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Nutria (*Myocaster coypus*) in Louisiana

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A report prepared for the

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By

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TASK I. BIOLOGY AND NATURAL HISTORY OF THE NUTRIA, WITH SPECIAL REFERENCE TO NUTRIA IN LOUISIANA

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Abstract: The nutria or coypu (*Myocastor coypus*) is a rodent native to South America that has been introduced almost worldwide since the early 1900's, originally with the intent of fur farming in many cases. The nutria is a large (over 6 kg), semi-aquatic rodent with a voracious appetite and high reproductive potential. Nutria became established in the Louisiana wetlands in the 1930's. The habitat proved to be ideal and populations exploded, reaching an estimated 20 million animals in less than 20 years. Trapping of nutria for their pelts formed the backbone of the Louisiana trapping industry from the 1960's until the early 1980's when prices for furs on the world market and in Louisiana fell drastically. Since then the annual trapping harvest, which was over one million animals per year for many years, has dwindled to 29,544 in the 2000-2001 season. Since the virtual cessation of the annual harvest, nutria numbers have increased dramatically. Reports of damage to wetland habitats emerged in the late 1980's. Numerous studies of the wetland environments of Louisiana since then have documented the deleterious effects nutria grazing is having on the habitat. While nutria serve as an important prey item for the alligator, effects of nutria activity on other animals are primarily negative. Their most important impact is habitat modification and in many cases, habitat destruction. When impacts of intense nutria herbivory are added to the abiotic forces that are degrading the Louisiana coastal marshes the potential for lasting loss of wetland area is magnified. This report reviews the general biology and natural history of nutria; the chronology of nutria establishment in Louisiana and historic population fluctuations; interaction of nutria with other animals in Louisiana, and impacts of nutria herbivory on the wetland plant communities.

CHAPTER 1

General Biology and Natural History of the Nutria

Introduction

The nutria, or coypu, (*Myocastor coypus*) is a rodent native to southern Brazil, Bolivia, Paraguay, Uruguay, Argentina, and Chile (Cabrera and Yepes 1940, Cabrera 1961). Five subspecies of *Myocastor coypus* are recognized in its native range, with *M. c. coypus* occurring in central Chile, *M. c. melanops* restricted to Chiloe Island, Chile, *M. c. santacruzae* found in Patagonia, *M. c. bonariensis* in northern Argentina, Bolivia, Paraguay, Uruguay, and southern Brazil, and *M. c. popelairi* in Bolivia (Osgood 1943). *Myocastor coypus* is the sole member of the family Myocastoridae, which belongs to the large group of native South American rodents of the suborder Caviomorpha (this group also includes guinea pigs, chinchillas, and New World porcupines, among several other groups of South American rodents). Woods and Howland (1979) compared the cranial musculature of the nutria with that of its near relatives, and Murphy et al. (2001) placed the nutria in a phylogenetic framework based on analysis of mitochondrial DNA sequences.

Since the early 1900s, the nutria has been introduced almost worldwide, and today it is established in the United States, Canada, England, France, Holland, Scandinavia, Germany, the Caucasus, northern and central Asia, Japan, the Middle East, and East Africa (Aliev 1966a, Van den Brink 1968, Corbet 1978, Hall 1981, Bar-Ilan and Marder 1983).

Head and body length of adult, non-captive nutria ranges between 472 and 625 mm, and weight averages approximately 6.7 kg in males and 6.3 kg in females (Gosling 1977). Specimens as large as 17 kg (> 37 pounds) have been reported (Grzimek 1975). The upper parts of the nutria range from yellowish brown to dark brown and the underparts are pale yellow (Chabreck and Dupuie 1970). The head is large and roughly triangular in shape, with eyes, ears, and nostrils located high on the head reflecting the aquatic habits of the nutria (Mann 1978). The tail is round in cross-section (unlike the laterally flattened tail of the muskrat (*Ondatra zibethicus*), scaly, and thinly haired except at the base (Woods 1984, Nowak 1999). The digits of the hind legs are partially webbed, whereas those of the forelegs are not. Females have four pairs of thoracic mammary glands that are located on the side of the body, rather than on the belly (Dobson and DeViney 1967, Gosling 1980). Presumably, this positioning of the mammary glands allow the young to nurse with their nose above the water's surface while the mother is swimming (Newson 1966).

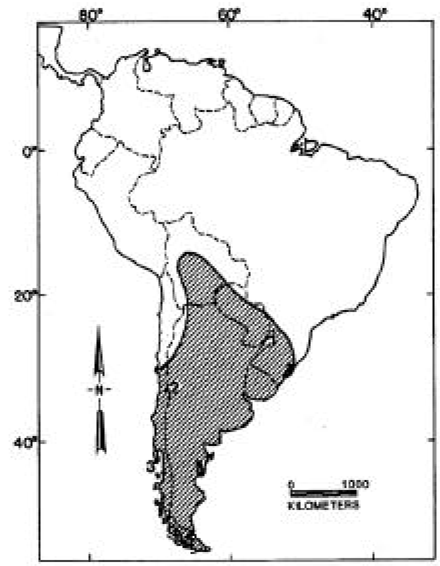

Figure 1 - Native range of *Myocastor coypus* in South America. Modified from Woods et al. (1992)

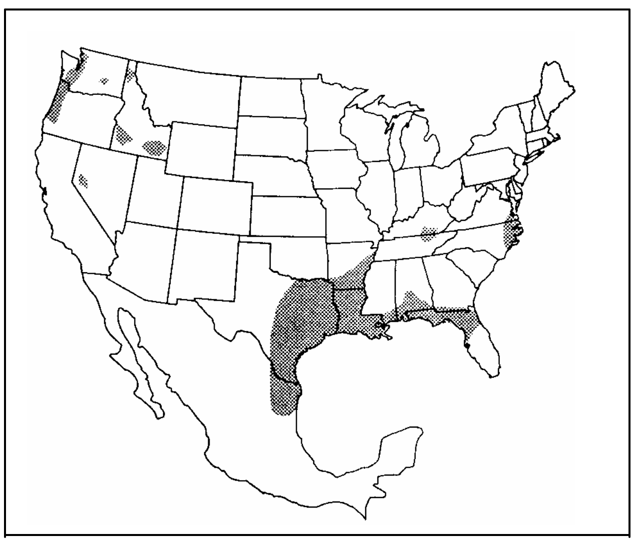

Figure 2 - Range of *Myocastor coypus* in North America. Modified from Le Blanc (1994)

Habitat Use

Nutria are semi-aquatic rodents that live along lakes, marshes, and slow-moving streams, and are abundant in freshwater, brackish, and saltwater marshlands. In their native range, nutria seem to prefer freshwater situations, however they are known to occur in both brackish and saltwater areas at several localities, such as the Chonos Archipelago in Chile (Nowak 1999). Along the Gulf Coast of the United States, nutria are most abundant in freshwater situations, and seem to prefer areas with dense stands of Chairmaker's bulrush (*Scirpus olneyi* = *Schoenoplectus americanus*). Throughout their range (both native and introduced), nutria prefer wetlands with emergent (above-water) vegetation and areas with succulent vegetation along the banks. Although most nutria populations occur at low elevations, populations exist at elevations above 1000 m in the Andes of South America (Greer, 1966).

A study of nutria density and distribution in the Pampas region of Argentina showed nutria density to be positively correlated with availability of grasslands used for cattle grazing and negatively correlated with local human perturbations (Guichón and Cassini 1999). In contrast to studies conducted throughout the introduced range of the nutria, Guichón and Cassini (1999) found little evidence of crop damage by nutria and concluded that nutria may not be a threat to agriculture in their natural range.

Nutria often collect a large mat of vegetation, which they use as a feeding, grooming, and resting platform. Although they occasionally take over muskrat and armadillo burrows for nesting purposes, nutria are avid diggers and often dig their own burrows in banks along waterways and wetlands (Lowery 1974). Burrows are most common along banks with 45-90° slopes (Peloquin 1969) and range in size from short, unbranched tunnels 1-6 m in depth, to elaborate burrow systems, often extending 15-46 m or more into the bank (Atwood 1950, deSoriano 1960, Laurie 1946, Peloquin 1969, LeBlanc 1994). Multiple entrances to a single burrow system are common. Their nests are crude mats of local vegetation located on narrow soil shelves (0.3 m wide) or in large chambers (up to 1 m in diameter) within the burrow (Willner 1982, LeBlanc 1994). Well-worn paths, or runways, usually emanate from the borrow opening and extend into the nearby vegetation. Burrow systems provide, not only protection from predators, but also effective thermal buffering—a study in Argentina by deSoriano (1960) showed internal burrow temperatures to range between 8-10°C daily (2° range), while outside temperatures ranged between –4° and 24°C (28° range).

Social Behavior

The nutria is a gregarious rodent and often lives in groups containing from 2 to 13 or more individuals (Ehrlich 1966, Warkentin 1968, Gosling 1977). These groups usually are composed of related individuals, including one to several adult females, their young, and one adult male. As young males mature, they are driven away from the group by the resident adult male (Warkentin 1968, Gosling 1977). As a result, young males are often solitary. Resident males participate actively in nest defense (Carill-Worsley 1932, Ryszkowski 1966, Ehrlich 1966), and Warkentin (1968) reported that females are behaviorally dominant over males, except while mating.

Nutria males are territorial and typically exclude other males from their territories, which are normally larger than those of females (Doncaster and Micol 1989, Gosling and Baker 1989). As a result, males spend more time in the water patrolling for intruders than do females. In France, this behavior may contribute to the observed male-biased mortality (Doncaster and Micol 1989) because males may continue to defend their territories even when water temperatures fall dangerously low (Moinard et al. 1992).

In Louisiana, activity patterns of nutria appear to be influenced by ambient temperature (Warkentin 1968). When temperatures were below 28°C, diurnal activities were restricted primarily to sleeping and sunning. At temperatures above 28°C, most animals fed, groomed, or slept. No animals were observed sunning when ambient temperatures rose above 34°C. Nutria are known to huddle in small groups during cold nights (Gosling et al. 1980a), which would appear to be an adaptation for energy conservation (Contreras 1984). Moinard et al. (1992) showed that metabolic energy expenditures of nutria huddling in groups of three were reduced approximately 20% over single (non-huddling) individuals. In a laboratory study of non-evaporative heat loss from the tail of the nutria, Krattenmacher and Rübsamen (1987) showed that heat loss from the tail is of major thermoregulatory importance.

As with most mammals, the olfactory lobes of the nutria's brain are well developed and much of the nutria's social behavior is influenced by the sense of smell. Oily secretions from scent glands located near the mouth and anus are used, not only in grooming, but also in marking of territories (Ehrlich 1958). As with other aquatic and semiaquatic mammals who spend much of their time foraging in murky waters (e.g., Sea Lions, *Zalophus*, and River Otters, *Lutra*), the nutria's vibrissae (whiskers) are richly endowed with sensory neurons at their base, which may enable them to navigate in dark waters using only the sense of touch (Mann 1978). Unlike many other aquatic and semiaquatic mammals who show a reduced dependence on the sense of hearing, the nutria seems to have a well developed sense of hearing (Mann 1978), which probably reflects its dual existence in both water and air. Eyesight in the nutria is thought to be poor (Le Blanc 1994).

Feeding and Nutritional Ecology

Nutria are generally thought to be strict vegetarians, but like many other rodents, they may consume small arthropods and nestling birds that they happen to encounter while foraging. Nutria feed while on land or in the water, using their forelegs to deliver food materials to the mouth. Although voracious eaters, nutria rarely cause habitat damage, except at high densities (Hillbricht and Ryszkowski 1961, Ehrlich and Jedynak 1962, Harris and Webert, 1962, Ellis 1963, Wentz 1971, Litjens 1980).

A study of nutria food consumption in Chile documented an average of 1,100 g of vegetation (range 700 to 1,500 g) per individual per day (Christen 1978), which amounts to approximately 25% of individual body mass consumed per day. The diet consists of a wide variety of plant materials, including leaves, stems, roots, and bark (Warkentin 1968, Murua et al. 1981). Unlike muskrats, nutria consume only small quantities of algae (Willner et al. 1979).

Nutria may have been introduced to certain regions of the world based on the hope that they would eat undesirable aquatic plants (Woods et al. 1992). However, nutria do not seem to be an effective control agent for introduced species, such as common water hyacinths (*Eichhornia crassipes*), alligatorweed (*Alternanthera philoxeroides*), coon's tail (*Ceratophyllum sp*.), and bladderwort (*Utricularia sp*.). Instead, nutria seem to prefer native plants and also are known to eat crop plants, such as rice, sugarcane, alfalfa, ryegrass, and fruit and nut trees (Schitoskey et al. 1972, Kuhn and Peloquin 1974). In addition to crop plants, nutria are also known to damage trees including conifers, deciduous forest trees, and seedlings of bald cypress, *Taxodium distichum* (Blair and Langlinais 1960, Kuhn and Peloquin 1974, Myers et al. 1995).

A study of nutria diet in their natural range (the Pampas region of Argentina) showed that 40-60% of their diet consisted of aquatic monocots and 30-35% consisted of terrestrial monocots (Borgnia et al. 2000). Nutria consumed dicots only occasionally (0-15%). In Argentina, spikerush (*Eleocharis bonariensis*) was the preferred monocot in winter and spring, and duckweed (*Lemna sp*.) was preferred in summer and fall.

A study of nutria diet in Maryland (Willner, et al. 1979) showed that nutria feed heavily on plant roots. Likewise, Ellis (1963) and Gosling (1974) reported that root crops are an important dietary constituent during winter in England. In Louisiana, nutria are known to eat the roots and rhizomes of many native plant species. Because of this behavior, they are considered wasteful feeders (Linscombe et al. 1981), and estimates suggest that nutria may waste more than 90% of the plant material damaged while feeding on the bases of plants (Taylor et al. 1997). Nutria appear to be opportunistic feeders in Louisiana (Atwood 1950, Wentz 1971, Shirley et al. 1981, Tarver et al. 1987). Common food plants in Louisiana include cordgrasses (*Spartina alterniflora, S. cynosuroides,* and *S. patens*), duckweeds (*Lemna minor* and *Spirodela polyrrhiza*), arrowheads (*Sagittaria latifolia* and *S. platyphylla*) and chairmaker's bulrush (*Scirpus olneyi* = *Schoenoplectus americanus*), but nutria also consume many other native and non-native plant species (Lowery 1974, Conner 1989, Wilsey et al. 1991). Ellis (1963,

1965) reported that nutria feed on a large variety of crops in England, including cowbane (*Circuta virosa*) and great water dock (*Rumex hydrolapathum*).

There have been numerous studies of the impact of nutria on wetland plant communities in Louisiana. Certain of these studies conclude that nutria and other herbivorous vertebrates reduce the number of plant species living in a study area (e.g., Fuller et al. 1985, Rejmanek et al. 1990, Shaffer et al. 1990, Nyman et al. 1993), whereas other studies suggest that herbivores have little or no effect on plant species diversity (Smith 1988, Taylor and Grace 1995). Regardless of the potential effect of nutria on plant species diversity, all studies agree that nutria can have major impact on total above-ground biomass of important native plant species, such as chairmaker's bulrush, *Scirpus olneyi* = *Schoenoplectus americanus* (Johnson and Foote 1997) and arrowheads, *Sagittaria latifolia* and *S. platyphylla* (Llewellyn and Shaffer 1993). The negative impact of nutria on soil building processes, such as below-ground plant productivity and surface litter accumulation, was documented by Ford and Grace (1998).

Like many other vegetarian species, nutria are coprophagious (i.e., they reingest fecal pellets to extract additional nutrients). Although defecation occurs throughout the feeding period (with approximately 86% of the feces produced while in the water), coprophagy appears to occur only at the nest (Gosling 1979). A study of the digestive tract of the nutria by Snipes et al. (1988) revealed an unusually large cecum (first portion of the large intestine) that can hold approximately 47-55% of food material in the entire digestive tract.

Nutria are proficient divers, and can remain submerged for periods exceeding 10 minutes (Katomski and Ferrante 1974). Studies by Ferrante (1970) indicate that nutria show bradycardia (slowing of heart rate) and peripheral vasoconstriction (reduction of blood flow to the skin and appendages), while diving. Apparently, the nutria's respiratory system is able to tolerate the physiological consequences of diving, which include high levels of carbon dioxide and lactic acid in the blood (Ferrante and Miller 1971). Although nutria have low red blood cell counts relative to other mammals, their red blood cells are unusually large (Scheuring and Bratkowska 1976).

Although nutria can be active both day and night, they are primarily nocturnal and most feeding activity occurs at night (Gosling 1979). However, in instances of low food availability, feeding may be observed at all hours of the day (Lowery 1974). Gosling (1979) reported that the period of nocturnal feeding activity in nutria is shorter during colder weather, however Chabreck (1962) reported no relationship between activity and temperature.

Nutria metabolism is quite labile and correlates positively with ambient temperature (Segal 1978). Nutria studied in Cuba during the summer showed basal metabolic rates consistent with expectations based on body mass (Kleiber 1961, Segal 1978). However, when air temperatures drop, the metabolism of the nutria also drops and core body temperature in 0°C weather may drop to 33°C. Hull (1973) showed that newborn nutria control their body temperatures over a wide range of ambient temperatures.

Primary bile acids of the nutria are similar to those in humans, which has made the nutria a potential model organism for study of gallstone formation in humans (Tint, et al. 1986).

Breeding Biology, Population Density, and Genetics

As with most rodents, the nutria is a prolific breeder. Females are polyestrous (i.e., they show post-partum estrus, and are ready to breed again within a day or two following birth of a litter; Matthias 1941, Skowron-Cendrzak 1956, Gosling 1981a). The gestation period of the nutria ranges from 127 to 139 days (Atwood 1950, Skowron-Cendrzak 1956, Weir 1974), which is somewhat longer than would be predicted based on body size alone (Blueweiss et al. 1978, Kleiman et al. 1979, Sacher and Staffeldt 1974). Litter size normally is 3 to 6 individuals, but litter size can range anywhere from 1 to 12 individuals (Federspiel 1941, Gosling 1981b). Litter size generally is smaller in winter (Gosling and Baker 1981), and is larger in areas with mild winters and abundant food (Brown 1975).

In Maryland, reproductive output for the nutria was estimated at 8.1 young per female per year (Willner et al. 1979). In areas with plentiful food and low predation, adult females may produce three or more litters per year (mean = 2.7) with an average total of 15 young per female per year (Brown 1975).

A high percentage of nutria litters (estimated between 26 and 28%) are wholly or partially aborted during gestation (Gluckowski and Maciejowski 1958, Newson 1966). Evans (1970) reported that a large percentage (estimated at 40%) of nutria embryos are resorbed in the mother's uterus and thus do not survive to birth. Newson (1965, 1966) reported that the nutria embryo develops slowly during the first month of gestation.

Ovarian hormone cycles of the nutria are not well understood, and the biological consequences of food restriction on catabolism and ovarian activity are only vaguely understood (Sirotkin et al. 2000). The normal (non-pregnant) estrous cycle of the nutria varies from 5 to 60 days (Newson 1966, Wilson and Dewees 1962), with one to four days of estrus ("heat") during the cycle. This variation, along with the fact that healthy females may show no cycles for several months, suggests that estrus in females is induced by copulation (Asdell 1964). The structure of male and female reproductive systems of the nutria have been studied in detail by Hillemann et al. (1958) and Stanley and Hillemann (1960).

Nutria are non-seasonal breeders (Brown 1975, Gosling et al. 1980b, Kim 1980). Studies in Louisiana report high birth rates in December, January, June, and July (Adams 1956). In Oregon, birth rates peak in March, May, and October (Peloquin 1969). The female nutria usually gives birth to her litter in an open nest at the water's edge or in a nest chamber within her burrow system (Gosling et al. 1988).

Nutria young are precocial, and are born fully furred, active, and with eyes open. Mean birth weight is approximately 225 g for both sexes (Newson 1966), although males eventually become 15% heavier than females as adults (Doncaster and Micol 1989). Young nutria are able to swim and eat very soon after birth, and they gain weight rapidly during their first months of life (Peloquin 1969). Dixon et al. (1979) reported that growth rate of young may be retarded by cold weather. Weaning occurs at five to eight weeks of age (Gosling 1980), and sexual maturity may be reached in four to eight months, depending on food availability and habitat conditions. Male young born in early summer may breed within four to six months, whereas those born in early winter may not breed until reaching seven or eight months of age (Pietrzyk-Walknowska 1956, Evans 1970). In females, age of first reproduction ranges from 6 to 14 months (Gosling 1974, Konieczna 1956). The sex ratio in adult populations ranges from 0.6 to 1.6 males per female (Le Blanc 1994).

The potential life span of the nutria is approximately 6.5 years (Woods et al. 1992), although Le Blanc (1994) stated that captive animals may live as long as 15-20 years. Nutria can be aged based on molar wear and eruption patterns (Aliev 1965b, 1965c, 1965d), body mass (Willner et al. 1980), or mass of the lens of the eye (Gosling et al. 1980b). Willner et al. (1983) proposed a four-parameter model for aging nutria that incorporated body length, body mass, hind foot length, and tooth eruption. Whereas tooth characteristics and body mass show sexual dimorphism and can be influenced by food type and abundance, Gosling et al. (1980b) showed that sex and environmental factors had little effect on lens mass. Nutria can be divided into rough age categories (i.e., juvenile, subadult, and adult) based on weight and pelage characteristics (Brown 1975) or length of the hind foot (Adams 1956). Estimates of fecundity rate, age distribution, and mortality schedules for a population of nutria in Maryland were calculated by Willner et al. (1983).

Density of nutria populations will vary with climate, habitat, food availability, predation and hunting pressure, prevalence of diseases and parasites, pollution, density of competitors, and many other environmental variables (Brown 1975, Willner, et al. 1979). Doncaster and Micol (1989) found that nutria densities in their study area (in France) were independent of food availability, but this contradicts the findings of other researchers working in other areas (e.g., Lowery 1974, among others). Nutria populations appear to be very sensitive to climatic fluctuations. Populations can grow dramatically during mild winters and in the presence of heat-producing pollution

(Doncaster and Micol 1989, Litjens 1980). Cold weather can cause direct mortality of nutria and can also cause dramatic loss of fat stores, which may increase abortion rates, thereby causing reproductive failure (Newson 1966 and Norris 1967). Local nutria populations are susceptible to severe storms and prolonged flooding. Waldo (1957) estimated that perhaps 60 to 65% of the nutria population in the White Lake and Grand Lake marshes (southwestern Louisiana) perished as a result of hurricane Audrey in 1957. Further east, at Marsh Island, perhaps 70% of the nutria were killed or driven away during the same hurricane (Harris and Chabreck 1958).

Density estimates of nutria populations range from 0.1 individuals per hectare in a Louisiana study (Valentine et al. 1972) to 138 individuals per hectare in Oregon (LeBlanc 1994). Greer (1966) estimated densities of 25 animals per hectare in Malleco Province, Chile. In Maryland, Willner, et al. (1979) estimated population densities to range between 2.7 to 16 individuals per hectare. Other estimates of population density are listed in Table 1.

Table 1. Published estimates of nutria population density.

Locality	Density Estimate (individuals/hectare)	Reference
Chile	25	Greer (1966)
France	2.42 in May, 9.14 in November	Doncaster and Micol (1989)
Florida	5.9 (unpolluted pond), 24.7 (polluted pond)	Brown (1975)
Louisiana	0.1 to 1.29 over 5-year period	Valentine et al. (1972)
Louisiana	43.7	Kinler et al. (1987)
Louisiana	44 (in floating freshwater marshes)	LeBlanc (1994)
Maryland	2.7 to 16	Willner et al. (1979)
Oregon	138 (in freshwater marshes)	LeBlanc (1994)

There have been only a few genetic studies of nutria populations. An electrophoretic study of a Maryland population by Morgan et al. (1981) found complete absence of genetic variation in liver enzymes and serum and lens proteins. This result is not unexpected in an introduced population that likely experienced a genetic bottleneck at the time of introduction. Ramsey et al. (1985) surveyed protein variation in feral, introduced nutria from a variety of locations and found only three of 22 presumptive loci to be polymorphic. Average individual heterozygosity was about 5% in Louisiana populations, but only 0.2% in England and 0% in Washington state. Isolated inland populations and populations periodically reduced by severe weather in Louisiana had less variation, perhaps due to founder effects or genetic drift. Maum (1986) found electrophoretic variation in three coastal Louisiana populations, as well as morphological variation in pelt and cranial characteristics.

Nutria populations contain at least two antibody blood groups, types CO1 and CO2 (Szynkiewicz 1968). Szynkiewicz (1971) reported variation in beta-globulin gene frequencies among several Polish populations of nutria, and Brown (1966) reported ontogenetic (age-related) differences in lipoproteins as well as serum concentrations of globulins and albumins.

Chromosomal studies of *Myocastor coypus* report a diploid number of 42 chromosomes and a fundamental number (= number of chromosomal arms) of 76 (Tsigalidou et al. 1966, George and Weir 1974, Kasumova et al. 1976). No chromosomal variation in nutria has been reported to date.

Movements and Dispersal

Because it is an amphibious mammal that moves easily on both dry land and in water, the nutria has high potential for long-distance dispersal. Swimming by the nutria is particularly energy efficient—while swimming, the nutria's head and back are slightly above the water's surface and propulsion is provided by means of alternate thrusts of the webbed hind feet and graceful side-to-side undulations of the tail (Gosling 1979). Despite this ability to easily traverse both land and water barriers, nutria tend to remain in the vicinity of their natal area for their entire lives (Aliev 1968). However, freezing weather or drought may cause them to migrate in search of more favorable climate or habitat (Aliev 1968).

The daily home range of nutria is usually restricted to within 45 meters, or so, of their burrow entrance (Adams, 1956), individuals are often observed as much as 180 meters from their burrow opening (Nowak 1999). A study in the Netherlands documented daily movements of nutria up to 300 m by water and 50 m by land while foraging (Kim 1980), and Linscombe et al. (1981) reported movements of up to 3.2 km in Louisiana. Finally, Aliev (1968) documented a nutria range extension of 120 km over a 2-year period in Eastern Europe.

Estimates of home range size for nutria vary considerably with season, reproductive condition, and food availability. In a study of tagged nutria in Louisiana (all males), 50% were recaptured within 91.4 meters of their burrow, 80% within 0.4 kilometers, and 20% between 0.4 and 1.25 kilometers (Robicheaux, 1978). Home range size was estimated at approximately 13 hectares in Louisiana (LeBlanc 1994). Doncaster and Micol (1989) estimated the size of nutria home ranges in France to be approximately 2.47 hectares for females and 5.68 hectares for males. These authors concluded that home range size was independent of population density. Studies of nutria dispersal and home range have been facilitated by use of radiocollar telemetry (Coreil and Perry 1977).

Interactions with Other Species

Because nutria and muskrats are so similar ecologically, there is no question that they compete for food and space in areas where they co-occur. However, co-occurrence (at least in large densities) is not common because nutria are most abundant in freshwater situations, whereas muskrats seem to prefer salt or brackish waterways and marshes (Lowery 1974). In addition, muskrats prefer marshes dominated by chairmaker's bulrush (*Scirpus olneyi* = *Schoenoplectus americanus*), whereas nutria feed extensively in marshes dominated by cordgrass (*Spartina patens*), which is not a preferred food of muskrats (Chabreck et al. 1981, Nyman et al. 1993). Although direct evidence of competition between nutria and muskrats is only anecdotal, indirect evidence of competition is illustrated by the fact that removal of nutria populations from areas of coexistence result in rapid expansion of muskrat populations (Evans 1970). Where they co-occur, nutria are behaviorally dominant over muskrats, probably by virtue of their larger body size. Muskrat nests are sometimes taken over by nutria to be used as nests or resting platforms (see **Habitat Use** above).

Possible Limiting Factors

As discussed in the previous section, competition with native semi-aquatic mammals, such as the muskrat, does not appear to be a major limiting factor for nutria populations. In fact, absence of competition from native species may explain the ease with which nutria are introduced to suitable habitats worldwide.

Annual mortality estimates for nutria populations range from 53% (Chapman et al. 1978) to 74% (Newson 1969). These estimates include both natural and trapping mortality. Natural predation is an important limiting factor for nutria populations. In South America, caymans (*Caiman longirostris, C. niger*, and *C. sclerops*) are reported to be the major natural predator of nutria (Aliev 1966b). Similarly, in North America, the American Alligator (*Alligator mississippiensis*) is known to consume large numbers of nutria regularly. A study of the diet of the American Alligator in southeast Louisiana revealed that nutria constitute approximately 60% (by weight) of the alligator's diet. In alligators over 1.7 meters in length, mammals are the most important food group based on prey mass or volume in stomach analyses (Wolfe et al. 1987).

Other major predators of the nutria in South America include the jaguar (*Panthera onca*), mountain lion (*Puma concolor*), ocelot (*Leopardus pardalis*), the little spotted cat (*Leopardus tigrinus*), and other medium-to-large sized predatory mammals (Dennler 1930). In North America, the red wolf (*Canis rufus*), red fox (*Vulpes vulpes*) and ermine (*Mustela erminea*) have been reported to consume nutria regularly (Willner 1982). According to Aliev (1966a), the major mammalian predators of nutria in Eastern Europe include domestic dogs (*Canis familiaris*), golden jackals (*C. aureus*), gray wolves (*C. lupus*), and the jungle cat (*Felis chaus*).

Young nutria, as well as smaller adults, are often eaten in large numbers by birds of prey, including the bald eagle (*Haliaeetus leucocephalus*) (Dugoni 1980, Jeb Linscombe, *pers. comm.*), red-shouldered hawk (*Buteo lineatus*), the marsh harrier (*Circus aeruginosus*), and the tawny owl (*Strix aluco*) (Ellis 1965, Aliev 1966b, Warkentin 1968).

Young nutria are also consumed by large snakes, such as the cottonmouth (*Agkistrodon picivorous*), the gar (*Lepisosteus sp*.), and turtles of several species (Warkentin 1968, Evans 1970).

Human predation on nutria (trapping and shooting) takes a major toll on nutria populations in certain areas of their introduced range. In the mid-1970s, the number of nutria pelts taken in Louisiana reached an all-time peak of approximately 1.9 million pelts per year. Today, ?30,000 nutria are trapped annually by the Louisiana fur industry (data for 2000-2001 provided by the Louisiana Department of Wildlife and Fisheries) (Linscombe, 2001).

Microbial infections and endoparasites can cause considerable mortality, especially in times of high population densities. Nutria populations are known to be susceptible to rabies (Matouch et al. 1978), equine encephalomyelitis (Page et al. 1957), paratyphoid (Evans 1970), salmonellosis (Safarov and Kurbanova 1976), pappilomatosis (Jelinek et al. 1978), leptospirosis (Twigg 1973, Howerth et al. 1994), toxoplasmosis (Holmes et al. 1977, Howerth et al. 1994), richettsia (Kovalev et al 1978), coccidiosis (Michalski and Scheuring 1979), and sarcoporidiosis (Scheuring and Madej 1976).

Diseases caused by microbial infections can result in significant mortality in nutria populations, especially in times of high population densities. At least a dozen kinds of microbial infections have been reported in nutria populations (see **Breeding Biology and Population Density**), but estimates of actual mortality caused by these diseases are unavailable.

Endoparasites rarely kill their host, but they can reduce the fitness of nutria populations and thereby retard population growth. Internal parasites reported from nutria populations include the nematode *Strongyloides myopotami*, which infects most, perhaps all, populations of nutria along the Gulf Coast of the United States (Babero and Lee 1961). According to Lowery (1974) fur farmers in Louisiana claim that this nematode is responsible for occasional periods of low reproduction and mass mortality in nutria. *Strongyloides myopotami* also is known to cause "marsh itch" or "nutria itch," which is a severe rash caused by larval roundworms that enter the skin of trappers who handle nutria fur (Burk and Junge 1960, Lee 1962, Little 1965).

Other endoparasites reported in nutria populations (Babero and Lee 1961) include 11 species of trematodes (including *Echinostoma revolutum*, *Heterobilharzia americana*, and *Psilostomum sp*.), 21 cestode species (including *Anoplocephala sp*.), one acanthocephalan (*Neoechinorhynchus sp*.), and 31 nematode species (including *Trichostrongylus sigmodontis*, *Longistriata maldonadoi*, *Strongyloides myopotami*, and *Trichuris myocastoris*). The most prevalent endoparasites in South American populations of nutria include the trematode *Hippocrepis myocastoris*, the cestode *Rodontolepis sp*., and the nematodes *Dipetalonema travassoso, Graphidioides myocastoris,* and *Trichuris myocastoris* (Babero et al. 1979).

External parasites of nutria include the chewing louse (*Pitrufquenia coypus*), the flea (*Ceratophyllus gallinae*), and the tick species *Dermacentor variabilis, Ixodes arvicolae, I. hexagonus, I. ricinus,* and *I. trianguliceps* (Newson and Holmes 1968 and Willner 1982).

CHAPTER 2

Chronology of Nutria Establishment, Historic Harvest Levels, and Population Fluctuations in Louisiana

Nutria were reportedly first released in Louisiana in the marshes near New Orleans in the early 1930's. The animals from this release were recovered by trappers and did not establish a breeding population (Lowery 1974). During the 1930's, a series of accidental and perhaps intentional releases along the Gulf Coast quickly resulted in the establishment of feral populations. The origins and numbers of the founding stock or stocks are not known with any certainty at this time.

Nutria were found at Lake Arthur in 1940 (Ashbrook 1948). Sportsmen and trappers had begun trapping and transplanting feral nutria into marshes from Port Arthur, Texas, to the Mississippi River by 1941. A hurricane in Texas in 1941 is credited with further dispersing nutria in southeast Texas and southwest Louisiana (Evans 1970). By 1941-42, nutria were being trapped on the Sabine and Laccasine National Wildlife Refuges in Cameron Parish of western Louisiana (Ashbrook 1948). Nutria continued to expand their range in succeeding years through natural dispersal and stocking efforts. By 1947 nutria were found at the Delta National Wildlife Refuge at the mouth of the Mississippi River (Ashbrook 1948). In the late 1940's, nutria were being promoted as a biological agent for the control of aquatic weeds (primarily water hyacinth, *Eichhornia crassipes* at that time), and were transplanted throughout the southeast (Harris 1956; Lowery 1974; Evans 1970).

Historic Harvest Levels

Nutria were well established throughout the coastal areas of Louisiana by 1943, and exhibited rapid population growth for a number of years thereafter. Indications of nutria population levels in Louisiana since 1943 are largely indirect, and comes from two sources: 1) annual pelt harvest records as reflected in state severance tax records, and 2) incidence and degree of nutria damage to crops, levee systems and native marsh habitats. Local nutria population levels have been estimated in Louisiana in a number of studies using direct methods such as mark-recapture (Robicheaux 1978, Linscombe et al. 1981), night counts (Spiller and Chabreck 1975), and indirect indexes including as scat counts and active trail counts (Spiller and Chabreck 1975, Davidson 1984).

Historically, the primary indictor of the state-wide nutria population has been the annual fur trapping harvest level derived from severance tax records. The records show the first nutria being marketing during the 1943-44 trapping season, with 436 pelts (Lowery 1974). Table 2 summarizes the annual harvest levels, average pelt prices, and trapping license sales for the trapping seasons from 1950-51 to 2000-01 (Mouton et al. 2001). Figure 3 shows the same information graphically. Trapping seasons typically have run from December through February, when pelts are prime. The pelt harvest trend line reflects not only the nutria population but trapper effort, which is in turn driven by the international fur market.

By the 1961-62 trapping season the nutria harvest overtook muskrat in Louisiana for the first time (Tarver et al. 1987). From 1962 to 1982, an average of 1.3 million nutria were harvested from the coastal marshes each year (Linscombe 1992). The sustained high harvest over this period and the limited reports of damage problems suggests that the annual recruitment rate (primarily births) in the nutria population and the mortality rate (natural losses plus human harvest) were below the carrying capacity of the habitat on statewide level.

Due to vagaries of the international fur markets as well as the actions of anti-fur activists, the demand and price for nutria pelts began to decline in the early 1980's. The Louisiana nutria harvest declined dramatically in the succeeding years, from over 1.2 million in the 1980-81 season to 134,000 by the 1990-91 season (Linscombe 2001).

Population Estimation

The other long-term indicator of nutria population levels in Louisiana has been the level of nutria damage to wetlands, coastal agriculture and forestry. There was a rising incidence of complaints of damage to marshes, rice, sugarcane, and levee systems beginning in the mid-1950's (Lowery 1974, Mouton et al. 2001).

High nutria populations and severe over-grazing were noted, particularly in the Mississippi Delta (Linscombe 1992). Biologists described areas where nutria had completely denuded natural levees at the mouth of the Mississippi River. The nutria population was estimated to peak at 20 million animals during the years 1955-59. Many once dense stands of cattail (*Typha* spp.) were largely destroyed. "Eat-outs", areas of open water, appeared in many areas along the coast. Aggressive non-native plants, as well as unpalatable native plants filled the open water areas in places, but the structural integrity of the marsh had been weakened. Hurricane Audrey (June, 1957) made landfall in southwestern Louisiana. The value of the native marsh vegetation in buffering storm surges became apparent. The weakened marsh structure was unable to prevent a huge wave of seawater from inundating the interior marshes and the Chenier Plain (Lowery

1974). Although thousand of nutria are reported to have drowned in the storm surge, hurricane Audrey is also credited with pushing thousands of nutria inland (Harris and Chabreck 1958). Soon after, reports of agricultural damage increased.

Nutria were found to live in the rice fields year-round if not controlled. Damage to rice occurred in southwest Louisiana and consists of: grazing on plants which retards or prevents the production of mature grain and burrowing into levees which interferes with water management at various stages of cultivation which are vital to rice production. The burrowing problem is exacerbated when cattle grazing on large levees step into and enlarge nutria burrows, or become injured (Evans 1970).

Sugarcane damage occurs when nutria damage mature canes by gnawing or completely cutting the stalks. Young, transplanted canes may be completely uprooted. Many more plants are destroyed than are eaten. In contrast to the rice field situation, nutria typically visit rather than live in the sugarcane fields (Evans 1970).

In response to damage problems, the nutria was taken off the list of protected wildlife in 1958. A $0.25 bounty was authorized but the funds were never appropriated (Mouton et al. 2001). In addition, the Denver Wildlife Research Center (DWRC), attached to the Bureau of Sport Fisheries and Wildlife at that time, began a nutria damage control research program in 1963 that continued through 1967 (Evans 1970). The program identified and evaluated existing damage management techniques (trapping, shooting), and developed new methods including the use of toxicants and agricultural habitat management. While the DWRC program had some success in identifying and developing damage control methods, the pest status of nutria was at odds with the state fur industry efforts to promote the nutria as a wildlife resource. A compromise between competing interests was reached in 1965 when the nutria was returned to the protected wildlife list (Linscombe 1992; Mouton et al. 2001). However, control of any nutria determined to be an agricultural nuisance was still allowed without a permit (Evans 1970).

With the increasing economic benefits of trapping nutria the annual harvest climbed steadily during the 1960's and complaints of nutria damage to crops diminished (Linscombe 2001, Fowler 1992). By the late 1970's over 10,000 trapping licenses were being purchased per year in Louisiana (see Table 2). Most trappers operated on leased sections of privately held marshlands. Typical leases are about 2,000 ha (5,000 ac.) A trapper will usually set an average of 150 traps and is required to check them daily. Victor #2 leghold traps of Victor #11 double longspring traps were used most commonly. Traps are placed openly in nutria trails. Nutria are also harvested by shooting, although there is a risk of damaging the pelt, and visibility in some habitats limits this method. (Kinler et al. 1987).

At the same time harvest levels were increasing, the Louisiana nutria population was reduced by a severe freeze event in February 1962, in which the temperature dropped to 12º F (-10.4º C). The freeze is thought to have killed perhaps millions of nutria. Survivors with missing tails and feet were trapped for a number of years (Lowery 1974). In the succeeding years damage to sugarcane was localized and usually controlled by trapping or shooting nutria around the perimeter of fields. Rice production has gradually shifted to underground irrigation, which has had the benefit of limiting nutria damage as well (D. Reed, *pers. comm.*).

In 1987-88, at the same time the trapping harvest had dramatically decreased, reports of significant nutria damage to the wetlands were coming from coastal land managers (Linscombe 1992, Mouton et al. 2001). Aerial flights by the Louisiana Division of Wildlife and Fisheries in 1988 confirmed damage was occurring, particularly in the southeastern marshes, in Terrebonne and LaFourche Parishes.

Funding was not available for further flights and systematic aerial surveys for the next several years. Qualitative and anecdotal evidence of marsh damage due to nutria herbivory continued to mount and in 1992 a Nutria and Muskrat Management Symposium was organized. The conference participants, including state and federal wildlife biologists, wetlands scientists, agricultural extension service personnel, and private land managers, concluded that nutria herbivory (as well as muskrat to a lesser extent) was having substantial adverse effects on the agriculture, forestry and native wetland resources (Linscombe and Kinler 1997). The symposium findings provided the documentation and impetus to secure funds from the Barataria-Terrebonne National Estuary Program (BTNEP) to conduct systematic region-wide aerial wetland damage surveys. Aerial flights resumed in 1993. Additional surveys were conducted in 1995 and 1996 (Linscombe and Kinler 1997). Coast-wide aerial surveys were conducted in 1999, 2000, and 2001 under the Nutria Harvest and Wetland Demonstration Project (Mouton et al. 2001).

The objectives of the surveys were to "1) determine the distribution of damage along the transect lines as an index of damage region wide, 2) determine the severity of damage as classified according to a nutria relative abundance rating, 3) determine the species of vegetation being impacted and 4) determine the status of recovery of selected damaged areas" (Mouton et al. 2001).

The 1993 flights identified 90 damaged sites along transects, amounting to 15,000 acres of impacted marsh. Extrapolating from this figure, based on the transect swath width (1/4 mile) and distance between transects (1.8 miles), the damaged acreage in the survey area can be multiplied by a factor of approximately four, resulting in an estimated 60,000 acres impacted by nutria herbivory in the survey area. The 1996 survey found the impacted area on flight transects had grown to 20,642 acres, or 82,568 acres in the survey area (Linscombe and Kinler 1997).

The flights conducted in 1998-2001 followed the same transect patterns used earlier. Table 3 summarizes the results of four years of coast-wide nutria damage surveys, by coastal parish. The data is arranged by parish from west to east. The survey results clearly show nutria herbivory damage in recent years is concentrated in the Deltaic Plain in southeastern Louisiana. The most severely impacted Parishes are Terrebonne, LaFourche, Jefferson, and Plaquemines.

Terrebonne and Lafourche Parishes, both in the inactive delta, were the number one and two nutria pelt producers, respectively, for many years, and have the most nutria damage as well.

Table 4 summarizes the same data set sorted by marsh type. These data demonstrate the impacted areas are primarily found in the freshwater marshes (48%). The freshwater, floating mat marshes provide the most productive marsh habitat for nutria, since the floating mat vegetation provides a productive food resource as well as a stable habitat that rises and fall with fluctuations in the water level. The consistent water level is conducive to nutria reproduction (Kinler 1992).

Further analyses of the flight survey data from 1998-2001 show that while the areas damaged by nutria declined somewhat from 2000 to 2001, and the number of sites classified as having severe vegetative damage has declined as well. The area of marsh converted to open water from 2000 to 2001 increased from zero to 4,726 acres (Mouton et al. 2001). This suggests intense and sustained nutria herbivory in parts of the freshwater marsh, which in turn indicates high nutria populations that are exceeding the local carrying capacity.

Harvest data and damage indexes are only general indicators of nutria population densities. Harvest data are not based on equal effort over time, thus limiting the applications of such information. Flight damage survey results may vary with time of year, observer experience, and many other factors in addition to varying nutria populations. There is no accurate means of converting damage indexes to nutria density. However, if the surveys are carefully applied to minimize experimental error, repeated surveys can provide a reliable index for land managers to monitor habitat response to herbivory pressure. When analyzed with harvest records that can be keyed to particular areas and habitat types, these data provide a reliable basis for formulating management plans (Linscombe and Kinler 1984).

Nutria populations have been monitored using a number of indirect and direct indexes, usually applied to local populations only. Many of these studies have shown that populations at the same site can vary tremendously from year to year (e.g., Linscombe et al. 1981), and that nearby populations may be very different (Kinler et al.

1987). Therefore the results of small-scale population estimates cannot be reliably generalized to outside the study area.

Survey methods provide an index of activity that can be repeated over time to estimate population changes on a fixed plot or area. Survey methods for nutria such as night counts, scat counts, and active trail counts were used by Spiller and Chabreck (1975), and Davidson (1984). However, the correlation between the activity counts and the population size or density is rarely known. Without validation studies, these indexes cannot be used to generate population density estimates. Fagerstone (1983) was able to calculate the correlation equation and describe the necessary conditions to use visual counts of ground squirrels in Colorado to reliably estimate population densities on circumscribed plots. A similar approach might be used to validate survey methods for nutria in some circumstances.

Mark–recapture studies can be used to estimate density if the assumptions of the model are met. These include a "closed" population (no recruitment or loss to the population during each trapping period) and equal "catchability" of individuals during the study period. To approximate the stable population assumption, trapping periods for nutria are usually limited to 8-12 days (Ryszkowski 1966, Doncaster and Micol 1989). Simpson and Swank (1979) found a population under study in Texas to violate the equal catchability assumption. Adults and sub-adults became trap-shy and skewed the population estimate upwards by 45%. The actual density was determined by shooting and trapping out the entire population at the end of the study. Reggiani et al. (1995) analyzed the results of a nutria mark-recapture study in Italy using the program CAPTURE (Otis et al. 1978) that allows corrections for trap shyness or trap happiness.

Linscombe et al. (1981), used a variation of the mark-recapture method in which they captured and tagged nutria, then recovered tags from commercial trappers during the following trapping season to generate a population estimate.

Some nutria density estimates reported from mark-recapture studies are: 138/ha in Oregon (Wentz 1971); 1.3 to 6.5/ha in Louisiana (Robicheaux 1978); 21.4/ha in Maryland (Willner et al. 1979); 2.1 to 24/ ha over three years in a Louisiana brackish marsh (Linscombe et al. 1981); 24/ha in a Mississippi agriculture-marsh ecotone (Lohmeier 1981); 43.7 ha in Louisiana freshwater marsh (Kinler et al. 1987); and 0.72 – 3.7/ha in a riparian area in Italy (Reggiani 1995).

Nutria are live-trapped on floating rafts (Evans et al. 1971) or on land. Carrots are the most common bait used. Nutria have been anesthetized with ketamine hydrochloride (Lohmeier 1981), sodium pentobarbital, and diazepam (Evans et al. 1971) during marking and measuring procedures. Marking methods have included ear or web tagging with metal tags (e.g. monel #3) (Simpson and Swank 1979, Lohmeier 1981, Willner 1982, Reggiani et al. 1995), ear punch codes (Lohmeier 1981) and web clip codes (Reggiani et al. 1995).

Gosling (1981) used a technique of retrospective census combined with population simulation to reconstruct the population of nutria in England during the period 1973-1979. The method assumes all nutria deaths are recorded, and that all animals killed are randomly sampled and accurately aged. If adequate resources are available, this method may be applied for estimating limited populations in limited areas, but would not be practical to apply on a scale needed to estimate statewide populations in Louisiana (Kinler et al. 1987).

Finally, an indirect method of assessing nutria habitat quality that might be linked to population pressure is through the analysis of blood chemistry of nutria at a particular site. Ramsey et al. (1981) found that certain nutria blood parameters were effective indicators of habitat deterioration.

Estimating population growth rates is difficult and expensive. Gosling et al. (1980, 1981) and Kinler et al. (1987) describe the techniques and necessary information to be collected to estimate population growth in a study area. Data must be collected on age, reproductive condition, pregnancy rates, and embryo counts. Juvenile survivorship must also be determined or estimated. While useful for characterizing a given population, the results may not apply beyond the local and the time period of the study.

Landscape and Climate Effects on Nutria Populations in Louisiana Marshes

To briefly summarize the history of nutria populations in Louisiana since 1937: following the introduction of one or a few small founding populations imported from fur farms the state witnessed the rapid establishment and spread of nutria throughout the coastal marshes. Stocking efforts as well as periodic hurricanes, which, while at times causing high mortality among nutria also serve to disperse survivors, accelerated the rate of spread. For the first 20 years following their introduction, the growth trend followed a classic logistic or sigmoid pattern of ecological release of a colonizing species into a favorable habitat that encounters little environmental resistance.

The statewide population was estimated to have peaked at about 20 million nutria before hurricane Audrey hit in 1957 (O'Neil 1968). From 1962 until 1982, two primary factors kept the populations below the carrying capacity of the marshes. These were 1) the annual trapping harvest and 2) periodic severe weather events which are believed to have drastically reduced the populations in portions of the state and sometimes the entire state. Since 1982 the annual trapping harvest has declined to a fraction of previous levels, and damage to the marshes in the Deltaic Plain has increased to the point that local populations appear to be exceeding the carrying capacity of the habitat. However, populations in the Chenier Plain have caused little damage since the decline of the trapping trade. What might account for the difference? There is evidence that the differing topography of the Chenier Plain and the Deltaic Plain make the nutria more susceptible to severe weather events.

Landscape

The Chenier Plain is the area west of Vermilion Bay. It was formed from river sediments being swept westward by shoreline currents in the Gulf of Mexico. The deposition of silt and clay sediments from the Mississippi River against the shoreline created mudflats that eventually became covered with salt-tolerant vegetation, creating new marsh. This process continued during times when the active Mississippi delta was to the west of it's current location (Chabreck 1972). Two periods of delta building activity have occurred near Vermilion Bay and contributed to the building of the Chenier Plain in the last 7,000 years: the Teche Delta period, about 2500 B.C., and the LaFourche Delta period about 1300 B.C. Sediments from the river were picked up by the gulf currents during these periods and carried westward.

Between the Teche and LaFourche Delta periods, the Mississippi moved it's coarse far to the east and formed the St. Bernard Delta. During that period and the

Modern Delta period (the last 700 years), little sediment has entered the gulf currents. Consequently, the forces of wave action have eroded the marshes while simultaneously forming local beaches. When sediment deposition resumed during the LaFourche Delta Period, the marshes again extended the coastline, leaving stranded beaches or cheniers. The resulting east-west orientation of the region affects slows drainage when floods occur.

The Deltaic Plain, east of Vermilion Bay, consists of the four deltas described above. Only one, the Modern Delta, is currently active, or still growing. However, due to construction of levees as flood control structures all along the Mississippi River, there is very little delta building today. An exception is in Atchafalaya Bay, where 30% of the Mississippi systems flow is diverted to the Atchafalaya River. Sediments carried by the river are currently extending the delta into the bay. The Deltaic Plain has subsided much more than the Chenier Plain over the centuries, leading to saltwater intrusion and a much larger band of salt marsh than is found in the Chenier Plain. The freshwater, floating mat marsh is also more extensive in the Deltaic Plain (nearly 1 million acres (397 ha) *vs*. less than 0.5 million acres (191 ha) in the Chenier Plain) (Chabreck 1972). As a result of the historic geologic deposition patterns, drainage in the Deltaic Plain is oriented north-south.

Climate

It has been well established that severe or prolonged cold temperatures can cause high mortality in nutria. Aliev (1965, 1973) cited instances of mass mortality due to temperatures of –27ºC for 40 days in Russia. Axell (1963) attributed a nutria die-off in England to a particularly harsh winter in 1962-63. Gosling et al. (1981) reported a sharp decline in nutria numbers in England following a continuous 12-day freezing period in

1975. Doncaster and Micol (1990) described frostbite to nutria tails and feet following 20 days in which an ice sheet covered canals in France. It is common to find nutria with missing appendages following freezing weather in Louisiana and Maryland (Willner 1982). Reggiani et al. (1995) reported population decreases of 44-64% in Italy following two consecutive cold winters.

Ehrlich (1962) and Doncaster and Micol (1990) determined that the presence of unbroken ice sheets which prevent entering the water, and lack of thick vegetative cover above ground contribute to more severe impacts of cold events on nutria. Under cold stress in winter, nutria may shift to a diurnal feeding pattern to maintain adequate food intake (Gosling et al. 1980). Doncaster et al. (1990) found that territorial behavior of dominant males in winter limits access of (mostly juvenile) subordinates to open water when partial ice sheets form. Subordinate individuals therefore are more exposed to lower air temperatures, as well as being restricted from aquatic forage. This social interaction, along with the smaller body size of juveniles, likely accounts for the observations that juvenile mortality is disproportionately high during freeze events (Aliev 1973).

Gosling et al. (1983) developed a mathematical expression or index (dubbed "CRS") based on the cumulative weighted sequences of freezing days in a winter. The expression includes the length of a run of freezing weather and the number of runs each winter. Freezing days are defined as "24 h periods where temperature minima are = 0°C and maxima =5°C." (Gosling et al. 1983). The report concludes that nutria are most affected by continuous runs of freezing days, and that the effect of freezing runs is cumulative over the winter. Presumably this is because of the effects of freezes on food quantity as well as quality, and on diminishing nutria fat reserves as the season progresses. Mild to moderate cold weather impacts include reduced birth rates due to abortion, increased mortality of juveniles and, to a lesser extent, adults. Significant adult mortality due to cold is common only in severe circumstances.

In Louisiana, records of unusually severe or prolonged freezes have not been analyzed in terms of the Gosling winter severity index. However there may have been at least three freezes sufficient to have had impacts on some nutria populations in parts of the state in the 1980's (Greg Linscombe, *pers. comm.*).

Prolonged floods can also cause high mortality in nutria populations in certain circumstances. Doncaster and Micol (1990) reported no nutria mortality resulted from flood events in France with durations of 5 – 37 days. Foraging was re-directed toward stripping bark of trees during the floods. The habitat in these cases was riparian zones connected to canal networks. Ehrlich (1967) found that nutria in their native range in South America and in Poland, Greece, and Israel were well adapted to changing their feeding and nesting habits in response to seasonal flooding. If waters do not rise too quickly, nutria may be driven out of earthen burrows but are able to create floating nesting platforms from emerging vegetation instead.

In Louisiana, flooding of the marshes associated with hurricanes, inland rainfall and high tides can have catastrophic effects on nutria. Hurricane Audrey is credited with killing or driving inland 70% of the nutria on Marsh Island in 1957 (Harris and Chabreck 1958). Thirteen hurricanes made landfall in Louisiana in the period from 1950 – 1996. Rapid flood and rainfall events, especially if lasting a prolonged time, can leave nutria without resting sites and exposed to the elements. If cold temperatures occur at the same time, weather-caused mortality is very possible (Greg Linscombe, *pers. comm.*). Nutria in the Chenier Plain are probably more vulnerable to such events due to the topography and relatively limited floating marshes. Floodwaters tend to back up behind the locks and drain much more slowly than they would in the Deltaic Plain, where the natural flow is directed south to the Gulf. The more extensive floating marsh in the Deltaic Plain also offers more protection from floods, because the mat rises and falls with the water level. As with cold weather events, the severity and frequency of catastrophic flood events may have cumulative effects on nutria populations over time. It has been suggested that the combination of more frequent, prolonged, and severe freezing and flooding events during the1980's to 2001 may partially account for the lower population densities of nutria in portions of the Chenier Plain (Greg Linscombe, *pers. comm.*).

Other climatic events that may have an impact on nutria populations are excessive heat and drought. Aliev (1965) attributed nutria mortality during a drought in the Caucasus region to heat stroke. This occurred at temperatures of 35-40°C. Drought may shrink or eliminate bodies of water and concentrate nutria in higher densities than the local habitat can support. Under these conditions nutria are also more susceptible to predation, hunting and trapping.

Ecological Genetics and Nutria Populations in Louisiana

As would be expected with translocated populations of any organism derived from a small number of founders, most nutria populations outside South America are relatively monomorphic genetically. Ramsey et al. (1985) reported only three of 22 presumptive loci were polymorphic in introduced feral nutria populations. Comparisons of overall individual genetic heterozygosity in introduced populations found relatively high variation in Louisiana (5%) compared to other areas. For example, average individual heterozygosity was only 1% in Maryland nutria (Morgan et al. 1981), 0.2% in England, and 0% in Washington state populations (Ramsey et al. 1985). Low genetic diversity in introduced populations is often due to founder effects and genetic drift associated with population "bottlenecks", in which a population is reduced to a small size for one or more generations.

The relatively high heterozygosity in Louisiana populations may be a result of highly heterozygous founders, multiple introductions, or both. In general terms, *loss* of genetic diversity is negatively correlated with the minimum population size and positively correlated with the duration of the bottleneck (Nei et al. 1975). Although the numbers and origins of the nutria that founded the Louisiana populations are not known, little loss of genetic diversity is expected when a population passes through a short bottleneck of only a few generations. This assumes that most or all of the transplants contributed to the founding gene pool.

Inbreeding depression refers to a loss of individual (and population) fitness associated with a lack of genetic diversity. It is attributed to the increased homozygosity of rare, recessive alleles (alternate gene forms) and is often expressed most strongly in traits related to fitness such as fecundity. The converse of inbreeding depression is heterosis, a term describing hybrid vigor or increased fitness in the progeny of different genotypic parents, and is often expressed in greater fecundity and survival (Bodkin et al. 1999). Heterosis may be most pronounced when relatively genetically monomorphic or inbred demes (local populations) meet and interbreed.

There were likely multiple introductions in Louisiana. Later introductions of nutria from different sources could have contributed to a heterotic-effect that in turn might have hastened the spread and proliferation of nutria in the state. The rate of spread of fire ants (*Solenopsis saevissima*) in the southeast U.S. was observed to increase rapidly following a second introduction 11 years after the first (Carson 1968). Studies of old field mice (*Peromyscus polionotus*) have shown that highly heterozygous females are more aggressive, have higher reproductive rates, and are more active dispersers (Smith et al. 1975, Garten 1976). Among some species of voles (*Microtus* spp.) dispersing females tend to be more heterozygous than non-dispersers (Krebs et al. 1973).

There is little information available on genetic diversity levels of wildlife populations and the associated fitness and population growth. A study of remnant and translocated populations of sea otters (*Enhydra lutris*) found lower growth rates in remnant populations as opposed to translocated populations, although no relation was found between growth rates and haplotype diversity of the different populations (Bodkin et al. 1999). Haplotype diversity was correlated with the minimum population size and the number of years at the minimum population size. This result confirms the earlier work by Nei et al. (1975) regarding the effects of size and duration of bottlenecks. Repeated bottlenecks coupled with long population fluctuation cycle length may greatly reduce genetic variability in a population (Motro and Thompson 1982). In regards to ecological-genetic interactions, Bodkin et al. (1999) found that the quality of the habitat was an important determinant of population growth following bottlenecks.

In Louisiana nutria, isolated (non-coastal) populations and those periodically reduced by severe winter weather have shown reduced genetic variation, perhaps due to founder effects and genetic drift (Ramsey et al. 1985). Linscombe (*pers. comm.*) has indicated the western Louisiana populations may have been kept below threshold levels in the 1980's and 1990's due to a series of climatic setbacks. It is not known if these events created localized bottlenecks or affected the genetic diversity and population growth of western Louisiana nutria as a whole.

In terms of management strategies, the impact of efforts to reduce local nutria populations might be maximized by applying control efforts to populations during bottlenecks when they are both numerically and genetically depauperate. Isolated or remnant populations resulting from catastrophic climatic events, or from population crashes due to habitat degradation, may be most vulnerable to control efforts since their recuperative abilities in terms of fecundity and dispersal success may be genetically attenuated. Conversely, strategies to encourage populations with desirable traits as a resource, for example the higher quality pelts produced by western Louisiana nutria, may benefit from exploiting genetic diversity. An appropriate strategy would include translocating animals from different sources, using large numbers of transplants, and managing for optimum nutria habitat (Bodkin et al. 1999). Genetic characterization of potential transplants is also encouraged to prevent possible negative hybridization effects, such as abnormal meiosis resulting from crossing over within inverted chromosomal segments in inversion heterozygotes (Kinler et al. 1987).

CHAPTER 3

Interactions of Nutria with Other Animal Populations in Louisiana

Introduction

The experiences with introduced nutria in Louisiana and elsewhere have clearly demonstrated that the species has significant impacts on the flora, fauna, and landscape of the invaded ecological communities. This chapter will focus on the interactions of nutria with other animals in the coastal marshes of Louisiana.

While invasions by non-indigenous species often cause significant and deleterious changes in the newly colonized communities, there is no accepted framework for characterizing and evaluating the type of impacts, magnitude of impacts, data quality, and extent of impacts at the community level (Ruiz et al. 1999). By contrast, two-species population interactions have long been characterized by ecologists in terms of costs and benefits to each species. The following list describes many of the most common two-species interactions. A plus sign (+) indicates a benefit, a zero (0) indicates a neutral effect, and a negative sign (-) indicates a detrimental effect (Table 2).

Table 2. Categories of interspecies interactions. Adapted from Odum (1971).

	Interaction Category	Species 1	Species 2
1.	Neutralism	0	0
2.	Competition – direct interference	-	-
3.	Competition – resource use	-	-
4.	Amensalism	-	0
5.	Parasitism	+	-
6.	Predation	+	-
7.	Commensalism	+	0
8.	Proto-cooperation	+	+
9.	Mutualism	+	+

Most two-species interactions can be readily assigned to these categories. Moving beyond categorical descriptions is often difficult because quantitative aspects of the interaction are lacking. For example, the fact that alligators may prey heavily on nutria does not in itself indicate the relationship will have population level impacts on either species. Interactions of ecological significance are those that cause a significant and measurable change in the abundance or distribution of one or both of the species (Ruiz et al. 1999). Species known or suspected to have significant direct interactions with nutria are American alligator, muskrats, waterfowl, raptors, and to some extent other bird life.

American Alligator

The American alligator (*Alligator mississippiensis*) is the largest reptile in North America. Ancestors of the American alligator appeared about 200 million years ago. They currently range from Texas eastward to North Carolina. Louisiana has the highest population, estimated at nearly 2 million in the nearly 4.5 million acres of suitable habitat in the state. While found in cypress-tupelo swamps and lakes, and canals and rivers, the highest population are found in the freshwater coastal marshes. American alligators lack the buccal salt-secreting glands present in crocodiles, and therefore can tolerate only moderate salinity levels. This restricts their distribution to freshwater, intermediate, and brackish marshes, and to mangrove swamps with limited salinity (Anonymous, FAAC 2002).

Alligators may live to about 70 years. They are slow growing, gaining about a foot in length per year. Those reaching about 6-8 feet become breeders. Mortality among the young is high, with only 10-20 % surviving to reproduce. Many young are eaten by other, larger alligators (Wolfe et al. 1987).

Alligators have been harvested in Louisiana for at least two hundred years. In the early 1800's skins were used for boots and saddles, while their oil was used in steam engines and cotton gins. Over the years demand waxed and waned. There was an increased use of hides occurring during the Civil War. In the late 1800's, the development of commercial tanning processes in New England led to the production of more durable hides. In 1962, the alligator season was closed in Louisiana due to low numbers. The USFWS listed the American alligator as endangered in 1967.

Populations in the state slowly rebounded, and beginning with Cameron Parish in 1972, a harvesting season was reinstated. Other parishes followed and the season was opened statewide in 1981. The American alligator was removed from the USFWS endangered species list in 1987. It was removed from the International Union for the Conservation of Nature (IUCN) "Red List" of threatened species in 1996. The IUCN Crocodile Specialist Group (CSG) Action Plan for the species currently considers the availability of population survey data to be "Good", the need for wild population recovery to be "Low", and the potential for sustainable management "High". Research priorities are rated as "Moderate", and include investigations of population biology and husbandry techniques (CSG 2000). The principle threats to American alligators are considered to be habitat destruction and environmental contamination (IUCN 2001).

In Louisiana, a 30-day annual harvest season now takes place each fall. A special spring harvest has been allowed at times on Marsh Island in May, June and July (Anonymous 1990). An experimental "Bonus Tag" program was initiated in 1999 and continued through the 2001 season. Trappers are issued 10% more tags than they would normally receive. This program is intended to encourage harvesting of smaller, 4 – 5 feet long alligators, which are occurring in greater numbers than the normally harvested 6 – 7 feet alligators (Elsey 2000). In 2001, 34,583 wild alligators were harvested. The average length of those taken with regular tags was 7.25 ft. Those taken with bonus tags were 5.85 ft in average length. The total commercial value of wild hides and meat was $9.02 million. Additional non-consumptive alligator revenue is generated in Louisiana from swamp tours, valued at $4 million in 2001 (Linscombe 2001).

In 1986, the state of Louisiana began an alligator-farming program. Alligator farmers are issued permits to collect wild alligator eggs and hatch them under artificial conditions. The farmers raise the alligators in captivity. Currently they are releasing approximately 14% of the 48 inch long alligators each year to augment the wild breeding stock in the marshes. The percentage released is adjusted periodically based on breeding success in the wild, survival rates of various size alligators and other factors. Egg production in the wild is subject to fluctuations. Drought conditions led to low egg collections in 1998, but with higher water levels in 1999 production increased dramatically (Elsey 2000). Currently about 300,000 eggs are collected annually, and the hides and meat produced by the alligator farming industry were valued at over $12 million in 2001 (FAAC 2001). Both the wild and farmed alligator industries are tied to the success of wild alligator populations. This provides a strong incentive to public and private land managers in the state to maintain or improve marsh habitats.

Nutria-Alligator Interactions

The relationship between alligators and nutria is obviously that of predator and prey. Valentine et al. (1972) reviewed alligator food habit studies reported from 1929 to 1964, all conducted at the Sabine National Wildlife Refuge in southwest Louisiana. By combining the results of four studies from 1946 to 1964, they were able to analyze a sample of 731 alligators. They determined that crustaceans were the most important food class for alligators of all ages at the Sabine N.W.R. Fish, birds and mammals were also taken in varying proportions. Muskrats were found in 33-52% of alligator stomachs examine in two studies in the early 1940's (O'Neil 1949). By 1961, a survey of 25 alligator diets found nutria in 56% of the stomachs examined, comprising 46% of stomach volume. However, the following year nutria dropped to 5% occurrence in alligator stomachs analyzed. Nutria population estimates and fur harvest records for the Sabine N.W.R. indicated the nutria population was declining quite rapidly during the period 1961 – 1965, from an estimated population of 74,000 to 9,000. (Valentine et al. 1972). There is no data to suggest that alligator predation was driving the nutria decline. Fur harvests removed about 30% of the nutria each year through this period (Valentine et al. 1972).

Valentine et al. (1972) considered the alligator to be an opportunistic feeder that will eat anything that moves. Prey items are limited only by size. In their review, nutria were found only in stomachs of alligators over 3 feet in length. Wolfe et al. (1987) found a similar size threshold. Chabreck (1996) reported that cannibalism by alligators is common, and at times even adult alligators may be taken as prey by larger alligators.

Wolfe et al. (1987) examined stomach contents of alligators collected from southeastern Louisiana, and summarized previous work on alligator diets. Basing diet composition on actual or estimated live weights of intact, undigested prey items refined the diet analysis. Earlier studies often relied on occurrence and weight of partially digested remains to estimate the levels of diet components. In their survey of 100 alligator stomachs, muskrats and nutria together accounted for 83% of the diet weight and occurred in 77% of the stomachs. While muskrats occurred with greater frequency than nutria, the nutria accounted for more than two thirds of the mammalian flesh weight in the samples.

Crustaceans, mostly blue crabs (*Callinectes sapidus*) and crawfish (*Procambarus* spp.) had a high rate of occurrence but comprised only about 1% of the diet weight. As alligator size increased, there was a trend towards replacing the numbers of muskrats in the diet with fewer nutria. Feeding efficiency appeared to be maximized by selecting the largest practical prey item, which will be the nutria in areas where muskrats and nutria occur together, are equally abundant, and equally "catchable" (Wolfe et al. 1987). The same study also concluded that alligators are opportunistic feeders and diet composition is largely determined by availability and vulnerability of the prey.

In the past, trappers have expressed concern that they were competing with alligators for nutria and muskrat (McNease and Joanen 1977). No published information has been found to verify this. While it has been shown that nutria and muskrats are often taken by alligators in large numbers, it is unlikely that alligators have significant impacts on either prey species due to the high reproductive rates of both rodents (Wolfe et al. 1987).

Nor is there any information available on the possible dependence of the alligators on muskrat and nutria populations. The nature of these relationships represent a significant research need that should be pursued since populations of both nutria and alligator have large impacts on the Louisiana marsh ecology and economy.

Wild harvested nutria have been used as a feed supplement for the alligator farming industry, and for other animal feeds. In New Orleans, nutria collected during recent population reduction campaigns have been used for animal feed at the Audubon Zoo (A. Ensminger, *pers. comm*.). In order to expand these uses a number of logistical and economic obstacles must be overcome. Some of these are addressed in the accompanying report "Marsh Dieback and Nutria Control Research: Socioeconomic and Cultural Analysis" (Brown 2002). Nutria meat is currently being used in limited quantities to feed young, farm-raised alligators (D. Ledet, *pers. comm.*). Nutria meat is a high quality food for this purpose, whether used fresh or processed into a meal (Coulson et al. 1987). There are significant practical concerns about using nutria as animal food, including spoilage, contamination, and the need to develop a processing and storage infrastructure. There have been previous incidents of contamination with toxicants used to control nutria populations (Evans and Ward 1967), and lead. Secondary lead poisoning of farm-raised alligators has been attributed to bullet fragments processed with the nutria carcasses (Camus et al. 1998).

Muskrat

The historical record of the muskrat (*Ondatra zibethicus rivalicious*) in Louisiana has been reconstructed to the extent possible by Lowery (1974). There is very little mention of muskrat by the early explorers and naturalists, although the fossil record confirms their presence as far aback as the Pleistocene. Lowery concludes that muskrat probably occurred in low numbers up until about 1910. Earlier, populations were likely held down by a limited suitable food supply and an abundance of predators. The rise in muskrat populations in the early 20th century is tied to the alligator hunting trade at the turn of the century. As alligators became scarcer, hunters discovered they could more easily find the remaining reptiles by burning the marshes. Repeated burning held the marsh in an earlier successional stage dominated by three-cornered grass (*Scirpus americanus*) (formerly *S. olneyi*) and also called chairmaker's bulrush (*Schoenoplectus americanus*). This is prime food for muskrats, and soon thereafter populations exploded (Lowery 1974).

The muskrat trapping industry became established by about 1910. By the 1913-1914 season about 4.25 million muskrat were trapped in the state (Lowery 1974). There were radical swings in the harvest, and presumably the muskrat populations, over the next 40 years. The fluctuations are attributed to a large extent to the ability of muskrats to rapidly reproduce when conditions are good, and their susceptibility to climatic catastrophes. Female muskrats in Louisiana may produce up to nine litters a year, with 4-6 young per litter (Chabreck 1992). On the other hand, many muskrats may drown during floods or hurricanes, or perish because of drought or disease (Chabreck 1992). Louisiana muskrats also appear to go through population cycles of 10-14 years or longer.

The cycles may be driven by density-dependent factors relating to the local carrying capacity.

In addition to foraging, much more vegetation is destroyed for use in building muskrat houses. "Eat-outs," denuded areas resulting from overgrazing, are associated with over-population and may lead to population crashes. Following a crash the marsh vegetation gradually recovers and a new muskrat boom follows. Population cycles are local and rarely synchronized across the state. This is reflected in the harvest records. From 1923 to 1960 the annual harvest always exceeded 1 million pelts (Lowery 1974, Chabreck 1992).

Muskrat distribution and abundance is tied closely to the distribution and abundance of three-cornered grass. In turn, three-cornered grass is limited to areas with a proper range of water level fluctuations and salinity. The appropriate conditions are found along estuarine shorelines and in brackish marsh (Lynch et al. 1947, Palmisano 1972, Kinler et al. 1987, Chabreck 1992). Water management and annual burning in the brackish marshes maintain the three-cornered grass stands. These practices benefit muskrats as well as wintering snow geese (*Chen caerulescens*) (Kinler et al. 1987). Prior to the early part of the 20th century, only freshwater floating marsh consistently produced dense populations of muskrat in southeast Louisiana (Lynch et al. 1947).

The muskrat populations in Louisiana peaked in 1945-46, then went into a gradual decline which has persisted to this day, in spite of large vacillations at times. The decline has been attributed to a number of factors, including a decrease in the abundance and distribution of three-cornered grass, catastrophic weather events, industrialization of the marshes, and at times, over-population (Lowery 1974, Kinler et al.

1987). As saltwater intrusion has changed the salinity regime of the coastal marshes in the last few decades, brackish marsh and the associated plant communities have been reduced in area. Increasing salinity is unfavorable not only to the vegetation on which muskrats depend, but also has direct negative effects on muskrat litter production and survival of young (Dozier 19**).

Muskrat-Nutria Interactions

The decline of the muskrat beginning in the 1940's coincided with the tremendous increase in nutria seen in the late 1940's and through the 1950's. However, there is little evidence that the trends are related (Ensminger 1955, Evans 1970, Lowery 1974). The two species do occur together. However, there is a degree of niche separation due to different feeding habits and habitat preferences. Whereas the density of muskrat is tied closely to *S. olneyi* production, nutria are able to thrive on a variety of plants in addition to *S. olneyi*. In their native S. America as well as in the U.S., the highest quality habitat for nutria is freshwater environments with stable water levels (Atwood 1950, Coreil 1984, Kinler et al. 1987).

In Louisiana this describes the freshwater marsh, characterized by floating mat vegetation and species such as maidencane (*Panicum hemitomon*), bulltongue (*Sagittaria falcate*), spikerush (*Eleocharis* spp.), and alligatorweed (*Alternanthera philoxeroides*) (Kinler et al. 1987). High densities of nutria also occur at times in intermediate and brackish marshes. Where nutria and muskrat co-occur, the nutria appear to be behaviorally dominant. There are a few anecdotal reports of harassment and direct confrontations. For example Lowery (1974) describes incidents of nutria attacking muskrats held in traps. However, Evans (1970) concluded from field and pen studies that direct confrontations are rare and insignificant. However, he documents instances of nutria damaging or destroying muskrat houses in the course of feeding and burrowing. Evans (1970) also suggested there may be competition for high spots in marshes during floods. Perhaps the strongest evidence of competition for resources or through direct interference comes from Evans (1970), who reported that removal of nutria from an areas of co-occurrence was often followed by a surge in the muskrat population.

Bird–Nutria Interactions

The primary direct interaction between birds and nutria is a predator-prey relationship. Young nutria in particular are taken by bald eagles (*Haliaeetus leucocephalus*) (Dugoni 1980, Jeb Lincombe, *pers. comm*.), red-shouldered hawks (Warkentin 1968), and even magpies (*Pica pica*) (Willner 1982). Jemison and Chabreck (1962) found no evidence that owls fed on nutria in an area where nutria were abundant. However, in Europe and Asia, predation has been reported by tawny owls (*Strix aluco*) as well as great blue herons (*Ardea cinerea*), harriers (*Circus* spp.), and crows (*Corvus* spp.) (Ellis 1965, Aliev 1966).

Nutria interact indirectly with waterfowl and wading birds through habitat modification. Ponds of open water in the marsh resulting from nutria eatouts may actually be beneficial to waterbirds, including lesser snow geese, mottled duck and black-necked stilts (*Himantopus mexicanus*). Quality duck food plants may quickly become established in these open areas (Ensminger 1955).

An annotated listing of the USFWS Breeding Bird Survey trend results for Louisiana, 1966 – 2000, is listed in Table 3. In interviews conducted in February 2002, ornithologists at Louisiana State University identified some bird species that could be adversely affected by changes in the marsh habitats as a result of nutria herbivory (Mark Hafner, *pers. comm*.). None of the species listed are currently considered as threatened or endangered by the USFWS. The king rail (*Rallus elegans*), purple gallinule (*Porphyrula martinica*), least bittern (*Ixobrychus exilis*), pied-billed grebe (*Podilymbus podiceps*), and common yellowthroat (*Geothlypis trichas*), all displayed downward trends in Louisiana for the period 1966 – 2000.

The mottled duck (*Anas fulvigula*) is declining on a nationwide basis, although not in Louisiana. It is listed on the National Audubon Society "WatchList" (formerly the "Blue List"), which identifies birds undergoing non-cyclic declines on a region-wide or nation-wide basis.

The resident seaside sparrow (*Ammodramus maritimus*) and a species that does not breed in Louisiana but only winters in the coastal marshes, Nelson's sharp-tailed sparrow (*Ammodramus nelsoni*) are also on the Audubon WatchList.

Valentine et al. (1972) reported that alligators prey on herons, egrets, rails gallinules, and mottled ducks. While birds were not high in occurrence in alligator stomachs, they were high in volume. The role of nutria as an alternative prey source for alligators and positive or negative effects on bird predation by alligators has not been investigated.

Other Nutria Predators

Young nutria are also preyed upon by turtles, gar (*Lepisosteus sp*), and the cottonmouth (*Agkistrodon picivorous*) (Warkentin 1968, Evans 1970). Little information is available on the extent of interaction or the effects on the species involved.

Indirect Relationships Between Nutria and Other Animal Populations

As mentioned earlier, interactions of ecological significance are those that cause a significant and measurable change in the abundance or distribution of one or both of the species. Beyond the information cited above, there is little data available concerning direct nutria impacts upon the abundance or distribution of other marsh animals.

However, nutria herbivory impacts on the habitat may have even greater influences on the marsh ecology (Grace and Ford 1996). The distribution and abundance of many marsh dwelling animal species is closely linked to the plant communities. In turn, the distribution and productivity of plant communities depends on salinity regimes, water level fluctuations, water turbidity, and rates of tidal exchange (Chabreck 1976).

The vulnerability of the coastal marshes to both gradual and catastrophic processes that alter these characteristics at a given locale will impact all the animals that cannot relocate easily or quickly enough to avoid changing conditions. Storm surges may extend farther into the freshwater marshes now than in the past due to nutria grazing. The resulting saltwater intrusion will have an impact on both abundance and distribution of alligators locally. In the longer term, muskrats, which rely on *Scirpus americanus* in the brackish marsh, will be affected by saltwater intrusion. Resident and over-wintering birds can be expected to be affected by habitat changes as well, in some cases positively and in some cases negatively.

The coastal wetlands also provide structural shelter for aquatic organisms, serving as a nursery ground for marine fishes and crustaceans (Valentine et al. 1972). The wetlands cycle nutrients out of detritus and water, promoting the growth of micro-organisms at the bottom of the fishery food chain. The Gulf of Mexico is America's most productive shrimp fishery. Ninety-eight percent of the harvest of fish and shellfish from the Gulf comes from inshore areas (Anonymous 2001). Continued coastal wetland losses and habitat alterations, which are in part attributable to nutria herbivory, are expected to decrease the productivity of the Gulf's commercial and sport fishery industry (Kendrick 1998).

Table 3. North American Breeding Bird Survey - Louisiana Trend Results. Adapted from: Sauer, J. R., J. E. Hines, and J. Fallon. 2001. *The North American Breeding Bird Survey, Results and Analysis 1966-2000*. Version 2001.2, USGS Patuxent Wildlife Research Center, Laurel MD

Credibility Categories:

VL: Very Low. Data has an important deficiency, such as very low abundance (< 0.1 birds/route), very small samples (< 5 routes), or very imprecise (5% change/year would not be detected).

L: Low. Data has a deficiency, such as low abundance (< 1.0 birds/route), small sample size (< 14 routes), quite imprecise (3%/year change would not be detected), or sub-interval trends are significantly different (p<0.05, z-test) suggesting inconsistency in trend over time.

M: Moderate. At least 14 samples of moderate precision, and of moderate abundance on routes.

Trend: Estimated Trend, summarized as percent per year.
P: Probability that trend is significantly different from 0. "*" indicate significant difference.
N: Number of survey routes in the analysis.
95% C.I.: 95% confidence interval for the trend estimate.
R.A.: Relative abundance for the species, in birds per route.

VL	Pied-billed Grebe	-12.6	0.32	4	-26.0	0.9	0.08	--	--	--	-22.0	0.33	4
VL	Least Bittern	-0.7	0.94	5	-18.8	17.4	1.25	72.4	0.23	3	-5.4	0.16	4
VL	Mottled Duck	3.6	0.60	12	-9.4	16.6	4.55	17.6	0.55	4	6.7	0.29	10
VL	Clapper Rail	1.5	0.86	4	-14.2	17.3	0.85	--	--	--	2.0	0.86	4
VL	King Rail	-12.9	0.06	9	-24.6	-1.2	2.64	21.5	0.78	3	-11.1	0.34	7
VL	Purple Gallinule	-18.9	0.17	6	-42.0	4.2	0.39	--	--	--	-17.3	0.25	4
VL	Common Moorhen	7.3	0.24	11	-4.2	18.8	4.74	2.7	0.95	4	5.9	0.58	8
VL	Marsh Wren	12.1	0.02	3	8.4	15.7	2.31	--	--	--	11.0	0.00	3
M	Common Yellowthroat	-1.0	0.42	63	-3.3	1.4	8.39	-3.3	0.12	24	-1.0	0.44	57
VL	Seaside Sparrow	71.1	0.61	3	*****	305.5	0.18	--	--	--	232.5	0.20	3
L	Boat-tailed Grackle	1.4	0.66	17	-4.8	7.6	37.31	-2.6	0.91	5	0.3	0.93	15

CHAPTER 4

Impacts of Nutria on Louisiana Wetland Habitats

Introduction

Herbivory can have significant effects on both the physical aspects and plant communities of ecosystems (Ford and Grace 1998). In general, the impacts of introduced nutria on habitats have been considered neutral when population densities are low (Hillbricht and Ryszkowski 1961, Ehrlich and Jedynak 1962, Ellis 1963, Wentz 1971). At high densities nutria activity can have significant impacts in the form of reduced plant biomass, changes in plant species composition, and altered physical structure of the marshes (Llewellyn and Shaffer 1993, Johnson and Foote 1997, Ford and Grace 1998, Evers et al. 1998, Mouton et al. 2001).

Nutria have long been recognized as having the ability to alter vegetative communities when occurring at high densities (Hillbricht and Ryszkowski 1961, Ehrlich and Jedynak 1962, Harris and Webert, 1962, Ellis 1963, Wentz 1971, Litjens 1980). They are voracious eaters, consuming about 25% of their body mass in vegetation each day (Gosling 1974). For average adult nutria this amounts to about 1,100 grams per day (Christen 1978). Nutria direct their feeding efforts at the bases of some marsh plants, including the roots and rhizomes (Ellis 1963, Gosling 1974, Willner et al. 1979, Chabreck et al. 1981, Taylor et al. 1997). This destroys the whole plant, while as little as 10% may be eaten (Taylor et al. 1997). Nutria, like other semi-aquatic mammals such as beaver and muskrat, have additional impacts on the physical structure of marshes beyond their foraging activities. Intense grazing by nutria can have negative effects on soil building processes in the marshes (Ford and Grace 1998). These impacts may in turn lead to increased erosion, and setback or maintain the successional stages of plant communities (Ehrlich and Jedynak 1962, Myers et al. 1995). It has been shown that intense nutria herbivory can override plant community interactions such as mutualism and competition (Taylor et al. 1997). Nutria also manipulate the habitat by constructing resting platforms and nests from vegetation and burrowing into spoil banks and levees (Atwood 1950, Ehrlich 1962). Nutria grazing and excretion stimulates growth of some plants such as the invasive aquatic fern *Salvinia* spp. (Ehrlich 19**).

Nutria have been introduced to some areas at least in part because of their potential ability to reduce undesirable vegetation (Barabash and Morozova 1952, Ensminger 1955, Ehrlich 1962). In Poland and Israel, nutria activity converted plant-clogged lakes and waterways to open water, which improved conditions for irrigation, local fisheries, and boat travel (Ehrlich 1957, Ehrlich and Jedynak 1962). Ehrlich and Spielberg (1960) concluded that the stocking of nutria to clear reeds from ponds and waterways in Israel was preferable to chemical and mechanical methods. The increased water turbidity attributed to nutria foraging prevented the growth of filamentous algae, which furnish shelter for *Anopheles* mosquito larvae, vectors of malaria. In Oregon, creation of open water and increased nutrient cycling due to nutria herbivory were considered beneficial to inland marshes (Wentz 1971). Ensminger (1955) noted that in some cases, areas of Louisiana marsh converted to open water by nutria activity were quickly colonized by plants favored by waterfowl. Nutria were stocked in some parts of Louisiana with the intention that they might reduce the introduced water hyacinth (*Eichhornia crassipes*) which clogs waterways (Lowery 1974). However, in many cases these efforts have been ineffective because the nutria tend to select native species over invasive introduced plants (Lowery 1974, Woods et al. 1992).

The Impacts of Nutria Herbivory in Louisiana

The ecology of the coastal marshes of Louisiana is characterized by complex and very dynamic abiotic and biotic processes (Chabreck 1976, Fuller et al. 1985, Evers et al. 1998). Most of the Mississippi delta is now in a long-term phase of degradation driven by natural abiotic processes such as the rising sea level, subsidence, wave erosion, and saltwater intrusion. The effects of these processes may be amplified by man-made modifications to the marsh structure such as dikes, levees and canals. The natural processes of land maintenance and building, which were once fed by sediment deposits from the river, have been curtailed by the levees that now contain the river all the way to the Gulf of Mexico (Sasser et al. 1995).

While most of the Louisiana coast is losing land area, two locations are undergoing a net growth in land area. These are Atchafalaya River delta and the Wax Lake delta, both fed by the Atchafalaya River. The Atchafalaya River carries about 30% of the flow of the Mississippi and Red Rivers into the Atchafalaya Bay. Sediment deposits from the river water resulted in the emergence of islands at the river's mouth beginning in 1973. The site has provided a unique opportunity to study the interactive processes of sediment deposition, wetland development, vegetative succession, and herbivory by nutria, muskrat and waterfowl (Fuller et al. 1985).

Biotic processes in the marshes have been manipulated by man for a variety of purposes. In the brackish marshes, burning has been used as management tool for at least a hundred years to facilitate activities such a alligator hunting and muskrat and nutria trapping, and to encourage growth of *Scirpus americanus (*formerly *S. olneyi)*, which is a favored forage of lesser snow geese, muskrat and nutria (Kinler et al. 1987, Ford and Grace 1998). Weirs are used to manage water levels by dampening tidal surges. Ditching allows drainage to be controlled. Both types of structures enable land managers to stabilize or adjust water levels as needed to promote the desired vegetative community composition and abundance (Kinler et al. 1987).

Nutria damage first became evident in Louisiana in the 1950's when the population was estimated to have reached 20 million (Lowery 1974). Eat-outs appeared, areas that were either denuded of vegetation or converted to open water. Early exclosure studies by Chabreck et al. (1959) found that herbivory in the brackish marshes could reduce vegetation biomass by 40%.

The rise of the trade in nutria fur led to annual nutria harvests exceeding 1 million per year from 1962 to 1981 (La. Dept. of Wildlife and Fisheries records). The increased trapping pressure combined with nutria losses attributed to severe weather events in the late 1950's and early 1960's resulted in reduced populations of nutria. Reports of damage were mostly associated with agricultural crops (Evans 1970, Lowery 1974).

A similar situation has been described in the Chesapeake bay area for this same period. Exploding populations of nutria in the 1950's were associated with marsh damage as identified in aerial photographs. The damage has accelerated since the mid-1970's due to the decline of pelt prices and the trapping harvest (Haramis 1996).

In Louisiana, nutria are found in primarily in three types of marshes which are categorized by salinity levels. These are the freshwater, intermediate (= oligohaline) and brackish (= mesohaline) marshes. Nutria only occur in low numbers in the saline marsh (Linscombe and Kinler 1992). Additional populations may be found in the bald cypress swamps.

The floating freshwater marshes are the best nutria habitat in Louisiana, although the intermediate and brackish marshes can support very high populations at times (Kinler 1992, Linscombe 1992). The freshwater marshes are characterized by floating mats of vegetation. The most abundant plants are maidencane (*Panicum hemitomon*); bulltongue (*Sagittaria lancifolia* (= *S. falcata*)); spikerush (*Eleocharis* spp.); and alligatorweed (*Alternanthera philoxeroides*). Intermediate marsh is dominated by wiregrass (*Spartina patens*); reed (*Phragmites communis*); and bulltongue (*Sagittaria lancifolia*). In brackish marsh the most abundant species are wiregrass (*Spartina patens*); inland saltgrass (*Distichlis spicata*); and three-cornered grass (*Scirpus olneyi* (= *Scirpus americanus* = chairmakers bulrush, *Schoenoplectus americanus*)) (Chabreck 1970). The Atchafalaya delta is converting from a marine bay to a mainly freshwater marsh due to the infusion of river water (Llewellyn and Shaffer 1993).

Southeast Louisiana Studies

A number of studies in the Pearl River Wildlife Management Area (WMA), near the Louisiana-Mississippi border and north of Lake Ponchartrain, have investigated the role of herbivory in the marshes. Herbivory at the study sites was attributed primarily to nutria, although feral hogs are found in the area as well. Nutria populations in this area were estimated at about 22/ha. (Ford and Grace 1998). Researchers found herbivory reduction of above-ground biomass of intact stands of plants to be in the range of 30-50%

(Taylor and Grace 1995). Panic grass (*Panicum virgatum*) and aster (*Aster subulatus*) were significantly reduced by herbivory in the freshwater marsh, whereas in the intermediate marsh herbivory significantly increased *P. virgatum* and hairypod cowpea (*Vigna luteola*). In the brackish marsh, herbivory had no impact on species abundance. The results supported a conclusion that nutria herbivory had specific effects on some species and has a general plant community effect as well.

In other research in the Pearl River WMA, plant neighbor interactions and herbivory effects were studied (Taylor et al. 1997). Species biomass of *Spartina patens*, *Spartina alterniflora*, and *Panicum virgatum* was reduced by 75% due to herbivory in freshwater, intermediate and brackish marshes. Mutualistic plant neighbor effects were found for *S. patens* in the brackish marsh and for *P. virgatum* in the freshwater marsh. However, both species suffered from competitive suppression in other salinity regimes (*S. patens* in fresh and intermediate marshes, *P. virgatum* in the brackish marsh). In the presence of intense herbivory, the positive and competitive effects of plant neighbors were eliminated. These results applied to herbivory on isolated stands of transplants in the study area. Nutria were observed to feed preferentially on these isolated clumps of vegetation, a behavior which could promote the formation of eatouts in areas of persistent feeding (Taylor et al. 1997).

Ford and Grace (1998) conducted studies that focused on the interactive effects of herbivory and fire on the coastal marshes. The results suggested a hypothesis that fire impairs *S. patens* more than other species, while herbivory impairs other species more than it does *S. patens*. The hypothesis provides a basis for the long established practice of burning the relatively unpalatable *S. patens* in the brackish marshes to promote the growth and abundance of *Scirpus americanus*, which is considered a favored food of lesser snow geese, muskrats and nutria (Kinler et al. 1987). *Spartina patens* is found in *Panicum virgatum* and *Sagittaria lancifolia* dominated marshes as well whereas *Scirpus americanus* is generally restricted to the brackish marsh. However, in this study burning *S. patens* dominated marsh did not significantly affect the relative cover of *S. patens* and *Scirpus americanus*. The authors suggested this may have been due to the fact that nutria herbivory at the study site reduced the fuel load so much that hot, continuous burns could not be sustained (Ford and Grace 1998).

Other work by Ford and Grace (1996) at the Southeastern Louisiana University Turtle Cove Environmental Research Station suggested that herbivory can increase the susceptibility of freshwater marshes to damage from saltwater intrusion. Sods of *Sagittaria lancifolia,* a dominant plant of the freshwater marshes, were subjected to simulated herbivory (clipping), flooding and increased salinity (15%). None of the three treatments applied alone or in pairs caused long-term damage to the sods. But the simultaneous occurrence of all three stressors reduced growth and caused plant death. The experiment simulated conditions created by storm driven saltwater intrusions, which have been associated with vegetation diebacks. While this study simulated tropical storm effects and nutria herbivory, the results show that the combination of these stressors can potentially contribute to habitat loss in the freshwater marshes.

In experiments in the brackish marshes of the Pearl River WMA, Ford and Grace (1998) found that herbivore activity decreased above-ground biomass, below-ground production, soil elevation and root zone expansion. They suggest that in areas where mineral sediment deposition rates are high, marshes can withstand herbivory, but in the absence of such deposits, herbivore activity can have negative effects on soil-building processes that can lead to habitat destruction.

Atchafalaya Bay Studies

As noted previously sediment deposits from the Atchafalaya River resulted in the emergence of islands at the river's mouth, beginning in 1973. The early colonization of the islands by plants and animals as been described by Fuller et al. (1985). By 1980 the newly forming delta had grown to 17 km^2. About 11 km^2 were covered by vegetation. The islands were quickly colonized by broadleaf arrowhead (*Sagittaria latifolia),* and delta arrowhead (*Sagittaria platyphylla).* Nutria and muskrat colonized the islands within two years of their appearance. Researchers soon noticed that previously vegetated areas were reverting to un-vegetated mudflats. Year-round grazing by nutria and muskrat, and by fall and winter concentrations of waterfowl, were suspected of affecting the plant communities. Exclosure studies showed that nutria and muskrat herbivory were significantly reducing the biomass of *S. latifolia* and valley redstem or axil weed (*Ammannia coccinea).* In addition, the grazing and associated mechanical disturbance appeared to be holding the plant communities in a transitional stage (Fuller et al. 1985).

Vegetation succession on the growing delta was predicted to be rapid due to the warm climate, rich soils and unlimited moisture (Shaffer et al. 1992). However, during the period 1980-1986 vegetation surveys and continuing exclosure studies found trends of decreased vegetated area and increased species diversity. The decreased vegetation was attributed to two factors – increased nutria herbivory and prolonged flooding. The authors hypothesized that nutria herbivory of above-ground portions of *Sagittaria latifolia* leaves and the below-ground tubers made the plants more susceptible to the effects of flooding. Nutria populations on the islands were believed to have greatly increased during the study period, although census data were not available. These factors are slowing the initially predicted rates of plant community succession (Shaffer et al. 1992).

By 1993, the islands in the bay had grown to 50 km^2. However, 80% of this area consisted of mudflats. Nutria were identified as the primary cause of vegetation loss on the islands, although waterfowl also grazed the islands. Llewellyn and Shaffer (1993) investigated the potential of the willow species, *Justicia lanceolata* (Chapm.) Small, for freshwater and intermediate marsh restoration in the presence of nutria herbivory. The species is so unpalatable to nutria that it has been described as “repellent”. The authors concluded that the plant is well suited as a tool for marsh restoration, and can function as a barrier to nutria (Llewellyn and Shaffer 1993).

Evers et al. (1998) found in exclosure studies on the Atchafalaya delta that waterfowl and nutria herbivory were having roughly equal impacts on the vegetation. The experiments showed herbivory is having a “major impact on expansion, growth and species composition of emergent vegetation.” (Evers et al. 1998).

Barataria and Terrebonne Basin Studies

The Barataria and Terrebonne Basins comprise of an area of southeast Louisiana bounded by the Atchafalaya River on the west and the Mississippi River on the east. Changes in structure and vegetative composition of the freshwater marshes of Terrebonne parish during the period 1968 to 1992 were described by Visser et al. (1999). They found a large scale shift in the dominant vegetation of the study area. The *Panicum hemitomon* dominated marsh declined from 51% to 14% of the study area, and was replaced with *Eleocharis baldwinii*-dominated marsh, which increased from 3% to 41% of the study area. Herbivory, increasing water levels and changing water quality were identified as possible driving factors behind the change. The actual cause or causes of the changes were not determined.

Nutria herbivory may be responsible for weakening of the floating mats in freshwater marshes in the Barataria-Terrebonne Basins, which makes the creation of open water areas more likely in the event of storms and storm surges (A. Ensminger, C. Sasser, *pers. comm*.)

Aerial surveys of nutria herbivory damage to the marshes in the Barataria and Terrebonne Basins were conducted in 1993, 1995 and 1996 (Linscombe and Kinler 1997). The 1993 flights identified 90 damaged sites along transects, amounting to 15,000 acres of impacted marsh. Extrapolating from this figure, based on the transect swath width (1/4 mile) and distance between transects (1.8 miles), the damaged acreage in the survey area can be multiplied by a factor of approximately four, resulting in an estimated 60,000 acres impacted by nutria herbivory in the survey area. The 1996 survey found the impacted area on flight transects had grown to 20,642 acres, or 82,568 acres in the survey area (Linscombe and Kinler 1997).

The plants most affected were, in the freshwater marsh, *Eleocharis* spp. and pennywort (*Hydrocotyl* spp.); and in the intermediate and brackish marshes, *Eleocharis* spp. and *Scirpus americanus* (Linscombe and Kinler 1997, Mouton et al. 2001).

Foote and Johnson (1992) reported on work in the brackish marshes south of New Orleans. The area is losing an estimated 2-4% of the vegetated area per year, attributed to nutria herbivory. By tracking the plant biomass and stem turnover rate of *Scirpus americanus* and *Spartina patens*, the authors found that the vegetative community is responding to nutria herbivory with increased production, but vegetation biomass is not increasing. The increased plant production appears to be going into increased nutria production.

Jacoby et al., (1999) have developed models of nutria-wetland interactions linking data from the brackish marshes of the Barataria Basin. Among the results, they found the marsh-loss model is not sensitive to the nutria density at which marsh loss begins, but is sensitive to the biomass destroyed per nutria. Also, nutria numbers do not respond significantly to marsh area loss until the area approaches zero, because marsh loss occurs only during winter when marsh biomass is at it's annual low (Jacoby et al. 1999).

Coast-wide Surveys

Coast-wide aerial surveys were conducted in 1998, 1999, 2000, and 2001 under the Nutria Harvest and Wetland Demonstration Project (Mouton et al. 2001). The coast-wide flights conducted in 1998-2001 followed the same transect patterns used in the Barataria-Terrebonne surveys earlier. The survey results indicate nutria herbivory damage in recent years is concentrated in the Deltaic Plain in southeastern Louisiana. The most severely impacted Parishes are Terrebonne, LaFourche, Jefferson and Plaquemines.

The greatest damage is occurring in the freshwater marshes (48%). The flight survey data from 1998-2001 show that the amount of area damaged by nutria decreased somewhat from 2000 to 2001, and the number of sites classified as having severe vegetative damage declined as well. However, 44 sites comprising 8,531 acres had "old damage" and were not recovering, and 19 sites containing 4,726 acres had converted to open water. The majority of the damaged sites were predicted to recover partially by the end of the 2001 growing season. The overall decrease in damaged area may be attributable to the effects of drought on nutria populations (Mouton et al. 2001).

In spite of the partial recovery predicted for many of the lesser-damaged areas, the development of open water and failure of many areas to show recovery at all suggests nutria damage may be leading to permanent loss of coastal wetlands (Mouton et al. 2001). There is evidence that broken areas seen today in the brackish marshes of Marsh Island are remnants from muskrat eatouts that occurred in the 1940's (Linscombe 1992).

Baldcypress Swamps

Nutria are also found in the baldcypress (*Taxodium distichum*) and tupelo (*Nyssa* spp.) swamps. Damage is typically of three types: girdling of mature timber, impacts on natural regeneration, and impacts on artificial regeneration (Sparks 1992). Lethal damage to mature trees is not considered a serious problem. However, gnawing on mature trees may make the trees more susceptible to other stressors. Little is known about the impacts of nutria on natural regeneration. Nutria impacts on artificial regeneration are well documented (Blair and Langlinias 1960, Conner and Toliver 1987, Myers et al. 1995).

Nutria pull young seedlings, and eat the succulent bark from the taproot (Blair and Langlinias 1960). In other cases seedlings are clipped above ground. Some re-seeding efforts have been suspended due to nutria damage. A variety of taste and odor repellents, physical repellents and physical barriers have been used to reduce nutria impacts. Physical (wire) barriers appear to be the most effective (Conner and Toliver 1987, Mike Materne, *pers. comm.*). Research has shown that fall plantings suffer less damage than spring plantings because of the abundance of other food sources during the fall (Conner and Toliver 1987).

Summary

There is no question that nutria are playing an important role in the complex marsh ecology in Louisiana. A multitude of studies have shown that marsh damage is positively correlated to nutria density.

Deleterious effects of intense nutria herbivory include reduction in marsh biomass, setback of vegetation succession, elimination of mutualistic and competitive plant interactions, and stress to plants. When herbivory stress is combined with prolonged flooding and saltwater intrusion, vegetation die-offs may occur. Reduction of soil-building processes due to nutria grazing may lead to habitat destruction. Grazing may weaken the physical structure of floating mat vegetation, and can create open water which makes the marshes more susceptible to storm surge damage.

The Society of Wetland Scientists position paper entitled “Definition of Wetland Restoration” has defined Wetland Restoration as “actions taken in a converted or degraded natural wetland that result in the re-establishment of ecological processes, functions, and biotic/abiotic linkages and lead to a persistent, resilient system integrated within its landscape" (Anonymous 2000). The goal of wetland restoration is a persistent, resilient system. The restoration should result in the historic type of wetland but not necessarily the historic biological community and structure. Marsh creation is now a major policy objective of the government of the state of Louisiana and the Federal government (Evers et al. 1998).

There is strong evidence that current nutria population levels, particularly in the southeast portion of the state, are having significant impacts on the rate of marsh creation in the Atchafalaya delta and on the rate of marsh degradation elsewhere in the Mississippi delta. Without sustained reduction in nutria impacts there will be little chance of restoring or even slowing the degradation of the coastal marshes in Louisiana.

The probable impacts of continued marsh habitat modification and loss include decreases in sport and commercial fisheries production, decreased acreage available to treat pollution inputs to the Mississippi delta and the Gulf of Mexico, increased levels of eutrophication, decreased capacity to buffer storms, and decreased habitat for other species (Anonymous, BTNEP 1998).

Figure 3. Louisiana nutria harvest, average pelt value and annual trapping licenses for the period 1950-51 to 2000-01. Note the Y-axis is logarithmic.

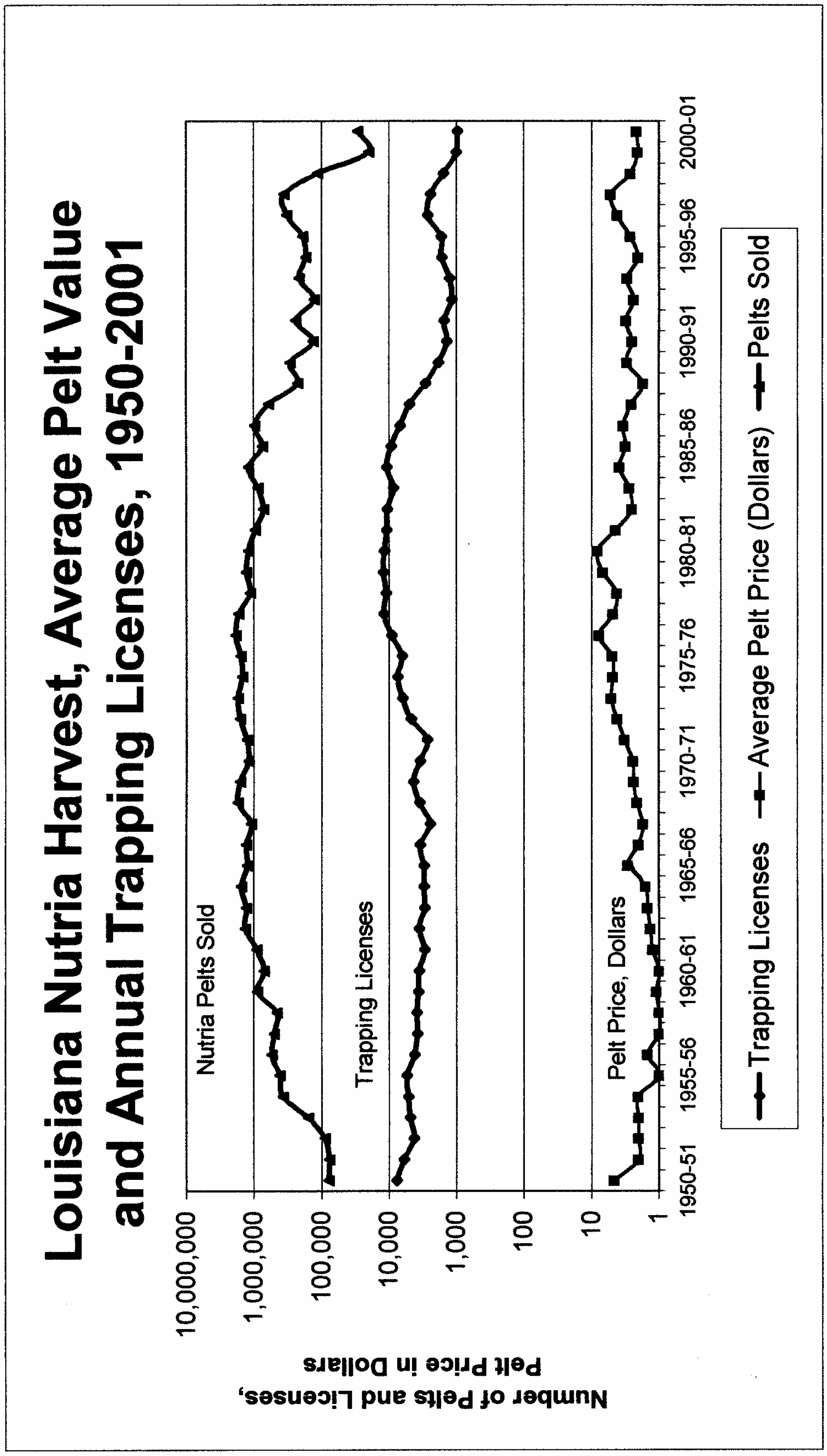

Table 4. Number of damaged sites and acres damaged along survey transects, by parish, in coastal Louisiana in 1998, 1999, 2000, and 2001. Parishes are listed from west to east. The extrapolated total is calculated by multiplying the total acreage by four to account for areas between transects. A longitudinal line roughly bisecting Iberia Parish is considered the boundary between "western" and "eastern" nutria populations, and also corresponds with the topographic boundary between the Chenier Plain (west) and the Deltaic Plane (east). Table adapted from Mouton et al. 2001.

PARISH	1998 Number of		1999 Number of		2000 Number of		2001 Number of	
	Sites	Acres	Sites	Acres	Sites	Acres	Sites	Acres
Cameron	9	720	4	665	2	8	-	-
Vermilion	1	10	0	0	0	0	-	-
Iberia	2	125	1	85	0	0	-	-
St. Mary	2	10	0	0	1	10	-	-
Terrebonne	69	10,700	62	11,101	64	12,887	57	11,703
LaFourche	24	5,041	22	5,166	10	3,552	8	1,433
St. Charles	9	975	8	910	4	660	7	841
Jefferson	22	4,212	21	5,109	22	5,314	21	4,647
St. John	6	95	3	100	1	50	-	-
St. Tammany	3	330	4	690	4	769	3	600
St. Bernard	7	280	5	560	5	560	6	563
Orleans	0	0	1	50	1	50	2	100
Plaquemines	16	1,462	19	2,920	18	2,079	20	2,252
TOTAL	170	23,960	150	27,365	132	25,939	124	22,139
EXTRAPOLATED TOTAL ACRES	-	95,840	-	109,460	-	103,756	-	88,556

Table 5. Number of damages sites and acres damaged along survey transects, by marsh type. The annual nutria harvest is listed as well. Adapted from Mouton et al. 2001.

HABITAT TYPE	1998		1999		2000		2001	
	Number of		Number of		Number of		Number of	
	Sites	Acres	Sites	Acres	Sites	Acres	Sites	Acres
Freshwater	85	8,666	73	9,966	62	11,112	59	10,554
Brackish	30	5,126	31	5,569	29	5,058	28	4,025
Intermediate	55	10,168	46	11,821	41	9,769	37	7,560
Total	170	23,960	150	27,356	132	25,939	124	22,139
Extrapolated Total Acres	-	95,840	-	109,460	-	103,756	-	88,556
Pelts Sold	-	359,232	-	114,646	-	20,110	-	29,544

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TASK II. SOCIOECONOMIC AND CULTURAL ANALYSIS OF NUTRIA IN LOUISIANA

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Abstract: Louisiana's coastal wetlands represent a very significant proportion (at least 40%) of the Nation's wetland resources. These wetlands represent an invaluable resource to the state and Nation, a resource whose wetland losses alone have been valued in the billions of dollars. Coastal storms and many factors contribute to wetlands loss. However, a major concern that is greatly accelerating the loss of coastal wetlands in Southeastern Louisiana is the overabundant population of nutria. Louisiana has a proud tradition of resource utilization. At one time it was the leading producer of fur pelts in North America and led all states in the production of muskrats and mink. The state still has a significant number of residents who utilize the land and coastal resources—trapping and fishing (including shrimping and oystering), to earn a living or supplement their livelihood. But this number is decreasing, in large part because fur prices have dropped so low in recent years that trapping isn't worth the trapper's time and effort. In 2000-2001, less than 1,000 trapping licenses were sold statewide in Louisiana. Many of these coastal resource users have been forced to seek employment in the oil and gas industry and elsewhere. It is questionable whether many will ever return to the traditional coastal resource uses. In an attempt to deal with nutria overpopulations, the Department of Wildlife and Fisheries, Fur and Refuge Division, has requested federal funds for an incentive program for trapping or shooting nutria. It is anticipated that such funds, if approved, would allow the payment of up to $4.00 per nutria taken. Our analysis of past trapping participation and pelts compared to pelt price suggests that $4.00 is a sufficient incentive to bring about the desired harvest of nutria. However, interviews of knowledgeable local people suggest that the specifics of program implementation could lead to significant problems if they are not thought through and implemented very carefully. The concerns include primarily trespass and poaching by trappers and hunters, and potential water quality problems if the harvested nutria are just left in the marsh and are not utilized. Thus, within the regulatory authority available to the Department and the Fur and Refuge Division, it should strive for procedures that protect against these concerns as much as possible.

Introduction

This report presents a review and analysis of information dealing with trapping and the fur industry in Louisiana, how fur prices have affected nutria control, and wetland values along with the economics of nutria damage to crops and marshlands. Information used to compile the report include (a) a thorough review of published literature, (b) historic data on trapping license sales, nutria pelt prices, and harvest from the Louisiana Fur and Refuge Division, Department of Wildlife and Fisheries, and (c) interviews held with key landowners, managers, and fur industry people. The report also examines a proposed nutria incentive program for which the Fur and Refuge Division has requested federal funding.

Development of the Fur Industry in Louisiana

New Orleans, almost from its founding in 1720, was a major fur center. However, in the 18th and 19th centuries, this was primarily because of the city's location as a major trading center on the Mississippi River. Hides and pelts obtained in the north central part of the U.S. were sent to New Orleans for shipping to overseas markets. During those times both local Native Americans and Anglo settlers hunted and trapped and used local furs for clothing, but there was no sizable local fur industry (Lowery 1974).

The backbone of the early trapping industry in Louisiana was the muskrat, which began to be trapped between 1900 and 1910 in the southeastern part of the state (O'Neil 1949). By 1912, muskrats were so plentiful and were damaging cattle range in Cameron Parish to the extent that local ranchers offered a bounty of 5 cents per animal killed. Muskrat skins began to make their way north to fur finishers, and their value became recognized. Also by 1912, trapping had become sufficiently widespread that the Louisiana legislature began to require that trappers be licensed and imposed a November 1 through February 1 season on mink, otters, muskrats, and raccoons (Lowery 1974). The state Department of Conservation began keeping harvest records, and for the 1913 season reported a take exceeding 5 million skins, over 4.25 million of which were muskrat pelts.

Lowery (1974) graphed muskrat take versus total take from 1913-14 through 1970-71. The muskrat take approached total take until the late 1950s when the trapping of nutria became significant. Through the late 1940s, the value of muskrat furs paid to trappers was a very high percentage of the total fur value.

Nutria were introduced in Louisiana in 1938, and by 1945-46 were being trapped and were bringing a good fur price. Nutria prices remained steady, in large part due to European demand, until 1955 when the supply overtook the demand and pelt prices fell from the $3.00 to the $1.00 range (Lowery 1974). The problem of overpopulated nutria and damage to sugar cane and rice fields became so severe that in 1958, the Louisiana House of Representatives set a $0.25 bounty on every nutria killed in 16 southern Louisiana parishes (Kinler et al. 1987), although they never appropriated the funds. By 1960-61, nutria surpassed muskrats both in number trapped and pelt value. The value of nutria meat as food for farmed mink added to the demand and price paid for nutria pelts.

The Department of Wildlife and Fisheries believed that the nutria problem had to be solved through finding markets for nutria products, and their work at developing them paid off in the mid-1960s when a German market developed that began using over a million pelts per year. In 1965, the state legislature reestablished a season on nutria (Kinler et al. 1987).

Peak and Decline of Trapping and the Fur Industry

The trend in the number of trappers in Louisiana can be conservatively estimated from license sales (Table 1). In 1950-51, 7,732 trapping licenses were issued. This number gradually declined to a low of 2,761 in 1971-72, at which time fur values rebounded. License sales then peaked at 12,239 in 1979-80. As late as 1984-85, 10,935 licenses were sold.

Table 1. Number of Louisiana Trapping licenses sold, average price per nutria pelt in annual dollars and in constant 2001 dollars, and number of nutria pelts sold, 1950-51 – 2000-01.

Year	Trapping Licenses Sold	Average Nutria Pelt Price ($)	Average Nutria Pelt Price in 2001 Dollars ($)	Nutria Pelts Sold
1950-51	7,732	4.65	31.81	78,422
1951-52	6,120	2.00	13.37	77,966
1952-53	4,328	2.00	13.27	89,526
1953-54	4,986	2.00	13.07	160,654
1954-55	5,202	2.05	13.50	374,199
1955-56	5,520	1.00	6.56	418,772
1956-57	4,211	1.50	9.52	543,160
1957-58	3,868	1.00	6.15	510,679
1958-59	3,932	1.00	6.08	461,311
1959-60	3,743	1.10	6.58	894,110
1960-61	3,613	1.00	5.90	716,435
1961-62	3,004	1.25	7.30	912,890
1962-63	3,666	1.35	7.81	1,357,806
1963-64	3,029	1.50	8.53	1,304,267
1964-65	3,061	1.60	9.02	1,568,233
1965-66	3,088	2.90	15.93	1,257,385
1966-67	3,492	2.00	10.87	1,307,121
1967-68	2,495	1.75	9.00	1,115,410
1968-69	3,601	2.15	10.56	1,754,028
1969-70	4,444	2.38	11.01	1,604,175
1970-71	3,510	2.42	10.66	1,226,739
1971-72	2,761	3.22	13.71	1,286,622
1972-73	4,741	4.18	17.13	1,611,623
1973-74	6,295	5.14	19.15	1,749,070
1974-75	7,528	4.83	16.18	1,502,617
1975-76	6,404	4.89	15.41	1,575,506
1976-77	9,329	7.81	23.23	1,890,853
1977-78	12,069	4.82	13.47	1,714,083
1978-79	11,106	4.21	10.71	1,145,084
1979-80	12,239	6.79	15.13	1,300,822
1980-81	11,801	8.18	16.36	1,207,050
1981-82	10,867	4.36	8.10	961,471
1982-83	10,668	2.53	4.54	730,731
1983-84	8,793	2.81	4.82	881,551
1984-85	10,935	3.95	6.55	1,214,600
1985-86	9,458	3.16	5.08	761,948
1986-87	6,947	3.41	5.37	986,014
1987-88	5,038	2.58	3.91	617,646
1988-89	2,888	1.72	2.49	223,222
1989-90	1,877	2.99	4.11	292,760
1990-91	1,414	2.53	3.30	134,196
1991-92	1,543	3.12	3.96	240,229
1992-93	1,189	2.38	2.92	129,545
1993-94	1,274	3.01	3.61	215,968
1994-95	1,686	2.07	2.41	171,470
1995-96	1,700	2.70	3.06	188,719
1996-97	2,691	4.13	4.55	327,286
1997-98	2,442	5.17	5.61	359,232
1998-99	1,578	2.69	2.88	114,646
1999-20	1,024	2.10	2.17	20,110
2000-01	987	2.18	2.18	29,544

From 1971 through 1981, the average value of nutria pelts received by trappers was $8.1 million (Kinler et al. 1999). The harvest peaked in 1976 at 1.8 million pelts worth $15.7 million to trappers. Since that time, the demand for furs has plummeted and trapping license sales have dropped precipitously. The average pelt price dropped from $8.19 in 1980-81 to $4.36 in 1981-82, and to $2.53 in 1982-83 (Table 1). From 1983-84 through 1986-87, prices fluctuated in the range of $3.00 to $4.00. Several factors combined to cause this huge drop in demand for furs after 1981. The animal rights movement began to have a significant impact on public attitudes toward wearing furs, especially in major urban markets. At least partially independent of this trend, a fashion shift from furs to leather also occurred. In addition, markets in Northern Europe became saturated, and demand for furs there dropped sharply. Finally, there was a series of warmer winters both in the U.S. and Europe.

Between 1988-89 and 1995-96, pelt prices remained at or below a $3.00 average. The price went up to $5.17 in 1997-98 due to strong demand from Russia. However, in September 1998, the Russian economy collapsed and weakness in Far Eastern economies hurt the demand from that region. In 1988, pelt values fell to $2.69 and the nutria harvest, as high as 1.2 million in 1984-85, fell to 114,646—the lowest since the mid-1950s (Kinler et al. 1999). In 2000-01, less than 1,000 trapping licenses were sold. Other markets for nutria products have largely diminished. For example, in the 1970s, several million pounds of nutria meat were purchased by the federal government to raise screwworm larvae for the screwworm eradication program in the Southwest (Tarver et al. 1987). This program no longer uses nutria meat. A limited amount of meat is still used to feed farmed mink and alligators.

Economic and Cultural Significance of Trapping

The economic and cultural significance of trapping in Louisiana is not well known nationally, as history texts have traditionally focused on Eastern Canada, the Northeast, and the North Central states that border Canada in this regard. This may have been appropriate for the early centuries of North American settlement, but by the 20th century, Louisiana led the nation in several aspects of trapping. In the 1924-25 season, 20,149 trapping licenses were sold, and the state had 941 resident fur buyers as well as just over 100 dealers (73 resident and 29 non-resident dealers) (Tarver et al. 1987). The total 1924-25 trapping take was 6.77 million pelts with a value at that time of $6.49 million.

According to the Louisiana Department of Conservation (1931), "Today [1931], Louisiana annually produces more pelts than any other U.S. state or Canadian province, and leads all states in the production of muskrats and mink." In 1945, in an era of exploding muskrat populations, over 9 million pelts worth $12 million were produced—more than the production of all other states combined (Linscombe 2001). At its peak in 1975-76, the value of pelts paid to trappers from all fur species approached $25 million. This figure exceeded $18 million as late as the 1980-81 season. Kinler et al. (1987), described a network of 130 local fur buyers and 35 resident or nonresident licensed dealers, who likely shipped 99% of the fur pelts out of state (trappers may ship 1% out themselves).

Against the backdrop of supply and demand, trapping was one of several forms of "living off the land" that was a part of the way of life of thousands of southern coastal rural families during the 20th century. Prior to the construction of the regional highway network, over 325 isolated settlements were scattered through the wetlands. The primary livelihood of these residents came from harvesting marsh animals (Davis 1978).

Before 1900 and the enactment of many game regulations, hunting was the primary source of living by rural peoples. However, in the early 1900s fur prices increased some 500%, and many marsh people changed their primary form of winter subsistence activity from hunting to trapping. Davis (1992) depicted in a series of concentric circles how these families lived through the course of a year by trapping in winter, crawfishing in late winter and spring, and fishing (including oystering, crabbing, and shrimping) in summer and fall (Figure 1).

As the price of furs increased, the large coastal landowners began to develop mechanisms for getting their share of the value of pelts harvested. Some of these owners leased their lands directly to trappers. Others rented their properties to leasing companies who in turn sublet the trapping rights to trappers (Lowery 1974). By assigning property to licensed trappers, owners eliminated competition and reduced the number of poachers. By 1940, nearly all the marsh was controlled and managed for trapping purposes (Washburn 1951).

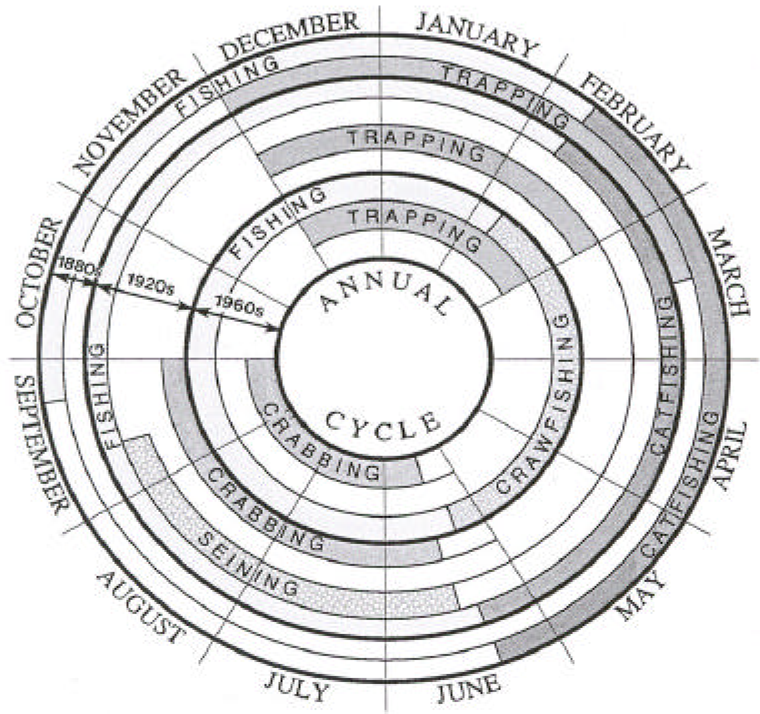


Figure 1. Annual use cycle of marshlands people in coastal Louisiana. Taken from Davis (1992) as modified from Comeaux (1972).

Traditionally, trapping leases covered only 100 to 300 acres (Lowery 1974). The trapper would bring his family, dog, and provisions for an extended stay and live in a small cabin on the marsh during the winter trapping season. Sometimes the land manager would visit the trapper periodically, bring provisions, and take away the dried pelts. The highlight of the season would be the fur sales, held every three or four weeks in central warehouses. After the last sale sometime in February, celebratory balls were held for the trappers. Today, it is rare that trappers would live on the marsh.

Though not highly visible to the outside world, the trapping and fur tradition continues today for a relatively small number of families. As described by Gomez (1998), the trappers will not be visible as one drives the ridges or glimpses at roadside canals. Fur sales are not advertised, and both buyers and sellers keep a low profile. The finished products from fur trapping do not appear on local store shelves. Yet, despite the lowered number of trappers and furs sold, the celebration of the trapping-fur tradition still emerges annually in the form of the Louisiana Fur and Wildlife festival, held annually in Cameron. Despite sometimes cold, wet January weather, there is a carnival-like atmosphere at the festival, with rides, bands, games of chance, craft displays, and beauty queens. The essence of the event, according to Gomez (1998), is in the vying for titles in muskrat and nutria skinning, trap setting, duck and goose calling, retriever dog trials, trap shooting, oyster shucking, and gumbo cooking. The festival has been an annual event since 1955, and while many of these wildlife-related events are still popular, only a few contestants enter the trappers' events.

Gomez quotes a local trapper whose family wins many of the skinning prizes at the festival as saying that he doesn't trap any more, that two of his sons do but they will be the last of the trappers, and that he sees a very limited future for trapping because of the economics of it. With the low demand for fur and low prices, the trapper just breaks even now, and has to find other employment—perhaps in the oil and gas industry, perhaps elsewhere.

In summary, to many coastal families, trapping along with other forms of fish and wildlife harvest, was not just a form of recreation or just a part of earning a subsistence income, it was part of an enduring way of life. Muth et al. (1996) studied trapping families in the Northeastern U.S. and found a combination of recreation and subsistence interests, with the recreational interest the more dominant. It is not clear without further study that is the more dominant motive in Louisiana—we might assume it to be subsistence. But regardless, the lack of significant fur prices is threatening an important traditional lifestyle in southern Louisiana.

Economic Estimates of Nutria Damage and Wetlands Loss

Nutria cause both market and non-market types of economic damage. Estimates of crop losses are reasonably easy to quantify, although thorough studies should be implemented. Coastal marsh damage is much harder to quantify, but some research on this topic is reported below.

Crop Damage

In addition to the damage nutria cause to marshes and levees, they also damage coastal crops. In the 1950s and 60s, nutria did substantial damage to sugar cane fields in southeastern Louisiana and rice fields in Southwestern Louisiana (Evans 1970, Linscombe 1998). Fairly good fur prices in the 1970s, combined with winter freezes and other habitat changes, and increased alligator predation, lessened nutria damage during that period. More recently, in 1991, Hebert (1992) estimated that nutria caused almost $2 million in damage to sugar cane, primarily by clipping the cane stalk. According to LSU Extension specialists, nutria are also causing some damage to rice levees, but are not currently causing major damage to agricultural crops.

Marsh Damage

Data from around 1990 indicated that Louisiana contains at least 40% of the Nation's wetlands, but has been undergoing 80% of its wetlands loss (Penland et al. 1992). From extrapolation of a year 2000 aerial survey, it is estimated that ?100,000 acres of coastal marsh have been adversely impacted by nutria (Kinler et al. 2000). The majority of sites with current damage were judged to be capable of recovering. However, many sites with old damage will not recover, and are gradually being converted to open water.

Farber (1996) estimated the economic loss in welfare of a series of projects designed to stop further wetlands disintegration. He included wetlands values pertaining to commercial fisheries, coastal recreation, storm protection, property losses, wastewater treatment, and water supply. Depending on various assumptions and discount rates used, Farber estimated the 1990 present value of wetland losses at $5.9 to $24.3 billion. Or, assuming an annual loss of from 25,500 to 27,500 acres per year, Farber estimated losses ranging from $8,437 to $15,763 per acre. He considers these estimates to be minimum annual losses because they do not include non-user losses and lifestyle losses, and they don't include the costs of dismantling coastal infrastructure.

Farber used various secondary data sources to estimate the coastal recreation component of wetlands losses and, using a typical 3% discount rate, arrived at a total value estimate of $756 to $815 million in 1990 dollars. Bergstom et al. (1990) conducted a detailed contingent valuation survey of coastal Louisiana recreationists in 1985-86, using a personal intercept method from 88 boat launch sites, followed by a mail questionnaire. He estimated total use at 1.8 million days and the total net value or aggregate consumer surplus at $27.36 million annually.

In an earlier (1983) study, Farber and Costanza (1987) estimated the annual value of wetland use on a per acre basis as $37.46 for commercial fishing and trapping, $6.00 for recreation, and $0.44 for storm protection.

The Nutria Trapping Incentive Initiative: Socio-economic Considerations

Wildlife professionals in Louisiana have known about the destructive potential of nutria to coastal marshlands for decades. Their strategy has always placed first priority on treating the nutria as a resource and working to help trappers find a market for the fur and meat. The Louisiana Fur and Alligator Advisory Council (FAAC) was created for this purpose as well as to educate the public about the need for trapping as a sound wildlife management tool. Since 1987, $20 of the $25 for each trapping license has gone into a dedicated fund to help find markets for alligators, nutria and other furbearers.

The FAAC has had some success over the years finding markets overseas, particularly in the former Eastern Block countries of Europe and in Asia, and it is currently investigating potential markets in the Far East. However, the latest setback occurred with the demise of the Russian ruble. Several combinations of events—adverse international currency fluctuations, the recent global recession, a series of warm winters, and public attitudes about wearing furs have all combined to reduce fur prices so low as to place trapping and fur production in serious jeopardy in Louisiana and elsewhere. In the 2000-2001 season, less than 1,000 trapping licenses were sold statewide, and the total value of pelts was only $315,428. This trend obviously does not portend well for the future of trapping—many former trappers have been forced to find other employment, and many may never return to trapping.

Although fur prices immediately prior to 2000-01 were not as bad as in 2000-01, the general declining trend in fur prices, trapping licenses sold, and pelts harvested has been evident for several years (Table 1). Of particular note in Table 1, not available in previous documentation, average annual pelt prices for nutria have been converted to constant 2001 dollars to show the comparative spendable value of that average price over time. At the high point of nutria pelt production in 1976-77, trappers were getting today's equivalent of $23.23 per pelt. In 1999-2000 and 2000-2001, trappers received less than 10% of that price.

The low pelt price and resulting severe decline in trapping effort pose a severe challenge to nutria control and protection of the coastal marshlands from dieback and subsequent erosion caused by excessive nutria populations. Louisiana Fur and Refuge Division staff estimate that the equivalent of 400,000 nutria pelts need to be removed from the population. This might be as high as 600,000 total animals (A. Ensminger, personal communication). As a strategy for achieving this goal, the Fur and Refuge Division of the Louisiana Department of Wildlife and Fisheries requested federal funds for a nutria control plan under Public Law 646, the Coastal Wetland Planning Protection and Restoration Act (CWPPRA), sometimes referred to as the Breaux Act. Phase I project development funds for program planning have been received, and a decision on Phase II implementation funds is anticipated in mid-April, 2002.

The mainstay of the CWPPRA nutria control plan for which Phase II funds would be used, if approved, is an incentive program that would pay trappers (up to) $4.00 per nutria trapped. As currently conceived, the trapper would only have to provide evidence of the take, such as producing a nutria tail, and he would receive the incentive payment plus any additional payment for the fur and meat. The next section provides a brief analysis of the likely impact of such an incentive payment. The basic initial question is: Given the recent history of trapping, in which prices have fallen so low that many formers trappers have become inactive, at the proposed $4.00 incentive rate, will enough people return to trapping, and will enough nutria be taken for this control program to be successful? Then, beyond this basic concern, there are also some concerns about how the program is implemented.

Two distinct methods are used to analyze the likely impacts of the incentive payment. First, we examine nutria pelt prices over time in constant dollars to see how pelt prices have affected (a) the number of participating trappers, and (b) the nutria pelt take. Second, we summarize the results of a focus group and other interviews in the coastal region in which knowledgeable trappers, landowners, and others were asked their opinions and concerns about the nutria incentive program.

Economic Analysis

Figures 2 and 3 graph the correlation between pelt prices in constant 2001 dollars and pelts sold (Figure 2) and number of participating trappers (Figure 3). For these graphs we have used the period starting in 1981-82 and going through 2000-01. We chose to start in 1981-82 because in the years immediate previous, the average nutria pelt price in 2001 constant dollars was much higher--$16.36 in 1980-81, and as high as $23.23 in 1976-77. Such high pelt prices are not relevant to the current situation. We emphasize that there are factors beyond the pelt price that affect trapping participation and take. The nutria population, weather conditions, and alternative income sources for trappers are among these other variables. Thus, the trend lines shown in Figures 2 and 3 should be treated simply as indicators of the likely impact of the incentive program.

An unresolved question that relates to trapper behavior is, will most trappers simply take the $4.00 incentive payment and not process the fur and meat, or will they process the fur and meat also, making the effective combined price approximately $6.00 pelt? This question was discussed in the focus group and we will return to it later. One could argue for using either a

linear or logarithmic curve to fit the data in Figures 2 and 3, so both are presented along with the linear equation and R^2 for that equation.

At an effective price of $4.00, the trend lines in Figures 2 and 3 indicate that roughly 400,000 pelts might be harvested by approximately 4,000 trappers. If the trappers reacted to the opportunity on the basis of getting $6.00, however (including $2.00 for meat and fur), Figures 2 and 3 suggest that based on past history, the effort would roughly double to 8,000 trappers, and if the supply of nutria is there, nearly 800,000 could be taken. In reality, these estimates are probably liberal or upward-biased. First, we believe the number of trappers who have stopped trapping and gone on to other types of work will serve as a dampening effect to their returning to trapping. Some will not return at all, and not all of those who will eventually return will come back the first year. Second, trappers never before in the period covered by the data had the option of receiving payment just for trapping the animal. Whether or not to then skin the animals and sell the meat for roughly $2.00 becomes an independent economic decision. It is quite likely that a significant number of trappers would not do so.

Figure 2. Nutria Pelts Sold by Pelt Price in Constant 2001 Dollars, 1981-82 through 2000-01

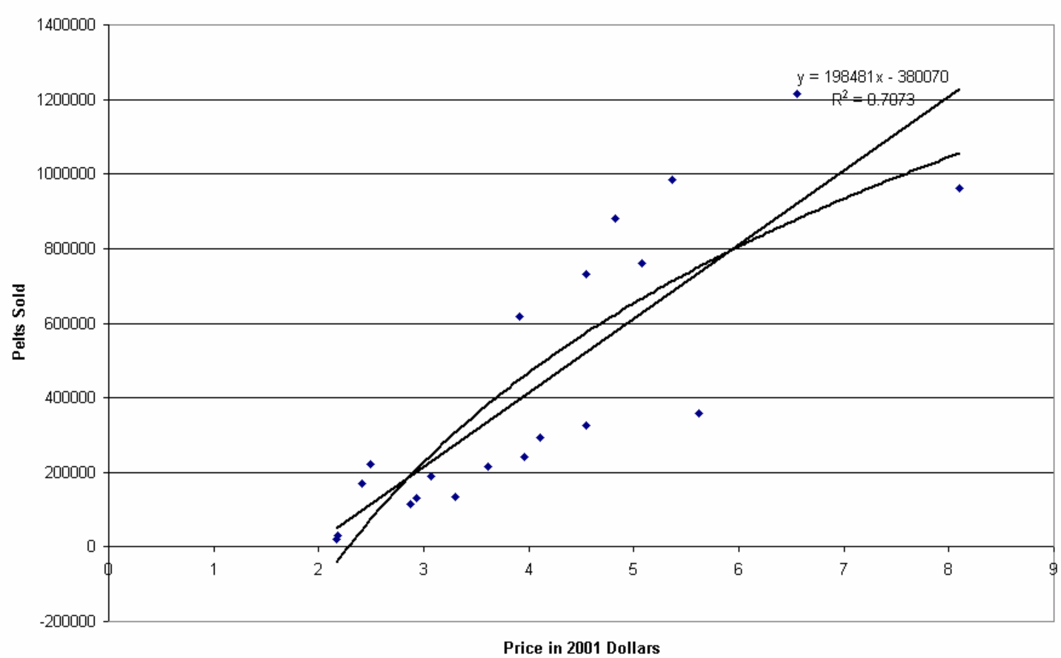
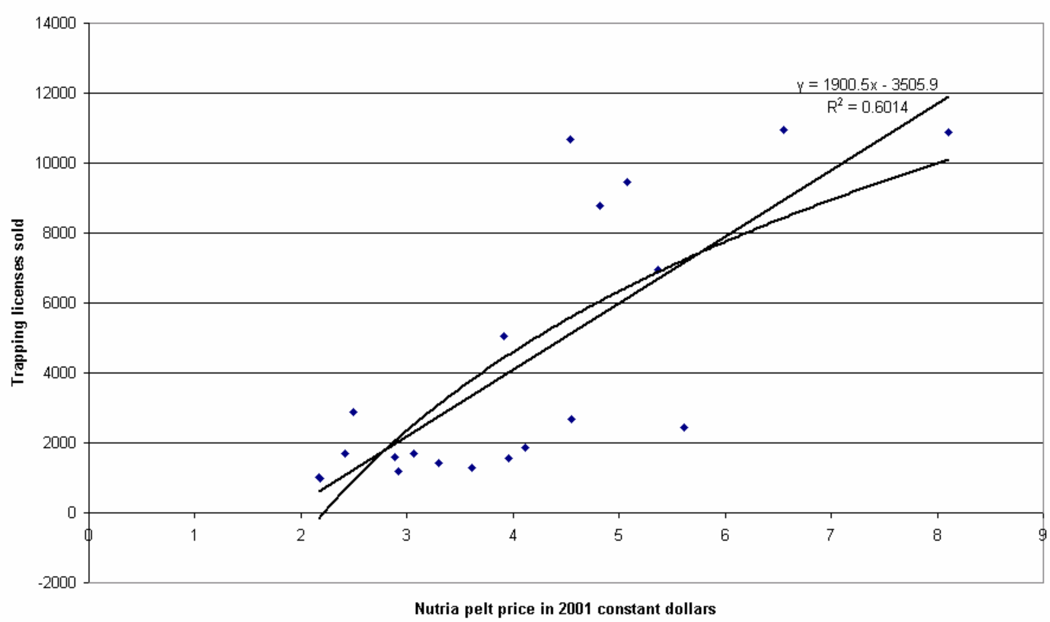


Figure 3. Trapping Licenses Sold at 2001 Constant Dollar Nutria Pelt Prices, 1981-82 through 2000-01



Analysis from Interviews

As part of the research, a focus group interview of eight people was conducted in Houma, LA in February 2002. The focus group included major coastal landowners-managers, trappers, and a federal refuge manager. Separate interviews were also held with a retired fur dealer and with the owner of an alligator farm in the area. The information gained from these interviews is necessarily qualitative, but each of these people was chosen on the basis of his considerable knowledge and expertise about nutria trapping, fur prices, and related topics.

Nearly everyone interviewed felt that the hunting and trapping way of life remains sufficiently strong in coastal Louisiana that former trappers would return to trapping if it became economically viable. Some believed the trappers would not all come back the first year, but there was a general sense that a reasonable and stable price over a several year period would bring trappers back. One person did not believe a sufficient number of trappers would come back, but felt that sufficient hunting would occur to meet the harvest objective. However, the former fur dealer felt that $4.00 was too much to offer, and recommended cutting the incentive offer to $2.00 per nutria.

At least one and sometimes more than one of these interviewees raised the following concerns about the nutria incentive program: (1) A $4.00 incentive would likely result in trespass and poaching problems from hunters rushing to get in on the action. This would provide difficulties for landowners/managers, trappers who had leases or permission to trap specific areas, and law enforcement officials. (2) If the incentive program simply required producing a nutria tail to collect the $4.00 incentive, many hunters would simply shoot the nutria, cut off the tail, and throw the dead carcass in the water or in the marsh. Not only is this distasteful in terms of wasting a potential resource, it could result in a major water quality problem. In fact, it was suggested that without appropriate safeguards, the nutria incentive program could be found to be in violation of the Louisiana Department of Environmental Quality's Clean Water Act.

A large alligator farmer in the region was interviewed to determine his thoughts about the feasibility of feeding nutria meat to alligators. He acknowledged that for very young gators, the growth curve is more rapid when they are fed meat than when they are fed the dry food the gator farmers are currently using. In fact, this farmer planned to use roughly 2,000 pounds of nutria meat in August when the baby gators hatch. As the gators grow larger, the costs of skinning and de-boning the nutria meat become too great for the nutria meat to be economically viable.

Based on local information about the number of gator farms in the region, quick calculations showed that if all farmers shifted to nutria meat at this initial stage of development of their young gators, the demand for nutria meat would only be for about 1.0% to 1.5% of the total nutria needed to be harvested. Thus other uses or methods of disposal of the nutria would need to be found.

Summary

Louisiana's coastal wetlands represent a very significant proportion (at least 40%) of the Nation's wetland resources and thus are invaluable resource to the state and Nation. Wetland losses alone in coastal Louisiana have been valued in the billions of dollars. Coastal storms and many factors contribute to wetlands loss. However, a major concern that is greatly accelerating the loss of coastal wetlands in Southeastern Louisiana is the overabundant population of nutria.

Louisiana has a proud tradition of resource utilization. At one time it was the leading producer of fur pelts in North America and led all states in the production of muskrats and mink. The state still has a large number of subsistence resource users who depend on the land and coastal resources—trapping and fishing (including shrimping and oystering), for a significant portion of their livelihood. But this number is decreasing, in large part because fur prices have dropped so low in recent years that trapping isn't worth the trapper's time and effort. In 2000-2001, less than 1,000 trapping licenses were sold statewide in Louisiana. Many of these coastal resource users have been forced to seek employment in the oil and gas industry and elsewhere. It is questionable whether many will ever return to the traditional coastal resource uses.

In an attempt to deal with nutria overpopulations, the Department of Wildlife and Fisheries, Fur and Refuge Division, has requested federal funds for an incentive program for trapping or shooting nutria. The funds, if approved, would allow the payment of up to $4.00 per nutria taken. An analysis of past trapping participation and pelts compared to pelt price suggests that $4.00 is a sufficient incentive to bring about the desired harvest of nutria. However, interviews of knowledgeable local people suggest that the specifics of program implementation could lead to significant problems if these aspects are not thought through and implemented very carefully. The concerns include primarily trespass and poaching by trappers and hunters, and potential water quality problems if the harvested nutria are just left in the marsh and are not utilized. Thus, within the regulations authority available to the Department and the Fur and Refuge Division, it should strive for procedures that protect against these concerns as much as possible.

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TASK III. NUTRIA CONTROL IN LOUISIANA

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Abstract: The nutria (*Myocastor coypus*) is a large semi-aquatic rodent that was introduced throughout much of the world as a means of increasing the fur market in the first half of the twentieth century. Although not considered a pest in their native range of South America, nutria presence in areas has often met with greater detriment than benefit. Nutria have damaged crops, marsh vegetation, and water control structures. The damage caused from the nutria has been described for decades, yet science is adding value to the marshes that provide prime habitat for many mammalian, avian, reptilian, and amphibian species as well as floral species. The uniqueness of the marsh and coastal habitats is in jeopardy of being damaged to an extent that the cost of repair would be astronomical. Current re-vegetation projects are often met with failure due to nutria foraging unless labor-intensive exclosures are constructed. It is the purpose of this document to review and discuss the methods to control the nutria in the state of Louisiana to a level that damage is more manageable. Techniques that are addressed in this document include: incentive payment, chemical control (toxicants), incentive-bonus, induced infertility, trapping, controlled hunting, and chemical repellents. These techniques are ranked by feasibility of implementation and the probability of obtaining the expected result--control to a manageable level.

Scope

This document is being drafted to describe control techniques that may be used for a nutria control program within the state of Louisiana to protect the coastal environment and the rehabilitation projects established by the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA). It reviews the current and past techniques, and other techniques that may be used to control nutria (*Myocastor coypus*) or nutria damage. It reviews many facets of a control program within Louisiana's ecosystems. However, given the list of control techniques, and their benefits and detriments, and knowledge of the current research and field of wildlife damage management, the feasibility of each technique is described. Varying degrees and types of control are reviewed in this document including: incentive payment, chemical control (toxicants), incentive-bonus, induced infertility, trapping, controlled hunting, and chemical repellents. Control is defined as: the reduction of damage to a tolerable level.

Introduction

The nutria has been listed by the Invasive Species Specialist Group (ISSG) as being one of the top 100 worst invasive species in the world. Louisiana, maintaining 15% of freshwater wetlands and 40% of brackish wetlands in the United States, has conservatively estimated the damage from nutria to exceed 100,000 acres in Southeast Louisiana. Protection of the 3.5 million acres of coastal marsh is required to save this unique landscape. Efforts to restore these damaged areas by the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) may be to no avail if the nutria is not controlled simultaneously. The Department of Natural Resources has already experienced such losses in areas of re-vegetation. To circumvent the problem, nutria exclusion devices have been used that are more labor-intensive and increase the cost of such plantings dramatically (Ken Bahlinger, *pers. comm.*). Nutria herbivory has been documented on species of bald cypress (*Taxodium distichum*) (Conner and Toliver 1987), *Sagittaria latifolia* and *S. platyphylla* (Evers et al. 1998, Grace and Ford 1996), *Spartina patens* and *S. alterniflora* (Taylor et al. 1997, Ford and Grace 1998, Taylor et al. 1994), and many other species of marsh vegetation (Fuller et al. 1985, Taylor and Grace 1995, Foote and Johnson 1992). As a whole, vegetative biomass is decreasing due to the herbivory and plant species composition is changing (Ford and Grace 1998, Visser et al. 1999)

Since the price-drop of the fur market in the 1980s, and therefore the trapping effort, nutria became a nuisance in agricultural commodities and Louisiana's nationally important wetlands. Wetlands support many aquatic and terrestrial animals, as well as a massive hunting and fishing industries that are jeopardized by the massive marsh loss. In addition, the storm impact is decreased on infrastructure and communities by the wetlands.

Figure 1. Nutria on a typical resting platform

Differing reports have been stated according to whom released nutria in Louisiana, but it did occur in the late 1930s or early 1940s. By the mid 1950s, over 400,000 were being harvested, but then fur values decreased, and serious damage to marsh vegetation occurred in southeast LA. After a failed attempt at a bounty system because of the lack of appropriated funds, a market developed in the early 1960s with between 1.0 and 1.9 million pelts harvested annually until the early 1980s. During this period, agricultural damage claims were uncommon. In the 1981-82 season the price dropped by 53% from the previous year ($8.19/pelt), and then by another 61% in the following season to $2.64/pelt. Through the mid-1990s prices remained low and annual harvest hovered at or below 300,000. The 1996-97 and 1997-98 seasons produced an increased harvest due to the increase in the pelt price to $4.13 and $5.17, respectively. These prices were not seen again after this period, and therefore, the harvest (was) has been limited to 29,544 nutria in the 2000-2001 trapping season. Trapping pressure is expected to be minimal until compensation for effort is rewarded.

Approximately 85% of muskrats in Louisiana are in one-fourth of the state's available marshlands. Competition has not been verified, but when nutria numbers drop, the muskrat population tends to increase dramatically (Lowery 1974). The harvest records from Louisiana (1940 to present) illustrate this point: as the nutria harvest increases, the muskrat harvest decreases. Some of the harvest is influenced by the market price of the animals. Yet, when prices are similar, nutria take is always greater than that of the muskrat. From 1943 to 1961, the nutria harvest increased dramatically from a non-existent market to one of greater value than the muskrat. In 1955, the pelt price of the nutria stabilized, and was comparable to muskrats through 1964. Through these 10 years, price would not have been a driving force for the increased harvest of nutria. Therefore, only the opportunistic trapping of the two species may have influenced the harvest. This suggests that nutria compete with muskrats.

In 1987, reports of marsh vegetation damage became common. Following vegetation surveys during the early 1990s, and recognizing the slight to severe dynamics of the ecosystem, it was observed that nutria were causing damage to many tracts of marsh, totaling over 100,000 by the late 1990s, conservatively (Mouton et al. 2001). The damage has been identified as some stage of vegetative impact leading to the potential conversion of tracts of vegetation to open water. Once the vegetation is removed then the substrate is exposed to tidal scour. This adds to the destructive consequence of the nutria foraging that then requires difficult and expensive marsh restoration techniques.

Early in the 20th century, floating mats, a type of vegetative community providing moderation of flood and drought conditions and stable food availability for wildlife of the coastal marshes, were recorded to be many feet thick, but has appeared to have decreased over the years and is now only inches thick (Harris and Chabreck 1958, Visser et al. 1999). The loss of biomass may be from continuous nutria feeding over almost 60 years--a result that is only now being understood as a detrimental problem. In addition, burning of marsh vegetation to promote muskrats changed from fall to late winter for nutria. This influenced floral species composition in favor of nutria, and therefore, increased the recruitment of nutria. Nutria typically stay in an area until it is denuded of vegetation which is called an "eat-out".

Figure 2. An example of a healthy floating marsh

Attempts have been made to develop the nutria market for sustained value and market stability in the areas of fur and meat for human consumption; but to present; these efforts have not been satiated. It is the intention of the State of Louisiana, after careful consideration of several management options, to promote a control program to decrease the nutria numbers to manageable levels of damage.

REVIEW OF MANAGEMENT TECHNIQUES

Incentive payment program

The use of an incentive payment program may be a valuable tool for the control of the nutria. This program provides a set amount of money for each animal taken, usually proven with tails of the respective animal. Trapping, shooting, and toxicants or rodenticides (if registered) are methods that can be used to take nutria. The program would likely decrease numbers in dense areas.

Gosling and Baker (1989) illustrated concerns for such a project. They point out that this type of program may provide a value to the nutria, which may encourage husbandry to provide income. In addition, trappers would seldom trap to extirpate an area, but rather proceed to other dense areas for a greater return on their effort. This method may be used to decrease dense numbers, but some other technique would be needed to reduce the low numbers to zero.

The Alligator and Fur Advisory Committee has illustrated their concern for the eradication of nutria, and because it does not appear to be even a remote possibility, eradication has not been pursued (Allan Ensmiger, *pers. comm.*). The nutria, through its incredible growth throughout the last 6 decades, has become a major proportion of the alligator diet in the wild (Valentine et al. 1972, Wolfe et al. 1987). It provides a large amount of protein for efficient growth (Coulson et al. 1987). Ideally, if the nutria population was to drop because of this type of program, the muskrat population would rebound from its low numbers and replace the nutria as the major portion of the alligator diet, however, plant community structure has changed due to the nutria herbivory and burning practices to promote nutria (Allan Ensminger, *pers. comm.*).

A lesser bandicoot rat (*Bandicota bengalensis*) bounty project was implemented in Bangladesh in which farmers were given one kilogram (2.2 lbs) of rice for each rat's tail delivered to a collection center (Poche 1980). Over the two-year program, more than 750,000 tails were collected. Although the project was deemed a success, the rodent management plan required the use of zinc phosphide baits in the field to adequately control the rodent infestations. This project also involved the development of species specific bait formulations, the establishment of local formulation plants, and the first ever distribution of baits for sale in local markets.

The bounty program may be a valuable technique for controlling nutria. It is speculated that $4.00 would be paid for each nutria tail, in addition to any price paid for pelt and nutria meat. An estimated take of 400,000 nutria/year would be required for control, for a total of approximately $1,600,000 (Dunne 2001). Between 1962 and 1980, nutria were taken out of Louisiana at numbers between 1,115,410 and 1,890,855. This period of nutria harvest was sustained for 18 years, which suggests that the population was stable, and that this amount of take was having little regional effect on the entire population. However, due to recent droughts of 1999 and 2000 and other unknown factors, the nutria population is believed to be at a much lower level since the mid 1980s.

Locally, populations could have dropped because of trapping pressure, but it appears a much larger scale of harvest would be required for many years. The amount of harvest has also closely followed the average pelt price through the years. Since the high prices of pelts in 1980 ($8.18), the market has not appeared to rebound except for short-term price jumps. In this case, the bounty may provide the added incentive to increase the harvest to a level that will bring the population down and decrease damage to marshes and crops. Motivation must be established for this program to work, and based upon the several calls the Louisiana Wildlife and Fisheries has been taking on this topic, the incentive has provided some motivation.

To aid in motivating the people who would harvest nutria, minimal regulations must be established. Typically, nutria are only harvested by trappers, and the number of active and experienced trappers has decreased due to the long-term depressed market value. If the number of trappers does not rebound to take part in the program as expected, the incentive payment program would most likely fall short of its goals. We believe additional help should be employed through hunters and fisherman. If those holding hunting or fishing permits, and a landowner's permission, for any type of wildlife are allowed to harvest nutria, we could expect a more thorough harvest. Thousands of acres are leased from various landowners for hunting deer, waterfowl, American alligator, fur-bearers, or a combination or more than one, as well as fishing. Hunters and fishermen may be able to gain entrance to areas that are not frequented by trappers resulting in much higher harvest pressure.

If a duck hunter could take two or three nutria, at $4.00/tail, the price of a box of shotgun shells would be recovered. This method may help some individuals to go out of their way to take nutria, therefore, adding harvest pressure that was previously non-existent. This plan could be instituted for a short period to decrease dense numbers (1 to 5 years), and integrated into another means of control. For this program, it would be imperative to increase pressure to a level that has not been observed previously, yet maintain established leases to provide a landowner with a degree of safety for liability purposes.

In addition, the design of this program should be left open-ended. It is important to read the responses of the success and failures of the program on a yearly basis, and then modify the design to limit the problems. Unlike many of the other programs in CWPPRA that invest several million dollars upfront and then evaluate the project on its expected success, the incentive payment program may be immediately modified to counteract any negative dynamics. The duration of this project may also be modified as seen fit, but it may be necessary to assure trappers the program would be long-term to get them into full-scale production. The primary effort is intended to be in Southeast Louisiana, but the established nutria populations in other coastal parts of the state should also be targeted.

Discussions were held with hunters and trappers in St. Martin Parish. Of the 15 interviewed, all seemed eager to have such a program developed in Louisiana. Several mentioned that if the tail sold for $4 each, then the meat delivered and inspected at a USDA facility, they could earn $7 per nutria, which was very attractive to all.

In a meeting of the Basin Management Association, a deer management unit in the Atchafalaya Basin, all board members would eagerly endorse such a program. It would provide added revenue for families during the recent layoffs from jobs in south Louisiana. All board members stated they would participate in the nutria incentive program, given the opportunity. To independent trappers, Paul and Joseph Autin said they would participate in the program on their respective leases. Tim Allen of Castex

Laterre, Frank Ellender of Burlington Reserve, and Herman Crawford of Centennial Land are in favor of the incentive payment program to help protect the coastal marshes that they manage (*pers. comm.*). For the past few years, trapping has almost ceased to exist on several of the lands because of the nutria market value, which is contradictory to the desires of the land managers. They prefer the trappers to be present on the land to help track poachers and trespassers.

Southeast Louisiana has the highest populations of nutria out of any state or area because of its prime habitat of approximately 3.5 million acres of coastal wetlands (Greg Linscombe *pers. comm.*). This comprises 15% of freshwater wetlands and 40% of brackish wetlands in the United States (Mouton et al. 2001). These numbers demonstrate the uniqueness of these lands and the protection that they require. Though the nutria problem is concentrated in southeast Louisiana, some pressure should be placed on the adjacent states to implement similar programs to control nutria. It may aid in controlling the immigration of nutria from outside the boundaries of the Louisiana program.

Chemical Control

Rodenticides can be an effective way of decreasing damage caused by rodent pests. These compounds have been utilized worldwide with long-term success. Rodenticides may be used as part of a nutria management program and may be an effective tool for control.

Zinc phosphide - Zinc phosphide is the only rodenticide that is currently registered for the control of nutria; however, its use is limited for use by certified pesticide applicators (LeBlanc 1994). The LD_{50} of zinc phosphide to nutria is between

15 and 20 mg/kg body weight (Spencer 1957). It often comes as a concentrate (63.2%) that is mixed with a carrier (carrots, sweet potatoes, watermelon rind, and/or apples). This type of baiting can often be effective with different types of presentation of the bait. A draw back is that pre-baiting is required, which results in several visits to potential treatment site before actually using any bait. Floating rafts in areas of suitable water sites has been very successful, with efficacy exceeding 95% of nutria in waterways (LeBlanc 1994). Baited rafts have been shown to be 50% more effective than traps set on land (Baker and Clarke 1988). Ground baiting can also be conducted, but care should be taken to limit non-target hazards, and should only be used to rid an area of the last remaining nutria. Baiting should be limited to areas nutria frequent (runways and burrow entrances). The product reacts with moisture to create phosphine gas, which is the actual toxic metabolite. Heavy rains and high humidity render the bait ineffective within weeks after exposure to the elements. This makes the use of zinc phosphide products labor-intensive. An alternative would be to develop longer-lasting baits that are paraffin based and would repel water while remaining attractive to nutria.

Poché et al (1981) developed zinc phosphide baits for the greater bandicoot rat (*Bandicota indica*). As with the nutria, this bread cake product was placed on floating platforms accessible to rats inhabiting the floating rice crop that grew in water up to 20 feet deep. Htun and Brooks (1979) identified zinc phosphide as being an effective bait for lesser bandicoot rats (*Bandicota bengalensis*), and having an LD_{50} of 25.0 ppm and an LD_{95} of 113.0 ppm. The greater bandicoot rat weighs up to 1.5 kg and inhabits much of South Asia. Unlike the nutria, both bandicoot rats are endemic to the region, and like the nutria it is difficult to control.

These baiting techniques are effective in the control of nutria, but there are some negative effects. First, in a field situation, the zinc phosphide bait may remain toxic for many months because mineral oil carriers protect it from weather degradation (Timm 1994). In contrast, at the soil-water surface environment, the zinc phosphide decomposes readily according to Hilton and Robinson (1972). Mineral oil may slow decomposition, but it appears that moisture, in general, will deteriorate zinc phosphide.

Second, it can cause primary poisoning in birds and rabbits (*Sylvilagus* spp.) (Hegdal and Gatz 1977, Savarie 1991). Third, secondary consumption by predators or scavengers may lead to death if undigested zinc phosphide bait is consumed. The Siberian ferret (*Mustela eversmanni*) has shown some toxicity signs, emesis, associated with zinc phosphide ingestion when fed poisoned rats (Hill and Carpenter 1982). In the Hill and Carpenter toxicity study (1982), emesis was noticed in three of the ferrets, which is a common characteristic of zinc phosphide acute intoxication, but none died. In the same study, they showed that sub-lethal doses of zinc phosphide (2%) caused altered blood chemistries in the ferrets, which has been associated with damage of the liver, kidney, and heart tissue (Chitty 1954, Stephenson 1967, Janda and Bosseova 1970). Another study reported zinc phosphide as having no secondary effects on domestic ferrets (Matschke et al. 1992), but no blood chemistry analyses were performed. Evans et. al (1970) identified zinc phosphide as being an effective tool for black-tailed jackrabbit (*Lepus californicus*) control. We expect that it would also be very toxic to species of lagomorphs in Louisiana. It has also been shown that kit fox (*Vulpes macrotis*) are susceptible to primary consumption of zinc phosphide (LD_{50} = 93 mg/kg), while they may receive up to 9 LD_{50}'s secondarily via rats and not succumb to the poisoning

(Schitoskey 1975). We could expect zinc phosphide to have similar toxicity to other canids (coyote (*Canis latrens*), red fox (*Vulpes vulpes*)). It has been identified that zinc phosphide is effective at controlling a number of species, but secondary hazards have been difficult to document (Table 1) (Timm 1994).

Although sufficient data exists to federally register this product for control of nutria, the label may need to be modified to facilitate ease of baiting. The widespread use of the bait may necessitate further research into its effects on white-tailed deer (*Odocoileus virginianus*), American alligator (*Alligator mississippiensis*), crayfish (*Procambarus clarkii*), and shrimp (*Mysis* spp.), for it is not understood how these species may be affected. Each of these animals represents a significant market for hunting, pelts, and food that must not be threatened with a large-scale baiting program (Figure 3).

Figure 3. American alligators provide leather and food to a growing industry.

Important steps to be considered when baiting with zinc phosphide is to pre-bait. The pre-baiting allows shy animals to become attracted to the baiting sites where others are feeding regularly. After they have become accustomed to feeding at these stations, the treated bait may be applied. The pre-baiting should use the same carrier and any oil or solvent that may be used to help distribute the active ingredient on the carrier. This will further accustom the animals to the taste of the bait. Pre-baiting should continue for at least 2 nights after sufficient feeding begins. If pre-baiting is interrupted with an unmonitored period, the pre-baiting should be restarted. The pre-baiting and baiting periods should be monitored daily and consistently.

Table 1. Toxicity of Zinc Phosphide to Animals

Species	Acute Oral LD_{50} (mg/kg)
MAMMALS	
Carnivores	
Cat (*Felis* spp.)	20 – 40 [a]
Dog (*Canis* spp.)	20 – 40
Desert kit fox (*Vulpes macrotis*)	93.0
Rodents	
California ground squirrel (*Spermophilus beecheyi*)	33.1
Black-tailed prairie dog (*Cynomys ludovicianus*)	18.0
Northern pocket gopher (*Thomomys talpoides*)	6.8
Norway rat (*Rattus norvegicus*)	27 – 40 [a]
Laboratory rat (*Rattus norvegicus*)	55.5
Black rat (*Rattus rattus*)	2.9 – 40.5
Polynesian rat (*Rattus exulans*)	23.0
Lesser bandicoot rat (*Bandicota bengelensis*)	25.0
House mouse (*Mus musculus*)	40 [b]
Deer mouse (*Peromyscus maniculatus*)	40.5
Meadow vole (*Microtus pennsylvanicus*)	18.0
California meadow vole (*Microtus californicus*)	15.7
Banner-tailed kangaroo rat (*Dipodmys spectabilis*)	8.0
Muskrat (*Ondatra zibethicus*)	29.9
Nutria (*Myocastor coypus*)	5.55
Woodrat (*Neotoma* spp.) (LD_{100})	25.0
Black-tailed jackrabbit (*Lepus californicus*)	8.25
Other Mammals	
Cow (*Bos taurus*)	50.0
Human (estimated minimum lethal dose)	40.0
Human, female (estimated minimum lethal dose)	80.0 [b]
Pig (*Sus scrofa*)	20 – 40
BIRDS	
Mallard (*Anas platyrhyncos*)	13.0 – 35.7 [a]
Snow goose (*Chen caerulescens*)	8.8
White-fronted goose (*Anser albifrons*)	7.5
Chicken (	20 – 40 [a]
California quail (*Calipepla californica*)	13.5
Partridge (*Perdix perdix*)	26.7
Pheasant (*Phasianus colchicus*)	8.8 – 26.7
Mourning dove (*Zenaida macroura*)	34.2
Red-winged blackbird (*Agelaius phoeniceus*)	23.7

[a] Hone and Mulligan (1982)
[b] Sweet (1993)

The baiting period will supply bait for a short time or until no additional bait is being removed from the feeding station. Do not apply more bait than what is being removed from the baiting station. The stations must be monitored and re-supplied daily with fresh bait. Baiting will typically last 4 nights, unless high populations require additional treatments.

The general baiting procedure has been described, but to further depict the difficulties of this type of baiting procedure, additional text is needed. Variations in presentation of the bait are available. The importance of these types of presentations is to aid in the limitation of the exposure to non-target animals (Figure 4).

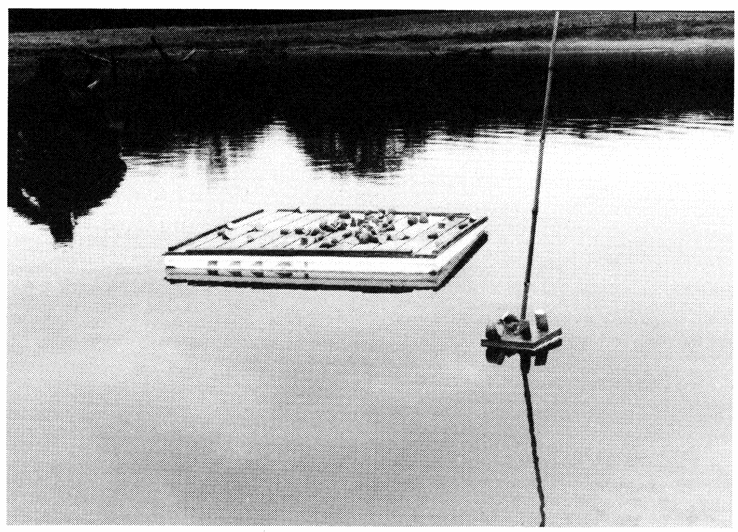

Figure 4. An example of a large baiting raft (left) and a small baiting raft (right).

The raft that will be used in large canals and areas of high densities must be constructed in the following manner:

- ? Use ½" to ¾" exterior plywood, 4' x 4' or 4' x 8', with 3" Styrofoam floatation.
- ? Install a small strip around the circumference of the raft to keep bait from rolling off of the raft.
- ? Anchor the raft to the bottom or side with a heavy weight or stationary item. Provide sufficient length on a rope to allow for tidal action.
- ? Space rafts about ¼ to ½ mile in waterways, or 1 raft every 3 acres in ponds.

- ? Only add to areas of permanent standing water.

Use smaller rafts for small canals or areas with low nutria density:

- ? Construct 6”x 6” floating bait boards with or without Styrofoam.
- ? Drill a hole in the center of the board to place a rod through to allow for water level change.
- ? Attach bait with small nails driven into the surface of the platform.

For use on small islands, tree stumps, and floating logs that nutria may visit:

- ? Baits can be attached by small nails above the water level.
- ? Add baits to flat surfaces.
- ? Don’t apply baits directly to muskrat house or beaver lodges.

This describes the types of rafts that must be constructed for the various types of areas that may be baited (Table 2). The placement of the rafts will take a large boat, small boat, and at least two people, to carry and distribute each of the rafts (Table 3).

Table 2. Total expense of constructing rafts for zinc phosphide baiting.

Type of raft	Area Baited	Cost of Materials (1/2” plywood @ $23.00/sheet, 3” Styrofoam @ $10/sheet, plus extra $4/raft (large), $0.50/raft (small), rebar $1/small raft)	Labor ($12/hour)	Total ($)
Large-pond	1,000 acres	6830	480	7310
Large-canal	100 miles	6150	432	6582
Small-5/acre	1,000 acres	8787	960	9747
Small islands, tree stumps and exposed logs	-	-	-	0

Table 3. Total expense of distributing rafts.

Type of raft	Area Baited	Estimated Expenses (2 Boats @ $200/day)	Estimated Labor ($15/hour)	Total ($)
Large-pond	1,000 acres	1000	1200	2200
Large-canal	100 miles	1000	1200	2200
Small-5/acre	1,000 acres	2400	2300	4700
Small islands, tree stumps and exposed logs	-	-	-	0

Table 4. Total expense of monitoring and baiting rafts for 6 days.

Type of raft	Area Baited	Estimated Expenses (1 Boat @ $100/day)	Estimated Labor ($15/hour)	Total ($)
Large-pond	1,000 acres	600	720	1320
Large-canal	100 miles	600	720	1320
Small-5/acre	1,000 acres	600	900	1500
Small islands, tree stumps and exposed logs	1,000 acres	600	900	1500

Table 5. Total expense for baiting project.

Type of raft	Area Baited	Total Expense ($)
Large-pond	1,000 acres	10,830
Large-canal	100 miles	10,102
Small-5/acre	1,000 acres	15,947
Small islands, tree stumps and exposed logs	1,000 acres	1,500

In short, we will be frequenting a baiting platform a minimum of 6 times on average after the placement of the rafts (Table 4). The obvious costs are incurred with the construction and distribution of the rafts (Table 5), which may be several thousand dollars depending on the type of area that is being baited. Using natural features to bait nutria is obviously the most cost-efficient baiting method when using zinc phosphide. Second, use of the large rafts is less labor-intensive, for they often can be spread out at further intervals. Use of the small rafts cost more up front for construction and then the labor for field placement is more intensive. Because of the expense for the baiting with rafts, other methods would be desirable, yet efficacy may be sacrificed.

It appears that this compound shows promise for use in limited areas, but the large-scale use is cost-prohibitive. Future development may be required for a more efficient use of time and labor, but it is unknown if phosphide baits would be feasible due to the mode of action and toxicity. Water or moisture, causes the compound to react, releasing the toxic phosphine gas. Oils are used in current formulations to concentrate such reactions to the stomach acids, instead of from ambient moisture or water. Any efficient bait application technique (Aerial application) would have bait applied to the waterways. Water quickly degrades typical baits, and the use of zinc phosphide for such bait may not be applicable.

Unregistered rodenticides – Many other toxicants are being used for the control of other rodent species throughout the world. These include other acute toxicants (strychnine, bromethalin), anticoagulants (warfarin, diphacinone, chlorophacinone, bromadiolone, brodifacoum, flocoumafen, difethialone), and fumigants (aluminum phosphide, gas cartridges). Many of these active ingredients could be used for effective control, yet they must be evaluated individually for their possible detriments (secondary poisonings, primary non-target deaths).

Rodenticides are developed to kill certain rodent species (primary target). Unfortunately, there is a risk with using such products, and non-target species may be impacted. If a scavenger consumes a rodenticide kill, depending upon the compound, the animal may be in danger of secondary toxicity poisoning. For the large-scale use of any compound, extensive work would need to be conducted to investigate potential effects to mammalian, avian, reptilian, amphibian, crustacean, and floral species.

These products could be tested for efficacy in laboratory, field pen, or field studies to determine palatable formulation and efficacy. After initial data is supplied, a Section 18 (Emergency Exemption) could be filed for by the State of Louisiana to the US Environmental Protection Agency (EPA). This could be initiated immediately, to aid in control of nutria within six months. Private firms may be contracted for this type of work. Development of such a product may range in the area of $300,000 for laboratory, chemistry, and field studies; and $500,000 for an Environmental Impact Statement (EIS).

Anticoagulants - Morin et. al (1990), confirmed that bromadiolone could be used as an effective toxicant for nutria in both chronic and acute doses. The acute dosing ultimately led to decreased levels of bromadiolone in the liver and kidney. The authors showed with chronic exposures that the nutria would be unnecessarily loaded with bromadiolone, and would increase the chance of secondary poisoning to non-target wildlife. Poché (1986) and Fisher (1991) demonstrated that bromadiolone was relatively safe secondarily when used at concentrations of 50 ppm or less. With an acute exposure, the initial half-life is approximately 2.4 days, with no notable change in the time to death. Bromadiolone (100 ppm) and chlorophacinone (75 ppm) is effectively used in France for control of nutria and voles (*Microtus* spp.), yet secondary deaths have been confirmed by tissue analysis of both anticoagulants in several species (Berny 1997; Eves Cohay, *pers. comm*). Diphacinone has been reported to kill a raccoon (*Procyon lotor*) and mountain lion (*Felis concolor*), but it was suspected that the bait was improperly used (Littrell 1988).

Warfarin was the first anticoagulant ever patented and used for rodent control (Campbell and Link 1941). Poché and Mach (2000), and Mach (1998) reviewed some primary and secondary toxicity studies with black-tailed prairie dogs (*Cynomys ludovicianus*), meadow and montane voles (*Microtus pennsylvanicus, M. montanus*), European ferret (*Mustela putorious furo*), and black-billed magpie (*Pica pica*).

In a secondary hazard study with warfarin (with ½ sulfaquinoxaline as the active ingredient), diphacinone, pindone, and PMP; mink (*Mustela vison*) and mongrel dogs (*Canis* spp.) died when fed anticoagulant-killed nutria *ad libitum* (Evans and Ward 1967). Evidence suggests that birds are not sensitive to primary warfarin toxicity (Rudd and Genelly 1956, Papworth 1958, Bailey et al. 1973). Fumarin, a compound similar in its toxicity to warfarin with the same dosage, showed no apparent intoxication to barn owls (*Tyto alba*) when fed fumarin-killed rats (*Rattus* spp.) (Mendenhall and Pank 1980). Fumarin, however, is no longer available or registered in the U.S. The secondary consumption of warfarin-poisoned rabbits that causes death in mink is >3.0 ppm/day for 28 days (Aulerich et al. 1987). Within the same study, an LC_{50} value of 11.7 ppm was determined for mink. If least weasels (*Mustela nivalis*) could have a constant exposure and a minimum daily intake of 0.3 mg warfarin/kg body weight, death could occur. Mink never displayed any signs of poisoning from the effects of warfarin in the laboratory. However, unlike laboratory settings, the susceptibility to anticoagulants in the field can be exacerbated by changes in diet (Colvin and Wang 1974, Laliberte et al. 1976) or increased activity (Oliver and Wheeler 1978, Penumarthy and Oehme 1978)

Warfarin could be an alternative as safer bait in an overall nutria management plan. The rodenticide, also used as a human drug, has been available for over 40 years in the U.S. Unfortunately, more toxic compounds have replaced warfarin because less bait is required to kill rodents. A study by Poché (1998) demonstrated that warfarin remains effective against most commensal rodents such as Norway rats (*Rattus norvegicus*) and house mice (*Mus musculus*). Commensal rodents are those species that have adapted to life in human habitation and survive because of mans refuse and habituation. These include the Norway rat, roof rat and house mouse. In a laboratory study with rats from

Chicago, that are notoriously "resistant" to warfarin, were killed when presented with 250 ppm warfarin bait (Poché 1998). The anticoagulant is efficacious, yet safe.

Perhaps another first generation anticoagulant bait could be used for control of nutria. Both chlorophacinone and diphacinone have been demonstrated as effective compounds with several species of animals (rats, mice, ground squirrels, voles, pocket gophers). These compounds may only require a single dose of bait to cause mortality. This may limit the amount of bait used. However, treatments would most likely be repeated to assure thorough efficacy. The one side-effect of using a compound with a higher toxicity is the number of non-target animals that may be affected. If the same carrier was being used for warfarin bait versus chlorophacinone bait, primary toxicity to animals would likely be similar, but the secondary toxicity would be increased. In short, the stability of the chlorophacinone or diphacinone is greater, therefore, increasing its ability to withstand the metabolic processes of the body and increasing its long-term toxicity.

Bromethalin – Bromethalin is an acute toxicant that has been used in the commensal rodent market. It has been shown to control rat and mouse (*Mus musculus*) populations in several field studies across the United States. The toxicity data suggests that other mammals are affected by similar doses per body weight, but avian species are much less susceptible and aquatic species are more susceptible (Jackson et al. 1982) (Table 6). It has also been shown that there is no secondary poisoning in dogs when fed bromethalin-killed rats. If this bait were applied similar to zinc phosphide, risk to non-target animals would be similar. But because of the palatability and stability of the bait, it may prove to be a valid alternative. Registration of bromethalin may require only limited testing, as much of the required toxicity data has been acquired. As with most rodenticides, bromethalin has its drawback: no antidote. Whereas zinc phosphide is a natural emetic and no antidote is needed for the most part, and anticoagulants have the antidote of Vitamin K_1, which is available with most doctors and clinics.

Benefits would exist with using this rodenticide because of the quick control and the safety factor in comparison to the other rodenticides. If people typically consumed nutria in an area, this toxicant would limit the poisoning risk to a person because the animal would die at a much faster rate and warn the would-be consumer that the animal must have been poisoned. In comparison, an anticoagulant-dosed nutria may live for many days with a toxic load in its system, and could be harvested by trapping or hunting and consumed, as it appears to be healthy. Also, the secondary risk to dogs with bromethalin is very low (Jackson et al. 1982). We could expect that the secondary risk to many other animals is low as well. This statement would have to be justified by laboratory testing with a variety of species common to Louisiana.

If such a management scheme were used, well-defined baiting periods would have to be defined to prevent human exposures. Many of the animals found in the coastal marshes may be food for a small portion of the population—and even nutria is served in several gourmet restaurants. If a baiting regime were ever used to control nutria, a strict constraint would need to be issued to maintain the safety to humans. Such a program would preclude the use of the meat during the baiting period and a duration after the baiting dependent upon the type of compound used for control.

Table 6. Toxicity of bromethalin

Species	Acute Oral LD_{50} (mg/kg)
Laboratory mouse	5.25 – 8.13
Laboratory Norway rat	2.01 – 2.46
Roof rat	6.6
Rabbit	13.0
Dog	4.7
Cat	4.8
Monkey	5.0
Adult quail	4.6
-	**Chronic Oral LD_{50} (ppm)**
Quail	210
Mallard	620

<u>Fumigants</u> – Since nutria usually do not inhabit a burrow in the marshes, this would not be an applicable technique; but in agricultural areas, this technique may be helpful where nutria burrow in the weir banks. However, this use is not registered and development would be required.

<u>Application of Unregistered Baits or Baiting Techniques</u> – The application of any bait would require a high efficiency. This would likely be achieved through aerial baiting by helicopter. The helicopter can quickly be loaded while in the air and it can accurately place bait where it is needed.

Gregg Howald applied brodifacoum bait to a 225-acre Channel Islands, California in ?1 hour (*pers. comm.*). This would calculate to 4.5 hours for a complete blanketing of 1,000 acres at 10 lbs/acre. Helicopter time for this study was $1,500/hour. Approximately 1800 acres could be baited in a day for $5,000. If we add labor for 4 people @ $15/hour, and a supply boat at $200/day, the result is $5,680 per application. This method is more cost-effective than any other method, but its specific of bait placement is only as good as the pilot's expertise.

As a whole, toxicants can be an effective means of a quick control that could be very important in areas of critical concern (i.e. areas of high populations, national or state parks, endangered species, critical impoundments, or agricultural commodities). Zinc phosphide would be the toxicant most easily used because of the current registration for use against nutria, and it has been shown to be effective. If other toxicants were to be explored for control, testing would be necessary to incorporate sufficient justification for its use and complex application problems would need to be rectified. Testing would delay full-scale use of a compound. In short, any change in techniques for applying a current rodenticide would require additional registration data. For non-specific use such as with aerial baiting many issues would have to be addressed including: American alligator, white-tailed deer, muskrat, shrimp, crayfish, fish, and birds. The approximate development cost for any toxicant application by helicopter would be $300,000 in testing and an Environmental Impact Statement (EIS) for $500,000.

Incentive-bonus Program

The program most widely recognized as completing successful nutria eradication was in Great Britain with a total harvest of 34,822 nutria (Gosling and Baker 1989) at an initial expected cost of £2,500,000 (Gosling and Baker 1987). Twenty-four full-time trappers were employed and averaged 48 ± 20 trap nights per trapper. They were supplied with traps, four-wheel drive vehicles, and boats. After nine years of trapping and monitoring, the program was declared a success in January 1989. Final cost was not given. Another program that was unsuccessful in the 1960s was in Great Britain on 2,645 mi^2 (Norris 1967). The author expected that it would be impossible for nutria to be eradicated in Great Britain.

The incentive-bonus program achieved the goal of eradication in Great Britain, but one must be careful to compare its success with a program in Louisiana. The environments are completely different. Access to sites in Great Britain was by vehicle, compared to several different types of boats would need to be used in Louisiana. Proximity to major roadways is a severe limitation in Louisiana. Also, size of the infested area in Louisiana (43,556 mi^2) is about 10 times larger versus the area in Great Britain (?4,500 mi^2). The freezing temperatures of winter in Great Britain played an important role in the eradication of nutria. Several colder-than-average winters in the mid 1980s aided in controlling the population (Gosling and Baker 1989). However, cold or dramatic events tend to synchronize reproduction enabling the nutria to maximize colonization (Doncaster and Micol 1990, Evans 1970).

In Maryland, nutria have established and caused the loss of 8,000 acres of marsh (Ted Mollet, *pers. comm.*). Seventeen federal, state, and private partners helped develop a plan to control the nutria to allow for restoration of Maryland's wetlands that has received funding for a pilot eradication program (Bounds 1998). Currently, baseline data is continuing to be collected. A master's student, Kari Margowan, has identified that the nutria are reproductively synchronous due to the winters and that the population appears lower than in past years (*pers. comm.*). Twelve full-time trappers have been hired to assist in the pilot plan that currently has 23 sponsors. Harvest is expected to begin in late March, 2002 (Dixie Bounds, *pers. comm.*). The program has the potential to achieve its goal because of higher trapping efficiency, better mobility, and lower population fecundity. Louisiana would most likely not have any of these factors that benefit the Maryland program, in addition to a population size that covers the entire state and adjacent states.

Although eradication is not a viable alternative for Louisiana due to its substantial alligator pelt industry valued at approximately $12,000,000 per year (Alan Ensminger, *pers. comm.*, Linscombe 2000) (Figure 5), and that this method of control is not recommended, it is listed as an effective technique for controlling nutria in a limited area and habitat. The incentive-bonus program that was used for this program provided the trappers/hunters with a salary for their work and then a substantial bonus when they locally eradicated nutria (Gosling and Baker 1989). The reward was a necessary item to prevent members from providing husbandry to maintain populations for career stability, and limit the trappers from becoming uninterested (Gosling and Baker 1987). Contracts would document all incentives and subsidies. Failure to achieve the specified goals would negate the contract and therefore, eliminate the full bonus.

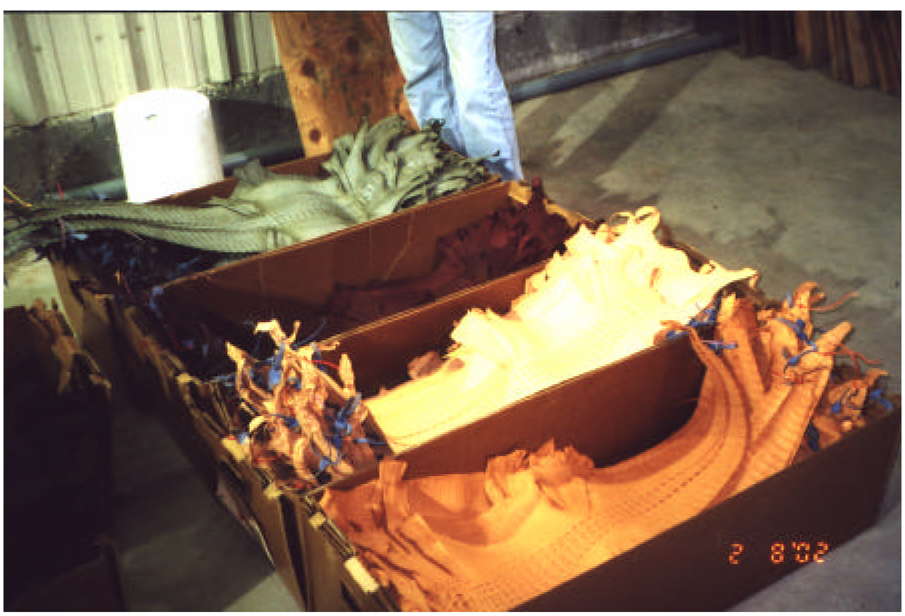

Figure 5. Alligator leather is valued at $12 million/year industry.

An example that could be used for such eradication is as follows (Gosling 2001):

? A salary would be provided during the eradication campaign (10 years).
? A sum of 3 times the salary would be paid for successful eradication within 6

years. The bonus would decrease on a yearly basis after 6 years.

- ? No money will be available after 10 years.
- ? A successful eradication would be evaluated by an independent monitoring team by the following means:
  - o The date of eradication is defined as the last day on which evidence of nutria is observed.
  - o When 1 year elapses from this date, without further evidence of nutria, a time period of final validation will initiate.
  - o The final validation of 6 months of monitoring will determine the success. It will commence if no nutria evidence is observed.
  - o If nutria are observed during this time, the trapping will continue until the end of the 6-month period and an additional 3-month period.
  - o If after an additional 3-month period, no nutria or nutria evidence is observed, the program will locally commence.
- ? High trapping pressure must be maintained until the end of the campaign.
- ? When individuals are detected, massive concentrations of traps must be placed to preserve the integrity of the program. At this time, one must remember eradication is the ultimate goal and failure is not acceptable.

The monitoring team must be independent of the trappers, for they stand to gain through the bonus after confirmation of eradication. The independent team may be government employees with knowledge of the area to be surveyed, or another public or private agency. The monitoring company must have a thorough knowledge of the nutria and its evidence as well. Lack of experience or geographical thoroughness could incorrectly validate the control of nutria.

The monitoring must be composed of several techniques to increase the chance of detecting lone nutria. These techniques may include, but not limited to:

- ? Census baits
- ? Live traps
- ? Kill traps
- ? Visual observation of nutria, scat, and burrows
- ? Auditory cues

In the event a false positive is recognized, immediate response is necessary. The position of the observation must be verified and then the trapping program must be re-initiated. Typically, animal damage control is synonymous with the reduction of damage to a tolerable level, but the eradication effort requires absolute obsession to reach the goal.

As in island restoration, isolated populations can be controlled much easier when immigration is minimized or cut off. Several islands throughout the world have been eradicated of different species of feral vertebrate pests including cats, rats, rabbits, goats and pigs. Intensive chemical control, initially by helicopter, has provided a quick means of extensive control for islands. With this approach, it may be possible to eradicate the nutria from small regions, and eliminate the source population for a larger area.

This program would not have many upfront costs if used alone. It would depend upon how many trappers/hunters were hired and at what salary they were paid. For example, $2 million would cover the salary of 10 full-time trappers paid $27,000 each and a large supply barge that could be used as a local "base of operations" (Table 7). There would be little increase in the cost of the project except when areas were verified as being eradicated. Then, the bonus would be incurred.

Table 7. Approximate expense for trapping materials.

Transportation	Cost/day (Rental)	1-year total (trapping every work day)	Include salary	Total/trapper
Supply barge [1]	550	143,000	-	143,000
Mudboat, airboat, or similar	500	130,000	27,000	157,000

[1] Not a trapper.
Note: Include fuel and maintenance in "cost/day". Use barge to supply 5 trappers.

Initially, this program would be extremely difficult to justify. Failure would be expected. In addition, because of the available funds, the program would be limited to approximately 10 trappers and 2 supply barges based on rental costs. Therefore, the 10 trappers would have to work smaller tracts of land. They would trap until regional eradication was achieved and then proceed to another adjacent area. Borders would need to be maintained after eradication. This would require additional personnel or an elaborate exclusion system. For the success of such a program, complete cooperation with all landowners would be required, isolation of populations by physical (fences) means, and many other biological factors to slow the recruitment of nutria. Based on the effective area of the trappers in Great Britain, 10 trappers could be expected to eradicate ?1,200,000 acres in 10 years, but this is probably a gross overestimate due to the difficulty of obtaining entry to many of these sparse and isolated marshes. The incentive-bonus program would likely have more success when the population was fragmented. Then, source populations could be targeted and eliminated.

However, if the program was implemented after one or more control techniques had dropped the population or isolated populations from each other, this may be a very effective way of controlling the nutria to a level that the other programs would most likely not achieve. The incentive-bonus approach could be used to methodically eradicate local populations. A contingency plan would be required for a quick response with the incentive-bonus program if the opportunity arose, but this may be against the desire of many interest groups, namely the alligator industry. In conclusion, due to the limitations of the incentive-bonus program, this approach would be almost impossible to control populations with the lack of sufficient funding, positive public perception, and physical logistics.

Induced Infertility

Induced Infertility, in theory, is the most effective technique of population management for an r-selected species, nutria. To do this, the birth rate must be manipulated to a point that is lower than the death rate. Then, the population would decrease. Several compounds are described below as to their potential use in the field for different species. They are listed according to the most feasible to the least feasible; however, many serious concerns should be stated about the use of contraceptives as a whole.

One recently registered contraceptive is ? -chlorohydrin that is marketed under the name Epibloc, Pestcon Systems, Inc. ? -chlorohydrin was effectively used as a toxicant-sterilant for control of male fertility in many rodents (Ericsson 1970, Ericsson 1982, Ericsson and Connor 1969, Cummins and Wodzicki 1980, Marsh 1988), but the primary mode of sterilization affected only males. At concentrations of 1-2%, death can be caused (Marsh 1973, Meehan and Hum 1979), and any survivors are at least temporarily sterilized. Studies by Genesis Laboratories, Inc. during the mid-1980s showed the product to have sporadic results in reducing reproduction rates. Palatability was a problem (Ericsson et al. 1971, Field 1971), but in recent years it has been encapsulated in a vinyl resin-based material and acceptance (palatability) has improved dramatically (Kirkpatrick and Turner 1987). Nutria have not been tested with this product, but it may serve as a tool in special situations or limited areas.

Diethylstilbestrol has been used as a temporary chemosterilant for black-tailed prairie dogs (Garrett and Franklin 1983). This study showed complete curtailment of reproductive success for one year on the treatment plot as the control plot reproduction was normal. During the next year, the treatments were reversed and the same result occurred. Colony expansion of the control plots was 4 times as much as the treatment plots. Prairie dogs breed only once a year, so applications would be yearly to control the populations on a long-term basis. Similarly, it has been demonstrated as an effective temporary chemosterilant for rabbits (Greenwald 1957), mink (Travis and Schaible 1962), and dogs (Jackson 1953). In addition, diethylstilbestrol was illustrated to be an effective chemosterilant of coyotes (Balser 1964) and red fox (Linhart and Enders 1964). This compound has some potential, but it would require registration that may take many years. Also, long-term sterility has not been demonstrated. For nutria, this product would have to be applied at least three times per year assuming reproductive synchrony.

Mestranol has been demonstrated to be an effective chemosterilant against Richardson's ground squirrels (*Spemophilus richardsonii*), however, yearly treatment was needed to maintain sterility (Goulet and Sadleir 1974). Evans et al. (1970) reviewed the management techniques of rabbits. They found that mestranol produced abortions at all stages of pregnancy, but exhibited only a short-term effect. When young obtain mestranol through the mother's milk, it produces sterility in both sexes (Howard and Marsh 1969).

This chemosterilant appears to affect a wide range of animals, which could be detrimental to an ecosystem when applying large quantities of bait over a large area. Since the chemosterilant is temporary, r-selected animals, like rabbits and nutria, will most likely not be appreciably affected because they are not reproductively synchronous. Consistent delivery of the chemosterilant would be required to maintain a long-term affect to suppress population recruitment and growth. However, the main detriment to this product is that if any male remains fertile or enters the population, he may inseminate many females. This could be used in closed populations, but few closed populations are present in the wild.

Diazacon is a cholesterol mimic that inhibits cholesterol production and blocks steroid hormone formation (Anonymous 2002). It has been registered under the trade name Ornitrol. It was used for population management of pigeons, blackbirds, starlings, and sparrows, but it has been necessary to maintain pigeon populations with a consistent supply because of their year-round breeding. Therefore, it became very expensive to apply. Mammals are affected the same as avian species, therefore, use of such a chemical would not be species-specific and could cause ecosystem-wide effects.

Porcine zona pellucida is an immunocontraceptive that coats the egg, and in conjunction with the animals natural zona pellucida causes the production of antibodies that prevent fertilization of the egg from the sperm (Anonymous 2002). Successful immunizations will allow for normal ovulation but, prevent fertilization. The use of this chemical for the control of deer populations has been successful in small and large penned deer herds with an average decrease in birth rate of 76% and 82%, respectively. Trials with coyotes showed that breeding activity was not decreased, yet the birth rate was decreased by 78%. Overall, because of the ability to maintain long-term effects, fecundity would also be dramatically decreased.

Gonadotropin releasing hormone vaccine induces a response that inhibits the production of sex hormones resulting in an infertile male and female (Anonymous 2002). White-tailed deer population birth rates were reduced by 81% for a 5-year period with some negative effects apparent in the lack of sexual activity of bucks, early loss of racks, and the antlers remaining in velvet. For a rodent population, this type of non-gender specific infertility would be of greater benefit. Yet, delivery by a dart gun or by capture and injection, results in a method that is highly cost-prohibitive for an abundant species like the nutria.

Many compounds have been investigated and proven to successfully inhibit fertility in the male or female or both, yet many logistical problems exist with the implementation of such a device. First, some of the contraceptives must be chronic exposures that can dramatically increase expense of a control campaign. In order to maintain non-reproductive nutria with current technology, repeated and regular aerial applications of bait to nutria would be required. These would have to be applied by aircraft at a minimum of every three months. If an effective compound could be applied in the form of bait, it would require approximately 5 lbs per acre for a total amount to 500,000 lbs of bait for 100,000 acres. Total cost per year would be approximately $ 6,000,000. Formulation, development, and testing costs would range about $10 million and take about 5-8 years until FDA approval MAY be guaranteed. The impact would also affect other rodent species, such as muskrat, beaver, cotton rats and various smaller marsh species. A detailed environmental assessment would have to be conducted, along with the potential effects on key avian species, such as ducks, herons, and other aquatic birds. Since shrimp is also a vital industry to south Louisiana, the potential impacts to shrimp would have to be assessed. A single application of a long-term compound would be highly preferred.

Second, the use of contraceptive devices or chemicals is potentially useful for closed or finite populations, where the influx of non-sterile males or females is likely. In widespread contiguous populations, similar to the nutria population in Louisiana and its adjacent states, it is difficult to prevent the invasion of reproductively viable animals into a population of sterile animals and not propagate the species.

Third, the field needs further development with the distribution of such conceptive devices or drugs to the target animals. In this way, it is a similar problem to use of toxicants. Contraceptives have been shown to be effective in the control of large mammal populations such as feral horses or white-tailed deer, but delivery devices (IUDs, vaginal rings, and implants) are labor-intensive and are unfeasible with small rodent populations (Bardin 1987). An effective delivery system is one of the primary concerns. According to Lowell Miller (*pers. comm.*), a scientist with the National Wildlife Research Center- APHIS/USDA that has spent 30 years studying induced infertility; there are no technologies available for field applications. Almost insurmountable hurdles would need to be circumvented for registration/approval; and if available, it would most likely be used to manage small populations of animals adjacent to human populations.

Finally, developments in the field have often resulted from failures in human contraception, where unacceptable human safety risks have aided in their development for rodents. However, chemical companies have not pursued this avenue because of the public perception. When damage is being reported, it is often unacceptable to only control the fecundity of a population. The effort is immediately placed on the individual(s) causing the damage, which is often by lethal means. Waiting for depression of the population from lack of reproductive success is not a popular premise when animals may be observed for many years.

In short, this approach to nutria management would not be desirable, relatively impractical, and pose substantial environmental implications. The field has not been developed enough for it to be a viable consideration for nutria control in Louisiana.

Trapping

During the years that the nutria pelt was highly prized, the nutria population was somewhat stable, according to harvest data and vegetative damage was not evident. But following the "bottoming out" of the market (1980's), harvest dropped and the nutria population responded by dramatically increasing.

For a control program, trapping will be one of the most valuable tools to complete the mission. It will be most important in the capture of the remaining sparse populations at the end of the eradication program. In addition, the trapping may serve as one of the important means of attaining low numbers as well. Trapping can be conducted by many techniques including: leg-hold traps, live traps, body-gripping traps, and snares. These can be used in a variety of situations.

The No. 2 Victor leg-hold (8.0 nutria/100 trap nights) caught significantly more nutria than the 220 Conibear body-gripping trap (6.1 nutria/100 trap nights) as well as non-target animals (birds) (Linscombe 1976). Palmisano and Dupuie (1975) observed similar results. Robicheaux and Linscombe (1978) also tested the 206 Tomahawk live trap (8 x 8 x 31.5 inches) for catching coastal marsh furbearers. This live trap was less effective than the others (1.2 nutria/100 trap nights), but could be applicable in special circumstances where leg-hold or body-gripping traps are not permitted.

To improve the success rate, live traps (10 x 10.5 x 32 inches) with carrot bait were placed on floating rafts. This was the only way to consistently recapture marked animals (Evans et. al 1971). Baker and Clarke (1988) also identified rafts as increasing trap efficacy by as much as 3 times, as well as being a way of reducing risk to non-target animals by 50%. However, there are great expanses of marsh that do not have open water to use such rafts (Linscombe *pers. comm.*). Gosling (1981) showed that the temperatures below –3ºC significantly reduced trapping success, an event that is uncommon in Louisiana. Another means of application would have to be used.

Using the trapping method alone would most certainly have little effect on the nutria population, as is demonstrated by the current means of control or harvest. Because sufficient market value is not present for the pelt, trapping pressure has been limited compared to the 1970s harvests of ?1,500,000 animals versus the harvest of 2000-2001 of 29,544. We could expect the same trend to continue if the market value fails to increase. For example, Richard Domagne (*pers. comm.*), a fur trader, believes that if the Argentinean recession continues, the native nutria harvest will be depressed, forcing Turkish and Grecian markets to examine additional markets. If such an event occurs, a temporary market may provide additional incentive, but this may be short-term and should not be considered a permanent solution. Opinions on the possibility of the fur market returning to stable growth are in general, apprehensive. Richard Domagne (*pers. comm.*) also believes that $4 per tail is too much for the trapper. He thought ½ of the money should be used to effectively develop the market for furs so market value could be maintained yearly.

The use of airboats has aided in the daily harvest in dense areas of nutria (Allan Ensminger, *pers. comm.*). However, the nutria becomes conditioned to the sound of the airboat and dive into deep water or hide under vegetation. Hunting is therefore, greatly decreased. But if trapping is used at intervals of 3 to 4 days, productivity is maintained.

In contrast, trapping will be used as a technique to support an incentive payment program. Trappers who partake in this trade are expected to increase their effort because the additive value that may be supplied secondarily to the value of the pelt or meat.

Controlled Hunting

Hunting may be a technique that could be used to decrease the nutria population, but to the extent that is necessary for the decrease of marsh damage is questionable. Hunting is often an opportunistic means to satisfy a desire of controlling a population, when actually it often has little impact on an r-selected species or large population of animals. With concentrated hunting efforts, one could expect a number of animals to become shy to hunters, and become very difficult to control unless other control techniques are implemented.

Hunting to control a population is often unrealistic, however, hunting may be used as another method to harvest nutria in an incentive payment program. Hunting would most likely be used opportunistically to harvest nutria, however, organized hunts in combination with trapping could also aid in control.

Chemical Repellents

No chemical repellents are registered for nutria. For the most part, repellents available on the U.S. market are for birds, such as geese and ducks. These products are generally sprayed on turf, seeds, or fruit to reduce bird depredations. Unfortunately, there are no effective repellents available for rodent repellency. Compounds such as methyl anthranilate and anthraquinone (Poche 1998) can be effective against birds, but of little value in repelling rodents.

Devall and Parresol (*In Press*) are conducting a two-year study on the effectiveness of Tangelfoot, Ropel, and plastic tree guards to protect bald cypress seedlings. These methods may or could provide some relief from damage, but will not be effective for large populations. The effect would eventually lose effectiveness and/or be overcome by hunger. Repellents may provide some control of damage, but use of repellents without the state and federal regulations is illegal. In addition, the development of a suitable repellent could be explored, yet the expense of this work versus the efficacy and benefit of such a product seems unfeasible.

Repellents may offer only localized protection against damage, however, as with most products, repellents tend to shift the damage to other areas. Consequently the problem is never solved, since the target population remains the name size and damage is shifted from one arena to another.

Even if an effective repellent is developed for nutria damage control, the delivery system will be of utmost importance. Since nutria inhabit a vast area of south Louisiana, applying the product to vegetation to curb damage would be costly and impractical. An adhesive would be required in the formulation in order to have the repellent adhere to vegetation for any length of time. Repeated applications would be required resulting in millions of gallons of product being used in the costal marshes. The subsequent impact on other rodents, such as muskrat and beaver, along with aquatic birds and shrimp would have to be assessed in terms of the benefit of such a control technique.

Justicia lanceolata has been used to revegetate damaged areas identified as being unpalatable to nutria, able to confine sediments, and is often out-competed by other species of wetland vegetation (Llewellyn and Shaffer 1993). This serves as a biological repellant.

We feel the use of repellents would be a waste of taxpayer money and effort. Repellents in effect “pass the buck” from one area to another and never really solve the problem of overpopulation.

Conclusions

Following a review of the control techniques for aquatic mammals and nutria, the personnel of Genesis Laboratories, Inc. believe that the incentive payment program may be the best option for statewide control (Table 8). Many of the other techniques have promise of wide success, yet the upfront costs for these techniques are a limiting factor. The method will not require environmental hurdles, while yet providing an urgent need to relieve damage in the state.

It should be clearly understood that the incentive payment program would not eliminate the problem, a benefit according to the Fur and Alligator Advisory Committee. This program follows the goal of wildlife damage management: to control damage to levels that are acceptable. Given the projected increase in nutria numbers, immediate attention should be focused on the nutria situation. It would be a monumental loss to implement this program; halt the program for unknown reasons then to have the populations revert to historical numbers.

Table 8. Cost-effectiveness Ranking. Given $2,000,000/year, the plans are ranked according to the following:

Ranking	Method	Description	Cost-effectiveness
I	Incentive payment program	A secondary value would be paid for the tail in addition to the pelt or meat.	$2 million maximum/year Money paid until yearly stipend is allocated. Control would be based upon area and pressure from trappers/hunters.
II	Chemical control	Use of toxicants to control nutria populations	$4 million per year. Bait applied to limited areas due to extreme cost. Cost would quickly exceed cap. Efficacy may be good.
III	Incentive-bonus program	Salaried trappers/hunters would control nutria and upon successful eradication, a bonus would be paid	$2 million maximum/year. If area where trapping occurs were sufficiently concentrated, this would be an effective method, yet ineffective spatially.
IV	Trapping	Lethal and non-lethal traps used by licensed trappers	29,544 nutria harvested last year (2000-2001). Lack of trapping due to market value of pelt ($2.18). Trapping would only succeed if long-term market value for pelt exceeds expenses for processing ($5.00/pelt). No expense to State or Federal Agencies, yet efficacy considered extremely low.
V	Hunting	Open season by licensed hunters	No value on price of the pelt for hunter, little nutria would be harvested. No expense to State or Federal Agencies, yet efficacy considered extremely low.
Not applicable	Induced infertility	Chemical compounds to limit fertility of males or females or both.	Lack of scientific knowledge in this field, this method would not be applicable for nutria control due to lack of delivery methods for sufficient efficacy and data gaps for state and federal registrations.
Not applicable	Chemical repellents	Used to repel animals using a non-lethal device to decrease damage. Not effective in many situations.	Lack of efficacy and long-term effect of these techniques, they will not be considered as a valid means of control.

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