AQUATIC COMMUNITIES OF THE OKEFENOKEE SWAMP

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Abstract. The Okefenokee Swamp lies over a perched water table on the Coastal Plain of southern Georgia. The swamp ecosystem consists of a mosaic of aquatic communities: cypress swamps, blackwater lakes, sand islands, floating peat batteries, prairies, and tree islands. It is kept in a dynamic disclimax by disturbance and hydroperiod. Nutrients, bound within refractory dissolved organic matter and peat, are released by physical processes such as drying, fire, and degradation by light. Maintenance of groundwater levels and hydroperiod is essential for the dynamic integrity of the swamp.

SITE DESCRIPTION

Within the southeastern Coastal Plain of Georgia lies a natural gem, the Okefenokee Swamp. Unlike anything materially precious, it has its value in the complexity and beauty of its ecosystem. The Seminoles named it "land of trembling earth" and hunted game and sought refuge within its boundaries. Sparse settlement in the mid-nineteenth century by "swampers" or "Georgia crackers" drove out the native Americans. Since the early 1900's, logging, canals and the building of the Suwannee River Sill in 1960-1962 have significantly altered the face of the swamp (Trowell, 1984; Cohen et al., 1984; Patten and Matis, 1984; Malcolm et al., 1994). Today, four fifths of the 1,754 km^2 swamp is protected and managed by the Department of Interior as a National Wildlife Refuge. The Swamp has been studied extensively for the past 25 years by faculty and students at the University of Georgia (see theses and publications in literature cited). Georgians are, therefore, in a position to effectively manage, maintain, and protect this fragile, dynamic ecosystem.

Biogeochemistry

The Okefenokee is a southern blackwater swamp (Mitsch and Gosselink, 1993), defined by its acidic, tea-colored water with an average pH of 3.5 to 3.9 (Blood, 1980; Auble, 1982). Swamp waters have 46 to 58 mg C/l of dissolved organic matter (DOM) with 63-78% of the dissolved carbon occurring as humic and fulvic acids originating from decomposing plant matter (Bano et al., in press). Due to the immobilization of nutrients in the peat and refractory DOM, the Okefenokee Swamp is poor in available nutrients (Flebbe, 1980). As a result, life in the swamp is dependent on abiotic processes, such as cycles of drying and inundation called hydroperiod (Blood, 1980; Duever and Riopelle, 1984), fire (Rykiel, 1984; Patten and Matis, 1984), and UV light mediated decomposition of DOM (Bushaw et al., 1996), to stimulate nutrient release and subsequent microbial and plant production. Decomposition of peat can also release toxins such as mercury that bioaccumulate in the food chain (Arnold-Hill et al., submitted). Nutrient regeneration in the swamp must be effective because the swamp has high microbial biomass and production (Murray and Hodson, 1984) and fish production (Freeman and Freeman, 1985).

Geology and Hydrobiology

The perched water table of the swamp lies above the Miocene limestone Hawthorne Formation in the coastal terrace province of Georgia and northern Florida (Cohen et al., 1984; Patten and Matis, 1984; Malcolm et al., 1994). Ground water and standing water up to 3 m deep is retained by clay layers below and to the east by a Pleistocene dune formation, Trail Ridge (Rykiel, 1984; Malcolm et al., 1994).

Water inputs to the swamp system are from precipitation (61%), runoff (39%) (Blood, 1980; Patten and Matis, 1984), groundwater additions (less than 2%) which are believed to be from the Trail Ridge region (Rykiel, 1984), and perhaps from springs (Malcolm et al., 1994). Patten and Matis (1984) state that surface sheet flow occurs mainly to the south and water leaves the swamp through the Suwannee River (71%), Cypress Creek (17%) which flows into the Suwannee, and the St. Mary's River (12%).

Plant Communities

Atop this underlying geology, the swamp has developed into a dynamic mosaic of modern habitats (Patten and Matis, 1984). Today, 46% of the 3,781 km^2 Okefenokee watershed is swamp and 54% is pine upland. Hamilton (1982) describes the swamp proper as more biotically diverse than the surrounding uplands and composed of the following typical habitat types: shrub swamps (34% of total swamp area), black gum forests (mainly in the NW and <6%), bay forests (<6%), mixed cypress forests (23%), *Carex* sedge prairies (21%), and tree islands (about 70 of them making up 12% of the swamp), as well as open water and lakes. The majority of peat (80%) is formed by waterlilies (*Nymphae odorata*) and cypress (*Taxodium*).

The successional climax community would be southern mixed hardwoods, but it is never realized due to continuous natural and anthropogenic disturbance. The model for plant community succession is from open marsh to cypress, or from shrub swamp to broad leafed evergreen or mixed hardwood forests (Hamilton, 1982; Glasser, 1986). Plant succession is routinely set back by such factors as historically frequent fires (INR Progress Report, 1987), the upwelling of peat batteries due to outgassing of methane from peat decomposition (King et al., 1981), and the influence of the fluctuating water table (Greening and Gerritsen, 1987). In the early 1900's, canals were dug and the swamp was logged of its dominant cypress communities, further altering evapotranspiration, water flow and community structure. These recurring disturbance regimes lead to a heterogeneous and ever changing "disclimax" ecosystem with a mosaic of habitats.

Animal Communities

Micro-organisms. Open water areas in the swamp are filled with microscopic bacterial, algal and zooplankton communities that live in association with the sediments, peat, and aquatic plants (Moran et al., 1988; Freeman et al., 1984; Schoenberg, 1986). During periods of high water, these aquatic microinvertebrate communities spread extensively into the prairies and increase the foraging range for higher trophic levels which include predatory insects, fishes, birds, turtles and alligators (Laerm et al., 1980). Utilization of decomposing plant material by these aquatic food webs is insignificant (Moran et al., 1988). The majority of food webs originate directly from the consumption of microbial, algal and plant production. One unique aquatic subcommunity is the *Utricularia*-periphyton association (Bosserman,1979). This self-contained system includes carnivorous plants commonly known as "bladderworts" and their associated microorganisms: algae, rotifers, crustaceans, insects, annelids, protists, platyhelminthes and gastrotrichs. Tight nutrient recycling within this microecosystem allows it to become abundant in the nutrient poor open waters of the swamp.

Insects. Insects play an important role in the cycling of nutrients (Auble, 1982; Gist and Risley, 1982). Insects are accountable for a projected 8% of total standing crop consumption of *Carex* sedge in the prairies. From 12 to 40% of the forest canopy is consumed, primarily by nocturnal Lepidoptera. Feeding by insects converts vegetation to frass that can readily be recycled at rates comparable to those in tropical rain forests (Auble, 1982; Gist and Risley, 1982; Hamilton, 1984).

Vertebrates. Within the swamp there is evidence of lower diversity of some smaller, fragile species relative to the typical biota for the southeastern US (Cohen et al., 1984). This may be due to harsh swamp conditions such as oligotrophy, blackwater, low oxygen concentration, low pH, and flooded organic soil. However, the vertebrates exhibit a higher diversity than otherwise found in the surrounding areas because of the diversity of habitats (Laerm et al., 1980). Vertebrates observed within the swamp are typical of the surrounding Coastal Plain area. Although there are no endemic species, in 1978-1980 there were 420 different species recorded. This diverse number includes 36 fishes, 37 amphibians, 66 reptiles, 233 birds, and 48 mammals. Eleven of these are threatened species, including the red wolf and the Florida panther (Larem et al., 1984).

Reptiles. There is an especially high species diversity of reptiles in the Swamp. Among the many reptiles observed are the American alligator and the spectacled caiman. Due to the softness of peat coupled with their feeding behavior, alligators have been known to create "gator holes" that eventually become sanctuaries for many aquatic animals, especially during the drier months. These creatures have a significant impact on the landscape and structure of the Florida Everglades and their presence is correlated with modifications of habitat in the Okefenokee Swamp as well (Mitsch and Gosslink, 1993; Laerm et al., 1980).

Birds. The many species of birds in the swamp are limited by the availability of suitable nesting habitat, which is at least as important as food resources to bird survival. There are fewer terrestrial birds present than one might expect (Meyers, 1982), however, aquatic bird diversity is high. Sandhill cranes, herons, and storks, are drawn to the Okefenokee National Wildlife Refuge. Aquatic birds also have a unique impact on nutrient cycling in the swamp, similar to that of insects, but much greater in magnitude. Nutrient-rich bird waste is concentrated at the site of bird colonies or "rookeries". The continued influence of guano even in abandoned rookeries is seen when higher waters of the hydroperiod cycle flush out the peat-trapped nutrients. Increased concentrations of nutrients in the water surrounding an active rookery alter water chemistry and the distribution and production of plant life.

Fish. Common fish species observed within the boundaries of the swamp include mosquitofish, sunfish and largemouth bass, topminnows, Florida gar, bowfin, and pickerels (Laerm and Freeman, 1986). Minnows have a low tolerance for high acidity and consequently are not observed within the swamp. Fluctuations in temperature and depth of shallow waters are especially harsh for the fish populations. In the natural cycle of hydroperiod, conversion of peat from anaerobic to aerobic, dry conditions produces a rapid release of nutrients. The reinundation of prairies and the increased nutrient levels increase production of algae and zooplankton, the basis of the food web. Smaller fish can respond with rapid reproductive rates and their populations increase. However, sustained higher water levels allow larger predator species, such as turtles and alligators, to establish widespread populations in the swamp. This has a direct, adverse effect on the usually dominant smaller, prey species. Drought periods lower water levels which subjects fish to the predatory affects of odonates, hemiptera, and coleoptera in the drying prairies and alligators and turtles in the subsiding lakes and canals. Smaller fish populations especially appear to be regulated by the prevalence of predatory Odonates whose populations are also managed by the effects of water drawdown (Freeman and Freeman, 1985).

CONCLUSIONS

The community structure, nutrient cycling and production dynamics of the Okefenokee Swamp are maintained in a dynamic disequilibrium. Water depth and cycles of flood and drought (hydroperiod) determine rates of nutrient cycling , productivity, and population growth. Anything that changes the hydrology can, therefore, have a major influence on the aquatic communities of the Okefenokee Swamp.

Human influence such damming and canals have altered water level and logging has changed the plant composition and evapotranspiration rates. Global climate change may have long-term effects on the swamp through predicted elevated temperature and increased rainfall. More immediate problems can arise from altered water table and flow regimes. These may occur if the Sill is altered, allowing increased drainage to the south, or if proposed titanium mining on Trail ridge allows flow of water toward the east.

Careful assessment of small-scale drainage patterns must be made and a water budget constructed that includes recent climate, vegetation and evapotranspiration patterns. This can then be used to predict effects on the mosaic of aquatic communities in the swamp.

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