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Establishment of peat-forming vegetation: A comparison of two constructed wetlands for oil sands mine reclamation in Alberta

Andrea K. Borkenhagen[1], Melissa House[2], Dale H. Vitt[2], and David J. Cooper[1]

[1] Department of Forest and Rangeland Stewardship and Graduate Degree Program in Ecology

[2] School of Biological Sciences, Southern Illinois University

Corresponding author present address: Advisian, Worley Canada Services Ltd. E-mail address: andreakborkenhagen@gmail.com (A.K. Borkenhagen).

Introduction

Reclamation solutions are needed for the oil sands region of Alberta, Canada where large areas of the boreal landscape dominated by peat-forming wetlands have been removed by mining activities. Reclamation is required to compensate for the losses, but previous reclamation projects have focused on constructing marsh or open-water wetlands because they often spontaneously form in disturbed basins (Daly et al. 2011, CEMA 2014) and are within the regulatory requirement of restoring to 'equivalent land capacity'. Peat-forming wetlands are highly specific in their hydrologic and geochemical requirements and are thought to require more precise construction designs (Price et al. 2010, Chimner et al. 2016). Regulators and operators have begun including peat-forming wetlands in their reclamation approaches, although uncertainty exists on best practices for implementation and appropriate success criteria (Ketcheson et al. 2016). To test design concepts, two landscape-scale wetlands were constructed in 2012 and 2013 on oil sands mines north of Fort McMurray, Alberta. The projects were designed to create peat-forming ecosystems similar in floristic composition and function to a range of natural regional peatland fens, within the constraints of a post-mining landscape (Ketcheson et al. 2016). The vegetation data from both sites were synthesized to evaluate responses to environment conditions and species introduction approaches.

The Sandhill Wetland and Nikanotee Fen are the first two landscape-scale constructed wetlands for oil sand mine reclamation in the world. While the wetland-watershed designs and species introduction approaches differed, clear patterns of species establishment and community formation have emerged since implementation. Our goal here is to extract the commonalities and determine the most effective approaches to establish peat-forming plants that are representative of regional peatland types or stages. We address the following five questions:

1) Which plant species are abundant in the constructed wetlands and how are they distributed along the water level gradient?
2) Do plant communities at the sites converge or diverge and how are they influenced by the species introduction approach and water level gradient?
3) Which plant communities support bryophytes and peat-forming species cover and richness and what is the influence of the water level gradient?
4) Where along the water level gradient are different species introduction approaches effective?

Method

Sandhill Wetland and Nikanotee Fen are located north of Fort McMurray, Alberta, Canada. Reclamation designs were developed based on modeling groundwater interactions with adjacent landscapes (Pollard et al. 2012), vegetation moisture requirements, and long-term climate data (Price and Whitehead 2001, Price et al. 2010). The species introduction approach for Sandhill Wetland included spreading a native seed mix dominated by *Carex aquatilis*. The five species introduction approaches at Nikanotee Fen that were included in this comparison are plantings of (1) *Carex aquatilis* seedlings, (2) *Juncus balticus* seedlings, (3) spreading moss layer transfer material (MLT), (4) *Carex aquatilis* seedlings and MLT, and (5) *Juncus balticus* seedlings and MLT. At both constructed wetland, vegetation composition was sampled and depth to water was measured in July in 2017 and vegetation composition was sampled again in 2019.

Results, Observations, Conclusions

Despite the challenges of oil sands reclamation, peat-forming bryophyte and vascular plant-dominated communities have developed in both constructed wetlands. Community convergence occurred across wetlands due to the dominance of *Carex aquatilis,* which spread from areas of introduction, obscuring other introduced species, and developed dense stands. Differences in plant communities across sites were attributed to water level gradients and certain species introduction approaches that formed diverse potentially peat-forming plant communities and excluded non-peat-forming plants. Future projects should aim to increase microtopography to enable summer depth to water level ranges between -10 and -40 cm that support peat-forming bryophyte and vascular plant cover and species richness. Co-dominant vascular plants, such as *Juncus balticus*, encourage bryophyte establishment and diverse plant communities. Bryophytes spontaneously colonized suitable areas, but introductions using the MLT increased establishment and diversity. Our results show that targeted plantings of peat-forming species along a broad water level gradient could exclude establishment of non-peat-forming upland or marsh plants.

Novel/Additive Information

Despite the challenges of oil sands reclamation, communities of peat-forming plants have developed in both constructed wetlands. The convergence and divergence of communities across constructed wetlands in response to abiotic and biotic conditions highlights the challenges of selecting species for novel environments and the importance of experimentation, comparative assessments, and long-term monitoring.

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