Flood Events and Pulse-Press in the McMurdo Dry Valleys

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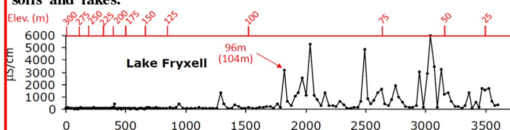
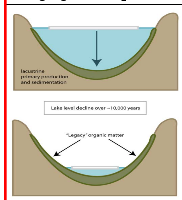
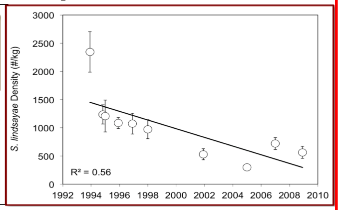
Lake Level: Ecological Legacies

Climate driven variations in lake levels since the Last Glacial Maximum (26,000-20,000 years ago) have created "resource legacies" seen today as gradients of biogeochemical properties in soils and lakes.

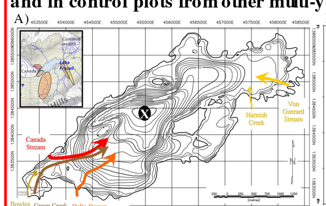


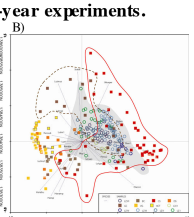
The soil legacy is seen in the high variation in soil salinity at lower elevations near existing lakes. Soil invertebrate biodiversity and abundance are related to salinity and soil water content, which are changing in response to recent pulse events.





Long-term soil studies along an elevation transect (ET) in Taylor Valley (1994-) show changes in soil habitat suitability and soil biota associated with changing hydrologic connectivity. *Scottnema* abundance has declined in the elevational transect and in control plots from other multi-year experiments.

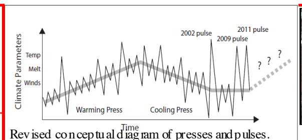




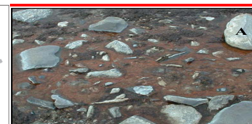
A) Bathymetric map of Lake Fryxell showing location of sediment cores (X) and inflow of streams. B) PCA of benthic diatom communities showing that those from sediment core (grey) are similar to those in mats from Canada Stream and Green Creek at the western end of the lake.

Limnological sampling of Lake Fryxell (G. Rue)

Lake and Stream Ecosystem Response

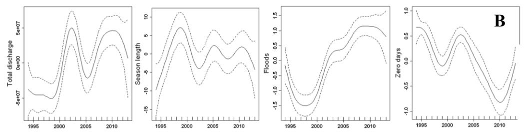


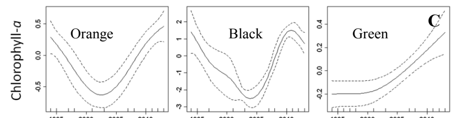
Revised conceptual diagram of presses and pulses.



Orange and black mats in Von Guerard Stream

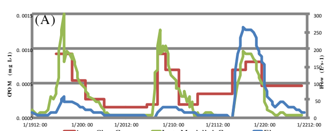
Aquatic ecosystems are expected to respond rapidly to flood events. Monitoring of flow characteristics and algal mat biomass for 16 long term sites in Taylor Valley show that sustained low stream flows in 1990-2001 followed by an extreme flood caused a large decrease in mat biomass. And with recovery occurring under subsequent higher flows.

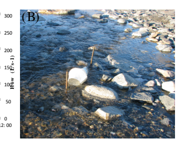




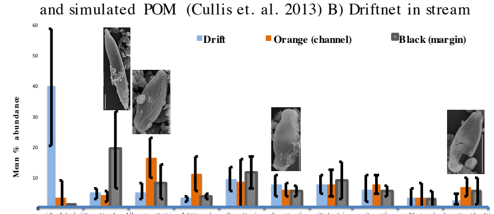
Changes in (B) hydrologic variables and (C) chlorophyll-a by mat type over time. (Kohler et. al., submitted)

Experiments collecting Particulate Organic Matter (POM) material in nets showed that daily flow pulses caused pulses in POM transport, which can be modeled assuming supply limitation. This POM contains diatoms that will be eventually deposited in the lake.





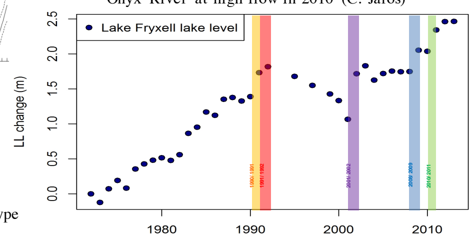
A) POM concentration in Von Guerard Stream compared with flow and simulated POM (Cullis et. al. 2013) B) Driftnet in stream



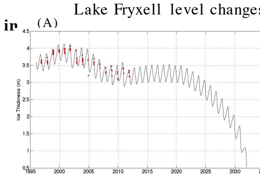
Relative abundances of diatoms transported with POM (drift) compared to diatoms in orange and black mats

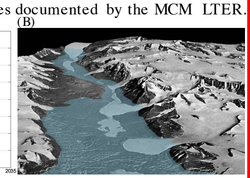
Lake level rise in the last half century is well correlated with the flow record from the Onyx River, which at 32 km in length is the longest river in Antarctica.

Onyx River at high flow in 2010 (C. Jaros)

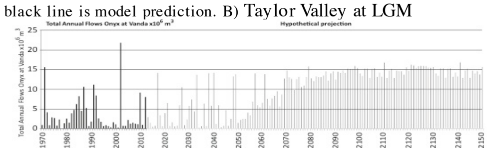


Lake Fryxell level changes documented by the MCM LTER.





A) Physics-based ice-cover model predicts future ice thickness based on weather conditions from 2002-2012. Red points are observations, black line is model prediction. B) Taylor Valley at LGM



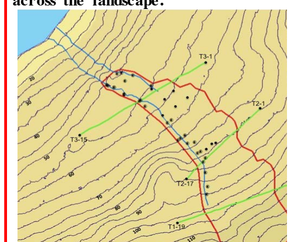
Revised hypothetical projection based on positive influence of ozone hole persistence on glacial meltwater generation. With the amelioration of the ozone hole, global warming is expected to drive regular high flows and lake level rise.

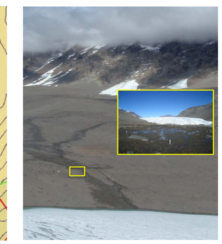
Citation: Cullis JD, Stanish LF., McKnight DM. 2013. Diel flow pulses drive particulate organic matter transport from microbial mats in a glacial meltwater stream in the McMurdo Dry Valleys. Water Resources Research.

Kohler, T., Stanish, L.; Crisp, S.; Koch, J.; Liptzin, D.; Baeseman, J.; McKnight, D. Hydrologic controls on microbial mat abundance in glacial meltwater streams in the McMurdo Dry Valleys, Antarctica: responses to sustained desiccation and extreme flows over two decades. Ecosystems (submitted).

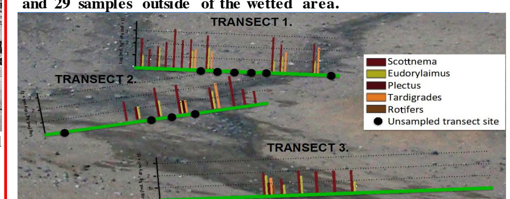
Soil Ecosystem Connectivity

Wormherder Creek is an ephemeral wetland system that has carried flow only three times in the past 20 years, making it an ideal site to investigate the long-term effects of extreme pulse/press events. The insert shows an experiment that was flooded during the high flows of 2001-02 and 2008-09. We hypothesize that climate driven increases in the frequency of flood events will lead to increased connectivity and redistribution of nutrients and biota across the landscape.





Blue lines **– main streams: both drain into Lake Bonney. *Red lines* represent the wetted zone. *Black dots* inside the red line represent the 39 samples analyzed in 2008-09. In 2009-10 we resampled these sites and established 3 transects (Green lines, 51 sampling points) across the watershed to compare the fauna in the dry and the wet areas and monitor the development of soil communities as dry, depauperate soils become colonized over time. This setup encompassed 61 samples inside the wetted area and 29 samples outside of the wetted area.**



<u>The effect of the pulse event (flood) was twofold:</u>

1. Periodic leaching of salts from flooding reduces soil osmotic stress to levels that are more favorable for soil organisms. The increased hydrological connectivity within the landscape unit led to improved habitat suitability, leaving a strong positive effect on soil animal abundance and diversity.

2. The hydrological pulse created increased connectivity within the watershed, providing increased reactivation and dispersal opportunities for soil fauna.

Citation: Stanish LF, Kohler TJ, Esposito RMM, Simmons BL, Nielsen UN, Wall DH, Nemergut DR, McKnight DM 2012. Extreme streams: flow intermittency as a control on diatom communities in meltwater streams in the McMurdo Dry Valleys, Antarctica. Can.J. Fish.Aquat. Sci. 69

Nielsen, U. N., D. H. Wall, B.J. Adams, R. A. Virginia, B. A Ball, M. N. Gooseff, D. M. McKnight. 2012. The ecolo[gy] of pulse events: insights from an extreme climatic event in a polar desert ecosystem. Ecosphere. 3(2)