Carl runs a garden center. ‘I trace my love of things botanical to childhood memories of farm meadows bursting into flower every spring. My very first recollection, full of color and perfume and the chirping of grasshoppers, is toddling through a flower meadow when the grass and the flowers were taller than me! You never see these multicolor farm meadows nowadays.’ When he can, Carl takes an early summer holiday in the Canadian Rockies, searching for the high meadows that, for a few weeks, put on similar breathtaking displays. ‘Funnily enough, some of the biggest sellers in my catalog are seed-mixes to recreate in your own garden that lost splendor of meadows in bloom. Ironic, isn’t it, that all this was once free?’

Carl can identify with the idea of niche-matching for species success (Chapter 2) – his brochure lists speciality seed mixes such as ‘made-for-shade’, ‘mountain-meadow-glory’ and ‘seaside-flowerburst’. However, Carl also has a guilty secret. In the early days, his ‘marsh-gold’ seed-mix included coltsfoot (Tussilago farfara) and lupin (Lupinus polyphyllus), which in our part of the world turned out to be enemies in disguise. Instead of simply contributing to the floral symphony and staying obediently in place, they spread and invaded wild habitats where they ousted delicate native plants. These invaders are now banned from sale, but Carl still worries: ‘How many other aliens are we helping, inadvertently or otherwise?’

Carl can take comfort from the fact that research is going on around the world to work out the best ways to restore natural biodiversity to agricultural landscapes. Much of this depends on understanding the life-history traits of candidate species – whether they are annuals or perennials, specialists or generalists, fast or slow growers, with or without persistent seed-banks, and so on (Box 3.1; Section 3.2). And this kind of life-history information proves to be just as important when predicting which species are likely to be problematic invaders (Section 3.3), and also which need special protection because of their vulnerability to human impacts such as harvesting, habitat fragmentation, logging and pollution (Section 3.4).

### Box 3.1 Essential life-history theory

#### Life cycles

To understand why one species is successful in a particular location while another is not, we often need to focus on the sequence of events that occur in the organism’s life cycle. At its simplest, the life cycle of a plant or animal comprises birth, followed by a pre-reproductive juvenile period, a period of reproduction, possibly a post-reproductive period, and then death (although various causes of mortality may intervene at any time). Some species squeeze several or many generations into a single year, some have one generation each year (annuals), but others (perennials) have life cycles that last for several or many years. Many plants and some animals (such as the fairy shrimp *Streptocephalus vitreus*) spend part of the year in a dormant phase (e.g. as seeds or eggs), and their ‘seed-banks’ can persist for years. All these features help determine the success of a particular species in a particular type of environment.

#### Species traits

Beyond contrasts in the characteristics of their life cycles, species differ in many other fundamental ways. Individuals may be small or large, invest few or many resources in their offspring (in seed biomass or parental care), have a short or long juvenile period, grow fast or slowly, and be more or less vulnerable to various sources of mortality. Some species are very specialized in their requirements, while at the other extreme are animals that are good at learning to exploit novel resources or plants with plastic tolerance limits that allow them to succeed in a range of circumstances. Species also vary in their competitiveness for limited resources, their tolerance of physically stressful conditions or of environmental disturbances, and their ability to find and exploit new habitats.
Several schemes have been developed that link particular groups of traits to particular kinds of environments (see Chapter 4 in Begon et al., 2006, for a detailed treatment). Two of these schemes will figure here – the $r/K$ and CSR concepts.

The $r/K$ concept
The potential of a species to multiply rapidly – producing large numbers of progeny early in life – is advantageous in environments that are short-lived (created, for example, by a disturbance such as the falling of a forest tree, or the storm-battering of a rocky reef), allowing the organisms to quickly colonize and exploit the new habitat. Such species have been called $r$-species because they spend most of their lives in a near-exponential phase of population growth where their intrinsic rate of increase ($r$) is being fully expressed. The habitats where they are favored have been called $r$-selecting.

At the other end of the scale are organisms with life histories that enable them to survive where there is often intense competition for limited resources. In this case the individuals leaving most descendants are those that capture a larger share of resources. They are called $K$-species because they spend most of their lives bumping up against the environment’s carrying capacity ($K$). Habitats where they are favored have been called $K$-selecting.

The $r/K$ concept (MacArthur & Wilson, 1967; Pianka, 1970) can be useful in the interpretation of contrasting patterns in nature. For example, many forest trees are excellent examples of $K$-species. They compete for light in the canopy and the survivors are those that put their resources into growth so they can overtop their neighbors. They usually delay reproduction until their branches have secured a place in the forest canopy, and hold on to their position and live for a very long time. Overall, they make a relatively low allocation to reproduction but many produce large, well-provisioned seeds. By contrast, in the more disturbed circumstances of $r$-selecting habitats, plants tend to conform to a contrasting group of $r$ characteristics: a greater reproductive allocation, but smaller seeds, smaller size, earlier reproduction and a shorter life.

The CSR concept
Grime (1974, Grime et al., 1988) produced a different, but not unrelated, classification of habitats and plant life histories. Habitats are seen as varying in two significant ways – in their level of disturbance (brought about by grazing, disease, trampling or adverse weather) and in the extent to which they experience ‘stress’ (shortages of light, water or nutrients that limit photosynthesis). Grime argued that a stress-tolerant strategy (S) is appropriate when ‘stress’ is severe but disturbance is uncommon. Conversely, a so-called ruderal strategy (R) is appropriate when disturbance levels are high but conditions are benign and resources abundant ($R$-species are essentially good colonizers). Finally, a competitive strategy (C) is appropriate when disturbance is rare, resources are abundant and crowded populations develop. Grime then classified a large number of plants on the basis of ecological characteristics he thought suited them for one or other of these strategies (C, S or R), or some intermediate combination (CR, CS, SR or even CSR). Grime suggests that strong competitors have a high relative growth rate, the ability to spread by vegetative means and a tall stature. Stress tolerators, on the other hand, are small in stature with a low relative growth rate. Finally, ruderal species are generally annuals or short-lived herbaceous perennials with a capacity for rapid seedling establishment and growth, and a tendency for a high proportion of photosynthate to be directed into seeds. Intermediate species possess combinations of these traits.

Native biodiversity is often compromised as a result of human activity, whether by mining, agriculture, forestry or urban development. The desire to restore these places to something approaching their pristine state may lead, through a political process, to legislation or economic incentives that foster recovery. In other cases, economic circumstances change and previous activities are no longer sustainable – mines close, agricultural land is put out of production, forestry is no longer viable. Whatever the background, effective restoration needs to be based on knowledge of