The Effects of Wildfires on Alligator Nests on Rockefeller Refuge

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Abstract: Environmental factors such as flooding, drought, and predation can adversely affect alligator nesting success. No prior studies have documented the effects of wildfires on alligator nesting ecology. In July 1995, wildfires burned over 1,300 ha of alligator nesting habitat on Rockefeller Refuge in southern Louisiana. Although most alligator eggs from nests in the burned area had previously been removed by staff biologists, the burned area was searched to evaluate fire damage to remaining nests and eggs. Twenty-nine (46.0%) of 63 nests located were not damaged by the wildfires, due probably to water and moist vegetation adjacent to the nest site. Fourteen nests (22.2%) were deeply burned, with the nest cavity exposed and damaged. Uncontrolled summer wildfires can limit alligator nesting success. Management implications for alligator egg ranching programs are discussed.

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Controlled burning in the southeastern states can be beneficial to wildlife (Folk and Bales 1982). Fire is a tool used in coastal marsh management to remove dead vegetation and re-establish lower successional stages (Lynch 1941, O'Neil 1949, Hoffpauer 1968, Daiber 1974, Chabreck et al. 1989, Nyman and Chabreck 1995). In wetlands, burning can increase availability of shoots, roots, and rhizomes for geese, remove accumulations and limit excessive growth of climax species, allow seeds to become more available, and create edge and deep pools for waterfowl feeding and nesting (Wright and Bailey 1982).

Studies have documented the effects of burning on reptiles and amphibians (Kahn 1960, Erwin and Stasiak 1979, Mushinsky 1985), but little is known about the effects of fire on aquatic herpetologic species (Landers 1987) such as alligators. Five major wildfires in 1954 and 1955 during an extended drought in the Okefenokee Swamp burned over 128,000 ha; alligator populations were thought not to be adversely affected (Cypert 1961). Vogl (1973) studied the effects of a controlled burn in a Florida wetland, and found that alligators used the burned shoreline habitat almost exclusively. Similarly, Lyon et al. (1978) and Landers (1987) suggested that alligators benefit from habitat changes caused by occasional burning of shoreline vegetation.

The nesting ecology and reproductive biology of the American alligator (*Alligator mississippiensis*) has been studied extensively in Louisiana (Joanen 1969, Fleming et al. 1976, Joanen and McNease 1989, Platt 1990, McNease et al. 1994) and other southeastern states (Woodward et al. 1992). Nesting success of alligators can be impacted by many environmental factors, including flooding, drought, and predation (Joanen and McNease 1989, Kushlan and Jacobsen 1990, Hunt and Ogden 1991). However, no studies have documented the effects of wildfires on alligator nesting ecology. Alligators construct their nests in early summer (Joanen 1969), while prescribed marsh burning is generally conducted in fall and winter to benefit waterfowl, furbearers, and marsh vegetation. Winter burning also limits fuel accumulations and minimizes damage from undesired summer lightning fires (O'Neil 1949).

In July 1995, wildfires burned a moderate section (approximately 1,330 ha) of excellent alligator nesting habitat on Rockefeller Refuge in Grand Chenier, Louisiana. This paper describes observations on the effect of these summer fires on alligator nests in the affected area, and provides management implications of this potential mortality factor.

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Methods

This study was conducted on portions of Rockefeller Wildlife Refuge, a 32,000-ha coastal marsh in Cameron and Vermilion parishes in southwestern Louisiana. The refuge boundaries and predominant vegetation were described by Joanen (1969).

Rockefeller Refuge has an alligator population of approximately 20,000 animals. Extensive research has been conducted on alligator culture at Rockefeller, leading to development of a statewide alligator farming and egg ranching program (Joanen and McNease 1991). Approximately 10,000–15,000 alligator eggs are collected annually on Rockefeller for research and ranching programs. Nesting rates on the refuge are very high and can be as dense as 1 nest per 4–5 ha under optimum environmental conditions (Joanen and McNease 1989). These areas are burned by prescription approximately every other year. Numerous bayous, ponds, and lakes act as natural firebreaks, resulting in a mosaic pattern of incomplete burns. The area involved in this study was prescribed burned on 5 January 1994. It was surveyed for alligator nests on 8 June 1995 and all nests were marked with 3.05-m PVC pipes and plotted on an aerial map to aid egg collections by ground crews.

On 18 July 1995, a wildfire was noted in the Superior Canal system area on Rockefeller Refuge, presumably ignited by 1 or more lightning strikes (Fig. 1, burn A). The fire was first observed about 0300 hours; the fire could have started on 17 July. The fire was not extinguished until the evening of 21 July after it burned 970 ha. Another small area (ca. 360 ha) of the refuge west of Little Constance Bayou had

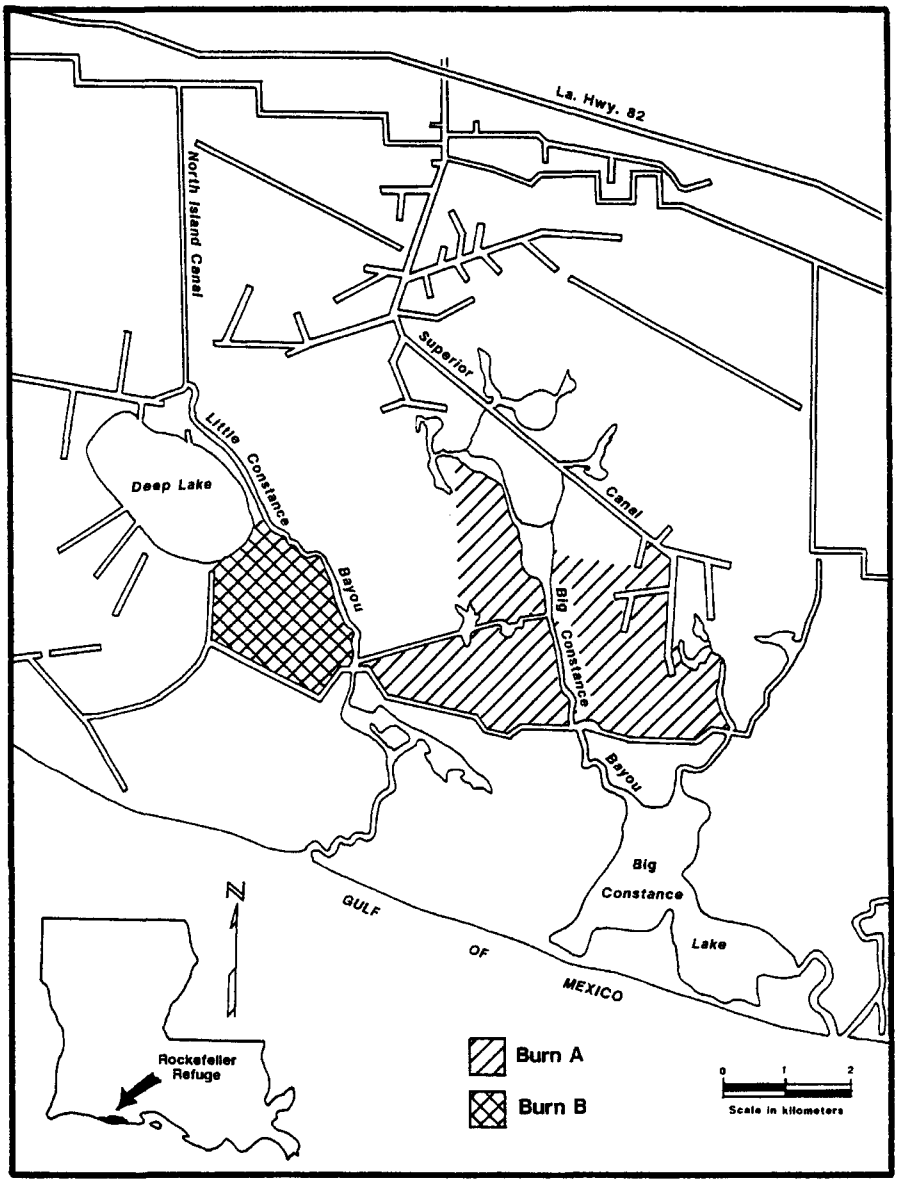

Figure 1. Map illustrating areas burned by wildfires in July 1995 on Rockefeller Refuge, Grand Chenier, Louisiana.

burned on 6 July 1995, also presumably by a fire started by a lightning strike (Fig. 1, burn B).

The burned areas were systematically searched by airboat on 1 August, 2 August, and 10 August 1995 to locate and evaluate fire damage to alligator nests. It was decided to wait approximately 2 weeks to evaluate the area for possible alligator nest damages caused by the 2 fires; any eggs collected from the burned areas would then have completed the temperature sensitive period for sex determination (Lang and Andrews 1994). This would also allow comparisons of hatch rates in burned areas to hatch rates in an unburned area which was part of another concurrent study and in which eggs were scheduled to be collected the first week of August. The majority of eggs from nests in the area already had been removed from the nests for research and ranching programs. Efforts were made to gather eggs early in the nesting season (within the first week of oviposition) to avoid mechanical damage during the more sensitive period (day 7–16, Joanen and McNease 1987) and avoid deleterious flooding and predation which increase in likelihood the longer eggs are left in the marsh.

Alligator nests were easily visible and exposed on the burned areas in this study because surrounding vegetation had been burned. Some nests were located by the PVC nest markers, despite the fact that many pipes were melted or burned due to the intensity of the fire. All nests in the study area were located in the marsh proper; none were on levees. All were constructed predominantly of wiregrass (*Spartina patens*), occasionally with some overgrowth of deerpea (*Vigna sp.*).

Burn damage to nests was documented. Nests were subjectively assigned a grade from 0 to 2 depending on the severity of damage. Grade 0 nests had sufficient water or moist vegetation around the nest such that the nest was unharmed by the fire. Grade 1 nests were burned superficially or moderately on the outer surface of the nest, but the fire did not penetrate to the inner egg cavity. Grade 2 nests were deeply burned, with the nest cavity exposed and lower reaches of the nest cavity involved. Empty nests found in the burned areas could have been incomplete nesting attempts known as "false nests" commonly built by alligators (Joanen 1969) or nests in which eggs previously had been collected by researchers. Therefore, Grade 2 empty nests could have resulted from this collection or because the eggs were completely burned to ash. We noted any other observed affected species.

Eggs collected from the burned areas were examined and incubated at the laboratory as described by Joanen and McNease (1987) if viable. In a concurrent study 10 clutches were collected in August 1995 from an adjacent, unburned marsh on Rockefeller to compare the hatch rates of eggs collected at approximately the same stage of development/incubation from the burned and unburned sites. Hatch rates were calculated as the number of live hatchlings obtained divided by the number of fertile eggs incubated (excluding infertile eggs and cracked or leaking eggs, or those known to have died early in development).

Results

Sixty-three alligator nests were located and evaluated in the burned areas. Twenty-nine (46.0%) were Grade 0, and the nest location and construction was such

that sufficient surrounding water protected the nest from fire damage. Eight of these 29 Grade 0 nests contained viable eggs, 1 contained 12 abnormal eggs, and 20 nests were empty; eggs having been previously collected or incomplete or false nesting attempts. The hatch rate from eggs gathered post-fire from the 8 Grade 0 nests located in burn A was 84.8% and from the 10 controls was 89.4%. The abnormal eggs were located in burn B and were kidney shaped and heavily calcified with unusual chalky deposits. Two were cracked and leaking, and were discarded. The other 10 were artificially incubated, but failed to hatch. When opened, they were found to have died early in incubation prior to the fire event. Twenty nests (31.8%) were classified as Grade 1; none contained eggs.

Fourteen nests located were categorized as Grade 2 (22.2%). We believe the damage to these nests was so extensive that the eggs would not have survived the fire and been viable. One Grade 2 nest contained 10 charred and darkened eggs which were laid very superficially; the top 3 eggs were exposed. We planned to artificially incubate these eggs to determine viability; however, the entire clutch was found to be infertile.

Two Grade 2 nests contained burned eggs/eggshell parts. One nest was depredated, and only charred eggshells remained. Predation could have occurred before or after the fire. Two burned alligator osteoderms were located in the nest cavity, and a left mandible from an adult alligator (approximately 2 m in body length) was found in the water adjacent to the nest. No other parts of the carcass were located. The other Grade 2 nest with egg remnants present had a single burned alligator egg left in the nest cavity. Approximately half of the shell with the burned embryo remained. The dead alligator was approaching hatching size.

Numerous burned muskrat (*Ondatra zibethicus*) houses were observed on the study area. One house contained 7 speckled kingsnake (*Lampropeltis sp.*) eggs that had been severely burned and contained dead embryos. Skeletal remains of muskrats were found on 2 muskrat houses.

Discussion

Results in this study suggest uncontrolled summer wildfires can adversely impact alligator nesting success. As we previously noted, 14 of 63 nests (22.2%) in the study area were categorized as Grade 2, and were sufficiently damaged such that egg viability would have been unlikely had the eggs not previously been collected.

Some (46.0%) nests (Grade 0) in the study area were unaffected by the burn because surrounding water limited fire damage. The nature of alligator nest construction may serve as a protective agent. The female alligator gathers surrounding vegetation to shape the conical nest mound (Joanen 1969). Thus, the majority of the adjacent vegetation is removed, leaving bare moist soil around the nest creating a natural firebreak. Marsh fires are frequently patchy, as fires move amongst clumps of irregular vegetation. Certain nests may have been spared due to position and natural firebreaks of interspersed ponds and bayous. Summer lightning fires are often localized by associated rain occurring with the thunderstorm (Nyman and Chabreck 1995).

In many crocodilians, nesting occurs during the wet/rainy season, when wildfires are rare (C. Manolis, pers. commun.). In late 1995, some nesting areas for *Crocodylus novaeguineae* (a dry season nester) in Papua New Guinea were burned extensively; 1 completely burned nest and 1 partially burned nest were observed (C. Manolis, pers. commun.). Presumably, nest losses due to fires would be greater in years of drought or low water levels than in years with above average rainfall. Precipitation was approximately average on Rockefeller in 1995 with 168.3 cm as compared to the average 1990–1995 annual rainfall of 176.8 cm.

Eggs collected and incubated from the Grade 0 nests had hatch rates comparable to eggs collected from nests in non-affected areas. Because I was unable to locate any Grade 1 nests containing eggs, I was not able to determine if superficial or moderate burning would adversely affect hatch rates of alligator eggs in the nest cavity. Viability may have been affected by temperature extremes or oxygen depletion due to fire. At temperatures > 36 C, alligator embryos fail to develop beyond stage 18, and at incubation temperatures of 35 C, embryonic survival is only 11% (Lang and Andrews 1994). As previously noted, I was able to document embryonic mortality probably caused by the fire in 1 of the Grade 2 nests located. Burned eggs from another Grade 2 nest were infertile, and the other Grade 2 nest with eggs was depredated.

Some studies have suggested that habitat alteration due to burning may not adversely affect alligators or may be beneficial (Cypert 1961, Vogl 1973, Lyon et al. 1978, Landers 1987). Cypert (1961) reported that the alligator population appeared unchanged after extensive wildfires in the Okefenokee Swamp, and probably thrived on conditions secondary to the antecedent drought (prey concentration in the few remaining open water areas). After an experimental controlled burn in a Florida wetland, Vogl (1973) found that only 1 alligator was found on the unburned shoreline, while 20 (ranging in length from 1–3.5 m) were observed on the burned shoreline. Alligators may have moved to preferentially use the burned shoreline habitat, or they may have been more easily observed because of reduced cover. Landers (1987) suggested that aquatic herpetologic species which thrive in or adjacent to sizable water bodies are probably affected little by fire, while Lyon et al. (1978) stated the American alligator and other marsh animals benefit from occasional burning of shoreline vegetation.

A recent review on the use of fire in coastal marshes suggests that alligators may be unable to find sufficient nest material in marshes burned in late winter (Nyman and Chabreck 1995). On Rockefeller Refuge, a 200-ha natural fire occurred on 1 April 1981, much later than usual winter prescribed burning and just prior to initiation of alligator nest construction in late May/early June. Nesting effort in the affected area averaged 12 nests/year in the 2 years prior to and the 2 years after this fire. No nests were built in the interior of the burned area in 1981, probably due to a lack of vegetation for nest construction. However, the area clearly had recovered by the 1982 nesting season. Similarly, crocodile nesting habitat in floodplains of the Adelaide River in the Northern Territory of Australia recovers during the next wet season after a burn (C. Manolis, pers. commun.). Conversely, swamp habitat in the same region takes much longer to recover; little nesting has occurred in an area of the Melacca

swamp that burned several years ago (C. Manolis, pers. commun.; J. Scott, unpubl. honours thesis, Northern Territory Univ., Darwin, Australia, 1994). Scott noted a 40% reduction in *Crocodylus porosus* nesting in a section of that swamp which burned in the 1987 dry season. The area had not recovered after 7 years.

To my knowledge, this is the first documentation of the effects of burning on eggs in alligator nests. Recent development of an extensive alligator farming/ranching program in Louisiana has made alligator nesting/egg availability an important part of land management goals in coastal marshes (Joanen and McNease 1991). Thousands (150,000–300,000) of alligator eggs have been collected annually in Louisiana in recent years as a source of stock for alligator farms. The economic revenue from this resource encourages land managers to preserve their wetlands and maintain quality alligator habitat (Perry et al. 1993, Joanen et al. 1997).

Many land managers attempt to control water levels in their marshes to enhance alligator nest production (Joanen and McNease 1989). Maintaining adequate water levels would also minimize damage from lightning strikes, which could intensify under drought conditions. Alligator nest/egg losses could be costly if wildfires were widespread; nearly one-quarter of the nests in our study were deeply burned. Fortunately, lightning fires are usually localized.

It can be advantageous for alligator ranchers to collect alligator eggs early in incubation to avoid later flooding, predation, and desiccation. Predation levels vary tremendously and have been reported from a low of 6.6% in the Florida Everglades (Kushlan and Jacobsen 1990) to 86.4% in Georgia's Okefenokee Swamp (Metzen 1977). Flooding is a widely variable factor causing nest losses. Studies in Louisiana, Georgia, and Florida have documented flooding rates of 2.1%, 3.6%, and 6.8% (Joanen 1969, Metzen 1977, Dietz and Hines 1980). However, catastrophic flooding can inundate alligator nests, resulting in total mortality (Joanen et al. 1977, Joanen and McNease 1989). In 1973 tropical storm Delia flooded 52.6% of the alligator nests monitored in a study on Rockefeller Refuge (Fleming et al. 1976), and tropical storm Beryl in 1988 led to 100% mortality of alligator nests marked on Manchac Wildlife Management Area in southeastern Louisiana (Platt 1990). The present study suggests alligator egg mortality can also occur as a result of summer lightning fires, thereby providing another reason alligator egg collections should be scheduled early after oviposition, although avoiding the sensitive period when mechanical damage due to transport is likely (Joanen and McNease 1987).

Egg mortality and nest losses may have been greater as a result of the fire described if it had been an excessively dry year; if the marsh had not been controlled burned regularly, limiting fuel substrate; or if the great majority of eggs in the affected area had not already been collected early in incubation. Although not as common as predation nor as deleterious as major flood events, uncontrolled wildfires can be an important mortality factor limiting alligator nesting success.

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