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How to do seed-based restoration in 8 easy steps

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LISS Spring Meeting

May 19, 2026

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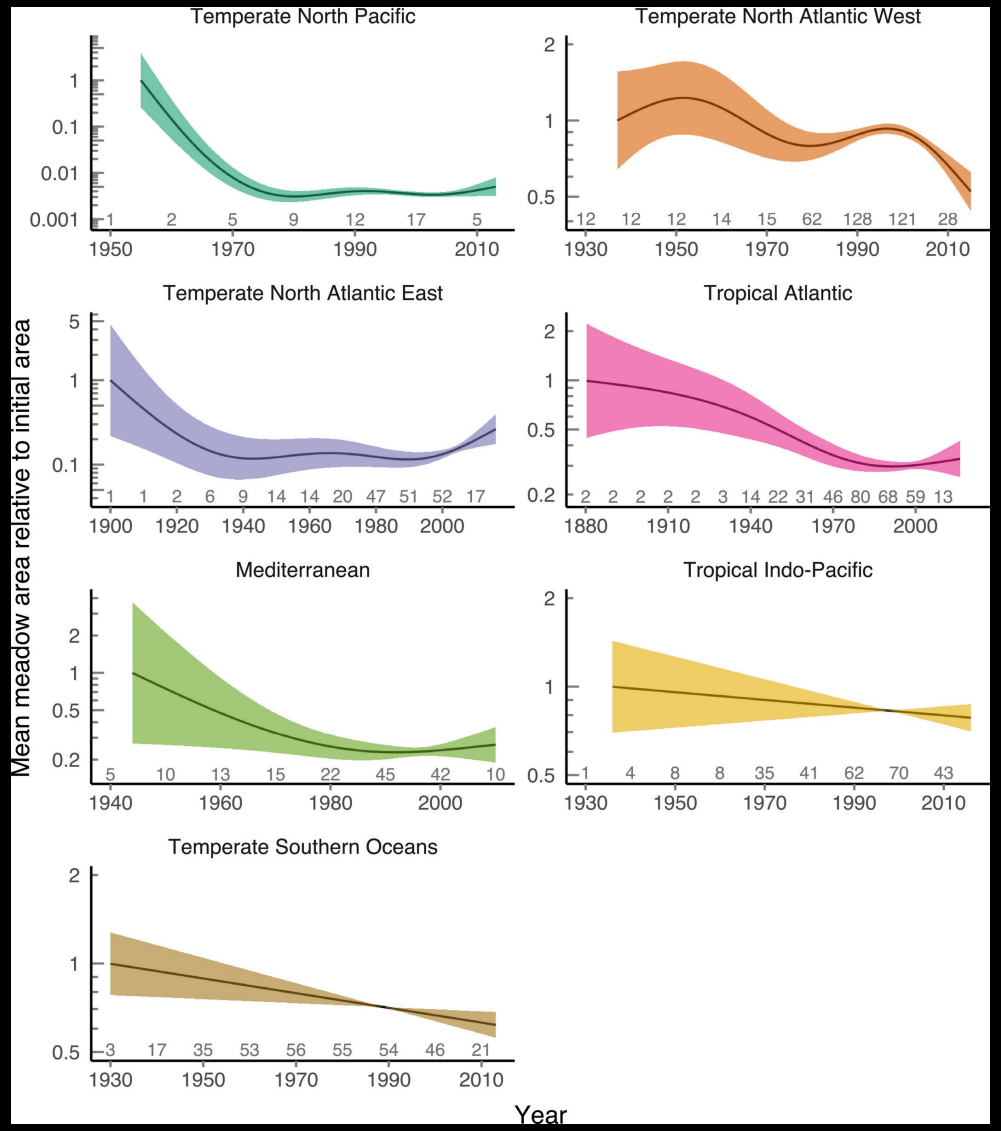
Coastal Productivity

Seagrass meadows are some of the most widespread and productive coastal habitats on every ocean save the Antarctic.

A global crisis for seagrass ecosystems

The Status of Seagrass Today



Dunic et al. 2021

- Good news:
  - Declines in many areas have leveled out
  - Seeing some signs of recovery
- Bad news:
  - Ongoing declines in some regions
- How can we reverse these declines?
  - Habitat Management (stressor amelioration)
  - Seagrass Restoration

Seagrass Restoration

- Various methods
  - Plugs, seeds, transplants, etc.
- Many are expensive and time consuming
- Success is highly variable
  - Worldwide reportedly 62% failure rate (Bayraktarov et al. 2016)
  - USA similar at 63% failure rate (Rezek et al. 2019)
  - Europe reportedly 85% failure rate with transplants (Cunha et al., 2012)

These disappointingly low success rates may be overly optimistic, because many small mitigation projects that aren't successful are probably not reported anywhere.

You add the specter of climate change to that and, all in all, its pretty depressing

Seagrass Restoration

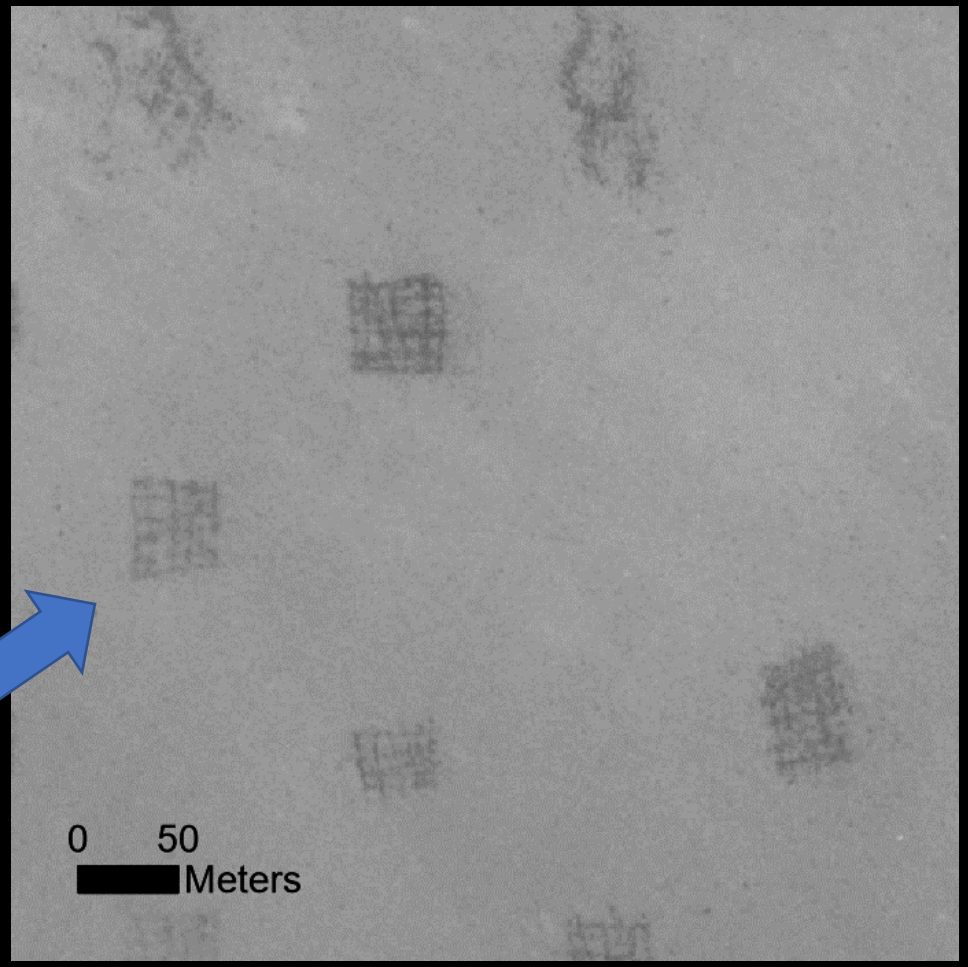
- Funders are wary of supporting seagrass restoration and rightfully so, why invest in something with a high probability of a poor outcome?

- But there are some bright spots of very successful projects. For example, VIMS has this incredible track record of success that JJ Orth kicked off resulting in the largest successful restoration in the world

A Famous Restoration Success Story

VIMS lead restoration of VA's coastal lagoons

One acre plots ~100,000 seeds distributed per plot



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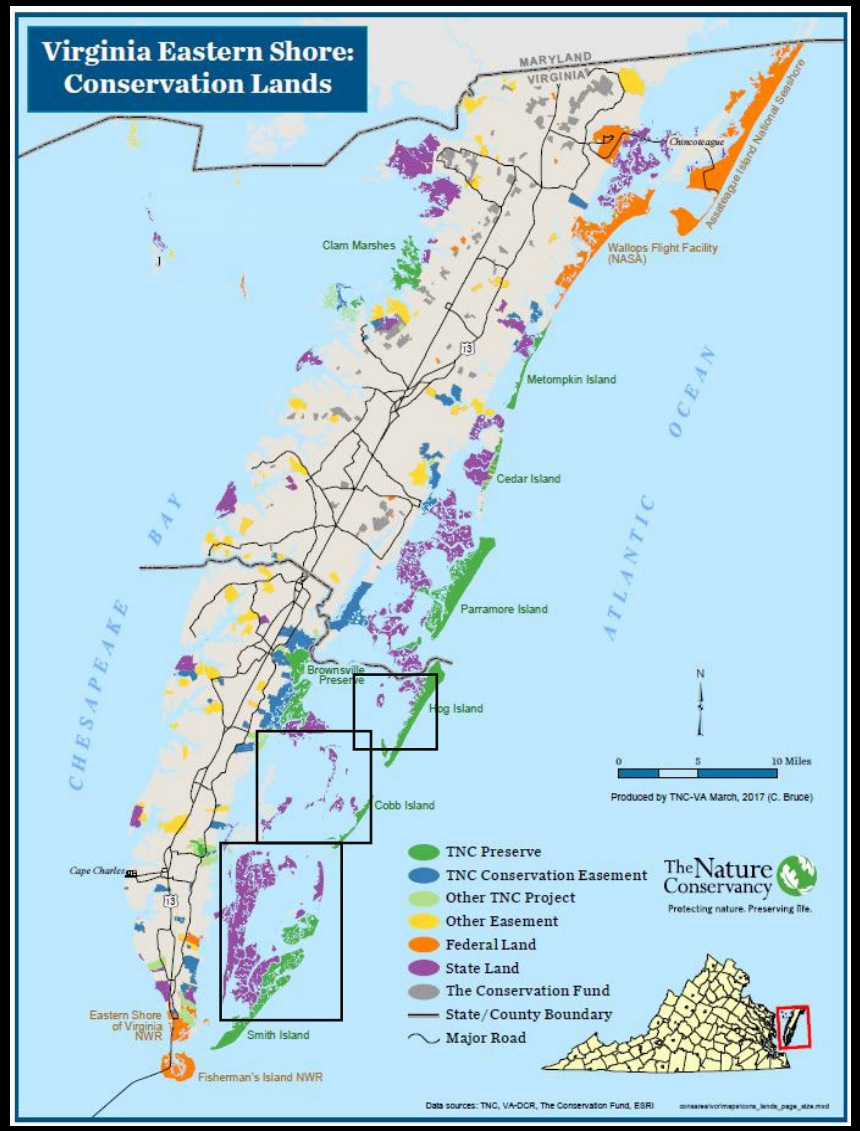

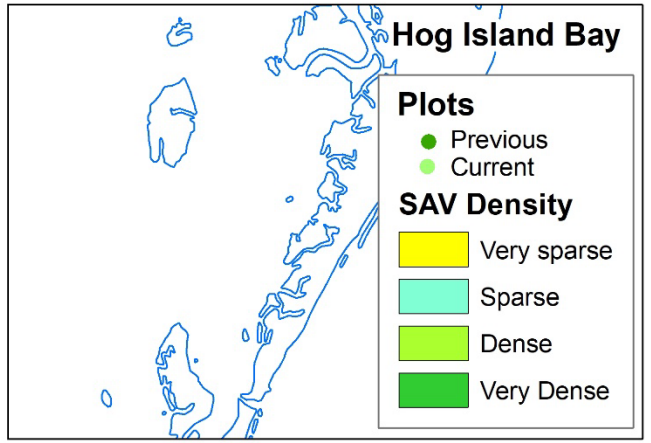

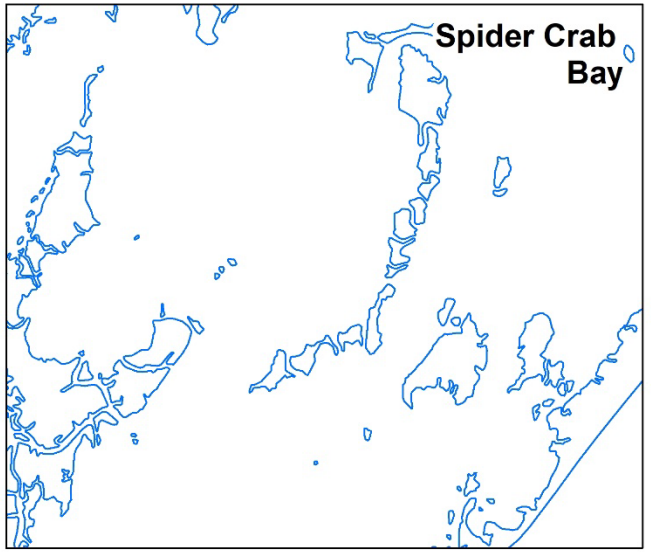

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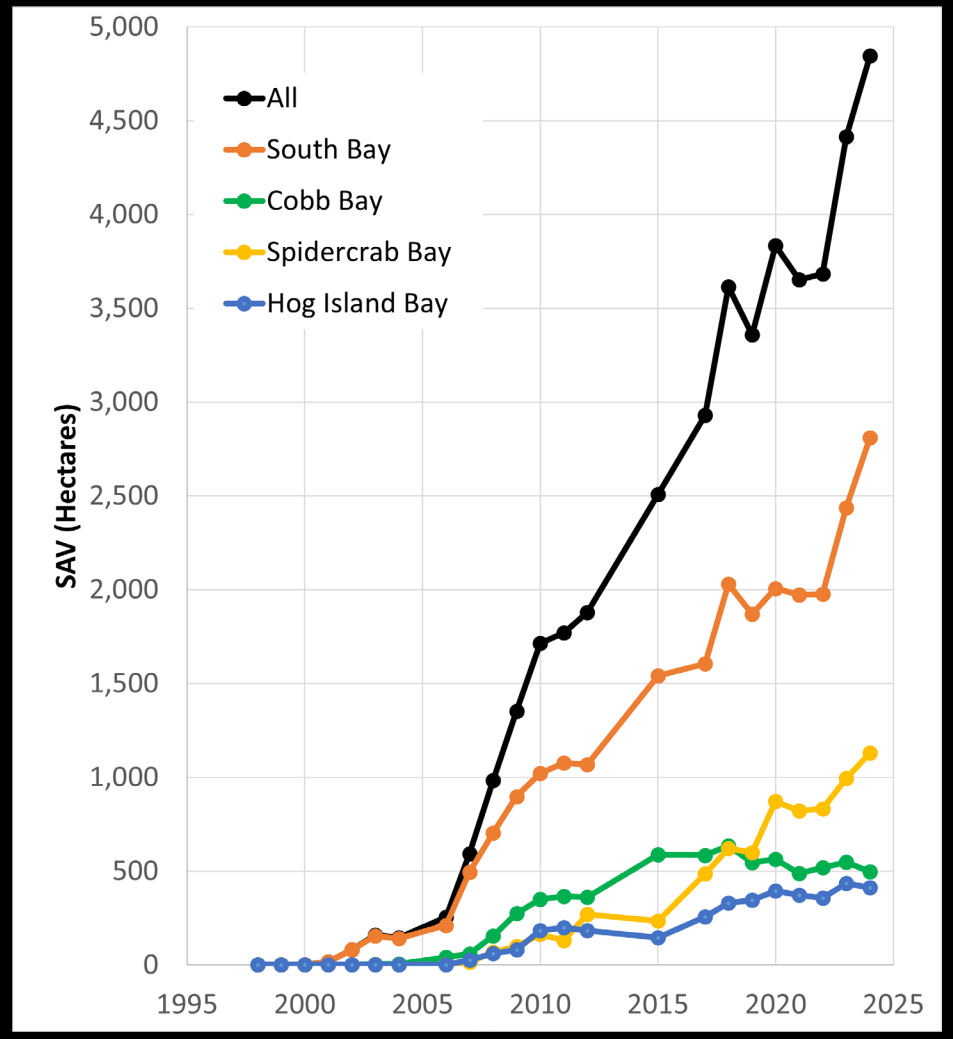

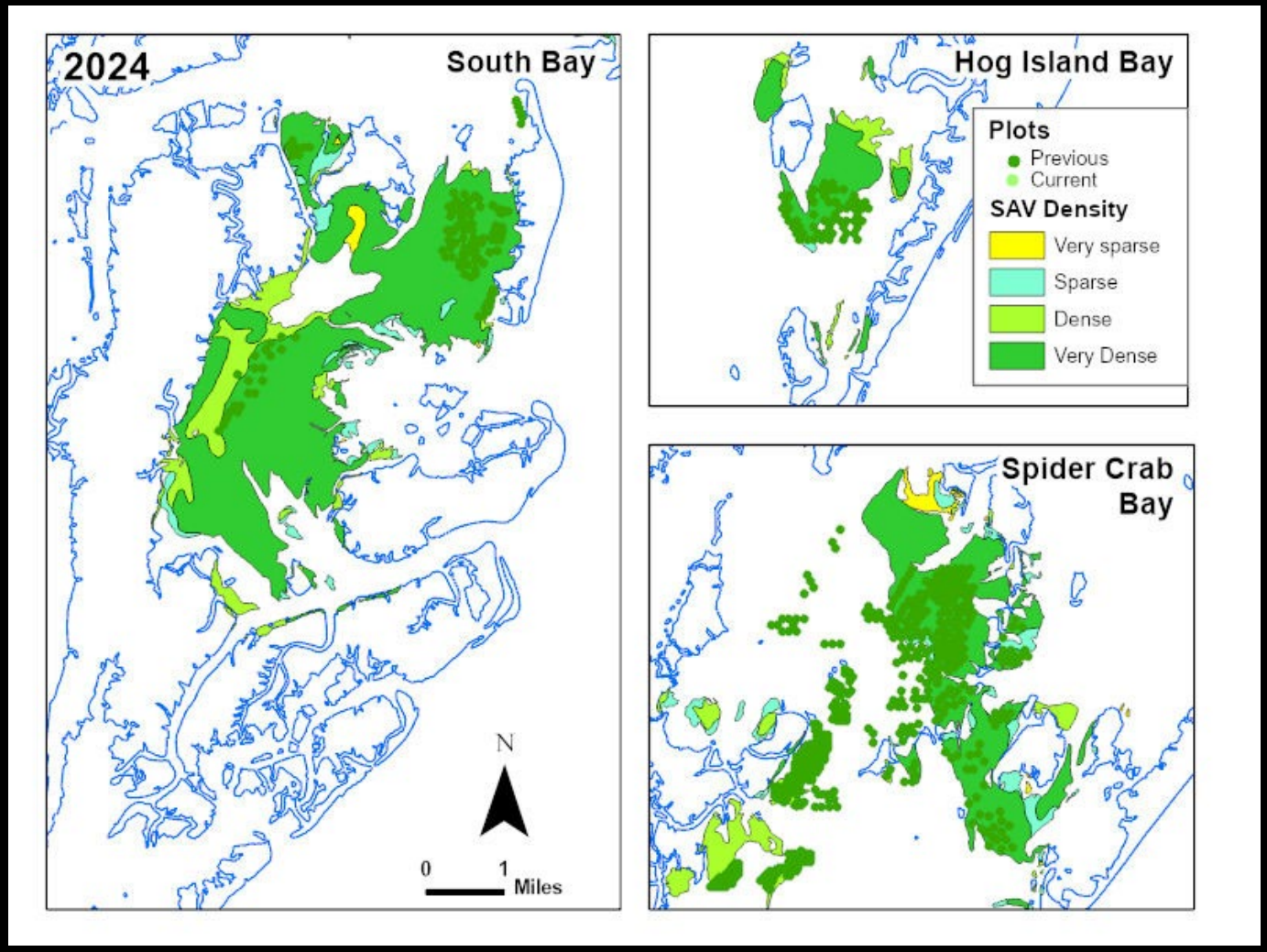

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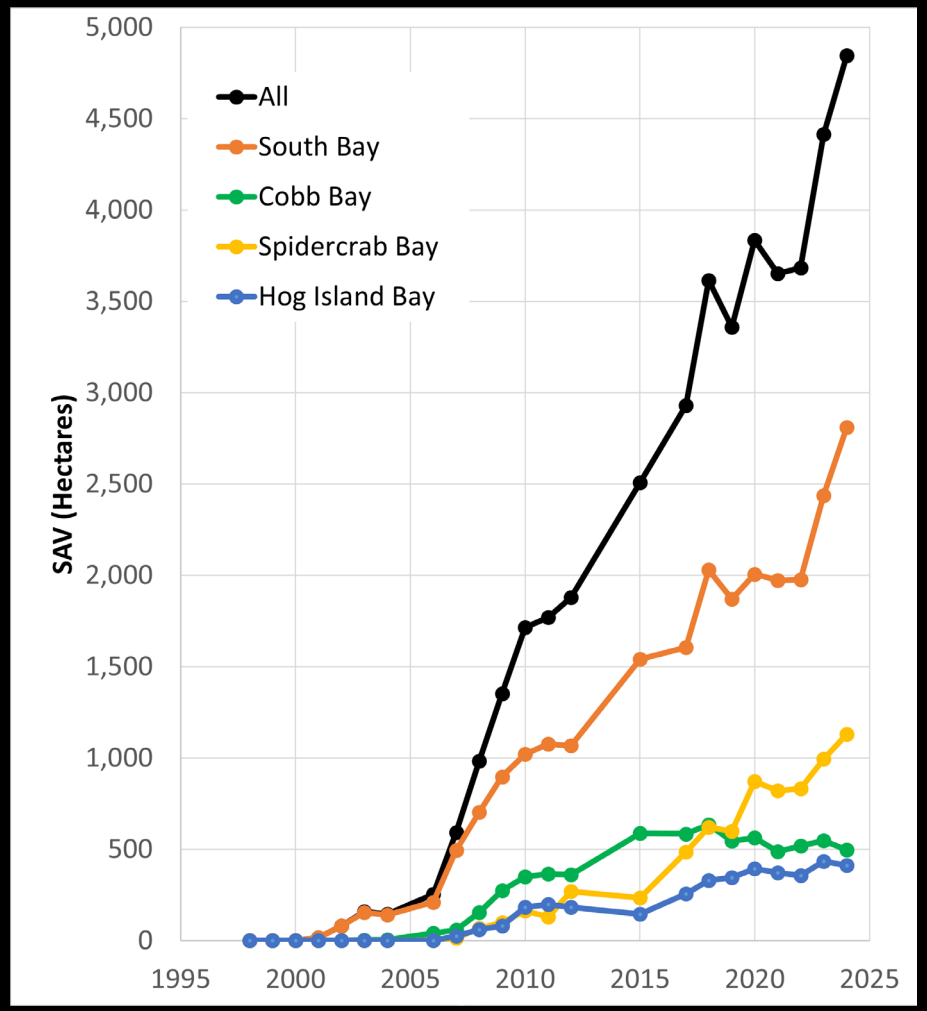
A Famous Restoration Success Story



This is the most successful seagrass restoration on the planet. 11,978 acres and counting

Demonstrates amazing potential for rapid recovery of seagrass in years not decades to centuries.

Cost effective: ~ 15 acres for every acre planted

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Our Process (in 8 “easy” steps)

1)Check the meadows for seed development
2)Harvest seeds from the wild
3)Process them in the lab
4)Hold them until disbursement
5)Select your sites for planting
6)Plant them in the Field
7)Assess seeds over the winter in the lab
8)Assess field plots the Following Spring

1) Check the Meadows

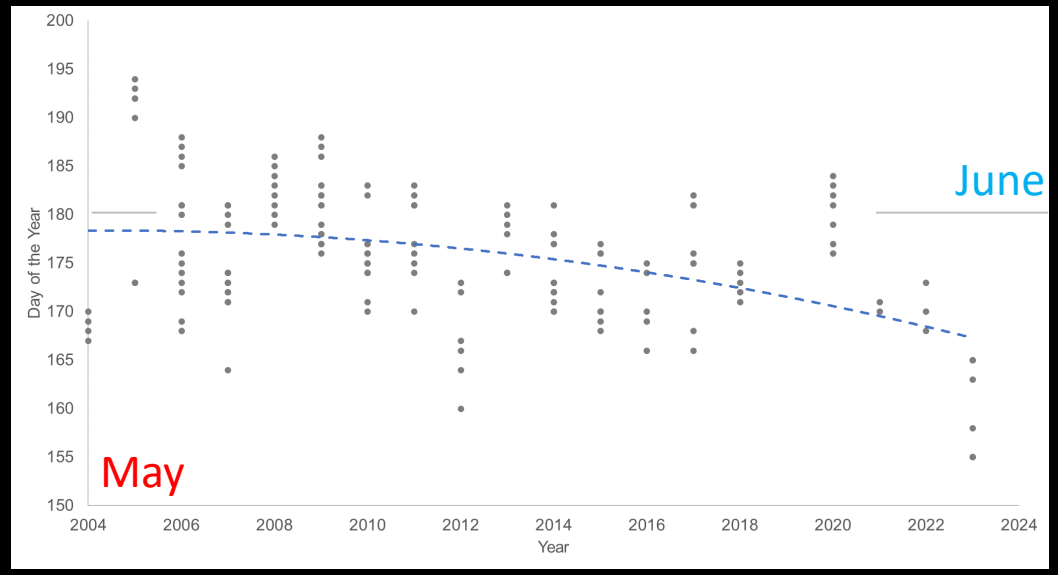
We visit multiple potential donor meadows to assess variation in shoot density and seed stage

Looking for Chartreuse Branching shoots (*"if it ain't Chartreuse, it ain't no use"*)

1) Check the Meadows

- Timing is critical (we think?) !
- Here, we visit beds frequently through April and May to identify which donor beds are most productive that year and to time collections based on seed status
- Too early “might” (we’re investigating) lead to larger proportion of non-viable seeds
- A day or two too late can result in missing the harvest

Clark et al. 2021



Harvest date is trending earlier each year, climate change effect.

2) Harvest Seeds from the Wild

- VIMS Staff from the SAV Restoration & Monitoring Program as well as volunteers organized by TNC collect eelgrass flowering shoots by hand

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- VIMS Staff from the SAV Restoration & Monitoring Program as well as volunteers organized by TNC collect eelgrass flowering shoots by hand
- Snorkeling or SCUBA

- Collection usually in May
- Multiple collecting trips in a season (3 to 5 water days with 6 to 12 people)
- Laundry bags for reproductive shoots
- 30k to 90k back end “good” seeds per person per hour

2) Harvest Seeds from the Wild

- Reproductive shoots with seeds transported to SAV Program at VIMS

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- Reproductive shoots with seeds transported to SAV Program at VIMS

3) Process them in the “lab”

- Reproductive shoots are “fluffed” volumetrically measured into 55-gallon allotments using large trash cans

- Several bags per can but number varies due to variation in how tightly filled the bags are

3) Process them in the “lab”

- We aim for 6 or 7 cans per circular water tank at our facility
- Tanks are ~ 900 gallon
  - Standpipe with mesh cap
  - Heavy aeration
  - Flow through river water
    - 20-22 salinity comparable to collection site
    - Coarse sock filter cleaned once every few days
    - 10 gallons per minute flow rate to each tank
  - Repro shoot to water volume is roughly 1:3
- Typically, we fill 10 tanks at our facility

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3) Process them in the “lab”

- Stir the tanks ~ 5x per week
- 2 interns x 1-2 hrs per day
- Mesh paddles to gently remove large material from water column after seeds are released

3) Process them in the “lab”

- After 6- 8 weeks when tanks are cleared of all material other than fines and seeds, we collect the seeds
- Attach a drain pipe to the bottom of the tank
- Attach a 1mm mesh collecting bag

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- Crack the stand pipe to let seeds flow into the bag a little at a time

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- Crack the stand pipe to let seeds flow into the bag a little at a time
- Fill the collecting bag with seeds!

3) Process them in the “lab”

- Pass material through a 4mm sieve to get rid of big shell fragments
- Then run the seeds through the flume

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- Pass material through a 4mm sieve to get rid of big shell fragments
- Then run the seeds through the flume

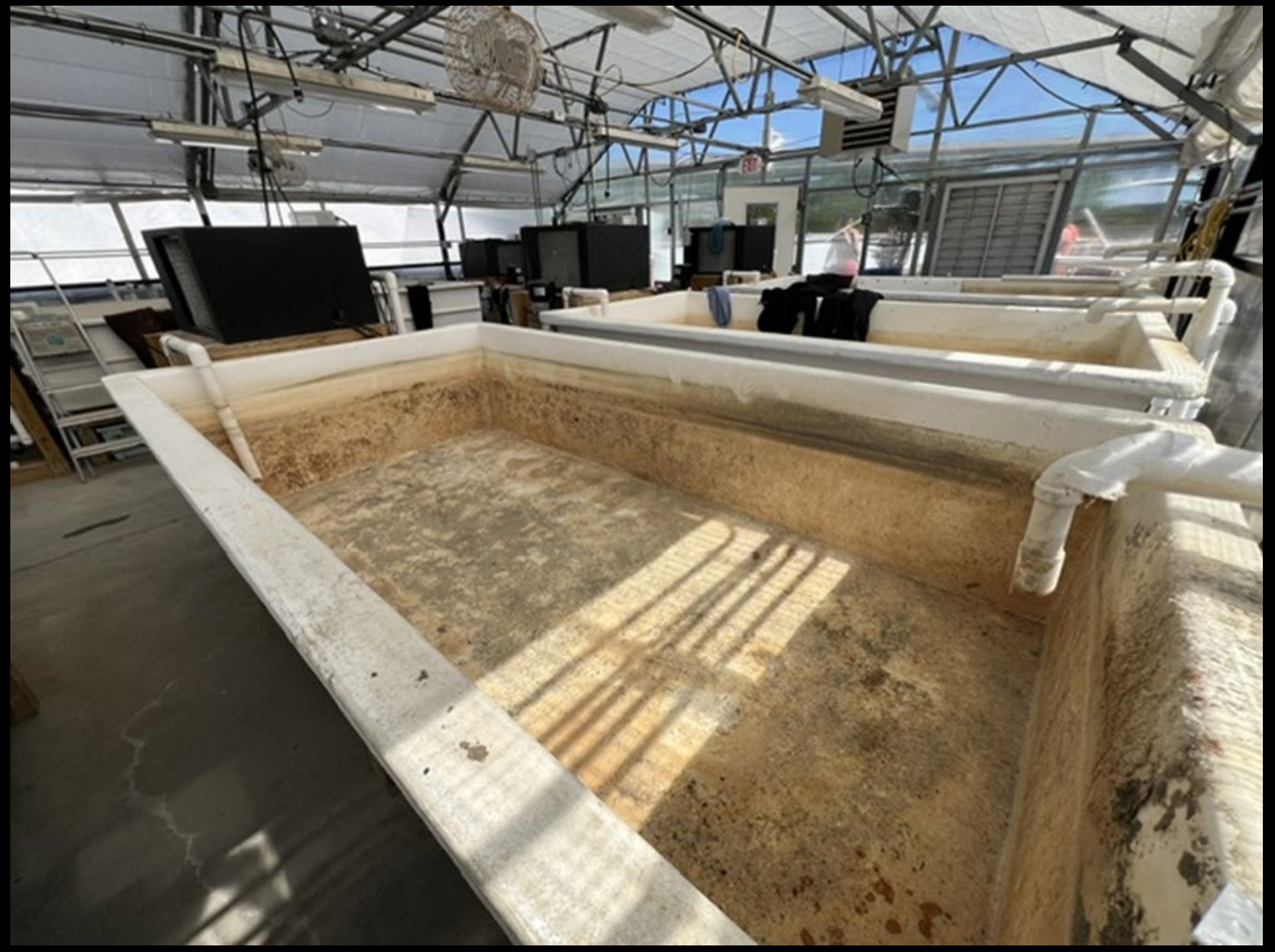
- Fill flume up, attach mesh separator basket, flow at ~ 5cm per second
- Good seeds fall closer to the basket, ok seeds go further, bad seeds go down the drain

3) Process them in the “lab”

- Split seeds in “A” and “B” batch based on travel distance
- Suck up into sieve stacks to remove remaining debris

4) Hold them until disbursement

- Water Table(s) for holding seeds
  - Matching salinity
  - Vigorous Recirculating
  - 22°C temperature
  - UV sterilization
  - Sand or Bead Filter



- Seeds in plastic tubs
  - One (or more) per batch per source
  - 3cm deep
  - Brick to hold in place

4) Hold them until disbursement

- Quality Assessment

1) Repeated for each batch and source
2) Total volume measured
3) 4 to 7 2ml replicates collected
4) For each rep:
    1) Seed count
    2) # good seeds
        1) Squeeze and drop tests
5) Back end you get # of good seeds available in the fall

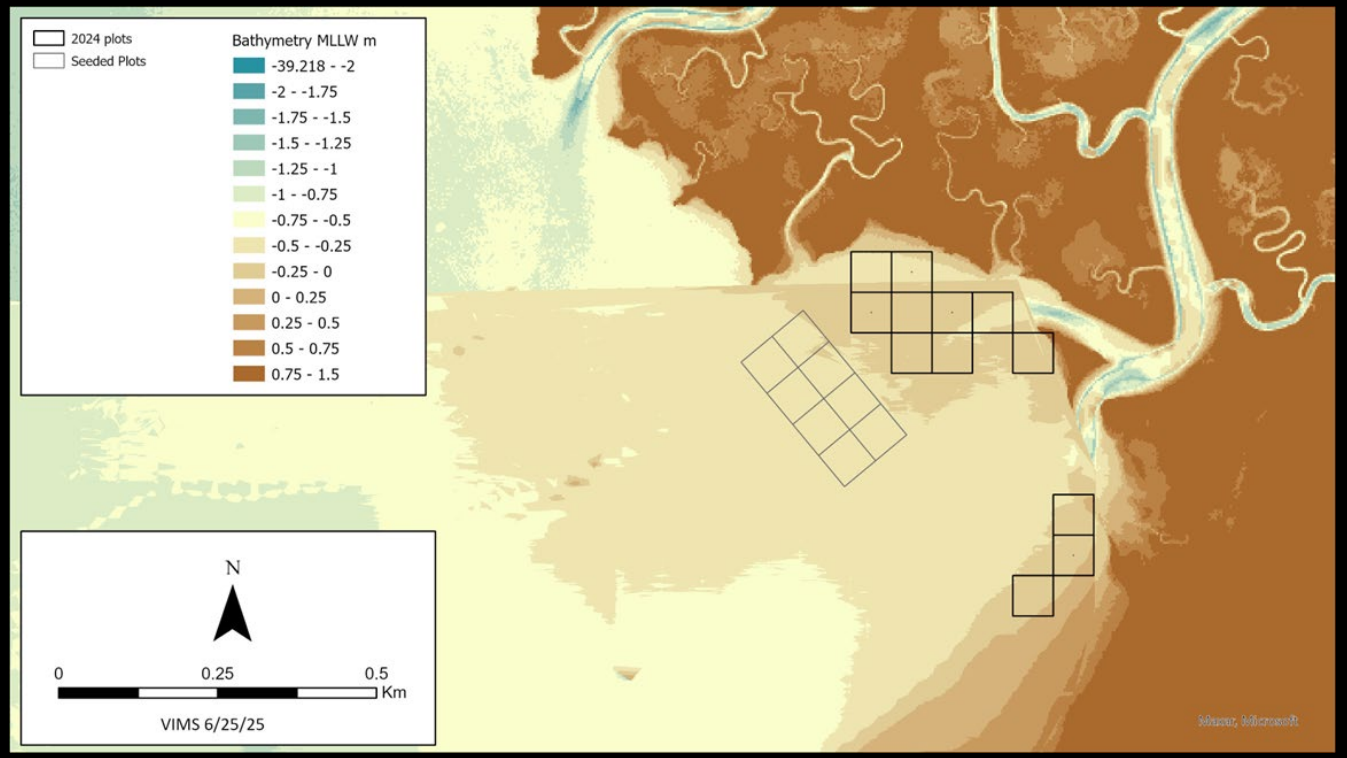
4) Hold them until disbursement

- We often get white biofilm growing on our seeds, its not a problem
- Sometimes polychaetes and other critters that can eat seeds get into tanks, we deal with that as best we can
- If a seed bin is really smelly and has lots of black build up, its probably experiencing a problem

5) Select your sites for planting

- If you know your planting density (e.g. 100k seeds per acre) and you know how many seeds you have, you can figure out how many acres you can/will plant
- Always plan with some margins for error and some buffers, you will lose seeds during holding (5 to 60% possible, usually about 10%)
- Site selection based on:
  - Available
  - Light and Depth
  - Temperature
  - Currents
  - Sediment type (sand is better)
  - Formerly vegetated
  - Faunal community

  (holes are good, shell is bad)

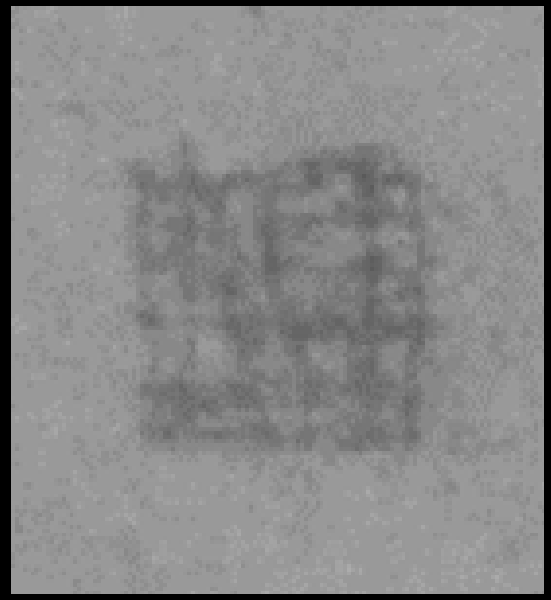


6) Plant those seeds!

- Timing aligns with natural field germination (October for us)
- Warm holding tanks will delay germination until you are ready
- First thing you do is repeat your assessment of the seeds
  - Final count for planting estimates
  - Assessment of mortality
- Divide seeds so that you have one bag per plot
  - Volume is based on seed assessment info
  - 90 good seeds per ml requires 1.111 liters for a 100k seed plot

6) Plant those seeds!

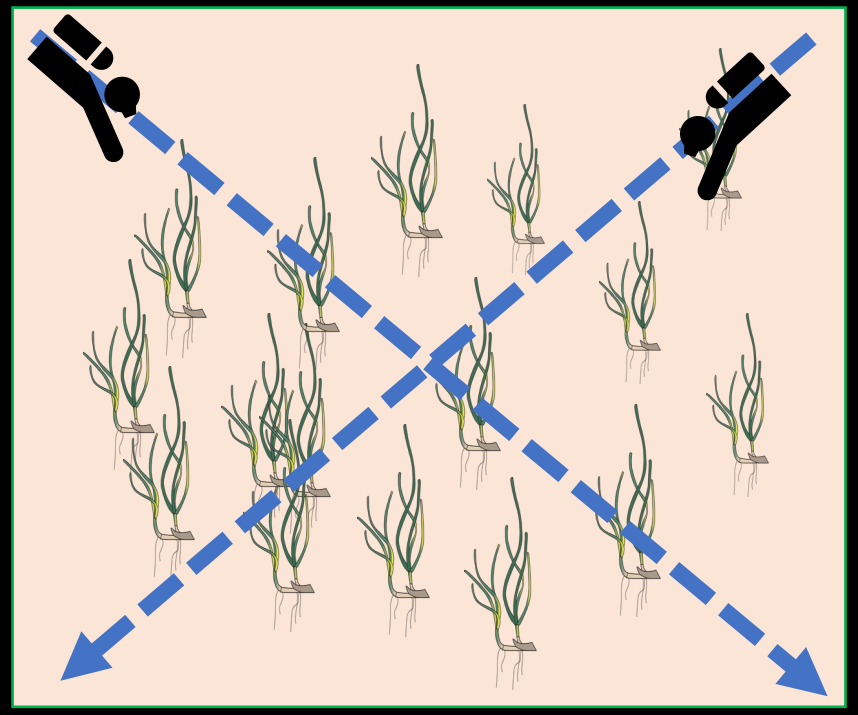
- 4 people per boat
- GPS delineated plot boundaries
- Marker on each plot corner
- 4 passes in each direction to make a waffle
- Seeds sprinkled by 2 people, one on each side of the boat
- 4th person helps prep seeds



7) Winter Lab Assessment

- 80 seeds per batch in groups of 20 seeds
- Planted to 7mm depth
- Weekly checks to record seedlings
- Stop after 2-3 weeks no shoots (February)

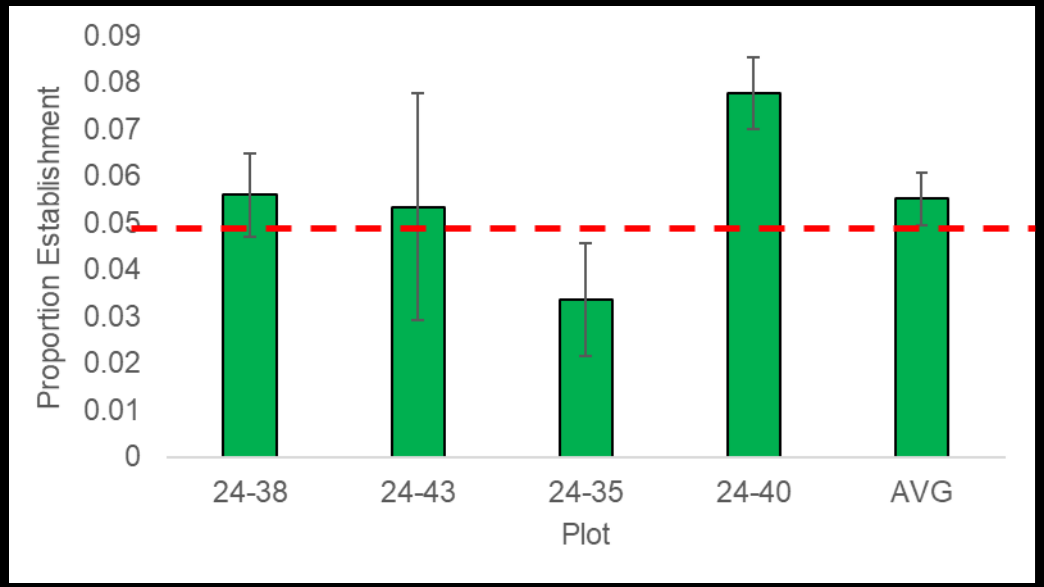
8) Spring Field Assessment

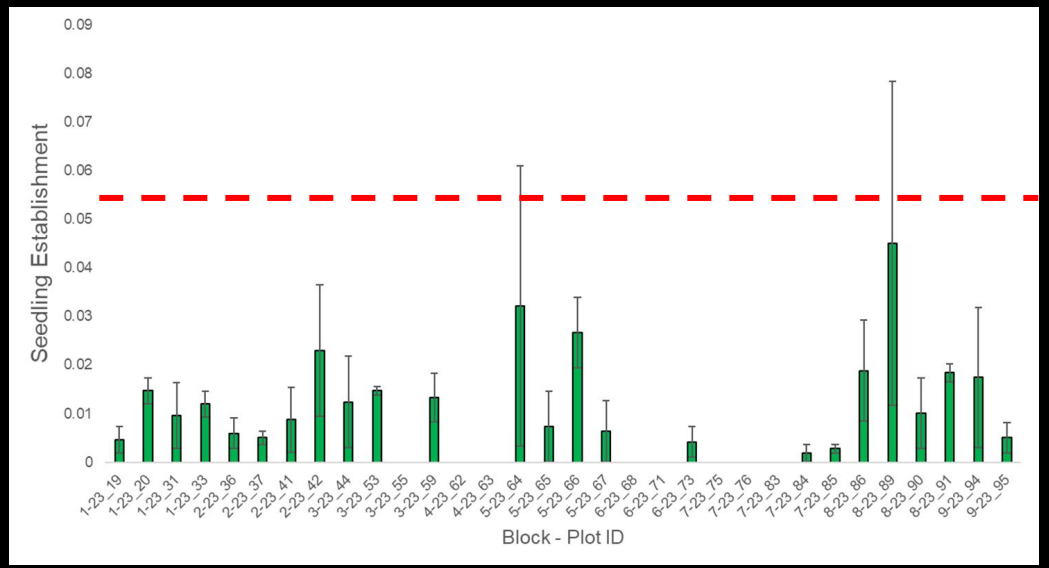


- Assessments occur in the field and lab
- Lab germination study to assess % good seed germination (usually 70-90%)
- Field assessment in April to count seedlings (5% OK, 20% great!)

8) Spring Field Assessment

- Celebrate your success!
- Or drown your sorrows then do a post-mortem about why it didn't work
- Remember the failure is normal
  - VIMS runs 22 to 43% success rate for plot establishment





Quick Stats About Our Process

- We collect 25k to 50k seeds per person per hour
  - We invest typically invest 100 to 200 person hours seed collecting each season
- Human labor for tank stirring is about 30k seeds at the end per person hour spent stirring
- We usually end the season with 2.2 to 6.5 million good seeds ready to broadcast annually
- We can seed 5 acres an hour in a team of 4
- We typically seed 30 to 60 acres annually (90 acres most we've done)

Acknowledgments

Huge thank you to the VIMS Mapping Team for GIS support, the Coastal & Estuarine Ecology Lab, and to the hundreds of volunteers who collected SAV species information over the last 36 years!

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CEEL Coastal Estuarine Ecology Lab

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