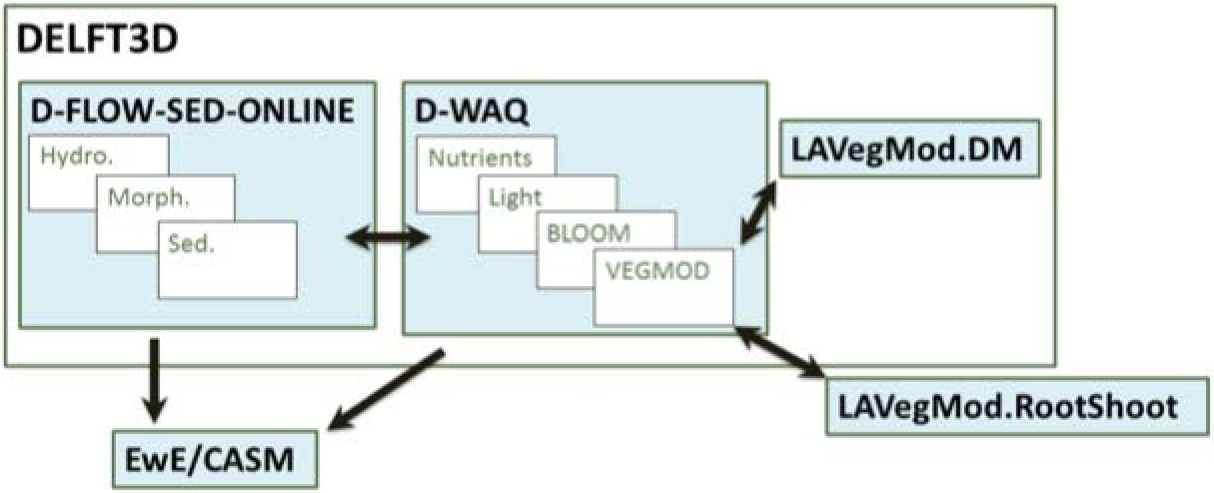
The Water Institute of the Gulf Delta Management Vegetation Models

Scott M. Duke-Sylvester[1]
Jenneke Visser[1]
Melissa Baustian[2]

1. *The University of Louisiana at Lafayette*
2. *The Water Institute of the Gulf*

Models

- LAVegMod.DM
- LAVegMod.RootShoot
- Delft3D: VEGMOD



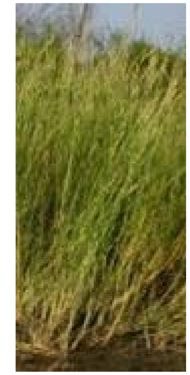
Vegetation

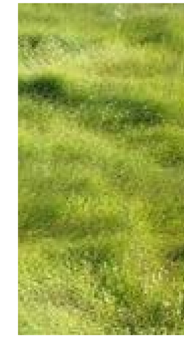
Focus on 7 emergent marsh taxa:

- *Spartina alterniflora* (oyster grass)
- *Spartina patens* (wiregrass)
- *Sagittaria latifolia* (arrowhead)
- *Sagittaria lancifolia* (bulltongue)
- *Zizaniopsis miliacea* (giant cutgrass)
- *Typha* spp. (cattail)
- *Phragmites* spp. (common reed)

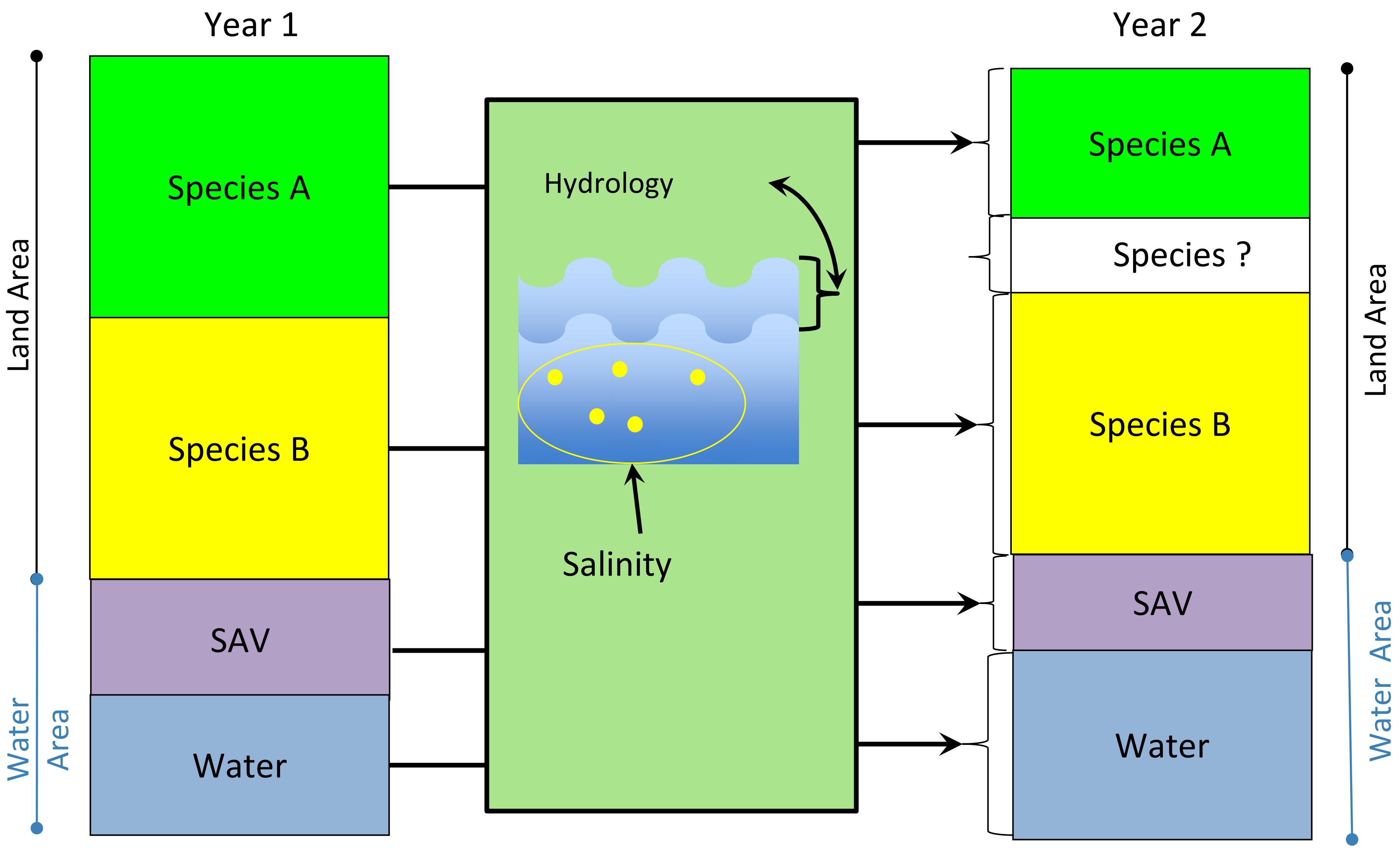
Submerged Aquatic Vegetation (SAV)

- Generically modeled (*Ruppia maritima, Myriophyllu*





LAVegMod.DM


Year 1
Year 2
Land Area
Species A
Species B
SAV
Water
Water Area
Hydrology
Salinity
Species A
Species ?
Species B
SAV
Water
Land Area
Water Area

LAVegMod.DM

$$\Delta C_i = -d_i(W_t, S_t)C_{i,t} + \left[\left(1 - \sum_j C_{j,t}\right) + \sum_j dC_{j,t}\right]P_i(W_t, S_t)$$

- i,j index species, t = time
- $C_{i,t}$= cover by species i in year t
- W_t = Annual wave amplitude in year t
- S_t = Annual mean salinity in year t
- $d_i(W_t,S_t)$ = rate of cover loss for species i
- $P_i(W_t,S_t)$ = rate of cover gain for species i

Establishment Probability $P_i(W_t, S_t)$

Standard Deviation of Stage (m)

Salinity (ppt)

SPAL	0	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36	0.4	0.44	0.48	0.52	0.56	0.6	0.64	0.68	0.72	0.76	10
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1.8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0.1	0.1	0.1	0.05	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0.25	0.25	0.25	0.2	0.15	0.1	0.05	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0.1	0.4	0.4	0.4	0.35	0.3	0.25	0.2	0.15	0.1	0.05	0	0	0	0	0	0	0
6	0	0	0	0.25	0.55	0.55	0.55	0.5	0.45	0.4	0.35	0.3	0.25	0.2	0.15	0.1	0.05	0	0	0	0
7	0	0	0	0.4	0.7	0.7	0.7	0.65	0.6	0.55	0.5	0.45	0.4	0.35	0.3	0.25	0.2	0.15	0.1	0.05	0
8	0	0	0.15	0.55	0.85	0.85	0.85	0.8	0.75	0.7	0.65	0.6	0.55	0.5	0.45	0.4	0.35	0.3	0.25	0.2	0.15
9	0	0	0.3	0.7	1	1	1	0.95	0.9	0.85	0.8	0.75	0.7	0.65	0.6	0.55	0.5	0.45	0.4	0.35	0.3
10	0	0	0.3	0.7	1	1	1	0.95	0.9	0.85	0.8	0.75	0.7	0.65	0.6	0.55	0.5	0.45	0.4	0.35	0.3
12	0	0	0.3	0.7	1	1	1	0.95	0.9	0.85	0.8	0.75	0.7	0.65	0.6	0.55	0.5	0.45	0.4	0.35	0.3
14	0	0	0.3	0.7	1	1	1	0.95	0.9	0.85	0.8	0.75	0.7	0.65	0.6	0.55	0.5	0.45	0.4	0.35	0.3
16	0	0	0.3	0.7	1	1	1	0.95	0.9	0.85	0.8	0.75	0.7	0.65	0.6	0.55	0.5	0.45	0.4	0.35	0.3
18	0	0	0.1	0.5	0.8	0.8	0.8	0.75	0.7	0.65	0.6	0.55	0.5	0.45	0.4	0.35	0.3	0.25	0.2	0.15	0.1
20	0	0	0	0.3	0.6	0.6	0.6	0.55	0.5	0.45	0.4	0.35	0.3	0.25	0.2	0.15	0.1	0.05	0	0	0
22	0	0	0	0	0.4	0.4	0.4	0.4	0.35	0.3	0.25	0.2	0.15	0.1	0.05	0	0	0	0	0	0
24	0	0	0	0	0.2	0.2	0.2	0.1	0.05	0	0	0	0	0	0	0	0	0	0	0	0
26	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Senescence Probability $d_i(W_t, S_t)$

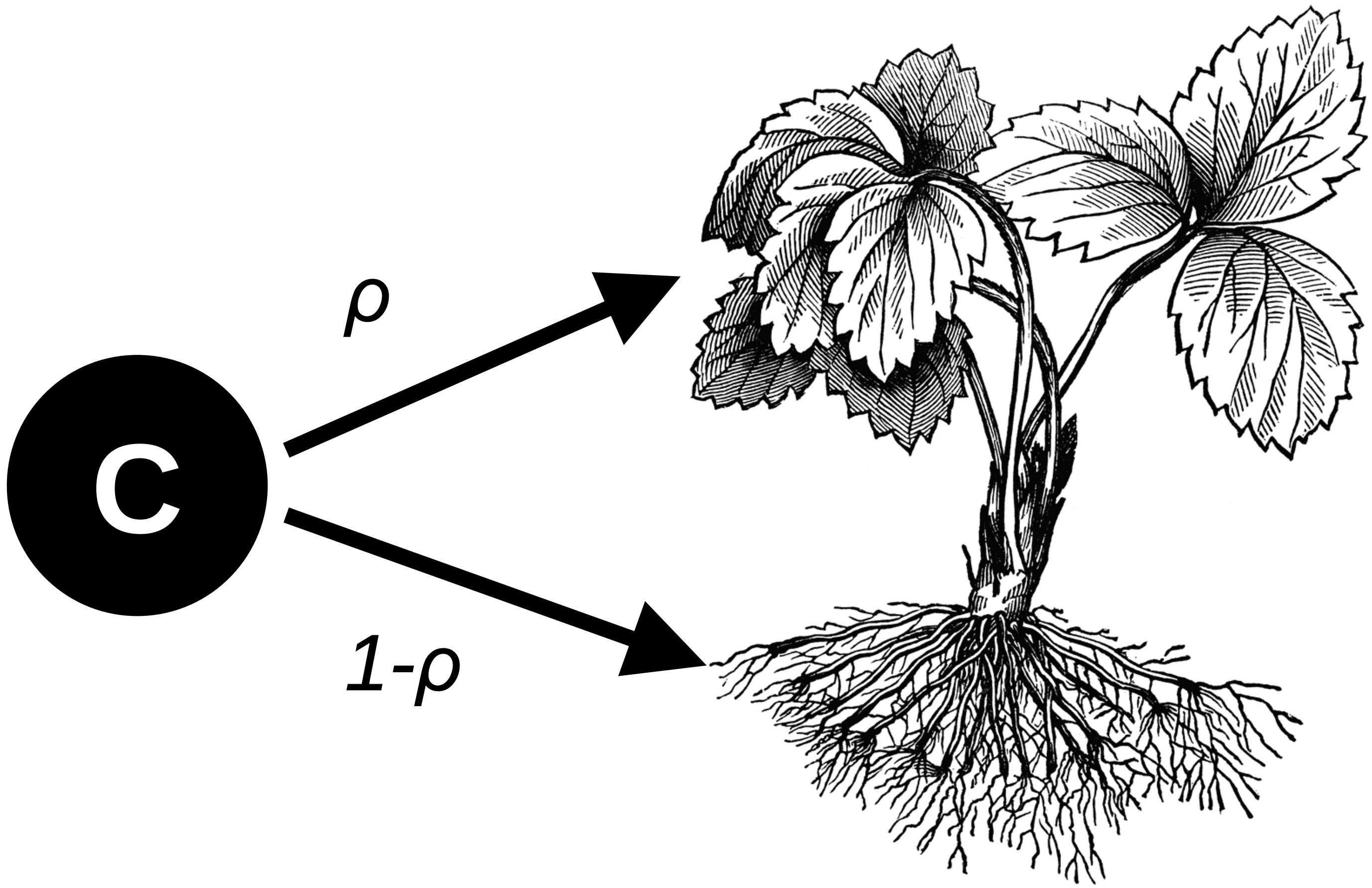
Standard Deviation of Stage (m)

Salinity (ppt)

SPAL	0	0.04	0.08	0.12	0.16	0.2	0.24	0.28	0.32	0.36	0.4	0.44	0.48	0.52	0.56	0.6	0.64	0.68	0.72	0.76	10
0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0.2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0.4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0.6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
0.8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.4	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.6	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.8	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
3	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
4	1	1	1	0.9	0.9	0.9	0.95	1	1	1	1	1	1	1	1	1	1	1	1	1	1
5	1	1	1	0.75	0.75	0.75	0.8	0.85	0.9	0.95	1	1	1	1	1	1	1	1	1	1	1
6	1	1	0.9	0.6	0.6	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1	1	1	1	1	1	1
7	1	1	0.75	0.45	0.45	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1	1	1	1
8	1	1	0.6	0.3	0.3	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.9	0.95	1	1
9	1	0.85	0.45	0.15	0.15	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	1
10	1	0.7	0.3	0	0	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	1
12	1	0.7	0.3	0	0	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	1
14	1	0.7	0.3	0	0	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	1
16	1	0.7	0.3	0	0	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	1
18	1	0.7	0.3	0	0	0	0.05	0.1	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	1
20	1	0.9	0.5	0.15	0.15	0.15	0.2	0.25	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	1
22	1	1	0.7	0.3	0.3	0.3	0.35	0.4	0.45	0.5	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.95	1	1	1
24	1	1	1	0.45	0.45	0.45	0.55	0.6	0.65	0.7	0.75	0.8	0.85	0.95	1	1	1	1	1	1	1
26	1	1	1	0.6	0.6	0.6	0.65	0.7	0.75	0.8	0.85	0.95	1	1	1	1	1	1	1	1	1
28	1	1	1	0.75	0.75	0.75	0.8	0.85	0.95	1	1	1	1	1	1	1	1	1	1	1	1
100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

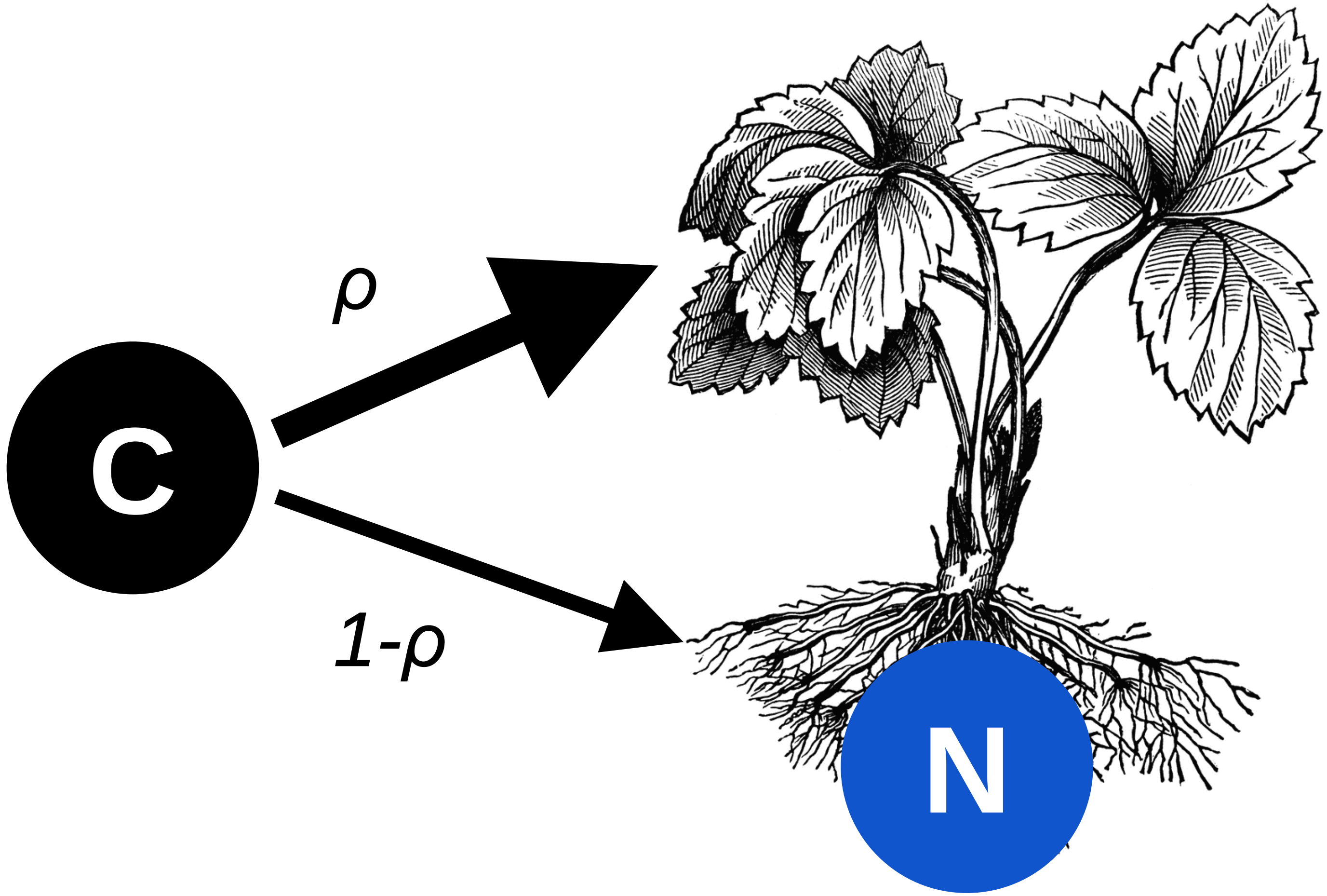
LAVegMod.RootShoot

Plants allocate biomass to maximize growth



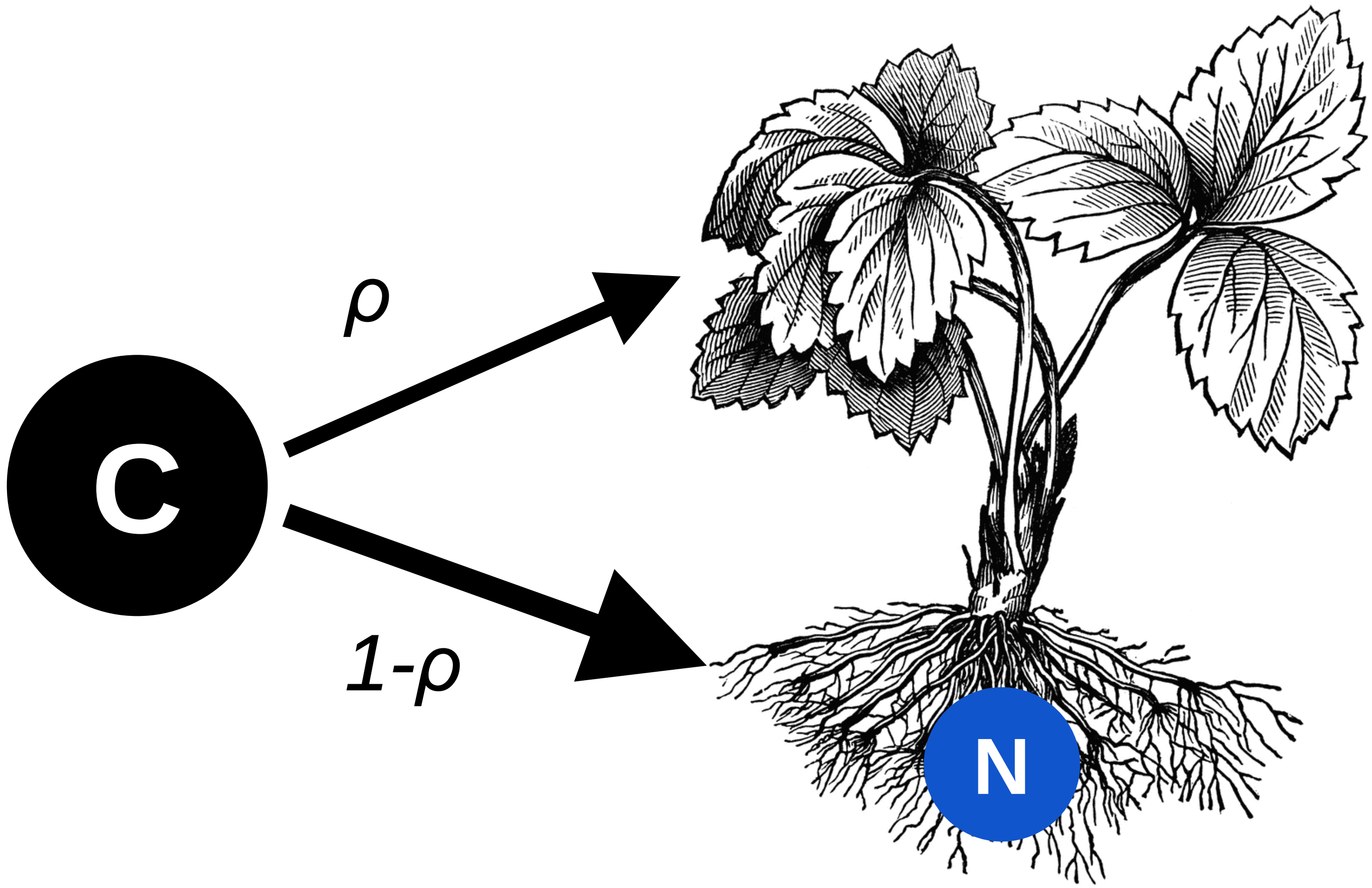
LAVegMod.RootShoot

Plants allocate biomass to maximize growth



LAVegMod.RootShoot

Plants allocate biomass to maximize growth



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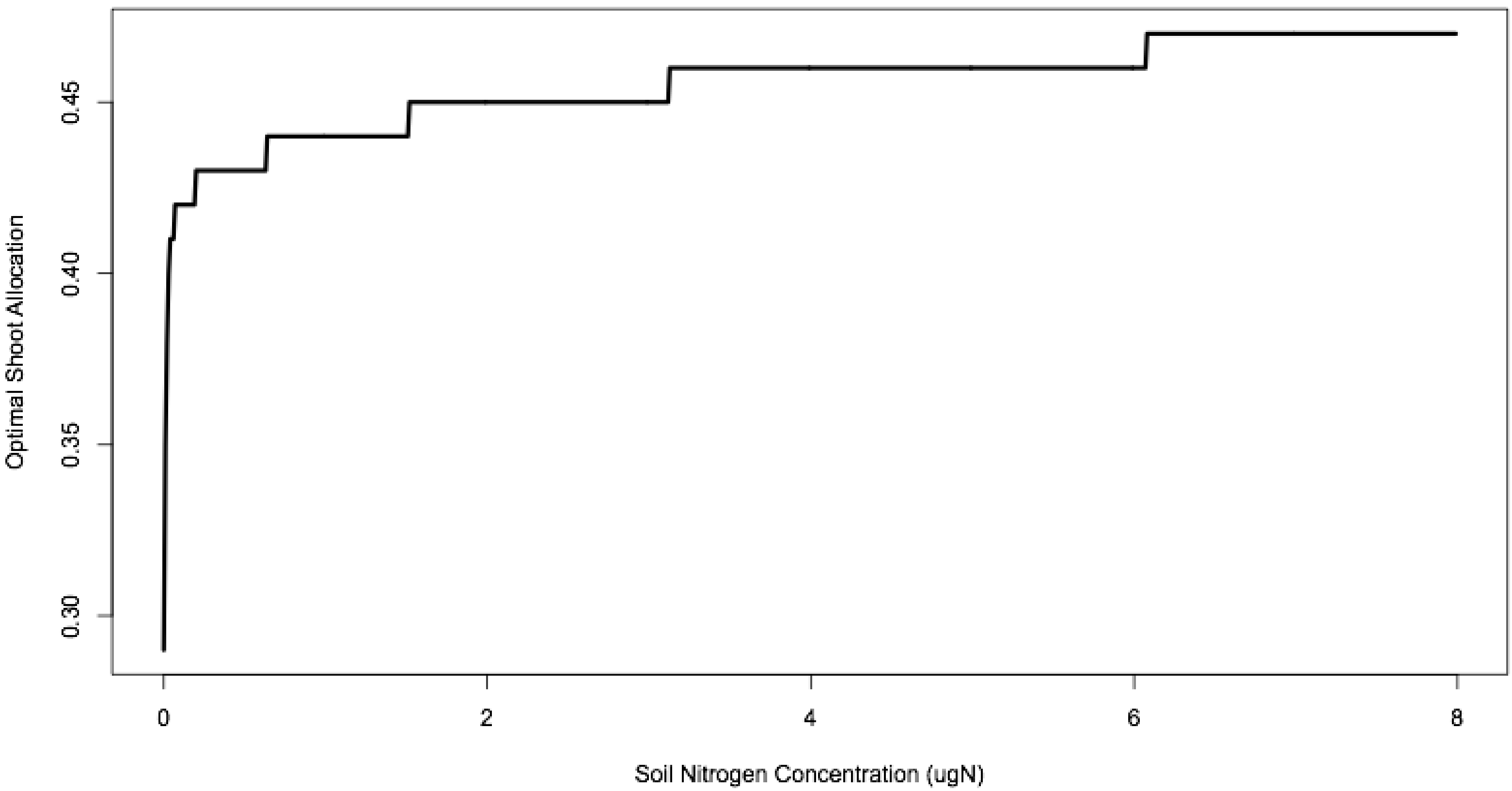


LAVegMod.RootShoot

- What value of ρ maximizes growth rate (dT/dt)?
- ρ = fraction of biomass allocated aboveground

$$\frac{dA}{dt} = \rho\kappa\gamma NC \quad (1)$$

$$\frac{dB}{dt} = (1-\rho)\kappa\gamma NC \quad (2)$$

$$\frac{dC}{dt} = \phi A^{\alpha} - \gamma NC - \eta TC \quad (3)$$

$$\frac{dN}{dt} = \varepsilon B^{\beta}\left(\frac{aN_e}{1+ahN_e}\right) - \frac{\gamma}{\sigma}NC \quad (4)$$

$$A(0) = A_0, B(0) = B_0, C(0) = C_0, N(0) = N_0 \quad (5)$$

$$T = A + B \quad (6)$$

LAVegMod.RootShoot

- Dynamics and optimization solved numerically.
- For each level of soil nutrient, N_e search values of ρ to find the value that produces the largest value of *dT/dt*

$$\frac{dA}{dt} = \rho\gamma\kappa A \qquad (1)$$

$$\frac{dB}{dt} = (1-\rho)\gamma\kappa B \qquad (2)$$

$$\frac{dC}{dt} = \phi A^{\alpha} - \gamma\kappa(\rho A + (1-\rho)B) \qquad (3)$$

$$\frac{dN}{dt} = EB^{\beta} - \frac{\gamma}{\sigma}\kappa(\rho A + (1-\rho)B) \qquad (4)$$

$$A(0) = A_0, B(0) = B_0, C(0) = C_0, N(0) = N_0 \qquad (5)$$

LAVegMod.RootShoot

A = aboveground biomass
B = belowground biomass
C = carbon store
N = nitrogen store
γ = rate of new tissue construction
κ = resource conversion efficiency
ρ = fraction allocated to aboveground biomass
φ = per unit biomass net rate of carbon fixation by photosynthesis
α = allometric scaling constant from biomass to leaf area
β = allometric scale constant from biomass to root area
E = maximum per unit root area rate of N absorbtion
σ = C:N ratio

LAVegMod.RootShoot

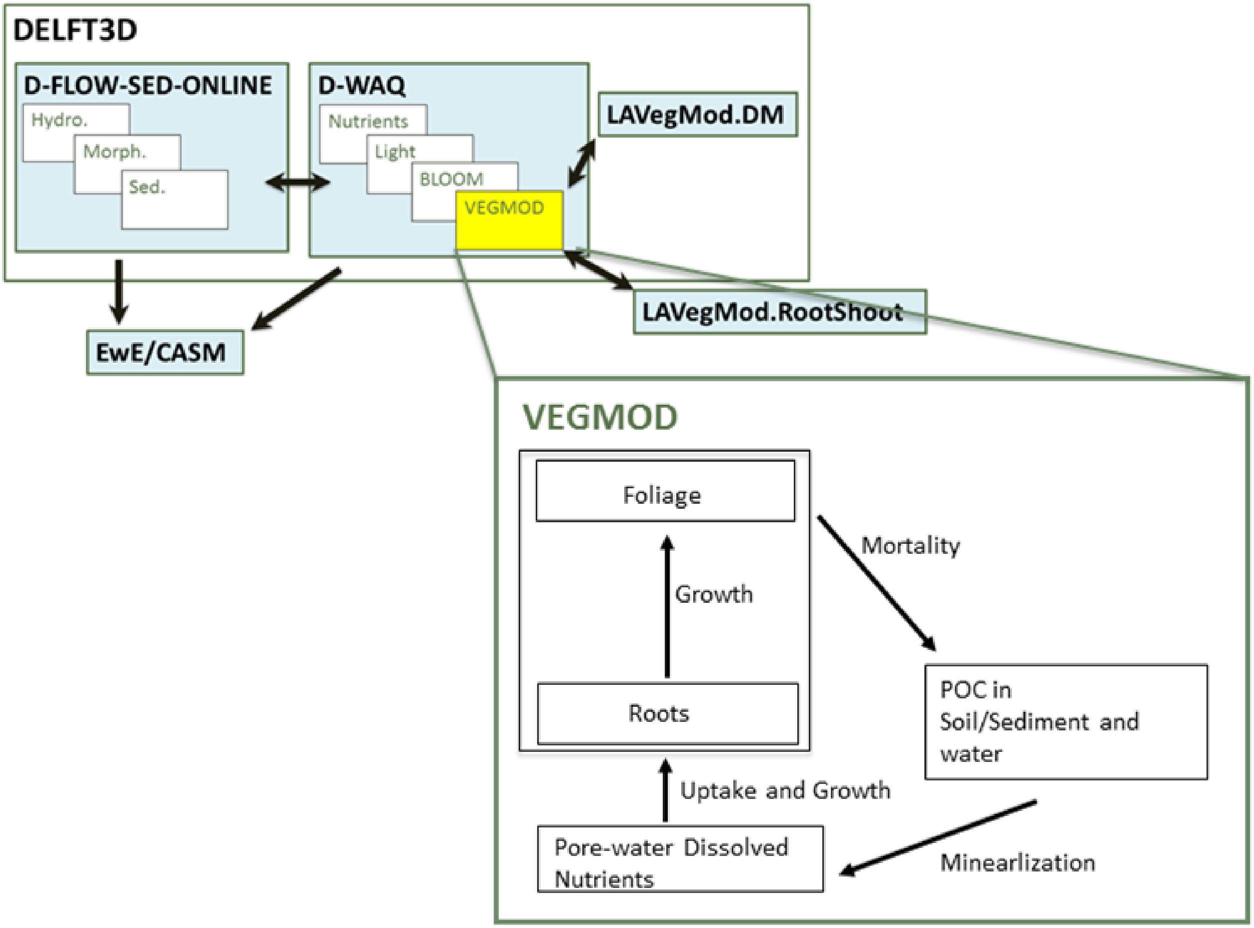
Parameterized based on literature search

- 300 citations found
- 125 citations reviewed
- 35 had useful information
- ~5% papers unavailable

Parameter Value

	S. alterniflora	*S. patens*	*Phragmites spp*	*S. lancifolia*	*S. latifolai*	*Typha spp*	*Z. miliacea*
γ *(gC/gC m2 day)*	0.072	0.056	0.083	0.07	0.04	0.067	0.052
φ *(gC/gC m2 day)*	0.137	0.115	0.111	0.098	0.137	0.137	0.137
α	1.35	1.35	1.35	1.35	1.35	1.35	1.35
β	1.0	1.0	1.0	1.0	1.0	1.0	1.0
σ *(mols C/mols N)*	32.4	51.5	35	16.7	32.4	32.4	50.5

Delft3D: VEGMOD

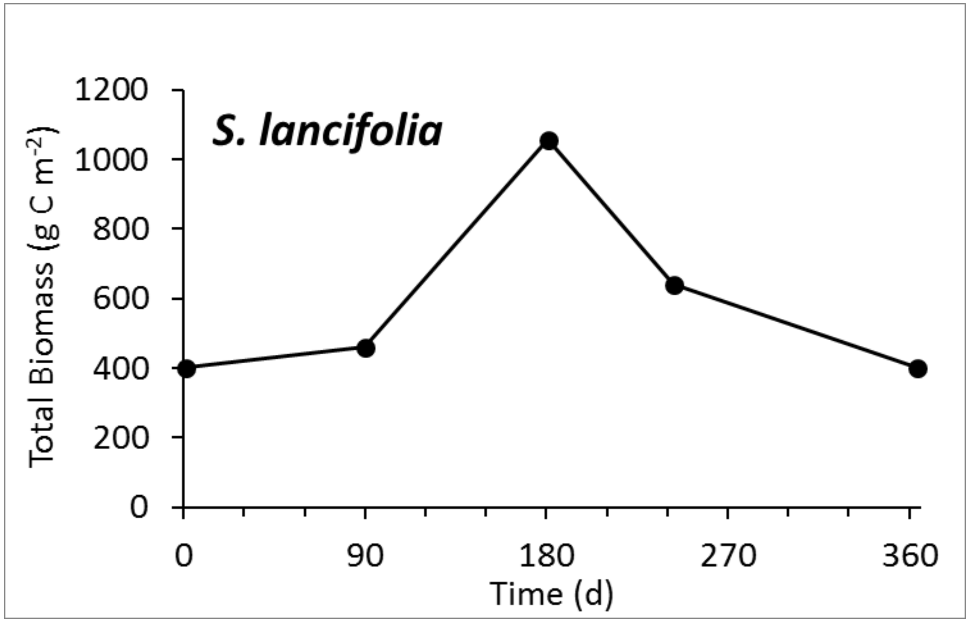


Modified from Smits 2013 Delft3D-ECO

Delft3D: VEGMOD

- Input parameters (e.g, C:N, C:P, stem height) – compiled literature data for 7 taxa
- Target Total Biomass (A+B) – compiled literature data for 7 taxa

Sagitaria lancifolia



Based on *Hopkinson et al. 1978*

LAVegMod.RootShoot

$$\frac{dA}{dt}=\rho\gamma\kappa A \qquad (1)$$

$$\frac{dB}{dt}=(1-\rho)\gamma\kappa B \qquad (2)$$

$$\frac{dC}{dt}=\phi A^{\alpha}-\gamma\kappa(\rho A+(1-\rho)B) \qquad (3)$$

$$\frac{dN}{dt}=EB^{\beta}-\frac{\gamma}{\sigma}\kappa(\rho A+(1-\rho)B) \qquad (4)$$

$$\kappa=\frac{CN}{f+CN}e^{-\frac{(\sigma-\frac{C}{N})^2}{\delta}} \qquad (5)$$

$$E=\frac{aN_e}{h+N_e} \qquad (6)$$

$$A(0)=A_0, B(0)=B_0, C(0)=C_0, N(0)=N_0$$