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Resource-mediated competition between two plant species with different rates of water intake

We propose an extension of the well-known Klausmeier model of vegetation to two plant species that consume water at different rates. Rather than competing directly, the plants compete through their intake of water, which is a shared resource between them. In semi-arid regions, the Klausmeier model produces vegetation spot patterns. We are interested in how the competition for water affects the co-existence and stability of patches of different plant species. We consider two plant types: a "thirsty" species and a "frugal" species, that only differ by the amount of water they consume per unit growth, while being identical in other aspects. We find that there is a finite range of precipitation rate for which two species can co-exist. Outside of that range (when the rate is either sufficiently low or high), the frugal species outcompetes the thirsty species. As the precipitation rate is decreased, there is a sequence of stability thresholds such that thirsty plant patches are the first to die off, while the frugal spots remain resilient for longer. The pattern consisting of only frugal spots is the most resilient. The next-most-resilient pattern consists of all-thirsty patches, with the mixed pattern being less resilient than either of the homogeneous patterns. We also examine numerically what happens for very large precipitation rates. We find that for a sufficiently high rate, the frugal plant takes over the entire range, outcompeting the thirsty plant.