



Assessment of salt tolerance threshold for wetland plants

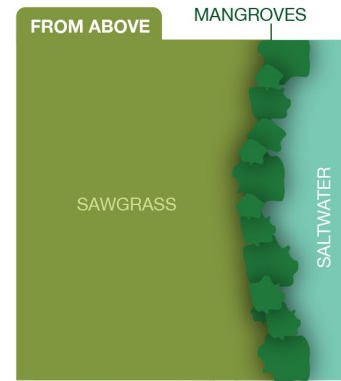
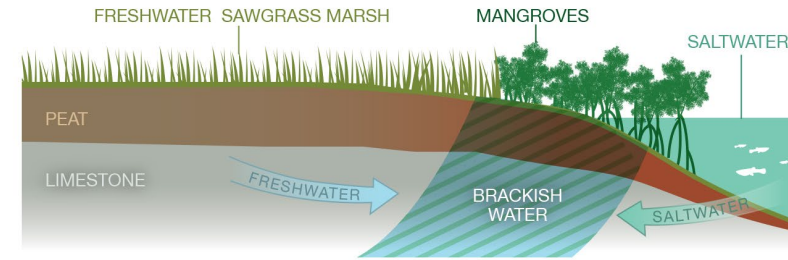
Mohsen Tootoonchi, Lyn Gettys, Kyle Thayer, Ian Markovich and Joseph Sigmon

Water Institute 2020
February 2020

Sea level rise and saltwater intrusion

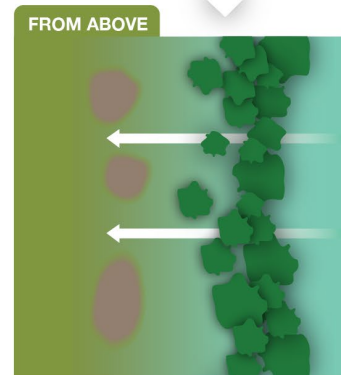
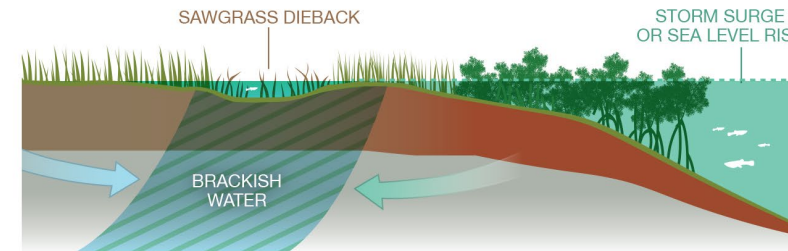
① Current

Sawgrass marsh builds peat soil on top of the limestone only in freshwater areas. Mangroves develop peat soil in saline and brackish conditions.



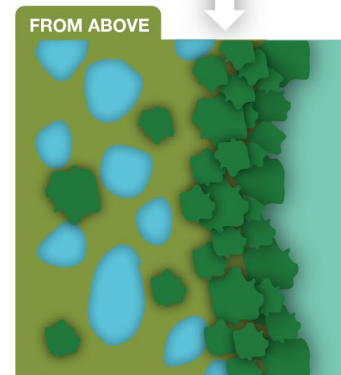
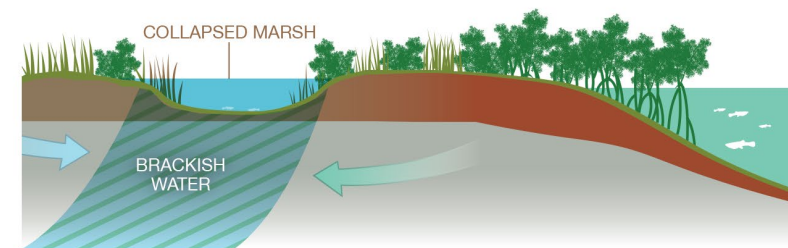
② Saltwater Intrusion

Intrusion of saltwater causes sawgrass dieback and mangrove expansion. Freshwater peat soil begins to degrade with exposure to saltwater.



③ Peat Collapse

Freshwater peat collapses and the water is too deep for plants to become established. Mangroves established elsewhere help to re-stabilize soil.



Aerial photo

- ➔ Saltwater intrusion leads to peat collapse and made these ponds or potholes in the Everglades National Park.









Factors that impact plants ability to tolerate salt

- Increasing salinity (gradual vs. abrupt)
 - Salt used for increasing salinity level



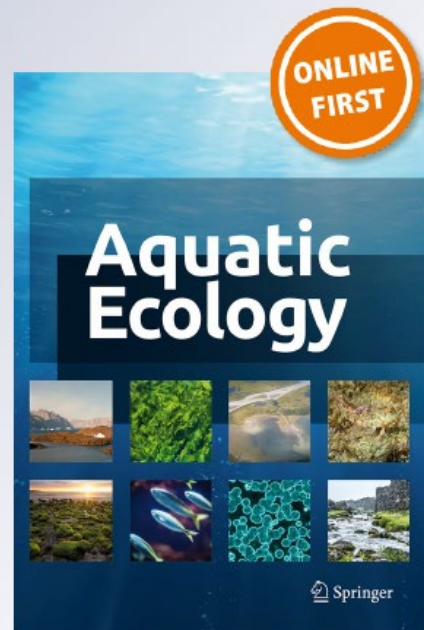
Testing salt stress on aquatic plants: effect of salt source and substrate

Mohsen Tootoonchi & Lyn A. Gettys

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Organizational Levels

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Testing salt stress on aquatic plants: effect of salt source and substrate

► <https://link.springer.com/article/10.1007/s10452-019-09692-6>

Factors that impact plants ability to tolerate salt

- Increasing salinity (gradual vs. abrupt)
 - Salt used for increasing salinity level
 - **Variability among ecotypes**





Variability among ecotypes

- ▶ Tapegrass ecotypes
- ▶ 24 different ecotypes from FL

Ecotypes of Aquatic Plant *Vallisneria americana* Tolerate Different Salinity Concentrations

Mohsen Tootoonchi *, Lyn A Gettys, Kyle L Thayer, Ian J Markovich, Joseph W Sigmon and Shabnam Sadeghibaniani

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Abstract: Increased salinity caused by saltwater intrusion or runoff from de-icing salts can severely affect freshwater vegetation and deteriorate aquatic ecosystems. These habitats can be restored with freshwater ecotypes (locally adapted populations) that tolerate above-normal salinity. *Vallisneria americana* is a prominent species in many freshwater ecosystems that responds differently to abiotic conditions such as substrate composition and fertility, so, in this study, we evaluated the effects of salt stress on 24 ecotypes of *V. americana*. Instant Ocean aquarium salt was used to create saline solutions (0.2 to 20.0 parts per thousand (ppt)), then plants were abruptly exposed to these solutions and maintained in these concentrations for five weeks before being visually assessed for quality and destructively harvested. Analysis of variance and nonlinear regression were used to calculate LC₅₀ values—the lethal concentration of salt that reduced plant biomass and quality by 50% compared to control treatment. Growth rate and visual quality varied significantly among ecotypes, and ecotypes that were most and least sensitive to salt had 50% biomass reductions at 0.47 and 9.10 ppt, respectively. All ecotypes survived 10.0 ppt salinity concentration but none survived at 20.0 ppt, which suggests that the maximum salinity concentration tolerated by these ecotypes is between 15.0 and 20.0 ppt.

Keywords: aquatic macrophytes; freshwater systems; salinity tolerance; intraspecific variation; lethal concentration; genotypic variability; ecotype; salt stress; effective concentration; growth rate; health condition; visual screening

1. Introduction

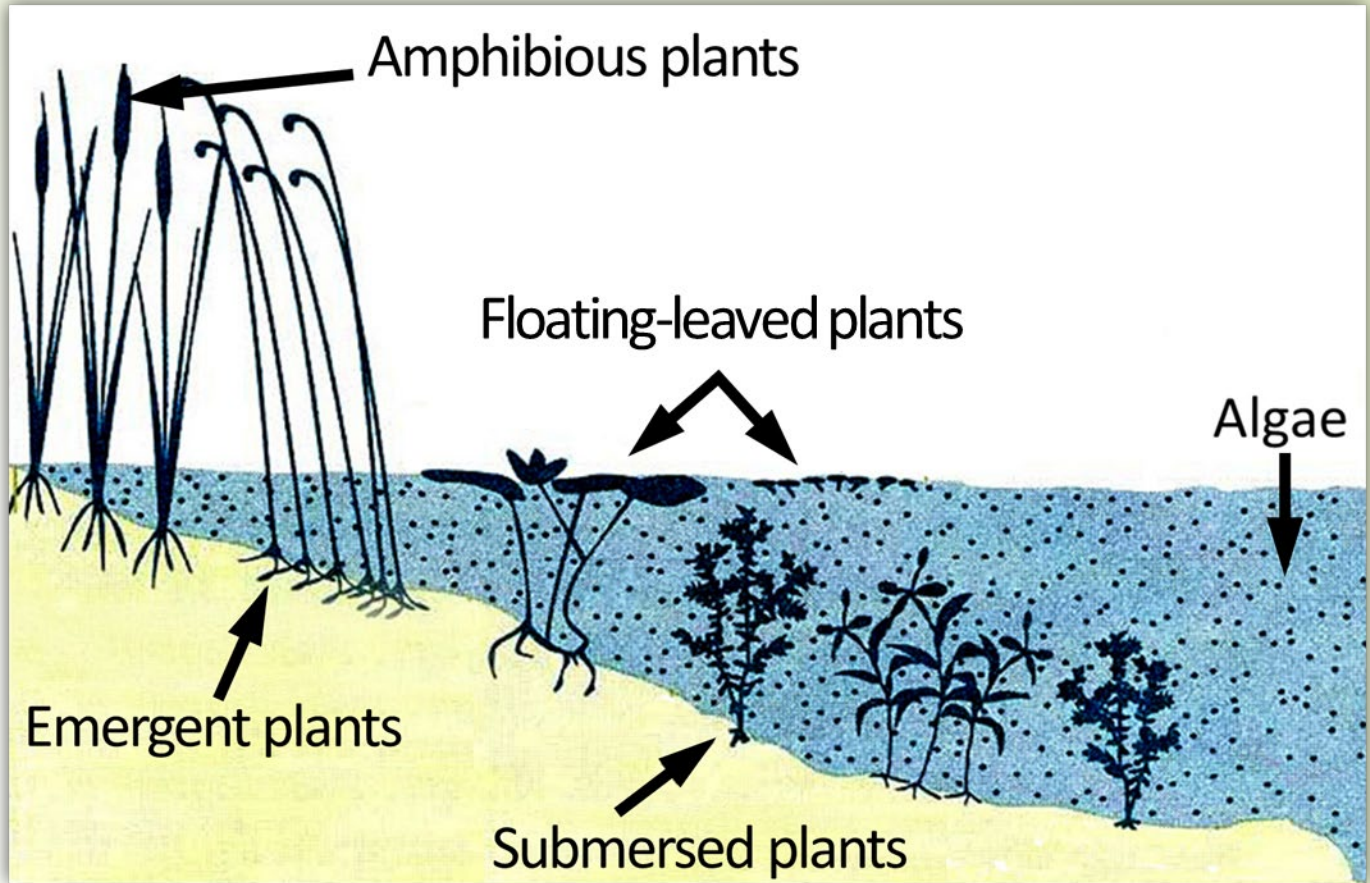
Local adaptation is a well-established phenomenon that is driven by natural selection and may result in plant ecotypes that are adapted to stresses in different habitats [1]. By definition, a distinct form of a plant species that occupies a particular ecosystem or habitat is called an ecotype. Intraspecific variation or ecotypic variability in salt tolerance has been investigated in several plant species [2–5]. For example, different ecotypes of *Spartina patens* from the Gulf Coast of the United States reportedly tolerate different salinity concentrations [3]. Such differences are the result of local adaptations and originate from genotypic traits as opposed to non-heritable acclimation to adverse conditions. Selection of ecotypes that are capable of tolerating extreme salinity conditions is important and useful in developing strategies for stabilization and revegetation of deteriorating marshes and wetlands that are subject to saltwater intrusion [6,7].

Vallisneria americana is a key species in many aquatic ecosystems [8–12]. This perennial submersed macrophyte provides food and habitat for fish, mammals, and invertebrates and affects nutrient cycling, sediment stability, and water clarity in lakes and estuaries [13]. Gettys and Haller

Ecotypes of aquatic plant *Vallisneria americana* tolerate different salinity concentrations

► <https://www.mdpi.com/1424-2818/12/2/65>

Aquatic plants



Aquatic macrophytes (Adapted from the Minnesota Dept. of Natural Resources)

How may aquatic plants in Florida react to future salinity levels?

How

aff

s p

ants?

Submersed



(e)



(ve)



Amphibious



(e)



(ive)



(ve)

Floating-leave



(tive)



ena



(Not Native)

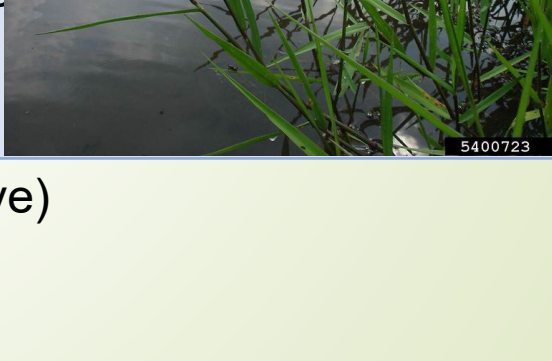
Emergent



)



ative



ative)

Woody/trees

(Native)

Brazilian pepper-tree
Schinus terebinthifolius
Photo by Ann Murray
© 2000 University of Florida

5400723

Salinity experiment



Plants were grown in 68 oz pots



4 Replications



Plants were allowed to grow in freshwater for 4 weeks



Saline solutions were produced using Instant Ocean aquarium mix



Salinity levels: 0.2, 2, 4, 10, 15 and 20 ppt



Plants were exposed to 6 weeks of increased salinity (except trees, 9 weeks)

Plant evaluation



Visual rating: plant health was rated a number between 1 and 10

1= Dead

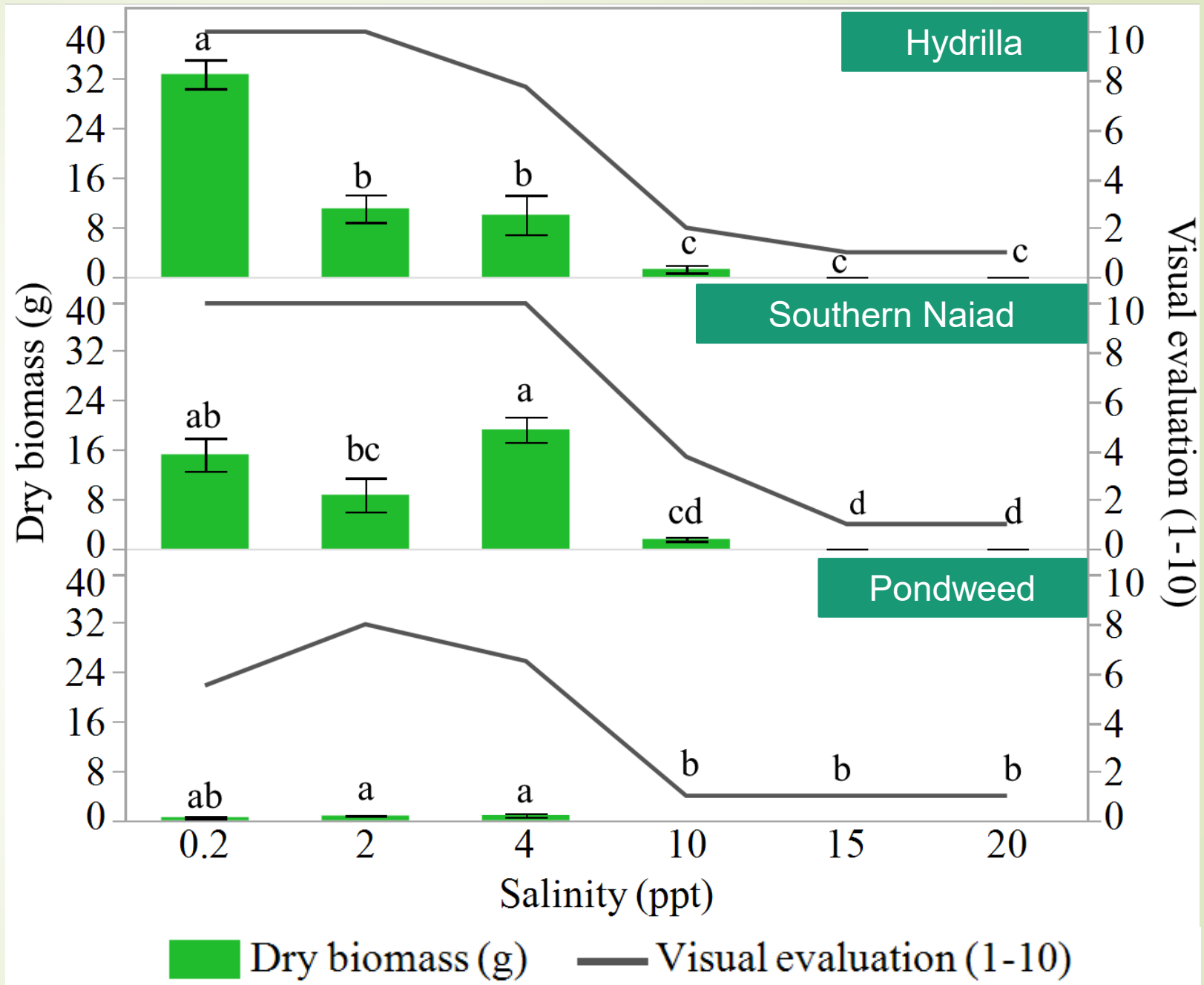
10= No damage



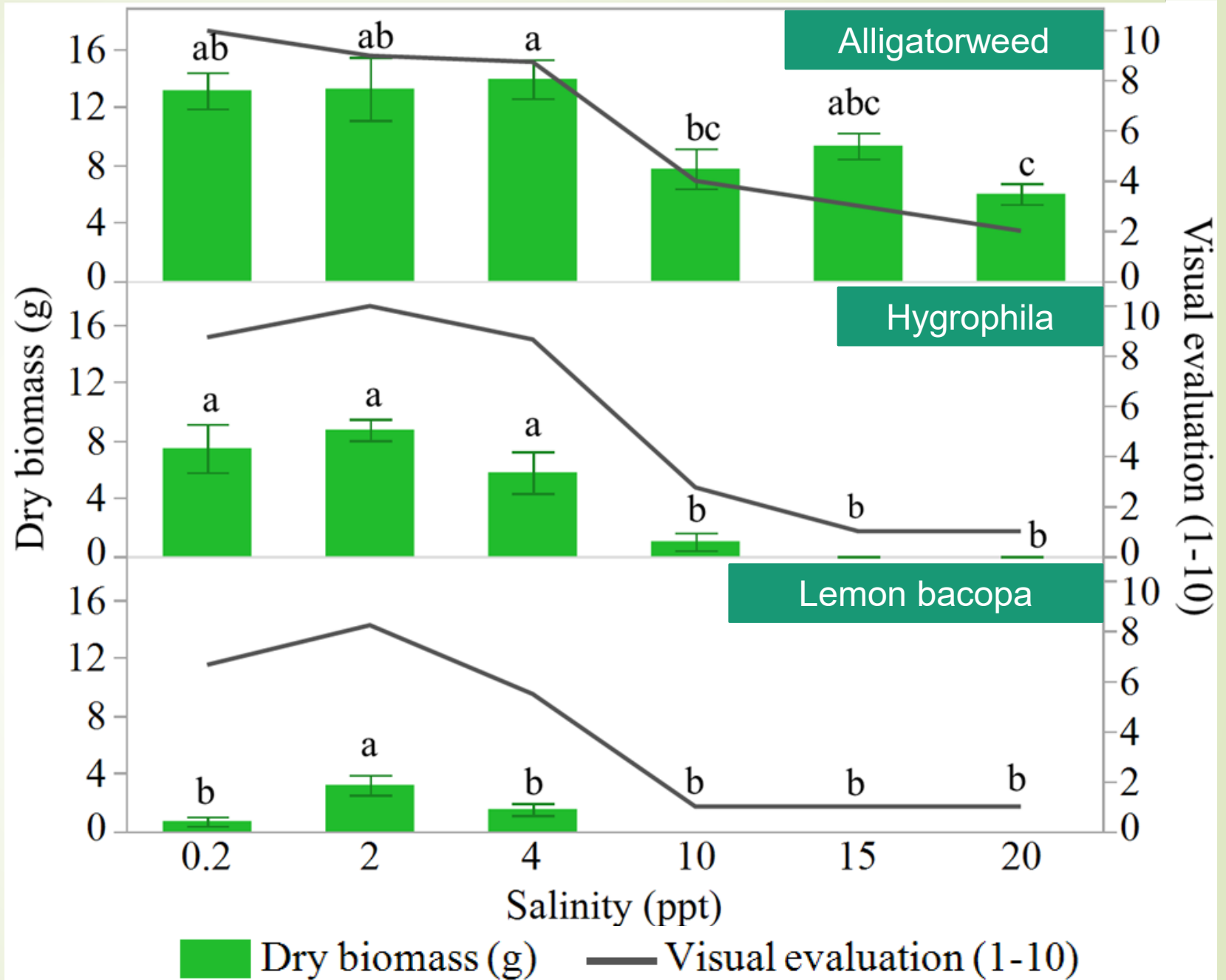
Shoot and Root growth: shoot and root biomass was destructively harvested and dried for two weeks (65 °C)

$$\text{Growth rate} = \frac{W_2 - W_1}{T_2 - T_1}$$

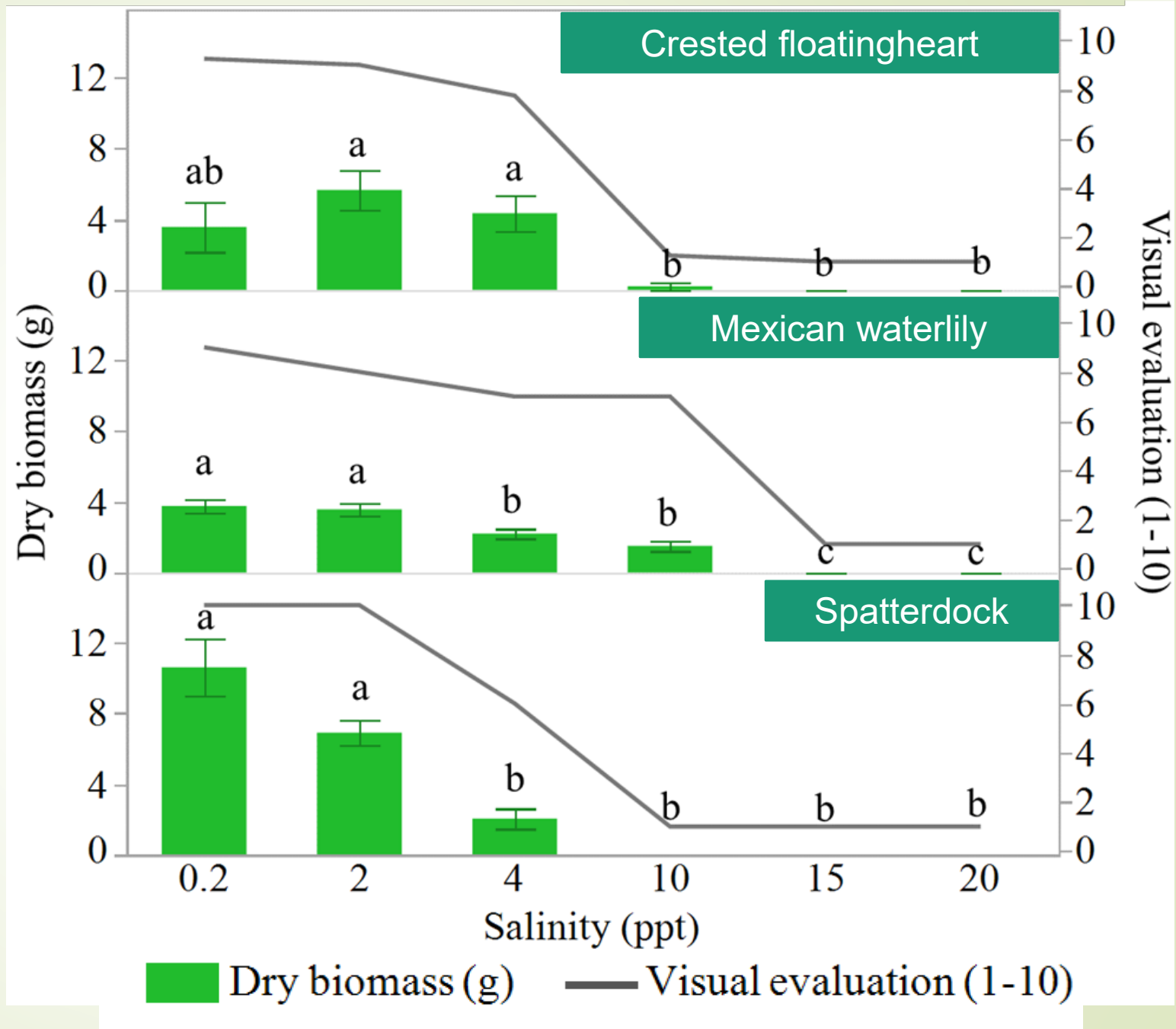
Submersed

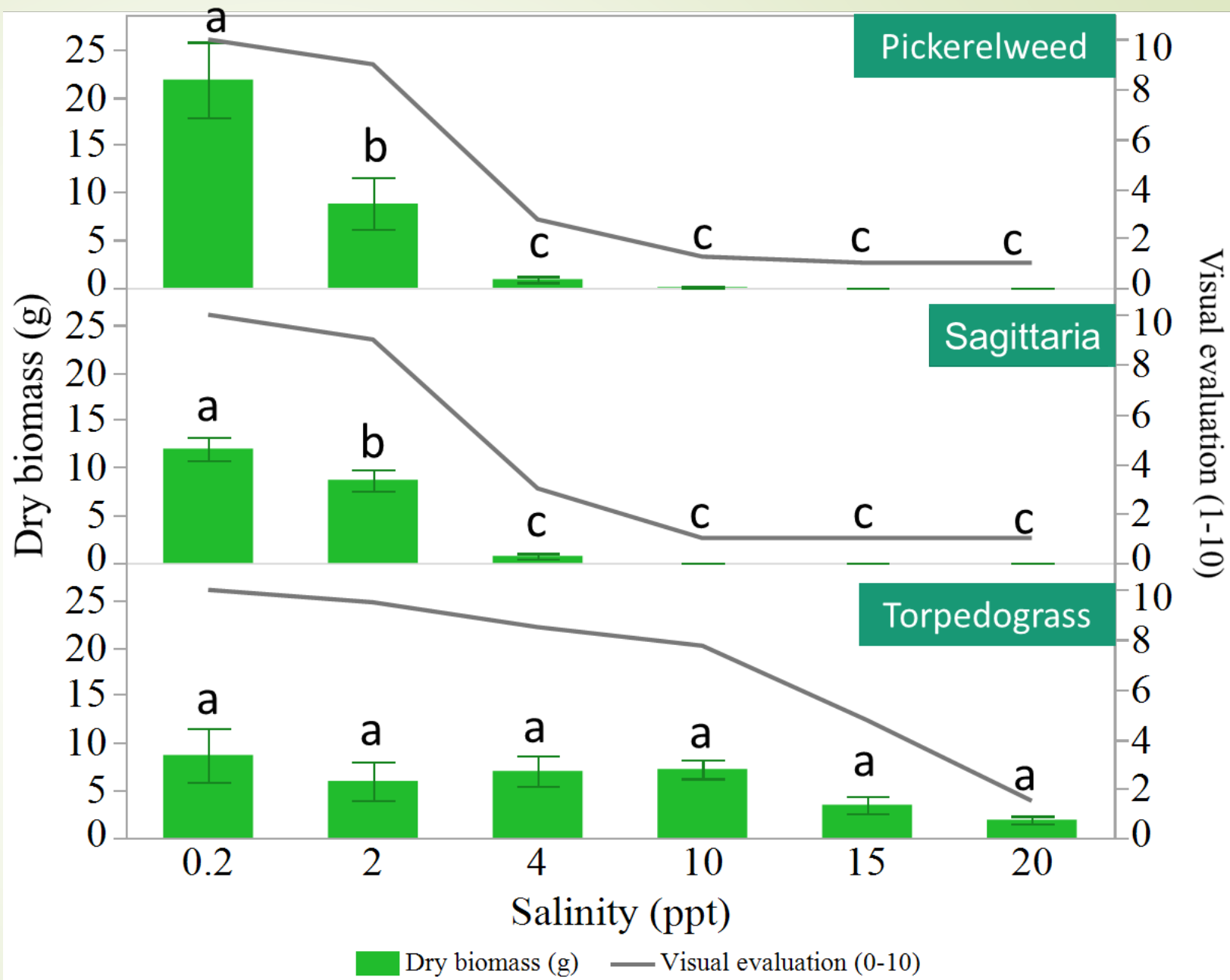
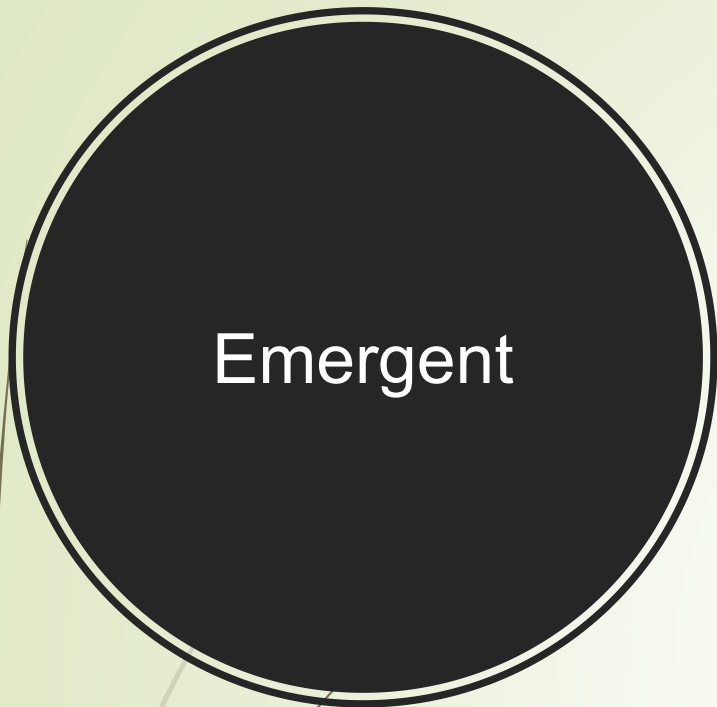


Amphibious

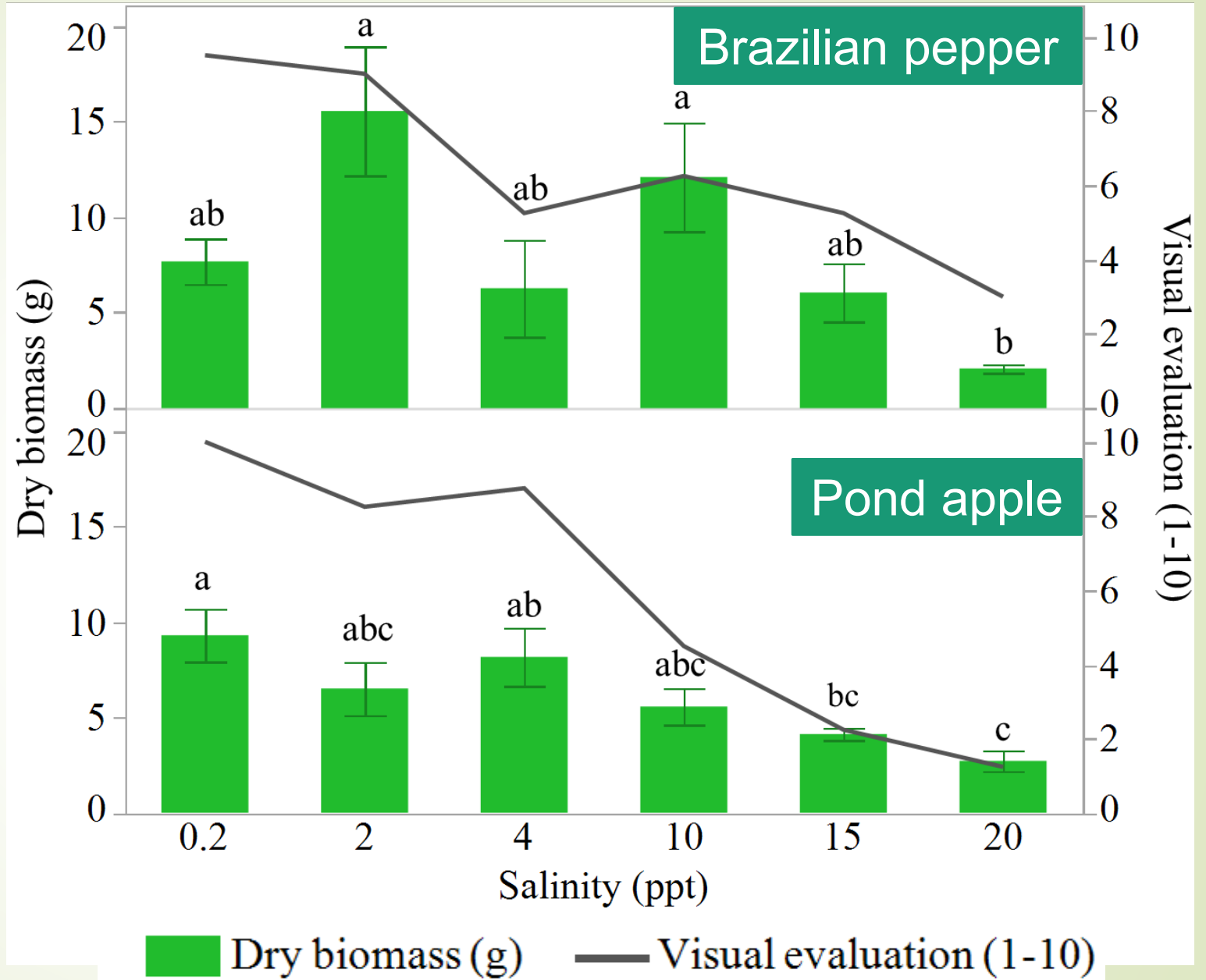


Floating-leaved





Tree

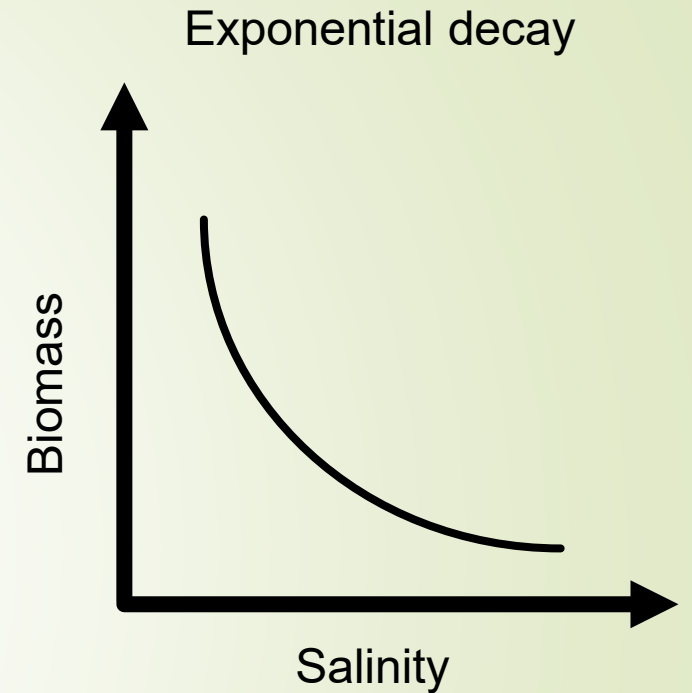


LC calculation

Lethal concentration (LC) of salt that reduces plant biomass and quality by 50% compared to control treatment.

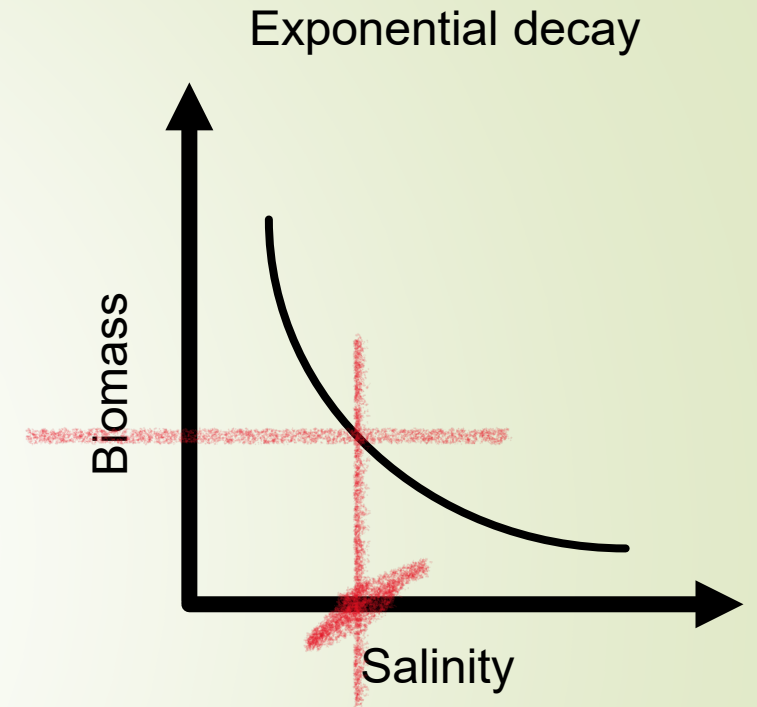
$$U = \frac{d}{1 + \exp[b(\log(\text{concentration})) - \log(LC_{50})]}$$

U: plant response; d: upper limits of the plant response (commonly control treatment but here 2 ppt treatment); LC_{50} : concentration required to reduce the biomass by half b: proportional to the slope of the curve around LC_{50}



LC calculation

Lethal concentration (LC) of salt that reduces plant biomass and quality by 50% compared to control treatment.



$$U = \frac{d}{1 + \exp[b(\log(\text{concentration})) - \log(LC_{50})]}$$

U: plant response; d: upper limits of the plant response (commonly control treatment but here 2 ppt treatment); LC₅₀: concentration required to reduce the biomass by half b: proportional to the slope of the curve around LC₅₀

Category	Species	Affected	Death	Visual LC ₅₀	Shoot LC ₅₀	Root LC ₅₀
Submersed	Southern naiad	2	10	6.6	5.3	2.6
	Pondweed	4	4	3.8	2.7	3.8
	Hydrilla	2	10	5.3	1.6	2.7
Amphibious	Lemon bacopa	2	4	3.3	1.8	2.0
	Alligatorweed	10	>20	7.6	15.9	>20
	Hygrophila	2	10	4.5	2.8	4.3
Emergent	Pickerelweed	4	4	3.2	1.4	3.8
	Broadleaf sagittaria	2	4	3.2	1.8	4.0
	Torpedograss	10	>20	16.1	12.7	11.3
Floating-leaved	Crested floatingheart	2	4	3.9	2.8	4.5
	Mexican waterlily	2	10	6.8	5.0	7.2
	Spatterdock	2	4	4.3	2.3	2.0
Tree	Brazilian pepper	4	>20	14.7	11.2	11.5
	Pond apple	2	15	7.7	12.6	14.5
Average		2-4 ppt	4-10 ppt	5.0	5.7	4.7

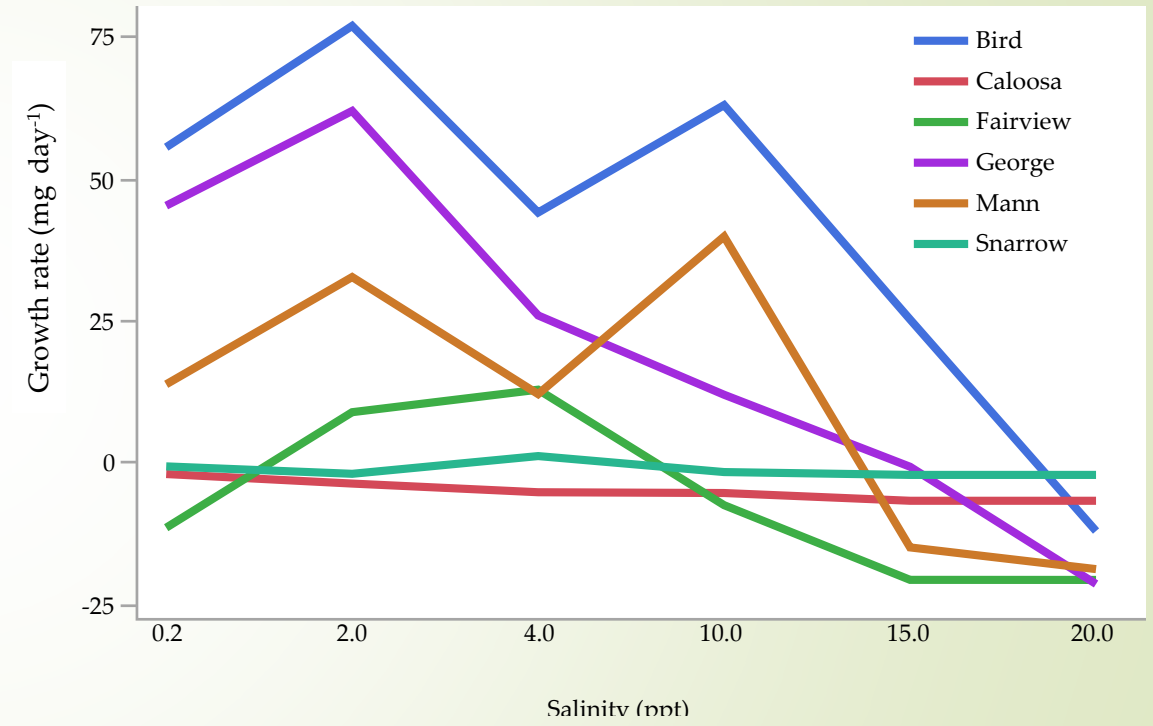
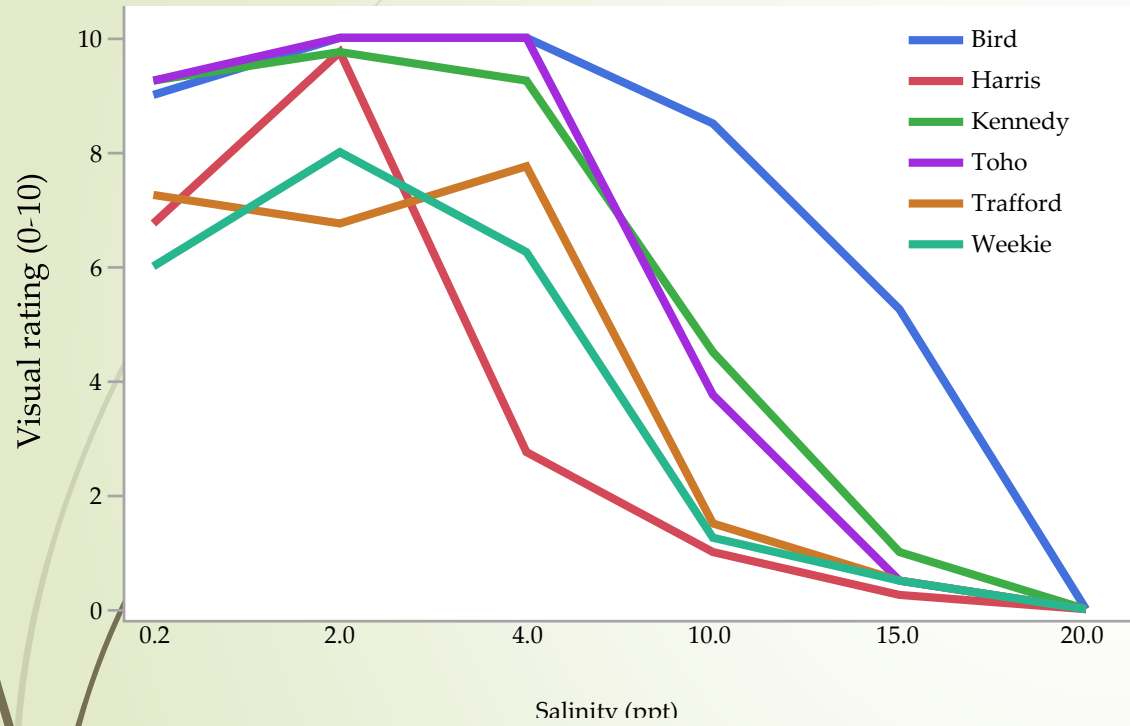
Summary

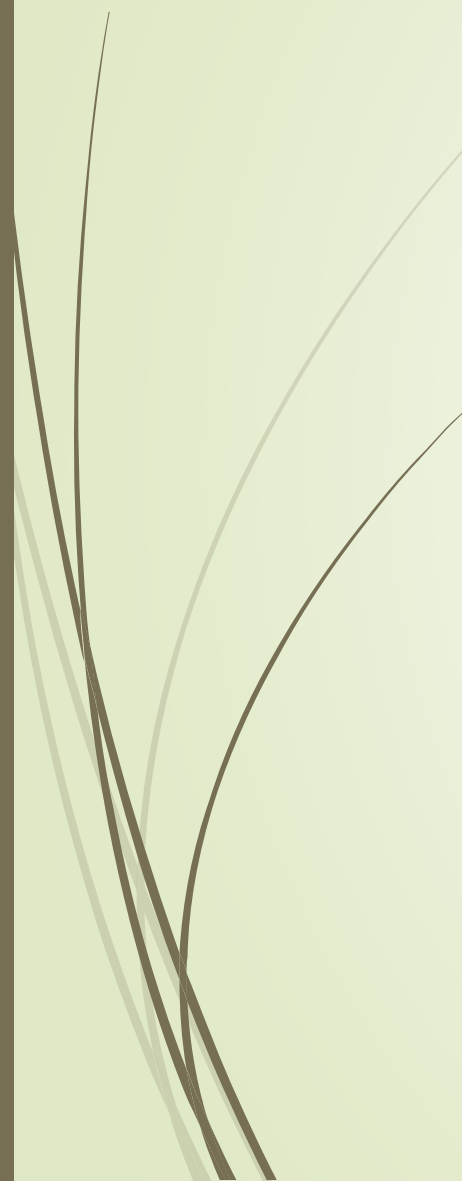
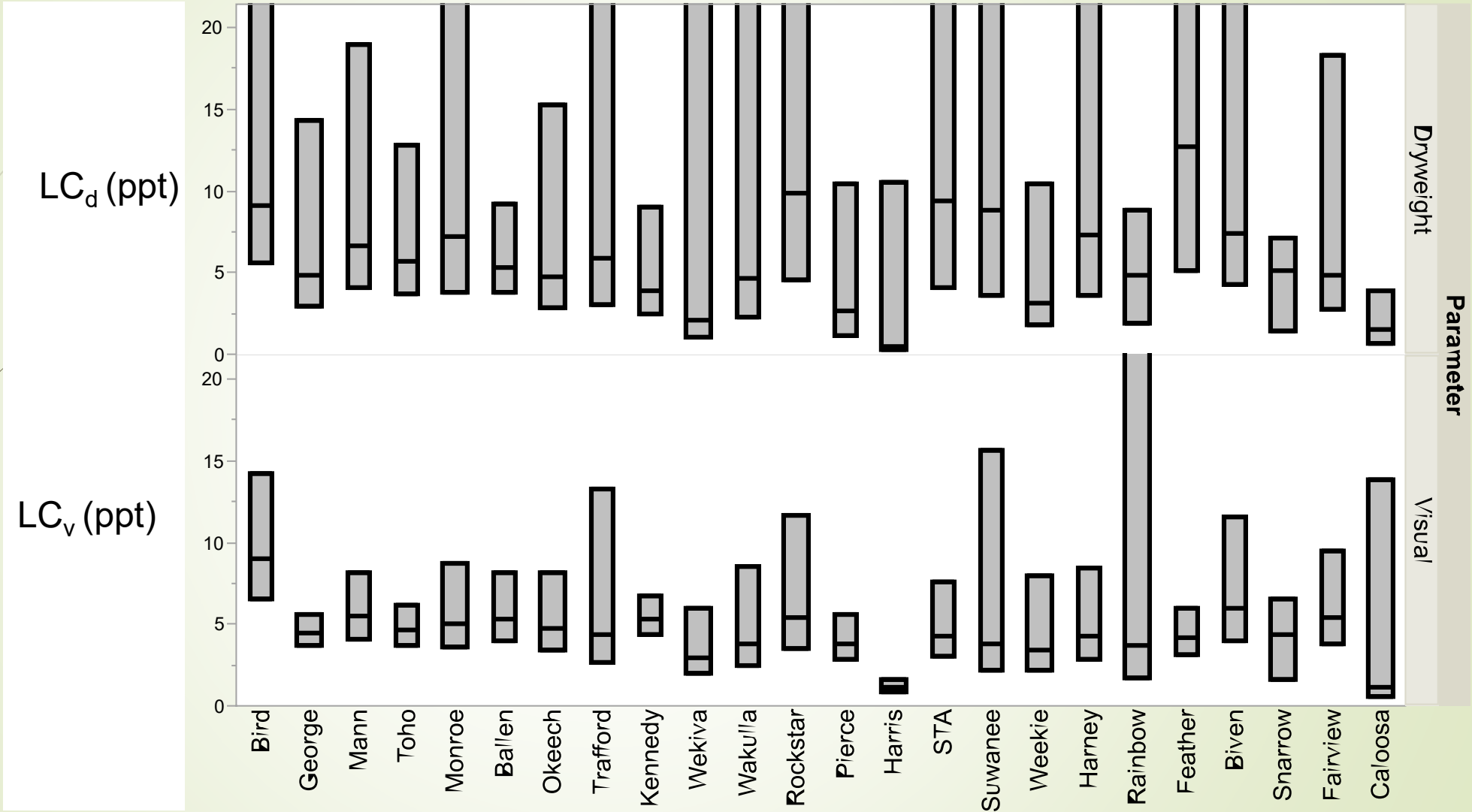
- ▶ The response of aquatic plants to increased salinity varies greatly depending on their mechanism for dealing with harmful ions.
- ▶ Increased salinity affects photosynthetic ability (leaf loss and chlorophyll content).
- ▶ Factors such as flooding and micronutrient deficiency synergistically influence plants with salinity.
- ▶ Lower limit for most tested species is 2 to 4 ppt and at 5 to 6 ppt most species may lose half their biomass and visual quality.
- ▶ Several invasive species such as alligatorweed, torpedograss and Brazilian peppertree were able to tolerate hypersalinity, while native species died or had significant declines in their growth and visual quality.
- ▶ Invasive species may pose a bigger threat to the ecosystem if salinity levels increase.

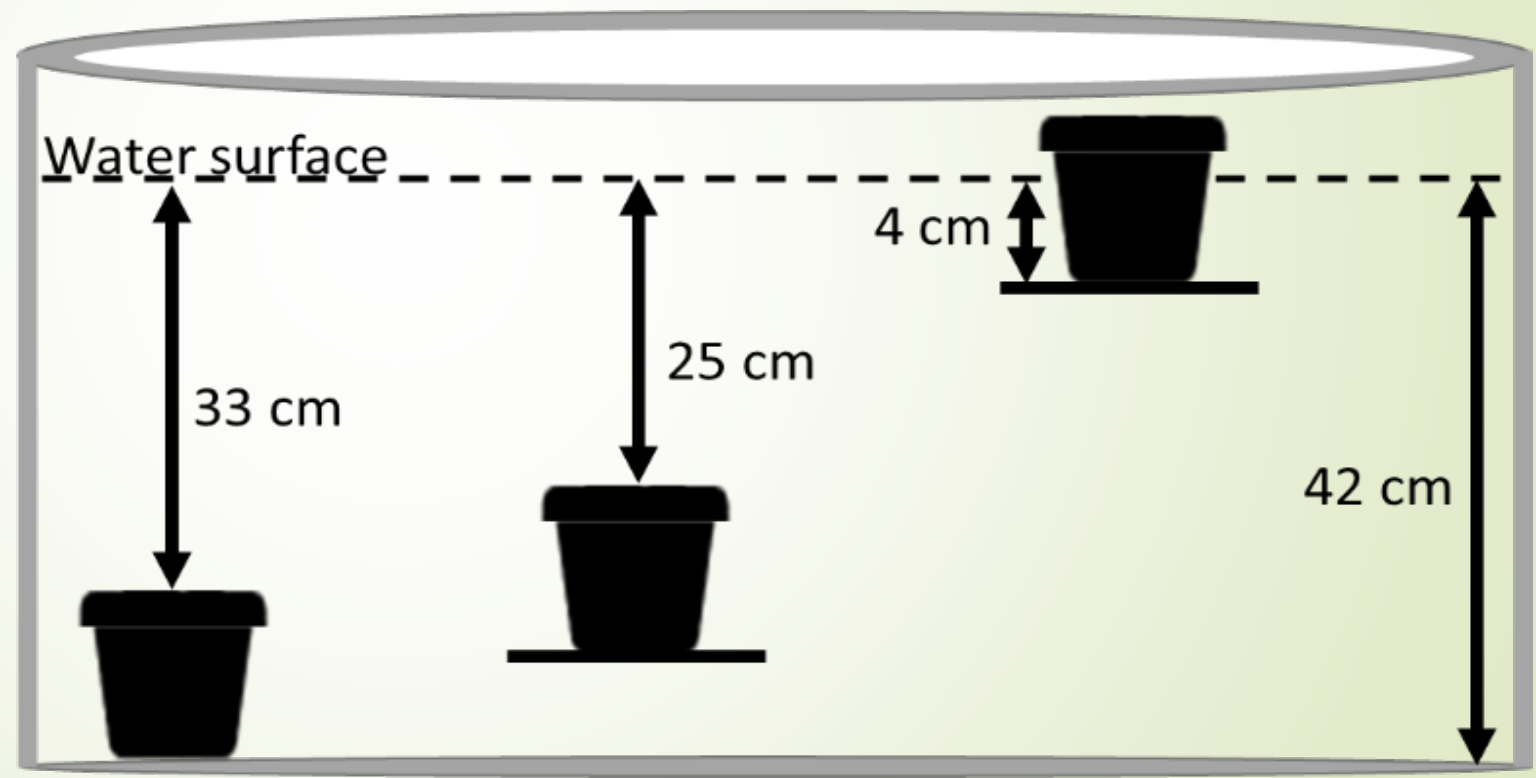
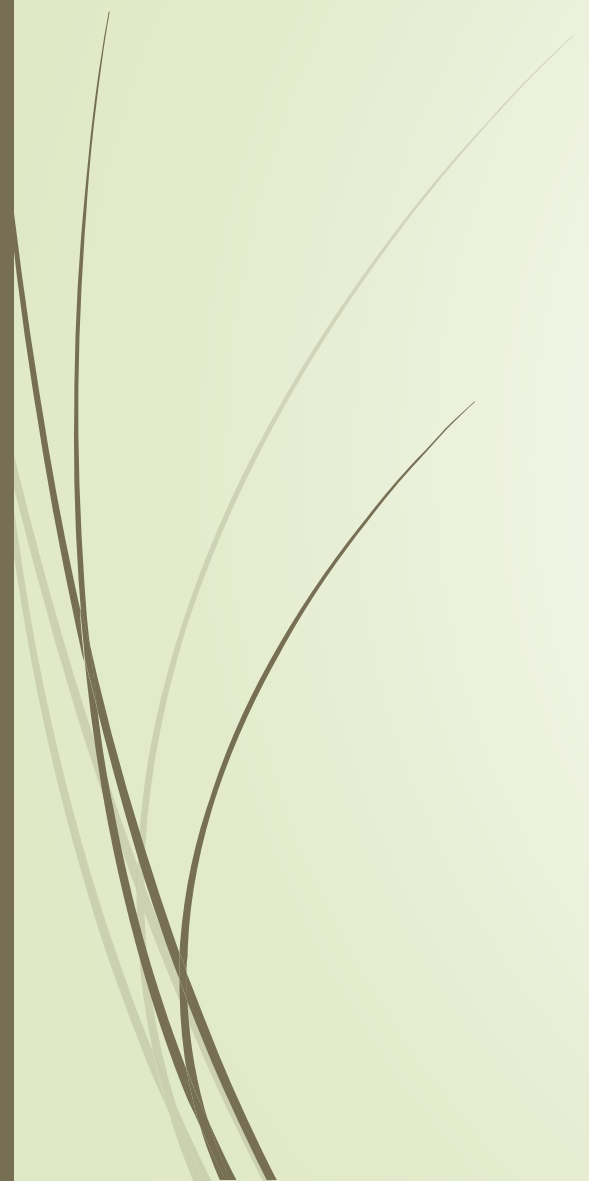



Thank you

Seems like a useless slide!









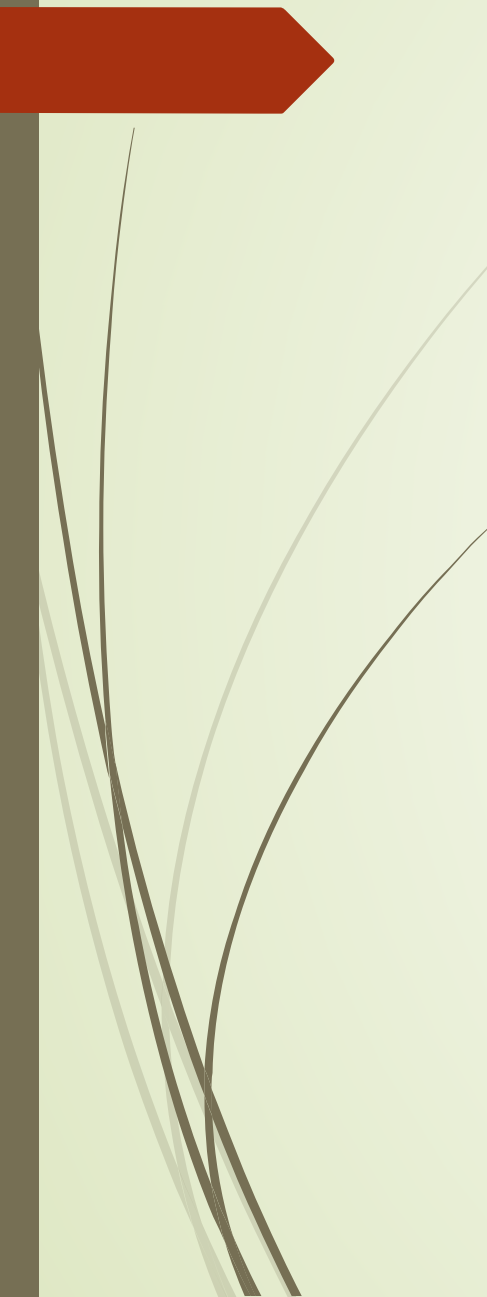
Let's ask questions?

How can we test saltwater intrusion in the lab?

Can we find the salt-tolerance threshold for a species?

Does salt stress impact competition between species?

How may aquatic plants in Florida react to future salinity levels?



Scale	Old Tissue	New/Young Tissue	Growth
10	Green	Green	High
9	Green	Green	High to moderate
8	Green	Green	Moderate
7	Green to yellow	Green	Moderate to low
6	Green to yellow	Green	Low
5	Yellow	Green to yellow	Low
4	Yellow	Yellow	Very low to none
3	Yellow	Yellow	None
2	Necrotic old tissue	Yellow	None
1	Necrotic old tissue	Necrotic new tissue	None
0		Necrotic, lost integrity	

Elemental composition of 5.0 ppt saline solutions

Salt source	Na	Cl	Ca	Mg	S
	(ppm)				
Seawater	1675 b	3320 a	36 b	207 a	151 b
Instant Ocean	1672 b	3263 a	57 a	203 a	189 a
Morton	2053 a	3228 a	10 c	2 b	4 c
NaCl	1935 a	2826 a	3 c	1 b	0 c

- Seawater and Instant Ocean have:
- Less Na (16%)
- More Ca, Mg and S
- Cl was highest in Seawater and lowest in NaCl

Tapegrass, Eelgrass, or Wild Celery (*Vallisneria americana* Michaux): A Native Aquatic and Wetland Plant¹

Mohsen Tootoonchi, Lyn A. Gettys, and Jehangir H. Bhadha²

Introduction

Tapegrass and wild celery are the common names of *Vallisneria americana* Michaux (Figure 1). It is sometimes referred to as eelgrass, which can be confused with some seagrass species with the same common name. It is native to Florida and is considered a key species in aquatic ecosystems due to its ability to provide sediment stability, water clarity, and food and habitat for aquatic organisms such as fish and invertebrates and large mammals such as manatees. Tapegrass can be used as an aquarium plant in fish tanks, and for restoration of lakes, estuaries, and natural areas. This fact sheet describes the main features of tapegrass and summarizes important habitat requirements for its growth and restoration. This document aims to inform and educate the general public and assist academic and Extension faculty in advising regulators and stakeholders.

Classification

Common Names

Tapegrass, eelgrass, vallisneria, wild celery, water celery, eelweed, duck celery, and flumine-Mississippi

Family

Hydrocharitaceae (frog's-bit)

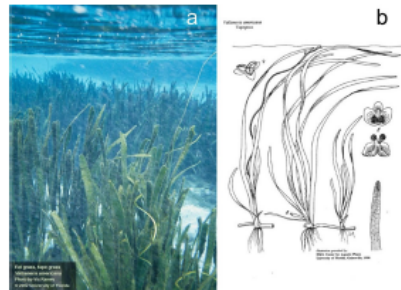


Figure 1. Tapegrass, *Vallisneria americana*. a) Tapegrass underwater meadow. b) Illustrations of male and female plants. Credits: UF/IFAS

Scientific Name

Vallisneria americana Michaux

Synonyms

Vallisneria spiralis var. *americana*; *Vallisneria neotropicalis*

Related Species

Vallisneria anhuiensis X.S.Shen

Tapegrass, Eelgrass, or Wild Celery (*Vallisneria americana* Michaux): A Native Aquatic and Wetland Plant

➔ <https://edis.ifas.ufl.edu/ag437>

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2. Mohsen Tootoonchi, graduate student, Agronomy Department; Lyn A. Gettys, associate professor, Agronomy Department, UF/IFAS Fort Lauderdale Research and Education Center; and Jehangir H. Bhadha, assistant professor, Department of Soil and Water Sciences, UF/IFAS Everglades Research and Education Center, UF/IFAS Extension, Gainesville, FL 32611.

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Can we find the salt-tolerance threshold for a species?

➔ Example: Tapegrass can tolerate:

➔ 5.0 ppt or less

➔ 6.6 ppt

➔ 8.0 ppt

➔ 12.0 ppt

Reports are not consistent!

Vallisneria americana
Tapegrass

Biogeography of

Estuaries and Coasts

Estuaries Vol. 10, No. 3, p. 311-321 September 1990

The Growth of Submersed Macrophytes Under Experimental Salinity and Light Conditions

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ABSTRACT: The growth, morphology, and chemical composition of *Hydrilla verticillata*, *Myriophyllum spicatum*, *Potamogeton perfoliatus*, and *Vallisneria spiralis* were compared among different salinity and light conditions. Plants were grown in microcosms (1.1 m²) under ambient photoperiod adjusted to 50% and 8% of solar radiation. The culture solution in five pairs of tanks was gradually adjusted to salinities of 0, 1, 4, 6, and 12‰. With the exception of *H. verticillata*, the aquatic macrophytes examined may be considered euryhaline species that are able to adapt to salinities one-third the strength of sea water. With increasing salinity, the photosynthetic production decreased in *M. spicatum* and *P. perfoliatus*, yet asexual reproduction in the latter species by underground buds

of *P. perfoliatus* and a concentration of aquatic macrophytes in lot. The nitrogen concentration (N), and the tolerance of *V. spiralis*. This may be related to the ability of *V. spiralis* to exhibit growth in low light and low nutrient conditions.

of macrophytes in the other tributaries of associated with variations in water quality (Kemp 1985). Although many of these communities have been identified, the water quality factor is confounded with the natural conditions (Hara-

L., which had previously dominated the littoral zone of the Chesapeake Bay region. During 1983 and 1984 there was a resurgence of macrophytes in the tidal freshwater zone of the Potomac River estuary, including *Ceratophyllum demersum*, *Vallisneria spiralis*, *Zostera marina*, *Potamogeton perfoliatus*, *Heteranthera dubia*, and *Myriophyllum spicatum* (Rybcicki et al. 1985). Changes in distribution


Along with the resurgence of submersed macrophytes in the tidal freshwater region of the Potomac River estuary was the introduction of a new species, monoeocious *Hydrilla verticillata* (Steward et al. 1984; Rybcicki et al. 1985). Because of the highly competitive nature of the diocious biotype of this species, common in the subharvested United States, monoeocious *H. verticillata* may outcompete native

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Competition between *Hydrilla verticillata* and *Vallisneria americana* ecotypes under increased salinity condition



Special Issue



diversity