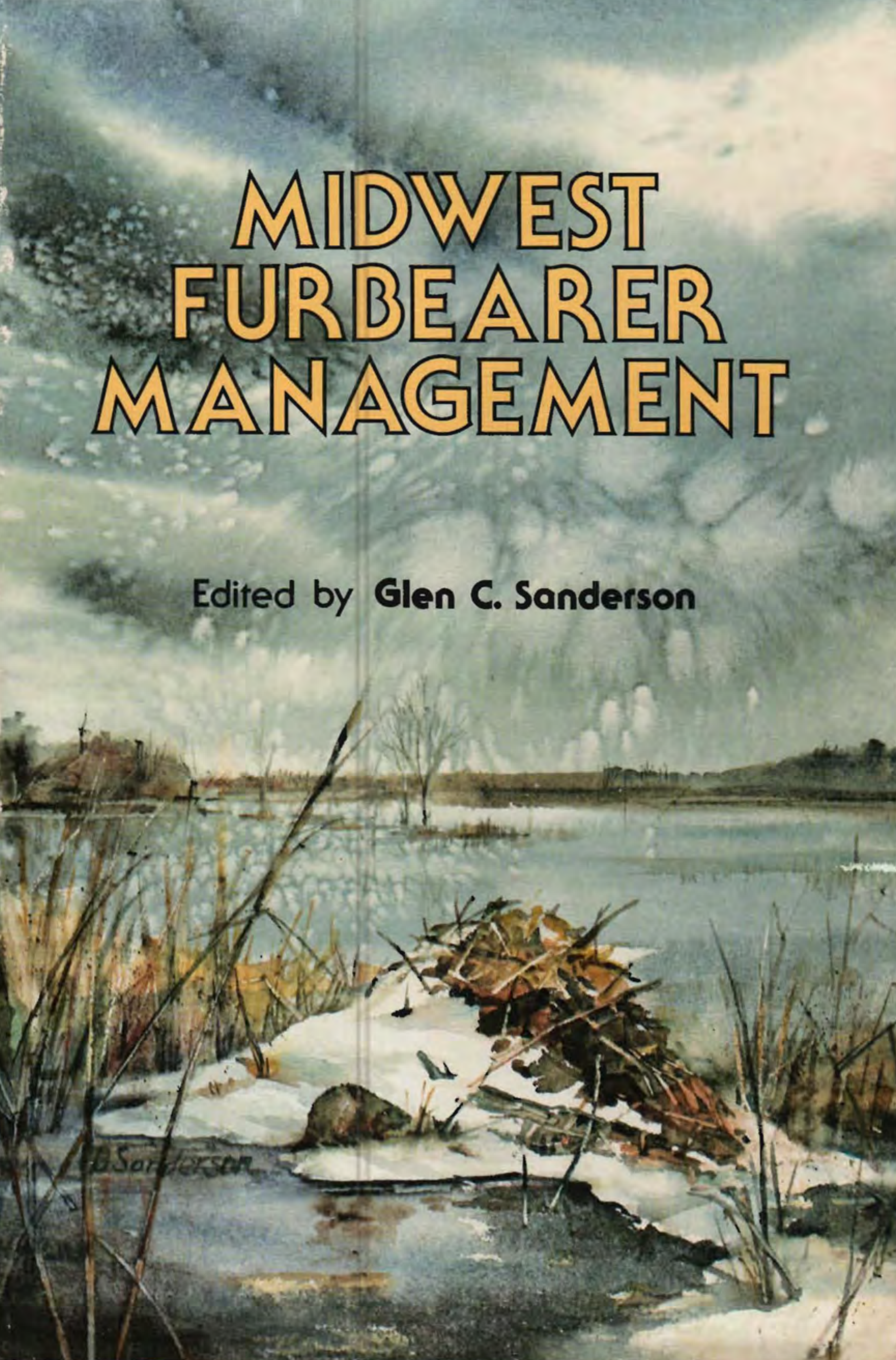

MIDWEST FURBEARER MANAGEMENT

Edited by **Glen C. Sanderson**

Alan Crossley

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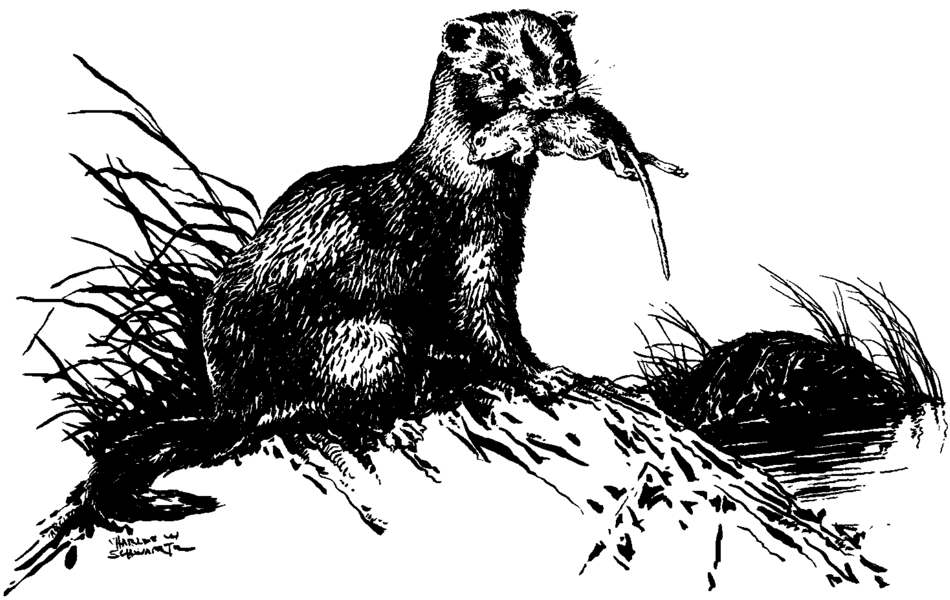

MIDWEST FURBEARER MANAGEMENT

Edited by

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Section of Wildlife Research
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Proceedings of a Symposium
held at the 43rd Midwest Fish and
Wildlife Conference, Wichita, Kansas
7–8 December 1981

1982

Sponsored by
North Central Section, Central Mountains and Plains Section,
and Kansas Chapter of The Wildlife Society

Library of Congress Catalog Card Number
83-080045

The Kansas Chapter of The Wildlife Society acknowledges the contributions made by the following companies and individuals toward the publication of the 1981 Furbearer Symposium proceedings. Without this generous support, the Chapter would have had difficulty meeting its goal of promoting sound wildlife management in Kansas and throughout the Great Plains.

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Steven G. Sorensen, 808 West 5th, Concordia, KS
Robert Wood, 502 Commodore, Pratt, KS

The Central Mountains and Plains Section of The Wildlife Society acknowledges the contributions made by the following companies, individuals, and agencies toward the publication of the 1981 Furbearer Symposium proceedings.

Colorado Chapter, The Wildlife Society
Joseph Hnatiuk, Saskatoon, Saskatchewan
Dean Hoffman, Central States Furs Corp., Aurora, IA
North Dakota Chapter, The Wildlife Society
Northwoods Import-Export, Greensburg, PA
O'Gorman Enterprises, Inc., Broadus, MT
South Dakota Chapter, The Wildlife Society

Charles Flora: Art Director and Designer
Office of Printing Services
University of Illinois at Urbana-Champaign

ABOUT THE BOOK

The seed from which this symposium sprouted was sown during a Midwest Furbearer Workshop, held in Manhattan, Kansas, in April 1979. At this informal gathering of midwestern biologists, it was evident that interest and activity in furbearer management had significantly increased as was demonstrated by the large number of new furbearer biologists present, representing states that had just upgraded their programs. The need for enhanced communication among the group was expressed unanimously, and the concept of a special furbearer management program was developed. Later in 1979, during the Midwest Fish and Wildlife Conference in Champaign, Illinois, strong interest was shown in using the biennial symposium sponsored by the North Central Section of the Wildlife Society as a means to bring the furbearer biologists and managers together again and share their information with the rest of the wildlife community. We, as co-chairmen, had no trouble finding willing participants and an anxious audience. The format and subject matter of the symposium were developed by us with much advice from state, federal, and university biologists, but the faults and omissions are ours. The initial papers are reviews of techniques necessary to carry out progressive furbearer management programs: census techniques, aging and tooth histology, productivity measurements, and harvest surveys. Two papers deal with the use of scientific information to interpret population phenomena. The 3 papers that follow address some special problems relating to the fur resource: identifying the resource users, the fur marketplace, and rabies. Next, the history of the red fox describes how people and management can interact with a valuable furbearer. The paper on reintroduction of mustelids reviews information from diverse sources on what is becoming a population management practice. The final paper is a historical overview and a discussion of the future of furbearer management in the Midwest, pointing out some of the major problems that may face managers in years to come.

Some of the information presented in these papers is restricted to the Midwestern states and provinces: North Dakota, South Dakota, Nebraska, Kansas, Missouri, Iowa, Minnesota, Wisconsin, Illinois, Michigan, Indiana, Ohio, Ontario, and Manitoba. Nonetheless, we hope professionals and students interested in the management of furbearers throughout North America will find it useful.

Neil F. Johnson
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FOREWORD

Furbearers have always attracted special management interest because they are among the few species of wildlife that have a legal trade value in North America. This interest has intensified in recent years because pelts of certain species have been particularly valuable and methods of taking fur have become controversial. The time was ripe for furbearer biologists to meet and review current management problems and programs.

A furbearer management symposium was originally proposed by the Kansas Chapter of The Wildlife Society to be held in conjunction with the 43rd Midwest Fish and Wildlife Conference at Wichita. The North Central Section offered to co-sponsor the symposium in keeping with its objective (since 1965) of conducting biennial symposia. The Central Mountains and Plains Section provided some financial assistance. So, a unique opportunity was present for sub-units of The Wildlife Society to cooperate in an effort to disseminate information on furbearer management. The final result is this book. It is evident that the symposium chairmen, authors, and editor have done their work well.

Like many cooperative ventures, this symposium was a success because of effective teamwork. The contents of this book should be useful to wildlife workers for many years. Hopefully, the main beneficiaries will be the furbearing mammals of the Midwest.

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The pen and ink drawings used at the beginning and ends of the chapters were drawn especially for this publication by **Beverley C. Sanderson**, Champaign, Illinois. **Charles W. Schwartz**, formerly with the Missouri Department of Conservation, provided the pen and ink drawing used in the program for the symposium and as the Frontispiece for this publication. Both artists donated the use of their drawings, and we thank them for their contributions.

PREFACE

The role of furbearers in the settlement of North America is well known and several major studies dealing with furbearers were published prior to 1950. Furbearers in the Midwest and in much of North America received little attention from researchers, managers, and administrators from the late 1940's through the 1960's. Interest in furbearers increased rapidly in the 1970's with dramatic increases in pelt prices, an increased awareness of the values of all wildlife, endangered species legislation, increased demands for outdoor recreation, and the development of antihunting and antitrapping sentiment. This symposium is one result of the increased interest in furbearers in the Midwest.

This symposium was organized by Neil F. Johnson and Erik K. Fritzell. We thank Eva Steger for editorial assistance and Elizabeth Anderson and Cynthia Jackson for retyping some of the manuscripts; all are with the Illinois Natural History Survey. We give a special thanks to the individuals who reviewed the manuscripts. They were: Ernest D. Ables, Stephen H. Allen, Major L. Boddicker, William L. Clark, William R. Edwards, David W. Erickson, Larry Frederickson, Erik K. Fritzell, Lonnie P. Hansen, George F. Hubert, Jr., Douglas H. Johnson, Neil F. Johnson, Stephen R. Kellert, W. D. Klimstra, Carl O. Mohr, Tony J. Peterle, Charles M. Pils, Ernest E. Provost, Alan B. Sargeant, Howard J. Stains, G. L. Storm, B. J. Verts, and Vernon Wright.

Thirteen papers were presented during the symposium. The theme was management of furbearers in the Midwest, but several reports include information from beyond this geographical area. Twelve of the papers presented at the symposium are included in these proceedings. Only the abstract of the remaining report is included as the authors failed to submit a completed manuscript.

Financial support for publication of this book was provided by the North Central Section, Central Mountain and Plains Section, and Kansas Chapter of The Wildlife Society.

Success of the symposium can be measured by the large attendance registered at the sessions, the enthusiasm of the speakers, and the quality of the papers presented. Because of that success, special recognition is warranted for those individual society members who volunteered their time to serve on the committees and many work details necessary to organize and coordinate the symposium. We also recognize Mr. George Gragg of Gragg Furs International of Wichita and the Kansas Fish and Game Commission, whose significant financial support of the Kansas Chapter made their part in hosting the symposium possible.

CONTENTS

1

A Perspective on Furbearer Management[1]

Erik K. Fritzell, School of Forestry, Fisheries and Wildlife, University of Missouri, Columbia.
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Abstract: Furbearer management, an integral part of today's wildlife management scene, has several unique characteristics. First, the annual fur harvest creates a flow of goods and services. Fashion trends may be as important as population levels in determining harvest pressure. Second, the furbearer manager must manage diverse populations of mammals occupying different trophic levels and living in a variety of habitats. Management strategies for these populations may differ greatly. Third, management of furbearers often generates conflict among the wildlife profession because population levels of many furbearer species may directly impact other wildlife resources. Fourth, furbearer management has developed relatively slowly as a discipline within the wildlife profession. Only recently has a national identity emerged among furbearer managers. A rise in prices of long-haired furs during the 1970's stimulated harvest pressure and increased the need for management programs. Demands for improved or increased management continue today, but funding sources have not expanded. We propose that traps and trapping supplies or native fur products be included among the items taxed under the Pittman-Robertson federal aid program.
Key words: furbearer, management, history, trapping, economics, taxation.

Furbearer management is an integral part of today's wildlife management scene, yet it is a unique subdivision of the profession. The milieu of the furbearer biologist includes economic, biological, and managerial considerations and constraints not customarily faced by most other wildlife specialists. We have identified 4 unique aspects of furbearer management.

[1]Contribution from Missouri Cooperative Wildlife Research Unit (School of Forestry, Fisheries and Wildlife, University of Missouri-Columbia; Missouri Department of Conservation; U.S. Fish and Wildlife Service; and Wildlife Management Institute, cooperating) and Missouri Agricultural Experiment Station, Project 179, Journal Series Number 8970.

The first, and most obvious, discriminatory characteristic is economic. Unlike those of other groups of wildlife species, the pelts and carcasses of furbearers can be sold. The annual fur harvest, therefore, creates a flow of goods and services. The resource offers potential economic gain, as well as recreational and aesthetic values. Therefore, harvest pressure upon the various furbearer populations can be influenced markedly by the marketplace and ultimately by the fashion trends in Paris, New York, and other cities. While other biologists struggle to determine the monetary value of their "unpriceable" resources, the furbearer biologist deals daily with the changing market value of his resource.

The promise of monetary gain from pelts can result in excessive harvests, as in the halcyon days of the mountain men. Beaver (*Castor canadensis*), which today are one of the more important "pests" in many states, were once near extinction because of the insatiable demand for their pelts. With the restoration of furbearer populations and the advent of regulated harvests, the danger of overharvest has lessened; nonetheless, the furbearer biologist must make management decisions directly influenced by the marketplace. Traditional training in wildlife management seldom provides adequate exposure to economics. Indeed, we feel that there is significant potential for integrating economics into the furbearer management system. The refinement and use of economic models may someday provide the manager with a powerful tool to predict harvest pressure well in advance of open seasons. The unique economic arena in which furbearer management is staged must be used to the advantage of the resource.

The second distinguishing characteristic of furbearer management is biological. Most biologists and managers employed by state agencies have responsibility over populations of species with similar biological characteristics, such as waterfowl or big game; or they manage species inhabiting a single habitat type, such as forest wildlife. Furbearer biologists, however, are given responsibility for a diverse group of mammals occupying different trophic levels and living in a variety of habitats. Witness the 1979–80 harvest of furbearers from each of the midwestern states (Table 1–1). Typical midwestern furbearer biologists conduct research and surveys and make management recommendations for mammals in 3 orders and 8 families (Table 1–2). The rodents, such as the muskrat (*Ondatra zibethicus*), are herbivorous and *r*-selected; most carnivorous furbearers are long-lived with relatively low biotic potentials; and others, such as the raccoon (*Procyon lotor*), striped skunk (*Mephitis mephitis*), and opossum (*Didelphis virginiana*) are omnivorous. Obviously, these populations require vastly different management strategies. The existence of a large "harvestable surplus" in muskrat populations was established by Errington (1963). In contrast, Powell (1979) suggested that harvests of fishers (*Martes pennanti*) exceeding 1–4 per 100 km^2 would extirpate local populations. Furthermore, even though habitat management specifically for furbearers is relatively uncommon, the fact that furbearers occur in all habitat types necessitates some knowledge of diverse manipulations of land and water areas. Marsh muskrats, farmland foxes, woodland bobcats (*Lynx rufus*), and urban raccoons are all subjects for concern by the furbearer biologist. Clearly, the furbearer biologist must have expertise in broad areas of wildlife biology and management.

The third unique characteristic of furbearer management can be labeled "bio-professional." The furbearing mammals, which the furbearer biologist is charged to conserve and manage, often are the cause of conflict within the wildlife management community. Most wildlifers are familiar with conflict among the diverse groups of resource users, yet few face such animosity within their chosen profession as do furbearer biologists. Finding agreement on population management objectives among wildlife professionals is often complicated by conflicting values placed on the furbearer resource. A healthy red fox (*Vulpes vulpes*) population in the Prairie Pothole Region managed for optimum sustained yield may not be desirable to the waterfowl manager trying to maximize duck production. An abundance of muskrats that pleases the Wisconsin trapper and furbearer biologist might be the scourge of the marsh manager who must repair dikes weekly. An increase in coyotes (*Canis latrans*) or beavers may please the trapper and hunter in Missouri so that the furbearer biologist is held in high esteem, but a simultaneous increase in damage complaints may generate a crisis for the wildlife damage control agent. Recent research has identified predation by coyotes on white-tailed deer (*Odocoileus virginianus*) fawns as a significant factor affecting local deer populations (reviewed by Porath 1980). The fact that deer and deer hunters receive high priority in management decisions can complicate the management goals for coyotes. Although the furbearer biologist must develop his objectives with diverse consumptive and nonconsumptive "publics" in mind, he may also find his management plans of great interest to other professionals within his own and other management agencies.

A final unique characteristic of furbearer management has been its relatively slow development as a discipline within the wildlife profession. The management of furbearing mammal populations can be considered the oldest form of wildlife management in North America. The Hudson's Bay Company established management objectives for various trading areas early in the 19th century (Galbraith 1957:10). A form of sustained-yield management was practiced in the interior of Rupert's Land where a complete monopoly was held. In the areas at the edge of the Company's chartered lands, where competition from both small and large fur-trading companies developed, the Company policy was to encourage local extirpation of furbearers by paying exceptionally high prices. The Company was willing to operate at a presumably short-term loss from its peripheral posts in order to preserve the lucrative monopoly in the heart of Rupert's Land. Although extirpation is hardly a noble goal for

Table 1-1. Estimated 1979-80 fur harvest in 12 states and 2 provinces in the

Species	Illinois	Indiana	Iowa	Kansas	Michigan	Minnesota
Badger			3,274	3,725		2,000
Bear					919	743
Beaver	7,345	2,001	12,498	14,140	26,793	76,000
Bobcat				2,898	597	291
Coyote	9,831	2,485	7,745	93,648	3,000	8,000
Fisher						3,032
Gray fox	10,547	22,920	3,093	245		8,000
Red fox	14,136	19,126	17,629	887	15,000	60,000
Lynx						42
Marten						
Mink	22,971	18,502	31,270	3,377	12,000	66,000
Muskrat	460,674	532,278	741,403	75,961	450,000	707,000
Opossum	28,626	42,234	10,978		15,000	1,000
Raccoon	381,006	313,697	308,277	207,578	363,400	162,000
River otter					1,157	1,186
Striped skunk	3,111	3,939	10,022	23,297	10,000	47,000
Spotted skunk						<1,000
Weasels	145	345	122		3,000	10,000

today's manager, this early application of "zone management" served the Company well for many years. Furbearer management has come a long way since then, but it has developed more slowly than other management specialties.

Following the advent of "modern" wildlife management in the mid-1930's, commonly recognized specialties evolved: waterfowl management, upland game management, big game management, and others. Each has prospered and developed somewhat independently. Management philosophies, management objectives, methods, research directions, and communication channels have evolved so that biologists in these specialties have clear identities within a group of professionals having common backgrounds and interests. We believe that furbearer management, however, has not shown such signs of maturity as a discipline. The neoteny of furbearer management may be caused, in part, by one of several factors: delayed initiation of specific furbearer programs and positions in many state wildlife agencies, a lack of adequate funding, the lack of management-oriented research by university and state scientists, or the lack of organized communication mechanisms among the researchers, managers, and users of the furbearer resource. Clearly, furbearer management needs to be nurtured to its full potential.

Wildlife management programs throughout the country are faced with fiscal dilemmas. Income from traditional funding sources for state agencies are not

Midwest. Estimates made by state and provincial officials, but methods vary.

Missouri	Nebraska	North Dakota	Ohio	South Dakota	Wisconsin	Manitoba	Ontario	Totals
327	3,725	4,629	51	7,929		1,132	4,629	28,958
						434		2,595
10,491	15,300	4,836	4,927	3,942	29,447	68,311	4,836	485,166
	52	45		206	141		33	4,263
20,202	18,700	4,425		9,012	2,815	6,219	3,146	189,228
						2,864	4,457	10,353
13,325			21,510	20	5,637		3	85,300
	1,840	28,306	20,814	17,541	22,961	10,436	17,520	246,196
						5,047[a]	2,485	7,574
						2,395	45,861	48,256
10,951	7,060	10,512	14,517	8,545	34,692	24,869	27,377	292,643
137,385	173,350	96,521	591,342	64,035	958,318	328,704	605,966	5,922,937
56,936	13,130		48,510	124	1,709			372,370
289,592	79,650	15,463	261,123	26,915	179,075	6,983	74,841	18,486
					1,448	3,583		2,669,600
7,671	11,700	5,012	3,329	18,322	3,314	442	48	147,207
177	130			140				<1,447
94	140	1,343	397	661	519	21,314		38,080

[a]Includes bobcat and lynx.

keeping pace with the galloping inflation rate. In addition, these agencies are assuming new responsibilities. Budgets that cannot adequately address traditional problems are expected to finance expanded resource management programs. Furbearer management is not a new resource field, yet it too requires expanded funding to meet the needs of the 1980's. Funding opportunities generated from the fur resource itself are undeveloped.

Consideration of the mechanisms used to generate funding for traditional game management programs may provide the key to new sources of funds for furbearer management. The passage of the Federal Aid in Wildlife Restoration Act in 1937 dedicated excise taxes on sporting arms and ammunitions to the acquisition, restoration, research, and management of wildlife populations and habitats. This cornerstone of wildlife management funding stimulated the development of scientific wildlife management in state agencies. These "user taxes," however, may have favored the development of game management programs designed to benefit those who contributed most heavily: the upland game, waterfowl, and big game hunters. Trappers contributed only with their purchase of arms and ammunition. Furbearer management, therefore, probably had lower priority within state agencies.

Trappers contributed relatively less money to total license sale revenues than hunters during the developing stages of state wildlife programs. Trapping

Table 1–2. Management status of furbearers in the Midwestern United States

Species	Illinois	Indiana	Iowa	Kansas	Michigan	Minnesota
Badger	a[a]	a	c	bc	a	bc
Black bear	n	n	a	n	be	be
Beaver	c	c	c	c	ce	c
Bobcat	a	a	a	bc	bc	bce
Coyote	bcd	bc	bcd	dg	dg	dg
Fisher	n	n	n	n	a	a
Gray fox	bc	bc	bc	bc	bc	bc
Red fox	bc	bc	bc	bc	bc	bc
Lynx	n	n	n	a	a	bce
Marten	n	n	n	n	a	a
Mink	c	c	c	c	bc	c
Muskrat	c	c	c	c	c	c
Opossum	bc	bc	bc	bc	dg	dg
Raccoon	bc	bc	bc	bc	bc	bc
River otter	a	n	a	n	ce	ce
Striped skunk	bc	c	c	bcd	dg	dg
Spotted skunk	n	n	a	a	n	dg
Weasels	c	c	c	c	dg	dg

[a] = Total protection, [b] = Hunting season, [c] = Trapping season, [d] = Year-around harvesting, [e] = Limited harvesting (daily/seasonal bag limit), [f] = Limited harvesting (area quota), [g] = Unprotected, [n] = Not present.

licenses were not required in Ohio and Indiana until 1979 and 1980, respectively (Hubert 1982). The role of the furharvester was probably viewed differently than was the role of the hunter. The prevailing idea that predators competed with the hunter for game may have made the trapper important in the production of larger game populations. It was not necessary nor prudent to tax trappers who performed a valuable management service. Nor was it logical to offer bounties for the killing of predators while concurrently requiring the trapper and furbearer hunter to be licensed for the privilege of controlling "vermin." Needless to say, times have changed. The rise in prices of long-haired furs during the 1970's stimulated harvest pressure that generated a response from agencies. License fees are now collected from almost all fur trappers and hunters, and many states have active furbearer management programs. We believe, however, that new funding sources are needed to enhance the management of our nation's furbearer resource.

No less than for other disciplines of resource management, a surfeit of demands exists for improved or increased furbearer management activities by state agencies. For example, trapper education programs have been initiated in Pennsylvania and Missouri in response to requests from the trapping community.

and Canada, 1980.

Missouri	Nebraska	North Dakota	Ohio	South Dakota	Wisconsin	Manitoba	Ontario
bc	dg	bc	c	bcd	a	c	c
a	n	a	a	n	be	bc	bce
c	c	bc	ce	bcd	c	cf	ce
bc	bc	bc	a	bc	bce	c	ce
bcd	dg	d	dg	d	dg	c	bc
n	a	a	n	n	a	cef	ce
bc	dg	bc	bc	bcd	bc	n	bc
bc	dg	bc	bc	bcd	bc	c	bc
n	n	a	n	n	a	c	ce
n	n	a	n	a	a	c	ce
c	c	c	c	c	c	c	ce
c	c	c	c	c	c	cf	c
bc	bc	n	bc	d	dg	n	c
bc	bc	bc	bc	bcd	bc	bc	c
a	n	a	a	n	ce	cef	c
bc	dg	d	bc	d	dg	bc	g
bc	a	n	n	d	dg	n	n
bc	dg	c	bc	c	dg	c	bc

Seventy-two percent of the National Trapper's Association members surveyed in the nationwide "Kellert Study" (Kellert 1981) favored mandatory trapper education programs; another study (Boddicker 1981) found that 56% of the trappers surveyed favored mandatory trapper education programs. Continued concern about the ethics and image of hunters and trappers by the general public will probably result in further need for trapper education programs. Trappers and trapping are often at the forefront of the debate with antiharvest groups. Development of successful trapper education programs are likely to have immediate impacts upon public attitudes toward all methods of wildlife harvest.

Potential for expanded furbearer research and management can also be identified in a survey of the readers of *Trapper Magazine* (Boddicker 1981). Trappers were asked to indicate areas where state agencies could improve or increase efforts in furbearer management. Forty-nine percent desired increased effort to "collect harvest data, population information, and get a better handle on how many animals are available to harvest;" 37% desired an increased effort to purchase or improve habitat for furbearers; 77% wanted increased communication with trappers; 47% desired improved law enforcement; and 77% wanted increased enforcement of "trap and catch theft." Agency responses to these and other concerns of the trapping public will necessitate increased funding.

A prime example of increased state responsibility without increased funding for furbearer management activities concerns the management of bobcats and river otters (*Lutra canadensis*). Federal regulations written to comply with the Convention on International Trade in Endangered Species of Flora and Fauna (CITES) place additional burdens on state programs. The monitoring of bobcat and river otter populations and the issuance of export permits for each bobcat and otter sold adds significantly to the workload of state agency personnel. Likewise, improved methods for monitoring populations of these sensitive species should be developed. Adequate response by wildlife agencies to these and other needs will require an adequate funding base.

In recent years, wildlife agencies and organizations have scrambled to identify new mechanisms for funding. States such as Colorado, Minnesota, Oregon, Kansas, and others have enacted laws allowing taxpayers to designate part of their income tax refund for nongame programs. Washington directs revenues from the sale of personalized license plates to fund wildlife programs. Many states have required sportsmen to purchase special stamps before pursuing a variety of species; the stamp revenues are dedicated to specific management programs. Missouri citizens increased the revenue available for conservation purposes by amending their constitution to provide a ⅛-cent sales tax increase. Other states are trying to require that hunting and fishing license fees be adjusted annually to the inflation rate. These innovative funding mechanisms have stimulated a variety of new management programs. We believe, however, that the existing Pittman-Robertson program is the best way to generate additional funds for furbearer management.

We propose that an excise tax be levied on either traps and trapping supplies or on native fur products at some stage in their manufacture. This revenue should be added to existing Federal Aid coffers and subsequently distributed to the states. We do not pretend to comprehend all the nuances of taxation principles and practices, but we believe the Federal Aid method provides the best means to generate and distribute additional funding. It seems to be a logical, efficient, equitable, and generally acceptable taxation mechanism. We do not propose specific details but urge a comprehensive study of the economics, feasibility, and acceptability of such a user tax to support the management of the furbearer resource. It is noteworthy that 82% of the public and 70% of trappers sampled in the Kellert study (Kellert 1981) agreed that an excise tax on fur clothing should help to pay for the cost of wildlife conservation.

Furbearer research will reach the required level of sophistication only after funds are available to pay for it; trapper education will remain the exception rather than the rule without additional funding; and furbearer management will never reach maturity without adequate funding.

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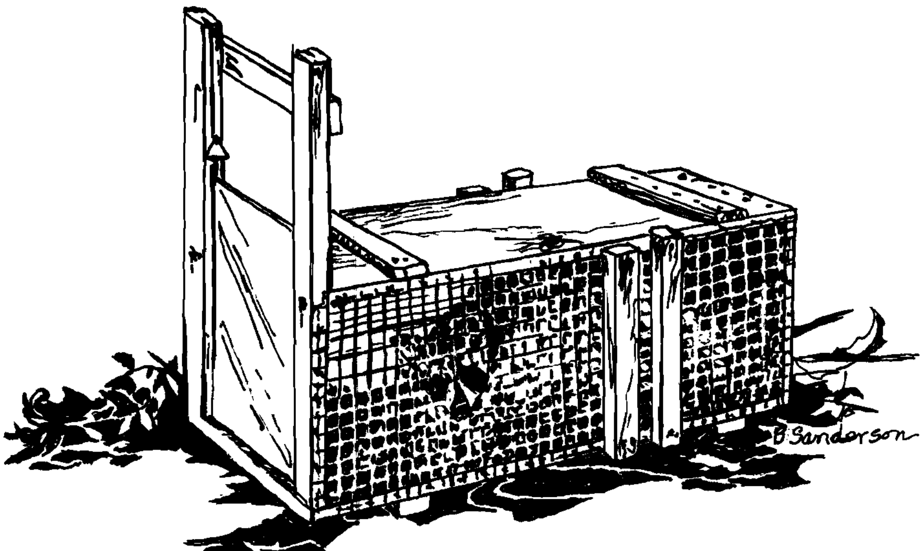

2

Review of Population Indices Applied in Furbearer Management[1]

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Ronald D. Andrews, Iowa Conservation Commission, Clear Lake.

Abstract: Population indices of furbearing mammals are used by resource managers to monitor population trends, set harvest regulations, and to inform the public about the value of furbearers. Techniques currently used by agencies in the North Central Region vary depending on the species being sampled and the intended use of the data. Statistical design is often absent because of lack of expertise or excessive expense in implementing adequate procedures. A well-designed procedure should be adequately tested before implementation and have constant annual bias and reasonable precision. Computerized data storage should encourage that statistical analyses can be completed before decisions must be made. Well-designed indices could allow managers to anticipate changes in furbearer populations rather than react to such changes.

Key words: density, index, population estimation.

Historically, few sportsmen and resource managers in the North Central Region have held as strong an interest in furbearers as in other wildlife. Resource managers now recognize the importance of furbearers in ecosystems and are concerned not only with regulating exploitation, but also with protecting threatened species. The challenge for the manager is to balance changing habitat conditions, exploitation, and furbearer population levels.

Furbearer management has become increasingly difficult because of unusual ecological, economic, social, and political problems. Effective management for consumptive and nonconsumptive use and limited funds for conservation programs require that management decisions be based on sound biological data. Accurate prediction of furbearer population levels or trends is fundamental to formulating management goals, making decisions regarding harvest, and

[1]Journal Paper J-10475 of the Iowa Agriculture and Home Economics Experiment Station, Ames. Project 2401.

to public relations. Yet adequate population census techniques are either in their infancy with no long-term data to evaluate them, or they are subjective measures that cannot be quantified.

Managers used estimates of absolute numbers and relative changes in populations to set seasons, bag limits, and total harvest quotas. The data are widely used for public relations, particularly to provide statistics on the potential economic and recreational value of the furbearer resource. Resource managers often must use their data to refute public concern about overharvest of valuable species or poor control of pest species. Occasionally the same data are used by special-interest groups to argue that a species is being overharvested or to enhance campaigns against trapping. The basic data are available for exchange with other states, with the federal government, and with researchers at universities.

Some researchers use population level and trend data as input and validation for population models (Molini et al. 1981, Smith et al. 1981, Johnson 1982). Modeling approaches may be the only reasonable way to project trends in low-density species such as bobcat (*Lynx rufus*) and river otter (*Lutra canadensis*).

In this paper, we review general characteristics of adequate sampling procedure, review population indices currently used by midwestern states and provinces, discuss problems associated with present methods, and make recommendations on useful techniques for censusing furbearers.

We recognize the following wildlife biologists who provided information on furbearer population monitoring in their respective states: Stephen H. Allen, North Dakota Game and Fish Department; Karl E. Bednarik, Ohio Department of Natural Resources; William Berg, Minnesota Department of Natural Resources; David W. Erickson, Missouri Department of Conservation; Larry F. Frederickson, South Dakota Game, Fish and Parks Department, George Hubert, Jr., Illinois Department of Conservation; Neil F. Johnson, Kansas Fish and Game Department; Larry E. Lehman, Indiana Department of Natural Resources; G. W. Pepper, Saskatchewan Department of Renewable Resources; Charles M. Pils, Wisconsin Department of Natural Resources; George Schildman, Nebraska Game and Parks Department; Howard Smith, Ontario Ministry of Natural Resources; Richard R. P. Stardom, Manitoba Department of Natural Resources; and Joseph E. Vogt, Michigan Department of Natural Resources. This work was supported in part by U.S. Fish and Wildlife Service Cooperative Agreement No. 14-16-0009-81-53 with Iowa State University, and Pittman-Robertson Project No. W-115-R of the Iowa Conservation Commission.

POPULATION SAMPLING

Before any monitoring plan is implemented, it is vital to clearly define the objectives. Any reasonable plan for monitoring populations must be capable of detecting both site-specific and systemwide density changes depending on objectives. Methods selected to detect such changes must be both statistically repeatable and cost efficient for the responsible agencies to make effective use of them (Eberhardt 1978). Unfortunately the state of the art makes the above goal a difficult one to attain for most mammalian wildlife.

Rarely can we measure population abundance by a complete count (that is, by a true census); rather we must estimate abundance from a series of samples of some fraction of the total population. In this paper, we will use the term "population census," or simply "census," to refer to any attempt to estimate population density, such as in a mark-recapture experiment. "Index" will be used to refer to any measurable correlate of density, such as the number of visits/scent station/night. In either case, the samples have associated error, which must be reported so that estimates can be compared statistically. The ideal estimate is precise and has small bias (Overton 1971:405), yet most available procedures for estimating wildlife populations give variable results and are biased to some unknown degree. However, if the bias can be shown to be constant between sampling periods, relative comparisons can be made as long as estimates are sufficiently precise. Estimates will generally be more precise if techniques are applied by trained personnel, using the same procedures each time, and if the circumstances (season, weather, time of day) of measurements are carefully controlled. Density indices (such as catch/effort or feces/m^2) can be used to detect relative changes in population size and are generally less costly than population censuses for sufficiently precise data. Ideally, a density index is linearly related to absolute density, but nonlinear indices are sometimes sufficient if something is known of the underlying relationship (Caughley 1977*a*). Unfortunately, almost no field data exist that compare population indices or censuses with known population densities of furbearers.

Estimates of absolute density such as population counts, counts on sample transects, aerial surveys, and mark-recapture studies should not be considered indices because they may be biased and imprecise. The goal should be to estimate the magnitude of bias and improve precision rather than ignore the problems by calling the estimate an index. If the sampling procedures can be sufficiently refined and are not too costly, estimates of absolute density are superior to indices because they are applicable to a greater variety of management problems.

A fundamental question to be asked before designing a sampling procedure is, "How large a change in species abundance do we wish to be able to detect?" The answer determines how sensitive our statistical comparisons must be and, thus, what kind of sampling scheme is necessary to meet the objective (Eberhardt 1978). Only 1 indicator of population level may be needed every few years to detect dynamics in slow-changing species. However, highly reliable data on abundance, plus other vital statistics such as survival, condition, or recruitment, must be obtained for rapidly fluctuating populations such as some furbearers. Resource managers may be forced by limited funds to expend data-collection efforts only on species of significant economic, scientific, or recreational value (Downing 1980).

A computerized data bank should be established to encourage consistent data collection and analysis techniques. Such data systems exist for habitat inventories at the regional and national levels but rarely include meaningful data on animal populations. Standardized data forms allow data to be entered directly into a computerized data bank after each sample period. Recently, computer programs have been developed to analyze capture data from closed populations (Otis et al. 1978) and open populations (Arnason and Baniuk 1980), the latter being especially useful because data easily can be manipulated and summarized.

Current Sampling Techniques

Sampling techniques used to assess population trends of furbearers generally can be divided into the following categories:

1. Harvest surveys, derived from samples of furdealers and trappers, which are designed to assess trends in harvest and possibly trends in population levels,

2. Population indices, derived from samples of signs such as dens or tracks, which are designed to monitor relative population trends but not actual density,

3. Population indices, derived from reports by rural residents or field personnel, which are designed to monitor relative population trends but not actual density, and

4. Population censuses, derived from a direct sample of the furbearer population or from an indirect sample of signs, which are designed to estimate population density.

We questioned furbearer specialists in all 15 states and provinces within the North Central Section of the Wildlife Society about the methods used in their jurisdictions (Table 2–1). All states and provinces use harvest surveys of various kinds to monitor harvest trends as a basis for management decisions. Population indices of Category 2 are widely used, especially aerial samples, scent post samples, and road mortality samples. Many agencies reported using more subjective indices of Category 3 to monitor general trends in abundance, although only a few have formalized reporting systems. Actual population censuses of Category 4 are generally used only for intensive population research.

Techniques based on harvest data are not the primary focus of this paper; the reader is referred to Erickson (1982) for further discussion of the problems associated with such methods. Emphasis will be placed on comparing techniques in categories 2, 3, and 4.

Aerial Surveys.—Aerial surveys are widely used for censusing beaver (*Castor canadensis*) colonies. Dickinson (1971) described a technique using infrared

Table 2-1. Furbearer population indices currently used by agencies in the North Central Region.

Index technique	Species indexed	n
Fur dealer reports	all	15
Trapper questionnaire	all	6
Mandatory registration	beaver, river otter, bobcat	3
Bounties and collections	coyote	5
Aerial samples of houses or dens	beaver, muskrat, red fox	10
Direct aerial samples	timber wolf (*Canis lupus*)	2
Ground samples of houses or dens	beaver, muskrat	2
Road mortality samples	opossum, raccoon, spotted skunk, striped skunk	4
Scent post samples	coyote, red fox, gray fox, raccoon, badger, striped skunk, timber wolf	5
Spotlight samples	opossum, striped skunk, raccoon	2
Track counts	coyote, red fox, gray fox, marten, fisher, river otter	2
Depredation index	beaver, coyote, timber wolf	2
Rural resident observations	coyote, red fox, gray fox	2
Rural mail-carrier observations	coyote, red fox, striped skunk	1
Field personnel impressions	all	1

aerial photographs for estimating population trends and current occupation of beaver range, but most counts of colonies are made directly from the aircraft (Payne 1981), often using transect procedures (Caughley 1977b). Errors due to unknown proportion of bank colonies, mistakes in classifying active colonies from the air, and changes in beaver family patterns make aerial counts insensitive except to large (50–100%) changes in population size. Aerial colony counts are biased low, often missing 30% of colonies compared with ground counts (Payne 1981). Food caches are considered by some to be better indicators of active colonies than houses, because caches usually are limited to 1/colony (Davis and Winstead 1980).

It is possible to convert aerial colony indices to population size estimates if an independent estimate of beavers/colony and its variance are available. The number of beavers/colony is variable, ranging from 3.6/colony (Hay 1958) and 4–6/colony (Svendsen 1980) to 7.6/colony (Novak 1977). Colony indices should be adjusted by reliable estimates of colony size made by management personnel every 2 years.

Counts of muskrat (*Ondatra zibethicus*) houses (Dozier 1948) are used with moderate success as an indicator of population trends and as a basis for estimating population density of marsh-dwelling muskrats, although even early managers recognized their limitations. In addition, the proportion of "live" and "dead" houses must be estimated, and dwellings must be distinguished from feeding and resting platforms.

Perhaps the most cost-efficient means of monitoring muskrat populations is aerial counts of houses. Ideal conditions would be a calm, sunny day, after initial freeze following a light (1–2 cm) snowfall. Snow will melt more quickly on the tops of "live" houses sheltering warm animals than on "dead" houses, thus minimizing that source of bias. Low-level observation (75 m) is necessary to easily distinguish houses. Photographs of areas taken from this altitude can be examined later in the laboratory, insuring accurate counting (Smith and Jordan 1976).

Aerial surveys are used with good reliability for red foxes (*Vulpes vulpes*) and might be applicable in most prairie states and provinces. Direct counts of animals are unreliable, but sighting of dens works well in open terrain (Sargeant et al. 1975, Allen 1979).

On-the-Ground Samples.—Counts of houses or dens from the ground have been widely used for only 3 species—muskrats, beaver, and red foxes—although some other species occasionally are tallied such as coyotes (*Canis latrans*), badgers (*Taxidea taxus*), and striped skunks (*Mephitis mephitis*). Extensive sampling from the ground for fox dens is an old technique (Scott 1941) that has largely been replaced by aerial sampling methods. Ground counts of lodges also have been used to survey populations of beavers (Arner et al. 1969).

For intensive study and management, ground counts of muskrat houses are considered more accurate than aerial samples because of differential visibility of some houses from the air. Determining which muskrat houses have active sign around them also is easier from the ground. Total counts of houses on an area often are applied to the management of specific marshes (Bishop et al. 1979), although subsampling is used when counts are to be applied to large areas (Poll 1980). Smith and Jordan (1976) used a 10% sample of the total area to validate aerial samples of muskrat houses.

In large marshes, muskrat houses could be counted using line-transect techniques (Burnham et al. 1980) on the ice that would allow precise estimation of house density with minimum of sampling. As with aerial surveys of beaver colonies, population indices are sometimes converted to estimates of population size with appropriate data on muskrats/house. Dozier (1948) used an estimate of 5 muskrats/house to convert house counts to absolute numbers, but this value is highly variable, depending on litter size and survival.

Road Mortality Indices.—A number of agencies use roadkills as an indicator of population trends. Others plan to test some scheme for tallying roadkills as an index to raccoon (*Procyon lotor*) populations. Road kills also are related to vehicle traffic volume, vehicle speed, weather, season, movement patterns, and other factors that must be measured to produce a population index. Unsolicited reports by field personnel or highway patrolmen usually are insufficient, so sampling of fixed routes is recommended. Rates of occurrence for species such as raccoons may vary only from 4 to 12 per 10,000 km and are likely to be nonlinearly related to actual density. Road mortality indices could be useful for detecting large, long-term changes but as presently applied are not sensitive enough to be of use in annual management decisions.

Scent Station Samples.—Interest in scent station sampling has grown rapidly since 1972 when the U.S. Fish and Wildlife Service introduced the method (Linhart and Knowlton 1975). The Service has recently decided to extend the survey into the East, and many states that now use the technique record data from badgers, skunks, foxes, and coyotes.

Scent station samples are conducted in a variety of ways, with a variety of scents and scent containers (Frederickson 1979, Roughton 1979). Although the original technique called for 2 lines with 50 stations placed 0.48 km apart sampled for 4 nights, Roughton (1979) recommended using 10 stations at similar spacings but sampled only 1 night to avoid repeated visitation biases. Lines must be placed along roads, but statistical considerations suggest random selection of roads to be most representative. However, Hatcher and Shaw (1981) concluded that, in areas with low densities of coyotes and foxes, nonrandom selection of roads yielded higher visitation rates and a more sensitive index.

Scent station procedures have an advantage over other techniques because statistical testing procedures have been developed (Roughton 1979). However, tests usually can be performed only for samples over large areas rather than for small management units. Other problems associated with scent stations are adverse weather and road conditions, personnel fatigue, and confusion of visitation signs among species. Scent station data are an example of a frequency-density relationship that is likely to be highly nonlinear and therefore care must be taken in their interpretation.

Spotlight Indices.—Rybarczyk et al. (1981) used night-lighting samples along roads to monitor raccoon populations in southern Iowa farmlands. Raccoons were easily visible up to 180 m from a vehicle equipped with spotlights. Most raccoons were observed on humid, but not rainy, nights from 1 to 5 hours after sunset. Fountain (1976) used similar methods to sample raccoons in marshes from airboats.

The mean number of raccoons seen in spotlight routes in Iowa during 1978 and 1979 was 0.27/km (Andrews 1979). Frederickson (1979) examined the statistical precision of spotlight surveys in South Dakota for small carnivores, including raccoons, red foxes, badgers, striped skunks, and spotted skunks (*Spilogale* *putorius*). Raccoon sighting rate was much lower there than in Iowa, 0.05/km, and all species combined were seen only at a rate of 0.09/km. Only by pooling harvest study areas was Frederickson (1979) able to achieve confidence levels of 90%, and coefficients of variation were 20–30%.

The major appeal of the spotlight method is that it readily targets the desired species. Users of the technique have, however, found estimates produced by this technique to be variable with regard to observers, vehicle speed, habitat types, and weather conditions (Rybarczyk et al. 1981).

Rural Resident Observations.—There are many variations of this technique, which is based on the fact that citizens in rural areas see many furbearer species during their daily activities. Presence or absence is commonly used as an index to density, although observations tend to be biased downward because animals may be either absent or not sighted (Caughley 1977a). Similar sampling methods must be used for determining presence or absence each time if comparisons are to be made. Such indices are particularly valuable for rare or secretive species such as river otter and bobcat where their appearance or disappearance could be of special significance. These indices are obviously subjective, vary between observers, and are usually nonlinear with respect to absolute density. Application of density class indices is distinctly limited because they are not easily compared statistically.

The oldest technique involves sending questionnaires (Lemke and Thompson 1960, Pils and Martin 1978), which ask rural residents to document their sightings during the year of red foxes, gray foxes, and other carnivores. North Dakota has enlisted the cooperation of rural mail carriers who record their observations of red foxes at selected times of the year (Allen 1979). Almost all states have at one time or another used field biologists, conservation officers, and technicians who work in rural areas to record their subjective impressions.

Observations by rural residents can detect low densities of carnivores; however, the index is nonlinear at higher population densities because changes cannot be detected once all respondents have reported sightings of a species (Hatcher and Shaw 1981). Surveys by rural mail carriers and field personnel avoid this problem somewhat because these observers can give graded responses, even at greater densities.

Mark-recapture Techniques.—Perhaps the most widely used techniques in population estimation in wildlife research are mark-recapture methods. Such techniques have been applied to intensively studied furbearer populations (Sanderson 1951, Sather 1958, Davison 1980).

Application of mark-recapture studies to furbearers is limited by the low expected capture and recapture probabilities (Otis et al. 1978), which are a function of low population density, nonuniform distribution of animals, nonrandom mixing of marked animals in populations, and trap avoidance. If sampling is conducted for short enough periods, populations may be considered "closed" to births or deaths (Otis et al. 1978), but movements of most furbearers make analysis by "open" population models (Seber 1973, Arnason and Baniuk 1980) more realistic. Open models require large numbers of recaptures for reasonable precision, an unlikely event with furbearers. Variations in trap response biases are introduced by such factors as bait type and length of the prebaiting period, type of trap, location of traps, and length of the trapping period.

In general, it may be possible to increase capture probabilities by intensive capture efforts with many traps placed over a large area, thus increasing the likelihood of getting an adequate sample. Recapture bias may be avoided by injecting captured animals with a radioactive isotope as a marker and sampling ratios of unmarked to marked scats as recaptures (Kruuk et al. 1980). This technique has been applied to wide-ranging carnivores, but its precision may not be sufficient to justify its expense (Davison 1980). Intensive removal experiments, which can be accomplished by marking animals as well as physically removing them (Otis et al. 1978), may be most successful with large furbearers. Nonrandom removal can be allowed in order to maximize capture probability as long as effort is constant.

A great danger with mark-recapture experiments is the possibility of obtaining biased and misleadingly precise estimates of population size. Only studies verifying estimators against known populations will allow determination of the magnitude of the bias. Unfortunately, this is difficult to attempt, and therefore few studies of the validity of population census techniques exist. Population levels cannot be converted to density by dividing by the study area unless the area of trap influence is simultaneously estimated (Otis et al. 1978). Because of their intensity and the expense involved, mark-recapture studies therefore will be applicable to limited areas and to specific research problems regarding furbearers.

DISCUSSION

When all these methods are compared with the characteristics outlined earlier regarding statistically repeatable procedures, few seem to meet the criteria. Nearly all indices discussed are probably nonlinearly related to density. Intensive marking studies avoid this problem because they attempt to directly estimate density but bias may be severe. Unfortunately no testing, even simulation, has been done comparing the sampling procedure with known populations levels. Tests comparing one method against another are of little use if the actual density is not known. If an index varies from 1 year to the next, there is no assurance that it is reflecting real changes in the population. Simulation may prove the only way to reasonably test an estimator (Otis et al. 1978) because field tests may be prohibitively expensive.

Intensive marking studies, aerial sampling of dens and houses, intensive ground samples, and scent station indices are presently the only techniques with moderate to high precision. Emphasis should be placed on further research on these techniques to determine their relationship to actual population density over a wide range of densities for particular target species. Although the other methods discussed may be useful under limited circumstances, they presently are not generally applicable as indicators of furbearer populations because of poor precision and undocumented bias.

The methods in use today are used largely because they yield information at low cost. This reason for use is particularly true of harvest statistics that are readily available but are affected by many variables besides population size (Erickson 1982). Unfortunately, other methods such as road mortality and spotlight indices, which are probably biased and are imprecise, continue to be used in place of more suitable approaches because they are inexpensive.

Many of the techniques presently available as population indices for furbearers are not capable of detecting changes of less than 50% of the mean with any degree of confidence. This lack of precision implies that resource managers will have to spend much more time and money than in the past if they wish to detect changes of less than this range (Davis and Winstead 1980). Well-designed population indices and estimation procedures could allow managers to anticipate changes in furbearer populations rather than react to such changes.

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3

Population Modeling for Furbearer Management

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Abstract: The management of furbearers has become increasingly complex as greater demands are placed on their populations. Correspondingly, needs for information to use in management have increased. Inadequate information leads the manager to err on the conservative side; unless the size of the "harvestable surplus" is known, the population cannot be fully exploited. Conversely, information beyond what is needed becomes an unaffordable luxury. Population modeling has proven useful for organizing information on numerous game animals. Modeling serves to determine if information of the right kind and proper amount is being gathered; systematizes data collection, data interpretation, and decision making; and permits more effective management and better utilization of game populations. This report briefly reviews the principles of population modeling, describes what has been learned from previous modeling efforts on furbearers, and outlines the potential role of population modeling in furbearer management.

Key words: furbearer management, population model, population dynamics.

Wildlife management has historically involved decisions made in an *ad hoc* manner on the basis of biological and political information. The biological contribution includes data such as population indices, age ratios, and harvest numbers. The political elements are influences that represent biological data, as viewed and interpreted by the public, together with popular sentiment about wildlife. Professional wildlife management strives to rely on objective biological information, rather than subjective political pressures, a goal that necessitates the collection and interpretation of biological data. In this paper I discuss how objective informational needs, in the context of furbearer management, can be met by population modeling.

Wildlife management usually involves the regulation of the number of animals in a particular area at some specified time. For a population that has 1 breeding cycle annually, the dynamics can be described by the flowchart in Figure 3–1, where dispersal into or out of the area is ignored for the moment.

The population is augmented by recruitment in the breeding season and is diminished by hunting and trapping in the fall and by other mortality forces, segregated into seasonal components. For the sake of simplicity, spring mortality is subsumed under summer mortality, and fall "natural" mortality is grouped with winter mortality. Depending on when the population under study is subjected to mortality, these assumptions may or may not be adequate.

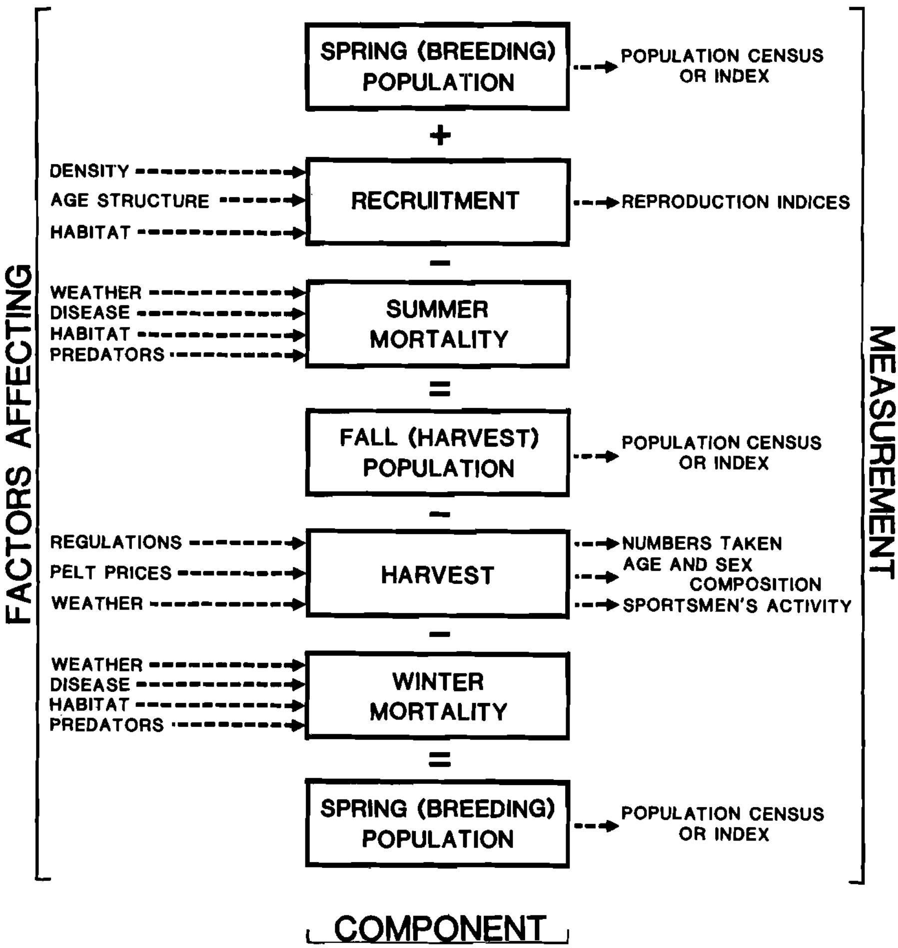

Fig. 3-1. Outline of population dynamics of a species with single breeding season (in spring) and negligible dispersal. Some typical factors influencing various components are shown on the left, and possible monitoring measurements are listed on the right.

The processes of reproduction, harvest, and natural mortality are influenced by a number of factors. Although the importance of each factor may vary among species, or even among populations within a species, certain common ones can be identified. Reproduction is often affected by the density of the population, its age structure, and habitat conditions, including abundance of foods. Harvest has been shown to depend on regulations, pelt prices, numbers of sportsmen and their interest in the animal, and weather conditions during the harvest season. Natural mortality has been related to weather conditions, population density, disease, and the habitat—including available foods and numbers of predators. The study of each process is a formidable task, even for a single species. Our need here is not for an exhaustive review of all facets of the population dynamics process, but for a simple outline of the mechanics.

Although not all aspects of population dynamics can be measured, except perhaps in some laboratory situations, various measurements provide information on the status of the population. For example, indices to or estimates of population size might be available either for the spring (breeding) population or for the population at the onset of the hunting or trapping season. The harvest can be estimated, and the age and sex composition of harvested animals used to assess recruitment (but see Caughley 1977:121, who warned that additional knowledge is required). Harvest information can also yield insight into the population size, particularly if the effort of hunters and trappers can be ascertained. If aging techniques are accurate for all ages, life table techniques may in some circumstances be employed to monitor the population, particularly if reproduction data are available (Caughley 1977, Dixon 1981).

Certain variables are often considered as monitors of populations, without the need for extensive analysis. Dixon (1981) suggested 5 indicators of population status for furbearers: (1) percentage of females that are pregnant, (2) trends in population indices, (3) changes in species composition of the harvest, (4) changes in the shape of the survival curve, and (5) measures of the population's growth rate. These data can usually be derived from harvested animals. Downing (1980:264–267) suggested 18 kinds of information that can potentially be monitored to assess the status of a population. In addition to those offered by Dixon (1981), Downing included possibilities such as physical condition and parasite loads. Although each measure has some deficiency, in combination they can be used as checks against one another.

The processes described above, with associated variables, constitute the population dynamics system. What is needed for management, in addition to a basic understanding of the system, is an objective—a statement of the goals of management. Caughley (1977:168) listed only 3 objectives of population management: increasing a population, exploiting it to take a sustained yield, and stablizing or reducing a population. Although other objectives could perhaps be identified, most of those commonly established involve these 3, singly or in combination. For example, an objective might be to maximize harvest over a period of years. Another may be to maintain the spring population at some desired level. For a pest species, the objective could be to minimize the population at the time of year when it is a problem. The objective can be multiple, perhaps to maintain high harvest while not letting the spring population become too large. Determining the objectives of wildlife management is often more difficult and divisive than anticipated, particularly when interests conflict, but it is a necessary step, whether or not the management approach is quantitative.

Population modeling is a powerful tool for many wildlife management applications. Its purposes are varied. Models are often used as research tools to answer specific questions (for example, Zarnoch et al. 1977, Johnson and Sargeant 1977) or to determine the most productive avenues of further study (for example, Preston 1973, Cowardin and Johnson 1979, Nichols et al. 1980). Three objectives of more direct application to management problems can be identified: (1) to determine if information of the right kind and proper amount is being gathered; (2) to systematize data collection, data interpretation, and decision making; and (3) to permit more effective management and intensive exploitation of game populations. As will become apparent in the next section, where some published models of furbearers are reviewed, the third objective has received the most attention to date.

This report reflects current work being conducted on population models by furbearer biologists and their colleagues. It could not have been written without the generous sharing of ideas by many workers, including Stephen H. Allen, William E. Berg, Douglas M. Crowe, Kenneth R. Dixon, Fred F. Knowlton, Richard M. Mitchell, and Roger A. Powell, all of whom offered suggestions for the report. Glen C. Sanderson and 2 anonymous referees also provided helpful comments.

SOME MODELS DEVELOPED FOR FURBEARERS

In this section I review some recent modeling efforts on furbearers. The review is not comprehensive, but illustrates the variety of approaches, the success of the efforts, and the management potential of the models. Most models discussed below involved only a furbearer; 3 models were of predator-prey systems, with a furbearer in the predator's role. I do not discuss large-scale models, such as of ecosystems, although interactions among numerous species may need to be considered in management plans.

Preston (1973) developed a stochastic model of a rabies-controlled population of red fox (*Vulpes vulpes*). His objective was to examine the epizootiology of rabies in that furbearer. He included information on home range characteristics and movements, juvenile dispersal, density-dependent reproduction, and rabies transmission and incubation. The data were fundamental in nature and emphasized biological processes rather than demographic numbers. The resultant model was successful in establishing research priorities, demonstrating that a simple density-dependent transmission mechanism can result in varied aspects of observed rabies epizootiology, and evaluating alternative strategies of rabies control.

A second model of the red fox was constructed by Zarnoch et al. (1977). Their objectives were to evaluate selected harvest strategies and to determine the time needed for a depleted population to recover. Their data were demographic and behavioral and related to reproduction, mortality, dispersal, population structure, and harvest. Experimentation with the model indicated the importance of movements in population regulation, the significant reductions caused by sustained heavy harvest, and the need for predator control to be continuously applied in order to be effective. An annual harvest of 55% was found to yield a stable fox population in their model. This model was modified by Pils et al. (1981) for red fox in Wisconsin.

A predator-prey model involving the red fox was presented by Johnson and Sargeant (1977), who used it to determine how predation by the red fox affected mallards (*Anas platyrhynchos*). Inputs to their model were fox and mallard population sizes, mallard survival rates, and rates of fox predation on mallards. Their model was stochastic and they assessed it by sensitivity analysis, comparison of model outputs to real data, and tests of the model's stability. They found that fox predation was sufficiently intensive to inflict heavy losses on breeding mallard populations, and it was sufficiently hen-selective to outweigh drake-selective sport hunting and cause an imbalance in the population of about 6 males per 5 females.

An early model of coyote (*Canis latrans*) population dynamics was produced by Knowlton (1972), who sought implications for management of that species. His model was demographic and involved information on density, various components of reproduction, age and sex structure of the population, and movements—both within home ranges and among dispersing animals. His results emphasized the need for specific objectives in an animal control program and showed that removal is most effective after dispersal wanes and before whelping begins. More recently, Knowlton (personal communication) has suggested that demographic models are inadequate and should ultimately be supplanted by models incorporating behavioral components such as territoriality, group-size dynamics, and mortality related to food supplies and social pressures.

Four simulation models of coyote populations, developed by various authors, were reviewed by Connolly (1978). The models were substantially similar, relied on much the same sources of data, and were intended to explore the effect of coyote control on population dynamics. The models differed in assumptions used to bridge gaps of missing information and in the control strategies evaluated. The major conclusion reached from all models was that coyote populations can withstand high levels of control, certainly an affirmation of field experience. Some of the models found that birth suppression might be effective for reducing coyote predation during spring and summer, but not in winter, and that coyote populations can recover rapidly when control ceases. Connolly recognized the dearth of information relating births and natural mortality to coyote density.

Crete et al. (1981) developed a model to explain how fluctuations in a moose (*Alces alces*) population in Quebec were influenced by hunting and by wolf (*Canis lupus*) predation. Their model was deterministic (variables were held constant) and included information on reproduction of both predator and prey, rates of predation, wolf mortality (ascribed to only starvation), moose mortality from hunting, and access of wolves to an alternative food supply—garbage dumps. Results from their model for an unharvested population did not mimic real-world trends, but their conclusion that access to alternative foods increased the stability of the predator-prey system led to a practical hypothesis testable by fencing garbage dumps.

Crowe (1975) advanced a model of bobcat (*Lynx rufus*) populations in Wyoming to determine the effects of exploitation. His data involved the composition of collected animals by age, sex, and date; reproductive rates; and annual records of bobcats trapped by the U.S. Fish and Wildlife Service. Despite limitations due to inadequate information on density dependence and to the assumption of no immigration or emigration, the model was useful in suggesting that indirect population determinations are an alternative to costly census estimates, that environmental conditions influence juvenile mortality rates, and that trapping is largely responsible for adult deaths. Crowe (personal communication) indicated that modeling work on the bobcat is continuing and is used operationally.

Though clearly not a furbearer of the Midwest, the African lion (*Leo leo*) was the subject of a model that had some interesting aspects (Starfield et al. 1981). The model incorporated information about reproduction, mortality, and social and territorial behavior. Conclusions showed the importance of knowing the social status of animals taken in a culling operation. Taking pride males causes far greater population declines than taking nonbreeding subadults. Starfield et al. (1981:26) also found that "local culling is . . . analogous to scooping water out of a pool; the surrounding water flows in to fill the void, but the total level of the pool is inevitably reduced."

Another predator-prey study (Powell 1979) involved the fisher (*Martes pennanti*) and porcupine (*Erethizon dorsatum*). The objective was to determine the effects of fisher trapping. Data included population densities of fishers, porcupines, and alternative prey (hares and deer carcasses); rates of predation; mortality rates of fishers; and feeding efficiencies. A variety of published theoretical predator-prey community models were applied to the situation; the similarity of ensuing results suggested that conclusions were in a sense robust. Powell

(1979) found that the predator-prey communities were stable in the model, but that only a small increment to fisher mortality rates may cause local extirpation of the species. Although the degree of compensation between trapping and natural mortality was unknown, he concluded that only widespread and well-established fisher populations should be trapped.

Molini et al. (1981) published a model for the growth phase of an unexploited population of beavers (*Castor canadensis*). Their model was stochastic (variables had a random component) and incorporated dispersal and pair formation, both dependent on population density, as well as survival and reproduction, both independent of density. Their model produced a stabilization level of the population, which presumably represented the habitat's carrying capacity, even though the level was not explicitly included in the model.

A model for muskrats (*Ondatra zibethicus*) was developed by Smith et al. (1981), who sought to determine optimal sustained yield, to explore the effect of trapping on population resiliency, and to evaluate the importance of precocial breeding on population regulation. Their data involved survival rates and density- and age-dependent reproduction. They found no evidence of precocial breeding. Analysis of the model suggested that a harvest rate of about 74% was optimal, but that a rate in excess of 80% could be detrimental to the population. Their model unrealistically predicted a far more rapid recovery from depleted levels than those observed in nature. They appropriately take this deficiency as a warning of the dangers of extrapolating beyond the reach of available information.

THE CURRENT SITUATION

Dixon and Swift (1981) elaborated upon Karplus' (1975) idea that the evolution of modeling in a scientific discipline progresses through 3 stages:

1. The scientific discipline develops a quantitative orientation.
2. Creative practitioners within the field begin to develop mathematical models.
3. Modeling and simulation of systems belonging to the discipline become a formalized activity.

The progression has perhaps been slowed within the wildlife profession by "math fright," the reluctance of wildlife biologists to adopt quantitative methods. This resistance has been largely overcome, and many wildlife ecologists now possess strong training in mathematics and statistics. As Berryman (1981:26) noted, many biologists, although able to see the picture, were unable to paint it because they were unfamiliar with the tools—mathematics. He added that those who were able to paint the pictures, the mathematicians, did so, but their products were often incomplete or inaccurate.

Furbearer biologists are further along the quantitative progression than I realized when I began my review. The popularity of modeling for big game species was well known (Pojar and Strickland 1979) and reflected the developmental efforts of Gross and coworkers (Gross et al. 1973). Game birds were the subject of several population models as well, but most of these were directed toward specific research or management questions, rather than intended to serve as tools in operational decision-making.

One good example of modeling for furbearer management is the work of Stephen Allen (personal communication) on red foxes in North Dakota. The objective is to maintain the fox population at a "moderate" level, thereby affording adequate opportunities to hunters and trappers but preventing untoward effects of high populations of that predator. Regulations are established in part as a result of a modeling exercise. Data used in the model are spring fox population indices and anticipated values of reproduction and harvest mortality. All measurements are indirect and relatively inexpensive. Population size is indexed by counts of foxes seen by rural mail carriers along their routes (Allen and Sargeant 1975). Anticipated reproductive success is estimated from age ratios among foxes harvested late in the previous winter (a measure of age ratios in the breeding season) together with known parameters of age-related reproduction. Harvest effort is predicted by following early pelt price bulletins, which indicate trends in fur values and associated interest by hunters and trappers. After the harvest season, the predicted harvest is compared with estimates from fur-buyer records and from a harvest questionnaire senttto licensed hunters and trappers, and the results used to evaluate the model. Despite the informal nature of the model and the use of indirect measurements, results have proven the effort to be worthwhile and inexpensive.

Natural resource agencies in several other states have applied models in order to justify export of certain pelts. According to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the scientific authority of a nation must determine that exports of listed species will not be detrimental to the welfare of those species. The U.S. Fish and Wildlife Service has requested that states in which bobcat, lynx (*Lynx canadensis*), or river otter (*Lutra canadensis*) are harvested provide biological evidence that the take will not adversely affect the species. One requirement is a description of any population model used to evaluate the status of the species. Several states indicated that such models were in active use. The Wyoming Game and Fish Department applied the ONEPOP population model of Gross et al. (1973) to reproductive and mortality data on bobcats, and used the results to establish management objectives on an annual basis. Inputs to the model were developed from bobcat harvest statistics and included effort expended by sportsmen, age distribution in harvested samples, counts of corpora lutea and placental scars, and estimated population sizes by biogeographic region. The Washington Department of Game also employed population modeling for bobcats and has initiated a similar effort on lynx. Two population estimates for bobcat, one based on densities by habitat and the other developed from a population model, were found to be in substantial agreement (J. David Brittell, personal communication). The Montana Department of Fish and Game has used POSIM, a computerized population model based on life tables, to simulate population changes of bobcats under variable conditions. That exercise suggested that harvest was less significant than natural mortality, and that kitten mortality was the factor most significant in regulating the population. The Minnesota Department of Natural Resources has developed and used a basic model of animal population dynamics. It was initially applied to the fisher, which it suggested was being overexploited; the season was closed for a year as a result of this finding. The model was more recently adapted for bobcat and river otter. The North Carolina Wildlife Resources Commission is employing the method of Tabor and Wight (1977) for river otter information. The importance of modeling and recognition of its value are underscored by its role in meeting the requirements of international conventions.

THE FUTURE

Any modeling effort requires a sacrifice of 1 of the following attributes (Levins 1966): generality, realism, or precision. Generality refers to the breadth of applicability of the model, realism is the extent to which the model corresponds to the biological "real world," and precision is the ability of the model to produce quantitative, as opposed to qualitative, predictions (Walters 1971). The diversity of models in the biological literature reflects the different strategies adopted by the model-builders. Most models developed for wildlife management application have implicitly or otherwise foregone generality; realism is critical for credibility, and precision is necessary for predictive and decision-making purposes. The modeler can readily admit that his model, developed for red fox in North Dakota, does not apply to fire ants in Florida (a sacrifice of generality). He would be hard-pressed, however, to justify a population estimate of 200 foxes per hectare (inadequate realism), or an anticipated harvest of between 0 and 40,000 animals (insufficient precision).

Models can also be classified as demographic or functional. The former represents a "black box" approach; we do not profess to understand the exact operation of the system, but we know enough about the outcomes to predict its behavior. For example, the exact determinants of reproductive success may not be fully known, but average production values could nonetheless yield a useful model. In the functional approach to model building, the fundamental components of the system are identified and individually analyzed. The predator-prey models of Holling (1966) are excellent examples of this type and Medin and Anderson (1979) developed a functional model for a big game population.

Management models are characteristically of the demographic form; functional models are typically used for one-of-a-kind or research applications.

Demographic models have proven successful, not only for furbearers, but more conspicuously for big game. I anticipate continued success as further models are developed, applied, and refined. Nonetheless, I am inclined to agree with F. F. Knowlton's (personal communication) suggestion that behavioral models, incorporating the most salient aspects of a species' breeding biology, will eventually prove more powerful and useful.

Such functional models must not become too complicated—not all details should be included. But they must be based on the important components, which will vary according to species and possibly geographical area. Availability of winter food supplies may be an important component for one species and of minor consequence to another; the population models should reflect that difference.

Demographic information should not be ignored but used as validation criteria for functional models. For example, a functional model can be developed from previous studies or general observations, and used to predict survival and reproductive rates under a particular set of circumstances. These values can then be compared with available demographic information, and used to identify deficiencies in the model or to determine if the data are in error. Research initiated to overcome inadequacies in the model is likely to be rewarding.

One aspect in which a population model may readily be inadequate involves density-dependence or compensation (Storm and Tzilkowski 1982). Data on this feature are difficult to obtain for many species, yet the importance to the dynamics of a population, particularly one that is exploited, cannot be overstated. Modeling does offer some help in this regard; various levels of density-dependence or compensation can be modeled, and results of each evaluated. For example, Johnson (1979) modeled 768 combinations of density-dependent survival and recruitment functions for sandhill cranes (*Grus canadensis*) and found that all but 37 yielded population sizes or age structures that were inconsistent with available data. A second aspect that is sometimes ignored in population models is dispersal. Its omission is not because it is thought unimportant, but rather because of inadequate information. Models that have incorporated dispersal usually led to the conclusion that it is a significant feature, so data gaps should be filled by studies of dispersal when necessary. Models that incorporate an understanding of the biology of a species and provide results in substantial concordance with demographic information will prove extremely valuable for management purposes, both for satisfying immediate needs and for providing guidelines for long-term decision-making.

Modeling is a tool, which like any other should be employed only when appropriate and then in a proper manner. Connolly (1978) recognized this by observing the potential for circular logic when assumptions of the model are retrieved as conclusions. Romesburg (1981) distinguished between scientific and planning roles for modeling; the former is filled uncomfortably—models do not contribute new information—but the latter is a natural and appropriate application. Connolly (1978) also noted that the coyote models he examined tended to reinforce the good field studies, rather than offer new insights. Nonetheless, deficiencies in existing data were identified, and other modeling efforts have yielded unanticipated conclusions.

Population modeling has proven its worth as one of many tools for the management of wildlife, including furbearers. The existing models, as described in this report, have more often than not been successful in meeting the desired objectives. Comments from biologists who develop or use furbearer models were uniformly positive, evincing an optimism about the future of modeling for furbearer research and management. Based on published reports of wildlife models, personal communications with their developers, and my own experience, the following suggestions are offered for developing a population model for furbearers:

1. Involve personnel at all levels, including administrators, biologists, and conservation officers. If the model is to be a useful tool, it must be used, and administrators will use it only if they understand its purpose, function, and limitations. Biologists will be able to contribute to and improve the model only if they too appreciate its role; make sure that the model reflects their biological acumen. And the conservation officers or their counterparts will likely be involved in the operational gathering of data to use in the model. The better they understand its purpose, the more diligent and accurate they will be in their effort. Also, they may be manning the front line in the agency's battle to justify the regulations that are established, so a clear comprehension of how those regulations were decided upon will be invaluable. The considerable experience involving big game modeling has amply demonstrated the need for full participation in model development (Pojar and Strickland 1979, Williams 1981).

2. Begin simply. Add components to the model only as necessary; sophistication may not be a virtue. Although the model should be biologically "realistic," not all aspects of the species' life history need be included. Incorporate those components that are influential; omit those that may be real, but of minor significance. The tools of model-building, such as sensitivity analysis, will assist in this regard; see Innis (1979) and references cited therein for details of such techniques.

3. Use operational data whenever possible. The most useful models will be based on data that are gathered routinely. Management models should be initially constructed with the thought to use operational data both as input and as a check to monitor the model's performance. It will perhaps be desirable to use research data to get a better understanding of the population system—indeed, I suggested that approach above for developing a model based on functional components, but with demographic parameters used in monitoring.

Although research will often be needed to make improvements, the model's acceptance will be greatly enhanced if it uses data routinely gathered in the field (Williams 1981).

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4

Assessing Productivity of Furbearers

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Abstract: Furbearers in midwestern North America represent 7 families in 3 orders, with a variety of reproductive characteristics. Essentially, the methods to assess productivity are ovarian and uterine analysis, lactation, hormone levels, vaginal smears, field classification, denning sign, and age ratios. Sample size generally is built from harvest collections, in which young-of-the-year usually are unrepresentative, thus biasing age ratios unless adjusted. Embryo counts can be made during late gestation, corpora lutea counts throughout gestation, blastocyst counts during the delayed implantation period of gestation in mustelids, and placental scar counts outside gestation in some species. Factors affecting reproduction include gestation period, breeding age, sex ratio, density, and habitat.

Key words: furbearer productivity, gestation, corpora lutea, blastocyst, embryo, placental scar.

Basic to intensive management of any wildlife species is an understanding of its reproductive performance. The number of young produced annually is a function of pregnancy rate, litter size, and number of litters per year. Species managed primarily because of the monetary value of fur, the furbearers, have a variety of reproductive characteristics because in midwestern North America they are represented by 19 species from 7 families in 3 orders (Table 4–1). This paper discusses methods for determining productivity and factors affecting reproductive performance of these furbearers. I thank M. Wodyn for assistance in literature review.

METHODS FOR DETERMINING PRODUCTIVITY

Ovarian Analysis

Ovarian analysis generally is restricted to the gestation period. Follicle-stimulating hormone causes growth in the ovary of the follicle and luteinizing hormone causes ovulation. During estrus the follicles of some species rupture spontaneously and shed their ova. In species such as long-tailed weasel,

Table 4-1. Pertinent references on ovarian and uterine analysis for determining productivity of furbearers in midwestern North America.

Opossum (*Didelphis virginiana*)	Reynolds 1952
Muskrat (*Ondatra zibethicus*)	Enders 1939, Forbes and Enders 1940, Sooter 1946, Gashwiler 1950, Donohoe 1966
Beaver (*Castor canadensis*)	Hodgdon 1949, Provost 1962, Brenner 1964, Leege and Williams 1967
Raccoon (*Procyon lotor*)	Steuwer 1943*a*, *b*, Sanderson 1950, Wood 1955, Sanderson and Nalbandov 1973, Fritzell 1978
Red fox (*Vulpes vulpes*)	Englund 1970, Kolb and Henson 1980
Gray fox (*Urocyon cinereoargenteus*)	Sheldon 1949, Layne and McKeon 1956*b*, Layne 1958
Coyote (*Canis latrans*)	Gipson et al. 1975, Kennelly and Johns 1976
Wolf (*Canis lupus*)	Rausch 1967
Bobcat (*Lynx rufus*)	Provost et al. 1973, Crowe 1975, Fritts and Sealander 1978
Lynx (*Lynx canadensis*)	Nellis et al. 1972, Brand and Keith 1979, Mech 1980
Short-tailed weasel (*Mustela erminea*)	Wright 1942, Hamilton 1958
Long-tailed weasel (*Mustela frenata*)	Wright 1942, Hamilton 1958
Mink (*Mustela vison*)	Enders and Enders 1963, Larson 1967
River otter (*Lutra canadensis*)	Hamilton and Eadie 1964
Marten (*Martes americana*)	Marshall and Enders 1942, Wright 1942, Jonkel and Weckworth 1963, Wright 1963
Fisher (*Martes pennanti*)	Hamilton and Cook 1955, Eadie and Hamilton 1958, Wright and Coulter 1967
Wolverine (*Gulo gulo*)	Wright and Rausch 1955, Rausch and Pearson 1972
Striped skunk (*Mephitis mephitis*)	Verts 1967
Badger (*Taxidea taxus*)	Wright 1966

mink, striped skunk, otter, bobcat (*Lynx rufus*), and lynx (*L. canadensis*), ovulation is induced through coition. The ruptured follicle fills with a protein-type substance called lutein and becomes the corpus luteum. During gestation, estrogen and progesterone prevent growth or maturity of other follicles (Turner and Bagnara 1971) so all members of the litter are born at once. In furbearers with delayed implantation (mustelids), corpora lutea do not enlarge until the blastocyst is implanted (Wright 1963, Enders and Enders 1963). In others, it enlarges immediately after fertilization and remains enlarged throughout gestation; in beaver it attains 6–8 mm in size (Provost 1962). If ova are not fertilized or blastocysts fail to implant, corpora lutea of ovulation will ensue, which in the early stages are indistinguishable from corpora lutea of pregnancy, at least in beaver (Provost 1962). Corpora lutea of ovulation apparently do not exceed the size of the follicle and soon degenerate. Corpora lutea of pregnancy can be recognized by size within a few days following ovulation. A corpus luteum of pregnancy degenerates into a corpus albicans within 1 or 2 weeks after birth.

An advantage of using counts of corpora lutea to ascertain litter size is that the counts can be made throughout pregnancy. A major disadvantage of such counts is that they fail to identify intrauterine losses. The difference between numbers of corpora lutea and embryos is an estimate of intrauterine mortality that includes both pre-implantation losses of ova and post-implantation losses of embryos through resorption and abortion. The difference between numbers of corpora lutea and placental scars (if present) is also an estimate of intrauterine mortality, except when scars from more than one pregnancy are involved. Corpora albicantia generally are not considered reliable for determining recruitment. Corpora albicantia in wolverine (Rausch and Pearson 1972) and otter (Tabor and Wight 1977) do not persist after pregnancy, and in bobcat and lynx they persist for years (Nellis et al. 1972, Provost et al. 1973, Crowe 1975, Brand and Keith 1979).

In most furbearer species, ruptured follicles, which develop into corpora lutea, and unruptured follicles may be counted macroscopically to provide additional measures of reproduction (Kirkpatrick 1980).

Ovaries should be placed in AFA to accent characteristics. They should be sliced longitudinally (Kirkpatrick 1980) into 1- to 2-mm sections but not severed completely, thus leaving the sections hinged like a book for future reexamination. Ovaries may be preserved in 10% formalin, but characteristics are more pronounced in AFA (Kirkpatrick 1980).

Uterine Analysis

Blastocysts.—After conception, all mustelids in the Midwest have delayed implantation of blastocysts on the uterine wall (Enders and Enders 1963). During this delay blastocysts can be flushed from the fallopian tubes and uterus (Hamilton and Cook 1955, Wright 1966) and counted, usually with aid of a binocular dissecting scope. Because this delay is extensive (Table 4–2) and the harvest season often coincides with delayed implantation, it is possible to build a substantial sample size with blastocyst counts from harvest collections of mustelids.

Embryos.—The easiest and most accurate method of obtaining data on litter size is by fetal counts. Because resorption of embryos normally occurs early in gestation (Kirkpatrick 1980), the closer to parturition they are counted, the more reliable the data will be. Embryos are visible macroscopically only during the last 2/3–3/4 of pregnancy (Kirkpatrick 1980), which does not occur when most collections are made during trapping and hunting seasons.

Placental Scars.—Prominent placental scars occur in those species which have an endotheliochorial, hemochorial, or hemoendothelial placenta, where there is an erosion of uterine tissue, a closer association of maternal blood supply, and parturitional bleeding (Gunderson 1976). Most species qualify in the orders Carnivora, Rodentia, Lagomorpha, Insectivora, and Chiroptera (Kirkpatrick 1980). However, placental scars are not readily discernible in furbearers with delayed implantation (Table 4–1). Uterine analysis outside the gestation period involves counting placental scars. These pigmented sites of trapped blood fade with time, but are recognizable for about 1 year for most furbearers, although scar duration even with the same species can be erratic. If scars persist into the next pregnancy, accuracy of counts is reduced. Englund (1970) recognized 6 shades of darkness for placental scars in red fox, attributing darker scars to embryos born alive, and gray scars to early resorptions or successful earlier pregnancies. Sanderson and Nalbandov (1973) found placental scars for all raccoon embryos that reached 20 days of age, including resorptions. However, interpretation of placental scars to indicate production will remain imprecise in furbearers because fresh placental scars can be confused with those of resorbed or aborted embryos, or from those of previous litters the same season in muskrats, or from those persisting more than 1 year. The best information is available from rodents. Martin et al. (1976) reported uniform intensity of scars in primiparous prairie voles (*Microtus ochrogaster*), but multiparous females often contained scars of 2 or 3 degrees of intensity. Conaway (1955) reported placental scars of resorbed and term fetuses indistinguishable in rats (*Rattus rattus* and *R. norvegicus*), but Martin et al. (1976) reported such scars distinguishable in prairie voles, with scars from embryonic loss darker.

Special treatment of uteri is unnecessary to read placental scars accurately in many furbearers. In some species, it is useful to open the uterine horns longitudinally with a scissors to observe the pigmented sites more clearly.

Elder (1952) reported that placental scars in mink are not visible. But Larson (1967) noted scars of orange pigment in fresh mink uteri, and identified scars in preserved material using the prussian blue reaction method (Humason 1972). The prussian blue reaction method and the clearing technique (Orsini 1962, Henry and Bookhout 1969), or some variation of these, are the 2 most common methods for accentuating placental scars. Preservatives and fixatives for reproductive tracts are summarized by Wobeser et al. (1980) and Kirkpatrick (1980).

Table 4–2. Reproductive characteristics of furbearers in midwestern North America.

Species	Minimum breeding age (months)	Breeding season	Gestation period (days)	Implantation to parturition (days)	Parturition	Authority
Opossum	9	Feb & May	13	—	Mar & Jun	Asdell 1964; Hartman 1963
Muskrat	5	Apr–Aug	28	—	Apr–Sep	Asdell 1964
Beaver	21	Feb–Mar	ca 90	—	May–Jun	Asdell 1964
Raccoon	10	Feb–Mar	63	—	Apr–May	Asdell 1964, Fritzell 1978
Red fox	10	Jan–Feb	49–55	—	Mar–Apr	Asdell 1964
Gray fox	10	Jan–Feb	ca 63	—	Mar–Apr	Asdell 1964
Coyote	22	Mar	60–65	—	May	Asdell 1964; Kennelly and Johns 1976
Wolf	22	Jan–Mar	60–63	—	Mar–Jun	Asdell 1964
Bobcat	10	Mar–Apr	70	—	May–Jun	Provost et al. 1973, Crowe 1975
Lynx	10	Apr–May	60–70	—	Jun–Jul	Brand and Keith 1979, Nellis et al. 1972
Short-tailed weasel	2–2½	May–Jul	300–330	unk	Apr–May	Wright 1963
Long-tailed weasel	3	Jul	270	23–24	Apr–May	Wright 1963
Mink	10	Mar	39–75	28–30	May	Enders and Enders 1963
River otter	24	Jan–Apr	285–365	unk	Dec–Apr	Wright 1963
Marten	27	Jul–Aug	259–276	25–28	Mar–Apr	Wright 1963
Fisher	12	Mar–Apr	327–358	unk	Mar–Apr	Wright 1963
Wolverine	15	May–Jul	245–276	30	Feb–Mar	Wright 1963
Striped skunk	10	Feb–Apr	59–77	unk	May–Jun	Verts 1967, Wade-Smith and Richmond 1978
Badger	16	Jul–Aug	225–240	30–45	Mar–Apr	Wright 1963, 1966

Other Methods

Pregnancy rate can be determined from the proportion of females in estrus or lactating, and number of young produced can be extrapolated if mean litter size is known. For those species with conspicuous dens, the proportion of dens with sign indicating presence of a litter can be used as a measure of reproduction. Because furbearers are secretive, often nocturnal, and not generally gregarious—possibly except beaver, wolves, and coyotes—field classification is of limited value due to the time and expense in obtaining an adequate sample size. However, Sargeant et al. (1975) used aerial censusing to locate red fox dens, Harris (1979) counted red fox pups at dens, and Pils and Martin (1978) captured red fox pups inside dens. Dorney and Rusch (1953) opened muskrat houses to count young.

Age ratios are readily available from the harvest, but may be biased because of unrepresentation of young-of-the-year in samples collected by trappers and hunters. The ratio of yearlings might be a better indication of net productivity and rearing success, especially if adjusted with a vulnerability factor, as Simkin (1974) did for moose (*Alces alces*). Downing (1980) presented a change-in-ratio equation for calculating the percentage of young in the fall population. Caughley (1974) and Grier (1979) discussed problems with interpreting changes in age ratios when productivity data are lacking.

Other methods of determining productivity, such as hormone levels, vaginal smears, palpation, and laparotomy, have limited application (Kirkpatrick 1980). Jonkel and Weckworth (1963) used palpation and laparotomy to determine pregnancy in marten, as did Kennelly and Johns (1976) in coyotes, and Sanderson (1950) in raccoons. Median date of birth can be estimated from the observed ratio of newborn to females at least 3 times during the season and once at its end (Caughley and Caughley 1974). The reproductive value, net reproductive rate, and generation length can be calculated if age ratios and reproductive data are known (Caughley 1967).

FACTORS AFFECTING REPRODUCTION

Gestation Period

The time and length of the gestation period is particularly important for counts of corpora lutea, blastocysts, and embryos. Unlike other furbearers, mustelids have delayed implantation (Table 4-2), which extends the gestation period for most of them into the harvest season, the time when most collections of carcasses are made. Mink is the only midwestern furbearer in which both breeding and fertilization may occur during delayed implantation (Enders and Enders 1963). The shorter the gestation period, the more litters that can be produced. Some species, for example the raccoon in Illinois (Sanderson and Nalbandov 1973), will breed again if mortality of litters occurs shortly after birth. Perhaps these second litters occur only at lower latitudes.

It is possible to calculate the approximate date of conception by measuring embryos of raccoon (Llewellyn 1953), striped skunk (Verts 1967), red fox (Layne and McKeon 1956*a*, Storm et al. 1976), coyote (Kennelly et al. 1977), and otter (Hill and Lauhachinda 1980).

Breeding Age

Minimum breeding age has a major influence on population growth. Although pregnancy rates and litter size are often relatively low for females during their first breeding season, this age class is usually large and often contributes more offspring than any other age class, or even all others combined. Moreover, younger breeders contribute more to the rate of increase because their succeeding generations are available sooner to begin reproducing (Birch 1948). Maximum breeding age has little influence on recruitment because few animals survive to this age.

Productivity of furbearers probably follows the typical pattern of low average litter size and pregnancy rates for young and old, with peak production during middle years (Kirkpatrick 1980), as documented for beaver (Payne 1975). Thus, age-specific reproductive rates should be calculated. The fecundity rate, which combines survivorship with fertility, may reveal certain age classes to be more important reproductively than others, as with long-lived species such as beaver (Payne 1975) in which varying fecundity rates in different age classes could influence management.

Sex Ratio

Because pregnancy rates can vary widely, they can have more impact than litter size on recruitment. Sex ratios can influence pregnancy rates, especially in monogamous species. For maximum productivity, monogamous species need at least 1 male per female. Surplus males replace mated males that are killed. Beaver, a monogamous midwestern species that breeds in February, can seldom seek mates during fall and winter because behavior and climatic conditions restrict movements. Thus, mortality of an adult during that period will reduce pregnancy rates (Leege 1968). If a subadult is present to breed (Payne 1975, Brooks et al. 1980), litter size is smaller (Payne 1975). Although striped skunks are polygamous, they are monestrus and breed during winter dormancy; severe winters may influence breeding rates by reducing mobility of males to emerge from dens and approach receptive females (Verts 1967). Wolves are monogamous, but in undisturbed populations their social hierarchy usually prevents subordinate males and females from breeding (Woolpy 1968, Allen 1979). A pack usually produces 1 litter per year.

Density

Indications are that reproduction and survival in furbearers is density-dependent. For example, when lynx populations are high, kittens do not survive the first year of decline in their primary prey species, snowshoe hares (*Lepus americanus*) (Nellis et al. 1972). Survival and reproductive rates are low in muskrats when density is high (Errington 1961). Pearson (1960), Gunson (1970), and Payne

(1975) showed an inverse relationship between litter size and colony size or density of beaver. Parsons and Brown (1979) documented little or no yearling reproduction of beaver when more than 40% of the potential colony sites were occupied. When population levels are too low, reproductive rates also may be low if mates cannot be found during estrus.

Habitat

Samples should be analyzed relative to habitat. Differences in productivity between populations of the same species may reflect different habitat conditions. It may be possible to monitor habitat conditions of certain furbearers, perhaps monestrous herbivorous species (beaver) particularly, by changes in productivity, as Gross (1969) suggested for ungulates. In general, the closer to carrying capacity a population is, the lower the reproductive and survival rates. For example, when beaver densities are high, reproduction by yearlings decreases (Parsons and Brown 1979), and only marginal habitat with limited food and water would be available (Payne 1975). Young, colonizing beaver in marginal habitats may starve to death if food becomes unavailable when the food cache or plunge hole, or both, are locked in ice (Boyce 1974, Payne 1975). Litter sizes are higher when high quality food is abundant. Resorption rates may be higher in areas of poor habitat, at least for beaver (Rutherford 1964, Gunson 1970). The same density in different habitats will produce different recruitment rates.

DISCUSSION

Sample size can be calculated statistically for various confidence levels, but it must be substantial for age-specific analysis. To determine pregnancy rate and litter size, only females of reproductive age are required. For some species, for example, fox, there are more males than females in the harvest, because males roam farther, have larger home ranges, and come into contact with more traps and hunters (Sheldon 1949). Young-of-the-year usually are the largest single age class, and are nonreproductive. Elimination of these 2 groups reduces the sample size substantially. The remaining sample is divided by age class; older age classes are weakly represented, consistent with their representation in the wild population.

Reproductive rates are difficult to interpret without age ratios, and vice versa. Grier (1979) showed that the same reproductive rates could produce different population levels if survival rates varied. Because most collections come from hunters, trappers, and furbuyers, analysis of counts of corpora lutea, blastocysts, and placental scars will produce best results because they occur during the harvest period of most furbearers. These need to be related to representative age ratios from the harvest, which may need adjustment for different vulnerability, especially for young-of-the-year but perhaps also for yearlings and for sex ratio.

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B Sanderson

5

Estimating and Using Furbearer Harvest Information[1]

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Abstract:—Harvest data are valuable to furbearer managers because they often reflect the results of management programs. Harvest-estimation techniques are classified into 5 general categories—pelt registration, trader transaction reports, export permits, furtaker reports, and sample surveys. The procedures vary in ease of application and in the nature and utility of the estimates they produce. All 5 techniques are used successfully in the United States and Canada, often concurrently. Management agencies should select harvest-estimation techniques that address their specific management needs. The data may be used to (1) evaluate management alternatives, (2) assess the impact of hunting and trapping on furbearer populations, (3) estimate the commercial and recreational value of furbearer resources, (4) portray animal distribution, (5) identify geographical variations in relative abundance and shifts in abundance, and (6) provide a basis for cautious evaluation of population status. Harvest information is useful in public relations and, in general, is essential for assessing the success of management programs.
Key words: estimating furbearer harvest, furbearers, harvest.

Furbearer harvests are the annual result of managed hunting and trapping seasons. Because of their commercial nature, they differ from harvests of most other wildlife. Changing fur markets influence the number of harvesters, their efforts, and the harvest itself. In Missouri, for example, numbers of fur traders, trappers, and raccoon (*Procyon lotor*) hunters, raccoon hunter efforts, and harvests of numerous furbearers correlate directly with prevailing market demands (Erickson and Sampson 1978).

The economics of the fur trade create a dynamic harvest system, but also contribute to a fairly predictable process of pelt collection that may aid estima-

[1]Supported in part by Federal Aid Project W-13-R.

tion of the annual take. In most of the Midwest, furs taken by hunters and trappers are sold to local furbuyers. Typically pelts progress through a succession of other, usually larger, traders, then enter national or international markets (Foner 1982). In principle, the number of furs harvested or marketed in a state or province can be estimated at any stage of the collection process: the taker, furbuyer, larger dealer, or at the time of export from the area of jurisdiction.

The efforts of many harvesters are motivated by recreational as well as economic incentives. For some species, the recreational return is the predominant factor stimulating involvement by the harvester. The relative importance of these incentives varies among participants and probably within individuals as fur demands fluctuate. Thus, for certain species (or during certain market periods) commercial pelt transactions provide inaccurate estimates of actual harvest. Nonetheless, the recreational incentive for pursuing the furbearer and need for monitoring the annual kill may be significant, just as they are for other game species.

Furbearer harvests are also unique because several species are taken by both hunters and trappers. There would be little reason, for example, to estimate only the trapped harvest of Missouri raccoons because 85–90% of the total harvest is taken by hunters. It may be important to include both types of harvest either collectively or separately in annual harvest estimates.

Midwest furbearer management frequently centers on data describing the annual harvest (Hubert 1982). In their simplest form, harvest data summarize hunting and trapping mortality for a particular species, area, and year. Harvest data will not answer all management questions. However, they often indicate the relative success of management programs. The objectives of this paper are to (1) review techniques for estimating furbearer harvests, (2) identify the limitations and advantages of the techniques, and (3) describe potential applications for harvest information.

Much of the information reported in this paper was graciously provided by colleagues in the USA and Canada. Their contributions are appreciated. I thank E. K. Fritzell, G. F. Hubert, Jr., W. R. Porath, and S. L. Sheriff for reviewing an earlier draft of the paper.

ESTIMATING THE HARVEST

Techniques for estimating furbearer harvests include: (1) pelt registration, (2) trader transaction reports, (3) export permits, (4) furtaker reports, and (5) sample surveys. All procedures are currently used in the United States and Canada. The precision, accuracy, and utility of data estimated by different techniques vary because of biases inherent in each procedure and because the techniques often measure different phenomena. Thus, numerous agencies in the Midwest use more than 1 technique to estimate harvests (Table 5–1).

Table 5-1. Furbearer harvest estimation techniques used by Midwest wildlife agencies.

State/Province	Harvest Estimation Techniques
Illinois	Trader transaction reports, trapper and hunter mail surveys.
Indiana	Trader transaction reports, trapper mail surveys.
Iowa	Trader transaction reports, hunter mail surveys.
Kansas	Trader transaction reports, trapper and hunter mail surveys, pelt registration (bobcat).
Michigan	Trapper and hunter mail surveys, pelt registration (beaver, bobcat, river otter).
Minnesota	Trapper and hunter mail surveys, pelt registration (lynx, bobcat, fisher, river otter).
Missouri	Trader transaction reports, trapper and hunter mail surveys, pelt registration (bobcat).
Nebraska	Trader transaction reports, trapper and hunter mail surveys, pelt registration (bobcat).
North Dakota	Trader transaction reports, trapper and hunter mail surveys, pelt registration (bobcat).
Ohio	Trader transaction reports, hunter mail surveys, pelt registration (beaver).
South Dakota	Trader transaction reports, pelt registration (bobcat).
Wisconsin	Trader transaction reports, trapper mail surveys, pelt registration (beaver, bobcat, river otter).
Ontario	Pelt registration (all species except muskrat), export and tannery permits, trader transaction reports.
Manitoba	Trader transaction reports, export permits, furtaker reports (registered traplines).

Pelt Registration

Pelt registration requires the submission of individual pelts or animals to authorized representatives of management agencies. Usually, pelts are marked to facilitate enforcement of the registration requirement. The technique ideally permits enumeration of all animals harvested. Registration has commonly been used in the northern United States and Canada for determining harvests of beaver (*Castor canadensis*) and river otter (*Lutra canadensis*) as well as certain other species. Implementation of the Convention on International Trade in Endangered Species of Wild Fauna and Flora has led to wide use of registration elsewhere in the United States for harvests of bobcat (*Lynx rufus*) and river otter.

A crucial assumption of registration is that all harvested animals are submitted. Thus, compliance by harvesters is essential. Rigorous enforcement helps ensure compliance. Regulations that prohibit the sale, purchase, or export of unregistered pelts make sellers and buyers less willing to handle any unregistered furs. Ideally, requirements should specify that all animals be submitted even if they are not destined for the fur market. In Missouri's 1980–81 bobcat harvest, for example, 38 of 805 registered bobcats were used for trophy rather than fur market purposes. Had regulations not specified that all bobcats be registered, tabulated harvests would have underestimated the actual kill by nearly 5%.

A major advantage of pelt registration is its potential accuracy, provided registration requirements are adequately publicized and enforced. Harvesters submitting animals can provide additional information; for example, target species sought and specific locations, dates, and methods of harvest. However, registration does not supply information about the entire harvester population because only successful participants register, unsuccessful harvesters do not. Because submitted animals or pelts are available for inspection, biological information such as sex and age compositions of the harvest may be obtained. Some agencies require submission of a jaw, skull, or carcass for biological evaluations.

The principle disadvantage of registration is its unsuitability for large harvests. The technique is used primarily for species with well-defined management needs, typically species having relatively low abundance, limited distribution, or low tolerance to harvest. It would be logistically impractical, for example, to undertake registration of raccoon or muskrat (*Ondatra zibethicus*) harvests in most midwestern areas.

Agencies conducting registration either use their personnel and facilities or arrange for interested individuals or businesses to conduct the registration. In some states where bobcats and river otters are tagged for export, furtraders conduct the registration. Although convenient, this procedure has inherent risks because pelts from jurisdictions with closed seasons or more stringent tagging criteria may be tagged at the trader's discretion and possibly to his advantage. An inaccurate harvest estimate may result.

Trader Transaction Reports

Transaction reports are records of fur purchases maintained by licensed furtraders. Reports collected following or during the season are tabulated to estimate the number of furbearers harvested and sold as pelts.

Reporting requirements vary considerably among states and provinces. Some agencies require that traders provide only summaries of total fur purchases. Although convenient, this procedure has potential drawbacks because pelts are often exchanged among individual traders after their original sale by the furtaker. Inclusion of these secondary sales results in multiple tabulation of single pelts. By tabulating only original sales, pelts will not be tabulated more than once. Similarly, nonresident furs imported to the state for sale should be identified and excluded from tabulation. Resident furs sold outside the state can be estimated from harvester mail surveys. For example, mail surveys indicate that Missouri hunters and trappers sell 8–10% of their harvest outside the state. An appropriate out-of-state sales allowance is added to tabulated harvest totals to account for these sales.

A common form of transaction report requires traders to report the total number of furs of each species purchased from resident hunters and trappers (original sales), from other traders (secondary sales), and from outside the state (nonresident sales). Tabulation of only original sales from resident sources provides the estimated harvest of each species. It is important that traders' records accurately identify original, secondary, and nonresident purchases because the accuracy of the harvest estimate depends on the reliability of the traders' records and his tabulations.

A more detailed procedure requires traders to record for each transaction the type of seller (furtaker or furtrader); the seller's name, address, and permit number; the number of each species sold; and county of harvest. The state or province generally provides appropriate record forms. This system permits harvests to be summarized in an area-specific manner with standardized bookkeeping procedures. The managing agency identifies the original, secondary, and nonresident purchases and conducts all tabulations. Although more tabulation is required to calculate harvest results, the system is well received in many of the states and provinces where it is used.

Compliance by furtraders in maintaining accurate records and providing these records to the management agency is crucial to the effective use of trader transaction reports. Harvest tabulations should be based on the records of all furtraders. In Missouri, periodic unannounced inspections of transaction records by conservation agents have helped ensure report currency. Further, renewal of traders' permits is contingent on successful completion and submission of current year records. Relatively few citations are issued. However, the system has been used continuously since 1940 and traders are well acquainted with the system and their reporting obligations.

Harvests estimated from trader transaction reports include animals taken by both hunters and trappers, but only animals that are marketed. Under the market conditions that have prevailed since the mid-1970's, the actual harvest and the number of pelts sold have probably been quite similar. However, during periods of low demand, recreationally motivated harvests often are not sold and the actual harvest is underestimated. Some states use concurrent mail surveys to estimate hunter harvests of furbearers that are also important game animals. Hunter harvest surveys provide added flexibility to the agency's monitoring system by having a useful survey method in operation when harvest incentives change.

Export Permits

Export permits are documents authorizing shipment of furs across provincial or state borders. They are widely used in Canada, often to collect royalties or taxes on exported furs. Since most furs are exported from the harvest area, tabulation of export permits provides a convenient method to estimate commercial harvests. Export permits, however, provide no information on harvests that do not enter the fur trade; recreational harvests and animals used domestically are overlooked entirely.

Export permits are issued to fur traders or individual trappers who wish to export furs. Fur examiners or game officers are responsible for insuring the count of the shipment, issuing the permit and, in some areas, collecting the royalty. An independent count is beneficial because it eliminates the shipper's incentive to reduce his count. The approved shipment is then marked with a tag, seal, or papers for identification.

Export permits provide a good gauge of commercial harvest. Their major limitations are their labor demands (although in some areas they produce revenue) and their exclusion of noncommercial and domestically used harvests. Estimates of harvest derived from export permits provide state or provincial totals, but do not identify the specific locations of harvest within the area of jurisdiction. Thus, some agencies using export permits use additional techniques to determine other characteristics of the harvest.

Compliance is as important to the success of export permits as it is to other estimation techniques. Although some individuals may export furs illegally, the public apparently accepts and adequately complies with the system in areas where it has long been used. Furthermore, in Canada where export permits are commonly employed, interprovincial enforcement cooperation deters illegal shipments.

Furtaker Reports

Furtaker reports, in principle, enable tabulation of harvests reported by all fur harvesters. These reports are important in much of Canada where public lands are managed under systems of registered traplines. Harvesters receive report forms and instructions prior to the season, usually with license purchase or trapline assignment, and return them following the harvest period. Because participants know in advance what information is required, memory bias should be minimized. The entire harvester population is included. Thus, an adequate response will characterize the entire population and not just its successful members. Total harvest efforts such as trap nights, hunting trips and similar information are perhaps the most important of these characteristics.

Harvest estimates from furtaker reports can be reasonably accurate if the information reported is accurate and if nearly 100% of the harvesters respond. Unfortunately, furtaker reports are subject to a variety of response and non-response biases. Some harvesters may understate actual harvests to "protect" productive trapping areas or minimize scrutiny by tax authorities. More typically, they may exaggerate their catch to inflate their egos or reflect what their catch should have been under "normal" circumstances. Agencies should expect considerable bias in any information reported directly by the taker. Furtaker reports have no second party counting and reporting the participant's harvest.

Response rate determines whether harvests can be estimated by direct tabulation of the reports or whether the data must be expanded to account for nonrespondents. Nonresponding furtakers probably do not participate with the intensity or success of comparable respondents. Unsuccessful participants may feel their report serves no purpose. Nonparticipants may believe that since they did not hunt or trap, they are not obligated to report. If an agency assumes that respondent activities characterize nonrespondents, harvests are generally overestimated. In this respect, an incomplete response from furtaker reports is similar to sample surveys but without the latter's statistical advantages. Bellrose (1947) reported that the response of license holder reports required of Illinois hunters declined from 75%, the first year implemented, to 55% and 26% in the following two years. Reports submitted voluntarily cannot realistically be assumed to reflect entire populations of harvesters. If reporting response rates do not approach 100%, but are consistent through time, resulting estimates may provide satisfactory harvest indices. However, reports will almost certainly underestimate actual harvests if simply totalled or overestimate actual harvests if uncorrected expansion calculations are performed to account for nonrespondents. Moreover, annual variations in procedures or enforcement that affect response rate may jeopardize the value of the data even as harvest indices.

Agencies successfully using furtaker reports typically undertake rigorous enforcement of reporting requirements. Registered trapline assignments or license renewal may be used as leverage to attain compliance, or violation citations may be issued. Well supervised furtaker reporting systems can supply satisfactory harvest information. However, the procedure would be cumbersome for large, multiple populations of harvesters, and therefore, is generally used only for trappers. Furtaker reports are most useful if response rate is sufficient to allow tabulation of harvests directly from the reports; if not, managers should probably consider other estimation techniques.

Sample Surveys

Sample surveys do not directly enumerate the harvest. Instead, data are obtained from a representative sample of harvesters to estimate the efforts and success of the entire population. Importantly, the precision of the estimates can be estimated from the survey itself (Cochran 1977). Mail surveys are commonly used to estimate the size and distribution of wildlife harvests (Ryel 1980, Filion 1980) and are relatively efficient because labor, data entry, and other costs are usually reduced. Telephone and interview surveys are alternate techniques but are not currently used to monitor harvests of midwestern furbearers.

Hunters or trappers are the populations normally included in sample surveys.

Because the sample includes participants of varying degrees of participation and success, estimates of total harvest effort, recreation days, and success rates are readily obtainable. These data may especially interest furbearer managers because of the fluctuating nature of furbearer harvests and market incentives. In general, licensing requirements that identify specific harvester groups provide the most usable sampling frames.

In mail surveys, questionnaires are sent to sampled hunters or trappers who complete and return them for processing. Adequate response rates are essential; thus nonrespondents are contacted 2, 3, or possibly more times. Unfortunately, 100% response is seldom attained. If it is assumed that the success of respondents and nonrespondents does not differ, the estimated harvests will typically exceed actual harvests. Nonrespondents usually participate less and are less successful than respondents (Overton 1953, Martinson and Whitesell 1964, Sen 1971, Filion 1975, Wright 1978). The review of sample surveys by Filion (1980) provides a useful background for maximizing response rate and correcting nonresponse bias.

The reliability of estimates from mail surveys also depends on the accuracy of responses. Responses do not always accurately reflect actual events and may have intentional or unintentional biases. In surveys of deer hunters (MacDonald and Dillman 1968), small game hunters (Martinson and Whitesell 1964), and waterfowl hunters (Atwood 1956, Wright 1978), respondents reported greater success than was indicated by other bag and kill records. Although inflated responses may also occur for respondents to furbearer surveys, some respondents may use the commercial and often competitive nature of furbearer harvests as a rationale for deflating their reported harvests. The latter possibility, however, has not been adequately investigated and, in any event, the effects are probably surpassed by numerous other biases that lead to overestimation.

Memory bias can be reduced by contacting sample participants while their recollection of the activity is still fresh. Preseason notification of survey participants may also reduce recall difficulties. Other possible solutions to memory bias are summarized by Filion (1980).

Harvest estimates for some furbearers may be subject to additional response biases. An example, illustrated by Krause et al. (1969), describes the effect of incidental taking of coyotes (*Canis latrans*) on hunter-mail-survey estimates of coyote harvests. They found that harvests were biased upward because many coyotes were killed incidental to other activities. Many hunters reported that they were hunting coyotes only if they happened to kill one. They probably would have attempted to bag an animal on any occasion when the opportunity arose. Krause et al. (1969) suggested wording questions so that they clearly identify incidental and directed coyote harvests. Incidental take bias likely occurs for other furbearers including bobcat, foxes, and other hunted species.

Some species are commonly pursued by groups of hunters. Responses that result in more than 1 person reporting the harvest of a single animal inflate harvest estimates. Group bias for furbearers has not been thoroughly evaluated, but the problem may be minimized by carefully wording questions to identify the actual harvester or by identifying group size and success parameters.

Furbearers in the Midwest are most commonly harvested by hunting and trapping; a harvester may use each technique at different times. Surveys designed to estimate specific hunting or trapping harvests should permit the respondent to report his total harvest for each technique. Thus, reportings of combined harvests under questions that pertain solely to one technique could be minimized.

USING HARVEST INFORMATION

Regulation of harvests continues to be the primary emphasis of most furbearer management programs. Although management objectives, strategies, and problems vary regionally, virtually all agencies estimate annual harvests. Harvest data are often an important gauge of management success, although usually other related data are needed. The harvest, viewed simply, is determined by animal availability and annual harvest effort (Erickson and Sampson 1978, Erickson 1981). The harvest should be evaluated in relation to the variables that affect these factors; for example, animal population size, reproduction, recruitment, pelt values, recreational demands, harvester numbers and efforts, regulations, weather, and others. If approached in this manner, the data can be applied in numerous ways.

Several authors have demonstrated the usefulness of harvest data to evaluate regulation alternatives and populations. Hubert (1979) used harvests estimated by mail surveys and reported by hunter and trapper cooperators to evaluate bag limits and season length and timing as techniques for manipulating Illinois raccoon harvests. When considered with information on primeness, reproductive timing, and other factors, an understandable rationale for adopting season length and timing rather than bag limits was presented. Parsons and Brown (1981) studied beaver populations and harvests under different season lengths to assist development of beaver management programs. Brand and Keith (1979) used Alberta lynx (*Lynx canadensis*) harvests with other data to estimate lynx mortality. Erickson (1981) examined relationships between harvests and annual population trends, market demands, season lengths, and weather conditions for muskrat, beaver, raccoon, and coyote. Various factors significantly affecting harvests were identified. The study also presented basic models to simulate hypothetical harvest situations, including management alternatives. In each of these studies, however, information on harvests was complimented by a variety of other data.

Harvest data are commonly used to estimate the commercial value of the harvest (for example, Deems and Pursley 1978, Sampson 1980). Trader transaction reports and export permits have potential for directly measuring commercial trade in pelts. However, commercial harvests can also be estimated by other techniques.

The recreational significance of the harvest is most easily determined from information obtained directly from harvest participants. Sample surveys have application for estimating total recreation days, hunting trips, and related information. In principle, mandatory furtaker reports could also be used; however, such reports are not usually required for recreational participants.

Harvests are generally poor short term indicators of animal abundance because of the dynamic character of the harvest system. A 40% rise or drop in estimated harvest, for example, will not necessarily signify a comparable change in population—or vice versa. Although changes may be due in part to changes in abundance, they may also result from market adjustments, weather variations, regulation changes, and other factors. In this respect, harvests of furbearers are unlike harvests of some wildlife for which annual efforts can be assumed to be relatively comparable. Indeed, for some species, harvests may not decline until after successive (and perhaps undetected) overharvests. Strickland and Douglas (1981) described such an account for fisher (*Martes pennanti*) in Ontario. Moreover, interpretive dilemmas are confounded as the area represented by the harvest data increases. Statewide compliations may mask regional harvest declines. Area-specific harvest information can be quite important to management efforts. Short-term changes in harvest may suggest changes in population. However, caution must be used in evaluating populations solely from harvest information. Harvest data should not replace independent population-trend data for furbearers.

Harvest data that cover many years (20–50) may depict trends in relative abundance. However, such trends should again be interpreted with caution and with the aid of other related information. Harvests of species with low commercial value are probably most reflective of their comparative status because their harvests are subject to less direct influence by the fur market and less regulatory manipulation by management agencies. Harvests of striped skunks (*Mephitis mephitis*), spotted skunks (*Spilogale putorius*), opossums (*Didelphis virginiana*), and long-tailed weasels (*Mustela frenata*) in Missouri, for example, suggest that historical population levels differed markedly from current populations (Sampson 1980). In reality, harvests alone offer little more than speculative evidence as to the possible magnitude of these differences.

Catch per effort indices may be useful as indirect indicators of furbearer population trends (Dixon 1981). Their applicability is greatest when annual harvest efforts are relatively stable, such as in systems of registered traplines or on public lands where harvests are regulated. Catch per effort indices are probably unreliable in competitive trapping and hunting systems because the index is greatly affected by variations in annual effort. Increased numbers of harvesters may distribute a relatively stable total harvest more broadly and decrease individual success. Correlations between raccoon pelt values and both hunter numbers and average hunting trips (Erickson and Sampson 1978) indicate that annual hunting efforts vary considerably and imply that hunters will work to harvest additional raccoons when fur values are more attractive. Missouri raccoon hunters often comment that "coons are down" because their average catch has decreased. They may then describe the intensely competitive hunting conditions that have prevailed since raccoon pelt values have increased. Overlooked is the impact of more competitors on personal hunting success. Mail surveys since 1967 verify the hunters' observations; individual harvest success has declined (Table 5–2). However, the decline probably does not signify a population decline, but instead may illustrate the influence of increased harvester numbers and total harvest efforts on individual success rates. Indeed, for Missouri raccoons, visitations to scent stations, harvest sex and age compositions, field reports and harvest estimates, suggest that populations have remained comparable to those present before pelt demand increased.

Table 5–2. Number of raccoon hunters, hunting efforts, success rates, and average values of raccoon pelts in Missouri, 1967–1980.

Season	Number of hunters[a]	Mean hunting trips per season[a]	Mean kill per trip[a]	Mean kill per season[a]	Raccoon pelt value[b]
1967	28,248	9.11	1.19	10.83	$ 1.75
1968	26,590	8.21	1.44	11.83	3.87
1969	37,147	8.91	1.34	11.97	2.55
1970	33,935	10.50	1.11	11.70	1.12
1971	30,704	10.34	1.22	12.59	2.60
1972	32,131	10.41	1.27	13.23	6.65
1973	41,651	10.21	1.22	12.41	7.45
1974	38,849	12.36	1.05	12.93	7.35
1975	42,122	12.36	0.96	11.86	13.90
1976	43,676	11.84	0.94	11.10	17.10
1977	40,240	10.30	0.87	8.95	15.50
1978	39,812	10.14	0.91	9.26	27.50
1979	48,567	12.40	0.83	10.31	21.85
1980	42,709	11.56	0.69	8.02	17.00

[a]Estimated from annual hunter mail surveys.
[b]Represents average value of all sizes and grades of pelts.

Harvest data, if summarized by locality, may indicate geographical differences in abundance and even identify temporal shifts in abundance and distribution. The assumption that harvest efforts and incentives do not vary greatly among regions may be justified in the populous midwest, but in more remote regions, harvests may reflect variations in harvest effort more than variations in population level. Harvest data have served as the basis for historical accounts of the distribution and status of furbearer populations (for example, Bennitt and Nagel 1937, Brown and Yeager 1943, Mohr 1943). The distribution of bobcat harvests in Missouri appears to accurately reflect the animal's historical distribution (Erickson et al. 1981). Further, these data identify the greatly reduced importance of the Mississippi Lowlands to bobcats resulting from the extensive destruction of lowland hardwood forests. Similar distributional changes are evident for other species.

CONCLUSION

Several techniques can be used to estimate furbearer harvests. The procedures vary in ease of application, overall usefulness, and often in what is actually measured. Thus, managers should consider their specific management goals and problems when selecting a technique. Concurrent use of more than 1 technique is often beneficial. Harvest data are very useful, but have greatest application when used in conjunction with other data pertaining to the harvest and furbearer populations.

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6

Techniques for Aging Furbearers Using Tooth Histology[1]

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Abstract: Many methods have been used to age furbearers, and usually there is little difficulty separating juveniles from adults in the harvest. Managers, however, often wish to know exact ages when monitoring population age structure and fecundity. We used annual cementum and dentine histology as rapid methods for determining ages of some of the major furbearing species. Decalcified teeth were sectioned by microtome and stained with various basophilic stains. Undecalcified teeth were sectioned with double-bladed diamond saws and the sections viewed directly. We used microscopical systems of brightfield, darkfield, ultraviolet, polarized, and interference contrast illumination. Annual and annular growth zones were interpreted relative to known-age and tetracycline-labelled specimens of representative furbearers including beaver (*Castor canadensis*), black bear (*Ursus americanus*), coyote (*Canis latrans*), fisher (*Martes pennanti*), red fox (*Vulpes vulpes*), marten (*Martes americana*), mink (*Mustela vison*), raccoon (*Procyon lotor*), skunk (*Mephitis mephitis*), and wolf (*Canis lupus*). We developed a technique for labelling free-ranging specimens with biomarkers—for example, tetracycline—to build up known-age reference individuals in local populations.

Key words: aging furbearers, tooth histology.

[1]The authors of this report given at the symposium did not submit a manuscript for publication.

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Furbearer Population Dynamics: A Local and Regional Management Perspective[1]

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Abstract: Compensations are any short-term adjustments by means of reproduction, mortality, and movements at the population level. Generally regarded as a holistic idea, compensation provides a conceptual framework for understanding the impact of hunting and trapping on furbearer populations. Differences in the nature of compensation among species arise from the different life strategies prevalent among furbearers. Continuous long-term density estimates of furbearer populations have been difficult to obtain; thus, few reports have quantified the rates of change in population processes. Data on rates of change would provide a more convincing measure of compensation. Currently, wildlife managers must deal with both dramatic and insidious changes in wildlife and their habitats because of man's activities. The needs of management require that researchers test hypotheses concerning population dynamics at the local level. At the regional level, an integrated research effort should be directed toward an evaluation of land-use and animal relationships so managers can better monitor and predict the health, distribution, and abundance of furbearers on a long-term basis.

Key words: beaver, compensation, coyote, furbearers, furbearer management, habitat, intercompensation, land use, muskrat, population dynamics, red fox.

Wildlife managers consider the main objectives of hunting and trapping to include recreation, economics, and control of diseases and nuisance animals. Like other game-management programs, the rationale behind the harvest

[1]A contribution from the Pennsylvania Cooperative Wildlife Research Unit, The Pennsylvania Game Commission, The Pennsylvania State University, U.S. Fish and Wildlife Service, and Wildlife Management Institute, cooperating, Unit Paper 249.

of furbearers is that most local populations produce excess numbers and that regulated hunting and trapping can help balance furbearer populations with other resources (Todd 1981). This balance has been referred to as the economic carrying capacity (Caughley 1979), when maximum sustained yields are achieved.

Within the past decade increased attention on energy development and production of food for humans has reduced and will continue to reduce habitats for wildlife, including furbearers. This problem poses at least 3 questions for wildlife managers: (1) To what extent, if any, are furbearers responding to land and water alterations? (2) Can the harvest of furbearers by hunters and trappers continue at the levels achieved during the past decade? (3) Will our society accept a new equilibrium between furbearers and their environment, especially if it means reducing the diversity and population density of furbearers? These questions cannot be answered because data concerning animal responses to changing habitats are lacking.

We thank R. G. Carson for help with the literature survey. R. P. Brooks, J. S. Wakeley, and R. H. Yahner provided valuable criticism of an earlier draft.

THE CONCEPT OF COMPENSATION

Responses, adjustments, and adaptations to environmental change are an essential part of the lives of all wild animals. Populations that adjust to change will survive; those that do not become extinct.

The idea of compensation has been used to discuss changes associated with vertebrate populations (Solomon 1949, Ricker 1954), including furbearers. Perhaps more than anyone else, Errington (1946, 1957*a*, *b*, 1963*a*, *b*) stressed the role of compensatory activity in predator–prey systems. Predation was regarded as compensatory if it substituted for or replaced other mortality factors; if predation added to all other mortality, it was regarded as additive or noncompensatory. According to Lidicker (1978) the idea of compensation appeared in the writings of many early ecologists. Compensation is viewed as holistic in that both abiotic and biotic factors influence populations.

The term compensation has been used to discuss the relationships among the primary forces (reproduction, mortality, and movements) of population dynamics. Interactions among different factors influencing the primary forces were also regarded as compensatory. Thus, Lehmann (1946) noted that damage by skunks (*Mephitis mephitis*) to quail (*Colinus virginianus*) did not increase as coyote (*Canis latrans*) predation decreased; in this situation, intercompensation between mortality factors was absent.

Thus, compensations involve the primary forces affecting animal density as well as the numerous factors in the animal–environment complex (Fig. 7–1). The abiotic and biotic factors, as related to density, have been referred to as regulatory, anti-regulating, or nonregulating (Keith 1974, Lidicker 1978), density dependent or density independent (Smith 1935), direct density dependent or inverse density dependent (Allee et al. 1949:332).

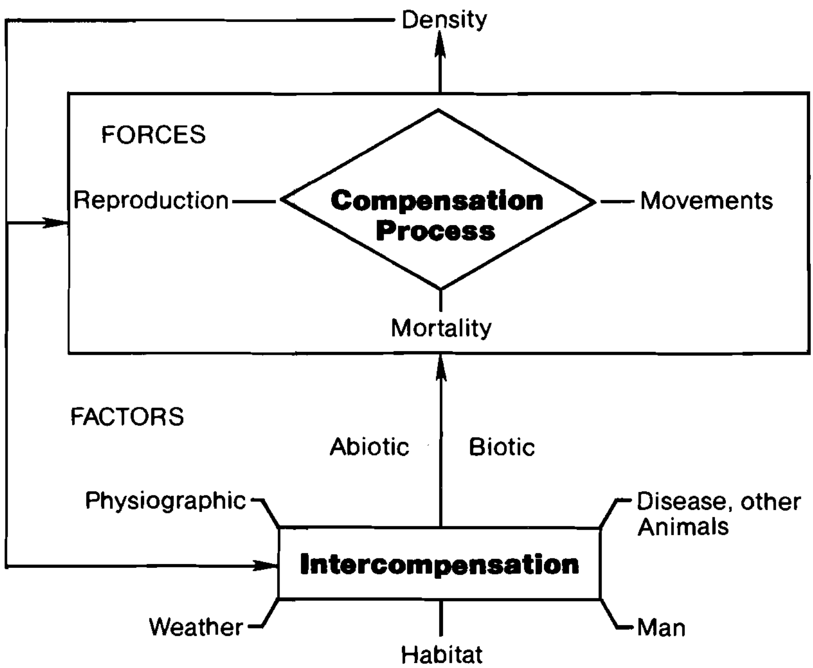

Fig. 7-1. The relationships between density and the 3 main forces of population dynamics and the abiotic and biotic environmental factors.

For the present report, we view compensations as any short-term changes at the population level that are implemented by 1 or more of the 3 primary forces of population dynamics and which operate within the limits of natural environments. In this broad sense, compensations may also be regarded as changes associated with behavioral or ecological adaptations (Pianka 1974).

The concept of compensation is central to the question of whether hunting and trapping have negative, positive, or neutral impacts on furbearer populations. Biologists tend to convey the idea that the basic relationships among harvest rates, compensatory processes, and density are generally well known. Typically, the literature indicates that in exploited populations, reproduction and immigration tend to be relatively high, whereas nonharvest mortality and emigration tend to be relatively low. Thus, the density tends to decrease if compensatory actions are not pronounced but is stable if compensations balance exploitation (Fig. 7–2). If, however, exploitation were eliminated or markedly reduced, the processes would tend to be reversed as compared with nonexploited populations (Fig. 7–2).

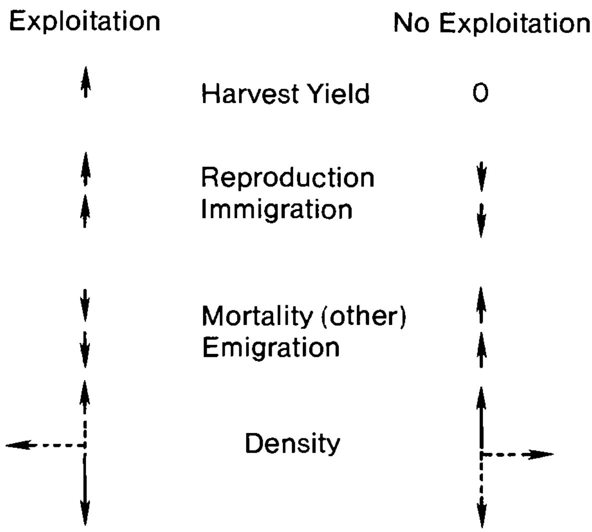

Fig. 7–2. Potential changes in the primary forces of population dynamics and density as related to exploitation. Arrows depict the direction of change when compensatory activity is present. Changes in the processes must be related to time (monthly, annual, multiannual) to be meaningful.

The question of whether the arrows associated with density (Fig. 7–2) are pointing up, down, or horizontally has plagued biologists for many years with a variety of wildlife species, including furbearers. For management purposes, we are interested in knowing about the degree of change in these processes with respect to hunting and trapping.

Our report attempts to explore the following questions: (1) Are compensatory processes a primary feature of some selected furbearer populations exploited by hunting and trapping? (2) How does the concept of compensation relate to studies of habitat–furbearer relationships and a research and management framework for the future?

The next section briefly reviews information relevant to compensations concerning 4 species of furbearers—the beaver (*Castor canadensis*), muskrat (*Ondatra zibethicus*), coyote, and red fox (*Vulpes vulpes*). This review is followed by a discussion of the complexities and problems in understanding compensations and the relationship of compensation to a research and management framework for the future.

COMPENSATION IN BEAVER

Historically, the beaver was found throughout most of North America. Exploitation by trapping and hunting extirpated the beaver from most of its range. However, reintroduction and protection enabled the beaver to become reestablished (Buckley 1950). This species is susceptible to overharvest but may create nuisance situations if underharvested (Parsons and Brown 1978).

The colony, consisting of an adult pair and progeny from 1 or more annual breeding seasons, is the common social unit (Novak 1977, Bergerud and Miller 1977). Densities vary from 1 colony/2.6 km^2 to 1 colony/0.5 km^2 (Bergerud and Miller 1977) or from 0.3/colony per linear km of stream to 1.3 colonies/km (Nordstrom 1972). Disease (Lawrence et al. 1956), intensive trapping (Nordstrom 1972), and depletion of food resources (Krefting 1968) are important factors that reduce populations. Unoccupied habitat is colonized primarily through the dispersal of 2-year-olds during spring (Bradt 1938, Aleksiuk 1968, Svendsen 1980). Novakowski (1965) and Nordstrom (1972) hypothesized that dispersal by 2-year-olds would be delayed 1 or more years as population densities increased. Boyce (1974) concluded that if high-quality sites were available, beaver might breed a year earlier; however, if good sites were occupied, the young might remain in the prenatal colony an additional year. If dispersal were delayed, the older individuals could have a competitive advantage over younger dispersers (Molini et al. 1981).

Nordstrom (1972) observed that compared to exploited populations, unexploïted populations had delayed sexual maturity, smaller litter sizes, lower reproductive rates in adult females, and fewer 2-year old dispersers. He concluded that areas in which vacancies were created by trapping were filled with migrant beaver the following year. Boyce (1974), however, found younger animals breeding in a high-density, exploited population and concluded that high density was a result of younger breeding age.

In summary, the mode of compensation in beaver populations that are subjected to regulated harvest appears to be a change in the proportion of pregnant females, particularly the younger age classes, and a change in the rate of dispersal.

COMPENSATION IN MUSKRATS

The muskrat is still one of the most abundant and heavily harvested furbearers in North America (Willner et al. 1975, Deems and Pursley 1978). This species is generally not prone to overharvest during regulated trapping seasons, although instances of overharvest have been reported (Mathiak 1966, Smith et al. 1981). In some localities an underharvest may be a more serious problem than overharvest (Errington 1963*a*, Mathiak 1966, Smith and Jordon 1976*a*).

Densities of muskrat populations are known to fluctuate considerably from year to year and among areas within years (Errington 1951:278, Butler 1962, Danell 1978*a*). Disease and starvation may at times limit muskrat populations (Errington 1963*a*:566), although disease may not be important in some areas, even when muskrat densities are high (Smith and Jordon 1976*b*).

The ability of muskrats to withstand heavy exploitation and to rapidly colonize vacant habitats can be attributed to high reproductive rates and a strong tendency to disperse. Two to 5 litters of 6 young each may be produced each year depending on latitude.

Errington (1956:307) gave strong support for compensatory activity by means of reproduction when he stated, "One of the commonest ways by which extraordinary losses are offset naturally is by accelerated reproduction." The records compiled by Errington (1951, 1963*a*) in Iowa showed that low densities were associated with high rates of increase expressed as percentage gains in populations from spring to fall. Apparently increased productivity in muskrat populations is caused primarily by an increase in number of litters produced during extended breeding seasons and to the increased survival of late-born young (Olsen 1959, Errington 1963*a*:527). Increased survival of young muskrats, rather than changes in litter size, was associated with intensive trapping pressure in Connecticut; immigration was considered negligible or nonexistent (Smith et al. 1981).

An annual harvest of 50 to 80% of local populations has been recommended to offset losses due to fighting, predation, and disease and to prevent habitat destruction (Errington 1951:275). Smith et al. (1981) concluded that 74% of the fall population could be harvested and an optimum yield maintained.

Relationships among density, social behavior, and movements are not well quantified for muskrat populations. Errington (1963*a*:71) reported that populations with 2 to 3 pairs of muskrats per acre showed as much intraspecific strife as those with 8 to 10 pairs per acre, and adult females tended to be more aggressive than adult males toward weaned young. Other workers have reported that overcrowding leads to more intraspecific strife, increased emigration, and higher mortality (Sather 1958, Mathiak 1966), but quantitative data are lacking.

Dispersal is a common feature of muskrat populations during both spring and fall (Sprugel 1951, Beer and Meyer 1951, Erickson 1963) and even in winter when ice depths are excessive (Mathiak 1966, MacArthur 1978). Dispersal may involve a substantial proportion of local populations, but long-distance movements (> 10 miles) are not common. However, data are lacking to determine whether the proportion of transients remains constant or changes significantly with a change in population density.

Our understanding of the relationships between quality of habitat and muskrat population size in marshes or along streams is still far from complete, especially with respect to riparian habitats (Brooks and Dodge 1981). Neal (1968) and Danell (1978*a*, *b*) indicated that muskrats living in poor habitat have shorter breeding seasons and produce fewer and smaller litters than those living under more favorable conditions. Neal (1977) reported that suitable habitat was more important than trapping in determining muskrat numbers in Iowa. Nichols and Chabreck (1981) reported that marsh habitats provided more preferred food for muskrats than swamp habitats. The abundance of muskrats in brackish marshes also seems to be influenced by the species of vegetation (Palmisano 1973). The impact of drainage and flood-control projects on muskrats can range from disastrous to highly beneficial (Errington 1963*a*).

In summary, the primary mode of compensation in muskrat populations involves an increase in number of litters during extended breeding seasons and increased survival of late-born young. If dispersal is an effective compensatory mechanism, it is probably on a small local level. Information concerning rates of change (changing rather than constant proportions) in reproduction, mortality, and movements relative to density are virtually nonexistent. Muskrats may be adversely affected by weather factors, but their high reproductive rates and mobility provide numerical resilience (Errington 1940). Habitat alteration and introduction of toxic chemicals may pose potential problems in the long run, but more information is needed to clarify muskrat–habitat relationships on a regional level.

COMPENSATION IN COYOTES

One major difference in the dynamics of coyote populations compared with other North American furbearers is that this species has been heavily exploited by depredation control in addition to the more traditional forms of exploitation, that is, sport hunting and trapping. Thus, many population parameter estimates have been obtained from populations that were subjected to varying intensities of depredation control.

Coyotes produce an average of 6 pups per annual litter (Connolly 1977). Information on dispersal is limited but suggests a fall and winter occurrence (Berg and Chesness 1978). Knowlton (1972) and Hibler (1976) reported that the proportion of transients was higher in females than males. Densities of coyote populations have been difficult to estimate; however, a common reported estimate is 0.2 coyote/km^2.

Increases in coyote densities have been related primarily to food availability (Gier 1968, Clark 1972, Todd and Keith 1976). Gier (1968) and Clark (1972) stated that increased food availability caused an increase in both litter size and the percentage of females pregnant. Knowlton (1972:371) stated that, "The percentage of female coyotes that are sexually mature and that successfully whelp is perhaps one of the most important variables in the reproductive capacity of local populations." Furthermore, litter size was positively related to the level of exploitation and presumably inversely related to density.

Reductions in coyote density, over broad geographic areas, have been attributed to a primary cause—the use of a variety of control methods, particularly toxicants (Robinson 1961, Wagner 1972). Murie (1940), Gier et al. (1978), and Todd et al. (1981) speculated that starvation or disease may have reduced the density of local populations.

From 1975 through 1978 Davison and Knowlton (1980) compared 2 coyote populations that were separated by 100 km but had similar food resources. One population was subjected to "substantial exploitation," and the other experienced "light to no exploitation." They drew 4 conclusions, but prefaced their conclusions with the admonition that depredation-control efforts (that is killing of pups at dens) may produce population responses different from those they observed: (1) spring and fall densities did not change as a result of substantial differences in exploitation, (2) recruitment rates were directly related to hunting mortality rates, (3) annual adult and perhaps juvenile survival rates were not related to intensity of harvest, and (4) emigration rates were affected by substantial levels of exploitation, and an inverse relationship existed between emigration rates and juvenile hunting mortality. Furthermore, Davison and Knowlton (1980) stated that losses of juveniles to hunting may not have been compensated for completely by reduced mortality from nonhunting causes. However, differences in loss rates among areas may have been a result of differential rates of emigration. They concluded that if exploitation increased hunting mortality rates but reduced losses from nonhunting causes and emigration in a compensatory manner, such exploitation should not decrease the size of the population the following spring.

In summary, reported changes in coyote density have reflected changes in food availability and intensity of predator-control efforts. The concept of compensation has received little attention. However, the limited data indicate that the primary mode of compensation may be an increase in litter size, an increase in the percentage of pregnant females, and a decrease in emigration rates.

COMPENSATION IN RED FOXES

Previous reports on red foxes indicate differences in reproduction, mortality, and movements among local populations, and that some changes in populations are compensatory. However, quantitative evidence for compensation among the primary forces affecting populations, or between mortality factors such as hunting and disease, has not been published.

One aspect of reproduction that seems to vary markedly among red fox populations is the proportion of nonbreeding females. Layne and McKeon (1956) reported that the proportion of barren females was higher in northern than in southern regions of New York (16.6 versus 2.1%). Englund (1970) also noted that fox reproduction was lower in northern than in southern Sweden; he attributed the difference to greater fluctuations in food supplies in the north. Unpublished data for North Dakota foxes indicated that the proportion of barren females varied by year and age of female (S. H. Allen, personal communication). Storm et al. (1976) reported that only 5% of 188 females were barren in a sample that included both adults and subadults. It is still unclear whether the variation in the proportion of nonbreeding females in local populations is a reflection of compensations related to density per se, or to a combination of factors such as food, weather, disease, and social behavior.

Marked variations in mortality rates of red foxes by locality were reported by Phillips (1970), who noted a high juvenile:adult ratio in central Iowa compared with northeastern Iowa. He attributed this difference in age ratios to higher mortality and immigration rates in central Iowa. Local differences in age structure were also reported by Johnston (1975) in Canada and Maekawa et al. (1980) in Japan.

Trautman et al. (1974) found mean litter sizes of red foxes ranged from 4.7 to 8.8 and concluded that litter size was inversely related to decreased density during an intensive reduction program. Because of the small sample size and the fact that litter sizes ranging from 4 to 8 have been reported for a variety of conditions (Storm et al. 1976), the impact of density on reproduction in their study was not conclusive.

In North Dakota, Sargeant (1972) reported that a combination of high pelt prices and ideal weather conditions resulted in high harvest levels; subsequently, local fox populations declined. Conversely, in Denmark Jensen (1973) noted that fox populations continued to expand despite high and increasing shooting pressure. These examples indicate that responses to harvest efforts differ among areas.

Knowledge of the responses of populations to infectious and parasitic diseases is far from complete. Cause-and-effect relationships are hard to sort out, especially when seasonal fluctuations in infectious disease coincide with changing food resources and unpredictable harvest rates.

Johnston and Beauregard (1969) and Voigt and Tinline (1982) reported that the incidence of rabies was related to density, and that rabies was a primary factor controlling fox populations. Evidence for compensatory activity in Johnston's (1975) studies in Ontario was based on the higher reproductive rates in rabies-endemic areas compared with noninfected areas. However, reports by Johnston and Beauregard (1969) and Johnston (1975) indicate that fox populations have never recovered to levels observed before the early 1950's when the first rabies epizootic was reported in Ontario. This information suggests that compensatory activity has not been able to restore fully the equilibrium density of the prerabies era.

Wandeler et al. (1974) also reported that rabies epizootics in Europe were dependent on fox density. Reports by Wandeler et al. (1974) and Davis (1974) indicate that harvest by either hunting or trapping was not effective in reducing local fox populations or in preventing outbreaks of rabies. Despite intensive fox-reduction programs, rabies is still endemic in Poland and West Germany (Anderson et al. 1981). This information suggests that reproduction and immigration apparently maintained local populations at high enough densities for rabies transmission.

The extent of intercompensations among mortality factors such as sarcoptic mange and harvest by trapping and hunting, has important management implications. Fox pelts are adversely affected by high infestations of the mange mite (*Sarcoptes scabiei*), so wildlife managers are interested in minimizing the damage by mange.

Trainer and Hale (1969:391) reported that fox numbers declined and fewer foxes were harvested after an outbreak of mange in Wisconsin during 1967–1968. Storm et al. (1976:58) provided information that indicated the annual harvests of 1 Iowa trapper may have declined during an increase in the incidence of mange in foxes.

Tullar and Berchielli (1981), Todd et al. (1981), and Ross and Fairley (1969) reported that incidence of mange was positively correlated with density of canids. Clark (1940), Olive and Riley (1948), and Arnold (1956) suggested that mange may play a major role in determining fox density. However, Storm et al. (1976) and Pils and Martin (1978) reported that hunting and trapping were more prominent mortality factors than mange. It seems likely that if hunting and trapping were eliminated, the number of foxes infected with mange would be higher (Tullar and Berchielli 1981). There are no data, however, to indicate that the actual proportion of the local population infected with mange would increase upon termination of trapping.

Whether mange-infested foxes are more prone to die from other factors is not clear. Infested animals may travel less and thereby avoid hunters and trappers. On the other hand, animals weakened by mange may be more susceptible to other infectious diseases.

The impact of density on the movements of foxes has not been studied in detail. Sargeant (1972) noted that as density increased, the size of territories decreased, but he suggested that territory size was limited by innate minimum and maximum spatial and environmental requirements.

High density was thought to increase emigration (Butler 1951, Englund 1970) but quantitative data were not provided. Tullar and Berchielli (1980) related dispersal of juvenile foxes to density within a 100-mile^2 study area and found that the dispersal rate of females from a high-density group was higher than from a low-density group. Data from Illinois and Iowa indicated that fox densities were higher in areas adjacent to the Mississippi River (Errington 1937, Phillips 1970). Storm et al. (1976) and Pils and Martin (1978) found more dispersal away from than toward the river, indicating a tendency for more dispersal from high-density areas.

Some evidence suggests that the distribution and abundance of foxes have been influenced by changes in land use. Davis (1974) determined that the number of foxes in Georgia was high from 1944 to 1952 when the amount of abandoned cropland was high. Conversely, relatively high acreages of forest and pasture during later years (1953–1969) corresponded with lower fox densities.

In the upper midwestern states, Johnson and Sargeant (1977) reported that settlement by European man and conversion of native prairie to intensive agriculture changed the composition of canids from one dominated by the wolf (*Canis lupus*) to one currently dominated by the red fox. However, species such as foxes also have been influenced by predator-control programs (Linhart and Robinson 1972) thus making it difficult to sort out the major factors affecting abundance.

A comparison of different levels of habitat quality with fox abundance has been reported by Wood (1954), Wood et al. (1958), and Davis (1974). Anderson et al. (1981) reported that control programs may be effective in poor habitat but had little impact on fox numbers in good habitat.

In summary, litter size is maximal in the highly exploited red fox populations of the midwestern states. However, the proportion of barren females is variable and may be influenced by changes in food resources and other factors. Infectious and parasitic diseases such as rabies and mange may strongly affect the density of some local populations, whereas hunting and trapping have been ineffective in preventing outbreaks of disease in foxes.

Reports of compensatory changes in red fox populations have not been explicit about the nature of the changes. For example, in a population that was increasing, it is not known if the same proportion of the population disperses from year to year, or whether an increased proportion disperses as the density increases.

One would predict on the basis of the available literature, that hunting and trapping would have the greatest impact on foxes in those areas with a high percentage of barren females, and where land use had adversely affected the food and cover resources for foxes.

COMPARISONS AMONG SPECIES

The nature of compensations is quite different among different species. We expected these differences because of the different life-history strategies among the species we examined. For example, coyotes and foxes have 1 litter per year, whereas muskrats may have as many as 5 per year. Dispersal in female coyotes may be more common than in female red foxes. Distances traveled during dispersal by coyotes and foxes are much greater than those of muskrats. Thus, management must take into consideration the basic life-history strategy, and the compensations that are a part of the life strategy, of each species at each locality.

The lack of information concerning the degree of compensations in populations was common to all 4 species. Thus, there is a need to quantify the rates of change in the population dynamics of these furbearers.

UNDERSTANDING THE COMPLEXITIES OF COMPENSATIONS

Like most facets of biology, the processes involving compensations in furbearer populations are extremely complex and not easily understood on the basis of short-term studies. An appreciation for the complexity and scope of this topic in mammals can be gained from key reports of different species living under changing conditions.

One can readily conclude from over 15 years of work on woodchucks (*Marmota monax*) in Pennsylvania (Davis 1962, Davis et al. 1964, and Davis and Ludwig 1981), that (1) long-term continuous studies are essential to gain insight into the mechanisms affecting the changes in local populations, (2) all 3 primary forces affecting populations should be monitored simultaneously and supplemented with information on behavior and health, (3) the impact of shooting and trapping on these populations was negligible compared with other factors, and (4) the role of changing habitat (food and cover) cannot be overemphasized as the ultimate factor affecting population levels on a long-term basis.

The need to obtain long-term and continuous data is also expressed in the work on both gray squirrel (*Sciurus carolinensis*) (Barkalow et al. 1970, Mosby 1969) and fox squirrel (*Sciurus niger*) (Nixon et al. 1974, 1975) populations. The key factor to sustained yield was habitat.

Squirrel populations in small and widely separated woodlots tend to recover slowly after years of heavy kill (Baumgartner 1943). Conversely, populations in extensive forested areas tend to tolerate heavy hunting pressure.

The important data base of the timber wolf is of interest because compensation in this species may be more clear-cut and of greater magnitude than in coyotes and foxes (Keith 1974). Reduced ovulation and pregnancy rates and higher loss of pups between birth and the subsequent winter have been highlighted as important mechanisms in stabilizing unexploited wolf populations (Mech 1970, Keith 1974).

Published reports indicate that long-term data concerning the primary forces on populations are essential to the understanding of compensatory activity in wildlife populations. Insight into compensations also requires an understanding of the interactions among different life-history parameters or factors. For example, to study the relationship between age ratios and productivity in a highly exploited fox population, it would be necessary to test the validity of certain assumptions: (1) juveniles are less productive than adults, (2) juveniles are more vulnerable to harvest by man than adults, and (3) the immigration rate of juveniles is greater than that of adults. If these assumptions are valid, the second and third assumptions could operate as opposing forces on the age ratio (Fig. 7–3), but intensive study would be required to disprove each assumption.

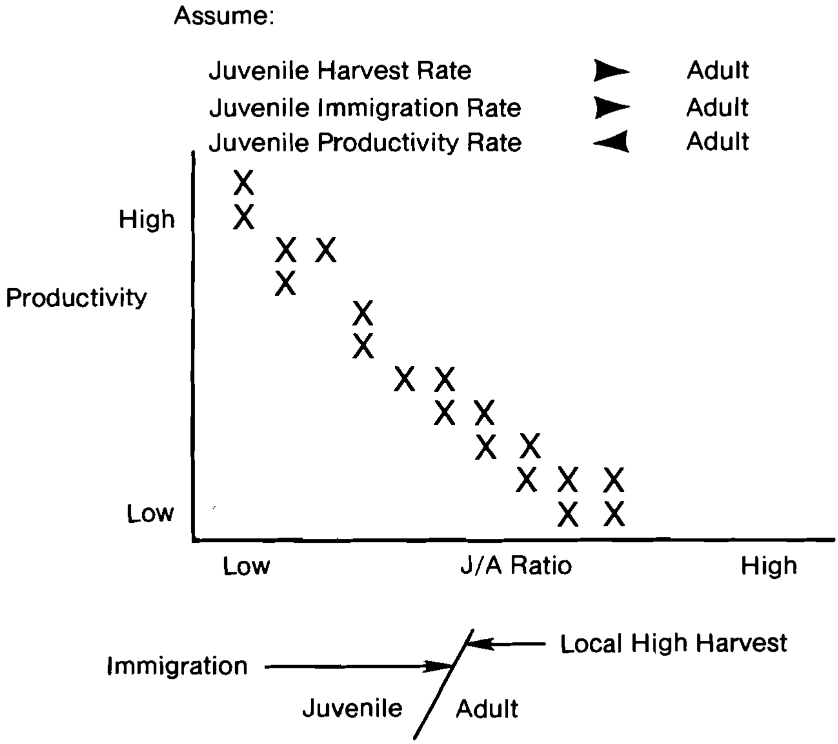

Fig. 7–3. The potential relationship between productivity and age (juvenile:adult) ratios. Note the 3 assumptions for consideration in developing this relationship. In an exploited population, the immigration and local harvest may act as opposing forces on the age ratio, if all 3 assumptions were valid.

Finally, it is important to note changes in animal behavior in response to man's activities. For example, coyotes learned to avoid traps, poisons, and even airplanes (Leopold 1966); foxes avoided dens that were gassed during control operations (Wandeler et al. 1974); and badgers (*Taxidea taxus*) became more wary of man after long-term persecution (Messick et al. 1981). Likewise, the ability of certain species to adapt to urban or suburban environments has been reported (Harris 1977, McComb 1981, MacDonald 1981).

SOME CONTROVERSIAL STATEMENTS—FACT OR FICTION?

Details on all facets of local furbearer populations on a long-term basis are difficult to accumulate; therefore, answers to some major questions concerning population dynamics and impacts of harvest on populations are incomplete. The following statements are presented as "fact or fiction" to illustrate the point.

1. *Hunting and trapping prevent outbreaks of disease.*

Data are not available to support this statement. Some evidence, referred to earlier in this report, indicated that infectious and parasitic diseases help regulate the periodic ups and downs of local populations. However, little evidence is available that demonstrates shooting and trapping during regulated seasons prevent outbreaks of disease.

2. *Intercompensations among mortality factors are well documented.*

Data are not available to support this statement. The lack of quantitative data concerning intercompensations among mortality factors is well known (Sanderson et al. 1979). Mortality in furbearers is difficult to study because harvest rates are not closely monitored, and mortality caused by nonharvest factors may go undetected.

Intercompensation among mortality factors is not even well described in large species for which the harvest rate is well documented. Unpublished data tabulated for the Pennsylvania Game Commission (G. Alt, personal communication) on black bear (*Ursus americanus*) illustrate 2 pertinent points (Table 7–1). First, the number of road kills increased after the hunting season was closed for 2 consecutive years (1977–78). These data indicate that some compensation may have occurred, but the density of bears may also have increased. The important point is, that to estimate intercompensation one must also look at data on density, reproduction, and dispersal during the same time. Second, a human factor was involved. After 2 seasons of closed seasons, local land owners and bee keepers became more concerned about nuisance bear; this concern may have resulted in increased kills.

3. *Evidence for compensation is based on rates of change.*

Data are not available to support this statement. Few, if any, reports present

Table 7–1. The number of black bear killed in Pennsylvania during legal hunting seasons, roadkills, and other factors in relation to 2 years of closed hunting seasons.

Year	Hunting	Roadkills	Other
1975	434	69	33
1976	703	57	19
1977	0[a]	59	14
1978	0[a]	84	18
1979	856	88	73
1980	921	112	90
1981	819	117	70

[a]Legal hunting season closed.

data that distinguish whether changes in mortality or dispersal rates, relative to increased density, mean a change (increase) in the proportion of animals that die or disperse, or whether the same proportion is affected at any density. Data on this topic are also lacking for small mammal populations (McClenaghan and Gaines 1976).

A RESEARCH AND MANAGEMENT FRAMEWORK

The backbone of population dynamics is the animal–habitat relationship at the local and regional level. Thus, to understand and manage furbearer populations one must understand the interactions between furbearers and their environment. In North America, 1 of the most dramatic offensives by man on the wildlife–habitat complex occurred during an era (1800 to early 1900's) when hunting and trapping were virtually unregulated. Today, we are witnessing a much different situation. Laws and regulations and enforcement of rules are at a peak, and a renewed insult to land and water is occurring in the form of chemicals and increasing acreages of homogenous units associated with agricultural and urban areas.

We believe a conceptual framework of the animal–habitat complex at local and regional levels will help put the idea of compensations into better perspective (Fig. 7–4). At the local level, we should continue to evaluate the relationships between habitats and local furbearer populations. The evaluations will provide the information necessary to delineate the factors influencing the fluctuations in animal numbers. It is at the local level that insights into mechanisms of compensation and their role in keeping populations within the carrying capacity will be achieved. At this level, we must ask better questions and shift from descriptive biology to hypothesis testing, experimental design in field research (Sanderson et al. 1979), and population modeling (Johnson 1982).

Numerous questions remain unanswered about the relationship between harvest and other mortality factors of furbearers, and between habitat and the physiological and demographic parameters of furbearers. Unanswered for many local situations are questions like: Is there an increase in the proportion of foxes killed by mange when trapping and hunting are reduced or eliminated? Is the quality of polluted habitats adversely affecting the health and productivity of muskrats?

Because management decisions are generally not made on the basis of 1 or 2 local conditions, we must appreciate the relationship between the local and regional situations, that is, how does your local situation fit into the big picture?

At the regional level, the basic task is easily stated—land use and habitat for wildlife must be periodically classified and inventoried, and trends in furbearer populations must be related to trends in land use and habitat. Only at the

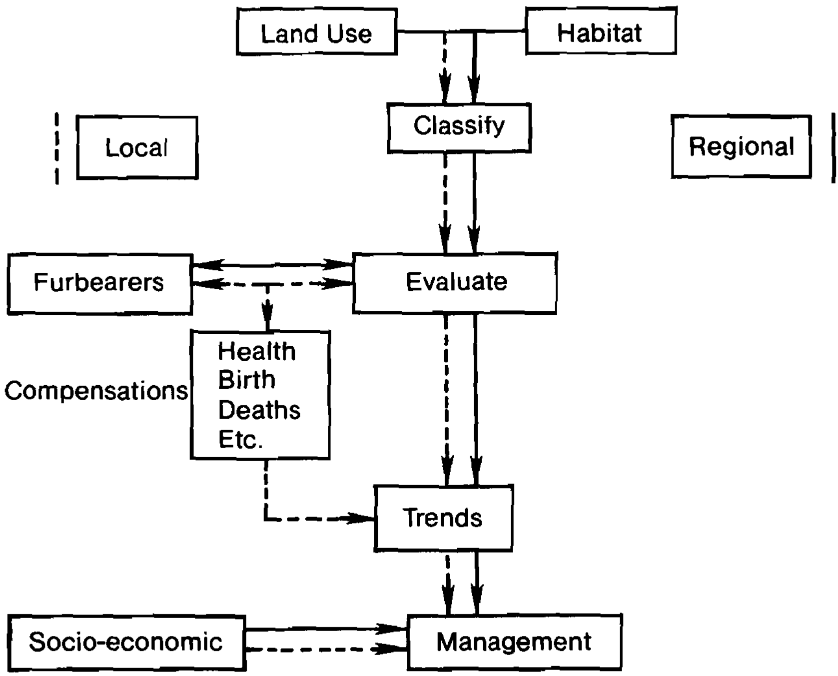

Fig. 7–4. A conceptual framework for furbearer research and management consisting of local (dashed line) and regional (solid line) components. Note that the concept of compensation is primarily related to studies at the local level. Socio-economic factors are relevant to the entire research and management process but are directed only to the management component in this diagram for the sake of simplicity.

regional level can we hope to detect long-term trends and make predictions of furbearer populations as related to changing environments. Data collection will be difficult because the whole framework will be affected and limited by numerous social and economic constraints. It will require cooperation among management agencies at the private and all public levels, uniform and consistent data-collection procedures, and development of an information storage system that can be accessed readily by all potential users.

CONCLUSIONS

1. Compensatory activity is a common feature of furbearer populations, but the nature of compensations varies considerably among species.

2. Few data are available to quantify the degree of compensation in population processes of furbearers. It may be that compensations help maintain local populations within the carrying capacity provided by food and cover resources, but supporting data are not available.

3. There is evidence to suggest that changes in landuse and habitat markedly influence furbearer populations; thus, habitat and its associated food and cover ultimately limit mean density.

4. Although habitat quality has been associated with density of furbearers, few studies have related habitat quality to the health of furbearers.

5. A research and management framework is presented that would facilitate an information system at the local and regional levels. The information obtained on a long-term basis should lead to new levels of knowledge and be useful in furbearer management.

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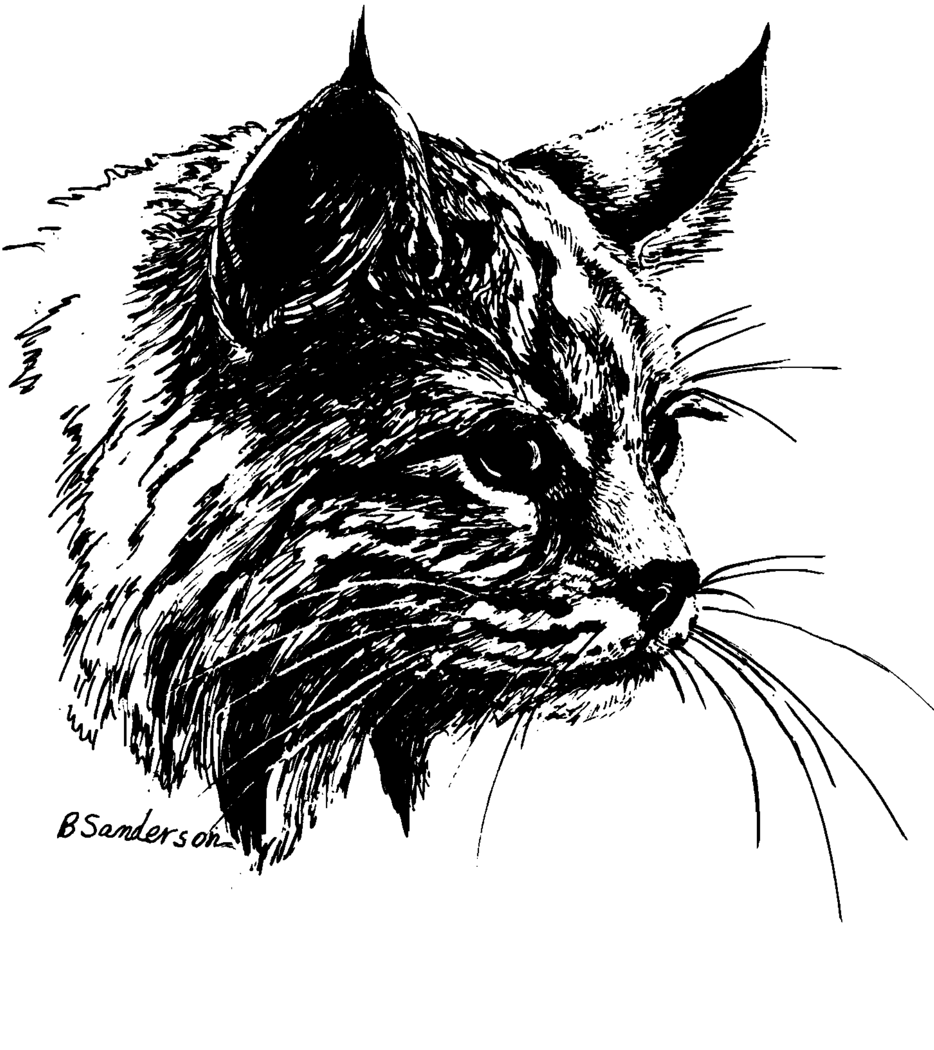
B Sanderson

The Public and the Furbearer Resource

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Abstract: Furbearer management involves management of people as well as management of furbearers. A variety of economic, aesthetic, recreational, and ecological values (both positive and negative) are associated with furbearing mammals. Management decisions must be based primarily on biological criteria but should also consider economic, social, and political ramifications. Although public attitudes and needs should be assessed, they should not dictate management policy. Public opinions are often based on lack of knowledge, misunderstanding, and emotion. Disagreements among or within specific publics concerned with furbearers lead to expenditures of time and money on divisive or nonproductive conflict. Activities of unaware, unconcerned, or antagonistic publics that lead to destruction or degradation of furbearer habitats pose a greater threat to furbearer populations than any harvest or nonharvest use. Public demand for more accountability by agencies that manage wildlife resources will require researchers and managers to develop and implement more sophisticated and sensitive techniques for monitoring and managing populations of native furbearers. Education and public relations programs directed at key publics will help to promote more responsible use of the resource and minimize conflicts, while maximizing benefits to wildlife and society.

Key words: furbearer resource, public.

The primary emphasis of modern furbearer management is not on managing the furbearer resource itself but on managing human use of the resource. This paper will review salient and significant characteristics of the publics that furbearer managers most commonly encounter and examine how they interact to affect management of that resource.

Some furbearer populations are managed directly by habitat improvement and manipulation. However, the primary management tool used in most areas

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is control of the harvest by regulating harvesters. Furbearer harvesters are composed of 2 groups—trappers and hunters. Furbearer hunting and trapping are considered by many to be, at least in part, recreational activities, but they are often motivated by economic considerations. This combination makes the management of furbearer harvest and harvesters unique in the field of wildlife management.

To add to the complications confronting the furbearer manager, a growing segment of the public is trending toward more nonharvest use of wildlife resources (Scheffer 1976). Wildlife in this country has been considered to be the property of the people, but the primary clientele of state wildlife agencies have traditionally been the hunters, trappers, and fishermen who have supported the cause of wildlife management for many years. That is as it should be, but times are changing and wildlife management agencies must maintain the responsiveness and flexibility to change with them. As Shaw et al. (1978) have stated, "wildlife and wildlife concerns are no longer solely the realm of select interest groups." This change does not mean that wildlife agencies should turn their backs on hunters and trappers, but it does suggest that the goals and objectives of management should be broadened to encompass a wider range of public needs, when warranted by public interest.

Agencies managing wildlife should do so in the public interest for the maximum collective benefits of society. In making management decisions, wildlife managers must consider not only biological factors and resource limitations but they must also take into account user preferences, economic imports, and political ramifications of those decisions. It is important for furbearer managers to consider the various values (in human terms) of the furbearer resource in relation to the potential impacts of planned actions. Recently, opinion surveys have become a common method of measuring public or user group attitudes towards natural resource issues (Kellert 1979, 1980 *a, b, c*; Arthur 1978; Arthur et al. 1977; Arthur and Wilson 1979; Stuby et al. 1979). Although these surveys provide useful information to the wildlife manager, they should be interpreted and used with caution.

The following data regarding attitudes and characteristics of publics of interest to furbearer managers are largely summarized from various studies reported by S. R. Kellert, Yale University, and L. M. Arthur, U.S.D.A. Economics, Statistics and Cooperative Service, with supporting data from other less extensive studies, when available.

THE GENERAL PUBLIC

Kellert (1980*b*) found that the American public, as a whole, had limited knowledge of animals. For example, "only 26 percent knew the coyote is not an endangered species." Public attitudes and opinions may be based on lack of information or misinformation; often a person may not form an opinion until asked to respond to a specific question. Also, as Kellert (1980*b*) has pointed out, the public seems more aware of emotional issues (such as trapping) that involve specific, attractive, and "higher" animals (such as furbearers) than more abstract issues or those that involve "lower" animals.

Shaw et al. (1978) found that a narrow majority (55%) of the American public approved of legal hunting. That finding is similar to, but lower than, the 64% approval of recreational hunting (if it included using the meat) found by Kellert (1980*b*). Arthur and Wilson (1979), in a national telephone survey, found that the general public valued all nonconsumptive uses of wildlife resources greater than any consumptive use. Surprisingly, this relationship held true for the 56% who approved of hunting (20% of whom were estimated to be active hunters). Arthur and Wilson (1979:33) also found that "the general public valued and enjoyed sport hunting less than any other use of wildlife, with the exception of wildlife as a source of furs." These findings parallel those of Kellert (1980*b*) who found that 29% of the public strongly objected to sport hunting and 57% disapproved of killing furbearers to make clothing even if the species were not endangered. Kellert (1980*b*) also found that 70% of a national sample objected to trapping wild animals with steel leghold traps. (Use of leghold traps was 1 of the 3 most widely recognized wildlife issues in the survey.) However, "it would not be warranted to conclude, based on the wording of the question, that the public would support a prohibition or restriction on the use of the leghold trap" (Kellert 1981). Dahlgren et al. (1977) also found that in Iowa, public opposition to trapping was greater than opposition to hunting.

HARVEST PUBLICS

Hunters

Recent surveys of attitudes and opinions have not distinguished between hunters of furbearers and hunters of other types of wildlife. Therefore, this discussion will focus on hunters in general, keeping in mind that some furbearer hunters will have different motivations (because of potential monetary incentives) than other types of hunters.

Kellert (1980*a*) found that most hunters were male (85%) and white (93%). The educational levels of hunters and nonhunters were roughly similar, and hunters had significantly higher incomes than nonhunters (Kellert 1980a). Hunters were more likely to reside in areas of lower human population density than nonhunters. This last finding is consistent with those of Hendee and Potter (1976) and Shaw (1977) who found that a majority of hunters were from a rural background.

Hunters scored significantly above nonhunters on knowledge of animals and the primary reasons given for hunting were for meat (44%), for sport (38%), and for contact with nature (18%) (Kellert 1980*a*). This finding contradicts that of Arthur and Wilson (1979) who found that the opportunity to experience the natural wildlife environment is a major determinant of user-satisfaction, followed by the opportunity to enjoy the companionship of others with similar interests.

Trappers

In a national sample, Kellert (1980*a*, 1981) found that only 0.7% of the general population participated in fur trapping during the preceding 2 years compared with 14.5% who hunted. Kellert (1981) found that trappers "were unusual in their exceptional degree of knowledge, affection and concern for wildlife and natural habitats, unrelated to any objection to the consumptive exploitation of wildlife or human mastery over animals and the natural world." Kellert (1981) found this protectionist concern encouraging, but pointed out that trappers' lack of empathy for ethical objections to exploiting animals would almost inevitably lead to conflicts and misunderstandings with humane and animal welfare interests.

Kellert (1980*a*) found that most trappers were male (76.5%) and white (95%), although 25% reported some American Indian ancestry. The educational mean of trappers was slightly below that of nontrappers, whereas income was significantly above. Trappers overwhelmingly opposed increased license fees because it would exclude many youthful trappers (87%), and a significant number (72%) supported a mandatory trapper education requirement (Kellert 1980*b*). These general findings are supported by similar results from more localized surveys (Todd 1981, Penkala 1981, Marshall 1981, Bailey 1981, Samuel and Bammel 1981).

NONHARVEST PUBLICS

Antiharvest

As mentioned previously, 29% of the public strongly opposed sport hunting, 57% disapproved of killing furbearers for clothing, and 70% objected to the use of steel leghold traps (Kellert 1978, 1980*b*).

Kellert (1978) found the following characteristics representative of antihunters: Demographically, antihunters included a disproportionately large number of females, were more likely to reside in urban areas, had less experience raising animals, and scored among the lowest on knowledge of animals of any group studied. Antihunters also strongly objected to the use of animals in circuses, killing wildlife for fur, steel leghold traps, rodeos, most animal laboratory experimentation, raising ranch mink, keeping birds in cages, cage zoos, and killing seals for skins. Kellert (1978) interpreted these findings to suggest an ethical concern for animals as a more common basis for antihunting sentiment than strong emotional attachments to animals.

Shaw and Gilbert (1974) found that negative responses to sport hunting could be divided into 2 distinct components—anti*hunting* and anti*hunter*. Antihunting (antikill) involves the value systems of individuals and is concerned with philosophical concepts or abstracts such as morals, ethics, and religion. Antihunter sentiment is generated by irresponsible, unethical, or unsafe conduct by hunters. Kellert (1980*a*) found that the most frequently cited primary reasons for opposition by the 40% of the public who objected to any form of sport or recreational hunting were: morally wrong to kill animals for this purpose, 56%; pain and suffering experienced by the animals, 18%; general love for animals, 15%; opposition to firearms, 5%; and disrespectful and unethical conduct of hunters, 6%. These findings suggest that individuals who oppose hunting are more opposed to hunting than to hunters.

A number of authors have linked the growing opposition to hunting to increasing urbanization (Leonard 1972, Shaw 1974, Applegate 1975). Kellert (1976) found that rural dwellers were more utilitarian than city residents and supported such practices as hunting for meat, the use of steel traps, and the killing of wild animals for fur. This finding is consistent with the rural orientation of hunters and trappers noted in preceding sections.

Livestock Producers

In Kellert's (1980*a*) survey, livestock producers made up 6.4% of the national sample and were the oldest activity group sampled. Livestock producers demonstrated relatively high knowledge of animals and had very utilitarian views towards them (Kellert 1980*a*). They exhibited "a generally unsentimental and highly pragmatic orientation to animals. . . . ," but indicated a general interest in wildlife and support for an ecological perspective of natural resources (Kellert 1980*a*:121). In Missouri, livestock producers were found to be more ecologically oriented than grain farmers (R. Evans, personal communication). Livestock producers were more antipredator than other groups and an overwhelming majority (80%) believed that most goals of environmentalists threaten the continued economic prosperity of this country (Kellert 1979).

Conservation Organization Members

This group represents a mixture of harvest and nonharvest users. Kellert (1980*a*) found the following membership and attitude characteristics from his national sample. A total of 11.3% of the national sample belonged to 1 or more of 36 conservation-related organizations grouped as follows: general conservation, 5.5%; sportsmen organizations, 3.7%; wildlife preservation, 2.9%; humane, 1.4%; and environmental protection, 1.1%. Sex differences in membership among the groups were considerable; humane organizations were only 20% male, whereas sportsmen organizations were over 89% male. Members of all conservation organizations had higher education levels than nonmembers;

environmental protection organizations had the highest and sportsmen and humane organization members the lowest.

Kellert (1980*a*) also found that members of all conservation organizations scored much higher on animal knowledge compared with nonmembers; wildlife preservation and environmental protection groups scored the highest and general conservation the lowest. A pronounced ethical concern for the rights and welfare of animals was found among members of wildlife preservation, humane, and environmental protection groups, whereas sportsmen ranked low in this category. All membership types indicated a strong personal interest in wildlife, the outdoors, and animals in general, although members of humane groups probably had greater affection for pets and less concern for wildlife. Sportsmen members showed strong interest in satisfactions derived from expressions of prowess and skill in relation to wildlife.

Photographers

In Kellert's (1980*a*) study, 42% of the national sample reported photographing an animal during the preceding 2-year period, although more than a third photographed domestic animals. However, no furbearers were among the top 8 groups of animals photographed. A 1975 study by the U.S. Fish and Wildlife Service found that 8% of the population over age 9 participated in wildlife photography, whereas a similar 1970 survey by the Bureau of Outdoor Recreation indicated 3% participated (from Kellert 1980*a*). Arthur and Wilson (1979) reported that more than half the wildlife photographers were also hunters and fishermen.

THE FURBEARER RESOURCE—VALUES AND CONFLICTS

Wild, native furbearing mammals in North America comprise a diverse, and often highly productive, renewable resource base. Most furbearers, like most other species of wildlife, normally produce an annual surplus, a portion of which can be removed under regulated harvest on a sustained-yield basis. However, if the surplus animals are not removed by man, other compensatory mortality factors (disease, starvation, exposure, predation, and others) hold the population within the limits of its environment. Furbearer population levels are ultimately determined by the quantity and quality of suitable habitat.

In the past, uncontrolled harvest was responsible for declines in furbearer populations (Trefethen 1975). Currently, hunting and trapping regulations prevent the overexploitation of furbearer populations. Such regulations, however, have no control over loss of habitat, which today is the single greatest threat to furbearer populations and wildlife in general (Allen 1954, Payne 1980).

Furbearers are a renewable resource that can be used indefinitely under regulated harvest or can be allowed to fluctuate naturally without utilization by man. Either way, annual surpluses will continue to be produced and will continue to be cropped, whether by man or by nature. Which course is the most desirable or ethical is a matter of individual opinion. Morality and ethics are human concepts relating only to man and cannot be extended to other organisms (Guthrie 1967) or to nature. However, even total prohibition of harvest by man is a form of management that could hardly be considered natural in the highly modified environments in which we live. Furbearing mammals, like most species of wildlife, have both positive and negative economic and social values, which can vary over time and space and among individuals. Any values applied to furbearers, positively or negatively, are purely human constructs, but the furbearer manager needs to consider the range of values associated with various furbearer species. Management objectives will usually be related to maximizing, minimizing, or optimizing specific values or combinations of values.

Economic Values

The primary positive economic value of furbearers is the value of the pelts. Of the 25 species of furbearers harvested commercially in the United States in 1975–76, muskrat (*Ondatra zibethicus*), raccoon (*Procyon lotor*), nutria (*Myocastor coypus*), opossum (*Didelphis virginiana*), and red fox (*Vulpes vulpes*) were the 5 most numerous—92.3% of the harvest (calculated from Deems and Pursley 1978). In terms of value, the top 5 species were raccoon, muskrat, nutria, red fox, and coyote (*Canis latrans*), accounting for 87.6% of the value (Deems and Pursley 1978). In Canada, of the 22 species harvested commercially, the top 5 in number were: muskrat, beaver (*Castor canadensis*), raccoon, mink (*Mustela vison*), and red fox; and in value were: muskrat, beaver, coyote, red fox, and lynx (*Lynx canadensis*) (Deems and Pursley 1978). Total value of raw pelts harvested in the U.S. and Canada in 1975–76 was more than $150 million (Deems and Pursley 1978).

Despite the size of these figures, however, only a small proportion of trappers derive most of their income from trapping. For most it is a recreational activity and source of supplemental income (Todd 1981, Penkala 1981, Marshall 1981, Bailey 1981, Samuel and Bammel 1981). Furbearer hunters probably also hunt primarily for recreational rather than economic reasons, although their reasons are poorly documented.

Some furbearers adversely affect man's economic interests in certain situations. Probably most important of these is direct predation by furbearers (such as coyote, bobcat (*Lynx rufus*), or fox) on domestic livestock. Beaver can do tremendous damage to crops, trees, and water-control structures by dam building, burrowing, and gnawing. Also, muskrat, raccoon, skunk (*Mephitis mephitis*), and badger (*Taxidea taxus*) may damage crops, lawns, and dikes by feeding or burrowing. Many furbearing mammals also serve as reservoirs and vectors of diseases and parasites that can affect man or domestic animals. No good estimate of total economic loss caused by furbearers is available nationwide, but it would amount to tens of millions of dollars annually.

Recreational Values

As mentioned previously, recreational enjoyment is probably the primary motivation for most furbearer hunters, particularly those who run hounds. Surprisingly, most trappers questioned also rated recreational values (nature enjoyment, challenge, relaxation, and companionship) above economic values as motivations for their activities (Marshall 1981, Bailey 1981, Samuel and Bammel 1981).

Planned recreational viewing of furbearers by nonharvest users is probably minimal, because of the largely nocturnal and secretive nature of most of these animals. These same traits make most furbearers difficult to photograph. More frequent activities of nonharvesters are probably observing sign of furbearers and tracking. Unfortunately, few good data exist quantifying recreational values of furbearers.

Aesthetic Values

Furbearing animals have positive aesthetic values for many people. However, these values are difficult to measure because of their highly personal and variable nature. Relatively few people intentionally set out to observe furbearers directly; larger numbers enjoy furbearers vicariously through magazines, television, and movies. Some people derive "existence satisfaction" just from knowing an animal is alive and living in its natural environment. One other value, related to both economics and aesthetics, is the value of furs and garments, which are attractive and aesthetically pleasing to many people.

Ecological Values

Many species of furbearing mammals play important roles in determining the composition and characteristics of the wildlife communities in which they live. For example, coyote, red fox, raccoon, striped skunk, badger, and long-tailed weasel (*Mustela frenata*) may, at times, prey on the nests, young, or adults of some upland game birds and waterfowl (Trautman et al. 1974, Chesness et al. 1968, Balser et al. 1968, Sargeant 1972, Duebbert and Kantrud 1974, Stout and Cornwell 1976, Greenwood 1979). Most upland game and waterfowl hunters would view this predation as a negative ecological value. However, this same predation might help to maintain diversity or stability in the community, which would be viewed by many as a positive ecological value.

Beavers, by building dams and cutting trees, dramatically change habitat conditions and may benefit many species of wildlife associated with aquatic and open environments. Similarly, muskrats in a marsh environment have significant impacts on emergent vegetation. These impacts make an area suitable or unsuitable for various types of waterfowl. Muskrats may also serve as prey for a variety of mammalian and avian predators.

Conflicts

Shaw (1977) and Todd (1980) lamented that the hunting–trapping controversy had pitted the 2 groups of people most concerned about the future of wildlife (hunters–trappers vs. antihunters–antitrappers) against each other. Even more unfortunate may be the dissension that often exists among the harvesters of the resource—the trappers and hunters (Boggess and Henderson 1981).

The first president of the American Trappers Association, E. J. Dailey, described the antitrapping movement a half century ago as led by "rich fox and 'coon hunters' organizations" (Reiger 1978). Even today, fox and raccoon hunters are in the vanguard of supporters of antitrapping bills in several states (Reiger 1978).

Often serious conflicts develop between those individuals who harvest furbearers and those who oppose harvest, yet both groups are among the most concerned for the welfare of wildlife populations (Shaw 1977, Kellert 1980*b*, Todd 1980). Unfortunately, this conflict is apparently based more on moral and ethical differences, which are strongly held and highly personal, than on concern for the welfare of the resource.

There is a potential for conflicts between fur harvesters and other users of furbearers, such as nature observers and wildlife photographers. However, these groups seldom conflict because few people other than trappers and hunters intentionally set out to observe furbearers.

As mentioned previously, some furbearing mammals can have significant impacts on the wildlife and plant communities of which they are a part. Whether these influences or resource trade-offs lead to conflicts depends on the preferences and goals of people. For example, if management objectives are to maximize production of upland game or waterfowl, high furbearer populations may conflict with those goals.

Economic damage inflicted by furbearers has already been briefly touched upon. Farmers, ranchers, engineers, homeowners, foresters, and others may find themselves in conflict with furbearers when those animals damage their economic interests.

MANAGING THE RESOURCE

The furbearer manager must manage a diverse and elusive resource for an even more diverse and oftentimes volatile public. State wildlife agencies have been given responsibility for managing resident wildlife in the public trust. Therefore, the primary concern of the manager is, and should continue to be, the welfare of the resource. But, furbearer managers also need to reassess the way that values of the resource are measured. If public opinion surveys are to be believed, even trappers (who are probably the most profit-oriented group of wildlife users) value recreational and aesthetic aspects of trapping experiences above monetary gain, as do hunters. Therefore, as Potter et al. (1973), Hendee (1974), Arthur (1978), and Arthur and Wilson (1979) have pointed out, wildlife resources may not be properly measured in hunting and fishing success rates, days afield, or numbers of animals. More important goals for managers might be ensuring the quality of natural habitats for wildlife, providing quality experiences for man in those environments, and preserving ample visual opportunities for naturalistic and vicarious observers in rural and urban settings (Arthur and Wilson 1979).

Payne (1980) discussed those regulations and management procedures that would protect furbearer populations and yet allow the public to use the resource to the fullest. Payne (1980) also discussed a variety of general harvest strategies that could be used to meet various management objectives. He concluded that "usually management objectives for both consumptive and nonconsumptive uses can be accomplished within the same general location. If harvest is carefully regulated so that the annual increment is not exceeded, the breeding stock remains for nonconsumptive users to observe the animals and/or their sign" (Payne 1980:347). Often, management objectives will not be as clear-cut as those described by Payne (1980), and an optimum management plan will require a blending of harvest strategies to meet multiple objectives.

Accurate and sensitive population censusing or monitoring techniques are a prerequisite to efficient and responsible furbearer management. Increasing public demands for accountability on the part of wildlife management agencies means that greater support for furbearer research and management will be needed if present programs are to continue. The recent bobcat controversy and litigation are dramatic evidence of increasing public involvement in the province of wildlife management. No longer is it publicly acceptable for wildlife management agencies to manage furbearers solely on the basis of past experience or "best guesses."

The importance of furharvester and public education to the implementation and success of furbearer management programs has been discussed previously (Boggess 1977, Harvey 1979, Todd 1980, Boggess and Henderson 1981). The education of hunters and trappers should reduce common abuses that result in nonselective capture and unnecessary animal suffering and provide a set of standards for ethical conduct in the field. These types of educational programs will lead to more responsible and selective harvest of the resource and a greater acceptance of furbearer harvesters by the public. However, because the attitudes of those who actively oppose trapping and hunting are derived primarily from strong moral and ethical convictions rather than specific activities of trappers and hunters (Kellert 1980*b*), it is doubtful that educational programs of any type will have much influence on this group.

Because a large segment of the nonharvest public is apparently not actively antiharvest, educational programs may have significant effects on those segments of the public not strongly committed on the hunting–trapping issue (Shaw 1977, Boggess 1977, Todd 1980). But even this optimistic appraisal of the potential effectiveness of educational programs must be tempered by the finding that over 50% of the hunting opponents in a national survey indicated that their attitudes were in the "extremely strong" category (Shaw et al. 1978).

Boggess (1979) and Boggess and Henderson (1981) outlined some of the types of educational programs that have been offered to harvesters in Kansas to improve their competency, ethics, and cooperation, while decreasing unnecessary abuses and resource waste. These programs have included trapping camps, hunter–trapper camps, evening trapping schools, coyote hunter schools, fur fairs, and a 4-H fur harvest project. To date, these programs have been strictly voluntary, which means that they have reached individuals with strong concerns and commitments, but they are probably not reaching the less-concerned individuals who would benefit the most. As Boggess and Henderson (1981) stated, "We must eventually reach a point, given the prevailing attitudes of today's society and the likely attitudes of the future, where some standard is established to assure that trapping and hunting are being conducted as responsibly as possible."

Petoskey (1980:97) believed that, "the usually silent citizen, given the facts and an opportunity to participate in a decision, most often makes the right choice." Assuming that the public will continue to take a more and more active role in the affairs of managing the peoples' wildlife, it is incumbent upon wildlife managers in general and furbearer managers in particular to become more involved in public education and public relations activities.

The proportion of hunters (and presumably trappers) to the general population will continue to decline (Peterle 1967, Hendee 1969). Shaw (1977) believed that "the real challenge facing the wildlife management profession lies not so much in devising effective defenses of hunting, but in enlisting the support of the growing segment of the population that is concerned with the welfare of wildlife, independent of their attitudes toward hunting." Surveys have shown that "anti" and humane organizations are not necessarily opposed to management. Kellert (1980*b*) found that 60% of humane-related organizations and 61% of antisport hunters approved of management efforts to control waterfowl and deer. Agencies need to project the image of a *wildlife* management agency rather than a *game* management agency (Shay 1977, Todd 1981). In most cases projecting a new image would require little shifting of emphasis in programs, but substantial shifting of emphasis in public relations. As Shay (1977) has pointed out, if the wildlife agency can build a strong image as the protector of *all* wildlife species, its credibility will be enhanced on hunting and other issues. The scope of responsibility of management agencies must be redefined from that of providing game for hunters to that of providing wildlife for people (Applegate 1975).

If furbearer managers consider all public attitudes and needs when planning the best use of the resource, the resulting management objectives and programs will be acceptable to a wider range of interested publics. Implementing this philosophy, however, implies some degree of public participation in decision making processes. As Wagar (1972:178) stated, "what ought to be, as contrasted with what can be, is not a technical matter to be left solely to professional judgment. Unfortunately, confusion between technical and nontechnical matters is the error that is getting resource managers into so much trouble lately."

Because resource management issues are so complex and require so many compromises and trade-offs, Wagar (1972) has proposed some alternatives to traditional public meetings and advisory groups. These alternatives include work sessions on specific topics held repeatedly over a period of time. Holding these sessions in combination with public meetings would allow for broader inputs.

Regardless of the specific mechanisms employed, managers of natural resources (including furbearers) should continue to encourage and upgrade public involvement in decision-making, particularly where relative values are concerned, without compromising the resource or scientific principles. Before the public can make informed judgments on management decisions, however, it must receive objective and accurate information about the resource through an effective educational system.

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The Fur Marketplace

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Abstract: The United States fur industry, although relatively small, is one of the most complex and diversified in our economy. Furs taken in the wild are distributed from the trapper and hunter to the country collector and then to the market-based dealer, broker, or fur auction company. Ranched furs move directly from the rancher to the auction company, aided by marketing associations. Furs are then dressed, dyed, and manufactured into garments. Most pelts taken in the wild are exported. During the 1960's the fur industry was dominated by mink. In the 1970's long-haired furs gained in popularity and broadened the appeal and economic base of the industry. Despite troubles in the nation's economy, the demand for furs has remained strong. The industry is constantly resisting attempts to curtail the supply of furs. Efforts to outlaw trapping and to implement excessive federal regulations are considered serious threats. The fur industry has a powerful economic incentive to maintain a sustained supply of wild furs. Sound wildlife management practices are the best guarantee of a successful and prosperous fur industry.

Key words: fur, marketplace.

The United States fur industry, although relatively small, is one of the most complex and diversified industries in our economy. It not only reaches into the controversial area of utilization *vs.* complete protection of animals, but it also occupies a vantage point in the glamorous world of fashion with designer labels that have become household words. Because of their lasting value, fur products are prized not only for their warmth and beauty, but also as good investments. The United States fur industry is an integral part of an international fur trade that affects almost every country in the world—East, West, and underdeveloped.

Furs are either ranch-raised or taken in the wild. Although all furs pass through the same channels of production and distribution, wild furs and ranch-raised furs enter the fur market in different ways.

The chain of distribution for wild furs starts with the trapper or hunter, proceeds to the country collector, and then to the market-based dealer, broker or fur auction company. Ranched furs move directly from the rancher to the auction company, aided by 1 of the 2 mink marketing associations. From the auction, both categories travel the same basic path. Eventually, the furs are tanned in a process known as "dressing." Ranched mink is tanned either by the auction company prior to sale or by the purchaser after sale. Wild furs are tanned by either the dealer or manufacturer. The same variations apply to the dyeing of those pelts that require it.

The processed skin is then manufactured into a fur garment that is sold to the consumer through a retail outlet. Most pelts taken in the wild are exported (*U.S. General Exports*, U.S. Department of Commerce, December, 1980; interview with Ralph Slenker, writer of the United Fur Brokers' *Market Bulletin*). An understanding of the complexities of the fur industry requires an examination of each step from furbearer to furwearer outlined above.

FUR TRAPPERS AND HUNTERS, COLLECTORS, AND DEALERS AND BROKERS

A survey by the Battelle research organization for the American fur industry in the late 1970's found almost a half-million licensed trappers in the United States during the 1976–77 trapping season, about 80,000 unlicensed trappers, and some 300,000 additional persons who trap on their own land or are either too young or too inaccessible to be included in any survey. Battelle concluded that there were over 800,000 trappers of one type or another in the United States, less than 3% of whom derive practically all of their income from trapping (Riddle and Scantland 1978). The substantial increase in Midwest permit sales since the Battelle study was made indicates that the overall figures would require revision upward to be brought up to date.

The furbearers most frequently trapped in the United States are the muskrat (*Ondatra zibethicus*), raccoon (*Procyon lotor*), and nutria (*Myocastor coypus*), which account for almost 70% of all trapped furs. They are followed in order by the opossum (*Didelphis virginiana*), red and gray fox (*Vulpes vulpes* and *Urocyon cinereoargenteus*), mink (*Mustela vison*), beaver (*Castor canadensis*), and coyote (*Canis latrans*) (Deems and Pursley 1978). About 50% of the harvested long-haired furs—raccoon, fox, coyote, and bobcat (*Lynx rufus*)—are taken by hunters (Slenker interview).

Both trapping and hunting take place mainly from mid-fall to late winter, the period during which furbearers develop full, dense coats for protection against the cold. Although furbearers are found in all states except Hawaii, wild fur production is greatest in the Midwest, West, Northwest, and in the marshlands of Louisiana and Texas.

Most efforts to curtail or eliminate harvests of furbearers have centered on trapping, particularly on the leg-hold trap, the type most commonly used to trap furbearers. Trapping is regulated by each state. Despite continued pressure in practically all states, to date only 3 (Florida, Massachusetts, and Rhode

Island) and 11 counties of a fourth (New Jersey) have banned the use of the leg-hold trap.

According to industry sources, there are 25,000 to 35,000 country collectors, many of whom are small operators who sell their furs to larger collectors (Slenker interview). The latter may gather furs from collectors in several states.

When a collector has accumulated a marketable number of skins, he sells them to a fur merchant or ships them to a selling broker or an auction company for sale. The broker or fur merchant often advances money to the country collector so that he may immediately pay the trapper and hunter for the furs. The small collector may receive money from the large country collector to pay the trapper and hunter.

There are 2 types of brokers in the fur industry—buying brokers and selling brokers. Selling brokers represent fur collectors or ranchers or both, and sell to export buyers through other brokers or sell directly to some manufacturers. Buying brokers represent foreign purchasers and some domestic manufacturers and retailers. There are 10 to 12 selling brokers and about twice that many buying brokers in the United States. Buying brokers' commissions range from 2 to 5%; selling brokers' commissions range from 5 to 9% (Slenker interview). The American Fur Merchants and Brokers Association provides a variety of credit services for its members and also serves as liaison with the International Fur Trade Federation, based in London.

FUR RANCHING AND FUR AUCTION COMPANIES

The predominant furbearer being ranched in the United States is mink. Other animals that either are or have been ranched include the red fox, rabbit (*Oryctolagus cuniculus*), chinchilla (*Chinchilla laniger*), beaver, nutria, and, recently, fitch (*Mustela putorius*). U.S. Department of Agriculture statistics show a total of 1,074 mink ranches in 1981, 150 to 200 of which also raise foxes. Some 40 to 50 ranches raise foxes only.

Over 4 million ranched-mink pelts were produced in the United States in 1980 (U.S.D.A. 1981). The average price per pelt was $40 for an estimated market value of $160 million (sales figures from Hudson's Bay Co.). Like wild furs, ranched-mink and fox prices are determined by consumer demand and pelt quality.

Mink color classes fall into 2 basic categories—standard and mutation. The standard, or "ranch" mink is a rich, dark brown color—the darker the color, the higher the value. Eleven basic mutation colors have been produced by rigorous cross-breeding. The 4 most popular colors are demi-buff, pastel, pearl, and violet. The principal ranched-fox colors are blue and silver.

The average mink ranch today has 1,000 female and 200 male breeders (Interview with Sam Bleiweiss and David Loffman, EMBA and GLMA marketing representatives). Although mink ranching is a full-time occupation, the work load varies with the season. Mink breed only in March. The kits (young mink) are born in April or May and develop a maximum coat in November and December, when they are harvested. Ninety percent of all United States ranched-mink pelts are marketed between January and May. Mink ranching is concentrated in the Midwest and Northwest. Wisconsin, Utah, and Minnesota produce half or more of the nation's annual ranched-mink crop.

The rancher markets his mink through a marketing association—either the EMBA Mink Breeders Association or GLMA (Great Lakes Mink Association)—that sells the pelts at auction. The major auction outlets in the United States are the Hudson's Bay Company in New York, the Seattle Fur Exchange, and the Minneapolis Fur Exchange. A relatively new association, the Amerimink Marketing Cooperative, markets its mink through Elbeco, a New York outlet, whose transactions are mostly private treaty sales. Recently, 2 of these auction outlets—the Seattle and Minneapolis Fur Exchanges—have been purchased by EMBA. Each fur auction house operates in a distinctive way, but they all perform similar functions for both producer and purchaser. An estimated 85 to 90% of all ranched-mink passes through these auction companies. (Bleiweiss–Loffman interview).

A representative of the auction company, the solicitor–grader, visits the ranchers to assist them in achieving desirable crops. He advises them on proper breeding techniques and grades their mink "on the hoof." These services are provided to encourage the rancher to ship his pelts to that particular auction company. Because the auction company's income depends on the volume of pelts it handles, there is a considerable amount of competition among them to secure the rancher's commitment to ship to them.

Meanwhile, the auction company lends the rancher up to 50% of the estimated value of the fur pelts he will ship to it. The loan functions as a chattel mortgage in that the pelts serve as collateral for the auction company.

When the pelts are sold, the auction company receives a commission of approximately 8.5 to 9%, for which it grades, sorts, displays, and sells the skins. Recently, the auction companies have been having skins dressed prior to sale and adding the dressing charge to the commission billed to the rancher.

A few days before each sale, the skins are put on "show" so that potential buyers may appraise them. At the auction, buyers try to maintain some secrecy about what furs they are purchasing; therefore, they bid by various facial and body movements recognizable only by the auctioneer. A visiting dignitary once commented ruefully that he had innocently scratched his ear during one such session and found that he had bought a lot of female pastels.

There are at least 3 types of buyers at an auction sale: (1) commission brokers, who operate for either domestic or foreign buyers and purchase an estimated 40 to 50% of the auction volume, (2) furdealers who sell to manufacturers here and abroad and buy about 40% of the volume, and (3) manufacturers who buy from 10 to 20% for their own use.

After the sale, the auction companies hold the furs until the buyers pick them up. If pelts are not picked up by the "prompt date," generally 2 weeks after the sale, buyers are charged for storage, interest, and insurance for the additional time.

In addition to selling mink at auction, both Hudson's Bay and the Seattle Fur Exchange maintain active wild fur departments through which they sell to brokers, dealers, and sometimes to manufacturers and foreign buyers. Auction companies may also sell mink by private treaty agreements without placing them up for auction.

FUR DRESSING AND DYEING

Either before or after sale, the fur pelt is sent to a furdresser. Fur dressing is the tanning process by which the raw fur skin is successively bathed in salts and chemicals to soften the leather and heighten the lustre of the fur, and then the excess flesh is removed by razor-sharp fleshing knives. The quality of the dressing will determine in large part the desirability and marketability of the finished garment.

Dressing is a service industry; the customer almost always retains ownership of the skins. The number of fur dressers has declined drastically during the past 2 decades. Today, only 7 "fancy" fur dressing firms remain in the greater New York metropolitan area, 1 is in Chicago, and a handful of rabbit dressing plants are scattered through the country.

Because the standard or "ranch" mink is highly valued, dressers have added certain substances to the tanning process that are considered dyes by the Federal Trade Commission, which has ordered that the skins be labelled accordingly. This addition to the tanning of mink should not be confused with the actual fur dyeing process, which is performed by a handful of establishments in the fur-market area. The variety of colors available is almost limitless. The increased popularity of long-haired furs during recent years has created a greater demand for the furdyer's skills. Dyeing, like dressing, is a service trade, and ownership of the skins remains with the customers.

FUR MANUFACTURING

The American fur manufacturing industry is located almost exclusively in a 4- or 5-block area at the edge of the ladies' garment industry in New York City. There, skilled craftsmen cut, sew, and nail skins into a wide variety of fur garments.

A network of so-called "contracting" shops has grown up in the fur industry. These establishments manufacture garments or parts of garments for the primary manufacturer. This practice causes considerable friction between the manufacturers and the employees' union because most contracting shops operate outside the realm of the wages, conditions, and benefits prescribed by the union contract. The problem of nonunion contracting is highly volatile. Fur manufacturers claim that they need these establishments because there is a shortage of skilled union help. The union, on the other hand, contends that the practice is a device to avoid paying union wages and providing union benefits to the contracting shop's employees. So far, these conflicting positions have not been satisfactorily resolved.

Presently, there are over 400 union manufacturing firms and an undetermined number of nonunion contractors. The average fur manufacturing shop employs 7 workers. Business has been concentrated more and more in the larger manufacturing firms. Battelle estimated that the largest firms (about 17% of the total) accounted for about 62% of the total shipments of the industry, whereas firms employing 4 or fewer employees accounted for only 18% of industry shipments. (Riddle and Scantland 1978).

Fur manufacturers are represented by 2 major associations that fulfill several functions. Most importantly, they negotiate and administer labor agreements with the union. Secondly, they identify buyers whose payments may be delayed or who may actually default on payments. Because manufacturers operate in a credit environment, the failure to receive funds for a significant portion of manufactured goods may cause a manufacturing firm to fail.

U.S. fur manufacturing has been threatened by competition from fur manufacturers in low-wage areas outside of the United States, such as Hong Kong, Taiwan, and Korea. The manufacture of rabbit-fur garments in the United States has already succumbed to this competition, and there are ominous signs that the manufacture of higher-priced furs is threatened as well.

FUR RETAILING

Manufactured fur garments reach the consumer through several channels. Resident buyers in the furmarket handle from 50 to 65% of all retail sales of domestically manufactured garments for both independent retailers and specialty stores. The independent retailer maintains the closest relationship with the consumer; he advises on purchases and handles repairs, storage, cleaning, and remodeling. The resident buyer surveys the stocks of fur manufacturers and recommends purchases to his clients. A resident buyer may represent a number of stores throughout the country, but he will never represent more than 1 store in any 1 city.

Buyers affiliated with department stores and leased outlets (departments operated by major retailers in large department stores) account for another 30 to 35% of sales from manufacturers. Finally, manufacturers sell directly to consumers. Direct sales are becoming more common and account for 5 to 10% of total sales in the fur industry. (Riddle and Scantland 1978). These sales represent one of the future growth areas.

Although imported fur garments make up a portion of the items that end up at the retailer, the United States fur industry has, for the past several years, generated a healthy favorable balance of trade (that is, an excess of exports over imports). Exports of fur garments and pelts for 1980 were $552.2 million, an increase of almost 70% over 1976 (*U.S. General Exports*, U.S. Department of Commerce). United States retail fur sales in 1980 were $944 million, representing a similar 5-year increase of almost 70% (figures from American Fur Industry).

THE FUR INDUSTRY'S WORK FORCE

One problem of the fur industry that is common to all skilled trades is the need for a reserve of skilled workers. In the fur dressing section, the unions administer their own apprenticeship programs. In the manufacturing section of the industry, labor and management have jointly established apprenticeship programs to train workers, largely from the minorities, for the various skilled jobs. The most recent such program, conducted in conjunction with the government-funded Comprehensive Education and Training Act (CETA) program, lasted for about 5 years with varying degrees of success. Now that CETA funds have been terminated, the industry is seeking other means of establishing a training program.

A similar problem, although on a different level, is the recruitment of talented designers and competent management and sales personnel. Currently, the industry is examining the feasibility of establishing a training program at the Fashion Institute of Technology, a 2-year college of the State University of New York.

SUPPLY AND DEMAND IN THE FUR INDUSTRY

Through the 1960's, the fur industry was almost exclusively a mink industry that appealed largely to the wealthy. This phenomenon resulted from the development and multiplication of ranched-mink, which has the advantages of predictable quantity and improved quality through fur breeding.

During the past decade, fur has entered the mainstream of fashion and appeals to an ever-wider segment of the population. Designers have turned their talents to a variety of furs other than mink, and their use of color and flair has produced an explosion in the popularity of fox, muskrat, raccoon, and other wild furs. In the future, designers will probably apply the same imagination and daring in designing for the hitherto more traditional mink and sable. Mink still represents from 50 to 65% of all fur sales, but the increasing popularity of other furs has broadened the attractiveness and the economic base of the industry.

Since the rise in popularity referred to above, the demand for fur products has remained relatively constant, despite developments in the country's economy that have adversely affected other consumer industries. The main threat to the fur industry lies in the ever-present attempts to curtail the supply of furs. For example, if efforts to outlaw trapping are successful, the effect on the industry will be crushing because an estimated half of the skins used today are obtained by trapping.

The supply of furs may also be limited by legislation and regulations to protect endangered species. The industry has no interest in endangering the supply of furbearers, the source of its economic well being. However, it is concerned with the indiscriminate application of endangered species legislation or regulations to animals that may not actually be endangered. For example, following the passage of the Federal Endangered Species Act, this country participated in the Convention on International Trade in Endangered Species of Flora and Fauna (CITES). At the first CITES meeting in Switzerland in 1977, the river otter (*Lutra canadensis*) and the entire cat family (Felidae) were placed on Appendix II, the list of species that are in danger of being threatened with extinction. At this writing, moves are under way to delist these species, but so far these efforts have been unsuccessful. In addition, the new proposed endangered species legislation contains a provision that would prevent administrative and judicial determinations from replacing sound wildlife management decisions.

Politically, the supply of furs has been limited by an embargo placed on 7 Russian furs and all Chinese furs. This limitation dates back to the anti-Communist hysteria of the 1950's, which was used by American mink ranchers to keep Russian and Chinese mink out of the country. The embargo is selective since neither Russian sable (*Martes zibellina*) nor Persian lamb was included in the ban. It also operates in a bizarre manner. For example, Russian mink skins cannot enter the country, but garments manufactured from them in neighboring Canada can enter. As a result of the active courtship of China being conducted by Washington, legislation has been introduced to permit fur skins from that country to enter.

THE ECONOMICS OF FASHION

Until a relatively few years ago, fashion trends for the United States fur industry were largely set by European designers. To a certain extent, this is still true. Today, however, practically every major fur manufacturing firm has its own "name" designer, and the domestic industry has achieved a much greater measure of independence, initiative, and recognition in fashion.

Symptomatic of this development has been the establishment in 1979 of the American International Fur Fair. This fair is held for 5 days in March of each year in New York City and attracts buyers from all over the world. Prior to 1979, there were annual fairs in such European cities as Frankfurt (the largest), Paris, and Milan. The American fair has become an established and prominent part of this circuit, and its share of the world fur fair market is constantly increasing.

The heightened attention to fashion in the United States fur industry resulted from a well-financed promotional program of the American Fur Industry. The AFI presents a major fashion show for visiting buyers and the trade press each year during Fur Fashion Month. Throughout the year, advertisements and press releases go out to the nation's press. The most ambitious effort to date is a 30-second television commercial that is being aired nationwide. Local retailers have an opportunity to identify themselves and add a message.

The promotional program is fueled by contributions from many sources, but the greatest amount comes from a percentage of the net sales of manufacturers, required by their union contract. The greater portion of the proceeds of this levy is used to finance the health, welfare, and pension benefit programs of fur manufacturing employees, but a substantial sum is allocated to industry promotion. Other sums come from a percentage charged by the fur auction companies, worldwide, on all purchases and administered by the International Fur Trade Federation. There are also contributions from other sectors of the industry. At this writing, an effort is being made to include the country collectors in this industry program. The participation of country collectors indicates that an ever-increasing portion of the funds raised by the industry is being devoted to the areas of conservation and legislation.

THE ECONOMICS OF CONSERVATION

At first glance, it might seem that an exposition of the fur industry's commitment to wildlife management and conservation at a Fish and Wildlife Conference attended by furbearer managers and scientists is somewhat like bringing the traditional coals to Newcastle. The fact is, however, that the issue is inextricably bound up with the economics of the industry. Whether by coincidence or not, the rebirth of interest in wild furs that has revitalized the industry's economic health during the past decade paralleled the birth and growth of the environmental movement in this country. The animal protectionists, who have always opposed the wearing of furs, seized upon this movement to cry out against the harvesting of furbearing animals. Their attack was multifaceted but always tuned to exploit the most emotional issues. They began with the cry of "endangered species." Congress, however, with the fur industry and its unions playing a recognized constructive role, enacted the Federal Endangered Species Act, and that issue has lost its urgency until 1982, when Congress is considering the reauthorization of the Act and a number of proposed amendments to it.

Next came the uproar over seals. Animal "welfare" organizations flooded newspapers with pictures of white baby harp seals (*Pagophilus groenlandicus*) and with horrifying accounts of their being clubbed to death. Lost in the emotion were the facts that the seal shown in the advertisements is not the northern (Alaska) fur seal (*Callorhinus ursinus*), which is the species from the Pribilof Islands utilized for fur garments, that government scientists have established that for both of these species, clubbing is the most humane means of harvest, and that the annual fur seal yield off the Pribilof Islands has been hailed as an outstanding example of international cooperation in wildlife management and conservation. However, the antiseal campaign took its toll. By the time Congress had passed the Marine Mammals Protection Act in the mid-1970's, the manufacture and sale of fur seal garments had been virtually eliminated in the United States. The only losers were the Aleuts, who depend for their livelihood on the fur seal harvest, and the American producers and consumers of fur garments.

The leg-hold trap was the next emotional issue. The fur industry was accused of profiting from unimaginable cruelty. In small print, the antifur organizations acknowledged that they were equally opposed to the ranching of mink, but their public tears were shed for the fox, raccoon, and coyote as they were captured and held in the "barbaric" leg-hold trap. Overlooked was the unanimous conviction of wildlife managers that furbearer populations are a renewable resource, that the periodic and systematic harvesting of those populations do not pose a threat to their survival, and that nature's way of controlling these populations, through starvation, disease, and predation, is infinitely more cruel than any man-made device.

By this time, even the most parochial furdealer and manufacturer realized that the industry needed allies if it was to successfully defend itself against these attacks. From this realization came the coalition of the urban-based fur industry with the sportsmen, farmers, and wildlife managers of the country. The first fruit of that coalition was the landmark victory in 1977, when an effort to ban the leg-hold trap in Ohio was defeated, 2 to 1, after early polls had shown that the public's first reaction was for the ban.

From that struggle and victory were formed the Wildlife Conservation Fund of America and the Wildlife Legislative Fund of America. The fur industry maintains strong ties with these organizations and contributes a substantial portion of industry promotional funds toward conservation and legislative activities. In addition, the industry's Committee for Wildlife Conservation and Legislation also maintains a relationship with the International Association of Fish and Wildlife Agencies and other wildlife management bodies. Through the International Fur Trade Federation, it also has a liaison relationship with the International Union for the Conservation of Nature and Natural Resources (IUCN), based in Switzerland. Both the American Fur Industry and the International Fur Trade Federation send representatives to the biennial meetings of CITES. Both operate on the philosophy that sound wildlife management is the best guarantee of a successful and prosperous fur industry. Because of this philosophy, the industry dispatches spokesmen to such forums as the Furbearer Management Symposium of the 43rd Midwest Fish and Wildlife Conference.

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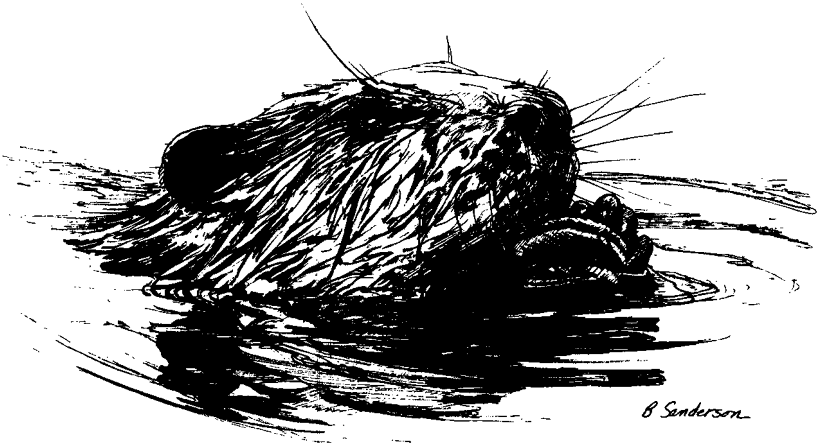

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A Case History of a Dynamic Resource—The Red Fox

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Abstract: Red fox (*Vulpes vulpes*) population trends in midwestern North America since 1800 were examined. During 1801–1900, the red fox expanded its range south to include most of the region, but populations remained low in most areas. During 1901–30, it became scarce or absent in many northern areas but was common in southern areas. During 1931–45, populations in most of the region increased to high levels. From 1946 to 1980 populations remained high and westward range expansions occurred on the northern plains. Three factors appear primarily responsible for major population changes. Habitat conditions improved after settlement, but in many areas population buildup was delayed. Interspecific canid competition, especially from expanding coyote (*Canis latrans*) populations, held red fox populations at low levels, especially in the west. Excessive harvest for fur contributed to holding populations down in many areas, especially during the early 1900's when pelt values were exceptionally high. Major population increases during the 1930's and early 1940's coincided with declining pelt prices and resulted in widespread implementation of fox bounties. In the 1960's, bounties were gradually discontinued, pelt prices increased, and restrictions on season length and harvest methods were implemented in most states.

Key words: harvest statistics, interspecific competition, pelt value, population trends, red fox, (*Vulpes vulpes*).

The red fox has a unique and complex relationship with man. It is a valuable furbearer, predator of livestock and game, sporting game animal, carrier of diseases, and species with aesthetic appeal. It is also a very adaptable and extraordinarily successful species. Except for the wolf (*Canis lupus*), it has the largest natural distrubition of all land mammals; its range encompasses nearly all of the holarctic region and it thrives in diverse habitats (Lloyd 1980, Zimen 1980). Unlike the wolf, however, it has managed to survive throughout most of its range and to increase in abundance in many areas (Zimen 1980).

Currently, the red fox occupies most of central North America known as the Midwest (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin, and southern Manitoba) (Hall 1981). During 1970–75, about two-thirds of North America's average annual harvest of over 266,000 red foxes came from this region (Deems and Pursley 1978). Red fox populations in the Midwest, however, have changed much since settlement of the region by Europeans began in the 1800's. The purpose of this paper is to trace population changes since 1800 and to identify major factors affecting population size and trends.

I appreciate the assistance of S. Allen, R. Andrews, K. Bednarik, T. Engel, D. Erickson, R. Fowler, L. Fredrickson, E. Fritzell, G. Hubert, Jr., N. Johnson, L. Lehman, R. Linder, C. Pils, G. Schildman, G. Storm, and J. Vogt for identifying pertinent literature and providing fox harvest and pelt price statistics. I thank E. Bartels for library services and R. Greenwood for manuscript review.

METHODS

Furbearer biologists and other individuals were contacted in each midwestern state for information on fox population changes and harvest statistics. Except where indicated, pelt prices and harvest statistics are from records of state conservation agencies. The prices are averages of all pelts sold. Harvest statistics are difficult to interpret because of differences in reporting methods, incomplete records, failure to distinguish between red foxes and gray foxes (*Urocyon cinereoargenteus*), and lack of information relating harvests to actual densities. Therefore, harvest statistics are used only to establish trends. Harvest seasons are identified by first year only (that is, 1943 refers to harvest season 1943–44).

POPULATION TRENDS

Red fox population trends in the Midwest in recent times were divided into 4 periods: early settlement era, 1801–1900; fur boom years, 1901–30; transition period between low and high red fox populations, 1931–45; and management period, 1946–80. To examine population changes in each period, I divided the Midwest into 3 zones: the southern zone of mixed agriculture interspersed with hardwood forests and woodlots (Illinois, Indiana, Iowa, Missouri, and Ohio), the heavily forested northern zone (Michigan, Minnesota, and Wisconsin), and the western zone composed largely of prairie (Kansas, southern Manitoba, Nebraska, North Dakota, and South Dakota).

1801–1900

The history of the red fox in North America during the settlement era is not well documented. It is also confused because of introduction of European red foxes into eastern areas about 1750 for sport hunting (Churcher 1959) and later from eastern areas into the Midwest as far west as Kansas (Lantz 1904). Seton (1953) and Churcher (1959) indicated, however, that before arrival of Europeans, the red fox was native north of latitude 40° or 45°N but was scarce or absent in the unbroken forests; populations expanded into lands cleared for agriculture as pioneers moved west toward the Great Plains.

Red foxes were apparently rare or absent throughout nearly all of the southern zone during the early 1800's. Doutt et al. (1966:186) stated that no red fox remains from pristine times have been found in Pennsylvania or "south of New England or east of Illinois," an area that includes Indiana and Ohio. Lyon (1936:138) suggested that "the Red Fox . . . appeared [in Indiana] when the country became half settled." Bowles (1975) concluded the red fox was neither common nor widespread in Iowa before settlement, and Bennitt and Nagel (1937) found no evidence that it was present in Missouri. However, bones of a single red fox from before 1850 were found in northeast Missouri (Parmalee and Jacobson 1959).

During the 1800's, especially after 1850, the red fox expanded its range to include nearly all of the southern zone (Cory 1912, Forbes 1912, Churcher 1959, Bowles 1975). Densities are unknown but in most areas populations apparently were low. Galland (1921) did not mention their presence in Iowa in 1840, but Allen (1870) found red foxes common in northern Iowa and occasional in southern Iowa in 1867. Nutting (1895) indicated the population was increasing in southeast Iowa in the 1890's.

Red foxes were widespread but not abundant in the northern zone before settlement. According to Arnold (1956) red foxes may have occurred in scattered areas of Michigan before settlement. Jackson (1961:301) reported red foxes were present in Wisconsin when settlers arrived but in "lesser numbers than now." Records of the American Fur Company from 1835 to 1839 provide insight into red fox abundance because they apparently account for a large portion of the pelts traded in the Midwest (Johnson 1969). Included were 7,298 red foxes; 40% were from the northern zone. Compared with numbers of other pelts traded [for example, 245,367 raccoons (*Procyon lotor*), 2,543 wolves, and 10,638 kit foxes (*Vulpes velox*)], the records indicate that the red fox, although widespread, was not numerous.

Information compiled by Swanson (1940) on the fur trade in Minnesota during 1850–1900 also depicts the red fox as widespread but not abundant. Relatively few or no foxes (red and gray) were included in most local fur sales, although accounts indicate they may have been common in some areas. For example, in 1863 a furbuyer in St. Cloud in central Minnesota purchased 71 red foxes, and in 1878 a boy took 14 foxes (presumably red foxes) in Clay County, northwest Minnesota. Shipping records of the Ullmann Company, St. Paul (probably the largest furbuyer in Minnesota at that time), for 1870 include 1,896 red foxes, 128 cross foxes, and 27 silver foxes from a buying area that extended throughout Minnesota and into neighboring states and Canada. Bailey (1929) reported red foxes were common in Sherburne County in eastern Minnesota up to about 1887 but then became very scarce, and Johnson (1930) recalled they were common in areas of extreme northwest Minnesota in the 1890's.

Red fox populations in the western zone were also low prior to settlement. In Kansas and Nebraska, red foxes occurred only in eastern counties (Lantz 1904, Jones 1964) but farther north they were widely distributed. According to Over and Churchill (1945), early voyagers frequently mentioned seeing red foxes in South Dakota. Bailey (1926:161) reported that Lewis and Clark mention a red fox killed at Fort Clark on the Missouri River in west-central North Dakota in 1805 and Maximilian found them common "though by no means so numerous as the wolves" in the vicinity of the fort in 1833. Reid and Gannon (1928), in summarizing Alexander Henry's journals, reported that during 1800–07, 1,155 red fox skins were traded at 8 posts in North Dakota, whose trading areas included northeast North Dakota, northwest Minnesota, and portions of southern Manitoba. Bailey (1926:161) relayed a quote by Maximilian in 1833 that "about 2,000 red-fox skins, 200 to 300 cross foxes, and 20 to 30 silver foxes" were brought annually to Fort Union in extreme western North Dakota. The American Fur Company records summarized by Johnson (1969) include 1,851 red foxes received during 1835–38 by the Upper Missouri Outfit trading along the Missouri River in North Dakota and South Dakota.

Settlement of the western zone did not begin in earnest until late in the 1800's and shortly thereafter red fox populations declined. Lantz (1904) and Jones (1964) referred to post-settlement declines in Kansas and Nebraska. Lantz, however, distinguished between native and eastern red foxes, which threatened to become a pest in some eastern areas after they were stocked by sportsmen. In North Dakota, the decline was first noticed in the southwest, but it soon spread throughout the state (Anonymous 1949). Wrigley (1974) reported red foxes, originally common in the sandhills of southwest Manitoba, were almost exterminated in the early 1900's.

1901–1930

During this period, red fox populations in the southern zone gradually increased. Leopold (1931) identified areas in Illinois, Indiana, Missouri, and Ohio where red foxes were relatively abundant or increasing in numbers, but he also identified some areas that were devoid of foxes. Cory (1912), Lyon (1936), and Bowles (1975) also indicated that red foxes were common in much of the southern zone. Referring to the latter part of this period, Scott (1937) stated that the red fox was found thoughout Iowa but was most numerous in the north.

In the northern zone, population declines noted during the late 1800's occurred in nearly all the area; in some localities the red fox disappeared. Bailey (1929) reported the red fox was no longer present in Sherburne County, eastern Minnesota; the last available record was a pup killed in 1891. Leopold (1931) identified numerous other foxless or nearly foxless areas in the northcentral states. On the status of game in Michigan in 1930, Leopold (1931:221) received a letter stating "The red fox has become scarce, rare, or altogether lacking in fully two-thirds of the lower peninsula . . . and in nearly all of the upper peninsula." Douglass and Bradt (1945), however, believed the red fox was still common in wild and sparsely settled parts of Michigan at that time. Leopold (1931) also identified southwest Minnesota and southeast Wisconsin as having few or no foxes. During the 1920's, red foxes were reported uncommon or occurring in moderate numbers in the heavily forested regions of northern Minnesota and Wisconsin (Cahn 1921, Johnson 1922, Komarek 1932). Surber (1932) reported that in about 1930 red foxes were locally common in the forested region of Minnesota and almost absent from the open farmlands.

The red fox population also declined in the western zone. The red fox is conspicuously absent from a list of over 440,000 furs taken in Nebraska during the 1926 fur season (Anonymous 1927). In North Dakota, few red foxes remained west and south of the Missouri River by 1916 and a low statewide population was reported from 1895 to 1935 (Anonymous 1949). Johnson and Sargeant (1977) reported red foxes were so scarce in North Dakota during this period that many long-time residents thought they were absent. Red foxes were also scarce in southern Manitoba from the early 1900's until 1930 (Bird 1961).

1931–1945

During the 1930's and early 1940's, red fox populations throughout the Midwest began to increase and by the end of that period they were abundant in much of the region. Fur harvest statistics compiled by state conservation agencies depict the magnitude of change that occurred; data sets for Iowa (southern zone), and Minnesota and Wisconsin (northern zone) are the most complete (Fig. 10–1). The average annual number of red fox pelts sold or reported taken per state increased from 3,000 during the first 5 years to 11,500 during the last 5 years of this period.

Limited information for the other states in the southern zone also indicated substantial population increases. In Ohio, the annual red fox harvest increased from about 5,000 during the late 1930's to about 15,000 during 1943–45 (a reported harvest of 30,000 in 1933 and 20,500 in 1934 was disregarded because the data are inconsistent with other findings, the estimating procedures are unknown, the reporting procedures were discontinued in 1935, and the reported harvest for nearly all furbearers during those years greatly exceeded that

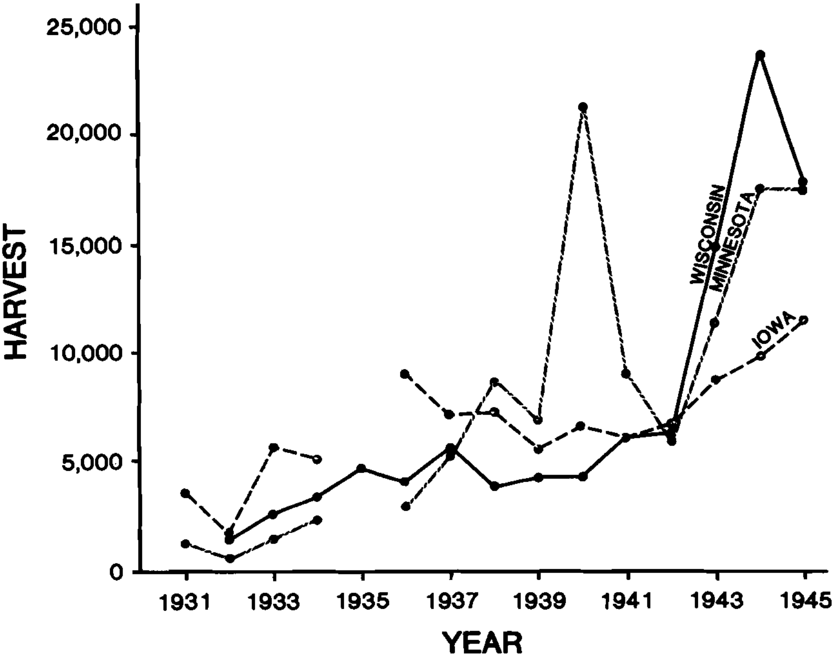

Fig. 10–1. Number of red fox pelts sold or reported taken in Iowa, Minnesota, and Wisconsin during 1931–45. Data from state conservation agency records.

reported after harvest estimating was resumed in 1937). No comparative data were available for Illinois and Indiana, but Brown and Yeager (1943) reported an average of about 8,500 red foxes were taken annually in Illinois during the 1938 and 1939 harvest seasons. The red fox harvest in Missouri increased from less than 5,000 in 1934 to between 10,000 and 15,000 annually during 1940–45 (Sampson 1980).

The magnitude of change in northern zone states was greater than in the southern zone states (Fig. 10–1). Swanson et al. (1945:69) described the change in Minnesota as "a remarkable increase in red foxes." A major increase also occurred in Michigan. Douglass and Bradt (1945) reported that around 1930 the red fox was regarded as scarce and in need of protection, but by 1934 the population was believed to be increasing slightly. By 1937 red foxes were distributed throughout Michigan and were abundant in the northern half of the lower peninsula. The estimated number of red foxes taken annually for fur in Michigan increased from an average of about 1,000 during 1935–37 to about 36,000 during 1943–45 (U.S. Fish and Wildlife Service 1943, Ashbrook 1947).

In the western zone, population increases were most pronounced in the north. For South Dakota, Over and Churchill (1945) reported the red fox was still restricted to the northeast quarter of the state. The population, however, was building. Ashbrook (1947) listed 500–1,600 pelts taken annually for fur in South Dakota during 1941–45, but South Dakota bounty records show a total of 32,000 were taken during 1945–47. Hence, by 1945 red foxes were abundant in eastern South Dakota. In North Dakota, the red fox was restricted to the eastern two-thirds of the state (Anonymous 1949). State harvest data show an increase in pelts taken from about 3,000 in 1937 to an average of about 15,000 annually during 1943–45. Major population increases also occurred during this period in southern Manitoba (Bird 1961, Soper 1961, Wrigley 1974). In Kansas and Nebraska, however, red fox populations remained low and restricted to eastern areas (Jones 1964, Janes and Gier 1966). The only datum found for the 1930's is a single record of 501 red foxes taken in Kansas in 1938 (U.S. Fish and Wildlife Service 1943). Fur catch statistics compiled by Ashbrook (1947) show that during 1941–45 only 300–1,800 red foxes were taken annually in Kansas and Nebraska.

1946–1980

The high red fox populations of the mid-1940's have persisted in nearly all states, although the populations fluctuated in some areas (for examples see Richards and Hine 1953, Johnson and Sargeant 1977, and Sampson 1980). Annual state harvests, pelt sales, and bounty statistics for this period are summarized by 5-year averages in Table 10–1. Pelt sales during the first 20 years, especially the 1950's, represent only a fraction of the total harvest because prices were too low to encourage high harvests or fur sales (Fig. 10–2). In North Dakota, the number sold during the 1950's averaged only 23% of the number bountied.

In spite of limitations, the harvest data in Table 10–1 indicate that large numbers of red foxes were present in nearly all states. Data for harvest and pelt sales for 1970 are directly comparable because high pelt prices (Fig. 10–2) resulted in intensive hunting and trapping in all areas, and nearly all foxes taken were sold. Annual harvests in the southern-zone states ranged from about 7,000 to 22,000, except in Missouri where harvests averaged less than 3,000. In the northern-zone states, harvests ranged from about 13,000 to 59,000 annually and in the western-zone states from less than 2,000 annually in Kansas and Nebraska to 20,000 to 40,000 annually in North Dakota and South Dakota.

Major range expansions occurred in the western zone during this time period. In Kansas, an expansion westward began in the mid-1950's, and by 1959 red foxes probably occurred in every county (Janes and Gier 1966). Jones (1964) reported that by the early 1960's red foxes occurred sparingly in suitable habitat in central Nebraska and ranged west along the Platte River to Wyoming. Nebraska harvest statistics for 1978–80 show about 500 red foxes were taken during these years in the 11 western-most counties. Jones and Henderson

Table 10–1. Average number of red foxes harvested, sold, and bountied annually in midwestern states, 1945–79. Except where indicated, data are based on State Conservation Agency records. Averages based on 2 years or less data are underlined.

	Source	1945–1949	1950–1954	1956–1959	1960–1964	1965–1969	1970–1974	1975–1979
Southern zone								
Illinois	harvest	22,540[a]	10,330[a]					11,300[b]
Indiana	sold		300	350	2,660	4,480	7,230	15,650
Iowa	harvest	8,720						
	sold		3,380	2,050	6,300	15,960	18,190	20,670
Missouri	harvest	8,400	3,480	740	850	1,610	1,990	3,440
Ohio	sold	9,430	1,500	1,030	3,930	9,120	12,680	22,065
	bounty[c]	13,500	10,600	10,840	12,960	9,870	5,890	
Northern zone								
Michigan	harvest						13,000[b]	
	bounty	19,160	20,550	27,860	31,160	29,300		
Minnesota	harvest		40,600	42,320	63,960	45,700	51,000	59,000
	bounty[c]	25,550	37,210					
Wisconsin	harvest	19,330	25,410	33,910	34,750	34,150	26,780	24,920
Western zone								
Kansas	sold	840[a]	*90*[a]	30	250	120	700	600
Nebraska	harvest	440[a]	260[a]	560[a]		600	530	1,690
North Dakota	sold	8,170	3,400	8,380	14,800	21,780	32,930	40,000
	bounty	17,000	17,540	31,390	18,290			
South Dakota	harvest						21,860	20,332
	bounty	15,700	8,700	12,310	14,610	31,090	18,080	

[a]From U.S. Fish and Wildlife Service Annual Fur Catch statistics.
[b]From Deems and Pursley (1978).
[c]Estimated by prorating number of foxes (red and gray combined) bountied using species ratio in annual pelt sales data.

(1963) reported the noteworthy taking of a red fox in the southwestern-most county of South Dakota in 1960. In North Dakota, red fox populations increased rapidly in western areas after 1950. Adams (1961) reported an increase from about 100 to over 2,500 red foxes bountied annually west of the Missouri River in North Dakota from 1950 to 1959.

CAUSES FOR POPULATION CHANGE

Three factors appear to have had greatest influence on red fox populations in the Midwest: habitat change, interspecific canid competition, and direct human impact. Other factors, such as disease, have had a limited influence on populations. For example, an outbreak of sarcoptic mange was associated with

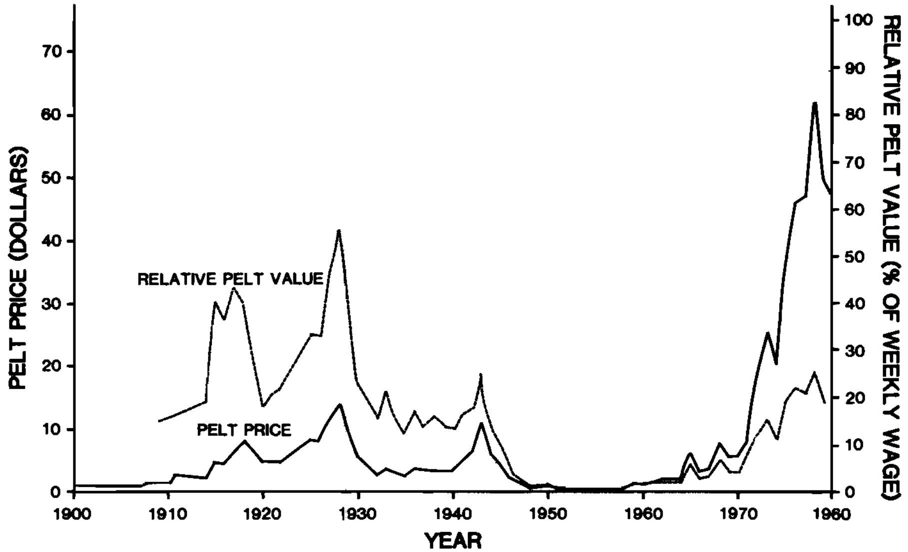

Fig. 10–2. Average red fox pelt prices in midwestern states 1900–80 and relative value to seller expressed as percentage of the average weekly wage of U.S. manufacturing workers. Pelt price data are from Bennitt and Nagel (1937) and from state conservation records. Manufacturing worker wages are from U.S. Bureau of the Census (1975:169–170) and U.S. Bureau of the Census (1979:419).

a downward trend of red foxes in Missouri and Wisconsin during the 1960's, but in Missouri the mange subsided in a few years (Sampson 1980) and in Wisconsin the population remained high (Trainer and Hale 1969, Pils and Martin 1978).

Habitat Changes

Settlement of the Midwest resulted in habitat changes that in general have been highly favorable to the red fox. The cutting of forests and development of agriculture (except where too intense) created habitat diversity in which red foxes thrive. Red foxes use a broad array of animal and plant foods (Scott 1943) and an increase in habitat diversity broadens the available food base and insures a more stable food supply. Agricultural crops, livestock carrion, and discarded refuse are among new foods available to midwestern foxes. Perhaps these changes increased reproduction and enabled red foxes to occupy smaller territories or to live in previously inhospitable areas.

Although the major habitat changes favored population increases, fox populations in many areas were slow to respond. As previously discussed, populations declined in much of the Midwest during the late 1800's and early 1900's despite habitat improvement. In much of the western zone, the benefits of habitat change to red foxes were delayed for more than 50 years. The apparent imprecise link between habitat and population size prompted Leopold (1931:217, 222) to challenge the widely accepted assumption that "if the condition of the country remains the same, the species of fox and the density of the population will tend to do likewise." He was puzzled by inconsistencies and referred to "invisible" factors that affect fox density.

Interspecific Canid Competition

The red fox is 1 of 6 midwestern canids. Others are the gray wolf, red wolf (*Canis rufus*), coyote, gray fox, and kit fox (Hall 1981). In pristine times, the gray wolf occupied nearly all of the region except portions of the southern zone where the red wolf lived. The wolves were extirpated from nearly all of the region by the early 1900's (Cory 1912, Young 1944).

The coyote occurred primarily on the western plains when white man arrived in the Midwest, but elimination of wolves and disruption of the environment resulted in an expansion of its range (Nowak 1978, Young and Jackson 1978). A major eastward movement of coyotes into the Great Lakes region occurred during the late 1800's, and by 1920 its range included all of Michigan (Nowak 1978). In the 1920's coyotes also appeared in southern Missouri and within 20 years were abundant in the Ozarks. Although the coyote expanded its range to include nearly all of the Midwest (Hall 1981), it generally has become numerous only in sparsely settled or heavily timbered areas.

The gray fox originally occupied the deciduous forest region where it still thrives. The range expanded but populations changed the least of any midwestern canid (Lyon 1936, Richards and Hine 1953). The kit fox occurred throughout the western plains but by the early 1900's it had disappeared from most areas. Small populations remain in western parts of Kansas, Nebraska, and South Dakota (Hillman and Sharps 1978, Hall 1981).

There is considerable evidence linking changes in abundance of 1 canid species to changes in abundance of another. Linhart and Robinson (1972) allude to the negative impact coyotes may have on red fox numbers. Johnson and Sargeant (1977) summarized data for gray wolves, coyotes, and red foxes relative to red fox population changes in the northern plains. They concluded that elimination of gray wolves in the late 1800's resulted in a buildup of coyotes that, in turn, caused a drastic decline of red foxes. They found no areas where both coyotes and red foxes were simultaneously abundant, and they provide numerous examples of red fox populations that expanded after coyote populations declined. High coyote populations in Kansas and Nebraska probably explain why red foxes have never been abundant throughout those states. Recently, Sampson (1980) linked the downward trend in red foxes in Missouri in the late 1960's to an increase in coyote numbers.

It was widely believed that red foxes tended to displace native gray foxes in hardwood forest areas of the southern zone, but proportions of the 2 species have varied greatly (Leopold 1931) and the gray fox has remained common or abundant in most of the area. There is no conclusive evidence showing dominance by 1 species over the other. Where both occur they occupy similar size territories but there is considerable interspecific and intraspecific territory avoidance (Follmann 1973). Apparently in habitats suitable to both species, the density of the 2 species approximates the density either species would probably achieve alone. The relative abundance of each species might then be determined through indirect competition associated with behavioral interactions or by factors associated with natality and mortality. Hence, the generally lower populations of red foxes in the southern-zone states may result from sharing habitat with gray foxes. No information was found on the relationship between red foxes and kit foxes.

Human Impacts

Pelt price has influenced man's attitude toward the red fox, especially in northern areas. Fox pelts sold for about $.50 each in Missouri in 1805 (Sampson 1980:3) and for up to $2 in Minnesota during 1850–1900 (Swanson 1940:33). Average pelt prices for 1900–80 and their relative value to man expressed as a percentage of the average weekly wage of manufacturing workers show that red foxes were exceptionally valuable from 1915 to 1930, almost worthless from 1945 to 1965, and increased to a relatively high value again during the 1970's (Fig. 10–2).

The increased value of the cross fox and the extraordinarily high value of the silver–black color phases provided further incentive for taking red foxes during the 1800's and early 1900's. The silver fox was the region's most valuable furbearer and it was occasionally taken, especially in northern areas. Swanson (1940:34) reported Minnesota silver foxes sold for $35 in 1859 and between $50 and $100 in 1885. Silver fox pelt prices remained exceptionally high until 1930 (Manitoba Department of Renewable Resources and Transportation Services, no date).

Because of high pelt prices, red foxes were sought after for their fur from 1800 to the early 1940's. At first, they were harvested by American Indians and then by professional white trappers (Sampson 1980). With the influx of white settlers, large numbers of part-time trappers and hunters competed for the fur resource. Few laws governed the taking of foxes, especially in the northern and western zones. Even in 1921, when red fox populations were low in many areas and pelt prices were exceptionally high, red foxes were unprotected in the northern and western zones except Nebraska (Lawyer and Earnshaw 1921). Nebraska and nearly all southern-zone states had seasons in at least parts of each state. Seasons began on 1–15 November and ended 31 January to 15 March, but there were few restrictions on methods of harvest. Harvest pressure was intense and I believe sufficient to reduce or hold populations to low levels in many areas. Osborn and Anthony (1922:228) stated that the red fox was "such a prime favorite that great numbers of his skin have come to the fur sales, and we understand that in some regions of the north the fox is virtually on the brink of extermination." Surber (1932:52–53) reported "persistent trapping in recent years in efforts to obtain, alive, the rare silver phase has hastened their destruction [red foxes in Minnesota] in many localities where they were once abundant." Excessive furbearer harvests became a matter of considerable concern to conservationists (Dearborn 1920, Ashbrook 1922, Osborn and Anthony 1922, Ashbrook 1925).

The increase in numbers of red foxes during the 1930's and early 1940's coincided with the decline and eventual crash of the longhair fur market, with the great depression, and with World War II years, when social factors may have reduced harvest pressure. If excessive harvest caused a decline in red foxes during the early part of the century, the reduction of harvest pressures during the 1930's and early 1940's probably allowed populations to increase.

From the mid-1940's to the mid-1960's, prices of red fox furs were too low to encourage intensive fur harvesting (Fig. 10–2). Since the mid-1960's, however, prices have risen to high levels and increased harvesting has reduced populations. For example, in North Dakota the estimated spring density of red fox families in the 94,245 km^2 pothole region (half of the state) declined from over 13,000 annually during 1963–65 to less than 5,000 in 1969 (Johnson and Sargeant 1977:8), when it probably reached its lowest level since the early 1940's (Allen et al. 1974). Harvest restrictions were imposed and the population rebounded even though pelt prices continued to increase (Allen et al. 1974). Similarly, a closed season in Missouri during 1977–79 is credited with a gradual rebuilding of a reduced population (Erickson 1981). Concern for maintaining adequate numbers of red foxes during the recent years of high pelt prices has prompted most states in the Midwest to impose regulations governing status, season length, and harvest methods (Pils and Martin 1978).

The exceptional increase in red fox populations during the 1930's and early 1940's coupled with declining pelt prices resulted in a changed public attitude toward the species. With positive economic values greatly reduced, attention focused on negative aspects, especially predation on livestock and game, and pressures grew to lower fox populations. Concern for these pressures prompted Errington (1937:31) to conclude, "it would be to the interests of public and foxes alike to lower the present fox population level by any reasonable means." He recommended increased hunting. In Illinois, Brown and Yeager (1943:484) also concluded "it may become desirable to reduce local red fox populations, and increased hunting and trapping in season is the method recommended." Leopold (1945:4), discussing the "tremendous upsurge of foxes" in Wisconsin, also believed foxes were "far too abundant, and should be reduced to a reasonable level." However, because of declining pelt prices, fur trapping and hunting were no longer effective in controlling population levels. As pressures mounted, large scale bounties were gradually adopted by nearly all midwestern states (Arnold 1956, Hubert 1982). Bounty payments, however, were generally under $5 (Balser and Moyle 1958, Pils and Martin 1978) and proved ineffective in reducing populations, although they may have contributed to holding populations below maximum levels. Bounties were vigorously opposed by conservation agencies and were discontinued in nearly all areas in the 1960's. The decline in bounties coincided with an increase in pelt prices.

Although pelt price and predation influenced man's attitudes toward the red fox in northern and western parts of the Midwest, sport hunting, especially the nonshooting custom of hunting with hounds, influenced attitudes in southern areas (Leopold 1931, Bennitt and Nagel 1937, Scott 1955). Introduction of red foxes for sport hunting was widely practiced and may have been important in the post-settlement range expansion of the species (Lantz 1904, Churcher 1959). Foxes were released to populate new areas, to bolster populations in other areas, to add new genetic stock, and for immediate hunting purposes—a practice that may still occur in some areas (Leopold 1931, Bennitt and Nagel 1937, Scott 1955, Janes and Gier 1966). This interest in traditional fox hunting was responsible for the more protective regulations affecting red foxes in the southern zone during the fur boom and bounty years (Lawyer and Earnshaw 1921, Arnold 1956) and probably contributed much to the greater stability of red fox populations in that zone.

SUMMARY AND CONCLUSIONS

Red fox populations in the Midwest have undergone major range expansions and tremendous increases in population size since the white man arrived. Until the 1940's, man had little way of knowing the potential of the species to populate the region and, without such knowledge, could not gauge his impact on populations.

Initially, habitat and interspecific canid competition restricted red foxes to certain areas and held populations low. Habitat improved markedly with settlement but, except in the southern zone, the benefits to red fox populations were delayed until the 1930's or later. In the southern zone, red foxes were regarded by many people as desirable game animals. This attitude was stronger in the southern zone than in the others and was responsible for moderating man's negative impact on populations and allowing populations to build. Red fox populations in the southern zone gradually increased during the 1800's and red foxes were common in much of the zone during the fur boom years.

In the northern and western zones, fur value and predation impacts have been dominant factors affecting man's attitude toward red foxes. During the

1800's and early 1900's, exploitation of the fur resource was largely unchecked and limited only by the ability and restraint of the individual. With such pressures, red fox populations failed to increase substantially and declined in some areas. Competition from expanding coyote populations became another, perhaps more important, factor restraining populations in many areas.

The rapidly increasing red fox populations in the 1930's and early 1940's, probably first viewed favorably, soon caused growing concern about over-population. Population levels reached unprecedented levels and there was concern over increased predation on livestock and game. Employing bounties to control undesirable animals, including foxes, had a long history in the Midwest (Richards and Hine 1953, Waller and Errington 1961). Hence, it is not surprising the public perceived bounties as a logical way to reduce fox numbers and a way for personal monetary gain. The fox bounty was used extensively during the 1940's to early 1960's but in the manner conducted, proved to be expensive, fraught with fraud, and generally ineffective (Switzenberg 1951, Richards and Hine 1953, Waller and Errington 1961). Most state conservation agencies did not favor the bounty and gradually the public was dissuaded from its use.

Increasing red fox pelt prices in the 1960's and perhaps a change in public attitudes toward wildlife resources, including red foxes, focused more attention on management of red foxes. Furthermore, exceptionally high pelt prices during the 1970's made regulations a powerful tool for controlling population levels. If fox harvest seasons and methods were uncontrolled now, populations in large parts of the Midwest would probably soon decline to low levels. Responsible and effective management, however, must be based on sound information. There is a need to develop, standardize, and implement effective and accurate population monitoring and harvest estimating schemes. Because of the profound effects of interspecific competition, red fox management must be treated in the context of total canid management. Of course, the first step in effective management is setting goals. These goals must take into account both the desirable and undesirable aspects of the red fox. As pointed out by Leopold (1931:225), "the fox question is not so much one of whether foxes do more harm than good, but rather a question of what density of fox population affords the best balance between harm and good."

The red fox will continue to thrive in the Midwest but major population changes may occur in the future. Increases in coyote numbers and distribution, outbreaks of disease, and perhaps other factors could reduce future populations to low levels. Given adequate protection, population increases might also occur; the upper limit of red fox densities in the Midwest is unknown. The red fox will remain a challenging species requiring imaginative, shrewd, and objective management.

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11

Fox Rabies and Trapping: A Study of Disease and Fur Harvest Interaction[1]

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Abstract: The harvest of red foxes (*Vulpes vulpes*) in Ontario was in excess of 59,000 pelts annually in the 1940's. The lowest annual harvest in this century (2,000 pelts) occurred after rabies invaded Ontario in the 1950's. Rabies has remained enzootic at a high level in southern Ontario (1,500 cases per year) during the last 20 years. Harvests have been lower than before rabies but recently both pelt prices and fox harvests have increased. Rabies and harvest levels varied among areas and between years, and the intensity and timing of both determined their interaction in each area. Highest levels of rabies occurred in areas of moderate harvest but low levels of rabies occurred in high harvest areas. Low levels of rabies also occurred in areas where fox density and harvest were low. The seasonal timing of rabies outbreaks modified the impact of rabies on fox harvest. Rabies decreased as harvests increased in southern Ontario but rabies was not eradicated by trapping in any area. This study showed that disease–harvest interactions are complex and may not be evident from average or long-term measurements from large areas such as whole provinces or states.
Key words: disease, harvest, Ontario, rabies, red fox, trapping.

The regulation of trapping and hunting is one of the most important tools for managing furbearers. Diseases also affect furbearers, but their impact and interactions with trapping and hunting rarely are understood. Laboratory studies of a disease are often divorced from epizootiology, whereas field studies seldom combine ecological and disease viewpoints.

The red fox is a furbearer that has been studied extensively throughout its range (reviews in Ables 1976, Lloyd 1980); many studies were motivated by the desire to control rabies, although studies have been in both rabies-free and rabies-enzootic areas (Sargeant 1972, Wandeler et al. 1974, Storm et al. 1976,

[1]Ontario Ministry of Natural Resources, Wildlife Branch, Contribution No. 81-21.

Macdonald 1980). Control programs often used the same harvest methods as trappers and hunters (Linhart 1960, Lewis 1975). Studies have not presented simple, clear relationships between incidence of disease and harvest of foxes (Johnston and Beauregard 1969, Muller 1971, Preston 1973, Bogel et al. 1974). Although rabies epizootics have been used to justify the need for hunting and trapping, literature on the impact of harvest on incidence of disease in wildlife is inconclusive (Storm and Tzilkowski 1982).

The purpose of this paper is to describe the incidence of rabies in foxes in Ontario, the harvest of foxes in Ontario, and the evidence for their interactions. We identified 3 sets of hypotheses and predictions that would explain the interactions between incidence of rabies and harvest of foxes (Fig. 11–1). The hypotheses assume a density dependent relationship between fox density and mortality due to rabies and trapping.

Hypothesis 1. When densities of foxes are low but increasing, mortality rates due to rabies and trapping harvest are low. Prediction: the trapping harvest of foxes will increase as rabies increases (Fig. 11–1a).

Hypothesis 2. When densities of foxes are high, mortality rates due to rabies and trapping are high. Prediction: the trapping harvest of foxes will decrease as rabies increases (Fig. 11–1b).

Hypothesis 3. When densities of foxes vary, mortality rates due to rabies and trapping vary. Prediction: the trapping harvest of foxes will increase as rabies increases to epizootic levels; then harvest will increase as rabies decreases (Fig. 11–1c).

The complete, experimental testing of these hypotheses may be possible if rabies in foxes is controlled in the future. Evidence for interaction between rabies and harvest in this study is based on correlation.

The Rabies Research Unit of the Ontario Ministry of Natural Resources collected the ecological data during the 1970's. D. H. Johnston was Unit leader and other Unit members were I. Watt, F. Matejka, P. Bachmann, R. Bramwell, W. Lintack, B. Earle, M. Collins, E. Brolly, J. Rietveld, and the senior author of this paper. C. D. MacInnes was Research Section Supervisor throughout this work and was responsible for several insights and approaches in this work. M. Novak provided fox harvest data for Ontario, and Agriculture Canada provided rabies case data for Ontario. We also acknowledge B. Pond and L. Broekhoven, Queen's University. The paper was reviewed by C. D. MacInnes, F. Matejka, M. Collins, and R. Bramwell. The editing of G. C. Sanderson and the sharp critique of an anonymous reviewer were appreciated.

METHODS

This study was restricted to southern Ontario, south of a line from Parry Sound to Pembroke, where over 90% of the cases of rabies diagnosed in Ontario occurred (Johnston and Beauregard 1969). Data on incidence of rabies included

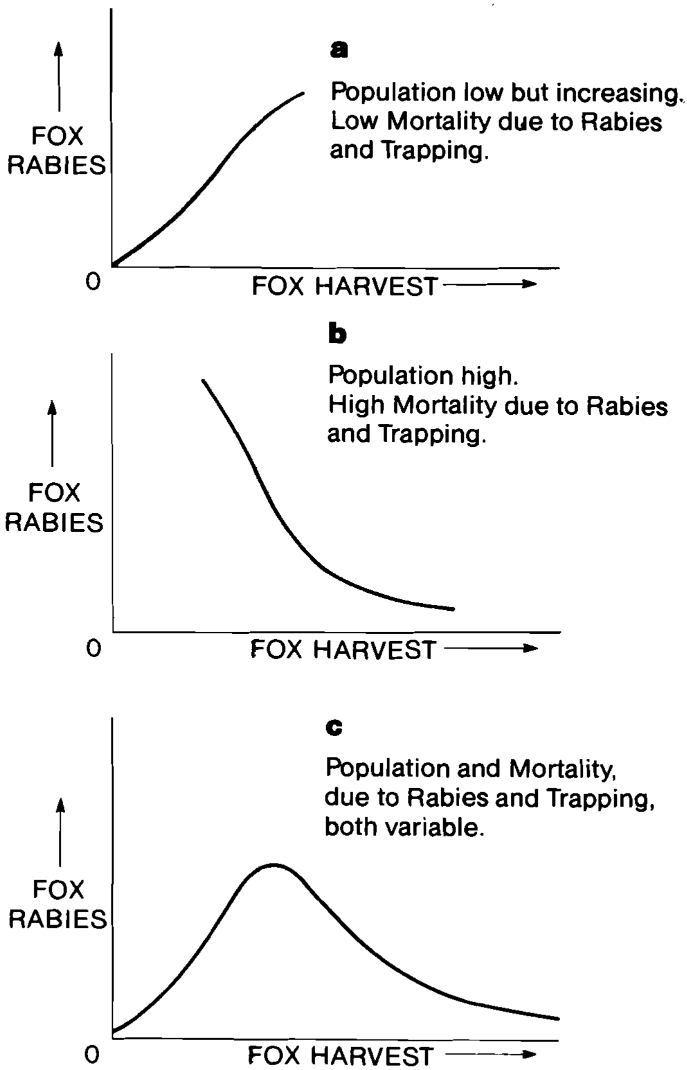
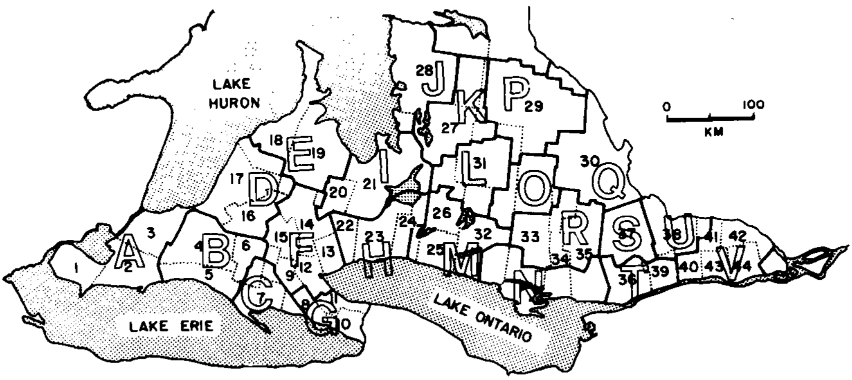


Fig. 11-1. Relationships between fox rabies and fox harvest for 3 hypotheses about rabies: harvest interaction.

species, date, county, township, lot, and concession. Records from 1958 through 1980 were used, but only records from 1976 through 1980 were analyzed in detail.

In Ontario, foxes are harvested by both hunting and trapping, but most are trapped during October and November. Hunting occurs each year after the trapping harvest when the ground is snow-covered. Because we did not have records of foxes harvested by hunting for the entire study area and period, we used only records for foxes harvested by trapping. We have used the terms trapping and harvesting interchangeably in this paper. Data on the harvest of foxes included the yearly number of foxes taken per township, per county, and per trapper. Aggregations of districts, counties, and townships, based on fox trapping and rabies, were tested for consistency of temporal and spatial patterns and their interrelationships. Townships in southern Ontario ranged from 40 to 400 km^2. The 431 townships comprised 42 counties. The 18 Ontario Ministry of Natural Resources administrative districts included 2–5 counties (Fig. 11–2). Districts averaged 5,000 km^2 in size. All cross-tabulations, analyses and statistical tests were done on a DEC PDT-11 computer with interactive inquiry and mapping packages (Q'UERY, Q'TEXT Q'MAP) developed at Queen's University, Kingston.



DISTRICTS

A	Chatham	L	Minden
B	Aylmer	M	Lindsay
C	Simcoe	N	Napanee
D	Wingham	O	Bancroft
E	Owen Sound	P	Algonquin Park
F	Cambridge	Q	Pembroke
G	Niagara	R	Tweed
H	Maple	S	Lanark
I	Huronia	T	Brockville
J	Parry Sound	U	Ottawa
K	Bracebridge	V	Cornwall

COUNTIES

11	Essex	16	Perth	31	Haliburton
2	Kent	17	Huron	32	Peterborough
3	Lambton	18	Bruce	33	Hastings
4	Middlesex	19	Grey	34	Lennox & Addington
5	Elgin	20	Dufferin	35	Frontenac
6	Oxford	21	Simcoe	36	Leeds
7	Norfolk	22	Peel	37	Lanark
8	Haldimand	23	York	38	Carleton
9	Brant	24	Ontario	39	Grenville
10	Welland	25	Durham	40	Dundas
11	Lincoln	26	Victoria	41	Russell
12	Wentworth	27	Muskoka	42	Prescott
13	Halton	28	Parry Sound	43	Stormont
14	Wellington	29	Nipissing	44	Glengarry
15	Waterloo	30	Renfrew		

Fig. 11–2. Map of southern Ontario showing districts and counties.

RESULTS

Incidence of Rabies

Rabies in wildlife in Ontario was first recorded in 1954 (Tabel et al. 1974). In 1958 there were 2,772 diagnosed cases of rabies in wild and domestic animals but only 242 cases occurred in 1960. Red foxes accounted for 45% of the cases during this epizootic phase. An enzootic phase followed and, during the last 15 years, the annual level of rabies has been reasonably consistent [$\overline{X} = 1,547 \pm 92$ (SE)], although the number of cases ranged from 1,097 in 1980 to over 2,230 in each of 1968 and 1971. Foxes continued to be the major species diagnosed and Ontario has averaged over 90% of the reported rabid foxes in Canada. Rabies occurred in the northern boreal forests of Ontario during the early epizootic but has not persisted there. Rabies in foxes was reported throughout southern Ontario from 1957 through 1980 (Fig. 11–3) but the number of cases varied from area to area. Spatial patterns remained similar from the initial invasion until 1978.

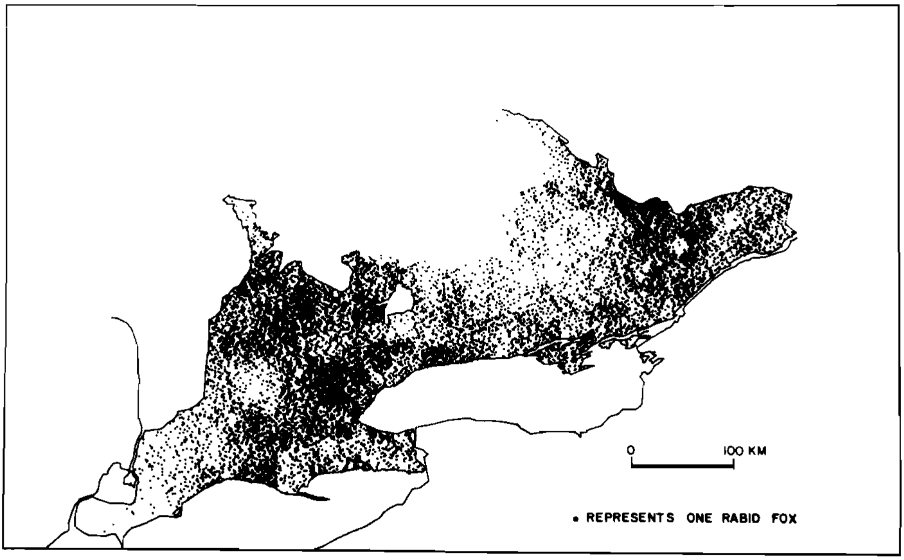


Fig. 11–3. The location of all diagnosed rabid foxes in southern Ontario in the enzootic area, 1957–80.

Incidence of rabies was cyclical, with a period of about 3 years at the county level (Johnston and Beauregard 1969). Cycles were also observed at the district level (Table 11–1), and a correlation matrix of districts was used to group contiguous districts that were in phase. Reports of rabid foxes in the districts of Pembroke, Brockville, Lanark, Ottawa, Cornwall, and Tweed were significantly correlated with each other. Reports in the districts of Chatham, Aylmer, Simcoe, Cambridge, and Niagara were correlated with each other. The contiguous districts of Lindsay, Tweed, and Napanee were correlated with each other. Huronia and Owen Sound districts had a consistently high incidence of rabies in foxes but they were not significantly correlated with each other. The Wingham district was an area of low incidence of rabies and did not correlate with adjoining districts.

A province-wide peak in rabies occurred in 1978–79 but cases of rabies declined during 1980. This decline was recorded over more districts than any trough since the low after the initial 1958 epizootic. Further, fox rabies was not clumped in large areas but was scattered across the southern part of the province (Fig. 11–4). The patterns of incidence from 1976 through 1980 showed apparent movements among and within the groupings of districts previously identified.

Harvest of Foxes

Since the early 1900's, harvest of foxes in Ontario by all methods ranged from 59,000 pelts in the mid-1940's before rabies epizootics to 2,000 pelts imediately after the rabies invasion in the late 1950's (Fig. 11–5). Since then the provincial fox harvest steadily increased to over 20,000 pelts in 1980. In southern Ontario, where most of the change occurred, the number of foxes harvested by trapping alone rose from 3,000 in 1973 to 7,500 in 1980. Much of that gain may be a result of the dramatic change in average pelt price from less than $20 (CDN) to $90 (CDN) (Fig. 11–6). Attractive fur prices usually increase both trapper effort and the number of active trappers. From 1976 through 1980 in the rabies area there was a 137% increase in the number of trappers and a 160% increase in the number of foxes trapped. The spatial distribution of trappers and trapped foxes (Fig. 11–7) remained similar over the 4 years, although local variation was evident.

The catch per trapper at the district level varied over the years despite the above trends. The average catch per trapper in 1980 was 1.09 foxes, a decline from 1.19 foxes in 1979 (Table 11–2). Catch per trapper in 15 of the 18 districts declined during the 1978–79 and 1979–80 trapping seasons.

Trappers in Huron county (3,496 km^2) harvested 2,127 foxes during the 4-year period 1976–80 or 0.152 fox/km^2/yr. That was the highest average over any large area in southern Ontario; some townships within Huron County provided as many as 0.42 trapped fox/km^2/yr.

Interaction of Rabies and Harvest of Foxes

Hypothesis 1 suggests the harvest of foxes will increase if rabies increases. We grouped counties into 5 classes based on the number of foxes trapped. The number of foxes trapped increased in a linear fashion as the incidence of rabies

Table 11-1. Cases of fox rabies reported in districts in southern Ontario from 1957 to 1980.

District	Year[a]																								
	57	**58**	**59**	**60**	**61**	**62**	**63**	**64**	**65**	**66**	**67**	**68**	**69**	**70**	**71**	**72**	**73**	**74**	**75**	**76**	**77**	**78**	**79**	**80**	**Total**
Owen Sound	3	207	1	0	127	23	27	78	31	54	87	144	39	93	58	49	39	53	146	58	71	100	54	120	1,662
Huronia	63	93	1	13	66	16	22	28	24	55	35	58	41	31	35	26	44	33	22	82	32	45	25	34	924
Wingham	0	89	3	3	13	24	25	11	40	11	24	56	36	12	37	41	23	28	12	10	25	18	19	37	597
Chatham	0	6	3	0	0	1	0	2	8	1	0	0	32	15	8	4	21	14	0	4	37	2	0	3	161
Aylmer	1	106	40	2	2	9	11	47	17	8	17	85	75	37	53	39	57	42	17	73	94	37	27	22	918
Simcoe	0	13	17	0	1	1	3	6	2	0	6	29	8	6	34	13	5	5	51	30	7	10	7	7	261
Niagara	0	0	0	1	0	1	0	0	0	3	0	3	7	3	45	25	0	0	66	6	10	13	3	6	192
Cambridge	15	155	20	0	24	46	34	43	59	19	44	83	72	55	78	62	101	55	83	95	54	67	33	44	1,341
Maple	29	140	7	3	23	19	19	13	11	39	27	27	90	24	69	41	46	97	13	26	56	52	9	9	889
Lindsay	50	209	9	17	40	31	39	51	11	35	44	88	42	16	77	36	22	60	85	45	110	85	41	39	1,282
Napanee	0	61	0	0	8	40	16	36	10	15	98	35	39	17	61	12	5	40	61	12	97	23	2	0	688
Tweed	9	20	0	0	15	18	1	45	5	16	28	22	10	5	12	13	6	28	11	12	13	26	7	1	323
Bancroft	14	27	0	0	14	1	1	14	2	5	1	24	1	0	0	0	0	6	6	0	0	5	1	5	127
Pembroke	23	10	4	33	38	10	3	46	19	11	40	60	4	6	73	10	25	72	20	13	3	101	17	0	641
Lanark	14	5	0	3	15	5	12	24	13	29	5	49	11	10	107	5	3	94	10	3	17	68	4	6	512
Ottawa	21	17	2	9	15	2	37	10	3	75	16	38	14	9	129	7	13	50	21	27	28	64	5	4	616
Brockville	3	10	0	1	4	7	19	12	27	33	20	74	25	44	47	9	10	96	42	12	34	118	42	3	692
Cornwall	142	52	6	6	20	2	34	26	4	47	46	33	24	16	49	21	14	8	24	4	21	57	28	24	708
Total	387	1,220	113	91	425	256	303	492	286	456	538	908	570	399	972	413	434	781	690	512	709	891	324	364	12,534

[a]Years are "rabies years"—from July to June of following year (1980 = July 1980–June 1981).

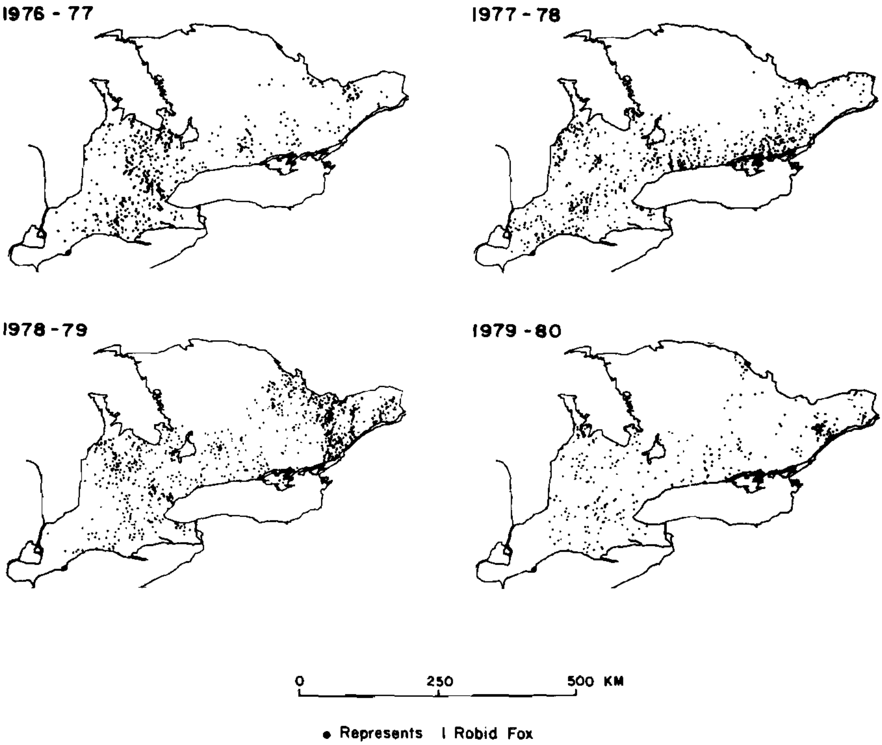


Fig. 11-4. The location of rabid foxes in southern Ontario during each of the 4 rabies-years, 1976–80.

increased (r^2 = 0.93). Both catch per trapper and incidence of rabies in foxes declined.

Because county grouping could mask exceptions in smaller areas, interactions at the township level were tested. No significant correlations existed between incidence of rabid foxes and number of trapped foxes (Table 11-3). Therefore, the grouped county correlation described above disagreed with results from townships and individual counties indicated a different type of interaction.

Hypothesis 2 suggests that the harvest of foxes decreases as the incidence of rabies increases when rabies and trapping causes high mortality. Values would be consistent for a specific carrying capacity or average density of foxes.

We derived a mortality index as a surrogate for carrying capacity by combining the number of foxes reported rabid and trapped. Rabies and trapping were

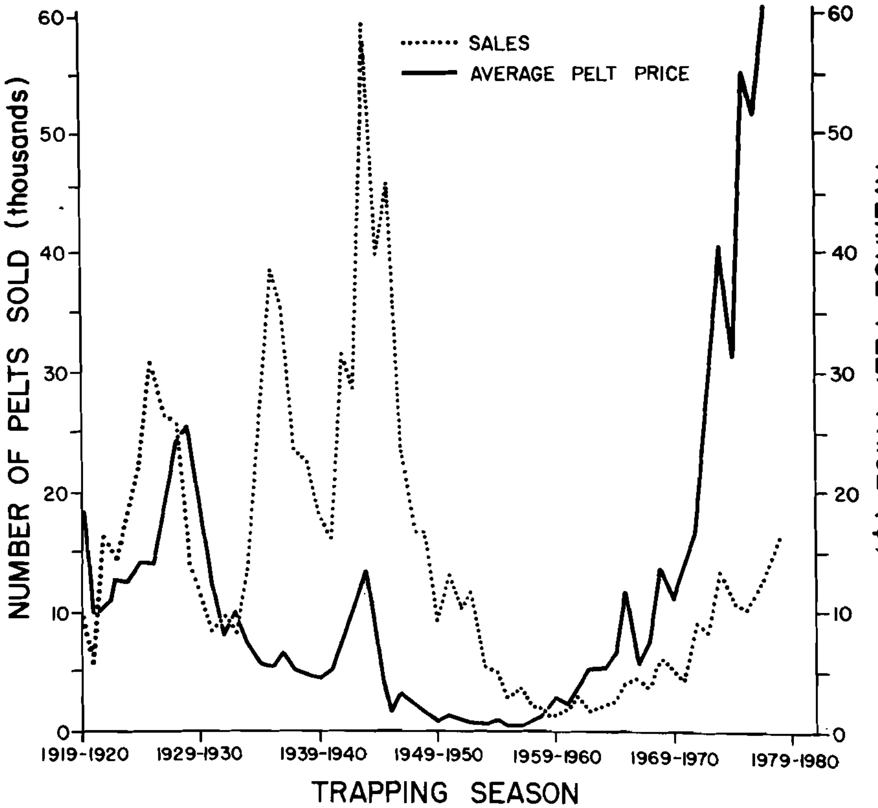


Fig. 11-5. The number of fox pelts sold and average price per pelt ($CDN) in Ontario from 1920 through 1980.

the major causes of mortality of southern Ontario foxes and the number killed over a period of years should provide a measure of an area's ability to produce foxes. A mortality index was obtained by adding the ranking based on incidence of rabies to the ranking based on number of trapped foxes for each county (1976–80). A mortality index derived from the product of the number of foxes reported rabid and the number of foxes trapped was correlated ($P < 0.05$) with the index derived by ranking. Because the product index was easier to derive than the ranking index, it was used as a surrogate for carrying capacity.

Counties were placed into 4 groups based on their mortality index (Fig. 11–8). Both eastern and western Ontario showed high to low index areas. The relationship between rabies and trapping was investigated for these groups

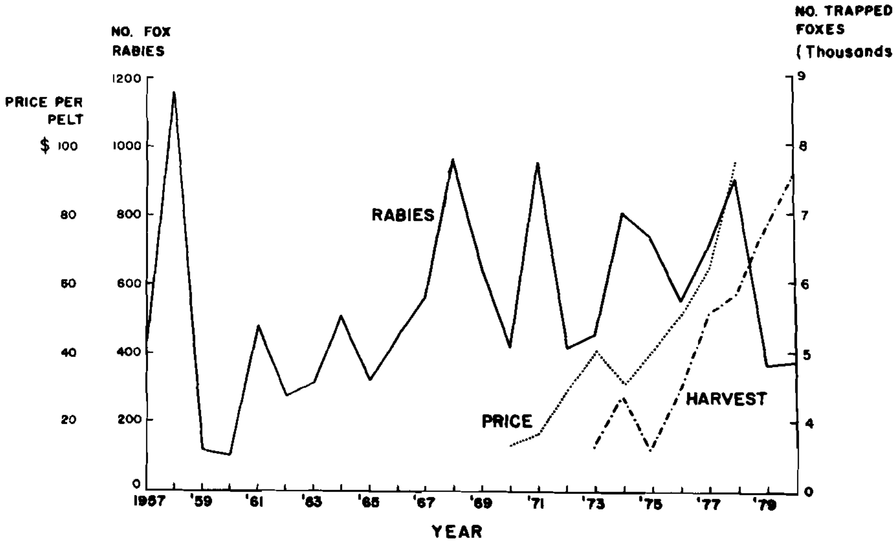


Fig. 11-6. Annual number of fox rabies cases and trapped foxes, and fox pelt values in southern Ontario, 1957–80. (Values for harvest and price not available on same basis.)

(Fig. 11–9) using a model of the form:

$$ln\ r = ln\ a - b_0\ ln\ h - b_1 q_1 - b_2 q_2 - b_3 q_3$$

where r = no. of rabid foxes/250 km^2

h = no. of trapped foxes/25 km^2

a = intercept value (mortality index level)

$b_0 - b_3$ = regression coefficients

$q_1 - q_3$ = dummy variables representing county groups

This model can be rewritten as $r = ah^{-b}$. It assumed that b_0 (the harvest exponent) was the same for all levels of the mortality index.

Dummy (qualitative) variables permitted 1 model to fit the 4 groups. All 40 observations (counties) were used to estimate b, as it was assumed to be the same for all levels of mortality index. Though simplified, these relationships permit predictions of rabies cases for trapping levels over periods of 3–4 years.

Hypothesis 3 predicted that low rabies levels would occur at both low and high trapping levels but high rabies levels would occur at medium harvest levels. A contingency table of number of townships, classed by 3 levels of trapping versus 3 levels of rabies, produced a significant X^2 value (Table 11–4). There were more medium-harvest townships with medium and high levels of rabies than expected. The cases of rabies in these high-, medium-, and low-harvest townships during each year from 1976 through 1980 also supported

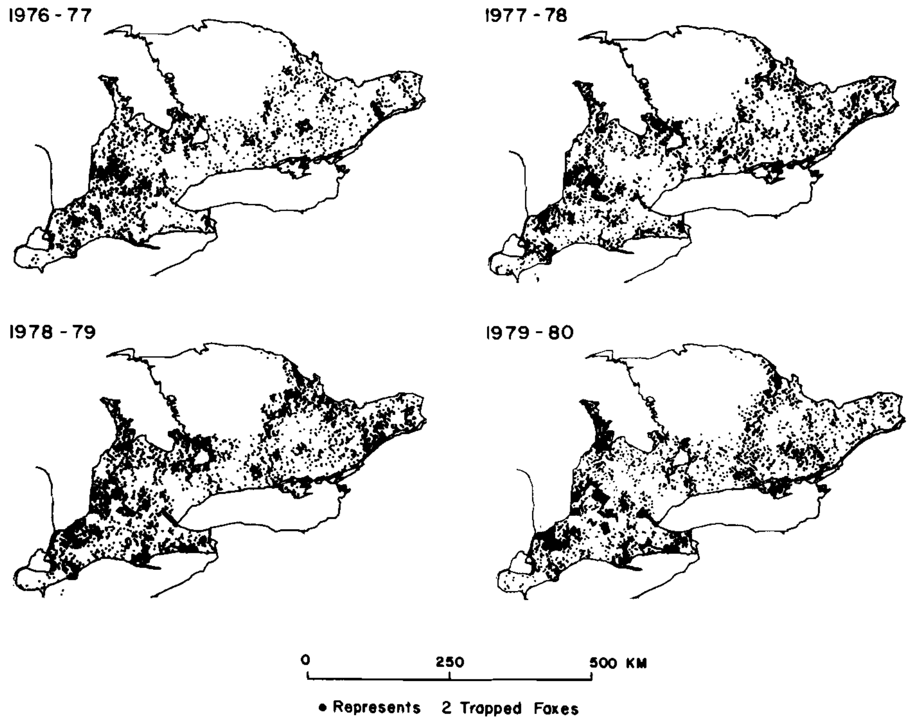


Fig. 11-7. The location of trapped foxes in southern Ontario during each of the 4 rabies-years, 1976–80.

Hypothesis 3 (Table 11-5). High- and low-harvest townships had fewer rabies cases per year ($\overline{X}$ = 4.27 and 0.87, respectively) than medium-harvest townships ($\overline{X}$ = 6.93). The medium-harvest townships had the largest absolute drop in harvest after the 1978–79 peak, indicating that they experienced the largest impact due to rabies.

Classifying Rabies Areas in Southern Ontario

During the analyses described in this paper, we recognized areas in southern Ontario that showed similar patterns—boundaries, time of outbreaks, and rabies-trapping interactions appeared consistent over time. We identified 12 areas of 2–4 counties each, after grouping counties by mortality index, by including patterns of seasonal rabies occurrence. We also employed clustering algorithms that grouped contiguous counties with significant correlation coefficients from rabies: harvest data for the study period. Four examples described below represent the types of units identified. They demonstrate the potential

Table 11-2. Number of foxes trapped and number of foxes per trapper for each district in southern Ontario, 1976–80.

District	No. foxes trapped (No. foxes/trapper)			
	1976–77	**1977–78**	**1978–79**	**1979–80**
Owen Sound	346 (1.23)	458 (1.44)	610 (1.61)	801 (1.76)
Huronia	402 (1.70)	443 (1.86)	581 (2.39)	374 (1.30)
Wingham	717 (1.85)	924 (2.35)	821 (1.85)	812 (1.76)
Chatham	384 (0.99)	588 (1.51)	622 (1.34)	762 (1.67)
Aylmer	364 (1.30)	303 (1.07)	330 (1.08)	444 (1.23)
Simcoe	154 (0.87)	201 (1.28)	317 (1.68)	316 (1.44)
Niagara	89 (0.52)	160 (0.88)	230 (1.13)	352 (1.54)
Cambridge	367 (1.16)	276 (0.99)	415 (1.27)	544 (1.46)
Maple	71 (0.32)	147 (1.52)	152 (1.41)	191 (1.39)
Lindsay	233 (0.78)	341 (1.14)	287 (0.85)	390 (0.98)
Napanee	180 (0.38)	257 (0.50)	207 (0.35)	472 (0.65)
Tweed	286 (0.71)	226 (0.53)	240 (0.48)	326 (0.54)
Bancroft	165 (0.71)	256 (1.03)	341 (1.32)	360 (1.22)
Pembroke	327 (0.99)	491 (1.33)	825 (2.06)	507 (0.96)
Lanark	103 (0.58)	158 (0.81)	182 (0.77)	128 (0.47)
Ottawa	30 (0.44)	79 (0.96)	134 (1.31)	98 (0.82)
Brockville	66 (0.22)	164 (0.48)	209 (0.57)	172 (0.44)
Cornwall	251 (1.18)	357 (1.27)	342 (1.24)	190 (0.60)
Total	4,535 (0.94)	5,829 (1.14)	6,845 (1.19)	7,239 (1.09)

Table 11-3. Correlation matrix of trapped foxes and rabid foxes for 431 townships in southern Ontario, 1976–80. (Values over 0.12 are significant, $P < 0.01$). Annual means ($\pm$ *SE*) for each variable are also listed.

		Rabid foxes				Trapped foxes			
		77–78	**78–79**	**79–80**	**80–81**	**77–78**	**78–79**	**79–80**	**80–81**
	77–78	1.00							
Rabid	78–79	0.14	1.00						
Foxes	79–80	0.19	0.03	1.00					
	80–81	0.10	0.00	0.10	1.00				
	77–78	0.04	−0.00	−0.03	0.10	1.00			
Trapped	78–79	−0.08	−0.04	−0.02	0.07	0.61	1.00		
Foxes	79–80	0.01	−0.06	0.04	0.14	0.54	0.76	1.00	
	80–81	−0.01	0.02	−0.07	0.07	0.42	0.60	0.66	1.00
	Mean	1.21	1.60	2.05	0.77	10.12	12.89	15.16	15.94
	$\pm$ *SE*	0.10	0.11	0.15	0.08	0.59	0.75	0.85	1.03

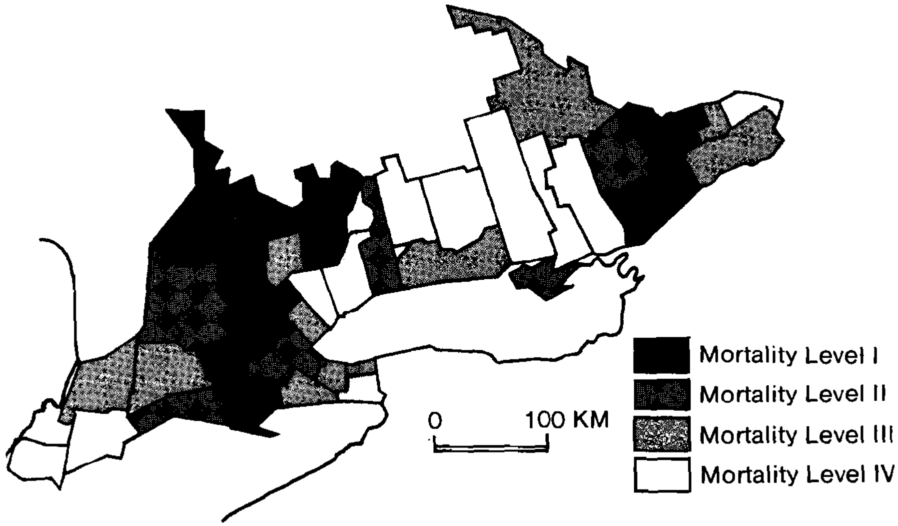


Fig. 11–8. Locations of 4 levels of mortality index (rabies x trapping) in southern Ontario, 1976–80. Mortality level 1 was highest.

value of these classifications to fur managers or rabies control managers in the future.

Wellington–Dufferin–Simcoe–Wentworth Unit.—A high-rabies area. Outbreaks start in spring and summer, continue through the fall, and depress the harvest after outbreak. The annual rabies level does not fluctuate greatly, because local outbreaks occur almost every year. This area is also characterized by high incidence of rabies in skunks.

Huron–Perth Unit.—A high-harvest area. Rabies starts in late summer in epizootic years but a consistently large harvest dominates and rabies declines during the fall. The area has a relatively high density of foxes but very low incidence of rabies.

Carleton–Renfrew–Lanark–Leeds Unit.—A unit subject to dramatic epizootics after which harvest levels decrease for 1 year, then increase for about 2 years. Rabies starts in the spring during an outbreak year and continues through the fall with little apparent impact by trapping. Years following outbreaks are characterized by low rabies incidence and fox harvest.

Frontenac–Lennox Unit.—Small outbreaks start in spring or summer and decrease the harvest. However, the next year the harvest increases and rabies continues to decline. This unit is not a high-mortality index area, but it is adjacent to the Carleton unit. It may be an area where densities of foxes are

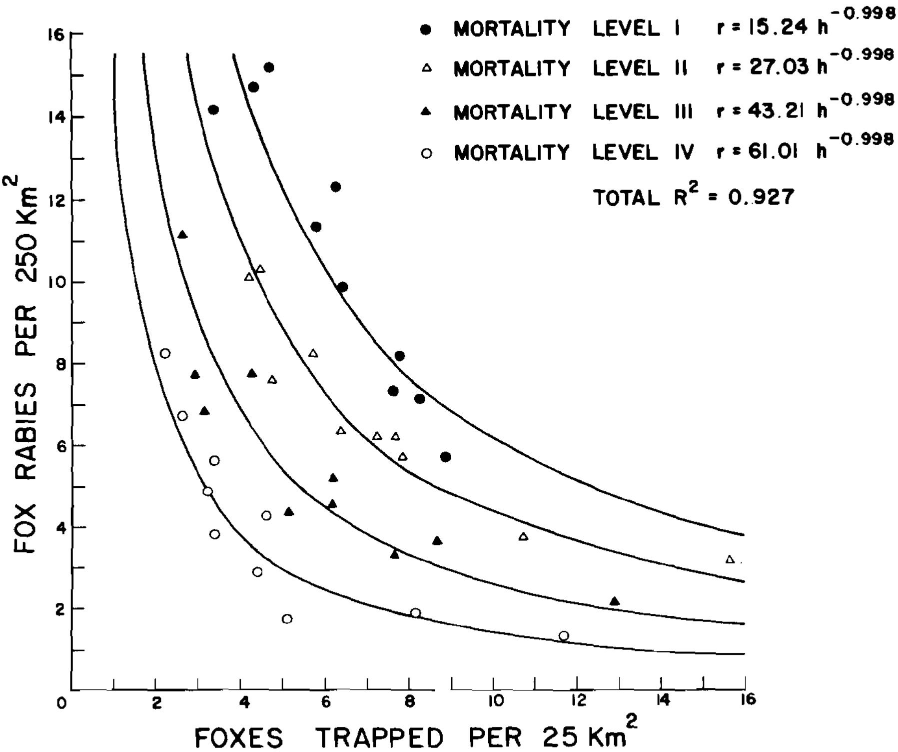


Fig. 11-9. Relationship of cases of rabies to number of trapped foxes, for 4 levels of mortality, 1976–80.

Table 11-4. Contingency table of number of townships in southern Ontario classed by fox trapping level versus fox rabies levels over 4 years, 1976–80 ($X^2 = 14.84$ d.f. $= 4$, $P < 0.005$).

Rabies Level	Harvest level		
	Low (<50 pelts)	**Medium (50–99 pelts)**	**High (100+ pelts)**
low (<5 cases)	126(122)[a]	40(55)	51(40)
medium (5–10 cases)	67(67)	38(30)	14(22)
high (10+ cases)	49(53)	31(24)	15(18)

[a]Expected values are in parentheses.

Table 11–5. Cases of fox rabies for 3 levels of trapping harvest for 1976–80 in southern Ontario.

	No. cases of rabies			
Harvest level	**1976–77**	**1977–78**	**1978–79**	**1979–80**
High harvest	79	108	97	53
(>100 foxes)	(0.99)[a]	(1.35)	(1.21)	(0.66)
N = 80 townships				
Medium	160	220	284	78
(≤50 and <99 foxes)	(1.46)	(2.01)	(2.61)	(0.72)
N = 109 townships				
Low	257	383	441	133
(<50 foxes)	(1.06)	(1.58)	(1.82)	(0.55)
N = 242 townships				

[a]Value in parentheses is cases per township.

barely sufficient for an outbreak; harvests can decrease that potential but outbreaks in nearby counties increase it.

Other units with consistent patterns included Grey–Bruce, Kent–Lambton, Elgin–Oxford, and Haldimand–Brant.

DISCUSSION

Rabies has an uncommon characteristic—it causes aberrant behavior that helps perpetuate the disease by increasing contact and virus transmission. Usually rabid foxes are reported only during the final infective stage. If they are aggressive or have no fear, they wander into exposed places during daylight.

Southern Ontario has the highest number of reports of rabies of any similarly sized area in North America. This study used reported cases of rabies as an estimate of incidence. We had no method of measuring the percentage of rabid foxes in various populations during epizootics. The relationship between fox rabies and trapping would be clearer if the density of foxes and true number of rabies cases were known. Elsewhere, estimates of the percentage of foxes that were rabid in the population ranged from 2 to 80% (Braunschweig 1980). Brains of foxes were collected by the Rabies Research Unit in Ontario, but less than 3% were rabid. The percentage of foxes diagnosed with rabies at any time will be low, because rabid foxes die soon after onset of clinical symptoms and earlier diagnoses are difficult. Compensation is paid to owners who lose cattle to rabies, thus there is incentive to report rabies, and cattle can be an indicator species. In cattle areas of Ontario we observed that incidence of rabies in cattle mirrored fox rabies patterns. Thus, the incidence data for Ontario provides an index of temporal and spatial patterns of rabies that can be compared with trapping records to assess interactions.

Fox harvest and pelt prices were higher in recent years than in any period since the rabies invasion, and fox rabies declined in 1980 to levels of the early 1960's. Previous declines, especially in 1959, 1970, and 1973, occurred after the rabies peaks in 1958, 1969, and 1972. The most recent decline, during a 3-fold increase in harvest, was the most widespread.

Rabies has not been effectively controlled by programs that trap, shoot, and gas foxes (Parks 1968, Lewis 1975, Winkler et al. 1975, Macdonald 1980, Steck and Wandeler 1980, Bogel et al. 1981). Therefore, less intensive harvests—such as for fox pelts alone—would appear to have little effect on incidence of rabies in foxes. Our investigations indicate, however, that high levels of harvest in southern Ontario can decrease the severity, if not the frequency, of rabies outbreaks. These high harvest levels are low compared to world-wide values (Hewson and Kolb 1973, Wandeler et al. 1974, Lloyd et al. 1976). Fox densities in Ontario are lower than those reported for Europe and parts of North America (Sargeant et al. 1975, Lloyd 1980). The fox density at which rabies is epizootic in Ontario is the density at which Europeans claim rabies will disappear (Bogel et al. 1974, 1976). Intensive surveys of spring fox families indicated that densities of 1 fox/km^2, including pups and adults, were common (Voigt unpubl. data).

The density of foxes obviously affects both incidence of rabies and trapping success, but the effort and success of each trapper is neither equal nor solely a function of fox density. In the Wingham District, 5% of the trappers captured 50% of the foxes caught during the study period. In this high harvest area, the average number of foxes trapped per trapper per year was 4.16 ± 0.83.

Investigations of individual counties revealed that the relationship between rabies and trapping was influenced by the seasonal occurrence of a rabies epizoötic. Outbreaks that occurred in winter and spring months depressed harvest levels the next fall, but epizootics that occurred during the fall had little influence on harvest levels. In high-harvest areas, rabies outbreaks were short-lived and less severe. In low- or medium-harvest areas, outbreaks were more severe and lasted throughout the fall and winter. In eastern Ontario areas, rabies outbreaks consistenly occurred in late winter or early spring. Low but erratic levels of fox harvest occurred in these areas even though the density of trappers was higher than in western Ontario.

SUMMARY

The interaction of rabies and trapping and its effect on fox density is important to both fur managers and rabies control operations. The occurrence of rabies and harvest of foxes in Ontario vary spatially and temporally. Areas grouped by a

mortality index showed that rabies declined as harvest increased (*Hypothesis 2*) over a 4-year period. In high-harvest areas, where more than 3 foxes per 25 km^2 were trapped annually, rabies levels were low (*Hypothesis 3*) and outbreaks were short-lived. Although rabies epizootics started during summer months, they declined during the fall harvests. In low- or moderate-harvest areas, epizootics caused a decreased harvest and rabies levels increased during fall and winter; the next fall, both fox harvest and rabies incidence declined (*Hypothesis 1*). This relationship could explain the 1980 decline in much of southern Ontario.

This study indicates that averaging values from large areas, or over long periods, can mask interactions and effects of fur harvests and disease incidence. Future studies may better elucidate fundamental mechanisms and permit prediction of disease or harvest, but local patterns and conditions must be considered.

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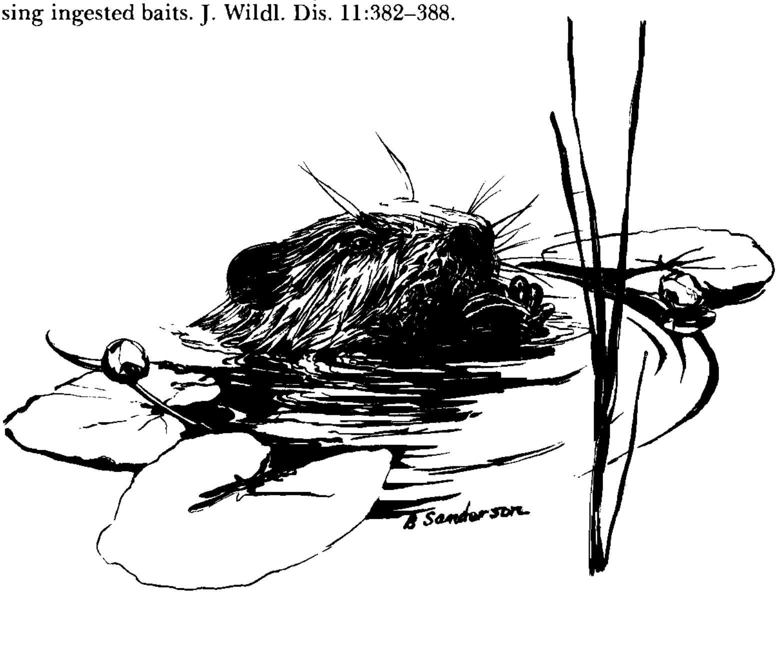

12

Reintroduction of Fisher, Pine Marten, and River Otter

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Abstract: Fisher (*Martes pennanti*), pine marten (*M. americana*), and river otter (*Lutra canadensis*) are frequently translocated in the northern states and provinces. This translocation is a result of their high fur value, previous extirpation, niche availability, predation value, public relations benefit, and the need to preserve locally rare or threatened species. Of 33 northern states and provinces queried in 1981, 22 have been or are involved in transplanting these species, 4 anticipated transplants in the future, and 7 had no plans. Fisher and marten were the most frequently transplanted species. Fisher, marten, and otter were trapped by agency personnel, private trappers, and environmental consultants. Reimbursement was by cash paid directly to the agency or trapper, trade for another wildlife species, or gratis. The most successful transplants incorporated feasibility studies, use of box traps of solid side rather than cage construction, introduction of more than 30 animals, sex ratios favoring females, short handling and transportation periods, and an acclimatization period in the new area prior to release. Most problems in transplanting programs result from inadequate planning, too few animals transplanted, trapping or handling related injury or death, inadequate niche assessment, and opposition of the local populace to a new predator species. Methods for trapping, immobilizing, holding, transporting, and releasing fisher, otter, and pine marten are discussed. Transplant success is best evaluated by a combination of field sign and radiotelemetry. The most successful transplants to date have been of fisher in Vermont and both fisher and marten in Wisconsin and Michigan.

Key words: fisher, livetrapping, mustelid, pine marten, reintroduction, river otter.

Fisher, pine marten, and river otter populations declined dramatically in North America during the first half of this century, mainly because of over exploitation, habitat loss, and perhaps environmental contaminants. Fisher and marten populations declined until the mid-1900's in Canada (Anderson 1947), the Lake States (Schorger 1942), and the eastern (Hamilton and Whitaker 1979), western (Hagmeier 1956), and southwestern United States (Hall 1942). Under complete protection or regulated harvests, together with habitat maturation, fisher and marten have since increased in much of their range (Hagmeier 1956), particularly in the northeast (Hamilton 1957, Coulter 1960) the Lake States (Irvine et al. 1964), and California (Yocom and McCollum 1973). Dramatic increases occurred under complete protection in northeastern Minnesota (Balser 1960, Balser and Longley 1966).

Otter populations, more evenly distributed over North America than fisher and marten (Hall and Kelson 1959, Park 1971), also declined, especially in the central plains states (Park 1971, Hamilton and Whitaker 1979). Otter populations have stabilized under controlled harvests or complete protection but have not shown the marked increases of fisher and marten.

Fisher occur in 16 states and all provinces except Newfoundland and Prince Edward Island, (Deems and Pursley 1978, Strickland and Douglas 1981). Marten and otter occur in 16 and 44 states, respectively, and in all provinces except Prince Edward Island (Deems and Pursley 1978).

Fisher are harvested in 14 states and provinces, marten in 17, and otter in 39 (Deems and Pursely 1978). The 3 species comprised 1.3% and 1.9% of the total North American furbearer harvest and value, respectively, in 1978 (Deems and Pursley 1978). In Minnesota these species comprised 0.4% of the harvest and 3% of the dollar value (Department of Natural Resources, unpublished data).

Fisher, marten, and otter are the most frequently reintroduced furbearers in North America because of their extirpation from still suitable habitats, high fur value, predatory nature, and aesthetic and public appeal. This paper reviews many successful and unsuccessful reintroductions; lists methods for trapping, handling, and releasing these animals; and provides criteria for evaluating reintroductions.

Appreciation is expressed to the following personnel of the Minnesota Department of Natural Resources: Blair Joselyn, Pat Karns, Todd Fuller, and David Kuehn for reviewing the manuscript; Shirley Piekarski for library assistance; and Judy Summers for typing.

Several persons from the U.S. and Canada contributed information from unpublished records and memory. Citation of the following persons without dates in the text represents acknowledgement of their cooperation and are referenced as personal communication in the text: Carman Douglas, Midge Strickland, and Howard Smith (Ontario); Richard Leonard and Richard Stardom (Manitoba); John Davie and Arlan Todd (Alberta); Herbert Melchior (Alaska); Carl Dugger and David Brittel (Washington); John Thiebes (Oregon); Larry Fredrickson (South Dakota); Carrol Henderson, James Schneeweis, Pat

Karns, and William Marshall (Minnesota); Charles Pils and Phil Vanderschaegen (Wisconsin); Margaret Herman, William Irvine, Joseph Vogt, and John Stuht (Michigan); Gary Parsons (New York); John Hunt (Maine); Robert Fuller and Walter Cottrell (Vermont); Henry Laramie (New Hampshire); and Jack Cromer and Roger Powell (West Virginia). Appreciation is also expressed to the several questionnaire respondents whose agencies had no involvement in mustelid reintroductions.

METHODS

The results of few reintroductions have been published; many exist as either unpublished file reports or unwritten recollections. To augment the literature, questionnaires were mailed to 57 furbearer resource persons in 37 northern and plains states and provinces. Questions asked were: (1) Has your agency been involved in a mustelid reintroduction? (2) Is such an effort planned? and (3) Summarize or enclose reports of these efforts.

RESULTS

Replies or literature were obtained from agencies in 33 states and provinces. Twenty-two agencies had each been involved in at least 1 reintroduction, 4 planned reintroductions and had completed feasibility studies, and 7 had no such plans (Fig. 12-1). Animals were usually moved interstate or province but were occasionally moved within the boundaries of a state or province.

Reintroduction Summary

The following review lists sex ratios, when available, abbreviated as males (M), females (F), and unknown sex (U).

Fisher.—Nineteen fisher transplants occurred between 1955 and 1981. The first, in Nova Scotia, stocked 12 (6 M, 6 F) ranch fisher and succeeded in establishing a population (Benson 1959). Several agencies began reintroductions simultaneously in the late 1950's and early 1960's. From 1959 to 1963, fisher from British Columbia were reintroduced in Montana (16 M, 20 F) (Weckwerth and Wright 1968), Idaho (20 M, 19 F) (Williams 1962, 1963), and Oregon (10 M, 14 F) (J. Thiebes). The Montana and Idaho efforts were considered successful, whereas success of Oregon's effort was questionable despite the early optimism expressed by Kebbe (1961).

From 1956 to 1958, 18 fisher (6 M, 12 F) were transported from New York to the Nicolet National Forest in Wisconsin (Irvine et al. 1964, Petersen et al. 1977). An additional 42 (30 M, 12 F) from Minnesota were stocked on the Nicolet in 1958–63 (Petersen et al. 1977), and as part of the same program, 61 (42 M, 19 F) Minnesota fisher were introduced on the adjoining Ottawa National Forest in Michigan (Irvine et al. 1964). In 1966–67, Minnesota also sent 60 fisher (30 M, 30 F) to the Chequamegon National Forest in northwestern Wisconsin (Petersen et al. 1977). The Nicolet–Ottawa and Chequamegon

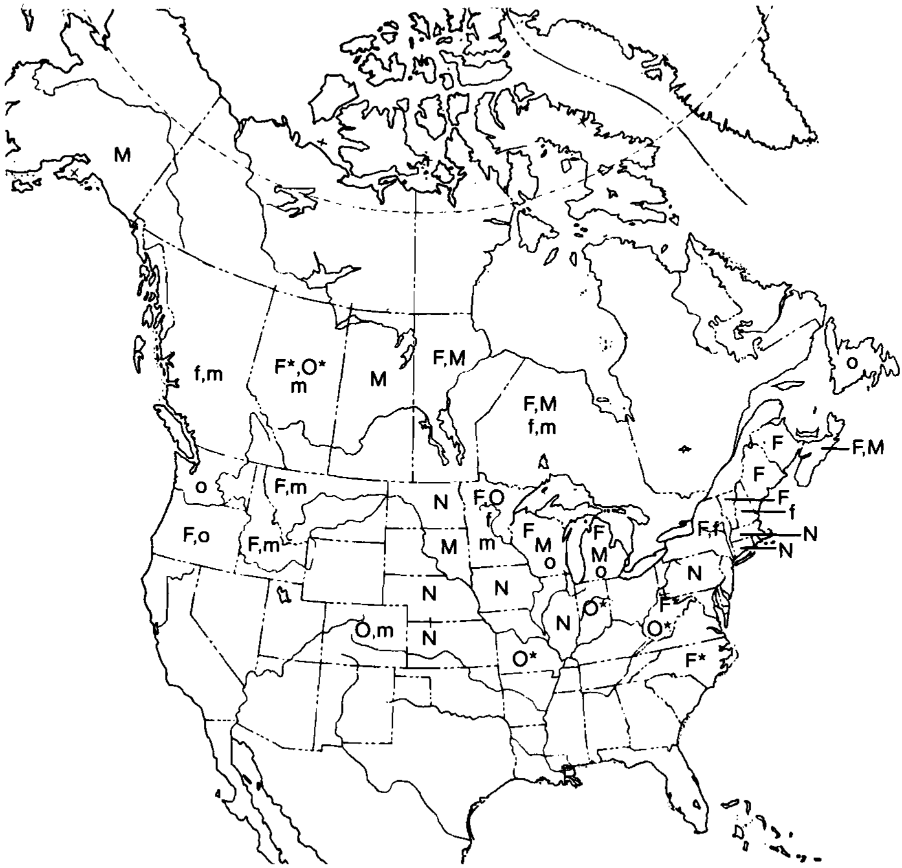

Fig. 12–1. Northern mustelid reintroduction summary for the United States and Canada. Capital letters indicate that fisher (F), marten (M), or river otter (O) were imported to or translocated within a state or province; lower case letters indicate the species were exported for reintroduction elsewhere. Future reintroductions indicated by (*), no reintroduction plans by (N), and no answer or not queried indicated by blank.

reintroductions were all successful; the latter population increased more rapidly than the earlier ones (Powell 1977, Petersen et al. 1977). In 1968, 15 fisher of unknown sex were transported from northeastern to northwestern Minnesota (Itasca State Park) to control porcupines (*Erethizon dorsatum*) but no formal evaluation was conducted (W. Marshall).

The result of transplanting 25 (25 U) fisher from Algonquin Park, Ontario, to the Patricia portion of northern Ontario in 1956 is unknown, but another transplant of 97 (37 M, 60 F) from 1956 to 1963 from Algonquin to Parry Sound, Ontario, was successful to the extent that animals have been trapped for several years (C. Douglas). A reintroduction of 4 fisher (4 U) to Riding Mountain National Park in Manitoba in 1972–73 produced no discernible results (R. Leonard). From 1979 to the present, 57 fisher (27 M, 30 F) were stocked from Bancroft Island to the Manitoulin and Bruce Peninsula areas of Ontario (C. Douglas).

In the northeastern U.S., Maine provided Vermont with 124 fisher (19 M, 16 F, 89 U) from 1959 to 1967 and trapping seasons began in 1974 (Fuller 1975). No reproduction was noted from 25 fisher (10 M, 15 F) transplanted from northern to southern New Brunswick in 1966–68 (Dilworth 1974). A 1972 transplant of 7 fisher (7 U) from western to eastern Maine failed to establish a population (J. Hunt). A reintroduction suggested by Hamilton and Cook (1955) from the Adirondack to the Catskill region of New York began in 1976; 43 (19 M, 24 F) were stocked by 1979 (G. Parsons). In 1969, 23 fisher (6 M, 10 F, 7 U) were livetrapped in New Hampshire and released in West Virginia, resulting in a general range expansion (Pack and Cromer 1981, H. Laramie). By 1974–75 fisher from this release had entered Maryland (Cottrell 1978).

The most recent fisher reintroduction was in autumn 1981; 13 (8 M, 5 F) were transported from Minnesota to Oregon (J. Schneeweis). Future reintroductions are planned for the Great Smoky Mountains in North Carolina (R. Powell), Riding Mountain National Park of western Manitoba (R. Leonard), and the Kananaskis area of southern Alberta (J. Davie).

Pine Marten.—Alaska was the first of several agencies to reintroduce marten. It reintroduced 58 marten (10 M, 16 F, 32 U) in 5 or more projects on southeastern Alaska islands between 1934 and 1952 (Burris and McKnight 1973). These re-established several populations, but the transplants were considered failures because of low pelt values and minimal economic gain. A 1954 stocking of 24 marten (24U) from Banff National Park in Alberta to Prince Albert National Park in central Saskatchewan produced uncertain results (R. Leonard). Between 1960 and 1969, Manitoba stocked 154 marten (154 U) from British Columbia, Ontario, and northern Manitoba into 3 west central areas (van Zyll de Jong 1969). One reintroduction failed completely, another resulted in increasing marten numbers 4 years later, and the third resulted in densities of 0.4 marten per km^2 (compared to a planned density of 2 per km^2) by 1969 (van Zyll de Jong 1969, R. Stardom). No record exists of the success of 12 marten (5 M, 7 F) transplanted from Ontario to Nova Scotia in 1956 (C. Douglas).

Several reintroductions of marten have been made in the Lake States since 1953. Five (5 U) marten were transported from Montana to 1 of the Apostle Islands (Jordahl 1954) but the results are unknown. Between 1956 and 1963, 249 marten (155 M, 94 F) transported from Algonquin Park to Parry Sound, Ontario, established a population (C. Douglas). A transfer of 19 marten (12 M, 7 F) from Ontario to the Porcupine Mountains of northwestern Michigan in

1957 apparently failed (J. Stuht). In 1969–70, 99 marten (62 M, 37 F) from the Thunder Bay area of Ontario were transplanted to the Hiawatha National Forest in Michigan's Upper Peninsula (C. Douglas). Although juvenile progeny have appeared through 1981 (J. Stuht), Schupbach (1977) failed to document a viable population in 1975-76. In 1975–76, 124 marten (97 M, 27 F) from Algonquin Park were released in Wisconsin's Nicolet Forest, with unknown results to date (Davis 1978, P. Vanderschaegen).

The success of 5 recently completed marten reintroductions has yet to be determined. A reintroduction to northern Michigan from Algonquin Park stocked 148 marten (77 M, 71 F) (Churchill et al. 1981). During 1980-81, 19 marten (9 M, 10 F) from Colorado (P. Vanderschaegen), and 18 marten (9 M, 9 F) from Ontario (Churchill et al. 1981) were stocked on the Nicolet Forest, and in 1982 an additional 4 (4 U) were obtained from Colorado (C. Pils). By autumn 1981, 43 (25 M, 18 F) marten were reintroduced from Idaho to the Black Hills of South Dakota (L. Fredrickson).

Except for a possible transplant to Riding Mountain National Park in western Manitoba (R. Leonard), no future reintroductions of marten are planned.

Otter.—Few attempts have been made to reintroduce the river otter, and only Colorado and Minnesota are currently involved. By autumn 1981, 55 otter (8 M, 2 F, 45 U) of a planned 80 were reintroduced by the Colorado Division of Wildlife (Goodman 1981); included in this total were 7 stocked on Rocky Mountain National Park in 1978 (Stevens 1980). Sources were Newfoundland, Washington, Oregon, Michigan, and Wisconsin. Success is unknown, but Stevens (1980) observed sign 18 months after release. An ongoing project begun in 1980 has transplanted 15 otter (4 M, 10 F, 1 U) from northeastern to extreme west-central Minnesota (C. Henderson).

Several agencies plan future otter reintroductions, as evidenced by feasibility studies by Alberta (Jalkotzy 1980), Missouri (Erickson 1981), and West Virginia (Bottorff et al. 1976). A feasibility study by Lehman (1979) advised against reintroducing otter in Indiana until other agencies completed ecological and reintroduction studies.

Handling and Management Strategies

Reintroduction Objectives.—With few exceptions, the primary reason for transplanting northern mustelids was their depletion or extirpation. The fisher's high pelt value (Deems and Pursley 1978) and ability to control porcupines (Cook and Hamilton 1957, Irvine et al. 1964, Powell and Brander 1977) were major reasons for reintroductions in the Lake States (Irvine et al. 1964), Pacific Northwest (Weckwerth and Wright 1968), New York (G. Parsons), and Vermont (R. Fuller). Marten currently have a lower pelt value than either fisher or otter (Deems and Pursley 1978) and have little economic effect as a predator (Murie 1961). Marten were primarily reintroduced because of their recognition as a unique and desirable component of wilderness forest ecosystems (Marshall 1951, Koehler et al. 1975). Otter were also stocked due to previous extirpation and their "aesthetic furbearer qualities" (Goodman 1981). West Virginia termed otter a "bonus" furbearer for trappers (Bottorff et al. 1976).

Problems and Procurement.—Mustelids were usually taken by private, expert trappers following handling procedures specified by the purchasing agency. Payment was usually equal to fur value, plus some travel expenses, and was paid by the acquiring agency. In 2 instances all phases of reintroduction and preliminary evaluation were handled by a private consultant (Ecological Research Services, Inc.) (Churchill et al. 1981, P. Vanderschaegen). Agencies also trade various species, such as New Hampshire fisher for West Virginia wild turkeys (*Meleagris gallopavo silvestris*) (Pack and Cromer 1981), Idaho marten for South Dakota turkeys (L. Fredrickson), Colorado marten for Wisconsin otter (P. Vanderschaegen), and Ontario marten for Michigan fox squirrels (*Sciurus niger*) (P. Karns). Kentucky purchased otter from an individual in Louisiana, and traded them to Missouri for wild turkeys (D. Erickson).

Sex ratios in most successful fisher reintroductions were equal or favored females. According to Petersen et al. (1977), stocked fisher multiplied more rapidly on the Chequamegon than on the Nicolet site in Wisconsin despite seemingly better habitat on the Nicolet, because of even sex ratios stocked over a shorter period. The trapper's tendency to retain the more valuable female fisher may account for some unbalanced sex ratios in reintroductions (G. Parsons). However, male marten predominate in reintroductions despite their approximately 60% greater pelt value (M. Strickland). Agencies should specify even sex ratios in a contract, pay more for females when necessary (G. Parsons), and release excess males prior to shipment (Churchill et al. 1981).

Marten reintroductions caused no bio-political problems, but the fisher's "predatory efficiency" may alarm people concerned with domestic and wild animals (G. Parsons, R. Fuller). For example, West Virginia citizens were opposed to importing "fierce" fisher and exporting native wild turkeys (Pack and Cromer 1981). The otter's ability to raid fish hatcheries (Melquist and Hornocker 1979, C. Dugger) and possibly affect sport fisheries may warrant consideration.

Reintroductions should utilize animals from the nearest viable population to minimize genetic differences (van Zyll de Jong 1969). Newfoundland otters will be introduced in West Virginia because they are the same subspecies as that extirpated (Bottorff et al. 1976). Marten from British Columbia were stocked in Manitoba because of their dark sable color (van Zyll de Jong 1969).

Although otter can thrive in cloudy or turbid water, they do not thrive in chemically unclean water (Penkala, *in* Lehman 1979). Organochloride residues, mainly PCB's, have been identified in tissues of otter and mink (*Mustela vison*) in Oregon (Henny et al. 1981) and Georgia (Halbrook et al. 1981), and methylmercury was identified in otter tissues by O'Connor and Nielsen (1981). These pollutants adversely affect reproduction in mink and otter and may be linked to otter population declines in certain areas of North America (Halbrook et al. 1981, O'Connor and Nielsen 1981). Water quality was addressed in otter reintroduction feasibility studies in Indiana (Lehman 1979) and Missouri (Erickson 1981), where abundant, apparently suitable, habitat fails to sustain even remnant otter populations.

Interspecific competition between predator species should be addressed in feasibility studies. For example, marten and fisher food habits are similar at certain times (Clem 1977), and direct competition between these species was questioned by Carpenter (*in* Newby and Hawley 1954).

Trapping and Handling.—Live-trapping dates were often unspecified; however, most reintroductions of fisher and marten occurred in winter. Irvine et al. (1964) suggested March as the time to trap fisher because of the mating period and milder weather. Churchill et al. (1981) had slightly better success live-trapping marten in autumn than in spring, and Miller et al. (1955) had better trapping success with the onset of winter because of increased sign visibility and attractiveness of baits. The livetraps used for otter by Northcott and Slade (1976) became inoperable during winter months. Caution should be used when using foot-hold traps to livetrap animals in winter.

Fisher and marten trapping sites were often prebaited with deer (*Odocoileus virginianus*) (Irvine et al. 1964) or beaver (*Castor canadensis*) carcasses (Churchill et al. 1981). The same meat can be used to bait traps. In California, fisher were lured with tuna cat food and strawberry jam (Buck et al. 1979). Newby and Hawley (1954) baited marten with kippered herring, rotted fish, and oil of catnip. Miller et al. (1955) suggested that nearly any bait would produce results; they listed several. Unlike other carnivores, otter are not baited easily with meat and are usually taken near activity centers such as mud slides (Northcott and Slade 1976).

With few exceptions, fisher and marten were taken in cage-type livetraps. Marten were livetrapped in padded, steel traps by deVos and Guenther (1952) and accidentally caught in wolf (*Canis lupus*) foot-hold traps (Mech and Rogers 1977), and in cage traps set for lynx (*Lynx canadensis*) (D. Brittel). Marten are most easily caught in cage traps measuring 15 × 15 × 48 cm (de Vos and Guenther 1952, Hawley and Newby 1957, Miller et al. 1955, Churchill et al. 1981). The next larger size (20 × 20 × 80 cm) is most appropriate for fisher (Irvine et al. 1964, Kelly 1977, H. Laramie) but may also be used for marten (deVos and Guenther 1952). Larger traps (40 x 40 x 120 cm) can also be used for fisher; however, use of the smallest trap possible increases species specificity (de Vos and Guenther 1952) and eases placement of "cubby" sets. Otter are more difficult to trap than fisher and marten. No. 2 foot-hold traps were used to capture otter in Idaho, but the otter usually escaped (Melquist and Hornocker 1979). Use of No. 3 and larger traps resulted in injury in Idaho and Washington (C. Dugger). Injuries were minimal in Minnesota, where only No. 1½ unpadded, or No. 2 padded coilspring traps were used (C. Henderson). Most otter are livetrapped using Bailey (P. Vanderschaegen) or Hancock livetraps (Melquist and Hornocker 1979) modified and set according to Northcott and Slade (1976).

Traps should be checked once or twice daily (Churchill et al. 1981). Most (69%) marten catches in Ontario were at night (Churchill et al. 1981). Tooth damage incurred in traps or during handling may reduce survival of transplanted individuals (Davis 1978, C. Douglas). Despite extreme care, 46% of the marten handled by Churchill et al. (1981) incurred some tooth damage.

Use of metal-lined transportation and holding cages or boxes (Kelly 1977, Churchill et al. 1981, G. Parsons), drilled for ventilation (M. Herman) reduced tooth injuries. Straw-lined nest boxes facilitated holding of otter (Melquist and Hornocker 1979, P. Vanderschaegen), whereas wood chips were best for marten (M. Herman). If possible, animals should be held no longer than 5 days (Davis 1978, C. Douglas); however, fisher have been held for up to 60 days (J. Thiebes) and otter for up to 65 days (Melquist and Hornocker 1979). Otter accept confinement readily and eagerly eat fish while in the smaller cages (C. Henderson). Animals should be held and transported under dark, quiet conditions, such as an enclosed vehicle, to reduce stress.

Because marten are relatively small, they can be handled with the aid of a wire cone (Newby and Hawley 1954, Davis 1978), or thick leather gloves (J. Stuht). For prolonged handling, marten were anesthetized with ether, halothane, ketamine hydrochloride, or phencyclidine hydrochloride in combination with promazine hydrochloride, administered in doses listed in Table 12–1. Drugs administered to fisher included chlordiazepoxide, phencyclidine hydrochloride in combination with promazine hydrochloride, and ketamine hydrochloride combined with either atrophine or acepromazine maleate (Table 12–1). Otter have been anesthetized with ketamine hydrochloride or phencyclidine hydrochloride with promazine hydrochloride (Table 12–1). Gas was administered in anesthetizing chambers (Balser and Kinsey 1962, Davis 1978, Herman et al. 1982, Churchill et al. 1982). No anesthetic was used for otter held and transported in Minnesota (C. Henderson). Davis (1978) and Melquist and Hornocker (1979) used tetracycline to reduce infection in marten and otter, respectively.

Table 12–1. Immobilization agents used on fisher, pine marten, and river otter in North America. Drugs used in combination are enclosed in parentheses.

Species	Agent	Dose	Reference
Fisher	Chlordiazeproxide	Not specified	Irvine et al. 1964
Fisher	(Ketamine hydrochloride) (Atrophine)	11.1 mg/kg live wt. 0.1 mg/kg live wt.	G. Parsons
Fisher	(Ketamine hydrochloride) (Acepromazine maleate)	2.2 mg/kg live wt. 2.5 mg/animal	Kelly 1977
Fisher	(Phencyclidine hydrochloride) (Promazine hydrochloride)	0.7–1.0 mg/kg live wt. 0.5–2.0 mg/kg live wt.	Seal et al. 1970
Pine marten	Ether (gas)	Not specified	Davis 1978
Pine marten	Halothane (gas)	4% concentration	Herman et al. 1982, Churchill et al. 1981
Pine marten	Ketamine hydrochloride	15 mg/animal	D. Brittell
Pine marten	Ketamine hydrochloride	22.0 mg/kg live wt.	Melquist and Hornocker 1979
Pine marten	Ketamine hydrochloride	15 mg/animal	L. Fredrickson
Pine marten	(Phencyclidine hydrochloride) (Promazine hydrochloride)	1.0 mg/kg live wt. 0.5–2.0 mg/kg live wt.	Seal et al. 1970
Otter	Ketamine hydrochloride	22.0 mg/kg live wt.	Melquist and Hornocker 1979
Otter	(Phencyclidine hydrochloride) (Promazine hydrochloride)	0.7 mg/kg live wt. 0.5–2.0 mg/kg live wt.	Seal et al. 1970

Release and Protection.—Release sites must be in appropriate habitat and spaced to minimize crowding. For example, in 8 years, 124 fisher were stocked over most of Vermont in areas of high porcupine populations (Fuller 1975). Over an 8-year period, 60 fisher were stocked on a 560 km^2 area on the Nicolet Forest in Wisconsin (Irvine et al. 1964, Petersen et al. 1977), and in 2 years, 124 marten were placed on the same area (Davis 1978). A more dense stocking occurred in Michigan, with 78 marten placed on 93 km^2 in 2 years (Churchill et al. 1981). Otter must be stocked along watersheds, but the optimum spacing is unknown.

Before transplanting fisher and marten, release areas should be saturated with food such as deer and beaver carcasses (Davis 1978, Churchill et al. 1981), especially where prey is not abundant. Animals should be transported as quickly to the release site, then either "quick" (immediately) or "slow" released. The latter involves holding the animal for up to 5 days at the release site to acclimatize it to new surroundings. Davis (1978) and Churchill et al. (1981) suggested that slow-released marten spent more time in the release area and made fewer immediate post-release movements. Slow release was used on South Dakota's marten reintroduction (L. Fredrickson).

Because of the fisher's vulnerability to trapping (Coulter 1960), complete protection, as emphasized by Weckwerth and Wright (1968), followed all reintroductions except in West Virginia (Pack and Cromer 1981). Under favorable conditions, fisher in refuge situations expand to surrounding habitats (deVos 1951); in Montana tagged fisher emigrated up to 103 km from the release site (Weckwerth and Wright 1968). Because marten are easily trapped (Miller et al. 1955) and readily enter sets made for other species (Mech and Rogers 1977, D. Brittell) they also need protection in release areas. For example, the primary fisher and marten release sites on the Chequamegan and Nicolet National Forests were closed to dry-land trapping (Davis 1978). As otter are often caught in traps set for beaver, water-set trapping should be closed until populations become established (P. Vanderschaegen). On Colorado otter release sites, snares, No. 3 and larger foot-hold, and 220 and larger Conibear traps were prohibited (Goodman 1981). In Minnesota, otter were reintroduced in 2 refuge areas closed to beaver trapping (C. Henderson).

Evaluation

Criteria for evaluating reintroductions should be established before conducting field evaluations. Various goals may be the establishment of a harvestable population, aesthetics, prey or pest control, or economic benefit. By different criteria, the same reintroduction may be judged as a failure (Schupbach 1977) or a success (J. Stuht). Despite the biological success of Alaska's marten reintroductions, they were judged failures because of minimal economic gain (Burris and McKnight 1973).

Survival of stocked animals can be evaluated within 1 year after the reintroduction. Evaluation for re-establishment of a viable population should begin at least 3 years after the reintroduction.

Because of the secretive nature of these furbearers, direct census is impossible and indirect methods must be used. One index for monitoring fisher population increases was the decline of porcupines (Olson 1966). Other methods applicable to fisher and marten are censuses of tracks or other sign, or visits to bait posts (Irvine et al. 1964), ear-tag returns and recaptures, and numbers of confiscated or accidentally trapped animals (Balser and Longley 1966). No adequate technique currently exists for estimating otter densities, but indices of relative abundance may be determined from tube-like tracks (especially in snow), scats, and slides (Melquist and Hornocker 1979).

Radiotelemetry facilitates any reintroduction evaluation, and can be used to monitor movements, survival, and dispersal. Design and techniques for radio tracking terrestrial furbearers, including marten and fisher, were summarized by Voight and Lotimer (1981). Transmitter collars have been placed on fisher (Kelly 1977, Buck et al. 1979), marten (Mech and Rogers 1977, Davis 1978, Churchill et al. 1981, L. Fredrickson) and with limited success on otter (Melquist and Hornocker 1979). An improvement over collars was intraperitoneal transmitter implants developed for otter by Melquist and Hornocker (1979) and planned for use in evaluating Missouri's otter reintroduction (Erickson 1981).

SUMMARY AND RECOMMENDATIONS

At least 40 reintroductions of fisher, marten, and otter have occurred since 1934 in North America. Many probably failed because of inadequate habitat, poor handling techniques, small sample size, unbalanced sex ratios favoring males, or age structure of stocked females.

Following are recommendations based on the most successful reintroductions:

1. Conduct a feasibility study containing objectives, evaluation criteria, literature review, historical aspects, habitat capabilities, subspecies determination, potential problems, and mechanics of the reintroduction. For otter, determine water quality.
2. Utilize experienced trappers who use proven handling techniques.
3. Use box or cage traps when possible, and check sets once or twice daily.
4. Transport and hold animals for as short a period as possible, and use metal-lined cages to reduce tooth breakage. Hold and transport animals in a dark, quiet place.
5. Reintroduce the animals over a short period and space release sites by respective territory size to minimize crowding.
6. Release animals in even sex ratios or, preferably, in ratios greatly favoring females.
7. "Slow release" animals to acclimatize them to the release sites. Release sites can be saturated with food such as deer or beaver carcasses in winter.
8. Conduct releases in refuges or regulate trapping to prevent accidental catches.
9. Define success–fail criteria and evaluate the reintroduction using a combination of field sign and telemetry.
10. Report reintroduction results to benefit future efforts.

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13

History of Midwestern Furbearer Management and a Look to the Future

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Abstract: Early North American history reveals a total lack of furbearer management in the Midwest. By the mid-1800's some furbearers had become extremely rare or were locally extirpated. Initial management emphasized protecting man and his possessions from the wild furbearers, primarily by bounties. Regulations that protected furbearers did not become widespread until around 1900, although some regulations were enacted as early as 1829. Most protective regulations followed major declines in furbearer populations caused by habitat changes and overharvest. Modern furbearer management began around 1930 with the establishment of annual harvest surveys. Subsequent management efforts included reintroductions, propagation and release programs, nuisance-furbearer control, and census programs. Noticeably absent were habitat management and land acquisition specifically for furbearers. Little attention was paid to furbearers before the 1970's because most sportsmen, wildlife managers, and administrators were more concerned with upland game, waterfowl, and big game. During the last decade, however, interest in furbearers has increased because of record high pelt prices, enactment of endangered species regulations and federal treaties, major decline in upland wildlife hunting opportunity, and growing antihunting and antitrapping sentiment. Current research needs center on the development of new and the improvement of existing furbearer population census techniques. Furbearer management will probably continue to expand even if pelt values decline. Adverse public opinion is a major problem that faces the sporting public and wildlife managers involved with furbearers.

Key words: Furbearer management, history of furbearer management, midwestern furbearer management.

EARLY HISTORY

Early midwestern history reveals a total lack of furbearer management although the search for furbearers was the driving force behind much of the early exploration in this region. When the white man invaded the Midwest (Fig. 13–1), fur was readily available and represented one of the few natural resources that could be exchanged for gold and merchandise in the Old World. Before the early 1800's, most fur animals were taken by shooting, snares, deadfalls, and other ingenious woodsmen's traps. In 1823 Sewell Newhouse began to manufacture leg-hold traps (Russell 1967:382), which enabled early furtakers to make larger catches. By the mid-1800's the consequences of over 200 years of unrestrained harvest began to show on the once vast reservoir of furs. Some furbearers became scarce; others were extirpated from some areas. The fur trade was forced to revolve around those species that maintained their numbers in the face of exploitation and changing land use (Sampson 1980). Simultaneously, the number of settlers in the Midwest rapidly increased. Most of them hunted and trapped, initially for their entire cash income, and later, as markets for grain and livestock developed, for supplementary income, predator control, and sport. Although the number of professional trappers declined during the late 1800's, fur harvesting intensified and remained high until at least 1900. The great loss of wildlife throughout the Midwest after 1880 generated widespread calls for conservation. However, most wildlife, including many furbearers, continued to decline into the 20th century.

BOUNTIES

As farming became more important than hunting in the Midwest, the need for furbearer management arose. The early settlers wanted their livestock and property protected from such predators as bobcats (*Lynx rufus*), wolves (*Canis lupus*), and coyotes (*Canis latrans*). The objective of early management, therefore, was the adoption of regulations that would protect the early settlers and their property from wild animals. In many cases, bounties were offered to encourage the killing of predatory furbearers.

Furbearer management by legislation was initiated in the Midwest on 19 December 1799 when the General Assembly of the Northwest Territory passed an act to encourage the killing of wolves. The act established a bounty of 75¢ for wolves 6 months or older and 50¢ for wolves less than 6 months old. To collect, the hunter had to swear the wolf was killed within 6 miles of a settlement and that he had not purposely spared the life of a bitch wolf to produce more pups (Reeves 1976).

Furbearer bounties have been paid in every midwestern state at one time or another (Table 13–1). Since 1800, coyotes and foxes (*Vulpes* spp. and *Urocyon cinereoargenteus*) have been bountied in 11 states, wolves in 10, bobcats in 8, lynx (*Lynx canadensis*) in 2, black bears (*Ursus americanus*) in 1, and badgers

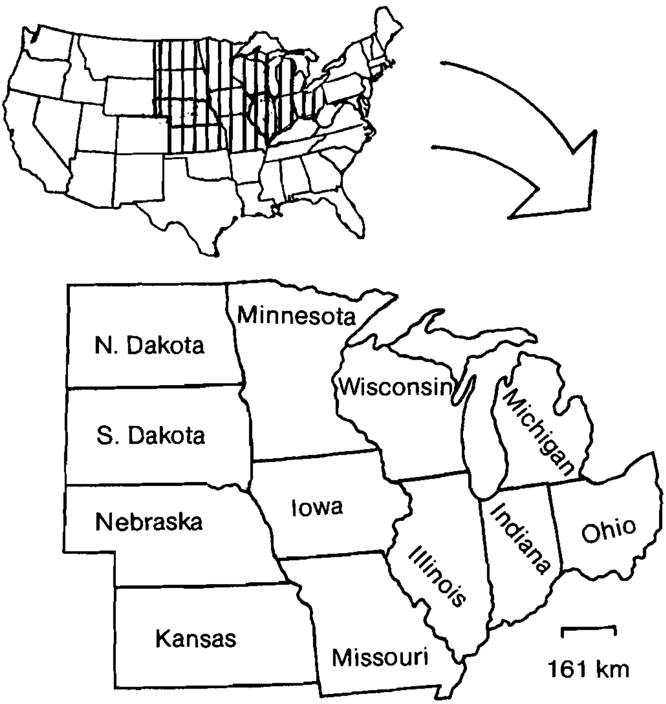

Fig. 13-1. The midwestern United States.

(*Taxidea taxus*) in 1. Over the years the bounty system has proved highly ineffective in keeping furbearer predator populations low to achieve either of its chief goals: (1) increasing the game supply, and (2) reducing losses to livestock and poultry owners (Cain 1971). Today, all state wildlife agencies recognize the pitfalls of the various bounty systems and oppose them. However, the death of the bounty as a means of furbearer management has been slow because of its popularity with citizens and legislators. Today, coyotes are still bountied in 4 states and the bobcat is bountied in 1 (Table 13-1).

INITIAL MANAGEMENT ERA

Positive management of furbearers in the Midwest began with the establishment of protective regulations. Unlike bounties, these laws were designed to protect fur animals from destruction by man. Most protective regulations were precipitated by the tremendous decline in furbearer populations that resulted from overharvest and habitat loss associated with settlement. Before the late 1800's, the early settlers and resident Indians had sufficient wildlife to satisfy their needs and no legal effort was made to conserve the supply.

Table 13–1. Summary of furbearer bounties in the midwestern United States.

State	Species	Period bountied	Source of funds[a]	Remarks
IL	Wolf, Coyote	1877–1967	C	4 of 102 counties still paid coyote bounty in 1977, but no statutory authority exists.
	Fox	1943–1973	C	
IN[b]	Wolf, Coyote	1800–1803	T	
		1807–1875	TS	
		1875–1972	C	
	Fox	1875–1877	C	
		1911–1972	C	51 of 92 counties paid fox bounty in 1968.
IA[c]	Wolf, Coyote	1817–present	C	13 of 99 counties paid coyote bounty in 1980.
	Fox	1817–1897	TSC	All counties paid fox bounty
		1951–1974	C	from 1951 to 1959; 1 of 99
		1977	C	counties paid in 1977.
KS[d]	Coyote, Fox, Wildcat (Bobcat), Wolf	1877–1970	SC	Source of funds varied from state to county and back to state.
MI[e]	Bobcat	1897–1921	SC	Bobcat bounty eliminated in 1965.
		1935–1937	SC	
		1940–1965	SC	
	Coyote	1935–1980	SC	Coyote bounty eliminated in 1980.
	Fox	1917–1921	SC	Fox bounty eliminated in 1965.
		1947–1965	SC	
	Wolf	1838–1921	TSC	Wolf bounty eliminated in
		1935–1960	SC	1960.
MN[f]	Wolf	1849–1965	SC	Bounty ended statewide on all
		1969–1974	S	species in 1965. Payments re-
	Black bear	1943–1965	S	sumed under Directed Predator
		1969–1971	S	Control Program in 1969 and
	Bobcat, Fox	1943–1965	S	continued to present or until
		1969–1977	S	species became a game
	Coyote	1943–1965	S	animal or received protection.
		1969–present	S	
	Lynx	1943–1965	S	
		1969–1976	S	
MO[g]	Bobcat, Coyote	1825–present	C	3 of 109 counties paid bobcat bounty in 1977; 26 of 109 counties paid coyote bounty in 1977.
NB[h]	Coyote	1927–1963	C	Bounty records incomplete

Table 13-1. (continued)

State	Species	Period bountied	Source of funds[a]	Remarks
	Wildcat (Bobcat) Wolf Fox	1927–1950's 1927–1950's 1950's	C C C	because of inconsistency among counties. By late 1950's about half of counties ceased to appropriate bounty funds. No bounties paid after 1963.
ND[i]	Wolf Wolf, Coyote Fox Bobcat	1890–1897 1897–1961 1943–1961 1945–1961	C C C C	No state wolf or coyote bounties from 1917 to 1919. Bounties abolished by legislature in 1961.
OH[j]	Wolf Fox	1820–1850 1944–1972	? C	 No fox bounty paid since 1972.
SD[k]	Wolf Coyote Bobcat, Fox Badger	1890–? 1899–present 1929–1972 1951–1961	C? SC SC SC	Wolf bounty still existed in 1943. Bounty funds appropriated by counties from 1929 to 1944. Since 1945, ½ bounty funds from Wildlife, Parks and Forestry Dept. and ½ from surtax on livestock not in feedlots.
WI[l]	Bobcat, Coyote, Fox, Lynx, Wolf	1865–1963 1963–1980	SC C	Bounty payments not made during 11 various years from 1865 to 1963. No bounties paid after 1980.

[a]T = territory; S = state; C = county.
[b]Brooks (1959), Kirkpatrick (1970), Reeves (1976).
[c]Andrews (1981), R. D. Andrews, Iowa Conserv. Comm., personal communication 1981.
[d]N. F. Johnson, Kansas Fish and Game Comm., personal communication 1981.
[e]J. N. Stuht, Michigan Dep. Nat. Resour., personal communication 1981.
[f]W. E. Berg, Minnesota Dep. Nat. Resour., personal communication 1981.
[g]Sampson (1980).
[h]Schildman et al. (1980), G. Schildman, Nebraska Game and Parks Comm., personal communication 1981.
[i]Adams (1965).
[j]Maslowski (1953), K. E. Bednarik, Ohio Dep. Nat. Resour., personal communication 1981.
[k]L. F. Fredrickson, South Dakota Dep. Wildl., Parks and Forestry, personal communication 1981.
[l]C. M. Pils, Wisconsin Dep. Nat. Resour., personal communication 1981.

The first protective law was passed in Ohio in 1829 and established a closed season on muskrats (*Ondatra zibethicus*) (Table 13–2). This regulation provided "that if any person shall, between the 1st of May and the 15th of October following, kill or destroy any muskrats and be thereof convicted–he shall forfeit and pay one dollar for each muskrat–except–where muskrats are destroying property" (Dambach 1948:210). The other states followed Ohio's lead and by 1911 all had legislated a closed season on 1 or more furbearers. Several of the

Table 13–2. Years of establishment for initial furbearer protective regulations, trapping licenses, and furbuyer licenses in the midwestern United States.

State	Protective regulation (type)	Trapping license	Furbuyer license
IL	1907 (Season on all furbearers)	1919	1925
IN[a]	1905 (Furbearer hunting season)	1980	1934
IA[b]	1872 (Beaver season closed)	1935	1930
KS[c]	1911 (Season on various furbearers; beaver and otter season closed)	1921	1927
MI[d]	1833 (Muskrat season)	1915	1929
MN[e]	1867 (Muskrat, mink, and otter season)	1979	1923
MO[f]	1877 (Muskrat, mink, raccoon, and otter season)	1953	1934
NB[g]	1906 (Beaver season closed)	1918	1919
ND[h]	1909 (Beaver and otter season closed)	1915	1927
OH[i]	1829 (Muskrat season)	1979	1933
SD[j]	1909 (Harvest regulations for muskrat, mink, beaver, and otter)	1909	1929
WI[k]	1865 (Beaver season)	1917	1931

[a]L. E. Lehman, Indiana Dep. Nat. Resour., personal communication 1981.
[b]Sanderson (1953), R. D. Andrews, Iowa Cons. Comm., personal communication 1981.
[c]N. F. Johnson, Kansas Fish and Game Comm., personal communication 1981.
[d]J. N. Stuht, Michigan Dep. Nat. Resour., personal communication 1981.
[e]W. E. Berg, Minnesota Dep. Nat. Resour., personal communication 1981.
[f]Sampson (1980).
[g]G. Schildman, Nebraska Game and Parks Comm., personal communication 1981.
[h]Kruckenberg (1973), C. R. Grondahl, North Dakota Game and Fish Dep., personal communication 1981.
[i]Dambach (1948), K. E. Bednarik, Ohio Dep. Nat. Resour., personal communication 1981.
[j]L. F. Fredrickson, South Dakota Dep. Wildl., Parks and Forestry, personal communication 1981.
[k]C. M. Pils, Wisconsin Dep. Nat. Resour., personal communication 1981.

first season closures involved beaver (*Castor canadensis*), the mainstay of the early fur trade.

The next regulatory measure was the licensing of fur-resource users. A special trapping license was first legislated by South Dakota in 1909 (Table 13–2). By 1935 all but 3 of the midwestern states had similar requirements. Nebraska mandated a fur-buyer license in 1919, and furbuyers were licensed throughout the Midwest by 1934.

MODERN MANAGEMENT ERA

Harvest Surveys

The furbearer management program in every midwestern state currently includes, and frequently centers on, an annual survey of the number and value of pelts harvested. The initiation of harvest surveys in the late 1920's and 1930's marked the beginning of the collection of biological management data throughout much of the Midwest. Harvest surveys started as early as 1927 in Kansas

(N. F. Johnson, Kansas Fish and Game Comm., personal communication 1981). By requiring furtakers and furbuyers to be licensed, the user groups could be identified and sampled to obtain harvest information.

The first efforts to estimate midwestern fur harvests were stimulated by economic and political factors and public interest. Later, harvest surveys were expanded with funds provided by the Federal Aid in Wildlife Restoration Act of 1937. Biological concerns and scientific interest have also been important, but political and public pressures appear to have frequently overshadowed them. For example, the federal government's involvement in the Convention on International Trade in Endangered Species resulted in specialized programs to monitor bobcat harvests.

Five basic harvest-estimation techniques have evolved: (1) fur-buyer transaction reports, (2) fur-taker reports, (3) export permits, (4) pelt registration or tagging, and (5) sample surveys (Erickson 1982). The procedure most widely used to estimate annual fur-bearer harvest during the last 50 years has been some form of fur-buyer reporting system. Currently, every state wildlife agency in the Midwest relies on furbuyers for harvest information. Pelt registration or tagging, a procedure first used in the Midwest by Michigan in 1934 to monitor beaver harvests (J. N. Stuht, Michigan Dep. of Nat. Resour., personal communication 1981), has received increased attention since 1972, especially for species with low harvest and high value such as the bobcat. Today, all 8 midwestern states that permit the harvest of bobcats require that bobcat pelts be registered. In addition, 3 states tag beaver pelts, 3 register the pelts of river otter (*Lutra canadensis*), and 1 tags the skins of fisher (*Martes pennanti*) and lynx.

Reintroductions/Transplants

Furbearer reintroductions and transplants in the Midwest have mainly involved the beaver and high value, low density mustelids (Table 13–3). These species were extirpated or greatly reduced in numbers over sizable portions of their range in the early 1900's. The early impetus for restoration came from the enactment of protective regulations and the formation of wildlife agencies to enforce these regulations and carry out relocation projects. Public interest was also a factor. In addition, suitable habitat again became available over extensive areas as trends in land use changed.

The first attempt to restore beaver to portions of its original range began in North Dakota in the mid-1920's (Adams 1961) (Table 13–3). During the next 10 years, the beaver was reintroduced in several midwestern states and its spread was accelerated by subsequent livetrapping and transplanting. All projects were successful and beaver have been harvested annually throughout the Midwest since the early 1950's.

Mustelids were not reintroduced until the mid-1950's (Table 13–3). Before then, there were no large, continuous tracts of suitable habitat, especially for fisher and marten (*Martes americana*), nor was there sufficient public and

Table 13–3. Furbearer reintroductions/transplants in the midwestern United States.

State	Species	Nature of project	Period of release	Outcome of project	Remarks
IL	Beaver	Reintroduction	1929–1938	Successful	Annual trapping season since 1951.
IN[a]	Beaver	Reintroduction	1935	Successful	Annual trapping season since 1951.
IA[b]	Beaver	Reintroduction	1928–1945	Successful	Annual statewide trapping season since 1950.
KS[c]	Beaver	Reintroduction	1940	Successful	Annual trapping season since 1951.
MI[d]	Marten	Reintroduction	1955–1957,	Unsuccessful	
			1969–1970,	Successful	Releases in Hiawatha National Forest.
			1979–1981	Pending	148 animals released.
	Fisher	Reintroduction	1956–1963	Successful	Harvest season under consideration.
	Wolf	Reintroduction	1974	Failed	Five animals released; all killed.
MN[e]	Fisher	Reintroduction	1965	Unknown	Fifteen animals released in Itasca State Park for porcupine control.
	River otter	Reintroduction	1980–1981	Pending	Attempt to reestablish river otter in Minnesota River bottoms.
MO[f]	Beaver	Reintroduction	1928–1929	Successful	Annual trapping season since 1953.
ND[g]	Beaver	Transplant	1925–1951	Successful	Annual trapping season since 1952.
OH[h]	Beaver	Transplant	1956–1965	Successful	Annual trapping season since 1960.
SD[i]	Muskrat	Transplant	1938	Unknown	1,246 animals transplanted from La-Creek Refuge.
	Beaver	Transplant	1938–1941,	Unknown	
			1980–1981	Pending	
	Marten	Reintroduction	1980–1981	Pending	Attempt to reestablish marten in Black Hills area.
WI[j]	Marten	Reintroduction	1953–1981	Unknown	
	Fisher	Reintroduction	1956–1967	Successful	Statewide population estimated at 2,000 animals in 1981.

[a]Brooks (1959).
[b]R. D. Andrews, Iowa Cons. Comm., personal communication 1981.
[c]N. F. Johnson, Kansas Fish and Game Comm., personal communication 1981.

Table 13–3. (continued)

[d]J. N. Stuht, Michigan Dep. Nat. Resour., personal communication 1981.
[e]W. E. Berg, Minnesota Dep. Nat. Resour., personal communication 1981.
[f]Sampson (1970).
[g]Adams (1961).
[h]K. E. Bednarik, Ohio Dep. Nat. Resour., personal communication 1981.
[i]L. F. Fredrickson, South Dakota Dep. Wildl., Parks and Forestry, personal communication 1981.
[j]Petersen et al. (1977), C. M. Pils, Wisconsin Dep. Nat. Resour., personal communication 1981.

scientific interest (Berg 1982). To date, fisher and marten have been reintroduced in 3 states each. Success has varied. In 1977 Minnesota held its first fisher trapping season since 1928, and a limited season is planned for 1981 (W. E. Berg, Minnesota Dep. of Nat. Resour., personal communication 1981). However, the recent harvest seasons did not result from reintroduction efforts. The river otter was recently reintroduced in portions of Minnesota. Missouri has a river otter release planned for 1982 (D. W. Erickson, Missouri Dep. Conserv., personal communication 1981). Illinois is currently evaluating the status of the river otter and, if results are encouraging, may draft a reintroduction plan.

Projects to reestablish large, predatory furbearers have been essentially nonexistent in the Midwest (Table 13–3). Michigan made a single release of 5 wolves in 1974 (J. N. Stuht, Michigan Dep. Nat. Resour., personal communication 1981); all were soon killed by hunters, trappers, or vehicles. Both public and political concerns have precluded widespread consideration of similar projects.

No exotic furbearer has ever been introduced by any midwestern state agency and none is being considered. A need to do so has never been recognized because of the tremendous diversity among native furbearer species. However, the nutria (*Myocaster coypus*), a rodent native to South America, was introduced in Michigan and Ohio with the establishment of private nutria ranches in the 1930's (Evans 1970). When the nutria farming industry virtually collapsed a few years later, dejected ranchers released their animals or abandoned those that escaped. Between the early 1940's and 1966, nutria were reported from every midwestern state except North and South Dakota. Nutria were still living free in Indiana, Michigan, and Nebraska as late as 1966 (Evans 1970), but by 1976 they persisted only in Michigan (Deems and Pursley 1978).

Propagation

Leopold (1933:356) recognized game farming (propagating wild species in confinement) as an intensive form of game management and listed 2 major functions: (1) provision of gentle stock for experimental research and (2) provision of stock for "reseeding" coverts accidentally depleted by overharvest or natural disasters. Since 1930, furbearers have been artifically reared in the Midwest for both of these uses, especially the latter (Table 13–4).

The furbearer most often propagated and released by midwestern state wildlife agencies has been the raccoon (*Procyon lotor*) (Table 13–4). From 1930 through 1957, over 26,000 raccoons were raised and released by 5 states for population enhancement. The raccoon population was apparently low throughout much of the Midwest in the 1930's and early 1940's (Sanderson 1951*a*, 1951*b*, Brooks 1959), and state agencies responded to public concern with a major propagation program. However, restocking probably did not cause the raccoon population increase that followed (Sanderson 1951*a*, 1951*b*, Keefe 1953, Brooks 1959, Sampson 1970).

Other furbearers that have been raised over the years include mink (*Mustela vison*), red fox (*Vulpes vulpes*), gray fox, and swift fox (*Vulpes velox*) (Table 13–4). Wisconsin raised mink from 1935 through 1945 for use in genetic studies related to fur farming. Red and gray foxes were reared and released in token numbers only, probably because of political pressure generated by fox hunting organizations. The recent propagation of swift foxes in South Dakota perhaps marks a renewed interest in raising furbearers to restore threatened or endangered species.

Furbearer Control Programs

All states in the Midwest have long had to cope with complaints of damage to livestock, poultry, and property caused by furbearers—mainly muskrats, coyotes, foxes, and, more recently, beaver. Some states have developed extension programs to deal with such problems; others have provided instructions for controlling nuisance furbearers or have issued permits to relocate or destroy problem animals.

Five midwestern states presently have extension programs that employ trappers to train property owners in methods of controlling wildlife damage. The first extension program was organized in Kansas in 1929 (N. F. Johnson, Kansas Fish and Game Comm., personal communication 1981). Others were initiated in Indiana in 1940 (L. E. Lehman, Indiana Dep. Nat. Resour., personal communication 1981), Iowa and Missouri in 1946 (R. D. Andrews, Iowa Conserv. Comm., personal communications 1981, Sampson 1980), and South Dakota in 1973 (L. F. Fredrickson, South Dakota Dep. Wildl., Parks and Forestry, personal communication 1981). Such extension programs provide sufficiently prompt and immediately effective service to all requests for assistance in reducing property damage caused by furbearers.

Five states have predator control programs that employ agents to remove furbearers to reduce the population or control damage. Two of these (Nebraska and North Dakota) involve U.S. Fish and Wildlife Service personnel (G. Schildman, Nebraska Game and Parks Comm., personal communication 1981, S. H. Allen, North Dakota Game and Fish Dep., personal communication 1981). Since 1969 Minnesota has utilized certified damage trappers for all

Table 13–4. Furbearer propagation activities in the midwestern United States.

State	Species	Period of propagation	Estimated number raised and released	Purpose of propagation program
IL	Raccoon	1942–1948	1,400	Population enhancement
IN[a]	Red fox	1931 1933–1940	21 218	Population enhancement
	Raccoon	1933–1949	6,682 (state) 2,901 (clubs)	Population enhancement
IA[b]	Raccoon	1940–1950	200	Population enhancement
OH[c]	Raccoon	1930–1952	Unknown	Population enhancement
SD[d]	Swift fox	1978–1981	25	Restoration of threatened species
WI[e]	Raccoon	1932–1957	15,183	Population enhancement
	Red fox	1935–1955	Unknown-267 from 1935–1942	Population enhancement
	Mink	1935–1945	0	Genetic studies
	Gray fox	1937–1955	Unknown	Population enhancement

[a]Krauch (1976), L. E. Lehman, Indiana Dep. Nat. Resour., personal communication 1981.
[b]R. D. Andrews, Iowa Cons. Comm., personal communication 1981.
[c]K. E. Bednarik, Ohio Dep. Nat. Resour., personal communication 1981.
[d]L. F. Fredrickson, South Dakota Dep. Wildl., Parks and Forestry, personal communication 1981.
[e]Unpubl. Rep., Wisconsin Dep. Nat. Resour., Wisconsin Game and Fur Harvests, A Summary 1930–1975, C. M. Pils, Wisconsin Dep. Nat. Resour., personal communication 1981.

species except wolves, which are handled by U.S. Fish and Wildlife Service agents (W. E. Berg, Minnesota Dep. Nat. Resour., personal communication 1981). Since 1973 South Dakota has used state-employed agents to handle damage complaints (L. F. Fredrickson, South Dakota Dep. Wildl., Parks and Forestry, personal communication 1981). In 1979 Ohio established a program in which authorized beaver trappers respond to damage complaints (K. E. Bednarik, Ohio Dep. Nat. Resour., personal communication 1981).

Census Activities

Census techniques and programs to monitor population trends for midwestern furbearers have developed slowly, especially when compared with similar efforts for upland game, waterfowl, and big game. Most furbearers are secretive and difficult to observe, frequently leave little obvious sign, and often are active only during the hours of twilight or darkness. Early wildlife researchers found it more productive to concentrate on the highly popular game species that could be readily counted.

Furbearers were first censused in the Midwest in 1936 when Missouri researchers began to monitor bobcat and coyote population trends by bounty records (Bennitt 1948, Sampson 1980). In the 1940's and 1950's the main furbearers censused were the muskrat and beaver, 2 species whose construction activities leave obvious sign. Prior to 1960, only 5 states initiated furbearer census projects. Public interest in furbearers was low and the logistics of investigating furbearer populations regionally or statewide were frequently overwhelming. In many cases, cost-and-time efficient techniques were not available.

Few, if any, real advancements in census procedures for furbearers were made in the Midwest during the 1960's. Indiana started to tabulate road-kill records for raccoons (L. E. Lehman, Indiana Dep. Nat. Resour., personal communication 1981) and North Dakota began using spring aerial den counts and rural mail carrier observations to index red fox populations (S. H. Allen, North Dakota Game and Fish Dep., personal communication 1981), but little else was done. Public interest in furbearers continued to be low, and, as before, attention was directed toward more popular species.

Finally, in the 1970's furbearer census programs began to expand. Public concern for the welfare of furbearer populations increased rapidly as pelt prices for many species climbed to record highs. Consequently, state agencies were forced to intensify their efforts to monitor furbearer population trends. The scent post survey came into widespread use for coyotes in 1972 (Linhart and Knowlton 1975) and has since been modified to include other furbearers in several states. Experiments to evaluate applicability of other techniques were conducted. One such experiment led to the development of a spring spotlight survey for censusing raccoons (Andrews 1979). By 1980 at least 11 midwestern states were collecting population trend data for 1 or more furbearers. Clark and Andrews (1982) summarize the census techniques currently in use in the Midwest.

Habitat Management

Wildlife management has been described as the science and art of changing the interrelationships among wild animals, habitats, and man (Giles 1969:1). Mohr (1943:536) stated the need for furbearer habitat management 38 years ago: "It is important to recognize that the fur crop is in addition to all other crops and values realized from . . . land and waters. In general, it has persisted not because of any favorable attention paid to it but in spite of what has been done." His words are as valid today as they were in 1943, but they are not heeded.

Records of habitat management projects specifically for furbearers are virtually nonexistent in the Midwest. Apparently, there has never been sufficient impetus to warrant the manipulation of habitat primarily for furbearers. High costs of the projects and the tremendous adaptability of most fur species have contributed to this inaction. Wisconsin experimented with level ditching in the late 1940's to enhance muskrat productivity (Mathiak 1953). Similar studies were conducted in Indiana in 1951 (L. E. Lehman, Indiana Dep. Nat. Resour., personal communication 1981). Around 1952 Nebraska tried constructing small ditches in marshy areas to bolster muskrat populations (G. Schildman, Nebraska Game and Parks Comm., personal communication 1981), and Minnesota occasionally manipulates water levels for the benefit of muskrats (W. E. Berg, Minnesota Dep. Nat. Resour., personal communication 1981). Fortunately, many states have habitat management programs that benefit furbearers indirectly. These programs have traditionally been aimed at upland game birds, waterfowl, and big game species, which are considered more important in the public eye. No public land has ever been acquired specifically for the benefit of midwestern furbearers.

Today's Scene

During the last decade, record high pelt prices, enactment of endangered species regulations and federal treaties, a major decline in upland wildlife hunting opportunity, and growing antihunting and antitrapping sentiment have renewed and expanded the interest in furbearers. Before 1970 approximately half of the state wildlife agencies in the Midwest employed a furbearer biologist; now all have 1 or more staff members assigned to various furbearer programs. As noted earlier, systems to monitor furbearer harvests are now widespread and census activities are beginning to expand. In 1980 at least 22 furbearer species had a clearly defined management status in the Midwest. Furbearer research projects became commonplace in the mid-1970's (Deems and Pursley 1978). The first trapper-education program appeared in Kansas in 1972 (Boggess 1979) and by 1981, 7 midwestern states had functional programs and 2 others were in the developmental stage. A midwest furbearer workshop was held at Kansas State University in 1979 (Kansas State University and Kansas Fish and Game Comm. 1979). Last year, the first international furbearer conference took place (Chapman and Pursley 1981), and the first furbearer management symposium at the Midwest Fish and Wildlife Conference is presently being held. The management of the Midwest's fur resources is finally receiving long-overdue attention. Furbearer management will continue to mature as a discipline in the wildlife field only if adequate funds are available (Fritzell and Johnson 1982).

THE FUTURE

The current management programs for midwestern furbearers are often based on minimal knowledge of the species in question. The most pressing research need is the development of new and the improvement of existing furbearer population census techniques. Population trends of both abundant and rare furbearers need to be documented. Biologists have too often been forced to rely on harvest information for an after-the-fact analysis of furbearer populations. Instead, furbearer population status needs to be predicted prior to a harvest season rather than viewing the results of a completed harvest as a measure of population welfare.

Additional research should focus on how harvests affect furbearer population levels, reproductive performance, survivorship, and total recruitment; and the importance of harvests as a source of total mortality. These investigations should make definitive assessments of the specific effects of various management regulations on target species (for example, beaver, bobcat, raccoon) *and* secondary species [for example, river otter, striped skunk (*Mephitis mephitis*), and opossum (*Didelphis marsupialis*)]. The market–harvest–social interactions that affect furbearer utilization warrant expanded study. The development of population models appears to offer 1 logical approach.

Still needed are basic ecological studies of several furbearers, especially such sensitive, high-value species as the bobcat, fisher, and river otter. The status of many furbearers classified as threatened or endangered on the state level needs to be evaluated. Special emphasis should be placed on species of federal interest.

Many unique regional problems require attention. Examples include muskrat ecology in the Great Plains, the impact of a recently expanded coyote population on other wildlife species in the eastern Midwest, and studies related to zoonotic diseases. New cost-efficient methods to eliminate or minimize conflicts between wild furbearers and man in both urban and rural settings need to be developed.

Various traps and trapping methods should be studied. For example, what percentage of each species escapes from each type of trap? How many nontarget animals, both domestic and wild, are captured in each type of trap? What is the mean time to death for each species caught in each type of trap? Also, the development of new and innovative trap designs should be encouraged. In Canada, the Federal–Provincial Committee for Humane Trapping has made tremendous progress in this area since its establishment in 1973.

Furbearer management will probably continue to expand. Even if pelt prices drop sharply, management will not decline to pre-1970 levels. Instead, recreational values of furbearers will receive more emphasis, harvest regulations will increase and become more species oriented, and education programs for trappers (and fur-hunters) will be expanded and become mandatory.

Habitat management for furbearers will become more widespread as the importance of furbearers to biological communities becomes accepted. Efforts to preserve the remaining wetland habitats and wildlife water rights will intensify, especially in the Great Plains where agriculture makes great demands on water resources. How long furbearers remain important to the Midwest's economic and recreational base depends on future land use policies and decisions.

The biological problems referenced above will be solved as more data are collected. But what about the future of the wild fur industry as a whole? Can the fur resources of the Midwest continue to produce large, harvestable surpluses in spite of tremendous land use changes? Will the demands on the recreational values of furbearers eventually force the elimination of commercial values? Will furtakers and their traps go the way of the market hunter who pursued waterfowl with his 8-gauge shotgun in the late 1800's? Only time will tell.

Adverse public opinion is a major problem that faces the sporting public and wildlife managers involved with furbearers. The issue of leg-hold traps erupted emotionally in the U.S. Congress during 1975. Bills to ban or control the use of leg-hold traps have been at the forefront of many state legislatures. Ohio and Oregon have had referenda to prohibit trapping. Federal legislators recently considered a bill to outlaw the use of dogs for chasing furbearers and other game. Preservationists influenced regulations by the Convention on International Trade in Endangered Species thus complicating the management of certain species (Johnson 1980). In most instances, the public-at-large does not know or understand the issues involved. If the future challenges of the anti-hunting and anti-trapping factions are not met, many aspects of furbearer management addressed by this symposium may only be subject to hypothetical discussion the next time we meet.

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