Aquatic Vegetation Low-flow Threshold Studies:

Laboratory Trials and Pond Experiment

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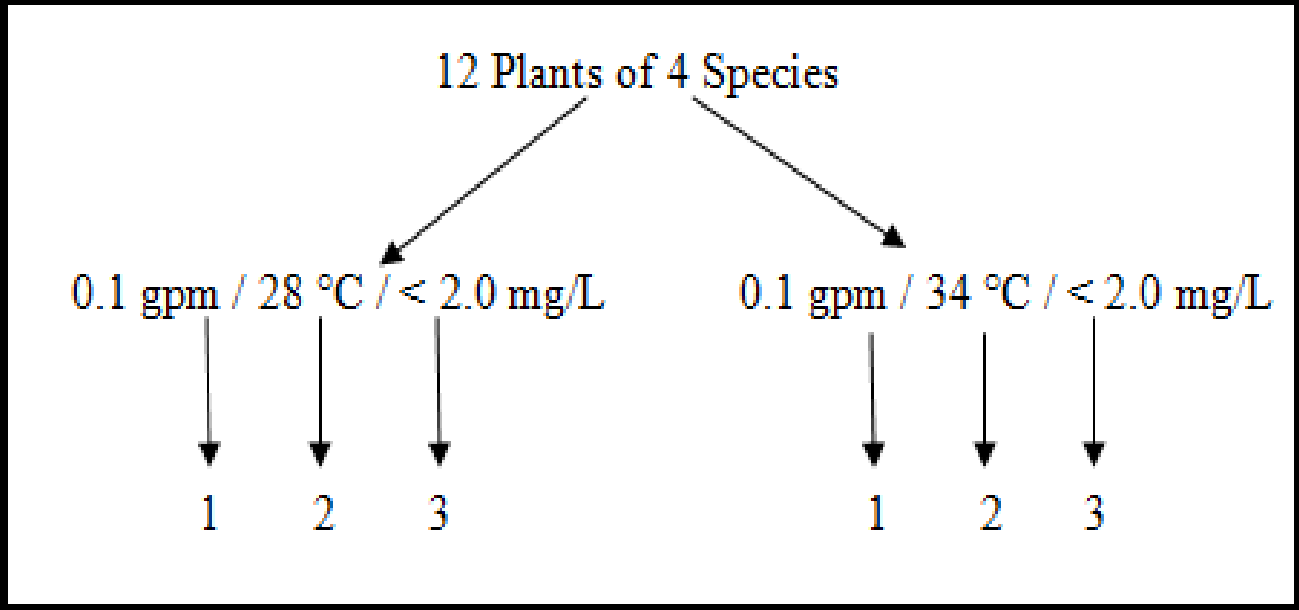
BIO-WEST

Applied Research: Low Flow Threshold (initial laboratory trials)

- **Objective:** Evaluate effects of low-flow conditions on aquatic vegetation survival/growth

- **Approach:** grow plants in lab under simulated low-flow conditions.
  - Minimal flow velocity (0.1 gpm)
  - Low CO_2 (< 2.0 mg/L)
  - Two Temperatures (28 & 34 C)

Experimental Design



MAJOR FACTORS:

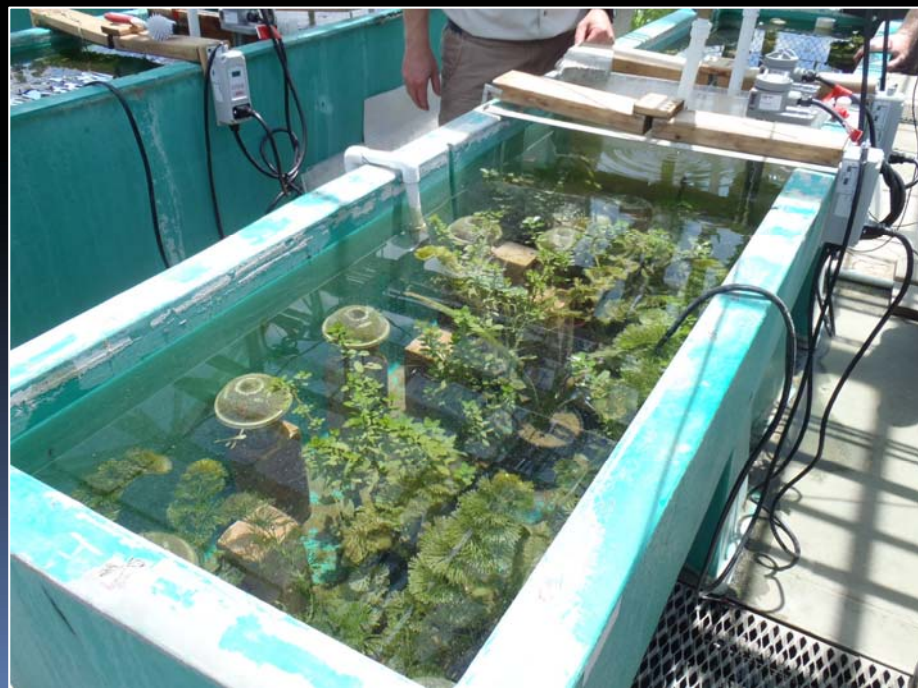
4 species X 1 flow/CO_2 X 2 temps

REPLICATION:

3 tanks of each temp X 12 plants of each species

Methods

1. Grow plants from stock culture materials until well established
2. Transplant to experimental tanks at ARC
3. Monitor, survival, growth, WQ
4. Multiple harvests (each 2 weeks)
5. Determine plant dry biomass



Response Variables

- **Survival**
- **Biomass**
  - Total biomass (AFDM for bryophytes)
  - Relative Growth Rate (change biomass/time)
  - AG:BG
- **Morphology**
  - Number of stems
  - Total length of all stems
  - Maximum stem length

Analyses

Key response focus = RGR

RGR = change in biomass (W) relative to initial biomass (g g^{-1} d^{-1})

$W_1 = W_0 e^{rt}$

RGR (r)= $(\ln W_2 - \ln W_1)/(T_2 - T_1)$

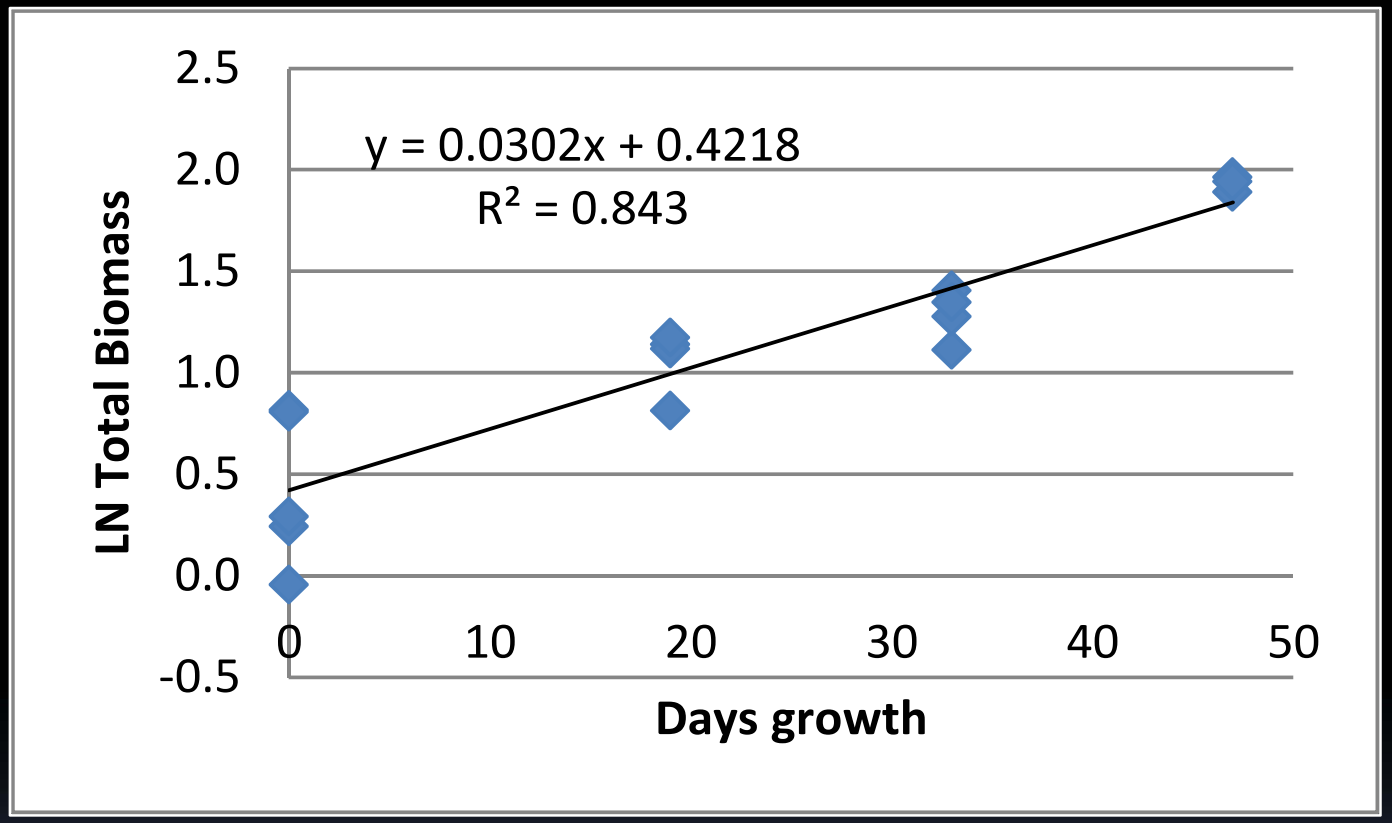
Expect that obligate submersed plants may show negative RGR- leading to plant demise

Cabomba, Vallisneria, Riccia

Heterophyllous plans (which can grow emergent) may simply shift to emergent growth form & keep positive RGR

Ludwigia, Hygrophila, Justicia, Sagittaria, etc

RGR Primer



Slope of line of Ln Biomass vs. Time

Integrated measure of growth rate

"%/day" (0.03=3%/day)

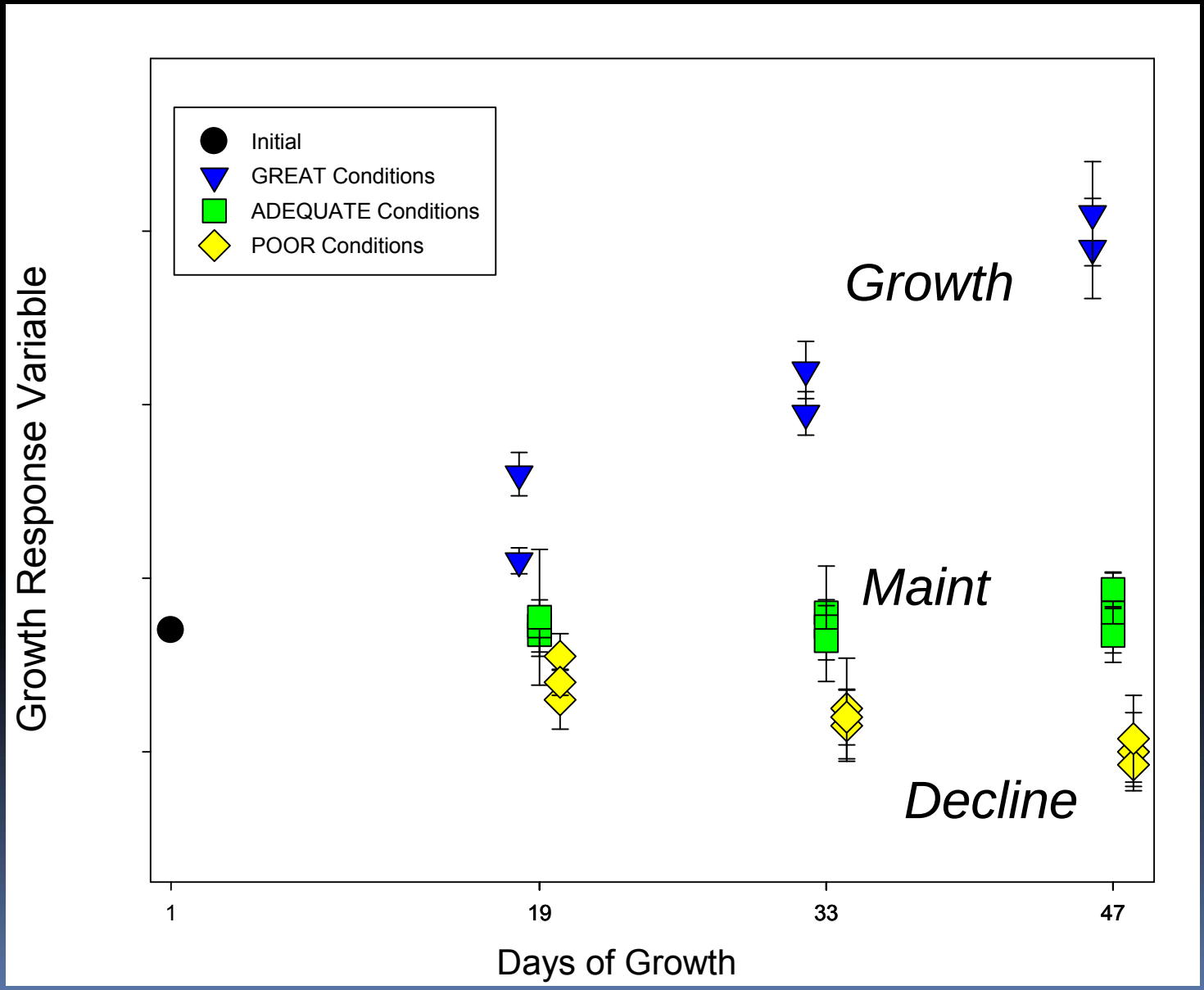
ARC (Lab) Experiment

- **Survival: All species survived well at all temperatures (some signs of stress evident)**

SPECIES	22 °C [a]	28 °C	34 °C	COMMENTS
Cabomba	0/12	1/36	2/36	Plants in 34 °C were noticeably stressed with heavy algal cover. Many plants in both 28 °C and 34 °C produced flowers during the trial.
Ludwigia	1/12	0/36	0/36	Generally healt… tips while those… experiencing al…
Riccia	0/12	0/36	0/36	Clumps in 28 °C… bladderwort, a…
Vallisneria	0/12	0/36	0/36	Plants appeare… rhizomatous gr…

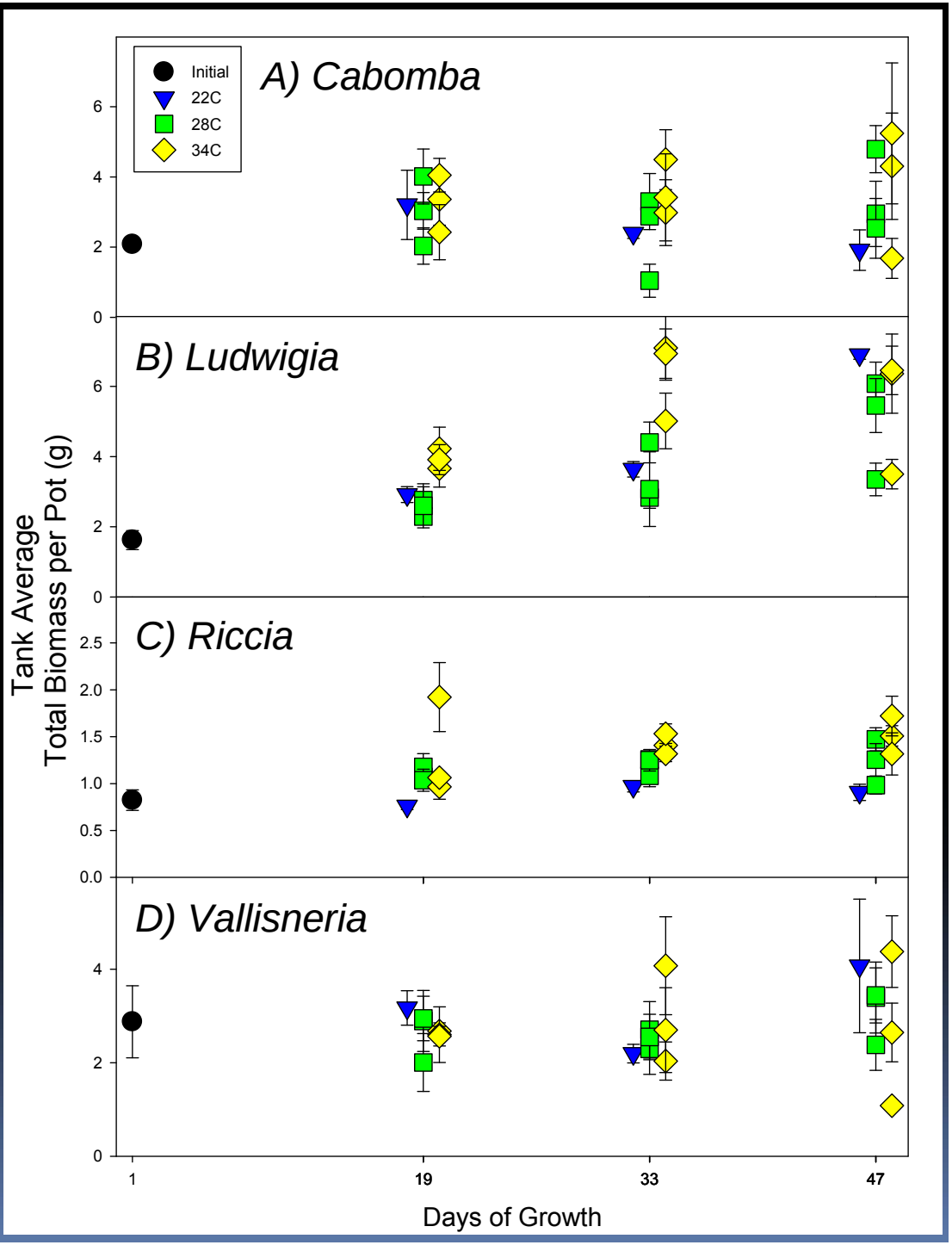
Shown = #dead / #planted

Expected Results



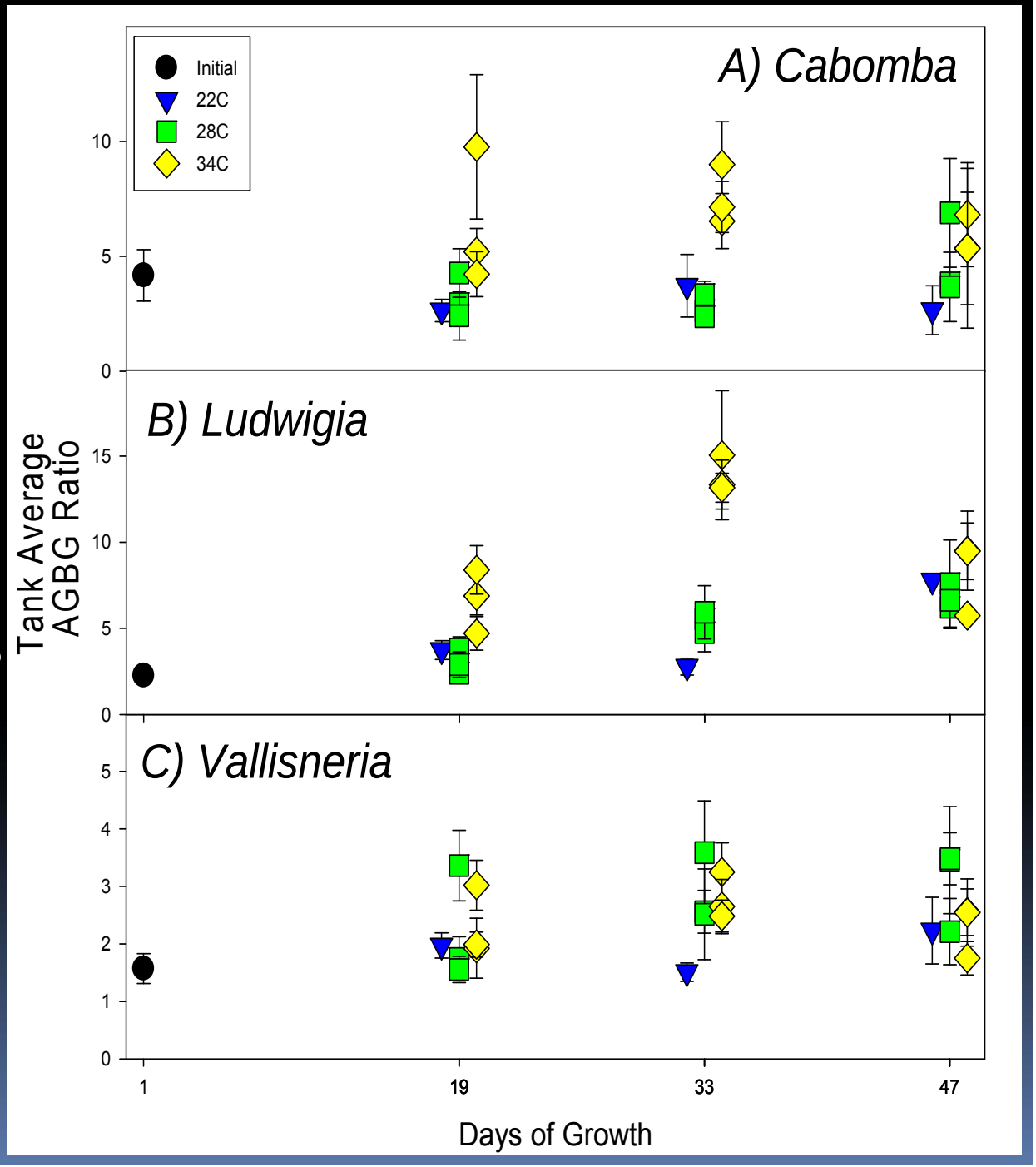
Total Biomass

- **No clear separation through time**



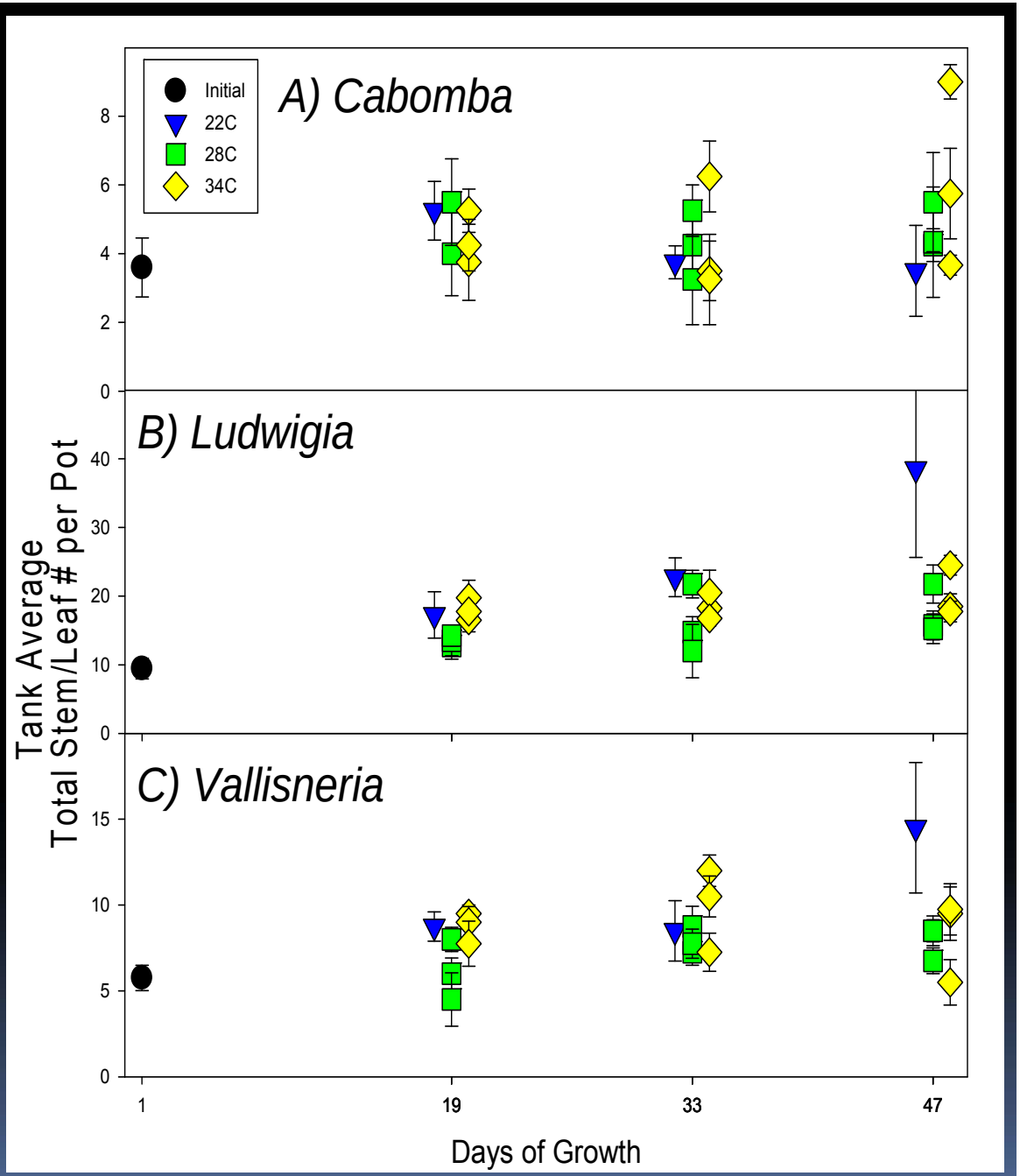
AG:BG

- Early separation for *Cabomba* & *Ludwigia.*
- No differences at end of growth period



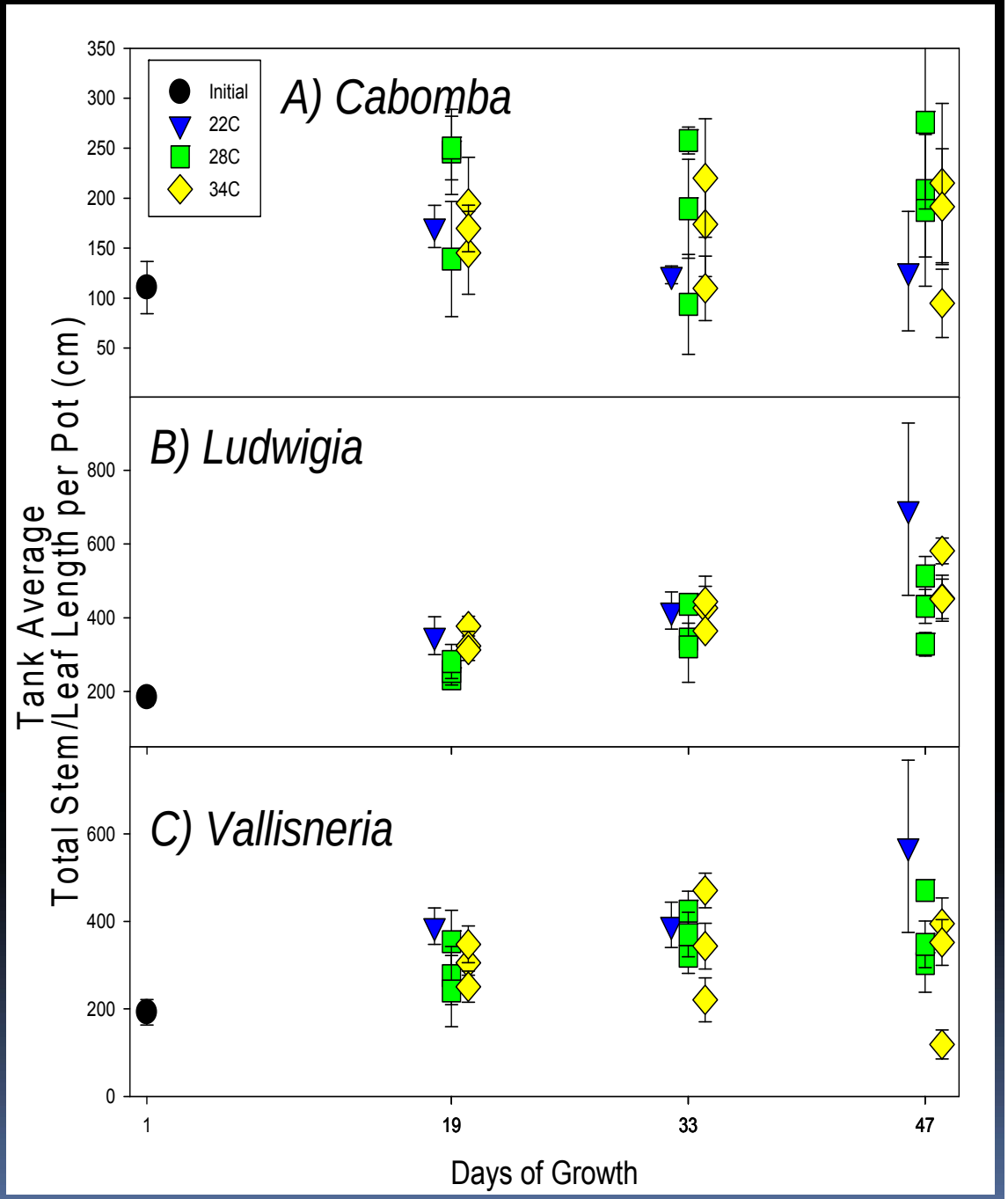
stems/leaves per pot

- No clear separation through time for 28 & 34 C



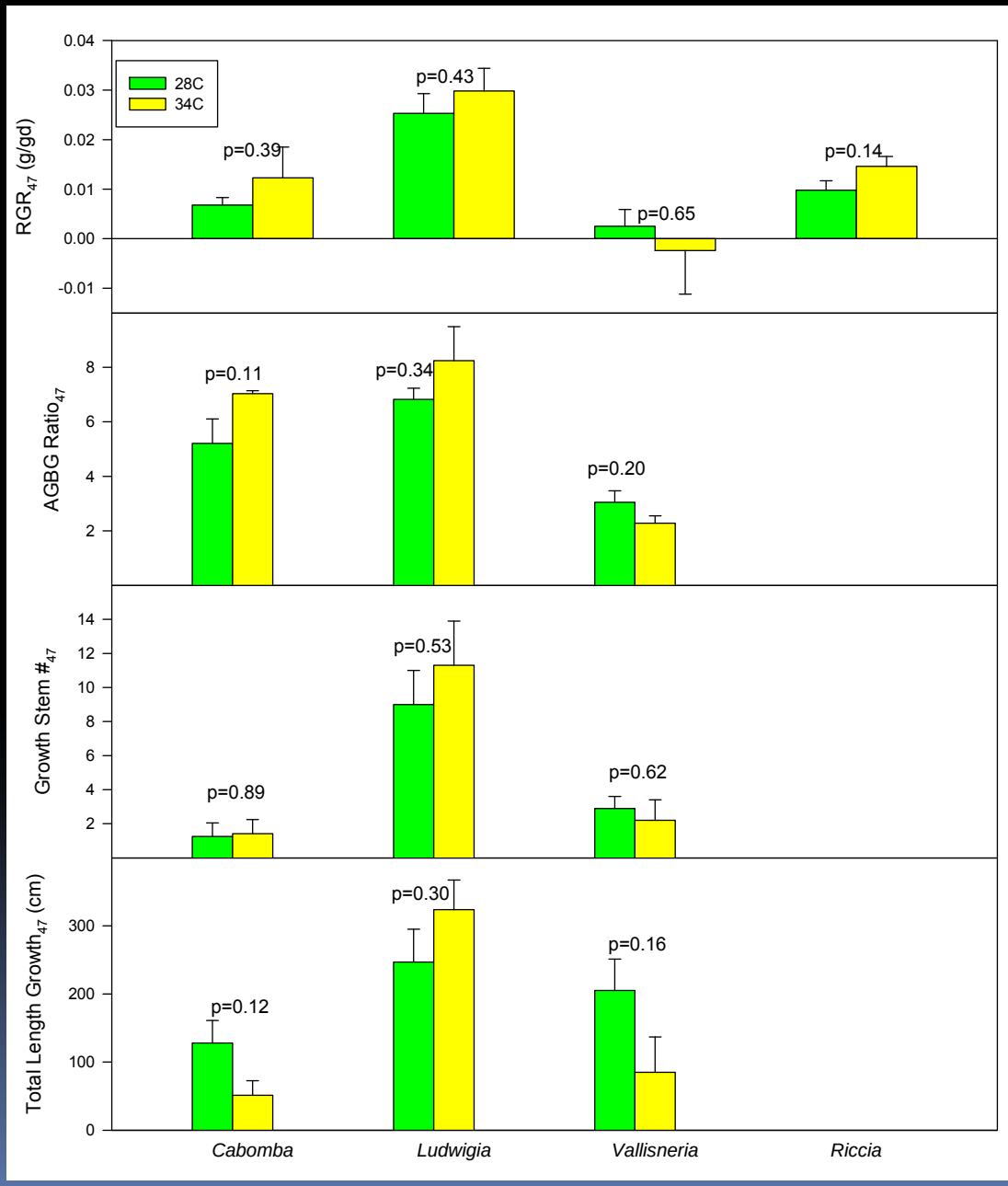
Total stem/leaf length per pot

- No clear separation through time for 28 & 34 C



t-Test

- No difference between 28 & 34 C.
- In general- trend is for better growth at 34 C!



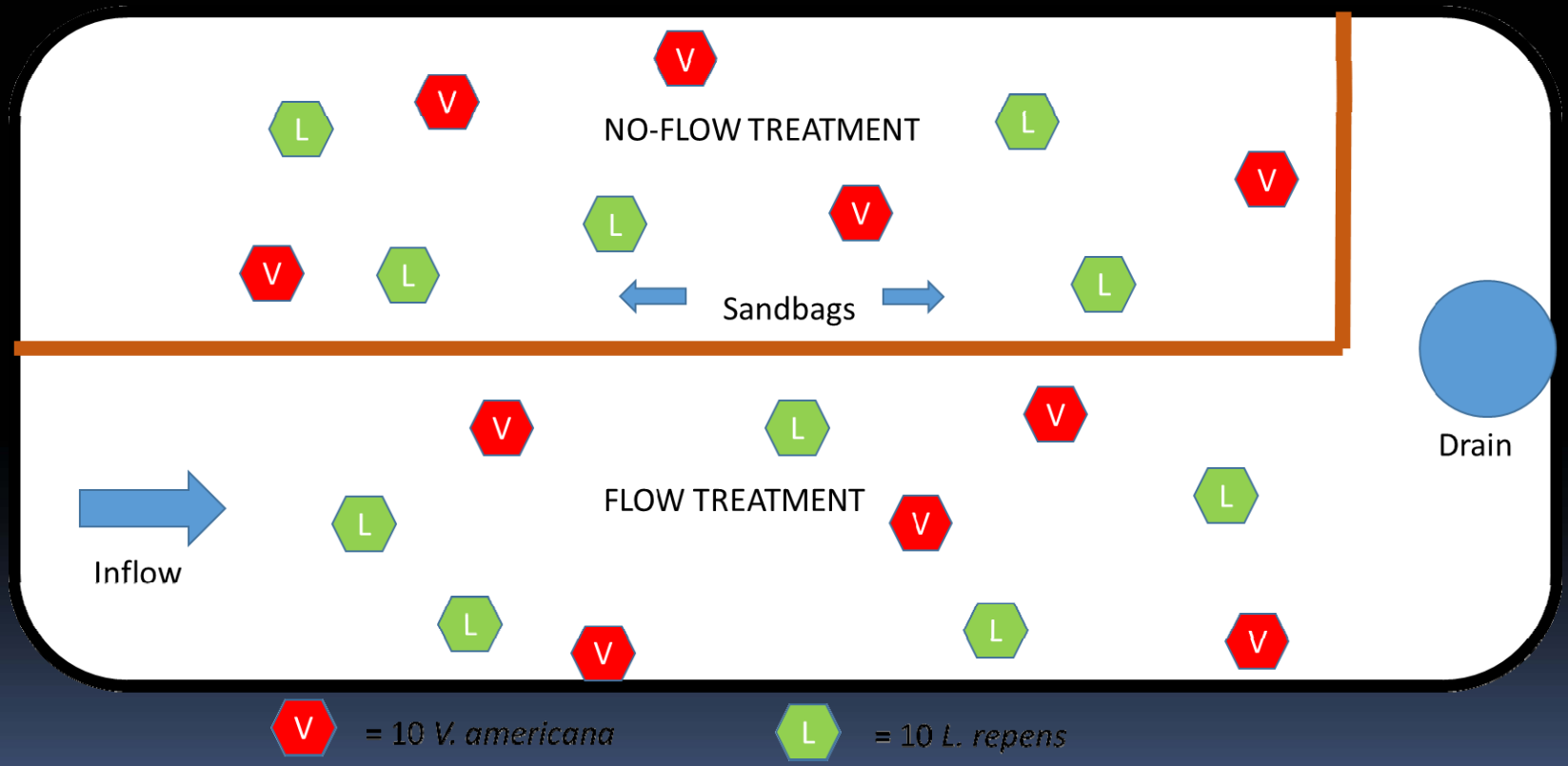
Low Flow Threshold Pond Study

Applied Research: Low Flow Threshold Pond Study

- **Objective:** Evaluate effects of low-flow conditions on aquatic vegetation survival/growth

- **Approach:** place established plants (*Ludwigia repens* and *Vallisneria Americana*) in experimental pond under simulated minimal flow (0.035 cfs, $\bar{v}$ = 0.022 ft s^{-1}) and non - flowing conditions.

Pond Study Design



Response Variables

- Growth
  - Δ Total Stem Length
- Biomass
  - Final biomass compared by species among treatments

Water Quality Data

Minimal Flow

	Max	Min	Mean
Temp	32.4	21.5	26.2
DO	17.49	4.48	7.87
CO_2	15	2	6.78
pH	8.75	7.55	8.05

Non - flowing

	Max	Min	mean
Temp	35.4	24.3	29.45
DO	9.67	3.77	6.66
CO_2	5	1	2.33
pH	9.03	6.3	8.44

Results

- Growth (Δ stem length):
  - *L. repens*: significantly different between treatments (t=3.15, p=0.002)
    - Minimal flow (119.85 cm) > non-flowing (83.01)
  - *V. americana*: significantly different between treatments (t=4.26, p<0.001)
    - Minimal flow (-13.7 cm) < non-flowing (56.36 cm)
- Biomass:
  - Significant difference for *L. repens* only (t=10.86, p<0.001)
    - Minimal flow (2.014g) > non-flowing (0.931 g)

Results

- Correlation of depth and growth:
  - *V. americana*
    - Minimal flow = 0.456, $p < 0.001$
    - Non-flowing = 0.279, $p = 0.0495$
  - *L. repens*
    - Minimal flow = NS
    - Non-flowing = -0.605, $p < 0.001$
- Artifact of experimental design or real effect?
  - Range: minimal flow = 18.9”, non-flowing = 10.8”

End of Pond Experiment

Key Findings

Very good news- these key species likely to survive short-term periods of warm water!

Caution: While the species survived the *physiological* challenge of warm water- there may be additional stresses during low flow (desiccation, herbivory, excessive algae) that would make the *ecological* challenge more formidable.