

9.2.3 Integrated Hydrology and Water Quality

Direct rainfall and discharge from Lake Okeechobee onto a vast wetland landscape of low topographic relief, a pervious limerock geological setting, and a subtropical climate resulted in sheet flow and low levels of phosphorus and other chemical constituents in the pre-drainage Everglades. Together, these physical-chemical drivers defined the Everglades as a unique ecosystem and are a major influence on all of its ecological processes and attributes.

Restoration of the Everglades ecosystem depends on restoration of the volume, timing, and distribution of sheet flow and on restriction of inputs of phosphorus and other chemical constituents to levels approximating those in direct rainfall.

Sheet flow and inputs of phosphorus and other chemical constituents fundamentally affect all working hypotheses for greater Everglades wetlands ridge and slough landscape dynamics, plant community distributions along elevation gradients, predator-prey interactions of wading birds and their aquatic fauna forage base, crocodilian population dynamics, coastal salinity gradients, coastal transgression, and mangrove forest production.

Integrated Hydrology and Water Quality Conceptual Ecological Model

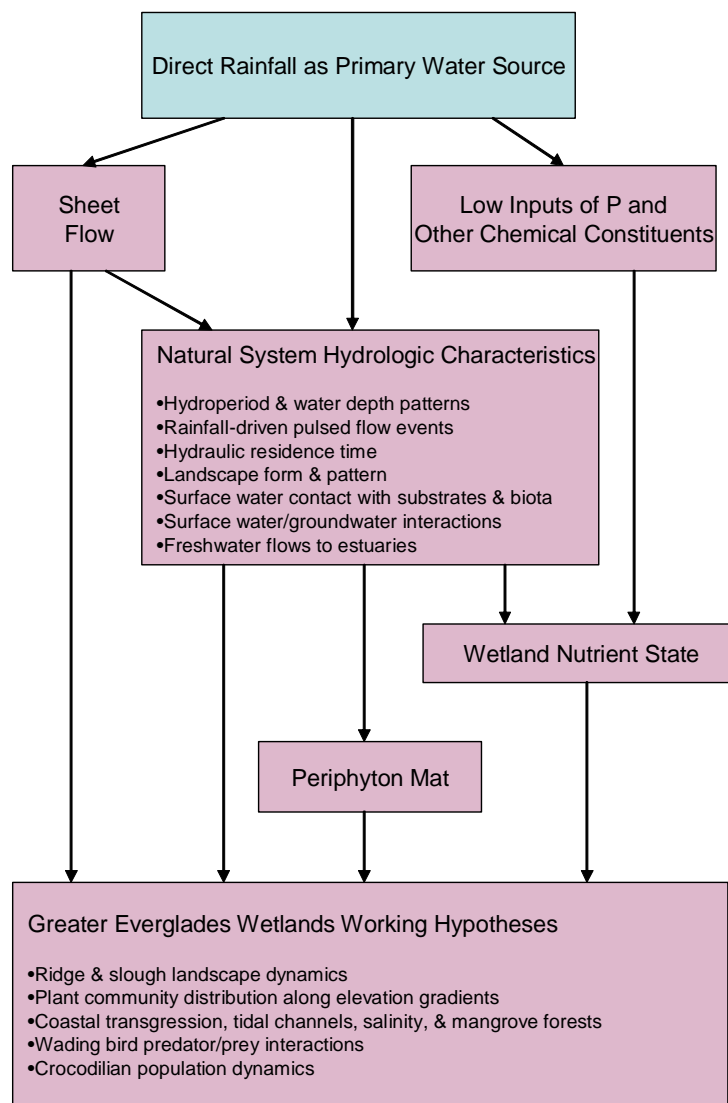


Figure 9-2-2: Integrated Hydrology and Water Quality Conceptual Ecological Model

Hypothesis 1

Rainfall and Sheet Flow as Determinants of Natural System Hydrologic Characteristics in the Everglades

The volume, timing, and distribution of sheet flow, in combination with direct rainfall, produced fundamental hydrologic and landscape characteristics of the pre-drainage Everglades that can be described by the following parameters:

- Hydroperiod and water depth patterns
- Rainfall-driven pulsed flow events
- Hydraulic residence time
- Landscape form and pattern
- Surface water contact with substrates and biota
- Surface water/groundwater interactions
- Freshwater flows supporting beneficial salinity patterns in the mangrove estuaries of Florida Bay and the Gulf of Mexico

Compartmentalization has altered or eliminated sheet flow and related natural system hydrologic and landscape characteristics throughout the Everglades. Decompartmentalization, combined with resumption of natural volume, distribution, and timing of freshwater delivery is expected to restore sheet flow and pre-drainage hydrologic and landscape characteristics to an undivided ecosystem encompassing much of Water Conservation Area 3A, Water Conservation Area 3B, eastern Big Cypress, and Everglades National Park.

Rationale: Specific hydrologic restoration targets associated with the resumption of sheet flow and related hydrologic characteristics include:

- Multi-year hydroperiods in ridge and slough landscape
- Conditions conducive to peat formation in ridge and slough landscape
- Hydropatterns that sustain co-existing sloughs and sawgrass ridges in the ridge and slough landscape
- No distinct or persistent changes in water levels across boundaries such as canals, levees, or roads
- Large-scale surface water flow directions that follow the historic landscape directionality
- Hydropatterns that support the long-term stability of tree islands in ridge and slough landscape
- Hydroperiods from two months to less than one year conducive to marl formation and muhly grass (*Muhlenbergia filipes*) community persistence in Southern marl prairies

- Persistent pools of fresh to oligohaline water along the interface of the freshwater Everglades and the mangrove ecotone of Florida Bay and the Gulf of Mexico
- Dry season water recession patterns conducive to successful wading bird foraging
- Multi-year flood and drought cycles supporting formation of wading bird super-colonies
- Absence of harmful regulatory releases of excess fresh water to the Greater Everglades
- Freshwater flow discharges to Florida Bay and the Gulf estuaries that maintain a near shore salinity gradient characteristic of pre-drainage conditions.

Natural system hydrologic restoration targets are necessarily qualitative due to uncertainty regarding pre-drainage hydrology. Successive iterations of the Natural System Hydrology Model (NSM) quantify these targets for planning purposes despite high levels of uncertainty. Successful restoration of natural system hydrologic characteristics as CERP is implemented ultimately must be guided by AM based on measured responses of the ecosystem to hydrologic changes.

Hypothesis 2

Nutrient Inputs and Sheet Flow as Determinants of Wetland Nutrient State in the Everglades

The dominance of direct rainfall as the primary source of water and phosphorus, in combination with sheetflow and related hydrologic and climatic characteristics, resulted in an oligotrophic, phosphorus-limited nutrient state throughout the greater Everglades wetlands prior to drainage.

Rationale: Increased phosphorus concentrations and loads in agricultural runoff water, and replacement of sheet flow with canal flows and point-source discharges, have produced phosphorus concentration gradients downstream of canal discharge structures, shifting wetlands from oligotrophic to eutrophic states. Water column total P concentrations are below ~10 ppb under non-enriched conditions in the Everglades. Most harmful ecological responses to P enrichment occur within a range of mean annual water column total P concentrations between ~10-30 ppb.

Reduction of the magnitude of nutrient inputs to the Greater Everglades will have the following effects:

- Reductions in phosphorus in inflow waters to the Greater Everglades will influence the downstream rate of recovery of ecosystem components.
- Existing gradients of phosphorus, nitrogen and sulfur will decrease between input locations and Everglades National Park.

- Where water quality constituent gradients currently do not exist, none will form.
- Non-impacted areas immediately downstream of impacted areas may be affected by phosphorus currently present in the impacted areas, *i.e.*, presently enriched zones in WCAs will continually move south, especially under sheet flow conditions.
- Phosphorus and nitrogen concentrations in soil, flocculent organic matter, and periphyton will reflect patterns and trends in surface water concentrations, integrated over various time scales, from months to years.

Hypothesis 3

Nitrogen Dynamics in the Everglades

Nitrogen dynamics, such as rates of nitrification, denitrification, uptake of inorganic nitrogen species, and production of organic nitrogen, are dominated by local cycling and processing under natural conditions in the Everglades.

Rationale. The importance of local nitrogen cycling and processing presently increases with distance from surface water inflow locations, while the importance of surface water nitrogen loading concurrently decreases. This trend is expected to continue under restored water inflows and associated nitrogen loadings.

Hypothesis 4

Periphyton Mat as an Indicator of Integrated Hydrology and Water Quality in the Everglades

Periphyton mat structure and community composition integrate hydrology and water quality across the entire wetland system of the Everglades. Hydrology and water quality interact to create a mosaic of periphyton community types throughout the Everglades.

Rationale: Periphyton responds quickly (weeks to months) to alterations in water management and can serve as early warning indicators of ecosystem change.

Shortened hydroperiods cause:

- Reduced proportion of diatoms and green algae relative to cyanobacteria
- Increased calcareous blue-green algae, possibly reducing food value of periphyton
- Increased proportion of sediment or plant-stem associated mats as opposed to floating mats attached to floating macrophytes (such as *Utricularia purpurea*).
- Decreased organic ash weight ratio of periphyton

Phosphorus enrichment through increased loading causes:

- Elevated nutrient content of periphyton material
- Increased organic content of periphyton communities

- Reduced calcareous floating and epiphytic periphyton mats
- Replacement of low nutrient-tolerant species by non-mat forming filamentous green algal species

Periphyton productivity is very high in the oligohaline zone of the southern Everglades. Increased freshwater delivery may broaden this zone of high periphyton productivity.

Detection of periphyton response to changes in hydrology and water quality needs to be based on comparison to a habitat-specific baseline (i.e. ridge and slough, marl prairie, rocky glades, or oligohaline zone). In addition, the effects of grazing on the periphyton community composition should be quantified.

9.2.4 Coastal Transgression, Tidal Channel Characteristics, Salinity Gradients, and Mangrove Forest Productivity

Ecological processes and attributes in the mangrove coastlines of the southern Everglades are hydrologically controlled by interactions between overland sheet flow from freshwater wetlands and the waters of the Gulf of Mexico and Florida Bay. Changes in freshwater flow from the implementation of CERP projects are relatively short-term in comparison to the longer-term, progressively increasing changes in salinity and coastal hydrologic budgets resulting from relative sea level rise.

The rate of relative sea-level rise in south Florida increased began increasing in about 1930. Since that time, relative sea-level in south Florida has increased about 23 centimeters (9 inches), or 30 cm (one foot) per century. Anticipated responses of sea level rise to global warming is projected to result in a global increase in sea level of about 60 centimeters (two feet) in the coming century.

The CEMs presented in this section differ from the others in this document in that the endpoints are the results of the impact of the stressors as manifest through the causal pathways.

Coastal Transgression Conceptual Ecological Model

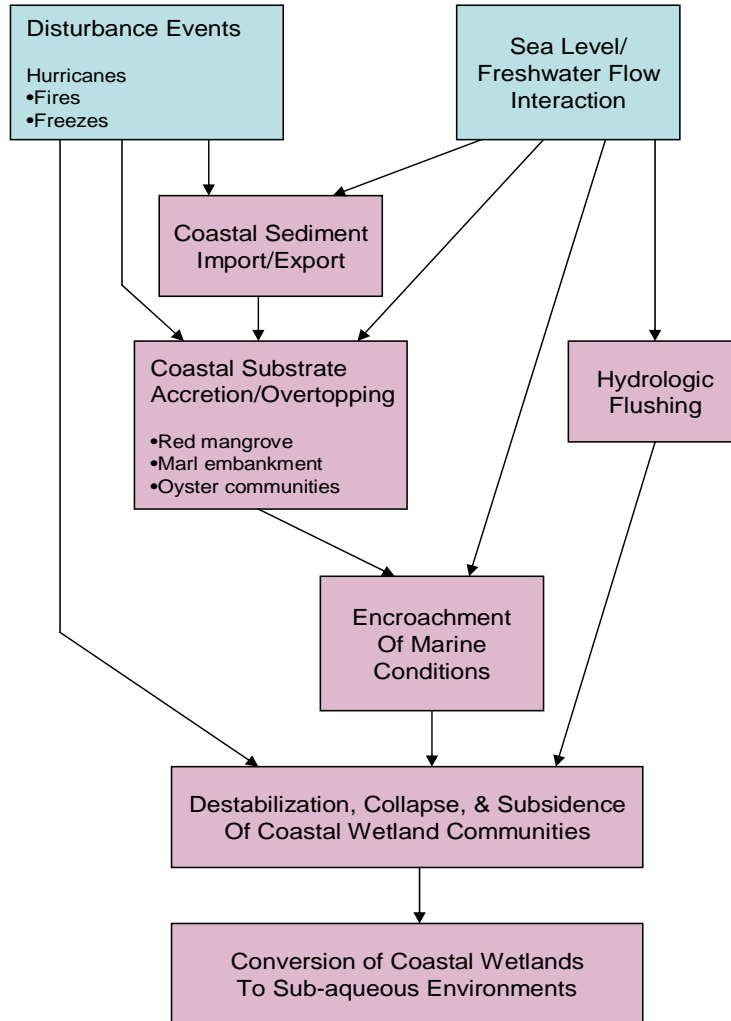


Figure 9-2-3: Coastal Transgression Conceptual Ecological Model

Hypothesis 1

Sea Level and Freshwater Flow as Determinants of Coastal Transgression

Sustained substrate buildup by physical and biological processes in many coastal marl and mangrove environments of South Florida may not be capable of keeping up with rates of sea-level rise during the 21st century.

Where rates of peat or marl elevation buildup do not keep up with rates of sea level rise, shoreline transgression and landward salinity intrusion into mangrove and freshwater wetlands will occur.

Rationale: Red mangrove forests in south Florida can potentially accrete organic peat substrate at 2-6 mm/year. Disturbances (major hurricanes, fire, freeze, and changing flushing) disrupt these peat accretion rates and commonly result in alternating phases of substrate subsidence and decay. Salinity stress may also reduce accretion rates. In this time of rapidly rising sea level, most mangrove communities are presently losing area of coverage. In the coming century the coastal mangrove community may be expected to become increasingly dissected. Sustained rates of accretion of coastal marl shorelines of Florida Bay may also be incapable of keeping up with the rate of sea level rise, and over-topping and breaching of embankments during storm events are likely under future scenarios of rising sea level.

Where rates of peat or marl elevation buildup do not keep up with rates of sea level rise, shoreline transgression and landward salinity intrusion will lead to mangrove erosion along shorelines and mangrove movement into interior landscapes. Saline intrusion into freshwater wetlands underlain by peat substrate may lead to wetland community collapse and transformation to open, saline ponds and estuaries. Saline intrusion into marl substrate wetlands results in an advancing zone of diminished productivity (this is often called the “white zone”). Restoration of freshwater flow volume, timing, and distribution may slow the inland movement but it is not expected to change the rate of erosion along the shoreline.

Hypothesis 2

Sea Level and Freshwater Flow as Determinants of Tidal Channel Characteristics

The dendritic pattern, channel width and depth, flow volume, and material transport of tidal watercourses and channels through the coastal mangrove estuaries are controlled by sea level interacting with the volume, timing, and distribution of sheet flow and channel flow from the southern Everglades.

Rationale: Restored freshwater inflow from the Everglades is expected to help sustain open watercourses through the estuary that will more closely resemble historic patterns, and re-open some channels that have partly filled because of reduced flow. Sea-level rise is expected to modify the patterns of connectivity and channel patterns through the coastal wetlands and create increased sediment loads.

With rising sea level, offshore marine waters become connected to interior depressions (interior lakes and collapsed freshwater marsh areas) by a combination of connecting channels, sheet flow through wetlands, and/or flow across inundated ridges, such as the buttonwood embankment. These connections increase the flood tidal prism (area and volume of flood tidal water) and result in enhanced flood and especially ebb tidal flow. This process is expected to result in stronger tidal currents through channels resulting in enhanced erosion and widening of those channels. Such conditions are expected to result

in an increased import and/or export (depending on setting) of particulates, nutrients and dissolved organics. Sea-level rise is expected to destabilize many coastal and nearshore marine sedimentary environments resulting in increased movement of fine-grained sediment in the coastal zone. Significant portions of this sediment probably will be moved inwards through tidal channels into interior coastal bays and wetlands.

Tidal Channel Characteristics Conceptual Ecological Model

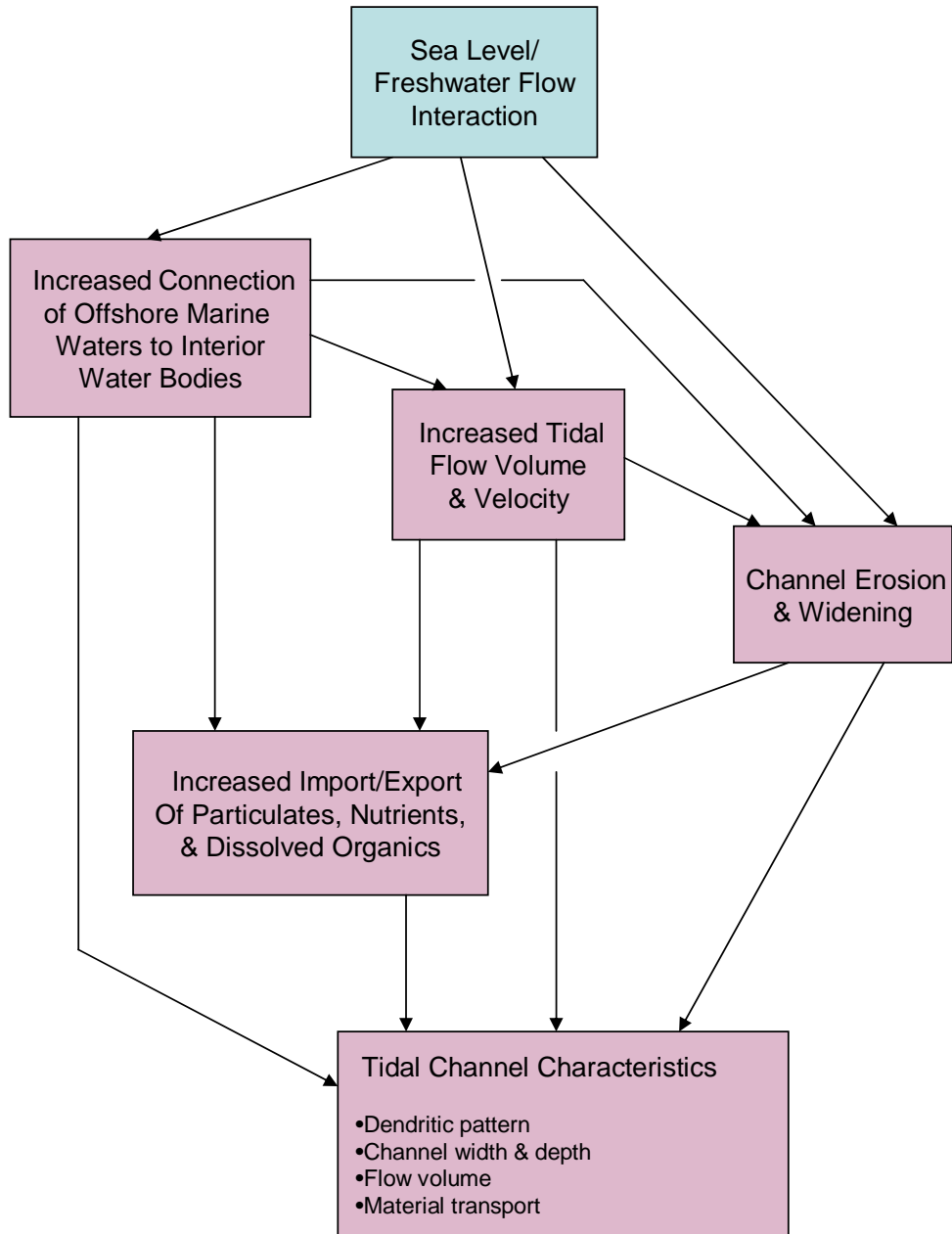


Figure 9-2-4: Tidal Channel Characteristics Conceptual Ecological Model

Hypothesis 3

Sea Level and Freshwater Flow as Determinants of Coastal Salinity Gradients

Sheet flow in the southern Everglades prior to drainage produced prolonged pooling of fresh water upstream of the mangrove estuaries and prolonged patterns of freshwater flow into the mangrove estuaries.

The freshwater pooling and inflow supported a wide salinity gradient, including a broad oligohaline zone, in the mangrove estuary.

A combination of historical reduced freshwater flow and increased relative sea level rise has resulted in higher salinities in the formally estuarine mangrove zone and significant saline intrusion into former freshwater marshes of the lower Everglades.

Rationale: Increasing seasonal freshwater sheet flow to the lower Everglades is expected to provide a broader zone of salinity gradients in the lower Everglades and coastal wetlands and should, in the short term, re-establish an oligohaline zone in the coastal wetlands.

Although surface water salinities fluctuate laterally through the wet and dry seasons, saline groundwater intrusion has moved and remains far inland of the position at the turn of the last century. The freshwater/saltwater interface in the shallow aquifer is slower to respond. The response or movement of the interface depends on the intensity and duration of freshwater flow stoppage to the lower Everglades during the dry season.

Over a long-term period, rising sea level is expected to result in high tides overtopping coastal marl ridges and saline waters penetrating more deeply through tidal channels and mangrove forests, shifting inland the areas of fresh and lower salinity waters.

Coastal Salinity Gradients Conceptual Ecological Model

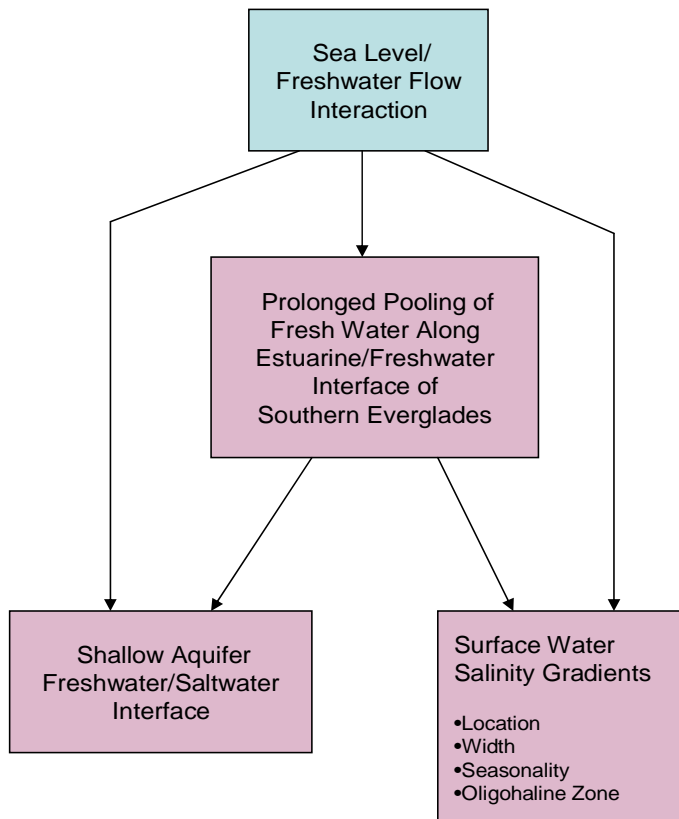


Figure 9-2-5: Coastal Salinity Gradients Conceptual Ecological Model

Hypothesis 4

Sea Level, Freshwater Flow and Phosphorus inputs as Determinants of Above and Belowground Production, Organic Soil Accretion, and Resilience of Coastal Mangrove Forests

Production and organic soil accretion in the mangrove forests of the coastal Everglades are controlled by phosphorus availability, with relatively high inputs from marine sources and low inputs from freshwater sources. Phosphorus availability, mangrove production, and soil elevation are thus driven by the opposing influences of sea level and sheet flow from the Everglades.

Resilience of the mangrove forests of the coastal Everglades after disturbance is dependent on hydrologic flushing by either fresh or saline water, which is driven by sea level and sheet flow from the Everglades. Resilience also varies with soil fertility.

Rationale: Aboveground biomass and production in the mangrove forests of Shark River Slough and other Gulf estuaries increase from the ecotone toward the Gulf of Mexico, reflecting the direct connection of these systems to the marine phosphorus source. Trees in the forests near the Gulf are able to allocate more biomass to aboveground growth. The dwarf mangrove forests along the northern margin of Florida Bay reflect suppressed levels of aboveground productivity, as influenced by minimal P supply from either the oligotrophic marshes of the southern Everglades or Florida Bay. High belowground production rates in the dwarf mangrove forests appear to be a biomass allocation phenomenon in which mangroves in the oligotrophic southern Everglades are foraging for nutrients. The counter-intuitive expectation is that maintenance of oligotrophic conditions in the southern Everglades [by increased freshwater inflows] may promote peat accretion in these mangroves.

Increased freshwater sheet flow caused by implementation of CERP projects is expected to maintain low nutrient conditions in the southern Everglades mangrove estuaries and in the oligohaline ecotone forests of the western mangrove estuaries. These low nutrient conditions are expected to enhance belowground productivity by mangroves, which will maintain peat production and soil elevation increases—ultimately enhancing the ability of these low salinity forests to maintain themselves against sea level rise.

An important feature for maintenance of an existing wetland environment, its recovery following disturbance events such as hurricanes, freezes, fires, or salinity changes, or the successful shift from one wetland type to another is maintenance of good flushing by either fresh or saline waters. This leads to an inland expansion of the white zone, or the mangrove-freshwater interface. Contraction and expansion of this “white zone” are regulated by freshwater flow dynamics and sea level rise. This phenomenon has implications for the long-term maintenance of mangrove communities and for mangrove communities trying to move into former sawgrass wetlands. Improved freshwater flow and flushing through the lower Everglades and coastal wetlands (through both channel and sheet flow) are expected to aid in recovery of wetlands from catastrophic setbacks (from hurricanes, fire, freeze and salinity changes).

**Mangrove Forest Production, Organic Soil Accumulation, and Resilience
Conceptual Ecological Model**

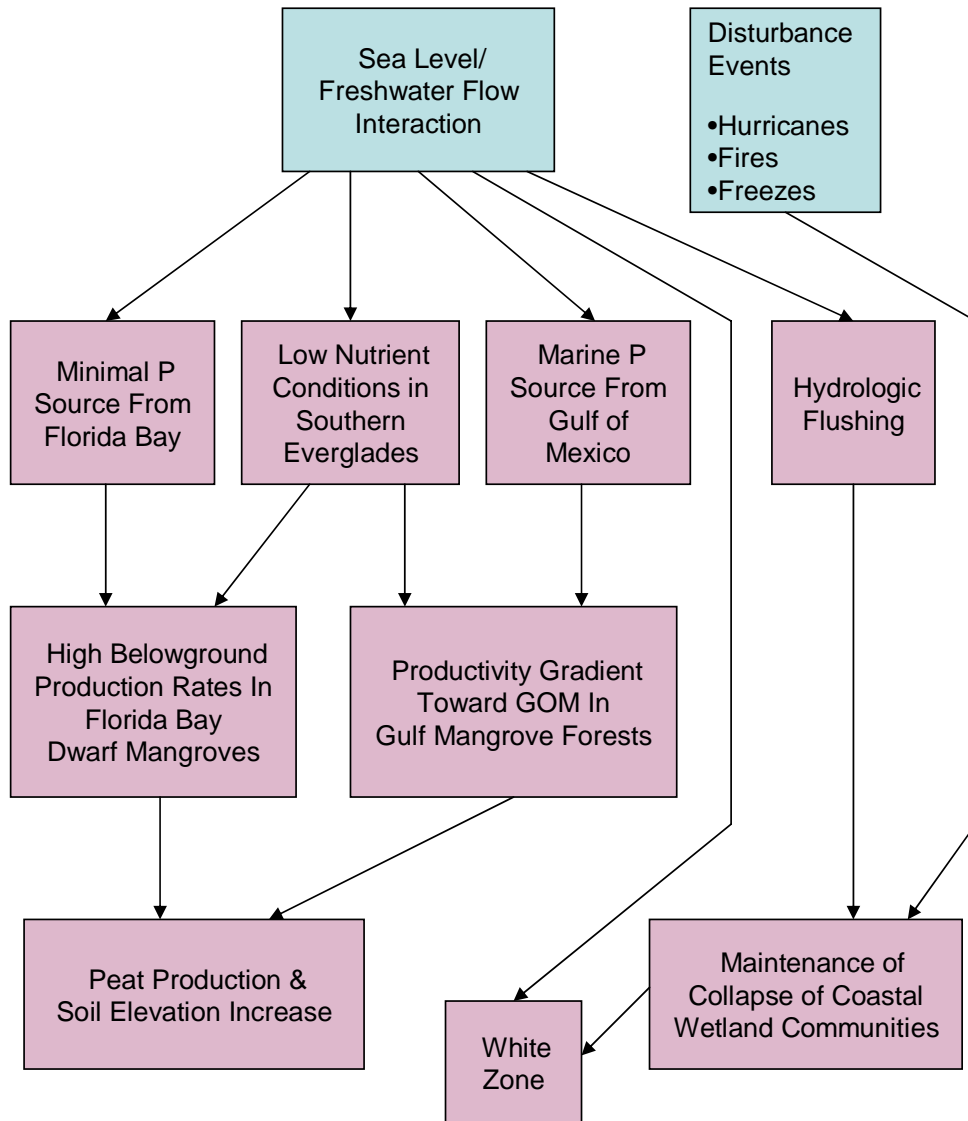


Figure 9-2-6: Mangrove Forest Production, Organic Soil Accumulation, and Resilience Conceptual Ecological Model

9.2.5 Wetland Landscape and Plant Community Dynamics

Hypothesis 1

Everglades Ridge and Slough Micro-topography in Relation to Organic Soil Accretion and Loss

Sheet flow interacts with hydroperiod, water depth, fire, and nutrient dynamics to maintain organic soil accretion and loss in a state of dynamic equilibrium.

Rationale: The dynamic equilibrium involves a balance of particulate organic matter transport, and the accumulation, oxidation, and combustion of organic soil. Altered magnitude, duration, and direction of sheet flow causes disequilibrium of accretion and loss processes. The disequilibrium is exacerbated by eutrophication. Disequilibrium of accretion and loss processes causes degradation in the ridge, slough, and tree island micro-topography toward a flattening of the landscape.

Restoration of sheet flow in combination with related hydrology, water quality, and fire patterns will re-establish the feedback conditions that sustain the micro-topography of ridges, sloughs, and tree islands.

Hypothesis 2

Everglades Ridge and Slough Landscape Pattern in Relation to Micro-topography

Degradation of micro-topography, changes in hydroperiod, water depth, eutrophication, fire, and vegetation, especially nonnative and invasive species, can reduce the diversity and stability of habitats which were previously long-term, large-scale features of the ridge and slough landscape.

Rationale: Decline in ridge and slough habitat diversity and stability includes expansion of sawgrass into sloughs and wet prairies, tree island drowning, tree island burn-out, conversion to cattail under eutrophic conditions, and takeover by exotic species, such as, *Melaleuca quinquenervia* and *Lygodium microphyllum*.

Resumption of sheet flow and related patterns of hydroperiod, water depth, water quality, and fire will significantly restore and sustain the microtopography, directionality, and spatial extent of ridges and sloughs and improve the health of tree islands in the ridge and slough landscape.

Ridge & Slough Landscape Dynamics Conceptual Ecological Model

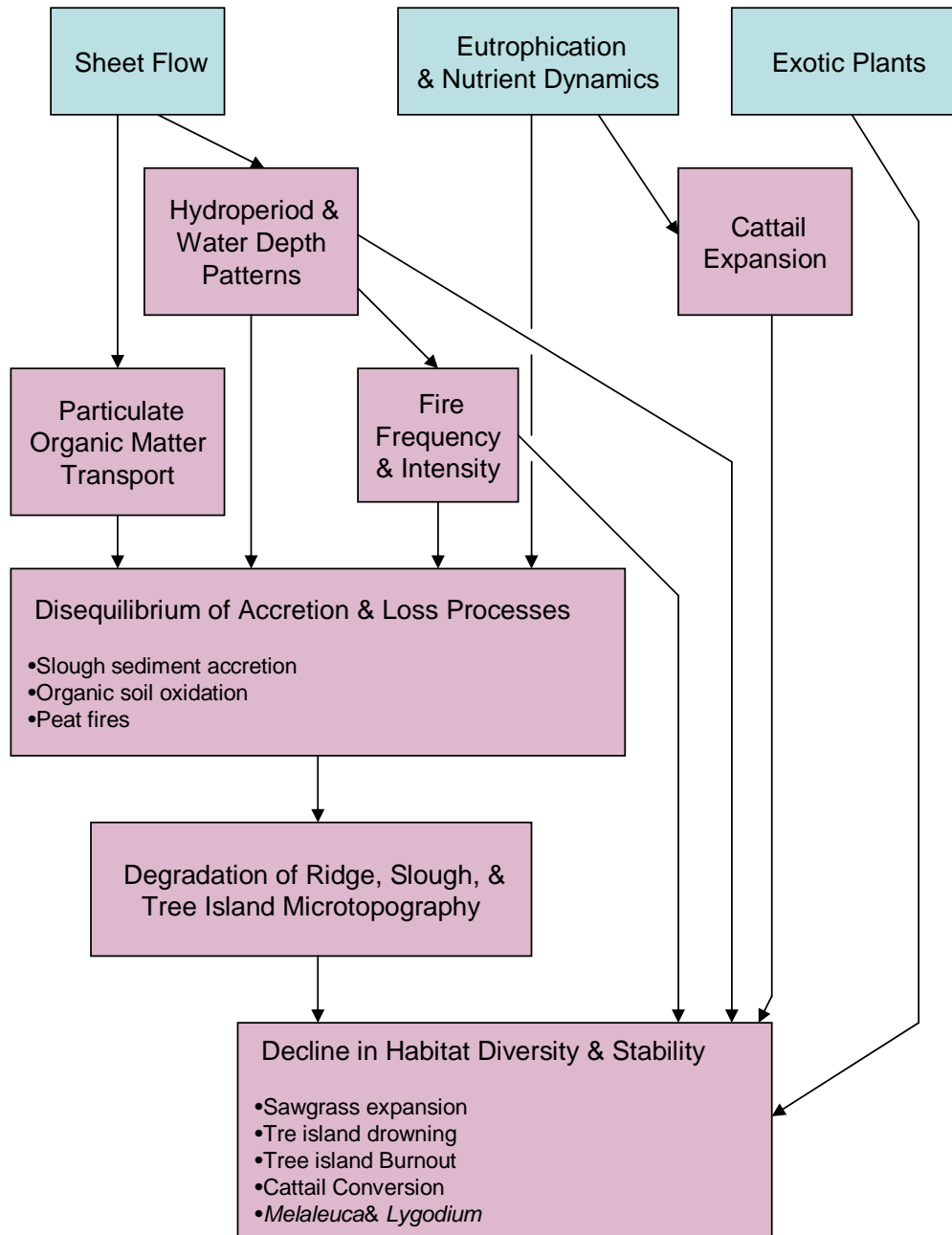


Figure 9-2-7: Ridge and Slough Landscape Dynamics Conceptual Ecological Model

Hypothesis 3

Plant Community Dynamics along Elevation Gradients

The composition and distribution of plant communities along elevation gradients are determined by patterns of hydroperiod, water depth, nutrient dynamics, and fire patterns throughout freshwater wetlands of the Greater Everglades.

Rationale: The dynamic equilibrium of the vegetation mosaic in relation to elevation gradients is maintained if biogeochemical processes in the soil support the physiological requirements of the vegetation. The dynamic equilibrium is altered if water depths or hydroperiods decrease or increase. Anthropogenic disturbances (i.e. past 100+ years) of hydroperiods, water depths, eutrophication, fire patterns, land use change, and the spread of exotic plants and animals have shifted the vegetation mosaic away from the historic dynamic equilibrium. These hypotheses are designed to focus monitoring and modeling at the ecotone boundaries between vegetation types which may be an early location of change.

In most of the greater Everglades wetlands where hydroperiods and water depths have decreased, the hydrologic tolerances of the surviving plant communities are adapted to greater hydroperiods and water depths than are currently maintained. For example, with regional drainage and altered fire regimes in the Big Cypress region there has been a gradual shift in landscape patterns, resulting in an increase in mesic rather than hydric-dominated communities.

Vegetation gradients between higher elevation marl prairies and lower elevation ridge and slough communities are of particular concern in the southern Everglades. Although a potential trade-off exists between ridge and slough habitat restoration and the extent and quality of habitat in adjacent marl prairies. It is thought that longer hydroperiods, greater water depths, and appropriate flow regimes will re-establish and sustain ridge and slough landscape patterns without significantly infringing on adjacent marl prairies, where short-hydroperiod, tussock growth habitats will persist.

Plant Communities/Elevation Gradients Conceptual Ecological Model

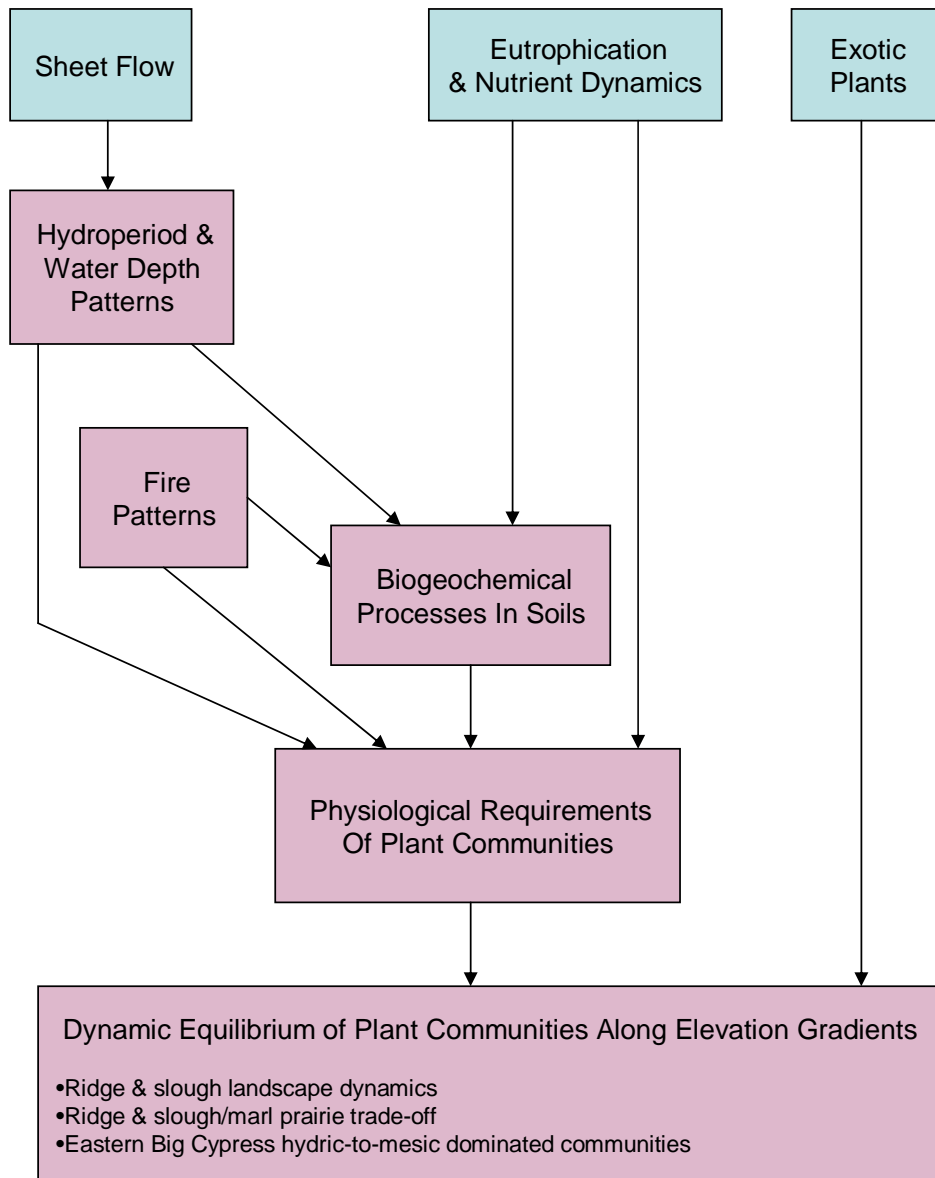


Figure 9-2-8: Plant Communities/Elevation Gradients Conceptual Ecological Model

9.2.6 Predator-Prey Interactions of Wading Birds and Aquatic Fauna Forage Base

The collapse of wading bird nesting colonies in the southern Everglades is attributed to declines in population densities and seasonal concentrations of marsh fishes and other aquatic prey organisms.

Restoration of natural hydrologic conditions will re-establish distributions of prey densities and concentrations across the landscape that in turn will support the return of large, successful wading bird nesting colonies to the southern Everglades.

Hypothesis 1

Aquatic Fauna Wet Season Prey Population

The wet-season density, size structure, and relative abundance of marsh fishes and other aquatic wading bird prey are directly related to the time since the last dry-down and the length of time the marsh was dry. Aquatic prey populations are further affected by salinity in coastal ecotones and by site nutrient status. Responses are non-linear and species specific.

Rationale: Persistent pools of fresh water, with multi-year hydroperiods and gradual water recession rates, occurred in ridge and slough landscapes and adjacent coastal ecotones of the southern Everglades under pre-drainage conditions. Expansive, naturally occurring pools in the southern Everglades have been replaced by artificial impoundments in the lower ends of Water Conservation Areas. As a result, population densities of aquatic fauna are low in much of the southern Everglades, while densities have increased in the artificial pools of the Water Conservation Areas, which now favor larger, longer-lived species.

Resumption of natural volume, timing, and distribution of freshwater flow will restore historical hydroperiods and salinity distributions to the southern Everglades. These changes are expected to increase wet-season density and size structure of wading bird prey in the southern Everglades within a four to seven year timeframe.

**Predator-Prey Interactions of Wading Birds and Aquatic Fauna Forage Base
Conceptual Ecological Model**

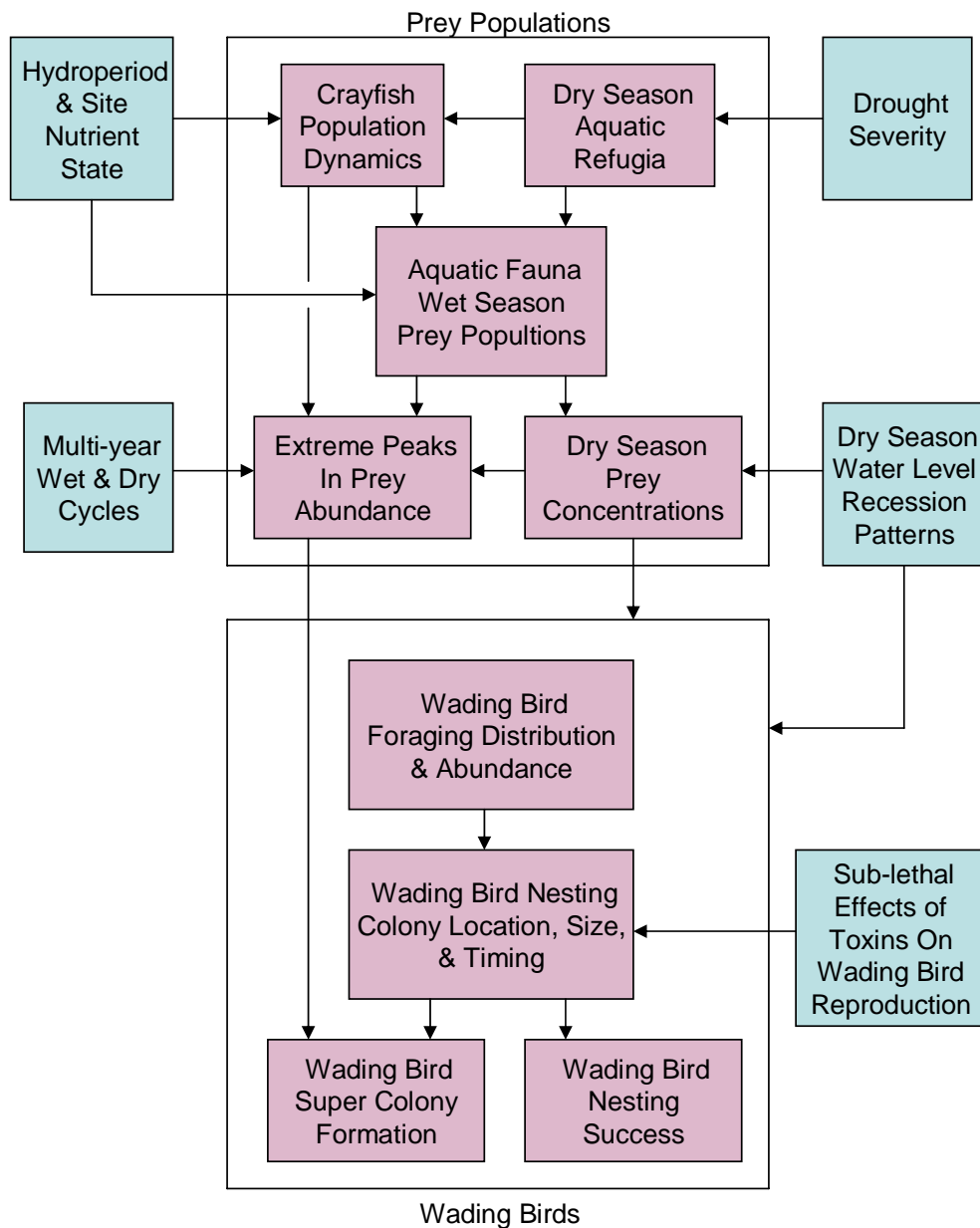


Figure 9-2-9: Predator-Prey Interactions of Wading Birds and Aquatic Fauna Forage Base Conceptual Ecological Model

Hypothesis 2

Aquatic Fauna Dry Season Prey Concentration

The concentration of marsh fishes and other wading bird prey into high-density patches where wading birds can feed effectively is controlled by the rate of dry-season water-level recession and local topography/habitat heterogeneity.

Rationale: Erratic water-level fluctuation in the remaining managed system, particularly in the Water Conservation Areas, commonly cause drying pattern interruptions, ultimately leading to ill-timed, fewer or less dense concentrations of aquatic fauna that serve as wading bird prey.

Drying edges extended along elevation gradients from upland pine flatwoods, and moved across marl prairies, to the lower-elevation ridge and slough and coastal landscapes as dry seasons progressed under pre-drainage conditions in the southern Everglades. The drying edges concentrated aquatic prey organisms and made them available to wading birds. Urban and agricultural development of the higher elevation eastern fringes of the southern Everglades, in combination with drying of marl prairies earlier in the dry season, have truncated in time and space the drying marsh edge and the concentration of aquatic prey organisms. During very wet years, the edge no longer occurs or occurs only briefly at the end of the dry season. In years with more typical rainfall, the edge may occur throughout the dry season, but it passes through the marl prairies very early and is well into the center of Shark Slough by the time it is needed to fuel wading bird nesting.

Resumption of natural volume, timing, and distribution of freshwater flow to the Everglades is expected to restore historical patterns of water level recession and drying edges, which will concentrate wading bird prey into a succession of high-density patches throughout the dry season in the remaining ridge and slough, marl prairie, and coastal landscapes.

Hypothesis 3

Wading Bird Nesting Colony Location, Size, and Timing

The collapse of wading bird nesting colonies in the tributary headwaters and southern mainland of the Everglades, the abandonment of Roseate Spoonbill nesting colonies in islands of northeast Florida Bay, and delay in the annual initiation of Wood Stork nesting have been caused by:

- decreased population densities of marsh fishes and other aquatic prey organisms in the southern Everglades, as described under Hypothesis 1
- a shift in the location and timing of seasonal concentrations of marsh fishes and other aquatic prey organisms, as described under Hypothesis 2
- reduced shallow-water foraging options for wading birds along elevation gradients

Rationale: Increased prey densities in artificial pools of the Water Conservations Areas have attracted wading bird nesting colonies to those areas after the collapse of the coastal

colonies. However, drying pattern interruptions in the Water Conservation Areas often disrupt prey concentrations that are required for successful foraging by the wading birds, resulting in failure of nesting colonies.

Restoration of historic spatio-temporal patterns of prey production and concentration is expected to reestablish wading bird nesting colonies in the coastal and tributary regions of the southern Everglades and Roseate Spoonbill nesting colonies in northeast Florida Bay. This restoration is also expected to increase numbers and success of nesting wading birds, Wood Storks, and Roseate Spoonbills and to cause Wood Storks to initiate nesting no later than January in most years.

Hypothesis 4

Wading Bird Super Colony Formation

Unusually large aggregations of nesting wading birds (super colonies) consisting of mostly White Ibis formed in the pre-drainage system in response to the effects of extreme, natural patterns of drought prior to colony formation.

Rationale: Super colonies periodically formed along the freshwater-estuarine transition zone (sawgrass-mangrove ecotone) at the lower reaches of the Everglades and Big Cypress basins. A substantial reduction in frequency of super colonies is attributed to disrupted multi-year wet and dry cycles, due to altered volume, timing, and distribution of flow in the managed system. Reduction in the size of super colonies may be related to reductions in wading bird prey populations due to reduced hydroperiods and disrupted water level recession patterns as described under Hypotheses 1 and 2.

Periods of extreme drought in natural multi-year wet and dry cycles appear to cue the occurrence of large pulses of secondary productivity that support the large nesting colonies which form after such droughts. The mechanisms by which these pulses are organized are poorly understood, but the effects of droughts on crayfish, predatory fishes, or nutrient dynamics may be involved. Population dynamics of crayfish (*Procambarus alleni* and *P. falax*) may play an important role, since the super colonies form when marsh fish populations would be expected to be minimal, and because White Ibis feed primarily on crayfish.

Resumption of natural patterns of volume, timing, and distribution of flow to the southern Everglades, in combination with interannual variation in rainfall, will restore natural multi-year wet and dry cycles as they would have occurred prior to drainage the southern Everglades. This is expected to stimulate pulses of secondary productivity that will likely involve Everglades crayfish populations. The pulses in secondary production are expected to result in an increase in the return frequency and size of ibis-dominated super colonies in the tributary headwaters of the Shark River and other Gulf of Mexico mangrove estuaries at a frequency of two or more events per decade.

Hypothesis 5

Linkage of Periphyton to Higher Trophic Levels

The floating mat comprised of the periphyton complex and various bladderworts provides critical support of the oligohaline Everglades food web, both as a food source and a refuge for aquatic invertebrates that are consumed by small fish, crayfish, and grass shrimp.

Rationale: The floating mat provides both food (algae and detritus) and habitat structure (hiding places) for macroinvertebrates, including midge larvae, nematodes, amphipods, and juvenile snails. The floating mat complex harbors much higher density of macroinvertebrates than epiphyton and benthic substrates; the daytime water column of oligotrophic Everglades wetlands is remarkably devoid of plankton, and relatively low densities of invertebrates emerge into the water column at night, compared to other North American ecosystems. These small invertebrates serve as a critical food source for Everglades consumers, including small fish, crayfish, and grass shrimp. Lengthened hydroperiods expand the aerial coverage of habitats where these food-rich mats are abundant. Shortened hydroperiod reduces the area of extensive floating mats and decreases the length of the season when habitat is available for aquatic organisms. These losses decrease standing crops available for consumption by higher trophic levels.

Higher nutrient levels stimulate invertebrate productivity, but change community composition to favor pollution-tolerant taxa. Short-lived low-level phosphorus enrichment leads to higher periphyton TP, which stimulates increased biomass and density of floating mat macroinvertebrate infauna. Macroinvertebrate community composition (relative abundance) changes with low-level nutrient enrichment, well below amounts favoring loss of the periphyton mat. The relative abundance of oligochaetes increases with enrichment, while amphipods and chironomids decline. However, sustained TP enrichment leads to dissolution of the floating mat, and loss of that habitat.

This hypothesis links the Everglades floating mat, and particularly periphyton primary productivity and detrital production, to higher trophic levels, which are the focus of management action.

**Linkage of Periphyton to Higher Trophic Levels
Conceptual Ecological Model**

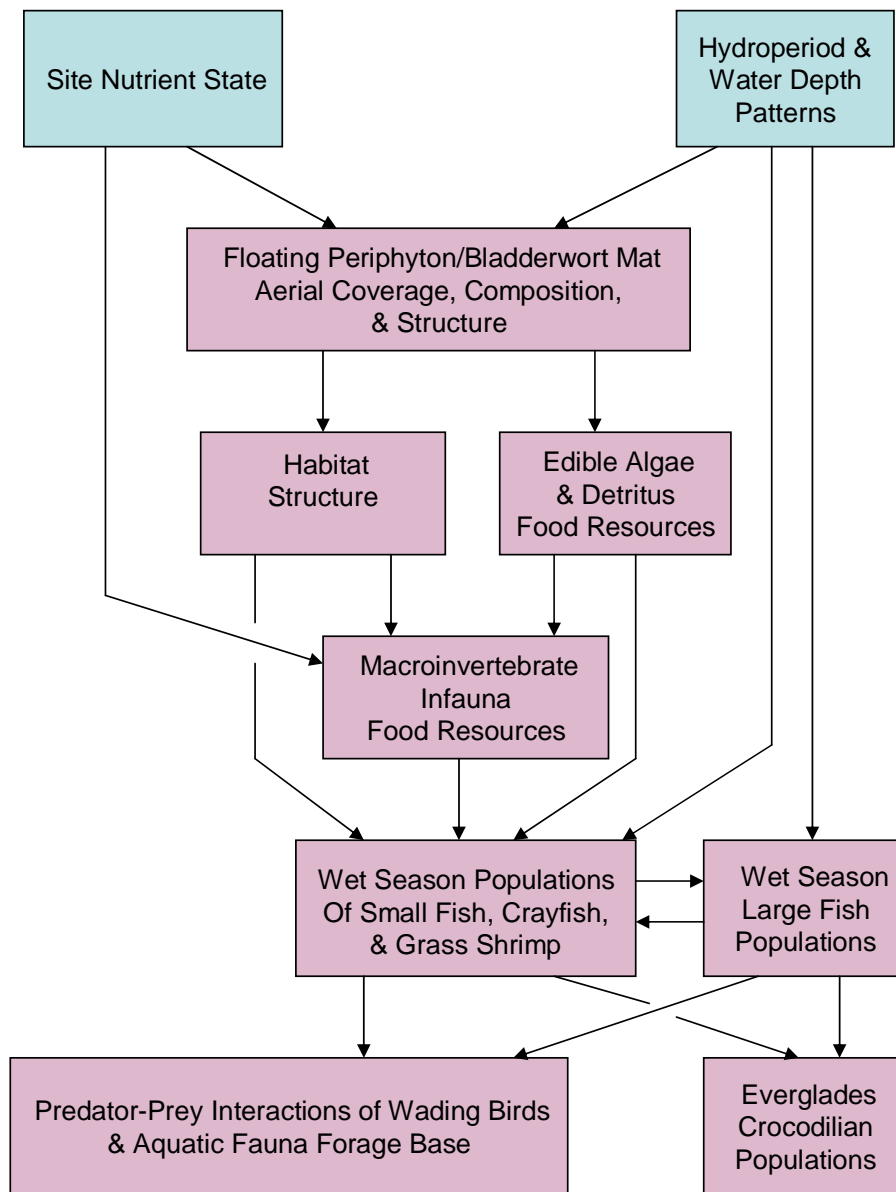


Figure 9-2-9: Linkage of Periphyton to Higher Trophic Levels Conceptual Ecological Model

9.2.7 Everglades Crocodylian Populations

Hypothesis 1

American alligator populations in relation to hydroperiod, water table, water depth, and salinity in the Everglades.

American alligator distribution, abundance, reproduction, and body condition in the Everglades are controlled by hydroperiod and water table in the Rocky Glades, salinity in the mangrove estuaries, and water depth patterns in the ridge and slough system, all of which were driven by direct rainfall and sheet flow prior to drainage.

Compartmentalization, disrupted sheet flow, and regulatory water releases restrict alligator populations in the ridge and slough landscape by causing nest flooding, unsuitable over-drained and pooled habitats in the Water Conservation Areas, and low hatchling and juvenile survival in canals during low water periods.

Rationale: Shortened hydroperiod and lowered water table in the rocky glades have reduced alligator abundance and reproduction because of loss of aquatic habitat required for survival and reduced aquatic prey base. A positive feedback loop of increased alligator populations and alligator holes (aquatic refugia) leading to increased aquatic fauna density (alligator prey) has been disrupted. That feedback loop is assumed to have been functional under pre-drainage conditions in the rocky glades where alligators were formerly abundant, although it is clearly not functional in the drained marshes today.

Reduced freshwater flow into the mangrove estuaries of the southern Everglades has resulted in succession of former freshwater mangrove areas to saltwater systems, reducing American alligator populations in tidal rivers and tributaries.

American alligator populations remain viable throughout most of the ridge and slough system. However, increased water depths during nesting seasons particularly near canals, the southern ends of each Water Conservation Area (1, 2, and 3), and Shark River Slough have led to high levels of nest flooding in some years. Alligator body condition is poor throughout the system during prolonged periods of increased water depth. Alligator density at the northern ends of the WCA's is low due to overdrained conditions leading to poor rates of survival and growth. Finally, a large portion of the adult population exists in canals but does not contribute to population growth due to the combination of increased nest flooding and decreased hatchling and juvenile survival during low water periods (predation and cannibalism).

With the resumption of natural patterns of volume, timing, and distribution of flow to the Everglades, the American alligator is expected to repopulate and resume nesting in the rocky glades and the freshwater reaches of tidal rivers in the mangrove estuaries and will increase in population size and body condition throughout most of the Greater Everglades wetlands.

Everglades Crocodilian Populations Conceptual Ecological Model

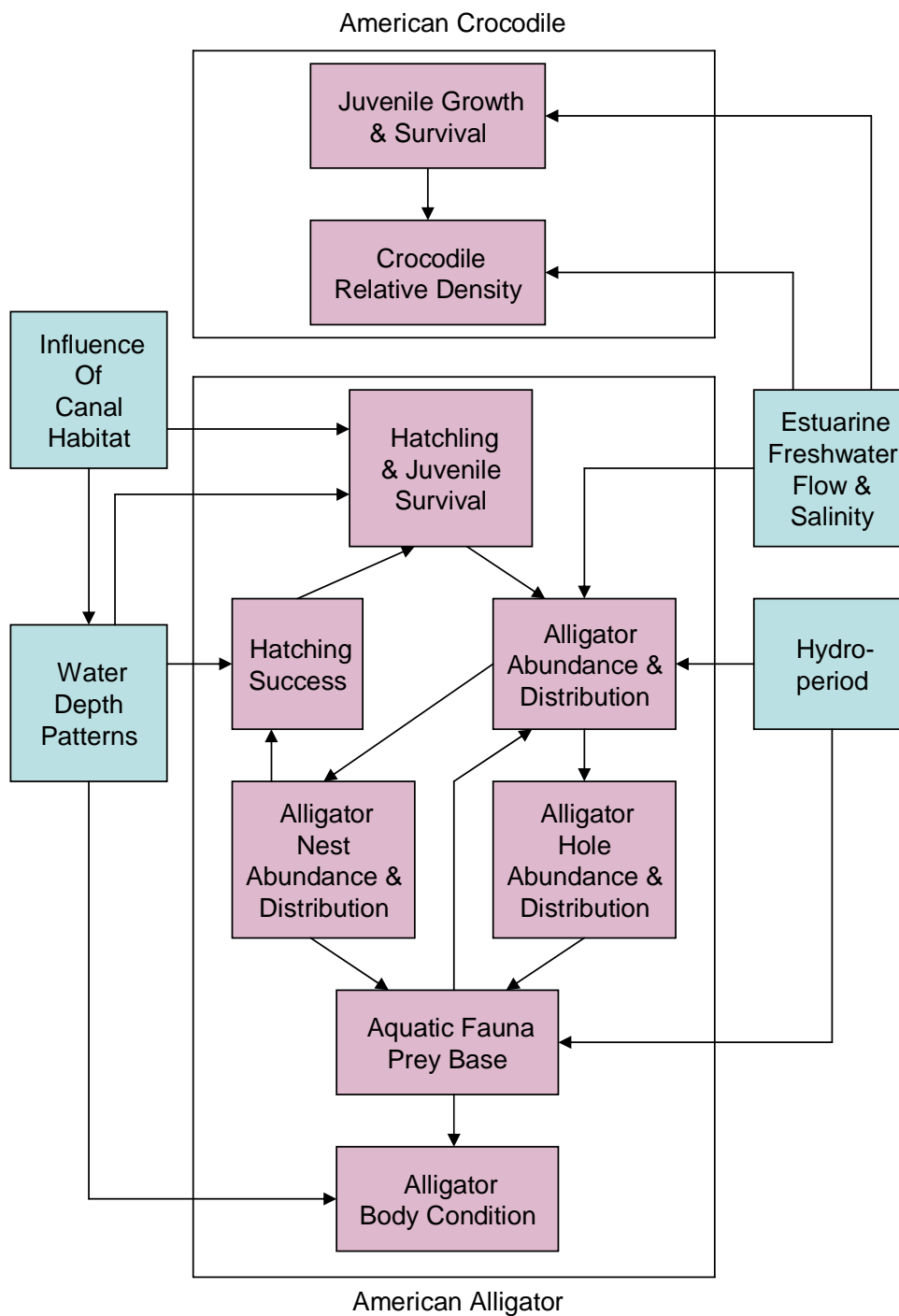


Figure 9-2-11: Everglades Crocodilian Populations Conceptual Ecological Model

Hypothesis 2

American Crocodile Relative Density and Juvenile Growth, Survival, and Condition in Relation to Salinity in Everglades Mangrove Estuaries

American crocodile relative density and juvenile crocodile growth, survival, and condition increase when salinity fluctuates below 20 ppt in shoreline, pond, and creek habitats in Everglades mangrove estuaries.

Rationale: Availability of freshwater limits the distribution and abundance of reptiles in estuaries. In estuaries, crocodylians of all species orient towards areas of low salinity and sources of freshwater. The American crocodile is a flagship endangered species that charismatically represents this relationship. In northeastern Florida Bay, diversion of freshwater flow, crocodiles have poorer growth rates and higher mortality than elsewhere in Florida.

Restoration of location of freshwater flow will result in an increase in relative density of crocodiles in areas of restored flow, such as Taylor Slough/Taylor River drainage. Reestablishing the salinity gradient in the estuary will increase growth and survival of juvenile crocodiles throughout the estuary.