Anthropogenic stresses and climatic changes have the potential to cause dramatic shifts in ecosystem states, which are often long lasting and difficult to reverse. Complex natural systems respond to external pressures through gradual changes that can be interrupted by drastic switches to a contrasting alternative state. This often entails a loss of the provision of valuable ecosystem services rendering the new state less desirable. In ecological communities such negative shifts often go along with changes of interactions among species and reduced biodiversity. This can result in a general loss of resilience, decreasing the ecosystem’s ability to endure disturbances without changing in fundamental ways. However, the importance of different types of species’ interactions as well as species’ and functional diversity for the functional stability of communities are hitherto poorly understood.

In this study we investigated functional shifts using laboratory mesocosms composed of 12 bacterial species growing on benzoate, a contaminant also found naturally, as their sole carbon source. Species were chosen such that half of them were able to use benzoate directly while the other half only could survive on metabolic intermediates of the degraders. In order to investigate the importance of different functional groups and diversity for community shifts and functional loss we conducted rows of extinction experiments. We started with assemblies of all possible combinations (N=4095) and estimated the occurring bacterial growth of each combination. Next we simulated random extinction events by stepwise removing single species. As soon as the communities lost the last degrader they rapidly shifted from a benzoate degrading community toward one that was no longer able to provide this function. To better understand the role of species interactions for the provision of the ecosystem function under stress we additionally conducted the same extinction experiments under two successive stress levels. In a first step we confronted the communities with 6 times higher benzoate concentration which has a toxic effect even on many benzoate degraders. In a second step we additionally added NaCl. Under the combined stress none of the species was able to grow as a monoculture, however many polycultures were able to survive. Interestingly species that were seemingly unimportant under none and/or intermediate stress levels suddenly became a prerequisite for the functioning of a community under high stress levels. Detailed analysis comparing similar extinction rows allowed us to determine multiple species combinations which occurred to be minimal communities necessary for the provision of benzoate degradation within our microcosms. From our experiments we can directly show that while competition was the main species interaction under no stress systems in highly stressed systems mutualistic species interactions dominated.