Southwestern Geographer
Vol.4, 2000, pp 30-53

The Diffusion of Exotic-Animal Ranching in Texas

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Since their first major introduction into Texas in the 1920s, exotic animals have become a major rural economic activity in the state. From early ranches in Kenedy and Kerr counties, foreign herds have diffused to selected areas of the state in a somewhat regular geographical pattern. Mapping data from six separate surveys of Texas Parks and Wildlife, we detected that early adoption of this innovation tended to be "hierarchical," while adoption since the 1950s has appeared to be "contagious" with a filling-in effect, especially in Kerr County. Reasons for and implications of this particular spread pattern are discussed. In particular, we evaluate the economic ramifications for Texas ranchers and conservation issues, given that fully one-third of the exotic animals in Texas is now free-ranging. *Keywords: exotic animal ranching, diffusion, Texas.*

Introduction

Exotic animal ranching has become "big time" in rural Texas. The introduction and diffusion of dozens of large-hoofed grazing species since the 1920s have produced several well-established animals today (Figures 1 and 2). Tens of thousands of axis deer (*Cervus axis*), sika deer (*Cervus nippon*), Indian blackbuck antelope (*Antelope cervicapra*), nilgai or blue bull antelope (*Boselaphus tragocamelus Pallus*), aoudad or Barbary sheep (*Ammotragus lervia*), and wild boar or feral pig

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(*Sus scrofa*) graze on large ranches and range free in more than half of the counties of Texas (Figure 3). Some of these new exotics, such as the nilgai antelope from Pakistan, have since been used for reintroduction in their native countries where they had become extinct (Mungall and Sheffield 1994). Fee-hunting and trophy-hunting ranchers make money year round for exotic animal has no seasons. Fenced-in herds, and especially free-ranging animals, have grown dramatically while professional wildlife managers and preservationists voice concern over how the increasing numbers of large exotic animals in Texas may threaten native plant and animal species (Armstrong and Harmel 1981). The "exotic" has become mundane.

This paper examines the spatial-temporal spread of exotic-animal ranching in the context of innovation diffusion processes. Several biological studies have examined exotic animals in Texas (Mungall and Sheffield 1994), yet it appears that no geographic research has traced the spread of this increasingly important part of the Texas environment and rural economy. In order to examine the historic diffusion trends of exotic-animal ranches, we meticulously reconstructed and amended information on the location and year of establishment of ranches with data from the Texas Parks and Wildlife Department (TPWD) animal censuses, earlier historical records and interviews. Mapping this data in order to gain insight on the growth of exotic ranches over time, the research addressed three related questions: What are the historic patterns of the diffusion of exotic-animal ranches in Texas? Who and where were the innovators and adopters? What factors facilitated and prevented adoption of this innovation?

Since their early introduction into Texas, exotics have been raised so successfully that they once were referred to as "Texotics". In fact, exotic-animal ranching in the United States started in Texas, the state that remains the center of the exotic-animal trade (Schreiner et al. 1987; McCorkle 1991). Texotics have increased so rapidly over the past few

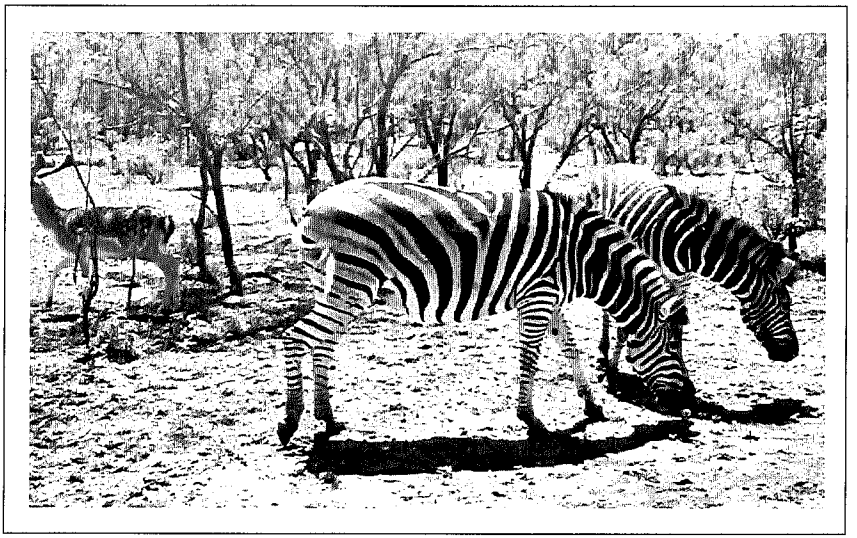

Figure 1. Common zebra (*Equus burchellii*) are commonly stocked on exotic-animal ranches in Texas.

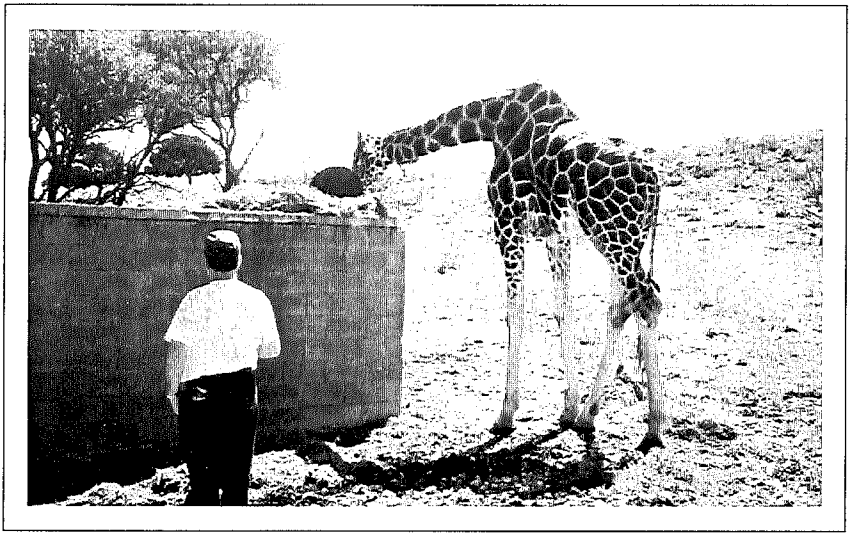

Figure 2. Giraffe (*Giraffa camelopardalis*) attract many visitors to "drive-thru" animal parks on the Edwards Plateau.

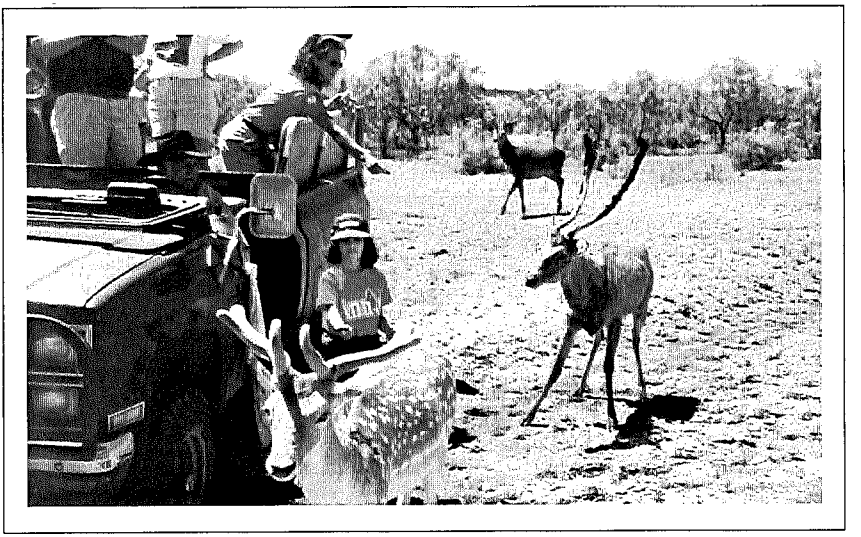

Figure 3. Axis deer (*Cervus axis*) and sika deer (*Cervus nippon*) are amenable to handouts and tolerate visitor contact.

decades that the TPWD, concerned with the proliferation of free-ranging exotic animals, has conducted periodic censuses of the state. The first, in 1963, found 13 species of exotic animals and approximately 13,000 animals (Jackson 1964). A follow-up study in 1994 showed an increase to 124 species and over 195,000 animals.[1] Exotic animals undoubtedly are in Texas to stay. It is imperative to understand how and where they became established and where they have since flourished.

Our study of the diffusion of exotic-animal ranches limits the definition of exotics to the large, hoofed foreign-imported animals, sometimes referred to as "exotic hoofstock" (Fohn 1996). This allows us to use exotic animal census data that were limited to artiodactyls, even-toed hoofed mammals such as deer, buffalo, sheep, goats, antelopes, and pigs, prior to 1984. We have excluded the larger, quite popular, birds such as the emu (*Dromaius novaehollandiae*) and ostrich (*Struthio camelus*)

[1] Note: Fifty-one ranches refused to participate in this last study, but wildlife biologists and managers estimate another 5,000 -15,000 exotics exist on these ranches (Traweek 1996).

because they have diffused very rapidly, largely due to "get-rich-quick" schemes. These birds have diffused in a different fashion and to different ranches than those that are the focus of this study. Since the bottom dropped out of the emu market a few years ago, banks have gone so far as to give the birds away to ranches (Jones 2000). Llamas (*Lama glama*), which also are not considered wild game or trophy animals, have likewise been excluded from the study.

Expert wildlife biologists support our definition of exotic-animal animals. Traweek and Welch (1992) identified exotic animals as the medium-to-large non-indigenous or non-native mammals introduced onto Texas ranches. Ramsey (1994) contends that foreign introductions are exotics in their new environment and may include species brought into bioregions where they used to occur but are no longer present naturally. One such example is the extinct species of wapiti or American elk, *Cervus merriami*, which inhabited the plains of West Texas. The elk has been reintroduced from the Black Hills of South Dakota, and *Cervus elaphus Erxleben* is expanding in the Guadalupe Mountains and Trans Pecos regions. The practice of introducing exotic animals onto Texas ranches has been commonplace since the early decades of the 20th century. The American bison (*Bison bison*), once commonly seen in Texas but later eradicated, was reintroduced as an exotic species on a Texas ranch as early as 1915. In our study we include ranches with once-native reintroductions, mainly because they are raised as "exotics" along with the African and Asian species on larger Texas ranches.

Exotic-Animal Ranching as an Innovation

Decades are needed to truly understand the diffusion of an innovation such as exotic-animal ranching. Unlike market or technological innovations, the adoption process for exotic ranch animals is not unduly affected by mass media or marketing strategies, but is limited by a natural reproduction rate

inherent in all living things. Even in native habitats there are few examples of species that reproduce to fill their natural niche in short time periods. The large species that are the subject of this research are all animals bound by slower reproduction, with the added burden of being thrust into an alien environment. This makes this analysis of the adoption and subsequent spread of exotic animals in Texas a long, but remarkable story within the literature on the spatial diffusion of innovations.

Since the first major introduction of exotic animals into Texas in the 1920s, exotic-animal ranching has grown significantly. The spread of exotic-animal ranches can perhaps be better understood in the context of the three stages of spatial diffusion introduced to Geography by Hagerstrand (Brown 1981) with the logistic or S-shaped curve popularized through Ryan and Gross's (1943) study of the diffusion of hybrid corn in Iowa.

Diffusion processes start slowly with a few special "hierarchical" persons or places (perhaps those better educated or connected) taking on the innovation (Figure 4). During this initial stage, the innovation is adopted first at a higher level; it then diffuses down to the next lower level, and so on. For example, among U.S. cities, an innovation may first be adopted in a large urban center, and later will diffuse down to smaller-sized cities. The second stage of diffusion involves contagion or the neighborhood effect: this is a people-to-people, place-to-place spread outward in a wave-like fashion from the center. The final stage moves toward saturation of an area. It involves filling in and can appear to be a spatially random process. The pace of adoption will resemble a logistic curve when graphed, having gone through an innovation period (when adoption reaches 10-25%), and then an adoption stage (when the largest number of adoptions occur), and finally a saturation stage (Rogers 1983). Many, though not all diffusion processes, follow these generalized stages, for innovation diffusion is a complex process, in part dependent upon the nature of the specific innovation.

This study suggests that the diffusion of exotic-animal ranching

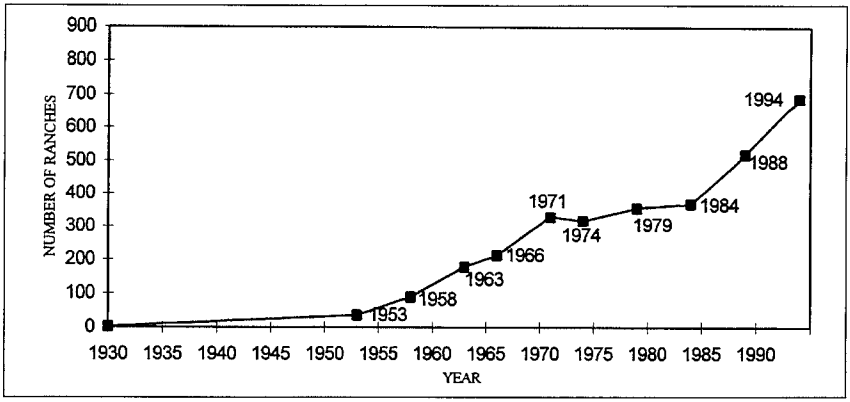

Figure 4. The idealized diffusion curve demonstrates the stages of change over time.

incorporates all three stages of diffusion outlined by Hagerstrand (1953). The innovators in Texas were wealthy and influential landowners. The next level of adopters had close ties with the innovators, receiving their initial stock of exotics as gifts (Mungall and Sheffield 1994). Progressively there was contagious spread where ranchers developed exotic herds, after observing their neighbors. This "expansion" (mainly contagious) phase was aided by the natural dispersion of exotic animals themselves. In some instances, nature played a role in the diffusion by providing opportunities for animals to escape confinement, sometimes slipping through water gaps in fencing caused by flooded streambeds (Mungall and Sheffield 1994). The sale of animals for broodstock and the financial opportunities afforded by trophy and for-profit hunting fueled later expansion. The final diffusion stage, saturation, perhaps is yet to come. Let us take an in-depth look into this diffusion process.

Spatial Patterns of Diffusion

The Initial Stage: 1920s – 1953

The period between the 1920s and 1953 can be considered the

initial period for exotic-animal ranching in Texas (Figure 5). The motivations of ranchers in this early period, the onset of innovation, were markedly different from later times. The diffusion process was hierarchical and related to the social network of the innovators. The initial innovators were ranchers with considerable wealth, property and personal connections (Table 1). Exotic animals were kept mainly for their aesthetic appeal, and like prize cattle, as status symbols.

The first known innovator to introduce foreign exotics on a Texas ranch was Cesar Kleberg, owner of the King Ranch, located in Kenedy County in the South Texas Plains ecological region (Figure 6). There are two stories about how the King Ranch obtained its first nilgai antelopes sometime in the 1920s. One version of the story indicates that the first group of animals introduced on the ranch was purchased from a bankrupt traveling circus around 1929-30 (Mungall and Sheffield 1994). The second, and more likely, story was that around 1924 Kleberg used his personal connections with the San Diego Zoo to purchase surplus animals (Cameron 1992). This is a reasonable scenario, considering that federal law required that most exotic animals, whether released on Texas ranches or elsewhere in the United States, be the offspring of animals

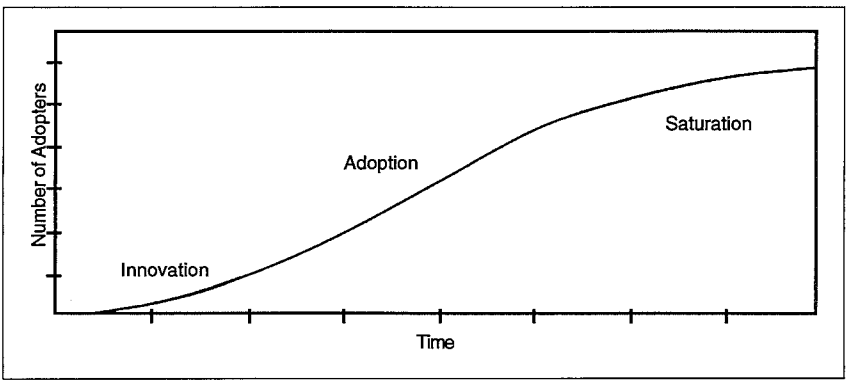

Figure 5. The number of exotic game ranches in Texas from 1930 to 1994.

Table 1. First known releases of selected exotic animals in Texas, 1924-60.

Animal	Year	Innovator	Place and Ecological Region
Nilgai antelope	Sometime between 1924 and 1929	Caesar Kleberg, King Ranch	Norias Division, Kenedy Co. South Texas Plains
Wild Boar	1930	Leroy Denman, Sr., Saint Charles	Blackjack Peninsula, Aransas Co. Gulf Prairies and Marshes
Fallow deer	1930	Leroy Denman, Sr., Saint Charles	Blackjack Peninsula, Aransas Co. Gulf Prairies and Marches
Axis deer	1932	Richard Friedrich, Bear Creek Ranch	Kerr Co. Edwards Plateau
Blackbuck antelope	1932	Richard Friedrich, Bear Creek Ranch	Kerr Co. Edwards Plateau
Eland	1932	Richard Friedrich, Bear Creek Ranch	Kerr Co. Edwards Plateau
Sambar	1932	Richard Friedrich, Bear Creek Ranch	Kerr Co. Edwards Plateau
Sika deer (Japanese)	1932	Richard Friedrich, Bear Creek Ranch	Kerr Co. Edwards Plateau
Red deer	1930s or 1940s	Richard Friedrich, Bear Creek Ranch	Kerr Co. Edwards Plateau
Barasingha	1939 or early 1940s	Richard Friedrich, Bear Creek Ranch	Kerr Co. Edwards Plateau
Mouflon	1946	Mark A. Moss, Moss Ranch	Llano, Llano Co. Edwards Plateau
Aoudad	1950	--	Blanco Co., Edwards Plateau & Titus Co., Post Oak Savannah
Beisa oryx	1960	Bert Wheeler, Camp Cooley Ranch	Robertson Co. Post Oak Savannah

Source: Mungall and Sheffield 1994.

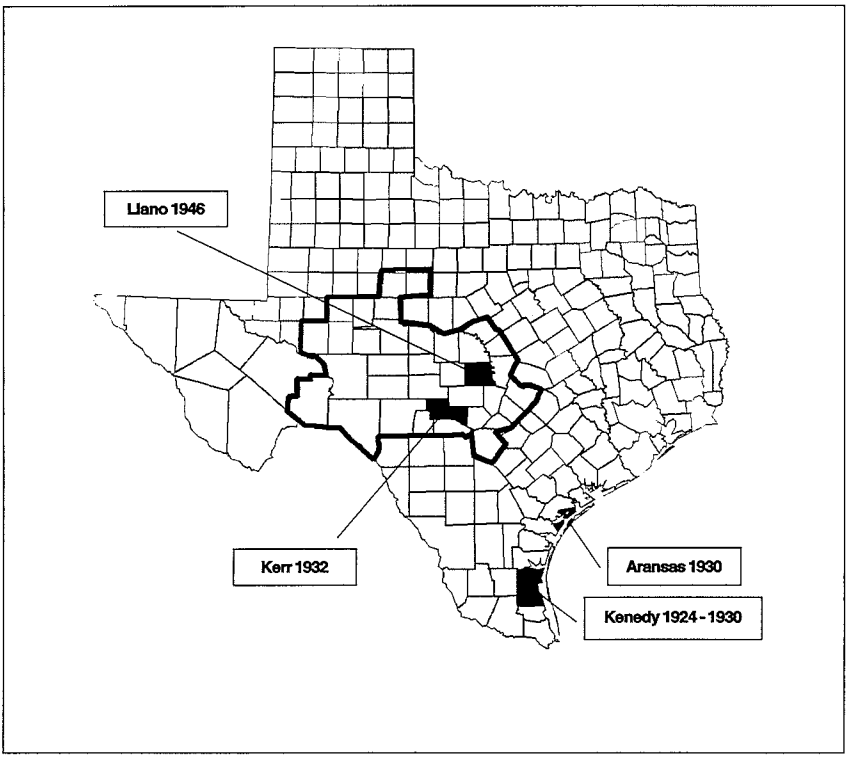

Figure 6. Counties with exotic animal ranches by 1971. This map highlights the counties adopting exotic animal ranches early and demarcates the Edwards Plateau Ecological Region.

quarantined in zoos (Mungall and Sheffield 1994).

Other pre-World War Two ranchers having close connections with the San Antonio Zoo introduced some of Texas' early exotics. The nilgai antelope, when first introduced, had limited success. However, it began to thrive as additions were made to the herd. The success of the nilgai and other exotics introduced around the same time proved that exotics could be a valuable supplement to native game species in Texas. The second center of innovation of exotic-animal ranching was the Saint Charles Ranch, owned by Leroy Denman in Aransas County. Denman, who obtained his initial stock of animals from zoo surpluses (Mungall

and Sheffield 1994), is credited with introducing European wild boar and fallow deer (Cervus dama) to the Gulf Prairies and Marshes ecological region in 1930. The wet climate of the coastal region was not suitable for the fallow deer, and a few years later the survivors were moved to another of Denman's ranches, in Kerr County in the Edwards Plateau. Contrary to the ranchers' experience with fallow deer, however, the European wild boar proved itself adaptable and prolific, diffusing unconfined from its original point of establishment.

Following Denman's and Kleberg's introductions, the next and most important center of innovation appeared in the 1930s on Richard Friedrich's Bear Creek Ranch in Kerr County on the Edwards Plateau (Figure 6). Richard Friedrich used his connections at the San Antonio Zoo to import exotics through the zoo and to obtain the offspring of the quarantined animals. This type of partnership was a forerunner to other such "sharing agreements" between the San Antonio Zoo and some influential Texas ranchers in the 1960s.

During the innovation period that started in the 1930s, the diffusion of exotic-animal ranching continued in a hierarchical pattern among close friends and associates of the early innovators until the 1950s; then the diffusion process became more "contagious." For example, in 1951 Captain Eddie Rickenbacher bought part of Friedrich's Bear Creek Ranch in Kerr County. Rickenbacher's son, David, lived on the ranch and began maintaining the exotics by offering trophy hunting to paying guests. The adjoining Y.O. Ranch, owned by the Schreiner family, operated a traditional cattle ranch supplemented with fee hunting of native game. The Schreiners and David Rickenbacher were friendly neighbors, and through their associations and David's encouragement, the Y.O. adopted exotic stock to add to their existing hunting enterprise as early as 1953 (Mungall and Sheffield 1994).

The Expansion Stage: 1953 - 1994

Until the 1950s much of the diffusion of exotic animals among ranches had occurred because of two main factors: the natural expansion and establishment of unconfined animals, and the generosity of early adopters. Once the exotic-animal trade generated commercial interest, either through hunting or selling surplus as broodstock, the rate of diffusion of exotic ranches increased, nearly doubling the number of ranches between 1958 and 1963 (Figure 5). With the wave of adoptions in the 1960s, exotics became a routine sight on many Texas ranches.

From 1959 to 1971 the rapid diffusion of the expansion stage was both hierarchical and contagious, with a "neighborhood effect" becoming evident on the Edwards Plateau, particularly in Kerr County. Between 1959 and 1963 there was a 49.4 percent increase in exotic-animal ranches. From 1964 to 1971 there was a 46 percent increase. During the 1960s fee hunting and commercial broodstock increased dramatically, and by 1971 the total number of ranches reached 330, or about half of the 1994 total.

By the early to mid-1960s, the survival and reproductive success of these earlier exotics encouraged exotic ranchers to experiment with importing and raising "super exotics", a loosely defined term for bigger, less commonly kept species (Sugg 2000). Like the exotics of the innovation period, the diffusion pattern of the "super exotics" was hierarchical, with the new arrivals going to wealthy and influential ranchers. Super exotics were generally not intended to generate income, but to add more variety to the existing herds of exotics. The commercial success of harvesting earlier exotics helped to defray the costs of raising the new arrivals.

By 1971, the Edwards Plateau clearly dominated exotic-animal ranching in Texas, with the diffusion emanating mainly from Kerr County, one of the early centers of innovation. The two tiers of counties close to Kerr County have contained at least half of all exotic-animal ranches in Texas since 1971, with the greatest concentrations directly adjacent to

Kerr County (Figure 7). With Kerr County as the center, the diffusion appears as a ripple effect with the concentration of exotic ranches diminishing with distance.

The growth of exotic ranches stalled between 1972 and 1974, and significant gains did not occur again until the mid-1980s. Only the regions of the Edwards Plateau, Rolling Plains, and Gulf Prairies and Marshes showed growth. The statewide decline in the early 1970s can be attributed to two factors. Many introduced species are not adapted to cold weather and covered forage, and after long periods of cold, snowy weather in the winter of 1972-73, many ranches reported losses as high as 95% of their exotic stock in the TPWD 1974 survey. A second cause of the reduction in the number of ranches may be attributed to the interbreeding of mouflon-barbados sheep with domestic sheep, thereby diluting the strain to such levels that they were no longer considered exotics.

Towards a Saturation Stage: The 2000s?

The modest growth in the diffusion rate in the 1970s contrasts sharply with the rapid diffusion in the 1980s and 1990s. Around 1985 the "early majority" period of the diffusion process set in. Between 1984 and 1988 there was a 24 percent increase in exotic-animal ranches and between 1988 and 1994 a 27.9 percent increase. The establishment of new ranches does not appear to be leveling off, and all but two regions reported major increases (Texas Agricultural Statistics Service 1996). It is possible that the diffusion of exotic-animal ranching will not enter the saturation stage until after the turn of the century.

Exotic ranches today are quite different from one another. Average ranch-size statistics are not calculated. Even the Exotic Wildlife Association, whose Executive Director Erik Sugg (2000) notes that it is hard to describe a typical ranch in terms of size and different ranching activities, does not distinguish ranches in this manner. Ranches that advertise on the Internet tend to be at least 10,000 acres, though exotic ranches range from a few hundred acres to the 50 square mile YO Ranch in Kerr

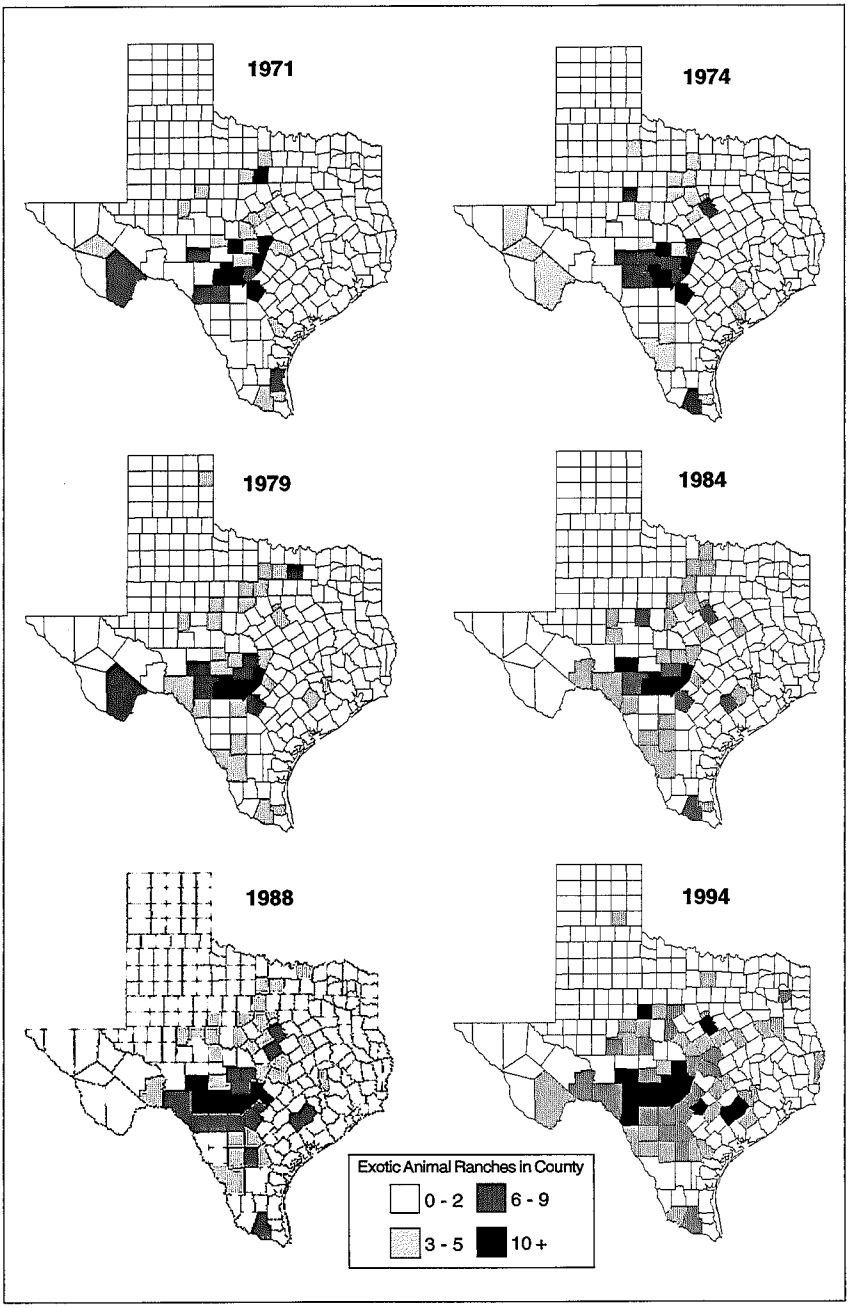

Figure 7. The adoption of exotic game ranches in Texas from 1971 to 1994.

County. The YO is among the largest and most diverse with 58 species and 7000 exotic animals complemented by more than 2000 longhorn cattle. The family ranch splits its land use into four parts: 20,000 acres for hunting free-ranging exotics and natives, like the white-tailed deer (*Odocoileus virginianus*); 10,000 acres for exotics, including fenced areas of about 100 acres for photo-safaris and other forms of ecotourism; and 10,000 acres for their longhorns (Hanks 2000)

The Diffusion Process: Facilitators and Impediments

One of the best ways to understand the diffusion of exotic-animal ranches in Texas is to account for the major impediments and facilitators in the process. Geographers in their discussions of "barriers and carriers" have pointed out that barriers can be both physical, such as mountains and rivers, and cultural, including linguistic, religious, political, psychological and other barriers (Abler et al. 1971). "Carriers" of the innovation can also accelerate the diffusion process through "facilitators" such as transportation routes. For the purposes of this study these influences on the diffusion of Texas exotic ranches might be distinctly categorized as: environmental, land use and economic.

Environmental Factors

Climate is a major environmental factor limiting the diffusion of exotic-animal ranching in Texas. With the exception of the hardy aoudad, most exotics, particularly those from Africa, do not do well in the harsh winter conditions that exist in the Trans-Pecos Mountains and Basins, High Plains, and Rolling Plains regions of Texas. In the Pineywoods and Gulf Prairies and Marsh regions, excessive humidity and rainfall create severe parasitic problems for introduced wildlife (Mungall and Sheffield 1994). Nevertheless, the regional physiographic and climatic characteristics of the state resemble those of many species' native habitats and

therefore a diversity of exotic animals has flourished in Texas. In particular, a dry climate, protected from extended periods of extreme temperature changes, is one reason the Edwards Plateau has become a center for exotic-animal ranching (Mungall and Sheffield 1994).

Predators also limit the diffusion of exotic animals in the South Texas Plains, as coyotes are a common threat to the young of many small species. The nilgai antelope are among the few species that are large and aggressive enough to withstand the threat of predation. Many years of predator control to protect small domestic stock in the Edwards Plateau has actually allowed many smaller exotic species to survive and prosper there.

Food supply is also important. Exotics can often thrive on vegetation that native livestock cannot subsist on. In areas where rangeland has been degraded to the point that it can no longer support traditional ranching, particularly in the Edwards Plateau, the versatile eating habits of exotic animals justify the adoption of exotic-animal ranching as an alternative (Cameron 1992). According to the experienced wildlife biologist on the YO Ranch, Vic Jones (2000), as many as six to eight exotic animals can be maintained on ranchland in the space needed to graze one cow.

Regional Land Use Considerations

The diffusion of exotic-animal ranching in the High Plains region has been limited because much land is used for purposes other than ranching. In 1994, only 12 exotic-animal ranches existed in the High Plains, totaling just over 50,000 acres. In contrast, High Plains' farms have over eight million total acres dedicated to cropland (U.S. Department of Commerce 1992). Twenty-one of the 28 counties in the High Plains had at least 42 percent of their acreage in cropland (U.S. Department of Commerce 1992). Outside that region, only 17 Texas counties were dominated by that much cropland.

In the South Texas Plains a limiting factor to the number of exotic-animal ranches is the presence of a few enormously large ranches, most

notably the King Ranch. For example, in 1994, the 99 ranches with exotics in the South Texas Plains totaled 1,435,645 acres. In the Edwards Plateau, the 294 ranches with exotics had 943,763 acres (TPWD 1994). Statistically, South Texas has more land available for exotic game, but most likely has used it less intensely.

The Edwards Plateau has had the largest concentration of exotic-animal ranches and species from early in the 20th century. The Edwards region had several innovative ranchers and became an early center of diffusion. It is also blessed with many favorable habitat characteristics. In addition, the region has many ranches with large pastures, often exceeding 1,000 acres, offering exotic species comparative freedom of movement and reproductivity.

Governmental administrative decisions also affect diffusion processes. Although the climate slowed the diffusion of exotic-animal ranching in the Gulf Prairies and Marshes region, the establishment of the Aransas National Wildlife Refuge in 1937 for native species (in particular, the whooping crane, *Grus americana*) was predicated on the removal of Denman's fallow deer and wild boar. Therefore, one of the earliest centers of innovation was removed.

Expansion of exotic-animal ranching on the eastern Edwards Plateau is threatened most by urbanization. Despite proximity to Kerr County, the most successful county in exotic-animal ranching, Bexar County (containing the rapidly growing city of San Antonio) has lost exotic-animal ranches since the 1970s. Comal and Hays counties, the semi-urban counties between Austin and San Antonio, have also witnessed declines between 1988 and 1994. Travis County, home of the burgeoning Austin metropolitan area, has not reported the presence of an exotic-animal ranch since 1979. This is most likely attributable to the rapid suburbanization and high population density in these counties, which are among the 35 most densely populated in the state. Continued urbanization of the Austin-San Antonio corridor will likely pro-

mote a further decline of exotic ranching in these counties, and slow the recent, modest spread of exotic-animal ranching into counties on the Post-Oak Savannah side of the corridor.

Economic Factors in Diffusion

With so much land in Texas in private hands, private-sector economic considerations play a major role in exotic ranching. Because of a declining economic base rooted in traditional ranching, many landowners have adopted exotic-game ranching as a means to supplement or replace lost income (Mungall and Sheffield 1994; Schreiner 1987; White 1986). Since the 1950s, four commercially viable activities have become popular for exotic-game ranchers: trophy hunting, broodstock, meat production, and ecotourism (Table 2). "Protection" of animals is an important non-economic concern of ranchers. Certain Texas exotics, such as the nilgai antelope and the Arabian oryx (*Oryx leucoryx*) have been used to reintroduce the species in their native regions (Pakistan and Saudi Arabia respectively). By and large, many ranchers share a concern for preserving exotic, especially endangered, species, though often outsiders view this as a cover for exotic ranchers' primary interest in broodstock and hunting.

Customarily, hunting has been an income supplement for many Texas ranches. Hunting of native game species has provided additional income to ranches that have experienced hard times caused by dwindling cattle prices and increasing degradation of ranch lands. The introduction of exotic-game hunting in the 1950s helped to offset the high cost of raising exotic stock, especially the super exotics. Prices for a high quality exotic trophy can bring in substantial income to a ranching/hunting venture. It is not unusual for a wealthy hunter to spend upwards of $20,000 on a single trophy hunt, or for hunters to travel from foreign countries to try their hand at bagging an aoudad or another trophy species. The trophy prices for an exotic at the YO Ranch include

Table 2. The common uses of exotic animals by ranchers in 1994. Shown as the percentage of ranches.

Protection	32.6
Hunting	34.8
Supply Broodstock	27.3
Other Commercial	5.4

Source: Texas Parks and Wildlife Department 1994.

$5000 for a red stag (*Cervus elaphus*), $7500 for a Nubian ibex (*Capra nubiana*) and $9500 for a markhor (*Capra falconeri*) (Jones 2000).

The main attraction for ranchers in turning to fee hunting for non-native game animals has to do with animal ownership. Unlike indigenous game species, which are maintained in the public trust, exotic animals are treated as domestic livestock and considered the property of the landowner (White 1987). With the exception of eight counties in the Palo Duro Canyon area in the Texas Panhandle, hunting exotic game is not restricted by law, and is left to the discretion of the landowner (Cameron 1992; Traweek and Welch 1992; Mungall and Sheffield 1994). This is probably the most important reason for the increased interest in the commercial breeding and hunting of these animals (Ramsey 1969).

Another important economic consideration in the diffusion of exotic-game ranching is the raising of exotics as broodstock to sell or trade to other ranches. Having been credited with the introduction of pay-as-you-shoot exotic hunting, David Rickenbacher was also instrumental in raising exotics for sale as broodstock, beginning in the 1950s. Prior to this, exotics usually spread to other Texas ranches as gifts to friends. Since then, most ranchers have had to purchase animals from a broker of exotic stock, of which Rickenbacher's operation was one of the earliest and largest, unless they were lucky enough to have escaping animals enter their property.

One of the latest trends in the adoption of exotic-game ranching is

the raising of exotic animals for meat products. There is a limited yet growing demand for exotic meat among select clientele, such as gourmet restaurants and specialty food markets (Cameron 1992). Exotics are considered private property, like domestic stock, so government regulations that protect native species do not apply to exotics. As a result, the sale of exotics for meat and meat by-products can occur year round and can provide a steady source of income.

Still in its infancy, an increasing number of exotic-animal ranching operations are entering the ecotourism industry. By providing an alternative to fee hunting and meat production, educational drive-through and photo-safari ranches offer a chance for a wider audience to enjoy and participate in the conservation of many endangered animals. For example, some 32 exotic species (including antelopes, oryx, addax (*Addax nasomaculatus*) and white rhinoceros (*Ceratotherium simum*) can be viewed and photographed at the 3000-acre Fossil Rim Wildlife Center, one hour's drive southwest from Fort Worth (Williams 1992).

Summary and Implications

While the diffusion of exotic-animal ranching during its innovation and early adoption periods was hierarchical in nature, by the 1950s the economics of raising exotics began to change, and adoption became contagious. This still persists, but with a definite weakening of the diffusion wave at the periphery of the Edwards Plateau region. Though exotic ranching is still expanding, there is more of a filling-in effect of ranches in Kerr and nearby Edwards Plateau counties. Weather-related barriers, colder climates to the north and wetter climates to the east of the Edwards Plateau, will limit diffusion to those regions. Even within the Edwards Plateau, encroachment of urban development threatens the diffusion of exotic-animal ranching, as it has in the counties of the Austin-San Antonio corridor. Indeed, counties closest to developing urban areas may

witness declines in exotic-animal ranching, while those closest to Kerr County may see continued growth.

The diffusion of an innovation theoretically does not reach saturation until 90 to 100 percent of the target population has adopted the innovation. It is clear from this study that the level of adoption of exotic-animal ranching is still increasing and has not yet reached saturation in Texas. As the center of exotic-animal ranching in Texas, Kerr County will increasingly benefit, as exotic-animal ranches become more diversified, widespread and commonplace on the Texas landscape.

Saturation will occur when new adoption ceases or when there are only minimal increases in new exotic-animal ranches. Social and economic barriers to adoption will limit the spread of exotic-animal ranching in areas economically independent of ranching. "Gentlemen" ranchers, who want a herd of exotics for viewing and showing to friends, will dwindle in numbers when the economy weakens. Resistance from other ranchers could occur because their values and social networks are not the same as exotic-animal ranchers. In other words, exotic-animal ranchers may run out of non-exotic-animal ranching friends, thereby having no one left to convert. Some ranchers may not be able to afford the startup costs. For others exotics may simply not be worth the investment. Indeed, there must be a limit to the number of exotic-animal ranches that Texas can reasonably support. Resistance could also be as simple as preferring traditional ranching to the novelty of exotic ranching, or not having exotic-wildlife management expertise. David Bamberger's "native" Blanco County ranch, featured nationally in Public Broadcasting System programs, with its land and water conservation programs, has little use for the non-native animal species still roaming the ranch (Bamberger 1999).

Unfortunately, further diffusion studies of exotic-animal ranching may become increasingly difficult, as less information about the ranches will be available to the public. Effective in 1995, House Bill 2012, the

Confidentiality of Wildlife Management Plan, prohibits state agencies from providing information to the public about private landowners without specific permission from the landowner (Leggett 1996). Furthermore, there are an increasing number of ranches refusing to participate in major wildlife studies, such as the TPWD surveys of exotic animals. Along with impeding management efforts, this loss of information may conceal the point of saturation in the diffusion of exotic-animal ranching, as well as why saturation occurred at that point in time. More importantly, the confidentiality law may mask how many ranches may change from hunting to conservation or protection.

This study in diffusion has been revealing in that it studied a somewhat unusual innovation. While the research focused on exotic-animal ranching as an industry or an enterprise, the product of that industry is a living organism. The complexities of dealing with living organisms are revealed in the difficulties of exotic-animal management. Unlike technological or market innovations of traditional diffusion research, such as automobiles or ice cream shops, living organisms can reproduce, adapt, die and escape, all without assistance from adopters. This study may have described the pattern of the diffusion of confined exotic animals, but one-third of the exotic animals in Texas now ranges free. Once exotic-animal ranching reaches saturation in Texas, the exotic animals will continue reproducing and diffusing, even without exotic-stock brokers. This may bring up serious conservation issues in Texas, and perhaps necessitate continued monitoring of the expanding animal population. Market, aesthetic and conservation trends may impact the popularity of exotic-animal ranching, but the reproductive success of unconfined exotic animals is favorable for their continued diffusion in Texas.

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