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Title: Diffusion of Eurasian Guarding Dogs into American Agriculture: An Alternative Method of Predator Control.

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Gordon E. Matzke

The diffusion of livestock guarding dogs into American agriculture provides an example of a developed nation adopting a peasant husbandry practice. Guarding dogs, associated with transhumant husbandry, have been used to protect sheep and other livestock from predators in Eurasia for 2000 years. However, they were virtually unknown by Anglo-American agriculturalists until the late 1970's. Guarding dogs were originally introduced to America's Southwest by Spanish settlers in the 1500's. The tradition disappeared after Anglo-Americans came to dominate the sheep industry.

The re-introduction of guarding dogs came about as the result of new scientific understanding in wildlife management and policy changes that required a search for alternative methods of predator control. Significant variables affecting the location and rate of diffusion included the strain of dog, flock size, and location of pilot projects.

Guarding dogs worked equally well across the major sheep producing regions of the United States after adjusting for flock size and strain. Suitable dogs were found within all strains, although statistical differences in performance were found between strains. Differences in performance between flock sizes, although statistically significant, should not impair the long-term prospects for adoption. By 1987, the total number of adopters across the United States was unknown, but it was probably less than 10 percent of all growers. Results of this study suggest diffusion will be greatest from areas where agents are actively promoting their use, from areas where concentrations of dogs currently exist, from areas where quality dogs are available, and on farms where flock size is less than 1000 sheep.

Analyzing time to failure of adopters provides a technique for tracking the long-term adoption of agriculturalists. Normally, rates of diffusion are calculated by estimating the number of adopters divided by the population of potential adopters at specified time intervals. This study suggests that the population of adopters counted in sequential intervals may not consist of the same individuals because many discontinue using the innovation. In addition, survivorship (time to failure) analysis showed rate of adoption by farmers was related to performance of the innovation. Thus, an increase in the percentage of adopters does not necessarily imply an increase in the number of adopters.

Diffusion of Eurasian Guarding Dogs into American Agriculture: An Alternative Method of Predator Control

by

Jay R. Lorenz

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CHAPTER I

INTRODUCTION

The Problem. Improvements in agriculture are generally associated with the invention and diffusion of new technologies. Agriculture itself was an innovation that replaced hunting and gathering in most societies. Beginning with the domestication of plants and animals, managing resources for food production has progressed through the use of simple hand tools using human energy and the harnessing of animal power to mechanization and use of fossil fuel energy (Pimentel and Pimentel 1979). Genetic resources have been harnessed through domestication, sophisticated schemes of breeding, and recently by genetic engineering. Two patterns are evident in the development of agricultural technology: primitive or less complex methods of resource management decline in use but rarely disappear, and primitive or less complex methods rarely replace or diffuse into areas where complex technologies have been adopted.

The patterns seen in the development of agricultural resources are not unique. Indeed, the application of increasingly complex technologies characterizes the evolution of energy, fisheries, timber, and wildlife production and management. In developed nations, the idea of replacing electric lighting with candles and oil lamps or replacing gasoline chain saws with hand saws is incongruous, if not entirely out of the question. Certainly, the adoption of complex technologies is one standard used to identify nations as developed or undeveloped (Dickenson et al. 1983).

The diffusion of livestock guarding dogs (*Canis familiaris*) into American livestock operations is an interesting process because it is an example of a developed nation adopting an ancient, peasant practice. Domestic sheep (*Ovis aries*) growers in Eurasia have used dogs to protect their flocks from predators for centuries (Farmer 1913, Carrier 1932). This tradition still persists in southern and eastern Europe and eastward into the Caucasian republics and Tibet (Achmatowicz-Otok 1985, Ryder 1983, Coppinger et al. 1983b, Coppinger and Coppinger 1980a, Aliev pers. comm., Jest 1979, Schmitt 1989). Their recent diffusion into American agriculture represents a primitive, rather than highly technical, approach to solving a nagging problem in predator control.

Until the late 1970's, livestock guarding dogs were virtually unknown among Anglo-American agriculturalists. Beginning in the 1970's dog breeders and wildlife professionals began to investigate the possibility of transferring Old World guarding dogs to American sheep ranches (Gerber 1974, Linhart et al. 1979). Since they were a time honored tradition in Eurasia, the problem was one of adaptation and adopting rather than invention and testing. Anglo-American sheep husbandry had a tradition of using dogs for herding flocks but no recent tradition of using dogs for protecting flocks from carnivores. Although an ancient practice, the use of livestock guarding dogs was essentially a novelty in the American sheep industry.

During the 1970's sheep growers felt an urgent need to find alternative methods of predator control. Coyotes (C. latrans) and to a lesser degree wolves (C. lupus), dogs, bears (Ursus spp.), cougars (Felis concolor), eagles (Aquila chrysaetos), and ravens (Corvus corax) were killing five to ten percent of the United States lamb crop annually (Wade 1982, Balser 1974, Wagner 1972, Henne 1975, Tigner and Larson 1977, Nass 1977, Davenport et al. 1973). Sheep and goat growers had identified predation as a significant cause for declines in their industries during the 1900's (Gee et al. 1977, Noh 1986, Scrivner 1985). In 1972 President Nixon signed Executive Order 11643 banning the use of poisons on federal lands and in federal predator control programs. Thus, unacceptable losses and restrictions in traditional programs created opportunities to explore alternative methods for reducing losses to predators.

The purpose of this thesis is to study the adoption of livestock guarding dogs in the United States. Two basic problems are proposed. The first question is what were the pre-conditions leading to the diffusion of guarding dogs in the 1970's? That is, if livestock guarding dogs were used in Europe for centuries, why did their spread into the United States begin in only the 1970's? The second problem is to evaluate prospects for universal and long-term adoption of guarding dogs in the United States. That is, where do guarding dogs work?

Justification. Historically, guarding dogs were associated with transhumant livestock husbandry in Eurasia (Carrier 1932, Ryder 1983). In the United States sheep are raised in a variety of conditions including small (<100) to large (>1000) flocks, within fenced pastures and on open range, and with or without constant shepherding. To this day, the primary predator in Eurasia is the wolf, whereas currently the primary predator in the United States is the coyote. In addition to differences in physical environmental conditions, differences in the cultural environment such as attitudes, laws, and customs could also limit the range of options available to resource managers in the United States (O'Riordan 1971). Therefore, studying the adoption of livestock guarding dogs requires investigation of how they will adapt to the diverse physical and social environments of the United States.

Another reason for asking the question of where livestock guarding dogs work is because the practicality of their universal application in the United States was called into question.

> Individual dogs with the aptitude and ability for guarding sheep and goats probably can be found, and they may be effective on smaller farms where close personal attention can be provided. For protecting range livestock, however, the possibilities for guard dogs seem limited (Wade 1982:14).

> Tests involving the use of guard dogs have also enjoyed less than stellar success...but studies conducted at the U.S. Department of Agriculture's Sheep Experiment Station in Dubois, Idaho, indicate that dogs are only effective in fenced pasturage or under direct human supervision on the open range (Martin 1985:149).

From 1978 through 1987 the Hampshire College Guarding Dog Project collected data from field trials of over 1000 livestock guarding dogs. The data collected by this project formed the basis for evaluating where guarding dogs work in the United States.

<u>Behavior and Identification of Sheep Dogs</u>. There are two basic types of sheep dogs: those which conduct or herd sheep and those which aid in guarding sheep from predators. Sheep herding dogs are generally small (25 to 35 lbs.) with a pointed muzzle and prick or tulip ears. In contrast, sheep guarding dogs are large (75 to 125 lbs.) with a rounded head and droopy ears. Border Collie, Kelpi, and Australian Shepherd are common herding breeds in the United States. Less familiar are the guardian breeds which include Anatolian Shepherd (Turkey), Castro Laboreiro (Portugal), Great Pyrenees and Spanish Mastiff (Spain and France), Komondor and Kuvasz (Hungary), Maremma (Italy), Shar

Planinetz (Yugoslavia), Polish Tatra (Poland), Ovcharka (eastern Europe and Asia), and Tibetan mastiff (Tibet) (Figure 1). Neither list is exhaustive of all breeds of sheep dog. Photographs of these breeds can be seen in many dog guides such as Schuler (1980).

Coppinger et al. (1987a) compared the behavior of both types of sheep dogs. Herding behavior is based on innate predatory motor patterns. Herding dogs were selected for their abilities to stare at, stalk, and chase sheep. Handlers conduct sheep from one location to another by controlling the pace and direction of chase behavior. Left unattended, the innate predatory behaviors of herding dogs can be disruptive to flocks. Guarding dogs were selected for their inhibition of predatory behavior. Non-threatening motor patterns toward sheep characterize guarding behavior. Guarding dogs display high frequencies of submissive postures, care soliciting, and investigatory and play behaviors. Guarding dogs may stay with flocks unattended by a shepherd.

Contrasting behaviors within a single species are possible through an evolutionary process called neoteny (Gould 1977). Neoteny is basically the process of inheriting the infant or juvenile morphology of the ancestor. Adult morphology of the ancestor is truncated and not displayed in the new descendent. The concept has been extended to include behavior as well as morphology.

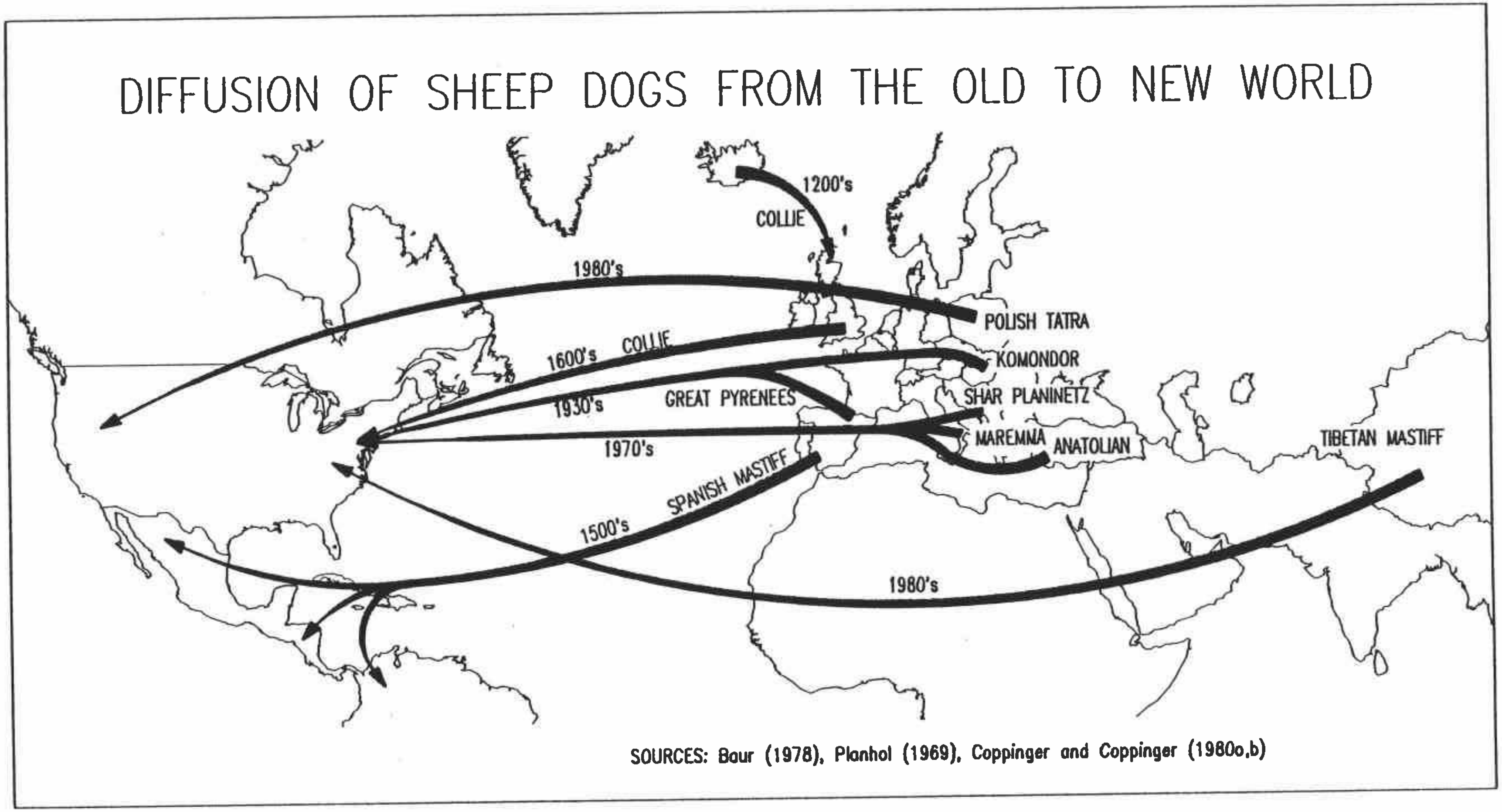

Figure 1. Diffusion of sheep dogs from the Old to New World. Dates are approximate times when the various breeds were first imported to the United States.

Selected truncation or retardation of ancestral behaviors has been hypothesized for explaining polymorphism in dogs (Fox 1978, Coppinger and Coppinger 1982, Coppinger et al. 1987a). Furthermore, neoteny is believed to be the primary evolutionary process of domestication (Zeuner 1963, Price 1984).

Geographical Approaches. A central question in geographic study is "Why is it like this here?" (Holt-Jensen 1980:6). Pattison (1964) suggested four complementary traditions or approaches used to answer the question: 1) earth science, 2) man-land, 3) area studies, and 4) spatial. The transfer of livestock guarding dogs from the Old to New World and an evaluation of where they work within the United States falls within the man-land and spatial traditions of geography. The man-land tradition is exemplified by studies of the relationship between humans and their natural environment. The spatial tradition focuses on spatial organizations and processes. Both deterministic and cultural explanations are used in the man-land tradition to explain the distribution of phenomena. Spatial patterns and processes are also used to explain the organization of phenomena such as livestock guarding dogs.

The deterministic approach would attempt to explain the distribution and success of livestock guarding dogs as a product of the physical environment. In human geography, examples of this approach can be found in the work of Ellen Semple and Ellsworth Huntington (James and Martin 1981). Many examples of a deterministic approach are evident in zoogeographical literature (for example: Semple 1922, Root 1988, Cox 1974).

In contrast, the cultural approach in the man-land tradition would attempt to explain where livestock guarding dogs work on the basis of human activities. Carl Sauer was recognized as a leading proponent for considering the impact of human activity on the physical environment (James and Martin 1981, Sauer 1956). O'Riordan (1971) suggested that the adoption of a particular management strategy is often influenced by the structure and operational guidelines of resource agencies. The physical environment is affected both directly by human actions and indirectly by institutions which limit our choices. Goudie's (1986) book provides a good review of human impacts on the physical environment.

The contrasting perspectives of determinism and culture in the man-land tradition can be polarized for purposes of discussion. However, in practice geographers recognize that "Man and nature are inseparable..." (Kish 1967:274). Climate, substrate, and biota limit the extent of resource development. Human intervention shapes distributions and patterns within those limits (Kish 1967, Sauer 1938). Both physical and cultural environments would be expected to influence where livestock guarding dogs work.

The diffusion of livestock guarding dogs into American agriculture could be studied from a spatial perspective. Such a perspective might map the locations where guarding dogs were placed over time and seek explanations (again physical and cultural) for expansion or decline. The theoretical roots of diffusion studies in geography can be traced to physics and laws of thermodynamics. Hagerstrand (1967) pioneered the application of diffusion studies in geography. He postulated that diffusion of a phenomenon could be measured as a function of distance from a core. For Hagerstrand (1967) communication was the variable that determined the rate of diffusion from the core.

Studies in the spatial perspective can be summarized as including information on the origin of the phenomenon (pre-conditions), information transfer, and spatial patterns (Morrill et al. 1988). Social scientists have suggested that information transfer and adoption of a new phenomenon are confounded by a number of factors such as economics (profitability), physical and social environments, and mass measured as the percentage of initial adopters within the core area (Babcock 1962, Bohlen 1964, Havens and Rogers 1961, Morrill 1985). All these variables have potential for explaining patterns of diffusion of livestock guarding dogs.

Historical perspectives also offer insights useful for understanding where and why resources developed. Patterns of resource management could be studied as an evolutionary process. The direction resource management takes would be dependent on founding concepts and practices. Current practices and methods could be explained as developments in preceding environmental conditions. From a cultural perspective, concepts and practices disperse in association with the dispersal of people throughout the world (Marten and Saltman 1986). New management practices and technologies evolve as old ones are adapted to new environmental settings. Examples of this approach are evident in Butzer (1988) and Kollmorgan (1969) who traced American ranching techniques to Spain. Smith (1943) and Semple (1922) discussed agricultural practices that evolved from the environmental conditions that existed in Mediterranean and Eurasian countries.

Geographers have a history of applied research in problems of resource conservation. Livestock guarding dogs appeal to our conservation ethic because protecting livestock is achieved without killing wildlife. In his presidential address to the Association of American Geographers, Bennett (1943) spoke of the need to adjust agricultural practices to the physical environment. He argued that treatments must be agreeable to the landscape as well as to farmers. Although Bennett was primarily concerned about soil erosion, his arguments for conservation could be applied equally to wildlife and predator control. Sauer (1938) also wrote of the necessity of learning to live within the limits of our environment. In summary, interactions between man and land and the spatial perspectives of geography offer interesting approaches for developing an understanding of the adoption of guarding dogs by American agriculturalists.

Review of Livestock Guarding Dog Programs and Research in the United States. In the past decade most of the American research on livestock guarding dogs was conducted from Hampshire College, Amherst, Massachusetts or from the U.S. Sheep Experiment Station (USSES), Dubois, Idaho. The focus of the Hampshire College project was on studying the behavior of livestock guarding dogs in field trials and controlled experiments. USSES also reported on the results of field trials although with less emphasis on the development of behavior. The intent of both projects was to gather information which would help introduce livestock growers to the dogs.

Surveys of sheep growers showed that two-thirds to three-fourths of guarding dogs worked well (Coppinger et al. 1988, 1983a, 1983b; Green and Woodruff 1980, 1983, 1988). Coppinger et al. (1983a, 1983b) suggested guarding dogs work equally well with small (<100), medium (100 to 1000), and large (>1000) flocks. Coppinger et al. (1983a, 1988) and Green and Woodruff (1983, 1988) reported differences in success between breeds. Using survivorship over the first six years as the measure of success, Lorenz et al. (1986) found differences between dogs working in fenced pastures and on open range. These comparative works tested one variable at a time without considering others as covariates.

A number of studies reported substantial reductions in predator losses (Coppinger et al. 1983a, 1988; Green and Woodruff 1980, 1983/84, 1988; Green et al. 1984). Economic savings on the order of hundreds of dollars per dog and thousands of dollars per ranch have been achieved (Coppinger et al. 1988, Green et al. 1984). Lorenz et al. (1986) showed that longevity of dogs affects the economic benefits that are achieved.

Identifying guarding dogs as the causal element for reductions in losses was confounded by the concurrent use of other methods of control. Growers using three or more techniques of control had 64 per cent fewer lamb losses than growers using two or fewer techniques in a study conducted in Oregon (de Calesta 1978). The confounding nature of this problem was ameliorated in the Hampshire College project (Coppinger et al. 1988) by reviewing a large sample (average of 165 surveys per year) over a period of seven years. The Hampshire College study assumed that the use of other methods of control could be considered constant over a large sample and covering several years.

Evaluating the performance of livestock guarding dogs has always been a difficult proposition. Genetic and environmental variables are difficult to control. In previous studies small samples of a youthful population distributed over many states made consideration of environmental covariates in statistical tests impossible. Yet another factor was that about half the dogs had multiple handlers (Coppinger et al. 1987b).

For the most part, dogs were the focal subject of previous studies. This study offers a geographic perspective and includes ranchers as well as dogs as the focal subjects. The large sample of subjects in the Hampshire College study make analyses with covariates possible. The aging population of both ranchers and dogs provides a basis for re-evaluating survivorship.

CHAPTER II

PRE-CONDITIONS OF DIFFUSION OF LIVESTOCK GUARDING DOGS INTO AMERICAN AGRICULTURE

A.--Introduction. If livestock guarding dogs were used to protect flocks in Europe for centuries, then why did their diffusion into Anglo-American agriculture begin only in the late 1970's? Historical accounts document the presence of guarding dogs in association with Spanish sheep in America's Southwest in the early 1800's (Lyman 1844). By 1900, the use of guarding dogs was essentially unknown among American sheep growers and wildlife professionals. What were the conditions that lead to the abandonment of the practice, and what were the conditions that led to their re-introduction? This chapter will review the history of sheep raising, predator control techniques, and institutional arrangements governing predator control in order to develop answers to these questions. A summary is provided in Table 1.

Conceptual Framework. The conceptual framework for understanding the conditions that led to the re-introduction of livestock guarding dogs is derived from literature on diffusion of innovations. Morrill et al. (1988) suggested three general conditions must be present for the diffusion of a phenomena to occur: 1) the phenomena has to be adoptable or adaptable, 2) there must be agents (inanimate

Table 1. Summary pre-conditions of diffusion of livestock guarding dogs into American agriculture.

PERIOD	SHEEP INDUSTRY
1500-1800	Spanish sheep imported to Southwest via West Indies and New Spain. Transhumant husbandry established in Southwest. English breeds imported to New England and East Coast.
1800-1900	Sheep industry expands across America peaking at 50 million. Merino (Spanish origin) stock imported to East Coast by Anglo-Americans. English and Merino stock spread westward from Northeast. Transhumant herds continue on public domain.
1900-1960	Sheep industry lobbies for federal intervention in predator control. Growers blame predation as major cause in decline of sheep numbers.
1960-1989	Sheep population declines to 12 million. Economic hardships exacerbate losses to predators.
	DOGS
1500-1800	Dogs used to protect flocks in southern Europe. Dogs used to herd flocks in England. Spanish mastiffs imported to New Spain and American Southwest.
1800-1900	Use of guarding and herding dogs continues in respective areas of Europe. Herding dogs imported and promoted among Anglo-Americans. Use of guarding dogs dissolves in Southwest except among Navajo.
1900-1960	Knowledge of guarding dogs among Anglo-American sheep growers virtually unknown. Herding dogs firmly established as the shepherd's dog. Komondors and Great Pyrenees imported by dog fanciers.
1960-1989	Guarding dogs (Anatolian Shepherd, Maremma, and Shar Planinetz) imported for use as breeding stock from Europe. Komondors and Great Pyrenees put to work as flock guardians.
	INSTITUTIONAL ARRANGEMENTS
1500-1800	Bounty payments offered for killing wolves and other predators. William Penn hires first government agent for controlling wolves.
1800-1900	Bounties continue.
1900-1960	Federal government becomes involved in wildlife management. Predator and Rodent Control program established in 1915. Animal Damage Control Act 1931 creates statutory authority for federal programs in predator control. Scientific research focuses on improving lethal controls.
1960-1989	Two scientific commissions criticize Animal Damage Control activities. Environmental legislation and Executive Orders place restrictions on ADC activities. Over 360 anti-trapping initiatives introduced. Research on non-lethal methods of predator control begins.

or animate) to transfer the phenomena, 3) adoption will most likely occur where there is a perceived need.

For the practice of using livestock guarding dogs to be adoptable we should identify and establish sources of dogs. Knowledge of the dogs must exist among potential users, and the physical as well as socio-economic environments must be conducive to their use (Hassinger 1959, Hagerstrand 1967, Havens and Rogers 1961, Morrill 1985). An infrastructure for transferring dogs from a source population to new users would facilitate adoption of guarding dogs. Documenting the threat of predation on livestock as well as dissatisfaction with alternative control strategies would establish a need for the dogs.

Hagerstrand (1967) hypothesized that diffusion of an innovation was primarily the outcome of learning and communication. He suggested that spatial arrangements of innovations could be explained on the basis of communication networks between people. Social and institutional characteristics of individuals offered resistance to the flow of information and therefore diffusion of an innovation. An understanding of sheep husbandry practices across cultures, scientific paradigms regarding predators, and laws governing predator control would reveal elements that offered resistance to the re-introduction of guarding dogs.

Social psychologists and philosophers of science have suggested that resistance to change is part of human nature (Sanders 1971, Triandis 1971, Kuhn 1970). Kuhn (1970) suggested that new paradigms arise after scientists find anomalies between observations and theories or models. From the perspective of a psychologist, Triandis (1971) suggested change in human behavior is motivated by cognitive dissonance between a behavioral practice and information about the practice. People basically want their behavior to conform to those around them and to conform with knowledge about a behavior. For example, dissonance is created between the habit of cigarette smoking and knowledge that smoking is harmful to health. An individual reduces that dissonance by either denying the scientific evidence or changing smoking habits.

The perspective of both Kuhn (1970) and Triandis (1971) suggests that even though livestock guarding dogs were available for centuries in Europe, their use would not be adopted in the United States if the behavior of the dogs did not conform to existing notions about sheep dogs or predator control. Adoption of guarding dogs would more likely take place at a time when it was perceived that other strategies were not meeting expectations.

Another sociological perspective suggests that adoption of an innovation will proceed more rapidly if it is similar to an already adopted phenomena (Havens and Rogers 1961).

This concept is referred to as congruence. For example, hybrid sorghum would be adopted faster after the adoption of hybrid corn. Adoption of livestock guarding dogs would be facilitated by research and adoption of other non-lethal techniques of predator control. Congruence between observations and theory as well as between practices contribute to adoption of innovations.

The discussion which follows sketches the origins of sheep production and history of predator control in the context of the prevailing literature on diffusion of innovation. In particular, origins of guarding dogs, patterns of European settlement in the New World, dissonance between English and continental European husbandry practices, institutional barriers, anomalies between practices and expectations, and congruence with the introduction of other non-lethal techniques of predator control will be reviewed.

Anglo Sheep, Dogs, and Predation. Citations in standard references (Carmen et al. 1892, Russell 1976, Ryder 1983, Wentworth 1948) document the transfer of English sheep along the East Coast of America in the 1600's (Figure 2). Several breeds of sheep, including Leicester and Romney, were brought to New England from England by colonists beginning in the 1630's. At first, sheep raising was limited by the lack of pasturage and predation by wolves

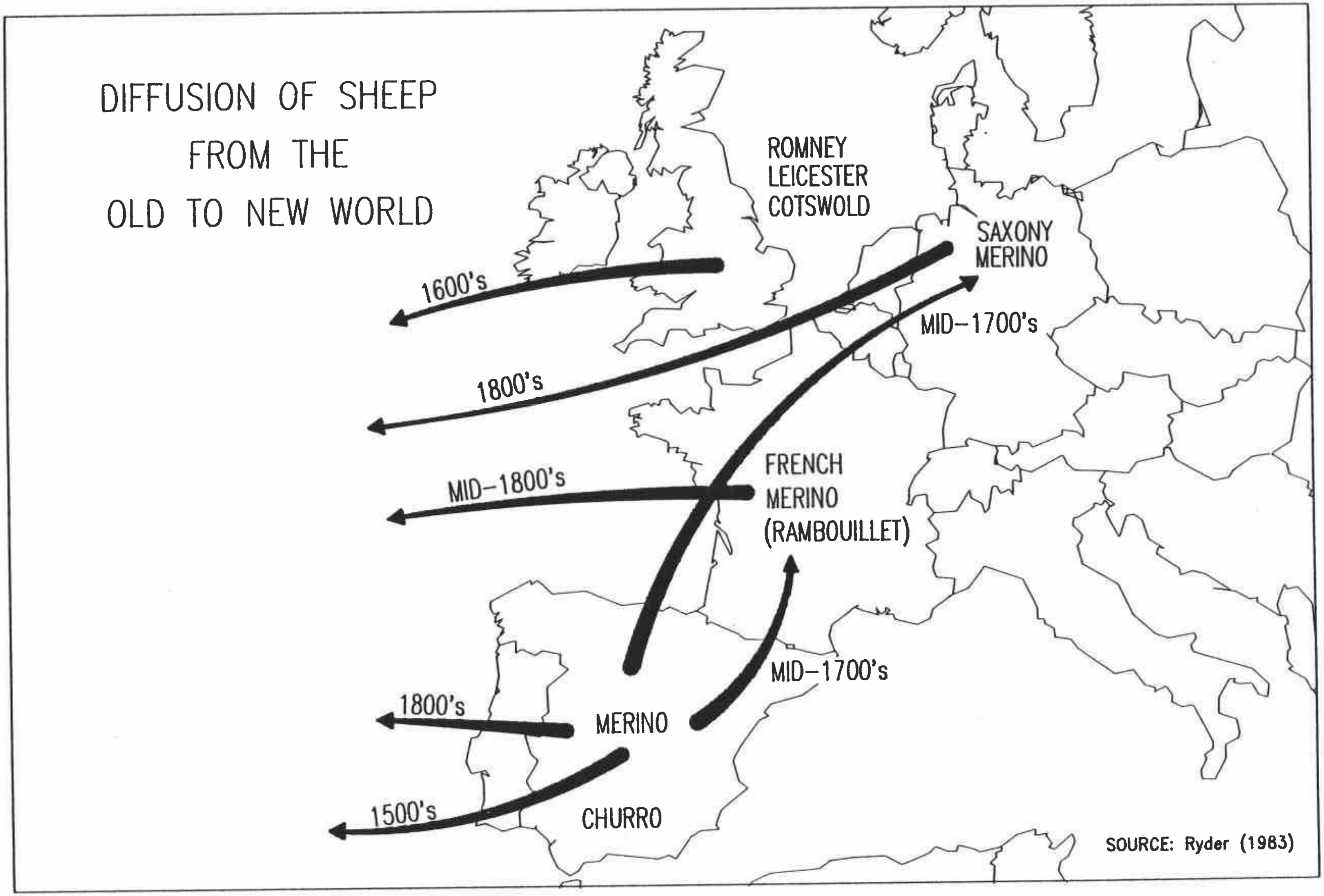

Figure 2. Diffusion of sheep from the Old to New World.

(Carmen et al. 1892, Russell 1976). For these reasons, early sheep raising was confined to coastal areas and islands. Sheep numbers increased as land was cleared, wolves extirpated, and demands for wool grew.

> Two types of animal are said to have composed the sheep population. One was a breed with dark or spotted faces and legs, from England's south coast; the other, a larger and longer type with white faces, originating in Holland, from which numerous purchases were made in the early years of the colonies. (Russell 1976:157)

There was an urgent need to protect livestock from predators in New England and other East Coast colonies. Wolves (*C. lupus* and *C. niger*) ranged throughout the United States at the time of European settlement (Hall and Kelson 1969). They are reported to have killed livestock the winter of 1630-31 (Russell 1976). Community wolf hunts and bounties were instituted as mechanisms to protect flocks (Russell 1976, Silver 1957). Given the presence of wolves and the interest in raising sheep it seems reasonable to assume that livestock guarding dogs would have been used had the English settlers been familiar with them.

However, there is no recent record of English sheep growers using livestock guarding dogs in either Old or New England. Predation on livestock was not a problem in 17th century England. Harting (1880), citing passages in ancient texts, believed wolves were exterminated from England by 1500. Ancient texts mentioned hunting wolves with hounds and bounties offered as incentives to eliminate them

(Harting 1880). Wolves persisted in remote parts of Scotland and Ireland until about 1743.

Planhol (1969) believed that herding dogs were used in Iceland in the 1200's, eventually making their way to England by way of the Shetland islands by the 1400's (Figure 1). By the 1500's, discussions of dogs working sheep in England referred to herding dogs. Ryder (1983) cited references of shepherds training dogs to fetch sheep, bark, run, and stop running in the late 1500's. These behaviors are typical of herding rather than guarding dogs (Coppinger et al. 1987a). Planhol (1969) and Laurans (1975) argued that the adoption of herding dogs followed the demise of wolf populations. At the time of English colonization of America's East Coast, wolves were all but gone and herding dogs well adopted in England.

<u>Continental Sheep, Dogs, and Predation</u>. Transfer of livestock guarding dogs to the New World would most likely have occurred from countries where wolves existed and guardian dogs were in continuous use. Wolves have menaced flocks in continental Europe and Asia for centuries and are still present, in small numbers, in Mediterranean countries (Mallison 1978, Smit and van Wijgaarden 1981). The author observed four Maremma sheep dogs chasing two wolves in the Abruzzi Mountains in July, 1982.

References to guardian breeds in continental Europe can be found in literature and art dating back 2000 years. Farmer's (1913) translation of Cato and Varro's writing on agriculture in Roman times contains a chapter on the use and care of guardian dogs. Shepherds were instructed to raise pups by suckling them on ewes. Planhol (1969) cited 17th and 18th century European texts that referred to guardian dogs in continental Europe. In a discussion of transhumant migrations in 18th century Spain, Carrier (1932:87) made the following statement: "The dogs were mastiffs, similar to the sheep-dogs used in the Pyrenees. Their work was to guard against robbers and wolves." Ryder (1985:411) reprinted a 1541 lithograph showing a French shepherd stabbing a marauding wolf in the neck. A floppy-eared dog with a spiked collar was at the shepherd's side.

Schmitt (1989) summarized four ecological conditions that were present where livestock guarding dogs were historically used in continental Europe: 1) predators were present, 2) rural landscape was not divided into cultivated parcels, 3) a pattern of transhumant livestock husbandry was present, and 4) a food source was available for the dogs. Dogs were traditionally fed whey, the by-product of daily cheese making. This source of nourishment for guarding dogs was observed in the Abruzzi Mountains during a study of guarding dog behavior (Coppinger et al. 1983b). In contrast, the use of guarding dogs was discontinued in regions where wolves disappeared and where intensive crop production disrupted transhumant livestock husbandry (Schmitt 1989, Planhol 1969).

The most logical time to expect the transfer of livestock guarding dogs to the New World would be during the importation of Spanish sheep. Spain, more than other Eurasian countries that had guarding dogs, was a major supplier of sheep to the New World. Spanish explorers brought sheep (probably representing several breeds) to the New World to have as a source of food. These sheep were first brought to the West Indies in the early 1500's (Ryder 1983, Wentworth 1948). From the West Indies, Spanish sheep were taken to Central America, Mexico, and then northward to missions in coastal California and ranches in the Southwest (Butzer 1988, Ryder 1983, Carmen et al. 1880, Wentworth 1948) (Figure 2).

A number of anecdotal accounts and the traditional use of sheep dogs by the Navajo provide evidence that guarding dogs were brought to the New World by Spanish settlers. Darwin's (1888:150) description of large dogs establishing "... so firm a friendship..." with flocks in Patagonia is evidence that guardian dogs were brought to South America. Wentworth (1948) and Baur (1978) believed that in the first two centuries of sheep raising in the Southwest, all sheep dogs were of the guardian type:

> Early New Mexico traditions indicate the willingness of dogs to follow and protect their

> sheep even when Indian bands had massacred the shepherds and were driving the flocks to captivity or slaughter. Wentworth (1948:406)

Wentworth's (1948) discussion was based in part on Lyman's (1844) glowing account of guarding dogs in New Mexico and Mexico. Lyman (1844) credited the origin of the dogs to Spanish mastiffs introduced during the conquest. Varner and Varner (1983) stated that cattle ranchers in Peru kept mastiffs because they wanted their herds to resemble those of their homeland, Spain. In 1560 a lad carried a mastiff pup from Cuzco to Lima in his saddlebag, delivering it to his father-in-law who raised sheep (Varner and Varner 1983). Baur (1978) indicated guarding dogs were also used to protect sheep in missions of coastal California, possibly persisting in that area into the mid-1800's. The current Navajo and Mexican tradition of using dogs to protect sheep is the only living evidence of the introduction of guardian dogs to the Southwest (Black 1981, Black and Green 1985).

The first Spanish sheep of record on the East Coast were brought to southern New England by David Humphreys and Seth Adams in 1800 (Carmen et al. 1892, Russell 1976) (Figure 2). Merinos, prized for their fine wool, were imported to improve the coarser wool of the English breeds. The first Merinos had to be smuggled because Spanish law did not allow their export. Export rules were relaxed in the 1800's, and more Merinos were imported. Seth Adams moved to Ohio with his sheep where they became the foundation stock

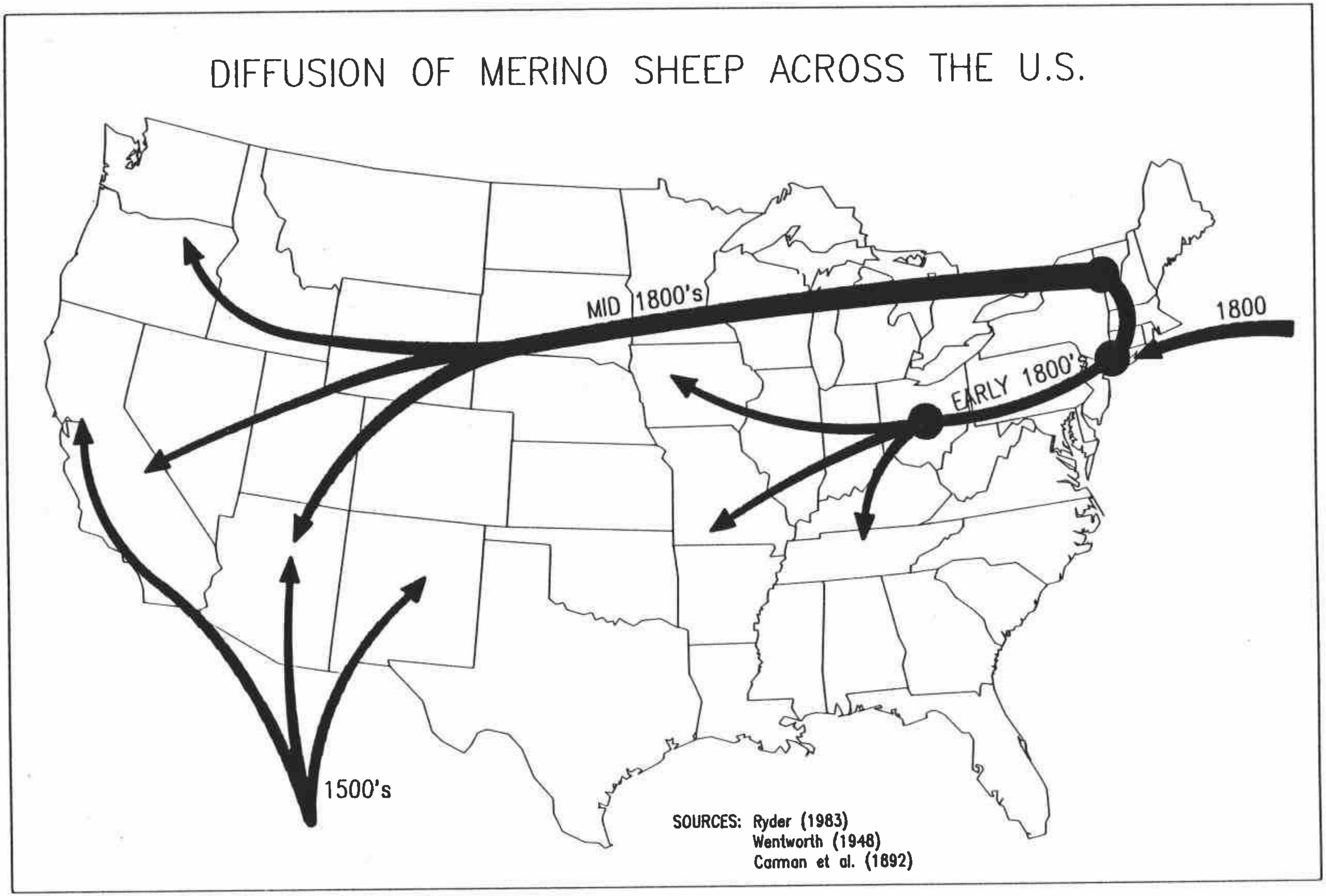

Figure 3. Diffusion of Merino stock across the United States.

for many Merinos in Ohio, Kentucky, and Tennessee (Carmen et al. 1892). Figure 3 illustrates the routes of diffusion of Merino stock across the United States. References to the importation of Spanish mastiffs into New England in association with Merinos were not found.

Decline of Guarding Dogs in 19th Century America. What happened to the Spanish mastiffs in the Southwest? Why was there a lack of interest in guardian dogs in New England? Coppinger et al. (1985) hypothesized three reasons for the disappearance of Spanish mastiffs in the Southwest: 1) hybridization with other dogs, 2) dogs were killed by soldiers, and 3) lack of knowledge about guarding dogs by English settlers who took over the sheep industry in the Southwest. This third point can be expressed in terms of dissonance between English shepherds with a tradition of herding dogs and Spanish shepherds with a tradition of guarding dogs. In addition, the extermination of wolves in the Northeast by 1800 further reinforced the English tradition of raising sheep in predator-free regions.

Loss of appropriate guardian behavior may have occurred as the result of crosses with other breeds of dogs. The Southwest and Mexico were abundant with dogs in the early 1800's. Mexico had the reputation of having an over-abundance of dogs:

> ...but eye-witnesses can assert, that there never was a country blessed with a greater and more abundant variety of miserable, snarling, cowardly

> packs, than the mongrel dogs of Mexico. (Lyman 1842:241)

One of Colonel Kearny's soldiers wrote that Santa Fe had more dogs than any other town in the Union (Baur 1978). Noise from barking and dog fights kept settlers in Tucson awake at night (Baur 1978).

The mongrelization hypothesis is further supported by the persistent use of such dogs by the Navajo (Black 1981, Black and Green 1985). While Navajos use mongrel dogs as flock guardians, they have not developed a breed type from such use. The tradition, rather than any recognizable mastiff type stock, remains in the Southwest. An unsuspecting observer would not think to identify the variety of breed types of dogs which accompany Navajo flocks as having any useful purpose. The use of mongrel dogs would in Hagerstrand's (1967) terms be a barrier to communicating the concept of guardian dogs.

Numerous conflicts between Spanish, Anglo-American, and Native American cultures in the Southwest probably contributed to the death of many guarding dogs. Lyman's (1844:242) anecdotal account was revealing in this regard:

> Of late years, when the shepherds of New Mexico have suffered so much from Indian marauders, instances have frequently occurred where the dog has not hesitated to attack his human foes, and although transfixed with arrows, his indomitable courage and faithfulness have been such as to compel his assailants to pin him to the earth with spears, and hold him there until despatched with stones.

Baur (1978) recounted another tale of soldiers from Colonel Stephen W. Kearny's regiment who stole a sheep for their supper. The dog, after being shot in the shoulder, chased after the soldiers. The soldiers succeeded in stealing a sheep, but not without first injuring the dog.

Lack of knowledge about guarding dogs appeared to be a limiting factor in New England and to some extent in the Southwest. The lack of a tradition of using guarding dogs by English shepherds sometimes manifests itself in negative statements about the flock guardians. One citation suggested that shepherds in New England knew guardian dogs were used in Europe, but were completely unaware of their use in the Southwest. The following advice appeared in an article on how to guard sheep from dog attacks in a magazine published in New York:

> The importation of the large Spanish shepherd dog has been recommended, as he will invariably attack and kill any dog that approaches his flock, but this would be an expensive and troublesome measure, and it would take a long while to breed a sufficient number of them here, before they could become generally effective. (Anon. 1842:6)

Lack of knowledge or at least lack of experience with guarding dogs may have been a limiting factor among some Spanish immigrants to the Southwest. Nearly half of the immigrants in the 1500's were from urban areas (Boyd-Bowman 1976). Many were poor and unskilled men, probably landless second or third sons looking for new opportunities (Butzer 1988). For many decades, farmers were not allowed to emigrate from Spain, although some probably did under the disguise of sailors or soldiers (Butzer 1988). Butzer (1988) concluded that livestock husbandry in New Spain could be partially explained as a re-creation of an Old World tradition rather the direct transfer of an agrotechnological system. As such, some of the cultural knowledge about managing and breeding dogs may have been left behind by settlers to the New World.

The dissonance between herding and guarding dogs was displayed in the use of the term "sheep dog." Until the late 1970's, the generic term "sheep dog" referred to collie type herding dogs in Anglo-American farming. For example, Peters (1844:76) wrote:

> Speaking of dogs, I think the shepherd's dog [Scotch collie] the most valuable of his species...the sagacity of the shepherd's dog is wonderful...I hope farmers will take more pains in getting the shepherd dog.

Recounting a story of sheep husbandry on the prairies, Allen (1845) talked about shepherd dogs herding and driving sheep by day and driving off prairie wolves (coyotes) by night. A photograph of a flock of Merino sheep attended by a "sheep dog" in Massachusetts in the 1880's displays a herding dog (Russell 1976:426). A pictorial history of American sheep raising identified herding dogs simply as sheep dogs (Paul 1976).

Recommending the use and importation of collie pups occurred in the same magazine and within two years of the advice that importing Spanish mastiffs was too expensive. One article spoke of importing two Scotch collie pups and sending them to Wisconsin (Anon. 1845). Triandis (1971) suggested that denial is a common way that people deal with dissonance. In the case of English agriculturalists, denial of guarding dogs was certainly evident.

Extermination of wolves and other large carnivorous predators from the East Coast prior to the introduction of Spanish sheep would have reduced the likelihood of guarding dogs being imported. Wolves were essentially gone from southern New England by 1800 and exterminated from remote northern regions of New England by the mid-1800's (Allen 1876, Crane 1931, Davis 1929, Jackson 1922, Linsey 1842). When Spanish Merinos and their derivatives (French Rambouillet and English Saxony Merino) were imported into the Northeast during the early 1800's there would have been little reason for the English importers to think of bringing guarding dogs with them. As previously argued, English importers appeared to have a negative attitude about guarding dogs. In addition, the early imports of Spanish Merinos were purchased to enhance the genetic stock of existing flocks. The interest was in genetics rather than the importation of an entire husbandry system.

Merino stock introduced by Adams and Livingston into Ohio and Kentucky and Merino stock from Vermont were primary sources of Spanish sheep into the Prairie states and through

Colorado to California (Russell 1976, Ryder 1983, Wentworth 1948) (Figure 3). East Coast Merino stock reached California by 1850 (Ryder 1983). Some portion of the western Merino stock was based on English (Saxony Merino) and French (Rambouillet) derivatives of the Spanish Merino. Wentworth (1948) estimated that 98 per cent of western sheep were 50 per cent Rambouillet by 1900. Guarding dogs did not accompany the westward expansion of Merino stock since they were not a husbandry practice of the Anglo flock owners. The eventual dominance of Spanish sheep (Merinos and their derivatives) in the western United States was promulgated by the westward expansion of Anglos rather than a northern expansion of Spanish culture from the Southwest.

One other possibility exists as a source of livestock guarding dogs for the United States. Basques from the Pyrenees Mountains have a reputation of being excellent shepherds and were hired to tend flocks in the western United States. By the 1850's Basques were herding sheep in California (Douglass 1985). Many came directly from Europe, and many came via South America (Douglass 1985). As they came from a region that historically used guardian dogs one might expect them to bring their shepherd dogs with them.

However, while they came to the United States to herd sheep, they do not appear to have imported sheep and dogs. Like their predecessors from the 1500's, many Basque shepherds probably had little experience raising sheep before coming to the United States. For example, in his autobiography, Paris (1979) said that he was poor and came to the United States with no money and little more than the clothing on his back. His family had a few sheep in the Pyrenees. However, most of his knowledge about sheep and shepherding was learned on the western range. The Western Range Association was responsible for making arrangements for many Basque shepherds, like Paris, to come to the United States on three year contracts. Saving their meager monthly earnings allowed many to eventually buy their own land and flocks (Wentworth 1948).

By the time they became owners, they were well indoctrinated into American husbandry practices. Paris (1979) recounted the necessity of having sheep dogs for conducting his sheep about the range. For him, the concept of a sheep dog was obviously that of a herding dog. Both Douglass (1985) and Paul (1976) reproduced numerous photographs of Basque shepherds with their herding dogs.

<ins>Summary</ins>. The sheep industry that matured in the United States in the 1800's was an interesting mix of sheep and cultural practices primarily from England and Spain. Sheep and transhumant husbandry practices were transferred from Old Spain to New Spain beginning in the 1500's. This tradition migrated northward and elements of transhumance have persisted in the intermountain West up to the present.

Merino sheep and their derivatives of Spanish origin which spread throughout the American West were imported primarily by Englishmen independent of their cultural context. Basque shepherds immigrated independent of their sheep husbandry context. The practice of moving sheep from drier areas in the winter to cooler, wetter pastures in summer can be traced to historical patterns of transhumance in continental Europe. The English tradition of using herding dogs, which spread west with the expansion of the sheep industry, dominated the tradition of using guarding dogs which prevailed in the Southwest.

B.--Institutional Arrangements and the Scientific Community. Although scientific game management did not begin in earnest until the late 19th and early 20th centuries, game management affecting sheep production was practiced by the early colonists (Allen 1974). An incentive, in the form of bounties, was paid to both Englishmen and Indians for dispatching wolves and other predators (Silver 1957, Allen 1974, Russell 1976, Lund 1980). Dislike of wolves was institutionalized in laws of the Massachusetts Bay Colony (Russell 1976, Lund 1980).

The concept of actively pursuing wolves and other predators with hounds as the result of bounty incentives is ancient, especially in English custom (Harting 1880). Indeed, the Irish wolfhound was named after its activity in pursuit of wolves. If predators were the problem, then it followed that their demise was the solution.

William Penn is credited with hiring the first government wolf hunter in America in 1705 (Allen 1974). This was an important precedent because government recognized that damage to private property was sufficient to justify public funding (Coggins and Evans 1982). The amount of predator control achieved through bounty incentives was dependent upon the amount of individual interest in hunting wolves. However, dispatching government hunters offered constant control analogous to police protection offered by the state (Coggins and Evans 1982).

Around the turn of the 20th century, wildlife managers and agriculturalists were disgusted with predators. Eliminating predators was the primary technique used for managing ungulates in the early 1900's. The classic example was the poisoning of predators on the Kaibab Plateau to increase populations of deer for hunters (Allen 1974). The elimination of predators on the Kaibab was only a recent manifestation of a long Western tradition of eliminating animals that threatened human safety or competed for human prey (Lund 1980, Harting 1880).

Sheep numbers in the United States peaked at about 50 million in the late 1800's (U.S.D.A. 1924). In the 17 western states, tens of millions of sheep were raised primarily on public land (Wentworth 1948). Livestock ranchers estimated losses to predators in the millions in 1907 (Matthiessen 1959). Losses of sheep motivated the sheep industry to request federal assistance.

The lobbying effort by the sheep industry was the primary reason federal agencies became involved in predator control at the turn of the 20th century. Two factors rationalized and justified federal involvement. First, the federal government owned the land upon which sheep grazed. Flocks were shepherded over hundreds of miles of range, many covering two or three states in the course of a year. Second, private property was being destroyed by a public resource, and the problem was larger than any individual shepherd could handle. As a policy problem, involvement by the federal government could be justified on the basis of its ownership of the land and on the idea that the benefits would be spread among many people.

A third factor that facilitated federal involvement was the federal government's willingness to pay for predator control. In the United States, wildlife ownership and management was historically a state's right (Lund 1980, Coggins and Evans 1982). However, states were not excited about paying for predator control, especially on land they did not own. Where states fought to maintain management of game species, they readily accepted federal support to get rid of undesirable pest species.

The first federal money for predator control was specifically designated in funding for the Department of Agriculture in 1909. Given society's general disdain of predators, the status of wildlife science, institutional precedents for killing wolves, and the apparent lack of knowledge about guarding dogs it should come as no surprise that the Act (March 4, 1909, Ch. 301, 35 Stat. 1051) passed by Congress awarded money to conduct "experiments and demonstrations in destroying noxious animals." The destruction of predators became more formalized as the predator control bureaucracy grew over the next two decades.

In 1915, the Branch of Predator and Rodent Control (PARC) was formed as a division of the Biological Survey. PARC instituted a mass campaign in the West to poison predators with strychnine. Congress gave PARC statutory authority when it passed the Animal Damage Control (ADC) Act in 1931 (7 U.S.C. 426). The ADC Act granted the Secretary of Agriculture authority to "...determine, demonstrate, and promulgate the best methods of eradication, suppression, or bringing under control..." a long list of predators and other species deemed harmful to agricultural and forestry interests.

The wording and authority of PARC and ADC firmly institutionalized an attitude and approach that was to dominate predator control activities over the next 50 years. The West was divided into predator control districts, and government agents were hired to eliminate wolves and coyotes. Until the 1960's, all research in the area of predator control was directed toward developing and improving methods of killing predators. For example, the Humane Coyote-getter (registered trademark), a device that ejects poison into the mouth of a coyote was introduced in the early 1940's and redesigned as the spring loaded M-44 (registered trademark) in the late 1960's (Robinson 1943, Henderson 1984). Compound 1080, originally designed as a rodenticide during World War II, was put to use as a predacide in the late 1940's (Azert 1971, Robinson 1948). Part of Compound 1080's appeal was its selectivity toward canines and its improved safety over another poison, thallium. The research establishment that included professional wildlife managers was reinforcing the ADC Act.

The administration of PARC and ADC has not been without challenges. In 1930, The American Society of Mammalogists held a special Symposium on Predatory Animal Control at its 12th annual meeting (printed in J. Mammal., Vol. 11). The debate, exemplified by one paper (Adams 1930), was whether PARC should proceed with a policy of eradication or whether it should target depredating individuals around livestock. Non-lethal methods of predator control were not even an issue at the symposium.

Major challenges to ADC came from anti-trapping interests. Gentile (1987) documented anti-trapping legislation in the 20th century. Of the 17 states west of the Mississippi River where ADC has maintained predator control programs, three attempted to ban leg-hold traps from 1925 to 1939, and five attempted to ban leg-hold traps from 1968 to 1986. Nationwide, 99 anti-trapping initiatives were introduced from 1925 to 1939 and 360 from 1968 to 1986. Six eastern states currently ban the use of leg-hold traps. Few anti-trap initiatives were introduced from 1940 through 1967.

Other challenges to the operation of ADC began in the 1960's. These came from a number of directions including environmentalists, legislators, and scientists. During the first half of the 1900's, ADC's use of traps and poisons had often been indiscriminate, killing non-target individuals that were not threatening livestock. Subsequent environmental legislation required ADC to re-examine their approaches to predator control. For example, the Multiple Use-Sustained Yield Act (1960, 16 U.S.C. 528-531) required National Forests to be managed for wildlife and other resources in addition to timber. The National Environmental Policy Act (NEPA 1970, 42 U.S.C. 4321-4361) required agencies to consider the consequences of their actions before instituting programs. NEPA provided environmental groups a mechanism to challenge government programs that could be construed as destructive to wildlife or the environment. Protection of golden eagles (Act of Oct. 24, 1962, Pub. Law 87-884, 76 Stat. 1246) reinforced an Act for the Protection of Bald Eagles (1972, 16 U.S.C. 668-668d). In 1973, the Endangered Species Act (16 U.S.C. 1531-1543) offered protection to a number of predators that ADC had at one time or another worked to eliminate. Directly and indirectly, the various environmental laws of the 1960's and 1970's placed restrictions on ADC's mandate to eradicate and suppress predatory species.

Environmental legislation was fueled by reports from the scientific community. In the arena of predator control, the Leopold Report (Leopold 1964) criticized ADC activities and recommended changes. Among the recommendations were requests to consider wildlife as well as livestock in its goals, to increase research in finding ways to minimize killing innocent animals, and to develop non-lethal methods. The Cain Report (Cain et al. 1971) again criticized ADC, offered similar recommendations, and stated that circumstances had changed little since the Leopold Report.

One landmark policy change did occur as a result of these reports. Executive Order 11643, signed by President Nixon in 1972, banned the use of toxicants on federal lands. The Environmental Protection Agency followed suit by cancelling the registration of predacides. The scientific community was recognizing that predators played an important role in complex ecological relationships. Indiscriminate killing of both target and non-target species would affect relationships in ecosystems and was no longer supported by a large segment of society.

In the 1970's, the sheep industry found itself facing problems from several fronts. Losses to predators, rising expenses, low prices for lamb and wool, and difficulty in finding good labor were cited as reasons for a decline in the number of sheep (Gee et al. 1977). Anti-trapping legislation and restrictions in predator control brought about by environmental legislation exacerbated an already bleak economic outlook for sheep growers.

Stuby et al. (1979) reviewed the antagonism that had developed between environmentalists and sheep growers. Sheep growers had three points: 1) growers thought lamb losses were unreasonable and could destroy their industry, 2) sheep convert low quality forage into food and fiber, and 3) if sheep numbers continued to decline consumer prices for their products would increase. Environmentalists countered with three points of their own: 1) they were concerned that natural balances between predators and prey should be maintained, 2) coyotes and other predators that were not killing sheep were being killed unnecessarily, and 3) some control methods endangered domestic and non-target animals. Secretary of the Interior, Cecil Andrus (1979), summed up the situation in his memorandum on Department of Interior Predator Control Policy in 1979 saying, "...neither the livestock industry nor the environmental community is satisfied with its [ADC] conduct or results." Furthermore, Andrus (1979) emphasized a need for non-lethal methods of predator control.

Economic and political events of the 1970's were forcing the sheep industry, government agencies, and environmental groups to seek alternative strategies of predator control. Suppression and eradication institutionalized in the 1931 ADC Act were no longer an acceptable policy. The motivation to change was different for each constituency: the sheep industry wanted some amount of control over their own destiny, government agencies wanted to find solutions that would satisfy Congressional mandates, and environmentalists wanted to preserve wildlife.

Tests of several methods of non-lethal predator control began in the 1960's. For example, Balser (1964) and Linhart et al. (1968) reported on the potential of anti-fertility agents for inhibiting coyote reproduction. Several investigators tested the use of electric fences (Nass and Theade 1988, de Calesta and Cropsey 1978, Gates et al. 1978, Linhart et al. 1982). Neither of these methods was found practical in open range sheep operations, although electric fences were found useful in smaller pasture settings. Gustavson et al. (1974) introduced the idea of aversive conditioning, a method designed to teach coyotes to avoid sheep. This technique has met with variable success (e.g., Bourne and Dorrance 1982, Burns 1980, 1983; Burns and Connolly 1980, Gustavson 1979, Gustavson et al. 1982). The status of non-lethal techniques of predator control and a comprehensive bibliography appeared in Linhart (1983).

Re-introduction of Livestock Guarding Dogs. Another alternative for predator control focused on the re-introduction of the ancient practice of using livestock guarding dogs. One family in the area of Ellensburg, Washington began using Great Pyrenees in 1951 (Anon. 1951, Woods pers. comm., see photograph of dog in Paul 1976:100). Sporadic use of guarding dogs may have taken place throughout the West in the first half of the 1900's. However, the full extent of their use prior to the late 1970's is unknown.

One of the first attempts to re-introduce guarding dogs to sheep growers failed. In 1969 or 1970, a dog breeder approached Phil Farrell, President of the Oregon Sheep Growers Association, about using Komondors for protecting flocks, and a field trial ensued (Gerber 1974, Farrell pers. comm.) Farrell (pers. comm.) recounted several reasons for the failure that reflected the attitudes of sheep growers. The dog breeder was not a sheep grower. The breeder had described the dogs as being vicious dogs that would attack coyotes. However, the dogs did not appear vicious. If they were, then sheep growers did not want the liability of such a dog. If, as observed, they were not, then sheep growers were suspicious of the knowledge of the dog breeder. The dogs that were presented came from pet class stock, and sheep growers knowledgeable in animal breeding were not convinced the available dogs had been selected to display the necessary behaviors. Finally, sheep growers had been presented with a host of cure-all methods of predator control over the years, and they were wary of trying a new method without adequate demonstration.

From a theoretical perspective, the failure of Komondors in Oregon can be explained on the basis of social interactions and cognitive dissonance (Sanders 1971, Triandis 1971). The diffusion of an agricultural innovation is more likely to take place if the innovator's social status and tradition is similar to other members of the community. In this regard, the fact that the dog breeder was not a sheep grower was significant. There were incongruities between the described and observed behavior of the dogs. The poor descriptions of Komondor behavior were inadequate for overcoming the concept of dogs as either sheep-herders or sheep-killers.

In contrast, the use of a Komondor by a ranch family in Texas and a field trial conducted by the U.S. Fish and Wildlife Service were significant for demonstrating the potential of livestock guarding dogs in the United States (Adams 1980, Linhart et al. 1979). The Adams family in

Texas raised Angora goats and obtained their first Komondor in 1975 from a cattle rancher. They tried the dog on a hunch, knowing only of the breed's reputation as a flock guardian in Europe (Adams pers. comm.). Having had a long-term interest in raising and training dogs, the Adamses looked upon the idea of using a dog for flock protection as a challenge. The Linhart et al. (1979) short-term trial achieved a reduction in losses after the addition of a Komondor, and they recognized a need for long-term studies. The results of the ranching family in Texas and the experimental trial of Linhart et al. (1979) were field demonstrations observable by other scientists and agriculturalists.

Two researchers at the Winrock International Livestock Research and Training Center, Richard Wheeler and Hudson Glimp, suggested the possibility of using livestock guarding dogs to Ray Coppinger of Hampshire College in 1976 (Coppinger and Coppinger 1980b). In the spring of 1977, Coppinger travelled throughout the western United States in search of dogs guarding sheep. He found one Komondor that seemed to be doing its job at the Adams ranch in Texas. The dog, Maggie, provided one impetus for the Livestock Guarding Dog Project at Hampshire College (Coppinger pers. comm.)

<u>Implications for Applied Research</u>. Several conditions already alluded to affected the design of the Hampshire

College Guarding Dog Project. 1) Scientific and cultural credibility of guarding dogs had to be re-established. Cultural history passed from one generation to the next on the use of guarding dogs was absent among Anglo-American sheep growers. 2) Breeding stock which would display desirable behaviors had to be identified and obtained. Genetic stock from Spanish mastiffs brought into the Southwest was no longer available. Komondors and Great Pyrenees were available in the United States. However, it was uncertain whether they retained traditional guardian behavior since they were kept primarily by dog fanciers. 3) Field testing and demonstrations had to be organized in a manner to overcome the cognitive dissonance between herding and guarding sheep dogs. Sheep growers held the concepts that canines were predators and shepherd dogs were used for herding. 4) Institutional barriers to the diffusion of livestock guarding dogs still existed in the late 1970's. Although two distinguished scientific commissions had recommended demonstrations in non-lethal predator control, there had be no implementing legislative changes to the 1931 ADC Act.

Several aspects of the Hampshire College Guarding Dog Project illustrate how that program responded to the cultural and institutional conditions of the late 1970's. First, breeding stock was imported from sheep raising districts of Italy, Yugoslavia, Turkey, and Portugal. They were purchased from shepherds who had presumably been selecting for desirable guardian behavior. The investigators maintained their own sheep farm, thereby reducing social distance with commercial sheep growers. Leasing rather than selling dogs provided a mechanism for minimizing economic risk to sheep growers as well as increasing the likelihood of objective evaluations. Dogs were raised for a year prior to their initial distribution to sheep growers. In other words, investigators stayed a year ahead of sheep growers in observing the ontogeny of behavior. Knowledge of the behavior of the dogs was developed through controlled ethological studies rather than reliance on anecdotal accounts of dog breeders or shepherds. Dogs were field tested by volunteer sheep growers where they could be observed by others. An outreach program to disseminate information was designed to overcome the dissonance between the two types of sheep dogs. Additional details may be found in Coppinger et al. (1983a, 1983b, 1988).

The analyses contained in this study were performed in the context of providing information useful for the diffusion of livestock guarding dogs into American agriculture. In terms of Morrill et al. (1988), the information in succeeding chapters speaks to the problem of the adoptability and adaptability of livestock guarding dogs in the United States.

Summary. Lethal methods of predator control, lobbied by western ranching interests and supported by prevailing advice from wildlife managers, became institutionalized during the 20th century. Institutional support for lethal controls created a barrier for the diffusion and re-introduction of livestock guarding dogs through the 1960's. Advances in scientific wildlife management, environmental legislation of the 1960's and 1970's, pressure from environmental groups, and on-going predation of livestock brought antagonism between various interest groups. A search for non-lethal methods of predator control began in order to relieve the tension between antagonists. The re-introduction of livestock guarding dogs in American agriculture was one of the alternatives that gained attention in the context of the search for non-lethal methods.

CHAPTER III

METHODS

Database. The adoption of livestock guarding dogs was evaluated by focusing on three subjects: 1) cooperators, 2) dogs, and 3) cooperator/dog interaction. A national database on both cooperators and dogs has been kept at Hampshire College since 1977. Date of birth, sex, litter number, breed, date and location of placements, and date of death were recorded for each dog. Each year cooperators were asked to evaluate the performance of their dog(s) on a questionnaire. Cooperators were asked a series of management questions, asked to rate the performance of their dog in three behavioral categories, and to estimate losses to predators. The 1986 and 1987 questionnaires also asked cooperators to check additional methods of predator control they used.

Questionnaires from 1980 through 1987 were available for this study. Earlier questionnaires were not referred to because of small samples and the youthful nature of the dog population. Additional details and comments about dogs, cooperator program, and database appeared in Coppinger et al. (1983a, 1983b, 1985, 1988).

Cooperator Program. Dogs were leased to volunteer cooperators for $1.00 for the first (puppy) year and $50.00 per year thereafter. The lease fee for adult dogs was increased to $120 per year in 1983. Sheep and goat ranchers qualified to participate if they owned a minimum of two dozen sheep or goats, had a history or threat of predation, agreed to answer an annual questionnaire and supply information on their dog(s), and paid the annual lease fee. From 1978 through 1987, 419 sheep and goat producers were volunteer cooperators. December 31, 1987 marked the termination of the cooperator (lease) program. The following year dogs were offered for sale to cooperators.

Initially, dogs were distributed to cooperators from Hampshire College. As word of successes spread new systems for delivering dogs were employed. Beginning in 1980 a system of group delivery was established. Groups of producers, often organized by a local agricultural leader or Extension agent, applied for dogs. Delivery expenses were then shared among the group members. In 1984, the author began directing a pilot demonstration project for the Oregon State University Extension Service (the author was a research associate at Hampshire College from 1980 to 1984). From 1984 to 1987, cooperators in Oregon, Washington, and northern California obtained Hampshire College dogs that were bred and whelped on cooperator farms in Oregon.

Cooperators were given written and verbal instructions on the behavior and management of guarding dogs. They were encouraged to view slide talks usually presented by R. Coppinger or the author. Producers were invited to contact staff at Hampshire College or Oregon State University Extension Service if they had questions or encountered problems.

The lease arrangement permitted cooperators to return dogs to the program if they were not satisfied with their performance or if the producer went out of business. Returned dogs were transferred to a new ranch or culled due to lack of attentiveness or trustworthiness. Replacements were offered in cases of unacceptable dog behavior or death due to accident or disease.

The diffusion of livestock guarding dogs was mapped using information from the database. The focal subject of this map was the cooperator/dog interaction, essentially the number of placements. Only dogs of the three main breeds, Anatolian, Maremma, Shar Planinetz, and their crosses were counted. Additional details of the cooperator/dog interaction are described below.

Rate of adoption by flock size was evaluated by comparing the distribution of flock sizes among cooperators to that of the actual population. The actual distribution of flock sizes, taken from the Census of Agriculture (U.S. Dept. of Commerce 1982), was used for estimating expected frequencies used in Chi-square statistics. This evaluation included flocks of more than 25 sheep since cooperators were required to own two dozen head to participate.

Survivorship of cooperators was defined as the length of time of adoption by cooperators. Length of time of adoption of livestock guarding dogs was analyzed using life table analysis, also known as an analysis of time to failure. Life table analysis (or time to failure), illustrated in a survivorship curve, provided a method for comparing adoption of guarding dogs by cooperators to the survivorship of dogs. This comparison was used to test whether long-term adoption was a function of the performance of individual dogs. The procedure measured adoption independent of the failure or death of an individual dog.

Life tables and survivorship (time to failure) curves were generated using the standard proportional hazards model with right-censored data as described by Lawless (1982). All life tables were computed using the Lifetest procedure of SAS (SAS Institute 1987). Time was estimated to within 0.25 years, calculated from the date of receiving the first dog to date of failure of the last dog. Four events constituted cooperator failure: 1) death of dog with no replacement, 2) transfer of dog to a new cooperator with no replacement, 3) death of the cooperator, or 4) cooperator sold entire flock. Cooperators were right-censored by time (December 31, 1987).

All strains of dogs were included in this analysis because it provided a full account of cooperator participation. The initial adoption may have been a dog of a minor strain (see below), followed by a dog of a major strain or vice versa. Interruptions in leasing a dog for less than a year were not considered as failures.

Dogs. Dogs used in this study were the offspring of stock imported from Europe. In 1977, Hampshire College imported Maremma pups (< 0.5 years old) from Italy, Shar Planinetz pups from Yugoslavia, and Ovcharka pups from eastern Turkey. Breeding began when these dogs reached sexual maturity in 1978. Anatolian Shepherd pups were imported from Turkey in 1979 and 1980. Castro Laboreiro pups from Portugal were imported in 1980. Additional Maremmas were imported in the early 1980's. Between 1978 and 1989 several Tibetan mastiffs, Great Pyrenees, Kuvasz, and Komondors were donated to the Hampshire College project. However, these donated individuals were not used in the breeding program. Anatolian Shepherd, Maremma, Shar Planinetz, and their crosses were the main breeds used in evaluating performance. The remaining breeds are referred to as the minor breeds.

Founding genetic stock represented small samples of each European breed. Genotypic and phenotypic variations exist between individuals of any population. Because each breed was represented by small samples of the native populations, comparisons represented statements about strains rather than breeds.

From 1978 through 1987 over 1000 dogs, averaging 109 per year, were placed on sheep and goat farms (Coppinger et al. 1988). Pups were born at the Hampshire College kennels or on cooperator farms. They were placed with sheep by eight weeks of age. The College maintained breeding rights for all dogs.

A sample of 721 dogs from the population of >1000 was selected for analysis. They were of the three main strains (Anatolian, Maremma, and Shar Planinetz) and their crosses, born between April, 1978 and June, 1987. Small samples of Anatolian X Maremma (n<40) and dogs placed in Canada or Alaska (n<15) were considered outliers and not used in the analyses. Infant and juvenile dogs dying before being placed on a farm were not included in the evaluations. Imported breeding stock, occasionally loaned for emergency service, was not included.

Life table analysis using the standard proportional hazards model was again used to calculate survivorship (Lawless 1982). Survivorship of dogs was calculated as the time from birth to failure. Failure corresponded to death of the dog as defined by Lorenz et al. (1986) and included three causes: accidental, cull, and disease. Dogs still alive on December 31, 1987 were right-censored by time unless death was documented through August, 1989.

Cooperator/dog. The cooperator/dog interaction was defined as the association between a discrete dog and cooperator. For example, one dog placed on two different ranches constituted two cooperator/dog events. Conversely, one cooperator with two discrete dogs also constituted two cooperator/dog events. Since dogs were frequently transferred between ranches, the cooperator/dog interaction permitted tests of association across genetic and environmental variables.

Two genetic (strain and sex) and three environmental parameters (flock size, ecoregion, rural population density) were selected as covariates. Preliminary screening revealed that other potential covariates (e.g., presence of a shepherd, pasture fenced or unfenced) were not independent of the selected parameters. Guarding dogs used in cooperator/dog evaluations were of the three main breeds described for dogs, above.

Cooperators and their dogs were assigned to ecoregions according to the first three digits of their zip code. Divisional levels as defined by Bailey (1978) were used for ecoregion assignments (Figure 4). Bailey (1978) proposed nine regional divisions for the continental United States. Cooperators lived in eight of those nine divisions. A small sample ($n<20$ per division) of dogs were placed in three divisions. They were treated as outliers. Comparisons were

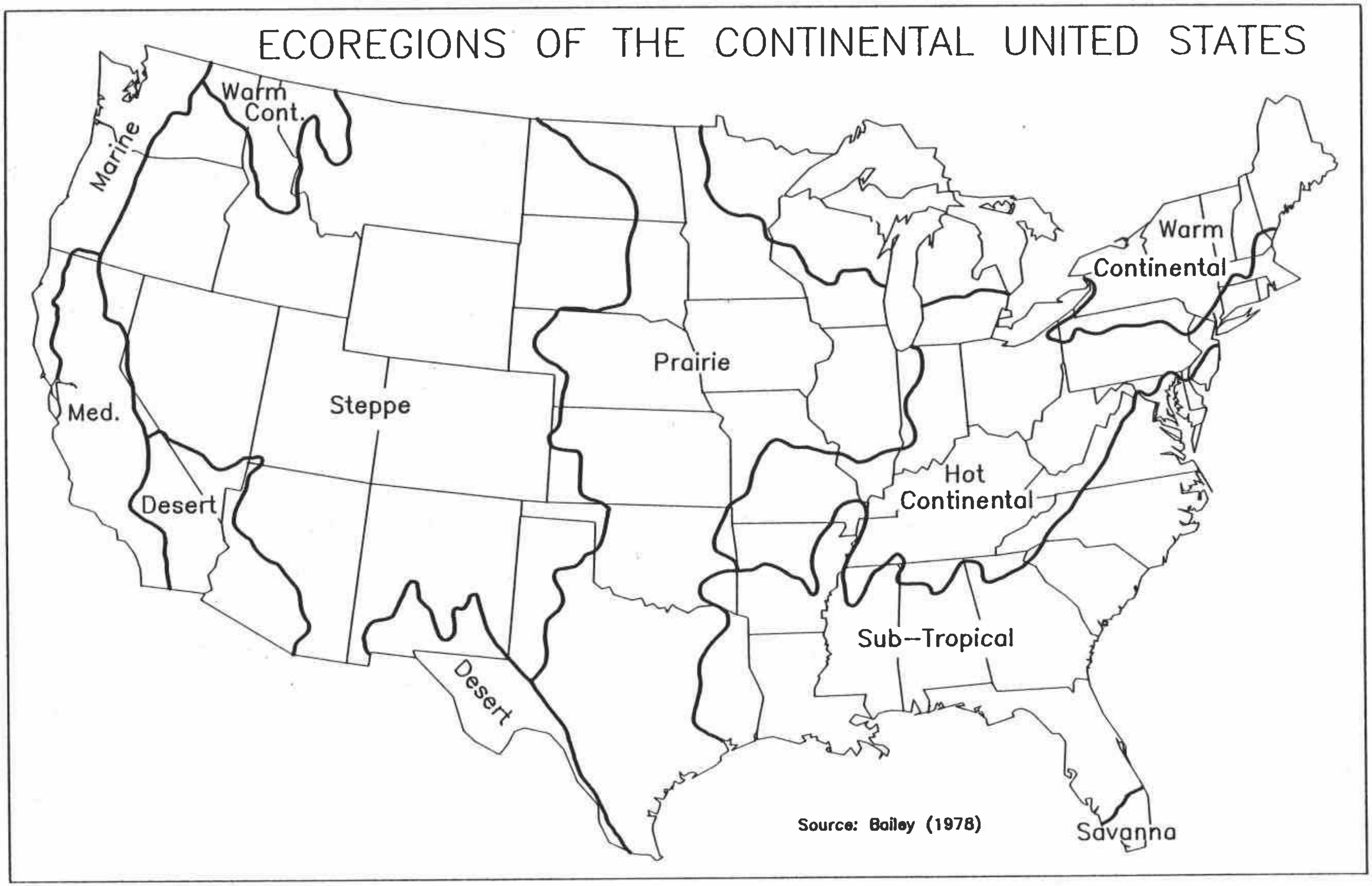

Figure 4. Ecoregions of the continental United States.

possible between the five remaining divisions: Warm Continental, Hot Continental, Prairie, Steppe, and Marine.

Rural population density was estimated at the county level for dog placements in Oregon. Densities were calculated by dividing the 1980 rural population (U.S. Dept. of Commerce 1980) by the area of the county. This was considered an estimate of rural density because urban areas were included in the divisions.

Variables were screened using pair-wise contingency tables and I X J Chi-square analysis (Steel and Torrie 1960). Probability values <.05 were considered statistically significant. Calculations were performed by computer using the Crosstabs option of SPSS/PC+ (SPSS/PC+ 1988).

Two life tests (time to failure) were used to evaluate the cooperator/dog event. As with cooperators and dogs, life table analysis (standard proportional hazards model) was used to estimate survivorship according to each class within each covariate. SAS procedure Lifereg (SAS Institute 1987), an accelerated life test, was used to test for covariance between three variables: breed, flock size, and ecoregion. The mathematical models used in Lifereg were presented in detail in Kalbfleisch and Prentice (1980).

The cooperator/dog event was calculated as the length of time (within 0.25 year) a dog spent on a particular farm or ranch. Longevity was calculated as the time from the date of placement to failure. In this case, failure corresponded to either cooperator or dog failure. Dogs and cooperators active on December 31, 1987 were right censored unless failure was documented through August, 1989. Dogs spending intervals of 0.25 year or more at the Hampshire College or author's kennel between transfers were treated as missing data. Incomplete placement records reduced the potential sample of cooperators by 25.

Two additional tests were conducted to supplement interpretations of survivorship analyses. A Chi-square test was used to check whether the distribution of dogs among flock sizes was the same between initial and succeeding placements. The concern was whether transfers appeared random according to flock size. Sheep-years of protection according to flock size was calculated as a supplement for evaluating statistical differences in survivorship by flock size. Multiplying the estimate of dogs surviving at each annual interval by flock size produced an estimate of the number of sheep that could be protected with the available living dogs.

CHAPTER IV

RESULTS

Cooperators. Over the ten year period, 1978 through 1987, 419 sheep growers participated as volunteer cooperators. Figure 5 illustrates the pattern of diffusion of guarding dogs and the location of cooperators by state. By the end of 1980, guarding dogs had been placed with cooperators in 24 states. Clusters of cooperators were evident in New England and Colorado. At the end of the study period, 1987, clusters of cooperators appeared in New England, Kentucky, Texas, and Oregon. Over the 10 years of this study, sheep ranchers in 35 states adopted livestock guarding dogs for some period of time.

Increases in the number of cooperators between 1980 and 1987 were notable in Kentucky, Texas, and Oregon. Over the same period, the number of cooperators in Colorado decreased. The number of cooperators remained constant in New England and Minnesota despite the many trials as evident in Figure 5.

The number of sheep and lambs and the number of farms with sheep and lambs is illustrated by state for 1982, in Figures 6 and 7, respectively. Interest in livestock guarding dogs from the Hampshire College project appeared to be independent of either the number of farms or sheep. For example, participation appeared high in New England and Kentucky where the number of farms and sheep was relatively

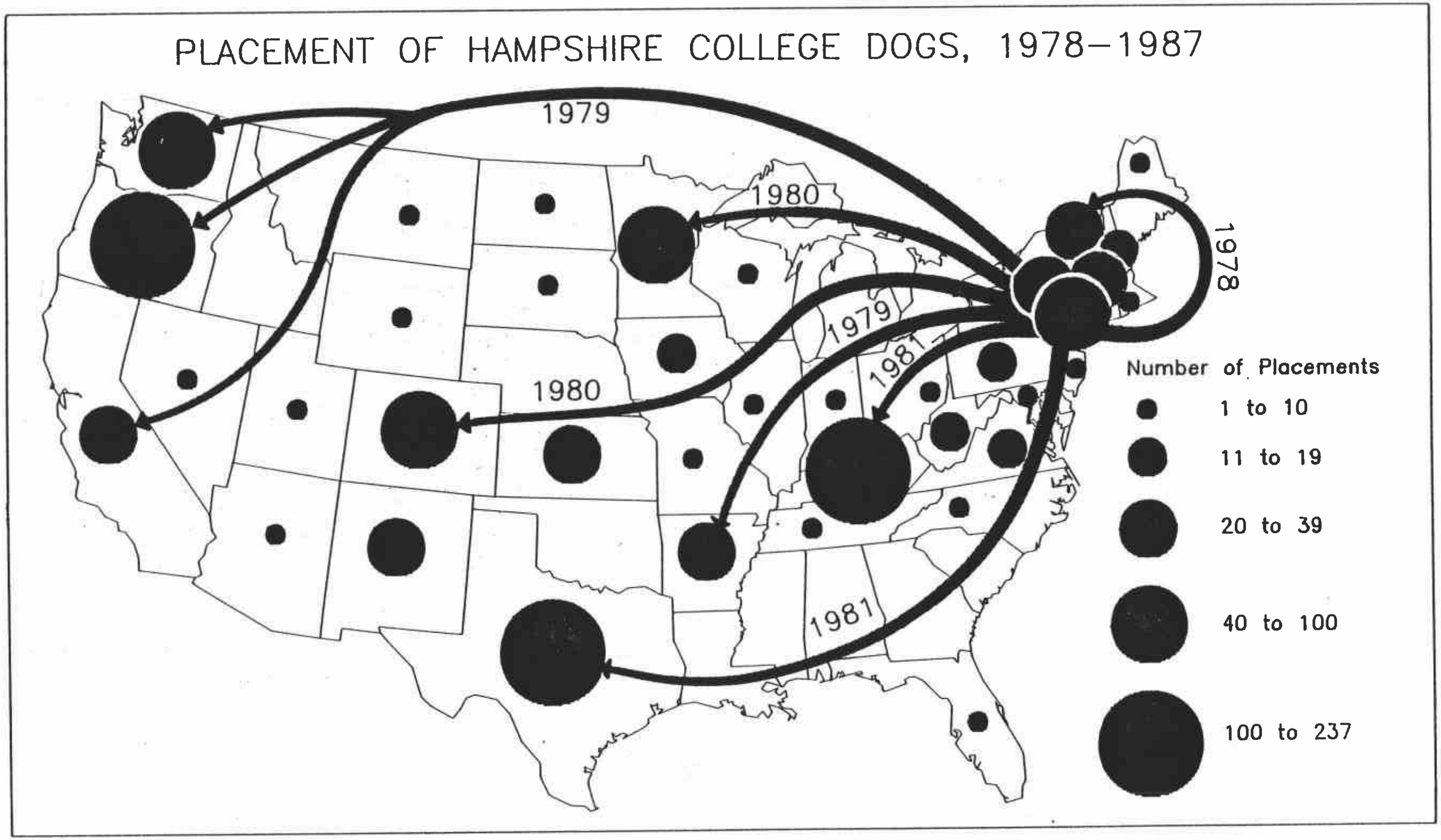

Figure 5. Diffusion of livestock guarding dogs from Hampshire College project across the United States, 1978-1987. Year of first placement is shown for several states.

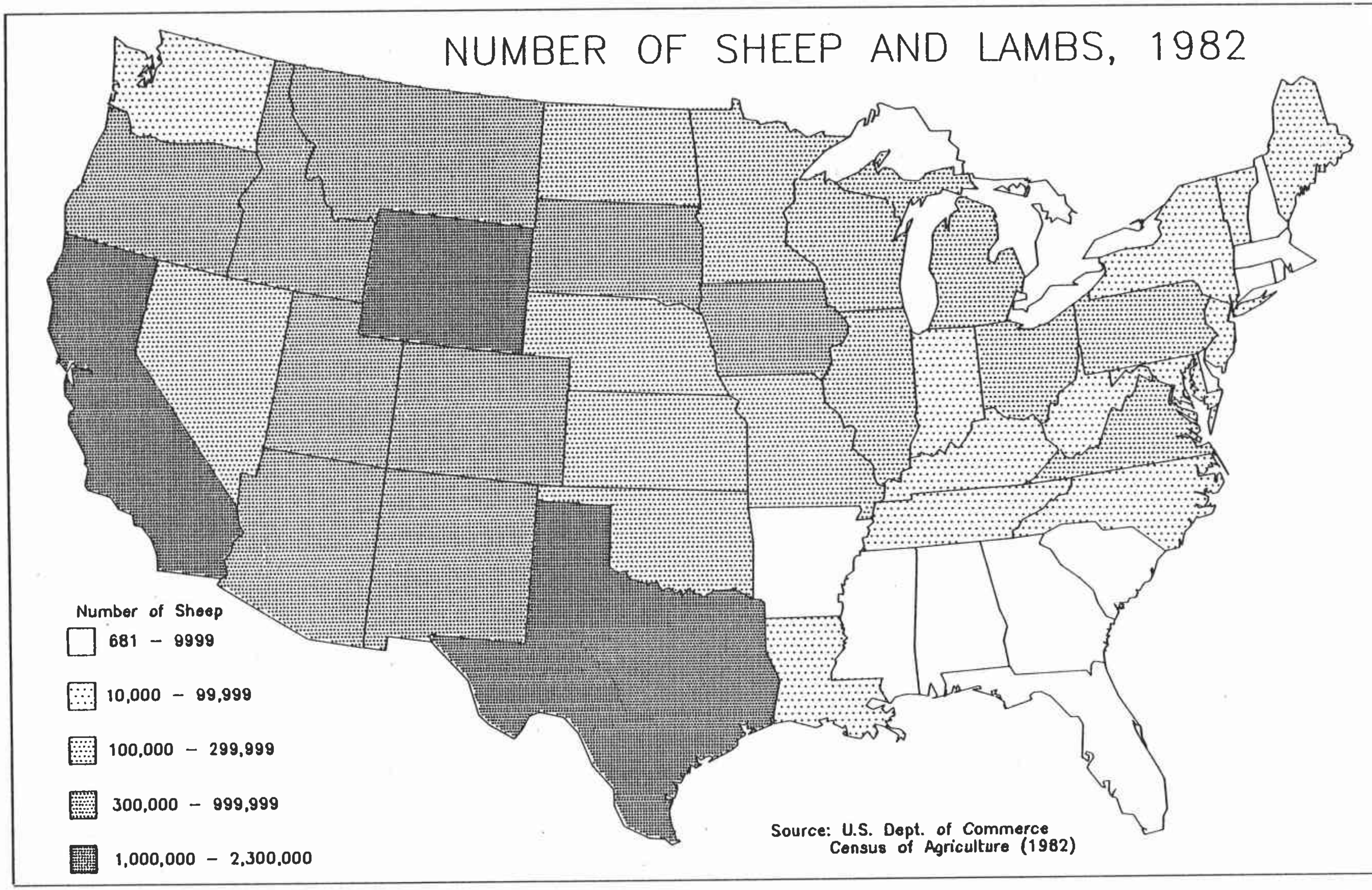

Figure 6. Number of sheep and lambs, 1982.

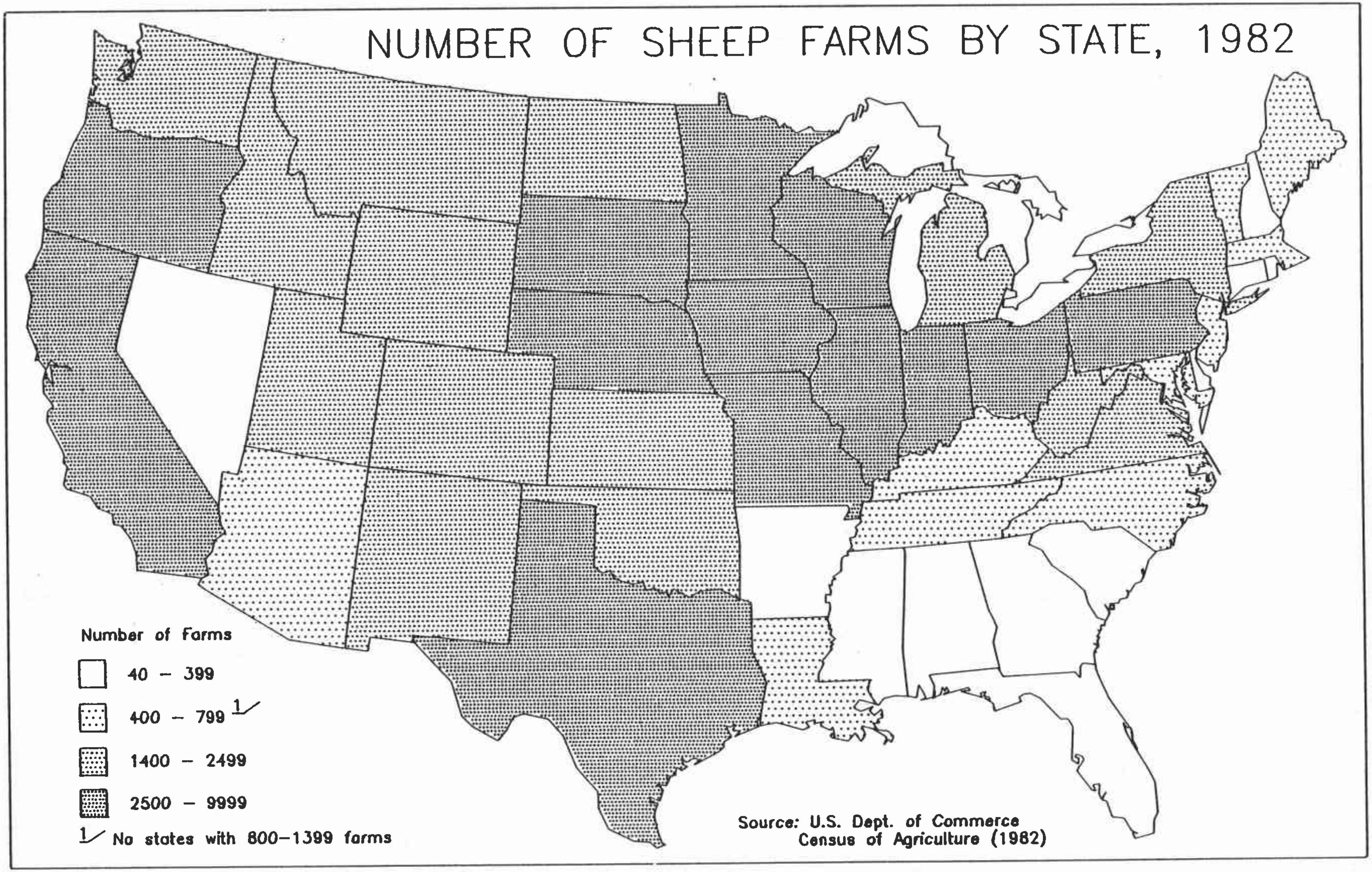

Figure 7. Number of farms with sheep and lambs, 1982.

low. Participation in Minnesota, Texas, and Oregon was relatively high where farms and sheep numbers were also high. Participation was low in Wyoming and California, two states with high numbers of farms and sheep. There was little interest in guarding dogs in the Southeast where numbers of farms and sheep were relatively low.

The distribution of cooperators by flock size in seven states (Kentucky, Massachusetts, Minnesota, New York, Oregon, Vermont, and Washington) was compared to the relative frequencies of flock size in those states (Table 2). States were selected on the basis of knowing flock sizes for >10 cooperators. Texas was not included because an unknown number of dogs were used on farms with only goats. Colorado was also deleted from the analysis because large operators (≥1000 sheep) were specifically targeted in a special study conducted in 1980. Volunteers in the seven states were a random sample from the perspective of the project.

Overall, cooperators owned flocks with >100 sheep with greater frequency than were represented in the actual population (Table 2, Chi-square >50, d.f.=18, $p<.01$). In general, cooperators owned small flocks (<100), less than their relative frequency in the general population. However, exceptions appeared in the Northeast in Massachusetts, New York, and Vermont. In these three states the distribution of cooperators was the same as their

Table 2. Number of cooperators by state and flock size.

State		Flock Size 25-99	100-499	500-999	≥ 1000
Kentucky	Count	10	19	2	0
	Expected Value	20	6	0	0
Massachusetts	Count	10	3	0	0
	Expected Value	9	2	0	0
Minnesota	Count	9	11	0	0
	Expected Value	16	3	0	0
New York	Count	13	1	0	0
	Expected Value	12	2	0	0
Oregon	Count	18	35	8	4
	Expected Value	41	18	18	1
Vermont	Count	11	6	1	1
	Expected Value	14	4	0	0
Washington	Count	4	6	2	3
	Expected Value	12	2	0	0

Chi-square < 1, d.f. 3, P > .05 for Vermont, New York, Massachusetts
Chi-square > 10, d.f. 3, P < .05 for Oregon, Washington, Minnesota, Kentucky
Chi-square > 50, d.f. 18, P < .01 for all seven states

relative frequency in the general population (for each state, Chi-square <1, d.f.=3, p>.05).

Figure 8 (see also Appendix, Table 12) displays a survivorship curve estimating the longevity of cooperator participation (n=419) in the Hampshire College dog project. Fifty percent of cooperators who tried using a guarding dog had discontinued the practice after 3.0 years of participation. Adoption of guarding dogs over 9.5 years, the length of the study, was continuous for 20 percent of cooperators. Cooperator failure was greatest, 6% per year, between one and three years of participation. Failure rate of cooperators after three years was reduced to <5% per year.

Dogs. Figure 8 (see also Appendix, Table 13) illustrates longevity of the total sample of 687 dogs, independent of strain or cooperator. For all dogs, the median age of failure was approximately 2.75 years. The oldest dog of record lived to 9.75 years, although that could be surpassed by dogs that are still living. The probability of a dog's failure was high (7% per year) to 3 years, low (3% per year) between 3 and 9 years, and high (24% per year) after 9 years.

Figures 9 through 14 (see also Appendix, Tables 14 through 19) illustrate survivorship of dogs by strain. The extremes were represented by Maremmas and Maremma X Shar Planinetz with the best records and Anatolians and Anatolian

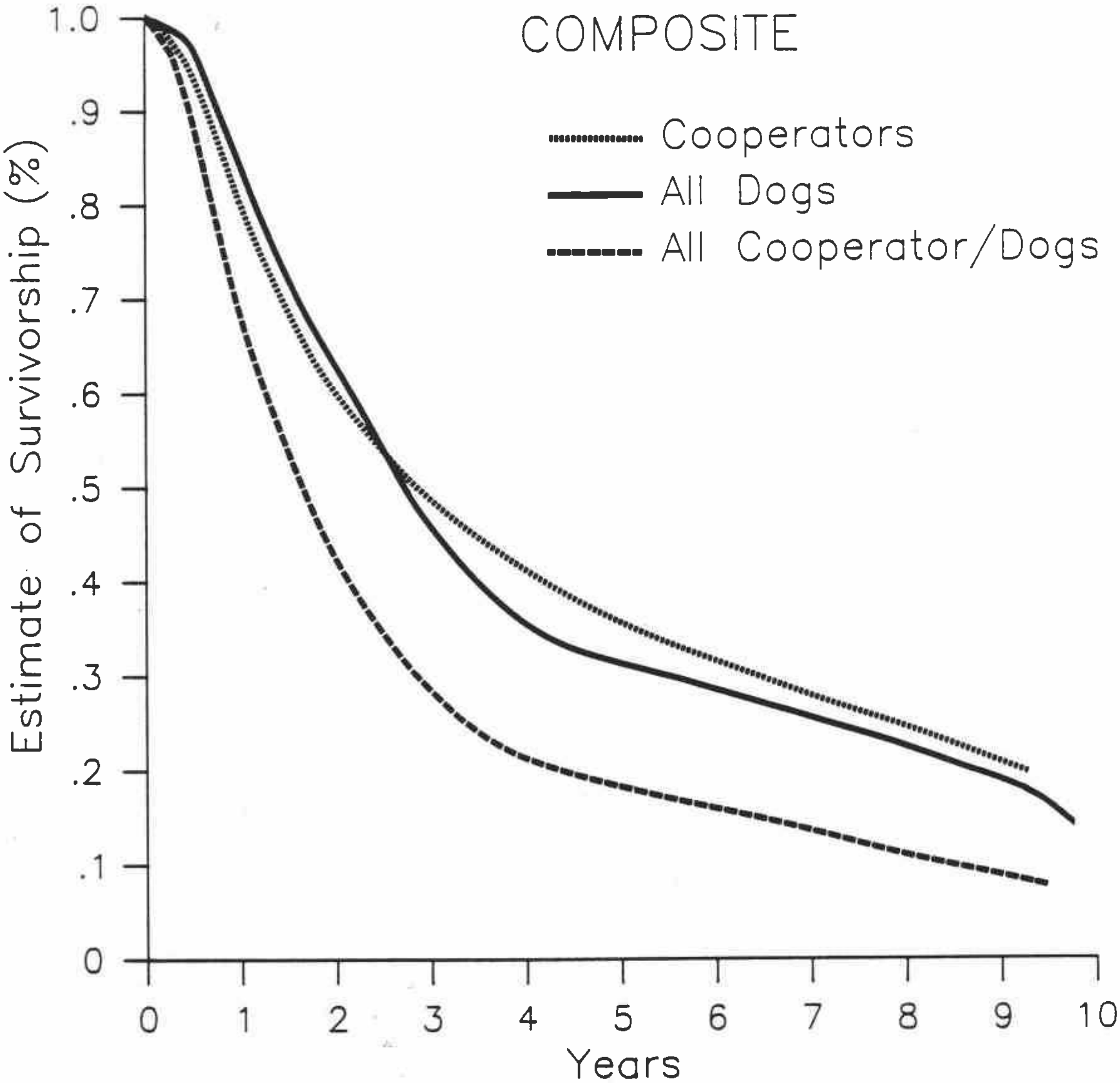

Figure 8. Comparison of survivorship (time to failure) for cooperators, all dogs, and cooperator/dog interaction.

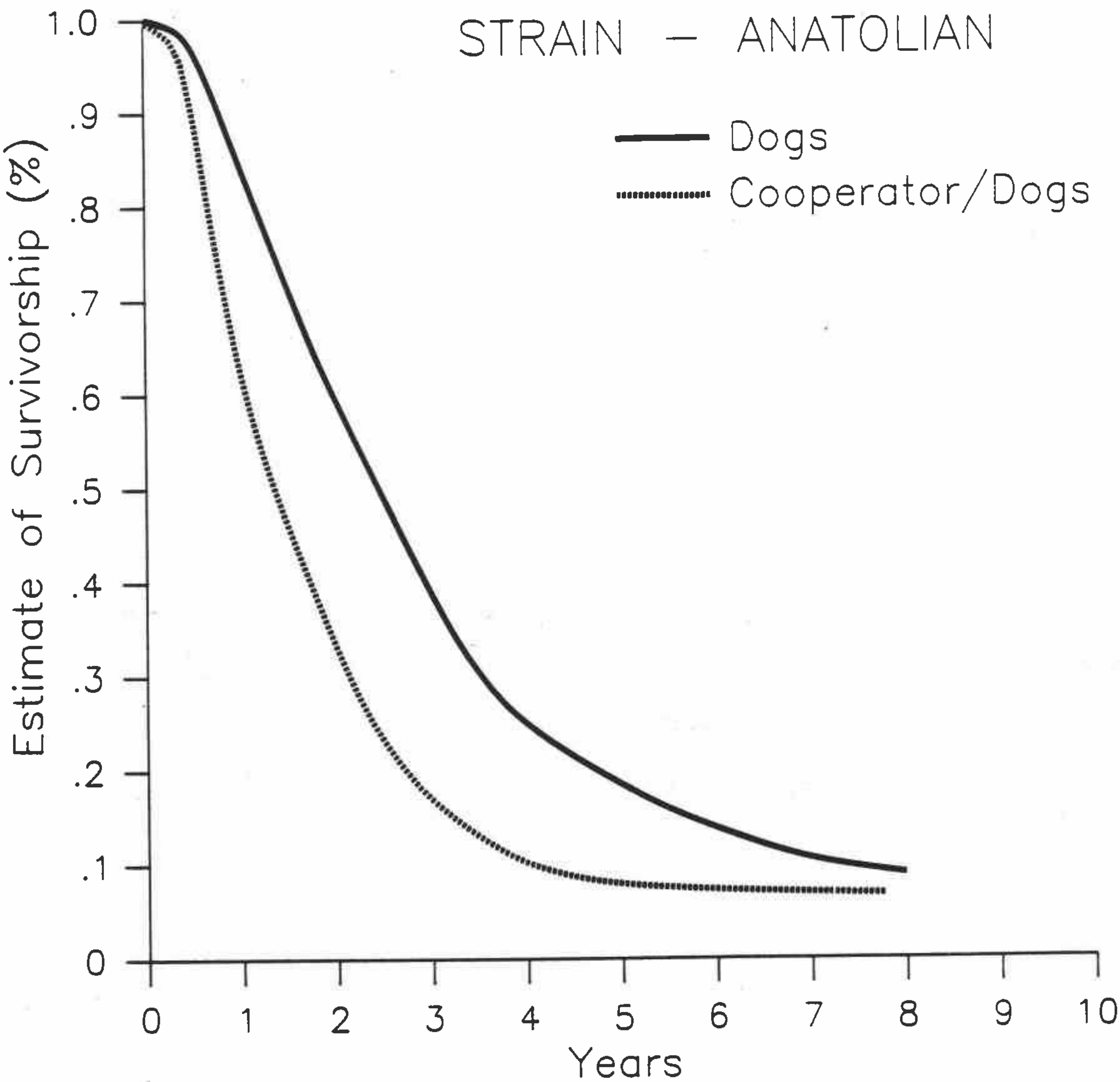

Figure 9. Survivorship of dogs and cooperator/dog according to Strain, Anatolian.

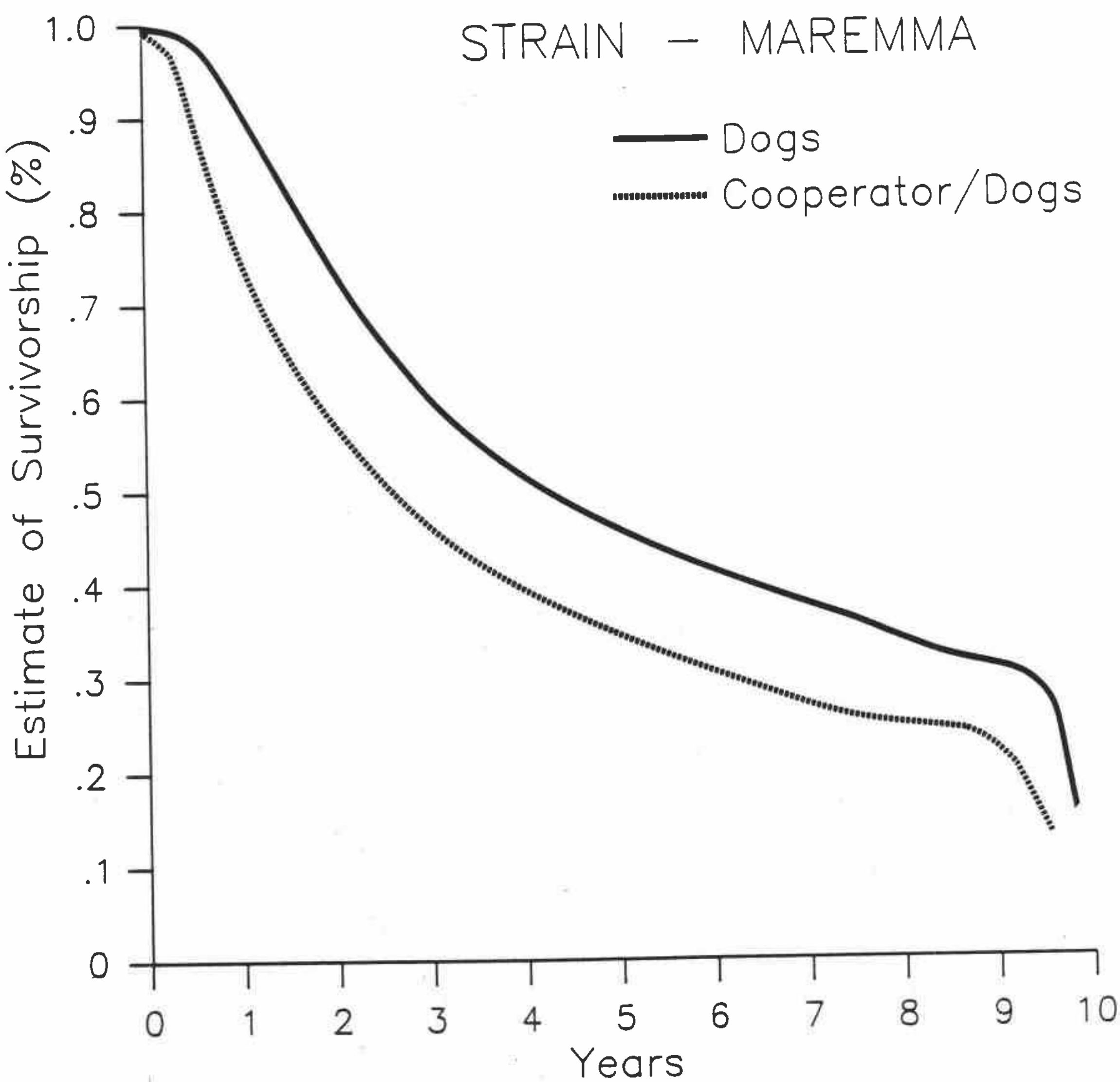

Figure 10. Survivorship of dogs and cooperator/dog according to Strain, Maremma.

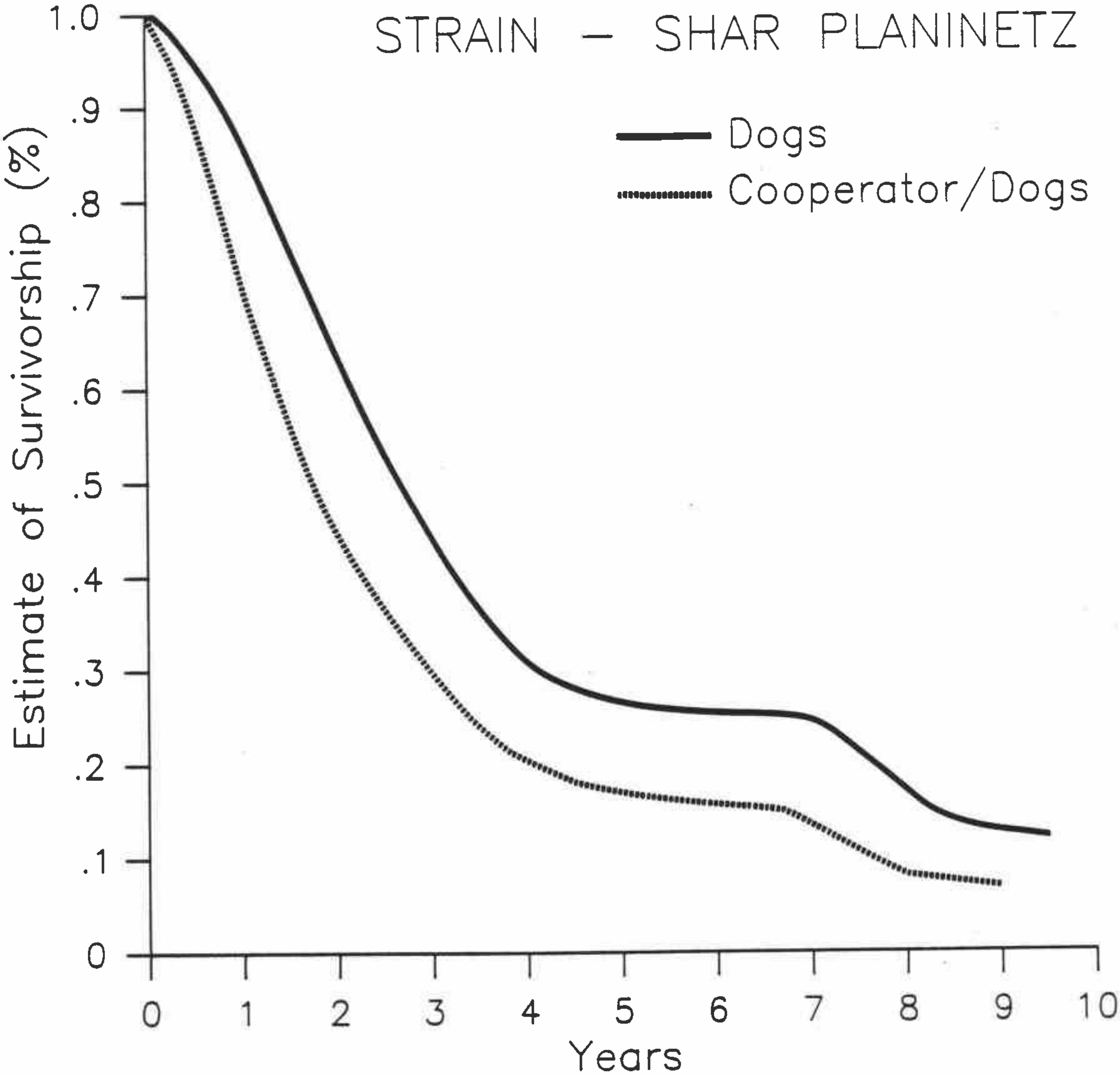

Figure 11. Survivorship of dogs and cooperator/dog according to Strain, Shar Planinetz.

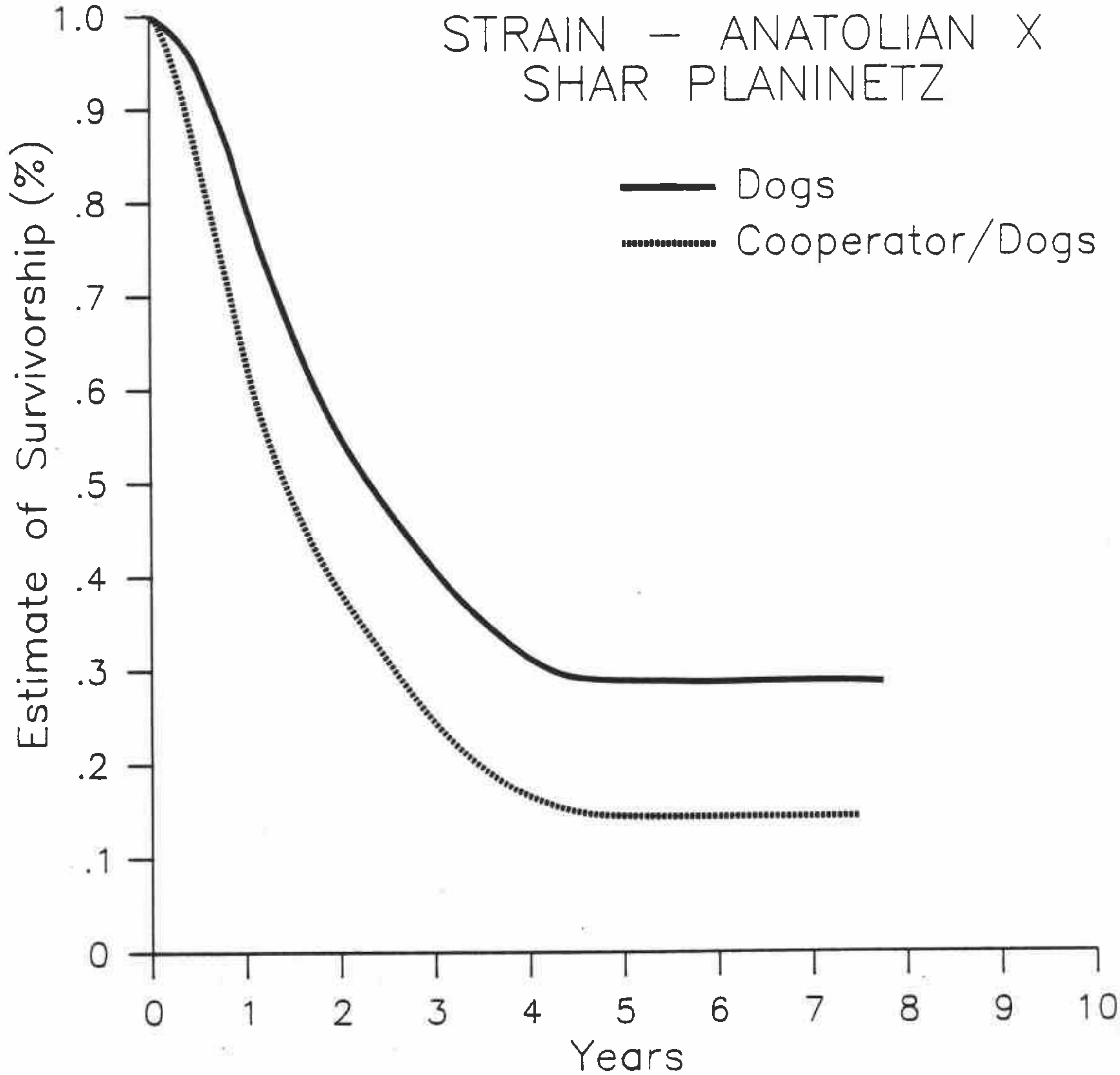

Figure 12. Survivorship of dogs and cooperator/dog according to Strain, Anatolian X Shar Planinetz.

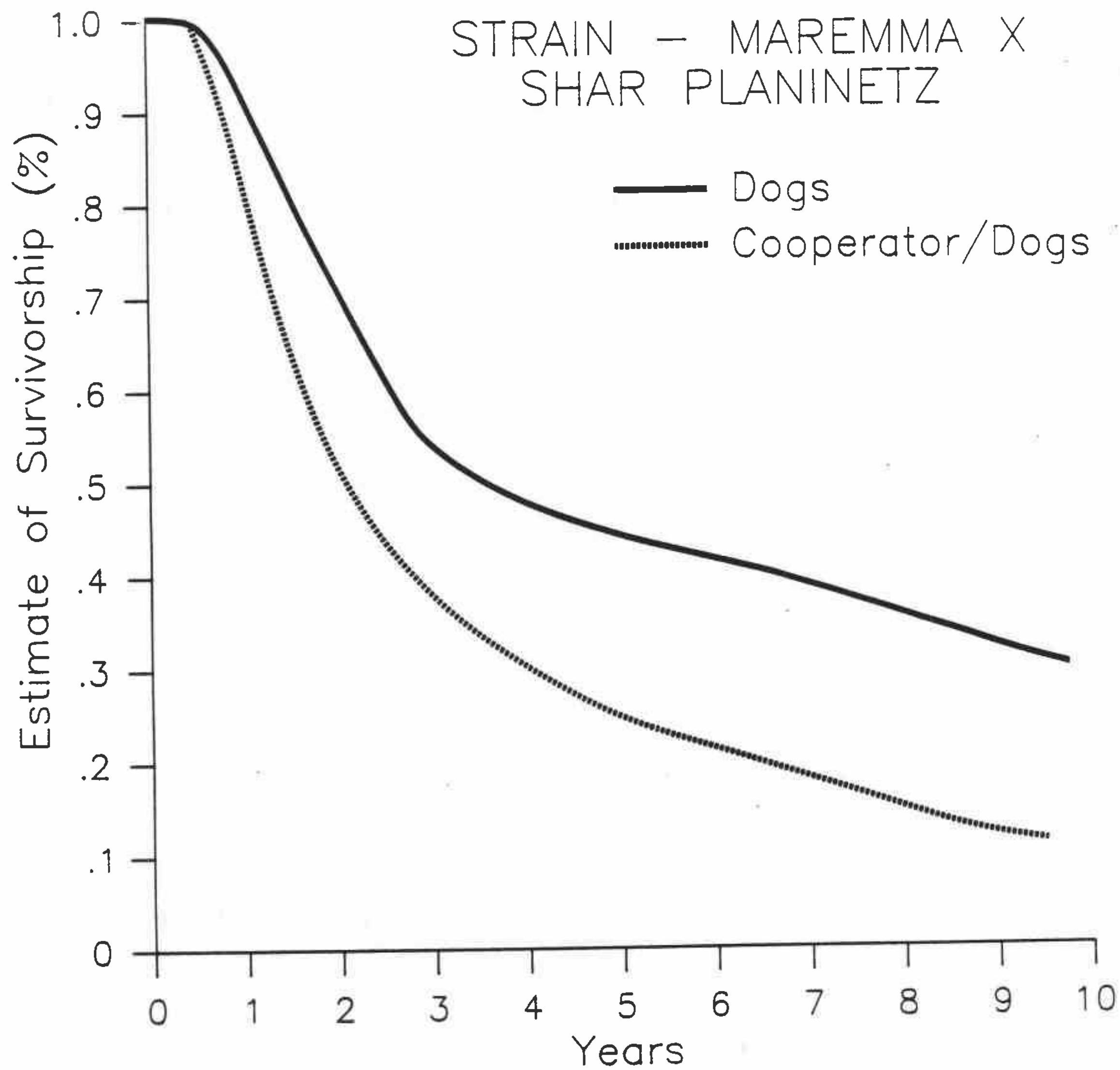

Figure 13. Survivorship of dogs and cooperator/dog according to Strain, Maremma X Shar Planinetz.

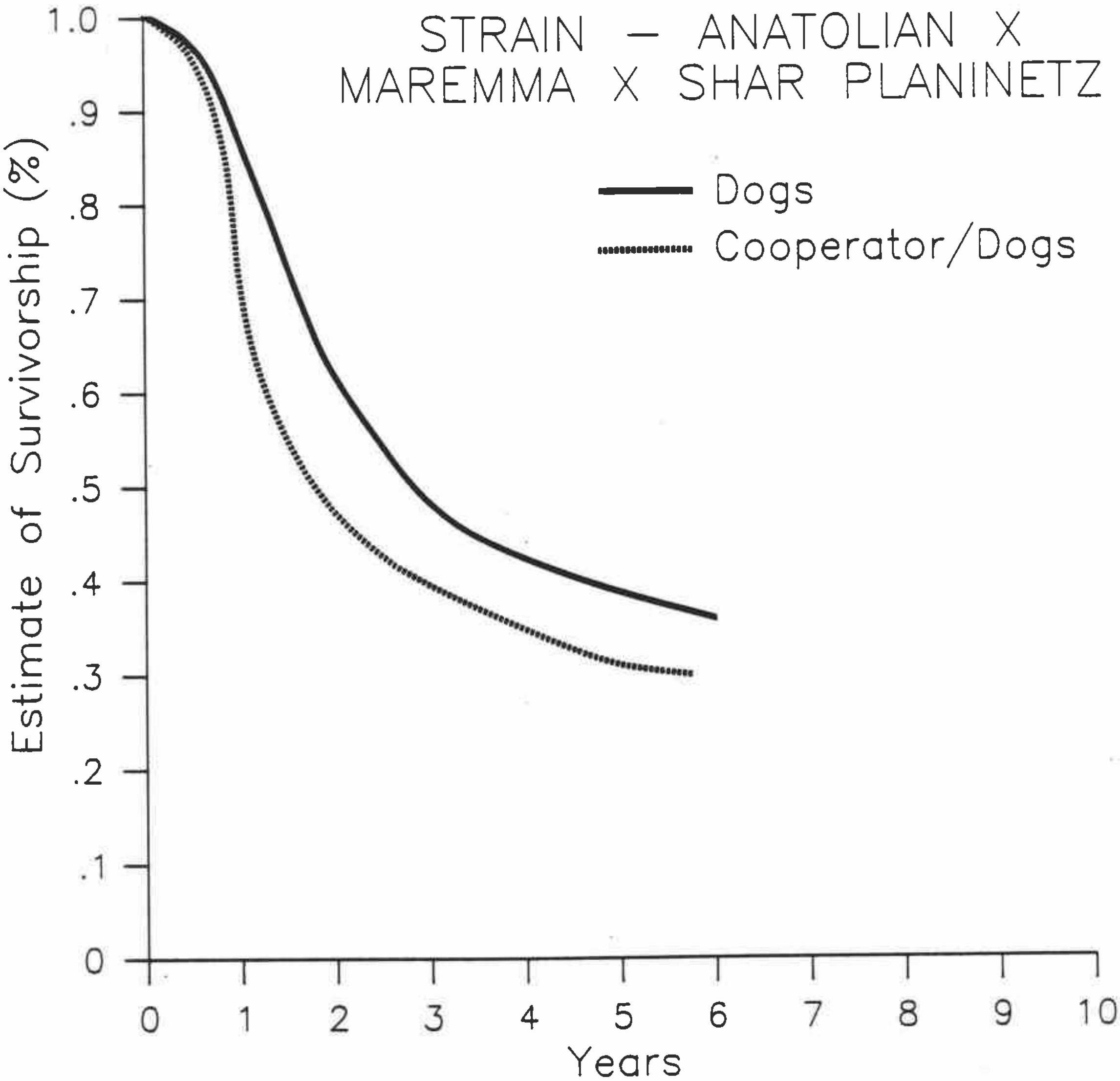

Figure 14. Survivorship of dogs and cooperator/dog according to Strain, Anatolian X Maremma X Shar Planinetz.

X Shar Planinetz with the poorest records. Fifty percent of Maremmas and Maremma X Shar Planinetz survived to four years whereas 50 percent of Anatolians and Anatolian X Shar Planinetz survived to 2.25 years. The remaining strains were intermediate between these two extremes. The oldest dogs were Maremmas and Shar Planinetz because the breeding program began with these two strains.

Survivorship according to sex is presented in Figure 15 (see also Appendix, Tables 20 and 21). Survivorship of males was nearly identical to that of females. Therefore sex was eliminated as a covariate in subsequent survivorship analysis.

Cooperator/dog. Data were first screened to test for pair-wise associations between variables (Tables 3 through 7). Table 3 compares the distribution of the cooperator/dog interactions according to strain and flock size. The relationship was not statistically significant (Chi-square=20, d.f.=15, p>.05), and no particular trends could be detected that might skew subsequent analyses.

Table 4 compares the cooperator/dog event according to strains and ecoregion. Dogs assigned to five of Bailey's (1978) nine divisions were used in the analysis. The statistical test was significant (Chi square=122, d.f.=20, p<.01), and trends were evident. Most notable were the Hot Continental and Prairie Divisions. In Hot Continental,

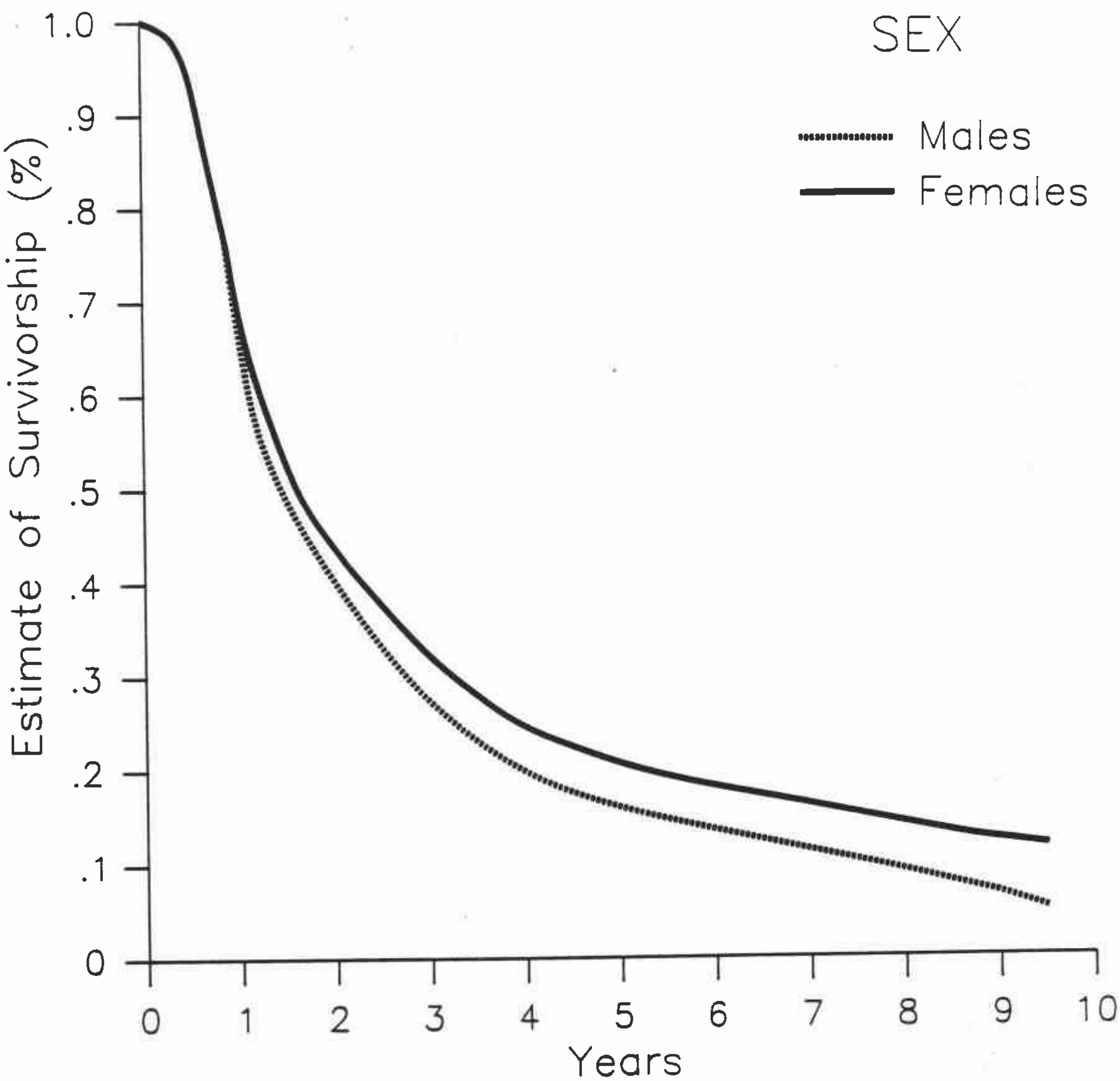

Figure 15. Survivorship of dogs according to sex.

Table 3. Crosstabulation and Chi-square analysis, strain by flock size.

Strain		Flock Size 25-99	100-499	500-999	≥ 1000	Row Total
Anatolian	Count	58	89	22	27	196
	Expected Value	62.4	81.9	24.0	27.7	
Maremma	Count	43	43	13	13	112
	Expected Value	35.6	46.8	13.7	15.8	
Shar Planinetz	Count	28	26	10	21	85
	Expected Value	27.0	35.5	10.4	12.0	
Anatolian X Shar Planinetz	Count	33	48	15	15	111
	Expected Value	35.3	46.4	13.6	15.7	
Maremma X Shar Planinetz	Count	35	59	19	19	132
	Expected Value	42.0	55.2	16.2	18.6	
Anatolian X Maremma X Shar	Count	36	28	7	4	65
	Expected Value	20.7	27.2	8.0	9.2	
	Total Column Count	223	293	86	99	701

Chi-Square 20
d.f. 15
P .19

Table 4. Crosstabulation and Chi-square analysis, strains by ecoregion.

Strain		Ecoregion: Warm Continental	Hot Continental	Marine	Prairie	Steppe	Row Total
Anatolian	Count	36	51	33	60	59	239
	Expected Value	38.4	54.8	30.1	44.5	71.2	
Maremma	Count	31	48	6	27	29	141
	Expected Value	22.7	32.3	17.8	26.2	42.0	
Shar Planinetz	Count	22	22	7	15	38	104
	Expected Value	16.7	23.8	13.1	19.4	37.8	
Anatolian X Shar Planinetz	Count	21	32	10	33	31	127
	Expected Value	20.4	29.1	16.0	23.6	37.8	
Maremma X Shar Planinetz	Count	19	9	26	15	69	138
	Expected Value	22.2	31.6	17.4	25.7	41.1	
Anatolian X Maremma X Shar	Count	5	29	23	5	22	84
	Expected Value	13.5	19.3	10.6	15.6	25.0	
	Total Column Count	134	191	105	155	248	833

Chi-Square 122
d.f. 20
P .00

Table 5. Crosstabulation and Chi-square analysis, ecoregion by flock size.

Ecoregion		Flock Size 25-99	100-499	500-999	≥ 1000	Row Total
Warm Continental	Count	69	30	3	0	102
	Expected Value	32.1	42.8	12.3	14.7	
Hot Continental	Count	57	62	5	1	125
	Expected Value	39.4	52.5	15.1	18.0	
Marine	Count	39	46	12	7	104
	Expected Value	32.8	43.7	12.6	15.0	
Prairie	Count	15	72	14	10	111
	Expected Value	35.0	46.6	13.4	16.0	
Steppe	Count	34	75	48	80	237
	Expected Value	74.7	99.5	28.6	34.2	
	Total Column Count	214	285	82	98	679

Chi-Square	236
d.f.	12
P	.00

Table 6. Crosstabulation and Chi-square analysis, strain by rural population density for Oregon.

Strain		Rural Population Density 1-4	6-16	20-52	Row Total
Anatolian	Count	21	20	15	56
	Expected Value	18.2	23.1	14.7	
Maremma	Count	5	5	3	13
	Expected Value	4.2	5.4	3.4	
Shar Planinetz	Count	6	10	6	20
	Expected Value	6.5	8.3	5.2	
Anatolian X Shar Planinetz	Count	8	10	6	24
	Expected Value	7.8	9.9	6.3	
Maremma X Shar Planinetz	Count	15	25	15	55
	Expected Value	17.9	22.7	14.4	
Anatolian X Maremma X Shar Planinetz	Count	12	15	11	38
	Expected Value	12.4	15.7	10.0	
	Total Column Count	67	85	54	206

Chi-Square 3
d.f. 10
P .99

Table 7. Crosstabulation and Chi-square analysis, flock size by rural population density for Oregon.

Flock Size		Rural Population Density 1-4	6-16	20-52	Row Total
25-99	Count	21	19	18	58
	Expected Value	18.7	24.1	15.2	
100-499	Count	24	32	30	86
	Expected Value	27.7	35.8	22.6	
500-999	Count	2	25	4	31
	Expected Value	10.0	12.9	8.1	
≥ 1000	Count	18	8	1	27
	Expected Value	8.7	11.2	7.1	
	Total Column Count	65	84	53	202

Chi-Square 41
d.f. 6
P .00

Anatolians were near their expected frequency while Maremmas and Anatolian X Maremma X Shar Planinetz crosses were over-represented. In Prairie, Anatolians and Anatolian X Shar Planinetz were over-represented while Maremmas were near-expected and Maremma X Shar Planinetz were under-represented. This indicated a skewed distribution that should be accounted for when interpreting longevity of adoption between regions.

Table 5 compares the distribution of the cooperator/dog interactions according to ecoregion and flock size. This relationship was highly significant (Chi-square=236, d.f.=12, p<.01). According to the method used for calculating expected frequency, flock sizes greater than 500 sheep were under-represented in the Warm Continental and Hot Continental Divisions, whereas flocks of ≥1000 were over-represented in the Steppe Division. Conversely, flocks of 25 to 99 were over-represented in eastern divisions and under-represented in the Steppe and Prairie Divisions. The cross-tabulation suggested skewness that should be considered in subsequent survivorship analysis.

Table 6 compares the distribution of the cooperator/dog interactions according to strain and rural population densities in Oregon. The statistical test was not significant (Chi- square=2.7, d.f.=10, p>.05), and strains appeared evenly distributed over three densities of rural population.

Table 7 compares the distribution of the cooperator/dog subject according to flock size and rural population density for the state of Oregon. The relationship between the variables was highly significant (Chi-square=41, d.f.=6, $p<.01$). Flocks $\geq$1000 appeared in counties with the lowest population densities. Flocks of 25 to 499 were represented equally well in the three categories of population density. Based on the apparent correlation between the largest flocks and lowest population density in Oregon, population density was eliminated as a covariate in subsequent survival analysis.

The median time to failure of the cooperator/dog subject was approximately 1.75 years, Figure 8 (see also Appendix, Table 20). The probability of a cooperator/dog failure was high (10% per year) to 3 years, low (4% per year) between 3 and 9 years, and high (33% per year) again after 9 years. For all strains, the median time to failure for the cooperator/dog association was .75 to 1.0 year less than median age of dog survival.

The differences between the dog and cooperator/dog survivorship curves were a function of the number of times a dog was transferred to a different farm or ranch (Figures 9 through 14, see also Appendix, Tables 14 through 19 and 21 through 26). Table 8 presents the average number of placements per dog by strain. Anatolians and Maremma X Shar Planinetz were highest, averaging nearly 1.3 placements per

Table 8. Number of cooperators per dog by strain.

Strain	Dog Numbers	Cooperator Numbers	Cooperator Numbers Per Dog
Maremma X Shar Planinetz	103	137	1.3
Anatolian	174	229	1.3
Shar Planinetz	83	100	1.2
Anatolian X Maremma X Shar Planinetz	75	84	1.1
Anatolian X Shar Planinetz	124	132	1.1
Maremma	128	134	1.1

dog. Shar Planinetz was intermediate averaging 1.2 placements per dog. Maremmas, Anatolian X Shar Planinetz, and Anatolian X Maremma X Shar Planinetz averaged 1.1 placements per dog.

Figure 16 (see also Appendix, Tables 29 through 32) graphs survivorship of the cooperator/dog event by flock size. Survivorship in flocks of 100 to 499 and 500 to 999 were nearly the same (median 2.25 years). The largest flocks of ≥1000 had the poorest survivorship (median 1.25 years). Flock size 25 to 99 appeared intermediate between these extremes.

An analysis was performed to check if transferred dogs accumulated in a particular flock size (Table 9). If dogs were continually transferred to the largest flocks (≥1000), then the less favorable survivorship of dogs in that category could be explained on the basis of the directed transfer of problem dogs. Expected frequencies for succeeding placements were based on the distribution of flock sizes of the first placement. A trend was noticed where the percentage of dogs in the smallest flock size (25 to 99) decreased, the largest flock size (≥1000) increased, and the middle flock sizes (100 to 999) stayed the same. However, this trend was not statistically significant (Table 9 Chi-square=4.2, d.f.=6, p>.05).

Figure 17 (see also Appendix, Tables 33 through 37) graphs survivorship of the cooperator/time event by

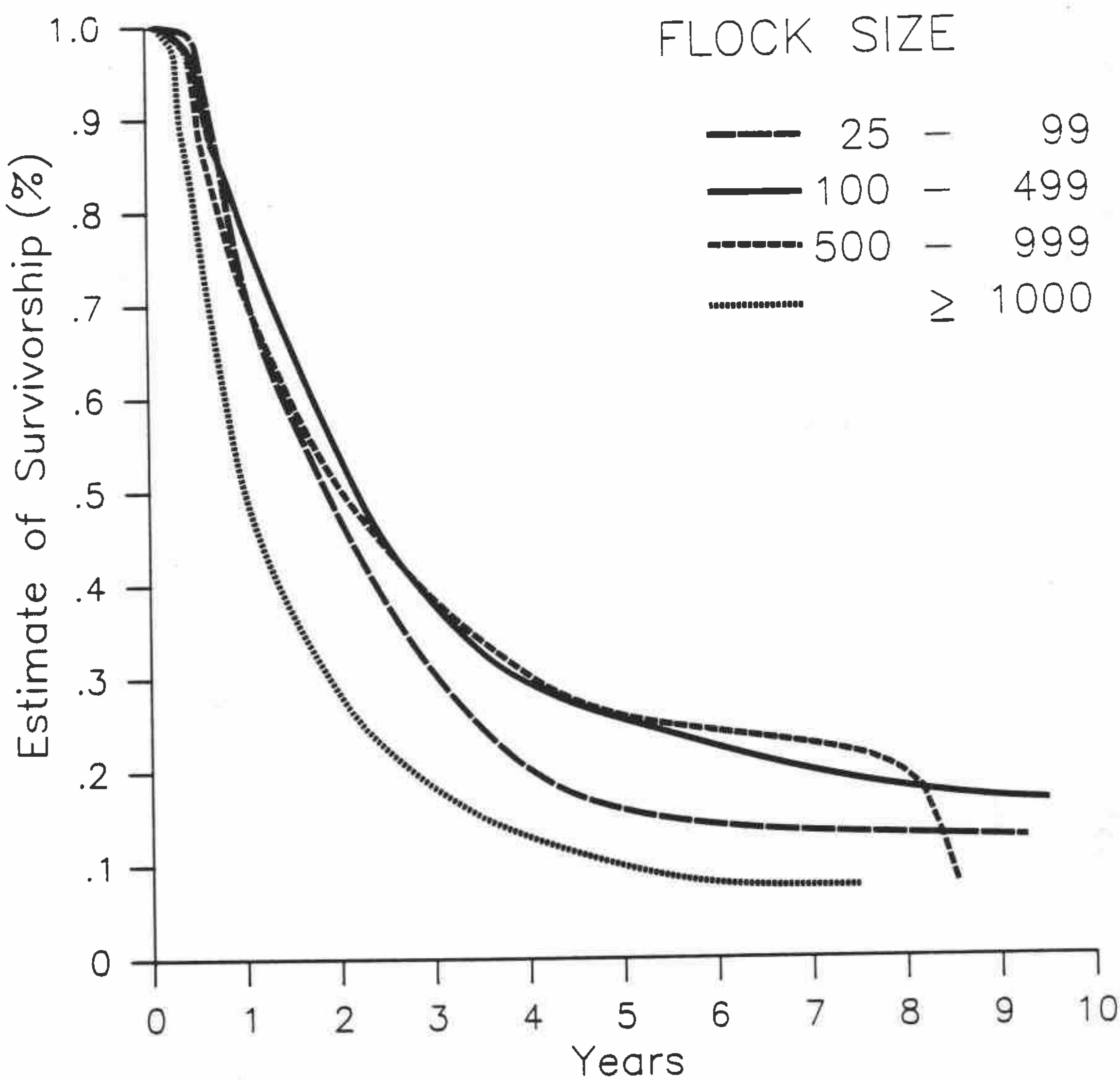

Figure 16. Survivorship of cooperator/dog according to flock size.

Table 9. Comparison of the distribution of flock size by order of placement with cooperators. Analysis covers placements during 1978 through 1987 for dogs born 1978 through 1985. Expected values in second and third placements based on distribution in first placement.

Flock Size		Order of Placement with Cooperator 1	2	3	Row Total
25-99	Count	137	30	11	172
	Expected Value	137	24	9	
100-499	Count	188	47	9	244
	Expected Value	188	43	13	
500-999	Count	54	14	6	74
	Expected Value	54	12	4	
≥ 1000	Count	68	13	5	86
	Expected Value	68	15	5	
	Total Column Count	447	98	31	576

Chi-Square 4.2
d.f. 6
P > .05

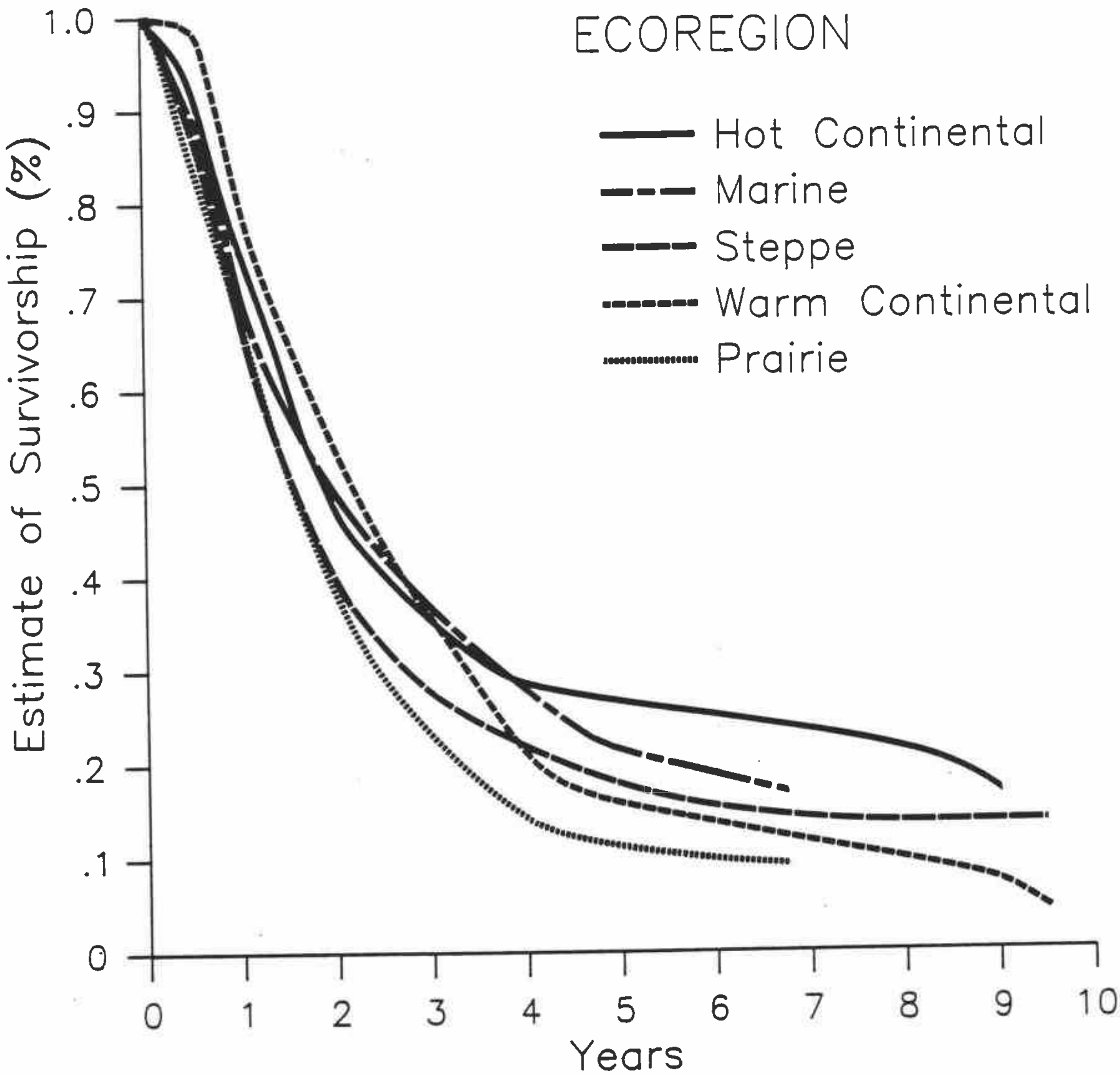

Figure 17. Survivorship of cooperator/dog according to ecoregion.

ecoregion. Differences between regions were not as pronounced as between strains or flock sizes. Overall survivorship was best in the Hot Continental Division where two strains with high survivorship, Maremma and Anatolian X Maremma X Shar Planinetz, were over-represented. Survivorship was poorest in the Prairie Division where two strains with poor survivorship, Anatolian and Anatolian X Shar Planinetz, were over-represented. Survivorship of dogs in the Steppe Division appeared intermediate. Maremma X Shar Planinetz, a strain with high survivorship, was over-represented in the Steppe Division (Table 4). This was counter-balanced by an over-representation of flocks of ≥1000, the flock size with the poorest survivorship.

The Lifereg procedure of SAS (SAS Institute 1987) was used to evaluate survivorship as a function of three covariates: breed, flock size, and ecoregion (Table 10). Both breed and flock size were highly significant ($p<.001$). Data were fitted to three distributions: log-normal, Weibull, and Exponential. Results were the same from all three models. Thus, the results of only one model, log-normal, were selected for purposes of display.

Sheep-years of protection according to flock size is listed in Table 11. Although flock size ≥1000 had the poorest record of survivorship, it showed a potential for protecting the most sheep. Greater survivorship in the

Table 10. Accelerated life test fitted to log normal distribution with three covariates. N = 628, noncensored values = 430, right censored values = 198.

Source of Variation	Chi-square	d.f.	P-Value
Ecoregion	7.7	4	.1
Strain	26.9	5	< .001
Flock Size	24.2	3	< .001

Table 11. Sheep-years (flock size X number of dogs surviving at age interval) of protection. Assumes one dog per flock. Estimates based on a cohort of 1,000 for each class.

Flock Size	Year	Sheep-Years Protection
25-99	1	17,500-69,300
	2	10,650-42,174
	3	8,450-33,462
	4	4,850-19,206
	5	4,225-16,731
	6	3,900-15,444
	7	3,900-15,444
100-499	1	78,700-392,713
	2	52,900-263,971
	3	37,600-187,624
	4	29,500-147,205
	5	25,400-126,746
	6	22,700-113,273
	7	20,100-100,299
500-999	1	353,500-706,293
	2	245,000-489,510
	3	206,000-411,588
	4	150,000-299,000
	5	123,000-245,754
	6	123,000-245,754
	7	123,000-245,754
≥ 1000	1	≥ 514,000
	2	≥ 281,000
	3	≥ 184,000
	4	≥ 132,000
	5	≥ 101,000
	6	≥ 79,000
	7	≥ 79,000

other flock sizes did not increase the potential number of sheep protected to the level observed in flock size >1000.

CHAPTER V

DISCUSSION

The adoption of livestock guarding dogs by American livestock growers appears to be influenced by cultural traditions, institutional arrangements for predator control, and the behavior of the guarding dogs within several environmental settings. The Anglo-American tradition of using herding dogs was a barrier for the diffusion of livestock guarding dogs during the 1800's when the sheep industry was expanding in both area and numbers. This cultural barrier toward using livestock guarding dogs was reflected in the Animal Damage Control Act of 1931 which established lethal methods of control as the federal policy. The re-introduction and diffusion of livestock guarding dogs in the United States required establishing a knowledge base about the behavior and management of the dogs, overcoming cultural and institutional inhibitions toward their use, establishing a breeding population of dogs, and conducting trials to evaluate their effectiveness. Field trials demonstrating the capabilities of guarding dogs helped overcome cultural and social inhibitions toward their use in the United States.

<u>Pre-conditions</u>. A review of the history of sheep husbandry in the United States revealed two major cultural traditions: English and Spanish. English shepherds brought

their tradition of using herding dogs to the East Coast of America was colonized in the 1600's. In contrast, Spanish colonists brought their tradition of guarding dogs to Central America and the Southwest beginning in the 1500's.

The evolution of two types of sheep dogs reflected differences between ecological conditions in the British Isles and in continental Europe. The evolution of herding dogs was associated with the extermination of wolves and division of land into narrow strips (Planhol 1969). Guarding dogs were traditionally used where predators were present and in association with transhumant husbandry (Carrier 1932, Planhol 1969). During the westward expansion of the sheep industry in the United States in the 1800's, English traditions predominated and the use of guarding dogs essentially disappeared.

Cultural dissonance was reflected in Anglo lack of understanding and willingness to work with guarding dogs. Baur (1978) indicated that Anglo shepherds, upon meeting Spanish flocks in the Southwest, thought guarding dogs were lazy and useless. In the 1840's, shepherds in the Northeast were unaware that guarding dogs were in use in the Southwest and suggested that they would be too expensive to import. Concurrently, they hailed the virtues of collies and reported news of recent imports (Anon. 1842, 1845). The epitome of the dissonance between English and Spanish traditions came with the passing of the Animal Damage

Control Act in 1931 which established lethal methods of predator control as law.

During the latter half of the 1800's and into the 1900's the use of livestock guarding dogs declined in continental Europe in association with changing ecological conditions. Wolves declined and patterns of crop farming in lowlands and valleys disrupted transhumant migrations (Carrier 1932, Planhol 1969, Butzer 1988, Mallison 1978). By the mid-1900's guarding dogs were rare and relegated to mountain regions of southern and eastern Europe where the remnants of wolf populations and transhumant husbandry still existed (Coppinger and Coppinger 1980a, Laurans 1975, Achmatowicz-Otok 1985).

In the case of adopting livestock guarding dogs in the United States cultural barriers inhibited the diffusion of guarding dogs which began in the 1500's. Hagerstrand (1967) stressed the importance of communication networks for the diffusion of innovations. The cultural barrier blocking communication of a concept was analogous to a physical barrier such as a mountain limiting the range of species of plants or animals. In the 1900's, communicating the concept of livestock guarding dogs, already inhibited by dissonance between Spanish and Anglo culture and federal policy calling for the demise of predators, was further exacerbated by the decline in use of guarding dogs in their traditional homelands.

The re-introduction of livestock guarding dogs in the 1970's was associated with what Kuhn (1970) referred to as a crisis in paradigm. The eradication of predators had proven to be unsuccessful and undesirable, and sheep growers were still in need of effective solutions to their problem (Leopold 1964, Cain et al. 1972). Restrictions placed on lethal methods of control, the result of environmental legislation during the 1960's and 1970's, forced people in the sheep industry to re-examine their attitudes and approaches to predator control.

Pressure from outside the livestock industry coupled with on-going needs inside the industry was ample reason to find ecologically sound and cost-effective alternatives to killing predators. Interestingly enough, the innovative change began outside the established sheep industry. With the exception of Linhart et al. (1976) exploratory studies into the potential use of guarding dogs were initiated by private foundations and one corporation at Hampshire College, a liberal arts college. Federal involvement, in terms of depth of research and amount of funding, lagged behind and in some measure was due to the work conducted at Hampshire College. Turning to a liberal arts college rather than a land-grant university for advice was an unusual circumstance for sheep growers.

Federal and state agencies have since taken positive steps to facilitate the diffusion of livestock guarding dogs. For example, the first scientific field trials of guarding dogs, conducted by ADC personnel (Linhart et al. 1976), were followed by studies conducted under the auspices of the Agricultural Research Service of the U.S. Department of Agriculture (Green and Woodruff 1982). Initially funded by private sources, Hampshire College later received grants and contracts for the project from the U.S. Departments of Interior and Agriculture. Oregon and federal Agriculture departments funded a pilot demonstration project in Oregon between 1984 and 1988. In 1987 The Animal Damage Control program hired two specialists to facilitate the diffusion of livestock guarding dogs onto American sheep ranches (Green 1989). However, the long-term commitment to these specialists and programs is uncertain since wording of the ADC Act has yet to be amended to require federal support for non-lethal predator control.

Sources and direction of funding, federal policy, and long-term commitments to programs can influence the geographic direction and rate of adoption of innovations. For example, federal funding directs the current guarding dog specialists to conduct their activities in Oregon, Washington, Idaho, Wyoming, and Minnesota. Morrill et al. (1988) suggested that diffusion of an innovation takes place more rapidly where agents are actively communicating information about the concept or phenomena. Thus, expanded use of guarding dogs is expected to occur more rapidly in the aforementioned states than in the states receiving less federal support.

In the case of guarding dogs, the theory that geographic diffusion is a function of distance from a core provided a simplistic model for predicting where livestock guarding dogs would work. Future studies of the diffusion of livestock guarding dogs or any other innovation should consider policies and locations of project funding as potential variables affecting the direction and rate of diffusion. Indeed, both federal and state policies supporting the re-introduction of guarding dogs were selective as to where some programs took place. The effect was to limit the number of livestock growers who had access to educational assistance.

Geographers have long recognized that public policies play an important role in determining human-land relationships (Mitchell 1979). However, public policy is rarely, if ever, considered as a dependent variable on par with physical geography, economics, information exchange, or distance in predicting patterns of diffusion. This study of livestock guarding dogs suggests that public policies affect the adoption of resource management practices in several different ways. Public policy can have a direct effect on resource management by determining where practices are legal. They can have an indirect effect on practices by establishing favorable conditions for information exchange or economics. For example, Executive Order 11643 had the direct effect of making the use of certain predacides illegal. A congressional mandate to conduct a demonstration program for guarding dogs in Oregon had a direct effect on patterns of diffusion. On the other hand, the Animal Damage Control Act (1931) had an indirect effect by creating a policy that supported information exchange about lethal methods of predator control and reduced the likelihood of information exchange about non-lethal controls. Modelling the effects public policies have on the allocation and distribution of resources and practices appears to be an unexplored area of research in geography.

Cooperators. Three spatial models reviewed by Morrill et al. (1988) are useful for interpreting the spatial distribution of cooperators. These models represent stereotypes along a continuum: 1) contagious--where diffusion is simply a function of distance from a core, 2) hierarchical--where size or urban position in a central place hierarchy is controlling, and 3) random. As stereotypes, they represent forms which are rarely, if ever, found in the real world. Combinations of the three are usually present in any diffusion process.

Elements of all three models were seen in the early patterns of adoption of livestock guarding dogs. By 1980 (Figure 5) most of the cooperators were located in the

Northeast, relatively close to the core at Hampshire College in central Massachusetts. The contagion model could explain variation in diffusion in 1980. By 1987, concentrations of cooperators were found in the Northeast, Kentucky, Texas, and Oregon (Figure 5). These areas obtained breeding stock from Hampshire College and represented second tier cores in a hierarchy. Once a primary or secondary core was established within a region, contagion patterns appeared to develop.

By 1987 the pattern of secondary cores appeared to be random with respect to distance from the primary core in Massachusetts (Figure 5). In the absence of barriers to diffusion, Hagerstrand's (1967) model predicted that the number of placements would decrease gradually in proportion to the distance from Massachusetts. However, small numbers of placements between distant states such as Kentucky, Texas, Oregon, and Massachusetts inferred barriers to the diffusion process.

A second hypothesis was that diffusion of guarding dogs was a function of either the number of sheep or the number of sheep growers in a state. For example, the number of placements was expected to be higher in states with many sheep farms than in states with few sheep farms. However, the data did not support this hypothesis.

No correlation appeared between the number of placements and the number of sheep or sheep farms.

Livestock guarding dogs appeared to be growing in popularity in Kentucky, a state categorized as having relatively few sheep growers (Figures 5, 6, and 7). Adoption appeared to be relatively low in California, the Rocky Mountain states, and Plains states where numbers of sheep growers are relatively high. Adoption was high in Oregon and Texas as might be expected on the basis of number of sheep growers. Interest in livestock guarding dogs appeared to be low in the Southeast where sheep growers and numbers of sheep are low.

Social scientists have presented alternative hypotheses for explaining the diffusion of phenomena. Rates of diffusion are expected to be higher where agents are actively promoting a phenomena as opposed to passive diffusion that depends more on adopters coming into contact with one another. The location of agents can be dependent on or independent of policies and funding.

For example, in 1980 the Hampshire College project had a grant to study the performance of guarding dogs in range operations (≥1000 sheep). The Extension Sheep Specialist helped identify potential volunteers for this study, conducted on the western slope of Colorado. In contrast, the core in Minnesota began with the delivery of a dozen dogs while en route to Colorado. That delivery, organized by a vocational agriculture instructor, was independent of any grant or policy.

The presence of a supporting infrastructure appeared to play a role in the long-term adoption of guarding dogs in several states. On-site support in the form of educational programs and a localized program for raising new and replacement dogs never developed in Colorado. The lack of infrastructure may have contributed to the apparent decline in numbers of adopters in that state between 1980 and 1987. On the other hand, a pilot demonstration program could account for the relatively high number of adoptions that occurred in Oregon. This demonstration program had as objectives the development of educational materials and a dog breeding program.

Why relatively large numbers of livestock growers adopted guarding dogs in Kentucky and Texas as opposed to other states appeared anomalous. The contagion model provides a weak argument for the diffusion of guarding dogs in Kentucky. Several states with more sheep and sheep farms than Kentucky are closer to the primary core. Neither state had a special relationship to the primary core prior to diffusion as might be expected in the hierarchical model. Neither state had an organized infrastructure supported by agricultural agents as seen in Oregon.

The scattered locations of secondary cores and cooperators may be a function of the location of early adopters, basically a random occurrence. Secondary cores may represent contagious diffusion around early adopters whose voluntary participation was random. Bohlen (1964) hypothesized that the process of information exchange is a function of socio-cultural status of the potential adopters. He characterized a continuum of innovators: early adopters, early majority, majority, late majority, and laggards. Innovators tended to be young, operate large farms, have a high level of education, and be in positions of leadership within their community. They generally relied on technical sources for their information. At the other end of the spectrum, laggards were the oldest and least educated. They were not active in community affairs and relied on neighbors, friends, farm salesmen, and radio as sources of information.

The pattern of cores forming around early adopters is a plausible hypothesis for Oregon and Texas. The first dog in Oregon was requested in 1979 by a young couple in their twenties with college degrees in agriculture. Their flock size was above the average for the state. They were active in agricultural organizations and worked closely with their county Extension agent. A second family in the same community with similar characteristics also obtained a dog in 1979. Early success by these two cooperators stimulated the county Extension agent to suggest that other sheep growers adopt guarding dogs. In Texas, the first request also came from a young college educated sheep grower.

Anecdotal evidence suggested that the socio-economic status of early adopters influenced the pattern of adoption. However, more information is needed from a larger sample to confirm this hypothesis. Developing a profile of adopters over the first ten years of diffusion would be an interesting topic for further research.

Bohlen (1964) provided another development of Hagerstrand's (1967) concept that information exchange was a key to diffusion. Adopters, Bohlen (1969) suggested, passed through a five stage process: awareness, interest, evaluation, trial, and adoption. He argued that the complexity of a phenomenon affected the rate of change. A simple change in materials and equipment would be adopted rapidly because it requires minimal change in the status quo. An improved practice, a change involving two or three variables, requires greater analysis although basic values remain unchanged. True innovations involve many variables simultaneously and require a change in values and approach. Rate of adoption would be directly related to the complexity of the concept or phenomenon.

According to Bohlen's (1964) model, the adoption of guarding dogs would be expected to be a long slow process because they are a true innovation like tractors or hybrid corn. The adoption process is complex in that cooperators were required to adopt a practice that differed from prevailing values and attitudes about predator control and sheep dogs. Raising and training a livestock guarding dog required sheep growers to re-evaluate farm management and husbandry practices. Thus, the complexity of using livestock guarding dogs probably influenced the rate of adoption.

By 1987, the percentage of adopters was less than 10 percent (<10,000) nationwide. Estimating the percentage is difficult since sheep farmers could obtain dogs from sources other than Hampshire College and no nationwide surveys have been conducted for this purpose. In Oregon, a state with many adopters, cooperators represented about 5 percent of the farms with flock size $\geq$25. The relatively small number of adopters ten years after diffusion began is consistent with other complex innovations (Casetti and Semple 1969, Morrill 1985).

Survivorship (time to failure) analysis of cooperator participation provided a technique for evaluating the long-term adoption of guarding dogs by livestock growers. This estimate of survivorship was conservative for several reasons. Some Hampshire College cooperators, counted as failures in this study, purchased dogs from other sources after they dropped out of the cooperator program. Beginning in the late 1970's there were few breeders supplying guarding dogs to the livestock industry. However, by 1987 many private breeders were contributing to the demand for dogs.

Counting cooperators who sold their flock as failures tended to exaggerate the failure rate of cooperators. An argument could be made that cooperators who sold their sheep should have been right-censored rather than counted as failures. However, records on which cooperators sold their sheep concurrent with dropping out of the project were incomplete. In any event, cooperators who sold their sheep, as in the death of a cooperator, represented a decline in the actual and potential adoption by the livestock industry.

The point at which cooperator survivorship surpassed dog survivorship, between two and three years, marked the time when the concept was embraced independent of the survivorship of any individual dog. During the first two years, more dogs than cooperators survived (Figure 8). Some cooperators tried a dog for a year or two and did not adopt the practice for a longer term. The dog survived and was transferred to another operation. From three years and beyond cooperator survivorship was greater than dog survivorship.

Dogs surviving with greater frequency than cooperators through two years suggested some cooperators decided not to adopt because of a poor initial experience. A positive first experience would more likely lead to long-term adoption than would a negative experience. A majority of early failures were associated with strains with poor records of survivorship. Of 170 cooperators who failed in $\leq$

2.25 years, 72 (42 percent) had as their first dog an Anatolian or Anatolian X Shar Planinetz whose median age was 2.25 years. Adding minor strains to Anatolian and Anatolian X Shar Planinetz, accounted for 96 (56 percent) of the 170 early cooperator failures. Coppinger et al. (1988) noted that Anatolians and Anatolian X Shar Planinetz received the poorest behavioral ratings from cooperators, and Lorenz et al. (1986) found a disproportionate number of culled dogs from this sample of major and minor strains.

A conclusion that may be drawn is that the quality of the initial experience had an effect on the spatial distribution of adopters. Contagious diffusion was more likely from areas where an initial successful experience was visible to other growers. Improvements in long-term adoption by cooperators is expected as the knowledge base and genetic stock improve. Whereas early cooperator failure can inhibit diffusion, early success can act as a stimulus.

A number of other variables confound diffusion of innovations in addition to information exchange, infrastructure, and quality of initial experience. For example, in the case of hybrid corn, Griliches (1957) suggested that adoption was a function of profitability. However, Havens and Rogers (1961) retorted that the perception rather than actual profitability was the driving force behind adoption. Morrill (1985) re-examined Casetti and Semple (1969) arguing that rates of tractor adoption varied according to direction. Morrill (1985) assumed that all farmers knew about tractors by 1920. Thus, information exchange played a minimal role in explaining the diffusion of tractors. Size of farm, farm income, and type of farming were found to influence the direction and rate of adoption of tractors in the central United States (Morrill 1985). Babcock (1962), in his review of the adoption of hybrid corn, argued that while researchers weigh the merits of one model or variable over another, they should remember that a number of approaches can provide valid perspectives on the problem of explaining diffusion.

For livestock guarding dogs, one perspective derived from the evaluations of hybrid corn and tractors would be that rates and patterns of diffusion are a function of where they work. For example, tractors pulling plows work better on relatively level terrain in deep glacial soils than on steep terrain and rocky soils. As far as livestock guarding dogs are concerned, their diffusion over space and time could be viewed as a function of where they work. Two additional events were evaluated to analyze where guarding dogs work: dogs and the cooperator/dog interaction.

Evaluation of Dogs and Cooperator/dog Interaction. Survivorship analysis was used to evaluate the performance of dogs for the entire sample (Figure 8) and by strain (Figures 9 through 14). Survivorship of two-thirds of the sample was previously evaluated by Lorenz et al. (1986). The earlier study covered the first six years of the Hampshire College project involving 449 dogs born between April, 1978 and December, 1983. Minor strains included in the previous study were omitted in this analysis. This study re-examined survivorship of the aging population including new dogs born through June, 1987.

The median age of survival was estimated to be 2.75 years of age. The oldest dogs were censored by time at 9.75 years. As reported by Lorenz et al. (1986) there are few studies of other populations of dogs with which to compare guarding dogs. In a study of kennel dogs concerned with death caused by disease, Comfort (1960) found the median age of death for mastiffs and wolfhounds to be 6 and 7 years, respectively. The median age for smaller spaniels and Pekinese was 11 and 12 years, respectively. The median age of dogs in this study was slightly better than the median of 2.3 years reported for stray dogs in Baltimore (Beck 1973).

The high death rate in dogs, especially during the first 2.5 years, reduced the rate at which livestock guarding dogs could be adopted. One hundred new pups (approximately 15 litters) were needed every year to maintain a constant population of 200 dogs. From another perspective, half of each litter goes toward maintaining a constant population. Given the geometric nature of reproductive increases, the high replacement rate would have a greater negative effect during the early years rather than later years of the diffusion process.

Increasing survivorship of guarding dogs could help increase their rate of adoption. Lorenz et al. (1986) identified accidents followed by culling as the major causes of death. They concluded that good breeding stock and management could increase survivorship of dogs.

The relative survivorship ranking by strain was the same as the behavioral ranking (Coppinger et al. 1988). Maremmas and Maremma X Shar Planinetz demonstrated the best survivorship with a median age of 3.75 years. Anatolians and Anatolian X Shar Planinetz had the poorest survivorship with a median age of 2.25. Shar Planinetz and Anatolian X Maremma X Shar Planinetz were intermediate between these extremes. Concordance between ranking systems reinforced comparisons between strains showing differences in performance between strains.

The difference in performance between strains could not be determined as significant until the management context in which the dog worked was considered. Lorenz et al. (1986) reported that survivorship of dogs on farms and farm/ranches was significantly higher than for dogs on range operations. A skewed distribution of strains by management style could alter conclusions made about the relative merits of each strain.

Taking the cooperator/dog interaction as the focal subject permitted analysis with covariates. The length of time a dog lived at a particular cooperator's was evaluated rather than total longevity of the dog. Each cooperator/dog combination could be assigned to a number of categories including strain, ecoregion, flock size, human population density, and sex. Ecoregion was selected as a possible source of variation because it was assumed that physical factors affecting sheep management would be relatively constant within each region. Flock size was included because it was identified as a contributing variable in a study by Lorenz et al. (1986). Getting hit by a vehicle was a major cause of accidental death in the previous study (Lorenz et al. 1986). Human population density was considered as a proxy for traffic density and the potential for a dog being hit by a vehicle. Strain and sex were two sources of genetic variation.

Two variables, human population density and sex, were dropped from analysis of covariance. As in Lorenz et al. (1986), differences between males and females were insignificant (Figure 15). Crosstabulation of human population density with flock size demonstrated a high degree of correlation between low human density and large ($\geq$ 1000) flock size (Table 7, $p<.01$). Small flocks may be managed across a gradient of human population densities. However, raising large flocks of 500 or more requires large areas of open space. Traffic congestion could be a contributing factor leading to dogs getting hit by vehicles. However, sample size and locations of cooperators were insufficient to discriminate survivorship according to human density independent of flock size.

Divergence between the dog and cooperator/dog curves was important for measuring the effect transferring dogs had on total longevity. If there were few transfers per dog then little difference between the dog and cooperator/dog curves would be expected. If there were many transfers per dog two extreme outcomes would be possible. Divergence between the dog and cooperator/dog survivorship curves would indicate that frequent transfers either improved the longevity of otherwise poor dogs or that longevity of good dogs was not disrupted by frequent moving. High transfer rate and convergence would suggest that transferring does not necessarily improve overall chances of survival.

Maremmas had 1.1 placements per dog. As expected, the difference between the dog and cooperator/time survivorship curves was relatively small in comparison to other strains which had more placements per dog. Maremma X Shar Planinetz had 1.3 placements per dog and the dog and cooperator/time curves diverged. The divergence between curves could be interpreted that Maremma X Shar Planinetz were poor dogs and that transferring improved overall longevity. The alternative, supported by the behavioral ratings (Coppinger et al. 1988) suggests that Maremma X Shar Planinetz are basically good dogs and that repeated transfers did not interfere with working ability or overall longevity. In contrast, Anatolians had the same (1.3) transfer rate as Maremma X Shar Planinetz, yet the age and time curves converged. Anatolians also received less favorable behavioral ratings by cooperators (Coppinger et al. 1988). Frequent transfers of Anatolians may be related to a higher frequency of undesirable behavior. If that was the case, then transferring did not improve overall longevity in Anatolians.

Strain appeared to be a source of variation in the performance of guarding dogs based on the apparent differences found in the dog and cooperator/dog events. Crosstabulation of strain by flock size was significant (Table 3, $p<.05$). However, flock size did not appear to confound strain as no trends were apparent. On the other hand, crosstabulation of strain by ecoregion appeared to yield significant (Table 4, $p<.01$) trends suggesting confounding between the two variables. Maremmas and Anatolian X Maremma X Shar Planinetz were over-represented in the Hot Continental while Anatolians were near expected. Anatolians and Anatolian X Shar Planinetz were over-represented in Prairie while Maremmas were near expected and Maremma X Shar Planinetz under-represented.

Observation of survivorship of the cooperator/dog event by flock size implicated flock size as a source of variation in where dogs work. Half the cooperator/dogs survived to 1.5 years in flock size ≥1000 whereas the median survival of medium flocks (100 to 999) was about 2.5 years. Flock size appeared to be correlated with ecoregion in the crosstabulations. Large flocks (≥1000) were over-represented in the Steppe Division, whereas small flocks (25 to 99) were over-represented in the Warm and Hot Continental Divisions. This result was to be expected. There are few flocks of ≥500 sheep in the Northeast. Most flocks of ≥1000 sheep are managed as range operations in the intermountain West. The statistical method for estimating expected frequencies in the Chi-square analysis for flock size by ecoregion may not be appropriate in this circumstance. However, data on flock size are available according to political rather than geographic regions. Thus, it was impossible to generate more realistic expected frequencies for the Chi-square test used in this crosstabulation.

The performance of the cooperator/dog event also appeared to vary across ecoregions (Figure 17). Survivorship was best in the Hot Continental, intermediate in Steppe, and poorest in Prairie. However, results of pair-wise crosstabulations suggested these apparent differences between ecoregions were an artifact of flock size and strain. Maremmas and Anatolian X Maremma X Shar

Planinetz were over-represented relative to Anatolians in Hot Continental. Conversely, Anatolians were over-represented relative to Maremmas and Maremma X Shar Planinetz in Prairie. A high frequency of Maremma X Shar Planinetz relative to Anatolians appeared to offset the high frequency of flocks ≥1000 in the Steppe, accounting for the intermediate ranking of that Division.

An additional test was performed to check whether dogs had a high frequency of transfers into flock size ≥1000. The question was whether placements of dogs in flocks ≥1000 accumulated as second, third, or fourth placements of these dogs. The Chi-square test was not significant. In other words, the poor survivorship of flock size ≥1000 could not be explained by an accumulation of the poorest strain that occurred as a result of transfers.

Results of the Lifereg procedure (SAS 1987) confirmed that the effects of both strain and flock size were highly significant ($p<.001$) and that the effect of ecoregion was not significant ($p>.10$). This procedure basically tested the effects of each variable while holding the others constant. Testing an interactive effect between variables was desirable, although impossible. Such an exercise would have created a matrix of data with too many parameters for analysis.

Comparative studies of survivorship according to genetic and environmental variables is significant to the diffusion process. Poor performance within any category could be identified as a barrier to diffusion. Conversely, good performance within a category would indicate conditions which could stimulate diffusion. For example, since males and females work equally well, sex could be considered neither a barrier nor stimulus to the diffusion process.

Likewise, the potential for adopting livestock guarding dogs appears equally well within the five ecoregions reviewed. Expanding the conclusion to say the potential for adoption appears equally well across the United States would be fairly safe since the five ecoregions covered the major sheep producing areas of the United States. Wade's (1982) suggestion that the use of guarding dogs for protecting range sheep appeared limited could not be supported by this study. Range (essentially Steppe Division) per se was not significantly different from any other region.

However, there may be areas within ecoregions where guarding dogs do not excel. For example, few sheep farmers from Oregon's southwest coast (Douglas, Coos, and Curry Counties) volunteered to participate. Nearly a third of Oregon's sheep are raised in this district. This raised the question of whether the sample of subjects from the Marine ecoregion was truly representative of the entire Division. Unfortunately, random spatial sampling, although preferable in many regards, was not practical.

The relatively weak performance of Anatolians and dogs in flocks $\geq$1000 appeared to be barriers to the diffusion process. Caution should be exercised in interpreting the statistically significant differences found among strains and flock sizes. Minimal levels of acceptable performance have yet to be established. Telling ranchers who have used Anatolians successfully that their dogs are not good would be counter-productive. The performance of Anatolians could probably be enhanced through selective breeding which has been done countless times with other strains of plants and animals. Thus, identifying a category as a barrier does not constitute an argument for discontinuing more introductions into those conditions.

The inductive approach taken in this study was insufficient for identifying the behavioral causes for differences between strains. For example, differences between strains might be accounted for on the basis of differences in rates of maturation or differences in the frequencies of specific motor patterns. Understanding the behavior of the dogs and a program of selective breeding would be essential elements leading to a positive first experience and long-term adoption.

Statistical significance is also insufficient for suggesting that guarding dogs should not be recommended dogs for a particular flock size. Larger flocks (>500) generally enjoyed 10 times the sheep-years of protection as smaller flocks (<500, Table 11). Some owners of flocks ≥1000 have reduced losses from >100 sheep to <10 a year after obtaining a livestock guarding dog (Coppinger et al. 1988, Green et al. 1884). Lorenz et al. (1986) showed that a two-year-old dog that provided one year of useful service would cost over $1000 for that year of service. A short lived dog would have to reduce predation by about 15 to 20 lambs (assuming a market of $65 cwt.) to pay for itself. Such a reduction is quite reasonable in flock size ≥1000.

The decline in adopters in Colorado was probably related to the relatively poor performance of guarding dogs in flock size ≥1000. This was unexpected for several reasons. The origins of husbandry practices in range operations of the western United States can be traced to transhumant sheep migrations of southern Europe. Guarding dogs historically travelled long distances with thousands of sheep. Current sheep husbandry observed in the Abruzzi Mountains of Italy appeared similar to range operations of the western United States (Coppinger et al. 1983b). Subtle management difficulties probably accounted for problems in adoption of guarding dogs in range operations with ≥1000 sheep. The adoption of guarding dogs in large range operations should increase, given their historical use under similar conditions in Europe.

Future Prospects. The results of the analyses in this study may be useful for predicting where the use of livestock guarding dogs will expand in the future. Important variables that will influence the diffusion process include the following: 1) policies and funding that support educational programs and placement of dogs, 2) areas where dogs are currently concentrated, 3) availability of quality dogs, and 4) flock size. Furthermore, adoption of guarding dogs will probably take place most rapidly where combinations of categories with good performance exist. For example, Maremmas are expected to diffuse more rapidly among farms with 100-499 sheep in Oregon than Anatolians among flocks with $\geq$ 1000 sheep in Utah. Presence of sheep and the threat of predation are assumed when predicting where guarding dogs will diffuse.

The location of politically motivated programs will likely influence where guarding dogs will be adopted independent of other variables such as breed, ecoregion, or flock size. This study demonstrated that guarding dogs were adopted in New England and Oregon, close to the location of research demonstration projects. The initial diffusion of guarding dogs in New England could be considered a random occurrence as that was a location where studies on guarding dogs began. However, the diffusion of guarding dogs in Oregon was politically motivated in that funding was specifically earmarked for that region. Why Oregon was selected over any other western state could be the topic of another investigation.

According to the contagion model, guarding dogs will likely diffuse from areas where they are currently in use. Guarding dogs will likely diffuse from areas of current concentration in New England, Kentucky, Texas, and Oregon. In the absence of organized educational programs, the contagion model would predict that the diffusion of guarding dogs would be a function of distance from these existing core areas.

Within any defined region, whether it be national, state, or local, the diffusion of guarding dogs will be influenced by the availability of quality dogs. Current evidence suggests that poor dogs are barriers to the diffusion process by discouraging potential adopters. Short lived dogs raise costs and create an economic barrier to the diffusion of guarding dogs. Good dogs may be found among all the strains analyzed in this study. However, Maremmas and Maremma X Shar Planinetz showed the highest rates of success. This would suggest that the location and availability of these two strains will influence where guarding dogs will be adopted.

Flock size will probably influence the rate at which guarding dogs are adopted within a region. Larger flock size, particularly $\geq$1000, appeared to be a barrier to diffusion. Flocks of <1000 sheep exist in all states.

However, flocks $\geq$1000 are infrequent in eastern states. Therefore, flock size would be expected to be a barrier to diffusion in western rather than eastern states. However, this barrier could be mitigated by the existence of policies and agents promoting the use of quality dogs in such states as Idaho, Oregon, Washington, and Wyoming.

Finally, according to Bohlen's (1964) theory, guarding dogs will likely be adopted by sheep producers according to their socio-economic and educational status. Bohlen's model would operate independent of location. It could be useful in explaining the diffusion of guarding dogs from core areas. It has the potential for explaining how core areas become established, especially in the absence of government sponsored educational programs.

Survivorship Analysis in Studies of Diffusion. The application of both the standard proportional hazard and accelerated life test models for analyzing the adoption of a phenomenon appeared to be an innovation in quantitative geography. Adoption is typically quantified as either a direct count or as a percentage of the potential population tabulated over discrete time intervals. A direct count is often useful for monitoring the diffusion of a new business, such as a chain of restaurants. Percentages are more frequently used when monitoring the diffusion of a phenomenon through an existing population, for example, the adoption of tractors by farmers. While counts and percentages provide good methods for evaluating the diffusion of a concept, they are weak in tracking the success of individual adopters through time.

The basic problem is whether the individuals counted in the first time interval are the same as those counted in the second or succeeding intervals. Suppose the number of new restaurants increased between the first and second time intervals. Was the increase simply due to an addition to the existing base number or a result of additions being greater than failures? If numbers decline, is it the result of failures being greater than additions or simply the decomposition of a base population?

Percentage increases could occur two ways. First, the number of adopters could remain constant and the potential population decline over time. Second, the number of adopters could increase relative to the potential population. It is conceivable that the adoption of an innovation could confer a competitive advantage to the adopter. Non-adopters might be forced to drop out of the population of potential adopters. In such a scenario, a simple calculation of the percentage of potential adopters may not provide an adequate representation of the dynamics of the diffusion process.

The total length of time and sampling intervals relative to the expected lifetime of the adopter or innovation are critical variables that affect dynamics of the diffusion process. Selecting inappropriate sampling intervals could lead to false conclusions. Suppose that, at time one, 10 of a population of 100 people were observed using the innovation. Suppose that, at time two, 15 people were using an innovation. Without knowing more about the adopters the investigator might report that adopters increased by 50 percent. However, suppose that the original adopters stopped using the innovation and that between times one and two another 50 individuals tried the innovation but stopped before the second sampling period. In the first case, the investigator might conclude that the innovation had merit as evidenced by the increase in adopters. Knowing more about the individual adopters might lead to a different conclusion.

Incorporating failures into the analysis of diffusion provided a more dynamic analysis than simple counts or calculations of percentages. For example, life table analysis could be used to predict the length of time an individual adopted the innovation, thereby providing insight into whether adopters counted between two time intervals were likely to be the same or different people. Calculating a general failure rate also provided the opportunity to estimate the number of new items that are needed if the phenomenon in question is to increase or continue to diffuse through a population. This study showed that the placement of an average of 109 dogs per year eventually supported an equilibrium population of about 200 dogs. More than 109 dogs per year would be required if resource managers decided to adopt a policy to increase the number of dogs in use.

The accelerated life test was especially useful because of its ability to incorporate discrete data as covariates. For biological phenomena where survivorship is a useful measure of success, the accelerated life test is able to make comparisons across geographical regions or across discrete variables. In summary, the use of life tests provided a method for capturing the dynamic nature of diffusion and for making predictions about the number of new individuals needed to support the continuation of diffusion.

Preservation of Peasant Agroecosystems. One of the many arguments for preserving biological diversity is that organisms provide the basis for human civilization (Ehrlich 1988). There is an inherent utilitarian value in preserving biodiversity. Two examples include the use of plant material for formulating drugs (Farnsworth 1988) and the discovery of pest resistant strains that can be hybridized with food crops (Brownlee 1989, Iltis 1988). A conclusion of this argument states that rare and endangered species should be preserved because of the possibility that they might contribute to the continuation of human civilization.

The re-introduction of livestock guarding dogs by American agriculturalists is yet another example of the advantages of preserving rare or endangered genetic strains. Once abundant among shepherds in Eurasia, livestock guarding dogs were declining in numbers in their native lands. The disappearance of wolves and transhumant husbandry was contributing to the decline of strains of domestic dogs that were particularly suited for protecting flocks from predators. The preservation of that genetic resource has provided American livestock growers with an alternative form of predator control.

Finding examples of peasant agricultural techniques that have been transferred to developed nations is difficult. The reverse is more often seen, as exemplified by the Green Revolution which was characterized by the transfer of agricultural technology from developed to underdeveloped nations. Certainly, modern day agricultural practices have historical roots in ancient, peasant agriculture. Genetic stock is transferred regularly between developed and underdeveloped nations. However, in developed nations, the adoption of ancient practices such as the use of animal power would be considered a step backward.

The widespread adoption of livestock guarding dogs in the United States appears to be a rare example of what may be called reverse technology. In this case, guarding dogs were taken out of their traditional, peasant context in

Eurasia and placed into a highly technological agricultural context. Although ranchers in the Southwest used guarding dogs some 200 years ago, current rancher use does not represent an evolutionary development of that earlier adoption. Thus, the adoption of livestock guarding dogs by American agriculturists supports the utilitarian value of maintaining biological diversity and agro-ecological systems.

<u>Summary</u>. The diffusion of livestock guarding dogs into American agriculture appeared to be a rare example of a developed nation adopting a peasant husbandry practice. Furthermore, the adoption of guarding dogs in America demonstrated the utilitarian value of maintaining rare genetic strains and peasant agricultural practices.

A number of variables influenced the diffusion of Old World livestock guarding dogs into American agriculture that began in the late 1970's. First, the timing of the re-introduction of guarding dogs was influenced by dissonance between Anglo and Spanish traditions. In the 1800's, Anglo sheep husbandry practices, including the use of herding dogs, preempted Spanish traditions, including the use of guarding dogs. The Animal Damage Control Act of 1931 reinforced the cultural dissonance by adopting lethal methods of predator control as federal policy. The recent re-introduction and diffusion of guarding dogs came about as the result of political events that stimulated a search for alternative methods of predator control.

The spatial pattern of adoption over the period 1978 to 1987 was influenced by the location of the primary core at Hampshire College in Massachusetts, the location of agents promoting the innovation, the location of initial volunteer cooperators, and the performance of the dogs according to strain and flock size. Barriers to diffusion included lack of knowledge and communication about livestock guarding dogs, a limited supply of dogs, and poor survivorship of some strains and within large ($\geq$1000) flocks. The perception of profitability, a function of dog survivorship and reduction in predation, was identified as another potential barrier.

The potential for continued diffusion of guarding dogs into the American sheep industry appears great. Results of this study suggested diffusion will be greatest from areas where agents are actively promoting their use, from areas where concentrations of dogs currently exist, from areas where quality dogs are available, and in areas where flock size is $<$1000.

Guarding dogs worked equally well across the major sheep producing regions of the United States after adjusting for flock size and strain. Suitable dogs were found within all strains, although statistical differences in performance were found between strains. Differences in performance according to flock size, although statistically significant, should not impair the long-term prospects for adoption. By 1987, the total number of adopters across the United States was unknown, but probably less than 10 percent of all growers. Strengthening institutional commitments to a supporting infrastructure should facilitate the diffusion of livestock guarding dogs across the country.

Life test analysis provided a technique for tracking the length of time innovators adopted livestock guarding dogs. Results indicated that many early adopters discontinued the practice. However, time to failure, overall, was greater for innovators than for dogs. This demonstrated that adoption of guarding dogs by American agriculturalists persists beyond the lifetime of an individual dog.

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APPENDIX

Table 12. Life table survival estimates--According to all cooperators.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	419.0	0.00	1.000
0.25 - 0.50	13	3	417.5	0.03	1.000
0.50 - 0.75	19	2	402.0	0.05	0.969
0.75 - 1.00	21	3	380.5	0.06	0.872
1.00 - 1.25	30	4	356.0	0.08	0.799
1.25 - 1.50	20	2	323.0	0.06	0.750
1.50 - 1.75	19	6	299.0	0.06	0.702
1.75 - 2.00	15	2	276.0	0.05	0.664
2.00 - 2.25	26	7	256.5	0.10	0.597
2.25 - 2.50	9	2	226.0	0.04	0.573
2.50 - 2.75	9	4	214.0	0.04	0.549
2.75 - 3.00	13	12	197.0	0.07	0.513
3.00 - 3.25	9	8	174.0	0.05	0.486
3.25 - 3.50	8	8	157.0	0.05	0.461
3.50 - 3.75	2	11	139.5	0.01	0.454
3.75 - 4.00	6	3	130.5	0.05	0.433
4.00 - 4.25	5	6	120.0	0.04	0.415
4.25 - 4.50	2	5	109.5	0.02	0.407
4.50 - 4.75	6	4	103.0	0.06	0.383
4.75 - 5.00	6	4	93.0	0.07	0.358
5.00 - 5.25	4	2	84.0	0.05	0.341
5.25 - 5.50	2	2	78.0	0.03	0.332
5.50 - 5.75	1	3	73.5	0.01	0.327
5.75 - 6.00	2	10	66.0	0.03	0.317
6.00 - 6.25	1	7	55.5	0.02	0.311
6.25 - 6.50	0	4	49.0	0.00	0.311
6.50 - 6.75	1	2	46.0	0.02	0.304
6.75 - 7.00	0	11	38.5	0.00	0.304
7.00 - 7.25	3	1	32.5	0.09	0.276
7.25 - 7.50	0	1	28.5	0.00	0.276
7.50 - 7.75	1	8	24.0	0.04	0.264
7.75 - 8.00	0	3	17.5	0.00	0.264
8.00 - 8.25	1	1	15.5	0.07	0.247
8.25 - 8.50	1	3	12.5	0.08	0.227
8.50 - 8.75	1	6	7.0	0.14	0.195
8.75 - 9.00	0	0	3.0	0.00	0.195
9.00 - 9.25	0	2	2.0	0.00	0.195
9.25 - 9.50	0	0	0.5	0.00	0.195

Table 13. Life table survival estimates--Age of dogs according to strain, all strains, Anatolian, Maremma, Shar Planinetz, Anatolian X Shar Planinetz, Maremma X Shar Planinetz, and Anatolian X Maremma X Shar Planinetz.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	687.0	0.00	1.000
0.25 - 0.50	33	0	687.0	0.05	1.000
0.50 - 0.75	31	20	644.0	0.05	0.952
0.75 - 1.00	38	9	598.5	0.06	0.906
1.00 - 1.25	34	28	542.0	0.06	0.849
1.25 - 1.50	42	9	489.5	0.09	0.795
1.50 - 1.75	35	32	427.0	0.08	0.727
1.75 - 2.00	18	12	370.0	0.05	0.668
2.00 - 2.25	27	15	338.5	0.08	0.635
2.25 - 2.50	25	9	299.5	0.08	0.584
2.50 - 2.75	18	5	267.5	0.07	0.536
2.75 - 3.00	12	13	240.5	0.05	0.500
3.00 - 3.25	20	16	214.0	0.09	0.475
3.25 - 3.50	8	8	182.0	0.04	0.430
3.50 - 3.75	9	4	168.0	0.05	0.411
3.75 - 4.00	11	9	152.5	0.07	0.389
4.00 - 4.25	9	10	132.0	0.07	0.361
4.25 - 4.50	1	8	114.0	0.01	0.337
4.50 - 4.75	1	5	106.5	0.01	0.334
4.75 - 5.00	3	9	98.5	0.03	0.331
5.00 - 5.25	2	2	90.0	0.02	0.321
5.25 - 5.50	2	1	86.5	0.02	0.313
5.50 - 5.75	1	4	82.0	0.01	0.306
5.75 - 6.00	3	0	79.0	0.04	0.302
6.00 - 6.25	3	11	70.5	0.04	0.291
6.25 - 6.50	1	6	59.0	0.02	0.279
6.50 - 6.75	0	4	53.0	0.00	0.274
6.75 - 7.00	1	5	48.5	0.02	0.274
7.00 - 7.25	2	9	40.5	0.05	0.268
7.25 - 7.50	1	1	33.5	0.03	0.255
7.50 - 7.75	0	1	31.5	0.00	0.247
7.75 - 8.00	2	3	29.5	0.07	0.247
8.00 - 8.25	1	7	22.5	0.04	0.231
8.25 - 8.50	0	1	17.5	0.00	0.220
8.50 - 8.75	1	7	13.5	0.07	0.220
8.75 - 9.00	0	1	8.5	0.00	0.204
9.00 - 9.25	0	1	7.5	0.00	0.204
9.25 - 9.50	0	3	5.5	0.00	0.204
9.50 - 9.75	1	1	3.5	0.29	0.204
9.75 - .	1	1	1.5	0.67	0.146

Table 14. Life table survival estimates--Age of dogs according to strain, Anatolian.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	174.0	0.00	1.000
0.25 - 0.50	9	0	174.0	0.05	1.000
0.50 - 0.75	9	2	164.0	0.05	0.948
0.75 - 1.00	11	0	154.0	0.07	0.896
1.00 - 1.25	11	0	143.0	0.08	0.832
1.25 - 1.50	11	0	132.0	0.08	0.768
1.50 - 1.75	12	11	115.5	0.10	0.704
1.75 - 2.00	6	4	96.0	0.06	0.631
2.00 - 2.25	13	8	84.0	0.15	0.592
2.25 - 2.50	5	0	67.0	0.07	0.500
2.50 - 2.75	7	0	62.0	0.11	0.463
2.75 - 3.00	2	1	54.5	0.04	0.411
3.00 - 3.25	9	3	50.5	0.18	0.395
3.25 - 3.50	3	0	40.0	0.08	0.325
3.50 - 3.75	3	0	37.0	0.08	0.301
3.75 - 4.00	6	2	33.0	0.18	0.276
4.00 - 4.25	1	1	25.5	0.04	0.226
4.25 - 4.50	0	0	24.0	0.00	0.217
4.50 - 4.75	0	3	22.5	0.00	0.217
4.75 - 5.00	0	0	21.0	0.00	0.217
5.00 - 5.25	1	1	20.5	0.05	0.217
5.25 - 5.50	2	1	18.5	0.11	0.207
5.50 - 5.75	0	0	16.0	0.00	0.184
5.75 - 6.00	2	0	16.0	0.13	0.184
6.00 - 6.25	0	4	12.0	0.00	0.161
6.25 - 6.50	1	5	7.5	0.13	0.161
6.50 - 6.75	0	1	3.5	0.00	0.140
6.75 - 7.00	1	0	3.0	0.33	0.140
7.00 - 7.25	0	1	1.5	0.00	0.093
7.25 - 7.50	0	0	1.0	0.00	0.093
7.50 - 7.75	0	0	1.0	0.00	0.093
7.75 - 8.00	0	0	1.0	0.00	0.093
8.00 - .	0	1	0.5	0.00	0.093

Table 15. Life table survival estimates--Age of dogs according to strain, Maremma.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	128.0	0.00	1.000
0.25 - 0.50	3	0	128.0	0.02	1.000
0.50 - 0.75	6	9	120.5	0.05	0.977
0.75 - 1.00	2	6	107.0	0.02	0.928
1.00 - 1.25	5	9	97.5	0.05	0.911
1.25 - 1.50	5	7	84.5	0.06	0.864
1.50 - 1.75	3	16	68.0	0.04	0.813
1.75 - 2.00	3	1	56.5	0.05	0.777
2.00 - 2.25	3	0	53.0	0.06	0.736
2.25 - 2.50	2	0	50.0	0.04	0.694
2.50 - 2.75	1	2	47.0	0.02	0.666
2.75 - 3.00	3	2	44.0	0.07	0.652
3.00 - 3.25	3	6	37.0	0.08	0.608
3.25 - 3.50	2	0	31.0	0.06	0.558
3.50 - 3.75	1	0	29.0	0.03	0.522
3.75 - 4.00	0	0	28.0	0.00	0.504
4.00 - 4.25	1	3	26.5	0.04	0.504
4.25 - 4.50	0	0	24.0	0.00	0.485
4.50 - 4.75	0	0	24.0	0.00	0.485
4.75 - 5.00	1	2	23.0	0.04	0.485
5.00 - 5.25	0	0	21.0	0.00	0.464
5.25 - 5.50	0	0	21.0	0.00	0.464
5.50 - 5.75	1	0	21.0	0.05	0.464
5.75 - 6.00	1	0	20.0	0.05	0.442
6.00 - 6.25	2	0	19.0	0.11	0.420
6.25 - 6.50	0	0	17.0	0.00	0.376
6.50 - 6.75	0	2	16.0	0.00	0.376
6.75 - 7.00	0	1	14.5	0.00	0.376
7.00 - 7.25	0	0	14.0	0.00	0.376
7.25 - 7.50	0	0	14.0	0.00	0.376
7.50 - 7.75	0	0	14.0	0.00	0.376
7.75 - 8.00	1	0	14.0	0.07	0.376
8.00 - 8.25	1	5	10.5	0.10	0.349
8.25 - 8.50	0	0	7.0	0.00	0.316
8.50 - 8.75	0	2	6.0	0.00	0.316
8.75 - 9.00	0	0	5.0	0.00	0.316
9.00 - 9.25	0	0	5.0	0.00	0.316
9.25 - 9.50	0	3	3.5	0.00	0.316
9.50 - 9.75	1	0	2.0	0.50	0.316
9.75 - .	1	0	1.0	1.00	0.158

Table 16. Life table survival estimates--Age of dogs according to strain, Shar Planinetz.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	83.0	0.00	1.000
0.25 - 0.50	5	0	83.0	0.06	1.000
0.50 - 0.75	2	1	77.5	0.03	0.940
0.75 - 1.00	5	0	75.0	0.07	0.916
1.00 - 1.25	5	0	70.0	0.07	0.855
1.25 - 1.50	9	0	65.0	0.14	0.793
1.50 - 1.75	3	0	56.0	0.05	0.684
1.75 - 2.00	1	0	53.0	0.02	0.647
2.00 - 2.25	1	2	51.0	0.02	0.635
2.25 - 2.50	8	0	49.0	0.16	0.622
2.50 - 2.75	1	0	41.0	0.02	0.521
2.75 - 3.00	2	2	39.0	0.05	0.508
3.00 - 3.25	7	0	36.0	0.19	0.482
3.25 - 3.50	2	0	29.0	0.07	0.388
3.50 - 3.75	2	0	27.0	0.07	0.362
3.75 - 4.00	1	0	25.0	0.04	0.335
4.00 - 4.25	4	0	24.0	0.17	0.321
4.25 - 4.50	0	0	20.0	0.00	0.268
4.50 - 4.75	0	1	19.5	0.00	0.268
4.75 - 5.00	0	3	17.5	0.00	0.268
5.00 - 5.25	1	1	15.5	0.06	0.268
5.25 - 5.50	0	0	14.0	0.00	0.251
5.50 - 5.75	0	0	14.0	0.00	0.251
5.75 - 6.00	0	0	14.0	0.00	0.251
6.00 - 6.25	0	3	12.5	0.00	0.251
6.25 - 6.50	0	0	11.0	0.00	0.251
6.50 - 6.75	0	0	11.0	0.00	0.251
6.75 - 7.00	0	4	9.0	0.00	0.251
7.00 - 7.25	1	0	7.0	0.14	0.251
7.25 - 7.50	1	0	6.0	0.17	0.215
7.50 - 7.75	0	1	4.5	0.00	0.179
7.75 - 8.00	1	1	3.5	0.29	0.179
8.00 - 8.25	0	0	2.0	0.00	0.128
8.25 - 8.50	0	1	1.5	0.00	0.128
8.50 - 8.75	0	0	1.0	0.00	0.128
8.75 - 9.00	0	0	1.0	0.00	0.128
9.00 - 9.25	0	0	1.0	0.00	0.128
9.25 - 9.50	0	0	1.0	0.00	0.128
9.50 - .	0	1	0.5	0.00	0.128

Table 17. Life table survival estimates--Age of dogs according to strain, Anatolian X Shar Planinetz.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	124.0	0.00	1.000
0.25 - 0.50	7	0	124.0	0.06	1.000
0.50 - 0.75	9	0	117.0	0.08	0.944
0.75 - 1.00	9	3	106.5	0.08	0.871
1.00 - 1.25	5	6	93.0	0.05	0.797
1.25 - 1.50	13	0	85.0	0.15	0.755
1.50 - 1.75	5	0	72.0	0.07	0.639
1.75 - 2.00	5	7	63.5	0.08	0.595
2.00 - 2.25	2	2	54.0	0.04	0.548
2.25 - 2.50	5	3	49.5	0.10	0.528
2.50 - 2.75	4	0	43.0	0.09	0.474
2.75 - 3.00	1	6	36.0	0.03	0.430
3.00 - 3.25	1	2	31.0	0.03	0.418
3.25 - 3.50	0	1	28.5	0.00	0.405
3.50 - 3.75	2	4	26.0	0.08	0.405
3.75 - 4.00	3	4	20.0	0.15	0.374
4.00 - 4.25	0	3	13.5	0.00	0.318
4.25 - 4.50	1	3	10.5	0.10	0.318
4.50 - 4.75	0	0	8.0	0.00	0.287
4.75 - 5.00	0	0	8.0	0.00	0.287
5.00 - 5.25	0	0	8.0	0.00	0.287
5.25 - 5.50	0	0	8.0	0.00	0.287
5.50 - 5.75	0	4	6.0	0.00	0.287
5.75 - 6.00	0	0	4.0	0.00	0.287
6.00 - 6.25	0	1	3.5	0.00	0.287
6.25 - 6.50	0	0	3.0	0.00	0.287
6.50 - 6.75	0	0	3.0	0.00	0.287
6.75 - 7.00	0	0	3.0	0.00	0.287
7.00 - 7.25	0	0	3.0	0.00	0.287
7.25 - 7.50	0	1	2.5	0.00	0.287
7.50 - 7.75	0	0	2.0	0.00	0.287
7.75 - .	0	2	1.0	0.00	0.287

Table 18. Life table survival estimates--Age of dogs according to strain, Maremma X Shar Planinetz.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	103.0	0.00	1.000
0.25 - 0.50	4	0	103.0	0.04	1.000
0.50 - 0.75	4	1	98.5	0.04	0.961
0.75 - 1.00	7	0	94.0	0.07	0.922
1.00 - 1.25	4	5	84.5	0.05	0.854
1.25 - 1.50	2	0	78.0	0.03	0.813
1.50 - 1.75	5	4	74.0	0.07	0.792
1.75 - 2.00	2	0	67.0	0.03	0.739
2.00 - 2.25	6	3	63.5	0.09	0.717
2.25 - 2.50	4	6	53.0	0.08	0.649
2.50 - 2.75	1	0	46.0	0.02	0.600
2.75 - 3.00	4	2	44.0	0.09	0.587
3.00 - 3.25	0	5	36.5	0.00	0.534
3.25 - 3.50	1	0	34.0	0.03	0.534
3.50 - 3.75	1	0	33.0	0.03	0.518
3.75 - 4.00	0	0	32.0	0.00	0.502
4.00 - 4.25	3	3	30.5	0.10	0.502
4.25 - 4.50	0	0	26.0	0.00	0.453
4.50 - 4.75	1	1	25.5	0.04	0.453
4.75 - 5.00	1	0	24.0	0.04	0.435
5.00 - 5.25	0	0	23.0	0.00	0.417
5.25 - 5.50	0	0	23.0	0.00	0.417
5.50 - 5.75	0	0	23.0	0.00	0.417
5.75 - 6.00	0	0	23.0	0.00	0.417
6.00 - 6.25	1	1	22.5	0.04	0.417
6.25 - 6.50	0	1	20.5	0.00	0.398
6.50 - 6.75	0	1	19.5	0.00	0.398
6.75 - 7.00	0	0	19.0	0.00	0.398
7.00 - 7.25	1	8	15.0	0.07	0.398
7.25 - 7.50	0	0	10.0	0.00	0.372
7.50 - 7.75	0	0	10.0	0.00	0.372
7.75 - 8.00	0	0	10.0	0.00	0.372
8.00 - 8.25	0	1	9.5	0.00	0.372
8.25 - 8.50	0	0	9.0	0.00	0.372
8.50 - 8.75	1	5	6.5	0.15	0.372
8.75 - 9.00	0	1	2.5	0.00	0.315
9.00 - 9.25	0	1	1.5	0.00	0.315
9.25 - 9.50	0	0	1.0	0.00	0.315
9.50 - 9.75	0	0	1.0	0.00	0.315
9.75 - .	0	1	0.5	0.00	0.315

Table 19. Life table survival estimates--Age of dogs according to strain, Anatolian X Maremma X Shar Planinetz.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	75.0	0.00	1.000
0.25 - 0.50	5	0	75.0	0.07	1.000
0.50 - 0.75	1	7	66.5	0.02	0.933
0.75 - 1.00	4	0	62.0	0.06	0.919
1.00 - 1.25	4	8	54.0	0.07	0.860
1.25 - 1.50	2	2	45.0	0.04	0.796
1.50 - 1.75	7	1	41.5	0.17	0.761
1.75 - 2.00	1	0	34.0	0.03	0.633
2.00 - 2.25	2	0	33.0	0.06	0.614
2.25 - 2.50	1	0	31.0	0.03	0.577
2.50 - 2.75	4	3	28.5	0.14	0.558
2.75 - 3.00	0	0	23.0	0.00	0.480
3.00 - 3.25	0	0	23.0	0.00	0.480
3.25 - 3.50	0	7	19.5	0.00	0.480
3.50 - 3.75	0	0	16.0	0.00	0.480
3.75 - 4.00	1	3	14.5	0.07	0.480
4.00 - 4.25	0	0	12.0	0.00	0.447
4.25 - 4.50	0	5	9.5	0.00	0.447
4.50 - 4.75	0	0	7.0	0.00	0.447
4.75 - 5.00	1	4	5.0	0.20	0.447
5.00 - 5.25	0	0	2.0	0.00	0.357
5.25 - 5.50	0	0	2.0	0.00	0.357
5.50 - 5.75	0	0	2.0	0.00	0.357
5.75 - 6.00	0	0	2.0	0.00	0.357
6.00 - .	0	2	1.0	0.00	0.357

Table 20. Life table survival estimates--Age of dogs according to sex, male.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	464.0	0.00	1.000
0.25 - 0.50	51	8	460.0	0.11	1.000
0.50 - 0.75	50	15	397.5	0.13	0.889
0.75 - 1.00	40	9	335.5	0.12	0.773
1.00 - 1.25	40	11	285.5	0.14	0.685
1.25 - 1.50	23	10	235.0	0.10	0.589
1.50 - 1.75	27	8	203.0	0.13	0.531
1.75 - 2.00	21	4	170.0	0.12	0.460
2.00 - 2.25	13	4	145.0	0.09	0.404
2.25 - 2.50	11	2	129.0	0.09	0.367
2.50 - 2.75	7	9	112.5	0.06	0.336
2.75 - 3.00	7	6	98.0	0.07	0.315
3.00 - 3.25	16	3	86.5	0.19	0.293
3.25 - 3.50	2	2	68.0	0.03	0.239
3.50 - 3.75	9	3	63.5	0.14	0.232
3.75 - 4.00	3	2	52.0	0.06	0.199
4.00 - 4.25	3	5	45.5	0.07	0.187
4.25 - 4.50	1	2	39.0	0.03	0.175
4.50 - 4.75	3	5	34.5	0.09	0.170
4.75 - 5.00	0	0	29.0	0.00	0.156
5.00 - 5.25	0	1	28.5	0.00	0.156
5.25 - 5.50	2	0	28.0	0.07	0.156
5.50 - 5.75	0	1	25.5	0.00	0.145
5.75 - 6.00	1	4	23.0	0.04	0.145
6.00 - 6.25	0	0	20.0	0.00	0.138
6.25 - 6.50	0	1	19.5	0.00	0.138
6.50 - 6.75	0	1	18.5	0.00	0.138
6.75 - 7.00	0	1	17.5	0.00	0.138
7.00 - 7.25	4	1	16.5	0.24	0.138
7.25 - 7.50	1	0	12.0	0.08	0.105
7.50 - 7.75	0	3	9.5	0.00	0.096
7.75 - 8.00	0	1	7.5	0.00	0.096
8.00 - 8.25	0	0	7.0	0.00	0.096
8.25 - 8.50	0	0	7.0	0.00	0.096
8.50 - 8.75	0	2	6.0	0.00	0.096
8.75 - 9.00	0	1	4.5	0.00	0.096
9.00 - 9.25	0	2	3.0	0.00	0.096
9.25 - 9.50	1	0	2.0	0.50	0.096
9.50 - .	0	1	0.5	0.00	0.048

Table 21. Life table survival estimates--Age of dogs according to sex, female.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	382.0	0.00	1.000
0.25 - 0.50	45	14	375.0	0.12	1.000
0.50 - 0.75	42	8	319.0	0.13	0.880
0.75 - 1.00	27	4	271.0	0.10	0.764
1.00 - 1.25	28	12	236.0	0.12	0.688
1.25 - 1.50	17	8	198.0	0.09	0.606
1.50 - 1.75	16	16	169.0	0.09	0.554
1.75 - 2.00	18	5	142.5	0.13	0.502
2.00 - 2.25	12	11	116.5	0.10	0.438
2.25 - 2.50	6	2	98.0	0.06	0.393
2.50 - 2.75	5	9	86.5	0.06	0.369
2.75 - 3.00	8	2	76.0	0.11	0.348
3.00 - 3.25	4	2	66.0	0.06	0.311
3.25 - 3.50	2	2	60.0	0.03	0.292
3.50 - 3.75	4	1	56.5	0.07	0.283
3.75 - 4.00	3	3	50.5	0.06	0.263
4.00 - 4.25	2	5	43.5	0.05	0.247
4.25 - 4.50	0	3	37.5	0.00	0.236
4.50 - 4.75	2	2	35.0	0.06	0.236
4.75 - 5.00	1	1	31.5	0.03	0.222
5.00 - 5.25	1	1	29.5	0.03	0.215
5.25 - 5.50	0	2	27.0	0.00	0.208
5.50 - 5.75	0	2	25.0	0.00	0.208
5.75 - 6.00	1	4	22.0	0.05	0.208
6.00 - 6.25	1	2	18.0	0.06	0.198
6.25 - 6.50	0	0	16.0	0.00	0.187
6.50 - 6.75	0	3	14.5	0.00	0.187
6.75 - 7.00	1	3	11.5	0.09	0.187
7.00 - 7.25	0	1	8.5	0.00	0.171
7.25 - 7.50	0	0	8.0	0.00	0.171
7.50 - 7.75	0	1	7.5	0.00	0.171
7.75 - 8.00	0	3	5.5	0.00	0.171
8.00 - 8.25	0	0	4.0	0.00	0.171
8.25 - 8.50	1	1	3.5	0.29	0.171
8.50 - 8.75	0	1	1.5	0.00	0.122
8.75 - 9.00	0	0	1.0	0.00	0.122
9.00 - 9.25	0	0	1.0	0.00	0.122
9.25 - 9.50	0	0	1.0	0.00	0.122
9.50 - .	1	0	1.0	1.00	0.122

Table 22. Life table survival estimates--Cooperator/dog event according to all strains and cooperators.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	816.0	0.00	1.000
0.25 - 0.50	91	21	805.5	0.11	1.000
0.50 - 0.75	87	22	693.0	0.13	0.887
0.75 - 1.00	65	13	588.5	0.11	0.776
1.00 - 1.25	67	23	505.5	0.13	0.690
1.25 - 1.50	38	18	418.0	0.09	0.599
1.50 - 1.75	42	22	360.0	0.12	0.544
1.75 - 2.00	36	9	302.5	0.12	0.481
2.00 - 2.25	24	14	255.0	0.09	0.423
2.25 - 2.50	17	4	222.0	0.08	0.384
2.50 - 2.75	11	17	194.5	0.06	0.354
2.75 - 3.00	15	8	171.0	0.09	0.334
3.00 - 3.25	19	5	149.5	0.13	0.305
3.25 - 3.50	4	4	126.0	0.03	0.266
3.50 - 3.75	13	5	117.5	0.11	0.258
3.75 - 4.00	5	5	99.5	0.05	0.229
4.00 - 4.25	5	10	87.0	0.06	0.218
4.25 - 4.50	1	4	75.0	0.01	0.205
4.50 - 4.75	5	7	68.5	0.07	0.202
4.75 - 5.00	1	1	59.5	0.02	0.188
5.00 - 5.25	1	2	57.0	0.02	0.185
5.25 - 5.50	2	2	54.0	0.04	0.181
5.50 - 5.75	0	3	49.5	0.00	0.175
5.75 - 6.00	2	7	44.5	0.04	0.175
6.00 - 6.25	1	2	38.0	0.03	0.167
6.25 - 6.50	0	1	35.5	0.00	0.162
6.50 - 6.75	0	4	33.0	0.00	0.162
6.75 - 7.00	1	4	29.0	0.03	0.162
7.00 - 7.25	4	2	25.0	0.16	0.157
7.25 - 7.50	1	0	20.0	0.05	0.132
7.50 - 7.75	0	4	17.0	0.00	0.125
7.75 - 8.00	0	4	13.0	0.00	0.125
8.00 - 8.25	0	0	11.0	0.00	0.125
8.25 - 8.50	1	1	10.5	0.10	0.125
8.50 - 8.75	0	3	7.5	0.00	0.113
8.75 - 9.00	0	1	5.5	0.00	0.113
9.00 - 9.25	0	2	4.0	0.00	0.113
9.25 - 9.50	1	0	3.0	0.33	0.113
9.50 - .	1	1	1.5	0.67	0.075

Table 23. Life table survival estimates--Cooperator/dog event according to strain, Anatolian.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	229.0	0.00	1.000
0.25 - 0.50	31	3	227.5	0.14	1.000
0.50 - 0.75	30	3	193.5	0.16	0.864
0.75 - 1.00	21	2	161.0	0.13	0.730
1.00 - 1.25	22	3	137.5	0.16	0.635
1.25 - 1.50	13	6	111.0	0.12	0.533
1.50 - 1.75	19	7	91.5	0.21	0.471
1.75 - 2.00	12	3	67.5	0.18	0.373
2.00 - 2.25	11	1	53.5	0.21	0.307
2.25 - 2.50	4	0	42.0	0.10	0.244
2.50 - 2.75	3	1	37.5	0.08	0.220
2.75 - 3.00	4	1	33.5	0.12	0.203
3.00 - 3.25	5	0	29.0	0.17	0.179
3.25 - 3.50	2	0	24.0	0.08	0.148
3.50 - 3.75	6	1	21.5	0.28	0.135
3.75 - 4.00	1	1	14.5	0.07	0.098
4.00 - 4.25	0	1	12.5	0.00	0.091
4.25 - 4.50	0	1	11.5	0.00	0.091
4.50 - 4.75	0	1	10.5	0.00	0.091
4.75 - 5.00	1	0	10.0	0.10	0.091
5.00 - 5.25	1	1	8.5	0.12	0.082
5.25 - 5.50	0	0	7.0	0.00	0.072
5.50 - 5.75	0	2	6.0	0.00	0.072
5.75 - 6.00	0	3	3.5	0.00	0.072
6.00 - 6.25	0	1	1.5	0.00	0.072
6.25 - 6.50	0	0	1.0	0.00	0.072
6.50 - 6.75	0	0	1.0	0.00	0.072
6.75 - 7.00	0	0	1.0	0.00	0.072
7.00 - 7.25	0	0	1.0	0.00	0.072
7.25 - 7.50	0	0	1.0	0.00	0.072
7.50 - 7.75	0	0	1.0	0.00	0.072
7.75 - .	0	1	0.5	0.00	0.072

Table 24. Life table survival estimates--Cooperator/dog event according to strain, Maremma.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	134.0	0.00	1.000
0.25 - 0.50	12	10	129.0	0.09	1.000
0.50 - 0.75	9	5	109.5	0.08	0.907
0.75 - 1.00	3	6	95.0	0.03	0.832
1.00 - 1.25	11	12	83.0	0.13	0.806
1.25 - 1.50	4	6	63.0	0.06	0.699
1.50 - 1.75	2	4	54.0	0.04	0.655
1.75 - 2.00	4	0	50.0	0.08	0.631
2.00 - 2.25	3	0	46.0	0.07	0.580
2.25 - 2.50	1	2	42.0	0.02	0.542
2.50 - 2.75	3	4	38.0	0.08	0.529
2.75 - 3.00	2	2	32.0	0.06	0.488
3.00 - 3.25	3	0	29.0	0.10	0.457
3.25 - 3.50	0	0	26.0	0.00	0.410
3.50 - 3.75	1	0	26.0	0.04	0.410
3.75 - 4.00	0	2	24.0	0.00	0.394
4.00 - 4.25	0	2	22.0	0.00	0.394
4.25 - 4.50	1	0	21.0	0.05	0.394
4.50 - 4.75	1	2	19.0	0.05	0.375
4.75 - 5.00	0	0	17.0	0.00	0.356
5.00 - 5.25	0	0	17.0	0.00	0.356
5.25 - 5.50	2	0	17.0	0.12	0.356
5.50 - 5.75	0	0	15.0	0.00	0.314
5.75 - 6.00	1	0	15.0	0.07	0.314
6.00 - 6.25	0	0	14.0	0.00	0.293
6.25 - 6.50	0	1	13.5	0.00	0.293
6.50 - 6.75	0	1	12.5	0.00	0.293
6.75 - 7.00	0	0	12.0	0.00	0.293
7.00 - 7.25	1	0	12.0	0.08	0.293
7.25 - 7.50	1	0	11.0	0.09	0.268
7.50 - 7.75	0	2	9.0	0.00	0.244
7.75 - 8.00	0	3	6.5	0.00	0.244
8.00 - 8.25	0	0	5.0	0.00	0.244
8.25 - 8.50	0	0	5.0	0.00	0.244
8.50 - 8.75	0	1	4.5	0.00	0.244
8.75 - 9.00	0	1	3.5	0.00	0.244
9.00 - 9.25	0	1	2.5	0.00	0.244
9.25 - 9.50	1	0	2.0	0.50	0.244
9.50 - .	1	0	1.0	1.00	0.122

Table 25. Life table survival estimates--Cooperator/dog event according to strain, Shar Planinetz.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	100.0	0.00	1.000
0.25 - 0.50	11	1	99.5	0.11	1.000
0.50 - 0.75	13	0	88.0	0.15	0.889
0.75 - 1.00	6	1	74.5	0.08	0.758
1.00 - 1.25	10	0	68.0	0.15	0.697
1.25 - 1.50	4	1	57.5	0.07	0.595
1.50 - 1.75	5	4	51.0	0.10	0.553
1.75 - 2.00	7	1	43.5	0.16	0.499
2.00 - 2.25	3	0	36.0	0.08	0.419
2.25 - 2.50	1	0	33.0	0.03	0.384
2.50 - 2.75	3	1	31.5	0.10	0.372
2.75 - 3.00	4	0	28.0	0.14	0.337
3.00 - 3.25	5	0	24.0	0.21	0.289
3.25 - 3.50	1	0	19.0	0.05	0.229
3.50 - 3.75	1	0	18.0	0.06	0.216
3.75 - 4.00	1	0	17.0	0.06	0.204
4.00 - 4.25	2	1	15.5	0.13	0.192
4.25 - 4.50	0	0	13.0	0.00	0.168
4.50 - 4.75	0	1	12.5	0.00	0.168
4.75 - 5.00	0	1	11.5	0.00	0.168
5.00 - 5.25	0	0	11.0	0.00	0.168
5.25 - 5.50	0	1	10.5	0.00	0.168
5.50 - 5.75	0	1	9.5	0.00	0.168
5.75 - 6.00	1	0	9.0	0.11	0.168
6.00 - 6.25	0	1	7.5	0.00	0.149
6.25 - 6.50	0	0	7.0	0.00	0.149
6.50 - 6.75	0	2	6.0	0.00	0.149
6.75 - 7.00	0	0	5.0	0.00	0.149
7.00 - 7.25	2	1	4.5	0.44	0.149
7.25 - 7.50	0	0	2.0	0.00	0.083
7.50 - 7.75	0	1	1.5	0.00	0.083
7.75 - 8.00	0	0	1.0	0.00	0.083
8.00 - 8.25	0	0	1.0	0.00	0.083
8.25 - 8.50	0	0	1.0	0.00	0.083
8.50 - 8.75	0	0	1.0	0.00	0.083
8.75 - 9.00	0	0	1.0	0.00	0.083
9.00 - .	0	1	0.5	0.00	0.083

Table 26. Life table survival estimates--Cooperator/dog event according to strain, Anatolian X Shar Planinetz.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	132.0	0.00	1.000
0.25 - 0.50	19	1	131.5	0.14	1.000
0.50 - 0.75	18	4	110.0	0.16	0.856
0.75 - 1.00	16	1	89.5	0.18	0.716
1.00 - 1.25	9	1	72.5	0.12	0.588
1.25 - 1.50	4	1	62.5	0.06	0.515
1.50 - 1.75	6	4	56.0	0.11	0.482
1.75 - 2.00	4	3	46.5	0.09	0.430
2.00 - 2.25	1	6	38.0	0.03	0.393
2.25 - 2.50	5	0	34.0	0.15	0.383
2.50 - 2.75	0	5	26.5	0.00	0.327
2.75 - 3.00	2	1	23.5	0.09	0.327
3.00 - 3.25	3	0	21.0	0.14	0.299
3.25 - 3.50	1	4	16.0	0.06	0.256
3.50 - 3.75	4	0	13.0	0.31	0.240
3.75 - 4.00	1	1	8.5	0.12	0.166
4.00 - 4.25	0	2	6.0	0.00	0.147
4.25 - 4.50	0	1	4.5	0.00	0.147
4.50 - 4.75	0	0	4.0	0.00	0.147
4.75 - 5.00	0	0	4.0	0.00	0.147
5.00 - 5.25	0	0	4.0	0.00	0.147
5.25 - 5.50	0	1	3.5	0.00	0.147
5.50 - 5.75	0	0	3.0	0.00	0.147
5.75 - 6.00	0	1	2.5	0.00	0.147
6.00 - 6.25	0	0	2.0	0.00	0.147
6.25 - 6.50	0	0	2.0	0.00	0.147
6.50 - 6.75	0	0	2.0	0.00	0.147
6.75 - 7.00	0	0	2.0	0.00	0.147
7.00 - 7.25	0	1	1.5	0.00	0.147
7.25 - 7.50	0	0	1.0	0.00	0.147
7.50 - .	0	1	0.5	0.00	0.147

Table 27. Life table survival estimates--Cooperator/dog event according to strain, Maremma X Shar Planinetz.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	137.0	0.00	1.000
0.25 - 0.50	14	0	137.0	0.10	1.000
0.50 - 0.75	10	3	121.5	0.08	0.898
0.75 - 1.00	9	1	109.5	0.08	0.824
1.00 - 1.25	10	3	98.5	0.10	0.756
1.25 - 1.50	8	4	85.0	0.09	0.679
1.50 - 1.75	5	3	73.5	0.07	0.616
1.75 - 2.00	8	2	66.0	0.12	0.574
2.00 - 2.25	5	5	54.5	0.09	0.504
2.25 - 2.50	4	0	47.0	0.09	0.458
2.50 - 2.75	2	1	42.5	0.05	0.419
2.75 - 3.00	3	4	38.0	0.08	0.399
3.00 - 3.25	3	1	32.5	0.09	0.368
3.25 - 3.50	0	0	29.0	0.00	0.334
3.50 - 3.75	1	2	28.0	0.04	0.334
3.75 - 4.00	2	1	25.5	0.08	0.322
4.00 - 4.25	3	0	23.0	0.13	0.297
4.25 - 4.50	0	1	19.5	0.00	0.258
4.50 - 4.75	3	1	18.5	0.16	0.258
4.75 - 5.00	0	0	15.0	0.00	0.216
5.00 - 5.25	0	1	14.5	0.00	0.216
5.25 - 5.50	0	0	14.0	0.00	0.216
5.50 - 5.75	0	0	14.0	0.00	0.216
5.75 - 6.00	0	1	13.5	0.00	0.216
6.00 - 6.25	1	0	13.0	0.08	0.216
6.25 - 6.50	0	0	12.0	0.00	0.199
6.50 - 6.75	0	1	11.5	0.00	0.199
6.75 - 7.00	1	4	9.0	0.11	0.199
7.00 - 7.25	1	0	6.0	0.17	0.177
7.25 - 7.50	0	0	5.0	0.00	0.148
7.50 - 7.75	0	0	5.0	0.00	0.148
7.75 - 8.00	0	0	5.0	0.00	0.148
8.00 - 8.25	0	0	5.0	0.00	0.148
8.25 - 8.50	1	1	4.5	0.22	0.148
8.50 - 8.75	0	2	2.0	0.00	0.115
8.75 - 9.00	0	0	1.0	0.00	0.115
9.00 - 9.25	0	0	1.0	0.00	0.115
9.25 - 9.50	0	0	1.0	0.00	0.115
9.50 - .	0	1	0.5	0.00	0.115

Table 28. Life table survival estimates--Cooperator/dog event according to strain, Anatolian X Maremma X Shar Planinetz.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	84.0	0.00	1.000
0.25 - 0.50	4	6	81.0	0.05	1.000
0.50 - 0.75	7	7	70.5	0.10	0.951
0.75 - 1.00	10	2	59.0	0.17	0.856
1.00 - 1.25	5	4	46.0	0.11	0.711
1.25 - 1.50	5	0	39.0	0.13	0.634
1.50 - 1.75	5	0	34.0	0.15	0.553
1.75 - 2.00	1	0	29.0	0.03	0.471
2.00 - 2.25	1	2	27.0	0.04	0.455
2.25 - 2.50	2	2	24.0	0.08	0.438
2.50 - 2.75	0	5	18.5	0.00	0.402
2.75 - 3.00	0	0	16.0	0.00	0.402
3.00 - 3.25	0	4	14.0	0.00	0.402
3.25 - 3.50	0	0	12.0	0.00	0.402
3.50 - 3.75	0	2	11.0	0.00	0.402
3.75 - 4.00	0	0	10.0	0.00	0.402
4.00 - 4.25	0	4	8.0	0.00	0.402
4.25 - 4.50	0	1	5.5	0.00	0.402
4.50 - 4.75	1	2	4.0	0.25	0.402
4.75 - 5.00	0	0	2.0	0.00	0.301
5.00 - 5.25	0	0	2.0	0.00	0.301
5.25 - 5.50	0	0	2.0	0.00	0.301
5.50 - 5.75	0	0	2.0	0.00	0.301
5.75 - .	0	2	1.0	0.00	0.301

Table 29. Life table survival estimates--Cooperator/dog event according to flock size, 25 - 99.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	214.0	0.00	1.000
0.25 - 0.50	19	1	213.5	0.09	1.000
0.50 - 0.75	23	4	192.0	0.12	0.911
0.75 - 1.00	21	2	166.0	0.13	0.802
1.00 - 1.25	20	9	139.5	0.14	0.700
1.25 - 1.50	6	7	111.5	0.05	0.600
1.50 - 1.75	12	2	101.0	0.12	0.568
1.75 - 2.00	13	1	87.5	0.15	0.500
2.00 - 2.25	5	4	72.0	0.07	0.426
2.25 - 2.50	4	3	63.5	0.06	0.396
2.50 - 2.75	4	4	56.0	0.07	0.371
2.75 - 3.00	1	2	49.0	0.02	0.345
3.00 - 3.25	8	1	46.5	0.17	0.338
3.25 - 3.50	1	2	37.0	0.03	0.280
3.50 - 3.75	8	0	35.0	0.23	0.272
3.75 - 4.00	2	1	26.5	0.08	0.210
4.00 - 4.25	1	1	23.5	0.04	0.194
4.25 - 4.50	1	0	22.0	0.05	0.186
4.50 - 4.75	1	1	20.5	0.05	0.177
4.75 - 5.00	0	1	18.5	0.00	0.169
5.00 - 5.25	0	1	17.5	0.00	0.169
5.25 - 5.50	0	0	17.0	0.00	0.169
5.50 - 5.75	0	1	16.5	0.00	0.169
5.75 - 6.00	1	5	13.5	0.07	0.169
6.00 - 6.25	0	1	9.5	0.00	0.156
6.25 - 6.50	0	1	8.5	0.00	0.156
6.50 - 6.75	0	1	7.5	0.00	0.156
6.75 - 7.00	0	0	7.0	0.00	0.156
7.00 - 7.25	0	1	6.5	0.00	0.156
7.25 - 7.50	1	0	6.0	0.17	0.156
7.50 - 7.75	0	0	5.0	0.00	0.130
7.75 - 8.00	0	2	4.0	0.00	0.130
8.00 - 8.25	0	0	3.0	0.00	0.130
8.25 - 8.50	0	0	3.0	0.00	0.130
8.50 - 8.75	0	1	2.5	0.00	0.130
8.75 - 9.00	0	0	2.0	0.00	0.130
9.00 - 9.25	0	1	1.5	0.00	0.130
9.25 - .	1	0	1.0	1.00	0.130

Table 30. Life table survival estimates--Cooperator/dog event according to flock size, 100 - 499.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	281.0	0.00	1.000
0.25 - 0.50	25	1	280.5	0.09	1.000
0.50 - 0.75	21	7	251.5	0.08	0.911
0.75 - 1.00	13	2	226.0	0.06	0.835
1.00 - 1.25	26	6	209.0	0.12	0.787
1.25 - 1.50	12	7	176.5	0.07	0.689
1.50 - 1.75	16	10	156.0	0.10	0.642
1.75 - 2.00	11	3	133.5	0.08	0.576
2.00 - 2.25	9	7	117.5	0.08	0.529
2.25 - 2.50	10	1	104.5	0.10	0.488
2.50 - 2.75	6	6	91.0	0.07	0.442
2.75 - 3.00	7	5	79.5	0.09	0.412
3.00 - 3.25	5	3	68.5	0.07	0.376
3.25 - 3.50	3	2	61.0	0.05	0.349
3.50 - 3.75	4	3	55.5	0.07	0.332
3.75 - 4.00	2	3	48.5	0.04	0.308
4.00 - 4.25	1	6	42.0	0.02	0.295
4.25 - 4.50	0	2	37.0	0.00	0.288
4.50 - 4.75	3	3	34.5	0.09	0.288
4.75 - 5.00	1	0	30.0	0.03	0.263
5.00 - 5.25	1	1	28.5	0.04	0.254
5.25 - 5.50	2	1	26.5	0.08	0.245
5.50 - 5.75	0	1	23.5	0.00	0.227
5.75 - 6.00	0	2	22.0	0.00	0.227
6.00 - 6.25	1	1	20.5	0.05	0.227
6.25 - 6.50	0	0	19.0	0.00	0.216
6.50 - 6.75	0	2	18.0	0.00	0.216
6.75 - 7.00	1	4	15.0	0.07	0.216
7.00 - 7.25	2	0	12.0	0.17	0.201
7.25 - 7.50	0	0	10.0	0.00	0.167
7.50 - 7.75	0	3	8.5	0.00	0.167
7.75 - 8.00	0	1	6.5	0.00	0.167
8.00 - 8.25	0	0	6.0	0.00	0.167
8.25 - 8.50	0	1	5.5	0.00	0.167
8.50 - 8.75	0	1	4.5	0.00	0.167
8.75 - 9.00	0	1	3.5	0.00	0.167
9.00 - 9.25	0	1	2.5	0.00	0.167
9.25 - 9.50	0	0	2.0	0.00	0.167
9.50 - .	1	1	1.5	0.67	0.167

Table 31. Life table survival estimates--Cooperator/dog event according to flock size, 500 - 999.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	82.0	0.00	1.000
0.25 - 0.50	9	2	81.0	0.11	1.000
0.50 - 0.75	8	2	70.0	0.11	0.889
0.75 - 1.00	6	4	59.0	0.10	0.787
1.00 - 1.25	1	1	50.5	0.02	0.707
1.25 - 1.50	5	2	48.0	0.10	0.693
1.50 - 1.75	3	4	40.0	0.08	0.621
1.75 - 2.00	5	2	34.0	0.15	0.574
2.00 - 2.25	2	2	27.0	0.07	0.490
2.25 - 2.50	0	0	24.0	0.00	0.454
2.50 - 2.75	0	2	23.0	0.00	0.454
2.75 - 3.00	2	1	21.5	0.09	0.454
3.00 - 3.25	5	1	18.5	0.27	0.412
3.25 - 3.50	0	0	13.0	0.00	0.300
3.50 - 3.75	0	0	13.0	0.00	0.300
3.75 - 4.00	0	1	12.5	0.00	0.300
4.00 - 4.25	2	2	11.0	0.18	0.300
4.25 - 4.50	0	0	8.0	0.00	0.246
4.50 - 4.75	0	1	7.5	0.00	0.246
4.75 - 5.00	0	0	7.0	0.00	0.246
5.00 - 5.25	0	0	7.0	0.00	0.246
5.25 - 5.50	0	1	6.5	0.00	0.246
5.50 - 5.75	0	1	5.5	0.00	0.246
5.75 - 6.00	0	0	5.0	0.00	0.246
6.00 - 6.25	0	0	5.0	0.00	0.246
6.25 - 6.50	0	0	5.0	0.00	0.246
6.50 - 6.75	0	0	5.0	0.00	0.246
6.75 - 7.00	0	0	5.0	0.00	0.246
7.00 - 7.25	2	0	5.0	0.40	0.246
7.25 - 7.50	0	0	3.0	0.00	0.147
7.50 - 7.75	0	0	3.0	0.00	0.147
7.75 - 8.00	0	1	2.5	0.00	0.147
8.00 - 8.25	0	0	2.0	0.00	0.147
8.25 - 8.50	1	0	2.0	0.50	0.147
8.50 - .	0	1	0.5	0.00	0.074

Table 32. Life table survival estimates--Cooperator/dog event according to flock size, $\geq$ 1000.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	97.0	0.00	1.000
0.25 - 0.50	20	1	96.5	0.21	1.000
0.50 - 0.75	15	2	75.0	0.20	0.793
0.75 - 1.00	11	2	58.0	0.19	0.634
1.00 - 1.25	6	2	45.0	0.13	0.514
1.25 - 1.50	4	0	38.0	0.11	0.445
1.50 - 1.75	6	0	34.0	0.18	0.399
1.75 - 2.00	4	0	28.0	0.14	0.328
2.00 - 2.25	3	0	24.0	0.13	0.281
2.25 - 2.50	2	0	21.0	0.10	0.246
2.50 - 2.75	1	2	18.0	0.06	0.223
2.75 - 3.00	2	0	16.0	0.13	0.210
3.00 - 3.25	2	0	14.0	0.14	0.184
3.25 - 3.50	0	0	12.0	0.00	0.158
3.50 - 3.75	1	0	12.0	0.08	0.158
3.75 - 4.00	1	0	11.0	0.09	0.145
4.00 - 4.25	1	0	10.0	0.10	0.132
4.25 - 4.50	0	1	8.5	0.00	0.118
4.50 - 4.75	1	2	7.0	0.14	0.118
4.75 - 5.00	0	0	5.0	0.00	0.101
5.00 - 5.25	0	0	5.0	0.00	0.101
5.25 - 5.50	0	0	5.0	0.00	0.101
5.50 - 5.75	0	0	5.0	0.00	0.101
5.75 - 6.00	1	1	4.5	0.22	0.101
6.00 - 6.25	0	0	3.0	0.00	0.079
6.25 - 6.50	0	0	3.0	0.00	0.079
6.50 - 6.75	0	1	2.5	0.00	0.079
6.75 - 7.00	0	0	2.0	0.00	0.079
7.00 - 7.25	0	1	1.5	0.00	0.079
7.25 - 7.50	0	0	1.0	0.00	0.079
7.50 - .	0	1	0.5	0.00	0.079

Table 33. Life table survival estimates--Cooperator/dog event according to ecoregion, Warm Continental.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	129.0	0.00	1.000
0.25 - 0.50	14	4	127.0	0.11	1.000
0.50 - 0.75	11	2	110.0	0.10	0.890
0.75 - 1.00	10	0	98.0	0.10	0.801
1.00 - 1.25	14	1	87.5	0.16	0.719
1.25 - 1.50	8	4	71.0	0.11	0.604
1.50 - 1.75	6	1	60.5	0.10	0.536
1.75 - 2.00	5	2	53.0	0.09	0.483
2.00 - 2.25	4	1	46.5	0.09	0.437
2.25 - 2.50	1	0	42.0	0.02	0.400
2.50 - 2.75	3	2	40.0	0.08	0.390
2.75 - 3.00	3	1	35.5	0.08	0.361
3.00 - 3.25	5	0	32.0	0.16	0.330
3.25 - 3.50	0	2	26.0	0.00	0.279
3.50 - 3.75	7	0	25.0	0.28	0.279
3.75 - 4.00	1	0	18.0	0.06	0.201
4.00 - 4.25	1	0	17.0	0.06	0.190
4.25 - 4.50	1	0	16.0	0.06	0.178
4.50 - 4.75	1	1	14.5	0.07	0.167
4.75 - 5.00	0	1	12.5	0.00	0.156
5.00 - 5.25	0	0	12.0	0.00	0.156
5.25 - 5.50	1	0	12.0	0.08	0.156
5.50 - 5.75	0	0	11.0	0.00	0.143
5.75 - 6.00	1	0	11.0	0.09	0.143
6.00 - 6.25	0	2	9.0	0.00	0.130
6.25 - 6.50	0	0	8.0	0.00	0.130
6.50 - 6.75	0	0	8.0	0.00	0.130
6.75 - 7.00	0	0	8.0	0.00	0.130
7.00 - 7.25	2	1	7.5	0.27	0.130
7.25 - 7.50	1	0	5.0	0.20	0.095
7.50 - 7.75	0	0	4.0	0.00	0.076
7.75 - 8.00	0	0	4.0	0.00	0.076
8.00 - 8.25	0	0	4.0	0.00	0.076
8.25 - 8.50	0	0	4.0	0.00	0.076
8.50 - 8.75	0	1	3.5	0.00	0.076
8.75 - 9.00	0	0	3.0	0.00	0.076
9.00 - 9.25	0	1	2.5	0.00	0.076
9.25 - 9.50	1	0	2.0	0.50	0.076
9.50 - .	1	0	1.0	1.00	0.038

Table 34. Life table survival estimates--Cooperator/dog event according to ecoregion, Hot Continental.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	181.0	0.00	1.000
0.25 - 0.50	15	11	175.5	0.09	1.000
0.50 - 0.75	18	2	154.0	0.12	0.915
0.75 - 1.00	10	3	133.5	0.07	0.808
1.00 - 1.25	18	9	117.5	0.15	0.747
1.25 - 1.50	9	2	94.0	0.10	0.633
1.50 - 1.75	8	7	80.5	0.10	0.572
1.75 - 2.00	8	1	68.5	0.12	0.515
2.00 - 2.25	4	1	59.5	0.07	0.455
2.25 - 2.50	5	1	54.5	0.09	0.425
2.50 - 2.75	1	2	48.0	0.02	0.386
2.75 - 3.00	2	1	45.5	0.04	0.378
3.00 - 3.25	4	0	43.0	0.09	0.361
3.25 - 3.50	2	2	38.0	0.05	0.327
3.50 - 3.75	2	4	33.0	0.06	0.310
3.75 - 4.00	1	0	29.0	0.03	0.291
4.00 - 4.25	0	7	24.5	0.00	0.281
4.25 - 4.50	0	0	21.0	0.00	0.281
4.50 - 4.75	1	0	21.0	0.05	0.281
4.75 - 5.00	0	0	20.0	0.00	0.268
5.00 - 5.25	0	1	19.5	0.00	0.268
5.25 - 5.50	1	0	19.0	0.05	0.268
5.50 - 5.75	0	2	17.0	0.00	0.254
5.75 - 6.00	0	3	14.5	0.00	0.254
6.00 - 6.25	0	0	13.0	0.00	0.254
6.25 - 6.50	0	0	13.0	0.00	0.254
6.50 - 6.75	0	1	12.5	0.00	0.254
6.75 - 7.00	0	0	12.0	0.00	0.254
7.00 - 7.25	2	0	12.0	0.17	0.254
7.25 - 7.50	0	0	10.0	0.00	0.212
7.50 - 7.75	0	3	8.5	0.00	0.212
7.75 - 8.00	0	3	5.5	0.00	0.212
8.00 - 8.25	0	0	4.0	0.00	0.212
8.25 - 8.50	1	0	4.0	0.25	0.212
8.50 - 8.75	0	1	2.5	0.00	0.159
8.75 - 9.00	0	1	1.5	0.00	0.159
9.00 - .	0	1	0.5	0.00	0.159

Table 35. Life table survival estimates--Cooperator/dog event according to ecoregion, Prairie.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	145.0	0.00	1.000
0.25 - 0.50	19	3	143.5	0.13	1.000
0.50 - 0.75	14	6	120.0	0.12	0.868
0.75 - 1.00	11	5	100.5	0.11	0.766
1.00 - 1.25	12	4	85.0	0.14	0.683
1.25 - 1.50	8	2	70.0	0.11	0.586
1.50 - 1.75	11	8	57.0	0.19	0.519
1.75 - 2.00	4	3	40.5	0.10	0.419
2.00 - 2.25	4	4	33.0	0.12	0.378
2.25 - 2.50	3	0	27.0	0.11	0.332
2.50 - 2.75	2	0	24.0	0.08	0.295
2.75 - 3.00	3	0	22.0	0.14	0.270
3.00 - 3.25	2	0	19.0	0.11	0.234
3.25 - 3.50	1	0	17.0	0.06	0.209
3.50 - 3.75	2	1	15.5	0.13	0.197
3.75 - 4.00	2	1	12.5	0.16	0.171
4.00 - 4.25	0	0	10.0	0.00	0.144
4.25 - 4.50	0	0	10.0	0.00	0.144
4.50 - 4.75	1	1	9.5	0.11	0.144
4.75 - 5.00	1	0	8.0	0.13	0.129
5.00 - 5.25	1	0	7.0	0.14	0.113
5.25 - 5.50	0	1	5.5	0.00	0.097
5.50 - 5.75	0	1	4.5	0.00	0.097
5.75 - 6.00	0	2	3.0	0.00	0.097
6.00 - 6.25	0	0	2.0	0.00	0.097
6.25 - 6.50	0	0	2.0	0.00	0.097
6.50 - 6.75	0	1	1.5	0.00	0.097
6.75 - .	0	1	0.5	0.00	0.097

Table 36. Life table survival estimates--Cooperator/dog event according to ecoregion, Steppe.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	240.0	0.00	1.000
0.25 - 0.50	29	2	239.0	0.12	1.000
0.50 - 0.75	26	9	204.5	0.13	0.879
0.75 - 1.00	22	2	173.0	0.13	0.767
1.00 - 1.25	16	3	148.5	0.11	0.670
1.25 - 1.50	12	4	129.0	0.09	0.597
1.50 - 1.75	12	3	113.5	0.11	0.542
1.75 - 2.00	17	1	99.5	0.17	0.485
2.00 - 2.25	10	3	80.5	0.12	0.402
2.25 - 2.50	6	0	69.0	0.09	0.352
2.50 - 2.75	4	6	60.0	0.07	0.321
2.75 - 3.00	4	5	50.5	0.08	0.300
3.00 - 3.25	7	2	43.0	0.16	0.276
3.25 - 3.50	0	0	35.0	0.00	0.231
3.50 - 3.75	1	0	35.0	0.03	0.231
3.75 - 4.00	0	4	32.0	0.00	0.225
4.00 - 4.25	4	2	29.0	0.14	0.225
4.25 - 4.50	0	3	22.5	0.00	0.194
4.50 - 4.75	2	4	19.0	0.11	0.194
4.75 - 5.00	0	0	15.0	0.00	0.173
5.00 - 5.25	0	0	15.0	0.00	0.173
5.25 - 5.50	0	1	14.5	0.00	0.173
5.50 - 5.75	0	0	14.0	0.00	0.173
5.75 - 6.00	1	2	13.0	0.08	0.173
6.00 - 6.25	0	0	11.0	0.00	0.160
6.25 - 6.50	0	0	11.0	0.00	0.160
6.50 - 6.75	0	2	10.0	0.00	0.160
6.75 - 7.00	1	2	8.0	0.13	0.160
7.00 - 7.25	0	1	5.5	0.00	0.140
7.25 - 7.50	0	0	5.0	0.00	0.140
7.50 - 7.75	0	1	4.5	0.00	0.140
7.75 - 8.00	0	1	3.5	0.00	0.140
8.00 - 8.25	0	0	3.0	0.00	0.140
8.25 - 8.50	0	1	2.5	0.00	0.140
8.50 - 8.75	0	1	1.5	0.00	0.140
8.75 - 9.00	0	0	1.0	0.00	0.140
9.00 - 9.25	0	0	1.0	0.00	0.140
9.25 - 9.50	0	0	1.0	0.00	0.140
9.5 - .	0	1	0.5	0.00	0.140

Table 37. Life table survival estimates--Cooperator/dog event according to ecoregion, Marine.

Age Interval	Number Failed	Number Censored	Effective Sample Size	Conditional Probability of Failure	Estimate Survival
0 - 0.25	0	0	103.00	0.00	1.000
0.25 - 0.50	11	1	102.50	0.11	1.000
0.50 - 0.75	16	3	89.50	0.18	0.893
0.75 - 1.00	8	3	70.50	0.11	0.733
1.00 - 1.25	6	5	58.50	0.10	0.650
1.25 - 1.50	1	6	47.00	0.02	0.583
1.50 - 1.75	4	3	41.50	0.10	0.571
1.75 - 2.00	1	2	35.00	0.03	0.516
2.00 - 2.25	1	5	30.50	0.03	0.501
2.25 - 2.50	1	3	25.50	0.04	0.485
2.50 - 2.75	1	7	19.50	0.05	0.466
2.75 - 3.00	2	1	14.50	0.14	0.442
3.00 - 3.25	1	3	10.50	0.01	0.381
3.25 - 3.50	1	0	8.00	0.13	0.345
3.50 - 3.75	1	0	7.00	0.14	0.302
3.75 - 4.00	1	0	6.00	0.17	0.258
4.00 - 4.25	0	0	5.00	0.00	0.215
4.25 - 4.50	0	0	5.00	0.00	0.215
4.50 - 4.75	0	1	4.50	0.00	0.215
4.75 - 5.00	0	0	4.00	0.00	0.215
5.00 - 5.25	0	1	3.50	0.00	0.215
5.25 - 5.50	0	0	3.00	0.00	0.215
5.50 - 5.75	0	0	3.00	0.00	0.215
5.75 - 6.00	0	0	3.00	0.00	0.215
6.00 - 6.25	1	0	3.00	0.33	0.215
6.25 - 6.50	0	1	1.50	0.00	0.144
6.50 - 6.75	0	0	1.00	0.00	0.144
6.75 - .	0	1	0.50	0.00	0.144