Legacy effects of catchment restoration on keystone invertebrate abundance

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Background

- Water quality of lakes and streams were heavily impacted from a century of mining
  - Has been improving since 1970s following emissions reductions and re-greening efforts
- Benthic macroinvertebrates are sensitive and ubiquitous organisms with slow rates of recovery[1]

- Amphipoda and Ephemeroptera were extirpated from many of these lakes due to pollution

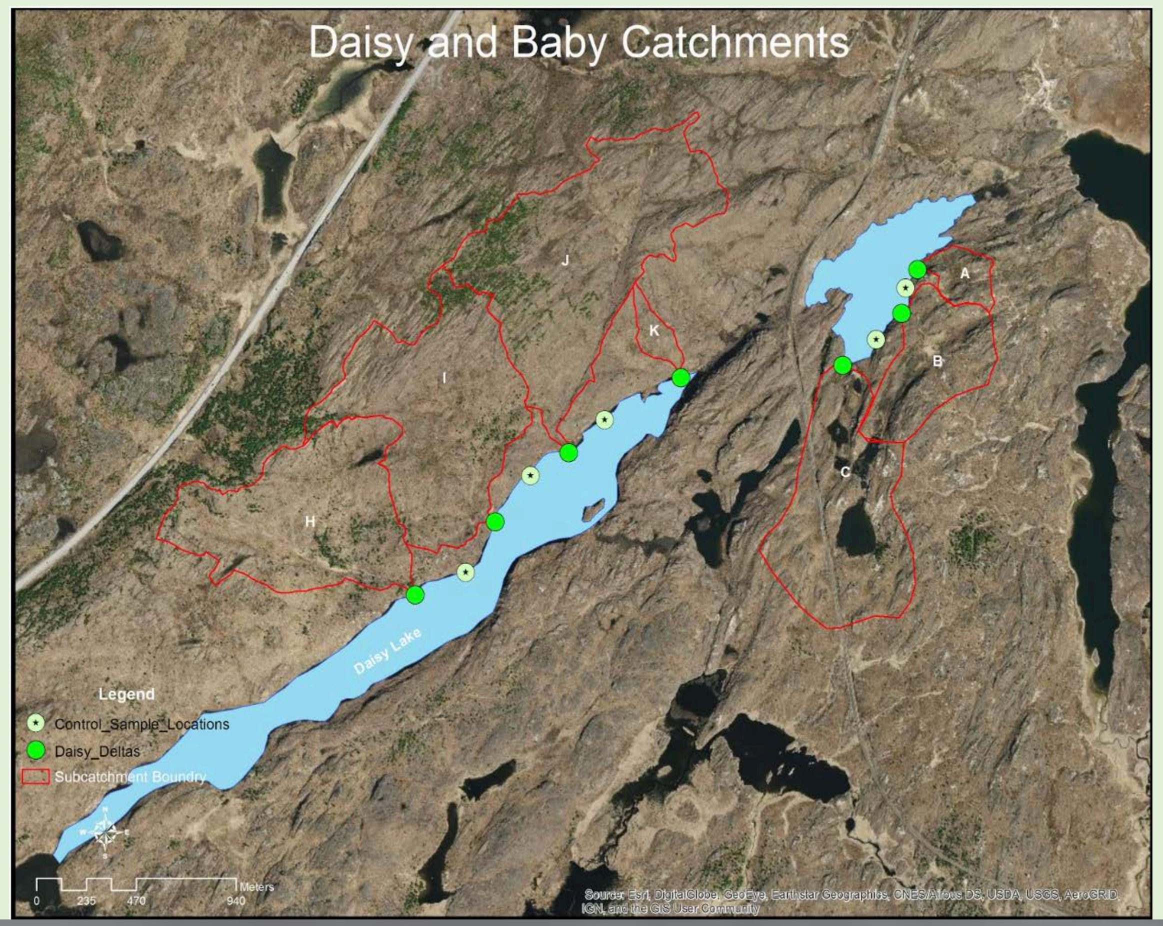
Fig. 1: Coniston smelter in 1935. Photo courtesy of Library and Archives Canada.

Objective

- Examine whether variation in benthic macroinvertebrate abundance correlates with catchment characteristics of 2 lakes in the Sudbury area

Study Area

- Baby Lake: 11.9 ha, 2.7 km from Coniston smelter[2]
- Daisy Lake: 36.1 ha, 3.5 km from Coniston smelter[3]
  - Catchment J: received 460+ tons of limestone in 1995[4]
  - Catchment H: valley area naturally protected from smelter emissions



Methodology

Field Methods

- Artificial invertebrate habitats (dendies) installed for 4.5 weeks → samples of benthic macroinvertebrate community
- Terrestrial catchment characteristics → classify each site by degree of reclamation completed and distance from smelter

Fig. 2: Underwater view of sample site design. **Fig. 3:** Aerial view of non-delta site setup.

Statistical Methods

- Subset of data: 3 randomly selected replicates
  - Multiple regression and marginal mean estimation

Amphipod Abundance

- Amphipod abundance increased with distance from smelter ($F_{1,31}$= 23.87, slope = 0.60, $p<0.001$)
- Amphipod abundance differed among study sites when accounting for distance ($F_{3,31}$= 3.90, $p<0.05$) **Figure 4**
- Abundance is greatest in treated deltas than all other site types (post-hoc test: all $p<0.05$) **Figure 4**
- Only completely restored deltas showed increased amphipod abundance among delta sites **Figure 5**

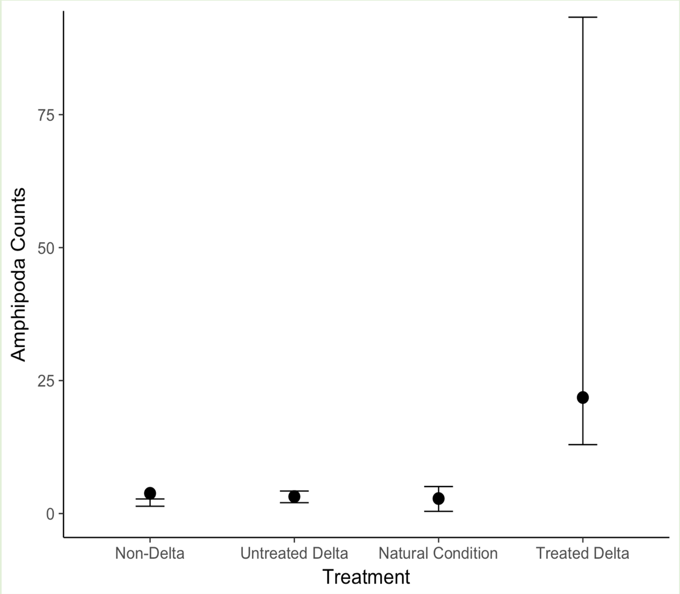


Fig. 4: Marginal mean (± 95% CI) amphipod abundance across study sites.

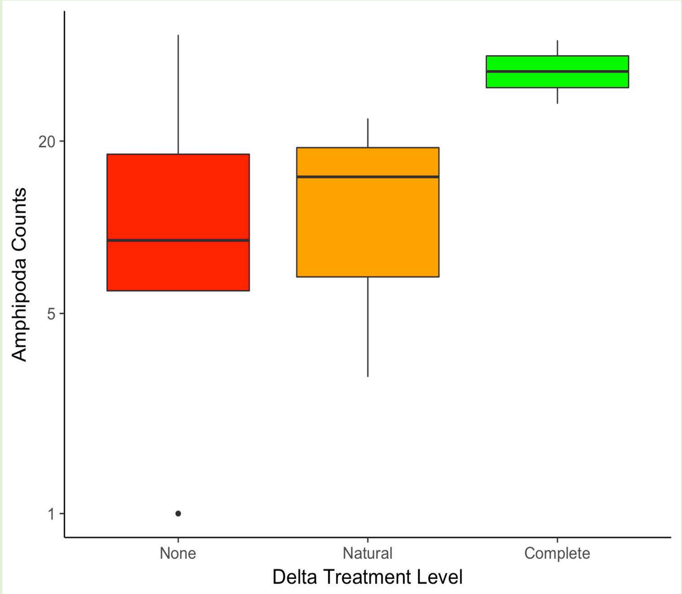


Fig. 5: Raw amphipod counts (log10) at each delta site in Daisy Lake.

Ephemeroptera Abundance

- Mayfly abundance increased with distance from smelter ($F_{1,31}$= 23.81, slope = 0.42, $p<0.001$)
- Mayfly abundance differed among study sites when accounting for distance ($F_{3,31}$= 21.96, $p<0.001$) **Figure 6**
- Mayfly abundance greatest in treated deltas than other sites (post-hoc test: all $p<0.01$) **Figure 6**
- Completely restored deltas were the only deltas demonstrating increased mayfly abundance **Figure 7**

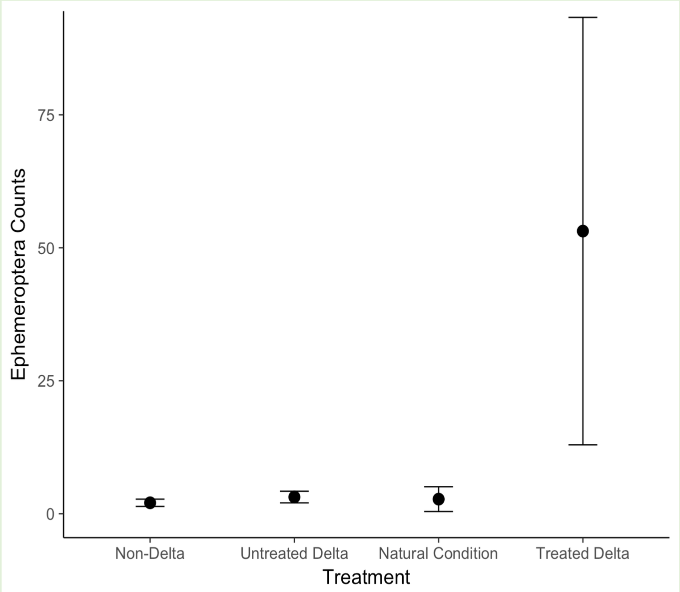


Fig. 6: Marginal mean (± 95% CI) mayfly abundance across study sites.

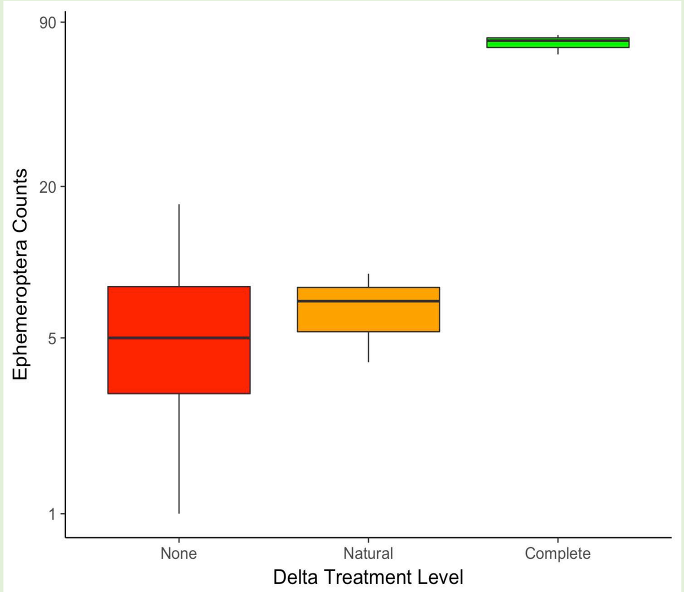


Fig. 7: Raw mayfly counts (log10) at each delta site in Daisy Lake.

Conclusions

- Complete restoration treatments of severely damaged watersheds beneficial at local scales
  - Re-establishment of extirpated keystone macroinvertebrates → driving bottom-up trophic cascades
- Highlights importance of land-water linkages in landscape restoration
- Demonstrates lasting legacy effects of intensive reclamation efforts on whole ecosystem health and recovery

References

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2. Corston, A., Gillespie, M., Gunn, J. 2014a. Baby Lake Urban Lake Fisheries Study. Unpublished report. Cooperative Freshwater Ecology Unit, Laurentian University, Sudbury ON.
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4. Gunn, J., Sein, R., Keller, B., Beckett, P. 2001. Liming of acid and metal contaminated catchments for the improvement of drainage water quality. *Water, Air, and Soil Pollution* **130:** 1439-1444.

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