Assessment of salt tolerance threshold for wetland plants

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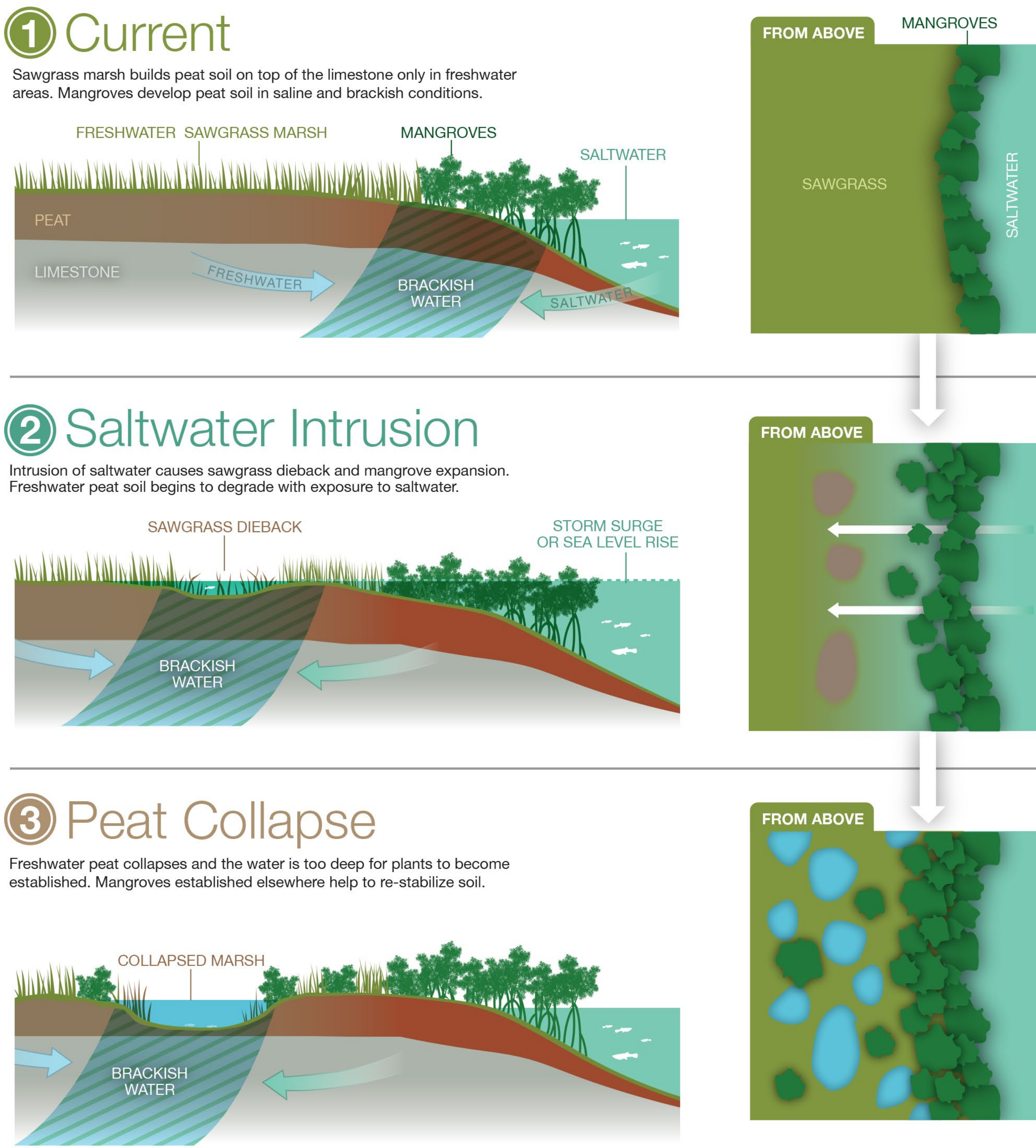
UF Aquatic and Wetland Plant Science
UNIVERSITY of FLORIDA

Sea level rise and saltwater intrusion



Sklar, F.H., Meeder, J.F., Troxler, T.G., Dreschel, T., Davis, S.E. and Ruiz, P.L., 2019. The Everglades: At the Forefront of Transition. In Coasts and Estuaries (pp. 277-292). Elsevier.

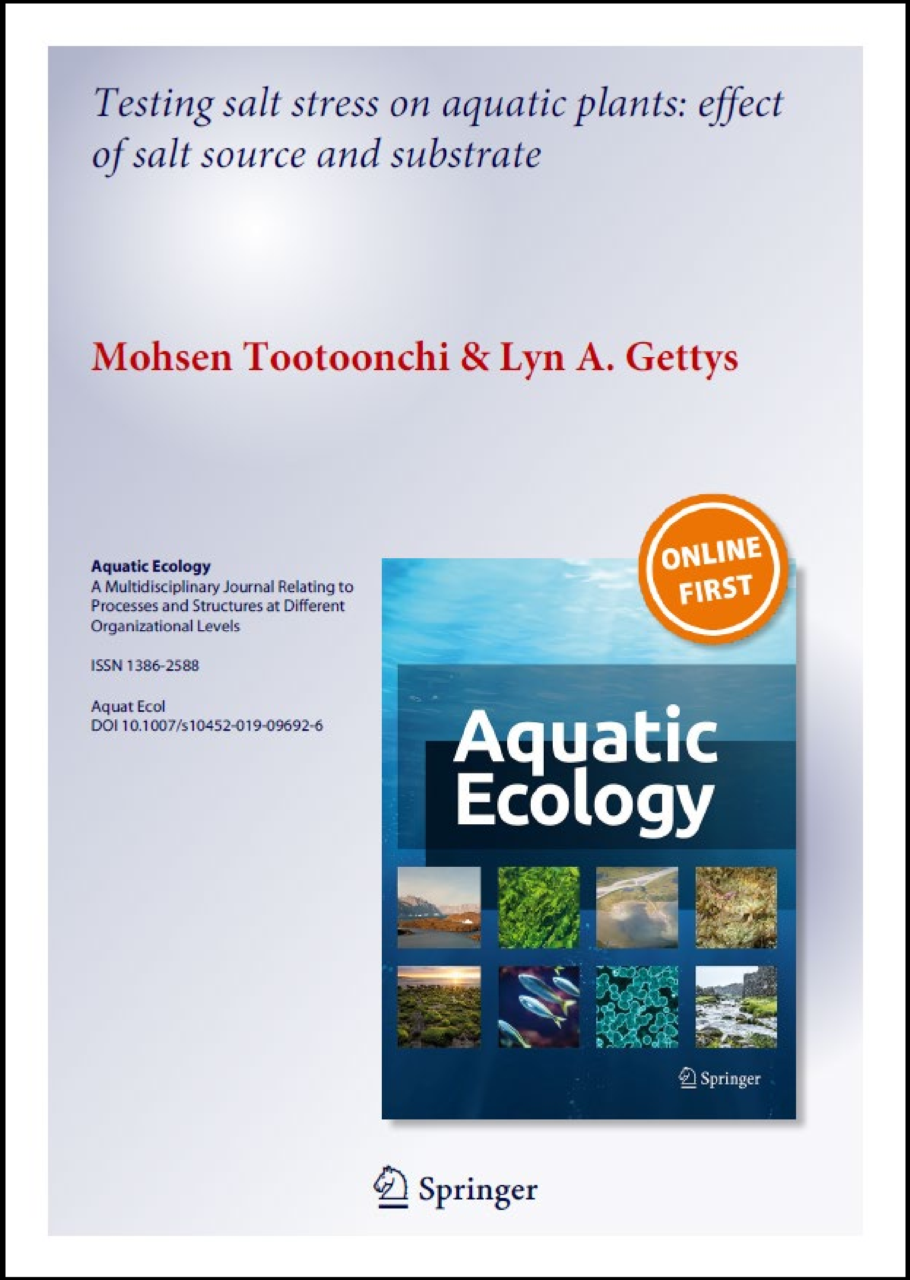
Aerial photo

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

Everglades Foundation/Stephen Davis

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

- 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

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

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Article

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

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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 LC_{50} 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.

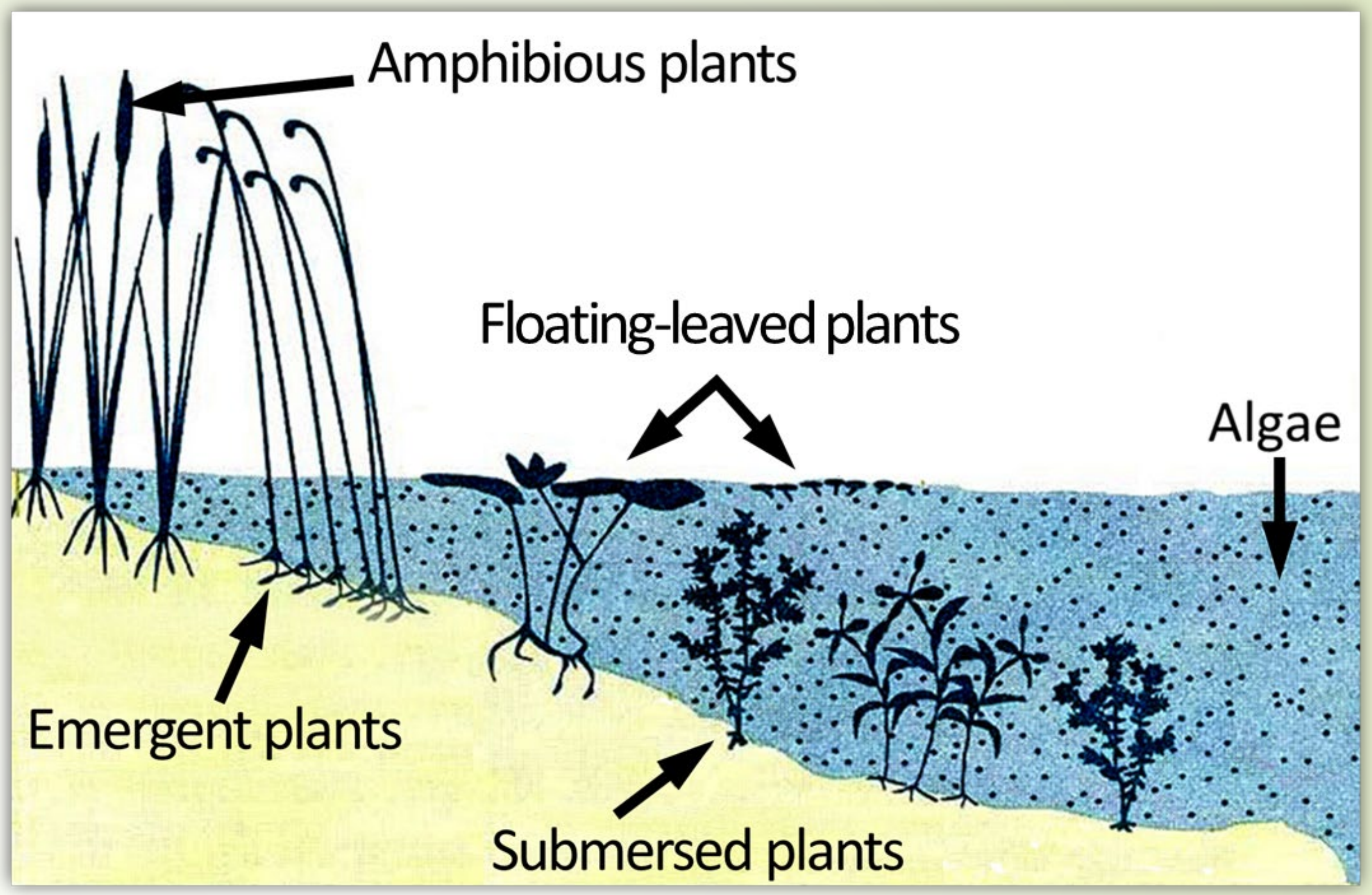
Keywords: aquatic macrophytes; freshwater systems; salinity tolerance; intraspecific variation; lethal concentration; genotypic variability; ecotype; salt stress; effective concentration; growth rate; health condition; visual screening

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

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) *s*	
Amphibious	e)	ive) *oides*	ve) *ma*
Floating-leave	tive)	*ena*	(Not Native)
Emergent	)	ative	ative)
Woody/trees		Native) *s*	

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

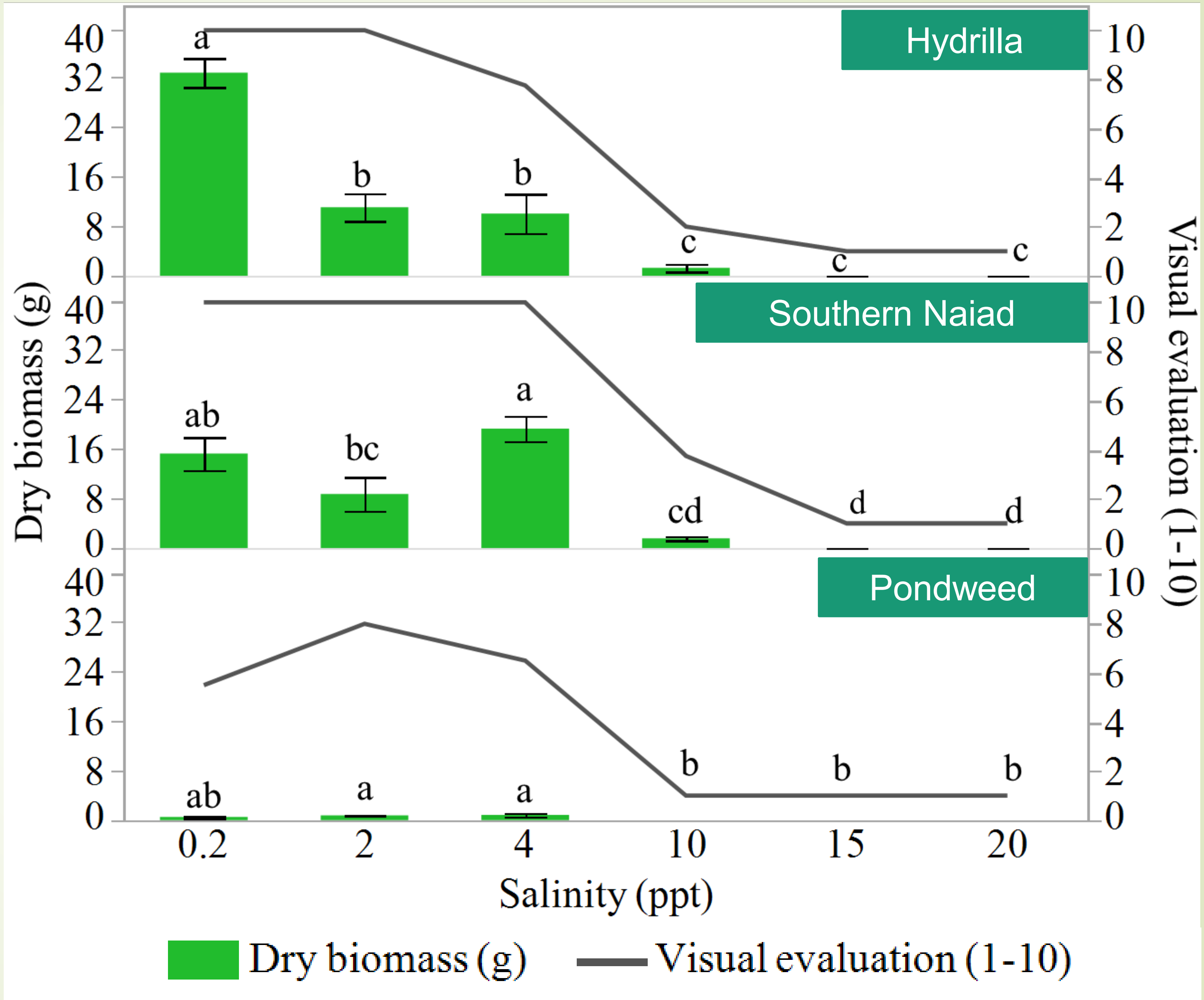
1= Dead

10= No damage

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

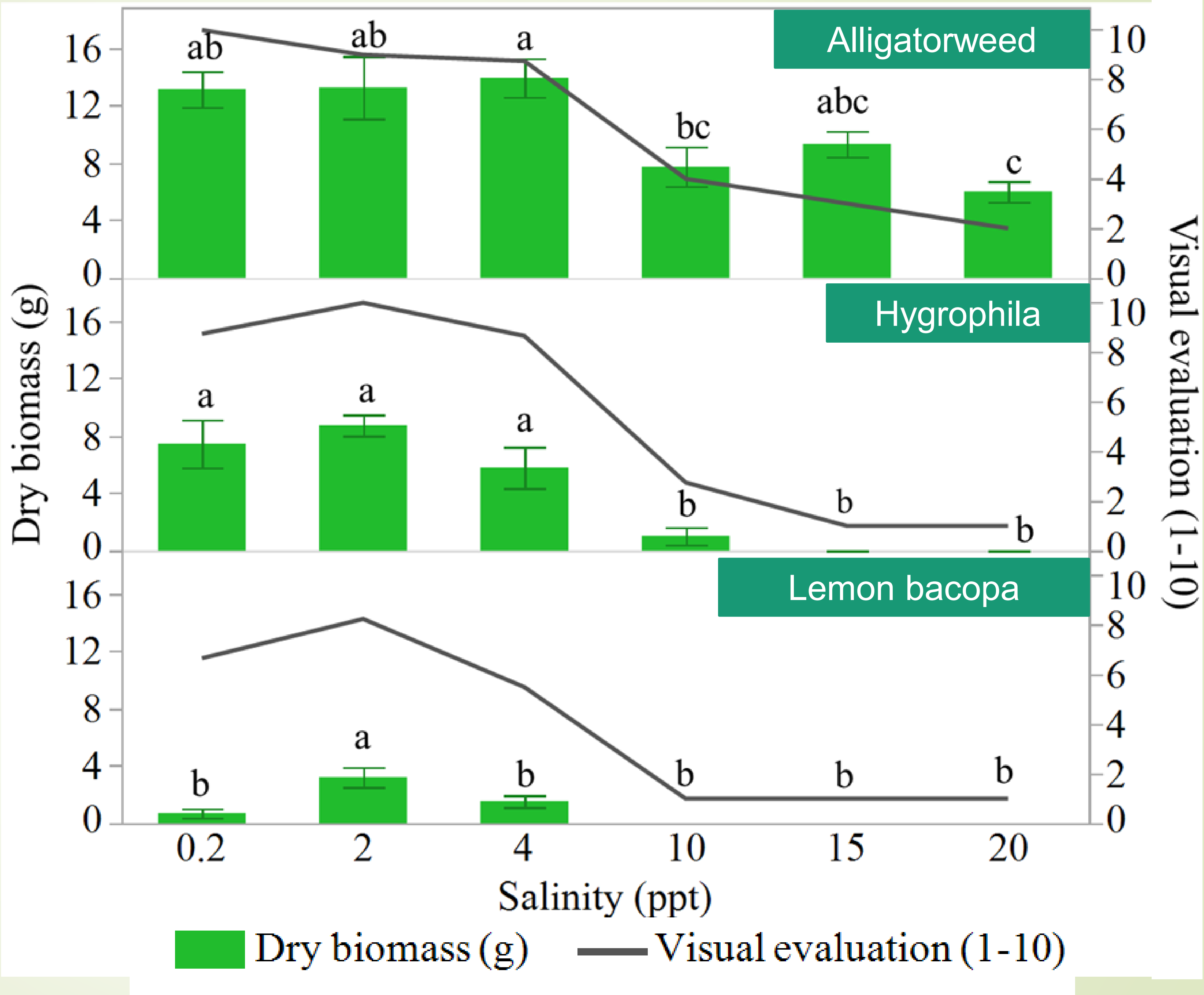
$$\text{Growth rate} = \frac{W_2 - W_1}{T_2 - T_1}$$

Submersed



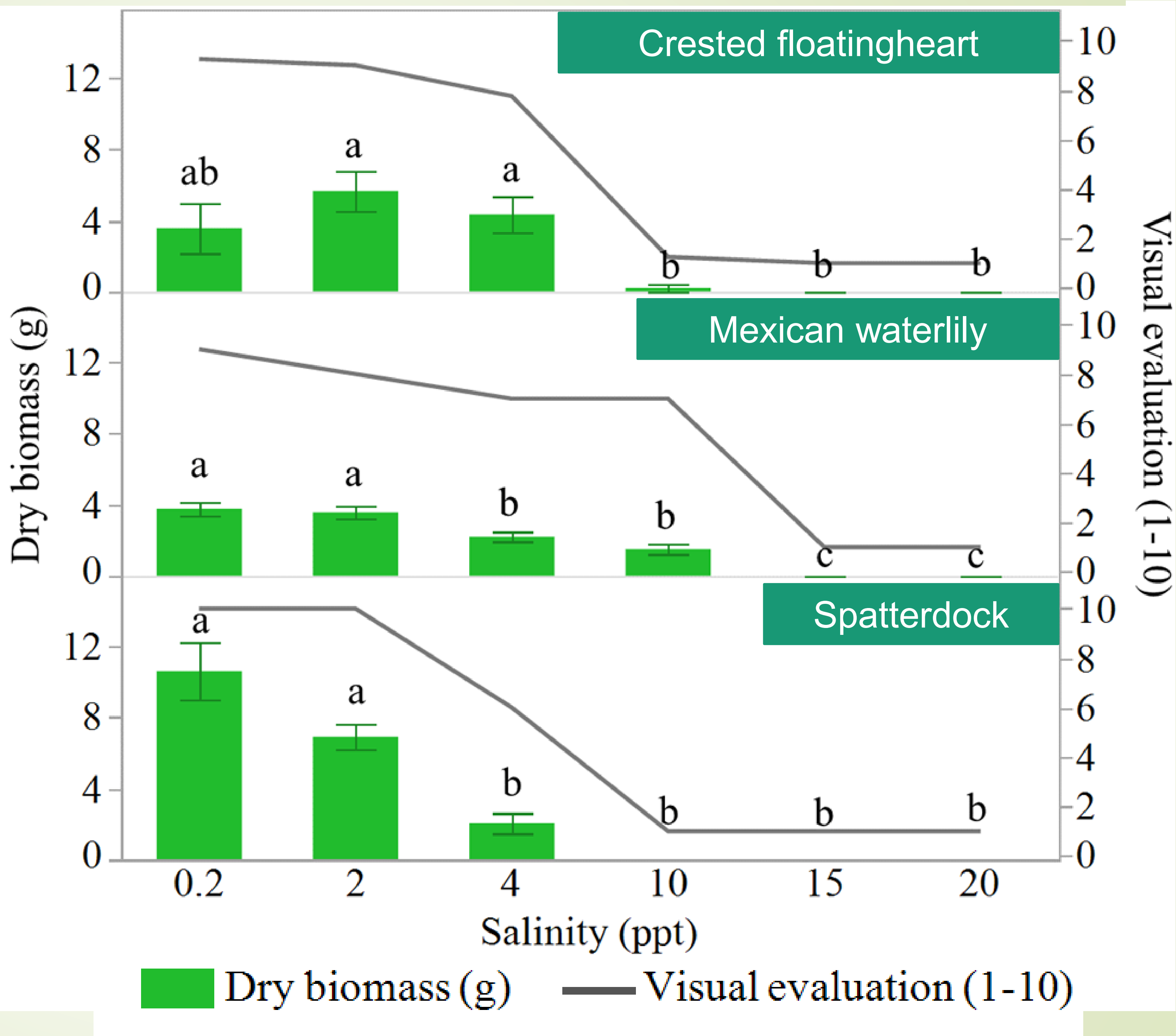
Hydrilla
Southern Naiad
Pondweed
Dry biomass (g)
Visual evaluation (1-10)
Salinity (ppt)
0.2
2
4
10
15
20
40
32
24
16
8
0
10
8
6
4
2
0
a
b
b
c
c
c
ab
bc
a
cd
d
d
ab
a
a
b
b
b
Dry biomass (g)
Visual evaluation (1-10)

Amphibious

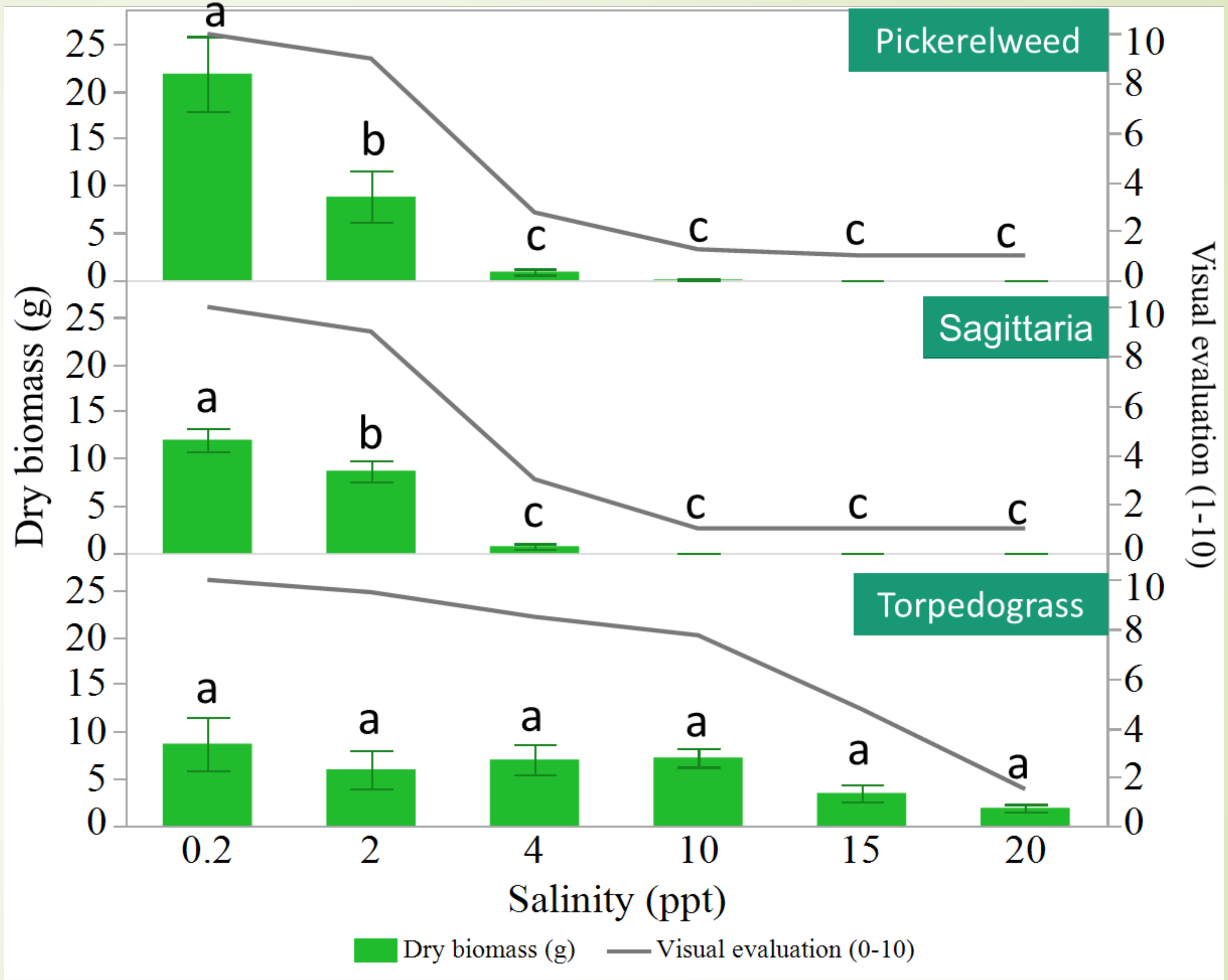


Alligatorweed
Hygrophila
Lemon bacopa
Dry biomass (g)
Visual evaluation (1-10)
Salinity (ppt)
0.2
2
4
10
15
20
ab
ab
a
bc
abc
c
a
a
a
b
b
b
b
a
b
b
b
b
Dry biomass (g)
Visual evaluation (1-10)

Floating-leaved

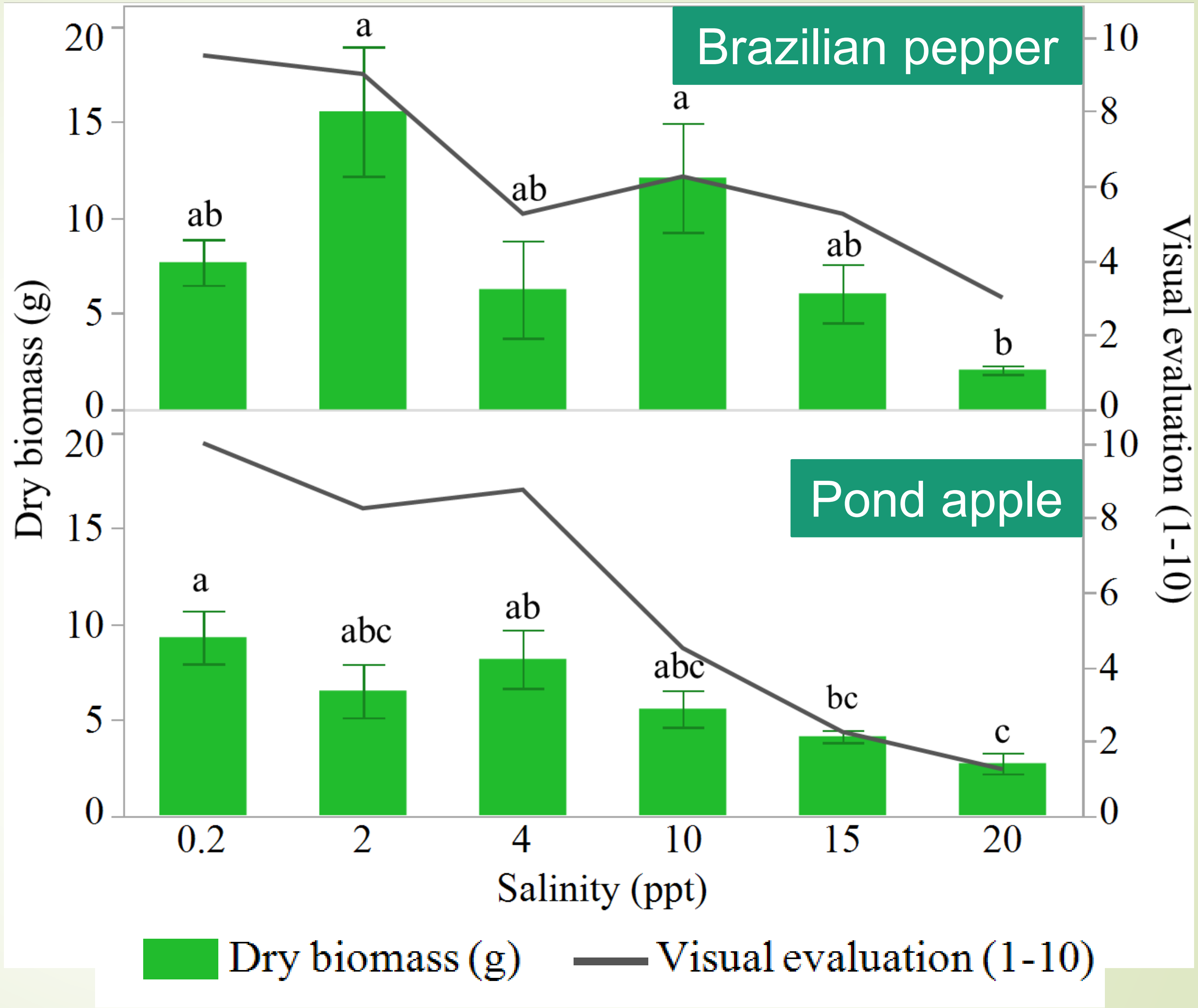


Emergent



Pickerelweed
Sagittaria
Torpedograss
Dry biomass (g)
Visual evaluation (1-10)
Salinity (ppt)
0.2
2
4
10
15
20
Dry biomass (g)
Visual evaluation (0-10)

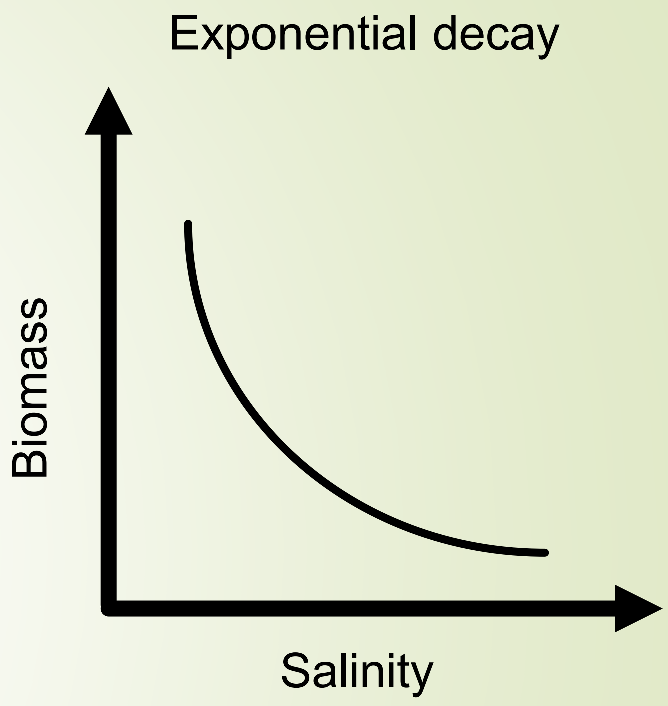
Tree



Brazilian pepper
Pond apple
Dry biomass (g)
Visual evaluation (1-10)
Salinity (ppt)
0.2
2
4
10
15
20
a
ab
b
abc
bc
c
Dry biomass (g)
Visual evaluation (1-10)

LC calculation

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



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

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}

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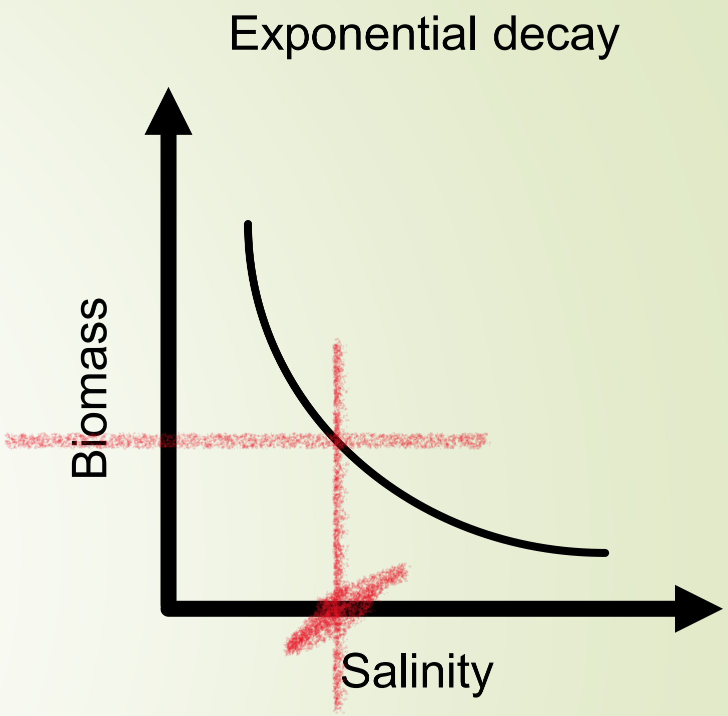


U: plant response; d: upper limits of the plant response (commonly control treatment but here 2 ppt treatment); LC_{50}: concentration required to reduce the biomass by half b: proportional to the slope of the curve around LC_{50}

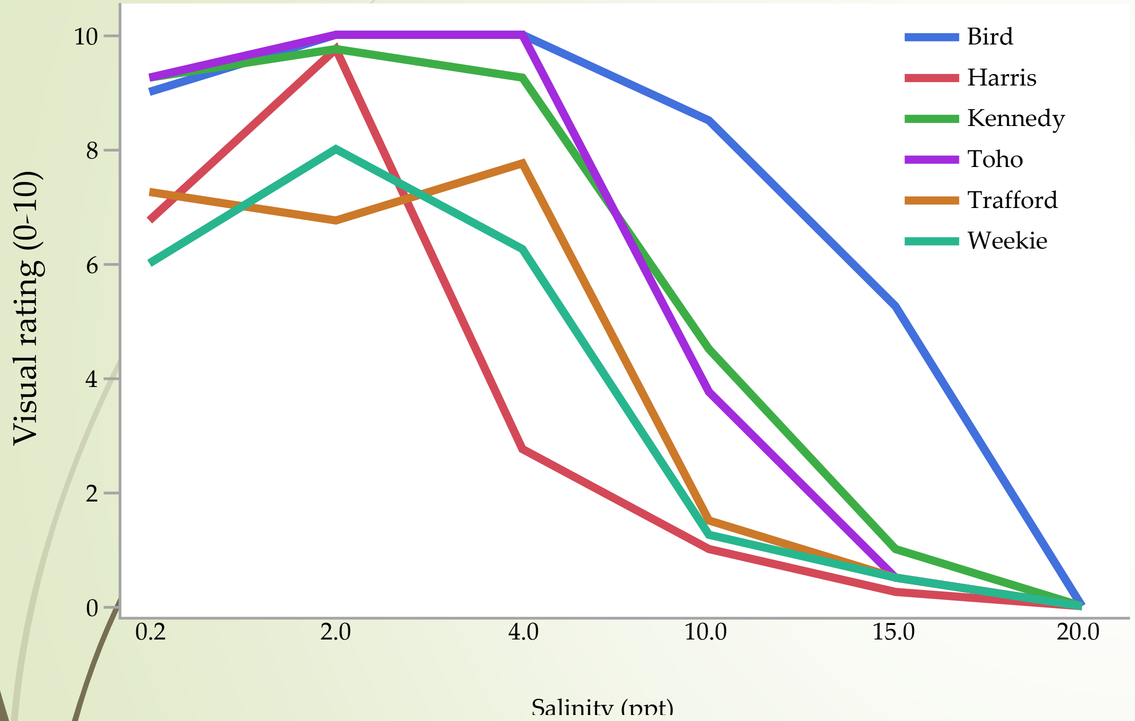
Category	Species	Affected	Death	Visual LC_{50}	Shoot LC_{50}	Root LC_{50}
Submersed	Southern naiad	2	10	6.6	5.3	2.6
	Pondweed	4	4	3.8	2.7	3.8
	Hydrilla	2	10	5.3	1.6	2.7
Amphibious	Lemon bacopa	2	4	3.3	1.8	2.0
	Alligatorweed	10	>20	7.6	15.9	>20
	Hygrophila	2	10	4.5	2.8	4.3
Emergent	Pickerelweed	4	4	3.2	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**

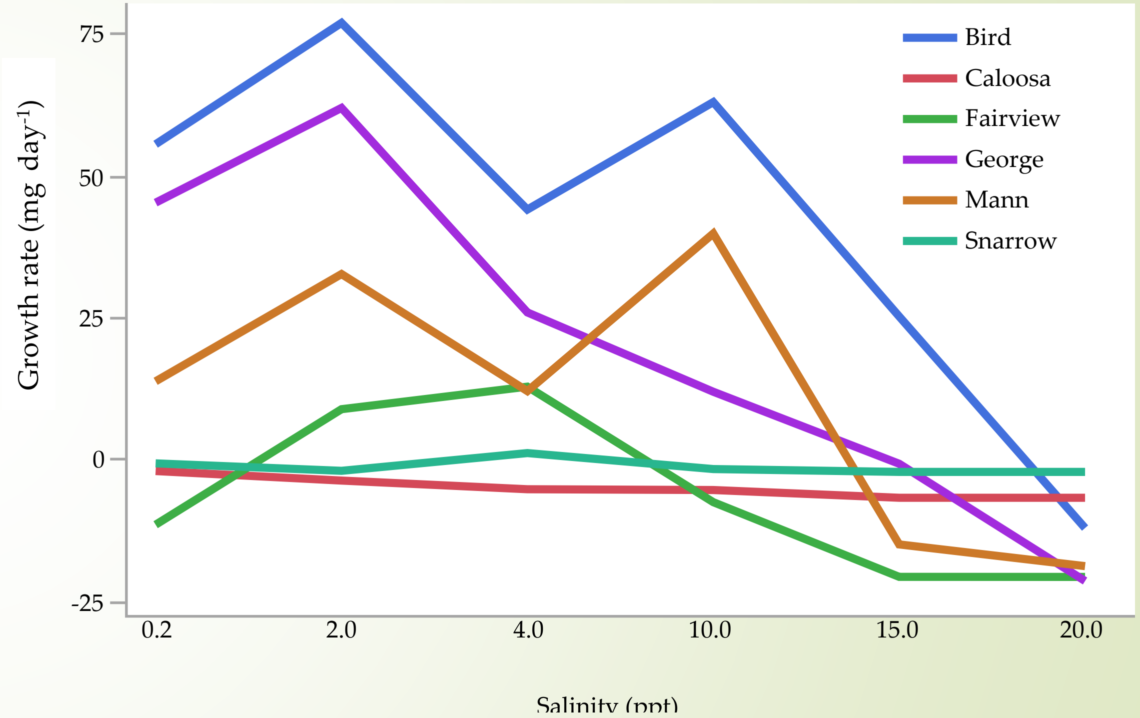
Summary

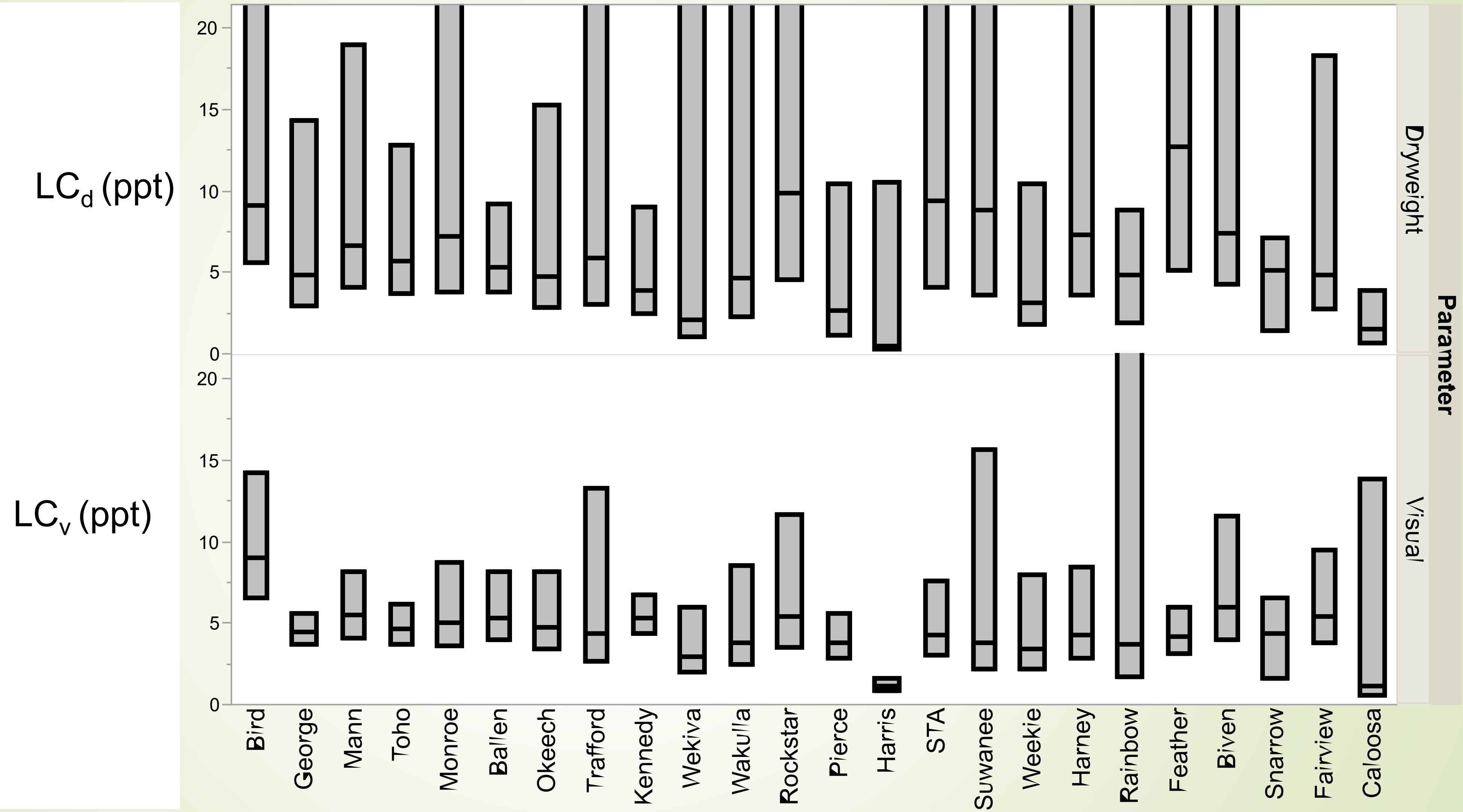
- The response of aquatic plants to increased salinity varies greatly depending on their mechanism for dealing with harmful ions.
- Increased salinity affects photosynthetic ability (leaf loss and chlorophyll content).
- Factors such as flooding and micronutrient deficiency synergistically influence 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

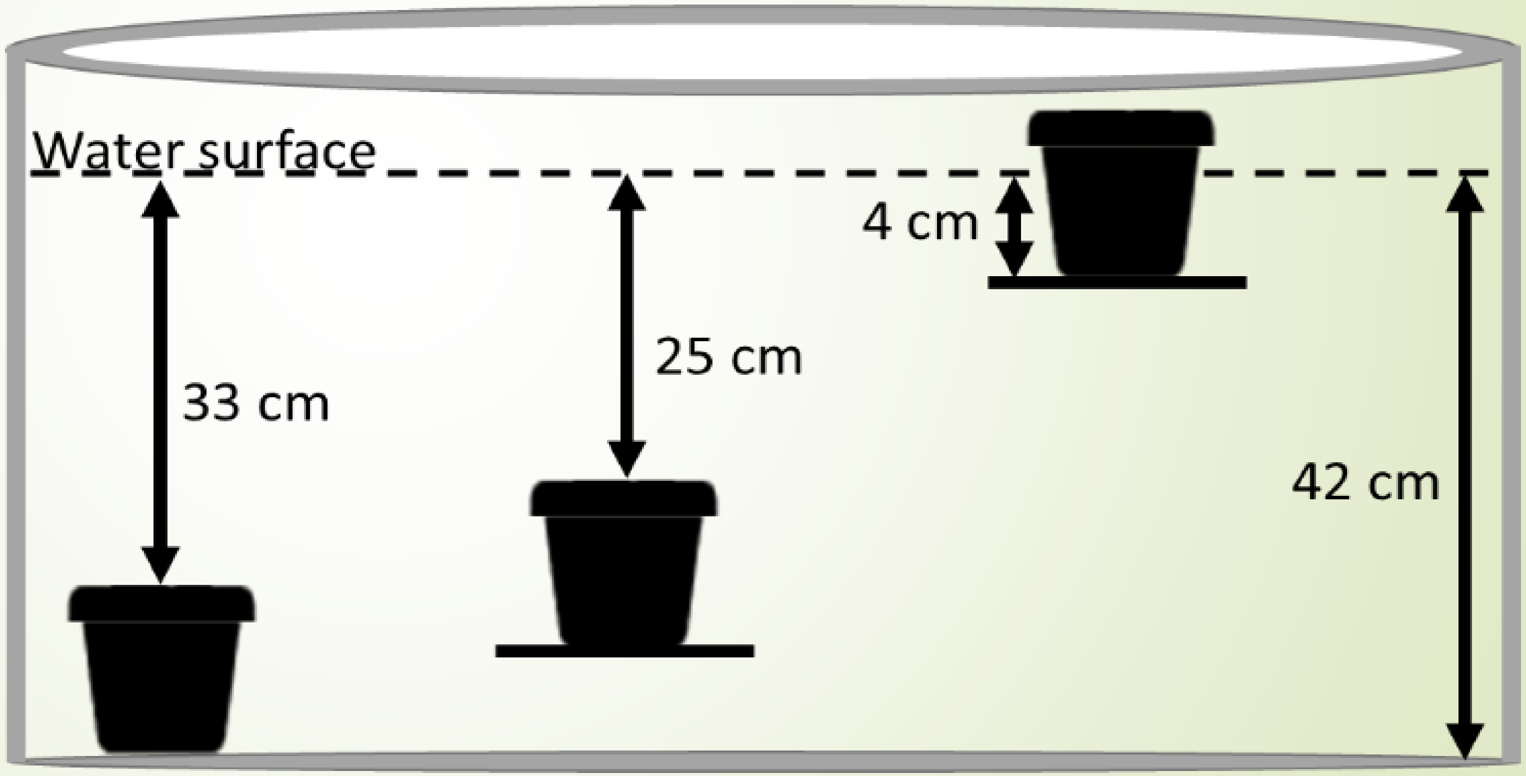
Seems like a useless slide!







LC$_d$ (ppt)
LC$_v$ (ppt)
20
15
10
5
0
Dryweight
Visual
Parameter
Bird
George
Mann
Toho
Monroe
Ballen
Okeech
Trafford
Kennedy
Wekiva
Wakulla
Rockstar
Pierce
Harris
STA
Suwanee
Weekie
Harney
Rainbow
Feather
Biven
Snarrow
Fairview
Caloosa


Water surface
4 cm
33 cm
25 cm
42 cm

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?

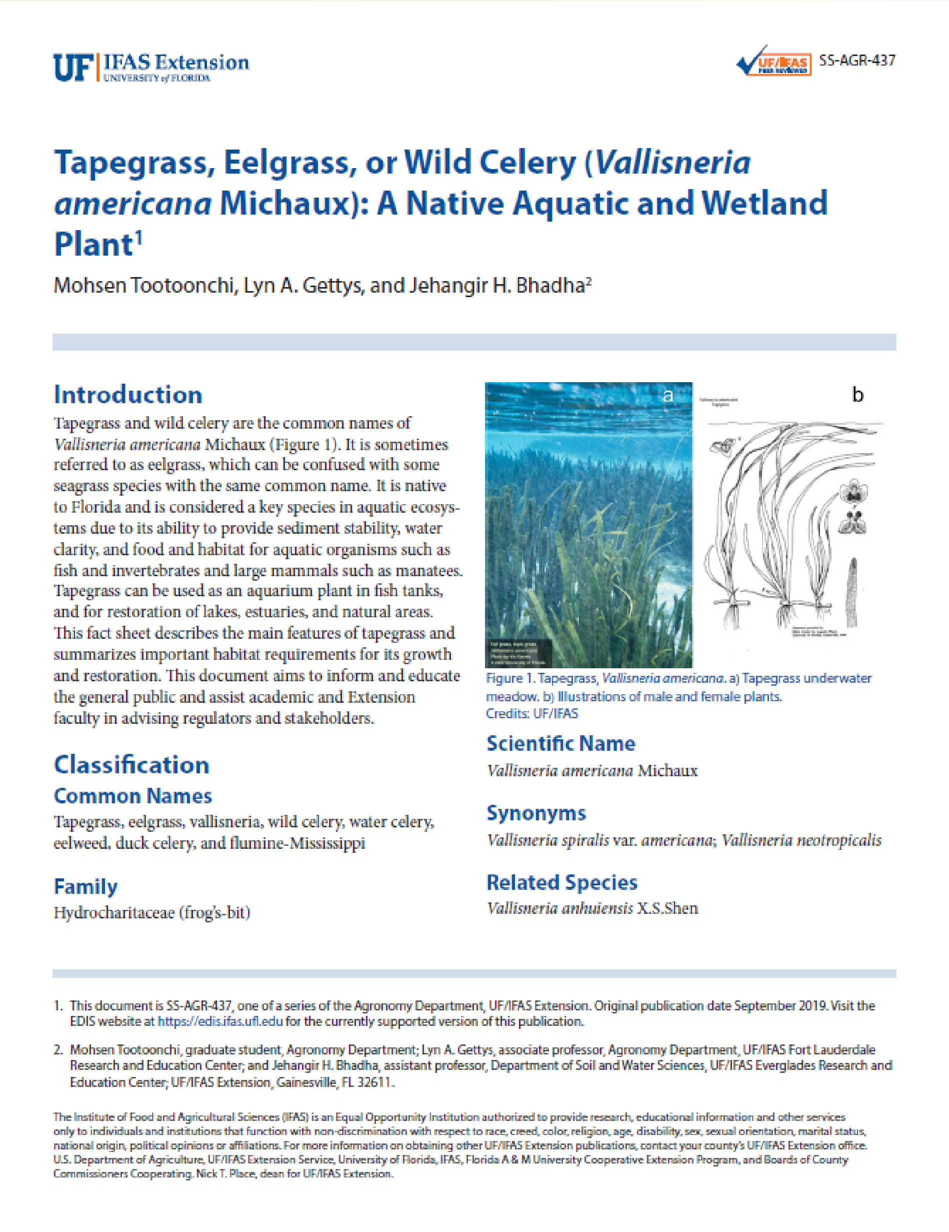
Scale	Old Tissue	New/Young Tissue	Growth
10	Green	Green	High
9	Green	Green	High to moderate
8	Green	Green	Moderate
7	Green to yellow	Green	Moderate to low
6	Green to yellow	Green	Low
5	Yellow	Green to yellow	Low
4	Yellow	Yellow	Very low to none
3	Yellow	Yellow	None
2	Necrotic old tissue	Yellow	None
1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



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SS-AGR-437

Tapegrass, Eelgrass, or Wild Celery (*Vallisneria americana* Michaux): A Native Aquatic and Wetland Plant[1]

Mohsen Tootoonchi, Lyn A. Gettys, and Jehangir H. Bhadha[2]

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.

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

Classification

Common Names

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

Family

Hydrocharitaceae (frog's-bit)

Scientific Name

Vallisneria americana Michaux

Synonyms

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

Related Species

Vallisneria anhuiensis X.S.Shen

1. This document is SS-AGR-437, one of a series of the Agronomy Department, UF/IFAS Extension. Original publication date September 2019. Visit the EDIS website at https://edis.ifas.ufl.edu for the currently supported version of this publication.
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.

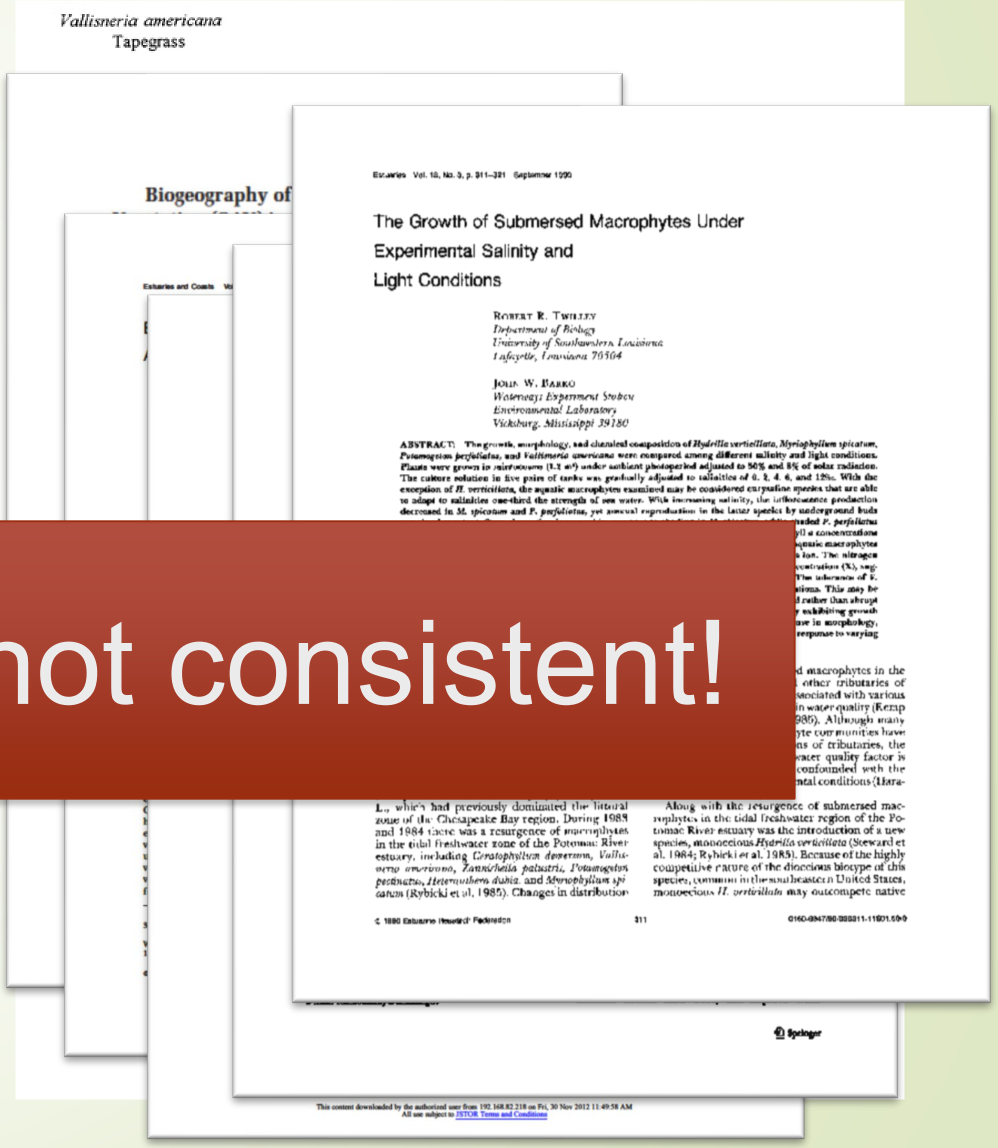
Tapegrass, Eelgrass, or Wild Celery (*Vallisneria americana* Michaux): A Native Aquatic and Wetland Plant

- https://edis.ifas.ufl.edu/ag437

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!

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

Special Issue

diversity