Assessing the Sustainability of Restoring Wetlands: the Case of the Bay of Fundy

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Introduction

- Rising sea levels threaten to inundate coastal lands[1]
- Policymakers are increasingly considering the sustainability of removing flood mitigation measures, such as sea walls and dykes[2]
- Advantages of restoring coastal wetlands:
  - Act as natural flood barriers[2]
  - Self-adaptive[3]
  - High annual rates of carbon sequestration[4,6] (Fig.1)

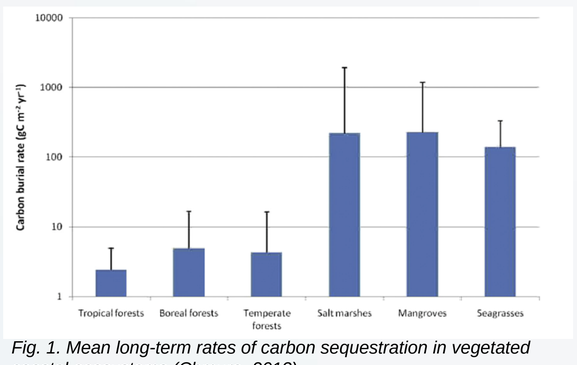

Fig. 1. Mean long-term rates of carbon sequestration in vegetated coastal ecosystems (Chmura, 2013).

Fig. 2. A dyke overlooking the Cumberland Basin (Craig Norris, fundy-biosphere.ca).

- 85% of salt marshes have been lost in the Bay of Fundy due to dyking by Acadian Settlers over 350 years ago[5]
- The Bay of Fundy's dykelands provide an interesting case study in evaluating the sustainability of restoring wetlands (Fig. 2)

Review of the Literature

- The literature emphasizes that accurate assessments in the region are dependent on topographic data, such as GIS and LiDAR[6,7] (Fig. 3)
- Researchers studied various factors and functions of numerous coastal wetlands in the Bay of Fundy region, with varied results in terms of successful restoration:

Carbon	• Higher rates of carbon accumulation and density[8] (Fig. 4 & 5) • Burial rates five times the average of a nearby natural marsh[9] • No net-benefit in restoring wetlands in Nova Scotia altogether, however certain wetlands should be targeted for their high rates of carbon sequestration[10]
Hydrology	• Subsurface hydrology of restored marshes can possibly be restored in half a century[11] • Water nutrients of impounded conversions do not reach levels high enough to support diverse wildlife[12] • Moisture variability in stratigraphic records provide evidence that recovered wetlands create critical habitats for endangered species such as the Blanding's turtle[13]
Cost	• Salt marsh restoration is a cost effective solution for creating natural barriers to combat rising sea levels[3] • Survey results show that respondents felt appropriate flood mitigation measures should be considered before cost, and prefer dykelands to wetlands for their cultural value[14]
Vegetation	• High probability of successful restoration based on recovery of plant species such a the *Spartina alterniflora*[15] • Classification of vegetation in relation to ecological functions provides a foundation of quantitative data for future modeling of each wetland in the region, to better guide sustainable restoration decisions[16]

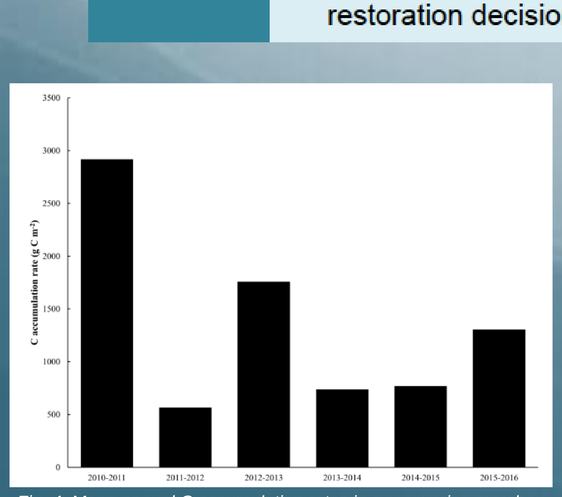

Fig. 4. Mean annual C accumulation rates in a recovering marsh from 2010-2016 (Wollenberg et al., 2018).

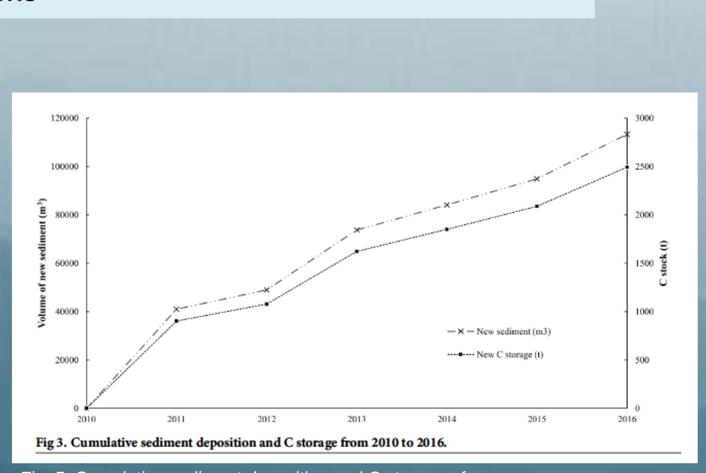

Fig 3. Cumulative sediment deposition and C storage from 2010 to 2016.

Fig. 5. Cumulative sediment deposition and C storage of a restored marsh from 2010-2016 (Wollenberg et al., 2018).

Discussion

- Assessing the overall sustainability of restoring wetlands in the Bay of Fundy proves to be a difficult task
- Numerous complexities in quantifying the net-benefits versus consequences of removing dykes for wetland conversions exist:
  - Difficulty including all ecosystem services, and various factors in the same study
  - Coastal wetlands in the region vary greatly, and are unique in terms of ecological composition, making paired comparisons difficult[11] (Fig. 6)

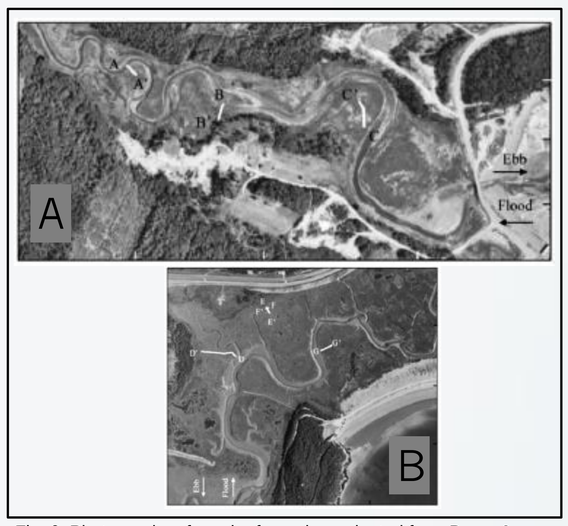

Fig. 6. Photographs of a pair of marshes adapted from Byers & Chmura's (2014) study, located in the outer and upper Bay of Fundy. (A) Dipper Harbour marsh, a natural reference study site; (B) Saint's Rest marsh, a recovering marsh study site. The photographs demonstrate the variations between each marsh, which impeded a quantitative analysis.

- A targeted approach to research and restoration is highly suggested throughout the literature
  - Cumberland Basin
  - Largest tides in the world[17]
  - Ideal conditions for high rates of sedimentation to occur[12] (Fig. 7)
- Suggested that future cost evaluations will need to consider:
  - Cultural values of dykelands[14]
  - Cost of private land acquisitions[9]
- Despite recommendations, LiDAR data appears to be absent in recent literature (Fig. 8)

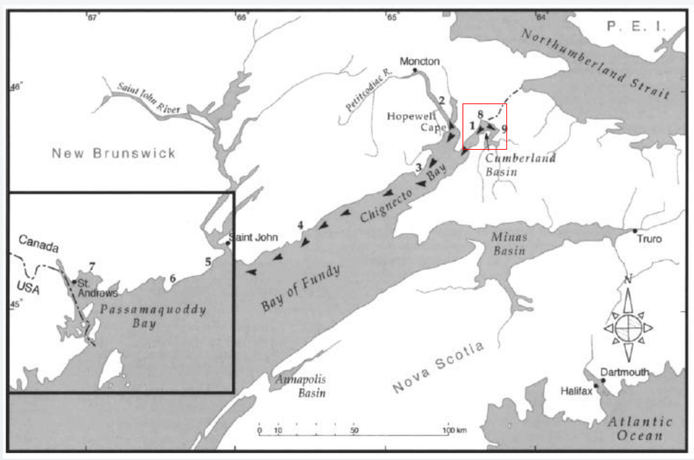

Fig.7. A map of the Bay of Fundy, depicting the direction of sediment transport. The Cumberland Basin is outlined in red, where wetland restoration research is concentrated (Adapted from Connor et al. 2001).

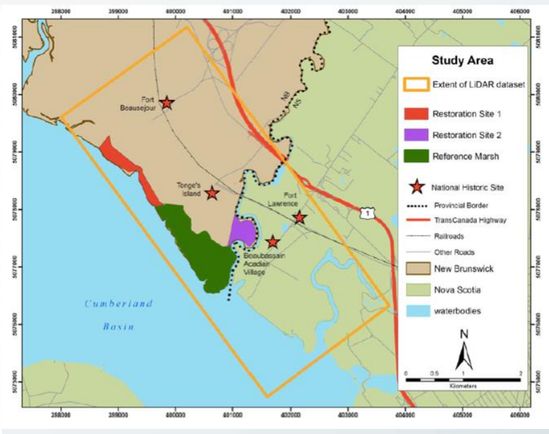

Fig. 8. A map from Millard et al.'s (2013) study, depicting the marsh sites and the extent of the LiDAR dataset that was used (outlined in yellow), located on the coastline of the Cumberland basin.

- Recommendations for future research in the Bay of Fundy:
  - Include numerous ecological services
  - Consider variations between wetlands
  - Continue to target research and restoration efforts in the Cumberland Basin
  - Consider the cultural value of dykelands and private land acquisition costs
  - Build and utilize LiDAR datasets

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