Climate-resilient Coasts
How long-term research and restoration informs management

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Virginia Coast Reserve LTER
VCR LTER:
Causes and consequences of non-linear ecosystem state change
Coastal Blue Carbon Systems

Challenges to incorporating blue carbon in global models:

- Estimating stocks and sequestration rates
- Understanding effects of habitat loss and recovery
Coastal habitats are global hotspots for blue carbon storage.
Global stock estimates led by LTER scientists

Adapted from Fourquean et al 2012, Pan et al 2011, Pendleton et al 2012
LTER site contributions to quantifying blue carbon stocks

Carbon stores in seagrass meadows 4x bare sediments

Carbon burial rates in Marshes exceeds forests

Carbon stores in mangrove forests 3x terrestrial forests

McGlathery et al. 2012

Drake et al. 2015

Jerath et al. 2016
Including blue carbon, ocean sequestration equals forests

Fate of anthropogenic CO₂ emissions (2006-2015)

91% Sources = Sinks

9% Blue Carbon = 25%

31% ocean sequestration

44%

32% 26%

Virginia Coast Reserve: Loss and recovery
Rate of seagrass loss has accelerated

29% loss since 1880’s; 1.5% per year

Waycott et al (2009)
215 studies, 126 years of data
VCR loss due to pandemic wasting disease and “Great Storm” of 1933

Slime mold wasting disease
Reversing the state change

- 500 acres seeded
- 70 million seeds
- 6200 acres meadow
  $= 25 \text{ km}^2$

web.vims.edu/bio/sav/
Reversing the state change

0.5 – 1 acre plots
100k seeds acre$^{-1}$

Meadow 2004
Meadow 2007
Meadow 2010
Meadow 2012
Meadow 2013
Recovery is non-linear

Density (shoots m$^{-2}$)

Meadow Age (yr)

Limited by seed recruitment

0 – 15 years

Nice to meet you. I'm a Zostera.
Restoration reinstates soil carbon stores

Plant density drives burial rates

After 12 yr, burial within range of natural systems

40% Seagrass
50% Benthic microalgae
10% Marsh

Greiner et al. 2013
Carbon sequestration in plant biomass
Measured by Aquatic Eddy Covariance

Data typically recorded at 32 - 64 Hz, 5 - 30 cm above benthic surface

Peter Berg
Carbon sequestration in plant biomass
Measured by Aquatic Eddy Covariance

For each 24-hour period, calculate GPP and R
Changes in metabolism with restoration
How resilient are these systems?

High temperatures cause dieback

Nice to meet you. I'm a Zostera.
How resilient are these systems?

Rate of recovery varies spatially
Temperature also drives recovery

28 °C is maximum temperature threshold
High temperatures cause dieback

In 2105 temperatures exceeded 28 °C threshold 50% of the time
High tides relieve temperature stress

High flushing, Short residence time

Higher resilience

bathymetry

Low Tide

High Tide
VCR contributions to blue carbon

- Stocks and sequestration returned within decade
- Temperature drives resilience and recovery
- Can provide guidance for management

LTER has unique capability to provide answers

- Combine long-term data with process studies to understand mechanisms
- Long-term trends and landscape scales needed to understand resilience
- Network of sites allows comparison to reveal generality