Individual plant species thrive in specific environments, some growing well across a wide area, others being restricted to survival in very narrow ecological niches. Within a niche, a species must compete for space, light and other resources with the same and other species. Many decades of work on crops has advanced our understanding of characteristics related to crop production and agronomy, with many studies involving the partitioning of components to the smallest part that can be measured, extensive experimental studies in both controlled and natural environments, linkage mapping or association genetics allowing the underlying genes or quantitative trait loci (QTLs) to be identified, and modelling of the effects of the genes on plant development. Now, with extensive segregating populations for most agricultural and many model species, high-throughput DNA sequencing is accelerating discovery of gene alleles related to functional traits, while DNA-based markers have increasing application in breeding programmes.

This Highlight section of *Annals of Botany* shows the novel and rapid advances now being made in the identification and characterization of functional traits in ecology, identifying genes that enhance plant adaptation to ecological niches within ecosystems. There are many contrasts with crop studies that make this work particularly challenging, particularly because of the enormous biodiversity within a natural ecosystem (both within individual species and in the number of interacting species) and the variation in the environment. As in many areas of evolutionary biology, Darwin (1859) put in place an understanding of trait variation and selection. Later, pioneers in population genetics and G × E (genotype-by-environment) studies have demonstrated many aspects of plant adaptation to their environment, leading to understanding of endemism and applications in ecosystem modelling. Now, the underlying traits are being investigated both within and between species using observational, experimental, genetic and modelling methods, as is shown within the five papers highlighted here. The results have clear predictive value for ecosystems, with importance for short-term management strategies and longer-term approaches, for example in mitigation of climate changes.

A small number of plants flourish when moved to a different environment, and are highly productive: a desirable outcome for crops, but not for plants that become invasive. One can argue that some invasives occupy niches where plants have hardly thrived, the obvious example being the *Eichhornia* species of water hyacinth, native to South America, but now forming dense mats and clogging the surfaces of water courses across sub-tropical Asia and Africa. Drenovsky et al. (2012) review dynamic approaches to understating key functional traits that make a species invasive, and in particular consider how global environmental change will affect non-native plant invasions. These authors emphasize the need for research at scales from the individual to the ecosystem, and their review points to the range of science-based policies that need to be implemented to cope with the devastating impacts that invasive species are having on important ecosystems, whether in terms of preventing future invasions or mitigating the spread of invasive through interventions including restoration ecology.

*Mondoni et al. (2012)* study a novel aspect of the seed germination trait, considering the impact of climate change on timing of germination in alpine species. In the extreme short seasons of the alpine ecosystem, vegetative reproduction and the spread of clones is widespread, and seed germination has often been considered rare, albeit of genetic importance. In contrast, migration of plants is normally (although not universally) through seed dispersal, and migration can include the response of species to the movement of their optimum environment because of climate change. Taking an experimental approach, the authors show that seeds of many alpine species are closely adapted to their current environment. For six of the eight species they study from an ice-free site at 2500 m, timing of seedling emergence is shifted to the less-favourable autumn season under conditions where the autumn is warmer. Seed dormancy factors can affect the nature and rate of species’ migration and establishment in ways that are not related to the success of the vegetative plant.

A different aspect of ecological genetics is studied in the work by *Milla et al. (2012)*. Kin co-operation and rivalry has long been studied by ecologists in mammalian species, with extensive modelling being used to examine the advantages to individuals and species of competition or co-operation for dissemination of their own genes. The occurrence of co-operation between related plant genotypes is more controversial, and in this report the authors find no evidence for kin recognition and modification of growth strategies based on relatedness in pot-based experiments with siblings (1/2 related), cousins (1/8 related) and unrelated plants of the legume *Lupinus angustifolius*. Clearly, more examples are required to investigate whether kin co-operation does occur in plants, particularly given the importance of monocultures to agricultural production, and the significance of genetic homogeneity for disease epidemiology in both natural and agricultural environments.

The abundance of angiosperm trees since the Cretaceous and their replacement of the previously dominant gymnosperms, except in some extreme ecosystems, has been widely discussed. A number of models involving water transport, reproduction and vegetative growth have been developed to explain the success of angiosperms. In this issue, *Lusk et al.*...
(2012) collect data from seedlings of conifers and angiosperms in five temperate rainforests. A modelling approach then shows that leaf structure, and particularly the superior light interception of angiosperm seedlings over the gymnosperms, gives them a substantial competitive advantage: it seems that the small number of larger leaves giving high light interception are important. The advantage is particularly high in light-limited environments, so gymnosperms continue to be successful in environments where other factors limit growth, and the authors conclude that traits related to seedling competitive ability are an important advantage for angiosperm trees.

The final paper in this Highlight compares the behaviour of two successful species that co-occupy a single niche despite contrasting traits and hence strategies for survival. Surprisingly, in a seasonally dry tropical forest, both evergreen and deciduous angiosperm trees are successful, while in most environments the successful species tend to follow similar growth strategies within a niche. Fu et al. (2012) show that numerous fundamental traits, including stem hydraulic efficiency, photosynthetic rate, xylem cavitation resistance and leaf turgour-loss-point water potential, differ between the species. Thus a suite of characters have co-evolved in each species to cope with the seasonally dry tropical environment, and both strategies are equally successful. More generally, crop biologists will need to consider different solutions to environmental challenges, and it is probable that several approaches will be equally valuable in increasing the robustness of whole systems to environmental instability.

These five articles show how understanding of plant traits and their significance for interactions with the environment is advancing using a range of approaches. The articles emphasize the impact that the ecosystem research is having on both fundamental knowledge of plant growth and development, and on the management strategies required for communities that are so critical in providing ecosystem services. I am sure the area will continue to develop, but I also hope that the lessons will be used in development of policies in a shorter timescale.

LITERATURE CITED


