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**ENVR 6334**

**Florida Pine Communities**

**Historical Accounts:**

Davis, Jr. J. H. 1943. The natural vegetation features of southern Florida, especially the vegetation and the Everglades. Florida Geological Survey Bulletin No. 25.

This Vegetation survey in 1943 describes pine flatwoods,pine rocklands, and saw-palmetto prairies. It reports these 3 types as covering a similar area of south Florida as marshes and wet prairies. Many of the dry saw-palmetto prairies seen are the result of cutting of pine forests and fires. The forests are made up Long-leaf pine, *Pinus ellioti* Engelm . (what they call swamp-pine) and south Florida slash pine (what they call *Pinus caribaea* Morelet). It is interesting to note that in 1943 they were classifying *Pinus elliotii* var.densa as *Pinus caribaea* Morelet, or Caribbean pine. The saw palmetto is the most typical plant in the understory except in the lower, poorly drained parts of flatwoods. The most abundant grass is wire or poverty grass, while the broom or beard grasses are also common. Grasses known as carpet grasses are more rare, yet they provide better forage for cattle than the other grasses and ranchers are beginning to expand this grass by clearing out saw palmettos, plowing and drainage. Where the sand soil is thinner and more calcareous you can find cabbage palm scattered about, along with saw grass, wax-myrtle and gallberry. The sand soil flatwoods form a mosaic with depressions of wet-prairies/marshes or cypress along with elevations of hammocks.

**General Description:**

Abrahamson, Warren G. and Hartnett, David C. 1990. Pine Flatwoods and Dry Prairies. Pages 103-149 in R. Myers and J. Ewel, editors. *Ecosystems of Florida*. University of Florida Press, Orlando.

This is a broad overview of pine flatwoods in Florida. Pine flatwoods occur on poorly drained acidic soils. The presence of clay or hardpan can alter soil moisture conditions altering the spatial distribution of flatwoods. Hydrology varies with elevation and pines adapt to wet and dry conditions. During rainy periods, soils can become waterlogged due to the hardpan, and during droughty periods, soils dry out while the hardpan can block deeper moisture. Fire plays an important role in the health of pine flatwoods by helping the germination of seeds and turning over litter and nutrients. In the absence of fire, hardwoods are likely to invade the flatwoods. Undisturbed sites are usually resistant to invasion by exotics, except moist south Florida conditions are susceptible to invasion by melaleuca, Brazilian pepper and Australian pine. Although flatwoods have been heavily influenced by logging and ranching, pine flatwoods are known to establish themselves on land formerly cleared for agriculture.

**Fragmentation of Habitat:**

Pearlstine, Leonard G., Brandt, Laura A.,, Mazzotti, Frank J., and Kitchens, Wiley M. . 1997. Fragmentation of pine flatwood and marsh communities converted for ranching and citrus. *Landscape and Urban Planning*. 38:159-169.

This study looked at the effect ranching and citrus in the past century have had on the spatial characteristics of pine flatwoods and marshes in southwest Florida. With development, natural habitiats can either be completely removed or fragmented, in which contiguous areas are broken into smaller patches. This can degrade the habitat by edge effects, creating barriers for dispersal, or simply crowding. The edge regions often have communities that are different than interior, so an increase in edges reduces habitability for interior species, and opens the door invasive species to come in. A core area is the interior of a patch being surrounded by the edge. Thus one patch can be made up of multiple cores. When the edges of a patch move in creating multiple cores, it is considered fragmentation. This study looked at the change in land use from 1900 to 1973 to 1989. Between 1900 and 1973 complete removal of habitats was the primary process observed. Between 1973 and 1989 fragmentation of flatwoods and marshes was the primary process observed, although complete removal of marshes slowed down. Also nearest neighbor coefficients for flattwoods increased, revealing a clumped pattern of pine habitats. Proximity between pinelands and marsh also increased with time, which could seriously affect wildlife that uses both habitats. 273 of 326 species use either pine or marsh habitats while 117 use both pine and marsh habitats. Reduction in corridors between habitats could affect the range of large mammals such as bear and panther. Fragmentation could also reduce the diversity of bird populations in these habitats, and also decreased pairing success due to higher population density. Increased dispersal distance has been linked to higher mortality rates. Another important effect of fragmentation is blocking species that use both habitats such as turtles or amphibians. These species connect the two habitats and reveal the importance in maintaining the two habitats together opposed to looking at them as separate entities.

**Natural Re-establishment:**

O’Hare, Nancy K. and Dalrymple, George H. . 2006. Growth and Survival of South Florida Slash Pine (*Pinus elliotti* var. *densa*) on Restored Farmlands in Everglades National Park. *Ecological Restoration* 24(4):242-249.

31 acres of former farmland in the Everglades Long Pine Key adjacent to rockland pine was allowed to naturally re-establish slash pine (no planting or seeding) after disturbed soil was removed down to the bedrock. The other 3 sides of the site was invaded by Brazilian pepper (*Schinus terebinthifolius*), so removing the fertilized soil kept the Brazilian pepper from establishing itself. Within 5 years there was more than 3000 seedlings greater than 4 inches tall, with 72.4 percent of them being closer than 82 feet to the adjacent rockland pine habitat to the north. It was revealed that seedling survival was dependent on elevation. The study showed the maximum occurrence of seedling to be between 3.5 and 3.7 feet. At low elevation, high water levels would drown them, while at higher elevations water stress due to increased depth to water table limited their survival. Most upland pine habitat was developed before environmental regulations were put in place. Without the requirement of mitigation, restoration techniques are lacking. Although difficult in the rockland habitat due to thin soil, this report shows natural recruitment is possible when a nearby seed source exists. Some problems might be the lack of adult tree seed source or a reduced water table level due to water use. Although not performed on this site, the establishment of the understory plants would most likely require planting and seeding.

**Growth Patterns:**

Langdon, O. Gordon. . 1963. Growth Patterns of *Pinus elliotti* var. *densa*. *Ecology* 44(4):825-827.

Tree height and diameter were monitored biweekly over a 4 year period. Rainfall, groundwater level, and soil moisture were recorded and US Weather Bureau data was available for day length, min/max temperatures and mean monthly rainfall. The majority of diameter growth occurred over a 10 month period. The peak time for diameter growth was during the vernal/autumnal equinoxes. The growth seemed to be a function of day-length because the peak growth was still seen even during colder than normal fall 1956 and spring 1958. 1956 was a low rainfall year, yet the diameter growth didn’t seem to be affected. The soil moisture was kept above wilting point, but this still might suggest slash pines ability to resist dry conditions to some degree. On the other hand, there was a significant reduction in diameter growth during 1959 in which the area experienced high rainfall and high ground-water levels. The height growth seemed to be vary throughout the year without a noticeable pattern, yet height growth was observed throughout the year.

**Fire Regimes:**

Slocum, Matthew G., Platt, William J., and Cooley, Hilary C. . 2003. Effects of Differences in Prescribed Fire Regimes on Patchiness and Intensity o Fires in Subtropical Savannas of Everglades National Park, Florida. *Restoration Ecology* 11(1) :91-102.

Timing and frequency of fire along with the elevation of its location impacts the patchiness and intensity of fires. In south Florida, natural wildfires occur frequently and usually during the transition from the dry season and the wet season, when lightning begins to occur and dry material is available for fuel. Suppression of fire along with prescribed burns with unnatural timing and frequencies have allowed exotic non fire adapted to move in. This paper examines the affect timing/season, frequency and plant community have on patchiness (the more area burned, the less patchy) and intensity of the burn for plant communities in Long Pine Key Everglades. High and low pine savanna were not very patchy burns (91%, 89% burned) while short hydro-period prairie and shrub pine savanna were a bit more patchy (68%, 80% burned) and long hydro-period prairie was very patchy (9% burned). High pine savanna burned a bit more intensely than the other four communities. This makes sense because the higher pine has thick layer of drier needles for fuel. Frequently burned areas burned significantly less often (73%) than infrequently burned areas (82%), yet frequently burned areas burned more intensely than infrequently burned areas. It seemed to make sense that the less frequently burned areas would have less fuel for burning, yet seemed counterintuitive that they would be more intense. This could possibly be due to grasses that grow rapidly after fire that producing dry fine fuel near ground. Less frequently burned sites could have more plant litter on the ground and shading shrubs trapping moisture. Additionally, more areas burned during early/middle season burns (80%) versus late season burns (56%). Early/middle season burns were much more likely to have more intense burns than late season burns, while early season burns would have only slightly more intense burns. This study used roads as artificial fire breaks, but it still demonstrates the ability of fire to generate heterogeneous landscapes. It also supports the idea that non-natural timing will promote shrub communities versus species-rich herbaceous vegetation.

**Flammability of Undergrowth:**

Behm, Anna L., Duryea, Mary L., Long, Alan J., and Zipperer, Wayne C. . 2004. Flammability of native understory species in pine flatwood and hardwood hammock ecosystems and implications for the wildland-urban interface. *International Journal of Wildland Fire*. 13:355-365.

Different characteristics of plants are affect the 4 components of flammability (ignitability,sustainability,combustibility and consumability). This study investigates their contribution to flammability for various understory plants found in pine flatwoods and hardwood hammocks. Understory plants were allowed to develop at test sites consisting of both ecosystems. Before they were harvested they were measured and then tested for flammability in the lab. Measurements relating to the 4 components are litter depth, height to lowest branch, and foliar moisture content (ignitability), fuel bed bulk density (sustainability), energy content (combustibility), and fine fuel biomass and consumable solids (consumability). They found a range of flammability among the species tested, but for different reasons. The saw palmetto was considered flammable because it was highly consumable and ignitable. Inkberry and rusty lyonia were flammable due to more foliar energy thus combustibility. American beautyberry was not found to be flammable. Wax myrtle was not found to be flammable either, even though it has been listed as a highly flammable plant. Flammability of wax myrtle and saw palmetto was determined to be similar regardless of the ecosystem in which they were found. It was also determined that plants of the same genus possessed different flammability characteristics. They concluded that ignitability, sustainability and combustibility were greater in pine flatwoods compared to hardwood hammocks, but the consumability was similar. They also suggest that the dense understory and high flammability of pine flatwoods make fire planning critical where pine flatwoods create wildland-urban interfaces.

**Invasive Old World Climbing Fern:**

Permberton, Robert W., and Ferriter, Amy P. . 1998. Old World Climbing Fern (*Lygodium microphyllum*), a Dangerous Invasive Weed in Florida. *American Fern Journal*. 88(4):165-175.

Old World Climbing Fern (*Lygodium microphyllum*) is an invasive exotic plant is shown to be spreading west from the near the coast of Palm Beach and Martin Counties. The fern climbs up high into trees and spreads horizontally consequently smothering plant communities. It is known to invade pine flatwood communities along with marshes, saw grass, mangrove and cypress. A major problem with the fern is the ability to allow fire to climb up the fern and burn the tops of the trees that would normally be out of the reach of fire. Trees that normally would be resistant to ground fire, are now in danger, threatening the normal function of the ecosystem. The fern also allows fire to jump to new areas when the burning breaks free from its tree top. The plant was first naturalized in Florida in Martin County in 1965, but there is evidence showing it possible existence in Florida as early as 1888. The plant has the capability to spread long distances as the wind blows it spores to new locations. The study consisted of aerial surveys in which trained observers recorded the appearance of the fern over a four year period (1993-1997) and transposing a data from a 1978 study over the flight line. The study demonstrates the spread of the invasive plant to the west along the prevailing spring, summer and fall winds over a 20 year period. It was noted that herbicide was used for controlling the plant but resulted in damage to the native plants that were trying to be protected.

**Invasive Melaleuca:**

Lopez-Zamora, I., Comerford, N.B., and Muchovej, R.M. . 2004. Root development and competitive ability of the invasive species *Melaleuca quinquenervia* (Cav.) S.T. Blake in the South Florida flatwoods. *Plant and Soil*. 263:239-247.

*Melaleuca quinquenervia* is an exotic invasive plant in south Florida that is able to rapidly take over native ecosystems via high seed production/germination combined with the ability to smother other plants with its dense canopy. This report investigates the understudied area of root development in melaleuca and how it might give it a competitive advantage when invading ecosystems. 1yr, 2-4 yr and 5 yr old melaleuca was planted along a transect with native bluestem grass in a controlled moist environment to test its ability to tolerate competition. Root number, root length density and root biomass were measured and compared. Melaleuca had significantly higher root number and root length density compared to bluestem grass, and the difference increased for the older melaleuca. With time, the melaleuca root length density continued to increase while the bluestem root length density decreased until it was taking over, suggesting melaleuca’s ability to tolerate competition. The values for root length density was greater than those for 7 and 20 year old *Pinus Ellioti* grown on similar soils (1.3 x 10-4 m/m3 vs. 0.3 x 10-4 m/m3 and 0.7 x 10-4 m/m3). The same experiment was performed in a dry environment with bahiagrass in order to test the ability for melaleuca to avoid competition. The bahiagrass did not survive the dry conditions while the melaleuca was able to survive by rooting deeper, although the root length densities were less during the dry vs. moist conditions. In the dry conditions combinations of Strontium and CaHPO4 were used in order to test the ability for melaleuca to uptake nutrients. The melaleuca was found to be able to uptake nutrients even in dry conditions. Melaleuca roots are assumed to be able to compete with native tree species. 5 year old melaleuca root length density was estimated to exceed 20 year old slash pine by 284%, 400% and 900% at 0.25 m, 0.35 m and 0.55 m depths. In summary, even at an early age, melaleuca can efficiently root in wet or dry conditions in the presence or absence of competing vegetation. The report supports the idea that superior root activity gives melaleuca the ability to establish itself between germination and the establishment of its light blocking canopy.

**Endangered Red-cokaded Woodpecker:**

Haig, S.M., Bowman, R., and Mullins, T.D. . 1996. Population structure of red-cockaded woodpeckers in south Florida: RAPDs revisited. *Molecular Ecology*. 5:725-734.

The red-cokaded woodpecker is an endangered species that used to range from south-east Virginia to Texas to south Florida. In south Florida, red-cokaded woodpecker populations utilize south Florida slash pine, opposed to the longleaf pine that the more northern populations use. Thus south Florida populations have adapted to different conditions, creating problems for translocation of red-cokaded woodpecker. Donors should come from the nearest population of similar environment (genetically similar), but if donor populations are themselves small their populations may be disturbed. The study used RAPD (Random amplified polymorphic DNA) analysis to describe the variation in gene structure among different populations of red-cokaded woodpecker. This study added 6 populations from south Florida to the existing 14 populations that had previously been sampled in the southeastern US. Gene structure appeared to follow a gradient. Distinct changes were only evident across large distances. The study suggested that Florida red-cockaded woodpeckers are no more isolated than other populations, yet they warned that population fragmentation may not yet be reflected in the genetic analyses. They noted the importance of periphery populations like south Florida to the overall population, in adding breeding areas and acting as a buffer during catastrophes. Due to the genetic similarities, they suggested that translocating woodpecker from different habitat might not be genetically harmful. They deemed the use of RAPD a success, and noted the value in the ability to reproduce results in different labs by different people increased the usefulness of the technique. They stated it was important to not just look at subsamples, but also compare all populations together.

**Repairing Soil Chemistry:**

Marrs, Robert H. . 2002. Manipulating *the* chemical environment of the soil. Pages 155-183 in Perrow, Martin R., and Davy, Anthony J., editors. *Handbook of Ecological Restoration, Volume I*. Cambridge University Press, Cambridge.

In restoration damaged soils are either need to be aggraded or degraded. If a soil is low in nutrients in an early successional stage the soil must be aggraded in which the soil ecosystem is built up. If the site is in a late successional stage compared to the target, or it is located on former agricultural land, then the soil has too many nutrients and must be degraded. The idea of degrading soil may sound counter-productive, but it is necessary to get it back to something useful to natural plant communities. Agricultural land is usually over fertilized. It is important to maximize nutrient offtake so that losses are greater than inputs resulting in the target nutrient levels. Some methods of offtake are grazing, cropping, burning, and top soil removal. In addition to removing nutrients, they can also be sequestered in the soil so that they do not contribute to productivity. In the case of pine communities, many times the soil was “limed” when it was converted to agricultural land in order to get the acidic soil to become more basic. One approach to restore the soil to an acidic state is to add elemental sulfur to the soil. It has been shown to be successful although predictable techniques for determining the amount needed are not known and the necessary amounts need to be determined empirically for each situation.

**Response to Hydrology and Soils:**

Wallace, Peter M., Kent, Donald M., and Rich, Dan R. . 1996. Response of Wetland Tree Species to Hydrology and Soils. *Restoration Ecology*. 4(1):33-41.

Soil moisture and soil type are important factors in determining the survival and growth of trees. Although normally the target is to restore an ecosystem to its natural hydrology, this is often hard to perform in practice and trees have to withstand variable conditions. This report studied the effect of 7 different soil types (3 mineral/sands, 2 organics, 1 stockpiled topsoil, and 1 manufactured organic on sand) and 2 hydrological states (moist/field capacity vs. innundated/saturated) on 9 different species of wetland trees (red maple, pop ash, loblolly bay, sweetgum, swamp red bay, slash pine, pond pine, pond cypress, and bald cypress). 6 replicates of each combination were planted and monitored over approximately a 1 year period in which height, basal diameter/area were measured. At the end of the period biomass was measured. Mortality for most species, including slash pine, was low to none. The exception was loblolly pine and swamp red bay which experienced high mortality most likely due stress associated with outplanting. Slash pine net height was a depended on hydrology and soil with interaction, while total biomass depended on both without interaction. Slash pine net height was greatest on moist, organic soils and lowest on stockpiled topsoil. Slash pine growth in moist mineral soils was similar to the saturated organic soils. Slash pine total biomass was highest for moist, organics soils and the least for stockpiled topsoil. There was not much variation among the 3 mineral soils and there also wasn’t much variation among the 2 organic soils for slash pine. In general, most trees experienced a greater net height and total biomass on organic soils compared to mineral soils. In general, manufactured soil seemed to enhance growth due to the addition of organic soil on top of mineral soil. They concluded that due to the difficulty in recreating natural hydrology and soils, it might be difficult to reproduce natural looking landscapes.

**Soil Nutrients and Water Sources:**

Saha, Amartya K., da Silviera Lobo O’Reilly Sternberg, Leonel, and Miralles-Wilhelm, Fernando. 2009. Linking water sources with foliar nutrient status in upland plant communities in the Everglades National Park, USA. *Ecohydrology*. 2:42-54.

This report tries to determine the sources of nutrients as being either groundwater or soil water for both hardwood hammocks and pine rocklands along their ecotone. Hammocks are at a higher elevation thus it is a suitable location for hardwood trees that are not tolerant to drought. A deeper layer of litter which traps moisture while deterring fire compared to pine rocklands which experience frequent fires leading to a thin litter layer due to burning. Oxygen 18 isotopes were measured for the soil water, groundwater, and plant stem water in both communities. Since soil water and ground water possessed unique amounts of Oxygent 18 isotope, the fraction of groundwater vs. soil water in the stem water was found. Hammock species were found to use more soil water than rockland species especially in the wet season. Hammock species did not have to turn to ground water until the dry season. The foliar nutrients N and P were measured. Hammock species were found to have the high foliar nutrient levels and the rockland species have low levels. Species that were found in both habitats have intermediate levels, but the levels did not change much when the species was in rockland vs. hammock. Due to the thinner litter layer (less nutrients) and the tendency for rockland species to use groundwater (more nutrients in soil water) more often, the availability of nutrient is assumed to be higher in hardwood hammocks. It was suggested that the higher nutrients available for co-occuring species would not lead to higher foliar nutrient levels, but larger trees instead (but this could also be due to fire working against the growth in rocklands). Both habitat species were observed to have high Nitrogen to Phosphorous ratios, while the opposite is often a problematic consequence of agricultural run off. The paper correlated photosynthetic activity to foliar Nitrogen to foliar Carbon 13 isotope in hardwood species which suggested higher nutrients were responsible for increased photsynthesis. Rockland species were not correlated which suggested increased photosynthesis from other factors maybe a more open canopy with more light. Hammock species were more sensitive to both flooding an drought compared to rockland species, thus the management of water resources is important in order to protect these habitats.

**Hydrologic Effects of Climate Change and Deforestation:**

Lu, Jianbiao, Sun, Ge, McNulty, Steven G., and Comerford, Nicholas B. .2009. Sensitivity of Pine Flatwoods Hydrology to Climate Change and Forest Management in Florida, USA. *Wetlands*. 29(3):826-836.

A landscape scale model hydrologic model MIKE SHE was calibrated and validated against measurements of groundwater levels using historical climate data for a cypress wetland/pine upland mosaic in northern Florida. The model was calibrated by adjusting soil and evapotranspiration (ET) parameters until the model best fit the data for 1992-1993. Using this calibration, the model was validated for 1994-1996 data. The model had a tendency to overestimate the water table for uplands and underestimate it for wetlands. Possible explanations could be not enough spatial resolution for accounting for micro-topography, heterogeneity of soil, lack of spatial resolution for accounting for surface/groundwater interactions, and errors in modeling of ET. The model depicted groundwater flow from upland to wetland during wet periods. During transitions from wet to dry the upland water table drops faster than wetlands because of the standing water and the flow reverses into the uplands from the wetlands. During the actual dry periods flow went in and out of wetlands evenly. 3 simulations were run to account for the clear cutting of pine flatwoods and cypress wetlands, an increase in temperature by 2 K, and a decrease in precipitation of 10%. The clear cutting was shown to raise the water table compared to the baseline due to decreased ET. The warming was shown to decrease the water table due to increased ET. The decreased precipitation of course decreased the water table. These effects were more pronounced than during dry periods because of the way vegetation is able to transpire water from deep down that would not be evaporated if the vegetation was not there. The authors claim this is “the first attempt to validate a distributed wetland hydrologic model using measured water table depths at the landscape scale”. It does not account for vegetation feedbacks following the hydrologic changes and could also be coupled with biogeochemical models. The model could be useful in understanding the flow of nutrients between wetland and upland.

**Evapotranspiration in Flatwoods:**

Liu, Shuguang, Riekerk, Hans, and Gholz, Henry L. . 1998. Simulation of evapotranspiration from Florida pine flatwoods. *Ecological Modelling*. 114:19-34.

The authors developed a 3 part evapotranspiration model including interception, evaporation and transpiration. Evaporation was based on an empirical method similar to Priestly-Taylor method. Interception was modeled considering the dryness of the canopy. Transpiration was a multi-layer model taking into account variations in the canopy opposed to a simple one-layer canopy top-atmosphere model. It is based on a combination approach (energy balance + aerodynamic method) derived by L’homme which is similar to the Penman-Monteith equation. Evapotranspiration measured with an eddy covariance was available for comparison with the model. The stomatal conductance (gS) and leaf area index (LAI) of the leaves were measured in-situ at canopy level for both cypress and slash pine. The modeled results and eddy covariance data agreed fairly well. Evapotranspiration (ET) was not significantly different between cypress and slash pine, yet cypress was a bit more probably due to the evaporation of the water surface below the canopy. The seasonal variation between the two was different though. Although ET in the drier/colder winter months was low for both compared to the wetter/hotter summer months, the slash pine ET in winter was higher than cypress ET in winter. During the summer the cypress ET was slightly more than slash pine ET. Larger ET for slash pine in the winter months wasn’t due to stomatal conductance, but due to the difference in LAI (deciduous cypress lost leaves in the winter while slash pines are evergreen). Peak LAI was related to peak stomatal conductance, peaking in July for cypress and September for slash pine. Atmospheric conditions though shifted the peak month for ET to around May due to increased radiation along with low wind and vapor pressure deficit in July. A sensitivity analysis was performed with the modeling determining that ET was sensitive to LAI, incident radiation, vapor pressure deficit (e), and temperature but not wind (Note: temperature is strongly dependent on incident radiation and vapor pressure deficit is directly related to temperature. e=e-eSAT(T)). Cypress ET is more sensitive to incident radiation than slash pine ET while slash pine ET was more sensitive to vapor pressure deficit. The ETM model, as this is called, could be a useful model to couple with existing hydrological and ecological models.