HCO_3^- UTILIZATION POTENTIAL OF SUBMERSED AQUATIC VEGETATION AND ITS IMPLICATIONS FOR NATIVE PLANT RESTORATION IN A SPRING-FED CENTRAL TEXAS RIVER

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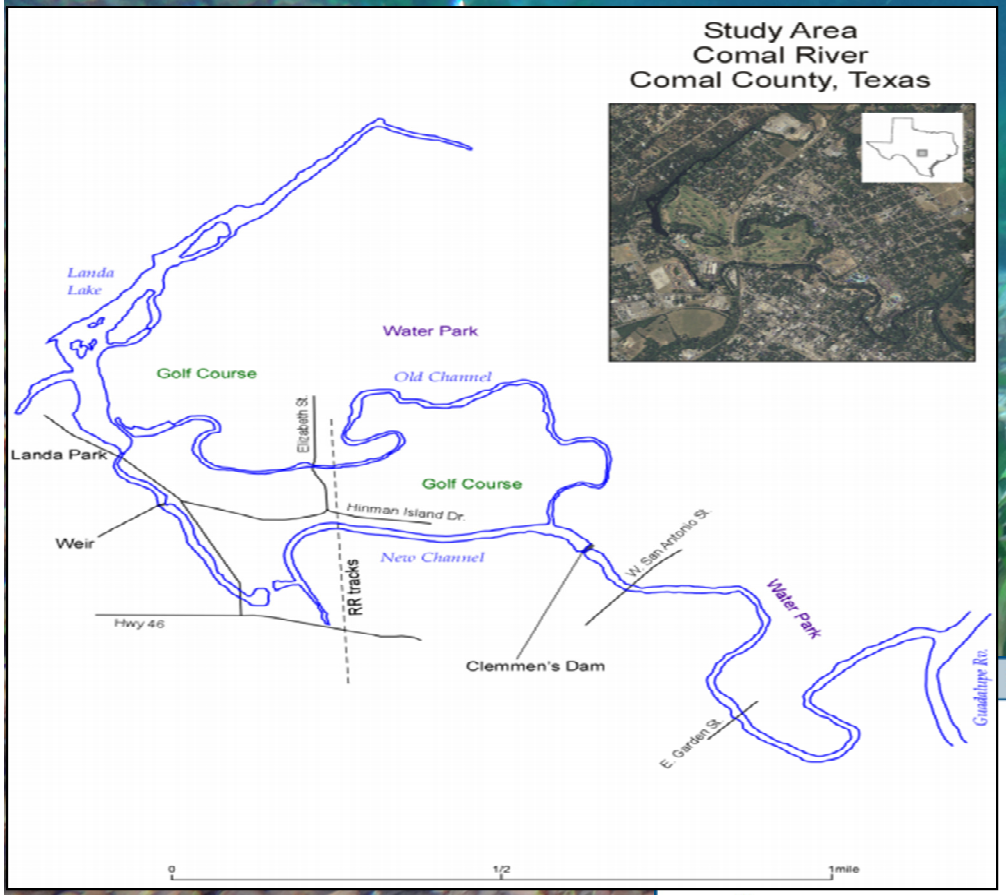
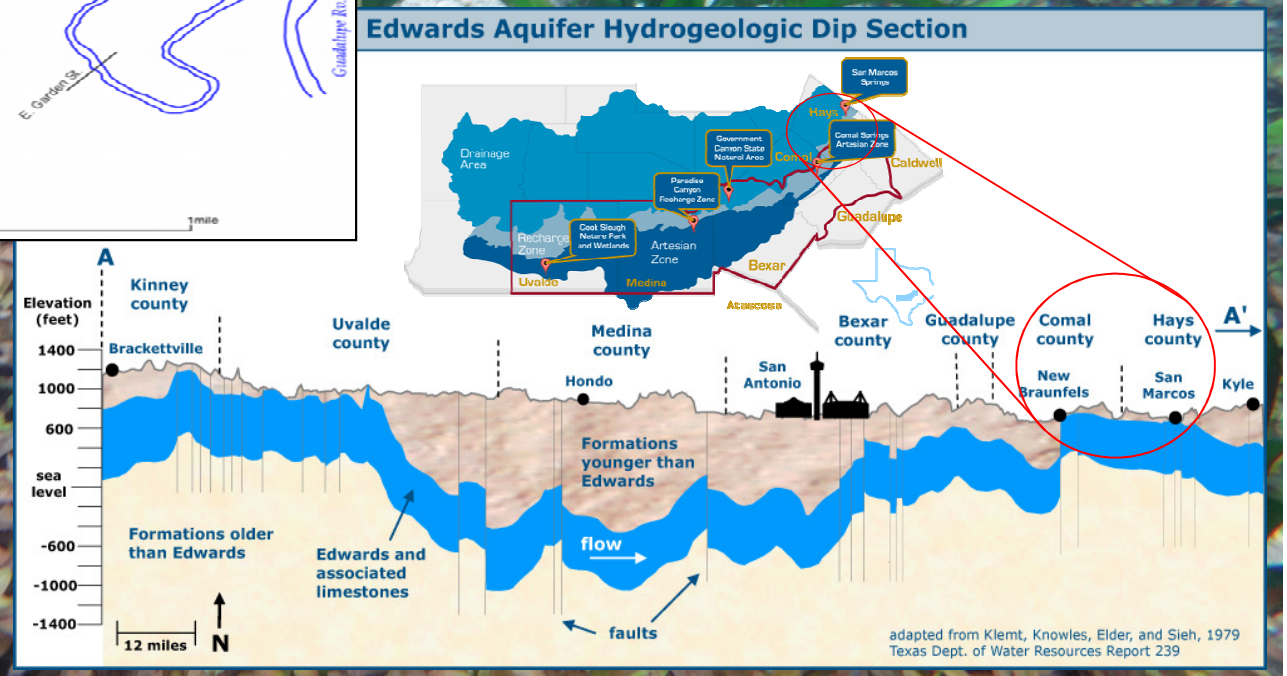
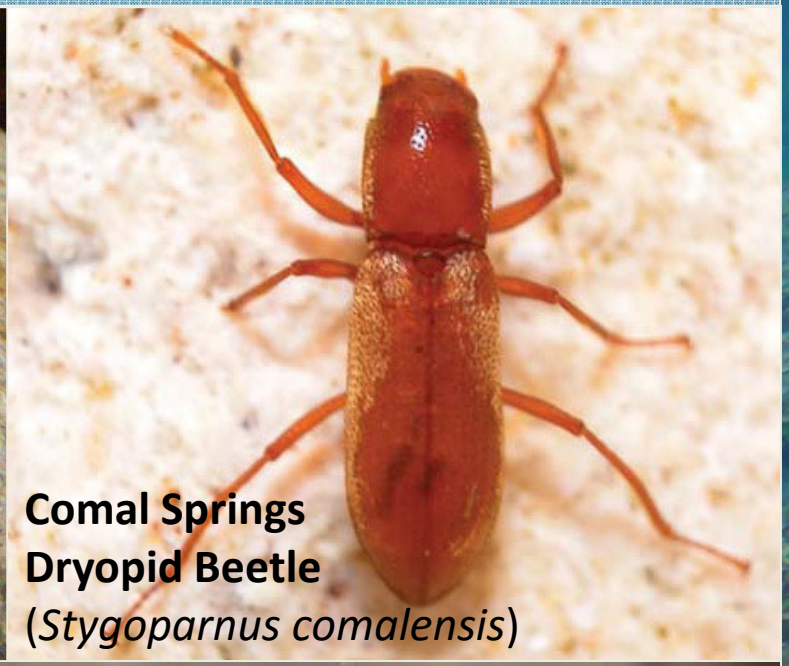
Study Location: Comal River





Endangered Species of the Comal River and associated Springs

Fountain Darter (*Etheostoma fonticola*)



Comal Springs Dryopid Beetle (*Stygoparnus comalensis*)

Comal Springs Riffle Beetle (*Heterelmis comalensis*)

Peck's Cave Amphipod (*Stygobromus pecki*)

Threats to Endangered Species:

1. Non-native, Nuisance & Invasive Species
   - Plants & animals
2. Diminished Springflow and Water Quality
   - Municipal, Agricultural, Industrial and Recreational Use
   - Urban & Agricultural Runoff
   - Drought
3. Habitat degradation
   - Loss or shifts in aquatic vegetation

Non-Native, Nuisance & Invasive Species

Malaysian trumpet snail (*Melanoides tuberculatus)*,

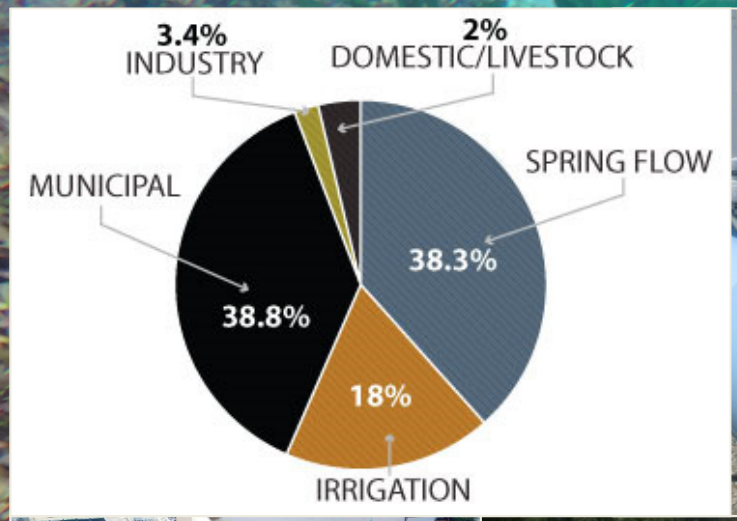
Melanoides tuberculatus
Color morphs from the Guadalupe R

Figure 8. Ventral view of a fountain darter (*Etheostoma fonticola*) with massive infection of *Centrocestus formosanus* and an uninfected fish (lower). Opercula flared outward by deformed and hyperplastic gill tissue (each division of scale = 1 mm).

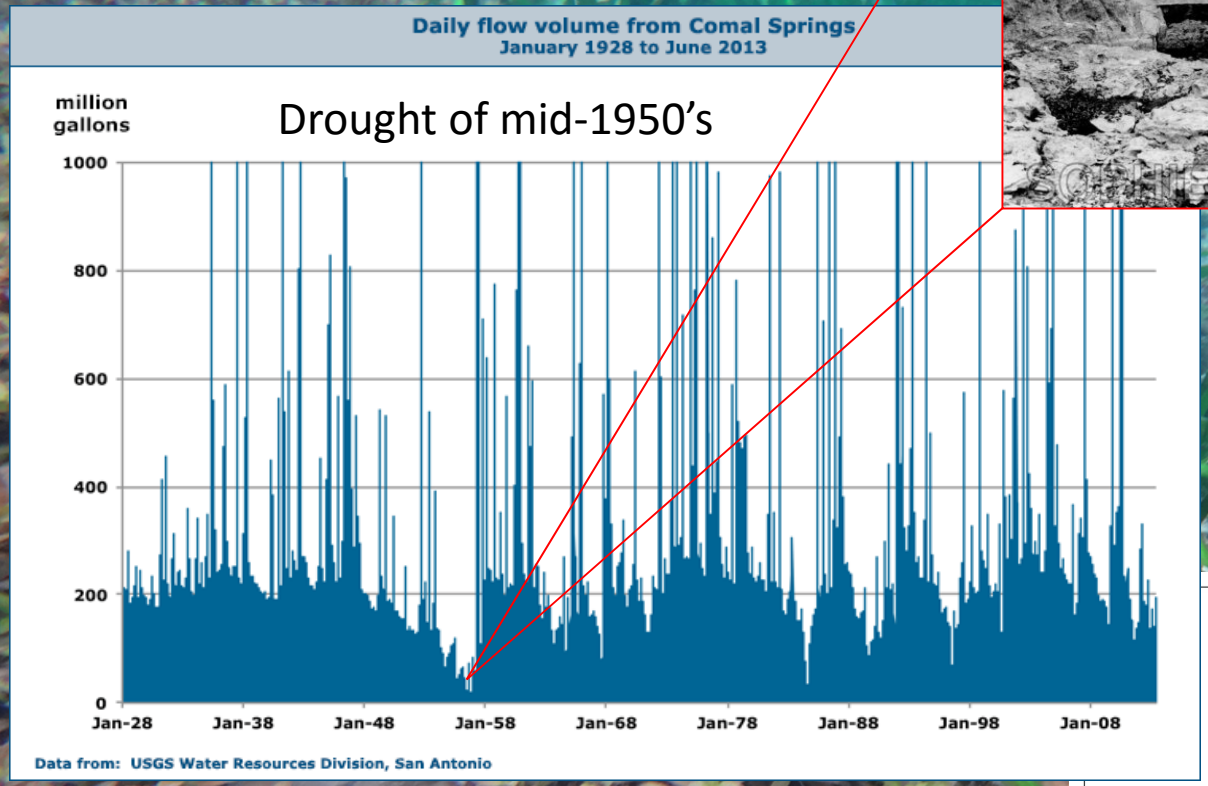
Non-Native, Nuisance & Invasive Species

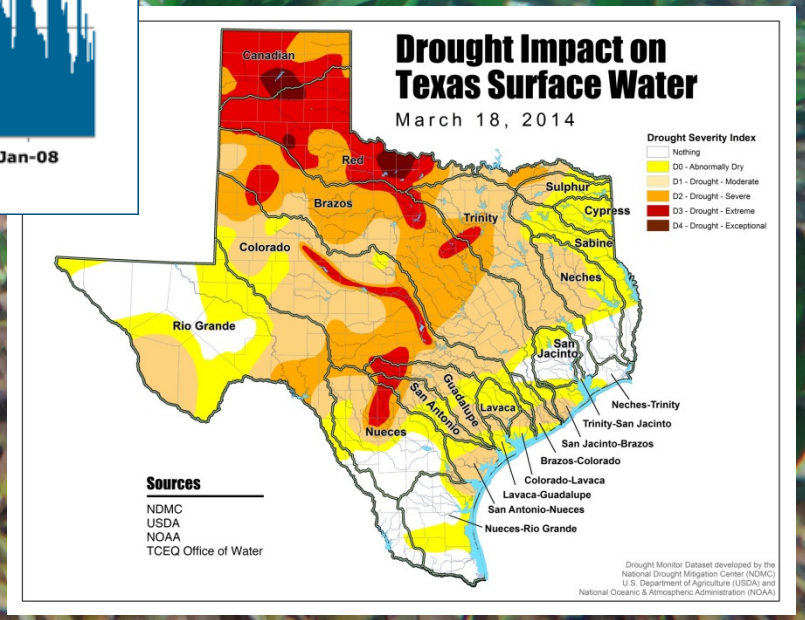
Giant ramshorn snail (*Marisa cornuarietis*), Red swamp crayfish (*Procambarus clarkii*), Armored catfish (*Pterygoplichthys anisitsi)* , Tilapia (*Oreochromis spp*), Indian waterweed (*Hygrophila polysperma*)

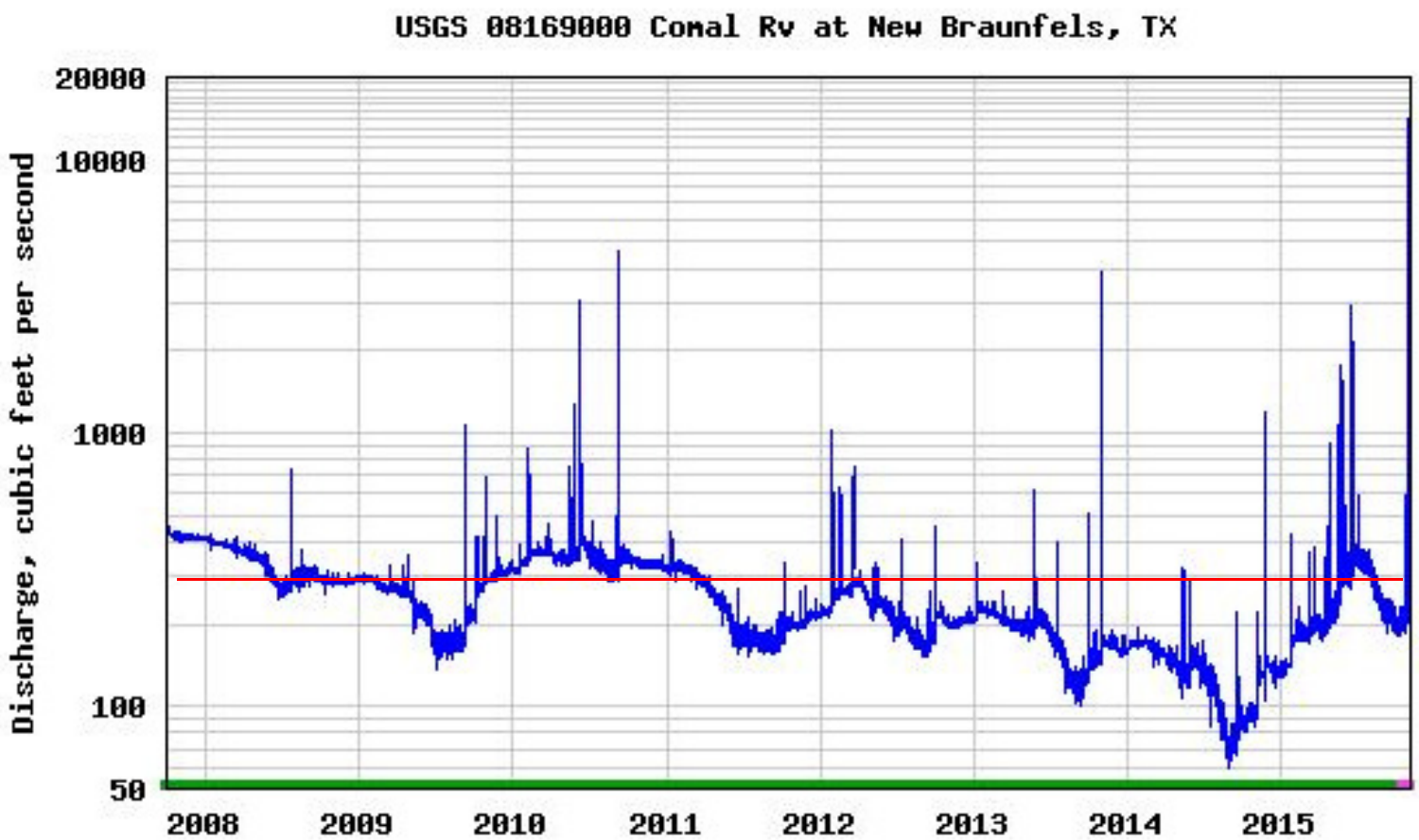
Municipal, Agricultural, Industrial, Recreational Use & Runoff



Drought

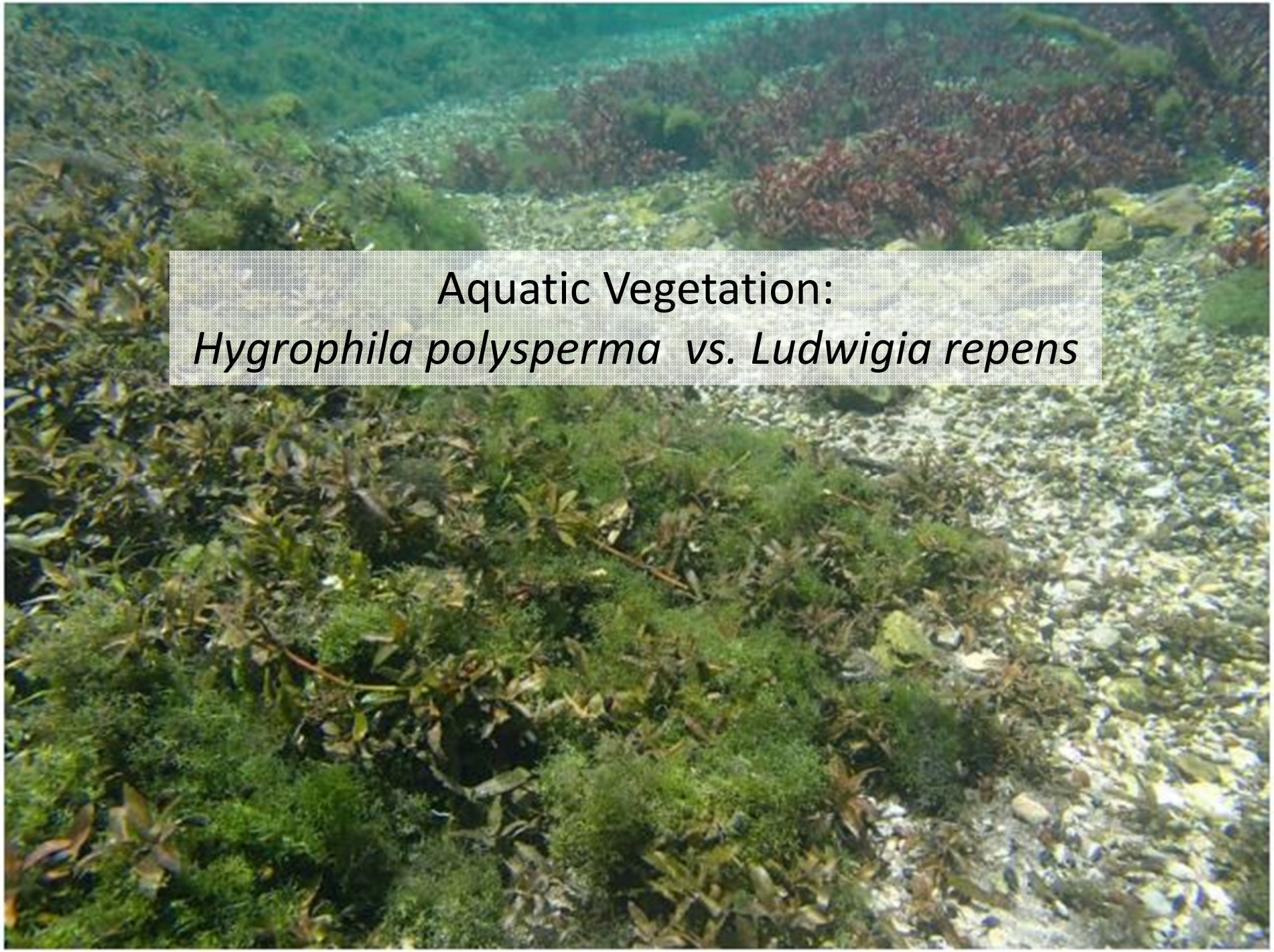

Daily flow volume from Comal Springs
January 1928 to June 2013
million gallons
Drought of mid-1950's
1000
800
600
400
200
0
Jan-28
Jan-38
Jan-48
Jan-58
Jan-68
Jan-78
Jan-88
Jan-98
Jan-08
Data from: USGS Water Resources Division, San Antonio


Drought Impact on Texas Surface Water
March 18, 2014
Drought Severity Index
Nothing
D0 - Abnormally Dry
D1 - Drought - Moderate
D2 - Drought - Severe
D3 - Drought - Extreme
D4 - Drought - Exceptional
Canadian
Red
Brazos
Colorado
Trinity
Sulphur
Cypress
Sabine
Neches
Rio Grande
San Jacinto
Guadalupe
San Antonio
Lavaca
Nueces
Neches-Trinity
Trinity-San Jacinto
San Jacinto-Brazos
Brazos-Colorado
Colorado-Lavaca
Lavaca-Guadalupe
San Antonio-Nueces
Nueces-Rio Grande
Sources
NDMC
USDA
NOAA
TCEQ Office of Water
Drought Monitor Dataset developed by the National Drought Mitigation Center (NDMC) U.S. Department of Agriculture (USDA) and National Oceanic & Atmospheric Administration (NOAA)

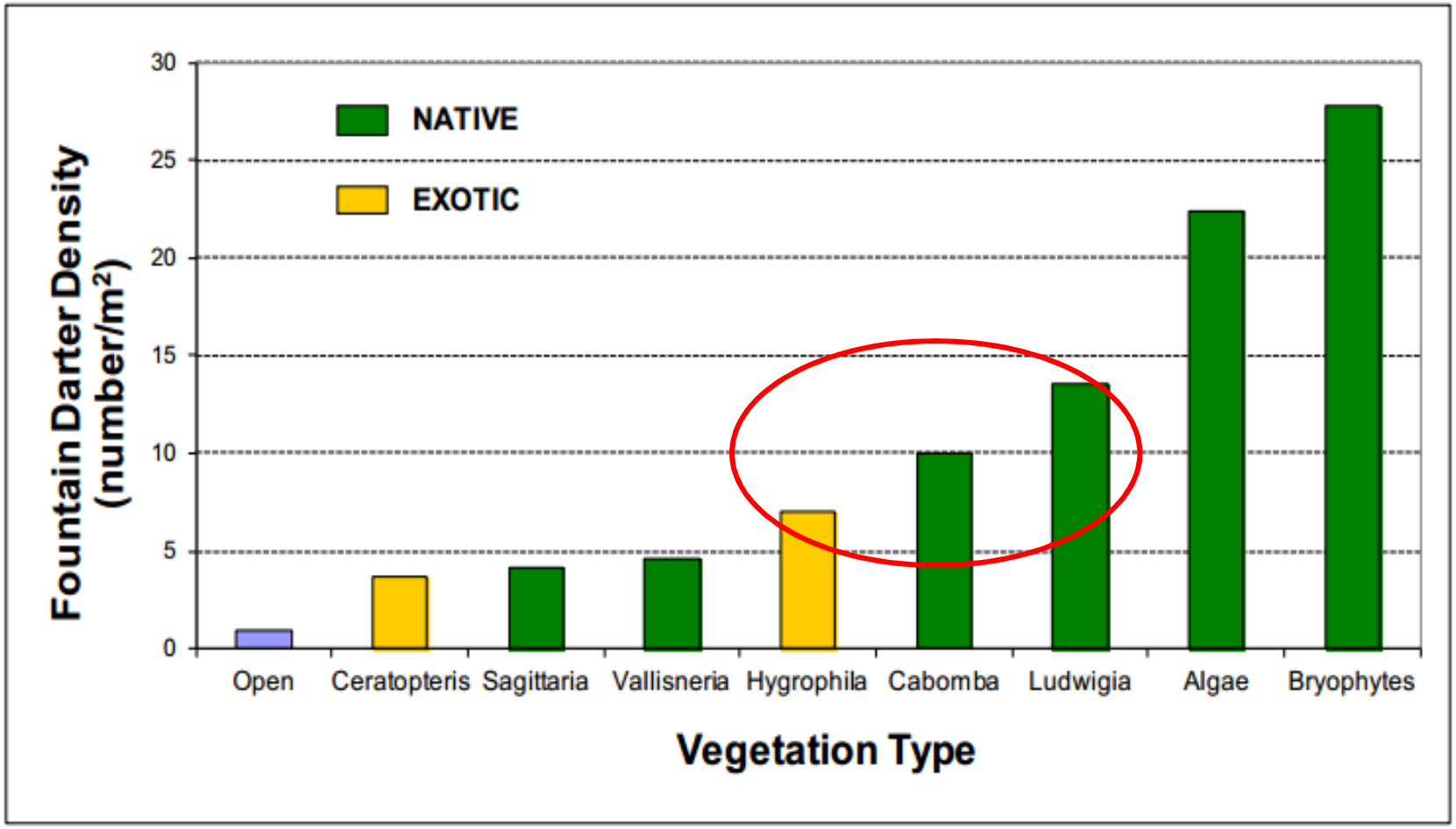


Daily discharge, cubic feet per second -- statistics for Nov 12 based on 83 years of record more

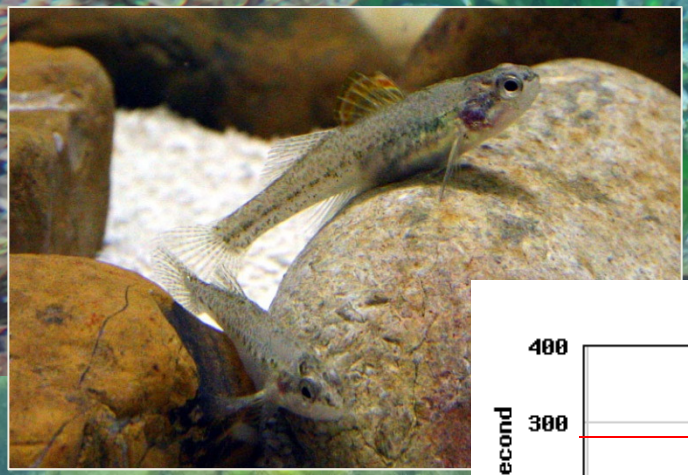
Min (1957)	Most Recent Instantaneous Value Nov 12	25th percen-tile	Mean	Median	75th percen-tile	Max (1974)
24	232	242	288	294	345	451

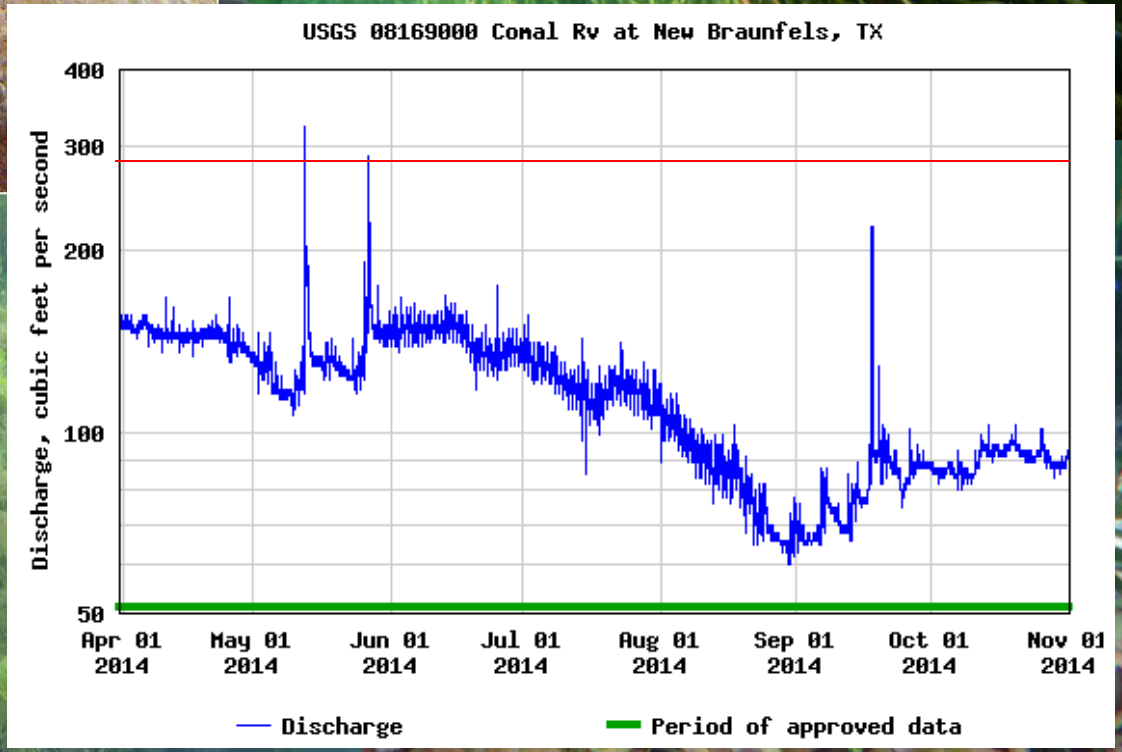

Aquatic Vegetation:
Hygrophila polysperma vs. Ludwigia repens

E. Fonticola Habitat Quality



What happens to *E. fonticola* habitat under extremely low-flow conditions?





HCO_3^- Utilization Potential

Objective: To determine which aquatic plant & bryophyte species are capable of using bicarbonate as a Dissolved Inorganic Carbon (DIC) source for photosynthesis (Ps)

Rationale: Under low-flow conditions, temperature and pH likely to increase, making CO_2 scarce

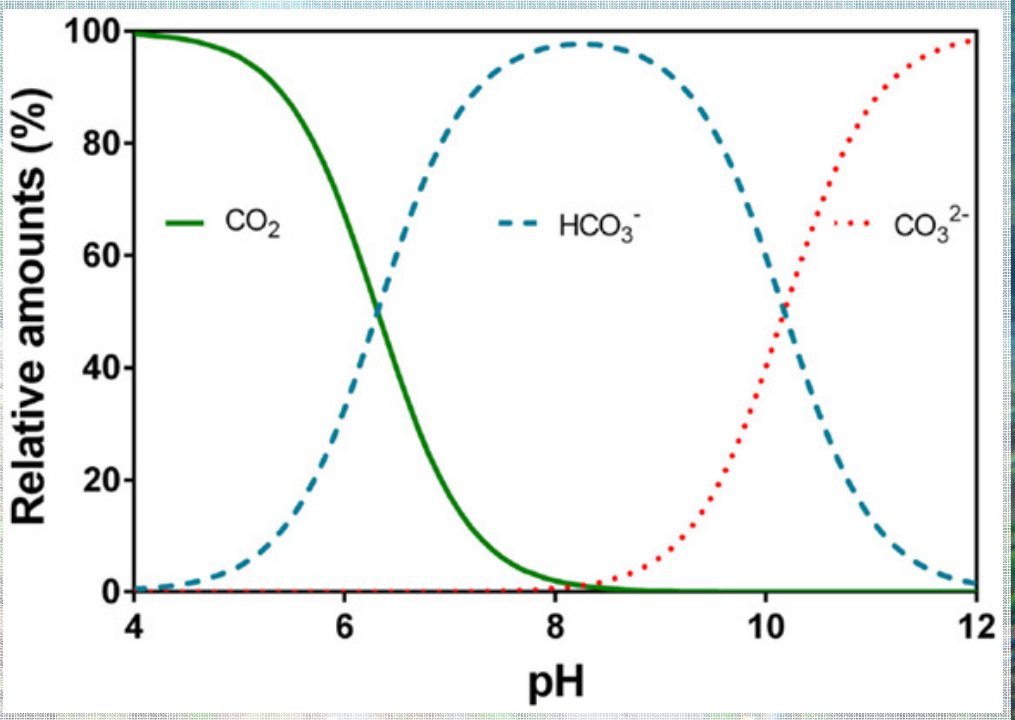
Approach: Assay plants under closed-system conditions and see how high they can drive pH.

CO_2 obligates: Ps stops when CO_2 depleted

HCO_3^- users: Ps continues to higher pH

HCO_3^- Utilization: pH Drift Method

- DIC is pH-dependent
- PS ↓ CO_2 (H_2CO_3) ↑ pH
- Synthetic culture solution w/known alkalinity & carbon composition
- initial pH ~8.3 (not much CO_2 in solution)
- CO_2 depletion lowers total inorganic carbon (C_T) only modestly.



- HCO_3^- use lowers C_T more conspicuously.
- Loss of CO_2 and HCO_3^- does not change alkalinity as (OH^-) replaces alkalinity lost.
- C_T:Alk ratio sensitive measure of HCO_3^- utilization potential.

Methods: HCO_3^- Utilization Potential of Aquatic Vegetation from the Comal River

Analyses

- Focus on major Comal species:
  - Non-native: *Hygrophila polysperma*
  - Native: *Ludwigia repens, Cabomba caroliniana, Vallisneria americana, Sagittaria platyphylla* & bryophytes
- Key response focus = final pH & C_T:Alk ratio
  - The more proficient use of HCO_3^-, the <u>higher</u> they can drive (drift) pH resulting in a <u>lower</u> C_T:Alk ratio
- One-way ANOVA will allow comparison among species & culture conditions.

Results: Relationship between pH and Ps

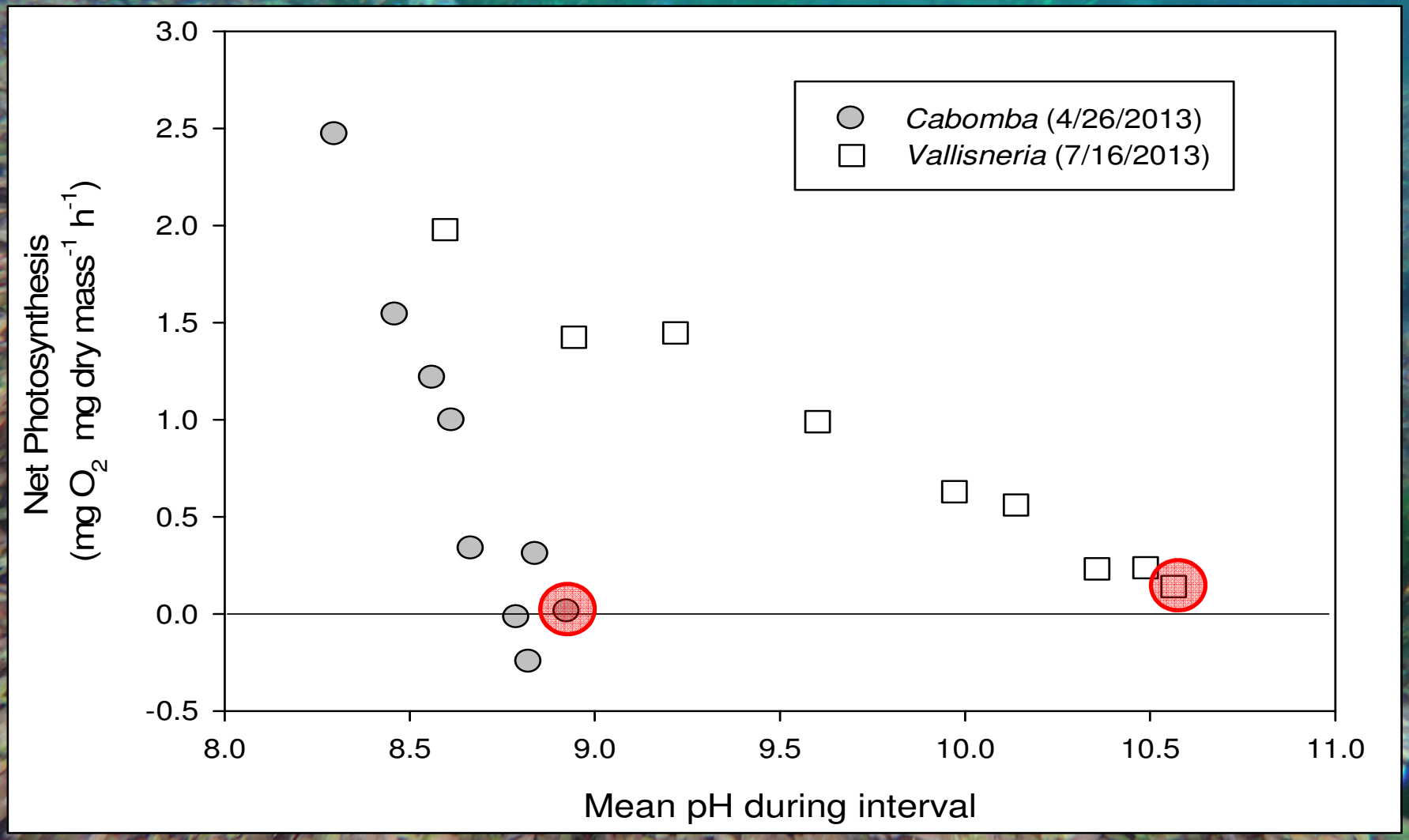
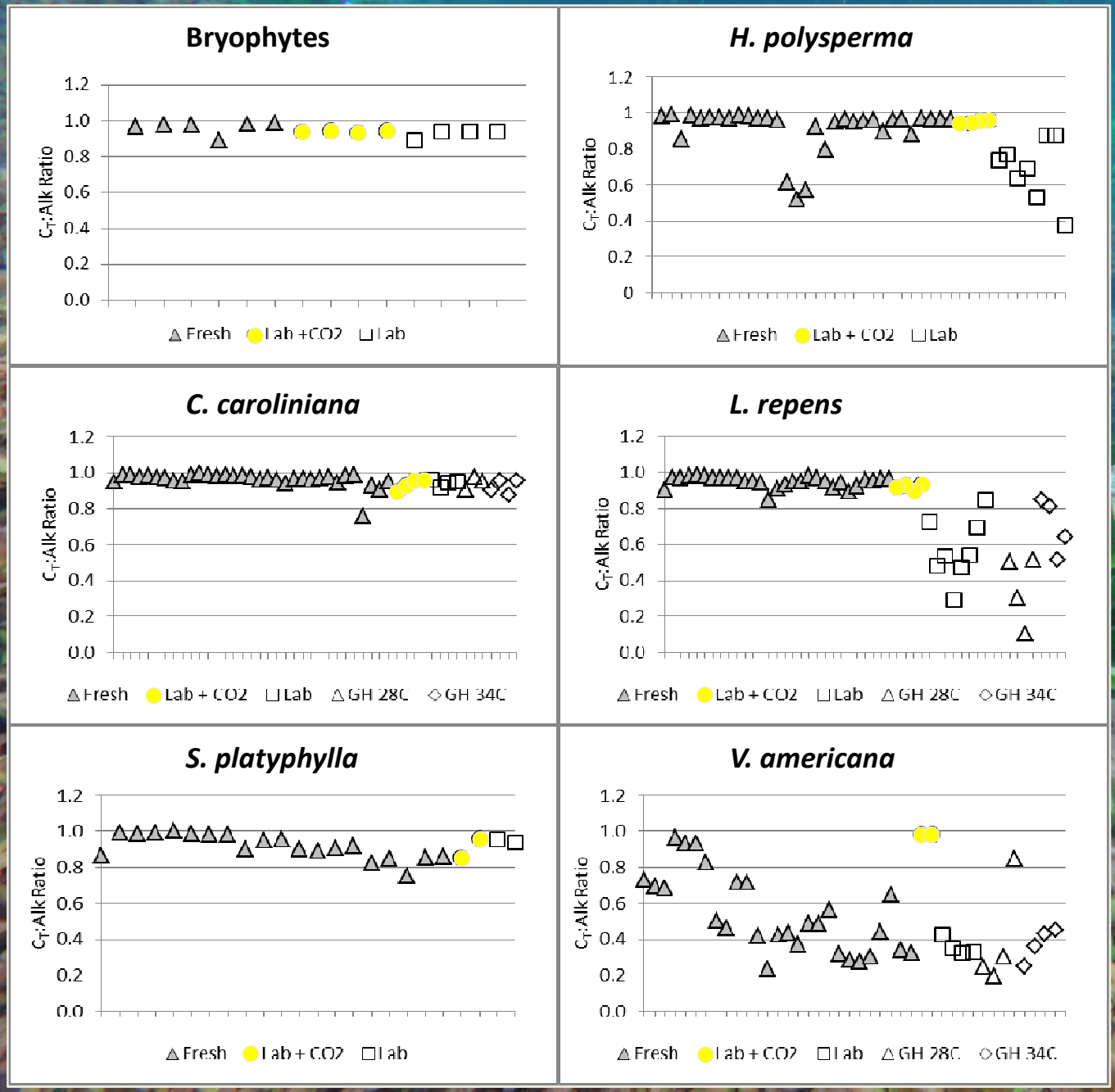


Figure 1. Comparison of prototypical CO_2 obligate (*C. caroliniana*) and HCO_3^- user (*V. americana*)



Results

Figure 2: C_T:Alk for 6 major species.

- There is no evidence for HCO_3^- use for bryophytes, *C. caroliniana* or *S. platyphylla.*
- HCO_3^- use not typical but potentially inducible *L. repens* and *H. polysperma.*
- *V. americana* readily uses HCO_3^-.

Results: One-way Analysis Of Variance

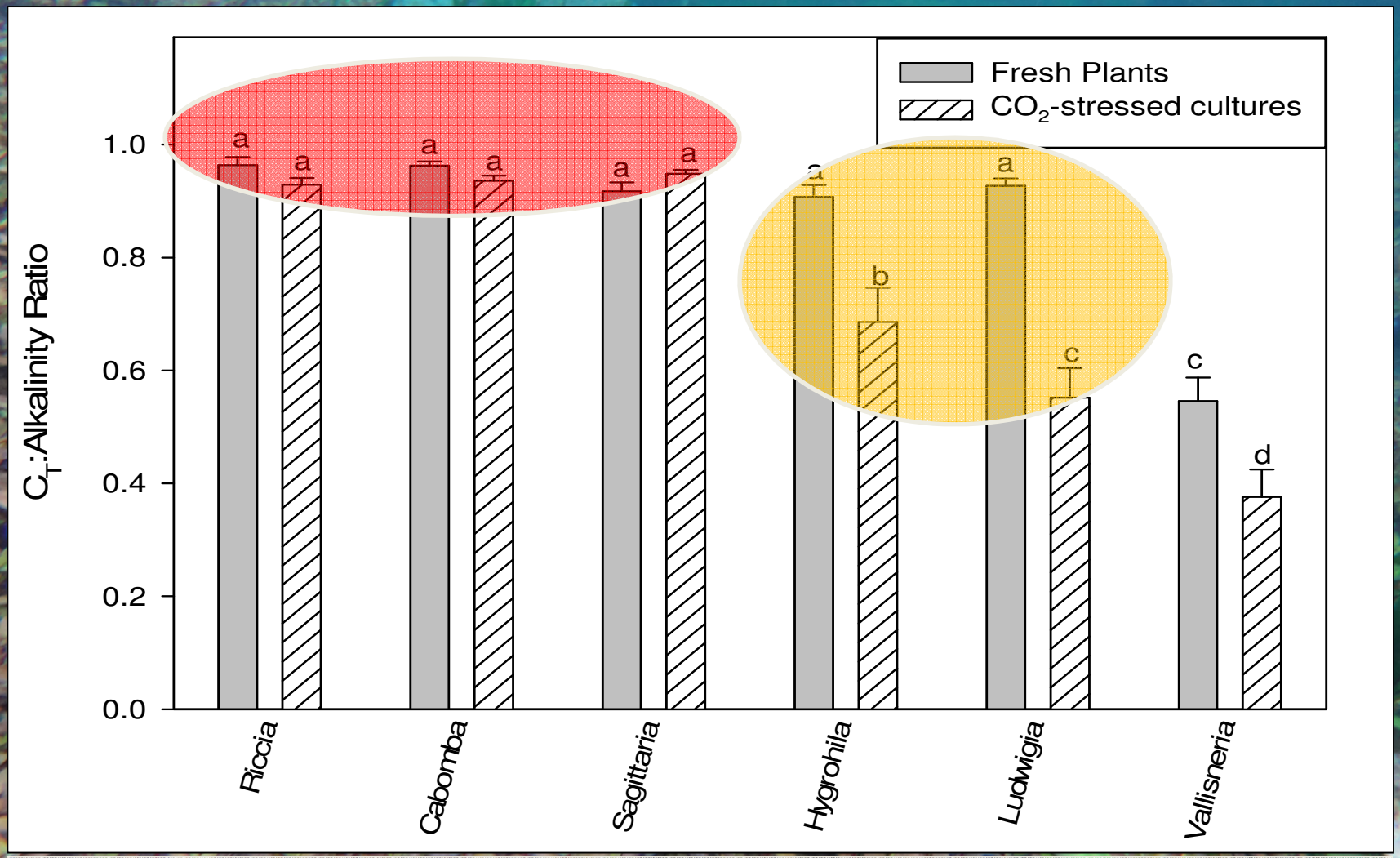


Figure 3. One-way ANOVA showing: a) bryophytes, *C. caroliniana* & *S. platyphylla* are not HCO_3^- users. b) *H. polysperma* & *L. repens* HCO_3^- utilization induced by CO_2 stress and c) *V. americana* strong HCO_3^- user & gets stronger under stress.

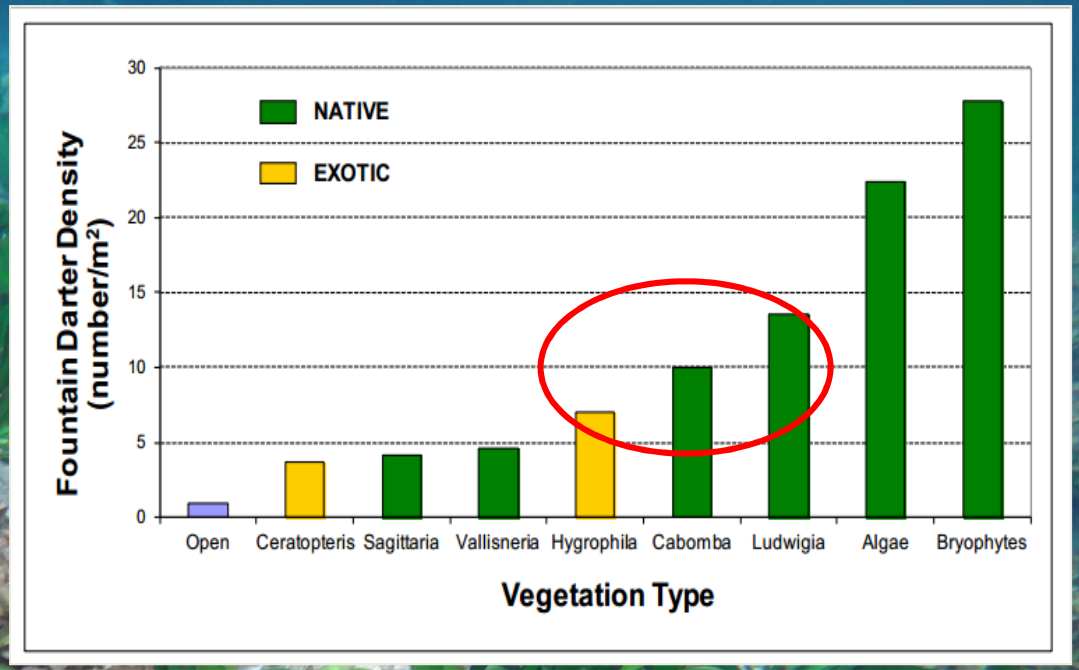
Conclusions

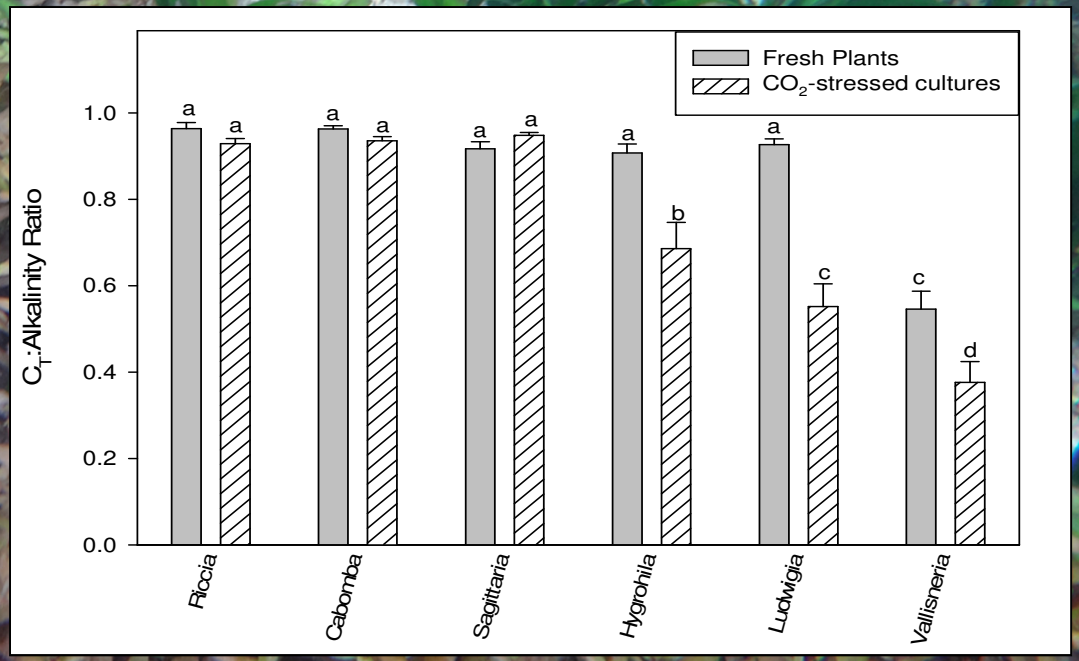
- Study determined HCO_3^- utilization potential for six key species within the Comal River system
  - 3 species (bryophytes, *C. caroliniana* & *S. platyphylla*) are not using HCO_3^- now and show no evidence that utilization can be induced.
  - 2 species (*H. polysperma* (non-native) & *L. repens* (native)) do not use HCO_3^- under normal conditions but evidence that utilization can be induced by CO_2 stress
  - 1 species (*V. americana*) is a strong HCO_3^- user and gets even stronger under CO_2 stress
- Implications for vegetation choice in *E. fonticola* habitat restoration?

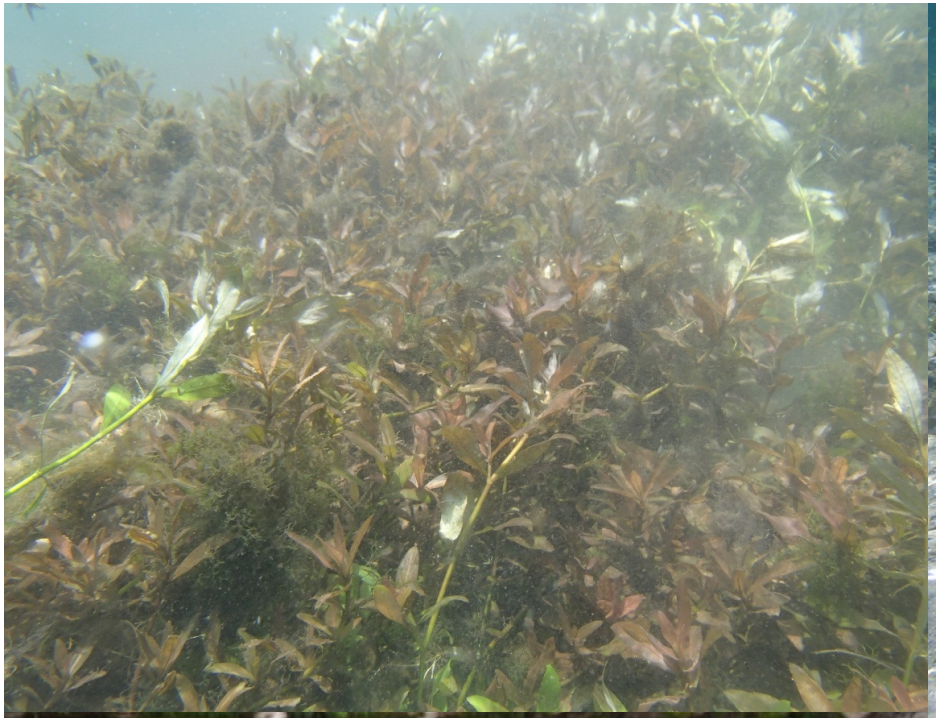
Conclusions

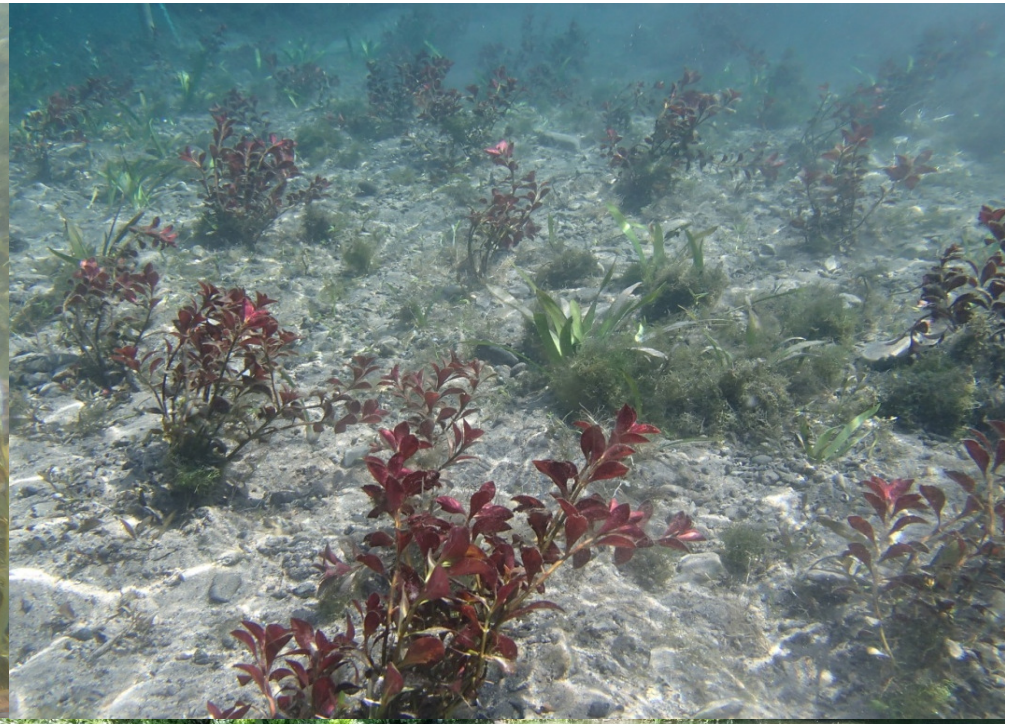
Implications for choice of vegetation in *E. fonticola* habitat restoration?

1. *L. repens*
2. *C. caroliniana*
3. *V. americana*
4. *S. platyphylla*
5. Bryophytes (colonize)









Special Thanks!

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