Bottom-up and top-down effects on algal community dynamics in an aridland river: the Middle Rio Grande, New Mexico

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Introduction

In this study, we examined interactive effects of nutrient availability and grazing pressure on algal biomass and species composition in the Middle Rio Grande, New Mexico. Algal community dynamics can be affected by both bottom-up and top-down factors. For example, algal production may be limited by low levels of nutrients or low light availability. Conversely, production is expected to increase when nutrient levels are high and light availability is not limited. Top-down factors such as grazing by invertebrates can also alter periphyton biomass and community composition.

Methods

1. Create nutrient-diffusing substrates (NDS) using agar, nutrients, terracotta saucers and plexiglass
   - Four nutrient treatments: control (C), nitrogen (N), phosphorous (P), nitrogen and phosphorous (N+P)
2. Attach to PVC arrays and place in river (Figure 1)
   - Exclude top-down grazing using electrical exclosure
3. Collect samples at weekly intervals (for four weeks)
4. Analyze chlorophyll *a*, algal community composition and invertebrate abundance

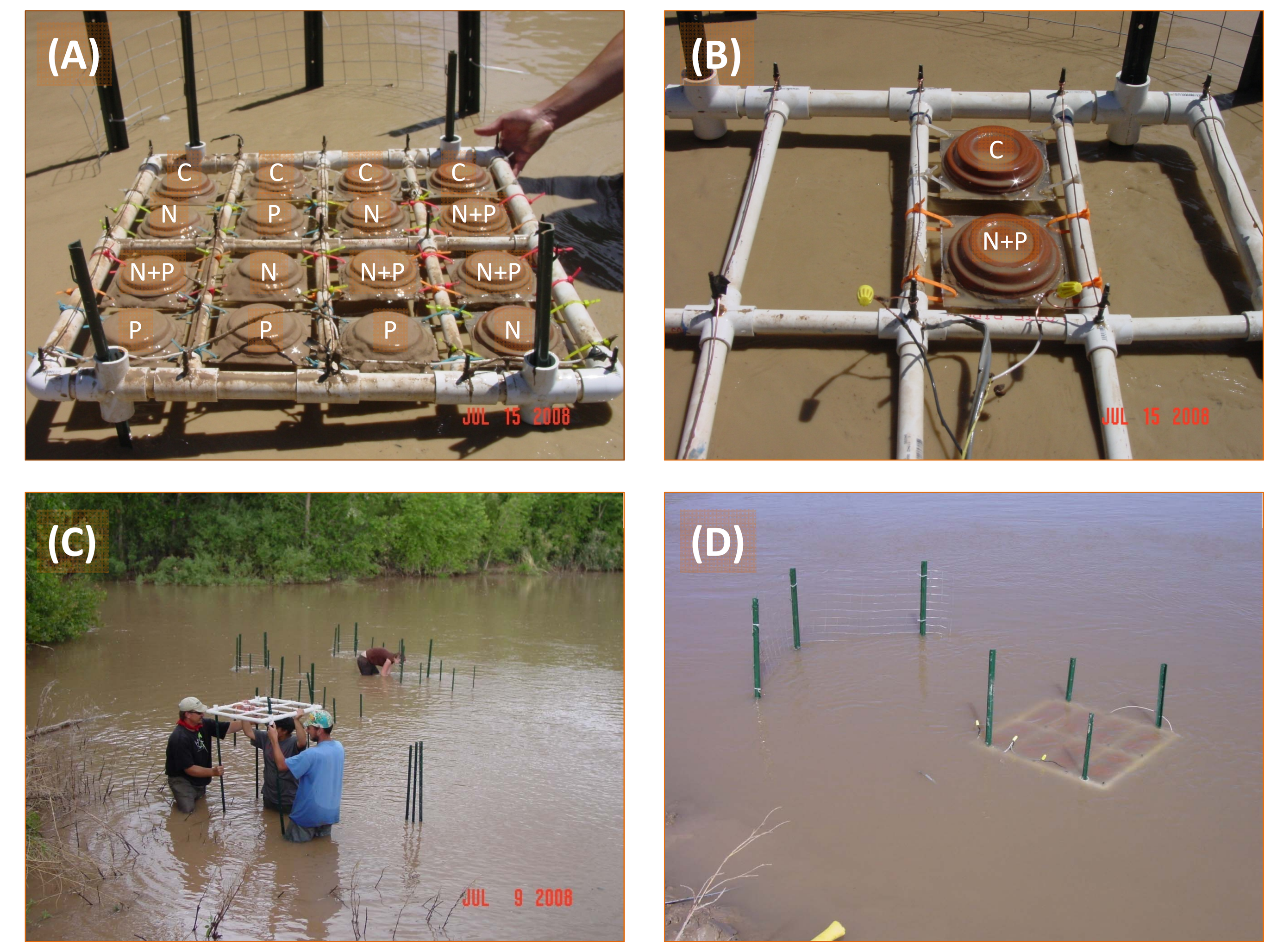

Figure 1. Design and installation of the NDS arrays. (A) – randomized design of nutrient treatments, with all control treatments placed upstream. (B) – electrified grazer exclusion arrays only included control and N+P treatments. If more treatments were included, the electrical circuit shorted out due to the relatively high conductivity (~300-400 µS/cm of river water). (C) – installation of the arrays in the Rio Grande floodplain, July 2008. (D) – one NDS array in place, with barrier upstream to limit debris accumulation on the array.

Figure 2. Arrays were exposed when water levels dropped at least 15cm between sampling week 3 and week 4. Periphyton dried out and aquatic invertebrate fauna were no longer present on the saucers. The arrays were lowered and the experiment was continued for one week longer.

Results

River conditions made it challenging to conduct the NDS experiment. Water levels were variable, turbidity levels were extremely high and it was difficult to submerge the arrays at the correct depth below the water surface so that there was enough light penetrating to encourage algal growth, without risking exposing the saucers. In fact, the saucers were exposed between week 3 and week 4 when water levels decreased more than 15cm (Figure 2).

Because of these physical limitations, **algal production was very low** (Figure 3, Figure 4). Biomass of chlorophyll *a* on the saucers was negligible. Initial surveys of the diatom communities indicate extremely low densities.

Invertebrate abundances differed significantly among sample weeks but not among nutrient treatments – blackfly larvae (Simuliidae) were most abundant at week 3 whereas chironomid larvae (Chironomidae) were most abundant at week 5 (Figure 5). Also, blackfly larvae were significantly more abundant on control saucers than on N+P saucers in the grazer/non-grazer experiment (Figure 6). Whether or not these differences in invertebrate population densities are related to the availability and diversity of periphyton for grazing is yet to be explored.

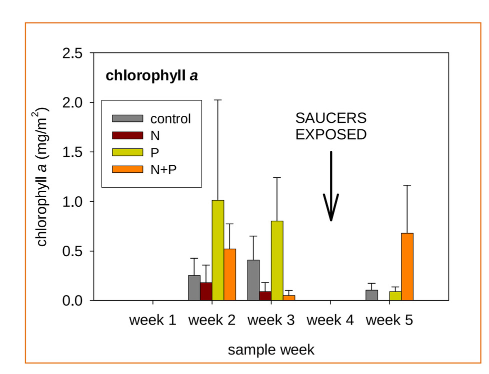

Figure 3. Mean (±SE) data for chlorophyll *a* from NDS arrays on each of the successful sampling weeks (weeks 2, 3, 5) from four different nutrient treatments (control, N, P, N+P).

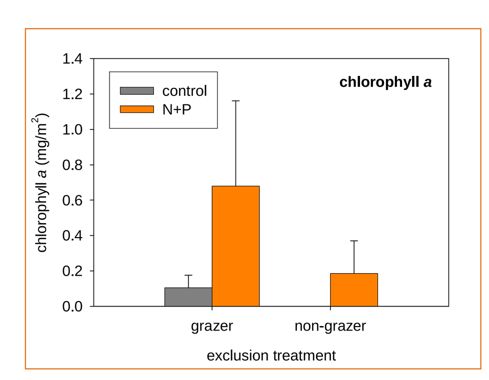

Figure 4. Mean (±SE) data for chlorophyll *a* collected at sample week 5 from NDS arrays with two nutrient treatments (control, N+P) and two grazer exclusion treatments (grazer, non-grazer).

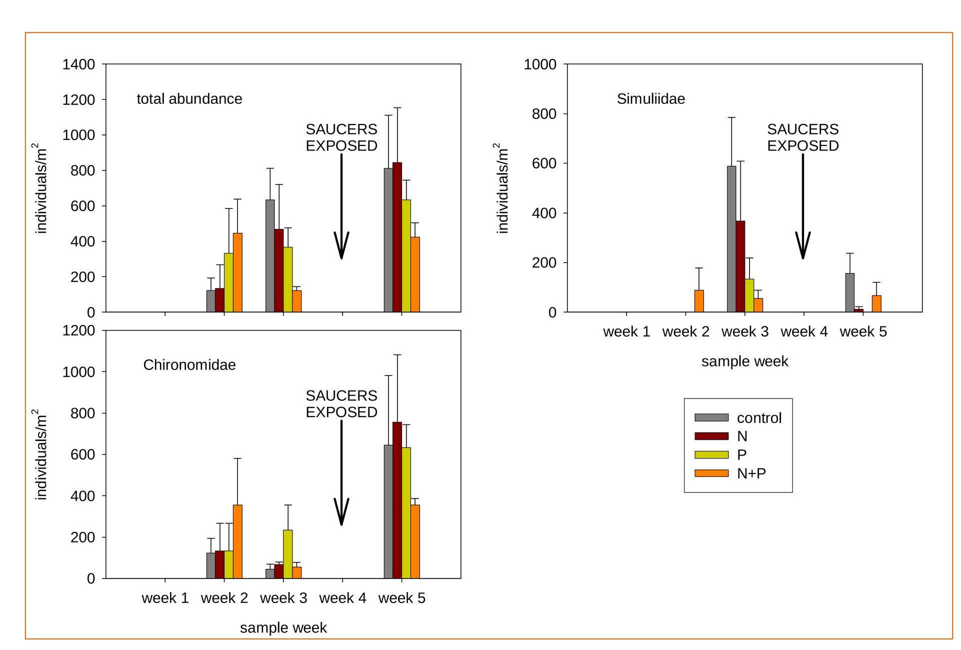

Figure 5. Mean (±SE) abundance of invertebrates collected from NDS arrays on each of the successful sampling weeks (weeks 2, 3, 5) from four different nutrient treatments (control, N, P, N+P): total abundance, simuliid (black fly) abundance and chironomid (midges) abundance. Note differences in scale on y-axis.

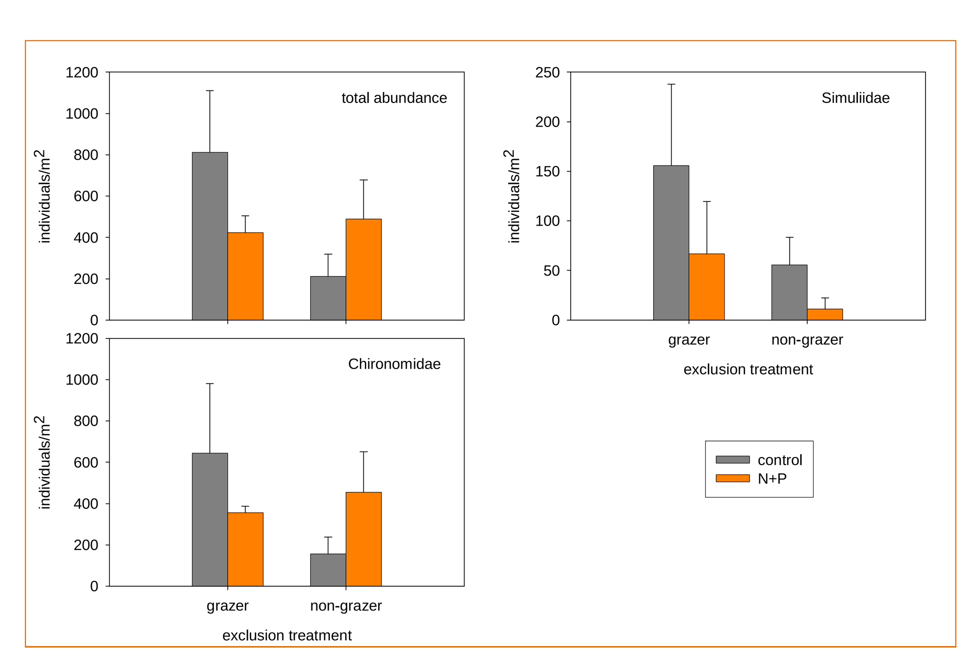

Figure 6. Mean (± SE) abundance of invertebrates from NDS samples collected at sample week 5 from NDS arrays with two nutrient treatments (control, N+P) and two grazer exclusion treatments (grazer, non-grazer): total abundance, simuliid (black fly) abundance and chironomid (midges) abundance. Note differences in scale on y-axis.

Discussion

The NDS experiment was problematic for a number of reasons. Firstly, **variable flow levels and high turbidity made it difficult to set the saucers at the correct depth** – and have this depth sustained. We are currently repeating the experiment at a new site with much greater success (Figure 7). The NDS arrays have been modified by including floatation devices, which eliminates the issue of variable water depth. Initial observations indicate good algal growth and high abundances of invertebrate fauna colonizing the saucers.

Secondly, **relatively high conductivity levels in the Middle Rio Grande caused difficulties with the electrical exclosure**. Initially, we had planned to include the same number of treatments and sample weeks in the grazed and non-grazed arrays, but this was not feasible. The experimental design was modified to include maximal growth (sampling at week 4) and only one nutrient comparison (control versus N+P).

NDS experiments are not often conducted in large, turbid rivers and the technical problems experienced in the Middle Rio Grande emphasize the need to **appropriately modify experimental techniques** to fit individual field situations.

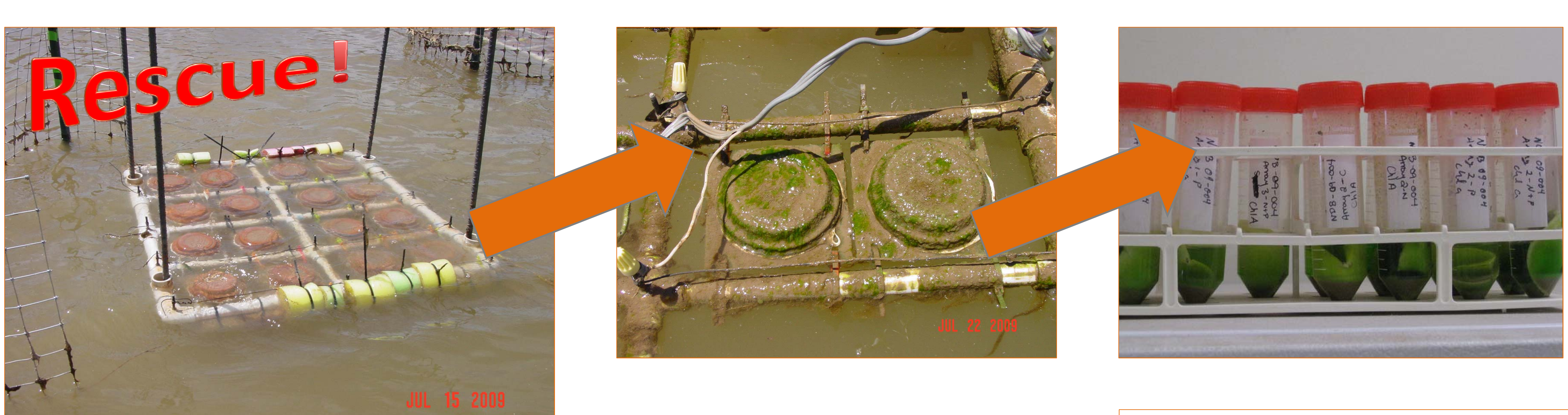

Figure 7. The experiment is currently being conducted again, at a new site. The arrays have been modified by including floatation devices and the new site has not dried down. Initial observations indicate that there has been substantial algal growth and considerable invertebrate colonization. Biomass of chlorophyll *a* appears to be relatively high compared to that found in our river surveys.

Acknowledgements

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