

**The Nutria in Louisiana:  
A Current and Historical Perspective  
FINAL REPORT**



**Prepared for  
The Lake Pontchartrain Basin Foundation  
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## Table of Contents

ACKNOWLEDGEMENTS .....	III
CONTENTS.....	V
LIST OF TABLES .....	VII
LIST OF FIGURES .....	IX
INTRODUCTION .....	1
A SHORT HISTORY OF THE NUTRIA IN LOUISIANA .....	3
REPRODUCTIVE POTENTIAL OF NUTRIA.....	8
MOVEMENTS, HOME RANGE, DISPERSAL .....	9
HABITAT PREFERENCES.....	10
DID NUTRIA DISPLACE THE NATIVE MUSKRAT? .....	11
FOOD SELECTION.....	12
NUTRIA GRAZING IMPACTS TO COASTAL LOUISIANA WETLANDS .....	15
NUTRIA BIOMASS CONSUMPTION RELATIVE TO MARSH PRODUCTION .....	24
HISTORICAL NUTRIA ABUNDANCE ESTIMATES.....	27
CONTEMPORARY HARVEST OF NUTRIA AS AN INDICATION OF ABUNDANCE .....	28
POPULATION MODELING .....	34
METHODS TO CONTROL NUTRIA POPULATIONS .....	35
COASTWIDE NUTRIA CONTROL PROGRAM.....	38
CNCP NUTRIA-DAMAGED MARSH DISTRIBUTION .....	38
CNCP PROGRAM SUCCESS .....	44
THE IMPORTANCE OF ALLIGATORS AS PREDATORS ON NUTRIA .....	46
SUMMARY .....	49

LITERATURE CITED ..... 52

## List of Tables

Table 1. Timeline of important events relating to muskrat and nutria populations in coastal Louisiana. ....	7
Table 2. Reproductive parameters of the nutria ( <i>Myocastor coypus</i> ) based on wild populations. .	9
Table 3. Coastal marsh and swamp forest area (ha) estimated for 2008 among the different geological provinces of Louisiana (Sasser et al 2009). ....	11
Table 4. Wetland plant species consumed by nutria in Louisiana. ....	13
Table 5. Summary of controlled field studies that report grazing impacts to above- and belowground biomass, soil processes and rates of change in Louisiana coastal wetlands. ....	15
Table 6. A budget of nutria metabolism and plant biomass consumption on an herbaceous marsh over one year. ....	24
Table 7. Nutria population density estimates in Louisiana. ....	27
Table 8. Summary of Coastwide Nutria Control Program (CNCP) nutria harvest by marsh types, 2003-2010 (data from LDWF reports). ....	29
Table 9. Methods used to control nutria populations based on Baroch et al (2002). ....	37

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## List of Figures

Figure 1. Historical harvest of muskrat and nutria from Louisiana during 1924-2010 .....	4
Figure 2. A color-infrared image illustrating the effects of nutria herbivory in a recently-developing delta. ....	21
Figure 3. Aerial views of a thin-mat floating marsh site where nutria exclosures were constructed and planted with <i>Panicum hemitomon</i> in Terrebonne Parish, depicting the differences inside and outside of the exclosures. ....	23
Figure 4. The relationship of a static nutria population on potential marsh production over time. ....	26
Figure 5. Total nutria harvested in western and eastern Louisiana, including that within CNCP and others harvested for pelts as reported to Louisiana Department of Wildlife and Fisheries for 2002-2010.....	30
Figure 6. Nutria damage as reported by LDWF for 2003-2010. ....	31
Figure 7. Summary of the Coastwide Nutria Control Program harvest by parish, 2002-2010....	32
Figure 8. The number of nutria hunter participants each year in the Coastwide Nutria Control Program. ....	33
Figure 9. Aerial image of the Louisiana Delta Plain showing the number of nutria damage sites by year. ....	39
Figure 10. Aerial image of the Louisiana Delta Plain showing highlighting the "Hot Spots" of nutria damage .....	40
Figure 11. Nutria damage by year in the northern marshes in Terrebonne Basin, Louisiana .....	41
Figure 12. Nutria damage by year in "The Pen" region in Batataria Basin, Louisiana .....	42
Figure 13. Nutria damage (acres) by marsh type for each year based on LDWF helicopter surveys.....	43
Figure 14. Louisiana Dept. of Wildlife and Fisheries estimates of nutria damage to coastal marshes (right axis, green line) and the harvest of nutria from 2000-2010 for all the coastal parishes (left axis). ....	44
Figure 15. Severity assessment of nutria damage by year based on LDWF helicopter surveys. ....	45

Figure 16. Nutria harvests from 1969 through 2010 from west (Chenier Plain) and east (Delta Plain) Louisiana..... 48

# **THE NUTRIA IN LOUISIANA: A CURRENT AND HISTORICAL PERSPECTIVE**

*The influence of nutria alone is sufficient to cause the marshes to continually decline, jeopardizing their existence.* Biologist, Allan Ensminger (Addison, 2000)

## **INTRODUCTION**

Seventy years since its introduction, the exotic nutria has changed the landscape ecology of Louisiana. Here we review some of the evidence for the capacity of this animal to affect ecological succession and the long-term stability of vegetated wetlands. We will look at the current nutria distribution and relative abundance across the major geographic provinces. We also examine trends in the extent and severity of nutria grazing damage to wetlands under the Coastwide Nutria Control Program (CNCP) developed by the Louisiana Department of Wildlife and Fisheries (LDWF) under the Coastal Wetlands Planning, Protection and Restoration Act (CWPPRA). We highlight the essential life history characteristics of nutria, but refer the reader to more comprehensive treatments (Kinler et al. 1987; Bounds et al. 2003; Baroch et al. 2002; Willner et al. 1982).

A once thriving global fur market fueled the development of a successful fur industry, based primarily on muskrat, in Louisiana dating back to the early 1900's. After the nutria's introduction to Louisiana in the late 1930's and its range expansion in the 1940's, the nutria was at first thought a threat to the coastal resident's livelihood, because muskrat populations declined as nutria were becoming more prolific. The State facilitated a market transition from muskrat to nutria by transplanting and protecting the nutria, until it was clear the nutria population had formed a stronghold in Louisiana's coastal marshes. Eventually nutria pelts became an increasingly valuable component of coastal Louisiana's economy, climaxing in the 1970's, when European processors could offer luxury nutria fur products.

Fashions changed, economies foundered, and animal rights activists challenged the ethics of trapping and fur ranching. The crash of the fur market in the 1980's left nutria population growth unchecked on over 1 million hectares of ideal marsh habitat. The nutria has since emerged as a significant threat to coastal wetland sustainability. An expert on bald cypress forests, William Conner eventually ranked nutria herbivory—along with salt water intrusion and flood inundation stress (land subsidence)—in the top three problems facing cypress-tupelo forest regeneration and sustainability in Louisiana. While it was recognized early that nutria caused acute damage to sugar cane and rice crops, it was only during the 1980's as trapping relaxed that land managers complained of chronic damage to their wetlands.

Quite common were the early accounts of the capacity of nutria to severely damage wetlands:

*I can show you places where nutrias and muskrats grew so thick 40 to 50 years ago, trappers could not catch enough of them. They ate up all the grass, and those areas are now ponds” (Ignace Collins, in Felsher 2000).*

*Two of the most intensively trapped and managed properties, on a tract of 150,000 acres in Vermilion Parish and a tract of 155,000 acres in Cameron Parish, were completely leveled by nutria, with peak takes of marketable pelts in the 60,000 to 70,000 figure, after which came sharp drops in production accompanied by poor pelt quality due to the lack of food supply. The active Mississippi River Delta, comprising about 350,000 acres...also went to pieces by 1956-57, as a result of the 250 nutria transplanted there in 1951. There was a gradual rise [of the population] from 1951 to the peak in the 1955-56 season, when nutria were everywhere with vegetative cover still standing. By the following season, only the pass banks appeared to be holding the delta together. (O’Neil 1963)*

There is ample scientific evidence that suggests that nutria have the capacity to alter wetland stability. Our current understanding emphasizes that nutria herbivory alone as a stress on plant productivity rarely explains what we could term ‘irreversible marsh collapse’, except at the highest densities. Instead, nutria grazing, interacting with other stresses (inundation or salt stress), may force a tipping point where the wetland is forced to another ‘stable’ state, perhaps with reduced productivity, altered plant composition, or ultimately a reversion to open water. These effects are real and have consequences for wetland loss that can take the form of: 1) inhibition of the reproduction potential for herbaceous and forested (cypress-tupelo) wetlands in the coastal zone; 2) marsh elevation loss with reduced organic matter accumulation, which further exacerbates inundation/salt stress to plants already experiencing broad-scale soil subsidence and rising sea levels; and 3) soil destabilization and susceptibility to accelerated erosion.

Coastal managers and scientists have wrestled with understanding just how severe the nutria damage problem is in Louisiana. The perceived impact of an exotic marsh rodent may seem negligible compared to the scale of the geological land subsidence, sediment deficits, and hydrologic impoundment afflicting coastal wetlands. Decades of cumulative deleterious effects of nutria grazing on the coastal landscape have been difficult to quantify and separate from other factors producing wetland loss. The extreme cases of population eruption and wetland damage that arise at local scales are a testament to the capacity of nutria to cause marsh collapse or inhibit forest regeneration, but the more subtle, chronic effects of grazing have been harder to document.

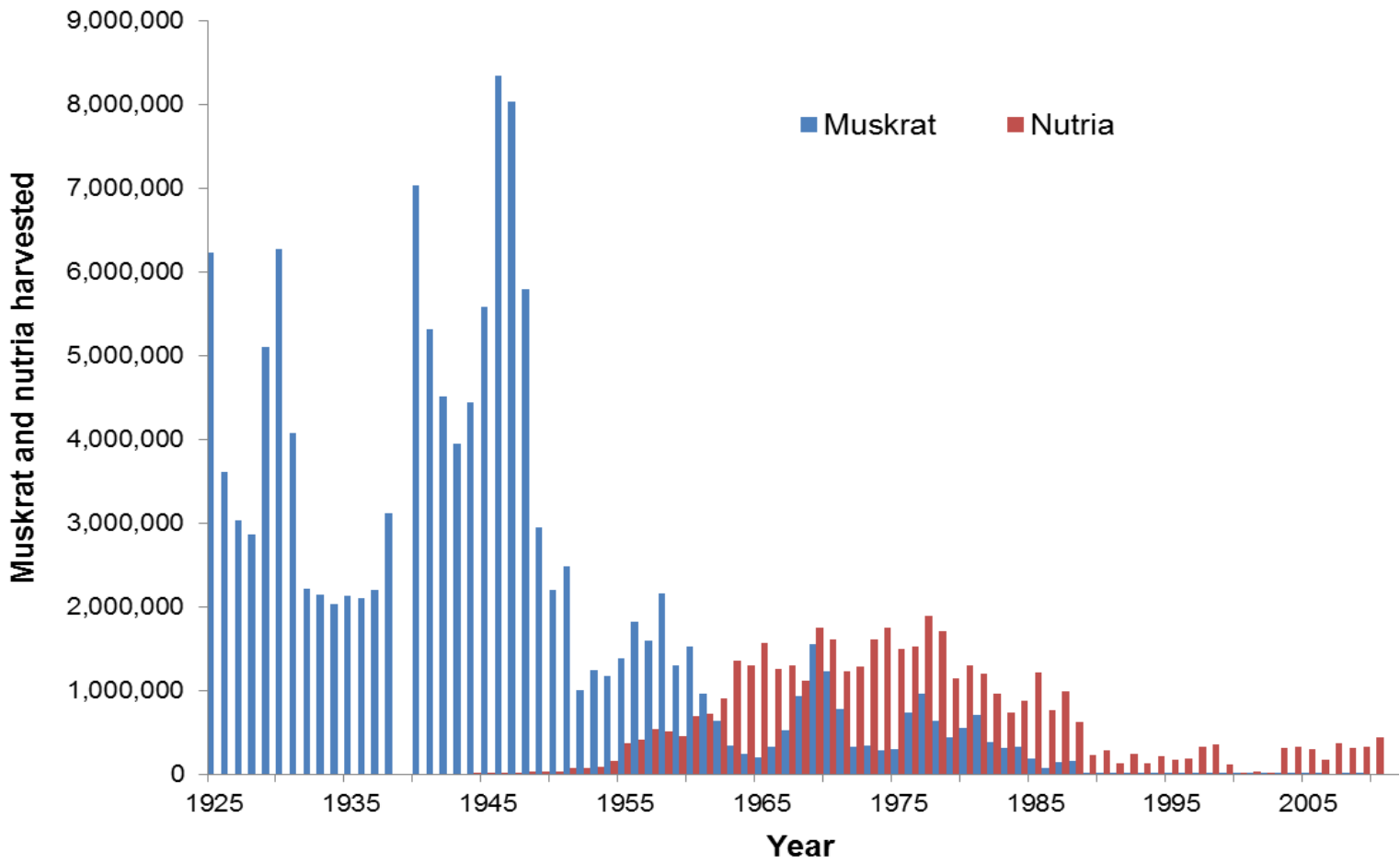
Most coastal managers and wildlife biologists advocate nutria control rather than eradication as the only realistic option, given the breadth of Louisiana’s wetlands. Eradication has been successful in the Blackwater Refuge in Maryland, USA and Great Britain where the wetlands comprising suitable nutria habitat are relatively discrete and accessible. Several points are worth considering about nutria population control, past and present in Louisiana:

- 1) The fur market once provided enough incentive to control the nutria population; largely this industry no longer exists.
- 2) Of the density independent mortality factors, severe freezes and tropical storms regulate the population. In Louisiana, no documented widespread disease outbreak has ever caused a significant reduction in the nutria population.
- 3) It is hypothesized that conserving large alligators will control nutria density. This is intuitively reasonable but there is a lack of strong evidence to support this at present.
- 4) Poisoning on a large-scale is unacceptable because of possible mortality of non-target species.
- 5) With adequate incentive, human predation is an effective control on the nutria population.

## **A SHORT HISTORY OF THE NUTRIA IN LOUISIANA**

Before the nutria was introduced into Louisiana, the native muskrat (*Ondatra zibethicus*) was the most numerous furbearer. Ted O'Neil, chief of the Fur and Refuge Division of LDWF, believed that muskrat populations began to increase in Louisiana's marshes as marsh burning became more common in the late 1800's and early 1900's (O'Neil 1949). The marsh burning helped increase access for trapping mink, otter, and raccoons, in addition to alligator hunting. The burning improved the muskrat's ideal forage, Olney's three-square grass (*Schoenoplectus americanus*=*Scirpus olneyi*). Eventually, muskrats moved from the southeastern marshes of the Delta plain to western marshes of the Chenier Plain. Muskrats became so numerous that in the early 1900's they were being hunted with 'dogs and pitchforks' to keep them from devouring cattle range. Although the earliest record of muskrat pelts trading from Louisiana to the northern markets occurred in New Orleans during 1878, it was not until the 1920's that Louisiana muskrat harvests became substantial. The good trapping years during the 1930's and 1940's yielded in excess of 4 million muskrat pelts statewide. During the 'great muskrat eat out' from 1945-1947, each year more than 7 million muskrats were harvested. The muskrat harvest largely collapsed thereafter (**Figure 1**). This collapse coincided with the introduction and expansion of the nutria (see, *Did the Nutria Displace the Native Muskrat?*).

Wild populations of nutria became established in Louisiana in the early 1940's after escaping from fur-ranches and with intentional introductions (often sold for noxious plant control) across the coast (Evans 1970). Armand P. Daspit, Director of the Fur and Refuge Division of LDWF, reported that "some effort was made by Captain Henry C. Brote in 1933 to develop a colony of nutria in and around Covington, St. Tammany Parish; his efforts to populate that section of the country with nutria were never realized. A great many were released by Captain Brote but this



**Figure 1.** Historical harvest of muskrat and nutria from Louisiana during 1924-2010. See Table 1 for a summary of important events that affected harvest numbers.

office has never heard of nutria being taken east of the Mississippi River” (Daspit 1947). The most popular story of the nutria’s introduction in Louisiana was by naturalist E.A. McIlhenny on Avery Island, where numerous escapes from his marsh enclosures happened after 1937 (Evans 1970).

In truth several McIlhenny was only one of several nutria farmers experimenting with nutria in the 1930s and 1940s. In fact, nutria farms existed in Louisiana before McIlhenny started his farm, and he bought his nutria from an established farm in St. Bernard Parish. Although it is sometimes stated that the first nutria release into the Louisiana marshes of approximately 150 nutria was from the McIlhenny farm after a hurricane in 1940, several nutria farms both had nutria escape and/or were released between the late 1930s to 1940. It should be noted that nutria were seen as a welcome addition to the Louisiana fur industry. A memo of McIlhenny several months prior to that hurricane states that he "liberated twenty-one nutria", and later in a letter to the state Department of Conservation explained his reasoning as "liberating them for the purpose of establishing an addition to our fur industry" (Bernard 2002).

During the 1942-43 trapping season, a nutria colony had become established in Vermilion Parish, some 30 miles away from Avery Island, in the freshwater marshes north of White Lake (Morgan and O'Neil 1976). These marshes had, “stable water levels, containing an abundance of saw grass, roseau cane, bulrush, cattail...the stable water levels and tall vegetation afforded the most desirable habitat requirements for the well being of this furbearer [nutria]” (O'Neil 1968)

In the 1945-46 season, a Louisiana firm accumulated the entire take of 8,784 nutria, at a price of \$5.00 each. This company continued to stock-pile at similarly high prices and make inquiries to outlets for Louisiana nutria, up through the 1951 season. By this time the fur and land operators throughout the coast were making a frantic effort to purchase live nutria from the Vermilion Parish area for transplanting into their marshes. In keeping with this nutria fever, the Fur and Refuge Division of the Wild Life and Fisheries Commission transplanted the first 250 animals to the Pass-a-Loutre Public Shooting Grounds located in the heart of the active Mississippi Delta (O'Neil 1968).

By 1950, nutria became abundant in western Louisiana in the Chenier Plain region, in St. Mary, Iberia, Vermilion, and Cameron Parishes. By the last half of the 1950's, the overall population of nutria peaked at about 20 million. Big events such as the passage of the very large Hurricane Audrey (1957) caused mortality to the nutria population across southwest Louisiana, but also dispersed significant numbers inland leading to damage to agricultural crops, especially sugar cane. This impact to agriculture interests was followed in 1958 by the Louisiana legislature declaring nutria an "outlaw quadruped" and establishing a 25 cent bounty.

A boost for the nutria fur industry came about with the development of a nutria fur market with Germany in 1960. The nutria trapping industry continued to grow, with more nutria than muskrat taken during the 1961-1962 season, with muskrat harvests never again exceeding that of

nutria. During this period in the 1960's the nutria population was so large that nutria caused extensive agricultural damage to sugar crops in coastal parishes, leading to disputes between the fur and agricultural (sugar) industries. In 1963 the nutria was considered an outlaw animal in 17 coastal parishes; however in 1965 nutria were given state-wide recognition as a protected furbearer except on agricultural lands. After nutria harvests surpassed that of muskrat in Louisiana in the 1960s, the Louisiana Department of Wildlife and Fisheries started a practice of capturing nutria from one area of the state and releasing in another to share the fur industry in Louisiana (Edmond Mouton, LDWF, pers. comm.)

The powerful effect of strong storms on wetland animal populations is illustrated by Hurricane Betsy in 1965 when she struck the coastal regions hard, resulting in loss of about 400,000 nutria and 70,000 muskrats.

The 1970's generally was a stable decade for nutria. Nutria harvest averaged about 1.5 million animals per year, with the peak harvest of 1.8 million taken in the 1976-1977 season. This trend generally continued into the 1980's, with nutria fur in demand and the price per nutria staying high and peaking in 1980-1981 at \$8.19. By the end of the 1980's however changes were occurring, with reports of severe damage to marsh and agricultural lands, foreign and domestic fur market in decline, and fur ranching and trapping ethics challenged. The 1988-1989 season was the first in 30 years that the nutria harvest fell below 500,000. With hindsight, it is not surprising that increased reports of severe marsh damage were coming in as fur markets, and ultimately the numbers of nutria trapped, declined.

Through the 1990's there was at least a continuing demand for nutria fur, driven by the Russian fur market, although much smaller than previous periods. By 1998-1999 the Russian fur market collapsed, thereby removing most of the market incentive for trappers harvesting nutria. The decadal harvest of nutria decreased in the 1990's to about 2.17 million compared to 15.26 million in the 1970's and 11.99 million in the 1960's. By 2000 there was virtually no demand for nutria fur (Wiebe and Mouton, 2009). Not surprisingly, LDWF reported nutria damage to coastal marshes at about 105,000 acres for 1999. Thanks to the vision and persistence of LDWF personnel knowledgeable about the nutria issues, a coastwide program was implemented through the CWPPRA program in 2002 to reduce the nutria population in the wake of worldwide fur market collapse. The new Coastwide Nutria Control Program (CNCP) is a welcome success, and began its first year with 300,000 nutria harvested in 2003, up to 445,000 taken in 2009-2010 (see additional discussion of this program below).

**Table 1.** Timeline of important events relating to muskrat and nutria populations in coastal Louisiana. Sources: Evans 1970; O’Neil and Linscombe 1977; McNease 2005

Time Period	Events and Observations
1800’s	<ul style="list-style-type: none"> <li>— trapping in Louisiana focused on mink, raccoon, and otter</li> <li>— alligator hunting common</li> <li>— marsh burning done to improve accessibility for hunting and trapping</li> <li>— 1878--earliest record of muskrat pelts being offered to the northern market by a New Orleans fur trader (O’Neil 1949)</li> <li>— marsh burning facilitates muskrat numbers; the muskrat spreads from the southeastern marshes to the west</li> </ul>
Early 1900’s	<ul style="list-style-type: none"> <li>— <i>“Cattle range by 1912 was being destroyed by eat outs caused by exploding populations [of muskrats] in the southwestern Louisiana marshes. The muskrats were hunted with pitchforks and dogs.”</i> (O’Neil and Linscombe 1977).</li> <li>— ranchers offer a bounty of five-cents per muskrat tail (O’Neil 1949)</li> <li>— 1924-1925 trapping season: 20,149 trapping licenses issued</li> <li>— 1933: the nutria is introduced into Louisiana</li> <li>— 1937-1940 nutria released or escaped from farms in south Louisiana (Bernard 2002)</li> <li>— 1943: first nutria trapping season with 436 pelts taken</li> <li>— 1945-1947: The Great Muskrat Eat-out--for these two seasons, more than 8 million muskrats were harvested each season; the most productive area during the peaks was the brackish marshes of St. Bernard parish. <i>“That year [1945-46] all the better three-cornered grass marsh along our Coast was completely ‘eaten-out’ and destroyed by this tremendous Muskrat population.”</i> (O’Neil 1971)</li> <li>— muskrat harvest plummets and never recovers to historical levels</li> </ul>
1950	<ul style="list-style-type: none"> <li>— nutria become abundant in western Louisiana: St. Mary, Iberia, Vermilion and Cameron Parishes</li> <li>— 1951: 250 nutria transplanted to marshes at the mouth of the Mississippi River</li> <li>— nutria implicated in the decline of muskrat populations</li> <li>— 1955-1959: nutria population peaks at an estimated 20 million</li> <li>— 1957: severe furbearer mortality and inland dispersal of nutria during Hurricane Audrey leads to agriculture (sugar) damage</li> <li>— 1958: Louisiana legislature declared nutria an “outlaw quadruped” with a twenty-five cent bounty (Evans 1970)</li> <li>— <b>decadal nutria harvest=2,753,677</b></li> </ul>
1960	<ul style="list-style-type: none"> <li>— nutria fur market develops with Germany</li> <li>— 1961-1962 season: more nutria than muskrat are taken; muskrat harvest never again exceeds that of nutria</li> <li>— 1962: freeze</li> <li>— extensive coastal parish agricultural damage by nutria</li> <li>— disputes between fur and agriculture (sugar) industry</li> <li>— 1963: nutria considered an outlaw in 17 coastal parishes</li> <li>— 1965: nutria given state-wide recognition as a protected furbearer except on agricultural lands</li> <li>— 1965: Hurricane Betsy caused the loss of 400,000 nutria and 70,000 muskrat (O’Neil 1971)</li> <li>— <b>decadal nutria harvest=11,987,685</b></li> </ul>
1970	<ul style="list-style-type: none"> <li>— a peak of 1.8 million nutria are harvested during the 1976-77 season</li> </ul>

	<ul style="list-style-type: none"> <li>— a stable decade: nutria harvest averages 1.5 million per year</li> <li>— <b>decadal nutria harvest=15,256,372</b></li> </ul>
1980	<ul style="list-style-type: none"> <li>— 1980-1981: price per nutria peaks at \$8.19</li> <li>— 1987: reports of severe damage to marsh and agricultural lands</li> <li>— 1989: severe freeze</li> <li>— 1988-89: first season in 30 years that nutria harvest falls below 500,000</li> <li>— foreign and domestic market decline; fur ranching and trapping ethics challenged</li> <li>— <b>decadal nutria harvest=8,885,055</b></li> </ul>
1990	<ul style="list-style-type: none"> <li>— 1993: <i>“There is ample reason to expect that nutria populations may have significant and important impacts on Louisiana coastal wetlands”</i> Grace 1993</li> <li>— 1998-99 Russian fur market collapses</li> <li>— 1999: LDWF coast-wide nutria damage assessment estimates 105,000 acres of marsh damage</li> <li>— <b>decadal nutria harvest=2,174,051</b></li> </ul>
2000	<ul style="list-style-type: none"> <li>— 2000: virtually no demand for nutria fur (Wiebe and Mouton 2009)</li> <li>— 2002: Coastwide Nutria Control Program (CNCP) begins with more than 300,000 nutria harvested</li> <li>— Hurricanes Katrina, Rita (2005) and Gustav and Ike (2008) cause nutria mortality and dispersal; hunter participation decreases for one season</li> <li>— <b>decadal nutria harvest=2,199,404</b></li> </ul>
2010	<ul style="list-style-type: none"> <li>— 2009-10 CNCP harvest: highest nutria harvest since 1987-88 season, with more than 445,000 nutria taken with an incentive of \$5.00 per nutria tail.</li> </ul>

## **REPRODUCTIVE POTENTIAL OF NUTRIA**

The nutria has a high reproductive potential. Based on a population of 8,000-11,000 nutria in Great Britain, Gosling (1974) calculated that a doubling could occur (15,000-18,000) within a 12 month period if not controlled. In Louisiana, the number of nutria harvested during the 1943-44 season was 436, and by the 1976-77 season, the peak of nutria harvested exceeded 1.8 million. The exceptional reproductive potential in Louisiana is attributable to extensive favorable habitat and climate, in addition to the nutria’s natural history traits, such as an early sexual maturity (occurring at 6 months age for male and female) and a high fecundity of 13 or more young produced per female per year (**Table 2**). Fecundity increases with age (Willner et al. 1979). Contributing to this high rate of production is the nutria’s continuous breeding cycle in Louisiana.

**Table 2.** Reproductive parameters of the nutria (*Myocastor coypus*) based on wild populations.

Parameter	Value	Region	Source
sexual maturity	male and female (4-8 months)	LA	Evans 1970
breeding season	entire year	LA	Atwood 1950
gestation	mean = 132 days	LA	Atwood 1950
litter size	mean = 4.73 range = 1-11	southwestern and southern LA marshes	Atwood 1950, Harris 1956, Evans 1970, Chabreck et al. 1981, Adams 1956
litters yr <sup>-1</sup>	2.76 <sup>a</sup>	LA	calculated <sup>a</sup>
young female <sup>-1</sup> yr <sup>-1</sup>	13.1 <sup>b</sup>	LA	calculated <sup>b</sup>
fetal sex ratio	1 male:1 female	LA	Adams 1956
embryo survival	60% <sup>c</sup>	LA	Evans 1970

<sup>a</sup> litters yr<sup>-1</sup> = breeding season length (365d) / gestation (132d)

<sup>b</sup> based on gestation (132 d), litter size (4.73), and year-round breeding potential (365 d); does not correct for embryo resorption, (see Harris 1950 for resorption in LA).

<sup>c</sup> over a three year study, Evans (1970) calculated embryo survival using the following parameters: entire miscarriages (32-45%), partial miscarriages (8%), embryo resorption (7%)

## MOVEMENTS, HOME RANGE, DISPERSAL

Nutria home range and dispersal distances are influenced by the habitat type where studies are conducted; that is, long distances were traveled in agricultural settings compared to herbaceous marshes. For example, in an agricultural environment (sugar cane fields), nutria with radio transmitters moved over 50 miles, but they averaged approximately three miles (Evans 1970). Most studies have shown that marsh nutria generally do not move much more than several kilometers. Linscombe et al. (1981) reported marsh nutria moving up to 3.2 km; however, 279 out of 310 recaptures were within a 324 ha study area and most of the nutria were within 400 m of the study area. Nolfo-Clements calculated 77 m as the mean distance traveled by nutria with radio transmitters in a freshwater floating marsh. In ponds near Belle Chasse, La., Warkentin (1968) found that marked nutria remained within 300 m of their capture site, with one nutria moving 600 m. In southwestern Louisiana marshes, daily cruising ranges of nutria were mostly less than 200 m (Adams 1956).

Nutria in marsh habitats have restricted home ranges. A home-range of 13 ha was estimated by LeBlanc (1994). Using two different calculations, nutria home-range estimates of 29 and 33 ha

were reported for freshwater floating marshes (Nolfo-Clements 2009), and there were no differences between sexes.

Wildlife biologists in Louisiana suggest that tropical storm and hurricane surge is responsible for inadvertently dispersing nutria to otherwise isolated areas, where they may establish new colonies (pers. communication, E. Mouton LDWF). One example is the reported colonization of an offshore island by nutria that floated from the Mississippi River delta on storm debris across the Mississippi Sound during Hurricane Katrina. The USFWS subsequently eradicated them from Gulf Islands National Seashore (pers. communication, G. Linscombe).

### **Habitat Preferences**

Nutria prefer freshwater wetlands compared to more saline environments in Louisiana. Ramsey et al. 1981 proposed that freshwater habitats provide more available calcium and digestible matter than more saline wetlands. Protein can be twice as high in freshwater versus brackish marshes (Wilsey and Chabreck 1991). As shown in **Table 3**, the fresher areas, comprising fresh and intermediate marshes and swamp forest, cover over one million ha in Louisiana. Brackish and salt marshes account for over 680,000 ha.

Freshwater floating marshes are optimal habitat for nutria (O'Neil 1949, Palimsano 1972 in McNease 2005; pers. comm. Mouton 2010; pers. comm. Linscombe 2010). There are likely several reasons for this, including the quality and diversity of forage, reduced exposure to flooding, and choice of escape routes, whether running aboveground on the marsh or diving beneath the surface and into holes or rivulets in the marsh mat. Given the susceptibility of coastal freshwater marshes to seasonal flooding from tropical storms and frontal set-up, floating or buoyant patches of marsh accommodate feeding, grooming, and resting areas that remain dry. In Barataria and Terrebonne basins, there is an estimated 140,000 ha of floating/buoyant marsh (Sasser 1994). Widespread deterioration of floating marshes has been documented in northern Terrebonne basin, and it is unknown to what degree historical nutria grazing can explain this decline in marsh quality and quantity (McNease 2005, Sasser 2005). This area has experienced persistent and severe nutria damage. During the 2009-2010 season, a record take of >60,000 nutria tails on approximately 120,000 lease acres occurred in this area on Continental Land Co. in the Coastwide Nutria Control Program (G. Linscombe, pers. communication).

**Table 3.** Coastal marsh and swamp forest area (ha) estimated for 2008 among the different geological provinces of Louisiana (Sasser et al 2009). Geological provinces follow Barras et al. (2008).

	Chenier Plain (ha)	Delta Plain (ha)	Total wetlands (ha)
Swamp forest	0	188,099	188,099
Fresh marsh	101,161	289,030	390,191
Intermediate marsh	213,711	250,251	463,961
Brackish marsh	115,302	223,413	338,714
Salt marsh	29,706	314,313	344,019
Total wetlands	459,879	1,265,105	1,724,984

### **DID NUTRIA DISPLACE THE NATIVE MUSKRAT?**

*“It is fortunate that the nutria increased during a period of declining muskrat populations. Many trappers have thus been able to continue their trade of trapping in the marshlands...Nutrias are also accused of competing with muskrats and preventing their increase.”* Harris 1956

It is well accepted that muskrat populations in Louisiana coastal marshes were once numerous in the early 1900’s and the marsh was intensely managed for their production, but their population collapsed in the 1960’s. Examining the historical trapping data (**Figure 1**), it is clear that the harvest of muskrat precipitously declined as nutria harvest increased. This can be partially explained by market forces; but the degree to which the introduction and rapid expansion of the nutria population influenced the demise of the muskrat has not been adequately understood.

There was historical disagreement on whether nutria negatively affected the muskrat populations. It was posited that the two animals’ different habitat requirements minimized any direct food competition. The muskrat was a specialist of the intermediate to brackish marshes that contained their favorite food source, *Schoenoplectus americanus* (= *Scirpus olneyi*) (Harris 1956). In addition, they required marsh that was less prone to flooding for mound building and reproduction. The generalist nutria preferred freshwater vegetation and did not need such strict investments in breeding and mound building. The muskrat positively responded to marsh management in the form of frequent burning to maintain the food source, and also marsh ditching, which reduced the magnitude of nest flooding.

In the mid-1960's, the muskrat harvest had severely dwindled. Ted O'Neil (1966) believed that the 'Great muskrat eat-out' of 1945-47 (the more than 14 million muskrats taken during this time period indicate its massive population), and the subsequent lack of habitat rebound could not explain a collapsing muskrat population. At the time, he stated, "it would not be a miscalculation to assume that over 30 to 40 million muskrats had been chewing away at the very foundation of our marshes during that 24-month period." He was forced to conclude, "industrialization coupled with the normal marsh erosion and subsidence, severe storms and prolonged summer dry cycles, plus the entry of our unprecedented Nutria population [contributed to muskrat declines]". He also pointed out that during the peak muskrat populations there were prolonged wet cycles accompanied by mild temperatures.

With the passage of a century, much of coastal Louisiana has succumbed to the pressures of hydrologic modification, especially in western Louisiana (Gammill et al., 2002), which has perhaps generally decreased the quantity and quality of habitat that sustained muskrat populations. Coupled with a decrease in fur demand, the marshes are no longer maintained (burned consistently) to increase muskrat production. The notable overall decrease in nutria and muskrat harvest in west Louisiana more recently may also reflect the restoration of alligator populations here since the late 1970's (pers. communication G. Linscombe, McNease 2005, Keddy et al. 2009).

## FOOD SELECTION

*The present studies and general observation attest to the catholic taste of the nutria in vegetation. Harris and Webert, 1962*

Nutria are opportunistic foragers that exploit a variety of emergent, floating aquatic, submersed, and woody species. Seasonal availability in forage quality and quantity influences their diet. More than 60 species occurring in Louisiana are eaten by nutria (**Table 4**). Nutria are considered wasteful feeders (Harris and Webert 1962), often destroying ten times more than they consume (G. Linscombe pers comm., in Bounds et al. 2003). They will consume leaves, roots, and reproductive organs and also consume bark when other food is scarce.

Howe and Westley (1988) present a basic summary on plant-herbivore interactions. The ecology of herbivory can be observed from the preference and evolutionary traits of the consumer and its forage. A plant may defend with digestibility reducers (cellulose, lignin, tannin, silica), which are common to woody species; or, it may defend with toxins (alkaloids, sulphur compounds, cyanogens), which are common to herbaceous species. There is some general agreement that species of late successional communities tend to possess digestibility reducers (complex polymers); whereas, early successional plants may rely on a prevalence of toxins for defense. Regardless, high rates of herbivory on early successional tissue (foliage) or young tissue is

predicted in the resource availability theory, which assumes that rapidly growing, but poorly defended tissue can be easily replaced.

Given the prevalence of fast growing herbaceous species in Louisiana marshes, we may expect that there is a broad selection of species that have foliage or organs that are palatable to nutria, at least during some parts of the growing or dormant seasons. In the studies we reviewed, we found few reports of plant species that nutria clearly avoid, but there are some species that have low preference (**Table 4**). From this, we may conclude that the nutria is capable of digesting a wide variety of herbaceous species to gain some nutritional value.

Some species of plants that nutria feed on can persist even under very intense grazing, such as *Eleocharis*, *Hydrocotyle*, and *Bacopa*. That is, these plants have a high resiliency or plasticity to grazing and may exhibit compensatory growth with grazing pressure. We found only one reference of nutria feeding on *Ludwigia* spp., which can be prolific in nutria damaged areas (Sasser et al. 2005). Some species are largely avoided given a high content of digestibility reducers, such as silica in *Justicia ovata*, or the presence of a noxious compound, like calcium oxalate in *Colocasia esculenta*. Based on our personal observations, there are species within a genus that may have different palatability or higher nutritional value, such as *Typha latifolia* (more preferred) and *Typha domingensis* (less preferred; but see Geho et al. 2007). Within the genus *Sagittaria*, the species *S. platyphylla*, *S. graminea*, *S. latifolia* are highly preferred by nutria especially on the early successional delta islands of the Mississippi and Atchafalaya Rivers (Fuller et al 1985; Shaffer et al. 1992; Evers et al. 1998;). On the other hand, *S. lancifolia* may be less palatable, but still constitutes a significant portion of the nutria diet when other species are scarce (Linscombe et al. 1981). Several studies have documented the effect of nutria grazing on the tender roots of *Taxodium distichum* seedlings. In a survey of survival rates of bald cypress plantings in Louisiana show that a very small percentage of plantings survive without protection (Conner 1993).

**Table 4.** Wetland plant species consumed by nutria in Louisiana.

Species	Common Name	Source
<i>Acer rubrum</i>	Red maple	4
<i>Aeschynomene indica</i>	Indian jointvetch	24
<i>Alternanthera philoxeroides</i>	Alligator weed	6, 7, 8, 9, 10, 12
<i>Bacopa monnieri</i> †	Herb of grace	1, 5, 13, 24
<i>Bidens laevis</i> †	Smooth beggartick	6, 8, 9, 10
<i>Brasenia schreberi</i>	Watershield	1, 14
<i>Castalia odorata</i>	American white waterlily	1
<i>Cladium mariscus</i> (= <i>Cladium jamaicense</i> )	Jamaica swamp sawgrass	1, 3
<i>Colocasia esculenta</i> *	Coco yam	15, 24
<i>Cyperus</i> spp.	Cyperaceae	6, 9
<i>Distichlis spicata</i>	Greene saltgrass	5, 8
<i>Echinochloa walteri</i>	Walter's millet	3

<i>Eichhornia crassipes</i>	Common water hyacinth	1, 6, 8, 9
<i>Eleocharis baldwinii</i> †	Baldwin's spikerush	13
<i>Eleocharis equisetoides</i>	Jointed spikesedge	1
<i>Eleocharis palustris</i>	Common spikerush	5, 6, 8, 10
<i>Eleocharis quadrangulata</i>	Squarestem spikerush	1
<i>Eleocharis</i> spp.	Spikerush	3
<i>Hydrocotyle</i> spp. †	Pennywort	6, 8, 9, 10, 13, 24
<i>Iris</i> spp.*	Iris	24
<i>Juncus roemerianus</i>	Needlegrass rush	5
<i>Justicia ovata</i>	Looseflower water-willow	11, 15, 16
<i>Leersia oryzoides</i>	Rice cutgrass	2, 15, 16
<i>Lemna minor</i>	Common duckweed	4, 8, 9
<i>Ludwigia</i> spp.*	Primrose-willow	6,13
<i>Najas guadalupensis</i>	Southern waternymph	6
<i>Nelumbo lutea</i>	American lotus	2
<i>Nuphar lutea</i> (= <i>Nymphaea advena</i> )	Yellow pond-lily	1
<i>Nymphaea elegans</i>	Tropical royalblue waterlily	2
<i>Nymphaea odorata</i>	American white waterlily	1
<i>Panicum hemitomon</i>	Maidencane	1, 7, 13
<i>Panicum</i> spp.	Panicgrass	2, 8, 18
<i>Panicum virgatum</i>	Switchgrass	1, 3, 19
<i>Peltandra virginica</i>	Green arrow arum	9, 23
<i>Phragmites australis</i>	Common reed	3, 5, 18
<i>Phyla nodiflora</i> *	Turkey tangle frogfruit	24
<i>Pluchea purpureascens</i>	Sweetscent	6
<i>Polygonum</i> spp.	Knotweed	9, 15, 16
<i>Pontederia cordata</i>	Pickerelweed	1, 2, 9
<i>Rhynchospora</i> spp.	Beaksedge	1
<i>Sacciolepis striata</i>	American cupscale	1, 6, 8, 9, 10, 17
<i>Sagittaria lancifolia</i>	Bulltongue arrowhead	1, 6, 8, 9, 17
<i>Sagittaria latifolia</i>	Broadleaf arrowhead	11, 15, 16
<i>Sagittaria platyphylla</i>	Delta arrowhead	1, 11, 15, 16
<i>Sagittaria</i> spp.	Arrowhead	2
<i>Saururus cernuus</i> *	Lizard's tail	9
<i>Schoenoplectus americanus</i> (= <i>Scirpus olneyi</i> )	Chairmaker's bulrush	3, 5, 8, 15, 17, 18
<i>Schoenoplectus californicus</i>	California bulrush	1, 3
<i>Schoenoplectus deltarum</i>	Delta bulrush	24
<i>Schoenoplectus validus</i>	Softstem bulrush	24
<i>Solidago sempervirens</i>	Seaside goldenrod	5, 8
<i>Spartina cynosuroides</i>	Big cordgrass	3, 5, 8
<i>Spartina patens</i>	Saltmeadow cordgrass	3, 5, 8, 17, 19, 21, 22
<i>Spirodela polyrhiza</i>	Common duckmeat	8, 9
<i>Taxodium distichum</i>	Bald cypress	20
<i>Typha angustifolia</i>	Narrowleaf cattail	18

<i>Typha domingensis</i>	Southern cattail	11
<i>Typha latifolia</i>	Broadleaf cattail	2
<i>Typha sp.</i>	Cattail	1, 2, 3, 15
<i>Utricularia sp.</i>	Bladderwort	6
<i>Wolffiella spp.</i> (= <i>Wolffiella floridana</i> )	Bogmat, Watermeal	4, 6
Woody tissue		9
<i>Zizaniopsis miliacea</i>	Giant cutgrass	1, 2

\*species that nutria may avoid or rarely utilize

† species often present in nutria-disturbed habitats

1. Atwood 1950; 2. Swank and Petrides 1954; 3. Harris and Webert 1962; 4. Warkentin 1968; 5. Chabreck et al. 1981; 6. Shirley et al. 1981; 7. Dozier 1985; 8. Wilsey and Chabreck 1991; 9. Wilsey et al. 1991; 10. Chabreck et al. 1993; 11. Llewellyn and Shaffer 1993; 12. Wilsey 1991; 13. Sasser et al. 2005; 14. Gainey 1949; 15. Shaffer et al. 1992; 16. Evers et al. 1998; 17. Gough and Grace 1998; 18. Willner et al. 1979; 19. Taylor et al. 1997; 20. Blair and Langlinais 1960; 21. Foote and Johnson 1993; 22. Willner 1982; 23. G. Shaffer personal communication; 24. personal observation (GOH, CES)

## NUTRIA GRAZING IMPACTS TO COASTAL LOUISIANA WETLANDS

*Nutria only had an impact upon biomass if another disturbance was present, and tended to amplify effects of disturbance.* (Keddy et al. 2007)

The use of cage-like enclosures has been the most popular method of assessing the impacts of vertebrate herbivores on marsh damage. In the Louisiana wetland studies reviewed here, nutria have been associated with most of the grazing impacts. Other herbivores such as boar (*Sus scrofa*), waterfowl (typically ducks and geese), and muskrat (*Ondatra zibethicus*) may have been present, but their contribution was not measured or in some cases were not considered important. In most cases, nutria herbivory has been shown to markedly decrease plant biomass or produce changes in species composition. Significant reductions to aboveground biomass (50% loss) commonly have been observed in enclosure studies (**Table 5**). The increase in dead aboveground biomass noted in the Ford and Grace (1998) study can be attributed to the destructive nature of nutria feeding. Although few studies have measured belowground impacts, those that have found where grazing pressure is extreme, it is possible for nutria to keep root material depleted. Marshes protected from grazing for four years and transplanted with maidencane resulted in 141% increase in belowground biomass compared to grazed areas (Sasser et al. 2005). Reduced soil organic matter accumulation and detectable losses in soil elevation have been documented with moderate nutria grazing (Grace and Ford 1996). We are not aware of any studies showing whether intermediate grazing intensity could increase productivity or species richness in Louisiana wetlands.

Plant community changes have been observed with nutria grazing (**Table 5**). This can take the form of reduced species richness or shifts in dominant species. Preferential grazing of some

species is well documented in the field across a variety of herbaceous marshes (Geho et al. 2007). Understanding how nutria could facilitate significant shifts in the plant community is complex. Nonetheless there are a number of disturbance-based species that are facilitated with the removal/reduction of competitive species and exposure of bare soil. In forested wetlands, a serious concern is the reduction in bald cypress regeneration as nutria destroy seedlings and saplings

Some of the most dramatic visual nutria damage to wetlands has occurred in the young delta marshes near the mouth the Atchafalaya River (**Figures 2 and 3**; Fuller et al. 1985, Shaffer et al. 1992, Evers et al. 1998, Sasser et al. 2009). Fuller and Sasser 1988 found that significant damage in the Atchafalaya Delta was caused by nutria and waterfowl. Severe nutria grazing also occurs in more mature, freshwater peat-based marshes. With persistent grazing, the peat soil can become destabilized as organic matter accumulation decreases and the soil weakens. This condition has been observed in thin-mat floating marshes in both Barataria and Terrebonne basins (Sasser et al. 1994). While there are multiple causes for freshwater marsh deterioration, persistent nutria

**Table 5.** Summary of controlled field studies that report grazing impacts to above- and belowground biomass, soil processes and rates of change in Louisiana coastal wetlands. G=grazed, UG=un-grazed, NSD=no significant difference

Study	Wetland Type	Plant/Soil Component	Outcomes and Differences
Shaffer et al. 1992	deltaic, early-successional freshwater herbaceous	species richness	47% decline 4.5 (G) vs. 8.5 (UG)
		plant coverage (cover values)	74% reduction 63 (G) vs. 240 (UG)
		species changes	In the presence of intense herbivory, these species significantly increased coverage over the 6-yr study: <i>Justicia ovata</i> , <i>Colocasia esculenta</i> , <i>Polygonum punctatum</i> , <i>Leersia oryzoides</i>
Evers et al. 1998	deltaic, early-successional freshwater herbaceous	total aboveground biomass	50% reduction, 597 (G) vs. 1,235 (UG) g m <sup>-2</sup>
		total belowground biomass	25% reduction, 248 (G) vs. 346 (UG) g m <sup>-2</sup>
		species changes	With grazing: 1) decline in species richness 2) decrease in <i>Sagittaria</i> spp. 3) increase in <i>Polygonum punctatum</i> , <i>Justicia ovata</i> , and <i>Leersia oryzoides</i>
Fuller et al. 1985	deltaic, early-successional freshwater herbaceous	total aboveground biomass	48% to 62% reduction,
Ford and Grace 1998	river mouth, late-successional, brackish herbaceous	live aboveground biomass	75% reduction, 112 (G) vs. 460 (UG) g m <sup>-2</sup>
		dead aboveground biomass	58% increase, 1,063 (G) vs. 614 (UG) g m <sup>-2</sup>
		belowground biomass	50% decrease, 0.75 (G) vs. 1.35 (UG) g cm <sup>-3</sup>
		species richness	NSD

		soil elevation increase	-0.50 cm difference, +0.22 (G) vs. +0.75 (UG) cm
		root zone thickness	0.48 cm decrease 0.19 (G) vs. 0.67 (UG) cm
		soil bulk properties	NSD
Gough and Grace 1998	river mouth, late- successional, intermediate herbaceous; <i>Sagittaria lancifolia</i>	total aboveground biomass*	28% reduction 1,000 (G) vs. 1,400 (UG) g m <sup>-2</sup>
	river mouth, late- successional, intermediate herbaceous; <i>Spartina patens</i>	total aboveground biomass*	NSD
		species biomass; <i>Schoenoplectus americanus</i> *	40% reduction 200 (G) vs. 350 (UG) g m <sup>-2</sup> <i>S. americanus</i> is selected over <i>Spartina patens</i>
Randall and Foote 2005	habitat type	species biomass; <i>Spartina patens</i>	12% reduction 1,870 (G) vs. 2,132 (UG) g m <sup>-2</sup>
		species biomass; <i>Schoenoplectus americanus</i>	70% reduction 388 (G) vs. 1,343 (UG) g m <sup>-2</sup>
Sasser et al. 2004	restoration of floating freshwater marsh degraded by nutria herbivory with transplanting and protection	transplant mortality of <i>Panicum hemitomon</i> within 6 months, without protection	almost complete mortality 90-100%
		coverage of <i>Panicum hemitomom</i> after 4-yr with transplanting and protection	70% areal expansion
		total aboveground biomass with transplanting	187.5% increase 400 (G) vs. 1,150 (UG-with transplanting) g m <sup>-2</sup>
		live belowground biomass with transplanting	141% increase 567 (G) vs. 1,367 (UG- with transplanting) g m <sup>-2</sup>
		root mat thickness	80 % increase 10 (G) vs. 16 (UG- with transplanting) cm

		soil strength (0-10 cm)	80% increase 0.25 (G) vs. 0.40 (UG- with transplanting) kg cm <sup>-2</sup>
Geho, Campbell and Keddy 2007	oligohaline marsh, Lakes Maurepas and Pontchartrain; examined the effects of herbivory, neighbors, and sediment addition	16 species transplanted	overall significant reduction in biomass was largely controlled by herbivory, less so for neighbors, and no effect of sediment addition; only two species had significant biomass reduction with grazing ( <i>Taxodium distichum</i> , <i>Typha domingensis</i> )
Slocum and Mendelsohn 2008	oligohaline marsh, Lake Pontchartrain	species composition	NSD
		total aboveground biomass*	after 14 months, 800 (G) vs. 1,700 (UG) g m <sup>-2</sup> after 26 months, NSD
Day et al 2011	fresh marsh, between lakes Pontchartrain and Maurepas	live belowground biomass*	157% increase 2,167 (G) vs. 5,573 (UG) g m <sup>-2</sup>
Blair and Langlins 1960	swamp, near Cypremort, LA	bald cypress seedling planting	100% mortality, (G, 2100 of 2100)
Conner and Flynn 1989	Swamp, Lake Verret Basin	bald cypress seedling planting	100% mortality (G, 100 of 100)
Brantley and Platt 1992	intermediate marsh that formerly was swamp, Manchac WMA	bald cypress seedling planting	95.8% mortality (G, 308 of 321) vs negligible mortality (UG)
		bald cypress sapling planting	28.6% mortality (G, 46 of 161)
Myers et al. 1995	intermediate marsh that formerly was swamp, Manchac WMA	bald cypress seedling planting, pilot studies	nearly 100% mortality (G)
		bald cypress seedling planting with nutria protection by trapping	50% mortality
		bald cypress seedling planting after 2 seasons	100% mortality (G)

\*interpolated from graph

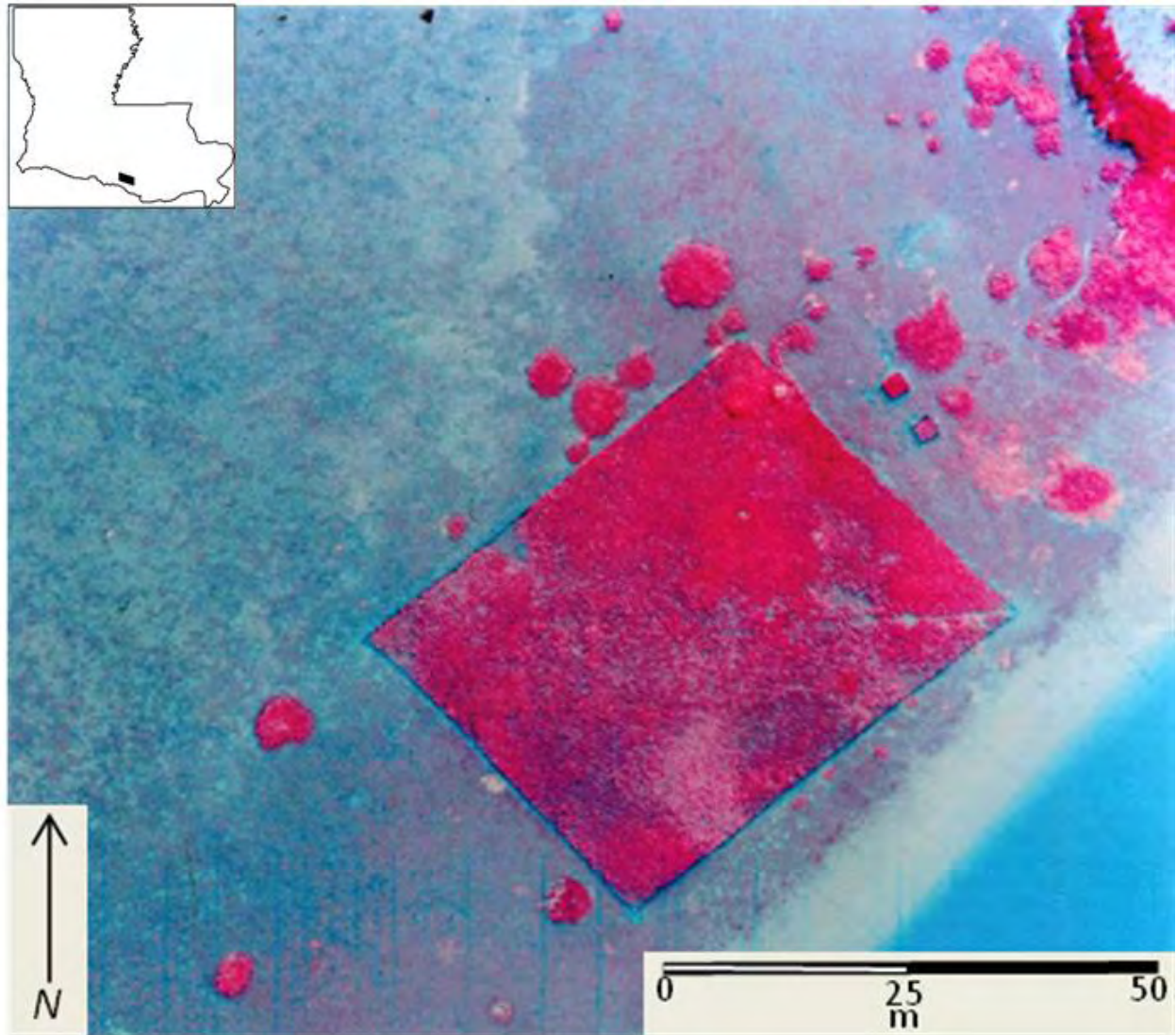
herbivory in the floating freshwater habitat can keep these habitats from recovery (Sasser et al. 2005, Sasser et al. 2009).

Nutrient additions can cause preferential nutria grazing to wetland plants. Nutrient enrichment of plant tissue, particularly with nitrogen, can increase the protein content of herbaceous plants. Wetland restoration projects often add fertilizer to recently-transplanted marsh plants. In a test to evaluate attractants for nutria in Louisiana, Jojola and Witmer (2006) found that nutria spent more time at fertilized plots of both *P. hemitomon* and *Spartina* plants. They concluded that nutria identified olfactory cues of fertilized plants.

The treatment of wastewater in wetlands can elevate wetland plant nutrients and potentially increase grazing. Day and Shaffer (2011) found that the added nutrients taken into the plants in the treatment area causes nutria to be even more attracted to vegetation. The degree to which treatment wetlands or river diversions can increase plant nutrition and, with time, theoretically enhance nutria population growth is not well understood but could act as a positive feedback loop. Much of the potential coastal areas to be restored will be in fresher marsh areas and these areas will likely experience nutria grazing. Where freshwater is used as a restoration nutria control measures will be needed to enhance the probability for long-term success.

The direct and indirect impacts of nutria grazing have the capability of causing significant wetland loss in Louisiana, perhaps not as a stress alone, but combined with other stresses of salt, inundation and physical energy. From their field studies in the oligohaline marshes of Lake Pontchartrain, Slocum and Mendelsohn (2008) concluded: “these effects of nutria in the marshes of the Mississippi River Delta suggest that the exotic rodent may create a cascade of multiple stressors that leads to wetland loss.” Gough and Grace (1998) summarized the susceptibility of wetlands to grazing: “High levels of herbivory will likely intensify or alter the effects of sea level rise on coastal wetland communities. Increased environmental stresses in the presence of intense herbivore activities may affect community biomass production, the relative abundance of dominant plant species, and diversity.” They found evidence for all these processes.

Nutria grazing directly influences the regeneration of bald cypress trees in Louisiana’s forested wetlands. In efforts to re-establish bald cypress forests, transplanted seedlings were heavily grazed by nutria. For example, Blair and Langlinais (1960) reported that 90% of 2,100 test seedlings were uprooted within four months after planting. Myers et al. (1995) and Brantley and Platt (1992) reported nearly 100% mortality of transplanted bald cypress seedlings due to nutria herbivory. Areas planted with bald cypress saplings do fair better possibly because their root masses are larger and can withstand attempts at uprooting. An expert on bald cypress forests, William Conner eventually ranked nutria herbivory—along with salt water intrusion and flood inundation stress (land subsidence)—in the top three problems facing cypress-tupelo forest regeneration and sustainability in Louisiana.



**Figure 2.** A color-infrared image illustrating the effects of nutria herbivory in a recently-developing delta in the Atchafalaya Bay in St. Mary Parish, Louisiana (located as shown in inset). Red indicates vegetated areas. The 40 m x 50 m rectangular feature excluded nutria. The area outside of the rectangle was open to herbivory, with only *Justicia ovata* (circular red areas) and de-vegetated mudflat (blue-gray) remaining.

a.



b.



**Figure 3.** Aerial views of a thin-mat floating marsh site where nutria exclosures were constructed and planted with *Panicum hemitomon* in Terrebonne Parish, depicting the differences inside and outside of the exclosures. Image (a) shows the study site with four rectangular exclosures. Image (b) is a close-up of the lower two exclosures shown in image (a) that shows the taller *P. hemitomon* vegetation inside of the exclosure.

## NUTRIA BIOMASS CONSUMPTION RELATIVE TO MARSH PRODUCTION

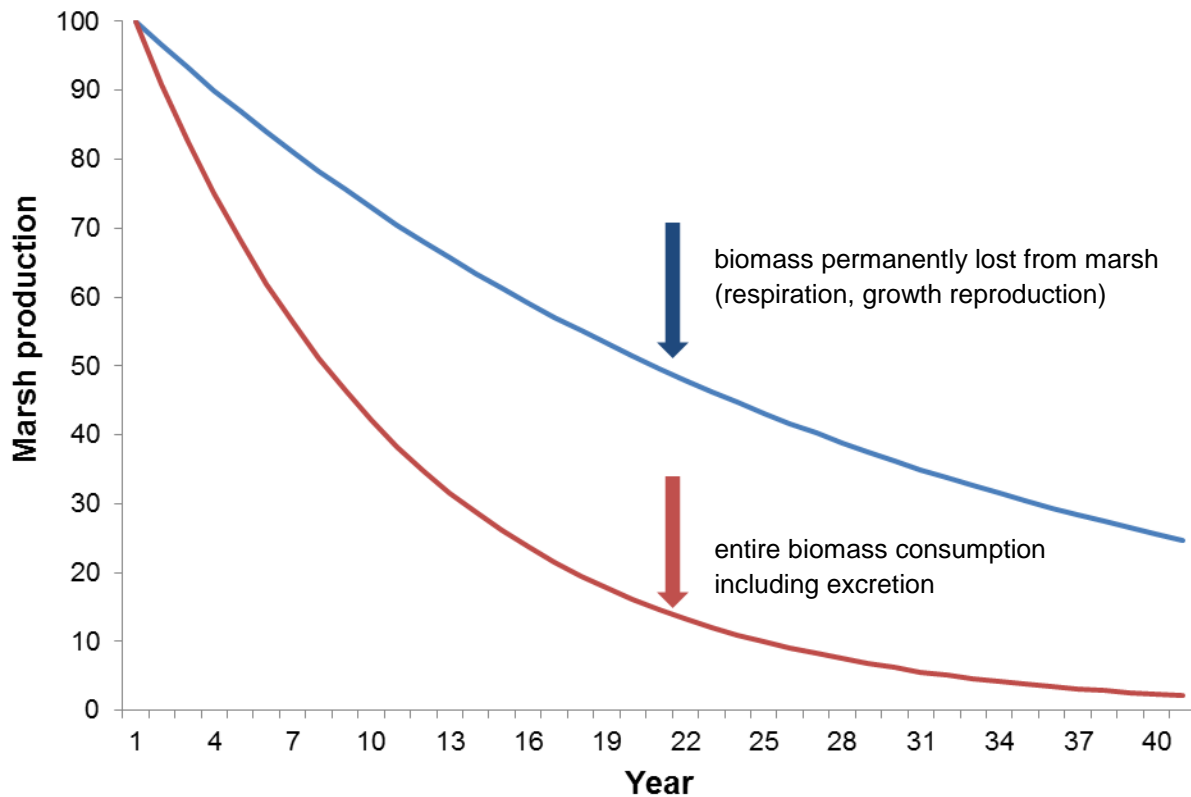
We calculated a budget of organic matter consumed and respired by nutria to develop an estimate of how much organic matter is lost from marsh production. **Table 6** contains a description of the calculations for nutria metabolism and marsh production. These calculations can be used to obtain a first order estimate of the reduction of wetland plant production by a static nutria population (Fig. 4). The amount of carbon lost from the wetland system with nutria grazing can be significant. In one year, an average-sized nutria can consume 72.4 kg of dry organic matter. While 64% of material consumed will be recycled back to the marsh, the other 36% ingested will be removed through metabolic respiration. Thus, the entire amount of biomass that is ingested is equivalent to the biomass produced and available for consumption each year on approximately 24 m<sup>2</sup> of marsh. The biomass completely lost is equivalent to 7.8 m<sup>2</sup> of marsh. If we assume that carbon content of food and feces is equal (K. Nagy pers. comm., UCLA) and the carbon content of organic matter is 58% on a mass basis, then the amount of carbon removed from the marsh by one nutria each year is approximately 15.1 kg. If we assume there were two million nutria in coastal Louisiana (approximately 450,000 were harvested during the winter of 2010), nutria grazing would result in the loss of an equivalent amount of carbon contained in 40,500 metric tons of coal or 12.5 million gallons of gas.

**Table 6.** A budget of nutria metabolism and plant biomass consumption on an herbaceous marsh over one year. These calculations result in a 3.5% yr<sup>-1</sup> permanent removal of plant production over a given area, with a density of 40 nutria ha<sup>-1</sup>. At this density, approximately 9.6 % yr<sup>-1</sup> of all the biomass produced would be consumed (6.1% returns to the marsh as fecal matter). If we assume that the complete removal of biomass “cohorts” represents a permanent loss in regeneration, then the carrying capacity of the land contracts commensurately. See Fig. 2 for an illustration of potential biomass removal over time.

	Explanation	Quantity
<b>Nutria metabolism</b>		
- average nutria mass	a conservative estimate; 15% lower than Kays (1956) population average of 5.4 kg	4.72 kg
- nutria daily fresh tissue consumption	25% of body mass consumed daily <sup>a</sup>	1.18 kg (FW)
- nutria daily dry tissue consumption	leaf tissue water content = 85% <sup>b</sup>	0.177 kg (DW)
- daily loss from marsh (36% of biomass goes to respiration+)	60% and 4% of mass consumed is excreted in feces and urine, respectively; this leaves 36% for respiration and	0.037 kg (DW)

maintenance)	maintenance to hold a constant body mass <sup>c</sup>	
- yearly biomass consumed from marsh	respiration+maintenance+excretion+growth/reproduction; 12% increase in mass for growth and reproduction over one year <sup>c</sup> ; (365 *0.177)*(1.12)	72.358 kg (DW)
- yearly biomass lost from marsh	respiration+maintenance+ growth/reproduction; 12% increase in mass for growth and reproduction over one year; (365 d*0.037)*(1.12)	26.049 kg (DW)
<b>Marsh production</b>		
<i>Yearly marsh production</i>		
- aboveground		2.0 kg m <sup>-2</sup> yr <sup>-1</sup>
- belowground		3.0 kg m <sup>-2</sup> yr <sup>-1</sup>
- total		5.0 kg m <sup>-2</sup> yr <sup>-1</sup>
<i>Standing stock available for consumption</i>		
- aboveground	assumes that 50% of annual production is available for consumption (unavailable: litter production, decomposition)	1.0 kg
- belowground	assumes that 70% of annual root/rhizome production is available for consumption (unavailable: decomposition)	2.0 kg
- total		3.0 kg m <sup>-2</sup> yr <sup>-1</sup> or 30,000 kg ha <sup>-1</sup>
<b>Nutria-Marsh Relations</b>		
- density of nutria	40 nutria ha <sup>-1</sup> <sup>d</sup>	
- biomass consumed from marsh	(72.358 kg nutria <sup>-1</sup> yr <sup>-1</sup> )*(40 nutria ha <sup>-1</sup> ) 2,894 kg ha <sup>-1</sup> yr <sup>-1</sup>	
- biomass lost from marsh	(26.049 kg nutria <sup>-1</sup> yr <sup>-1</sup> )*(40 nutria ha <sup>-1</sup> ) 1,042 kg ha <sup>-1</sup> yr <sup>-1</sup>	
% available biomass consumed		9.6 % yr <sup>-1</sup>
% available biomass lost		3.5 % yr <sup>-1</sup>

<sup>a</sup>Gosling 1974; <sup>b</sup> Touchette et al. 2010; <sup>c</sup> K. Nagy et al. 1999; <sup>d</sup>Kinler et al. 1987



**Figure 4.** The relationship of a static nutria population on potential marsh production over time. The relationship is based on nutria-marsh relations in **Table 6** where a population of 40 nutria  $\text{ha}^{-1}$  with mean weight of 4.7 kg can entirely remove yearly production of plant biomass (with no recovery) at  $3.5\% \text{ yr}^{-1}$  or consume  $9.6\% \text{ yr}^{-1}$  but return approximately 6.1% to the marsh as feces and urine. Thus, 64% of the total biomass consumed is returned to the marsh, 36% of the total biomass is lost to respiration and maintenance of a constant body mass, and an additional 12% of the total biomass consumed is allocated to growth and reproduction. In a period of less than 8 years, nutria could consume one-half of all the biomass produced on one hectare of herbaceous marsh. Within 20 years, a high density of nutria could result in the permanent loss of one-half of all the potential organic matter produced in a marsh. This permanent biomass removal theoretically will commensurately reduce the carrying capacity in the form of lost marsh area.

## HISTORICAL NUTRIA ABUNDANCE ESTIMATES

An early estimate of Louisiana’s nutria population was approximately 20 million during the period of 1955-59 (O’Neil and Linscombe 1977); however, it is unclear whether this included the entire state or just coastal parishes. Ascertaining nutria densities on different wetland habitats has been a complex issue in Louisiana. These estimates have been derived by mark-recapture studies and harvest statistics on tracts of known area. Mark-recapture techniques may over-bias density (pers. comm. Linscombe 2010). The published historical estimates that we gathered vary considerably (**Table 7**).

It is generally accepted that nutria carrying capacity is highest in freshwater marshes, and decrease with increasing salinity of the habitat. The actual density of any given wetland may fluctuate with localized conditions (weather, marsh management) that operate across seasons to years. The highest reported densities (43.7 ha<sup>-1</sup>) of nutria can be found on their optimal habitat of freshwater floating marsh (Kinler et al. 1987). Studies in brackish marshes show that at a density of approximately 24 nutria ha<sup>-1</sup> may exceed the carrying capacity of this habitat type and can result in devegetation (Linscombe et al. 1981).

**Table 7.** Nutria population density estimates in Louisiana.

Study	Density (individuals ha <sup>-1</sup> )	Wetland type
O’Neil 1949	19.8 – 24.7	freshwater marsh, Delta Plain
Harris and Webert 1962	7.4	brackish marsh, Chenier Plain
Valentine et al. 1972	0.1 – 1.29	brackish marsh, Chenier Plain
Robicheaux 1978	summer 1.3; winter 6.5	brackish marsh, Chenier Plain
Linscombe et al. 1981	24	brackish marsh, Marginal Delta Plain
Kinler et al. 1987	43.7	freshwater floating marsh, Delta Plain

## CONTEMPORARY HARVEST OF NUTRIA AS AN INDICATION OF ABUNDANCE

Acknowledging the differences in density estimate techniques and temporal local variables, we have provided the take of nutria from different habitat types from the dataset of the Coastwide Nutria Control Program (LDWF) as the best contemporary indicator of nutria abundance. The effort here is to provide a synthesis of the range in harvest (trapping and shooting) during a time period when the nutria bounty was fixed at or near \$5.00 per tail. We include summary information for the seasons 2003-04, 2005-06, 2006-07, 2007-08, 2008-09, 2009-10 (**Table 8**). These data include the immediate impact of Hurricanes Katrina and Rita which may have limited nutria hunter participation (2005-2006), but also includes the latest season (2009-10) when nutria hunter participation may have been relatively high with the national economic recession.

The nutria control program pays hunter/trappers to harvest nutria and receive a pre-determined amount of payment per animal. Participants typically obtain an agreement from landowners to hunt on leased wetland areas, primarily in freshwater and intermediate marshes. The nutria control program started with the 2002-2003 season and has been one of the best success stories in protecting and restoring wetlands of the ongoing coastal restoration program. Seasonal variability is determined by both population of nutria and ability to get to the nutria. The ability to reach hunting locations can be attributed to water levels, with higher water levels allowing participants to get deeper into the marsh itself. High water also concentrates nutria on areas of high ground where they are more easily hunted. The greatest number of nutria harvested totaled 445,963 in the 2009-2010 (**Table 8**), which was a year with very high water in the marshes. The smallest number of animals harvested was 170,407 in 2005-2006 season, during the period of hurricanes Katrina and Rita's impact. The totals for other years were consistently high, between 297,500 and 380,000. Based on harvest of nutria, Edmond Mouton (LDWF, personal comm.) estimates that there are currently several million nutria in the Louisiana coastal zone.

### Habitat Type

Fresh and intermediate marsh types are considered optimum habitat for nutria, and as would be expected, most of the nutria harvested in each of the nutria control program years were in the fresh and intermediate marshes. In 2008, 47% of the Louisiana wetlands were classified as fresh and intermediate (Table 3). Table 8 shows that over 59 % of the nutria were harvested within the fresh/intermediate marshes except in the 2006-2007 season, when 50% were taken in the "other" areas (comprising swamp, mixed forest, open water and agricultural land) and 47% in the fresh/intermediate marsh. Although salt marsh is not considered a good habitat for nutria, some nutria do use salt marshes. The greatest number of nutria harvested in salt marsh occurred in 2003-2004 season (8,336), with less than 1,000 taken in the 2005-2006 season.

**Table 8.** Summary of Coastwide Nutria Control Program (CNCP) nutria harvest by marsh types, 2003-2010 (data from LDWF reports).

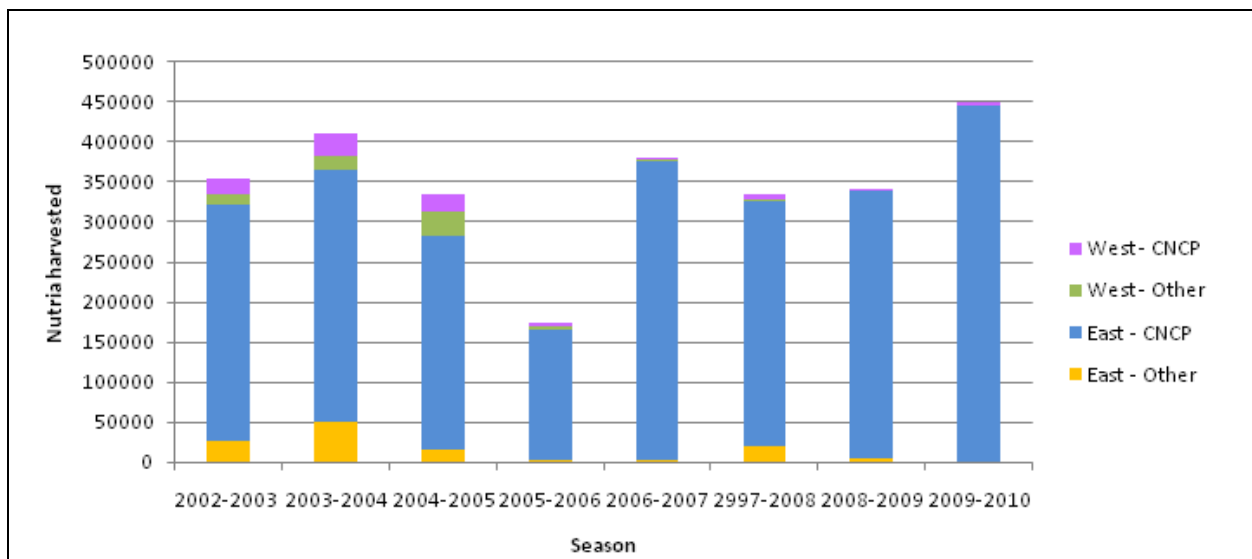
	2002-2003 (%)	2003-2004 (%)	2004-2005 (%)	2005-2006 (%)	2006-2007 (%)	2007-2008 (%)	2008-2009 (%)	2009-2010 (%)	Summary (%)
<b>Freshwater</b>	157,305 (51%)	158,568 (47%)	153,134 (51%)	96,916 (57%)	157,104 (41%)	130,284 (42%)	150,114 (45%)	206,109 (46%)	1,052,232 (46%)
<b>Intermediate</b>	67,008 (22%)	93,064 (28%)	44,571 (15%)	9,093 (5%)	21,087 (6%)	52,230 (17%)	54,118 (16%)	72,819 (16%)	346,983 (15%)
<b>Brackish</b>	20,158 (7%)	25,311 (8%)	17,694 (6%)	8,767 (5%)	10,201 (3%)	16,968 (6%)	22,217 (7%)	11,724 (3%)	112,882 (5%)
<b>Salt</b>	4,088 (1%)	8,336 (2%)	4,384 (1%)	660 (0%)	3,615 (1%)	3,228 (1%)	1,274 (0%)	4,140 (1%)	25,637 (1%)
<b>Other<sup>a</sup></b>	37,700 (12%)	49,366 (15%)	77,852 (26%)	54,371 (32%)	186,413 (49%)	102,923 (33%)	105,957 (32%)	151,171 (34%)	728,055 (32%)
<b>Open Water</b>	7,489 (2%)	307 (0%)		600 (0%)	1,970 (1%)	2,579 (1%)	358 (0%)		5,814 (0%)
<b>Unknown</b>			200 (0%)						200
<b>Grand Total</b>	<b>308,160</b>	<b>334,952</b>	<b>297,835</b>	<b>170,407</b>	<b>380,390</b>	<b>308,212</b>	<b>334,038</b>	<b>445,963</b>	<b>2,271,797</b>

<sup>a</sup>“Other” includes swamp, mixed forest, open water and agriculture land types

## Region

The eastern, or Delta Plain, wetlands have consistently accounted for the majority of nutria harvest since the CNCP began. The poor harvests of the Chenier Plain are indicative of low numbers of nutria in the region, which has not been true of this region historically. The records of nutria harvested outside of the program have been very small.

**Figure 5** represents both CNCP harvests and nutria harvested for pelts outside of the CNCP in Louisiana from 2002-2010. It illustrates that many fewer nutria were harvested in the western Parishes (Chenier Plain) than in eastern Louisiana in the Delta Plain. It also shows the effect of the CNCP, with a much greater number of nutria harvested as part of the CNCP.



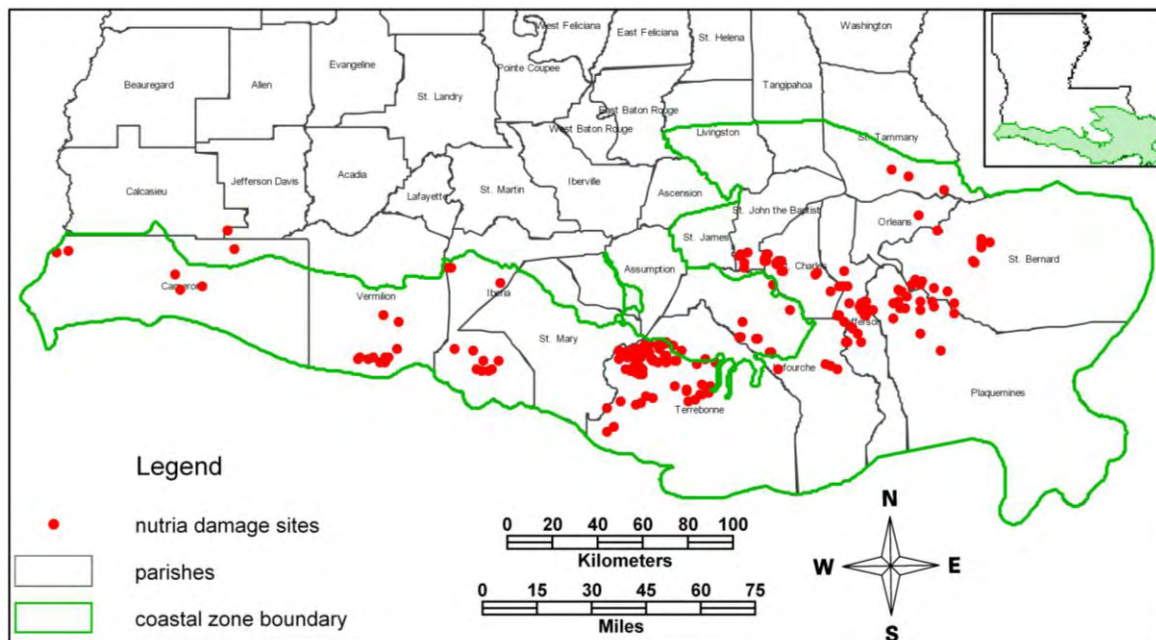
**Figure 5.** Total nutria harvested in western and eastern Louisiana, including that within CNCP and others harvested for pelts as reported to Louisiana Department of Wildlife and Fisheries for 2002-2010.

## Parish

Nutria are pervasive in coastal Louisiana, with damage and harvest reported for 12 coastal parishes, along with Jefferson Davis Parish (**Figures 6 and 7**). The highest harvest rates were consistently in Terrebonne Parish, which each year comprised over 21% of the nutria harvested. In the last two seasons, less than 2,450 nutria were harvested in Cameron Parish, with none harvested in Vermilion. In Vermilion and Calcasieu parishes—the two main parishes in the western portion of Louisiana—nutria harvesting associated with CNCP netted 74,506 nutria between 2003 and 2010. More than 100,000 nutria were harvested between 2002 and 2010 in

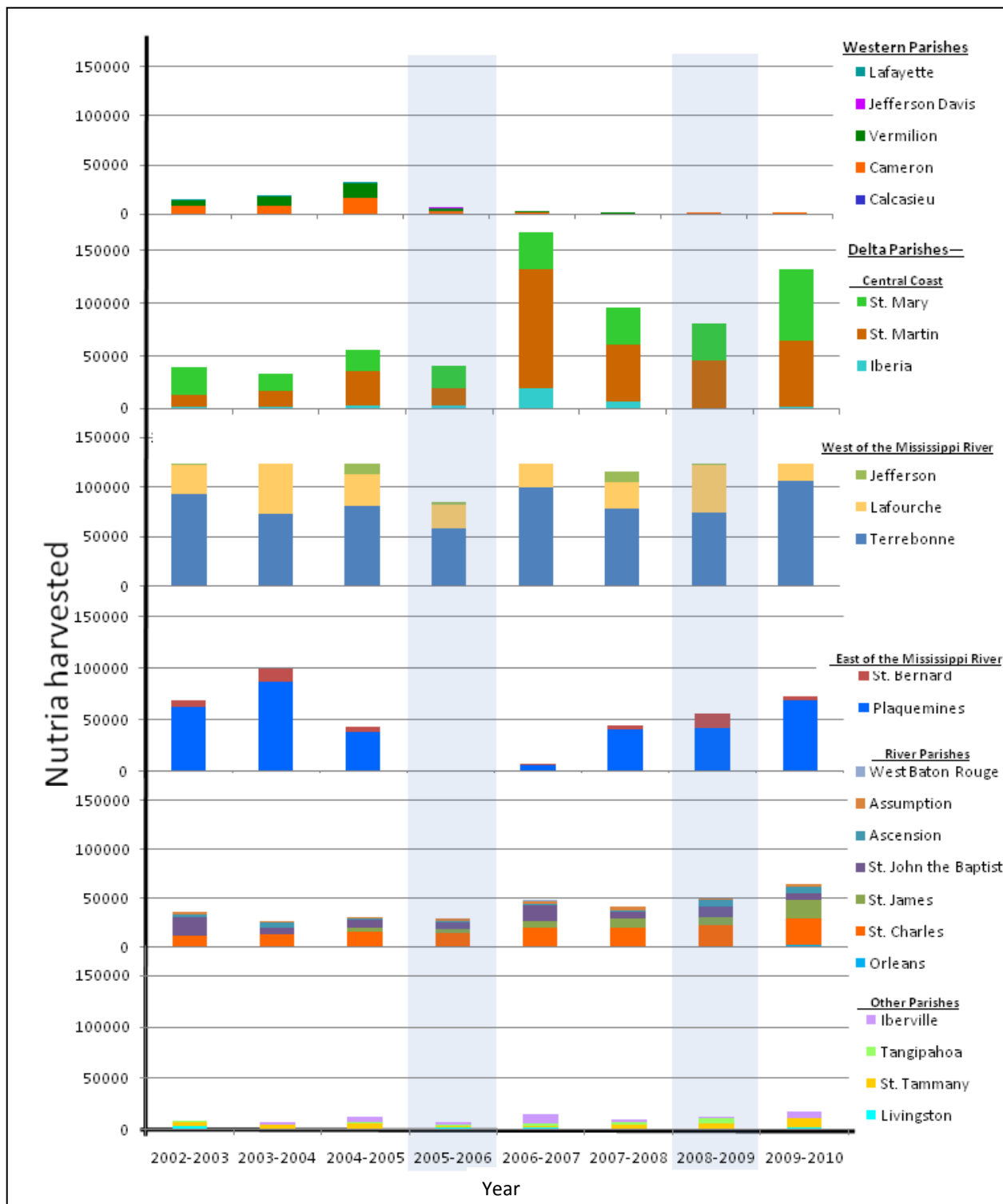
each of seven parishes in the Delta Plain. The greatest nutria harvest after the 2005-2006 season occurred in St. Martin Parish.

Hurricanes Katrina and Rita affected the nutria harvest in 2005-2006. The left-most blue shadow in **Figure 7** indicates the reduced harvest for the coastal parishes in that season. Overall, the fewest nutria were harvested in season 2005-2006, coinciding with hurricanes Katrina and Rita. LDWF attributed the reductions in harvest to Hurricanes Katrina and Rita in the west, through destruction and/or displacement of nutria populations, as well as the displacement of trappers and hunters from their homes prior to the trapping season.

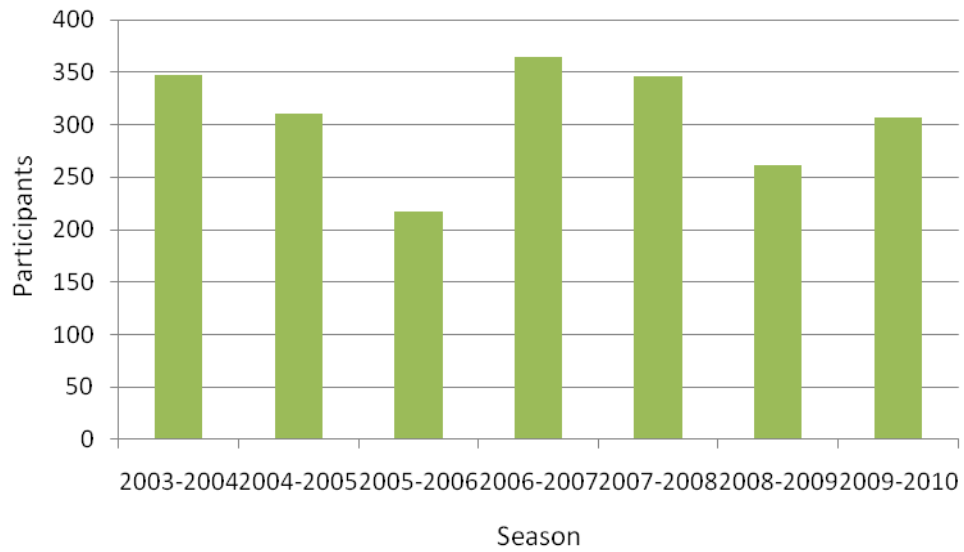


**Figure 6.** Nutria damage as reported by LDWF for 2003-2010.

Nutria harvests increased in the central and east of the Mississippi River portions of the delta after decreasing during the seasons that included hurricanes (**Figure 7**). After being devastated by the hurricanes in the 2005-2006 season, the eastern portion of the Louisiana coast was virtually shut down for hunting and fishing for a couple of years while infrastructure was rebuilt. As shown in **Figure 8**, fewer CNCP participants were involved in harvesting during the two seasons with the most damaging hurricanes. Only 217 participants were involved in the harvest in season 2005-2006, and in season 2008-2009, 261 participated. Other years had at least 40 more participants than did the seasons that included the four largest hurricanes. Perhaps it was because more nutria were in the area due to the lower harvest in the previous year. However, this area was not as affected by the 2008-2009 hurricane season, and the harvests continued upward.



**Figure 7.** Summary of the Coastwide Nutria Control Program harvest by parish, 2002-2010. Blue bars mark hurricanes Katrina and Rita (2005) and Gustav and Ike (2008).



**Figure 8.** The number of nutria hunter participants each year in the Coastwide Nutria Control Program.

## POPULATION MODELING

Carter et al. (1999) developed a nutria-biomass-area model that simulated changes in a nutria population in relation to plant biomass and marsh loss. Their analyses and conclusions were as follows:

- 1) The high population density and low survivorship rates in the literature were incompatible.
- 2) The nutria model was sensitive to adult and juvenile survivorship; it was not sensitive to gestation periods, impregnation rates or time to maturity.
- 3) The marsh area model was sensitive to the amount of biomass destroyed per nutria.
- 4) Nutria numbers did not significantly decrease in the nutria-biomass-area model until the total marsh area approached zero, because marsh loss only occurred during winter when marsh biomass was at its annual low.
- 5) Using their standard model parameters the population reached a dynamic equilibrium at 4.6 nutria ha<sup>-1</sup>.
- 6) The collapse of the nutria-biomass model indicated that the model system was not supportable, even in the absence of eat-out related losses of marsh area. This conclusion is very sensitive to the level of biomass loss per nutria assumed.

For conclusion number one, the authors are referring to published estimates of 20-40 nutria ha<sup>-1</sup> as potential overestimates of nutria density (Kinler et al. 1987). For point number six, the authors used an estimate of 96.25 kg nutria<sup>-1</sup> week<sup>-1</sup>, which was based on published literature from Maryland, USA (Willner 1982). The authors use this estimate with the expectation that this is the amount of biomass ‘destroyed’ by nutria, not the amount consumed or the amount needed for maintenance, growth, and reproduction.

A conservative estimate of 25% of a nutria’s body mass is consumed per day. If we assume that an average nutria weighs 4.72 kg, its daily consumption on a wet mass basis is 1.18 kg day<sup>-1</sup>, which translates into 177 g day<sup>-1</sup> dry mass or 1.24 kg week<sup>-1</sup> dry mass. This indicates there is an order of magnitude difference between these estimates (96.25 vs 1.24 kg nutria<sup>-1</sup> week<sup>-1</sup>), which may have led to the collapse of the model system. Their critical vegetation density (1,800 kg ha) is apparently on a dry mass basis. We calculated an alternative estimate of biomass consumed and general metabolic demand that may be useful for future simulation (see *Nutria consumption-marsh production relationships*).

## METHODS TO CONTROL NUTRIA POPULATIONS

The control of nutria in Louisiana historically has been related to the global demand for furs (Linscombe 1992), with the method of harvesting being trapping. In fact, so many nutria were harvested in the 1960s that by 1965 the Louisiana state legislature returned the nutria to the protected list. Fur demands from Germany (1960s) and Russia (1996-1998) kept the nutria market flourishing. The market for nutria crashed in 1998 when the Russian economy collapsed and demand for the fur fell. During the late 1980s and 1990s reports from land managers of marsh vegetative damage due to nutria became common, and a search began for new ways of controlling the nutria population. A comprehensive review of possible methods to control nutria was conducted for the LDWF including information available through 2001 and is included in Task III of Baroch et al (2002). The outcome of the review was the recommendation of implementing an incentive payment program to provide control on the Louisiana nutria population. **Table 9** presents a summary of those methods.

In 2002 Louisiana implemented an incentive payment program with a value for each tail. Pelt and meat could bring in other value for the harvester. This effort is called the Coastwide Nutria Control Program (CNCP), is currently funded as a part of Louisiana's coastal restoration efforts (CWPPRA) and is discussed in more detail in the next section.

Previously, the incentive/bonus plan was used in Great Britain (Gosling and Baker 1989) and Maryland successfully. This plan differed from Louisiana's plan in that the hunters were salaried, and received an incentive/bonus to make sure that all of the nutria were taken. With this type of plan in Maryland's (USA) Blackwater Refuge, nutria had successfully been eradicated by 2004. The effort took two years, \$2 million dollars and 15 trappers to eradicate the nutria by killing all 8,300 nutria on 95,000 acres, which is a small number compared to the 450,000 harvested over a much larger area in 2009-2010 in Louisiana (LDWF 2010). Maryland plans that it will eradicate nutria from the Eastern Shore by 2013. A similar program was implemented in Great Britain where eradication of nutria was achieved in 1989. It is generally not considered feasible to eradicate nutria in Louisiana. The conditions in Louisiana are very different than in Great Britain and Maryland, including climate (significantly colder in winter), landscape features (island vs mainland), accessibility of nutria habitat (automobile access in Great Britain compared to boat access and remoteness of habitats in Louisiana). The coastal area of Louisiana has the added factor of being surrounded on three sides with sources of nutria immigration. Texas, Mississippi and north Louisiana and Arkansas all have nutria populations which could conceivably move into Louisiana coastal marshes. Therefore the goal in Louisiana coastal area is not eradication but control of nutria.

Local actions have been taken in some coastal parishes to control nutria populations. For example, to try and stop nutria from destroying canals in Jefferson Parish, LA, the sheriff's

department began using their SWAT team to shoot nutria at night. An interesting side to this control effort is that nutria seem to have learned to react to sounds associated with hunting. The SWAT teams used trucks, with a shooter riding in the back of the truck. Nutria began to react to the sound of the shooter tapping on the vehicle to signal the driver to stop. Similarly, when airboats are used in the daily harvest in dense areas of nutria, a similar learned reaction cause the nutria to dive into deep water or hide under vegetation when an airboat is near.

Chemical controls are an option for nutria control, but presently only one chemotoxicant is licensed for the extermination of nutria. It is usually applied to a root vegetable like sweet potatoes on a floating mat. A major problem with the use of chemotoxicants is that they are not species-specific.

While acknowledging that the methods that they ranked may have merit in Louisiana for controlling nutria, Baroch et al (2002) determined that the only really feasible method of control was the incentive payment program.

**Table 9.** Methods used to control nutria populations based on Baroch et al (2002).

<b>Method</b>	<b>Purpose</b>	<b>Implementation</b>	<b>Louisiana: Successful/ Unsuccessful?</b>	<b>Reason</b>	<b>Ranking *</b>
Trapping: Fur Market	Control	Nutria trapped and sold for fur with no other compensation/reward	Successful and Unsuccessful	Success depends on fur market; only a few trappers remain	IV
Controlled Hunting		Open season by licensed hunters	Unsuccessful	With little pelt value, no incentive	V
Bounty	Control	Used in Louisiana in early 1960's—Turn in tail for price	Unsuccessful	Lack of appropriate funds	
Incentive/Pay	Control	CNCP	Successful		I
Incentive/Bonus	Eradicate	Incentive salary; Bonus after eradication to stop husbandry	Not useful	Too many sources of new nutria (ineffective spatially)	III
Chemical Control:					
Toxicants	Control	Bait an area, then add toxicants		Labor intensive; Effects on other wildlife need to be determined	II
Fumigants	Eradicate	Agricultural areas—into burrows Marsh areas—no burrows	Probably not	Must be contained to be effective; none registered nor found to be effective	NA
Chemical repellants			Doesn't kill; just moves	none registered nor found to be effective	NA
Induced fertility:	Control				
Bait		Must be baited approximately every 3 months; not species specific		Would be hard to stop invasion from untreated animals	NA
Injected		Must be injected; expensive but long-lasting results		Would be hard to stop invasion from untreated animals	NA

\*Cost-effectiveness ranking by Baroch et al (2002), with “I” being most cost-effective.

## COASTWIDE NUTRIA CONTROL PROGRAM

*If we can reduce the nutria population by at least 500,000 each year, the vegetative damage caused by these animals will be dramatically reduced.* Biologist, Greg Linscombe (Addison 2000)

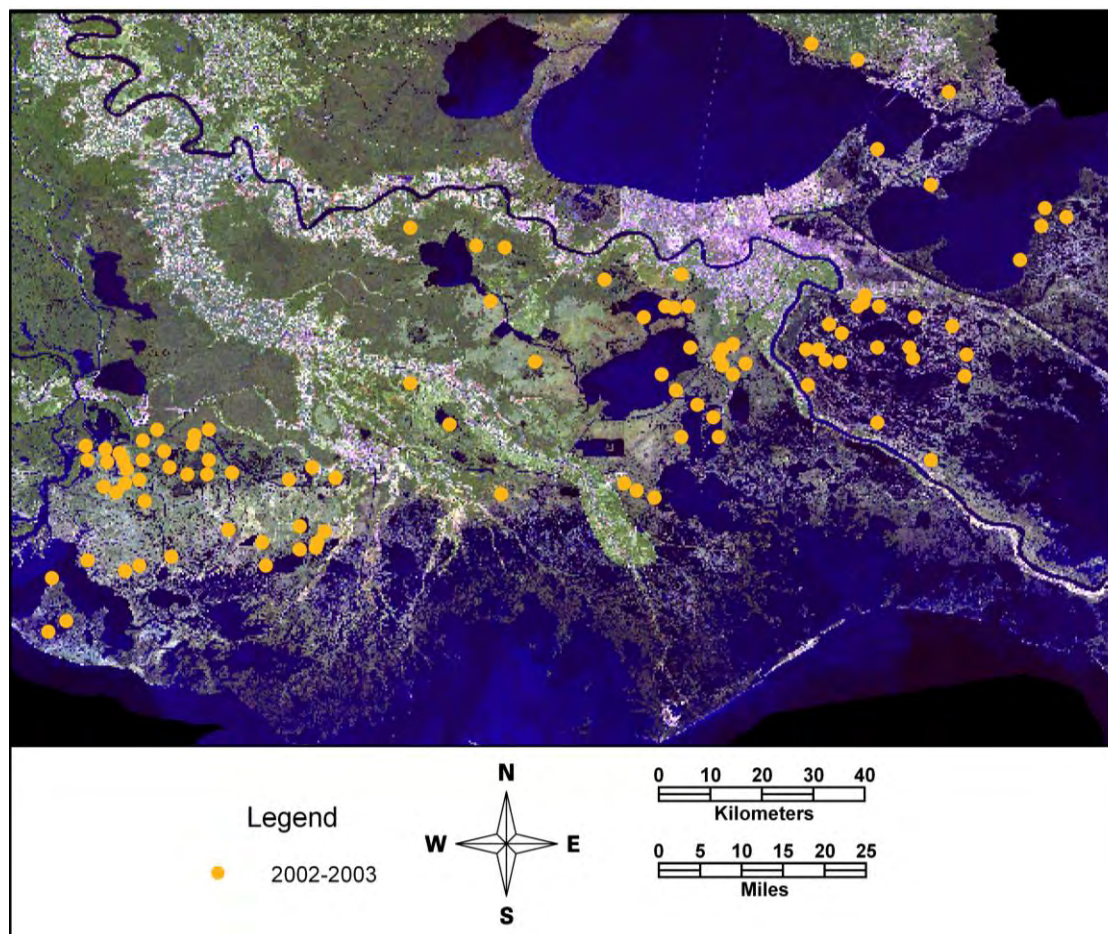
The Coastwide Nutria Control Program (CNCP) was first funded by CWPPRA to implement the nutria harvesting program in 2002-2003. A pilot Demonstration Program was initiated in 2000 with harvest occurring in 2001-2002. CNCP has offered \$5.00 for each nutria tail since the 2006-2007 season. Coastal zone land can be leased through the CNCP by landowners or their responsible parties, but it is not mandatory. The control program is an incentive plan that pays individuals for nutria tails turned in, meaning that participants may decide how much they participate in the program. It may not be their main source of income. For instance, a harvester may only harvest enough to cover expenses for another business.

### **CNCP Nutria-damaged Marsh Distribution**

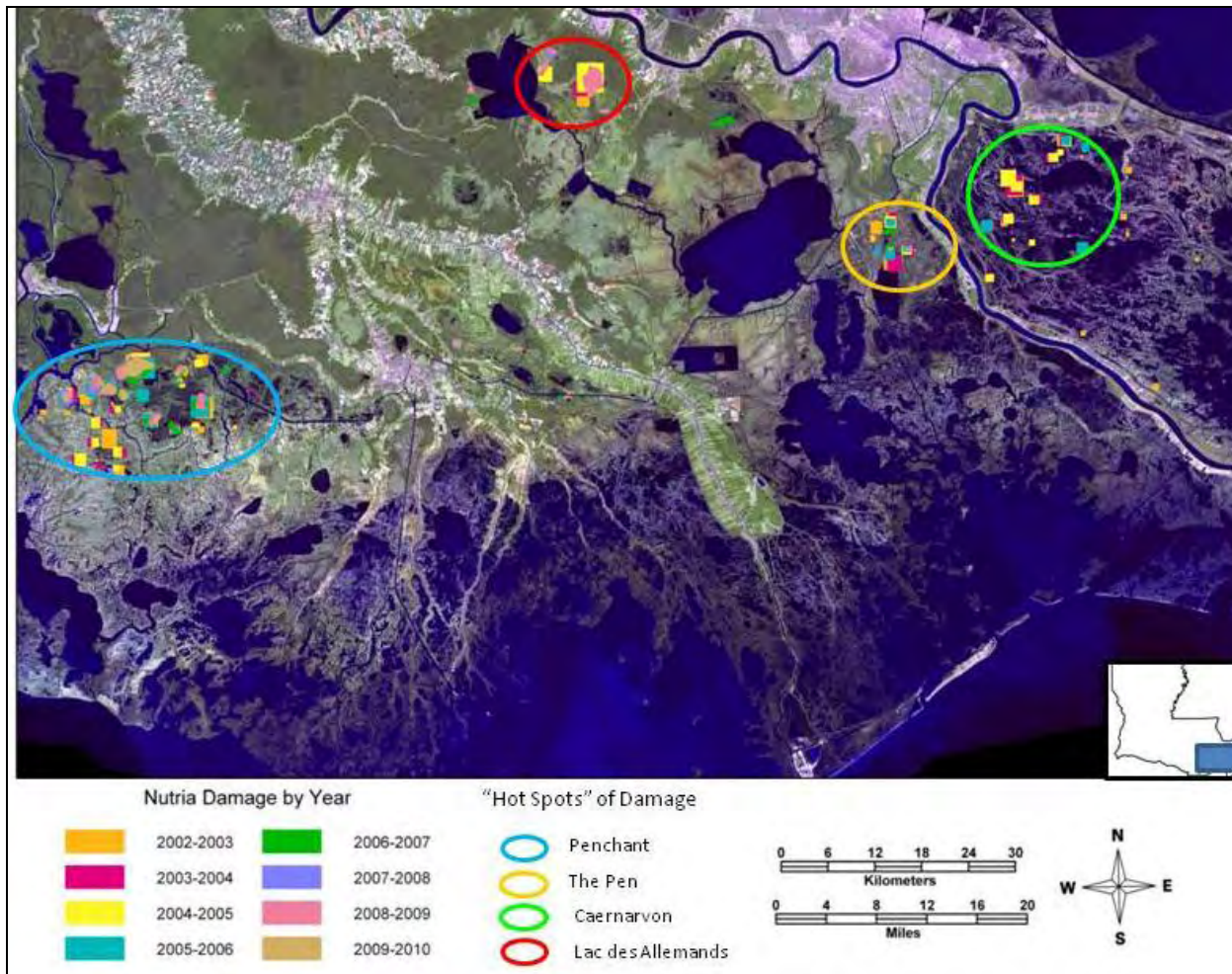
The distribution of nutria-damaged marsh is concentrated in the upper coastal basins, primarily in freshwater and intermediate marshes (**Figure 6**). **Figure 9** presents a view of the Louisiana Delta Plain region of the coast with dots representing damage areas determined by aerial surveys conducted by LDWF during spring/summer of 2003, which had the highest concentration of damage of all years. These surveys were conducted each year following techniques used in Kinler and Linscombe (1997) for the Coastwide Nutria Control Program funded by CWPPRA. Regions of high nutria impacts are reported to landowners. The landowners can then make a choice to target those affected areas by allowing more hunting.

“Hot Spots” of nutria activity are evident in several areas in the Delta Plain, with the most intense in the Penchant area of the upper Terrebonne Basin, the “Pen” area of Barataria Basin, the Caernarvon area of the Breton Sound Basin, and east of Lac des Allemands (**Figure 10**). All of the "Hot Spots" of nutria activity occurred in the fresh and intermediate marsh. **Figure 11** shows the damaged areas by individual year for the Penchant Basin "Hot Spot" as an example of the effect of CNCP. All of the damage in this "hot spot" was confined to the fresh marsh. In the early years of CNCP, the nutria damage was so pervasive that the area of the individual damaged areas were estimated and then marked on a map with a centroid. For early years, we therefore represented those areas by rectangles corresponding to the estimated area of damage. When nutria damage lessened, the damaged areas were circumscribed by a polygon, which were used from 2007 through 2010. In the first years, damage was wide-spread. By 2009-2010 the damage was confined to the northern fresh marsh.

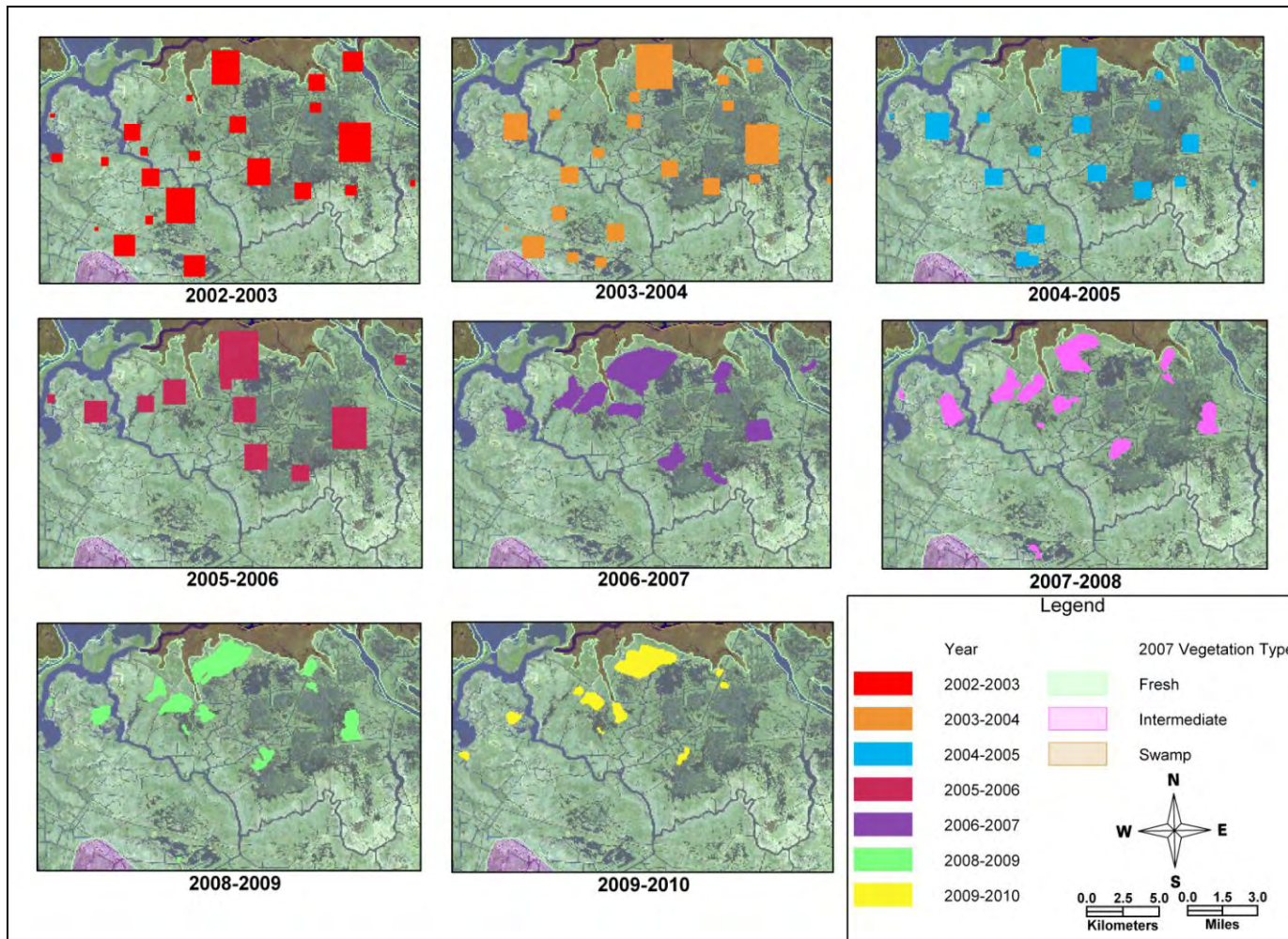
Two other "Hot Spot" areas are located in the region of the "Pen" (an intermediate marsh) and in Caernarvon (fresh/intermediate marsh). This small area had a high concentration of damage in 2002-2003 in 'The Pen', but in 2009-2010, no damage remained (**Figure 12**).



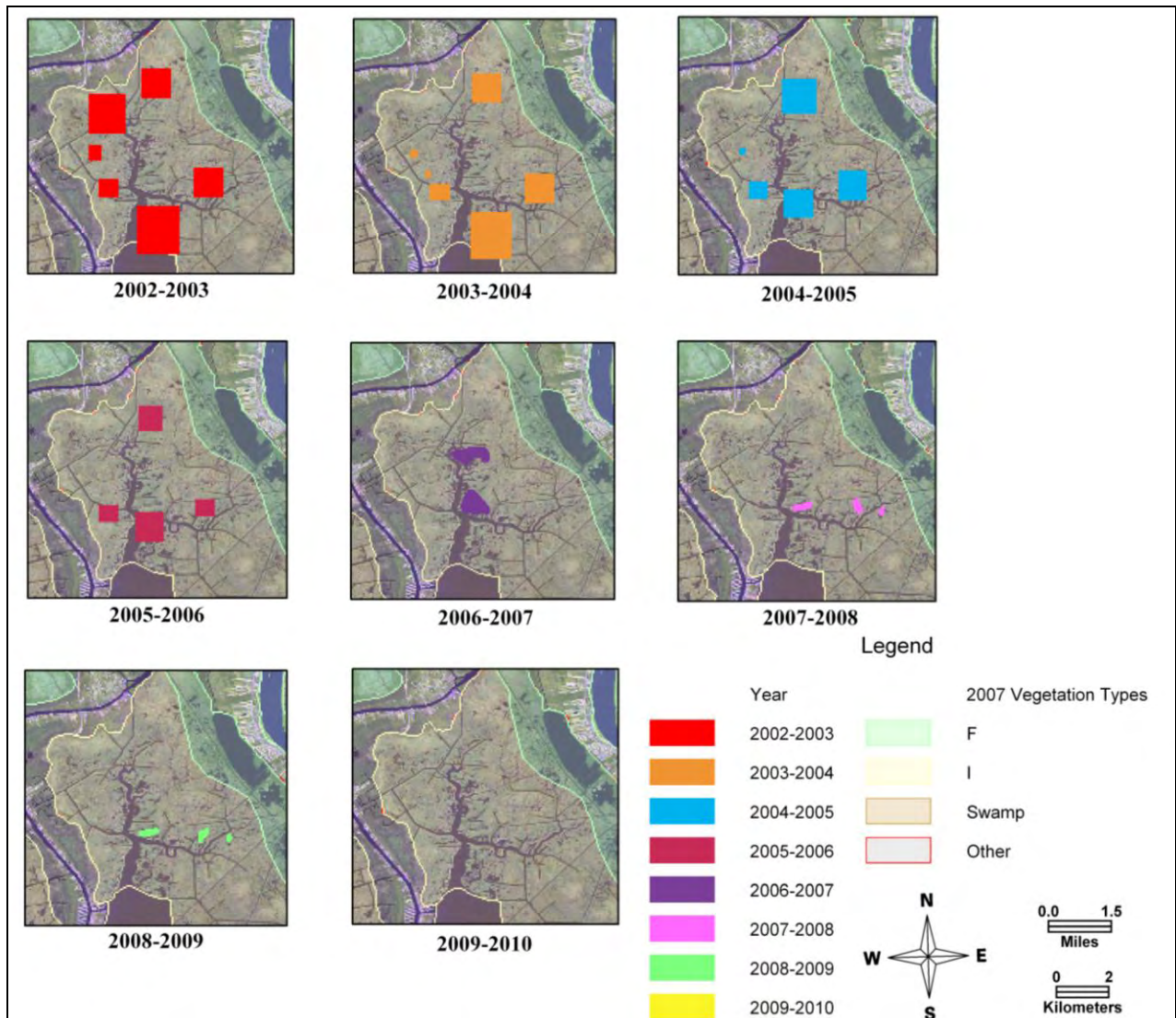
**Figure 9.** Aerial image of the Louisiana Delta Plain showing the concentration of nutria damage sites in 2003. Data on damage were collected by LDWF during spring/summer of each year following the aerial survey techniques used in Kinler and Linscombe (1998) for the Coastwide Nutria Control Program funded by CWPPRA. Background image is Landsat5 TM data from 2005, courtesy of LOSCO.



**Figure 10.** Aerial image of the Louisiana Delta Plain highlighting the "Hot Spots" of severe nutria damage within the circled areas. Data on damage were collected by LDWF during spring/summer of each year following the aerial survey techniques used in Kinler and Linscombe (1998) for the Coastwide Nutria Control Program funded by CWPPRA. Background image is Landsat5 TM data from 2005, courtesy of LOSCO.

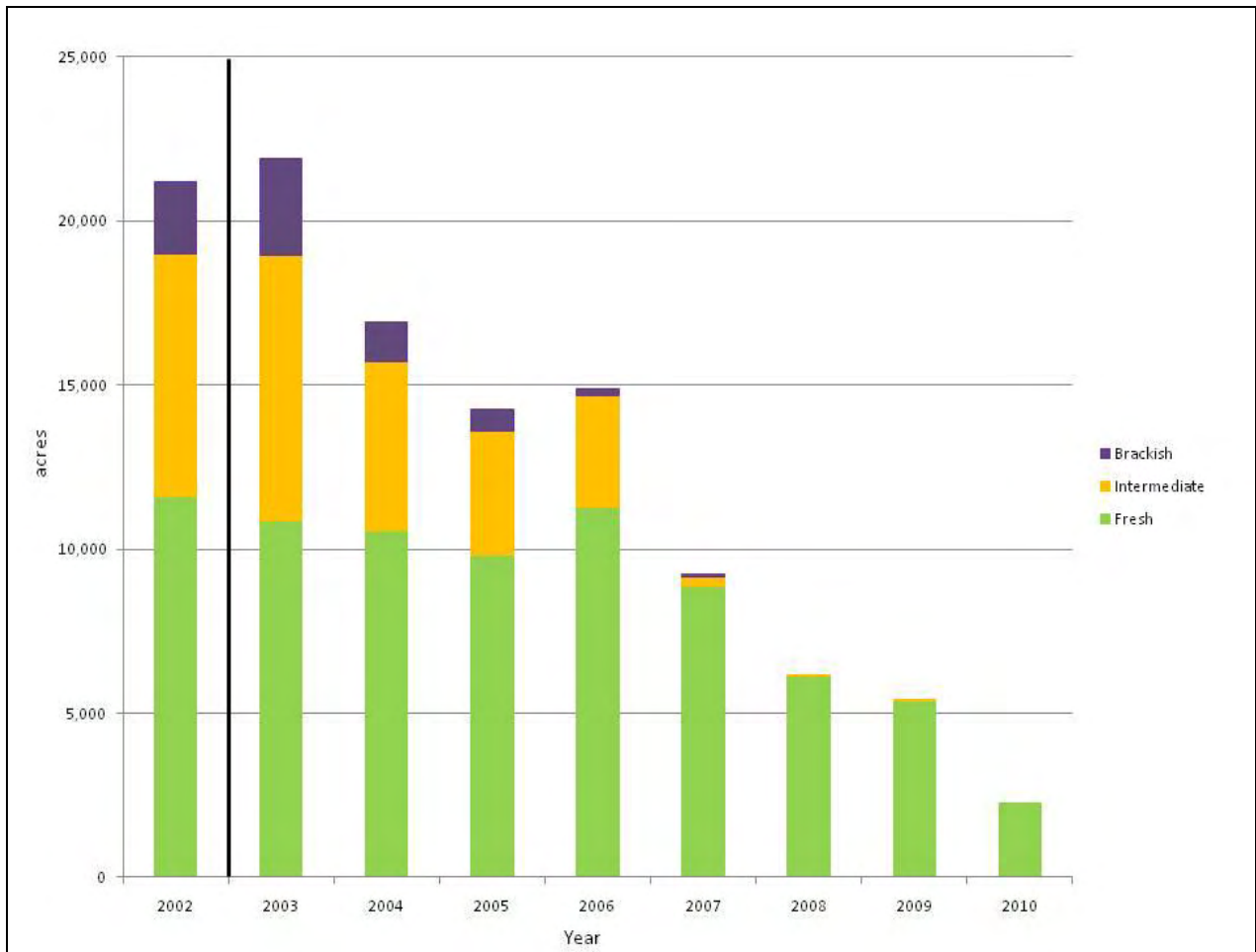


**Figure 11.** Nutria damage by year in the northern marshes in Terrebonne Basin, Louisiana (blue circle in **Figure 10**). Rectangular polygons represent the size of the area affected for 2002-2006 because areas of damage were not circumscribed until the 2006-2007 season. Vegetation type shows some swamp in the northernmost areas, a small area of intermediate marsh in the southwest, with the rest designated as fresh marsh.



**Figure 12.** Nutria damage by year in "The Pen" region in Batataria Basin, Louisiana (yellow circle in **Figure 10**). Rectangular polygons represent the size of the area affected for 2002-2006 because areas of damage were not circumscribed until the 2006-2007 season. Vegetation type shows some swamp in the northernmost areas, a small area of intermediate marsh in the southwest, with the rest designated as fresh marsh.

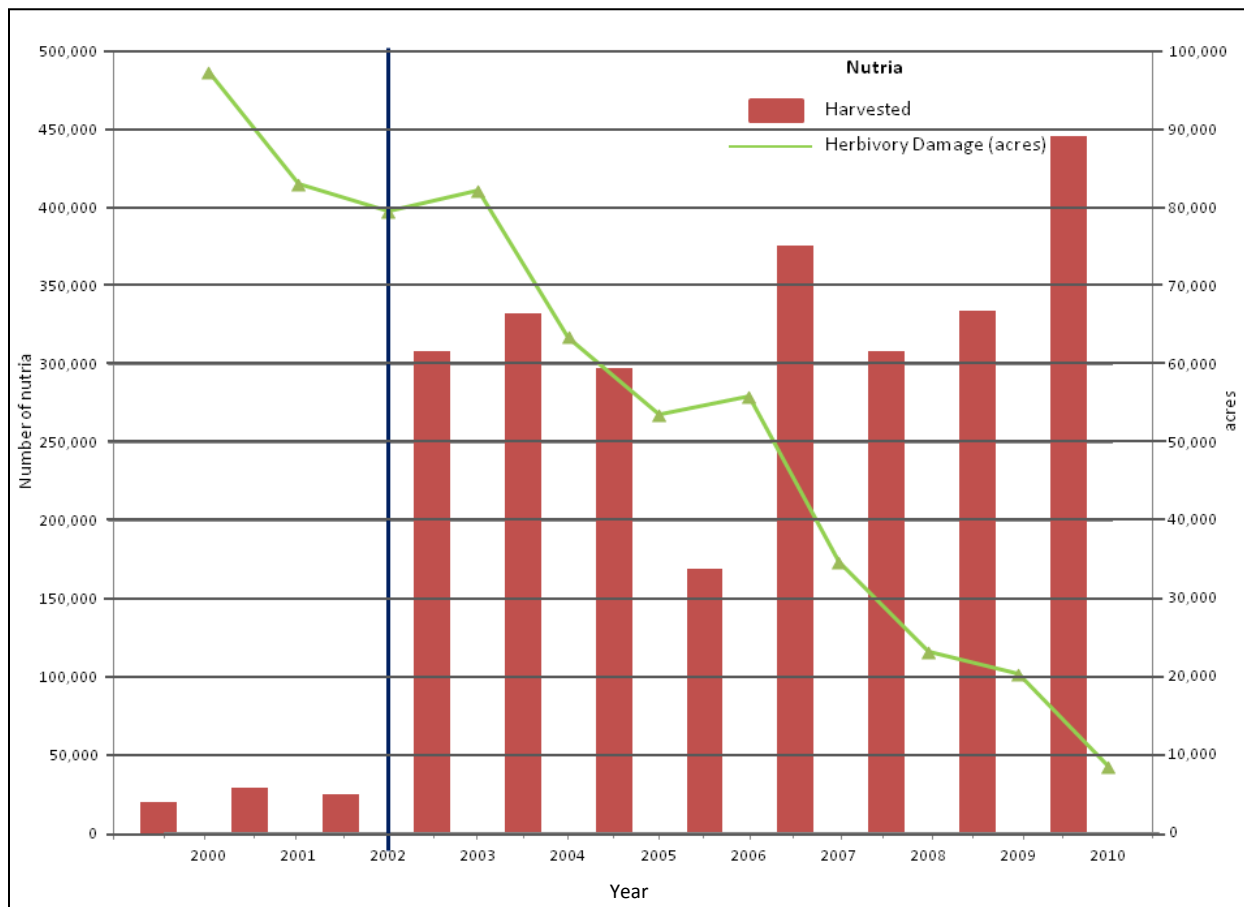
The most damaged areas are consistently in the fresh/intermediate marsh, however some damage is reported in the brackish marsh. This is evident from **Figure 6** that shows the distribution of damaged marsh, but also from **Figure 13** that indicates the acreage damaged by marsh type. The upper Terrebonne Basin is particularly heavily used by nutria. This is a region of mostly freshwater floating marshes that provide excellent habitat for nutria. The floating mats rise and fall with changes in water level, always providing a floating marsh mat for nutria to access for feeding, resting, and nesting. The damage is more or less continuous in these areas, although the intensity does seem to vary inter-annually – probably as marsh vegetative material is removed (e.g. quality is degraded) and the population moves to a more desirable location. It is also clear from the nutria control program data set that as more animals are removed, there is a trend toward vegetation recovery.



**Figure 13.** Nutria damage (acres) by marsh type for each year based on LDWF helicopter surveys. Black line indicates start of Coastwide Nutria Control Program.

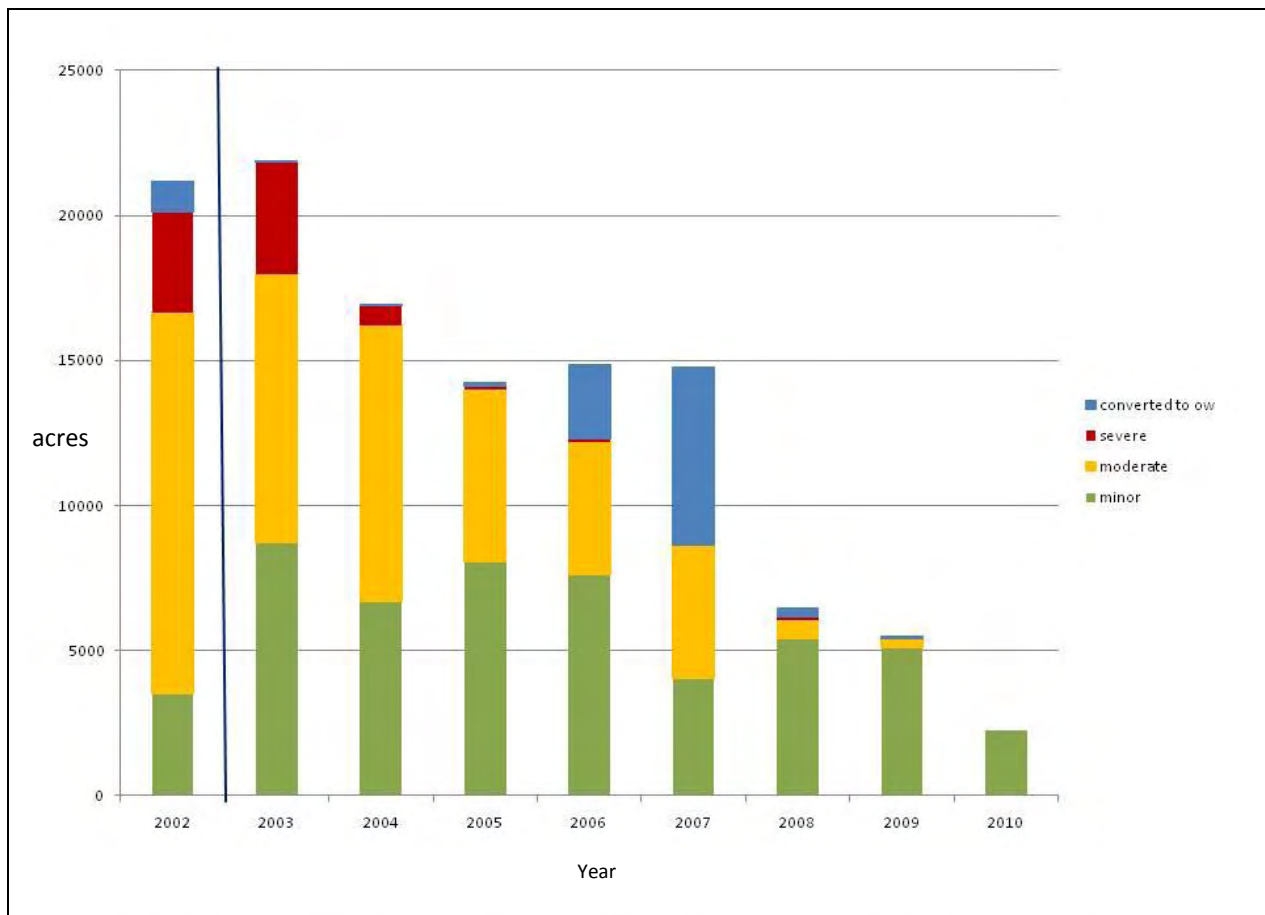
## CNCP Program Success

The extrapolated acres of marsh damage in coastal Louisiana with the numbers of nutria harvested for the years 1999-2010 is indicated in **Figure 14**. This graph indicates a clear trend of decreasing acres of damaged marsh from 2003-2010. The area of nutria-damaged marsh decreased from 80,000 acres in 2003 to less than 10,000 acres in 2010. At the same time the harvest of nutria was steady in the range of approximately 300,000 to 400,000 animals most years other than during hurricanes Katrina and Rita. The inability to separate damage due to hurricane effects and herbivory in 2006 accounts for the increase in damage that year. During the 2009-2010 season, a peak harvest was recorded with 445,963 nutria tails collected. The steady decline in nutria damaged wetlands while nutria harvest has exceeded 300,000 animals each year, is a strong indication that the incentive program is a success.



**Figure 14.** Louisiana Dept. of Wildlife and Fisheries estimates of nutria damage to coastal marshes (right axis, green line) and the harvest of nutria from 1999-2010 for all the coastal parishes (left axis). A pilot Demonstration Program was initiated in 2000 and continued to 2002. The Coastwide Nutria Control Program has offered \$5.00 for each nutria tail since the 2006-07 season. The black line indicates the start of the Coastwide Nutria Control Program.

Nutria damage intensity by year from 2002-2010 (from LDWF monitoring of CNCP) is indicated in **Figure 15**. The information in this graph indicates a clear trend of severe and moderate damage in the early 2000's to mostly minor marsh damage in 2008-2010. This trend follows that discussed previously of decreasing acreage of damage as the CNCP continued to remove nutria from the marsh ecosystem from 2002 through 2010. This is again clear evidence of the remarkable success of this program, with the severity of marsh damage decreasing from 16,660 acres of moderate to severe damage in 2001-2002 to only 2,260 acres of minor damage in 2010. These data are reliable because the assessment survey done each year to determine nutria damage to marshes is done systematically along the coastwide vegetation transects used since the 1970's (see Sasser et al. 2008) ensuring a high level of consistency in the monitoring data collected for all years.



**Figure 15.** Severity assessment of nutria damage by year based on LDWF helicopter surveys. The black line indicates start of the Coastwide Nutria Control Program. (Data from LDWF Coastwide Nutria Control Program).

## THE IMPORTANCE OF ALLIGATORS AS PREDATORS ON NUTRIA

Question, Dr. Galtsoff: “...*what are the natural enemies of nutria, if any?*”

Answer, Dr. Harris: “*If any is a good word...In Louisiana, I don't think there is a serious predator on the adult nutria...Of course, the alligator population is rather low so the effect on the nutria population is practically negligible.*” Harris 1956

The historical population of alligators in coastal Louisiana is unknown, but by the 1950's overharvesting was leading to an unsustainable population. Alligator hunting was suspended in the early 1960's. In 1970, LDWF began monitoring the population recovery and by 1981 alligator hunting resumed statewide. Alligator nests significantly increased from 1970 to 1993 (McNease et al. 1994). Over this 24 year period, average nest numbers increased by 13% each year. The highest nest densities (36.5 ha nest<sup>-1</sup>, 1984-1993) occurred in southwest Louisiana; nest density in southeast Louisiana was 51.9 ha nest<sup>-1</sup>.

An early study on Sabine NWR by Valentine et al. (1972) showed that nutria density contributed to diet of alligators. During periods when nutria populations were estimated at 74,000, nutria remains were identified in 56% of the stomachs of the alligators examined. In contrast, when nutria populations were estimated to be <10,000 animals on the refuge, <7.0% of alligator stomachs contained nutria. Valentine et al. suggested that the decline of nutria in the alligator diet was due to the nutria control program during that period of study, which accounted for a 30% reduction in the nutria population.

With the inception of the Coastwide Nutria Control Program, there was concern that nutria harvesting would deplete an important alligator food item. A study comparing the diet of alligators from areas where nutria control was present or absent failed to reveal any trend in the likelihood that an alligator stomach would contain nutria (Gabrey et al. 2009). Among the several parishes studied and 550 stomachs analyzed, overall, about 1/3 of the alligator stomachs contained nutria remains.

Based on a population modeling exercise of alligator-nutria interactions, Keddy et al. (2009) suggest that controlling the harvest of large alligators may have a significant impact on nutria populations and serve as a means to help control nutria impacts to wetlands. Their conceptual model provides insight to the behavior of nutria population dynamics with different nutria-alligator ratios and predation rates. Given the lack of empirical data from controlled experiments, the authors could not prescribe the number of alligators required to control a nutria population.

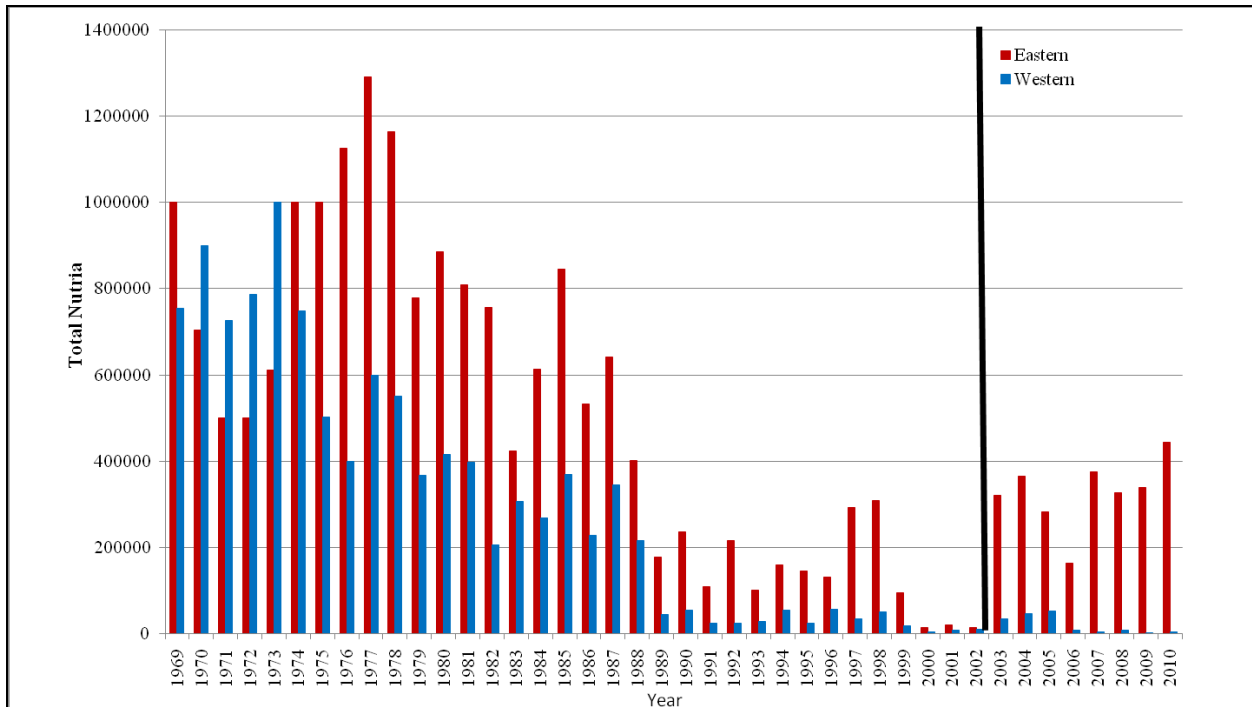
Based on LDWF surveys of marsh damage from nutria and local alligator nest densities, there has not been a strong indication of top down control of nutria by alligators. McNease pointed out that since 1994 Terrebonne Parish “outranked all the other coastal parishes in terms of alligator nesting density for fresh and intermediate marsh types. It is important to note that at the same time, Terrebonne Parish is also number one in terms of nutria herbivory damage and CNCP

harvest (Marx et al 2004)". Nonetheless, there are anecdotal observations of low nutria abundance where alligators are known to be numerous. Two of these areas are the freshwater maidencane-dominated marshes around Lake Boeuf and the Jean Lafitte National Park in the upper Barataria Basin. Although no cause and effect information is available, the Lake Boeuf floatant marsh region is in an area known to have high alligator population (1978-1998 mean density of 81.8 alligators  $\text{mi}^{-1}$ ; Visser et al 1999) that could help explain the lack of nutria damage in these marshes.

The Jean Lafitte National Park is an area where alligator harvest has not been allowed (David Muth, pers. comm.). Therefore the alligator population is probably fairly high, with older and larger animals within that population. Again, no studies have identified a relationship; however, it is possible that higher alligator populations may play a role in keeping the nutria population in check, thereby decreasing grazing impacts on the marsh vegetation. This topic is certainly worthy of further research.

Western, or Chenier Plain, marshes used to account for a high proportion of the nutria take in early years (**Figure 16**). In the recent years, even with a high incentive, there is not a significant harvest coming from the Chenier Plain marshes. The numbers of nutria taken in the Chenier Plain parishes in recent years were far below those taken in those in the Delta Plain. For example, summarizing CNCP data across years shows that when comparing two parishes of relatively equal size, the total harvest of nutria in Terrebonne Parish (Delta Plain; 663,748 tails) far exceeds the number in Cameron Parish in the Chenier Plain (41,709 tails). A number of factors may be responsible, such as hydrologic changes, an increase in the proportion of saltwater to freshwater habitat, hurricanes, and a high density of alligators (McNease 1994).

Other predators of nutria include coyote, eagles, domestic dogs, and humans. Great horned owls, foxes, great blue herons, hawks, eagles, and raccoons prey on young nutria (Washington Dept. of Fish and Wildlife, 2006). However, as observed by Edmond Mouton, LDWF (pers. comm (04/05/2011), "while all of these might eat nutria, they are obviously not controlling the population".



**Figure 16.** Nutria harvests from 1969 through 2010 from west (Chenier Plain) and east (Delta Plain) Louisiana. The black line indicates the beginning of the Coastwide Nutria Control Program.

## SUMMARY

- The Nutria is an exotic, aquatic rodent that was introduced to Louisiana wetlands during the early 1930's. From 1960-1990, over 36 million nutria were taken and the fur market was lucrative. By 2000, the worldwide fur market had entirely collapsed.
- With favorable conditions, nutria can rapidly reproduce. Nutria reach sexual maturity at 4-8 months, may have 2-3 litters per year, and average 13.1 young per female per year.
- Nutria have a small home range in marsh habitats, but long-distance dispersal (>20 miles) to new areas can occur during tropical storms.
- Nutria are pervasive across Louisiana coastal wetlands, but their ideal habitat is freshwater and intermediate marsh, where forage is most palatable. The organic nature of these soils makes them particularly susceptible to destruction with grazing.
- Nutria are opportunistic feeders, with a broad diet comprising more than 60 plant species in Louisiana.
- The entire amount of biomass that is ingested by an individual animal is equivalent to the biomass produced and available for consumption each year on approximately 24 m<sup>2</sup> of marsh. An average nutria can consume 26 kg of dry biomass per year. On one hectare of marsh, 40 nutria could cause the permanent loss of 50% of the biomass produced during a period of 20 years.
- In a period of less than eight years, 40 nutria could consume one-half of all the biomass produced on one hectare of herbaceous marsh. Within 20 years, a high density of nutria could result in the permanent removal of one-half of all the potential organic matter produced in a marsh.
- Carbon removal from the landscape by nutria can be significant. As an example, by assuming a population of 2 million nutria in coastal Louisiana (over 450,000 were harvested during the winter of 2010), the amount of carbon estimated to be permanently removed from the marsh each year by nutria results in an equivalent amount of carbon contained in 40,500 metric tons of coal or 12.5 million gallons of gas.
- Decades of cumulative deleterious effects from nutria grazing on the coastal landscape have been difficult to quantify and separate from other factors producing wetland loss. Scientific studies investigating effects of nutria on marsh habitats consistently conclude that nutria grazing is damaging to marsh vegetation. It is generally accepted that nutria damage-- in addition to larger scale subsidence, sea level rise, and salinity intrusion—can

create an accelerated deterioration of wetlands.

- Research studies conclude that nutria grazing damages limits regeneration in Louisiana swamp forests. Nutria grazing on bald cypress seedlings is extensive and remains a major factor in the inability of cypress-tupelo forests to regenerate. Plantings of saplings have withstood grazing pressure better than seedlings and may be a good choice for restoration projects when feasible. Projects designed to restore coastal swamp forests should include a nutria control component and suitable protection of transplants should be used to minimize mortality from grazing.
- Eruptions of populations of nutria can cause severe wetland damage and subsequent loss. Some areas of the coast have persistent populations creating "Hot Spots" of severe damage.
- The major "Hot Spots" of severe wetland damage occur in the freshwater-intermediate areas of Terrebonne, Barataria, and Breton Sound basins. Nutria densities are relatively low in the Chenier Plain currently compared to historic observations and harvest records.
- Damage from nutria was noted in 12 of the parishes in the Louisiana coastal zone.
- The Coastwide Nutria Control Program (CNCP) was implemented in 2002-2003 by the LDWF, and since then there has been a reduction in 70,000 acres of marsh damage, from 80,000 acres in 2003 to less than 10,000 acres in 2010. Approximately 446,000 nutria were harvested in 2010 in the CNCP .
- Nutria were harvested in 24 of the 63 Louisiana parishes from 2000-2010, but by far the greatest numbers were harvested in the Delta Plain.
- When considering the costs of creating new wetlands (approximately \$50,000-70,000 per acre), the Coastwide Nutria Control Program can be viewed as a successful wetland conservation program, that has produced measureable reduction in marsh damage. Since the program began with the 2002-2003 season, 2,571,480 nutria have been harvested under the CNCP. This program is a success and, from a resource management perspective, should be continued with improvement and expansion if possible.
- Considerations must be made to protect against nutria invasions for coastal restoration projects that add nutrients to wetlands. Nutrient additions can cause preferential nutria grazing to wetland plants and therefore potentially increase grazing damage to wetland habitats. Coastal restoration projects that include nutrient additions should incorporate effective nutria control measures and associated costs to maximize probability of success.
- The effect of predators on nutria population control is unclear. In particular, the predator/prey relationship between alligators and nutria is a worthy topic for further

investigation. Anecdotal information from western Louisiana marshes, suggests that the recovery of the alligator population has significantly reduced the population there. However, mortality from tropical storms and habitat modification may also be important.

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