Algae in a Warming, Nutrient-Rich World

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Climate warming and eutrophication are global drivers of ecological change in streams, including shifts in the structure and function of algal assemblages. Warm conditions may promote the growth of noxious or toxin producing cyanobacteria and fuel energy-rich processes like N_2-fixation. The addition of a limiting nutrient, like nitrogen (N) or phosphorus (P) may promote the growth of cyanobacteria, or result in species shifts between nutritious, palatable diatoms and less-palatable cyanobacteria. Interactions between climate warming and nutrient additions may further complicate our ability to predict, and thus manage, how a warm, nutrient-rich world might influence biofilm assemblages. In nitrogen-poor streams located along a geothermal gradient in Iceland, we explored the effect of temperature on rates on nitrogen-fixation and the species composition and abundance of nitrogen-fixing cyanobacteria and algae, like diatoms in the Rhopalodiaceae that contain N_2-fixing cyanobacterial endosymbionts. We then manipulated temperature (8 to 25°C) as well as N and P availability in streamside channel experiments to assess their interactive effect on biofilm structure and function. In general, under nitrogen-poor conditions in both stream and channel settings, N_2-fixers, especially cyanobacteria like *Nostoc*, dominated overall, though complexities in patterns emerged with species-level considerations and variation in substrate availability, temperature, and nutrients. Warmer temperatures promoted biofilm growth and increased N_2-fixation rates though rates declined with increasing nitrogen as biofilm composition shifted from N_2-fixing taxa towards diatoms like *Melosira* and *Diatoma,* and green algae. With both warming and P-addition, diatoms in the *Rhopalodia*ceae increased, using cyanobacteria like *Nostoc* as a substrate. With the addition of both N and P, N_2-fixing taxa remained present longer under warmer - conditions. Temperature and nutrient influences on the structure and function of biofilms not only determines how, where, and under what conditions N enters the ecosystem, but also the presence of nutritious or noxious species. Our results reinforce how different modes of resource acquisition and overall resource needs possessed by individual species can drive ecosystem responses to eutrophication and warming.