Variation is all around

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Adaptation of populations to large-scale spatial heterogeneity in the environment accounts for a significant proportion of genetic diversity found within species. For example, plant populations from diverse climates may exhibit genetic differences in quantitative traits related to phenology and growth. On a more local level classical evolutionary theory predicts the erosion of genetic diversity as selection removes non-optimal phenotypic variation from populations. However, considerable fine-scale adaptive genetic diversity characterizes numerous natural populations, a pattern whose causes are often poorly known. Because the adaptive capacity of populations under novel environmental conditions is dependent on the amount of genetic diversity in traits under selection, the maintenance of local genetic diversity in the wild has become a key question in modern evolutionary and conservation biology.

Using my earlier work on Scottish populations of Scots pine (Pinus sylvestris) and Rocky Mountain populations of the perennial forb Boechera stricta as examples, I discuss adaptation in heterogeneous environments and show how genetic diversity can be found at various levels in nature. For instance, in high-elevation populations of B. stricta in southeastern Wyoming, within-population genetic diversity in the circadian clock, the endogenous timekeeper regulating daily rhythms in various traits, exceeds that among populations.

Short-term experiments in growth chambers simulating natural conditions and longer-term experiments in the field have begun to shed light on the role of naturally occurring environmental heterogeneity in maintaining diverse genotypes within populations, with results revealing environment-dependent expression of genetic diversity in all traits from growth and flowering to reproductive fitness. Therefore, understanding spatial and temporal heterogeneity in environmental conditions is likely to help in solving how significant genetic diversity and capacity to adapt to changing environmental conditions can be preserved also on very fine spatial scales within populations.