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M.T. Brown (eds.), Carrying Capacity
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Florida, Center for Wetlands,
University of Florida, Gainesville,
Florida, 1975

FRESHWATER ECOSYSTEMS

Alligator Hole

J. A. Kushlan and J. A. Browder

Alligator holes are small ponds surrounded by marsh and swamp habitats and maintained by the activities of the American alligator (Alligator mississippiensis). Craighead (1968) and Kushlan (1972, 1974, in prep.) provide the primary information on alligator ponds. Besides sunlight, the driving external forces of the alligator hole subsystem are rainfall and surface water flow, which together supply energy and nutrients, determine water depth, and, most importantly, provide the medium for life in the pond.

Both sunlight and rainfall vary seasonally in south Florida and cause subsequent variation in water volume, as expressed by various water depth thresholds. This variation controls major energy flows through the system. Models for energy flow in the alligator pond are given in Figs. 1 and 2. Fig. 1 shows wet season values for stocks and flows, while dry season values for the same stocks and flows are shown in Fig. 2. Calculations for forcing functions, stocks, and flows shown on the model are given in Vol II. High water levels accelerate the growth of periphyton and vascular hydrophytes, whereas low water levels result in the death and disintegration of above-ground plant structures. Fish populations account for a major energy flow from primary production and detrital food sources. Standing stocks of fish and alligators are relatively low during high water but are supplemented by immigration from the surrounding marsh as water depth decreases. The fate of highly concentrated fish stocks depends on water depth fluctuation and predation pressure.

Fig 1. Unit Model for Alligator Hole Subsystem, with Wet Season Values (g/m^2).

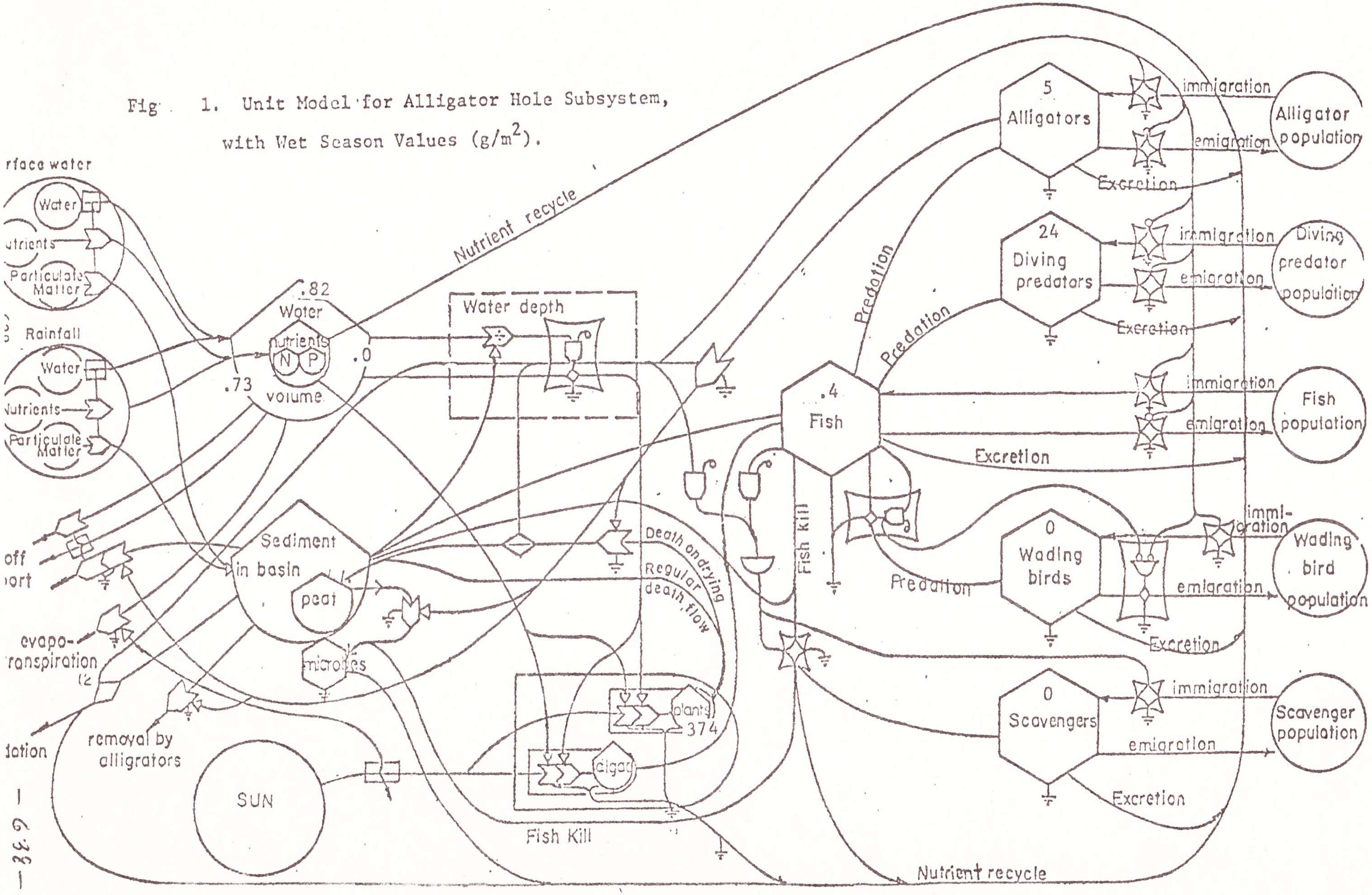
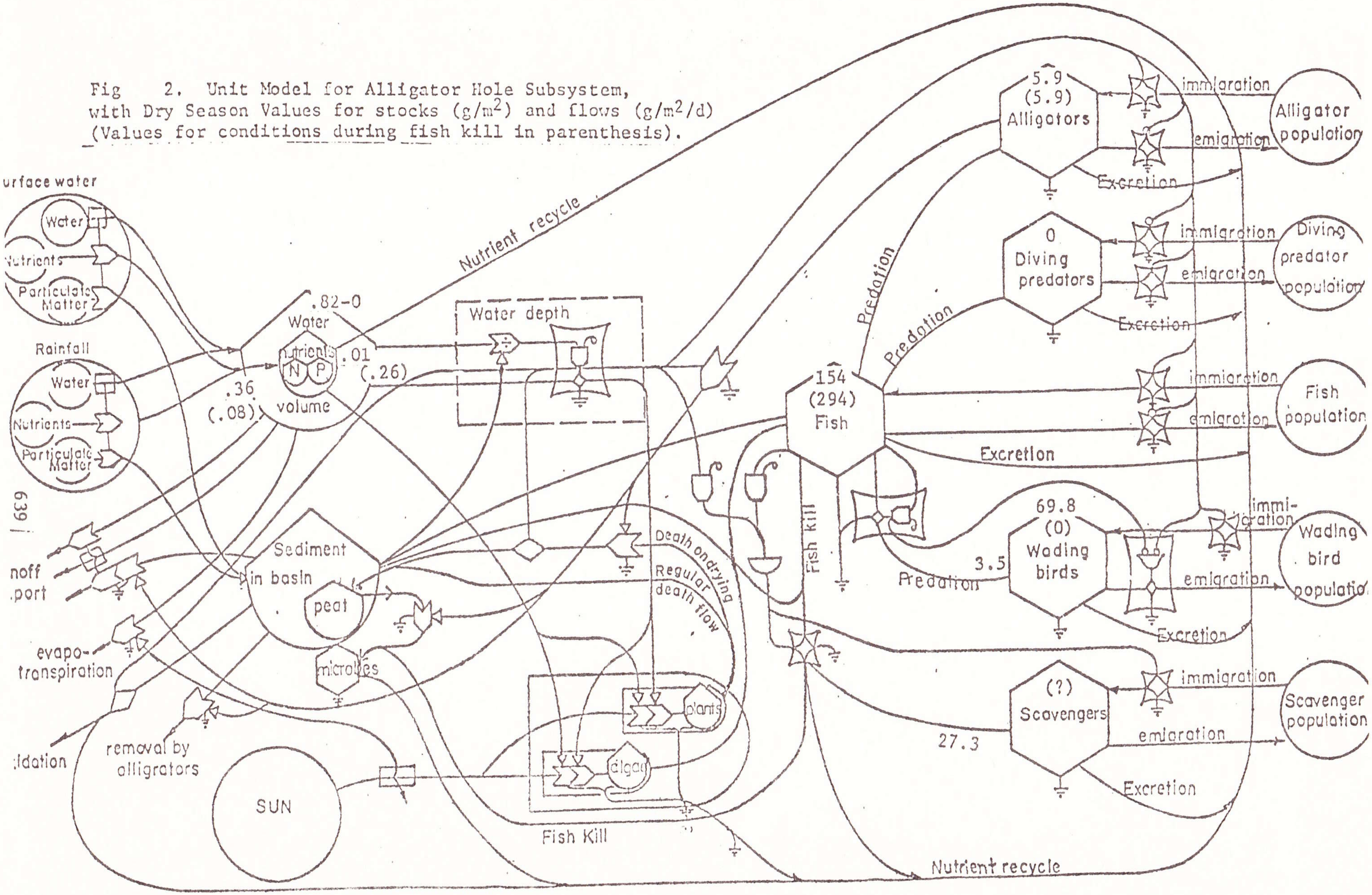


Fig 2. Unit Model for Alligator Hole Subsystem, with Dry Season Values for stocks (g/m^2) and flows ($g/m^2/d$) (Values for conditions during fish kill in parenthesis).



Low water depth during the spring causes movement of wading birds into the pond, where they feed until fish density falls or water depth increases. If predation pressure is low and fish densities exceed threshold levels, a fish kill diverts energy flow from predator to scavenger and microbial food chains.

Alligators actively maintain ponds by excavation of sediment and plant material as well as by their normal movements. This process is accelerated by low water depths and leads to microbial and subaerial oxidation of peat deposits in addition to the actual removal of material from the basin. Such maintenance work inhibits sediment accumulation and the encroachment by plants, and increases the carrying capacity of the pond during low water periods.

As the model shows, when alligators are removed from an area, ponds are deprived of the work they provide. Ponds gradually fill in and no longer serve as refuges for aquatic life during the dry season. Years of hunting reduced the alligator populations of south Florida, which appear to be coming back since stronger protective measures were instituted. Now legalized hunting is being considered for Florida. Such hunting, if allowed, would bear most heavily on the larger, older alligators, which are probably the most important for pond maintenance work, and pond systems will suffer.

Drainage reduces the period of time that wetland area surrounding a pond is flooded during the wet season, so that secondary productivity of the wetland is decreased and the eventual dry season accumulation of aquatic life in the pond is much lower. Drainage also lowers the water table during the dry season, causing many ponds to dry entirely. Reduced fish populations and fewer reservoirs where fish concentrate mean a reduction in the carrying capacity for larger wading birds that breed in south Florida or spend their winters here. Some populations, particularly Wood

Storks, are threatened by the many changes that have taken place in water patterns in south Florida in recent years.

As demonstrated by the model, the water level fluctuation is the vital mechanism that drives the alligator hole system. Drainage as well as prolonged high water, interferes with this fluctuation and destroys the healthy functioning of the pond. All the characteristics of the fluctuation should be maintained to avoid disruption of the alligator hole system. These characteristics are stage range, stage duration, maximum and minimum stages, and timing of fluctuations.

TABLE 1

Energy Flows from External Forcing Functions

Source	Description	Calculation	Reference
		High Water - Maximum Monthly	
I_1	Solar Insolation	530 g-cal/cm^2/day (Fig. 3)	Carter, *et al*, 1973
I_2	Rainfall	(11 inches/mo)(mo/30days) (25.4 mm/inch) = 9.3 mm/day (Fig. 4)	*Climatological Data*, 1972
		Low Water - Minimum Monthly	
I_1	Solar Insolation	310 g-cal/cm^2/day (Fig. 3)	Carter *et al*, 1973
I_2	Rainfall	(0.16 in/mo)(mo/30 days) (25.4 mm/in) = 0.2 mm/day (Fig. 4)	*Climatological Data*, 1972

TABLE 2

System Storages - Pond-alligator hole subsystem

Storage		Calculation	Reference
High water			
Q_1	Water volume	Average depth of pond 1500 m^2 is 0.82 or 0.82 m^3 per square meter of surface area.	Kushlan 1972: 12-13
Q_2	Nitrogen in surface water	Total N (NO_3, NO_2, NH_4; organic N) .91 ppm N .91 mg/10^{-3} m^3 x 0.82 m^3/m^2 x g/10^3 mg = 0.73 g/m^3	Kushlan 1972: 57
Q_3	Phosphorus in surface water	0.0 g/m^2 from one high water measurement	Kushlan 1972: 57
Q_4	Fish	Midpoint of high water range (0.08 to 0.8 g/m^2) = 0.4 g/m^2	Kushlan in prep.
Q_5	Alligator	Assume one large resident alligator 2 m long = 30 kg$^{(1)}$. 30 kg/1500 m^2 = 20 g/m^2 live weight Dry weight approximately 25% wet weight$^{(2)}$ of animals. 20 g/m^2 x .25 = 5 g/m^2 dry weight	(1) Kellogg 1929 (2) Weise 1962
Q_6	Wading birds	No wading birds in pond during high water	Kushlan in prep.
Q_7	Diving predators	Assume$^{(1)}$ 2 anhingas (2 kg)$^{(2)}$, 2 pied-billed grebe (800 g), 1 common gallinule (400 g), 1 river otter (33 kg)$^{(3)}$ per pond of 1500 m^2. 39 kg/1500 = 26 g/m^2. Assume dry weight 25% of wet weight$^{(4)}$. 26 g/m^2 x 0.25 = 6.5 g/m^2	(1) Kushlan 1972: 101-103 (2) Weight of birds from specimens in University of Miami Reference Collection (3) Burt and Grossinger 1952 (4) Weise 1962
Q_8	Emergent plants	Maximum standing crop of _Panicum_ in May 1970, representing annual net production.	Kushlan 1972: 42

Table 2. continued.

Storage	Description	Calculation	Reference
Low water (non-stress)			
Q_1	Water volume	**Varies 0.82 m^3/m^2 to 0. Midpoint, 0.4 m^3/m^2.**	
Q_2	Nitrogen in surface water	.91 ppm N=.91 $mg/10^{-3} m^3$ x .40 m^3/m^2 x $g/10^3$ mg = 0.36 g/m^3	Kushlan 1972: 57
Q_3	Phosphorus in surface water	P = 0.036 ppm = 0.036 $mg/10^{-3}$ m^3 x 0.40 m^3/m^2 x $g/10^3$ mg = .014 g/m^2.	Kushlan 1972: 57
Q_4	Fish	Midpoint of range (23 to 244 g/m^2) = 154 g/m^2.	Kushlan in prep.
Q_5	Alligator	Assume one moderate length resident alligator (2 m) at 5 g/m^2 (see Q_5 high water) plus 19 small year-old alligators(1) as immigrants at 290 g live weight(2). 19 x 290 g/1500 m^2 = 3.6 g/ m^2 live weight. Assume dry weight 25% of live weight(3). 3.6 x 0.25 = 0.9 g/m^2. 5.0 g/m^2 + 0.9 g/m^2 = 5.9 g/m^2.	(1) Kushlan 1972: 98 (2) Kellogg 1929 (3) Weise 1962
Q_6	Wading birds	279 g/m^2 wet weight from one measurement in spring 1969(1). Assume dry weight 25% wet weight(2). 279 g/m^2 x 0.25 = 69.8 g/m^2.	(1) Kushlan in prep. (2) Weise 1962
Q_7	Diving predators	0 at lowest water.	Kushlan 1972: 103.
Q_8	Emergent plants	Unknown.	

Table 2. continued.

Storage	Description	Calculation	Reference
Low water (fish kill)			
Q_1	Water volume	Same as Q_1 Low Water (non-stress)	
Q_2	Nitrogen in surface water	N (NO_3, NO_2 only).).22 ppm N = 0.22 mg/ 10^{-3} m^3 x o.40 m^3/m^2 x 1 g/10^3 mg = 0.08 g/m^2	Kushlan 1972: 136
Q_3	Phosphorous in surface water	Midpoint of range (0.03 ppm to 1.3 ppm) = 0.66 ppm = 0.66 mg/10^{-3} m^3 x '0.40 m^3/m^2 x g/10^3 mg = 0.26 g/m^2.	Kushlan 1974
Q_4	Fish	294 g/m^2 in May 1970.	Kushlan in prep.
Q_5	Alligator	Same as Q_5, low water(non-stress).	
Q_6	Wading birds	0 at fish kill.	Kushlan 1972
Q_7	Diving predators	Same as Q_7, low water (non-stress).	
Q_8	Emergent plants	Unknown.	

TABLE 3

System Flows - Pond-alligator hole subsystem

Flow	Description	Calculation	Reference
High water			
J_1	Feeding on fish by waders	none	Kushlan 1972
J_2	Feeding on fish by scavengers	none	Kushlan 1972
Low water (non-stress)			
J_1	Feeding on fish by waders	From one measurement, spring 1973$^{(1)}$, 80% of initial standing stock of 44 g/m^2 over 10 day period$^{(2)}$. 44 g/m^2 x 0.8 x 1/10 day = 3.5 g/m^2/day.	(1) Kushlan in prep. (2) Kushlan 1972: 115
J_2	Feeding on fish by scavengers	none	
Low water (fish kill)			
J_1	Feeding on fish by waders	Small, Unknown	
J_2	Feeding on fish by scavingers	From one measurement in spring 1970$^{(1)}$, 93% of initial standing stock of 294 g/m^2 over period 14 to 24 May 1970$^{(2)}$. 294 g/m^2 x .93 x 1/10 day = 27.3 g/m^2/day.	(1) Kushlan in prep. (2) Kushlan 1972:

TABLE 4
Switching Functions - Pond - alligator hole subsystem

Switch	Operation
1	Priming flow to primary producers occurs when water depth exceeds threshold.
2	Flow occurs when water depth falls below threshold.
3	Flow occurs when water depth exceeds threshold.
4	Flow occurs when fish density exceeds threshold.
5	Flow occurs when fish density falls below threshold or water depth exceeds threshold.
6	Flow occurs when fish density exceeds threshold and water depth below threshold.
7	Flow occurs when fish density exceeds threshold during the spring of the year.
8	Below water depth threshold, work of alligator increases.