Eelgrass Restoration in Chesapeake Bay:

The emerging issues with large-scale restoration using seeds

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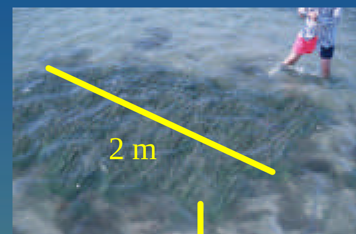


? ?

‘Strategy to Accelerate Protection and Restoration of SAV in Chesapeake Bay’

By Dec. 2008, plant at least 1000 acres at multiple sites!!

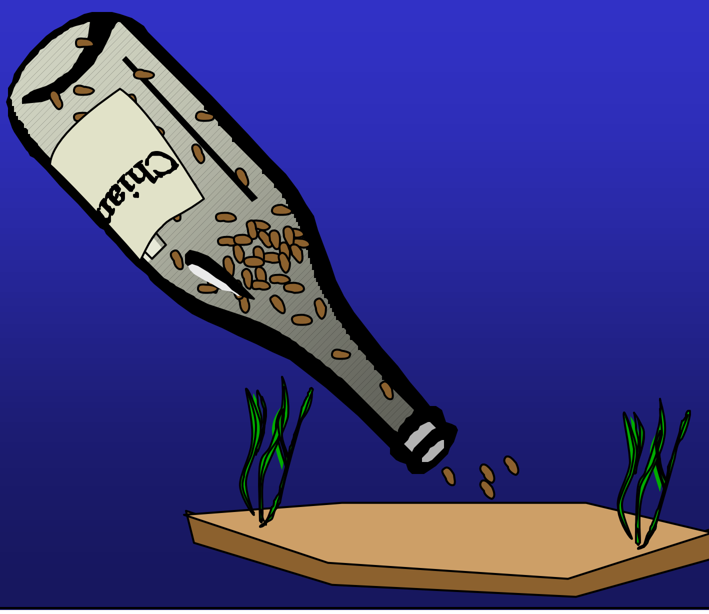
WHAT DO WE KNOW?

- Seeds available for harvesting in a 3 week window
- 10-20% of shoots are reproductive (although there are exceptions)
- Reproductive shoot densities: up to 370 m^{-2} (1.5 million $acre^{-1}$ but spatial and temporal patchiness is the norm)
- Viable seeds per reproductive shoot – 20-150 (depends on length) (225 million seeds $acre^{-1}$)

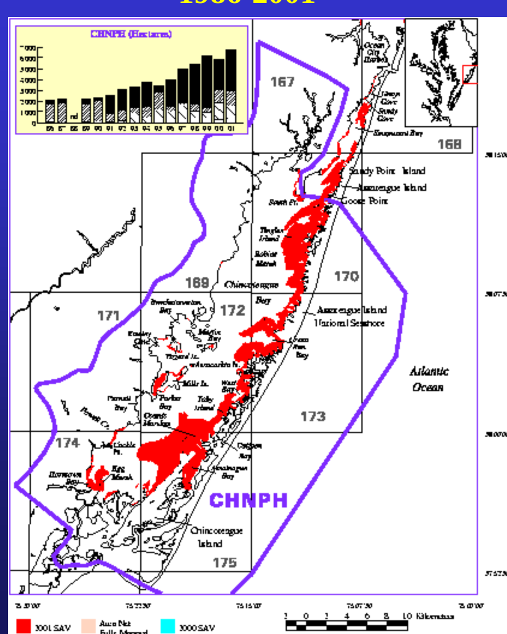
WHAT DO WE KNOW?

- Broadcast seeds remain close to where they settle on sediment surface
- Seed germination in mid-November related to temperature and anoxia in sediment
- Low initial rate of seedling establishment (5-10%)

WHERE ARE THE BOTTLENECKS?



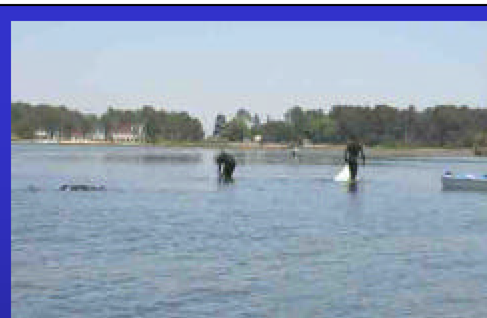
RECOVERY OF SEAGRASS TO CHINCOTEAGUE BAY 1986-2001




Avg. 600 acres
EACH year for 16
years!!


WHERE ARE THE BOTTLENECKS?
Hand harvest labor intensive and
only a few million seeds collected

**SEED
COLLECTION
LATE MAY – MID-JUNE**



2001
6.6 million seeds in 204 collecting hours = 32,500 seeds/hour

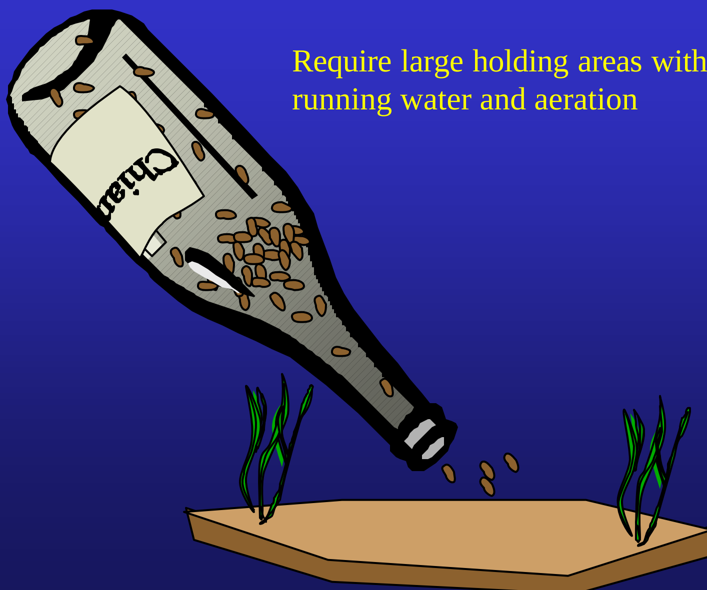
2002
2.5 million seeds in 246 collecting hours = 10,000 seeds/hour

2003
5.2 million seeds in 310 collecting hours = 16,800 seeds/hour

SOLUTIONS??

- Mass harvest reproductive shoots at period of peak seed release to insure collecting most number of viable seeds

WHERE ARE THE BOTTLENECKS?



Require large holding areas with adequate running water and aeration

SOLUTIONS??

- Build or use existing facilities that have the holding capacity, e.g. Piney Point Aquaculture facility

WHERE ARE THE BOTTLENECKS?

Problems of mass storage of plant material
i.e., Seed mortality

SOLUTIONS??

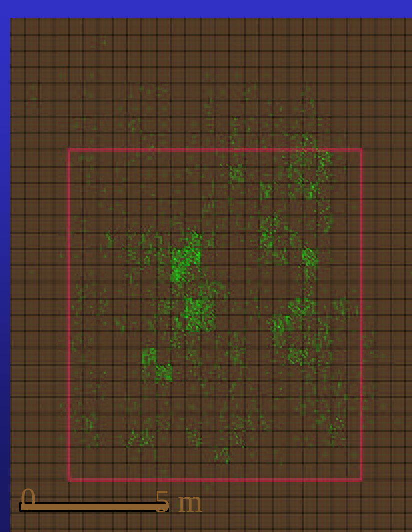
- Conduct experiments on effects of temperature and dissolved oxygen, as well as seed scarification


Is seed distribution a bottleneck?
Chiati


seeds
V25

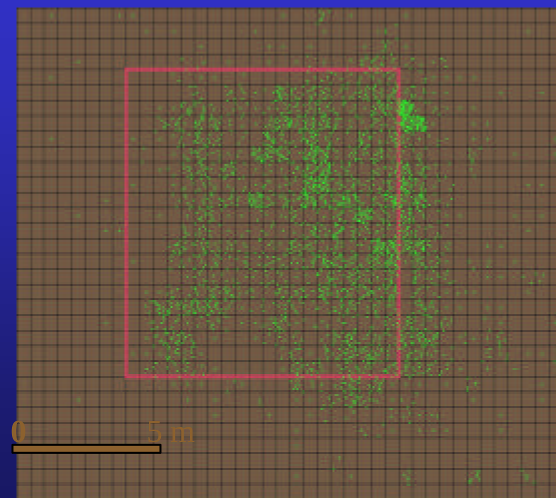
Rappahannock River

- 50,000 seeds broadcast in 100 m^2
- 2333 seedlings total (4% of all seeds broadcast)
- 2173 seedlings in plot (93% of total seedlings)

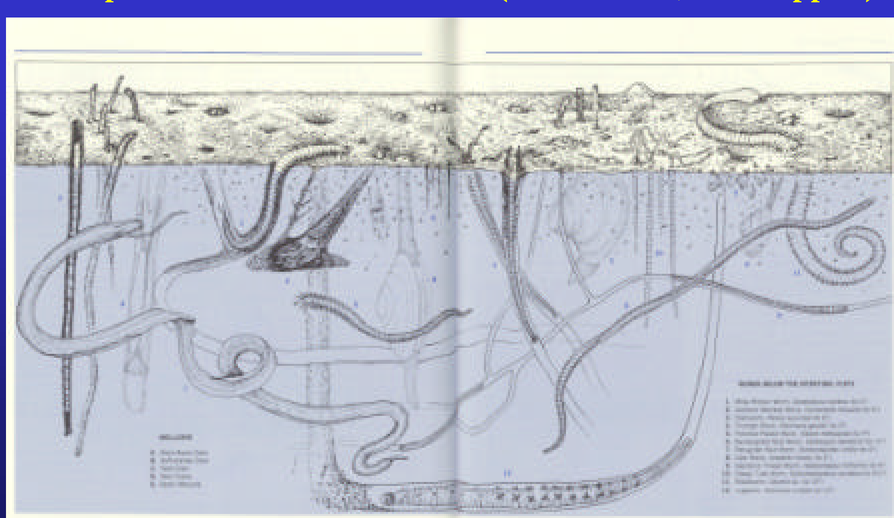


South Bay

- 50,000 seeds broadcast in 100 m^2
- 3237 seedlings total (6.5% of all seeds broadcast)
- 2295 seedlings in plot (71% of total seedlings)



Seeds retained close to where they settle due to topographic complexities of sediment surface (bioturbation, sand ripples)



Luckenbach and Orth (1999) Aquatic Botany 62:235-247

Why the meter-scale patchiness?

1) operator error

- correctable with broadcasting technology

2) patchy distribution of surface roughness

3) post-broadcast redistribution by waves

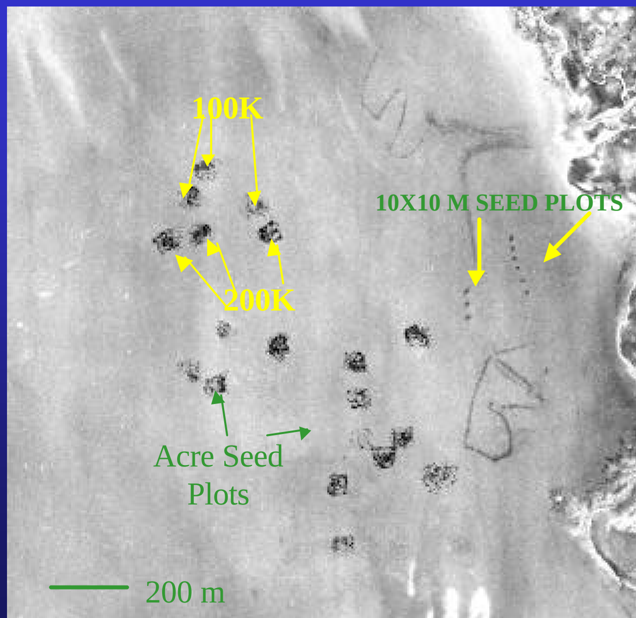
} facts of life

Does evenness matter to the PLANTS?

- At the highest densities (500-1000 seeds/m^2), shoot competition due to cm-scale clumping is observed
- Restoration applications utilize much lower densities (12-48 seeds/m^2)
- Uneven distribution on the scale of meters unlikely to affect plant growth (similar to natural patchy pattern)

⇒ Not a bottleneck, in terms of restricting plant growth

SOUTH BAY – JULY 2002 (Seeds broadcast fall, 2001)



Does evenness matter to the PLANTERS?

Monitoring methods may be sensitive to evenness:

- frequency counts
- % cover of random samples estimated by divers
- remote sensing – total pixel counts

⇨ Match distribution method to monitoring method

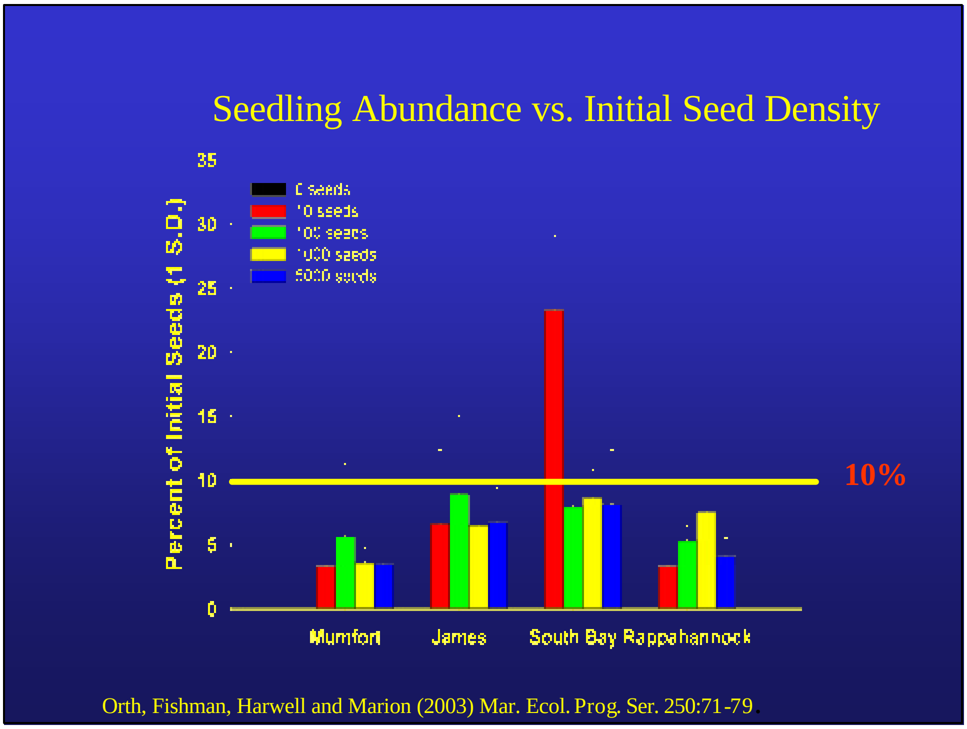
WHERE ARE THE BOTTLENECKS?

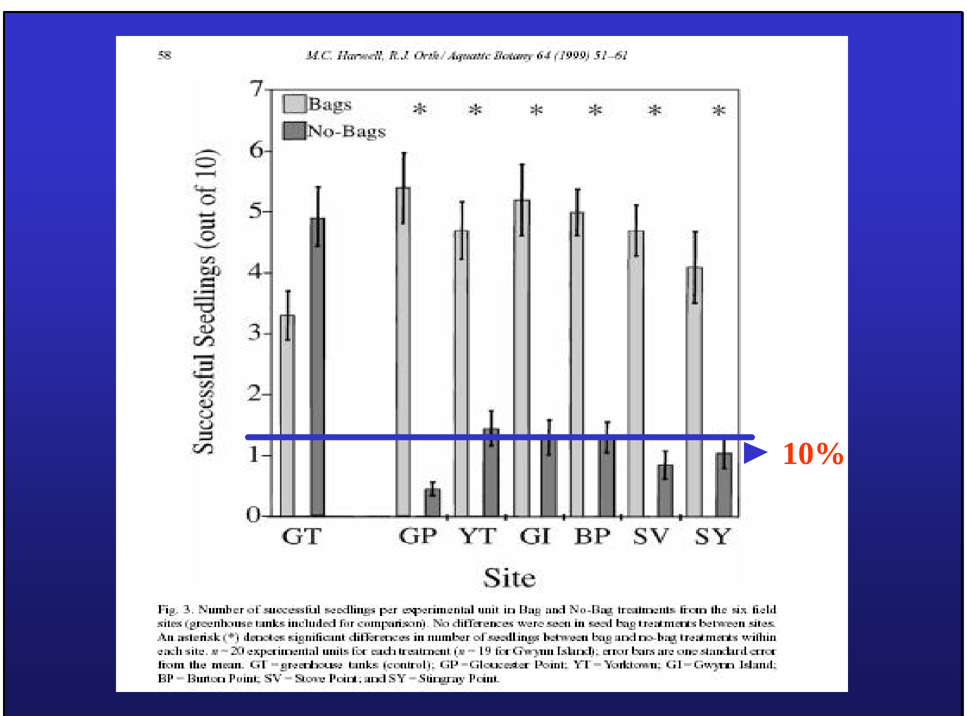
Low seedling success: 5-10%

100 Meter^2 Seed Plot Results

Site	No of quadrats	No of measured cells	Total # seedlings	% of 50,000 seeds	% seedlings inside plot
James	70	1120	6921.4	13.8	92.5
Rappahannock	49	784	2333.4	4.7	93.1
South Bay Offshore	63	1008	3237.2	6.5	70.9
South Bay Inshore	56	896	2127.4	4.3	79.3
Magothy Bay	49	784	5146.6	10.3	92.2
Lynnhaven	49	784	2351.9	4.7	85.7

Orth, Fishman, Harwell and Marion (2003) Mar. Ecol. Prog. Ser. 250:71-79

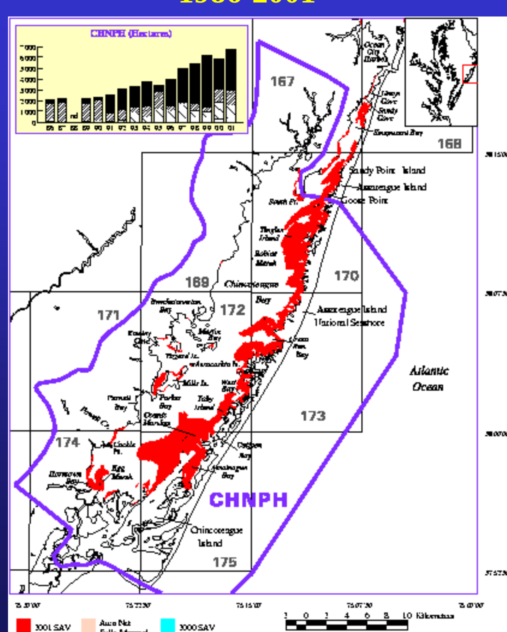

Seedling Abundance vs. Initial Seed Density
Percent of Initial Seeds (1 S.D.)
35
30
25
20
15
10
5
0
10%
Mumfort
James
South Bay
Rappahannock
Orth, Fishman, Harwell and Marion (2003) Mar. Ecol. Prog. Ser. 250:71-79


58
M.C. Harwell, R.J. Orth / Aquatic Botany 64 (1999) 51–61
Successful Seedlings (out of 10)
7
6
5
4
3
2
1
0
Bags
No-Bags
* * * * * *
10%
GT
GP
YT
GI
BP
SV
SY
Site
Fig. 3. Number of successful seedlings per experimental unit in Bag and No-Bag treatments from the six field sites (greenhouse tanks included for comparison). No differences were seen in seed bag treatments between sites. An asterisk (*) denotes significant differences in number of seedlings between bag and no-bag treatments within each site. n = 20 experimental units for each treatment (n = 19 for Gwynn Island); error bars are one standard error from the mean. GT = greenhouse tanks (control); GP = Gloucester Point; YT = Yorktown; GI = Gwynn Island; BP = Burton Point; SV = Stove Point; and SY = Stingray Point.

SOLUTIONS??

- Test methods of protecting seeds:
  - decrease predation
  - create more hospitable environment for seed germination
- Assess time compared to broadcasting for seedling success

RECOVERY OF SEAGRASS TO CHINCOTEAGUE BAY 1986-2001



The Adaptation and Application of Modern Agricultural Production Practices to SAV Restoration

- Tony Mazzaccaro Ph.D.
- Arthur L. Allen Ph.D.
- Eric B. May Ph.D.
- University of Maryland Eastern Shore, Dept. of Natural Sciences, Living Marine Resources Cooperative Science Center

Basic Needs for Successful, Large Scale SAV Restoration

- 1. A Large, Cost effective supply of Seed
- and Seedlings

- 2. Efficient Mechanical Means to Plant
- Them

Secondary Needs

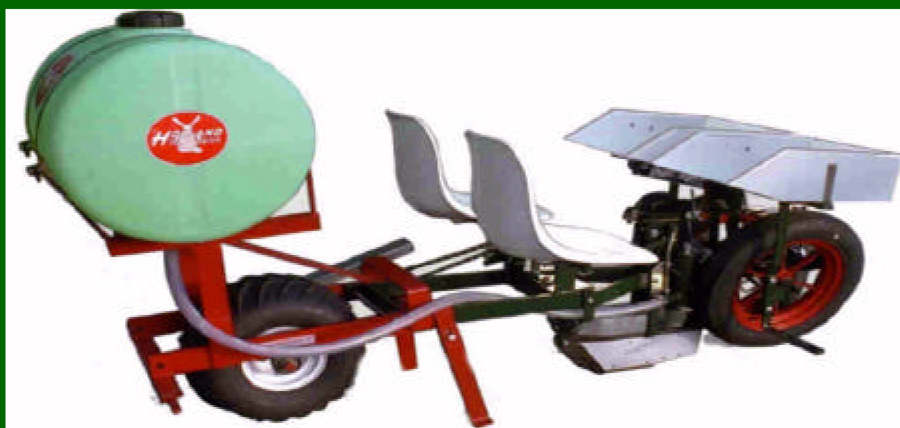
- 1. Selective Breeding to Produce Superior
- Performing Cultivars
- a. Higher Seed Germination Rates
- b. More Robust, faster growing Plants
- c. Increased Tolerance to Selected
- Environmental Conditions

d. Increased Seed Production, etc.

2. Judicious Restoration Site Selection

Basic Transplanting Machine

Advanced Model With possible Drive Wheel



Multiple Row Configuration

The Planting Arms on Disk Drive

Planting Arms on Chain Drive

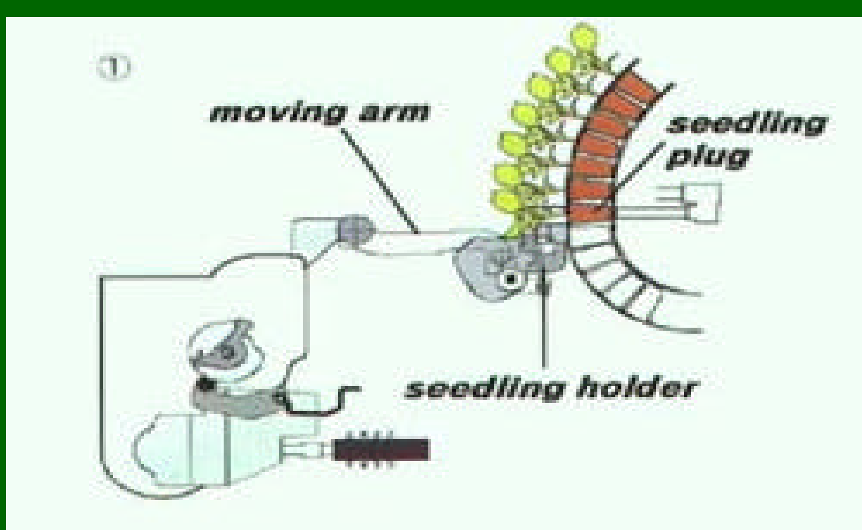
Various Planting Arms

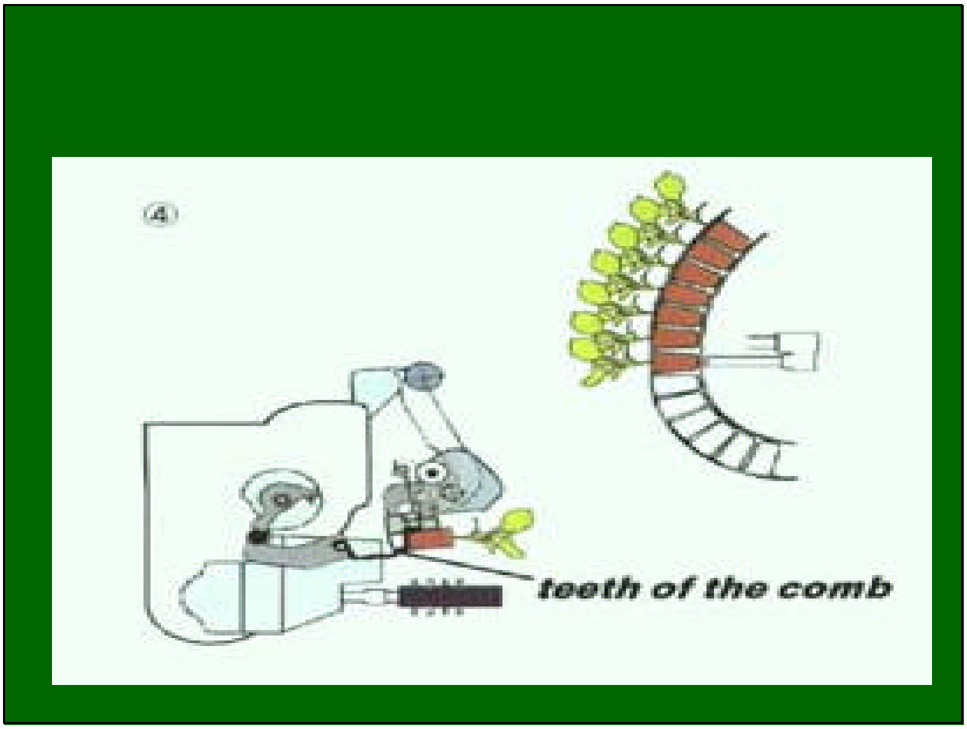
Small Acreage Rice Planter

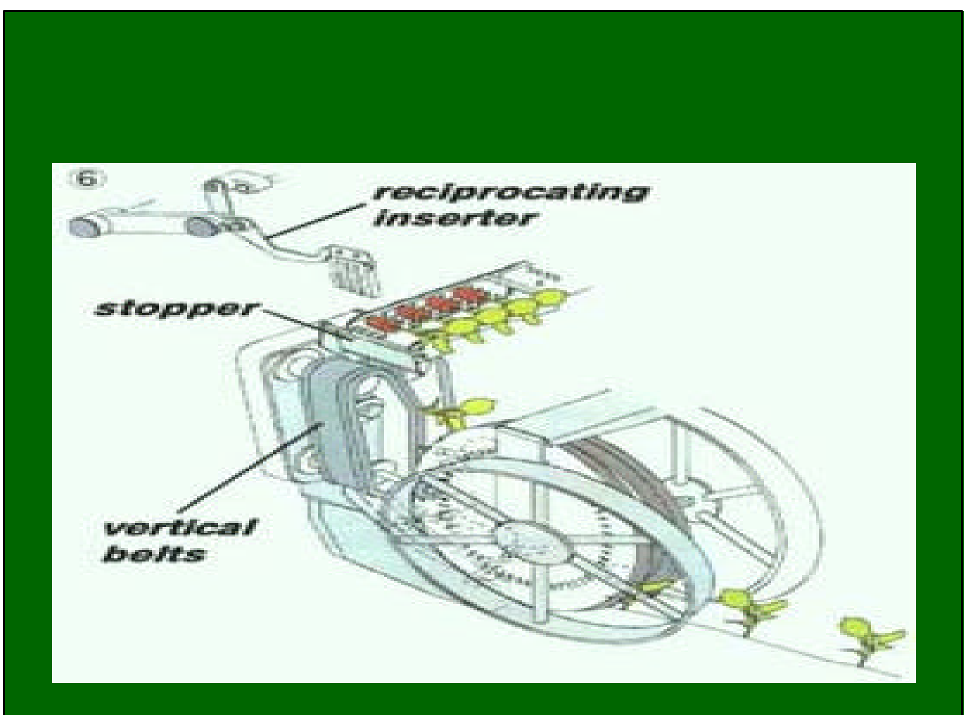
Rice Planter

Minoru Flexible Flats

The Minoru System




4
teeth of the comb


6
reciprocating inserter
stopper
vertical belts

Minoru Tractor pulled Planter

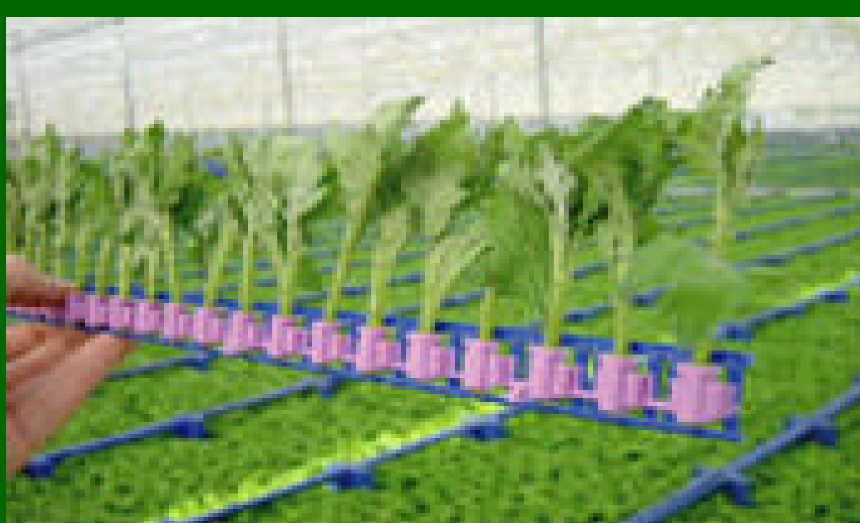
Minoru System Two Row Planter

Automatic Tray Filler and Seed Planter

Tray Planter 4,000 Plants Per Hour

Cutting Planting Machine, 20,000 plants per hour

Cuttings planted

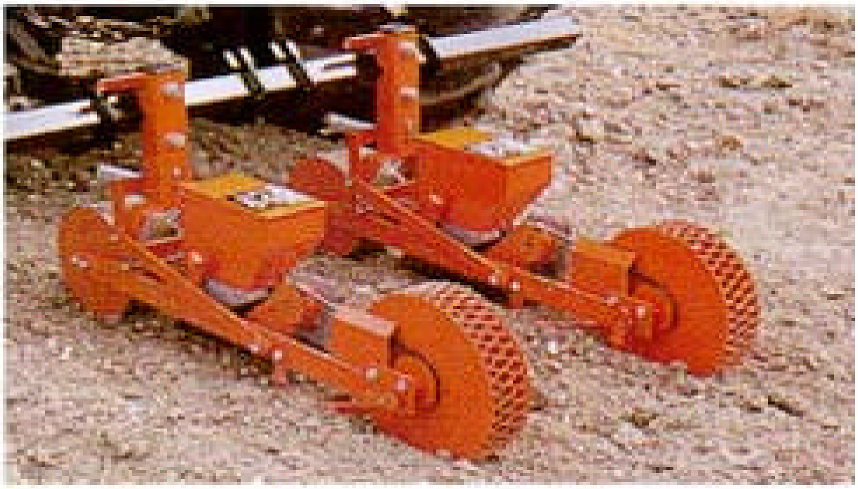


Cuttings in Greenhouse

Seed Drill

Seed Drill

Stanhay Planter



Stanhay Planter

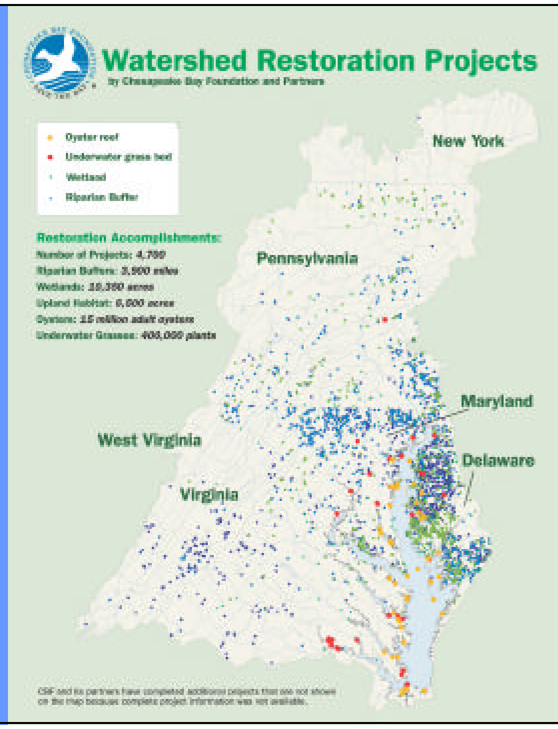
Onion Mower

Large Scale Underwater Grass Restoration: Experiences of the Chesapeake Bay Foundation

CBF's Underwater Grass Restoration Priorities:

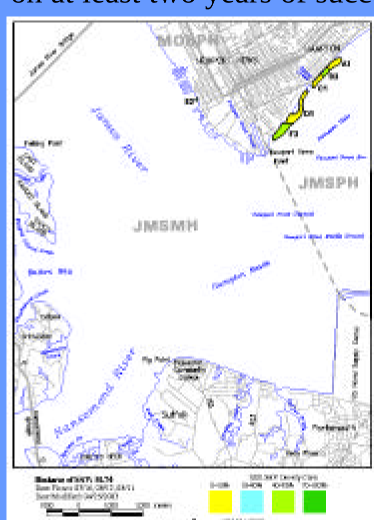
- ❖ Improve water quality by reducing nitrogen inputs into the Bay and it's tributaries
- ❖ Engage an active constituency in hands-on restoration and other water quality improvement goals
- ❖ Examine and test new planting technologies

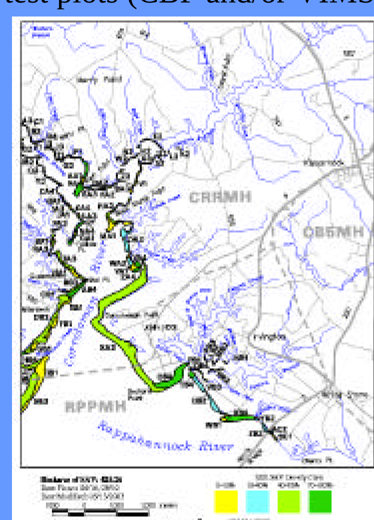
❖



Large Scale Test Planting: October 2001

Site Selection: Sites in Rappahannock and James Rivers chosen based on at least two years of successful test plots (CBF and/or VIMS)





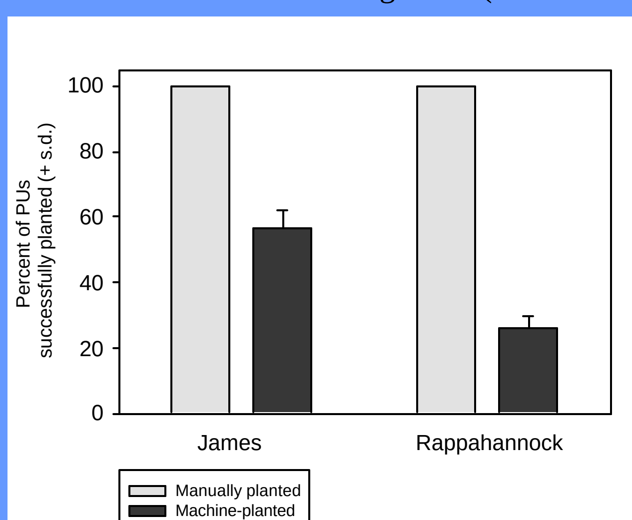
Eelgrass collected from donor beds in York River; Volunteers employed to collect plants and assemble for boat planting

Clip attachment used on two-wheeled pontoon planting boat (Seagrass Recovery, Inc.)

One acre plots planted at each site by CBF; adjacent test plot to compare hand versus machine planting coordinated by VIMS

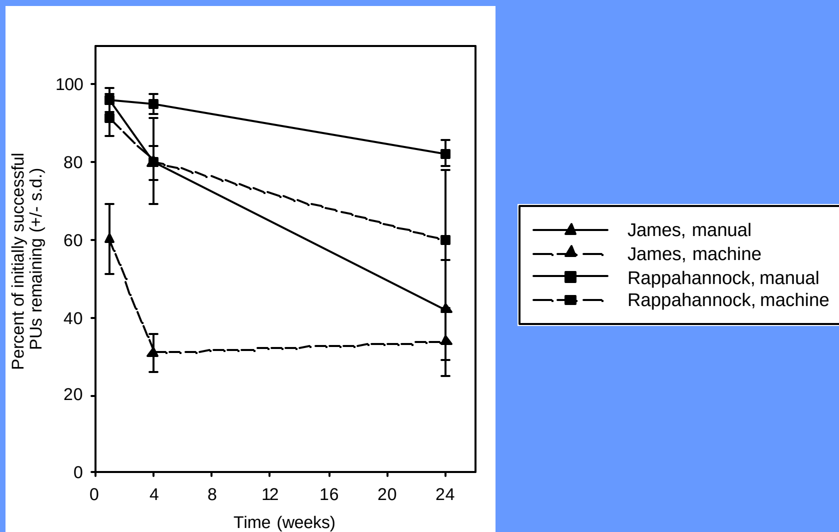
Results from Test Plots- Rappahannock and James Rivers

Percent of Successful Planting Units (VIMS Data)



Results from Test Plots- Rappahannock and James Rivers

Survival of Successfully Planted Planting Units (VIMS Data)



One Acre Plots in Rappahannock and James Rivers

(10-15,000 plants in each acre plot; planted bare root in bundles of 2-5 plants)

James River:

Nov 2001- 40% survival

May 2002- 30% survival

October 2002- 30% survival

June 2003- 30% survival

Rappahannock River:

Nov 2001- 65% survival

May 2002- 45% survival

October 2002- 40% survival

June 2003- 40% survival

Conclusions from 2001 Large Scale Planting

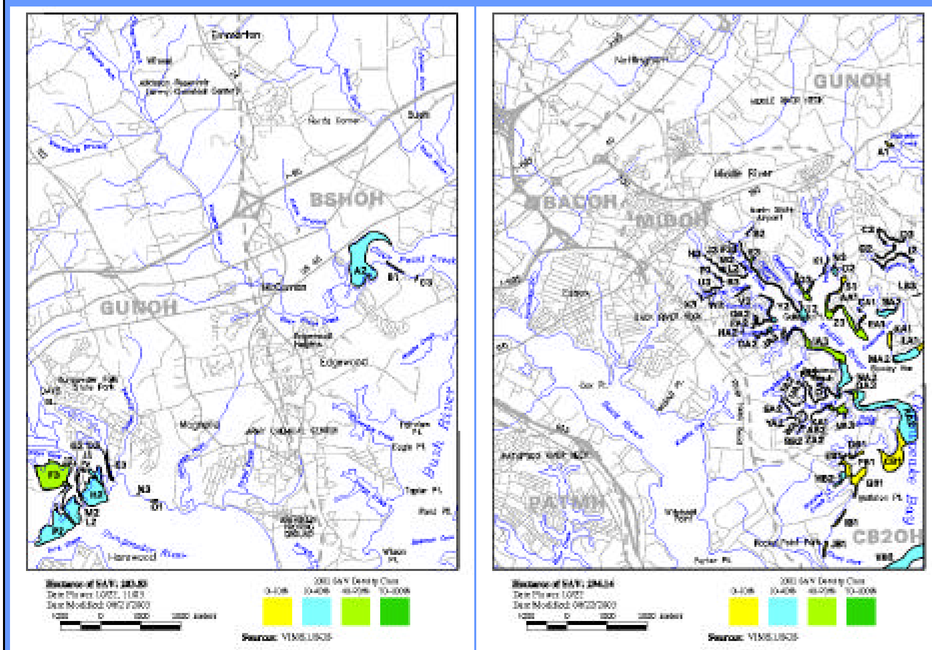
- ❖ Mechanical planting was not as efficient as hand planting
- ❖ Great loss of eelgrass when attaching to clip on wheel, but "floaters" were collected and planted
- ❖ Labor intensive collection and preparation process
- ❖ No large source of eelgrass plants without field collection
- ❖ More time required to fine tune mechanisms
- ❖ Increase planting efficiency – Different planting mechanism
- ❖ Test freshwater species – Wild Celery
- ❖ Avoid harvesting existing plants - Use plants grown in peat pellets according to protocol developed by Seagrass Recovery, Inc.

July 2003 Large Scale Test Planting

Funding provided by RAE and partners include NOAA CB office and MD NERRS

Site Selection:

- ❖ Otter Point Creek (Bush River) and Rocky Point (Middle River) both had at least 2-3 years of successful test plots
- ❖ Two different sediment types (muck and hard sand)
- ❖ Both easily accessible for subsequent monitoring as well as plenty of bottom for ½ acre plots as well as test rows



Plant Sources:

❖ Seedlings: wild celery grown in peat pots (5,500 total)

❖ Bare Root plants assembled in peat pots (12,500 total)

❖ Peat Pots with wild celery seeds (1,800 total)

❖ ½ acre plots planted with boat at each site

❖ 12 test rows (each row consisted of 2 hand planted and 2 machine planted rows) at each site

Conclusions from 2003 Large Scale Planting

- ❖ Study results not available yet, but planting efficiency appeared greater than 2001.
- ❖ Ability to grow material for mechanical planting was substantial improvement but it is still labor intensive propagation and preparation process
- ❖ Need biodegradable alternative to metal base for peat pellets
- ❖ Peat pellets with bare root appeared most effective
- ❖ Different sediment types require adjustments to mechanisms which in small scale projects can be a significant amount of time
- ❖ Bottom debris common in freshwater areas presents challenges to mechanical planting
- ❖ If successful, mechanical planting should be pursued further