Summary of the Workshop on Restoration of Submerged Aquatic Vegetation in the Hudson Estuary

October 8, 2014
Norrie Point Environmental Center
Hudson River National Estuarine Research Reserve (HRNERR), Staatsburg, NY 12580

On October 8th, a workshop on Restoration of Submerged Aquatic Vegetation (SAV) in the Hudson River Estuary was held at Norrie Point Environmental Center, at the offices of NYSDEC HRNERR. The goal of the workshop was to bring together experts to begin the discussion on SAV restoration in the Hudson Estuary, following a historic loss of Vallisneria americana after storm events in 2011. This summary consists of notes compiled during and after the workshop in order to document presentations, discussions, and break-out groups. Key points of presentations are outlined, and research gaps, monitoring needs, logistical questions, and next steps are identified. The workshop was developed around a draft decision tree for SAV restoration in the Hudson, with the goal of providing feedback and further refining the tree to guide future decision-making. Feedback on this decision tree from the workshop is also documented below.

The event was attended by 37 participants (Appendix A). See Appendix B for the brief agenda. Most of the presentations, the decision tree used in the workshop, maps of documented SAV, and other resources are available at https://www.hrerr.org/estuary-training/trainingtopic/sav-restoration-workshop/

Presentation key points

- **Betsy Blair (NYSDEC HRNERR) and Stuart Findlay (Cary IES): Welcome and Introduction**
  - The purpose of this forum is to figure out our management strategy for moving forward.
  - What do we know now, what do we need to learn before making any decision.
  - We’d like to be in a better position to know what to do about SAV restoration before and after the next storms.

- **Sarah Fernald (NYSDEC HRNERR): Previous SAV Extent and Functions**
  - Hudson River Estuary: SAV is very light limited, realistically found at 1m depth or less
  - The SAV mapping efforts (DEC) documented SAV inventories (1997, 2002, 2007) with minimum mapping unit of 163 m²
  - 2014 photos were taken in August but have not been interpreted
  - 2011 Hurricanes Irene and Lee had a very large sediment load (2.7 million tons) and high water levels and energy. Coincidentally we saw drastic loss of SAV in the following years.
  - *Hydrilla* is present in the Croton River and Bay (Chris Doyle provided facts)

- **John Ladd (NYSDEC Hudson River Estuary Program): Sediment Data from Shallow Water Mapping**
  - Shallow-water (<3 m) mapping efforts show water bottom elevation, acoustic reflectivity (substrate hardness), and side-scan imagery (sediment environment, flow regime)
  - We can look to determine what, if anything, controls where SAV can grow
  - Resources are at: http://benthic.info
Additional information sources include:
- Stevens Institute of Technology: hydrodynamic flow model
- Robin Bell, et al.: sediment environment mapping
- Bradley Furman, SUNY Stony Brook: study on relationships between water depth, flow characteristics, and presence of Vallisneria and Trapa; was not able to predict presence/absence of either species

- **Stuart Findlay (Cary IES): Current Status of SAV**
  - We know there is some SAV recovery going on in the estuary (Cheviot, ~river km 109-111, and Tivoli Bays, ~river km 98-100)
  - We need to interpret the 2014 photos to estimate recovery
  - SAV volunteer monitoring program (ongoing since 2003) – designed to look at change of known SAV patches between aerial photo coverage, not wholesale loss or recovery
    - Between 2013 and 2014, 165 repeat points monitored: 5 showed negative change, 3 showed positive; 18 targeted site visits: 4-6 new positive detections.
    - The vast majority of repeat points had NO SAV present.
  - After 2011 storms, light conditions did not seem too bad, didn’t see dramatic change; some spatial variability in light (up river – a little clearer)
  - Dave Strayer: In the initial sediment mapping (Findlay, Strayer, Bain, and Nieder, 2006) we found a relationship between SAV and sediment. Larger beds of SAV had finer sediments and higher organic content.

### Impediments to Recovery

- **Dave Strayer (Cary IES): Invasive Threats**
  - Invasions are frequent and ongoing in Hudson – new species establishes every 1.5 years
  - There are 3 kinds of invasions that might affect SAV in the Hudson: competitive new plants (e.g., Hydrilla, Brazilian waterweed, Australian stonecrop), species that kill plants (e.g., grass carp, mute swan), and species that live in SAV (e.g., snakeheads, amphipods)
  - New invasions will likely change SAV beds and their ecological functions in unpredictable ways, but we have good opportunities to reduce invasion rates before invasions happen.

- **Katia Engelhardt (University of MD Center for Environmental Science): Invasive Hydrilla**
  - Traits of Hydrilla make it highly invasive (lower light requirements than other species, no coevolved natural enemies, several dispersal strategies, grows really rapidly)
  - There are both positive and negative impacts on ecosystem
  - Evidence for interactions between Hydrilla and Vallisneria depends on density; Vallisneria can curb establishment/growth of Hydrilla; Hydrilla can facilitate establishment of Vallisneria; Hydrilla will compete with Vallisneria and other plants
  - Management options include: public education, bringing back competitors, herbicides (difficult in tidal rivers), mechanical removal (problematic because fragments of Hydrilla can propagate), biocontrols (potentially problematic)
    - Eradication is rare, not well documented
    - Management should start immediately

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Jonas Hamberg (SUNY ESF student and 2014 Polgar Scholar): Factors Impacting the Loss, Regrowth, and Successful Restoration of *Vallisneria Americana* in the Hudson River
- Investigating causes of SAV loss/impediments to recovery (focus: burial and herbivory)
  - Burial by sediment is possible explanation; no evidence for herbivory in the Hudson River Estuary from this study; increasing storms could be problematic
- Burial greenhouse study: 40 turions at 4 depths (5, 10, 20, 30 cm)
  - No growth of any turions – 5 cm might be too much for turions; sediment was compacted; high temperature and lack of flow
- Burial field study (Tivoli Bay): 30 turions from the river planted at 2, 5, and 10 cm
  - At 2 cm – 40% sprouting; 5 cm – 20% sprouting; 10 cm – no sprouting
  - Observations: apparent difference in growth due to depth; turions in the river are within 1 cm of the surface; there does not appear to be a 'bank' surviving between seasons; nursery stock plants seem to survive and thrive in the river and un-sprouted turions do not survive over the summer
- Herbivory field study: 12 plots (4 cage, 4 cage-controls, 4 open; 8 pots in each; 3 harvests)
  - Result: no apparent herbivory, no protection was needed for restoration
    - Bad year for blue crab; didn’t test herbivory of turions or herbivory from invertebrates/small fishes; cages increase sediment retention

Restoration experience from elsewhere
- Ken Moore (Virginia Institute of Marine Science/Chesapeake Bay NERR): Chesapeake Bay
  - We used historical photos to set SAV restoration goals. Work to accomplish goal through improving water quality, protecting existing beds, and restoring beds.
  - Annual mapping of SAV from aerial photos → variability, overlay water quality data
  - State of VA requires pilot tests (challenge: small-scale may not replicate large-scale)
  - Improve restoration efforts by quantifying factors affecting seed germination:
    - Light: no effect
    - Oxygen: germination increased in oxygenated water
    - Temperature: germination increased, time to germination decreased with increasing temp. (optimum between 13-22 ℃) → plant during warming periods
    - Salinity: time to germination increased with increasing salinity
    - Sediment type: increased percentage of sand had positive effects on germination
    - Burial depth: no effect on germination down to 10 cm
  - Restoration site selection: water quality, historical abundance, presence of SAV in adjacent areas (species diversity), substrate, accessibility

- Maile Neel (University of Maryland): Genetics of *Vallisneria*
  - *Vallisneria* reproduction: both sexual and asexual (turions, rafting vegetation)
  - In the face of environmental changes, extant populations will either: acclimate (requiring phenotypic plasticity), adapt (phenotypic variation and genetic variation), relocate (natural dispersal, local restoration, or assisted migration), or become extirpated
  - Genetic considerations for resilience/restoration: # of alleles or genotypes in populations; levels of heterozygosity within individuals; adaptation of individuals to local environment
  - Alternative approaches for active restoration (planting) – range of recommendations (represent local amounts and patterns of genetic diversity, or augment genetic diversity)
  - Hudson River *Val.* (data from Brittany Marsden) relatively low genotypic and allelic diversity; no significant inbreeding, but hints of bottlenecks; highly differentiated from *Val.* in other sampled rivers
  - Perspective from the Chesapeake: Restoration plantings from local stocks showed similar allele numbers to natural beds. Lack of data (can only look at successful examples).
Research questions

Analyze existing data:

- Can we map density classes? (Haven't done this with aerial imagery, but volunteers document density) – Can we do this with 2014 photos? Can we go back to earlier inventories and analyze?
- Erosion/deposition dynamics of areas where SAV has been changing
  - No pre-storm data for bathymetry/sediment; some core information
  - Has the bottom of the river gotten deeper or shallower?
- Where did the sediment go? Areas of accumulation vs. scour?
  - Haven't evaluated where sediment was coming from, but navigation folks may have some information; Stevens Institute tried to model that; USGS had sediment gauges; Hudson River Foundation has funded related studies – will know more in a few months
- Analyze correlation of fish to SAV, using fish data, maps, and studies
  - Are there some areas without documented SAV that are important for fish? – could be identified for planting. If not, another strike against areas without documented SAV
  - Do fish data show consequences of SAV loss?
  - Sources of data include: Utility fish and ichthyoplankton work, maps by AKRF, Inc., NYSDEC including Hudson River Fisheries Unit
  - Look into O'Connor et al., 2012
- Analyze volunteer monitoring data from this year.

Experiments:

- What's the role of ice? Which plants are affected? (have ice data from Stevens)
- How much is enough (density/extent) for herbivory not to be a factor? Is herbivory a problem? Which species? Exclosures – How big of an area is needed, and for how long? Different types?
- Can we plant *Vallisneria* around *Hydrilla* to help increase density?
- Seeds – how much is known about demography at early stage? Is it density-dependent?
- "Nurse crops" for *Vallisneria*?
- What planting approaches work best? What plant material work best in different habitat types? Do certain approaches work better than others with scaling up? → experiments
- Other species interactions with *Vallisneria* (waterfowl, plants etc..)
- Pilot the Grasses in Classes program?

Collect more data:

- SITE SUITABILITY
  - Test for suitable habitat (depth, light, soils)

- FACTORS IMPEDING RECOVERY
  - Evaluate conditions where SAV was before and isn’t now – any changes? → sondes during growth period to get baseline
  - Need to determine why SAV might be recovering in some areas but not others
  - Just hurricanes, or are there background stresses that would impact success anyway?
  - What plant diseases might be problematic?

- SEDIMENT
  - More understanding of sedimentation dynamics from storms – areas most affected?
  - What is the sediment threshold above which plants can't survive? Which plants?
GENETICS
- Data on genetic composition of plants that persisted or are recolonizing on their own; genetic composition of restoration stock and plantings
- Understand links between genetics and ecological performance
- More information about genetics and implications for restoration
- If there was a bottleneck, how long ago was it? (population modeling)

FISH
- More information about possible link between SAV loss/recovery and fish production
- Get more information about fish species and relationship to SAV – which species might need it more? More information about other life stages besides juveniles; indirect relationships; migratory fish compared to resident species – different usage of SAV? Larval fish use of different habitat types – is SAV important or not? Look at beach seine data and correlate to SAV locations.

INVASIVES AND OTHER SPECIES
- Interaction between Vallisneria and other species (e.g., Hydrilla) – benefits and problems
- Are there other species that could provide the same benefits? Depends on our goals.
- Do other species actually impact restoration success?
- Need more information on how management actions impact different species
- More research on Hydrilla

OTHERS
- What about smaller patches of SAV that might not be captured by aerial photography? Need to find a way to incorporate into recovery assessment
- What other species of plants could we use, besides Vallisneria?
- What size do recovering beds need to be before they can be harvested for transplanting?

Logistical questions/issues:
- Would a list of priority restoration sites need to go through regulatory review?
- Are there institutional obstacles to planting?
- Political challenges with invasive species management

Monitoring needs
- Consider revamping how we monitor (e.g., annual photos like in Chesapeake Bay)
- To determine trends/conditions, need more data points so we can make comparisons and inform decisions without having to wait too long
- Need simple metrics to be able to assess site suitability
- Monitoring program – overlap: invasives and SAV together
Next steps (other than research/monitoring)

- **Near-term:**
  - Interpret 2014 aerial photos
  - Analyze volunteer monitoring data
  - Look at SAV maps and fish data together with Hudson River Fisheries Unit and SAV folks
  - Define the criteria for suitable environmental conditions
  - Decide on Hydrilla management? Educational signs: Hydrilla and other invasive species
  - Start accumulating seeds and expertise for propagation in greenhouse or by transplantation

- **Next season:**
  - Additional fish sampling, research
  - Conduct more thorough search for small beds – more SAV could be recovering

- ** Longer-term:**
  - Aerial photos every year
  - Nursery for providing plant material for pilot projects and restoration efforts – so you’re not starting from scratch; maybe a few genotypes – need to get this going before next major disturbance; start collecting seeds over time and space – diversity
  - Pilot tests: could test after spring floods and still plant up to July; monitor weekly, bi-weekly to measure growth/conditions; minimum size = 10 m x 10 m, 3 replicates
  - Investigate management issues – public access conflicts, contaminant dredging/capping, dam removal and sediment release, tributary development/dynamics

**Other suggestions to think about:**
- Develop a database of restoration outcomes
- Use decision tree to create map of priority sites
**Decision-tree feedback**

(See [https://www.hrnerr.org/estuary-training/trainingtopic/sav-restoration-workshop/](https://www.hrnerr.org/estuary-training/trainingtopic/sav-restoration-workshop/) for the decision tree version used at the workshop)

- **Is there anything missing?**
  - Storm predictions, return interval, climate change considerations
  - Invasive species predictions
  - Ice
  - Plant diseases?
  - Clarify scope boundaries – river, site, watershed, state (resolution of scope)

- **Recovery**
  - Is SAV recovering – what if it’s a mix of these options? (e.g., slow and patchy recovery) – Where do you ask this question (river-wide/site-specific?)

- **Prioritizing areas/site assessment**
  - Density classes would be useful in determining where to prioritize – look for denser, more stable areas
  - Is there SAV in the region that is recovering near the site? That would make it a plus.
  - Think about ice in site assessment
  - Environmental trends → ‘positive, negative or stable,’ not just ‘positive’
  - Is there good source material nearby? – higher priority site
  - Site assessment → disturbance regime (ice, sediment – deposition or erosion)
    - Look for places with more longevity
  - Invasives: future and current; broaden – native species might impact restoration as well
    - Is the interfering species providing the same benefits that *Vallisneria* would?
  - Does area show lots of variability, or more stability? Prioritize areas with more persistence
  - Incorporating fish – hard to prioritize areas in particular, but want dispersed patches rather than concentration – fish use it throughout river; might be advantage to starting upstream; prioritize based on areas of loss – fish could have been dependent on those areas
  - Add site distribution/connectivity to site assessment – how is this site connected to others?

- Scales: river-wide/site-specific – limited, unclear; add watershed scale. What is scale of ‘site specific’?
- Add regulatory/political issues, institutional constraints to logistical requirements (do we have control of the site – permission and physical access)
- Other efforts: Are there things you can do in the tributaries that can improve conditions?
- Test plantings ~ 2 years to see how they do
  - If test plantings are successful, that’s reason to move forward. If not → why? Is it worth trying again?
- Go back to documented sites, see where SAV is now – pick spots where there are big gaps to fill
  - What conditions are like in areas where SAV is now vs. where it is not

- Would it be helpful to produce a GIS map with layers of priority restoration areas over bathymetry, documented SAV, etc. and use it along with the decision tree?
Other considerations to keep in mind

- **Monitoring, measuring success**
  - How to measure natural recovery/successful restoration?
  - Have to remember that conditions (e.g., water clarity, blue crab) in Hudson vary a lot year-to-year – keep in mind for pilot projects
  - How long for monitoring pilot projects?

- **Decision-making**
  - Identify temporal/spatial changes to site for a long time before making decision
  - Think about investment in restoration – next big disturbance could wipe out hard work
  - How much do you spend on research/monitoring vs. active restoration
  - Time lag – we see SAV loss, how long does it take for you to decide what to do? How long do you wait before you attempt something?
  - Locate SAV restoration along with other restoration efforts (e.g., side channel)

- **Recovery**
  - Set target based on historical records – get a reference
  - Aerial photos might miss early patches because of low density – need to ground truth
  - If 30% of peak coverage (2002) is back, don’t need to invest in active restoration
    - In the meantime: nursery, pilot planting, habitat suitability

- **Climate change**
  - Increase in big events → could pose problems for restoration efforts
  - Protection from storm surge – consider areas with emergent tidal wetlands – lower flow
    - Also opportunities for migration with SLR
  - We should not necessarily manage to Irene/Lee scenarios – these are rare events
  - SLR – focus restoration in shallower areas – less likely to be drowned

- **External factors that affect success:**
  - Institutional factors
  - Biogeochemical factors
  - Dredging
  - Combined sewer overflows
  - Energy projects (pipelines, cables)
  - Industrial discharges (thermal, etc.)
  - Wave energy
  - Adjacent land ownership, access
  - Plant diseases? Epifauna?
  - Marinas, boating patterns

  - How to consider shoreline characteristics?
  - Avoid areas such as tributary mouths – sediment pulses with increased storms

- **Proximity to other beds**
  - Where you see SAV currently growing does not necessarily mean it would be an easy site for restoration – need to consider sediment substrate
  - Could focus on areas where SAV did not come back
  - Instead of co-locating with returning beds, may be better to spread restoration throughout estuary. Also, adjacent areas may not be suitable. However, co-locating restoration with existing beds may help reduce herbivory impact
# Appendix A: Participant List

* Members of the planning team

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Appendix B: Agenda

SAV Restoration in the Hudson Estuary
An invitation-only working session to discuss SAV restoration in the Hudson River Estuary

Time: October 8, 2014, 8:30 a.m. until 4:30 p.m.
Location: Hudson River National Estuarine Research Reserve at Norrie Point
Purpose: To bring together resource managers, scientists, and others to discuss the feasibility of restoring Vallisneria americana in the Hudson River Estuary

Agenda

8:30 – Registration, coffee and breakfast

9:00 – Welcome and introductions – Stuart Findlay Cary IES, Betsy Blair NYSDEC HRNERR, Emilie Hauser NYSDEC HRNERR

9:30 – Introduction to the Hudson, current state of knowledge on SAV, and scope of loss
1. Previous SAV Extent and Functions – Sarah Fernald, NYSDEC HRNERR
2. Sediment Data from Shallow Water Mapping – John Ladd, NYSDEC HREP
3. Current Status of SAV – Stuart Findlay, Cary IES
4. Questions and answers

BREAK 10:30-10:40

10:40 – Impediments to recovery
1. Invasive Threats – Dave Strayer, Cary IES
2. Invasive Hydrilla – Katia Engelhardt, University of Maryland Center for Environmental Science
3. Factors Impacting the Loss, Regrowth and Successful Restoration of V. americana in the Hudson River – Jonas Hamberg, SUNY ESF student and 2014 Polgar Scholar
4. Questions and answers

LUNCH 11:50-12:50

12:50 – Restoration experience from elsewhere
1. Chesapeake Bay – Ken Moore, VIMS /Chesapeake VA NERR
2. Genetics of Vallisneria Americana – Maile Neel, University of Maryland
3. Questions and answers

1:40 – Facilitated discussion using a decision support tree

BREAK 2:50-3:00

3:00 – Breakout groups to discuss decision tree and information needs
3:45 – Debrief, next steps, and outputs

Evaluation and Adjourn by 4:30