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Final

Plant Community Parameter Estimates and Documentation for the Across Trophic Level System Simulation (ATLSS)

Data Report Prepared for the
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Document Objectives

This document describes the botanical parameters and the methods used to estimate those parameters needed to run the Across Trophic Level Systems Simulation (ATLSS). It also describes a series of simple successional models that incorporate hydrologic and fire disturbances into ATLSS. The ATLSS covers the Florida peninsula from Lake Okechobee southward. It uses plant communities defined by the Florida GAP (FGAP) analysis (version 6.6) as its basic ecosystem units. The objectives of this document are listed below.

1. Describe the limitations and assumptions used to estimate the botanical parameters and develop the succession models.
2. Determine hydroperiod ranges for all of the FGAP v. 6.6 plant communities in south Florida.
3. Estimate the amount of deer browse available in the plant communities where deer are expected to live.
4. Estimate the maximum and minimum water depths that vegetation grow in each plant community where deer forage.
5. Develop a simple set of succession models that incorporate hydrologic and fire disturbances. The succession models should include the direction and rate of succession for both disturbances.
6. Carefully document all parameter estimation and succession models with references from the scientific literature and expert professional opinion.

Limitations and Assumptions Used to Estimate Botanical Parameters and Develop Succession Models

It is important that the users of the data contained in this document understand how the information for the model parameters and succession sequences was gathered and synthesized. This is necessary to prevent them from making conclusions with the ATLS Simulation that go beyond the reliability of the input data. Gleaning data from a wide variety of sources in the scientific literature and the lack of data on certain plant communities limits the strength of the data as input to the ATLS Simulation. Use of the FGAP plant classification system also created certain limitations and assumptions. These limitations and assumptions are described below and should be read and carefully considered by all users of the data contained in this report.

1. <u>Differences in Plant Community Classification</u>

Plant community classification can vary significantly among different systems. For example between the different versions, v. 2.1, v. 3.0, and v. 6.6, of FGAP, between FGAP v. 6.6 and plant communities described in the literature, and between FGAP v. 6.6 and Harlow (1959), a reference used extensively in estimating deer browse. Many of the FGAP class descriptions are very vague and give few representative plant species. Discussions of plant communities in the literature are usually quite the opposite: detailed community descriptions often with species lists. Much time was spent matching similar plant communities between classification systems.

It is my *impression* that the plant associations created in the FGAP analysis mapping effort were based on the aerial signatures of plant communities that could be readily identified from aerial photographs. This results in the establishment of some plant associations that have wide hydroperiods or plant associations that do not correspond with the plant communities reported in the literature by botanists and ecologists working on the ground. Because some of the FGAP plant classifications do not match well with the plant communities described in the literature, the succession and hydroperiod data going into the model is either very broad or not very specific.

Incidentally, an alternative mapping system would be to establish a vegetation classification system, determine the air photo signature of each plant community in the classification system, and then proceed with the vegetation mapping. This procedure was followed by Madden et al. (1999) and I think that their vegetation classification system will be somewhat easier to adapt to the needs of the ATLSS model.

2. <u>The Difference between Hydroperiod and Hydrologic Regime</u>

Hydroperiod (the average number of days per year that the water level is at or above the soil surface) was estimated for the plant communities used in the ATLSS model. However, it is very important to note that wetland ecosystems have characteristic hydrologic regimes. A hydrologic regime has two components: the hydroperiod and a hydro pattern, that is, the seasonal occurrence of inundation and draw downs. When water is present in a wetland community is as important to the plants and animals as the length of inundation. Hydrologic regimes fluctuate seasonally, annually, and inter-annually. This report does not include information about the hydro patterns of specific plant communities.

3. <u>Net Primary Production Parameter Estimates</u>

To estimate the growth rates (kg/ha/month) of the portion of a plant community that could be used as deer browse, it was necessary to collect biomass estimates of each representative plant community. There are many methods of determining net primary production. However, the reported biomass values were not adjusted or calibrated with each other in any way.

4. <u>Water Depth Parameter Estimates</u>

In order to connect the biomass growth of deer forage to hydrology, several water depths were estimated for each plant community group. These water depths are tied to the minimum, optimal, and maximum growth rates of the plant communities in the ATLSS model. The water depths assigned to a particular plant community were obtained from the literature but are *not related* to the growth rates used in the model. Growth rate and water depth data were not collected at the same time, during the same season of the year, or in the same location. The development of the water depth parameters and their relationship to growth rates is purely a construct of the model.

5. <u>Succession Models</u>

The simple succession models designed for inclusion in the ATLSS model were developed with a number of assumptions. First, it was assumed that hydroperiod is the primary determinant of individual plant communities. The hydroperiods used in the succession models are reported in Table 1.

Second, it was assumed that plant communities succeeded for only two reasons: hydroperiod disturbance and fire disturbance. Therefore, each disturbance must have a time counter in the model that corresponds to the years since the last shift in average hydroperiod or years since last fire disturbance. Annual seasonal dry downs were not considered to be hydrologic disturbances. These annual changes in hydroperiod are a characteristic of the hydroperiod of the plant community. There was no data on the intensity of these disturbances and how the varying intensity of the disturbance affected the plant communities

Clearly, the plant communities in south Florida experience many other disturbances and many of them have been reported or studied in the scientific literature. Some of the disturbances described in the literature include:

- Anthropogenic disturbances on the landscape ranging from agriculture to urbanization
- Hurricanes
- Freezes
- Nutrient level
- Salinity gradient near the coasts and estuaries (also relates to sea level rise)
- Seed/propagule sources and dispersal (particularly with exotics).

Hydroperiod Parameter Determination

The ATLSS hydroperiod of a plant community is the average number of days per year that the water level is at or above the soil surface. Hydroperiod values ranged from 0 to 365 days and were determined from references in the scientific literature (Table 1). All hydroperiod references found for particular plant communities are listed and the hydroperiod range assigned to a plant community either encompassed the ranges reported in the literature or were averaged from the data available. The data collection period and the nature of the hydroperiod data reported were also factored into the final hydroperiod assignment.

Hydroperiod estimates were not found in the literature for three plant community types: Mixed Evergreen–Cold Deciduous Hardwood Forest [19], Coastal Strand [33], and Sea Oats Dune Grassland [40] (Table 1). The hydroperiods for these plant communities that are reported in Table 1 were estimated by Paul Wetzel using best judgment. Fortunately, these three plant communities represent only 0.021% of the project area (Table 1).

Other plant communities, such as Sand Pine Forest [14], Sand Cordgrass Grassland [48], or *Casuarina* Compositional Complex [12], have only one reference or indirect references to their hydroperiod. The indirect references are explained in Table 1 or in the notes on Table 1 whenever necessary. Hydroperiod references abound for well studied plant communities, such as Sawgrass Marsh and Cypress Forest (Table 1). All references found for any plant community are reported in Table 1 so that the reader may make their own judgments of the average hydroperiod for a particular plant community.

Table 1 (next page). Hydroperiod data and parameter estimates for all 48 plant communities used in the ATLSS model and the aerial coverage of each plant community. CG=Compositional Group, EC=Ecological Complex. Full reference citations are given in the Literature Cited section.

General Plant Community Type	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Dominant Plant Spp.	Aerial Coverage In Study Area (%)*	Hydroperiod (days)	References
High Pine and Scrub	14	Sand Pine Forest	*Pinus clausa*, sand pine Dry sand ridges interior & coast	0.06	0	Implied 0 d–Myers, 1990, pp. 159, 176 "Excessively well drained"–Abrahamson and Hartnett 1990, p. 111, Fig. 5.2
[Community Aerial Coverage = 0.31%]	26	Sandhill EC	Longleaf pine, *Pinus palustris*, xeriphytic oaks, *Q. incana*, *Q. geminata*, *Q. laevis*, and a wiregrass/*sporobolus* understory on sand	0.03	0	Implied 0 d–Myers, 1990, pp. 159, 176 "Excessively well drained"–Abrahamson and Hartnett 1990, p. 111, Fig. 5.2
	35	Xeric Scrubland	Shrublands on inland sand and coastal dune ridges; *Q. chapmanii*, *Q. geminata*, *Q. inopina*, *Q. myrtifolia*, *Ceratiola ericoides* (FL Rosemary), and *Lyonia ferruginiea*. Scattered *P. clausa*, *P. palustris*, and *P. elliottii*.	0.22	0–15	Implied 0 d–Myers, 1990, pp. 159, 176 "Moderately well drained"–Abrahamson and Hartnett 1990, p. 111, Fig. 5.2
Mesic Temperate Hammock	4	Xeric–Mesic Live Oak EC	Xeric to mesic hydrologic conditions. *Q. virginiana*, *Q. geminata*	0.36	0–15	"Moderately well drained"–Abrahamson and Hartnett 1990, p. 111, Fig. 5.2
[Community Aerial Coverage = 0.96%]	5	Mesic–Hydric Live Oak/Sabal Palm EC	Mesic to hydric hydrologic conditions; hydric hammocks. *Q. virginiana*, *S. palmetto*	0.04	0–60	0d for 1yr measurmnt–Vince et al. 1989, p. 13, Fig. 10 60–120d–Vince et al. 1989, p. 14 0–30d–Drew and Schomer 1984, p. 99, Fig. 62
	6	Bay/Gum/ Cypress EC	*Gordonia lasianthus*, *Magnolia virginiana*, *Persea palustris* (bays), *Nyssa* spp. (gum), *Taxodium* spp.	0.55	60–160	60–160d–Schomer and Drew 1982, p. 110
	19	Mixed Evergreen–Cold Deciduous Hardwood Forest	Southern mesic hardwood forest or upland hardwood forest. East: *Q. hemispherica*, *Q. virginiana* and *Carya glabra*. West: *Fagus grandifolia* and *Magnolia grandiflora*	0.01	0–15	No data available. Estimated. 1–15d–M. Dennis, personal communication
Tropical Hardwood Hammock	2	Tropical Hardwood Hammock	Coastal and interior hardwood hammocks.	0.49	10–45	0–60d–Schomer and Drew 1982, p. 110 10–45d–Drew and Schomer 1984, p. 104
[Community Aerial Coverage = 0.84%]	20	Buttonwood Woodland	Buttonwood (*Conocarpus erectus*) woodland. Found inland and adjacent to the mangrove zone over marl soils or on exposed bedrock.	0.35	44–120	Mean 244d for river fringe–Kolipinski and Higer 1969, pp. 16a, 27 **See Note 1.**
Pine Flatwood and	13	South Florida Slash Pine Forest	S. FL pine forest, *Pinus elliottii* var. *densa*. Found on sand in the north and limestone in the south of FL.	0.95	0–60	30–60d–Abrahamson and Hartnett 1990, p. 109 0–60d–Schomer and Drew 1982, p. 110

General Plant Community Type	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Dominant Plant Spp.	Aerial Coverage In Study Area (%)*	Hydroperiod (days)	References
Rockland	16	Mesic–Hydric Pine Forest CG	Multiple pine forest types. Dominated by *Pinus elliottii* var. *elliottii*	3.22	30–60	30–60d–Abrahamson and Hartnett 1990, p. 109 0–60d–Schomer and Drew 1982, p. 110
[Community Aerial Coverage = 6.64%]	25	South FL Slash Pine Woodland	Open, generally low stature south FL slash pine (*P. elliottii* var. *densa*) on sand, marl or rock. Understory usually graminoid w/ occassional *Taxodium distichum*	1.32	30–60	30–60d–Abrahamson and Hartnett 1990, p. 109 0–60d–Schomer and Drew 1982, p. 110 70–160d–Sun et al. 1995, wet edge of plant association
	30	Gallberry/Saw Palmetto CG	Shrub and graminoid communities in association with wet flatwoods. Gallberry (*Ilex glabra* and *I. coriacea*), fetterbush (*Lyonia lucida*), sweet pepperbush (*Clethra alnifolia*) and titi (*Cyrilla racemosa*)	0.98	30–60	30–60d–Abrahamson and Hartnett 1990, p. 109 0–60d–Schomer and Drew 1982, p. 110 ≤90d–Krauss 1987 70–160d–Sun et al. 1995, wet edge of plant association 30–90d–M. Dennis, personal communication
	36	St. Johns Wort Shrubland	Often found in isolated, small, acid wetlands. *Hypericum fasciculatum* may cover entire wetlands or the fringe of deeper water bodies.	0.17	30–150	Winchester et al. 1985. **See Note 2.**
Dry Prairie [Community Aerial Coverage = 1.08%]	29	Dry Prairie EC	Sparsely wooded savannas with mosaic of *Serenoa repens* and grasses *Aristida* spp., *Sporobolus* spp., and *Andropogon* spp.	0.91	30–60	30–60d–Abrahamson and Hartnett 1990, p. 109 ≤50d–Duever et al 1984a, p. 301 0–30d–M. Dennis, personal communication
Wet Prairie [Community Aerial Coverage = 4.75 %]	45	Muhly Grass Marsh	Marls soils and on dry coastal sands and shells. *Muhlenbergia capillaris*	2.51	60–120	<180d–Kushan, 1990, p. 337 60–210d–Schomer and Drew 1982, p. 110 100d–Porter 1967, p.938 111–155d–Duever et al. 1978, p. 537 70d mean–Gunderson and Loope 1982b ≥90d–Krauss 1987 but not more than 135d? 60–120d–Loope 1980
	52	Sparsely Wooded Wet Prairie CG	Graminoid or forb understory and sparse wooded overstory. Includes *Taxodium distichum* or *Pinus* spp.	0.01	60–120	60–210d–Schomer and Drew 1982, p. 110 70d–Duever et al 1984a, p. 301
	53	Dwarf Cypress Prairie	Graminoids (*Muhlenbergia capillaris*, *Rhynchospora* spp.) with sparse shrub overstory (*Taxodium distichum*)	1.62	120–150	120–210d–Schomer and Drew 1982, p. 110 150–210d–Ewel 1990, p. 298 120d–Brown et al. 1984, p. 308 120d– Duever et al 1984a, p. 301
	54	Temperate Wet Prairie	Located in northern and central FL. Graminoids, forbs, and hydrophyllic species.	0.61	166–290	166–290d–Goodrick 1974 146–237d–Hagenbuck, et al. 1974, p. 10b
Marsh	42	Graminoid	Graminoid marshes.	4.75	120–270	224–278d–Duever et al. 1978, p. 537

General Plant Community Type	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Dominant Plant Spp.	Aerial Coverage In Study Area (%)*	Hydroperiod (days)	References
[Community Aerial Coverage = 19.4 %]		Emergent Marsh CG				180–270d–Kushan 1990, p. 337 84–365d–McPherson 1973, p. 18 146–237d–Hagenbuck, et al. 1974, p. 10b ≤250d– Duever et al 1984a, p. 302
	43	Sawgrass Marsh	*Cladium jamaicense*	13.27	130–330	180–270d–Kushan 1990, p. 337 150–300d–Schomer and Drew 1982, p. 117 365d–Steward and Ornes 1975 117–310d–David 1996, p. 22 168–303d–Lowe 1986, p. 220 175–365d–McPherson 1973, p. 18 Mean 285d–Kolipinski and Higer 1969, pp. 16a, 27 90–240d–Loope 1980 73–180d–Hagenbuck, et al. 1974, p. 10c 133–335d, mean=259–Ross et al. 2000, p. 107
	44	Spikerush Marsh	*Eleocharis* spp.	0.54	150–300	180–270d–Kushan 1990, p. 337 150–300d–Schomer and Drew 1982, p. 117 193–310d–David 1996, p. 22 Mean 327d–Kolipinski and Higer 1969, pp. 16a, 27 >270d–Loope 1980 73–180d–Hagenbuck, et al. 1974, p. 10c (*Eleocharis* was 15–35% frequency) 266–333d–Ross et al. 2000, p. 107
	46	Cattail Marsh CG	*Typha domingensis* and *T. latifolia*	0.53	180–280	180–270d–Kushan 1990, p. 337 ~180–300d–Schomer and Drew 1982, p. 110 208d–David 1996, p. 22
	55	Maidencane Marsh	*Panicum hemitomon*	0.31	180–300	180–270d–Kushan 1990, p. 337 180–300d–Schomer and Drew 1982, p. 117 222d–David 1996, p.22 270–350d–Lowe 1986, p. 218
Shrub Island [Community Aerial Coverage = 6.03 %]	28	Broad Leaved Evergreen/Mixed Evergreen Cold–Deciduous Shrubland CG	Fetterbush (*Lyonia lucida*) [North FL] and cocoplum (*Chrysobalanus icaco*) [South FL]. Freshwater red mangrove dwarf shrubland, *Rhizophora mangle*, *C. icaco*. Highest density on Gulf coast.	0.30	120–150	120–150d; min of 60d–Schomer and Drew 1982, p. 115

General Plant Community Type	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Dominant Plant Spp.	Aerial Coverage In Study Area (%)*	Hydroperiod (days)	References
	32	Dwarf Mangrove EC	Shrub mangroves, regardless of species dominance.	1.23	150–300	116–360d, mean=300d–Ross et al. 2000, p. 107
	37	Saturated–Flooded Cold Deciduous Shrubland EC	Shrub wetlands. *Salix* spp., *Cephalanthus occidentalis*, *Betula nigra*, *Alnus serrulata*, and sometimes high proportions of *Typha* spp. or *Cladium jamaicense*	4.50	110–320	110–365d (tree islands)–Wetzel 2001 150–300d w/ willow–Schomer and Drew 1982, pp. 110,115 110–365d–McPherson 1973, p. 18 Mean 244d–Kolipinski and Higer 1969, pp. 16a, 27
Slough [Community Aerial Coverage = 0.96 %]	56	Forb Emergent Marsh	*Pontederia cordata*, *Sagittaria lancifolia*, and *Thalia geniculata*	0.96	230–360	240–360d–Schomer and Drew 1982, p. 117 ~222–350d–David 1996, p. 22 310–346d–Duever et al. 1978, p. 538
Pond [Community Aerial Coverage = 0.67 %]	57	Water Lily or Floating Leaved Vegetation	*Eichhornia crassipes*, *Hydrocotyle* spp., *Nuphar luteum*, *Nymphaea odorata*, and *Nymphoides aquatica*	0.67	330–360	330–360d–Gunderson and Loftus 1993, p. 205 220–350d–David 1996, p. 22 259–365d ["slough"]–McPherson 1973, p. 18 212–310d–Hagenbuck et al. 1974, p. 10a ~350d– Duever et al 1984a, p. 302
Bayhead [Community Aerial Coverage = 1.03 %]	3	Semi–Deciduous Tropical/ Subtropical Swamp Forest	Large strand swamps, low stature swamps or bayhead forest and tree islands. *Taxodium distichum*, *Roystonea elata* (royal palm), *Quercus laurifolia*, and *Acer rubrum*. In South FL, *Annona glabra*, *Magnolia virginiana*, and *Persea palustris*	1.03	60–180	120–150d–Schomer and Drew 1982, p. 115 60–180d–Gunderson and Loftus 1993, p. 213 Mean 244d–Kolipinski and Higer 1969, pp. 16a, 27 100–150d–Drew and Schomer 1984, p. 99, Fig. 62
Cypress & Mixed Swamp Forest/ Woodland	17	Swamp Forest CG	Deciduous and evergreen swamp forests of south and central FL. Some *Taxodium* spp. and the species of the Bay/Gum/Cypress EC (Class #6)	3.19	120–290	180–270d–Ewel 1990, p. 298 120–210d–Schomer and Drew 1982, p. 110 155–290d–Duever et al. 1978, p. 543
[Community Aerial Coverage = 6.78 %]	18	Cypress Forest CG	Cypress domes and river and lake fringes. May overlap with pines and cypress/gum ponds within pine flatwoods. *Taxodium distichum, T. distichum*	3.59	200–340	180–270d–Ewel 1990, p. 298 Nearly 365d–Sharitz and Mitsch 1993, p. 319 200–240d–Wharton et al. 1977 250–290d–Duever et al. 1984a, p 301 212–340d–Sun et al. 1995, p. 67, Msmts from pond. Range over 2yrs, one wet , one dry
Exotics	8	Cajeput Forest CG	*Melaleuca quinquenervia*	0.09	150–210	150–210d–Ewel 1990, p. 298 120–150d–Schomer and Drew 1982, p. 110

General Plant Community Type	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Dominant Plant Spp.	Aerial Coverage In Study Area (%)*	Hydroperiod (days)	References
[Community Aerial Coverage = 0.34 %]	12	Casuarina Complex	*Casuarina* (*equisetifolia, cunninghamia, glauca*)	0.01	0–60	"Less than Muhly Prairie"–Schomer and Drew 1982, p. 14
	31	Brazilian Pepper Shrubland	Monotypic stands of *Schinus terebinthifolius*.	0.24	0–120	0–120d–Schomer and Drew 1982, p. 110
Mangrove [Community Aerial Coverage = 3.53 %]	9	Mixed Mangrove Forest Formation	Contains all three mangrove species (*Laguncularia racemosa*, *Avicennia germinans*, *Rhizophora mangle*) with varying levels of dominance. White and black species gernerally dominate.	2.61	60–240	208d–data from Jamacia for *Laguncularia* only Chapman 1976, p. 192 **See Note 3.**
	10	Black Mangrove Forest	*Avicennia germinans* Forest	0.16	120–240	255–355d–data from Jamacia Chapman 1976, p. 192 **See Note 3.**
	11	Red Mangrove Forest	*Rhizophora mangle* Forest	0.57	240–365	355–365d–data from Jamacia Chapman 1976, p. 192 **See Note 3.**
	21	Mixed Mangrove Woodland	Forest species the same as the mixed mangrove forest [9] but canopy coverage reduced to 26–60%. Reduced canopy from Hurricane Andrew.	0.12	60–240	208d–data from Jamacia for *Laguncularia* only Chapman 1976, p. 192 **See Note 3.**
	22	Black Mangrove Woodland	*Avicennia germinans* with canopy coverage 25–60%	0.03	120–240	255–355d–data from Jamacia Chapman 1976, p. 192 **See Note 3.**
	23	Red Mangrove Woodland	*Rhizophora mangle* with canopy coverage 25–60%	0.04	240–365	355–365d–data from Jamacia Chapman 1976, p. 192 **See Note 3.**
Beach Dune/ Coastal Strand & Grassland [Community Aerial Coverage = 0.11 %]	33	Coastal Strand	Coastal dune, shrub dominated. In North FL: *Serenoa repens* and *Ilex vomitoria*. In South FL: *S. repens* and sea grape (*Coccoloba uvifera*).	0.01	5–30	No data available. Estimated. 5–30d–M. Dennis, personal communication
	39	Graminoid Dry Prairie EC	Coastal graminoid communities on landward side of dunes. *Muhlenbergia* spp. and *Eragrostis* spp. Also called Overwash Community (Stalter and Odum 1993, p. 124).	0.10	20–50	Water table 0–150cm below surface. Floods during heavy rains– Stalter and Odum 1993, p. 124 ≤50d–Duever et al. 1984a, p. 301
	40	Sea Oats Dune Grassland	Vegetated coastal dunes near beaches. Sea oats (*Uniola paniculata*) *Panicum* spp., *Sporobolus* spp., *Sesuvium*	0.001	5–30	No data available. Estimated. 5–30d–M. Dennis, personal communication

General Plant Community Type	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Dominant Plant Spp.	Aerial Coverage In Study Area (%)*	Hydroperiod (days)	References
			porulacastrum, and *Ipomoea pes–caprae*.			
Tidal Marsh [Community Aerial Coverage = 0.83 %]	38	Saltwort/ Glasswort EC	North FL: inland in association w/ salt marsh. South FL: on marl and limestone near coast with mangroves and buttonwood. *Batis maritima* (Saltwort) and *Salicornia* spp. (Glasswort)	0.23	12–21	12–21–Stout 1984, p. 14 Data from Mississippi coast 30–60d–M. Dennis, personal communication **See Note 4.**
	47	Salt Marsh EC	Salt water graminoid marshes.	0.13	30–90	12–44d–Stout 1984, p. 14 Data from Mississippi coast 60–90d–M. Dennis, personal communication
	48	Sand Cordgrass Grassland	On coast, in interface between salt marsh and adjacent upland. *Spartina bakeri*	0.26	12–21	12–21–Stout 1984, p. 14 Data from Mississippi coast. 60–90d–M. Dennis, personal communication **See Note 4.**
	49	Black Needle Rush Marsh	*Juncus roemerianus* salt marsh.	0.21	3–44	3–20d–Montaque and Wiegart 1990, p. 486 (original source Eleuterius and Eleuterius 1979) 21–44d–Stout 1984, p. 14 90–180d–M. Dennis, personal communication

* The aerial coverage values sum to 54% of the study area. The remaining area included urban and residential, agriculture, pasture, recreation, roads, and sand/beach.

NOTES FOR HYDROPERIOD PARAMETER ESTIMATION

1. Only one hydroperiod estimate for the *Conocarpus erectus* (Buttonwood) Woodland [20] has been published, Kolipinski and Higer (1969) reported 244d–which seems high. However, several authors (Ball 1980; Chapman 1975, p. 38, 41) report that *Conocarpus* is found on the inland fringe of the mangrove forests. Chapman (1975) reports that *Conocarpus* occupies the same landscape position as salt marsh at the Mean High Water level or Mean High Tide level. From this information, I estimated that the hydroperiod is 44–120d per year. The low end of the hydroperiod is the maximum days of inundation of the Salt Marsh EC [47] and Black Needle Rush Marsh [49]. The high end of the Buttonwood hydroperiod is the low end of the *Avicennia germinans* Forest [9, 21] hydroperiod. The datum of 244d from Kolipinski and Higer (1969) is an interpretation I made from a figure where they reported Buttonwood growing in a mixed plant community of Red mangrove, Willow, Pond–apple, and Cocoplum. These trees are all tolerant of long hydroperiods. Thus, I consider 244d to be the extreme wet end of the *Conocarpus* hydroperiod before it gets out competed by other species.

2. Winchester et al. (1985) do not directly report hydroperiod values for *Hypericum* plant zone. However, they do compare the mean edge for the *Hypericum* zone and three other vegetation zones for which hydroperiods are known, *Panicum/Rhynchospora*, *Cladium*, and *Fraxinus/Salix* (p. 111). Using this information I estimated the average maximum hydroperiod of the *Hypericum* plant zone at about 150d. The average minimum hydroperiod of the *Hypericum* plant zone is a guess based on the author's description in the text of the paper.

3. Hydroperiods of mangrove forests are not published in the literature. The position of a mangrove forest type on the shoreline is described relative to the mean high water level or mean high tide (MHW), mean tide level (MTL), and mean low water level or mean low tide (MLW). The location of the different mangrove communities on the cross–section of the shoreline are illustrated in three places: Chapman 1975, pp. 28–74, Montague and Wiegert (1990) p. 489 and Odum and McIvor (1990) p. 528. Generally, *Rhizophora mangle* is located slightly above MLW level. *Avicennia germinans* is located below the MHW level (Ball 1980, p. 232), and *Laguncularia racemosa* communities are located above the MHW level (Ball 1980, p. 232).

   To calculate hydroperiod, I assumed that on average MHW lasted 4 hours, MT level lasted 4 hours, and MLW lasted 4 hours. Since the tide fluctuations occur twice in 24 hours, each water level occurs at least 8 hours per day. In addition, when the tide is at maximum, the MT and MLW levels are also flooded for 8 hours. When the tide is at MT level, the MLW level is flooded. So, it was estimated that the MLW levels are always flooded and have a hydroperiod of 365d. The MT level is flooded approximately 66% of the time or 240d per year. The MHW level is estimated to be flooded 33% of the time or 120d per year. These assumptions provided the foundation hydroperiod values. Since the mangrove communities respond to many other factors, such as salinity, the physical forces of the ocean, and competition (Ball 1980, Lugo and Snedaker 1974, Lugo 1980), I estimated a hydroperiod range around the foundation values.

   The hydroperiod of the Mixed Mangrove Formation [9 and 21] is necessarily broad because all three mangrove species were included in the association. This association could experience water levels from MLW to above MHW. The FGAP v. 6.6 description said that the association contains mostly *Avicennia* and *Laguncularia* species so the hydroperiod was shifted to the "dry" end of the mangrove hydroperiod range.

I calculated MHW, MLW, and MTL elevations for several locations in south Florida. This information was not useful for establishing the hydroperiods, but may be useful in the future. The source for predicted high and low waters for the current year came from NOAA and the National Ocean Service on the internet at: http://co-ops.nos.noaa.gov/tides/gulf/. Published benchmarks, which include the MHW, MLW, and MTL calculated over a decade or two, were also accessed on the internet at: http://co-ops.nos.noaa.gov/benchmarks/.

The hydroperiod ranges are conservative and are probably much wetter than indicated. This is particularly true for the *Rhizophora mangle* forest association, which could quite easily be inundated all the time. Storm surges and spring tides also will move water higher on the landscape. Berm formation on the ocean side of the shoreline (see Montague and Wiegert 1990, p. 489) is also common. These berms retain the high tide waters and many *Avicennia germinans* forests could easily be inundated all the time.

4. The plant community downslope of the Saltwort/Glasswort EC [38] and Sand Cordgrass Grassland [48] is *Juncus roemerianus* salt marsh [49] (see Montague and Wiegert 1990 p. 489 for illustrations). The wet end of the Saltwort/Glasswort EC [38] and Sand Cordgrass Grassland [48] hydroperiod (21d) was determined by using the dry end of the hydroperiod of the *Juncus* plant community (Stout 1984 p. 14).

Succession Models

Introduction

Simple succession models have been developed that incorporate 31 (out of 48) plant communities and represent 88% of the total aerial coverage of the ATLSS model. The succession models incorporate hydroperiod and fire disturbances and generally extend over a time period of 20 to 50 years, depending on available information. The models were developed with the general idea that plant communities do not necessarily move toward or exist in an equilibrium state. They are simply a group of plants that are best adapted to the existing abiotic and biotic factors occurring in space and time at a particular location. The plant communities must constantly change in response to a continually changing and variable environment. Of course, this may lead to observable and quantifiable patterns and those patterns have been recorded in the succession models. All models were developed after extensive literature reviews and have been documented with the scientific literature.

A significant number of the remaining communities (13, 11% of the aerial coverage of the ATLSS model) were also extensively researched. These communities primarily consisted of mangrove and salt marsh communities. It was determined that these communities are generally very stable and tend to go through cyclic succession. While fire and hydroperiod were potentially important disturbances in these communities, they were not the disturbances widely studied by scientists, resulting in little available information in the literature. Other disturbances such as wave action, hurricanes, freezes, soil salinity and salt spray, were reported to play a more prominent role in these communities but were not included in the ATLSS model. Therefore, succession models were not constructed for these coastal communities. Greater explanation is given in the Coastal Communities and Mangrove Forest sections below.

The remaining four plant communities lacked enough data in the scientific literature to place them into the succession models. They will be included as data becomes available.

Integrating the Succession Models

The plant communities identified by FGAP v. 6.6 represent a mosaic landscape. Different plant communities have overlapping hydroperiods. Many plant communities could succeed to a variety of other plant communities and are used in multiple succession models. Hydroperiod and fire disturbances may occur at varying levels of intensity which will directly affect the successional pathway. Putting these ecosystem processes into a landscape computer model will require the integration of the succession models with each other. Several issues must be considered during the programming phase of the succession models.

1. Hydroperiod Overlap
   Hydroperiods of the plant communities overlap with each other (see Table 4 for example). Therefore more than one plant community could arise in the same hydroperiod at a particular location. One possible solution is to divide the succession model hydroperiod into small units (say 10 days). When there is a hydroperiod overlap between plant communities invoke a coin toss routine to pick the plant community that succeeds.

2. Plant Communities Used in Multiple Succession Models
   A number of plant communities are used in multiple succession models because they have been generally defined by FGAP or they are common plant communities. For example, Bay/Gum/Cypress [6] could succeed to swamp forest or become the "climax" vegetation community at a particular location. There is no practical way to determine which way the successional path will go except to use the existing surrounding vegetation as a guide. One possible solution is that when a branch point is reached the plant communities in the surrounding cells are censused. Based on the census results, the program selects the most common plant community to succeed toward. Having the hydroperiod exert some influence on the direction of the succession path would also create additional realism. Censusing surrounding cells could also be done to resolve the hydroperiod overlap between plant communities.

3. Disturbance Intensity
   The intensity or length of a disturbance can be an important factor in determining a successional pathway. Fire disturbances occur at varying levels of intensity. The succession models will require an integration of the fire interval listed on the succession model with a random incidence of fire disturbance. This is because one disturbance (fire or hydroperiod) may not be enough to transform one plant community into another. This is particularly true for the pine/scrub/flatwood succession model.

   Plant communities may also succeed with an extended (>2 years) change in hydroperiod. Successional changes caused by hydroperiod are not instantaneous and are expected to take a minimum of 3 years for shifts in herbaceous plant associations and up to 40 years for more mature woody plant associations. This may require a hydroperiod counter for each plant community.

Pine/Scrub/Flatwood Succession

How to Read the Pine/Scrub/Flatwood Succession Diagram

1. Succession for the flatwood and scrub plant associations is modeled in Table 2. Numbers in brackets [#] are the FGAP v. 6.6 plant class number. Bolded numbers (for example, **110–320**) refer to the actual hydroperiod in days of a particular plant community. These values are identical to those reported in Table 1. When more than one plant community could occur in a given hydroperiod, in a particular fire interval, and in the same geographic region then the probability that a plant association would occur was calculated. These probabilities of plant community occurrence are given in curly brackets {#}. The probabilities were calculated by adding the aerial coverage of each possible plant association together in the project area (based on the FGAP v. 6.6 mapping) and calculating what percent each individual plant association was of the plant communities added together. That percent became the probability of occurrence.

The hydroperiod scale at the base of Table 2 is relative and has been placed there as an aid to interpretation. The actual hydroperiods of a particular plant community may not match the scale. The bolded hydroperiod values or the values in Table 1 should be used for modeling purposes.

2. In this model both fire and hydroperiod disturbances are relevant to succession in flatwoods and scrub plant associations. However, successional shifts do not appear to follow a linear or stepwise pattern. **The plant communities on Table 2 with a hydroperiod between 0–15d (Sandhill EC [26], Xeric Scrubland [35], Sand Pine Forest [14], Xeric–Mesic Live Oak [4], and Mixed Evergreen–Decid. Forest [19]) are assumed to be disturbed only by fire.** The topography of these communities is high enough to not be disturbed by flooding.

In the Sandhill to Xeric–Mesic Live Oak EC community succession (Hydroperiod 0–15d), the Xeric Scrubland [35] and Sand Pine Forest [14] communities between 11–50 years old will recover within 1–2 years after a fire (Menges et al. 1993, p. 376; Abrahamson and Abrahamson 1996). Three fires within 10 years are needed to shift the Xeric Scrubland [35] and Sand Pine Forest [14] communities to Sandhill [26]. A similar observation was made in the Bayhead plant communities [6, 30] by Peroni and Abrahamson (1986, p. 186). Several fires occurred in a Bayhead community over a 37 year period and the Bayhead community recovered rapidly without passing through flatwoods (Slash Pine Forest [13, 16, 25]) stages. Thus, one fire in the scrub and forest communities does not automatically convert those communities to the more fire prone early successional communities listed at the top of a given hydroperiod.

If a fire disturbance occurs annually, Sandhill EC [26] and Xeric Shrubland [35] will result. Greater fire frequency intervals encourage the growth of Live Oak EC [4, 5]. If a severe fire or series of severe fires over a short period of time occurs in a Live Oak EC community, then the model assumes that the plant community returns to the first plant community at the top of the column, Sandhill EC [26] or Xeric Shrubland [35] in this case.

3. **Plant communities with a hydroperiod of 30–60d [6, 13, 16, 25, and 30] can be disturbed by both fire and hydroperiod.** Since fires are assumed to be more frequent during drought, flooding is considered the major hydroperiod disturbance in this successional model. As with fire disturbance, the severity of the hydroperiod disturbance is an important factor in the rate of succession. Hydroperiod severity is incorporated into the model through the length of

flooding. For example, Mesic–Hydric Pine Forest [16] is not expected to succeed to Galberry/Saw Palmetto CG [30] or Bay/Gum/Cypress EC [6] unless it has been flooded for approximately 10 years. Should the flooding disturbance recede, Mesic–Hydric Pine Forest CG [16] is expected to succeed in approximately 3 years and may be encouraged by a fire disturbance. The 30–60d hydroperiod of the Pine/Scrub/Flatwood communities had two possible successional sequences and is divided in Table 2 by a dashed line. It is not clear from the literature whether these two successional sequences would mix–they probably would under certain disturbance conditions.

4. Data confidence. Succession data on these communities for all the hydroperiods up to 20 years since the last fire is good. There are a few studies on succession over a 20 year period, but most of the succession patterns after 20 years are speculative. The values in the column, "Years Since Last Hydroperiod Disturbance" were estimated by P. Wetzel.

*Plant Classes Included in the Pine/Scrub/Flatwood Succession Table**

- **[4] Xeric–Mesic Live Oak EC**
- **[5] Mesic–Hydric Live Oak/Sabal Palm EC**
- **[6] Bay/Gum/Cypress EC**
- **[13] South Florida Slash Pine Forest**
- [14] Sand Pine Forest
- **[16] Mesic–Hydric Pine Forest CG**
- [19] Mixed Evergreen–Cold Deciduous Hardwood Forest
- **[25] South FL Slash Pine Woodland**
- [26] Sandhill EC
- [30] Gallberry/Saw Palmetto CG
- [35] Xeric Shrubland

* **Bolded** plant associations are used in more than one succession model.

References for the Pine/Scrub/Flatwood Succession Model

Abrahamson 1984a, p. 9–21
Abrahamson 1984b, p. 35–43
Abrahamson and Abrahamson 1996
Abrahamson and Hartnett 1990, p. 111
Abrahamson et al. 1984, good overview, see also pp. 239–245
Edmisten 1965, p. 40
Hartnett and Krofta, 1989
Menges and Hawkes 1998, p. 936–7
Menges et al. 1993
Myers 1985, p. 249
Peroni and Abrahamson 1986, p. 179, 182–4, 187, 188
Veno 1976

Table 2. Successional relationships for the pine/scrub/flatwood plant communities.

Years Since Last Fire	Years Since Last Hydroperiod Disturbance	Pine/Scrub/Flatwood Succession			
1	3	Sandhill EC [26] **0**	Xeric Shrubland [35] **0–15**	Mesic–Hydric Pine Forest CG [16] **30–60**	{.42} S FL Slash Pine Forest [13] **0–60** {.58} S FL Slash Pine Woodland [25] **30–60**
2	3	Sandhill EC [26] **0**	{.05} Xeric Shrubland [35] **0–15** {.73} Mesic–Hydric Pine Forest [16] **30–60** {.22} Gallberry/Saw Palmetto CG [30] **30–60**	Mesic–Hydric Pine Forest CG [16] **30–60**	{.42} S FL Slash Pine Forest [13] **0–60** {.58} S FL Slash Pine Woodland [25] **30–60**
3–5	3	Sandhill EC [26] **0**	{.05} Xeric Shrubland [35] **0–15** {.73} Mesic–Hydric Pine Forest [16] **30–60** {.22} Gallberry/Saw Palmetto CG [30] **30–60**	Mesic–Hydric Pine Forest CG [16] **30–60**	{.42} S FL Slash Pine Forest [13] **0–60** {.58} S FL Slash Pine Woodland [25] **30–60**
6–10	10	Sandhill EC [26] **0**	{.05} Xeric Scrubland [35] **0–15** {.73} Mesic–Hydric Pine Forest [16] **30–60** {.22} Gallberry/Saw Palmetto CG [30] **30–60**	Mesic–Hydric Pine Forest CG [16] **30–60**	{.42} S FL Slash Pine Forest [13] **0–60** {.58} S FL Slash Pine Woodland [25] **30–60**
11–20	10	{.79} Xeric Scrubland [35] **0** {.21} Sand Pine Forest [14] **0**	{.05} Xeric Scrubland [35] **0–15** {.73} Mesic–Hydric Pine Forest [16] **30–60** {.22} Gallberry/Saw Palmetto CG [30] **30–60**	{.66} Gallberry/Saw Palmetto CG [30] **30–60** {.34} Bay/Gum/Cypress EC [6] **60–160**	No Data
21–30	20	{.79} Xeric Scrubland [35] **0** {.21} Sand Pine Forest [14] **0**	{.35} Xeric Scrubland [35] **0–15** {.58} Xeric–Mesic Live Oak EC [4] **0** Mesic–Hydric Live {.06} Oak/Sabel Palm EC [5] **0–60**	{.66} Gallberry/Saw Palmetto CG [30] **30–60** {.34} Bay/Gum/Cypress EC [6] **60–160**	No Data
31–50	20	{.79} Xeric Scrubland [35] **0–15** {.21} Sand Pine Forest [14] **0**	{.35} Xeric Scrubland [35] **0–15** {.58} Xeric–Mesic Live Oak EC [4] **0–30** {.06} Mesic–Hydric Live Oak/Sabel Palm EC [5] **0–60**	{.66} Gallberry/Saw Palmetto CG [30] **30–60** {.34} Bay/Gum/Cypress EC [6] **60–160**	No Data
>50	–	{.97} Xeric–Mesic Live Oak EC [4] **0–15** {.03} Evergreen–Decid. Hardwood Forest [19] **0–15**	{.97} Xeric–Mesic Live Oak EC [4] **0–15** {.03} Mixed Evergreen–Decid. Hardwood Forest [19] **0–15**	No Data	No Data

| 0 | 15 | 30 | 60

Hydroperiod (days)

Cypress Forest Succession

How to Read the Cypress Forest Succession Diagram

1. Succession for the plant associations that contain cypress trees are modeled in Table 3. Numbers in brackets [#] are the FGAP v. 6.6 plant class number. Bolded numbers (for example, **110–320**) refer to the actual hydroperiod in days of a particular plant community. These values are identical to those reported on the master hydroperiod table. When more than one plant community could occur in a given hydroperiod, in a particular fire interval, and in the same geographic region then the probability that a plant association would occur was calculated. These probabilities of plant community occurrence are given in curly brackets {#}. The probabilities were calculated by adding together the aerial coverage of each possible plant association in the project area (based on the FGAP v. 6.6 mapping) and calculating what percent each individual plant association was of the total aerial coverage of the plant communities added together. That percent became the probability of occurrence.

The hydroperiod scale at the base of Table 3 is relative and has been placed there as an aid to interpretation. The actual hydroperiods of a particular plant community may not match the scale. The bolded hydroperiod values or the values in Table 1 should be used for modeling purposes.

2. **In this model only one disturbance, fire, is relevant to succession in cypress plant associations. Shifts in hydroperiod could occur in these plant communities, either from peat burning from a severe fire or drainage by humans (not incorporated into the ATLSS model), but the hydroperiods of most of the plant communities are so broad that it was assumed that hydroperiod changes would be rare.**

However, for these plant associations the severity of the fire is an important determinant of the successional path. A severe fire in any of the woody or forested plant associations would probably move the woody plant community to an herbaceous dominated plant community. Within a given hydroperiod, if a severe fire occurs, it is assumed that the plant community goes back to the plant community type at the top of the table in a particular hydroperiod (Casey 1997, p. 57; Gunderson and Loope 1982a, p. 20). For example, if a severe fire occurs in Swamp and Cypress Forest communities [3, 17, 18], these communities would succeed to Graminoid Marsh CG [42], *Cladium* [43], and *Eleocharis* [44] communities.

Forested plant communities [6, 17, 37, 18] are not expected to succeed to herbaceous dominated plant communities [42, 43, 44, 54, 55] after moderate or light fires or logging (not incorporated into the ATLSS model at this time) (Casey 1997, p. 57; Gunderson and Loope 1982a, p. 20). There is no specific information on the frequency of severe fires in Cypress forests, although a reasonable estimate would be between every 100-150 years.

3. Reviewing the location of the possible plant associations, a distinct geographic pattern occurs. Some plant associations related to cypress succession [communities 6, 54, 55] are only found north of the southern edge of Lake Okechobee. Other plant communities [3, 17, 18, and to certain extent 37] are found predominately south of the southern edge of Lake Okechobee. Because of this pattern, the successional patterns of cypress associations were divided into northern and southern components.

4. Data confidence. Succession data on the herbaceous communities for all the hydroperiods up to 5 years since the last fire are very good and information on succession up to 20 years since the last fire or logging activity is good. Successional models for cypress plant associations over 30 years are speculative.

*Plant Classes Included in the Cypress Succession Model**

- **[3] Semi–Deciduous Tropical/Subtropical Swamp Forest**
- **[6] Bay/Gum/Cypress EC**
- **[17] Swamp Forest CG**
- **[18] Cypress Forest CG**
- **[37] Saturated–Flooded Cold Deciduous Shrubland EC**
- **[42] Graminoid Emergent Marsh CG**
- **[43] Sawgrass Marsh**
- **[44] Spikerush Marsh**
- [53] Dwarf Cypress Prairie
- [54] Temperate Wet Prairie
- [55] Maidencane marsh CG

*** Bolded plant associations are used in more than one succession model.**

References for the Cypress Forest Succession Model

Casey 1997, p. 57
Duever et al. 1984a, p. 302
Ewel, 1990 p. 306
Gunderson and Loope 1982a, p. 20

Table 3. Successional relationships for the cypress plant communities south and north of the southern edge of lake Okechobee.

SOUTH OF LAKE OKECHOBEE

Years Since Last Fire	Cypress Succession	
	110–150	150–340
1–4	{.25} Graminoid Marsh CG [42] **120–270** {.7} Cladium [43] **130–330** {.03} Eleocharis [44] **150–300**	{.25} Graminoid Marsh CG [42] **120–270** {.7} Cladium [43] **130–330** {.03} Eleocharis [44] **150–300**
4–10	{.26} Dwarf Cypress Savanna [53] **120–150** {.74} Deciduous Shrubland EC [37] **110–320**	Deciduous Shrubland EC [37] **110–320**
10–20	Deciduous Shrubland EC [37] **110–320**	Deciduous Shrubland EC [37] **110–320**
20–30	Deciduous Shrubland EC [37] **110–320**	{.76} Swamp Forest [17] **120–290** {.24} Semi–decid. Trop./Sub Trop. Swamp Forest [3] **60–180**
30–100	{.76} Swamp Forest [17] **120–290** {.24} Semi–decid. Trop./Sub Trop. Swamp Forest [3] **60–180**	{.41} Swamp Forest [17] **120–290** {.13} Semi–decid. Trop./Sub Trop. Swamp Forest [3] **60–180** {.46} Cypress Forest CG [18] **200–340**
NORTH OF THE SOUTHERN EDGE OF LAKE OKECHOBEE		
1–4	{.66} Temperate Wet Prairie [54] **166–290** {.34} Maidencane Marsh [55] **180–300**	{.66} Temperate Wet Prairie [54] **166–290** {.34} Maidencane Marsh [55] **180–300**
4–10	{.16} Dwarf Cypress Savanna [53] **120–150** {.06} Bay/Gum/Cypress EC [6] **60–160** {.46} Deciduous Shrubland EC [37] **110–320** {.32} Swamp Forest [17] **120–290**	{.28} Swamp Forest CG [17] **120–290** {.32} Cypress Forest CG [18] **200–340** {.40} Deciduous Shrubland EC [37] **110–320**
10–20	{.15} Bay/Gum/Cypress EC [6] **60–160** {.85} Swamp Forest [17] **120–290**	Cypress Forest CG [18] **200–340**
>30	Swamp Forest [17] **120–290**	Cypress Forest CG [18] **200–340**

Hydroperiod (days)

Herbaceous Plant Communities Succession

How to Read the Herbaceous Plant Communities Succession Diagram.

1. In this model only two disturbances, fire and a prolonged (>3 years) change in hydrology, are assumed to cause one plant association to succeed into another (Table 4). The successional tables are designed to be read from top to bottom and from bottom to top for either fire or hydrologic disturbances. **It is important to note that succession can go either "forward" or "backward". It is also important to note that succession may not occur or the disturbance that would cause succession in one direction may be negated by another major environmental variable.**

Table 4 can also be read from right to left and left to right across hydroperiods. An extended (assumed to be >3 years) decrease or increase in hydroperiod is considered to initiate succession in plant communities within a fire disturbance interval (from left to right or right to left on the table). Succession by hydroperiod may also occur if the fire frequency gets longer or shorter, in which case the table is read from top to bottom or bottom to top.

Numbers in brackets [#] are the FGAP v. 6.6 plant class number. Bolded numbers (for example, **110–320**) refer to the actual hydroperiod in days of a particular plant community. These values are identical to those reported on the master hydroperiod table. When more than one plant community could occur in a given hydroperiod, in a particular fire interval, and in the same geographic region then the probability that a plant association would occur was calculated. These probabilities of plant community occurrence are given in curly brackets {#}. The probabilities were calculated by adding together the aerial coverage of each possible plant association in the project area (based on the FGAP v. 6.6 mapping) and calculating what percent each individual plant association was of the total possible aerial coverage. That percent became the probability of occurrence.

The hydroperiod scale at the base of Table 4 is relative and has been placed there as an aid to interpretation. The actual hydroperiods of a particular plant community may not match the scale. The bolded hydroperiod values in Table 4 or the values in Table 1 should be used for modeling purposes.

2. **Plant community succession by fire disturbance requires a number of assumptions and should be cautiously used in modeling efforts.**

Fire is a common disturbance in the Everglades (Gunderson and Snyder 1994, p. 302) and there are two basic cycles applicable to ATLSS. The annual cycle correlates with the wet and dry seasons of southern Florida. Driest conditions are created in April and May and this is when the largest areas in the Everglades National Park are burned (Gunderson and Snyder 1994, p. 302). The largest burns in the Water Conservation Areas occur in December and January. Generally, these fires are less intense, killing or pruning back woody vegetation and burning away dead organic matter, but they do not initiate peat fires and reduce the soil elevation.

The longer term fire cycle occurs at a 10–14 year frequency and corresponds with water levels, water flows, and evaporation cycles (Gunderson and Snyder 1994, p. 302). These fires are in conjunction with droughts of varying intensities and they produce hot fires. The severe fires may burn large areas of peat; killing woody species roots and reducing the soil elevation anywhere from 6–25 cm (see Zaffke 1983 for an example).

Plant community changes after a fire will depend greatly on the severity of the fire. Fires that do not burn deeply into the peat so that woody plant roots are not destroyed and hydrologic regime is not changed from soil burning generally will not cause one plant community to succeed to another. For example, tropical hardwoods growing on Hammocks are capable of resprouting and rapid recovery after a less severe fire, and survive fires at approximately 5-year intervals (Loope and Urban 1980, p. 6). Less severe fires maintain the current plant communities.

Hot or severe peat burning fires may alter plant communities. They can destroy hammocks and tree islands [Deciduous Shrub, 37] (Loope and Urban 1980, p. 6, Zaffke 1983). The oxidation of 10–20 cm of peat after a severe fire may cause wet prairie (Graminoid Marsh CG [42], Cladium [43], Eleocharis [44], and Typha [46]) to succeed into Forb Emergent Marsh [56] or Floating Leaved Vegetation [57] (Davis et al. 1994, pp. 436–438). However, information on severe fire effects is limited and will be added to the model as it becomes available.

The ATLSS model must incorporate both hot and cold fires. To a certain extent, cold or less severe fires maintain current plant communities in addition to other environmental factors such as hydroperiod and soil type. Hot fires are a more intense disturbance and have the potential to cause greater successional shifts in plant communities. These shifts would have to correspond to hydrologic regime, nutrient, and soil type limitations.

Within a given hydroperiod, plant communities will follow a path of succession from the top of the table downward. As long as a fire does not occur, herbaceous plant communities generally become more woody through time (Drew and Schomer 1984, p. 99; Gunderson and Loope 1982, p. 20). If a fire occurs, it is assumed that the plant community goes back to the plant community type at the top of the table in a particular hydroperiod.

3. Plant communities may also succeed with an extended (>3 years) change in hydroperiod. This could be either a 2 year flood disturbance or a 3 year drought disturbance. The expected number of years needed for a plant community to succeed to another plant community because of a change in hydrology is listed in the column, "Years Since Last Hydroperiod Disturbance". Clearly, a fire disturbance is much more likely during a drought hydroperiod disturbance and less likely during a flooded hydroperiod disturbance and these two disturbances have an interactive effect on the plant communities. The extent of this interactive effect is not well documented in the literature, especially over long time intervals.

To determine a path of succession because of changes in hydroperiod, the table should be read from left to right (or right to left), within a given fire frequency interval and up and down when there is a shift in fire frequency. Successional changes caused by hydroperiod are not instantaneous and are expected to take a minimum of 3 years for shifts in herbaceous plant associations and up to 40 years for more mature woody plant associations.

4. Several successional changes could not be included on Table 4 and are listed in Table 5. These changes are caused by severe disturbances and reflect major plant community changes. Note that only a reduction in hydrology would cause succession to occur in the opposite direction indicated in Table 5.

5. Data confidence. Succession data on the herbaceous communities for all the hydroperiods up to 5 years since the last fire are very good and information on succession up to 10 years since the last fire is good. There are a few studies on succession over a 20 year period, but most of the

succession patterns after 10 years are speculative. The values in the column, "Years Since Last Hydroperiod Disturbance" were estimated by Paul Wetzel.

*Plant Classes Included in Herbaceous Succession Model**

- **[2] Tropical Hardwood Hammock**
- **[3] Semi–Deciduous Tropical/Subtropical Swamp Forest**
- **[4] Mesic–Hydric Live Oak/ EC**
- **[5] Mesic–Hydric Live Oak/Sabal Palm EC**
- **[6] Bay/Gum/Cypress EC**
- **[16] Mesic–Hydric Pine Forest CG**
- **[17] Swamp Forest CG**
- **[18] Cypress Forest CG**
- **[25] South FL Slash Pine Woodland**
- [28] Broad–leaved Evergreen Cold–deciduous Shrubland CG
- [29] Dry Prairie EC
- **[30] Galberry/Saw Palmetto CG**
- **[37] Saturated–Flooded Cold Deciduous Shrubland EC**
- **[39] Graminoid Dry Prairie EC**
- **[42] Graminoid Emergent Marsh CG**
- **[43] Sawgrass Marsh**
- **[44] Spikerush Marsh**
- [45] Muhly Grass Marsh
- [46] Cattail Marsh CG
- [52] Sparsely Wooded Wet Prairie CG
- [56] Forb Emergent Marsh
- [57] Water Lily or Floating Leaved Vegetation

* **Bolded** plant associations are used in more than one succession model.

References for the Herbaceous Succession Model

Davis et al. 1994, pp. 431–438
Drew and Schomer 1984, p. 98–100
Gunderson 1994, pp. 323–340
Gunderson and Loftus 1993, p. 216
Gunderson and Loope 1982, p. 20
Gunderson and Snyder 1994, pp. 291–305
Herndon and Taylor 1986
Jordan et al. 1997
Loope and Urban 1982
Loope 1980
White 1994, p. 453

Table 4. Successional relationships for the herbaceous and forested plant communities.

Years Since Last Fire	Years Since Last Hydroperiod Disturbance	Herbaceous/Forested Vegetation Succession			
1	3	Dry Prairie [29, 39] 30–60	{0.996} Muhly Grass Marsh[45] {0.004} Sparsely Wooded Wet Prairie CG [52] 60–120	{.25} Graminoid Marsh CG [42] 120–270 {.7} Cladium [43] 130–330 {.03} Eleocharis [44] 150–300 {.03} Typha [46] 180–280	Forb Emergent Marsh [56] 230–360
2	3	Dry Prairie [29] 30–60 Graminoid Dry Prairie EC [39] 20–50	{0.996} Muhly Grass Marsh[45] {0.004} Sparsely Wooded Wet Prairie CG [52] 60–120	{.25} Graminoid Marsh CG [42] 120–270 {.7} Cladium [43] 130–330 {.03} Eleocharis [44] 150–300 {.03} Typha [46] 180–280	Forb Emergent Marsh [56] 230–360
3–5	3	{.53} Mesic–Hydric Forest [16] {.22} Slash Pine Woodland [25] {.16} Gallberry/Palmetto CG [30] 30–60 {.08} Hammock [2] 10–45 {.01} Live Oak [5] 0–60	{0.996} Muhly Grass Marsh[45] {0.004} Sparsely Wooded Wet Prairie CG [52] 60–120	{.25} Graminoid Marsh CG [42] 120–270 {.7} Cladium [43] 130–330 {.03} Eleocharis [44] 150–300 {.03} Typha [46] 180–280	Forb Emergent Marsh [56] 230–360
6–10	10	[16, 25, 30] 30–60 Trop. Hammock [2] 10–45 Live Oak [5] 0–60	Decid. Shrub [37] 110–320	{.91} Swamp Forest CG [17] 120–290 {.09} Brd Lvd/Mixed Evergreen Shrub [28] 120–150	Forb Emergent Marsh [56] 230–360; Floating Leaved Veg. [57] 330–360
11–20	10	[16, 25, 30] 30–60 [2] 10–45 [5] 0–60	{.77} Decid/Trop. Swamp Forest [3] 60–180 {.23} Brd Lvd/Mixed Evergreen Shrub [28] 120–150	Decid. Shrub [37] 110–320; Swamp Forest CG [17] 120–290	Floating Leaved Veg. [57] 330–360
21–30	20	[16, 25, 30] 30–60 [2] 10–45 [5] 0–60	Decid/Trop. Swamp Forest [3] 60–180	Decid. Shrub [37] 110–320; Swamp Forest CG [17] 120–290	Floating Leaved Veg. [57] 330–360
31–50	40	{.55} Trop. Hammock [2] 10–45 {.04} Live Oak [5] 0–60 {.4} Xeric–Mesic Live Oak EC [4] 0–30	{.35} Bay/Gum/Cypress EC [6] 60–160 {.65} Swamp Forest [3] 60–180	Decid. Shrub [37] 110–320; Swamp Forest CG [17] 120–290; Cypress Forest CG [18] 200–340	Floating Leaved Veg. [57] 330–360
>50	50		Decid/Trop. Swamp Forest [3] 60–180	No Data	

Hydroperiod (days): 0 | 30 | 60 | 90 | 120 | 150 | 180 | 210 | 240 | 270 | 300 | 330 | 360

Table 5. Additional successional relationships that occur in the central Everglades not represented on Table 4 (after White 1994, p. 453). Note that only a reduction in hydrology would cause succession of the plant communities to occur in the opposite direction indicated.

Initial Plant Community	Specific Disturbance	Plant Community After Succession
{.59} Decid. Shrub [37] **110–320** {.41} Swamp Forest CG [17] **120–290**	Hot Fire ⟶	{.59} Forb Emergent Marsh [56] **230–360** {.41} Floating Leaved Veg. [57] **330–360**
{.25} Graminoid Marsh CG [42] **120–270** {.7} Cladium [43] **130–330** {.03} Eleocharis [44] **150–300** {.03} Typha [46] **180–280**	Hot Fire ⟶	{.59} Forb Emergent Marsh [56] **230–360** {.41} Floating Leaved Veg. [57] **330–360**
{.59} Decid. Shrub [37] **110–320** {.41} Swamp Forest CG [17] **120–290**	Increased Hydroperiod ⟶	{.25} Graminoid Marsh CG [42] **120–270** {.7} Cladium [43] **130–330** {.03} Eleocharis [44] **150–300** {.03} Typha [46] **180–280**

Coastal Community Succession

Introduction

The coastal plant communities identified in FGAP v. 6.6 were divided into high energy (east coast) and moderate to low energy (Gulf coast and tip of peninsula) communities on the basis of their location, which is related to the tidal range, relative wave energy, and sea level rise (Montague and Wiegert 1990). The east and west coast lines are different enough to have different plant communities that result in different successional pathways.

The often well defined zonation of the coastal plant communities along Florida's coastline has produced a vigorous debate among ecologists as to how much of that zonation is autogenous succession and how much is due to environmental gradients. Hillestad et al. (1975), Montague and Wiegert (1990), Oosting (1954), and Stalter and Odum (1993) recognize that the coastal plant communities or zones of vegetation do not represent serial stages of succession. Rather, these communities exist where they do because they can successfully survive the environmental conditions at a particular site.

However, Stalter and Odum (1993) note that the colonization of vegetation on newly formed dunes will stabilize the dunes and contribute to dune development. Salt marsh plants have also been observed to trap sediments, where a sufficient supply of sediment is available, and promote a seaward expansion of the salt marsh boundaries (Montague and Wiegert 1990). Primary succession under such conditions is associated with soil development, an increase in soil nitrogen, and an increase in mature plant height (Stalter and Odum 1993). However, the development of plant community zonation also depends on wave action, salt spray (Laessle and Monk 1961; Oosting 1954; Stalter and Odum 1993), elevation (tidal flooding) (Eleuterius 1984), and soil water salinity (Eleuterius 1984; Ross et al. 1994). Fires, hurricanes, and freezes can also be important periodic disturbances to coastal plant communities, but they clearly do not have the same effect as the chronic environmental factors of wave action/tidal influence, salt spray, and soil salinity.

Primary coastal succession does not consistently occur and information about it is largely anecdotal. This type of succession is also on a scale and time frame (decades) that is beyond the scope of the current ATLSS model. For these reasons, primary succession of coastal communities was not included in the succession models. This is why the Sea Oats Dune Grassland [40] is separated from the other plant communities in Table 6. The Dune Grassland community can be used if soil salinity or salt spray disturbances are incorporated into the ATLSS model in the future.

However, if established coastal plant communities are disturbed by fire, hurricanes, or freezes a cyclic secondary succession is known to occur. Since fire and hydrology are the only disturbances used in the ATLSS model the literature search focused on research done on these disturbances. Enough information was obtained to include fire disturbance for only the plant communities found on the low energy old dune ridges (Table 6). No literature on the effects of hydroperiod changes was found. Plant communities in swales behind dunes and in other low places are known to succeed from grassland to shrub to low forest communities but no information was available on rates of succession or on the effects of fire or hydrology on succession of these communities. It is not uncommon for the environmental conditions at the coast to maintain grassland or scrub shrub "climax" communities for long periods (decades) of time. Plant communities in high energy low areas that are not dunes were noted in the third block of Table 6.

The plant communities located on the low energy Gulf coast and their position on the shoreline are listed in Table 6. Fire disturbance in salt marshes is reported (Schmalzer et al. 1991), but no specific information about rates and effects on succession were found in the literature. Schmalzer et al. (1991) report on community composition and biomass changes of *Juncus roemerianus* and *Spartina bakeri* marshes one year after the marsh was burned. Community composition in both marsh types remained the same as before the fire and live biomass was reduced to slightly less than half of the pre–fire biomass. This data suggests that the biomass of the salt marsh communities would recover in 2–3 years after burning. However, as with the high energy coastal communities, salt marsh and mangrove forest community zonation depend on wave action, salt spray, elevation (tidal flooding), and soil water salinity. It is expected that salt marsh communities will remain salt marsh communities even after fire disturbance because these other environmental factors appear to outweigh the importance of fire disturbance. No literature on the effects of hydroperiod changes was found other than references to increasing sea level allowing the salt marshes to advance inland (Montague and Wiegert 1990). No information was found about what determines whether salt marsh or mangrove forest will exist in a particular location. For these reasons, succession of low and moderate energy coastal communities was not included in the succession models. Mangrove forest succession is discussed in greater detail in the Mangrove Forest Succession section of this report.

Table 6. A. Successional relationships for the high energy coastal plant communities. Information on the effects of fire disturbance was available only for the plant communities found on old dune ridges. B. Plant communities found on low/moderate energy shorelines. Adequate information was not available to develop a succession model for these communities.

A. HIGH ENERGY COASTAL COMMUNITIES–Eastern Coast

Sea Oats Dune Grassland [40]

Years Since Last Fire	Low Energy Old Dune Ridges	Low Energy Low Areas or Swales	High Energy Low Areas
3–4	{.09} Coastal Strand [33] **15–45** {.91} Graminoid Dry Prairie [39] **20–50**	Graminoid Marsh CG [42] **120–270** Graminoid Dry Prairie [39] **20–50** Deciduous Shrubland [37] **110–320**	Graminoid Marsh CG [42] **120–270** Mixed Mangrove Forest [9] **90–180** Black Mangrove Forest [10] **60-150** Red Mangrove Forest [11] **150–240**
20–40	{.33} Tropical Hammock [2] **10–45** {.03} Live Oak/Sabel Palm EC [5] **0–60** {.64} Mesic–Hydric Pine Forest [13] **0–60**	Semi–decid. Trop./Sub Trop. Swamp Forest [3] **60–180** Deciduous Shrubland EC [37] **110–320**	
	0–45	>45	

Hydroperiod (days)

B. LOW/MODERATE ENERGY COASTAL COMMUNITIES–Western & Southern Coasts

Plant Community Location	Much Overlap Among All Plant Communities on West Coast	
Plant Communities Closest to Shoreline	Saltwort/Glasswort EC [38] **12–21** Graminoid Dry Prairie [39] **20–50** Salt Marsh EC [47] **12–44** Sand Cordgrass Grassland [48] **12–21** Black Needle Rush Marsh [49] **3–44**	Mixed Mangrove Forest [9] **90–180** Black Mangrove Forest [10] **60-150** Red Mangrove Forest [11] **150–240** Graminoid Marsh CG [42] **120–270** Buttonwood Woodland [20] **44–120**
Plant Communities Inland	Slash Pine Woodland [25] **30–60** Mesic–Hydric Pine Forest [13] **0–60**	Semi–decid. Trop./Sub Trop. Swamp Forest [3] **60–180** Swamp Forest CG [17] **120–290**
	0–60	>60

Hydroperiod (days)

How to Read the High Energy Coastal Communities–Eastern Coast Succession Diagram

1. Succession for the plant associations that contain high energy coastal communities are modeled. Numbers in brackets [#] are the FGAP v. 6.6 plant class number. Bolded numbers (for example, **110–320**) refer to the actual hydroperiod in days of a particular plant community. These values are identical to those reported on the master hydroperiod table. When more than one plant community could occur in a given hydroperiod, in a particular fire interval, and in the same geographic region, then the probability that a plant association would occur was calculated. These probabilities of plant community occurrence are given in curly brackets {#}. The probabilities were calculated by adding together the aerial coverage of each possible plant association (based on the FGAP v. 6.6 mapping) and calculating what percent each individual plant association was of the total possible aerial coverage in the project area. That percent became the probability of occurrence.

2. Data confidence. Succession data on coastal communities is scarce and of poor quality. The effects of fire disturbance on coastal plant communities are not reported in the literature. Therefore, only the communities on inland old dune ridges were modeled (Table 6). Adequate information was not available to develop a succession model for the remaining communities. It should be noted that fire disturbance interacts strongly with wind and wave disturbance, tidal inundation, salt spray, and soil water salinity levels. The general assumption of fire preventing woody species growth is reasonable, but the specifics of coastal plant community succession are poorly understood and speculative.

*Plant Classes Included in High Energy Coastal Communities–Eastern Coast Succession Model**

- **[2] Tropical Hardwood Hammock**
- **[3] Semi–Deciduous Tropical/Subtropical Swamp Forest**
- **[5] Mesic–Hydric Live Oak/Sabal Palm EC**
- **[9] Mixed Mangrove Forest Formation**
- **[10] Black Mangrove Forest**
- **[11] Red Mangrove Forest**
- **[13] South Florida Slash Pine Forest**
- [33] Coastal Strand
- **[37] Saturated–Flooded Cold Deciduous Shrubland EC**
- **[39] Graminoid Dry Prairie EC**
- [40] Sea Oats Dune Grassland
- **[42] Graminoid Emergent Marsh CG**

* **Bolded** plant associations are used in more than one succession model.

*Plant Classes Included in Low Energy Coastal Communities–Western and Southern Coasts Succession Model**

- **[3] Semi–Deciduous Tropical/Subtropical Swamp Forest**
- **[9] Mixed Mangrove Forest Formation**
- **[10] Black Mangrove Forest**
- **[11] Red Mangrove Forest**
- **[13] South Florida Slash Pine**
- **[17] Swamp Forest CG**
- [20] Buttonwood Woodland
- **[25] South Florida Slash Pine Woodland**
- [38] Saltwort/Glasswort EC
- **[39] Graminoid Dry Prairie EC**
- **[42] Graminoid Emergent Marsh CG**
- [47] Salt Marsh EC
- [48] Sand Cordgrass Grassland
- [49] Black Needle Rush Marsh

* **Bolded** plant associations are used in more than one succession model.

References for the Coastal Communities

<u>High Energy Coastal Communities–Eastern Coast</u>

Hillestad et al. 1975, p. 108
Johnson and Barbour 1990, pp. 441–461
Lassle and Monk 1961, pp. 49–54
Richardson 1977, pp. 321–328
Statler and Odum 1993, pp. 133–136

<u>Low Energy Coastal Communities–Western and Southern Coasts</u>

Eleuterius 1984, pp. 347–349
Montague and Wiegert 1990, p. 483–489
Schmalzer et al. 1991

Mangrove Forest Succession

Three primary mangrove communities are identified by FGAP and used in the ATLSS model, Mixed Mangrove Forest Formation [9], Black Mangrove Forest [10], Red Mangrove Forest [11], as well as, the corresponding mangrove communities with a reduced canopy [21, 22, 23] from Hurricane Hugo. Other mangrove communities or communities associated with mangroves include the Dwarf Mangrove EC [32] and Buttonwood Woodland [20]. The lack of long–term successional data, the evidence that mangrove forests go through short–term (<20 yrs) cyclic succession, and that mangrove forests appear to be self maintaining ecosystems in low–energy tropical saline environments, has prompted me to assume for the ATLSS model that mangrove forests do not undergo serial succession. Justification for this assumption is described below.

There has been great debate in the past concerning whether mangrove forests are a steady state system or whether the clear zonation seen in many mangrove forests represents serial stages of succession (Odum and McIvor 1990). The idea that mangrove forests are a successional community, first promoted by Davis (1940), also implies that mangroves promote active land accretion (Lugo 1980). Evidence suggests that mangroves have a passive role in the initial accretion of coast lines and that mangroves grow wherever environmental conditions and physical forces allow them to grow (Lugo 1980; Odum and McIvor 1990; Thomas 1993, p. 15). Once established, mangroves contribute to accretion by stabilizing the sediment and reducing erosion. However, on coastlines where conditions do not favor soil accretion, mangrove forests grow and maintain themselves for long periods of time. For the purposes of the ATLSS model it was assumed that mangrove forest zonation does not represent serial stages of succession.

Lugo (1980) expounds the ideas of Chapman (1976) to suggest that coastal ecosystems undergo cyclic succession. This is the idea that mangrove succession oscillates back and forth from one stage to another because of the recurrence of an environmental stress such as a hurricane or fire. In the absence of an environmental stress, succession would move to the next set of stages which are also cyclic. The process is reversible if the environmental stress is reapplied. Lugo (1980) suggests that air temperature, soil salinity, depth to water table, and nutrient availability are important mangrove forest stresses and will initiate mangrove succession.

Under high energy coastal conditions one mangrove community may succeed another. Lugo (1980) reports that *Rhizophora mangle* will be the pioneer species, followed by species that are adapted to longer hydroperiods and/or saltier conditions such as *Avicennia germinans* or *Laguncularia racemosa*. After a long enough time (>30 years) with no disruptive force or reversal in sedimentation patterns, terrestrial systems may replace mangrove forests. It is not clear from these papers if anyone has observed this last step of succession and it appears to be conceptual at this time.

The mangrove communities identified by FGAP v. 6.6, Mixed Mangrove Forest Formation [9], Black Mangrove Forest [10], Red Mangrove Forest [11] and the corresponding mangrove communities with a reduced canopy [21, 22, 23] are mostly located on the Gulf coast and in Florida Bay. The majority of this coastline has a low to moderate relative wave energy and low sea level rise (Montague and Wiegert 1990, p. 483) suggesting that the mangrove forests in those areas have a good chance of being self–maintaining systems and are expected to go through cyclic succession. This fact, plus the lack of long–term successional data, other evidence that mangrove forests go through short–term (<20 yrs) cyclic succession, and that mangrove forests appear to be self maintaining ecosystems in low–energy tropical saline environments, supports the assumption for the ATLSS model that mangrove forests do not undergo serial succession. Therefore, should a short–term (2–5 yrs) hydroperiod change or fire impact the mangrove forest classification, the mangrove community is expected to recover and maintain itself. The full canopy plant classifications may succeed to the reduced canopy classifications and back again (for example Black Mangrove Forest [10] may succeed to Reduced Canopy Black Mangrove Forest [22] after a fire. It is then expected that the Reduced Canopy Black Mangrove Forest [22] will succeed to the Black Mangrove Forest [10] after about 10 years), but the plant cover classification will remain basically the same.

Estimation of Deer Browse Parameters

Introduction

The goal of the individual based White–tailed Deer model is to track the behavior, growth, and reproduction of deer across the south Florida landscape. The individual model links individual animals to specific environmental conditions on the landscape, specifically water depth and food availability. The parameters needed for the White–tailed Deer model include an estimate of available deer browse for each plant community, an estimate of the rate of growth of deer forage in each plant community, and the minimum and maximum water depths at which the plant community grows as well as the optimal minimum and maximum that a plant community grows. Browse parameters were estimated for only a subset of plant communities that were expected to provide deer habitat. How these parameters were determined are explained in detail in the following sections.

Deer Forage Estimation for Each Plant Community

Deer forage in a particular plant community consists of woody twigs, forbs, sedges and grasses, mast (nuts), fungi, and some roots/rhizomes found within 2 m of ground level. Quality of available deer forage in the ATLSS model is divided into two categories, high quality and moderate/low quality. Actual published forage measurements for a given plant community are unusual and, forage estimates of plant communities in Florida are extremely rare. Harlow (1959) was the only reference found that contained forage estimates for south Florida plant communities. The plant communities measured in Harlow's (1959) study were cross referenced with the FGAP v. 6.6 plant communities (Table 7). Harlow's (1959) study also reports "utilization rates" for each forage class. The available forage for each plant community and its rate of utilization published in Harlow (1959) are reproduced in Table 7.

It was assumed that deer eat their preferred forage first and so the total available forage was multiplied by the utilization rate to calculate the amount of high quality forage available in each plant community (Table 7). The high quality forage amount was then subtracted from the total available forage to determine the moderate/low quality forage amount (Table 7).

Table 7. Deer forage data and estimates for the plant communities used in ATLSS. Biomass and productivity data and parameter estimates are also listed.

FGAP v. 6.6 Plant Communities	Harlow (1959) Plant Classification	Woody		Forbs		Grasses & Sedges		High Quality Forage[1]	Moderate / Low Qual. Forage[1]	Estimated Biomass of Deer Browse Plant Community[2]	Std. Dev.	Percent of Biomass That is Deer Forage–High[3]	Percent of Biomass That is Deer Forage–Mod/Low[4]	Estimated Growth Rate for Plant Community	Growth Rate of Deer Forage Only–High Quality[5]	Growth Rate of Deer Forage Only–Mod/Low Quality
		ave lbs/acre	% used	ave lbs/acre	% used	ave lbs/acre	% used	(kg/ha)	(kg/ha)	(kg/ha)	(kg/ha)	(%)	(%)	(kg C/ha/mo)	(kg C/ha/mo)	(kg C/ha/mo)
13, 16, 25, 30, 36	Flatwoods (includes palmetto)	1038	0.119	40.3	0.093	-	-	142	1064	7190	85	1.98	14.79	–	–	–
4, 35	Pine-Oak Uplands	52.2	0.157	27.5	0.097	-	-	12	77	25160	13420	0.05	0.31	420	0.20	1.29
14, 26	Sand Pine-Scrub Oak[6]	737.55	0.2	10.35	0.013	2.6	0	165	674	25160	13420	0.66	2.68	420	2.76	11.26
19	Swamps–Central FL	897.35	0.159	28.75	0.053	-	-	161	875	–	–	–	–	–	–	–
37	Swamps-Hardwood/Willow	37.9	0.74	129.2	0.418	-	-	92	95	12050	–	0.76	0.79	488	3.72	3.85
2, 3, 5	Hydric Hammocks (includes palmetto)	306.5	0.102	85.6	0.422	-	-	75	363	25160	13420	0.30	1.44	420	1.26	6.06
6,17,18, 28	Swamps-Cypress	109.72	0.314	130.84	0.101	-	-	53	216	208149	–	0.03	0.10	459	0.12	0.48
42, 43, 44, 46, 55, 56, 57	Fresh water Marshes	173.7	0.145	57.87	0.004	6.4	0	28	238	6949	–	0.41	3.42	941	3.85	32.19
32, 45, 52, 53, 54	Wet Prairie–Central FL	0.3	0	6.74	0	398	0.02	9	444	1278	–	0.70	34.75	745	5.19	258.90
29, 39	Dry Prairie	74.6	0.017	18.5	0	1130	0.34	431	937	831[7]	–	51.88	112.74	484	251.11	545.67

[1] Average forage available (lbs/acre) in each plant community group (Harlow 1959) was converted to kg/ha (1.1185 conversion factor for lbs/acre to kg/ha). The various plant type forages (woody, forb, grasses & sedges) were added together to get a total forage amount for each plant community. This value was then multiplied by the percent utilization rate to calculate a total high quality forage biomass value. To calculate the Moderate/Low Quality forage biomass, the high quality forage biomass amount was subtracted from the total possible forage amount.

[2] Estimated biomass of FGAP v. 6.6 plant communities included in the Harlow (1959) plant communities was averaged from values reported in the literature (Table 8).

[3] Estimated high quality deer browse was divided by the average total biomass of a plant community reported in the literature. This provided a percentage of biomass available to deer. That percentage is then used to calculate the growth rate of high quality deer browse in a plant community.

[4] Estimated Moderate/Low quality deer browse was divided by the average total biomass of a plant community reported in the literature. This provided a percentage of biomass available to deer. That percentage is then used to calculate the moderate/low growth rate of deer browse in a plant community.

[5] The percentage of total biomass available to deer was multiplied by biomass growth rates of the plant communities reported in the literature (Table 8). This provided a maximum growth rate of vegetation available to deer.

[6] No biomass or growth rate estimates were found specifically for Pine–Oak Uplands. However, Harlow (1959) describes these communities as being very similar to Sand Pine–Scrub Oak. Thus, the biomass and growth rate estimates for the Sand Pine–Scrub Oak were used for the Pine–Oak Upland community.

[7] No biomass or growth rate estimates were found specifically for Dry Prairie plant communities. These values were estimated to be 65% of the wet prairie biomass and growth rate estimates. The 65% value has no literature basis and was estimated by P. Wetzel.

Deer Forage Growth Rate Estimation

In order for the ATLSS White–tailed Deer model to reflect deer population shifts as hydrology changes, it is necessary to relate the rate of deer forage production in a plant community with changes in water depth (Figure 1). Modeling the growth rate of a plant community over water depth requires six parameters: the rate of growth of deer forage, the minimum and maximum water depths at which the plant community grows, the minimum and maximum optimal growth depths, and the rate that the forage growth declines (loss rate) near the maximum growth depth (Figure 1).

Only a small portion of the plant biomass of a plant community is available as deer forage and no one has measured the growth rate of the potential deer forage fraction. However, total biomass for a given plant community has been measured and reported in the literature (Table 8). To calculate the growth rates of the deer browse fraction of a plant community, the high and moderate/low quality forage values were divided by the biomass of that plant community. This resulted in a percent biomass that is deer browse for a given plant community (Table 7). That percentage was then multiplied by the estimated growth rate of the plant community published in the literature to obtain the growth rate of deer forage only for both high and moderate/low quality (Table 7). Biomass and net primary productivity values are listed and referenced in Table 8 for the plant communities for which data are available.

Table 8 (next page). Biomass and growth rate estimates for ATLSS plant communities. These values were used to estimate the growth rates of the deer browse component of the plant community. CG=Compositional Group, EC=Ecological Complex. Full reference citations are given in the Literature Cited section.

Plant Communities from Harlow (1959)	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Biomass (kg/ha)	Biomass References	Growth Rate (kg C/ha/mo)	Growth Rate References
Sand Pine–Scrub Oak	14	Sand Pine Forest				
	26	Sandhill EC				
Pine–Oak Uplands	4	Xeric–Mesic Live Oak EC	25160±13420 (L) 30840 (L+D)	Schmalzer & Hinkle 1996, p. 173 Schmalzer & Hinkle 1996, p. 173	420	Schmalzer & Hinkle 1996, p. 174
	35	Xeric Shrubland				
Hydric Hammocks	2	Tropical Hardwood Hammock Formation	83010±6680	Snyder 1984, p. 47		
	3	Semi–Deciduous Tropical/Subtropical Swamp Forest				
	5	Mesic–Hydric Live Oak/Sabal Palm EC	25160±13420 (L) 30840 (L+D)	Schmalzer & Hinkle 1996, p. 173 Schmalzer & Hinkle 1996, p. 173	420	Schmalzer & Hinkle 1996, p. 174
Pine Flatwoods	13	South Florida Slash Pine Forest	7130–N. FL (1 yr.) 7250–N. FL 8300–N. FL	Conde et al. 1983, p. 313 Swindel et al. 1986, p. 633 Wharton et al. 1982, p. 82	1091 (forest floor, understory, rhizomes)	Hough 1982, p. 366
	16	Mesic–Hydric Pine Forest CG	7130–N. FL (1 yr.) 7250–N. FL	Conde et al. 1983, p. 313 Swindel et al. 1986, p. 633		
	25	South FL Slash Pine Woodland	7250–N. FL	Swindel et al. 1986, p. 633		
	30	Gallberry/Saw Palmetto CG				
	36	St. Johns Wort Shrubland				
Swamps–Central Florida	19	Mixed Evergreen–Cold Deciduous Hardwood Forest				
Swamps–Hardwood/Willow	37	Saturated–Flooded Cold Deciduous Shrubland EC	12050	Lowe 1986, p. 224		
Dry Prairie	29	Dry Prairie EC				
	39	Graminoid Dry Prairie EC				
Wet Prairie	45	Muhly Grass Marsh	1003 (L), 3830 (L+D)	Caprio and Taylor 1984, p. 29	174–185 2370	Duever 1977, p. 722 Brinson et al. 1981, p. 129

Plant Communities from Harlow (1959)	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Biomass (kg/ha)	Biomass References	Growth Rate (kg C/ha/mo)	Growth Rate References
			3780 (L+D)	Carter et al. 1973, p. III–18, III–21	150	Porter 1967, p. 941
					1140±390	Carter et al. 1973, p. III–19
			1760±1190	Carter et al. 1973, p. XII–44 wet & dry season	1170	Carter et al. 1973, p. XII–55
			1070–1614 (L)	Porter 1967, p. 940		
			2060±830 (L+D)	Herndon & Taylor 1986, p. 64		
	52	Sparsely Wooded Wet Prairie CG				
	53	Dwarf Cypress Prairie			498–flooded	Brown 1981, p. 415
					1020–flooded	Brinson et al. 1981, p. 128
					57–dry	Brown 1981, p. 415
					120–dry	Brinson et al. 1981, p. 128
	54	Temperate Wet Prairie				
Freshwater Marshes	42	Graminoid Emergent Marsh CG	2120 (wet prairie, *Rhynchospora, P. hemitomon* dominants)	Volk et al. 1974, p. 661	341±133	Daoust & Childers 1998, p. 131
			2750	Jordan et al. 1997, p. 279 (2 yrs of data)		
			700±330	Daoust & Childers 1999, p. 266 (1 yr)		
			340	Wood & Tanner 1990, p. 139 (2 yr)		
	43	Sawgrass Marsh	6290±830	Craft et al. 1995, p. 263	2493±743	Daoust & Childers 1998, p. 131
			16000	Volk et al. 1974, p. 661		
			16340±5300 (dense)	Tilmant 1975, p. 91		
			14260±680 (sparse)			
			11360±7180	Hofstetter & Parsons 1976, p. 167		
			11240–31600	Lowe 1986, p. 224		
			11300±1100	Steward & Ornes 1975, p. 163		
			7400±300	Jordan et al. 1997, p. 279 (2 yrs of data)		
			6050±1430	Daoust & Childers 1999, p. 266 (1 yr)		
			1508-5340	Wood & Tanner 1990, p. 139 (2 yr)		
	44	Spikerush Marsh	930	Carter et al. 1973, p. XII–30	32.1	Carter et al. 1973, p. XII–30
			4760	Tilmant 1975, p. 91		
	46	Cattail Marsh CG	14930±5200	Tilmant 1975, p. 91		
	55	Maidencane Marsh	7350±3060	Tilmant 1975, p. 91	264	Duever 1977, p. 722

Plant Communities from Harlow (1959)	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Biomass (kg/ha)	Biomass References	Growth Rate (kg C/ha/mo)	Growth Rate References
			2890	Lowe 1986, p. 224		
	56	Forb Emergent Marsh	3460±1160 (w/ much *P. hemitomon*)	VanArman & Goodrick 1979, p. 188	1980 150–1107 (C. FL)	Brinson et al. 1981, p. 129 Federico et al. 1978, p. 93
			3890–7160 (no woodys)	Federico et al. 1978, p. 93		
	57	Water Lily or Floating Leaved Vegetation	936±610 1000	Worth 1988, p. 15 Jordan et al. 1997, p. 279 (2 yrs of data)		
Swamps–Cypress	6	Bay/Gum/Cypress EC				
	17	Swamp Forest CG	239071±1726 190000±47000 101000±21000	Duever et al 1984, p.339, Mitsch & Ewel 1979, p. 422–423 Mitsch & Ewel 1979, p. 422–423	315 N. FL 660	Brown 1981, p. 415 Brinson et al. 1981, p. 128
	18	Cypress Forest CG	266000 N. FL 190655 95000±26000–154000±29000 N. FL 103000±14000 (dryer) 192000±23000 (wetter)	Brown 1981, p. 413 Carter et al. 1973, p. XII-43 Mitsch & Ewel 1979, p. 422–423 Burns 1978, p. 126 Burns 1978, p. 126	114 683±38 (Dryer) 1142±63 (Wetter) 97.5 128±46–280±63	Brown 1981, p. 415 Burns 1978, p. 126 Burns 1978, p. 126 Carter et al. 1973, p. III–14 Mitch & Ewel 1979, p. 422–423
	28	Flooded/Saturated Brd Lved Evrgrn /Mixed Evrgrn Cold Deciduous Shrblnd CG				
Exotics (not in Harlow 1959)	8	Cajeput Forest CG				
	31	Brazilian Pepper Shrubland				
	20	Buttonwood Woodland			930	Carter et al. 1973, p. XII–30
Mangrove (not in Harlow 1959)	9	Mixed Mangrove Forest Formation	118860±33359 103300±48300 41367±29845	Odum et al. 1982, p. 27 Cintron et al. 1985, p. 60 Lugo & Snedaker 1974, p. 47	1440–2250 3780	Carter et al. 1973, p. 1–5; see also Lugo & Snedaker 1974, p. 53 Odum et al. 1982, p. 20
	10	Black Mangrove	420	Carter et al. 1973, p. XII–30	420	Carter et al. 1973, p.XII–30

Plant Communities from Harlow (1959)	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Biomass (kg/ha)	Biomass References	Growth Rate (kg C/ha/mo)	Growth Rate References
		Forest	720–1680	Odum et al. 1982, p. 20	720–1680; ave=840	Odum et al. 1982, p. 20 (see Miller 1972)
					840	Lugo & Snedaker 1974, p. 53
	11	Red Mangrove Forest	124613±7114	Odum et al. 1982, p. 27	540–891	Carter et al. 1973, p.XII–34,35
			136060±53516	Odum et al. 1982, p. 27	660–1680; ave=840	Miller 1972, p. 22
			5800	Ross et al. 2000, p. 106		
					0–1320	Lugo & Snedaker 1974, p. 53
	21	Mixed Mangrove Woodland			Same as #9	
	22	Black Mangrove Woodland			Same as #10	
	23	Red Mangrove Woodland			Same as #11	
	32	Dwarf Mangrove EC	7868	Odum et al 1982, p. 27	300	Odum et al. 1982, p. 20
Beach Dune (not in Harlow 1959)	33	Coastal Strand				
Tidal Marsh (not in Harlow 1959)	38	Saltwort/Glasswort EC				
	47	Salt Marsh EC	*Spartina* 6730	Carter et al. 1973, p. XII–30	88	Carter et al. 1973, p. XII–30
			2000–7500 (in Louisiana)	Hopkinson et al 1978, p. 762		
	48	Sand Cordgrass Grassland	7726±3712 (LIVE)	Schmalzer et al. 1991, p. 79		
			17362±6322 (L+D)	Schmalzer et al. 1991, p. 79		
			4290 (LIVE)	Chynoweth 1975, p. 61		
	49	Black Needle Rush Marsh	8130±2043 (LIVE)	Schmalzer et al. 1991, p. 77	1505	White et al. 1978, p. 756
			18092±4362 (L+D)	Schmalzer et al. 1991, p. 77	830–max	White et al. 1978, p. 753
			16970 (in Mississippi)	de la Cruz 1973, p. 354	600 Loss Rate–the only one found	White et al. 1978, p. 753
			5000–12000 (in Louisiana)	Hopkinson et al. 1978, p. 764		
			19590 peak (in Louisiana)	White et al. 1978, p. 756		

Water Depth Parameter Estimation

To relate deer forage growth to water levels, the minimum and maximum water depth at which plant community growth occurs and the minimum and maximum water depth at which optimal growth of a plant community occurs (Figure 1) had to be estimated for each plant community sampled by Harlow (1959). Values were needed for both high and moderate forage growth of a plant community. While there are some published data of biomass or growth rates in wet and dry years, there are no data that specifically relates the growth rate of a plant community to specific water depths. However, maximum and minimum water level data often do exist for many plant communities (Table 9). Using this data, the necessary water depth parameters were estimated in the following manner.

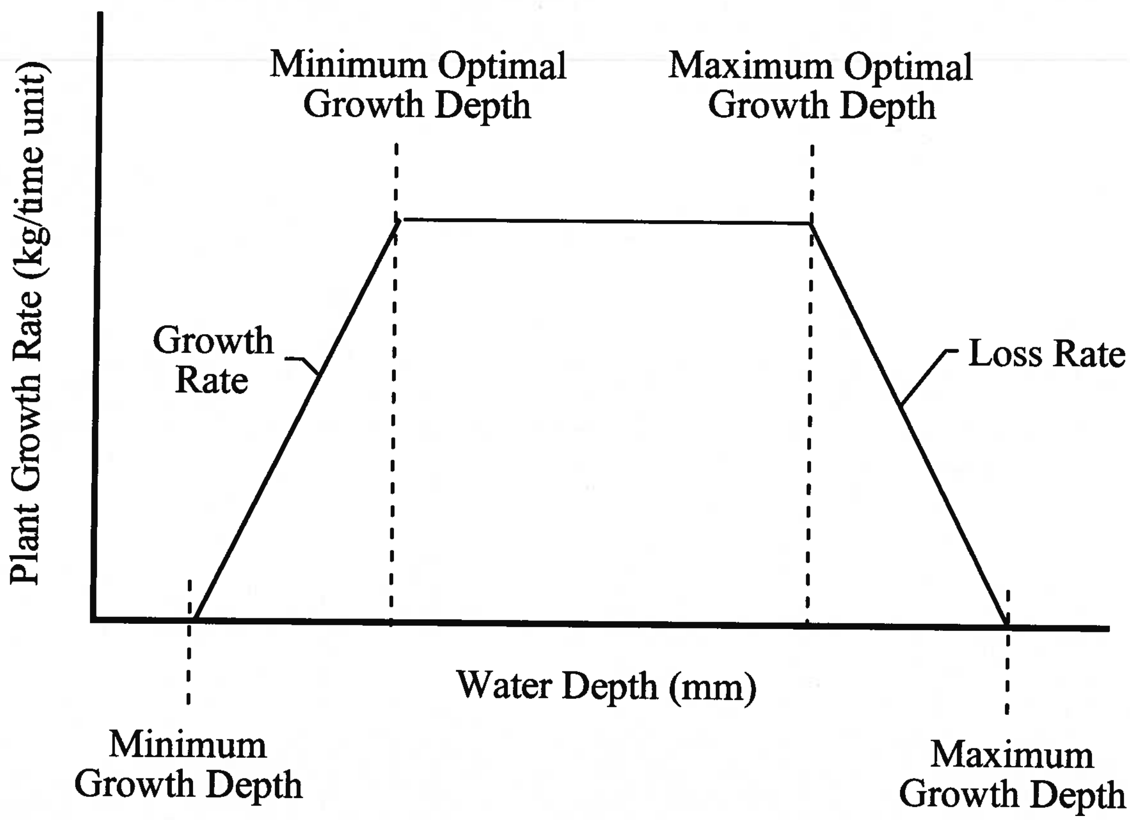

Figure 1. Relationship of deer forage to hydrology in the ATLSS model. Modeling this relationship requires the estimation of six parameters for each plant community: the rate of growth of deer forage, the minimum and maximum water depths at which the plant community grows, the minimum and maximum optimal growth depths, and the rate that the forage growth declines (loss rate) near the maximum growth depth.

First, it was assumed that the plant communities would maintain a maximum growth rate near the midpoint of the range between minimum and maximum water depths. For high forage parameters, 45% of the water depth range was added to the minimum to calculate the minimum depth of optimal growth and 45% of the water depth range was subtracted from the maximum water depth to calculate the maximum depth of optimal growth (Figure 2). The minimum depth of growth was estimated by adding 20% of the water depth range to the minimum value and subtracting 20% from the maximum value (Figure 2). This followed the assumption that the minimum water depth was dryer than optimal and that the maximum water depth was probably higher than needed for optimal growth.

Moderate forage parameters were calculated in a similar manner, except that 30% of the water depth range was added and subtracted from the minimum and maximum growth depths respectively to estimate minimum and maximum depth of optimal growth (Figure 2). The minimum and maximum growth depths of a plant community group were used as the minimum and maximum growth depth parameter estimates (Figure 2). All water depth parameter estimates are reported in Table 9.

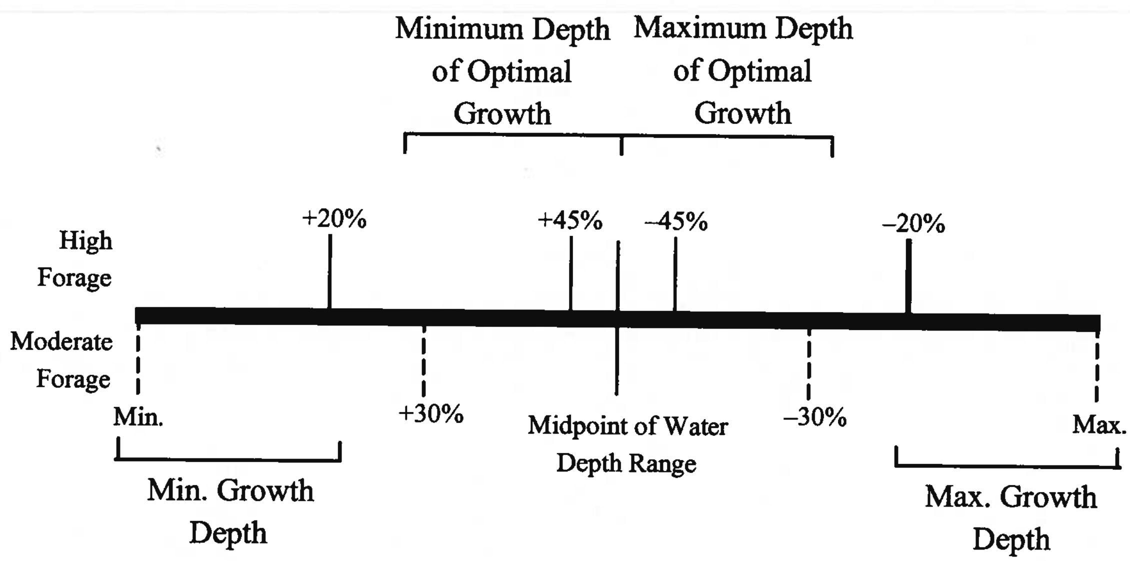

Figure 2. Schematic of how water depth parameters were estimated for high and moderate deer forage growth rates.

Limitations of the Water Depth Parameter Estimates

As mentioned earlier, although the ATLS Simulation ties water depths to the minimum, optimal, and maximum growth rates of the plant communities, it is important to remember that the water depths assigned to a particular plant community were obtained from the literature and are *not related* to the growth rates used in the model (also obtained from the literature). The growth rate and water depth data were not collected at the same time, during the same season of the year, or in the same location. The development of the water depth parameters and their relationship to growth rates is purely a construct of the model.

While the minimum and maximum growth rates are taken from the literature, these data cover a limited time period. They are often reported as averages over a season or the length of the study, usually 1 or two years, although they are occasionally 5–10 years long. The hydrologic regime of many wetlands follows intra– and inter–annual hydrologic cycles. These hydrologic patterns are missed by short data collection periods. Finally, many studies do not report below ground water levels and thus miss the true minimum water depth of a particular plant community.

It should also be noted that the length of inundation or the season of inundation is as important, or more important, than the depth of the water. After a certain water depth, many plant communities have the same physiological and ecological responses regardless of how much higher the water depth eventually goes. At that point, length of inundation becomes the most critical consideration. These threshold water depths are rarely reported in the literature, have never been related to deer browse, and have not been incorporated into the ATLSS model.

Table 9 (next page). Water depth data and estimates for ATLSS plant communities. These values were used to relate the productivity of a plant community with hydrology. CG=Compositional Group, EC=Ecological Complex. Full reference citations are given in the Literature Cited section.

Plant Communities from Harlow (1959)	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Water Depths Reported in Literature (cm)	Water Depth References	Minimum Growth Depth (cm)		Minimum Depth of Optimal Growth (cm)		Maximum Depth of Optimal Growth (cm)		Maximum Growth Depth (cm)	
					Mod.	High	Mod.	High	Mod.	High	Mod.	High
Sand Pine–Scrub Oak	14	Sand Pine Forest	0	Abrahamson 1984a, p. 10	–135	–123	–117	–108	–94	–103	–76	–88
	26	Sandhill EC	0 Max Mean –76±62.5 Min Mean –135±45.3 from Cen. FL	Abrahamson 1984a, p. 10 Vince et al. 1989, p. 13, Fig. 11 Vince et al. 1989, p. 13, Fig. 11								
Pine–Oak Uplands	4	Xeric–Mesic Live Oak EC	Ave. 60–76 Max Mean –76±62.5 Min Mean –135±45.3 from Cen. FL	Penfound & Hathaway 1938, p. 26–27. From LA coastal wtlnds Vince et al. 1989, p. 13, Fig. 11 Vince et al. 1989, p. 13, Fig. 11								
	35	Xeric Shrubland										
Hydric Hammock	2	Tropical Hardwood Hammock			–65	–52	–46	–37	–21	–30	–2	–15
	3	Semi–Deciduous Tropical/Subtropical Swamp Forest	Max Mean –35±30.3 Min Mean –63±37.7 from Cen. FL	Vince et al. 1989, p. 13, Fig. 11 Vince et al. 1989, p. 13, Fig. 11								
	5	Mesic–Hydric Live Oak/Sabal Palm EC	Max Mean –2±4.9 Min Mean —65±10.7 from Cen. FL	Vince et al. 1989, p. 13, Fig. 11 Vince et al. 1989, p. 13, Fig. 11								
Pine Flatwoods	13	South Florida Slash Pine Forest	+42–Max; –145–Min; ~Ave.=–15	Sun et al. 1995, p. 67	–145	–108	–89	–61	–14	–42	42	5
	16	Mesic–Hydric Pine Forest CG	Same as above									
	25	South FL Slash Pine Woodland	Same as above									
	30	Gallberry/Saw Palmetto CG										
	36	St. Johns Wort Shrubland										
Swamps–Central Florida	19	Mixed Evergreen–Cold Deciduous Hardwood Forest		No data available								
Swamps–Hardwood/ Willow	37	Cold Deciduous Shrubland EC		Estimated by P. Wetzel	–20	–6	1	12	29	18	50	36
Dry Prairie	29	Dry Prairie EC	5–Max	Duever et al. 1984a, p. 301	–150	–119	–103	–80	–42	–65	5	–26

Plant Communities from Harlow (1959)	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Water Depths Reported in Literature (cm)	Water Depth References	Minimum Growth Depth (cm) Mod.	Minimum Growth Depth (cm) High	Minimum Depth of Optimal Growth (cm) Mod.	Minimum Depth of Optimal Growth (cm) High	Maximum Depth of Optimal Growth (cm) Mod.	Maximum Depth of Optimal Growth (cm) High	Maximum Growth Depth (cm) Mod.	Maximum Growth Depth (cm) High
	39	Graminoid Dry Prairie EC	0 to –150	Statler and Odum 1993, p. 124								
Wet Prairie	32	Dwarf Mangrove EC			–10	–3	1	6	14	9	25	18
	45	Muhly Grass Marsh	Max 15 5.1–30.5, 1 yr record	Carter et al. 1973, p. III–18, 21 Porter 1967, p. 938								
	52	Sparsely Wooded Wet Prairie CG	Ave max 40	Duever et al. 1984a, p. 301								
	53	Dwarf Cypress Prairie	16–max; ~10–min Max 10, 1 yr record Ave. Max 15-20	Brown 1981, p. 409 Brown et al. 1984, p. 308 Duever et al. 1984a, p. 301								
	54	Temperate Wet Prairie										
Freshwater Marshes	42	Graminoid Emergent Marsh CG	Max 40 Mean Min –8.7±26 Mean Max 26±15 Mean 26±2 Max 45; Min 7.5	Duever et al. 1984a, p. 302 Duever et al. 1978, p. 543 Jordan et al. 1997, p. 279-280 (2 yrs of data)	–9	13	24	40	67	51	100	78
	43	Sawgrass Marsh	–33– +65 25 (±18) Mean 18±2 Max 38; Min 1	Tilmant 1975, p. 91 David 1996, p. 22 Jordan et al. 1997, p. 279-280 (2 yrs of data)								
	44	Spikerush Marsh	34 (±22)–71 (±11)	David 1996, p. 22								
	46	Cattail Marsh CG	24 (±12)	David 1996, p. 22								
	55	Maidencane Marsh	28 (±21) 40	David 1996, p. 22 Duever et al. 1984a, p. 302								
	56	Forb Emergent Marsh	24 (±18)– 29 (±20) Mean annual 30 Mean Min 14±26.6 Mean Max 49±15	David 1996, p. 22 Gunderson & Loftus 1993, p. 206 Duever et al. 1978, p. 543								
	57	Lily or Floating Leaved Vegetation	54 ±21; Mean annual 62 ≥100 Mean 38±2 Max 55; Min 19	David 1996, p. 22 Duever et al. 1984a, p. 302 Jordan et al. 1997, p. 279-280 (2 yrs of data)								
Swamps–Cypress	6	Bay/Gum/Cypress EC	+93–Max; –80–Min; Ave.=~6.5 +15–Max; +1–Min; Ave.=8	Sun et al. 1995, p. 67 from N. FL Casey 1997, p. 22, from N. FL	–6	25	41	64	103	80	150	119

Plant Communities from Harlow (1959)	FGAP v. 6.6 Class #	FGAP v. 6.6 Class Name	Water Depths Reported in Literature (cm)	Water Depth References	Minimum Growth Depth (cm)		Minimum Depth of Optimal Growth (cm)		Maximum Depth of Optimal Growth (cm)		Maximum Growth Depth (cm)	
					Mod.	High	Mod.	High	Mod.	High	Mod.	High
	17	Swamp Forest CG	150 max; 50 min	Duever et al 1984b, p. 336								
			Mean 70	Duever et al. 1978, p.								
	18	Cypress Forest CG	150 max; 50 min	Duever et al. 1984b, p.336								
			Max 30	Duever et al. 1985								
			65 max; 20 min	Brown 1981, p. 409								
	28	Broad Leaved Evergreen/Evergreen–Decid. Shrubland CG										

Future Additions or Changes to the ATLSS Model

During the course of collecting the information presented in this document, several potential changes or additions to the ATLSS model became apparent. One major change to consider is to use the vegetation database and classification system compiled by the Center for Remote Sensing and Mapping Science, The University of Georgia, the Everglades National Park, and the South Florida Water Management District (see the volume 65, number 2 [1999] of Photogrammetric Engineering & Remote Sensing journal for an entire issue devoted to the south Florida vegetation mapping project). To create the database a vegetation classification system was established and photographic signatures were determined for each plant community in the classification system. Then the vegetation was mapped. It is my impression that the plant associations created in the FGAP analysis mapping effort were based on what could be readily identified from aerial photographs. Because some of the FGAP plant classifications do not match well with the plant communities described in the literature, the succession and hydroperiod data going into the model are either very broad or not very specific. Hopefully, the University of Georgia/Park Service/District vegetation mapping would more closely correspond with the plant communities reported in the literature by botanists and ecologists working on the ground, making this vegetation classification system somewhat easier to adapt to the needs of the ATLSS model. In addition, this vegetation database appears to be more detailed, including some important plant communities, i.e. tree islands, that are not separately identified by the FGAP system.

A second possible change in the ATLSS model is to recognize that hydrology is not the only controlling environmental factor in the south Florida landscape. It is the major one in Florida, but other disturbances are also important. Such disturbances, in order of those having the greatest amount of information available to the least, include:

- Salinity gradient near the coasts and estuaries (relates to sea level rise). This would provide some mechanism of vegetation change for 11% of the aerial coverage of the ATLSS model.
- Impacts of hurricanes
- Impacts of freezes
- Nutrient levels/soil types
- Anthropogenic disturbances, including exotic plant invasions. Other disturbances include the obvious ones such as agriculture, urbanization, canal and levee building, but also ecosystem dissection.
- Seed/propagule sources and dispersal (particularly with exotics)

Including one or more of these disturbances into the model would make it much more realistic.

Finally, consideration should be given to basing the deer population model on the caloric output of various plant communities over time rather than deer browse production, browse utilization rates, and high and moderate forage grades. Caloric output appears to have a closer link to deer reproduction and survival than browse production. Because Florida goes through wet and dry seasons, the caloric output measured over annual seasons would correspond to hydrologic fluctuations. Basing the model on caloric output would have the added benefit of adding a seasonal component to the deer model.

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