APPENDIX I

Southwest Florida Feasibility Study

Vegetation Parameters for Hydrologic Modeling

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NSRSM Application

Southwest Florida Feasibility Study vegetation parameters in this appendix were cross-walked to corresponding NSRSM landcover for use as a starting point for NSRSM vegetation parameter development. Expanded documentation on vegetation parameter refinement (kveg, manning's roughness, root depth) will be provided in the revised NSRSM report.

VEGETATIVE PARAMETERS [MIKE SHE Model Application]

Mike Duever (5/4/03)

Seasonality of Vegetative Growth (Transpiration and Crop Coefficient)

The seasonal vegetative growth is related to a number of environmental factors, [discussed] in terms of long term averages. Vegetative growth is directly related to transpiration, although not necessarily in a linear fashion. Thus, the crop coefficient would also to directly related to vegetative growth, and ranges from 0.2 - 1.3 (Chow et al. 1988).

Day Length: longer day length means more growth.
longest in mid-June
shortest in mid-December

Water Availability: more below ground water means less stress from lack of water
more above ground water means more stress from lack of oxygen for roots
greatest in June - October
least in April - May

Air Temperature: the lower the temperature, the slower the growth
highest in May
generally high from June - September
lowest in December - February

Freeze Occurrence: freezes kill living herbaceous vegetation
December - February

Beginning and Cessation of Growth: growth is vigorous during leafout and for several months during early summer, but at some point the green foliage begins to lose its vigor and change color

begin leafout:	March
full leafout:	April
leaves start to change color:	August
leaves brown:	October
deciduous leaves gone:	November

SW Florida Plant Communities	Relative Seasonal Growth Rates (Lowest = 1, Highest = 10)											
	Jan	**Feb**	**Mar**	**April**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**
Xeric Flatwood	3	5	7	9	10	10	9	8	7	6	5	4
Xeric Hammock	3	5	7	9	10	10	9	8	7	6	5	4
Mesic Flatwood	3	5	7	9	10	10	9	8	7	6	5	4
Mesic Hammock	3	5	7	9	10	10	9	8	7	6	5	4
Hydric Flatwood	3	5	7	9	10	10	9	8	7	6	5	4
Hydric Hammock	3	5	7	9	10	10	9	8	7	6	5	4
Wet Prairie	3	5	7	9	10	10	9	8	7	6	5	4
Dwarf Cypress	3	5	7	9	10	10	9	8	7	6	5	4
Marsh	3	5	7	9	10	10	9	8	7	6	5	4
Cypress	3	5	7	9	10	10	9	8	7	6	5	4
Swamp Forest	3	5	7	9	10	10	9	8	7	6	5	4
Open Water												
Tidal Marsh	3	5	7	9	10	10	9	8	7	6	5	4
Mangrove	3	5	7	9	10	10	9	8	7	6	5	4
Beach	3	5	7	9	10	10	9	8	7	6	5	4

Root Distribution in Soil Profile

These data are based on measurements of live root biomass in root pits at Corkscrew Swamp Sanctuary in the 1975-76. Pits were dug in Mesic Flatwood (2), Hydric Hammock (2), Wet Prairie (1), Marsh (1), Cypress (1), and Swamp Forest (1). The data were extrapolated to similar community types that had not been sampled in the field.

Root Distribution in Southwest Florida Plant Communities

Plant Communities	Roots (g dry weight /m^2) in the Soil Profile (in)						
	0 - 6	6 - 12	12 - 24	24 - 36	36 - 48	48 - 60	60 - 72
Xeric Flatwood	2061	1200	749	504	83	14	
Xeric Hammock	635	80	55	4	1		
Mesic Flatwood	2061	1200	749	504	83	14	
Mesic Hammock	635	80	55	4	1		
Hydric Flatwood	2061	1200	749	504	83	14	
Hydric Hammock	635	80	55	4	1		
Wet Prairie	297	20	7				
Wet Prairie	297	20	7				
Dwarf Cypress	297	20	7				
Marsh	778	18	6				
Cypress	1008	557	1211	321	313	251	28
Swamp Forest	1008	557	1211	321	313	251	28

Plant Communities and Their Characteristics in South Florida

Plant Community	Topographic Setting and Soils	Dominant Vegetation	Hydrology	Fire
Lake, Pond	Basins of standing water that are too deep for emergent vegetation.	Aquatic plants: floating or submerged.	Normally have water above ground. Edges or all (depending on size and depth) could dry down in extreme (>50year) droughts.	During extreme droughts, exposed dry organics on bottom can burn. Can be created by organic soil fires.
Stream	Flowing water in a distinct channel that is too deep for emergent vegetation.	Aquatic plants: floating or submerged.	Normally continuous flows, with amounts and rates of flow dependent on size of pulses of water from rainstorms or water control structure releases. Groundwater baseflow inputs.	During extreme droughts, exposed dry organics on bottom of old oxbows can burn.
Floodplain Swamp	Lands associated with streams that are regularly, but not continuously, inundated by flowing water.	Canopy of cypress and/or mixed hardwoods, e.g. Carolina ash, red maple, pond apple, sabal palm, Florida elm.	Shallow-to-deep intermittent flooding, depending on size of pulses of water from rainstorms or water control structure releases. Groundwater baseflow inputs.	Fire about every 20 - 50 years promotes cypress along swamp edge. Less frequent fire ($\pm$100 years) promotes hardwoods in swamp interior.
Mixed Cypress - Hardwood Swamp	Wetlands with deep (>1 ft) organic soils.	Closed canopy of cypress and mixed hardwoods, e.g. red maple, sweetbay, Carolina ash, Carolina willow, pond apple, and dahoon holly with occasional sabal palm.	Inundated 8 - 10 months per year. Normal wet season water depths of 1.5 - 2 ft. Annual water table fluctuation of 2 - 4 ft.	Found on sites infrequently ($\pm$100 years) reached by fire, due to extended inundation and high soil moisture.
Cypress	Wetlands with sandy or shallow (<1 ft) organic soils.	Canopy dominated by small-to-medium sized cypress.	Inundated 6 - 8 months per year. Normal wet season water depths of 1 - 1.5 ft. Annual water table fluctuation of 3 - 5 ft.	Maintained by light - moderate intensity surface fires every 20 -60 years.
Mangrove Swamp	Tidal sites with sand, rock or organic	Canopy dominated by red, black, or white mangroves or	Daily tidal inundation. Water fresh to hypersaline.	Developed and maintained by the absence of fire.

Plant Communities and Their Characteristics in South Florida

Plant Community	Topographic Setting and Soils	Dominant Vegetation	Hydrology	Fire
	substrates.	buttonwood.		
Organic Soil Shrub Wetland	Wetlands, sheet-flow sloughs, and edges of lakes and streams with organic soils.	Single or mixed species, open-to-dense thickets of Carolina willow or buttonbush.	Inundated 4 - 10 months per year. Normal wet season water depths of 0.5 - 2 ft. Annual water table fluctuation of 1.5 - 3 ft.	Maintained by light intensity, surface fires every 18 - 30 years.
Freshwater Marsh	Depression and flowway wetlands, and fringes of lakes and streams on organic soils.	Tall (5 - 10 ft), dense herbaceous community, often only a few species, e.g. pickerelweed, arrowhead, tall sawgrass, maidencane, fire flag.	Inundated 6 - 10 months per year. Normal wet season water depths of 1 - 2 ft. Annual water table fluctuation of 2 - 3 ft.	Maintained by moderately intense fires about every 1 - 10 years.
Mineral Soil Shrub Wetland	Depression and flowway wetlands, and fringes of lakes and streams on mineral soils.	Single or mixed species, open-to-dense thickets of wax myrtle, groundsel tree, gallberry.	Inundated 2 - 6 months per year. Normal wet season water depths of 0.5 - 1.3 ft. Annual water table fluctuation of 3 - 4 ft.	Maintained by low intensity fires about every 9 - 15 years.
Dwarf Cypress	Depression and flowway wetlands, and fringes of lakes and streams on limestone bedrock.	Single species, open stands of stunted cypress with sparse groundcover	Inundated 2 - 6 months per year. Normal wet season water depths of 0.5 - 1.3 ft. Annual water table fluctuation of 3 - 4 ft.	Maintained by low intensity fires about every 10 - 20 years.
Wet Prairie	Depression and flowway wetlands, and fringes of lakes and streams on mineral soils.	Short (1.5 - 4.5 ft), open, diverse herbaceous community with many species of grasses, sedges, and forbs, e.g. sand cordgrass, beak sedges, milkworts, St. Johns-wort, muhly, short sawgrass.	Inundated 2 - 6 months per year. Normal wet season water depths of 0.5 - 1.3 ft. Annual water table fluctuation of 3 - 4 ft.	Maintained by moderate-high intensity fires about every 1 - 5 years.

Plant Communities and Their Characteristics in South Florida

Plant Community	Topographic Setting and Soils	Dominant Vegetation	Hydrology	Fire
Coastal Marsh	Coastal saline sites with sand, shell, rock or organic substrates.	Short <4.5 ft), open, diverse herbaceous community with many species of grasses, sedges, and forbs, e.g. smooth cordgrass, black needle rush, spike rush.	Daily tidal inundation. Water fresh to hypersaline. Freshwater sheet flow during wet season.	Maintained by moderate-high intensity fires about every 1 - 5 years.
Hydric Pine Flatwoods	Light-to-dark brown, sandy soils on sites with little topographic relief.	Canopy trees primarily slash pine. Diverse, primarily herbaceous groundcover with about 500 species, e.g. wiregrass, bluestems, saw palmetto.	Inundated 1- 2 months per year. Normal wet season water depths from 0 - 0.5 ft above ground. Annual water table fluctuation of 3 - 4 ft.	Maintained by moderately intense fires about every 1 - 6 years.
Hydric Pine Flatwoods Shrubby	Light-to-dark brown, sandy soils on sites with little topographic relief.	Canopy trees primarily slash pine. Understory dominated by open-to-dense thickets of shrubs, particularly wax myrtle.	Inundated 1 - 2 months per year. Normal wet season water depths from 0 - 0.5 ft above ground. Annual water table fluctuation of 3 - 4 ft.	Maintained by low-moderate intensity fires about every 8 - 15 years.
Mesic Pine Flatwoods	Light-to-dark brown, sandy soils or limerock on sites with little topographic relief.	Canopy trees primarily slash pine. Understory dominated by dense saw palmetto.	Inundated 0 - 1 month per year. Normal wet season water depths from 0 - 3 ft below ground. Annual water table fluctuation of 3 - 4 ft.	Maintained by moderately intense fires about every 1 - 6 years.
Mesic Pine Flatwoods Shrubby	Light-to-dark brown, sandy soils on sites with little topographic relief.	Canopy trees primarily slash pine. Understory dominated by open-to-dense thickets of shrubs, particularly gallberry, staggerbush, wax myrtle, blueberry, saw palmetto.	Inundated 0 - 1 month per year. Normal wet season water depths from 0 - 3 ft below ground. Annual water table fluctuation of 3 - 4 ft.	Maintained by low-moderate intensity fires about every 8 - 15 years.

Plant Communities and Their Characteristics in South Florida

Plant Community	Topographic Setting and Soils	Dominant Vegetation	Hydrology	Fire
Hydric Hammock	Loamy or sandy soils on elevated sites often within or adjacent to larger wetlands	Forest with a closed canopy that includes a variety of tree species, e.g. laurel oak, sabal palm, red maple, swamp bay. Groundcover is sparse.	Inundated 1 - 2 months per year. Normal wet season water depths from 0 - 0.5 ft above ground. Annual water table fluctuation of 3 - 4 ft.	Found on sites that have not experienced fire for more than 100 years.
Mesic Hammock	Sand, shell, or rock substrates on elevated sites often within or adjacent to larger inland or coastal wetlands	Closed canopy of live oak and/or tropical hardwoods. Groundcover is sparse.	Inundated 0 - 1 month per year. Normal wet season water depths from 0 - 3 ft below ground. Annual water table fluctuation of 3 - 4 ft.	Found on sites that have not experienced fire for more than 100 years.
Coastal Strand	Well-drained sands on beach ridges adjacent to high-energy beaches.	Dense thickets of salt tolerant shrubs and small trees, including saw palmetto, sea grape, scrub oaks, lantana, greenbrier, and cabbage palm.	Wet season water table usually more than 3 ft below ground.	Maintained by low-moderate intensity fires about every 2 - 15 years.
Scrub	White well-drained sands on locally higher elevations or at the top of steep slopes.	Dense thickets of low (<10 ft high) shrubs and xeric oaks, including myrtle oak, live oak, sand live oak, with scattered patches of mostly bare white sand and a very scattered overstory of slash pine.	Wet season water table usually more than 3 ft below ground.	Maintained by high intensity fires every 6 - 55 years.
Xeric Hammock	White well-drained sands on locally higher elevations or at the top of steep slopes.	Dense, tall (10 - 20 ft) closed canopy forest of xeric oaks, including myrtle oak, live oak, sand live oak, with a very scattered overstory of slash or sand pine and little ground cover.	Wet season water table usually more than 3 ft below ground.	Develops in the absence of fire for 50 years.

Some thoughts on Mannings n in South Florida (Mike Duever - 5/13/03)

I created a table [below] showing Mannings n for the various plant communities in SW Florida. One column shows my estimate of Mannings n based on habitat types shown in a table in Chow, Maidment, and Mays (1988). The other column shows relative density of vegetation in the water column in SW Plant communities, which I assume should be related to Mannings n.

There are major discrepancies between the ranking of SW Florida plant communities between Chow et al. and my estimates. I believe the discrepancies are associated with differences in the landscapes being considered. I believe Chow et al. are describing flood flows in floodplains in landscapes with more relief than occurs in South Florida. In these situations, herbaceous vegetation is flattened by the large, deep flood flows and has relatively little affect on flow rates. The main impediment to flow is the woody vegetation (shrubs, trees). It is likely that many of the shrubs are submerged in a flood, and offer less resistance to flow than do trees, which would never be submerged. This would explain the pattern of increasing Mannings n values used by Chow et al. and numerous other authors.

However, in low flat areas like South Florida, the model described above does not work. Flows during the wet season are shallow (generally $\leq$ 2 ft) and can cover broad areas (miles). In this situation herbaceous vegetation is not flattened by the slow flows, but can present a sparse (Dwarf Cypress) to moderate (Wet Prairie) to dense (Marsh) wall of stems that can slightly-to-greatly, respectively, slow water flow rates. The majority of the foliage of shrubs and trees is above the water surface and does not have much affect on flow rates. Since the dense foliage associated with woody vegetation is above the water surface, herbaceous or shrubby foliage in the water column is reduced to varying degrees as a function of the density of the canopy and the associated shading. Open canopy Flatwoods would have little affect on the herbaceous and shrub strata, while closed canopy Hammocks, Cypress, Swamp Forests, and Mangroves can greatly reduce the cover in these lower strata where the water flow occurs.

Mesic Flatwood and Hammock have smaller Mannings n because the shallow water stays mostly below the dense shrub layer, while the deeper water in the Hydric Flatwood and Hammock gets into the shrub layer. The Xeric communities rarely if ever have overland flow, but there is very little foliage within 2 ft of the ground surface to impede any flows that might occur.

Three columns [have been added] to the table that represents Roger Copp's estimate of Manning's n for low, medium and high density vegetation that is at least partially based on my input.

SW Florida Plant Communities	Mannings n				
	Chow et al.	Duever*	Roger Copp (DHI)		
			Low#	Medium#	High#
Xeric Flatwood	No Water	3	0.08	0.10	0.30
Xeric Hammock	No Water	2	0.08	0.20	0.40
Mesic Flatwood	0.07	5	0.10	0.20	0.40
Mesic Hammock	0.10	3	0.10	0.30	0.50
Hydric Flatwood	0.07	7	0.20	0.30	0.50
Hydric Hammock	0.10	5	0.20	0.40	0.60
Wet Prairie	0.05	7	0.10	0.30	0.50
Dwarf Cypress	0.05	2	0.10	0.20	0.30
Marsh	0.05	10	0.30	0.60	1.00
Cypress	0.10	4	0.20	0.40	0.60
Swamp Forest	0.10	3	0.20	0.40	0.60
Open Water	?	?	0.02-0.06	0.02-0.06	0.02-0.06
Tidal Marsh	0.05	7			
Mangrove	0.10	2	0.10	0.20	0.40
Beach	No Water	3			

* Relative Roughness Values (1=Low, 10=High)

Vegetation Density