Hope College

Hope College Digital Commons

19th Annual Celebration of Undergraduate
Research and Creative Activity (2020)

Celebration of Undergraduate Research and
Creative Activity

4-17-2020

Ecohydrological Changes in Interdunal Wetlands/ Slacks as a Response to Rising Lake Levels in an Evolving Eolian Landscape along Lake Michigan's Eastern Coast

Katherine Kay
Hope College

Rene Aerts
Hope College

Follow this and additional works at: https://digitalcommons.hope.edu/curca_19

Part of the [Environmental Sciences Commons](#), [Geology Commons](#), and the [Hydrology Commons](#)

Recommended Citation

Repository citation: Kay, Katherine and Aerts, Rene, "Ecohydrological Changes in Interdunal Wetlands/ Slacks as a Response to Rising Lake Levels in an Evolving Eolian Landscape along Lake Michigan's Eastern Coast" (2020). *19th Annual Celebration of Undergraduate Research and Creative Activity (2020)*. Paper 23.

https://digitalcommons.hope.edu/curca_19/23

April 17, 2020. Copyright © 2020 Hope College, Holland, Michigan.

This Poster is brought to you for free and open access by the Celebration of Undergraduate Research and Creative Activity at Hope College Digital Commons. It has been accepted for inclusion in 19th Annual Celebration of Undergraduate Research and Creative Activity (2020) by an authorized administrator of Hope College Digital Commons. For more information, please contact digitalcommons@hope.edu.

ECOHYDROLOGICAL CHANGES IN INTERDUNAL WETLANDS/SLACKS AS A RESPONSE TO RISING LAKE LEVELS IN AN EVOLVING EOLIAN LANDSCAPE ALONG LAKE MICHIGAN’S EASTERN COAST

SUZANNE J. DeVRIES-ZIMMERMAN¹, KATHERINE KAY¹, RENE AERTS¹ AND EDWARD C. HANSEN¹
¹DEPARTMENT OF GEOLOGICAL AND ENVIRONMENTAL SCIENCES, HOPE COLLEGE, HOLLAND, MICHIGAN

ABSTRACT
We are conducting ecohydrological studies in mature and incipient interdunal wetlands/slacks in a coastal dune complex on Lake Michigan’s eastern coast. The slacks are located in the Saugatuck Harbor Natural Area, ~200m inland of Lake Michigan within a large parabolic dune (mature slack) and smaller blowouts on its arms (incipient slacks). Slack water levels reflect Lake Michigan’s. Rising Lake Michigan water levels for the last 5 years have increased groundwater levels, monitored at 12 locations, >1m, rewetted the mature slack from its previous dry state, reflooded pools (>.5m rise), and expanded its extent. Adjacent blowouts now have incipient slacks with pools up to .5m deep. Pool water chemistry and vegetation indicate the slacks are minerotrophic fens. pH and dissolved oxygen values in the slack pools increase from morning to late afternoon, suggesting photosynthetic processes. The incipient slacks have a higher pH and DO overall, a microbial mat, and are sparsely vegetated with *Juncus balticus* and *J. brachycephalus*. Vegetation quadrat sampling has been done annually in the mature slack since 2016. This slack has a high species diversity, especially in damp to shallow water (<10 cm depth) areas, with almost half of these species preferring calcareous conditions. From 2016–2017 shallow water levels (<30 cm) prevailed. Large areas of the slack would dry and have damp soils by mid-summer. These areas were dominated by *Cladium mariscoides* and *Spiraea tomentosa*. Deep pools (~5 m depth) on the slack’s northern side remained wet. *Carex lacustris*, *C. aquatilis*, and *Juncus* species with *Utricularia* sp., a submergent species, vegetated these pools. Water levels have continued to rise from 2017–2019, expanding the slack. Much of it now remains wet throughout the season with standing water up to 40 cm deep (deep pools 60–70 cm). Vegetation coverage values have significantly decreased. *Cladium* and *Spiraea* are now absent from much of the slack. The vegetation is shifting to species tolerant of deeper water such as *Calamagrostis canadensis* and *Juncus* species. *Utricularia* occurs throughout much of the slack rather than being restricted to the deep pools. The slack’s wetland ecosystem is dynamic and reflective of water depth as wetland vegetation returns and then transitions to different wetland species as water levels rise.

Introduction and Site Description

Interdunal wetlands, or slacks as they are referenced in European literature, are found amongst the coastal dunes of Lake Michigan where the wind scours the sand to the water table. These areas tend to be ecologically diverse, albeit rare in occurrence. The Michigan Natural Features Inventory (MNFI) ranks their status as G-2, meaning they are “imperiled and at high risk of extinction due to a very restricted range...”(MNFI, 2016).

The studied slack (Fig. 1), ~1.25 ha in size, lies between the arms of a large parabolic dune approximately 200m inland from Lake Michigan. Smaller blowouts occur on the arms of the larger parabolic dune. These features are part of a coastal dune complex just south of the Kalamazoo River mouth (Fig. 2), in the Saugatuck Harbor Natural Area (SHNA) on Lake Michigan’s eastern coast.

Figure 2. DEM of the Lake Michigan coast southwest of Holland, Michigan (left) showing the study area, SHNA.

Figure 1. View of the interdunal wetland/slack at SHNA, looking east.

The hydrology of these slacks is generally connected to Lake Michigan (DeVries-Zimmerman et al., 2016). Lake level data collected for the Lake Michigan-Huron basin since 1860 show fluctuations of ~2m (USACOE, 2019). These fluctuations can profoundly change the ecosystem of the slacks as low levels will cause the slacks to dry and higher levels will inundate them. In 2014, lake levels rose from below average levels, causing the slack’s ecology to begin transitioning from dominant upland/dune species to wetland vegetation.

We initiated ecohydrological studies in this slack in May 2016, initially investigating the effect of rising lake levels on the slack’s ecology through vegetation quadrat sampling and remote sensing surveys. We have expanded those studies to examine the surface water and groundwater chemistry and the interactions between these systems and the slack’s ecology/vegetation. The initial results are presented here.

Vegetation Quadrat Sampling – Mature Slack

Rising lake levels have flooded the larger, main slack area (mature slack), creating pools of different depths where the vegetation varies with water depth. Beginning in summer 2016, we established 28 1m x 1m sampling quadrats in which we identified the plant species, then counted the number of stems and estimated the percent coverage by species (Fig. 3). Vegetation sampling has been done annually in the mature slack since 2016. As water levels rose and expanded the wetland area, four additional quadrats were established to include these new areas.

Figure 3. Vegetation quadrat sampling at SHNA.

In 2016–2017, the dominant species twig rush, *Cladium mariscoides*, together with steplebush, *Spiraea tomentosa*, grew throughout the slack except for the deeper ponds on the north side. At this time, much of the slack would dry and have damp soils by mid-summer. The damp wetland edges were especially notable for their high species diversity. The northern, deep pools had stands of *Carex aquatilis*, *C. lacustris*, *Scirpus cyperinus*, and *Juncus canadensis*. Rising lake levels from 2016–2019 have deepened the water throughout the slack, significantly shrinking the area vegetated by *Cladium* and *Spiraea* and creating large areas of open water (Fig. 3). Much of the slack now remains flooded with 40 cm or more of water throughout the season. Consequently, vegetation tolerant of deeper water, such as *Calamagrostis canadensis*, *C. aquatilis*, *C. lacustris*, *Scirpus*, and *Juncus* species are expanding their extent. In addition, bladderwort, *Utricularia* sp., a carnivorous submergent plant, was found in almost all of the quadrats in summer 2019. Prior to 2019, *Utricularia* was only found in the deep pools on the slack’s northern edge.

Vegetation Quadrat Sampling – Incipient Slacks

Incipient slacks with standing water pools have formed in the adjacent blowouts in the parabolic dune’s arms (Figs. 4A, 4B). In 2016, these slacks were typically wet sand patches that would have standing water up to 40 cm deep following heavy rain events (Fig. 4C). Wetland vegetation, including *Juncus balticus* and *J. brachycephalus*, colonized these areas. Since 2018, water levels have increased so that the incipient slacks now have standing water up to .5m deep throughout much of the year. A thick microbial mat covers the bottom of these slacks, potentially slowing the establishment of vegetation (Vázquez, 2008), as the slacks remain very sparsely vegetated (Fig. 4D).

Figure 4. A. 2017 Google earth image of slack showing monitoring well locations (Yellow: W1–W12), mature slack pools (Blue: P3, P5, P6, P7E), and incipient slack pools (Red: KP, P4, P7). B. 2019 true color drone image by Hope College Dune Group. Note expansion of both mature and incipient slacks. C. Incipient slack P4 in 2018. D. Incipient slack P7 in 2019. Note *J. balticus* and *J. brachycephalus* growing in foreground.

Groundwater and Surface Water Sampling

A network of 12 monitoring wells has been installed within and around the slack (Fig. 4A). Groundwater and surface water samples were collected and analyzed for selected dissolved ions, including calcium, using atomic absorption spectrometry. Calcium concentrations averaged 23 ppm, indicating the slack is a minerotrophic fen (Glaser, 1992).

Groundwater and surface water samples from the main slack (P3, P5, P6, P7E) and the incipient slacks (P4, P7, KP) were collected and analyzed this summer for dissolved oxygen (DO) and pH. pH values were measured in the field using an Oakton hand-held pH meter, DO values were measured in the laboratory using a LaMotte test kit (azide modification of the Winkler method). Diurnal surface water sampling for DO and pH was conducted on 23 and 24 May, 3 June, and 9 July. Surface water and groundwater samples for DO and pH analysis were collected on 15 May (monitoring wells W1, W2, W3, W4, W5, W6 and W7) and 9 July 2019 (Wells W1–W7, and new monitoring wells W9, W10, W11, and W12). The results of these analyses are shown in Figure 5.

Groundwater and Surface Water Sampling, continued

Figure 6. Analytical results for groundwater and surface water sampling.

Figure 5. Analytical results for groundwater and surface water sampling.

Results and Discussion

There is a positive correlation between DO and pH in samples collected during both the morning and evening (Figs. 5A–5C), a relationship that suggests the influence of photosynthesis. DO values in both the mature and incipient slacks increase from morning to afternoon. Within individual pools there is a rough tendency for pH to increase slightly from morning to evening. Both sunlight and warmer daytime temperatures increase photosynthesis which releases oxygen and consumes carbonic acid. Hence, this relationship also suggests a photosynthetic influence on water chemistry. Evening sampling on 18 June (Fig. 5B) shows DO values beginning to drop as temperatures and sunlight decrease and photosynthesis slows. Higher DO and pH values tend to occur in the incipient slack pools (P4, P7, KP) in comparison to the mature slack pools (P3, P5, P6, P7E). This may indicate that photosynthesis in the shallow incipient slacks with their higher algae populations has a greater influence on water chemistry. In addition, after several years of lush emergent plant growth in the mature slacks, there is now much decaying vegetation in them, creating a higher biological oxygen demand. In comparison, the incipient slacks are very sparsely vegetated and do not have a reservoir of decaying vegetation to depress oxygen values.

Seasonal differences in both the groundwater and surface water pH and DO values were noted (Fig. 6). With the exception of incipient slack KP, pH values were generally lower in May than July. The July samples show significantly lower DO values in the groundwater (W1, W2, W3, W5, W6) and surface water samples collected within the mature slack (P3, P5, P6, P7E) compared to groundwater samples obtained from monitoring wells outside the mature slack (W9, W10, W11, W12) and the incipient slack pools (P4, P7, KP). The differences can probably be attributed to photosynthetic processes which were considerably slower in May than in July. Cooler spring temperatures delayed the beginning of the growing season, thus slowing the consumption of carbonic acid and the production of oxygen. In addition, the colder water temperatures slowed the decomposition of dead vegetation (organic matter), thus lowering the demand of dissolved oxygen within the water column. As the growing season began, the water warmed, photosynthesis removed carbonic acid from the water and added oxygen to it. Warmer temperatures also increased the decay of the organic matter in the mature slack, thus decreasing the dissolved oxygen due to the higher biological oxygen demand.

Acknowledgements

April Scholtz, Land Protection Director of The Land Conservancy of West Michigan, and the City of Saugatuck for access to the SHNA. Justin Heslinga, Stewardship Director of The Land Conservancy of West Michigan, for his invaluable help in identifying the Cyperaceae and Juncaceae species. Funding was provided by the Department of Geological and Environmental Sciences, Hope College.

References

DeVries-Zimmerman, S., Fuller, J., Peterson, D., Watts, A., Van Gorp, B., and Hansen, E., 2016. Wet and dry slacks: The relationship between Lake Michigan water levels and the hydrology/ecology of an interdunal wetland/slack on the southeast cost of Lake Michigan. Geological Society of America Annual Meeting, Denver, Colorado, Abstracts with Programs, Vol. 48, No. 7, <https://gsa.confex.com/gsa/2016AM/webprogram/Paper287061.html>
Glaser, P. H., 1992. Vegetation and water chemistry in The Patterned Peatlands of Minnesota, University of Minnesota Press, Minneapolis, Minnesota, p. 15–26.
Michigan Natural Features Inventory (MNFI), 2016. <https://mnfi.nr.msu.edu/communities/ranking.cfm>
United States Army Corps of Engineers (USACOE), 2019. <https://www.glerl.noaa.gov/data/dashboard/GLWLD.html>
Vázquez, G., 2008. The role of algal mats on community succession in dunes and dune slacks in Coastal Dunes, Springer, Berlin, Heidelberg, p. 189–203.

Figure 7. Early morning sampling at SHNA on 24 May 2019. View is looking northeast over the mature slack.