netting, is the most effective, permanent, and safe way to eliminate local problems with nesting, roosting, or perching birds pests. Hardware cloth is very strong and an effective means of preventing birds from nesting or entering openings and landing on ledges. However, to cut costs, at least some manufacturers have reduced the thickness of their zinc-galvanized coating. This has resulted in premature rusting and screen failure in 3 years of outdoor exposure. Aluminum screening is usually prohibitively expensive. UV-stabilized polypropylene netting or screening is available in a variety of mesh sizes and strand thickness from many vendors (Appendix B). Black is the usual color but other colors, including yellow, are available. Plastic netting/screening is cheaper than hardware cloth and much easier to handle and apply. Plastic screening may have to be replaced more often than the better grades of hardware cloth. Although initial costs may be high for materials and labor, exclusion may represent a favorable solution in the long run since it is so effective, and if done correctly, is a permanent solution. Care should be taken to insure that the screen openings are sufficiently small and that the screening is completely and firmly attached. Birds can fit through surprisingly small openings relative to their body size, and they can easily gain access through weak or inadequately attached screens. Plastics and fibers may possess short life-spans because of weather deterioration, especially exposure to the ultra-violet (UV) portion of sunlight. However, the new UV-stabilized polypropylene screening or

netting should possess good weathering ability. Although nylon is strong, it deteriorates rapidly when exposed to sunlight. UV stabilization may not be as effective with nylon as it is with polypropylene.

99. A polyvinyl chloride (PVC) clad polyester yarn netting (Appendix B) has been designed primarily to protect masonry, buildings, structures, ornamental architecture, and statues from pigeons. It is available in gray, beige, and red-brown colors, possesses UV stabilizers, is very flexible, nearly invinsible, and relatively inexpensive.

100. Small openings or vents can be permanently blocked with wood, sheet metal, or masonary to prevent bird access.

101. Netting has been a highly effective method for protecting some agricultural crops. Although expensive in materials and labor, it has been cost effective when protecting relatively small areas of valuable crops that are heavily depredated by birds such as blueberries, strawberries, grapes, or commercial flower and vegetable seed crops.

Monofilament Line

102. Exclusion through the use of an overhead canopy of 10-gauge stainless steel wire or 23 to 45 kg test nylon monofilament line has been used successfully for several species of larger birds, particularly gulls. Steel wire has proven effective in excluding gulls and other large wading and fish-eating birds from fish ponds and water supply reservoirs (McAtee and Piper 1936, Amling 1980). Ostergaard (1981) used nylon monofilament fishing line to exclude gulls from fish ponds. Blokpoel and Tessier (1984) successfully used both stainless steel and nylon monofilament line in excluding ring-billed gulls from two large public places--Toronto City Hall Square and Ontario Place. The stainless steel wire was stronger and longer lasting than the monofilament but was much more expensive and difficult to install because it tended to kink. The monofilament line was economical and easy to install, but it was broken occasionally by colliding birds. Additionally, nylon deteriorates upon exposure to sunlight's ultra-violet rays. This exclusion method works very well for gulls since these birds fly and glide in open areas and do not like to maneuver around obstacles, particularly if the obstacles are

difficult to see or surprise the gull. The lines (or wire) are generally used 30 cm to 6 m above the ground or water in a parallel, zig-zag, or grid pattern (Lefebvre and Mott 1983). Spacing between the lines (or wires) is species specific: 1.2 m for gulls, 60 cm for mergansers, and 30 cm for great-blue herons and terns (Salmon and Conte 1981). Small herons (e.g., green and black-crowned night) can surprisingly negotiate closely spaced wires and therefore require netting (Salmon and Conte 1981).

Trapping

103. Trapping has not generally been effective for grain depredations since large numbers of birds cause damage over extensive areas, but it has been successful for removing birds from orchards. Small local problems are often successfully handled by live-trapping with subsequent release to another area, or unprotected species can be disposed of, usually with vehicle exhaust fumes. The principle advantage of live-trapping is minimal hazards to nontarget species and accepted public attitude. Trapping success, strategies, and trap construction are to some extent species specific. Therefore, further details can be found in the section pertaining to species specific management strategies (page 60).

Shooting

104. The use of a .22 rifle (lead cartridges or dust shot) or a .410 shotgun is a very effective and simple way to eliminate small numbers of local bird pests. However, there may be problems with local ordinances, public attitute, safety hazards, or Federally protected migratory species. Shooting should be used only as a last resort and would be more appropriate in rural areas.

Chemosterilants

105. Ornitrol® is a whole kernel corn bait treated with 0.1 percent 20,25-diazacholesterol dihydrochloride. It is only requested for use on pigeons, although it is effective on sparrows. This compound produces

temporary sterlity by inhibiting embryo formation in the egg. Although it is harmlesss to birds at recommended dosages, it is lethal if high concentrations are consumed. For it to be effective, female pigeons must be fed Ornitrol for 10 days, which produces sterility for about 6 months (Courtsal 1983). Therefore, the treatment must be done twice a year, initiating in February-March when reproduction is low. Prebaiting (see Toxins, Introduction, page 51) for 10 to 14 days at selected sites is recommended before using Ornitrol bait (Courtsal 1983).

106. Ornitrol has not been successful in controlling pigeons. Erickson (1983) reported that Ornitrol treatment for pigeons on a college campus resulted in only 15 to 30 percent infertility, and the birds laid fertile eggs in their second clutch after treatment. There are four main problems with Ornitrol: (1) because there is a time lag, it cannot solve immediate problems, (2) all the females in the population must consistently feed on the bait for the entire duration of the treatment, (3) there is usually a continued immigration of fertile females from surrounding areas, and (4) having a large sterile population of pigeons may not solve a persistent local problem.

Wetting Agents

107. The use of wetting agents (detergents) is restricted to the Division of Animal Damage Control, U.S. Department of Agriculture. The only chemical registered at this time for large-scale lethal control is the industrial surfactant Tergitol®* (PA-14) for use on blackbird/starling roosts (Lefebvre and Seubert 1970, U.S. Army 1975). Tergitol has also been used to control house sparrows (Fitzwater 1983). Applied in a weak aqueous solution, the surfactant dissolves the waterproof oil coating the birds' feathers. However, very rigid weather conditions are necessary for this treatment to be effective--at least 1.3 cm of rainfall shortly after treatment followed by temperatures of 5°C or lower (U.S. Army 1975, Lustick 1975, 1976, Lustick and Joseph 1977). Under these conditions, body heat loss by the birds exceeds heat produced by basal metabolism,

*See Appendix C for chemical nomenclature.

resulting in hypothermia. As their body temperature drops, unconciousness, damage to the central nervous system, and death follow. The dying birds do not exhibit alarm or distress behavior. At the concentrations used the chemical is safe to plants and other animals, with the possible exception of some potential aquatic hazards.

108. Since stringent weather requirements place severe restrictions on the practical applicability of Tergitol, a new delivery system has been developed and is presently being evaluated (Stickley et al. 1986). The system consists of overhead sprinklers, irrigation pipe, and a proportioning valve that allows Tergitol to be metered into water pumped from a fire hydrant. After the birds are sprayed with the Tergitol solution, enough water is provided by the sprinkler system to thoroughly wet the birds.

Repellents

Porcupine Wire

109. Porcupine wire (Nixalite® and Cat Claw®) have been developed to prevent birds from landing on ledges, beams, girders, gutters, roof edges, signs, or the complex decorative architecture found on historical buildings. Nixalite (two models) consists of a strip approximately 10 cm wide and 9.5 cm high of sharp 1 mm wire (40 per 10 cm of length) projecting in a 180° arc from a narrow (6 mm) flexible base. Because they are constructed of 302 stainless steel, maintenance is minimal. The bases can be attached to almost any surface with a variety of stainless steel hardware or adhesives. Nixalite provides a manual for applications and installations.

110. The practicality of Nixalite is limited by the size of the surface area to be protected. Porcupine wire is most practical with relatively narrow surfaces. A single strip protects a ledge 5 to 10 cm wide. A half-width 90° strip is also available for ledges less than 5 cm in width. Two strips will protect a ledge up to 22 cm in width, and five strips are necessary for a 60 cm wide ledge (Nixalite Applications Manual). Although Nixalite is expensive ($350 per 30 m), it represents a permanent and effective solution, and therefore, it may be cost-effective.

Electrical Shock

111. The Avi-Away® bird control system consists of a horizontally mounted cable which receives electrical pulses from a control unit, much like an electrical cattle fence. Typical installations of the cable include mounting it 4 to 6 cm above a ledge or just beneath the top of open airport hangar doors. Avi-Away cables can be mounted on or around a great variety of exterior structures or they can be used inside buildings (Avi-Away Bulletin). The cable appears as a perching site, and a landing bird completes the electrical circut between two wire conductors durably embedded in each lateral side of the cable. The bird receives a nonlethal shock and may emit an alarm or distress call when flying away. This behavior often disperses other birds in the imediate area (Avi-Away Bulletin). Its manufacturers claim complete avoidance of the area after the birds have had a few experiences. Lefebvre and Mott (1983) report that electrical shock devices are generally not effective because the thick skin of the birds' feet provides excellent insulation. Furthermore, electrical devices of this nature require excessive maintenance.

Sticky Contacts

112. Polybutenes (polybutylenes), polyisobutylenes, and polyethylenes represent a family of high molecular weight hydrocarbons that possess high viscosity. They are used as lubricants and additives (e.g., STP engine treatment) or as a wide variety of sticky compounds (e.g., Tanglefoot®, Roost No More®, and 4-The-Birds®) to keep damaging insect pests from climbing up trees. They are also used in roach motels and insect traps, mouse traps, and to repel perching, roosting, or nesting birds. Polybutenes, when used as sticky bird repellents, range in concentration from 2 to 97 percent. The remaining ingredients consist of one or more of a wide assortment of additives that aid in surface adhesion, control viscosity, or increase the compound's irritating properties. Frequently used additives include: mineral oil, lithium stearate soap, diphenylamine, zinc oxide, hydrogenated castor oil, petroleum naphthalenic oils, paloja, petrolatum, resins, calcium soaps, and aromatic and aliphatic petroleum solvents (Jacobs 1983). Tests by the Air Force indicated that all the products they evaluated were equally

effective and similar to ordinary automotive bearing grease (Lefebvre and Mott 1983).

113. Roost No More is available in two products possessing different viscosities; a liquid for treating trees, shrubs, or vines and a paste for applying to ledges and other surfaces. The paste comes in a cartridge and is applied with a standard caulking gun (aerosol cans are available for small applications like window sills or air-conditioners). A single cartridge will deposit a 1 cm bead 3 m long. Parallel strips 7.5 cm apart for pigeons and 5 cm apart for starlings should be applied on ledges or beams 1.25 cm from the edges (Roost No More Applications Manual). It is imperative that sticky compounds are applied over clean, dry surfaces. When metal surfaces are to be treated and air temperatures are greater than 32°C, 5 cm waterproof masking tape should be used to insulate the compound from the metal. Tape also protects surface discolorations and greatly facilitates removal of the compound.

114. Although sticky agents have been effective under ideal conditions, a common user complaint has been their short life-span and the necessity of repeated applications (Roost No More claims their products to be effective for a year). Sticky compounds quickly become ineffective in dusty, sandy, sooty, or windy conditions. They are sensitive to the weather, melting and running in hot weather and becoming brittle in the cold. Additionally, they are messy to work with, affect aesthetic appearances, may cause discoloration, and may interfere with mechanical or moving parts. These compounds are impractical to apply to large surface areas or to complex or inaccessable structures. Furthermore, all available sites must be treated or the birds will merely relocate nearby.

115. Mineral oil has been treated with bentonite clay (0.3 percent by weight) to produce a "non-drying film" that has been used on ledges to deter roosting birds (dialkyl ammonium bentonite and alkyl benzyl dimethyl ammonium bentonite) (Jacobs 1983).

116. Since sticky compounds are inexpensive and easily dispensed (assuming reasonable access), it may be worth the effort to experimentally determine if they are effective for a specific bird problem.

Chemical

117. Naphthalene - Naphthalene flakes or pellets (moth balls) have been used indoors or in small enclosed areas to repel nesting or roosting birds, generally pigeons, starlings, and house sparrows. This compound is registered for use against these three species in attics and wall voids (Jacobs 1983). The recommended dosage is 1 kg for 25 m^3 (Hawthorne 1980). After the birds have left, the area should be scaled off with wood, sheet metal, hardware cloth, or plastic screening/netting or continual applications of naphthalene will be necessary. Odors leaking into inhabited portions of the treated building may be annoying.

118. Methiocarb - Methiocarb or Mesurol® (3,5-dimethyl-4-[methylthio] phenyl methylcarbamate) (Mobay Chemical Corporation), an insectcide, is also an avian repellent that produces a conditioned aversion in birds by reinforcing a "bad taste" to its intoxicating effects (Rogers 1974). Guarino (1972) reported methiocarb to be highly effective at protecting agricultural crops. The compound has been reported to be effective with a wide variety of species, including blackbirds, starlings, sparrows, finches, pheasants, and a variety of tropical species. Apparently, the compound does not kill many birds (it mainly produces intoxicating and erratic behavior), and nontarget bird species suffer minimal damage (Holler et al. 1982).

119. Methiocarb has been used in two different ways for grain crops (Besser 1985). It can be applied at low concentrations (e.g., 0.1 to 0.5 percent by weight) to the seeds just before sowing and thus offer protection to the sprouting seedlings (corn, rice, sorghum, and soybeans), and it can be applied as treated bait to protect ripening corn, rice, sorghum, or wheat. To protect maturing crops, the application rate has generally been 1.5 to 10 kg of active compound per hectare.

120. Methiocarb is commonly sprayed on ripening fruit and has been successfully used to reduce bird damage to grapes, sweet cherries, sour cherries, and lowbush and highbush blueberries (Krzysik 1987). Application rate is 1.7 to 2.2 kg/ha (Besser 1985).

121. The effectiveness of methiocarb and the degree of protection it offers depend on a variety of factors. Its use requires a trial period to adjust to site- and species-specific conditions. A common problem is poor

adhesion of the compound to the surface of the grain. Although various adhesives and a latex slurry have been developed and used successfully in Germany and in experimental trials, they have not been accepted by corn growers in the United States (Besser and Knittle 1976).

122. Methiocarb has also been effective at reducing the use of lawns and golf courses by free-ranging Canada geese (Conover 1985b). A single application of 3.0 kg/ha was used for deterrence. Similar results were obtained in controlled experiments with captive geese.

123. Dimethyl Anthranilate. Mason et al. (1985) recommended dimethyl anthranilate (DMA) as a livestock feed additive to repel birds. DMA is an inexpensive nontoxic food additive readily accepted by mammals and approved for human consumption but apparently offensive to birds. Even in low concentrations (0.28 percent) birds find the compound unpalatable. Initial field tests indicated that DMA-treated cattle pellets and poultry crumbles significantly reduced feed consumption by birds (starlings represented 77 to 90 percent of the bird individuals). Birds in this study, as well as a previous laboratory evaluation (Mason et al. 1983), did not become accustomed to the compound.

124. The Animal Damage Control division of the Department of Agriculture is assessing the potential of this compound as a bird repellent (D. Mott, personal communication). Obviously, an effective bird repellent which is harmless to mammals and economical, would be one of the most important developments in bird management.

125. Curb. Aluminum ammonium sulfate (Curb) has been tried as an avian repellent on a very wide variety of crops in many regions of the world. Field results have been variable and inconsistent. The compound has been reported to impart a metallic flavor to treated grapes (Ewing et al. 1976). Preliminary tests by Ewing et al. (1976) indicated that house finches and starlings damaged significantly fewer treated grapes than untreated controls.

126. Miscellaneous Aversion Compounds. Three other aversion conditioning agents have been used to protect seeds and seedlings from bird predators. Coal tar (62.7 percent) and Copper oxalate (4 percent) are registered as seed corn treatments for repelling crows. Lindane (25

percent) containing 12.5 percent Captan, is registered as a seed treatment for corn, sorghum, and soybeans for deterring pheasants (Jacobs 1983).

127. Lachrymators. Tear gas has been tried as an avian repellent. The most widely used lachrymator is 2-chloroacetophenone (phenacyl chloride, Eastman Kodak Co.). Extensive testing of this compound as a potential nontoxic bird repellent was conducted with gulls, pigeons, and (house) sparrows (Vind 1969). This lachrymator was totally ineffective. Birds fed on seeds equivalently from panels coated with 5 or 10 percent solutions of this compound and untreated control panels. Experimenters could not approach the treated panels downwind nearer than 0.3 m without feeling the effects of the lachrymator. Birds possess a second eyelid that is transparent (nictitating membrane), which closes in irritating environments.

Frightening Agents

Acoustics

128. Introduction. A wide assortment of acoustical devices have been employed to disperse depradating, nuisance, or roosting birds (Hawthorne 1980). These devices fall into four categories in their order of importance: gas exploders, pyrotechnics, recorded alarm/distress calls, and electronic noise devices. A very important consideration when using acoustics is that birds habituate quickly to any repetitious or consistent pattern of noise. Temporal and spatial variability must be incorporated into any acoustical bird management program.

129. Gas Exploders. Gas-powered exploders have saved more ripening corn from bird depredations than any other means (Besser 1985). Automatic portable propane exploders (or guns) can be left unattended and are designed with adjustable unequal firing intervals. Solar cells shut off the units at night and again turn them on in the morning. The noise from a propane discharge is about ten times that of a shotgun blast. Acetylene or carbide models have also been used. Some models have adjustable barrel lengths to control sound levels. One model has twin barrels mounted on a bearing surface. The barrels fire in rapid succession and the blast from the recoil spins the barrels to a new random direction. Propane exploders

are relocated at weekly (or less) intervals. The Razzo® (Margo Supplies Ltd.) is a vertically mounted propane gun which sends a "metal butterfly" to the top of a 7.5 m pole, to add a visual effect. Gas exploders should be mounted on a stand just above the crop. A small steel drum with the ends removed positioned just beyond the barrel of the exploder amplifies the sound, increasing its effectiveness (Besser 1985). Each exploder fully protects 4 ha but actually benefits a much larger area (Mitchell and Linehan 1967).

130. Conover (1984) concluded that of the three methods being evaluated for reducing blackbird damage to field corn (Avitrol®, hawk-kites, and exploders), exploders were the most cost-effective, and they reduced damage by 72 percent. They required little labor, and a single exploder was sufficient to protect an area exceeding 100 m. See the following section on pyrotechnics for the problems and hazards associated with using explosive noises to disperse birds.

131. Pyrotechnics. An older and cheaper but more limited way to make a great deal of noise is the use of pyrotechnics. A wide variety of agricultural explosive devices (fireworks) have been used: silver salutes, M-80s, cherry bombs, and rope firecrackers. The latter consist of large firecrackers strung together by their fuses being inserted through 8 to 9.5 mm cotton rope. The burning speed of the rope is increased by overnight soaking in an aqueous 8 percent solution of potassium nitrate (saltpeter) and allowing it to dry (Booth 1983). The timing of the exlosions can easily be adjusted by varying the distance between the firecrackers inserted into the rope. Special precautions must be taken with this technique because of its serious fire hazard.

132. Other commonly used pyrotechnics are devices that are fired as projectiles into the air by a 12 ga shotgun or a modified .22 pistol. Air explosions appear to be more effective than ground explosions in frightening birds. Shellcrackers are fired from a 12 ga shotgun and explode 60 to 120 m away. Bird bombs, racket bombs, hissing rockets, noise rockets, and whistle bombs are all pyrotechnics propelled by blanks fired from a modified .22 pistol. The firing range is 30 to 120 m depending on particular models. The exploding types are more effective than whistling noise models (Booth 1983).

133. Exploders and pyrotechnic devices have proved to be very effective, particularly when they are moved every few days and explosive intervals are varied. Explosive devices are probably most effective when used in conjunction with other avian management strategies. These devices have several important shortcomings. High noise levels, especially explosive sounds, are unacceptable in many environments, including urban-suburban areas, airports, and recreational areas. The optimal time to disperse feeding or roosting flocks is early morning or evening--the times of the day when noise pollution is most annoying. Another important consideration is the fire hazards associated with explosive devices. This is particularly true with pyrotechnics, especially when slow burning long primary fuses are involved. Special precautions must be taken and safety criteria must be strictly adhered to when employing exploders or pyrotechnics.

134. Alarm/Distress Calls. Amplified recordings of alarm or distress calls have been used to disperse or frighten-off birds (Frings and Jumber 1954, Wright 1967, Lefebvre and Mott 1983). Alarm calls are given by birds to warn others of danger when a predator (e.g., man) is sighted. Distress calls are given by birds when under physical stress (e.g., when seized by a predator). Not all bird species elicit both types of calls; many possess neither call. Blackbirds, starlings, crows, and especially gulls are very responsive to these calls (Lefebvre and Mott 1983). Warning calls of a given bird species are not only interpreted by other individuals of that species but also by individuals of other bird species. Generally, these are related species or species found in common association with one another (Wright 1967). Some species that respond to warning calls of other birds do not themselves possess alarm or distress vocalizations. It is possible that these species are responding to the flight behavior of alarm or distress calling birds (Wright 1967, Brough 1968). Since these calls are natural, highly adaptive, and used frequently, birds should not habituate to them. However, birds gradually learn to recognize recorded calls and do not associate them with danger (Blokpoel 1976). Gulls and crows can habituate to a recorded call in 6 to 8 days (Gramet and Hanoteau 1963).

135. Avian vocalizations are commercially available (Appendix B). The recordings are generally used on a good quality cassette tape recorder and broadcast through ordinary automotive or public address components. It is necessary to use high quality cassette tapes. Components should possess a frequency response of 250 to 12,000 Hz with an amplitude of 120 dB (1,000 Hz) at 1.2 m from the speaker(s) (Boudreau 1971). Many birds (especially warblers) produce vocalizations at frequencies far above this range, but the only nuisance species of concern would be the horned lark. With these species, much more expensive hi-fidelity components would be necessary. If specific alarm/distress calls are not commercially available or if a specific local dialect is required, recordings will have to be made. This is a difficult and time-consuming task but guidance is available (Bradley 1977, Fisher 1977, Simms 1979). An excellent discussion of the use of alarm/distress recordings can be found in Lefebvre and Mott (1983).

136. Electronic Noises. Electronically produced sounds by a sound generator are usually not as effective as alarm/distress calls (Booth 1983). Av-Alarm® is an automatic electronic device that produces very loud, variable, intermittent sounds (1,500 to 5,000 Hz). The noise is broadcast from a large speaker(s) mounted on a pole. Av-Alarm is powered by a regular 12 volt storage battery which lasts 4 to 6 weeks between recharges. Three different electronic sounds can be selected, incorporating three on and off time modes (generally, 8 to 12 seconds on and 25 seconds to several minutes off). The manufacturer claims this device to be effective to 200 m in a 90 to 120° sector, and swivel-lock extension speakers increase coverage up to 5 ha.

137. Johnson et al. (1985) found that a combination of sounds (white noise) was initially as effective as distress calls in frightening starlings. However, the birds habituated faster to the white noise than to distress calls. A pure tone did not elicit a fright response in starlings.

138. Ultrasonics. Several manufacturers offer ultrasonic sound devices that produce sounds above 20,000 Hz, which are inaudible to man. Some animals can hear higher frequencies than man (e.g., dogs, most bats, some insects), but most birds generally do not (Frings and Frings 1967).

Ultrasonic sound devices have not been effective in frightening or dispersing birds (Lefebvre and Mott 1983, D. Mott, personal communication), and they have never been successful at removing birds from Air Force structures (Will 1985). However, Carl Cable (Chief, Construction--Operations Division, North Central Division, U.S. Army Corps of Engineers) has communicated an interesting report on the use of ultrasonics to control bird pests. The Dukane Corporation in the mid 1950's installed an Ionovac on Baltimore's City Hall to disperse the resident pigeon population. The device was operated above the canine hearing range at 115 dB. Nearly the entire bird population within a mile radius of the city hall, including pets, were exterminated.

139. Additional research is needed on the nature and interrelationships of sound combinations, acoustic variability, and avian habituation in order to effectively and consistently repel or disperse depredating or nuisance bird flocks.

Lights

140. Flashing, rotating, or strobe lights and powerful searchlights have had varying degrees of success frightening birds (Lefebvre and Mott 1983). Amber lights timed to flash for five seconds at three minute intervals combined with movable owl decoys dispersed a starling roost (Lefebvre and Mott 1983). Rotating beacon lights have not been successful in deterring pigeons, starlings, and house sparrows from roosting and nesting in Air Force hangars (Will 1985). Maintenance and the electric bill for the beacons was over $9,600 annually for a single Air Force base.

Models

141. Predator. Predator models have been in use for a long time with varying degrees of success (perched owl models are probably the most familiar). Models are often ineffective, however, since birds habituate very quickly to them, especially if their spatial context does not change (Shalter 1978). To be effective, the models must often be relocated. Suspending the models from wire or nylon monofilament line so that they move with wind currents makes them much more effective than stationary models.

142. Conover (1985a) demonstrated in field experiments that the placement of a plastic owl model on a weather vane to increase its mobility and the addition of an animated struggling crow model to the talons of the owl model was an effective deterrent to crows in tomato and cantalope plots. An identical but stationary owl model was totally ineffective, since crow damage was similar in treatment and control plots. The crow-killing owl models were inexpensive and easy to construct. An identical battery-powered animated model produced comparable results to the wind-powered model and would offer crop protection during calm weather but was more expensive and difficult to build.

143. Models of soaring hawks, falcons, or eagles have been used to frighten birds (Hothem and DeHaven 1982). The models can be attached to helium-filled balloons or tall poles. Birds habituate much less to hawk-kite models than to other disturbing objects (Conover 1979).

144. Conover (1982) demonstrated that although the hawk-kite model was somewhat less effective than netting or methiocarb for protecting blueberries from a wide variety of bird species, it was much cheaper, did away with the time interval required between spraying and harvest, and was a control method approved by consumers. Consumer concern about chemical residues is a particularly important consideration for fruit growers who mainly rely on customer harvesting.

145. Hawk-kites were also successful and cost-effective in reducing blackbird damage to field corn (Conover 1984). The kites were the most successful technique evaluated in reducing bird damage in their immediate vicinity, reducing damage by 83 percent. The main drawbacks of hawk-kites with balloons is their cost, high labor requirements, and vulnerability to weather and vandalism.

146. Bird Corpses. The display of dead-bird carcasses has been successfully used to repel some bird species, especially gulls and crows (Lefebvre and Mott 1983). Plastic or fiberglass models can also be used, if they are accurate replicas and made to look like corpses, but there are no commercial sources (Lefebvre and Mott 1983). Stuffed taxidermally prepared specimens and formalin preserved specimens have been successfully used at airport runways, but they lacked longevity (Blokpoel 1976).

147. Scarecrows. Scarecrows, one of the oldest bird control devices, can sometimes be highly effective. At least one scarecrow is needed per 4 to 6 ha, and they should be moved every 2 to 3 days since birds will habituate to them (Hawthorne 1980). They can be constructed from almost any material, but an important consideration in the design is that there are components that move or swing with the wind. An electrically powered mechanical version is available which periodically rotates its head and arms while an air horn sounds (Lefebvre and Mott 1983).

Chemical

148. 4-Aminopyridine. 4-Aminopyridine (4-AP), Avitrol®, or FC corn chops-99S (Avitrol Corporation) was developed in the 1960s for protecting field corn from depredating blackbirds (DeGrazio et al. 1971, 1972, Stickley et al. 1972, 1976, Besser 1976). Avitrol is generally used as a cracked corn bait containing 3 or 0.3 percent by weight of 4-aminopyridine (Phillips Petroleum). It is blended with cracked corn (1:99 or 1:9 respectively) so that one out of a hundred particles contain 4-AP when it is used in agricultural fields as a frightening agent. Therefore, the final concentration is 0.03 percent (Avitrol label). Avitrol formulations are available with varying bait carriers and concentrations of 4-AP (D. Mott, personal communication). When used as a frightening agent, the application rate of the final bait (0.03 percent) is 1.1 kg/ha (33g/ha of 4-AP) applied to the total area (Besser 1985). Avitrol is generally applied in swaths to only one-third (Kelly and Dolbeer 1984) or one-ninth of the field (Besser and DeGrazio 1985). Therefore, concentrations in the swaths would be 3.3 kg/ha and 9.9 kg/ha respectively. The usual distribution strategy is two to five applications, each applied every four to seven days during the milk and dough stages of kernel development (Kelly and Dolbeer 1984, Avitrol label).

149. Upon ingestion of 4-AP, blackbirds elicit strong distress and alarm behavior before death, which repels or frightens other members of the flock. The distress behavior consists of squawking and alarm calls, erratic flight, tremors, and convulsions. This behavior has been reported in red-winged blackbirds, grackles, starlings, and house sparrows (Goodhue

and Baumgartner, 1965). The effective use of Avitrol, therefore, requires the presence of a large number of flocking birds, with a sufficient proportion ingesting the treated bait over a short time span so that the flocks are dispersed before extensive crop damage occurs. A decided advantage of Avitrol is that less than 1 percent of the visiting flock is killed and there are minimal hazards to nontarget species (DeGrazio et al. 1972, Knittle et al. 1976, Mott 1976). Dolbeer (1981) estimated that in order for Avitrol to be cost effective a farmer must lose more than 5 percent of his crop. However, surveys throughout Ohio indicated that only about 1 percent of the cornfields received this level of damage (Kelly et al. 1982). Dolbeer (1981) reviewed blackbird damage to corn in 5 states and Ontario, and in most instances less than 1 percent of the crop was lost. Therefore, a common complaint from farmers was that Avitrol was not cost effective.

150. The addition of hydrochloric acid, forming the hydrochloride derivative, appreciably stabilizes Avitrol during storage and at high temperatures. This increased stability, the addition of insecticides (to prevent bait removal by insects), and the use of small bait particle sizes (e.g., 11 mg) have enabled Besser and DeGrazio (1985) to successfully and cost effectively repel depredating blackbirds. Their technique greatly improved the benefit/cost ratio. However, tests in Canada using the hydrochloride derivatives were inconclusive (Harris 1983).

151. Successful Avitrol use has been reported for sweet corn in Wisconsin (Knittle et al. 1976) and Idaho (Mott 1976), and for sunflowers in the Dakotas and Minnesota (Besser and Guarino 1976, Besser 1985, Guarino and Cummings 1985).

152. At higher concentrations Avitrol is used as an oral toxin (see Oral Toxins, page 53).

Toxins

Introduction

153. Toxins, either oral or contact, can be an effective means of eliminating persistent bird pests and these are often used as a last

resort when other methods have failed. It must be emphasized that the use of toxins requires a number of important considerations: (1) the toxins must only be used for the specific species and uses for which it is registered, (2) the manufacturer's instructions and safety precautions must be closely followed, (3) the application should be performed by experienced personnel, usually Federal or State animal damage control experts or commercial pest control operators, (4) toxins should be used when relatively small numbers of birds are involved, and (5) a careful monitoring program must be implemented to assess the hazards to nontarget species, secondary toxicity, and any potential environmental impacts. Secondary toxicity results from predators or scavengers feeding on eratic behaving, dying, or dead birds. Eratic behavior, distress calls, and birds in physiological stress attract predators. Scavengers and predators are also typically attracted to large numbers of bird carcasses, where they gorge themselves. Starlicide® is much less hazardous than typical toxins (see Starlicide, page 54).

154. Toxins that are presistent in the environment (e.g. chlorinated hydrocarbons such as DDT, endrin, chlordane, and their relatives) should not be used because they accumulate geometrically up food chains.

Prebaiting

155. Prebaiting is not only an essential step in achieving maximum bait acceptance by the majority of target individuals, but enables the pest manager to assess any potential hazards with nontarget species. Prebaiting is the consistent placement of untreated bait in appropriate troughs or trays in the same location and with the same type of bait for several days to 2 weeks. The location should be acceptable and convenient for the target species but unavailable to nontarget species (e.g., most sparrow species prefer or will only feed at ground level and pigeons need large flat surfaces). The prebaiting period concentrates the birds and gives them confidence in the bait, containers, and locality. If the treated bait was introduced immediately, only a few individuals would be affected since their behavior to the toxin would discourage others from feeding on the bait.

Oral Toxins

156. Strychnine. Strychnine (see Appendix C for chemical nomenclature) is a highly toxic alkaloid processed from the dried ripe seeds of *Strychnos nux vomica*, a small tree native to southern Asia and northern Australia. The LD_{50} for birds is usually between 3 to 25 mg/kg, depending on species. Some common LD_{50}'s are: mallard (2.9), house sparrow (4.0 to 8.0), pigeon (21.3), and ring-necked pheasant (24.7). Most mammals generally fall within this same range, but strychnine is especially toxic to dogs, cats, coyotes, and kit foxes (0.7 to 1.2) (Timm 1983b).

157. Strychnine baits (0.6 percent) are only registered for pigeons and house sparrows around farm buildings and municipalities (Jacobs 1983). Strychnine was used in a carefully planned program to eliminate pigeons from a large area of downtown Kansas City, Missouri (Franke 1983). Because of its toxicity, strychnine is very effective but nonspecific. A bird with an empty crop feeding in the morning on toxic bait will die in 5 to 10 minutes. Strychnine poses severe toxicity hazards for nontarget species, humans, pets, and scavengers. It should only be used as a last resort in very limited or small areas where there is minimal danger to nontarget species or secondary consumers. A prebaiting period is used with strychnine. The future of strychnine as a toxin for bird control is uncertain, since it will probably be withdrawn from Federal registration (Franke 1983).

158. 4-Aminopyridine. Avitrol® is available as a whole kernel or cracked corn bait containing 0.5 percent of the active ingredient, 4-aminopyridine (4-AP). Dilutions of 1:4 or 1:9 of treated bait to corn are usually used with equal success. These concentrations are registered for pigeons, house sparrows, starlings, blackbirds, grackles, and cowbirds for use in the area of structures, nesting, and roosting sites (Jacobs 1983). A prebaiting period should be used with 4-aminopyridine treated baits.

159. Birds are generally more sensitive to 4-AP toxicity than mammals. Most birds possess an LD_{50} < 10mg/kg, and death occurs in 15 minutes to 4 hours (Timm 1983b). A cat apparently remained healthly after

a four-day period when it was fed 51 sparrows that were killed with 19 times the lethal dose of 4-AP (Timm 1983b).

160. 4-Aminopyridine is often used in low concentrations so that the pest birds can disperse before dying to avoid public reactions to a toxicity program. Dilutions of 1:19 or 1:29 have been successful in eliminating large flocks of pigeons with few visible carcasses (Mampe 1976). However, it takes longer to achieve control when lower concentrations are used (Courtsal 1983). The duration of treatment to eliminate a particular bird problem is highly variable depending on the magnitude of the problem, bird species, season of the year, bait placement, success of the prebaiting schedule, and other site-specific conditions.

161. Avitrol is also available in 25 or 50 percent concentrated powder to be mixed with site-specific baits in controlling starlings in feedlots (see below) or gulls in landfills or roosting/nesting sites (Jacobs 1983).

162. Starlicide®. Starlicide, also known as DRC-1339, is the trade name of a slow acting toxicant developed by Ralston Purina Co. It consists of food pellets containing 1 or 0.1 percent 3-chloro-p-toluidine hydrochloride. Starlicide is also available in concentrated form (98 percent purity) for treating user-specific baits, but a permit is necessary to acquire the compound (D. Hall, personal communication).

163. Starlicide has most commonly been used to control starlings (the most serious bird pest) and blackbirds at cattle and hog feedlots and dairy and chicken farms. The normal application rate is 0.5 kg of Starlicide pellets (1 percent concentration) per metric ton (1 lb/ton) of livestock ration (West and Besser 1976), which results in an overall concentration of 5 ppm of active toxin. This concentration is highly toxic to starlings, blackbirds, and crows and ingestion of a single pellet is fatal. Higher concentrations of the toxin are unnecessary. Even at very high concentrations death never occurs in less than 3 hours. Death usually occurs within 5 to 24 hours and some individuals take up to 3 days to succumb (West and Besser 1976, Timm 1983b).

164. Glahn (1982) recommended the use of bait containers to attract foraging starlings. A prebaiting period using untreated bait was

considered essential to attract the starlings to bait containers strategically located in the feed lot. By this method starlings were fed a more concentrated diet of the toxin, the total amount of Starlicide was reduced, and livestock did not ingest any of the material. This method produced mixed results. The location and number of bait containers was important. Also, the prebaiting period using untreated bait was critical, so this method was more management/labor intensive.

165. Starlicide is also used as bait (0.1 percent) scattered lightly (10 to 55 kg/ha, depending on the size of the feedlot operation--higher concentrations are used in smaller feedlots) around pens and alleyways in livestock and poultry feedlots (Starlicide label).

166. Starlicide exhibits a much lower toxicity to mammals than to birds; however, cats are sensitive (D. Mott, personal communication). Bird species vary widely in their susceptability to Starlicide; starlings, blackbirds, crows, turkeys, and owls are very sensitive, but some hawks and sparrows show a low toxicity to the compound (Decino et al. 1966, D. Mott, personal communication). Pheasants, ducks, doves, and pigeons are moderately sensitive. Therefore, nontarget species feeding on the bait may vary considerably in their susceptability to the toxin. Appendix D gives the LD_{50} doses for selected bird and mammal species. Since a prebaiting period is necessary with DRC-1339 baits, a monitoring program should assess the potential hazards to nontarget consumers.

167. Starlings completely metabolize the compound in 2.5 hours, including the excretion of all metabolites (Timm 1983b). Since minimal survival time after ingestion is 3 hours, even at very high doses, there can never be secondary consumption of DRC-1339 by scavengers or predators feeding on carcasses. Additionally, since it is slow acting the affected birds disperse before dying, an important consideration when avoiding publicity.

168. Rhoplex® AC-33 (Rhom and Haas Chemical Co.) is a compound sometimes used in conjunction with Starlicide. It masks the flavor of Starlicide, so that late feeding arrivals of the flock are not diverted away by early feeders displaying aversion reactions. Additionally, it is also a sticking or adhesive agent, aiding the adhesion of the active toxin to the selected bait (Hall, personal communication).

169. Hall (1985) presents an excellent example of using Starlicide in a user specific bait. Starlings were nesting within fiberglass and styrofoam insulation, creating extensive damage. The birds were foraging and feeding their nestlings with large quantities of dead June beetles found beneath night lights. Crickets were purchased (readily available in bait and pet shops) and killed by hot water immersion. The cricket carcasses were treated with 1 g of Starlicide (98 percent concentration) disolved in 10 ml of warm water and 5 ml of Rhoplex AC-33 solution (5.7 mg of active compound per cricket). Therefore, a single cricket contained a lethal dose for starlings (see Appendix D). The bait was placed under the night lights early in the morning at a rate of five untreated crickets to one treated cricket. The nesting starlings were eliminated in two weeks.

170. The concentrated compound (98 percent) has also been added to French-fried potatoes and a wide variety of fruit to successfully control starlings (Johnson and Glahn 1983).

171. Starlicide has also been used for blackbirds, crows, and pheasants at a rate of 1 percent active compound on cracked corn (D. Hall, personal communication).

172. Starlicide is at present not registered for use on pigeons, but this compound should be much less hazardous than strychnine, Avitrol, or toxic perches to secondary consumers feeding on dead or dying birds. Pigeons are about four times less sensitive to Starlicide than starlings (Appendix D).

173. CAT. Peoples et al. (1976) recommended the use of a derivative of Starlicide known as CAT (2-chloro-4-acetotoluidine) as a substitute for Starlicide. They used 120 g per ton of feed (132 ppm). Both compounds possess similar toxicity to starlings, but CAT possesses several significant advantages over its parent compound; it is even less toxic to birds of prey and mammals, more stable and possesses a longer shelf life, and does not cause human skin irritations. The LD_{50} for starlings is 2.6 mg/kg. However, this compound is not registered for bird control and is unavailable (D. Mott, personal communication).

Contact Toxins/Toxic Perches

174. Contact toxins represent a variety of toxins that are absorbed through birds' feet. The usual method of application is through the use of toxic perches (e.g., Rid-A-Bird®), which dispenses the toxin (Jackson 1978). Rid-A-Bird perches are 1.3 cm diameter perforated metal tubes either 69 or 76 cm long. The company's flat perches are 3.8 cm wide by 61 cm long. The hollow perches are filled with a contact toxin that is wicked to the surface with the wick running the outside length of the perch. For outdoor installation, the wick is covered with fine wire mesh to minimize dilution from rain. Fenthion (11 percent solution in oil) is the usual toxin, but endrin (9.4 percent solution in oil) has also been used.

175. The placement and number of perches deployed depend on site specific variables and the nature and magnitude of the problem. It is very important that the birds are surveyed and their habits carefully observed before any perches are installed in order to optimize perch placement and potential effects on nontarget species. Most failures of toxic perch programs are due to inappropriate perch locations. Usually 10 to 12 perches are required, but 30 or more will be necessary for large jobs (Martin and Martin 1982, Courtsal 1983). In general, if perches are carefully located, a density of one perch for 200 to 400 m^2 is sufficient.

176. Fenthion is much more toxic to birds than to mammals (Timm 1983b). Originally developed as an insectide, it is an organophosphate, inhibiting acetylcholinesterase at nerve synapses. Death usually occurs in 24 to 72 hours after the birds have made contact with the toxin. Therefore, the dying birds may disperse over a wide area. Although organophosphates are not persistent in the environment, there is potential serious danger of secondary toxicity to predators or scavengers. Birds affected with nervous system disorders from organophosphates represent easy targets for predators who cue in rapidly on eratic behavior.

177. Endrin's toxicity to birds is similar to Fenthion's but the former is much more toxic to mammals. Endrin is highly toxic to insects and fish, and because of its persistence, it is very detrimental when introduced into aquatic ecosystems. Endrin should not be used because of its environmental hazards (see Toxins, Introductions, page 51).

178. Toxic perches have been registered for only pigeons, starlings, and house sparrows and are only to be used in the following areas: in and around farm buildings, pipe yards, loading docks, building tops, inside buildings, and bridges (Rid-A-Bird label).

179. Toxic perches have been very effective in eliminating pigeons (starlings, and house sparrows from aircraft hangars (Will 1985). Generally, 37 to 61 perches per hangar have been found adequate, taking several weeks to two months to completely eliminate hangar birds. In a Texas hangar containing about 1,000 birds, 40 perches eliminated 90 percent of the birds in 3 days. The use of toxic perches to eliminate pigeons in a California hangar had no effect on the resident population of 50 barn swallows. The cost per hangar of the Air Force program using Rid-A-Bird perches has been about 13 to 30 percent the cost of using netting (Will 1985). In other words, exclusion by netting was 3.5 to 7.5 times more expensive than toxic perches.

180. Other contact agents that produce harmful physiological effects when absorbed through a bird's feet have been patented: caffeine (1,3,7-trimethylxanthine), caffeine derivatives such as 1,3,7-triethylxanthine, lithium salts, amphetamine sulfate, amobarbital, procaineamide hydrochloride, phenmetrazine hydrochloride (3-methyl-2-phenylmorpholine), and trifluoperazine dihydrochloride (Kare 1972). Caffeine solutions proved equally lethal to all species tested (starlings, house sparrows, grackles, and cowbirds) when absorbed through the feet. Except for amphetamine, all the above compounds proved to be similarly lethal in all the bird experiments. When amphetamine was applied to the feed of cowbirds it drastically reduced food intake, which would be fatal under natural conditions. A large variety of solvents for the toxins were evaluated alone and in combinations (water, peanut oil, mineral oil, glycerine, dilute caustic and acid solutions, 70 percent ethanol, and dimethyl sulfoxide). Despite widely varying solubilities (e.g., lithium carbonate was not very soluble in oils), the nature or compatibility of the solvent system with the toxicant made no practical difference to the lethal effects of the toxic substances. Apparently these compounds are highly lethal to birds, and much lower (even drastically lower) concentrations than those evaluated by Kare (1972) would be sufficient.

These lower concentrations would be more economical, and the lower toxicity would allow dying birds to disperse from the contact site. These compounds have not yet been used commercially or even in field trials but are potential candidates for use in toxic perches or applications on the surface of specific bird loafing areas.

PART VI: SPECIFIC PROBLEM MANAGEMENT

Introduction

181. This section makes specific recommendations for controlling species-specific bird problems. The methodologies are not discussed in detail and references are a minimum. Therefore, the reader must consult the appropriate sections in Part V (Bird Management Strategies) for details and references concerning specific bird management technologies. These recommendations are based on the extensive literature survey which forms the basis of this report.

Specific Species

Pigeons

182. Pigeons only nest and roost on flat surfaces. The most effective, permanent, and safest method to eliminate problems with nesting or roosting pigeons is by exclusion using hardware cloth, poultry screening, or plastic screening or netting. However, this method is expensive when a large area is to be protected. In many instances, netting is impractical (e.g., lock and dam complexes). Bivings (1985) reported that plastic netting was the most effective solution for preventing pigeons from entering parking garages, empty buildings, and small aircraft hangars. Will (1985, personal communication) also found that plastic netting was very effective for eliminating pigeons from aircraft hangars.

183. A board or sheet metal placed over a ledge at a 45° angle prevents pigeons from roosting. See Appendix B for names of plastic screening/netting vendors.

184. Overhead monofilament lines do not exclude pigeons (Blokpoel and Tessier 1984) unless, of course, the lines are very closely spaced, making the technique impractical.

185. An effective way of keeping pigeons from landing on ledges, beams, girders, gutters, roof edges, and complex architectural structures is the use of porcupine wire (e.g., Nixalite, Cat Claw). The practicality

and cost of porcupine wire generally limit its usefulness to relatively narrow surfaces (< 22 cm). Therefore, it cannot be used to protect the large surface areas associated with Civil Works projects or bridges. An important consideration for many applications is that the product also prevents use of the protected surface by maintenance personnel. Although porcupine wire is expensive, it may be cost-effective since it is very effective and represents a permanent solution. Bivings (1985) reported Nixalite to be effective but expensive for deterring roosting pigeons, and recommends it only if netting cannot be used.

186. Toxic baits, with an appropriate prebaiting program, have been very effective at controlling pigeon populations, particularly small scale problems. Bait is readily acceptable year-round since pigeons are primarily grain feeders. There are personal and environmental hazards when using toxins (see Toxins, Introduction, page 51). Whole corn bait treated with 4-aminopyridine (Avitrol) is usually the preferred toxin for pigeons. Whole corn is generally too large to be accepted by small nontarget song birds.

187. Western Industries (West Orange, New Jersey) has had a great deal of experience in pigeon control and primarily relies on Avitrol (Mampe 1976). They adjust the concentration in the bait to vary its level of toxicity. Mampe (1976) stresses the importance of prebaiting with untreated corn, generally for 2 weeks, to accustom the majority of the flock to accept the bait. After the prebaiting period, if quick results are desired (e.g., an industrial site off-limits to the public) a 4:1 or 9:1 ratio of corn to Avitrol is used as treated bait. This blend is highly toxic to pigeons and results in many dead birds at the bait site. When downed birds are undesirable, such as in residential areas, a 29:1 ratio is commonly used for about 2 weeks after the prebaiting period. This mixture has been successful in eliminating large flocks with few, if any, visible carcasses. Mampe recommends that the area be maintained with a 9:1 mixture to prevent flock buildup.

188. For some pigeon control programs, plastic sandwich bags containing 112 g of Avitrol have been prepared and tossed by hand into hard to reach areas (e.g., overhead beams and building ledges) (Martin and

Martin 1982, Courtsal 1983). Prebaiting with untreated corn in identical sandwich bags was considered essential.

189. Strychnine should not be used as an avicide because of its high toxicity to humans, pets, and nontarget consumers--predators and scavengers.

190. Toxic flat perches (e.g., Rid-A-Bird), with proper placement, have been used successfully to elimiate pigeons from a variety of buildings. Environmentally, the safest place to use toxic perches is inside buildings. However, since death occurs 24 to 72 hours after the toxin is absorbed, birds may die some distance away. Therefore, toxic perches are hazardous to secondary consumers (predators or scavengers), particularly when a large bird-kill is involved.

191. Pigeons have been removed by grain baited live-traps placed on buildings. Since pigeons possess excellent homing ability, they are humanely disposed of after trapping. The walk-in bob trap is recommended for pigeons (Courtsal 1983) (see Figure 1). Pigeon traps are large; the bob trap is 2.4 x 1.2 x 1.2 m and some traps are much larger. Pigeon traps usually contain caged live decoys. Live-trapping is not usually recommended for controlling pigeons, especially if large numbers or continued immigrations are involved, because the method is expensive and very labor intensive (Mampe 1976, Will 1985). However, with small local problems or where public opinion is critical, this may be a desirable method.

192. A relatively inexpensive technique that can be tried to deter roosting or nesting pigeons is the use of sticky repellents (e.g., Roost No More). These compounds are impractical to apply to large surface areas or to complex and inaccessable structures. Sticky repellents work best on narrow ledges or beams where the tacky strips are applied in parallel rows 7.6 cm apart and 1.25 cm from the edge on clean, dry surfaces. Repeated applications may be necessary. Sticky compounds have not been successful in controlling persistent pigeon problems (Mampe 1976, Will 1985).

193. Electrical shocking devices (e.g., Avi-Away) may keep pigeons from roosting on specific structures, but this method is generally impractical for most pigeon problems since extensive surface areas generally need protection.

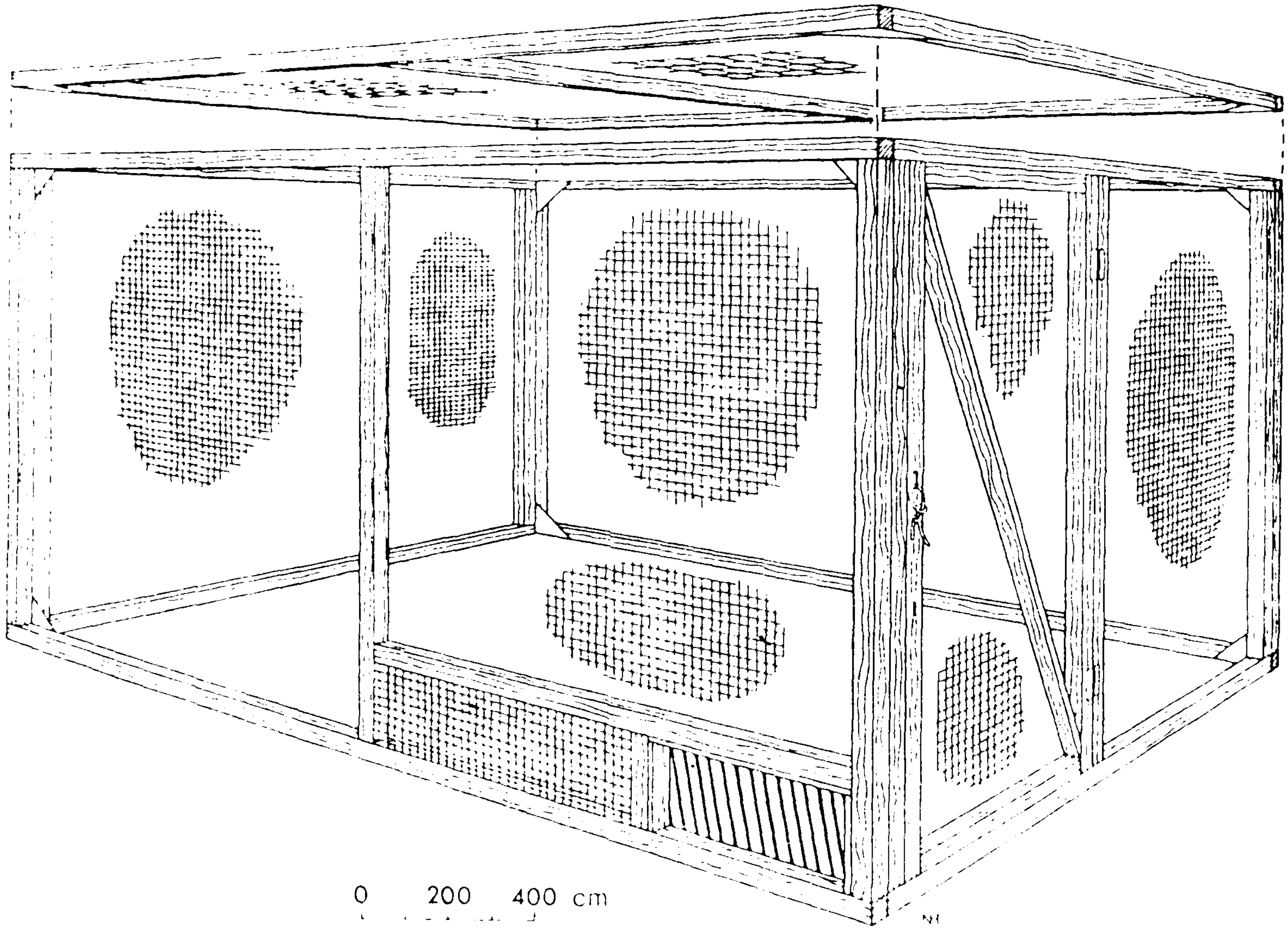

Figure 1. A bob trap for pigeons (Lefebvre and Mott 1983, Courtsal 1983).

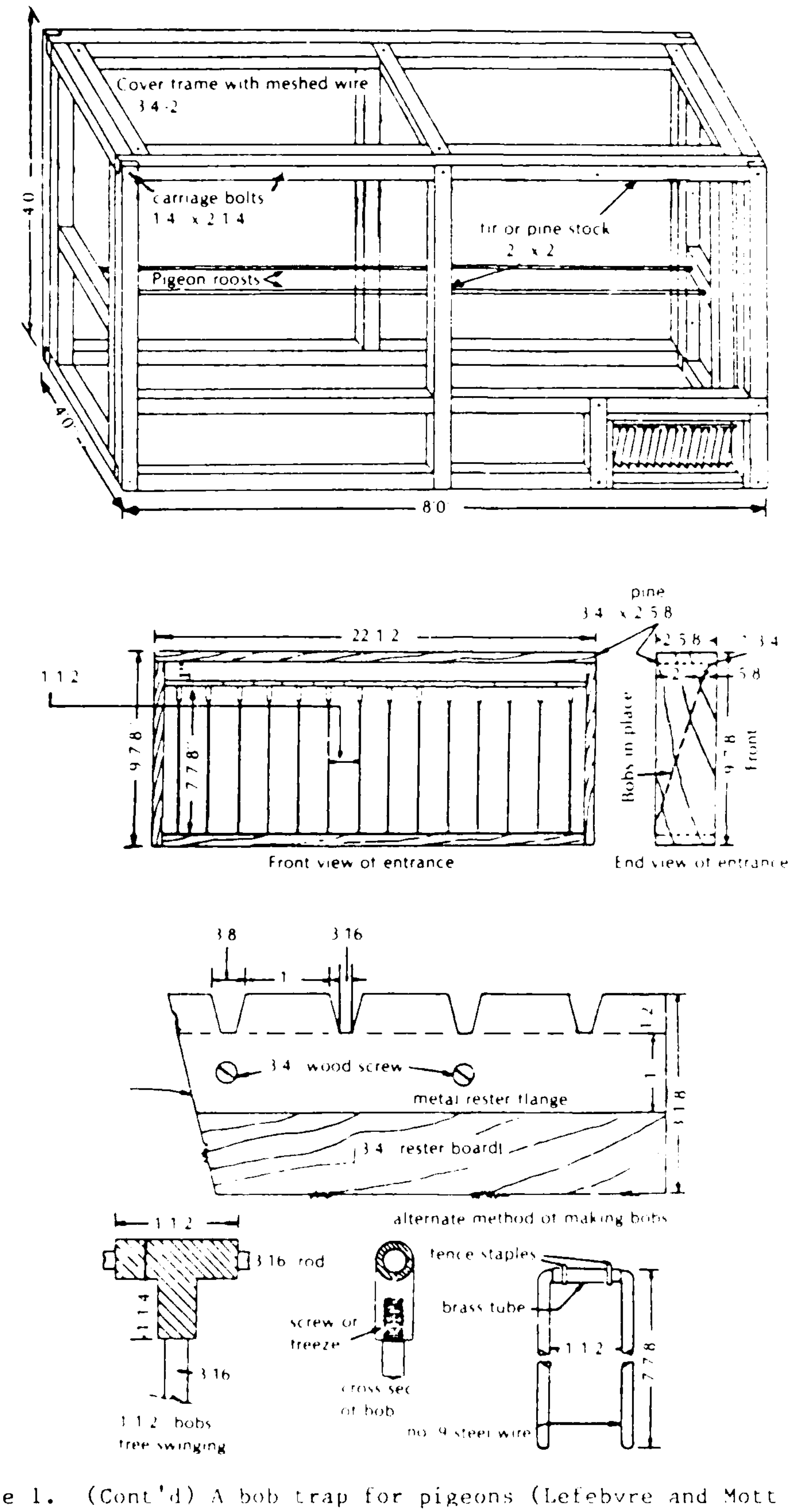

Figure 1. (Cont'd) A bob trap for pigeons (Lefebvre and Mott 1983, Courtsal 1983).

194. A wide variety of frightening devices have been tried to repel pigeons: pyrotechnics, electronic noise makers, rock music, ultrasonics, revolving lights, strobe lights, warning flags, balloons, and owl and rubber snake models. Although initially, most of these were at least partially effective, pigeons quickly habituated to the disturbances. Frightening devices are not considered effective for repelling pigeons (Mampe 1976, Marsh and Howard 1982, Will 1985).

195. Chemosterilants have not been effective at controlling pigeon populations (Courtsal 1983, Erickson 1983).

196. An interesting and potentially very valuable experiment to control pigeon populations would be to establish peregrin falcon eyries on bridges and skyscraper ledges. Peregrins are usually cliff nesters, therefore utilizing a nesting habitat similar to pigeons. Peregrins are effective predators of pigeons and have successfully nested and reared young on city buildings (Barclay and Cade 1983).

Starlings

197. There are four separate kinds of problems associated with starlings: (1) starlings cause local roosting and nesting problems around and in buildings and on man-made structures such as bridges and lock and dam complexes, (2) starlings are the primary species involved in depredations at livestock and poultry feeding pens, (3) starlings are important pests of fruit crops, especially grapes, and may cause local damage to sprouting wheat crops, (4) starlings, along with blackbirds, form large (thousands to millions of birds) winter roosts in tree groves or on man-made structures such as the girder complex of bridges.

198. Local roosting and nesting problems with starlings are similar to those caused by pigeons. Starling control strategies for the problems are therefore similar to those used for pigeons. Two important differences are that starlings are cavity or crevice nesters, and they may use round perches. Exclusion, porcupine wire, and sticky repellents have all been successfully used. Since starlings are smaller than pigeons, the spacing between rows of sticky strips should be decreased to 5 cm.

199. The most acceptable and appropriate toxin for starlings is Starlicide (used with a prebaiting schedule). Starlicide is in many ways

an ideal toxin. It is very toxic to starlings but possesses low toxicity to most mammals, at least some hawks, and many other bird species. It is completely metabolized by starlings in 2.5 hours and death never occurs before 3 hours, even at unusually high doses. Therefore, secondary toxicity hazards to predators and scavengers from carcasses is nonexistent.

200. Despite its seemingly "harmless" nature, applications of Starlicide, as is true of any toxin, should be done with extreme care by trained personnel, particularly when a large-scale program is involved, and should include environmental monitoring.

201. Avitrol is as effective on starlings as it is on pigeons but is probably more hazardous to nontarget organisms.

202. Toxic baiting programs may not be effective for starlings during the warm months of the year and especially during the breeding season since starlings at that time are highly insectivorous. However, starlings are very fond of fruit, and raisins, apples, and grapes have been successfully used as bait. Hall (1985) used Starlicide treated crickets to control nesting starlings (see page 55). French-fried potatoes have also been used successfully as a bait. Although toxic perches have been used successfully for starlings, Johnson and Glahn (1983) do not recommend their use because of secondary toxicity to predators or scavengers. The use of toxic perches should be restricted to small-scale problems within buildings or limited areas.

203. Frightening devices have had limited success in repellng starlings. Starlings respond very well to recorded alarm/distress calls but eventually habituate even to these. They habituate more quickly to random electronic noises than to alarm/distress calls, but do not show a fright response to pure tones (Johnson et al. 1985). Gas exploders and pyrotechnics have successfully dispersed starlings.

204. Frightening devices may be of potential use in dispersing starlings if used in conjunction with other methods. A very important consideration is that a combination of several scare devices work much better than a single technique, and maintaining variability in noise frequency, amplitude, interval between blasts, and location of noise sources is essential to delay or even prevent habituation.

205. Live-trapping of starlings has been successful when other methods could not be used. Nest-box traps (Figure 2) are very effective, but only during the spring nesting season. Knittle and Guarino (1976) used 20 nest-box traps for starlings and captured 294 birds during 57 days of trapping on an 81 ha site in Colorado. Modified Australian crow traps* (Figure 3) (a decoy trap) are most effective when the birds are flocking from late summer through winter (Johnson and Glahn 1983). Decoy traps are large traps containing grain or fruit bait and a smaller cage which houses live captives of the target species. Decoy traps have been effective in controlling starling populations in orchards (Ballard 1964) and urban areas (Stiles 1966). Funnel traps (Figure 4) have also been successful. The larger designs like A and B in Figure 4 are more effective than smaller traps. The size of openings in funnel traps is species specific for obvious reasons. Trailers used to transport cotton have been modified to trap large numbers of starlings (Clark 1976). Additionally, the mobility was highly beneficial. Trapping starlings, as is true of other species, is very labor intensive and takes a great deal of time. It may not be a feasible technique for large numbers of birds.

206. Starlings may be serious local pests at livestock and poultry feedlots. Twedt and Glahn (1982) recommended management methods to limit the availability of feed to birds depredating livestock pens. Most methods have proved inconvenient or too labor intensive to operators (e.g., daily opening and closing of feeding bin lids). Livestock feed could also be made into large pellet sizes which are unacceptable to birds (Mott 1984); this is a common practice in western feedlots (personal observation).

207. The usual starling (and blackbird) control technique at feedlots is the use of the toxin Starlicide. It is usually incorporated directly into the livestock feed. However, it has also been used in baited containers or as bait scattered on the ground between pens and walkways.

*Modified by reducing the opening sizes to accommodate species smaller than crows. Of course, the traps may also be made proportionally smaller.

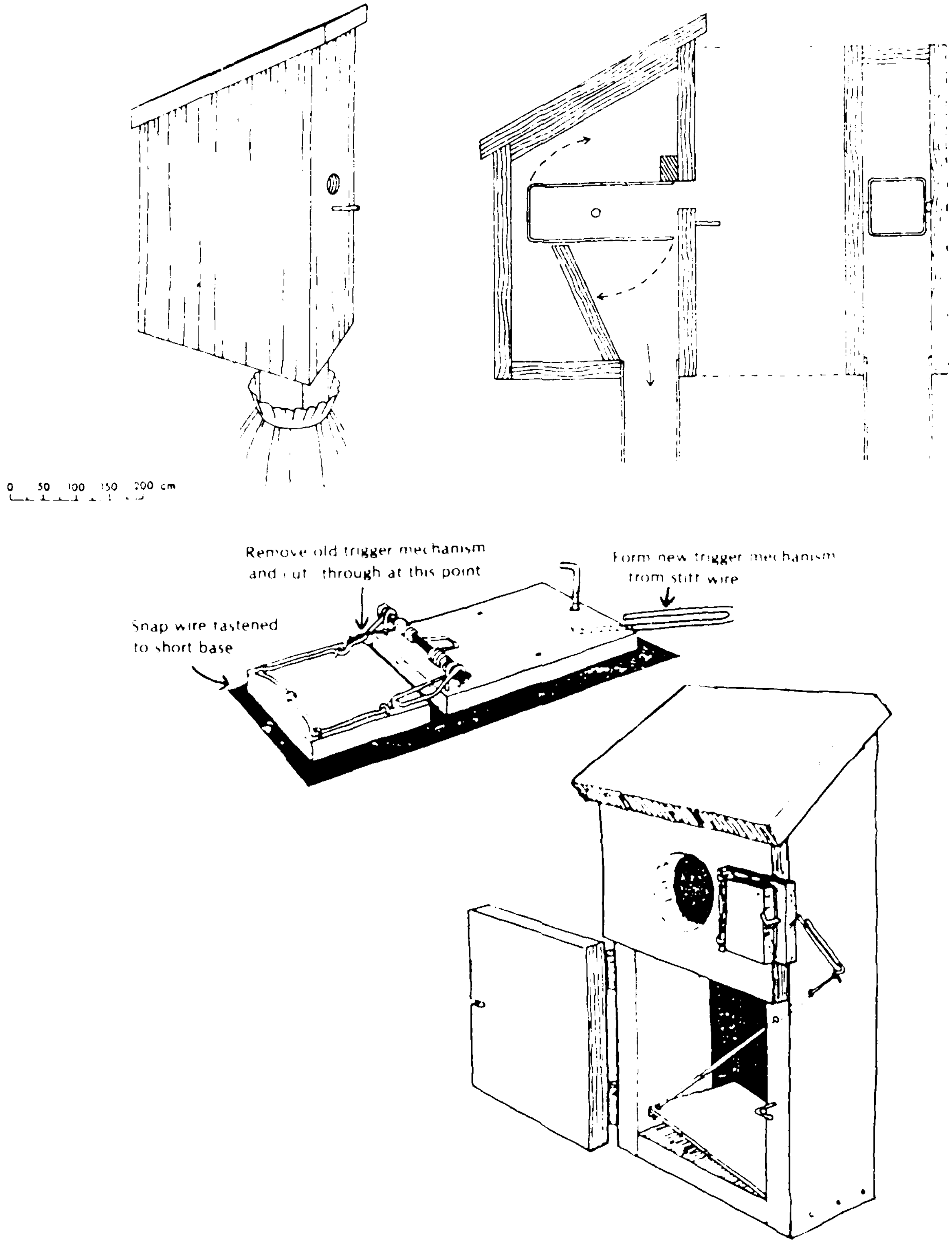

Figure 2. Nest box traps for starlings or house sparrows (a 2-bushel cloth bag is used for holding trapped birds in the Tesch trap. Note that the nest box trap using a modified mouse trap only captures single individuals). (Lefebvre and Mott 1983, Johnson and Glahn 1983).

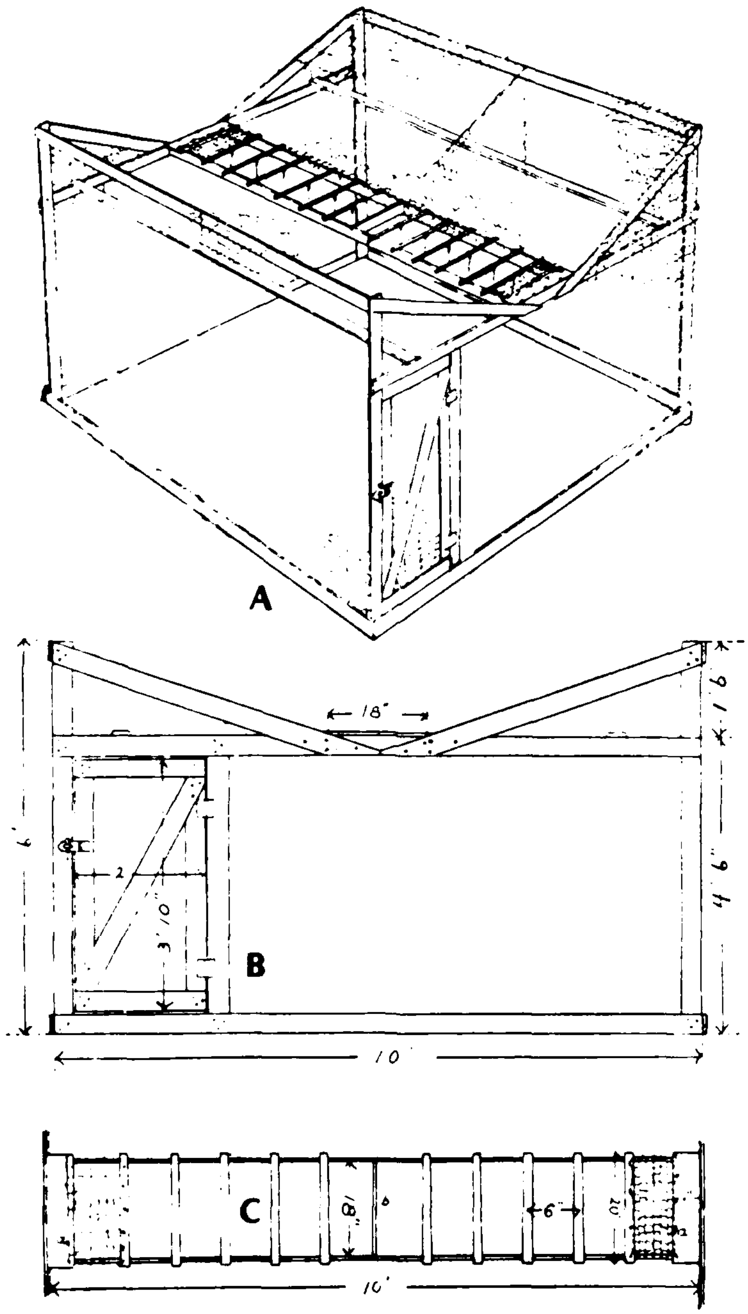

Figure 3. Australian crow trap (A-completed trap, B-end view, C-plan of ladder opening) (Johnson and Altman 1983, Johnson and Glahn 1983).

Materials Needed for Trap

15 pieces 1 x 4s 8 feet long
25 pieces 1 x 4s 6 feet long
4 pieces 1 x 1s 8 feet long

1 piece 1/2 x 16-in exterior plywood 8 feet long
2 hinges
2 lbs staples
40-ft length of 6-ft chicken wire 1-inch mesh

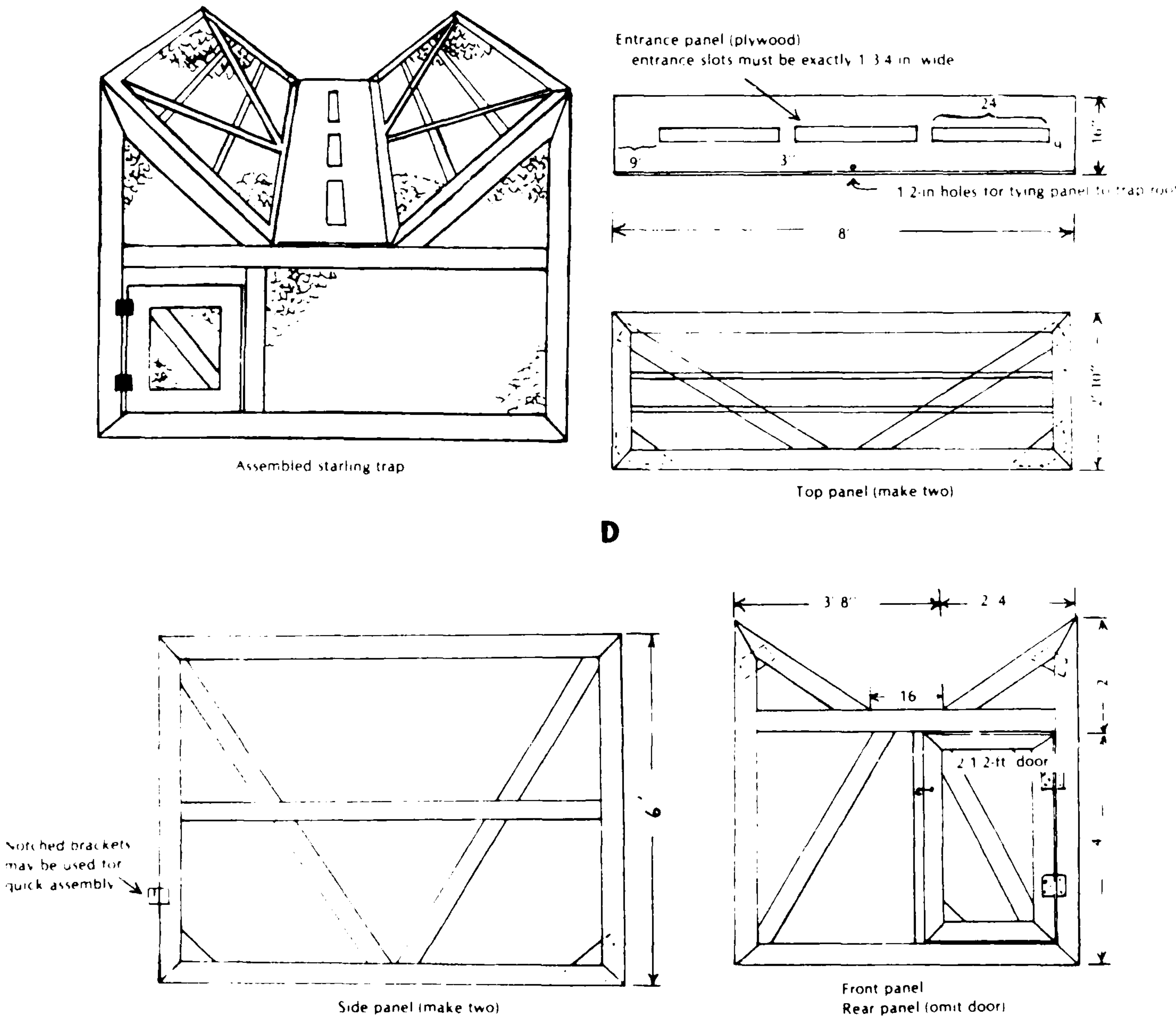

Figure 3. (Cont'd) (D-modified Australian crow trap for starlings.)

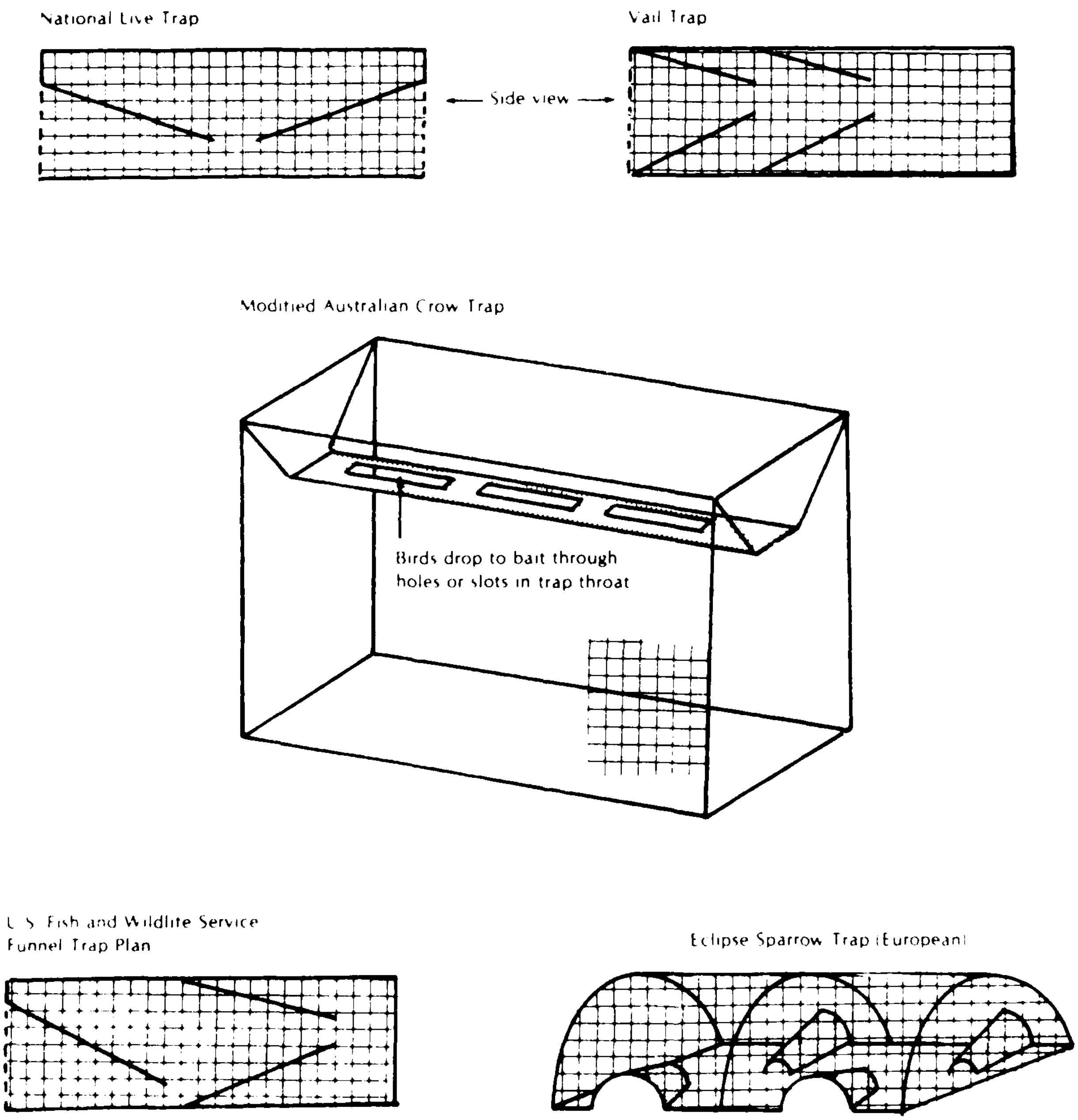

Figure 4. Funnel traps (A-miscellaneous designs) (Fitzwater 1983, Lefebvre and Mott 1983).

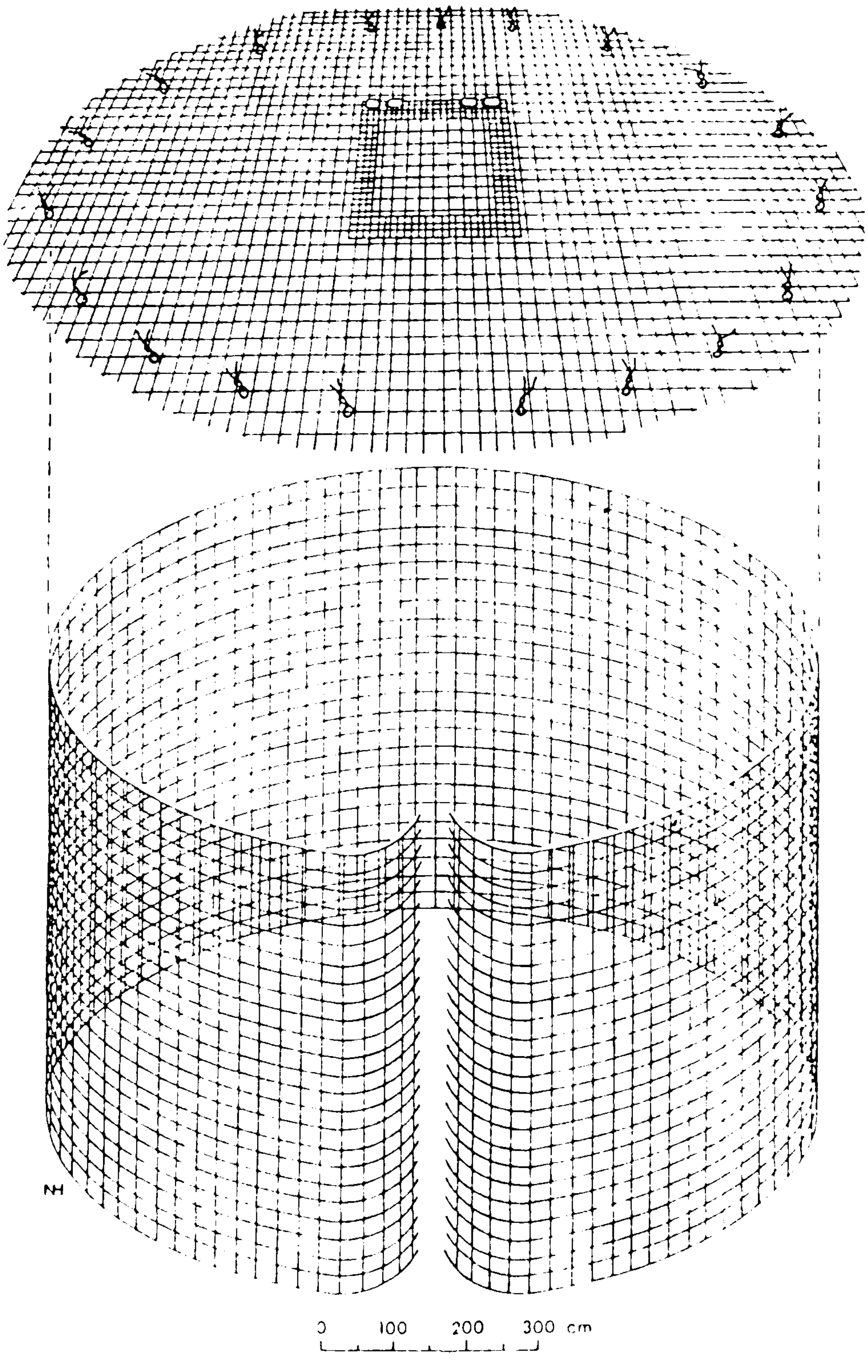

Figure 4. (Cont'd) (B-Lily pad trap effective for a variety of bird sizes--from sparrows to ducks--depending on width of entrance.)

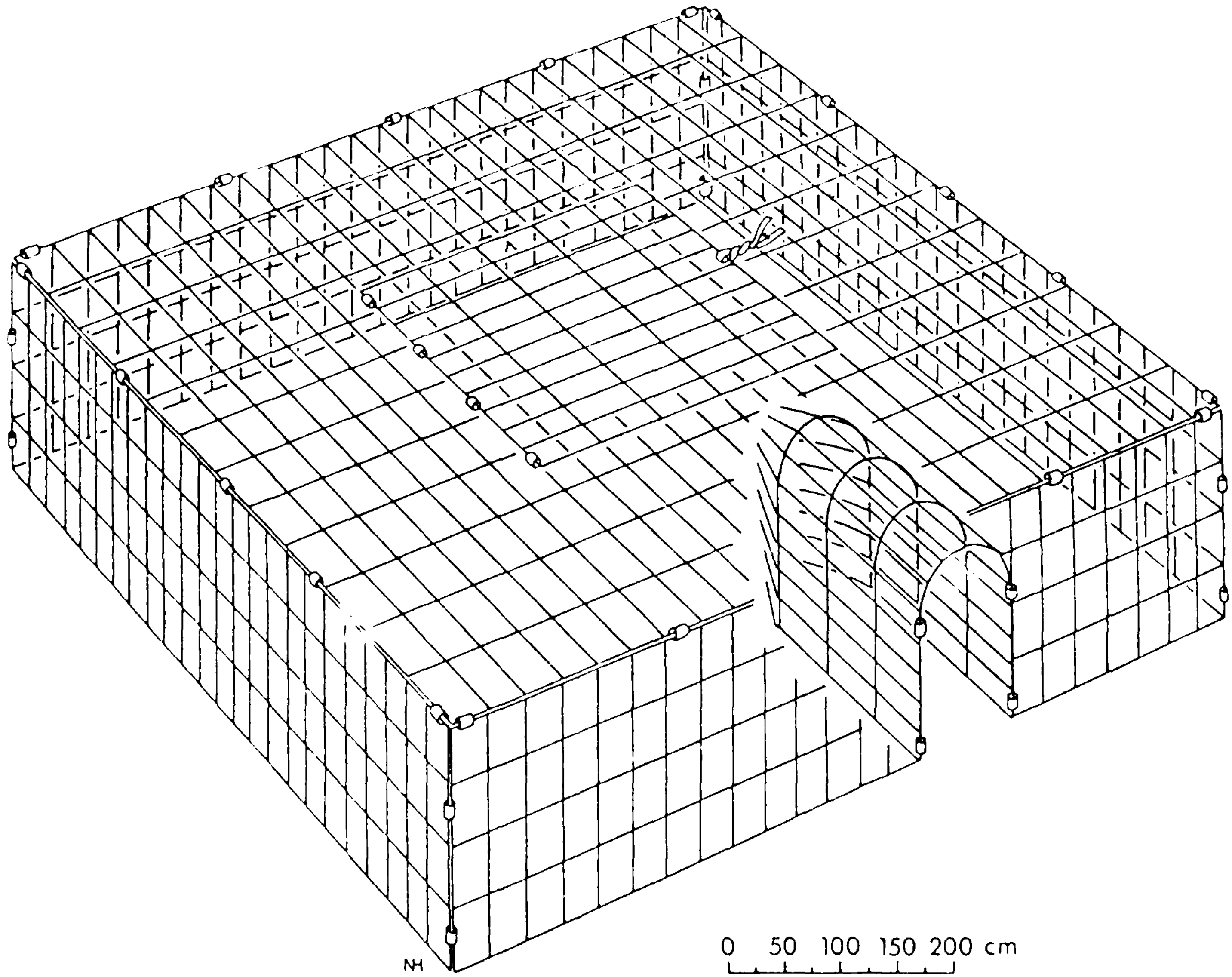

Figure 4. (Cont'd) (C-design effective for ground feeding birds, especially blackbirds, starlings, and mourning doves.)

208. For the control of starling depredation of fruit crops or winter roosts, see Fruit Crops page 87, or Bird Roosts, page 81.

House Sparrows

209. The control of house sparrows is in many ways similar to pigeon and starling control; however, there are some important differences that will be discussed. Often all three species will have to be dealt with together. As with pigeons and starlings, exclusion, porcupine wire, and sticky compounds are effective with minimal environmental damage. Since house sparrows are small birds, it is necessary to eliminate any openings over 2 cm for successful exclusion. Distances between strips of porcupine wire or beads of sticky compounds must also be proportionally shortened.

210. Strychnine and Avitrol are effective toxins for sparrows, and both have been used successfully. Strychnine is used more frequently, but it poses personal and environmental hazards. Starlicide is not very toxic to sparrows. When toxic perches are properly located they are very effective at eliminating sparrows, particularly in buildings. However, toxic perches are environmentally hazardous, particularly for predators and scavengers feeding on dying and dead birds.

211. House sparrows do not possess alarm/distress calls and usually only respond weakly to the alarm/distress calls of other species. House sparrows rapidly adjust to manmade noises, and therefore the various acoustical disturbances used against birds are usually not very effective (Clark 1976, Fitzwater 1983).

212. The wetting agent Tergitol has been used for large scale lethal control of house sparrows.

213. The most widely used method to eliminate sparrows from a given area is live-trapping with baited traps (Fitzwater 1983). By this method, nontarget species can be released unharmed. However, sparrows once caught will not be retrapped. Fitzwater (1983) illustrates the design of twelve traps which have been effective for catching sparrows. The traps fall into three generic categories: (1) Funnel traps (Figure 4) are the simplest and most commonly used but must be checked frequently since escape is easy. The working principle is identical to that of the well known minnow trap. Since the openings are tapered inward, it is much

easier to enter the trap than to exit. The Austrialian crow trap (Figure 3) is a common example. Modification to this design (or to any funnel trap) consists of varying the opening size to accomodate different sized species. Live decoy individuals are securely penned in a separate compartment inside, making these traps more effective. Of course, decoys must first be caught. (2) Automatic traps (Figure 5) possess a higher catch rate since there is no escape. Birds enter a baited or false nest-box compartment which is counterbalanced. The weight of the bird drops it into a holding compartment and the "nest box" springs back into place awaiting another victim. (3) Triggered traps (Figure 6) catch single birds or a small feeding flock, depending on trap design. The nest box trap is a common design used often on starlings. The bird triggers a closing door when it enters the "decoy" bird house. In some triggered trap designs a watcher must spring the net(s) or traps at the appropriate moment. Most species of sparrows can be caught in these trap designs.

Gulls

214. The simplest way to discourage gulls is the effective management of garbage or refuse, especially open dumps. Since gulls are the bird species that represent the greatest hazard to aircraft, garbage dumps are eliminated from the vicinity of airports (see Habitat Modifications, page 32). Gulls have been controlled at airports by breaking their eggs and spraying the nests with a water-oil-formaldehyde mixture (Seubert 1966).

215. A very effective method of excluding gulls from an area is the use of an overhead canopy of nylon monofilament line or stainless steel wire. Gulls are very susceptible to recorded alarm/distress calls. Gulls have also responded to gull corpse models.

Canada Geese

216. Canada geese are attracted to lawns for two important reasons. The grass supplies an appropriate food source and the open character and short grass provides grazing opportunities while they monitor approaching predators. They will not graze in tall grass or in

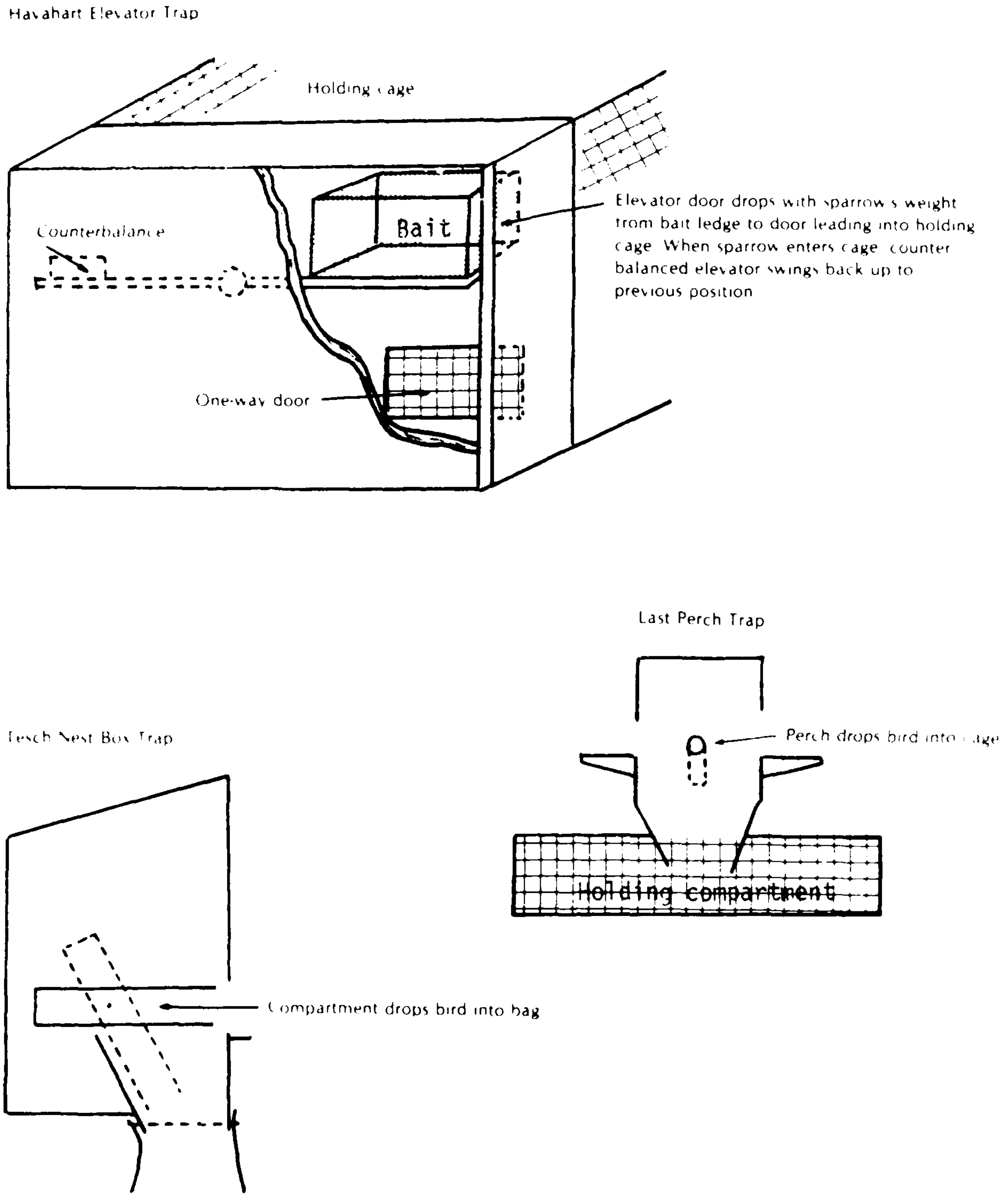

Figure 5. Automatic traps commonly used for sparrows (Fitzwater 1983).

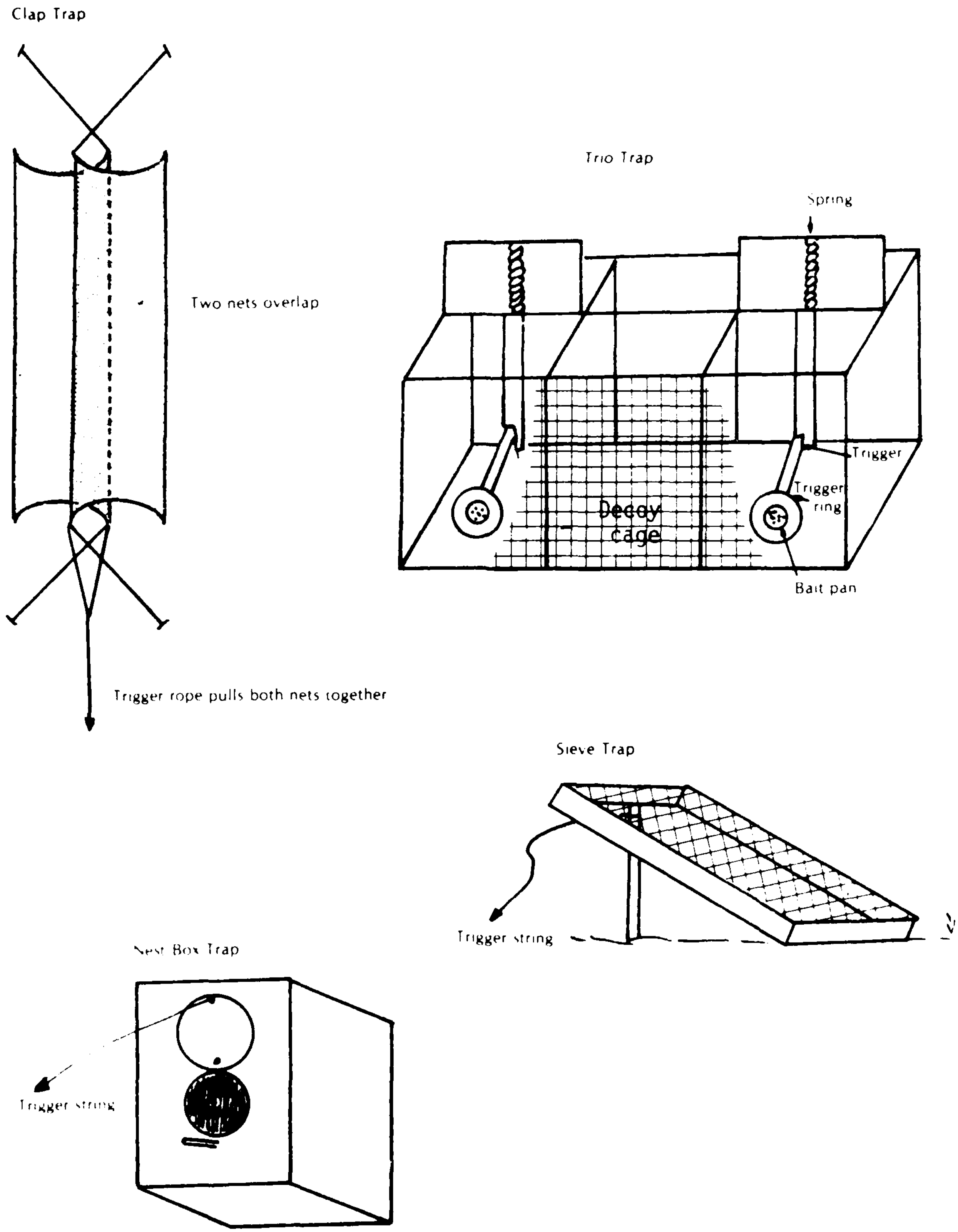

Figure 6. Triggered traps (Fitzwater 1983).

dense weedy or shruby growth. Therefore, habitat modification would be an obvious method to eliminate geese. However, this is not unusually acceptable (e.g., golf courses, beaches, recreational areas). Alternative grazing sites could be provided so that they may abandon an area where they are a nuisance. This could be reinforced if they were harassed or frightened in the nuisance area and the alternative area is baited with high preference food items (e.g., corn). Methiocarb has been used successfully as a repellent on golf courses and lawns. Dimethyl anthranilate is an inexpensive nontoxic food additive readily accepted by mammals and approved for human consumption but offensive to birds. Experiments are presently being conducted by the Animal Damage Control Division of the Department of Agriculture to assess its effectiveness in repelling Canada Geese. Further research is needed on deterring or repelling Canada Geese flocks.

Swallows

217. Swallows are a migratory species and therefore protected by Federal law. A permit from the Animal Damage Control Division of the Department of Agriculture is necessary before swallow control is implimented. When feasible, exclusion by netting or screening is the most effective method to prevent swallows from nesting and requires no permit. Mesh size should be 1.3 to 1.9 cm, but 2.5 cm has also been used successfully (Salmon and Gorenzel 1983). Since plastic netting is susceptible to weathering, especially ultra-violet light, the netting could be made removable and only needs to be in place during the spring nesting season. Swallows generally have a consistent nesting period that varies geographically, depending on the availability of flying insects.

218. A common control method is the removal of nests with a high pressure water hose (Salmon and Gorenzel 1983). Although effective, swallows are persistent at rebuilding nests and it may take many treatments before swallows abandon the locality to look for alternative nesting sites. Usually the swallows will return the following year.

219. The use of toxins, trapping, or shooting is not permitted for swallows. Repellants and frightening devices have not been effective (Salmon and Gorenzel 1983).

220. However, A.E. Bivings (personal communication) has had success in dispersing purple martins from shopping malls and aircraft hangars using propane exploders.

221. Swallows have been known to build nests on sticky repellents and porcupine wire. Additionally, these devices aided nest adhesion.

222. Architectural designs and surface texture are important for nest placement, but all factors are not yet totally understood by biologists. Smooth surfaces and metal surfaces are generally avoided as nest substrates, unless they are located at a joint or junction where the birds can get a foothold.

Woodpeckers

223. Exclusion with hardware cloth, plastic netting, burlap, and metal sheathing have all been successfully used to prevent reccurring damage to trees or houses that were selected as favorite drilling spots by woodpeckers.

224. Loud noises (e.g., gas exploders and banging on a garbage can) have successfully relocated woodpeckers if the harassment is repeated every time the bird returns (Marsh 1983). Ribbons, pie pans, or aluminum foil strips (1 m long by 5 cm wide) can be tied so they move with the wind to frighten off woodpeckers (Hawthorne 1980).

225. Pentachlorophenol has been used to discourage woodpeckers from enlarging holes (Fitzwater et al. 1972). However, Marsh (1983) reports that neither Pentachlorophenol or creosote treated utility poles and fence posts are protected from woodpeckers. A 5 to 10 percent paste of quinone was effective in repelling woodpeckers, but the compound is no longer available (Schafer 1979).

226. Sticky repellents (e.g., Tanglefoot, Roost No More) are recommended by Ostry and Nicholls (1976) to discourage sapsucker drilling and by Marsh (1983) to discourage woodpeckers. Individual woodpeckers have been controlled by shooting or rat-traps baited with suet or nutmeats, under a permit from the U.S. Fish and Wildlife Service (Clark 1976).

Crows, Ravens, Magpies, and Jays

227. Ravens are scavengers. Garbage management and using trash containers with snug fitting lids are effective at deterring these pests.

228. Acoustical frightening devices (e.g., gas exploders, shell crackers, recorded alarm/distress calls, and electronically generated noises) have been used effectively to disperse crows and magpies from nut orchards. Crows respond well to alarm/distress calls. However, acoustics have not usually been effective against jays (Besser 1985). Scarecrows are not generally effective against crows (Conover 1985a).

229. Whole corn baits treated with the frightening agent Avitrol have successfully protected pecan trees from crows (Wilson 1974). Methiocarb has been inconsistant in protecting nut crops from corvid species (Hall 1984). Two seed-treatment repellents are Federally registered for preventing crow damage to sprouting corn seedlings: refined coal tar with creosote (Stanley's Crow Repellent®) and copper oxalate (Crow-Chex®) (Johnson and Altman 1983).

230. Starlicide treated whole corn baits have been used to kill crows and treated pistachios to kill scrub jays that were damaging California nut crops (Besser 1985). These were experimental studies since Starlicide is not registered against any corvid species.

231. Crows have been successfully captured uninjured using the common Australian Crow Trap (Figure 3, a large decoy trap), or size 0 or 1 steel traps whose jaws have been wrapped with rubber or cloth (Kalmbach 1937).

232. Shooting is a common control method for crows, ravens, magpies, and jays. A Federal permit is necessary to shoot jays, but not the other species if they are depredating or about to damage agricultural products.

Eagles, Hawks, and Owls

233. Raptors are all protected by Federal law so an appropriate permit is necessary for their control. Toxins are illegal. Even visual or acoustical repellent techniques may need a depredation permit from the Department of Agriculture. Since raptors are highly beneficial to the environment, aesthetically appealing, and many species are becoming rarer or even threatend/endangered, raptor control should never be considered.

234. Baited or unbaited pole traps, like the Verbail (Figure 7), bal-chatri trap (Figure 8), Swedish goshawk trap (Figure 9), shotgun nets, snares, and shooting have all been used to capture or kill raptors. Pole traps have been very effective, especially in open country, since raptors actively seek out observation posts. Bal-chatri or similarly constructed traps have also been very effective. They require a live prey item in the trap. When the raptor attacks the decoy, its talons become entangled in the loops of nylon monofilament line. Struggling aids to tighten the nooses.

235. The relative effectiveness of frightening devices or repellents has not been adequately researched.

Bird Roosts

236. Habitats would not be suitable for roosts if they were heavily pruned (canopy opened) or if the tree density was reduced to less than 720 trees per ha (at least for fall roosts). However, heavy pruning every few years or thinning the trees may be economically unsound. At several reported roosts, 80 percent of the trees would have to be removed to achieve a density of 720 trees/ha (Lyon and Caccamise 1981, personal observation). However, once a roost relocates it may never come back to its original site, so a single treatment may be sufficient. Also, it is important to consider that habitat changes force the birds to relocate to another locality, which may be even more inconvenient for man. Eighty percent of the roosts in Tennessee are located in urban-suburban sites (Mott 1984).

237. Frightening birds out of roosts, including the use of chemical repellents and helium-filled ballons, has dispersed roosts, with 47 to 100 percent population reductions reported using balloons (Mott 1980, 1985). However, relocation will not solve the problem in a community with a persistent roost problem. Balloons cannot be used in large roosts where there is a high tree density nor in windy weather (> 19 km/hr [10 mph] winds) (D. Mott, personal communication).

238. Sometimes the use of recorded alarm/distress calls, exploders, firecrackers, shellcrackers, or other acoustical devices can be effective

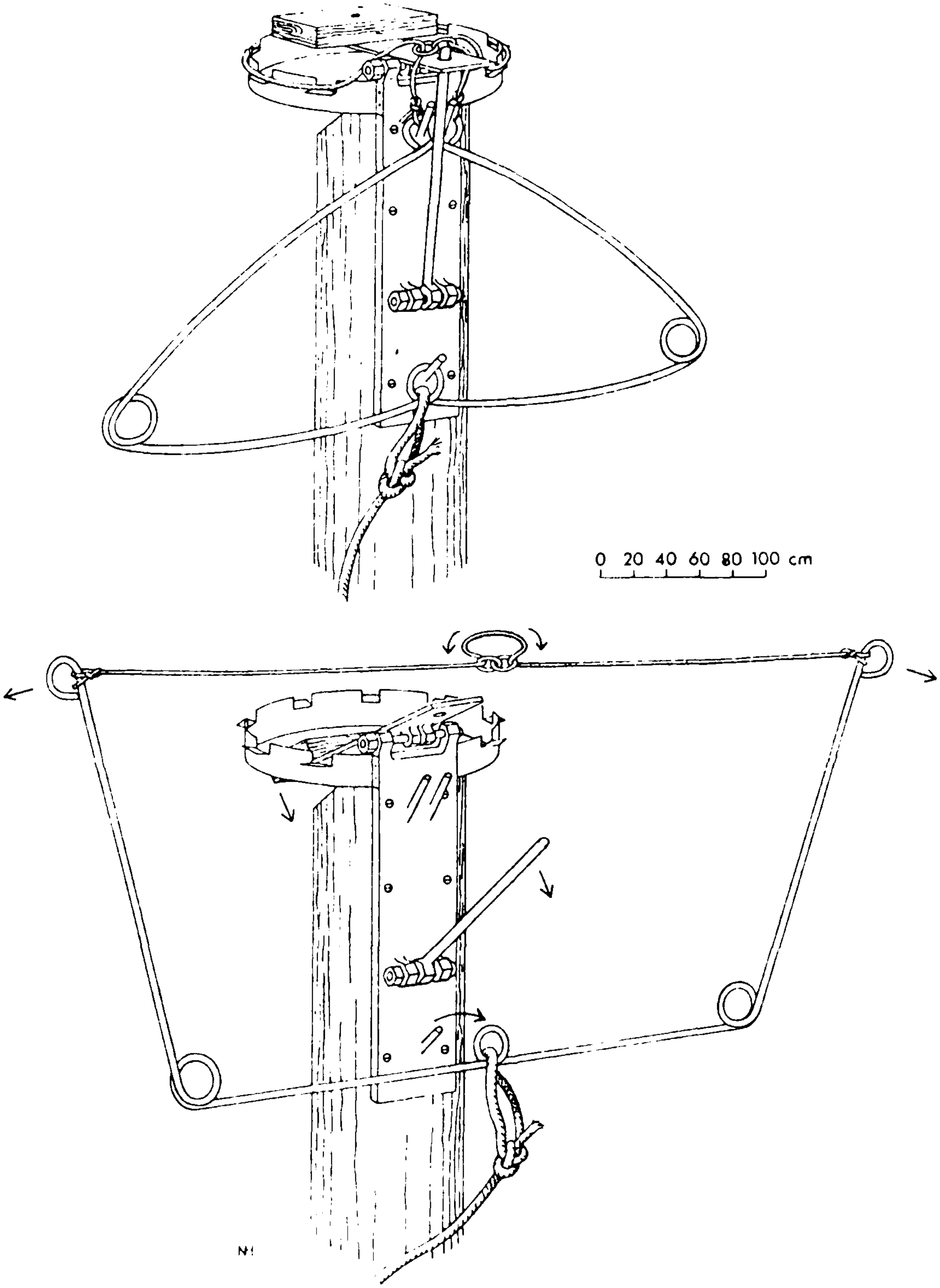

Figure 7. Verbail trap for raptors (landing on the treadle releases the spring arms which throw the noose around the bird's legs). (Lefebvre and Mott 1983).

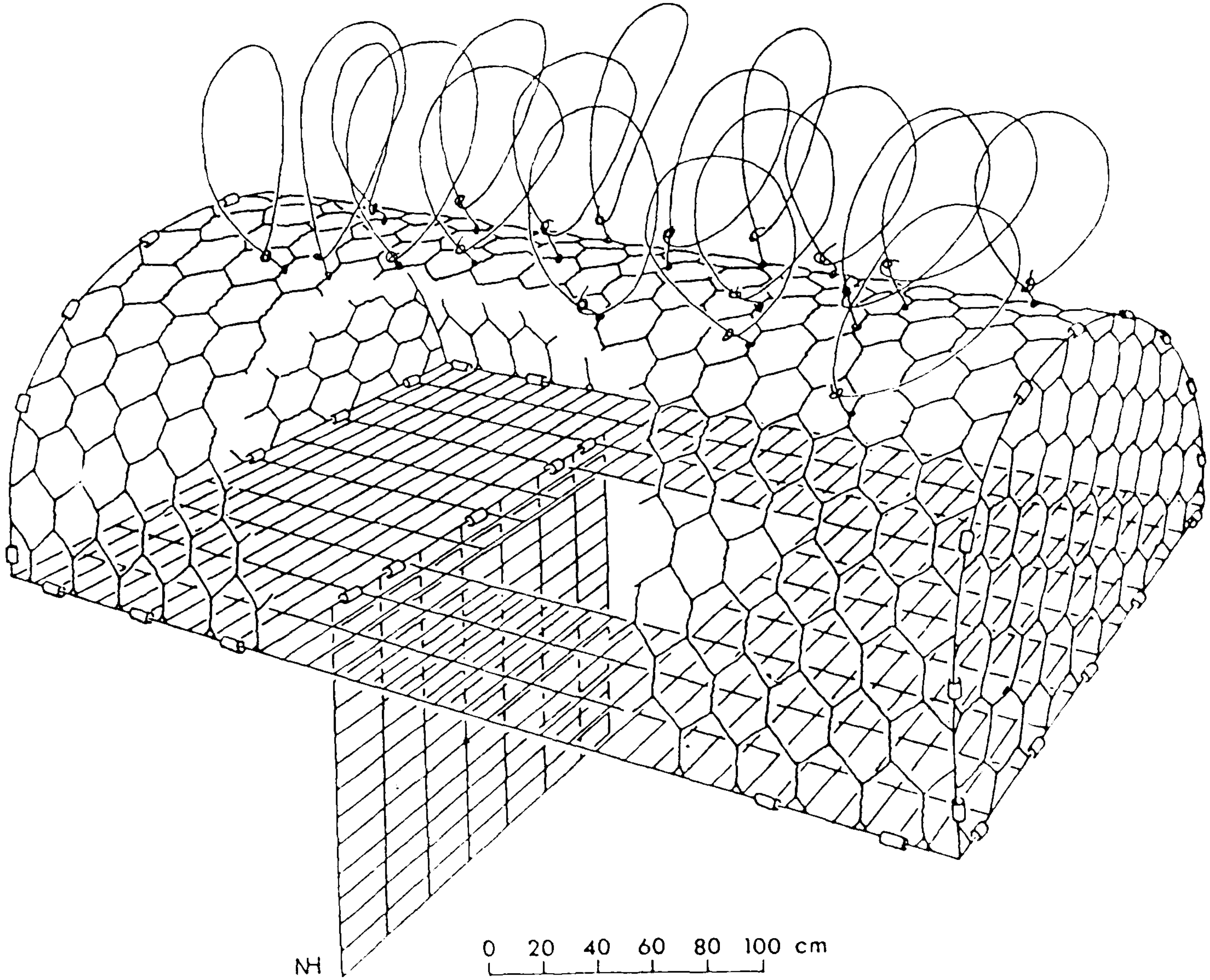

Figure 8. Bal-chatri trap for raptors (Lefebvre and Mott 1983).

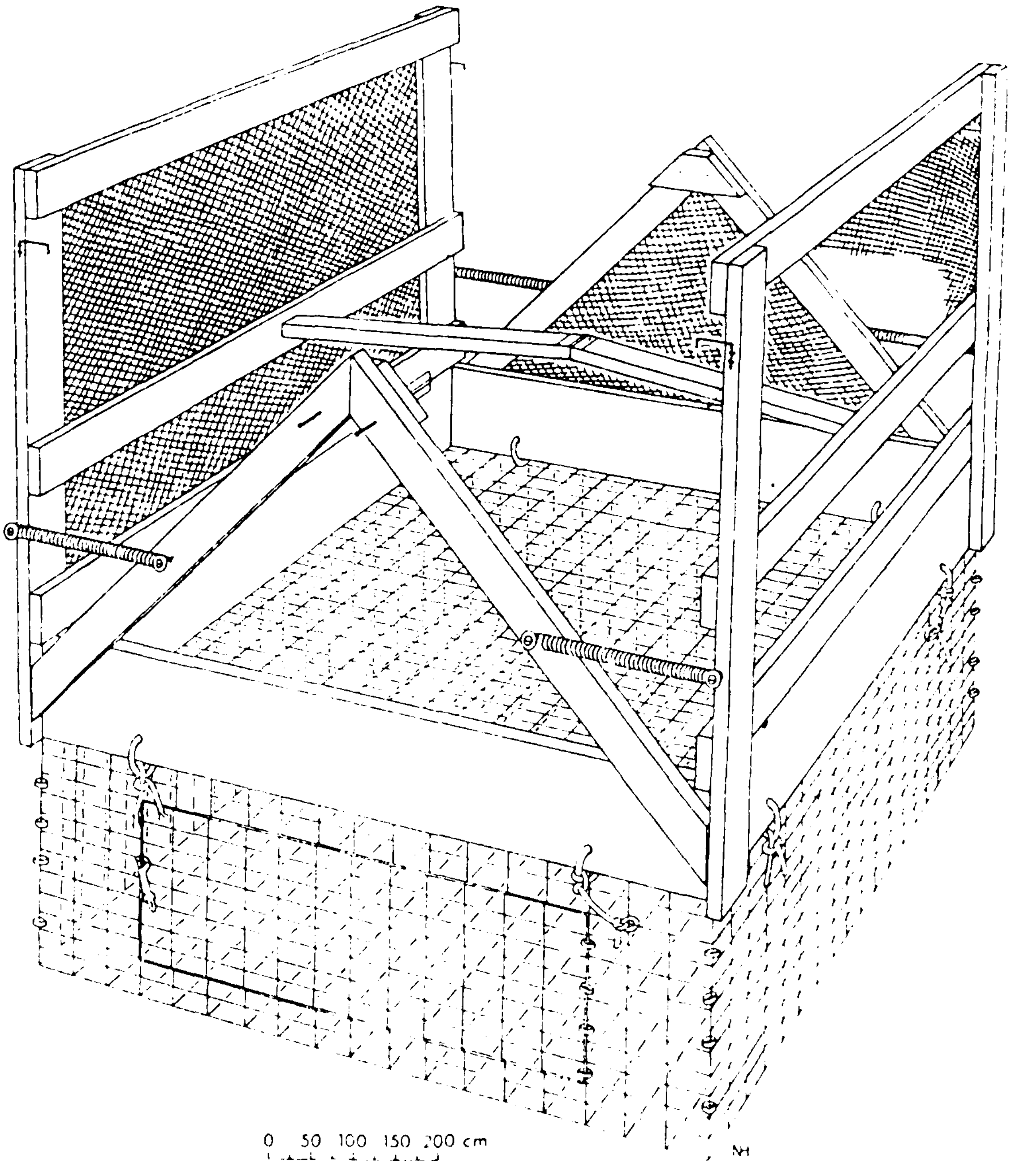

Figure 9. Swedish goshawk trap (Lefebvre and Mott 1983).

at moving or dispersing even large roosting flocks. These devices may solve a local roosting problem temporarily, but the flocks may return or relocate in a nearby area.

239. Wetting agents (e.g., Tergitol) have been used for large-scale lethal control of winter blackbird-starling roosts under the supervision of the U.S. Fish and Wildlife Service. The method is effective but requires rather exacting weather conditions. Large scale lethal control has not been favorable with the public (Free 1975, U.S. Army 1975, Graham 1978).

240. Starlicide has been used at blackbird-starling roost sites to attempt population control at the source (Knittle et al. 1980), but further research is necessary to evaluate potential environmental and nontarget species hazards (Mott 1984).

241. Histoplasmosis, caused by spores of the fungus *Histoplasma capsulatum*, is the major human health hazard associated with large persistent winter blackbird-starling roosts.

242. Researchers or workers around suspected histo-sites should be restricted to those personnel whose skin-tests register histo-positive, since these individuals already have acquired some immunity to histoplasmosis. However, these individuals may still be susceptible to a large dose of *H. capsulatum* spores. Immunization vaccines against histoplasmosis have not been developed, mainly because most infections are benign and the fungus has a world-wide distribution (Weeks and Stickley 1984). However, high risk occupations would benefit from a vaccine (e.g., laboratory and construction workers, public health epidemiologists, wildlife biologists, and speleologists) (Weeks and Stickley 1984).

243. Burying *Histoplasma*-infected sites with more soil, or the use of soil fumigants and other chemicals has not been successful in discouraging fungal growth (Tosh et al. 1966b). Cresol compounds and pentachlorophenol in fuel oil are effective but environmentally unacceptable (Weeks and Stickley 1984). Formalin solutions are a practical and effective means to decontaminate soil containing *H. capsulatum* (Tosh et al. 1966b, Weeks 1984b). The formalin solution is prepared by diluting commercial grade formaldehyde with water to form a

5 percent solution (0.15 percent by weight of formaldehyde gas). The formalin solution is applied at a rate of 13.5 L/m^2 in three applications, each on separate days (Weeks 1984b). When bird manure is deep, a dose of 40.7 L/m^2 should be applied on alternate days to insure deep soil penetration (U.S. Army 1985). The formalin solution should saturate the soil to a depth of 20 cm. Vertical walls should be decontaminated at the rate of 270 ml/m^2, while horizontal surfaces need 6.8 L/m^2 (U.S. Army 1985). Contaminated equipment should be soaked in 5 percent formalin for 15 minutes. Formalin also eliminates beneficial fungi, bacteria, and all the microorganisms from the soil. Although formalin rapidly biodegrades in the environment, treated soil may possibly be sterile and unproductive for extensive periods. Formaldehyde can cause severe irritation to the mucous membrane of the respiratory tract and eyes. Repeated exposure may cause dermatitis or allergic reaction. At present, there is a strong controversy concerning the carcinogenicity of formaldehyde, and a variety of tests have shown it to be mutagenic.

Agriculture

Grain Crops

244. Blackbirds, especially the common grackle and red-winged blackbird, can cause local damage to grain crops--primarily corn, rice, sunflower, and sorghum. Crop depredations have been more severe near roosting sites. Probably the most effective, economical method to disperse blackbird flocks depredating grain crops has been the use of gas exploders. The wide variety of available pyrotechnic devices are equally effective but require more manpower and pose a greater fire hazard.

245. Experiments with hawk-kite models mounted to helium balloons have been successful, and although cost-effective, are overall more expensive than gas exploders. Kite models are vulnerable to weather and vandalism but avoid the problems of noise pollution and fire hazards. A mechanical scarecrow has recently been developed, but its effectiveness is not yet known. Further research is needed with predator models.

246. Avitrol, a compound that elicits alarm calls in birds, and methiocarb, which produces a taste aversion in birds, have been used to

protect sprouting and ripening grain crops. Their effectiveness has been highly variable, particularly with Avitrol. The timing of applications is essential with Avitrol. These chemicals are not often cost effective, since potential damage to the crop must be relatively high if the cost of the compound is to be recovered.

247. Recorded alarm/distress calls and various electronic noise makers have been only partially successful. Further research is needed to optimize the use of acoustics to repell birds.

Flower and Vegetable Seed Crops

248. House finches and goldfinches (American and lesser) are known to feed heavily on mature flower and vegetable seed crops. The most effective method of protecting these crops is through protective plastic netting. Although expensive, it is cost-effective because of the very high value of the crop and the potential serious damage to unprotected crops. House finches have also been controlled by toxic bait using rape seed and/or canary grass seed or by trapping. Toxic baits should never be used for these species.

249. Horned larks and white-crowned and golden-crowned sparrows can feed extensively on newly planted seeds or sprouts/seedlings of flower and vegetable crops. Horned larks are controlled by toxic baits dispersed at ground level in troughs dug in the soil, since this species is accustomed to following furrows or seeder tracks (Clark 1976). White-crowned and golden-crowned sparrows generally feed near shrubby or brushy areas, so the elimination of this habitat component is important in protecting newly seeded or sprouting agricultural fields. Toxic baits have been used in the past, and trapping has been very effective using lily-pad, clover-leaf, or modified Australian Crow traps (Clark 1976). Toxic baits should never be used for these species.

Fruit Crops

250. Fruit is a high preference food item for many species of birds. These species include bird pests such as the starling and grackle, common birds such as robins, finches, cardinals, catbirds, and blue jays

and also desirable species such as bluebirds, waxwings, thrushes, thrashers, orioles, and mockingbirds.

251. Plastic netting is the most effective method for protecting fruit crops. Although expensive ($750 to $1,300 per ha) and labor-intensive, it is usually cost-effective when protecting valuable crops such as strawberries, blueberries, and grapes.

252. Methiocarb, an avian taste aversion compound, has generally been successful in protecting a wide variety of fruit from all frugivorous bird species. Exploders and pyrotechnics have been effective in dispersing birds out of orchards. Hawk-kite models suspended from helium balloons have been used to protect blueberries. Although the predator model was the least expensive technique, plastic netting and methiocarb were more effective at protecting the crop.

253. Decoy traps have been effective in eliminating local birds depredating orchards. An advantage of live-traps is that desirable or protected species can be relocated and released unharmed. Thirteen thousand house finches were trapped in 4 large decoy traps in 17 months of trapping, and 9,000 cedar waxwings have been caught using a single decoy trap for one week (Besser 1985).

Feedlots

254. The primary bird pest at livestock and poultry feedlots is the starling. During severe winter weather, especially after a heavy snowfall, grackles and, to a lesser extent, red-winged blackbirds may cause severe local problems. Feedlots located near large winter blackbird/starling roosts are particularly vulnerable. The primary means of control for all bird species at feedlots is the toxin Starlicide. Feed management to limit the availability of feed to birds has been suggested but may be too inconvenient and labor intensive. Livestock ration is being produced in pellet sizes too large to be acceptable to birds, but chicken feed cannot be made larger.

PART VII: CONCLUSION

255. Birds are an important component of the outdoor experience for society. Their visibility, abundance, diversity, and attractiveness, both visually and vocally, make them a conspicuous and integral part of the environment in any habitat. Birds represent the basis for a major segment of nonconsumptive wildlife recreation, and therefore contribute to a substantial economic basis for the products and services associated with outdoor recreation. They are also important economically because of their high consumption of insect pests, rodents, and weed seeds. For numerous reasons birds have been important subjects for a varity of scientific studies, particularly in ecological research. Therefore, bird control is a very sensitive public and political issue. The social, economic, and scientific importance of birds and their visibility and popularity with the public must be thoroughly understood, considered, and realistically appraised whenever a bird management program is planned and implemented. Project personnel should always contact their appropriate State or Federal agencies when planning a bird control program. Any toxic compound, even if mildly toxic, should only be used as a last resort and applied by experienced bird management specialists.

256. Management strategies for bird pest populations that cause extensive economic losses or represent serious threats to human health or safety have been well researched. However, small-scale or local bird nuisance or damage problems have not been as thoroughly addressed, particularly in controlled experiments. Even though the damage to materials, structures, equipment, and machinery by corrosive bird excrement must be substantial, the effects are generally so widespread that their economic impacts do not appear as obvious as local agricultural and feedlot depredations.

257. The methodologies to control or manage most bird pests are relatively well known and to varying degrees they are species and site specific. Nevertheless, there must usually be some fine-tuning by experienced and perceptive pest managers to effectively solve a specific problem or problems.

258. An integral part of any pest management program is the assessment and monitoring of potential environmental hazards. This would particularly be the case when using toxins or any chemicals whose environmental fate is uncertain. Habitat modifications may also contribute to environmental problems, including undesirable or unexpected changes in community structure, erosion, or sedimentation.

259. Birds represent a potential, although low, health or disease risk for humans. The most important human diseases associated with birds in the United States are histoplasmosis, encephalitis, chlamydiosis, and cryptococcosis. All four of these diseases are potential health hazards at Civil Works Projects because of the bird species present and site/habitat characteristics.

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APPENDIX A: SCIENTIFIC NOMENCLATURE
OF BIRDS CITED IN REPORT

Sequence of orders and families follows classification standards by the American Ornithologists' Union. Compiled from Robbins et al. 1983.

Pelecaniformes	
Cormorants	*Phalacrocorax* spp.
Anhinga	*Anhinga anhinga*
Anseriformes	
Swans	*Cygnus* spp.
Canada goose	*Branta canadensis*
Ducks	6 diverse tribes
Peking duck	Domesticated mallard *Anas platyrhynchos*
Falconiformes	
Northern goshawk	*Accipiter gentilis*
Cooper's hawk	*Accipiter cooperi*
Sharp-shinned hawk	*Accipiter striatus*
Golden eagle	*Aquila chrysaetos*
Bald eagle	*Haliaeetus leucocephalus*
Osprey	*Pandion haliaetus*
Prairie falcon	*Falco mexicanus*
Peregrine falcon	*Falco peregrinus*
Merlin	*Falco columbarius*
American kestrel	*Falco sparverius*
Galliformes	
Wild turkey	*Meleagris gallopavo*
Chukar	*Alectoris chukar*
Ring-necked pheasant	*Phasianus colchicus*

Ciconiiformes	
Herons/Egrets/Bitterns	Ardeidae
Great blue heron	*Ardea herodias*
Green heron	*Butorides striatus*
Black-crowned night heron	*Nycticorax nycticorax*
Wood stork	*Mycteria americana*
Ibises	Threskiornithidae
Gruiformes	
Cranes	Gruidae
Rails/Gallinules/Coot	Rallidae
Charadiiformes	
Shorebirds	
Sandpipers/Phalaropes	Scolopacidae
Plovers/Lapwings	Charadriidae
Avocets/Stilts	Recurvirostridae
Two other minor families in North America	
California gull	*Larus californicus*
Ring-billed gull	*Larus delawarensis*
Terns	Sterninae
Columbiformes	
Pigeon or rock dove	*Columba livia*
Mourning dove	*Zenaida macroura*
Psittaciformes	
Monk parakeet	*Myiopsitta monachus*
Strigiformes	
Great horned owl	*Bubo virginianus*
Caprimulgiformes	
Oilbird	*Steatornis caripensis*

Apodiformes

Hummingbirds	Trochilidae

Coraciiformes

Belted kingfisher	Ceryle alcyon

Piciformes

Red-headed woodpecker	Melanerpes erythrocephalus
Acorn woodpecker	Melanerpes formicivorus
Lewis' woodpecker	Melanerpes lewis
Sapsuckers	Sphyrapicus spp.

Passeriformes

Alaudidae	Horned lark	Eremophila alpestris
Hirundinidae	Barn swallow	Hirundo rustica
	Cliff swallow	Hirundo pyrrhonota
	Purple martin	Progne subis
Corvidae	Blue jay	Cyanocitta cristata
	Scrub jay	Aphelocoma coerulescens
	Black-billed magpie	Pica pica
	Yellow-billed magpie	Pica mutlali
	Common raven*	Corvus Corax
	American Crow*	Corvus brachyrhynchos
Mimidae	Northern mockingbird	Mimus polyglottos
	Gray catbird	Dumetella carolinensis
	Brown thrasher	Toxostoma rufum
Muscicapidae	American robin	Turdus migratorius
	Wood thrush	Hylocichla mustelina
	Other thrushes	Catharus spp.
	Bluebirds	Sialia spp.
Bombycillidae	Cedar waxwing*	Bombycilla cedrorum
Sturnidae	European starling	Sturnus vulgaris

*See the following page for similar species possessing restricted ranges in the United States.

Vireonidae	Black-capped vireo	Vireo atricapillus
Parulidae	Golden-cheeked warbler	Dendroica chrysoparia
	Kirtland's warbler	Dendrocia kirtlandii
	Ovenbird	Seiurus aurocapillus
Passeridae	House or English sparrow	Passer domesticus
Emberizidae	Bobolink	Dolichonyx oryzivorus
	Eastern meadowlark	Sturnella magna
	Western meadowlark	Sturnella neglecta
	Yellow-headed blackbird	Xanthocephalus xanthocephalus
	Red-winged blackbird	Agelaius phoeniceus
	Tricolored blackbird	Agelaius tricolor
	Rusty blackbird	Euphagus carolinus
	Brewer's blackbird	Euphagus cyanocephalus
	Common grackle*	Quiscalus quiscula
	Brown-headed cowbird*	Molothrus ater
	Orioles	Icterus spp.
	Northern oriole	Icterus galbula
	Northern cardinal	Cardinalis cardinalis
	Grosbeaks** (see page A5)	
	House finch or linnet	Carpodacus mexicanus
	American goldfinch	Carduelis tristis
	Lesser goldfinch	Carduelis psaltria
	Dickcissel	Spiza americana
	White-crowned sparrow	Zonotrichia leucophrys
	Golden-crowned sparrow	Zonotrichia atricapilla

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*Species resembling widespread pest species:

Chihuahuan raven	Corvus cryptoleucus
Southern U.S. generally near Mexican border	

Fish crow Southeastern U.S., generally coastal	*Corvus ossifragus*
Northwestern crow Extreme northwestern U.S., coastal	*Corvus caurinus*
Bohemian waxwing Summer range is northwestern Canada and Alaska	*Bombycilla garrulus*
Great-tailed grackle Southwestern U.S.	*Quiscalus mexicanus*
Boat-tailed grackle Florida and coastal southeastern U.S.	*Quiscalus major*
Bronzed cowbird Extreme southwestern U.S.	*Molothrus aeneus*

**Four species representing three genera of grosbeaks are widely distributed in the U.S.

APPENDIX B: BIRD DAMAGE CONTROL
PRODUCTS AND THEIR VENDORS

Exclusion

Hardware Cloth

Valentine Equipment Co.
9706 S. Industrial Drive
Bridgeville, IL 60455
(312) 599-1101

UV-Stabilized Polypropylene Netting and Screening

Conwed®

Almac Plastics Inc.
6311 Erdman
Baltimore, MD 21205-3585
(301) 485-9100

Conwed Corporation
Plastics Division
P.O. Box 43237
St. Paul, MN 55164-0237
(612) 221-1260

Green Valley Blueberry Farm
9345 Ross Station Rd.
Sebastopol, CA 95472
(707) 887-7496

Internet Inc.
2730 Nevada Ave. N.
Minneapolis, MN 55427
(612) 541-9690

Nixalite of America
1025 16th Ave.
P.O. Box 727
East Moline, IL 61244
(309) 755-8771

Orchard Supply Co. of Sacramento
P.O. Box 956
Sacramento, CA 95804
(916) 446-7821

Teitzel's Rainier View Blueberry Farms
7720 E. 134th Avenue
Puyallup, WA 98371
(206) 863-6548

Wildlife Control Technology
6408 S. Fig St.
Fresno, CA 93706
(209) 268-1200

Toprite®

J.A. Cissel Co. Inc.
P.O. Box 339
Farmingdale, NJ 07727
(201) 938-6600

Polyvinyl Chloride (PVC) Covered Polyester Yarn Netting

Conservare Pigeon Control

ProSoCo, Inc.
P.O. Box 1578
Kansas City, KS 66117
(913) 281-2700

111 Snyder Road
South Plainfield, NJ
(201) 754-4410

1601 Rock Mountain Blvd.
Stone Mountain, GA 30083
(404) 939-9890

Traps*

Grand Rapids Audubon Club 54 Jefferson Ave. SE Grand Rapids, MI 49503 Kroener Martin/Bluebird House Trap	Sp‡
Last Perch Box 426 Mitchellville, IA 50169 (515) 967-2853	Sp‡
Mustang Manufacturing Co P.O. Box 10947 Houston, TX 77018 (713) 682-0811	Pi**, St***, Sp‡
The Nature Society Purple Martin Junction Griggsville, IL 62340	Sp‡

*Most bird traps are "home-made."
**Pi = Pigeon.
***St = Starling.
‡Sp = Sparrow.

Tomahawk Live Trap Co. Pi**, Sp‡
P.O. Box 323
Tomahawk, WI 54487
(715) 453-3550

Woodstream Corp. Pi**, Sp‡
Lititz, PA 17543
(717) 626-2125
Havahart® Victor® Tender Trap

Chemosterilants

Ornitrol®

Avitrol Corp.
320 S. Bonton Ave., Suite 514
Tulsa, OK 74103
(918) 582-3359

Wetting Agents

Contact State Animal Damage Control Agency.

Repellents

Porcupine Wire

Cat Claw®

Shaw Steeple Jacks Inc.
2710 Bedford St.
Johnstown, PA 15904
(814) 266-8008

**Pi = Pigeon.
‡Sp = Sparrow.

Nixalite®

Nixalite of America
1025 16th Ave.
P.O. Box 727
East Moline, IL 61244
(309) 755-8771

Electrical Shock

Avi-Away®

Avi-Away Division
Monarch Molding Inc.
120 Liberty St.
Council Grove, KS 66846
(316) 767-5115

Sticky Contacts

Bird Repellent CB 1102

ArChem Corp.
1514 11th Street
P.O. Box 767
Portsmouth, OH 45662
(614) 353-1125

Bird Tanglefoot®

Forestry Suppliers, Inc.
205 W. Rankin St.
P.O. Box 8397
Jackson, MS 39204
800-647-5368
800-682-5397 (In Mississippi)

The Tanglefoot Co.
314 Straight Ave. SW
Grand Rapids, MI 49504
(616) 459-4130

Excelcide Bird Repellent

The Huge Co.
7625 Page Blvd.
St. Louis, MO 63133

Preferred Brand

Sun Pest Control
2945 McGee Trafficway
Kansas City, MO 64108
(816) 561-2174

Repel-O-Film

Baumes Castorine Co.
200 Matthew St.
P.O. Box 230
Rome, NY 13440
(315) 336-8154

Roost No More®

Velsicol Chemical Co.
341 E. Ohio St.
Chicago, IL 60611
(312) 670-4500

4-The-Birds®

J.T. Eaton & Co.
1393 Highland Rd.
Twinsburg, OH 44087
(216) 425-7801

Other Suppliers

Crown Industries
4015 Papin St.
St. Louis, MO 63110
(314) 533-0999

J.C. Ehrlich Chemical Co.
State College Laboratories
840 William Lane
Reading, PA 19612
(215) 921-0641

Hub States Corp.
419 E. Washington St.
Indianapolis, IN 46204
(317) 636-5255

Sanex Chemicals
5651 Dawson St.
Hollywood, FL 33023
(305) 961-6006

Methiocarb

Borderland Black

Borderland Products Inc.
P.O. Box 366
Buffalo, NY 14240
(716) 825-3300

Mesurol®

Mobay Chemical Co.
Chemagro Division
P.O. Box 4913
Kansas City, MO 64120
(816) 242-2000

Frightening Agents

Gas Exploders (Automatic)

Agricade Ltd.
Elm Tree House
North Fambridge
Chemsford, Essex
England, CM3 6NB
(0621-74112)

Alexander-Tagg Industries
395 Jacksonville Rd.
Warminster, PA 18974
(215) 675-7200

C. Frensch Ltd.
168 Main Street E., Box 67
Grimsby, Ontario L3M 4G1
Canada
(416) 945-3817

Hub States Corp.
1000 N. Illinois St.
Indianapolis, IN 46202

B. M. Lawrence & Co.
24 California St.
San Francisco, CA 94111
(415) 981-3650

Pisces Industries
P.O. Box 6407
Modesto, CA 95355
(209) 578-5502

Reed-Joseph International Co.
P.O. Box 894
Greenville, MS 38702
(601) 335-5822

Smith-Roles
1367 S. Anna St.
Wichita, KS 67209
(316) 945-0295; (701) 852-3726

Teiso Kasei Co. Ltd.
350 S. Figueroa St., Suite 350
Los Angeles, CA 90071
(231) 680-4349

Wildlife Control Division
Margo Supplies, LTD.
Site 8, Box 2, RR #6
Calgary, Alberta
T2M 4LS, Canada
(403) 285-9731

Pyrotechnics

Clow Seed Co.
1081 Harking Rd.
Salinas, CA 93901
(408) 422-9693
(whistlers, bird bombs)

J. E. Fricke, Co.
40 N. Front St.
Philadelphia, PA 19106
(fuse rope)

Marshall Hyde Inc.
P.O. Box 497
Port Huron, MI 48060
(313) 982-2140

Munitions Filling Factory
St. Marys, New South Wales,
Australia
(shell-crackers)

New Jersey Fireworks Co.
Box 118
Vineland, NJ 08360
(609) 692-8030
(rope firecrackers)

O.C. Ag Supply, Inc.
1328 Allec St.
Anaheim, CA 92805
(714) 991-0960

Stone Co., Inc.
P.O. Box 187
Dacono, CO 80514
(303) 893-2580

Sutton Ag Enterprises
1081 Harkins Rd.
Salinas, CA 93901
(408) 422-9693

Wald & Co.
208 Broadway
Kansas City, MO 64105
(816) 842-9299
(rope firecrackers)

Western Fireworks Co.
2542 SE 13th Avenue
Canby, OR 97013
(503) 266-7770

Wildlife Control Division
Margo Supplies Ltd.
Site 8, Box 2, RR #6
Calgary, Alberta T2M 4L5
Canada
(403) 285-9731
(bird bombs, racket bombs)

Alarm/Distress Calls (Recorded)

Applied Electronics Corp.
3003 County Line Rd.
Little Rock, AR 72201
(501) 821-3095

Schmidt, R. H., and H. L. Johnson. 1982.
Dispersal recordings, source of supply
Order from:
Department of Forestry,
Fisheries and Wildlife,
202 Natural Resources Hall
University of Nebraska
Lincoln, NB 68583

Signal Broadcasting Co.
2314 Broadway St.
Denver, CO 80205
(303) 571-5649
(Sells copies of Denver Wildlife Research Center calls)

Smith's Game Calls
P.O. Box 236
Summerville, PA 15864
(starling distress call)

Wildlife Technology
P.O. Box 1061
Hollister, CA 95023
(rents recordings of alarm and distress calls)

Electronic Noises

Av-Alarm Corp.
675-D Conger St.
Eugene, OR 97402
(503) 342-1271

Bird-X
325 Huron St.
Chicago, IL 60610
(312) 648-2191

Wildlife Control Division
Margo Supplies, LTD.
Site 8, Box 2, RR# 6
Calgary, Alberta
T2M 4L5, Canada
(403) 285-9731

Other Acoustics

Falcon Safety Products Inc.
1065 Bristol Rd.
Mountainside, NJ 07092
(201) 233-5000
(air horn)

Tomko Enterprises Inc.
Route 58, RD #2
P.O. Box 937-A
Riverhead, NY 11901
(516) 727-3932
(clapper device with timer)

Lights (Flashing or Revolving)

Bird-X
325 W. Huron St.
Chicago, IL 60610
(312) 648-2191

R. E. Dietz Co.
225 Wilkinson St.
Syracuse, NY 13201
(315) 424-7400

The Huge Co.
7625 Page Blvd.
St. Louis, MO 63133
(314) 725-2555

Tripp-Lite Manufacturing Co.
500 N. Orleans
Chicago, IL 60610
(312) 329-1777

Models (Predators, Kites, and Balloons)

Atmospheric Instrumentation Research (AIR) Inc.
1880 S. Flatiron Ct., Suite A
Boulder, CO 80301
(303) 443-7187
(polyurethane tetrahedron balloons and kites)

Bird-X
325 W. Huron St.
Chicago, IL 60610
(312) 648-2191
(suspended hawk model)

Clow Seed Co.
1081 Harking Rd.
Salinas, CA 93901
(408) 422-9693
(hawk-kite model)

Cochranes of Oxfort Ltd.
Leafield, Oxford
England, OX8 5NT
(099387-641)
(kites)

R. M. Fay
Rt. 2 Box 2569
Grandview, WA 95930
(509) 882-3258
(balloon supported hawk-kite model)

High-as-a-Kite
200 Gate Five Rd.
Sausalito, CA 94965
(415) 332-6355
(kites)

The Huge Co., Inc.
P.O. Box 24198
St. Louis, MO 63130
(314) 725-2555
(owl model)

Raven Industries, Inc.
P.O. Box 1007
Sioux Falls, SD 57117
(605) 336-2750
(Mylar tetrahedron balloons and blimps)

Saturn Inc.
P.O. Box 21
Kathryn, ND 58049
(701) 924-8645
(pop-up owl model with distress call of red-winged blackbird)

Sutton Ag Enterprises
1081 Harkins Rd.
Salinas, CA 93901
(408) 422-9693
(kites)

Teiso Kasei Co. Ltd.
350 S. Figueroa St., Suite 350
Los Angeles, CA 90071
(213)680-4349
(hawk-kite model)

Tiderider Inc.
P.O. Box 9
Eastern and Steele Blvds.
Baldwin, NY 11510
(516) 223-3838
(kites)

WeatherMeasure Corp.
P.O. Box 41257
Sacramento, CA 95841
(916) 481-7565
(weather balloons)

Scarecrows

W. Atlee Burpee Seed Co.
Warminster, PA 18974
(215) 674-4900
(inflatable plastic human figure)

Coleman Equipment, Inc.
332 Madison Ave.
New York, NY 10017
(212) 687-2154
(moving, noise-making scarecrow)

Lentell Marketing
Elm Tree House
North Fambridge
Chemsford, Essex
England CM3 6NB
(0621-741112)
(human figure)

4-Aminopyridine

Avitrol®
Avitrol Corp.
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Tulsa, OK 74103
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Chicago, IL 60610
(312) 648-2191

Excelcide Bird Trip

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St. Louis, MO 63133
(314) 725-2555

Coal Tar & Creosote (Stanley's Crow Repellent);
Copper oxalate (Crow-Chex)

Borderland Products Inc.
P.O. Box 366
Buffalo, NY 14240
(716) 825-3300

Toxins

Strychnine

ArChem Corp.
1514 11th Street
P.O. Box 767
Portsmouth, OH 45662
(614) 353-1125

B & G Co.
10539 Maybank St.
P.O. Box 20372
Dallas, TX 75220
(214) 357-5741

J. C. Ehrlich Chemical Co.
State College Laboratories
840 William Lane
Reading, PA 19612
(215) 921-0641

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Avitrol Corp.
320 S. Boston Ave., Suite 514
Tulsa, OK 74103
(918) 582-3359

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325 W. Huron St.
Chicago, IL 60610
(312) 648-2191

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7625 Page Blvd.
St. Louis, MO 63133
(314) 725-2555

Starlicide®

Ralston Purina Co.
Checkerboard Square
St. Louis, MO 63164
(314) 982-1000

Toxic Perches

Rid-A-Bird Inc.
1224 Grandview Ave.
P.O. Box 22
Muscatine, IA 52761
(319) 263-7970

APPENDIX C: CHEMICAL NOMENCLATURE OF COMPOUNDS USED FOR BIRD DAMAGE CONTROL

Avitrol®	4-aminopyridine (hydrochloride)*
CAT	2-chloro-4-acetotoluidine
Crow Chex®	copper oxalate
Curb	aluminum ammonium sulfate
DRC-1339	3-chloro-p-toluidine hydrochloride
Endrin	Mostly hexachloroepoxyoctahydro-endo, endo-dimethanonaphthalene
FC Corn Chops-99S	4-aminopyridine (hydrochloride)*
Fenthion	0,0-dimethyl 0-[3-methyl-4-(methylthio) phenyl] phosphorothioate
Methiocarb	3,5-dimethyl-4-(methylthio) phenyl methylcarbamate
Ornitrol®	20,25-diazacholesterol dihydrochloride
PA-14 (Tergitol)	α-alkyl (C_{11} - C_{15})-omega-hydroxypoly (oxyethylene)
Starlicide®	3-chloro-p-toluidine hydrochloride
Strychnine	2,4a,5,5a,7,8,15,15a,15b,15c,-dechydro-4,6-methano-6H,14H-indolo [3,2,1-ij] oxepino[2,3,4-de] pyrrolo [2,3-h] quinolin-14-one
4-AP	4-aminopyridine (hydrochloride)*

*The hydrochloride derivative is generally used since it is more stable.

APPENDIX D: TOXICITY OF STARLICIDE® TO SELECTED BIRD AND MAMMAL SPECIES

(Timm 1983b, after DeCino et al. 1966 and Clark 1975)

Bird	Approximate LD_{50} acute oral mg/kg
Sturnidae	
Starling, _Sturnus vulgaris_	3.8
Icteridae	
Red-winged blackbird, _Agelaius phoeniceus_	1.8-3.2
Columbidae	
Mourning dove, _Zenaidura macroura_	5.6-10.0
Pigeon (Rock dove), _Columba livia_	17.7
Phasianidae	
Ring-necked pheasant, _Phasianus colchicus_	10
Coturnix quail, _Coturnix coturnix_	< 10
Meleagrididae	
Domestic turkey, _Meleagris gallopavo_	5.6
Anatidae	
Mallard duck, _Anas platyrhynchos_	10-32
Blue-winged teal, _Anas discors_	10-100
Pintail duck, _Anas acuta_	> 32
Corvidae	
Common crow, _Corvus brachyrhynchos_	1.8
Black-billed magpie, _Pica pica_	5.6-17.7
Blue jay, _Cyanocitta cristata_	< 10
Accipitridae	
Cooper's hawk, _Accipiter cooperii_	320-1,000
Marsh hawk, _Circus cyaneus_	100
Falconidae	
Kestrel (Sparrow hawk), _Falco sparverius_	>320
Ploceidae	
House sparrow, _Passer domesticus_	320-448

Mammal	LD_{50} acute oral mg/kg	No Kill mg/kg
White rats	1170-1770	
Mice	2000	
White mice	960	
Dogs		100
Sheep	400+	200
Co		10

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