Ecological Modeling Update

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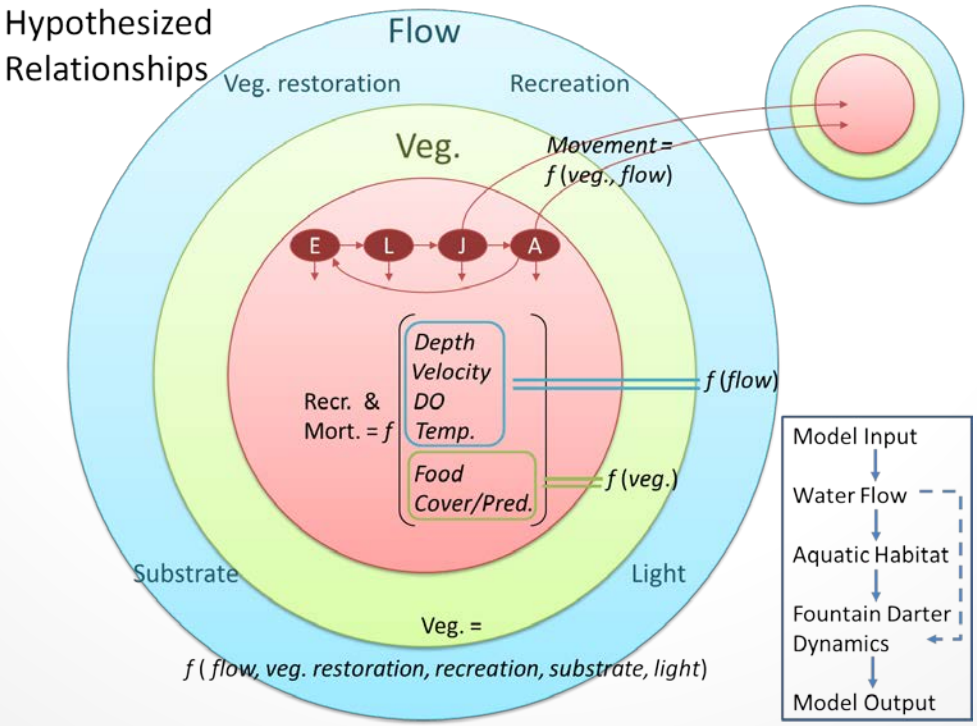
Background

- Developing an coupled hydrodynamic-ecological model that will be used to better understand the relationships between flow regimes, fountain darter dynamics, and vegetation growth/dispersal



Model structure

- Spatially-explicit, agent-based model, programmed in Netlogo

- Prototype: Old Channel, Comal River
  - Spatial domain and scale: same as fountain darter model, cell size of 0.25m^2 (can upscale if needed)

  - Temporal scale: varying, depending on the process within the model. Also scalable (e.g., darter-plant interactions may occur on a time scale that we haven't considered yet)

Fountain Darter Update

- Using multinomial logit regression model and all samples in Comal and San Marcos springs from 2000 to 2013 to understand the effects of environmental variables on the density of fountain darters.

$$P(Y_i = K) = \frac{exp(\alpha_K + \beta_K X_i)}{c_i}, \text{ where } K = 2, 3, 4, \text{ or } 5 \quad (1)$$

$$P(Y_i = K) = \frac{1}{c_i}, \text{ where } K = 1 \quad (2)$$

and where

$$c_i = 1 + \sum_{K=2}^{5} [exp(\alpha_K + \beta_K X_i)] \quad (3)$$

Model selection criteria: AIC

Model evaluation: AUC

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Fountain Darter Update

Model ID	Variable removed	AIC
a	None	2087.182
b	Open	2087.182
c	Bedrock	2080.263
d	Sagittaria	2073.303
e	Cobble	2070.058
f	Potamogeton	2082.773
g	Green algae	2075.917
h	DO	2073.684
i	Vallisneria	2068.423
j	pH	2064.734
k	Temp	2060.442
l	SpCond	3434.112
m	WaterDepthFt	3441.113

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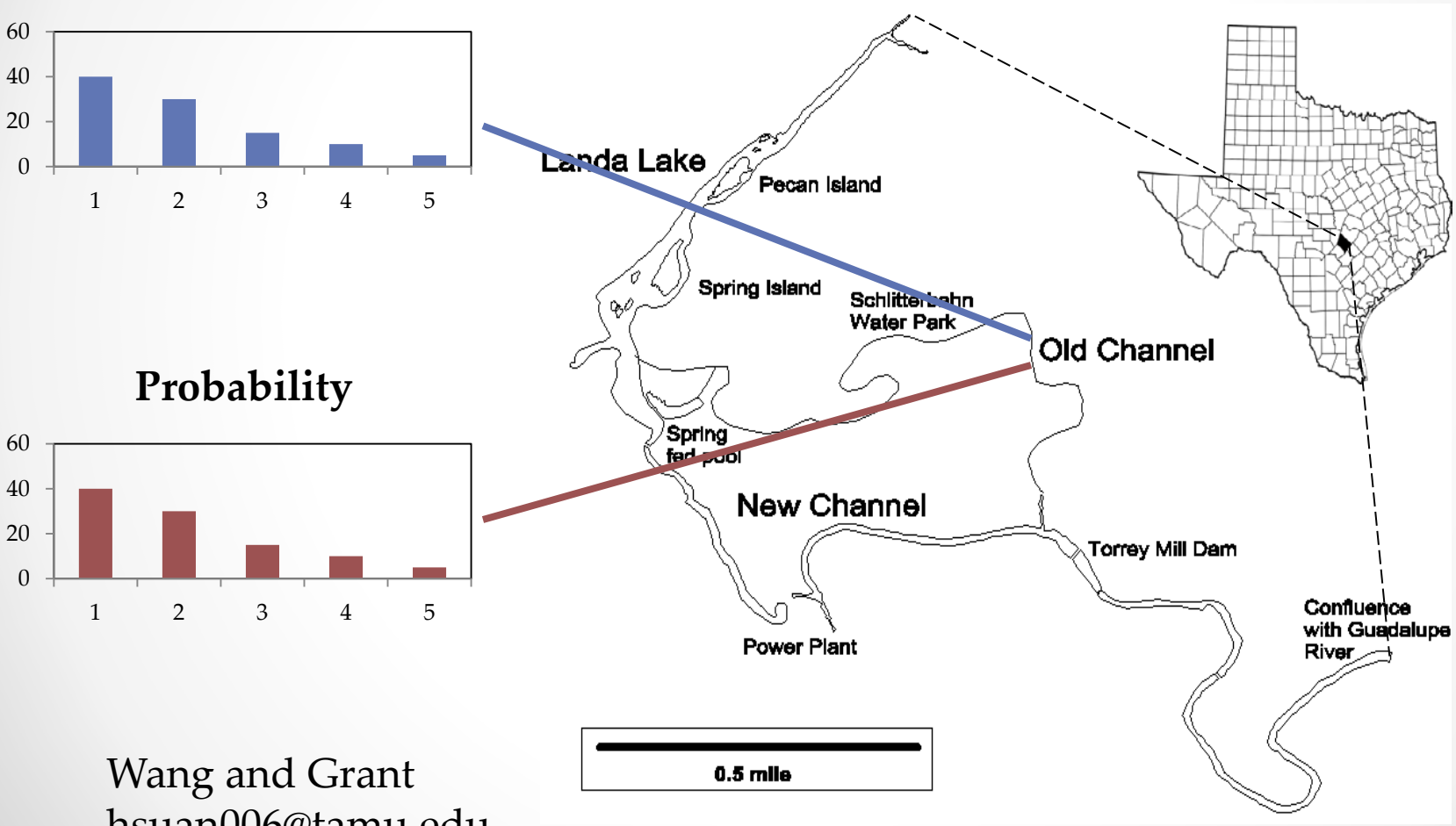
Fountain Darter Update

Variable	Overall *P*-value	Category 2		Category 3		Category 4		Category 5	
		Estimated coefficient	*P*-value	Estimated coefficient	*P*-value	Estimated coefficient	*P*-value	Estimated coefficient	*P*-value
Constant	–	0.6196	0.7452	-7.9018	0.0004	-13.2625	<0.0001	-18.3240	<0.0001
Bryophytes	0.0006	2.3115	0.0566	3.7323	0.0021	4.5881	0.0006	5.2690	0.0003
Cabomba	<0.0001	3.5416	0.0009	5.2066	<0.0001	5.3816	<0.0001	5.3257	<0.0001
Ceratopteris	0.0310	1.9023	0.0078	1.4136	0.0181	-10.5104	0.0854	-9.5265	0.0862
FAlgae	<0.0001	14.4100	0.0018	19.1906	0.0025	19.4989	0.0019	22.5046	0.0060
Hydrilla	0.0490	1.0638	0.0118	1.0090	0.0052	0.4889	0.6103	0.7305	0.1142
Hygrophila	<0.0001	1.5035	<0.0001	2.2374	<0.0001	2.0593	0.0007	1.6246	0.0574
Ludwigia	<0.0001	2.6431	<0.0001	3.7054	<0.0001	4.2030	<0.0001	3.9002	<0.0001
POT_HYG	0.0059	3.1083	0.0054	3.3643	0.0029	2.5123	0.1088	-8.9735	0.9847
VegPer	<0.0001	0.0114	0.4134	0.0794	<0.0001	0.0939	<0.0001	0.1372	<0.0001
VegHeight	<0.0001	-0.9266	0.2333	1.7744	0.0371	3.0889	0.0097	4.4971	0.0033
VegVol	0.0002	0.0124	0.1446	-0.0139	0.1329	-0.0289	0.0264	-0.0443	0.0078
WithBryo	<0.0001	1.3088	0.0995	2.8370	0.0002	3.3302	<0.0001	3.8677	<0.0001
WaterDepthFt	<0.0001	-0.6532	0.0002	-0.9541	<0.0001	-0.9467	<0.0001	-0.7526	0.0001
Gravel	0.0048	0.1786	0.7300	0.7942	0.1770	1.7812	0.0188	3.9518	0.0010
Sand	0.0410	0.6767	0.3130	1.7995	0.0143	1.9821	0.0518	3.6941	0.0254
Silt	0.0022	0.9754	0.0573	1.8355	0.0017	2.0219	0.0113	4.4331	0.0004
Silt_Gravel	0.0496	0.1198	0.1429	1.0638	0.1130	0.8677	0.1637	2.8651	0.0398
Speed	0.0458	2.6844	0.0973	2.2843	0.0720	-1.3615	0.0110	-4.7245	0.0377
SpCond	0.0479	-0.00217	0.0212	-0.00031	0.0925	0.00319	0.0779	-0.00146	0.0469

Fountain Darter Update



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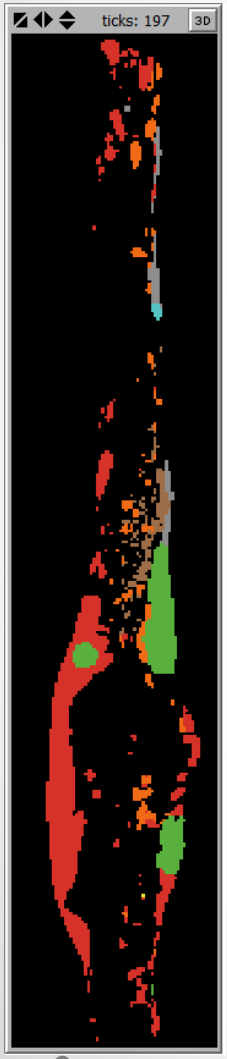
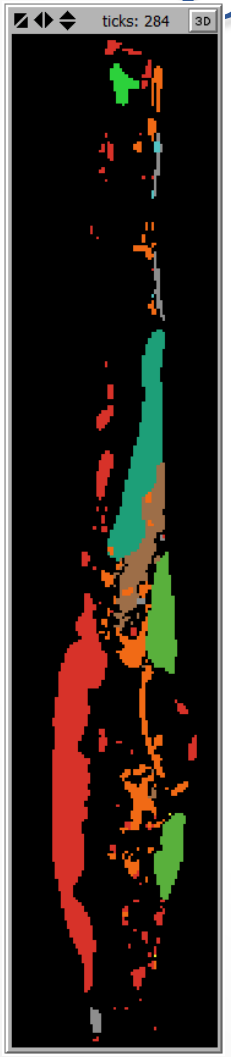
Vegetation Update



Summer 2003

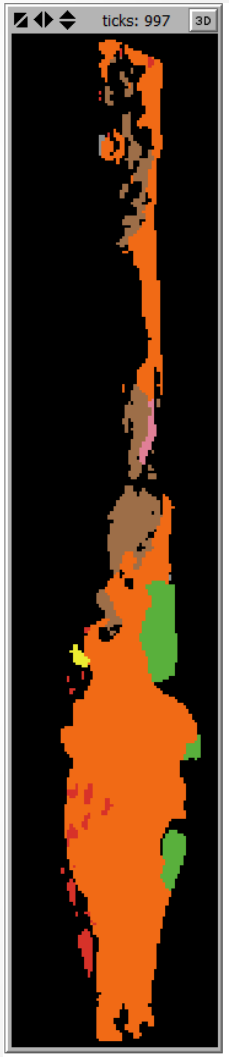


Fall 2003

Spring 2004

Fall 2004

Spring 2005



Fall 2005

Vegetation Update

- The plant growth model is based on three existing approaches: MEGAPLANT (Scheffer et al 1993), Charisma, a spatially explicit update of MEGAPLANT (van Nes et al 2003), ERDC Models (Best and Boyd)

$$\Delta W = W_s P - W(R_m + M) \quad (1)$$

$$R_m = r_{20} * Q_{10}^{((T-20)/10)} \quad (2)$$

$$P = P_{max} * \frac{I}{I+H_I} * \frac{S*T^{pt}}{T^{pt}+H_T^{pt}} * \frac{H_D}{D+H_D} \quad (3)$$

$$I_{z,t} = I_0 * e^{-K_d - K_p * b_z} \quad (4)$$

$$I_{z,t} = I_0 * e^{-K_d} \quad (5)$$

$$(T) = \frac{1.35 * T^3}{T^3 + 14^3} \quad (6)$$

$$N_j = \frac{a_s * B}{b_s} \quad (7)$$

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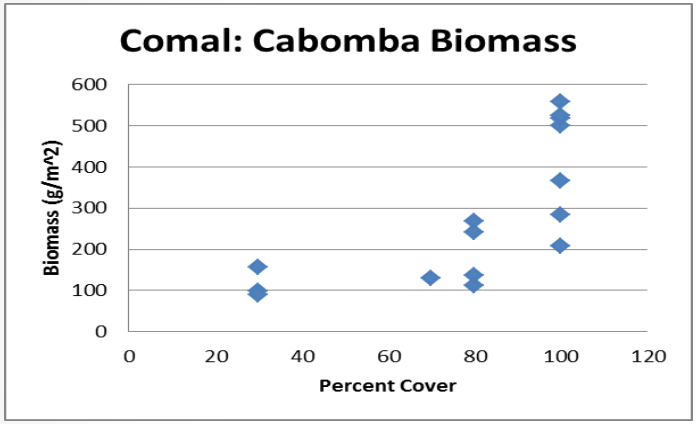
Vegetation Update

- Field studies completed for % cover to biomass



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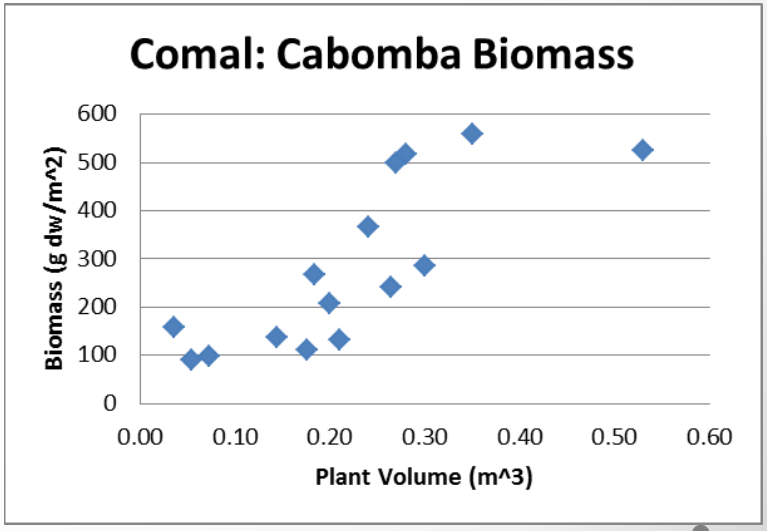

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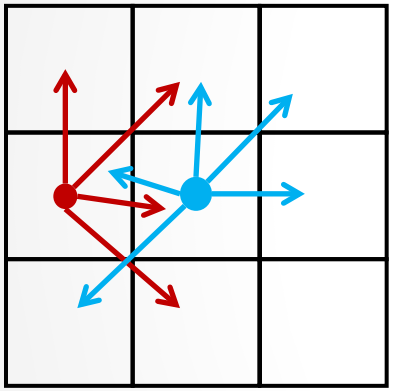
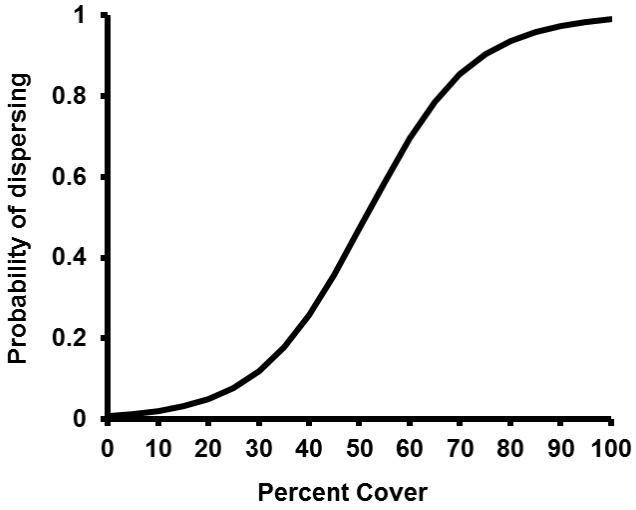
Vegetation Update

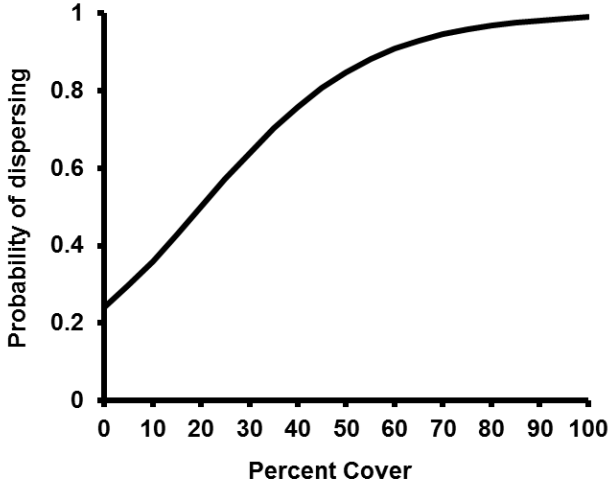
- Dispersal Model (Based on Wang et al. 2010, 2012)



$\uparrow : N_{j,t+1} = k_{ji} \cdot N_{j,t}$

- k = dispersal kernal, can have different functional forms based on species





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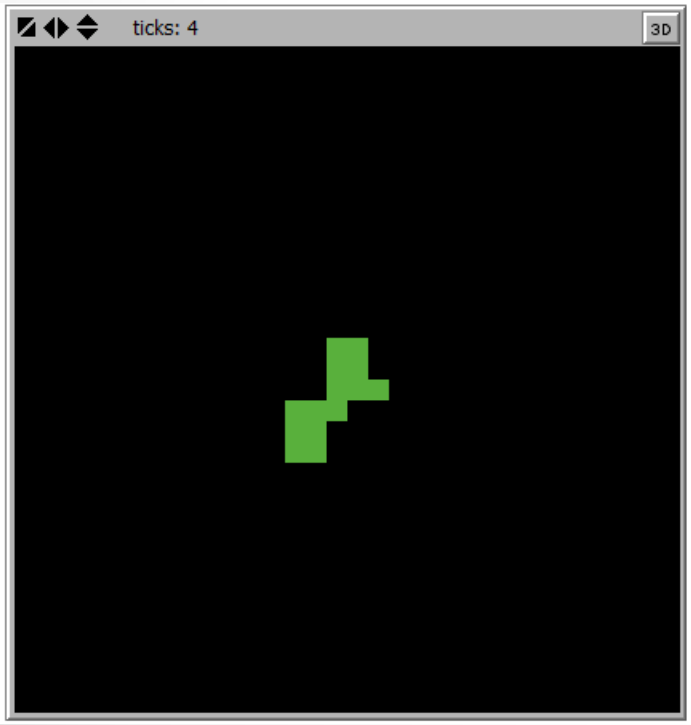
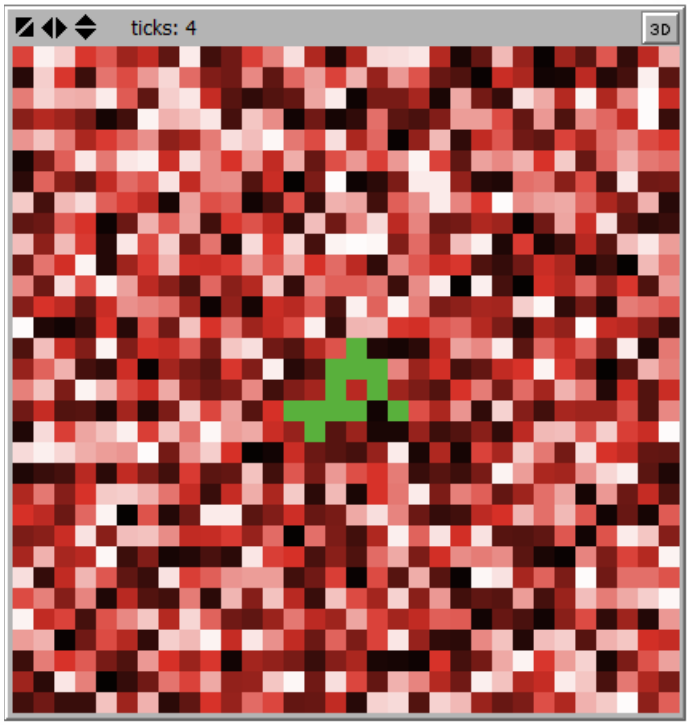
Vegetation Update

- Dispersal Model (Based on Wang et al. 2010, 2012)
- Using pattern-oriented modeling to test a suite of quantitative relationships for dispersal.





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Questions?