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Habitat Reconstruction at the Hudson River PCBs Superfund Site:

The Roles of Active Planting and Natural Recolonization/Recruitment

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Habitat Reconstruction As a Process

Habitat Characterization, Reconstruction, and Monitoring Activities have been Engaged Since 2003

<ul style="list-style-type: none">• Pre-remediation habitat identification, delineation, and assessment	2003-2008
<ul style="list-style-type: none">• Dredging, followed by backfill and stabilization measures placement• Pre-planting survey• RFW seeding and planting• Initial planting monitoring/maintenance	2009-2016
<ul style="list-style-type: none">• Post Construction Monitoring<ul style="list-style-type: none">○ Benchmark Monitoring Phase○ Success Criteria Monitoring Phase	Year following habitat reconstruction to present

Habitat Reconstruction Approach

- Planting with natural recolonization (NR)
- Dredging, planting, & monitoring plans approved after a thorough design review involving federal and state agencies
- Local/regional plant materials & nursery support
- EPA oversight of dredging habitat reconstruction, and monitoring
- Iterative post-construction monitoring, data evaluation, and assessment of potential response actions, also with EPA oversight



Habitat replacement was implemented in an Adaptive Management context to stabilize and reconstruct habitats impacted during dredging

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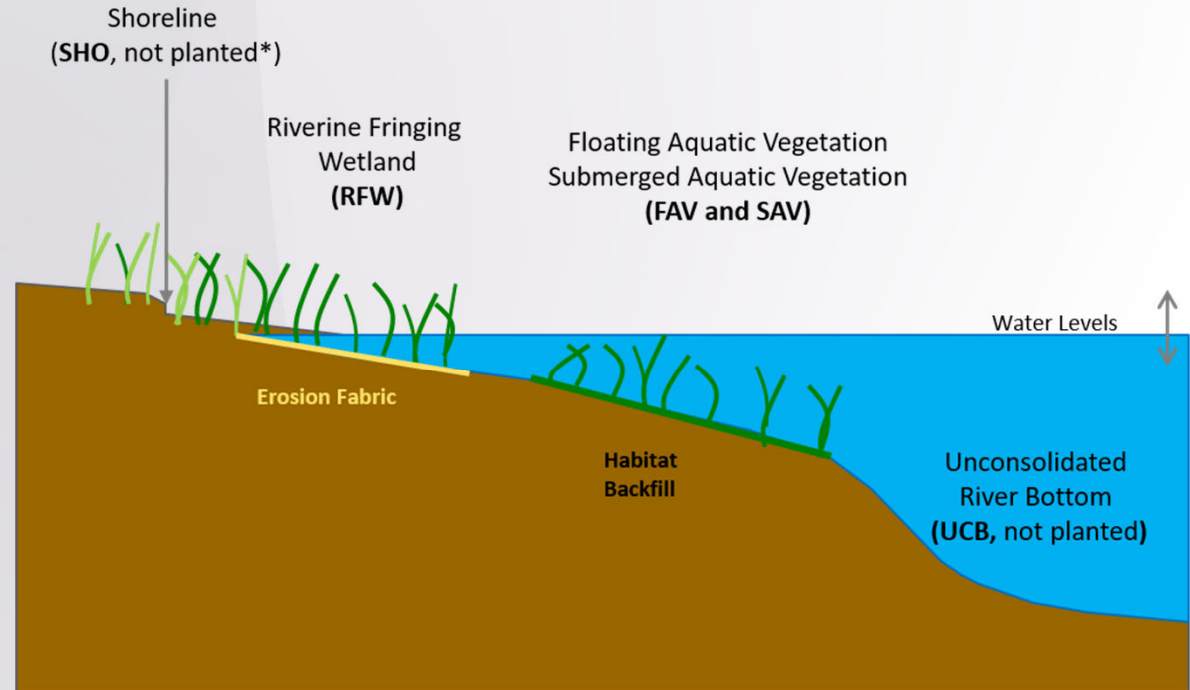
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Pre-Dredging Habitat Characterization

- Four habitats identified:
 - Shoreline (SHO)
 - Riverine Fringing Wetlands (RFW)
 - Submerged and Floating Aquatic Vegetation (SAV / FAV)
 - Unconsolidated (un-vegetated) River Bottom (UCB)
- Wetlands habitats field delineated 2008-2011 (before dredging)

Reconstructed Habitats



* SHO reconstruction includes planting if disturbed above design elevation, depending on energetics.

Upper Hudson River Dredging Operations Landscape Setting

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Habitat Reconstruction Overview

River Section 1
RM 194.5 - 188.5
Reach 8

308 Acres Dredged
6.0 River Miles

10.5 acres RFW established
61.9 acres SAV established

River Section 2
RM 188.5 – 182.4
Reaches 7 and 6

88 Acres Dredged
6.1 River Miles

12.9 acres RFW established
17.7 acres SAV established

River Section 3
RM 182.4 – 154
Reaches 5 through 1

96 Acres Dredged
29.2 River Miles

6.4 acres RFW established
15.4 acres SAV established

Note: SAV includes both planting and natural recolonization areas

Habitat Construction and Post Construction Monitoring Sequences

Since construction, the focus has been on non-harvesting monitoring to get a sense of overall plant community structure and trajectory

Habitat Reconstruction Accomplished by Year

Construction Year	Certification Units Involved	Habitat Types	Approx Acres Established	Post-Construction Monitoring Since
2010/2011	1, 2, 3, 4, 5, 6, 7, 8, 17 and 18	RFW	0.40	2012
		SAV/FAV Planting	6.70	
		SAV NR	3.19	
2012	9-16, and 19-25	RFW	0.37	2013
		SAV/FAV Planting	11.48	
		SAV Natural Recolonization	1.51	
2013	26-48	RFW	0.56	2014
		SAV/FAV Planting	5.46	
		SAV NR	11.25	
2014	49-59, 67-79, 84, and 100	RFW	18.54	2015
		SAV/FAV Planting	12.27	
		SAV NR	24.73	
2015	61-66, 80-83, 85-93, 97 and 98	RFW	1.84	2016
		SAV/FAV Planting	3.17	
		SAV NR	9.87	
2016	60, and 94-96	RFW	8.19	2017
		SAV/FAV Planting	0.74	
		SAV NR	5.19	

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Benchmark Evaluation

- Non-destructive, quantitative and qualitative monitoring of planting and natural recolonization areas
- Now and on-going (can last 5+ years for individual habitat reconstruction areas)
- Percent cover and species composition compared to reference areas (data reported annually)
- Potential response actions

EPA Review



Success Criteria Phase

- Not begun yet
- Additional 2-5 years of quantitative and statistically-based evaluations
- Includes destructive (harvest of biomass) survey methods
- Comparison to reference areas on reach-wide (or other) basis
- Could begin earlier for some areas depending on their year of planting and results of benchmark monitoring.

Monitoring Phases: Transition from Habitat Benchmark to Success Criteria Monitoring

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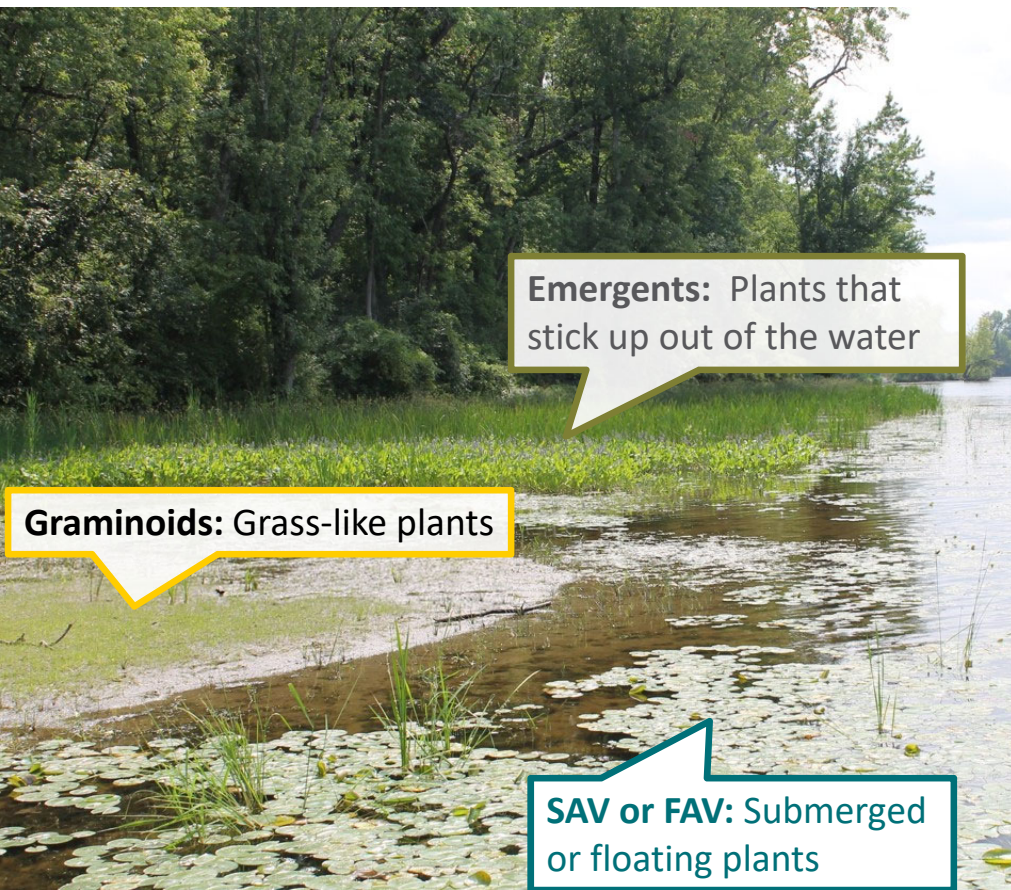
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Our Topics for Discussion

Focus on Post-Construction Riverine Fringing Wetland (RFW) Habitat Community Dynamics

- Data presented here are from GE's annual Monitoring, Maintenance, and Adaptive Management (MM&AM) reports 2012-2018
- Post-dredging vegetation plot-based (quadrat) data:
 - Plant community composition as percent cover, richness, and persistence
 - Changes observed in reconstructed plant communities are tracked over time, and
 - Comparison of installed (planted and seeded) communities to communities that have developed post-dredging
- Monitoring results are used to evaluate the roles of planting and natural recolonization (NR) toward achievement of the habitat reconstruction
 - When plants colonize RFW areas they tend to propagate where soil and water conditions are favorable
 - Data are presented at the scale of the Certification Unit (CU), which may include more than one discrete reconstruction area or habitat zone



Zones: Plant “neighborhoods” based on water depth

Species Richness: How many different species in one area

Percent Cover: Extent to which plants cover an area

Volunteer (recruit): A species we observe but did not install

Dominant: The plant or plants most populous in one area

Persistent: Existing in an area over time

Plot-based monitoring: Vegetation monitoring using a quadrat

Plotless monitoring: Vegetation monitoring without a quadrat

Vegetation Monitoring 101

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Emergent



Floating/Submerged



Graminoid

RFW and Shallow SAV/FAV Habitat Monitoring Using Quadrat-Based Approach

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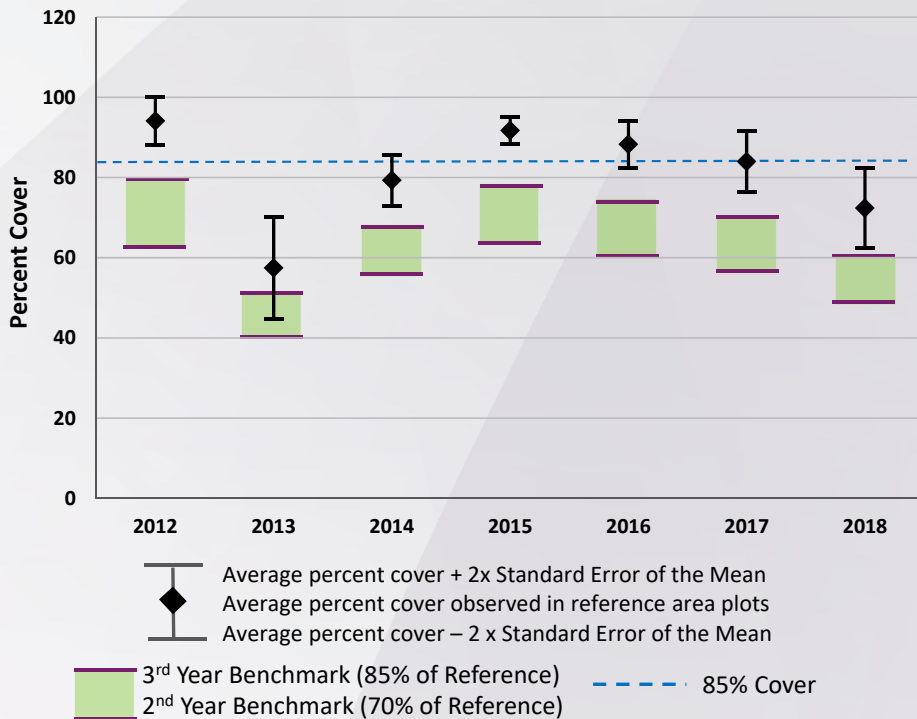


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RFW Reference Areas Percent Cover 2012-2018



- Benchmark monitoring requires RFW reconstruction areas data to be compared to reference wetland data
- Benchmark monitoring is non-destructive (no harvesting) and is meant to get a sense of reconstruction areas trajectories
- Wetlands in their 2nd year of monitoring should exhibit 70% of reference levels while areas in their 3rd or greater year should exhibit 85% of reference area cover
- Invasive species observed in reconstruction areas within the first 2 years need to be removed. After the 2nd year of monitoring, percent cover from volunteer species should exceed 40%

RFW reference area percent cover levels since 2012 and how this relates to benchmark monitoring thresholds



Conditions at approximately 4,800 cfs river flow



Conditions at approximately 2,700 cfs river flow

CU02 RFW Area “Bond Creek”

Dredged 2009, Seeded and Planted 2009 and 2010
Monitoring started in 2012 (due to 2011 high flows)

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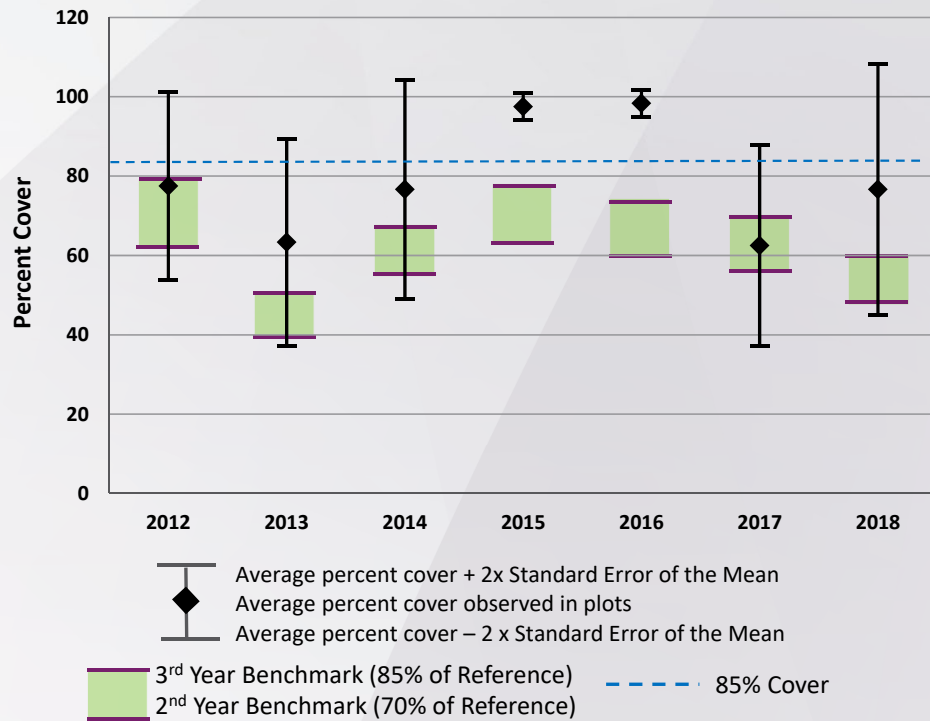


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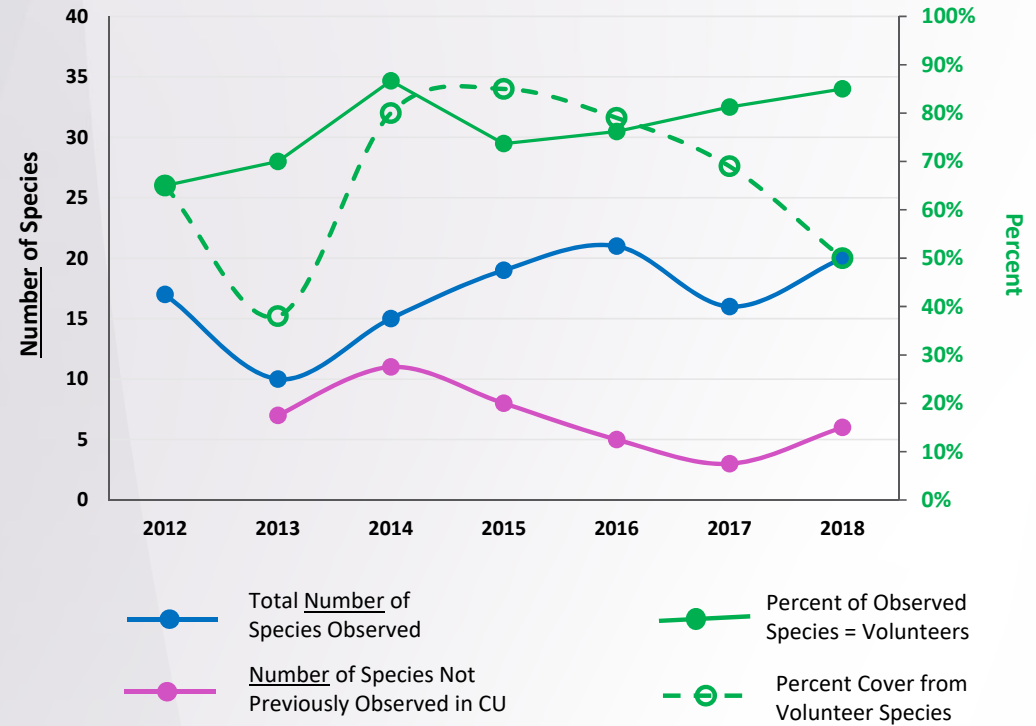
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CU02 RFW Percent Cover 2012-2018



CU02 RFW Species Diversity Measures 2012-2018



CU02 Percent Cover and Diversity Over Time

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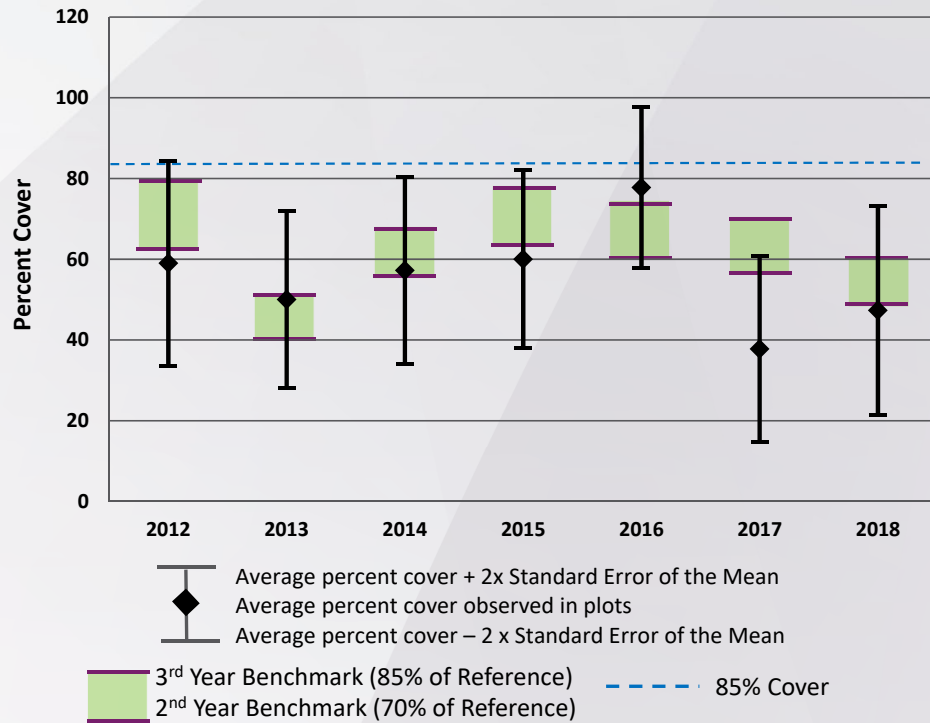


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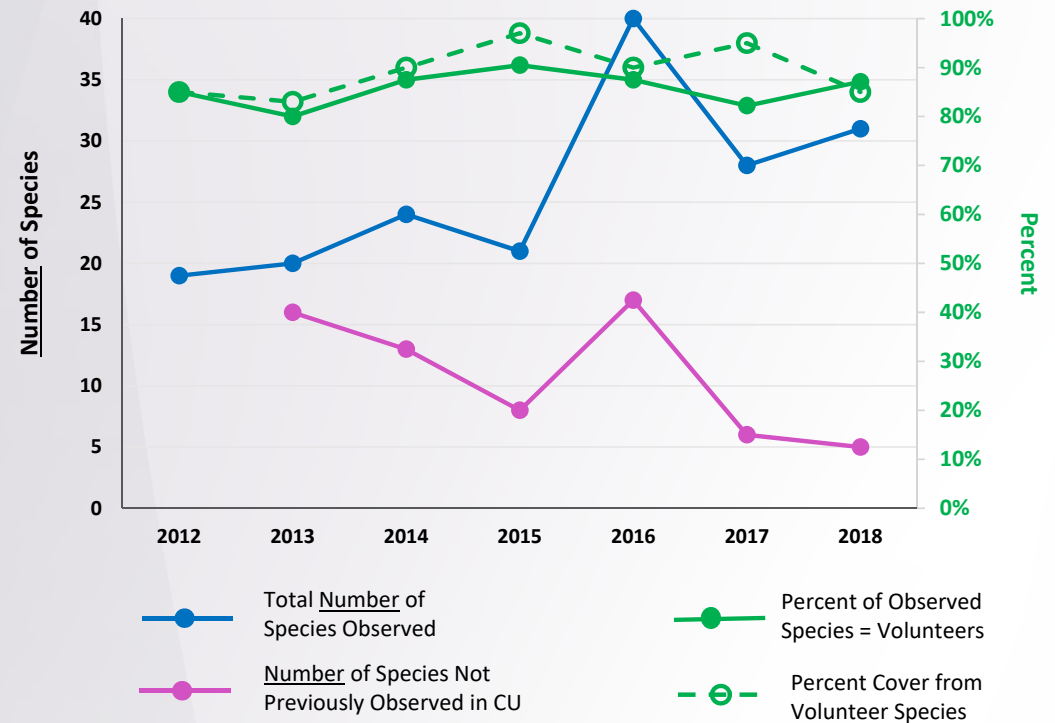
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CU08 RFW Percent Cover 2012-2017



CU08 RFW Species Diversity Measures 2013-2017



CU08 Percent Cover and Diversity Over Time

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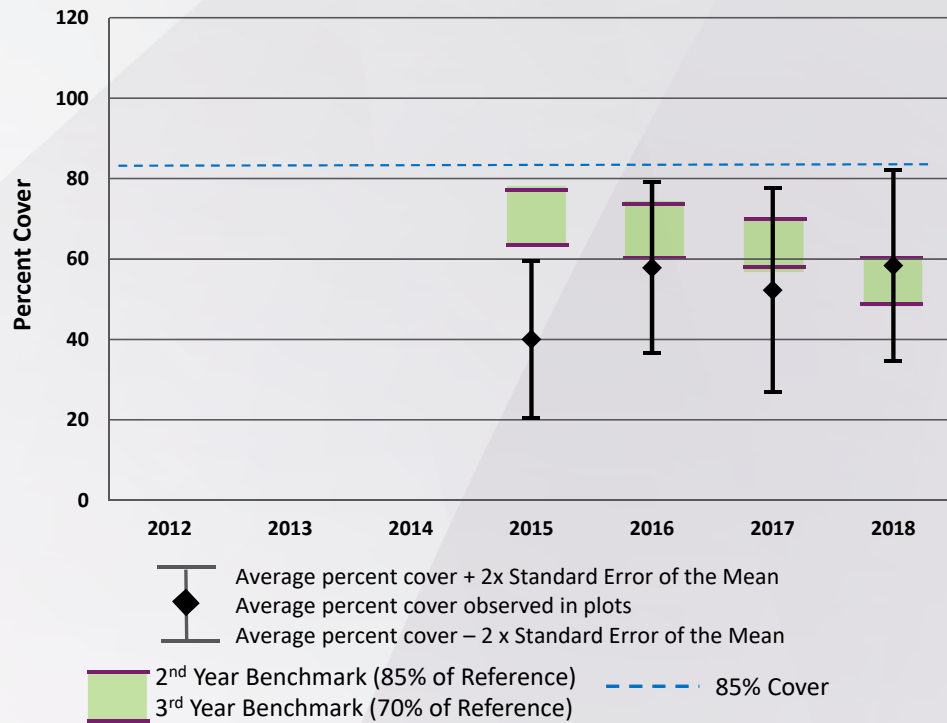


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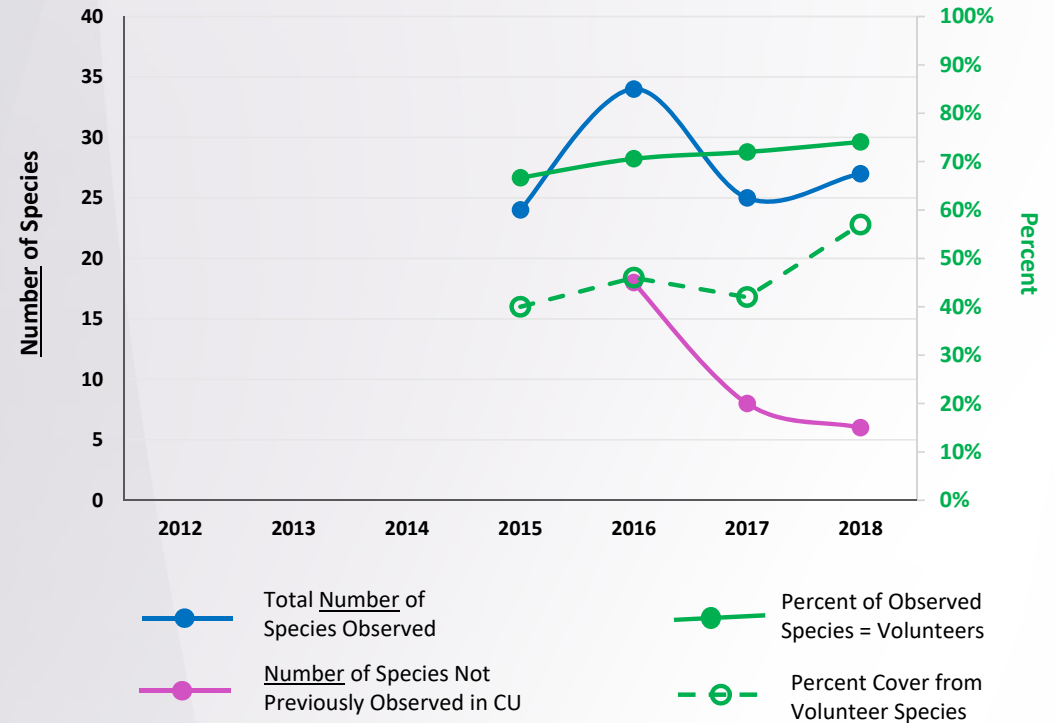
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CU53 RFW Percent Cover 2015-2017



CU53 RFW Species Diversity Measures 2015-2017



CU53 Percent Cover and Diversity Over Time

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Percent Cover and Richness with Persistence Data Summary

- At installation, RFW areas were occupied by volunteers but dominated by installed species, including seeded and several emergent (planted) species
- 70-90% of species currently observed in reconstructed RFW communities are volunteer graminoid and emergent species
- Installed species tend to account for only 10-25% of the species observed annually in quadrats
- New species (not previously observed in a CU) are recorded each year, indicating that volunteers are still populating reconstructed wetlands
- For installed species in Phase 1 RFW areas (CU02, CU07, and CU08) seeded species tend to persist better than planted species, but after several years most seeded species are also not typically dominant in these CUs
- In many River Section 1 Phase 2 RFW Areas, planted species are more persistent than seeded species (CU10, CU19, CU37, CU51-54, CU57, and CU60) and are often dominant species
- In some RFW areas (CU19, CU37, CU51/52, CU76) invasive species are increasing in coverage

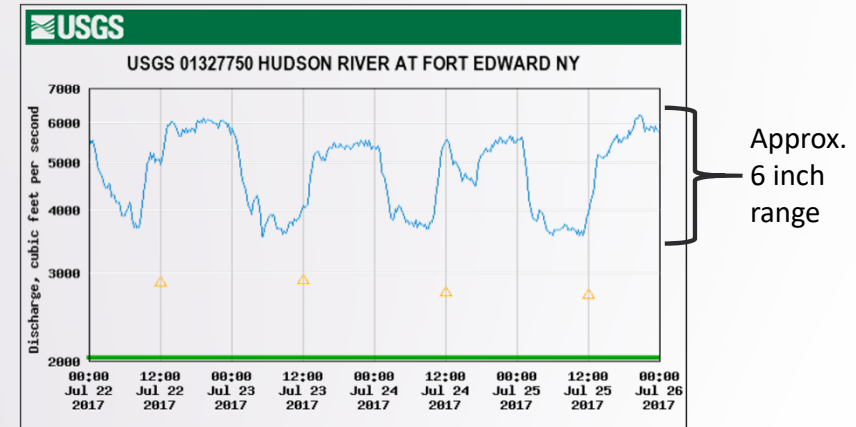
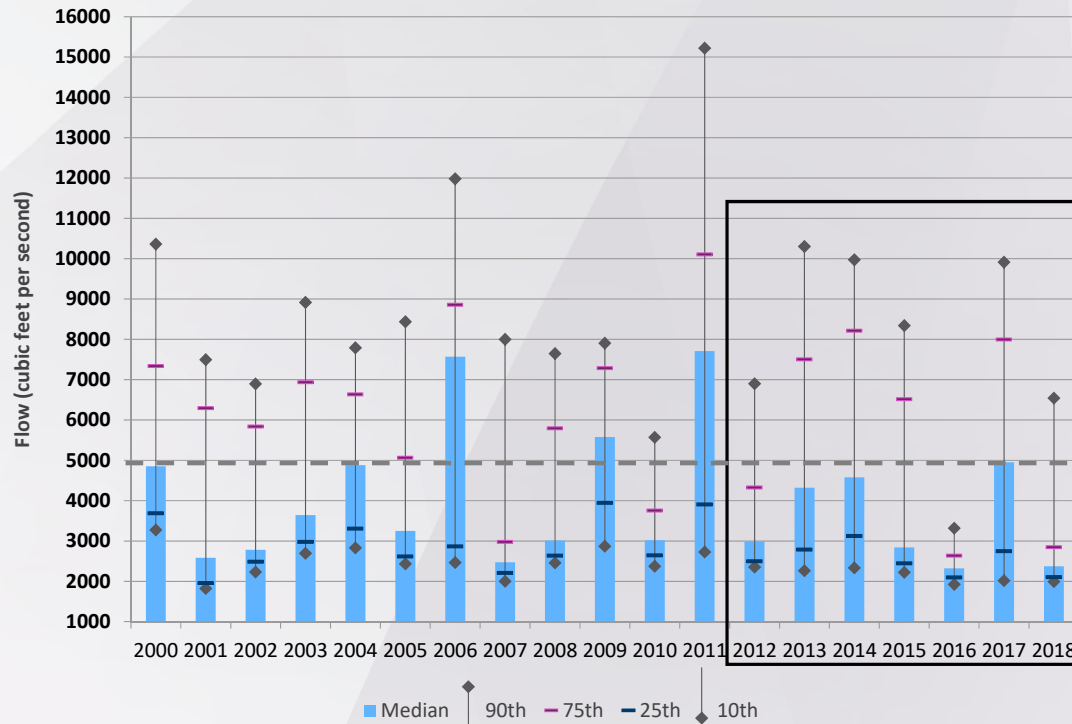
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River Section 1 (Reach 8 / Thompson Island Pool) Mean Daily Flows During Growing Season (May 1 - September 30)



119.0 ft (+/-) is approx. surface water elevation at 8,000 cfs

Dredging Design Water Surface Elevation (wse)
At 5,000 cfs ~ 118.00 ft (NGVD88)

117.0 ft (+/-) is approx. surface water elevation at 2,000 cfs

**Annual and Seasonal Mean
Annual Surface Water Elevations
are Highly Variable**

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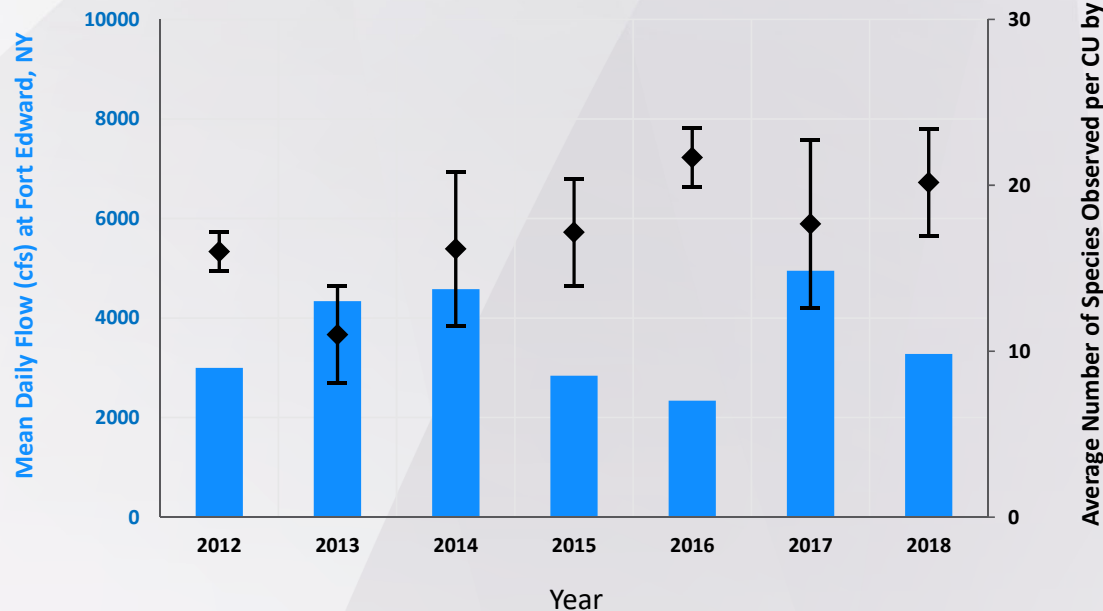
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Mean Daily Flows and Average Species per Plot in CU's 2, 7, 8, 9, 10, and 19*. 2012-2018

* RFW Reconstruction Areas for which at least 5 years of data exist.



- Data do not appear to suggest that species richness varies directly with flows or water levels as measured in mean daily flow
- Data do suggest that most RFW areas experienced lower percent covers and species richness levels in 2017 (a relatively high water year) after steady increases from 2013 to 2016
- Other potential stressors include herbivory and disruption by wave action from boats and fetch. The extent to which CUs indicate impacts from these stressors is also highly variable

River Flows and Species Richness Through Time

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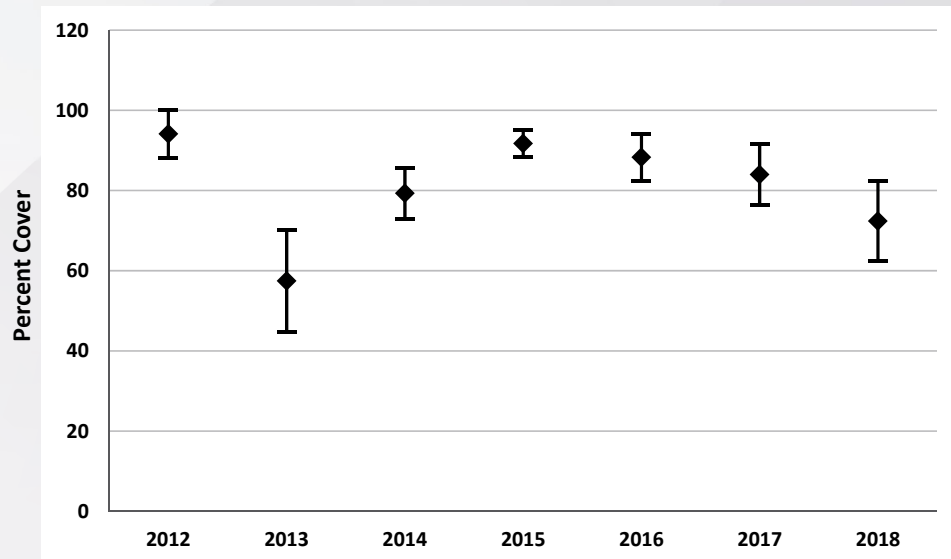





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RFW Reference Areas Percent Cover 2012-2018



 Average percent cover + 2x Standard Error of the Mean
 Average percent cover observed in reference area plots
 Average percent cover - 2 x Standard Error of the Mean



Reference area plot data trends and reconstruction area results

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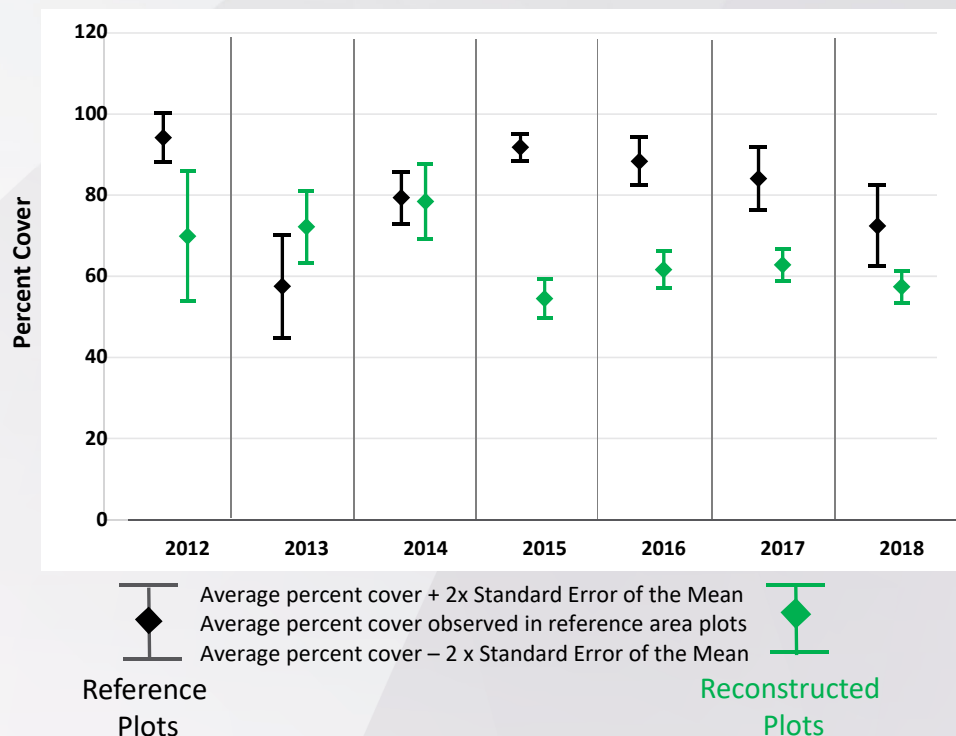


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RFW Reference and Reconstructed Areas Percent Cover 2012-2018



- Reconstructed plots do not appear to directly reflect reference plot year-to-year trends until after 2015
- Starting in 2015 approximately 18.5 of the over 29 acres of RFW reconstructed began benchmark monitoring in 2015
- The overall drop in percent cover observed starting in 2015 reflects an increase in monitored Zone B areas, which have generally not exhibited as much vegetation cover as Zone A areas.

Reference area plot data trends and reconstruction area results

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Key Points

- Approximately 10.5 acres of RFW habitat have been reconstructed in River Section 1 (Reach 8/Thompson Island pool); of this amount, 9.8 acres will enter the 5th year of benchmark monitoring in 2019
- An additional 12.7 acres of RFW in River Section 2 will also enter the 5th year of benchmark monitoring in 2019
- Available data suggest that some RFW areas, while performing at or near benchmark thresholds for percent cover metrics, tend to be dominated by volunteer graminoid and a few other emergent plant species
- Overall, while the number of species observed during data collection appears to be increasing and new volunteers are being recorded annually, percent cover may not be increasing, particularly in some RFW Zone B areas
- Invasive species cover is increasing within some RFW areas; earlier detection of these species may be more efficiently accomplished using plotless monitoring approaches
- Response actions for 2019 are being discussed by EPA and GE

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Questions or Comments?

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