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Salt tolerance variability among different ecotypes of *Vallisneria americana*

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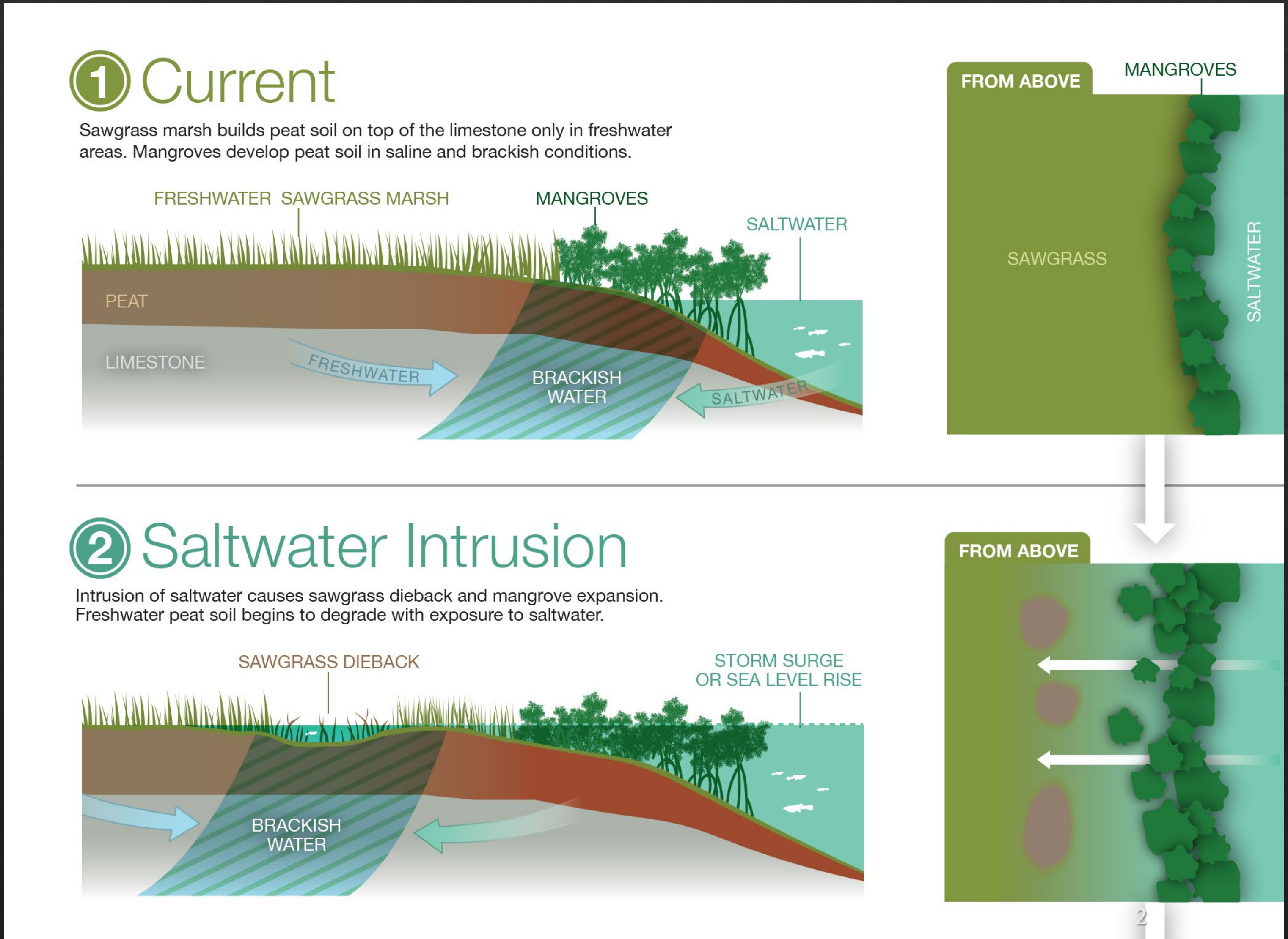
Sea level rise and saltwater intrusion



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

Salt stress

- Salt stress can cause:
  - Mature plant death
  - Reduced plant size
  - Decreased growth rates
  - Suppressed sexual and asexual reproduction

Variability among ecotypes

How are Florida ecotypes of tapegrass impacted by increased salinity?

Is there variability in salt tolerance among tapegrass ecotypes?

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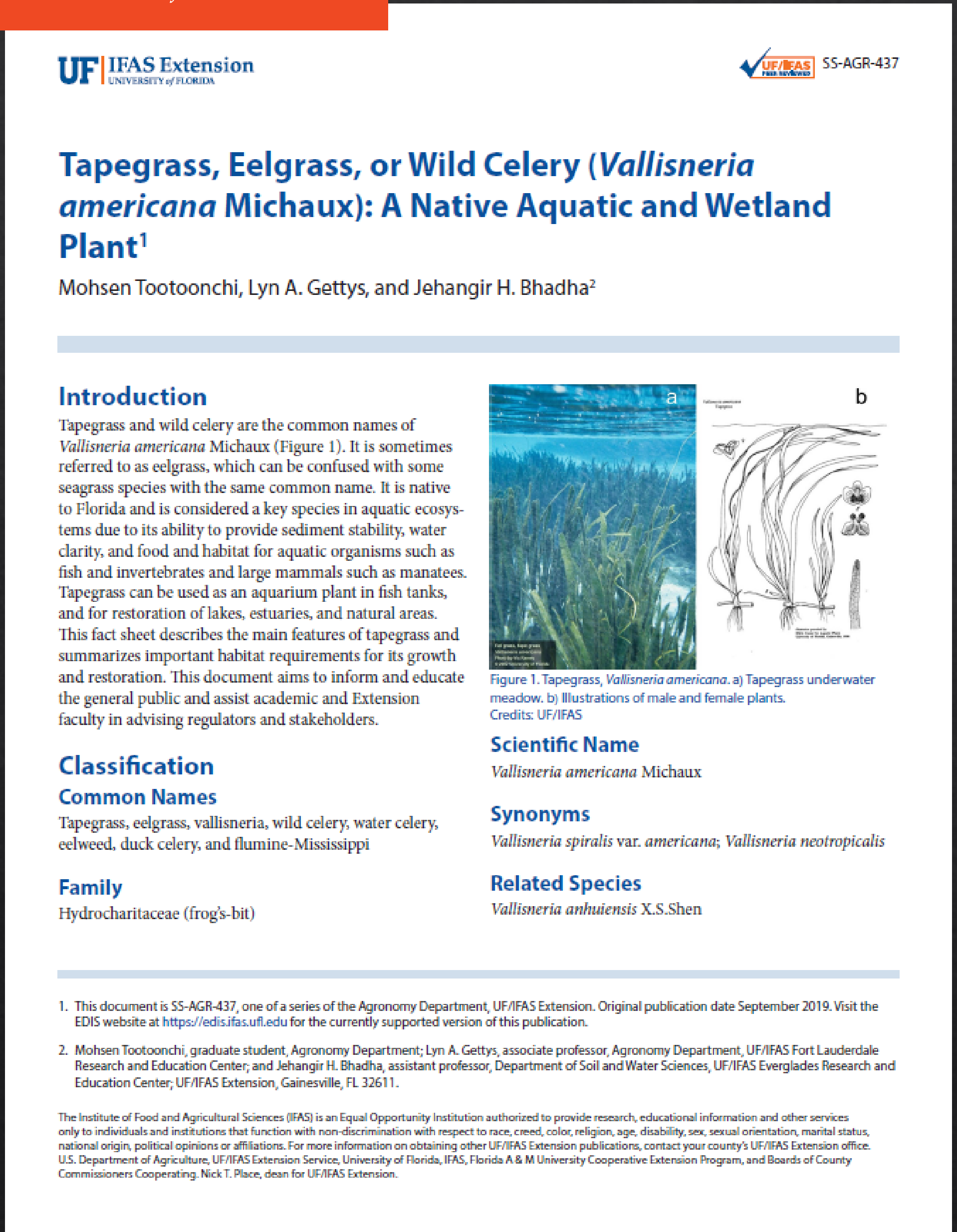

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SS-AGR-437

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.
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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.

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

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

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Variability among ecotypes

- Tapegrass ecotypes
- 24 different ecotypes from FL

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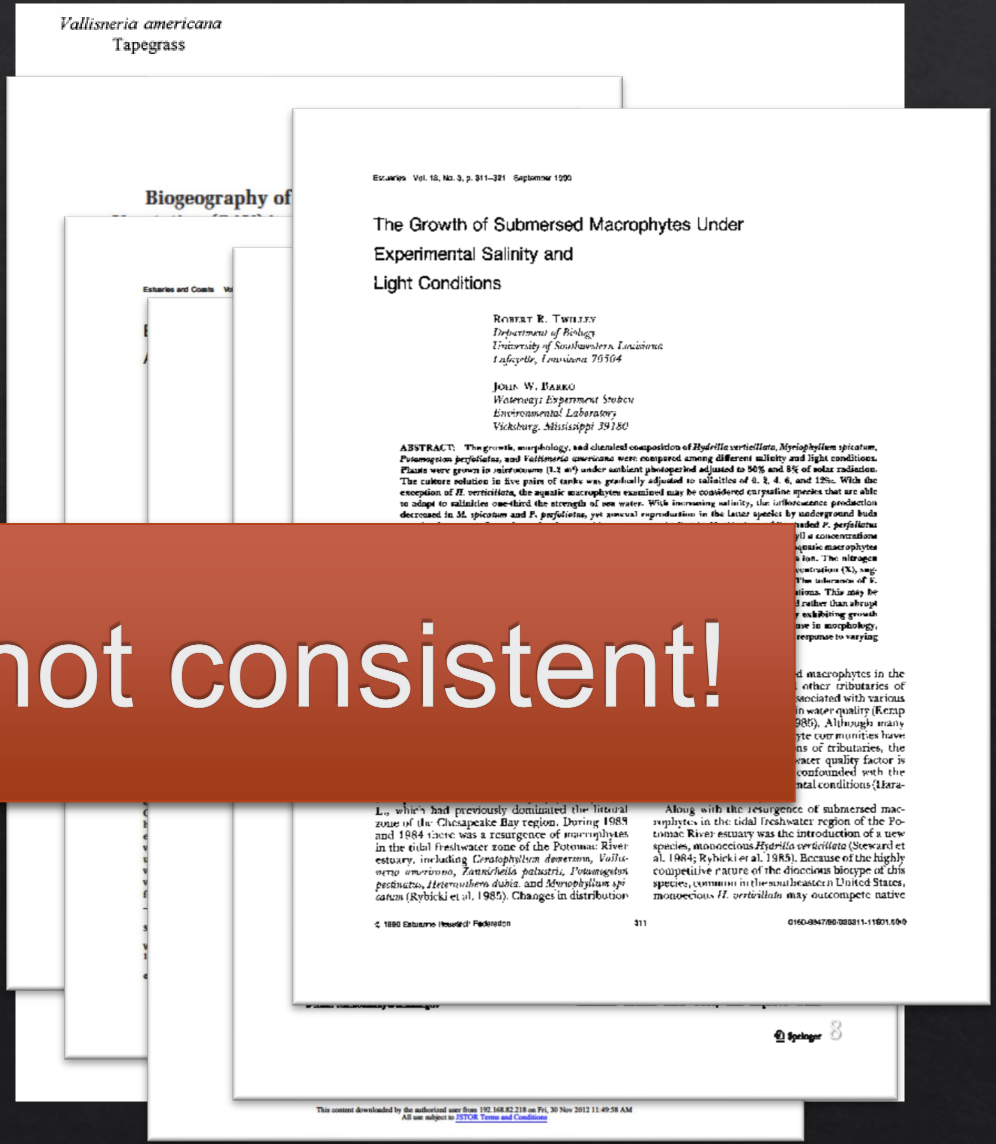
Can we find the salt-tolerance threshold for a species?

- Example: Tapegrass can tolerate:
- 5.0 ppt or less
- 6.6 ppt
- 8.0 ppt
- 12.0 ppt



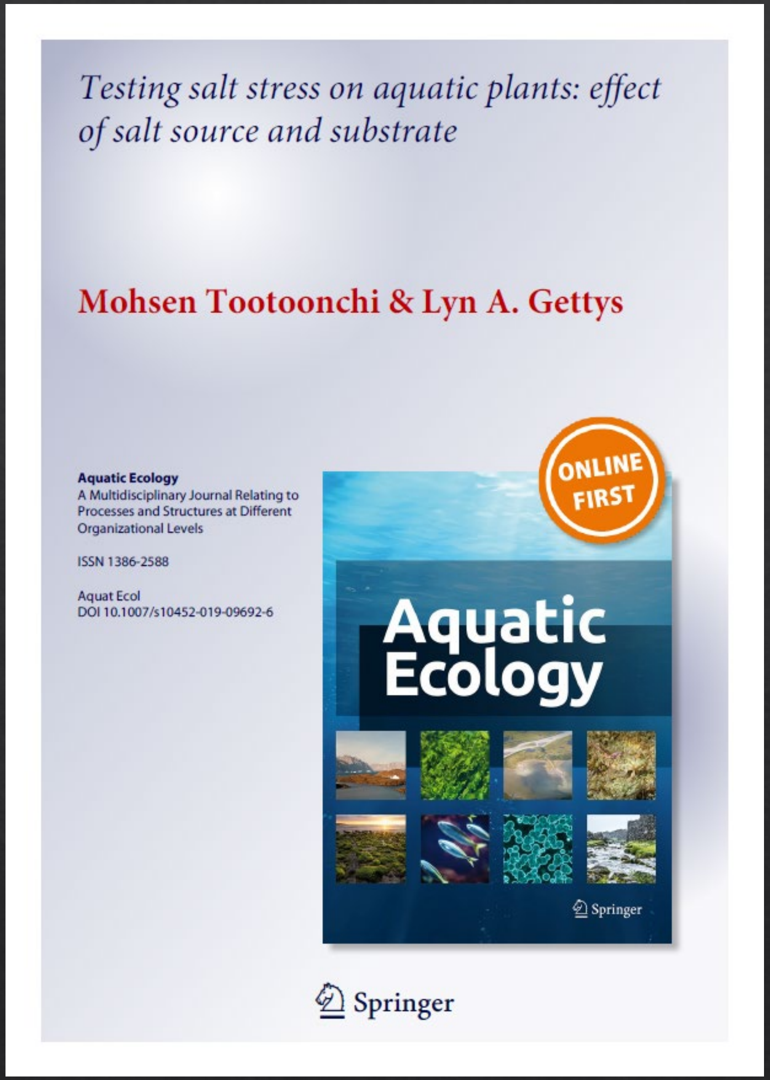
Reports are not consistent!

Factors that impact plants ability to tolerate salt

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

Salt source matters!

- Plant response to saline conditions is significantly affected by the salt source.
- This effect is due to differences in elemental composition of salts (Na, S, Mg, Ca, B).
- In this study, effects of salinity induced by Instant Ocean was similar to seawater.
- Instant Ocean appears to be a good proxy for mimicking seawater.



Factors that impact plants ability to tolerate salt

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

Do ecotypes have different abilities in tolerating salt?

Salinity experiment

- Plants were grown in 14 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 5 weeks of increased salinity

Plant evaluation

Visual rating: plant health was rated a number between 0 and 10

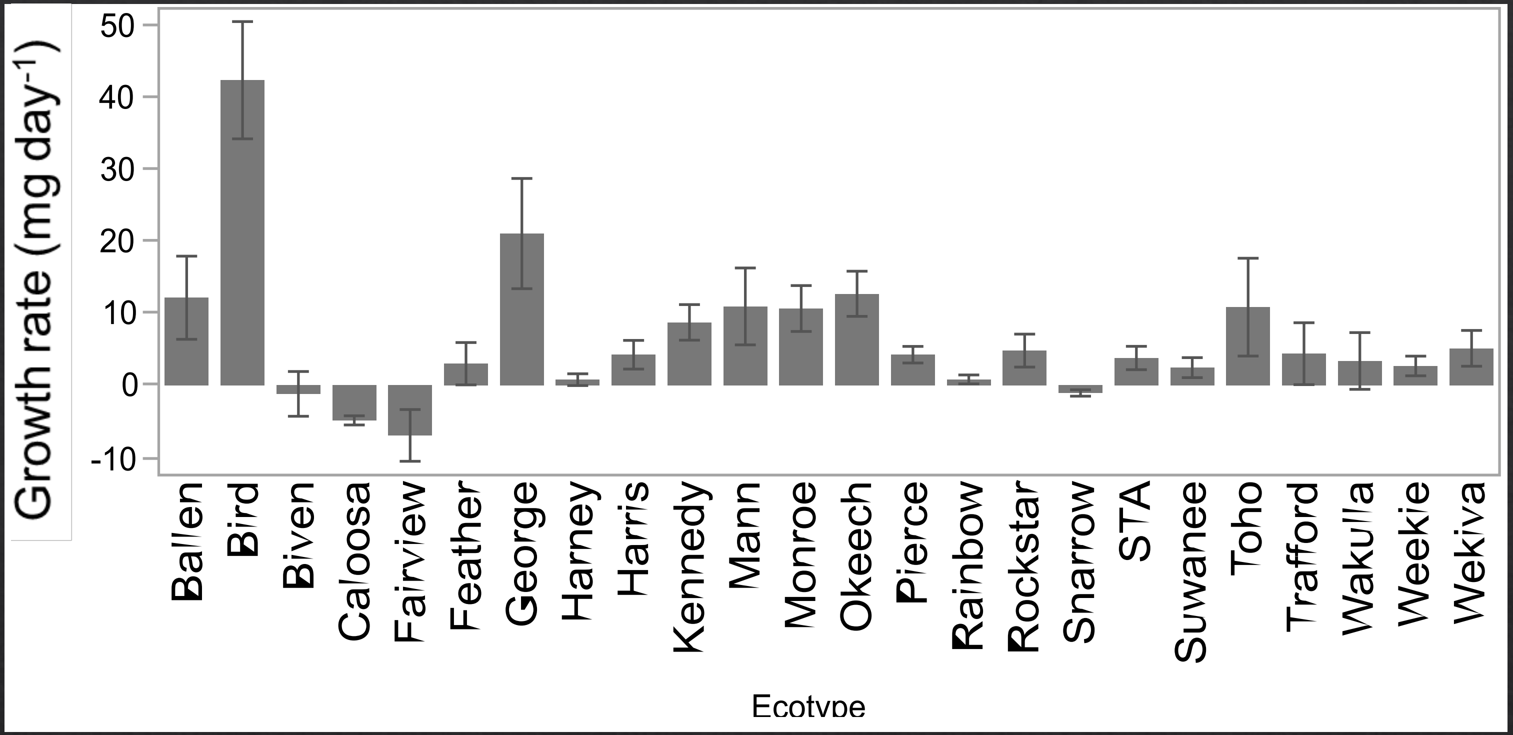
0= Dead

10= No damage

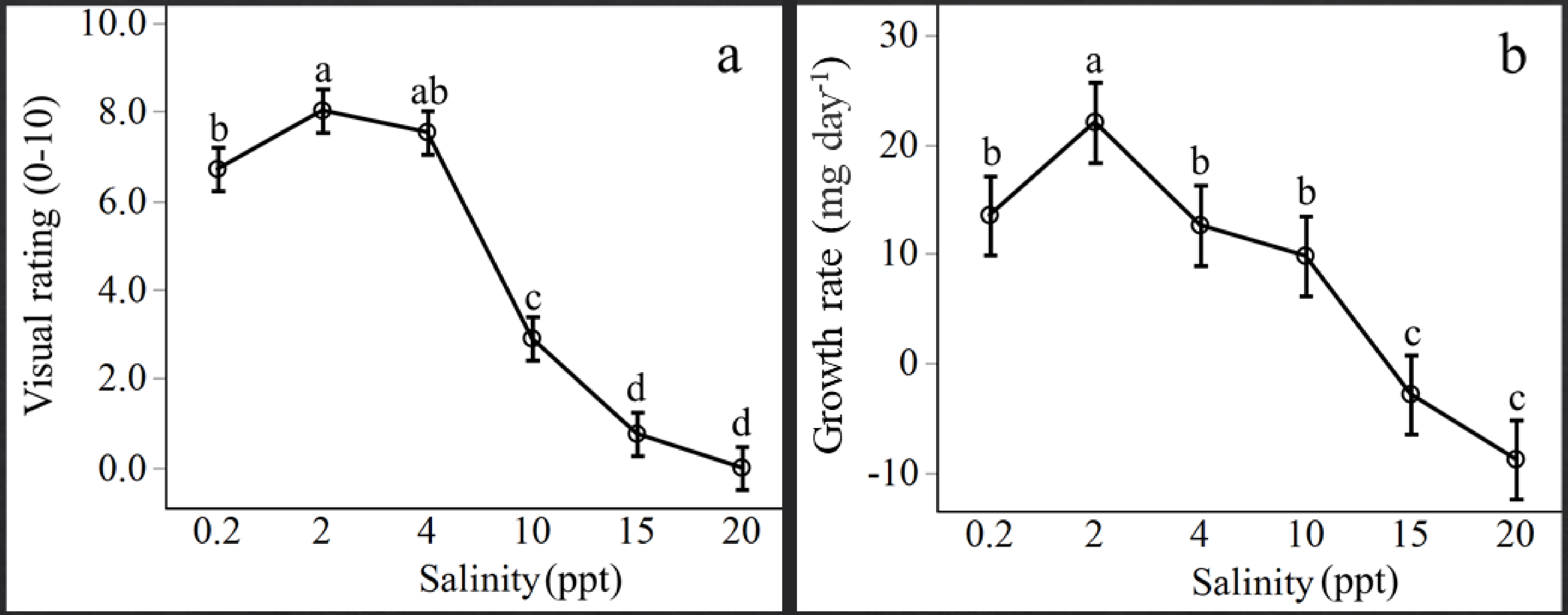
Shoot biomass: aboveground biomass was destructively harvested and dried for two weeks (65 °c)

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

Is there variability among ecotypes?



		Growth rate $r^2=0.71$		Visual rating $r^2=0.87$	
Source	DF	F	P	F	P
Salinity	4	88.71	<.0001	508.43	<.0001
Ecotype	23	9.64	<.0001	11.02	<.0001
Ecotype x Salinity	92	3.33	<.0001	2.95	<.0001



- Lower growth and visual rating at 0.2 than 2 ppt
- Reduced visual quality at 10 ppt and decreased growth at 4 and 15 ppt
- All ecotypes died at 20 ppt

		Growth rate r^2=0.71		Visual rating r^2=0.87	
Source	DF	F	P	F	P
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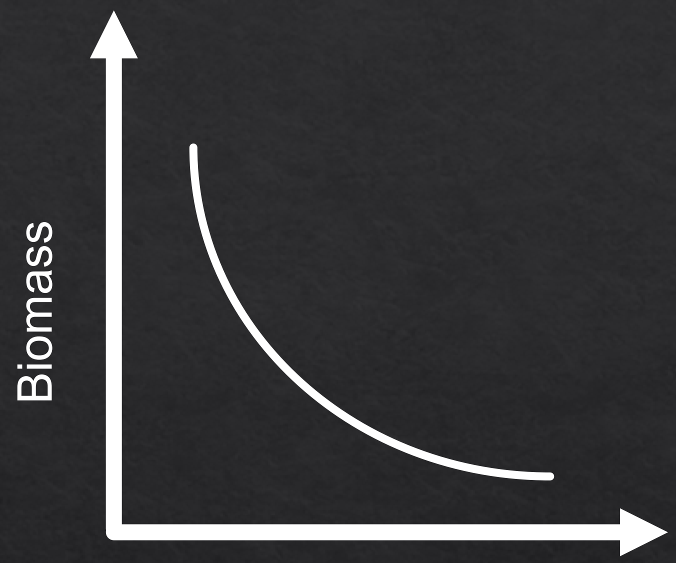
LC calculation

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

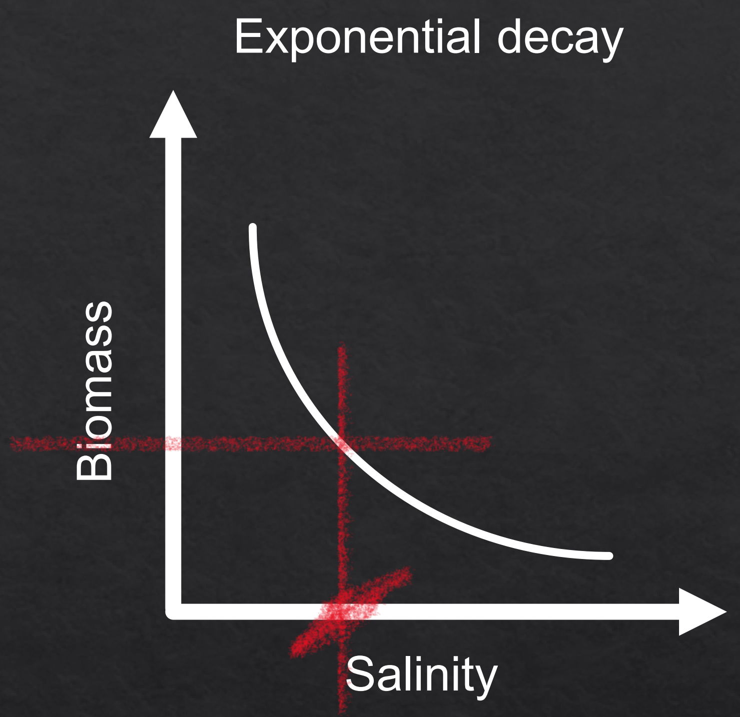


$$U = \frac{d}{1 + \exp[\, b(\log(concentration)) - \log(LC_{50}))]}$$

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}

LC calculation

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



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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}

- LC_v and LC_d and the 95% upper and lower confidence intervals.
- NA, Ecotype did not show a significant response to salinity gradient.

Ecotype	LC_v	Lower	Upper	r^2	LC_d	Lower	Upper	r^2
Bird	9.00	6.58	14.24	0.76	9.10	5.55	>20.00	0.51
Biven	5.94	4.00	11.53	0.70	7.42	4.30	>20.00	0.45
Mann	5.48	4.12	8.16	0.86	6.65	4.03	18.95	0.57
Rockstar	5.42	3.53	11.65	0.68	9.85	4.59	>20.00	0.24
Fairview	5.37	3.75	9.45	0.76	4.83	2.79	18.28	0.55
Ballen	5.35	3.98	8.17	0.84	5.34	3.76	9.19	0.76
Kennedy	5.28	4.35	6.73	0.93	3.87	2.46	9.01	0.7
Monroe	5.06	3.56	8.77	0.78	7.22	3.82	>20.00	0.39
Okeech	4.78	3.37	8.20	0.80	4.78	2.83	15.28	0.57
Toho	4.64	3.71	6.19	0.92	5.72	3.68	12.77	0.65
George	4.47	3.73	5.59	0.95	4.87	2.94	14.33	0.6
Trafford	4.36	2.61	13.29	0.62	5.92	3.02	>20.00	0.33
STA	4.30	2.99	7.63	0.8	NA	NA	NA	NA
Harney	4.29	2.88	8.45	0.76	7.33	3.60	>20.00	0.31
Feather	4.14	3.16	6.00	0.89	12.74	5.16	>20.00	0.16
Wakulla	3.81	2.46	8.50	0.69	4.68	2.25	>20.00	0.31
Pierce	3.76	2.84	5.58	0.89	2.62	1.16	10.39	0.39
Suwanee	3.76	2.14	15.68	0.59	NA	NA	NA	NA
Weekie	3.45	2.20	7.94	0.74	3.11	1.83	10.44	0.66
Wekiva	2.98	1.99	5.95	0.81	2.09	1.00	>20.00	0.49
Harris	1.13	0.86	1.62	0.93	0.47	0.24	10.54	0.87
Rainbow	NA	NA	NA	NA	NA	NA	NA	NA
Snarrow	NA	NA	NA	NA	NA	NA	NA	NA
Caloosa	NA	NA	NA	NA	NA	NA	NA	NA

Ecotype	Visual Rating	Growth Rate	LC_v	LC_d	Mean Rank	Overall Ranking	
Bird	1	1	1	4	1.75	1	A
Mann	5	3	3	9	5	2	AB
Ballen	4	6	6	12	7	3.5	ABC
Toho	3	4	10	11	7	3.5	ABC
Rockstar	11	12	4	2	7.25	5.5	ABC
Monroe	8	5	8	8	7.25	5.5	ABC
George	6	2	11	14	8.25	7	ABC
Biven	7	21	2	6	9	8	ABC
Kennedy	2	9	7	19	9.25	9	ABC
Okeech	10	7	9	17	10.75	10	ABCD
STA	13	15	14	3	11.25	11	ABCD
Trafford	18	8	12	10	12	12	ABCD
Feather	14	20	16	1	12.75	13	ABCD
Fairview	9	23	5	16	13.25	14	ABCD
Harney	15	18	15	7	13.75	15	ABCD
Waqulla	12	11	17	18	14.5	16	BCD
Suwanee	20	16	19	5	15	17	BCD
Pierce	17	13	18	21	17.25	18	BCD
Wekiva	16	10	22	22	17.5	19	BCD
Snarrow	24	22	13	13	18	20	BCD
Rainbow	22	19	20	15	19	21	CD
Weekie	19	17	21	20	19.25	22	CD
Harris	21	14	24	24	20.75	23	CD
Caloosa	23	24	23	23	23.25	24	D

Overall Ranking

Ecotypes were numerically ranked from “best” to “worst” based on visual rating, growth rate, LC_v and LC_d.

LC_{50} values

LC_{50} for 2 ecotypes with the highest and lowest salt tolerance

Rank	Ecotype	LC_v (ppt)	LC_d (ppt)
1	Bird	9.00	9.10
2	Mann	5.48	6.65
22	Weekie	3.45	3.11
23	Harris	1.13	0.47

Summary

- Salt tolerance differed among ecotypes (growth rate and visual rating).
- Most ecotypes stopped their growth at 10 ppt and decayed at 15 ppt.
- One ecotype tolerated 15 ppt!
- On average, tapegrass had an average LC_{50} of 5 ppt.

Rank	Ecotype	LC_v (ppt)	LC_d (ppt)
1	Bird	9.00	9.10
2	Mann	5.48	6.65
22	Weekie	3.45	3.11
23	Harris	1.13	0.47

Thank you

diversity

MDPI

Article

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 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

Hydrobiologia
https://doi.org/10.1007/s10750-022-04934-5

EFFECTS OF CHANGES IN SALINITY

Check for updates

Salt tolerance assessment of aquatic and wetland plants: increased salinity can reshape aquatic vegetation communities

Mohsen Tootoonchi · Lyn A. Gettys · Jason A. Ferrell · John E. Erickson · Jehangir H. Bhadha

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Abstract Salinization is a great threat to wetlands and freshwater ecosystems. Increased salinity can disturb native aquatic vegetation and provide an empty niche for invasion of non-native species. To understand the fate of aquatic flora under increased salinity levels, 14 dominant wetland species with different growth forms (submersed, amphibious, floating-leaved, emergent and woody/tree) were exposed to increased salinity conditions. The objective was to assess the salt tolerance threshold for each species and model their performance in response to a salinity gradient ranging from 0.2 to 20 parts per thousand (ppt). Plant growth and survival rate were analyzed using a nonlinear regression model to project sublethal salinity concentrations that would reduce biomass and visual quality of each species by 50% (LC_{50}). Results showed that a few non-native species (alligatorweed: *Alternanthera philoxeroides* (Mart.) Griseb., torpedograss: *Panicum repens* L., and Brazilian peppertree: *Schinus terebinthifolius* Raddi) survived 20 ppt salinity, whereas all other native and non-native species perished at salinity below 10 ppt. Increased salinity can suppress salt-sensitive native plants and increase the opportunity of invasion for salt-tolerant non-native species. This suggests that alligatorweed, torpedograss and Brazilian peppertree pose a more significant threat to the ecosystem if salinity levels continue to increase in freshwater ecosystems and exacerbate the encroachment of non-native species into native plant communities.

Keywords Coastal wetlands · Dose–response model · Health screening · Invasion ecology · Non-native species · Saltwater intrusion · Sodium (Na) toxicity

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