



## Climate change and ecological decoupling

The near-surface temperature of the planet has risen about 0.6° C in the past 100 years. The 1990s was the warmest decade on record.

In 2002 the Intergovernmental Panel on Climate Change (IPCC) reported that of the more than 500 birds, amphibians, plants and other organisms studied, 80 percent had changed the timing of reproduction or migration, length of growing season, population size or population distribution in ways that might be expected from warming temperatures.

This Factsheet reviews the latest research into how climate change is disrupting ecosystems as organisms respond to changing temperatures.

### Flowering times

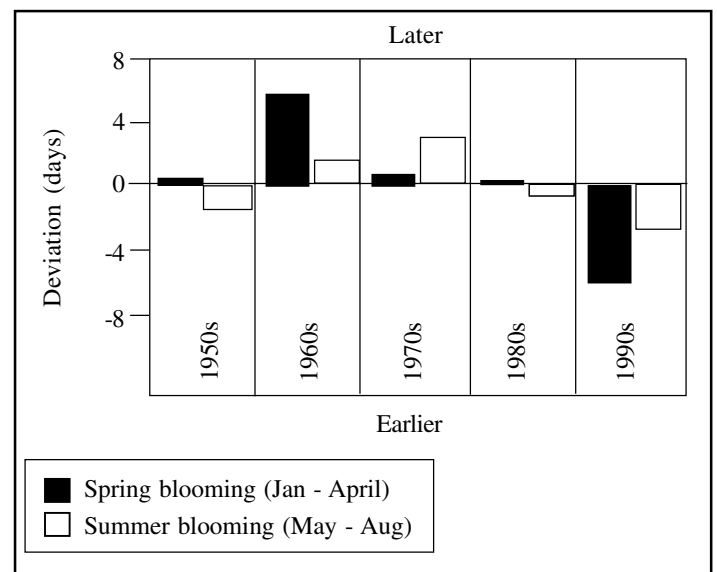
The timing of flowering is a key event for plants. It affects their chances of pollination, especially when the pollinators (e.g. bees and other insects) are themselves seasonal, and determines the timing of seed ripening and dispersal.

Flowering time also influences animals for which pollen, nectar, and seeds are important resources and earlier flowering also implies earlier activity in other processes such as leaf expansion, root growth and nutrient uptake. Large changes in flowering date will therefore disrupt ecosystem structure.

One study in the UK compared the first flowering dates of plants in the 1990s with those of 1940–1990 (Fig1). Negative values indicate earlier than average flowering, positive values indicate later than average flowering.

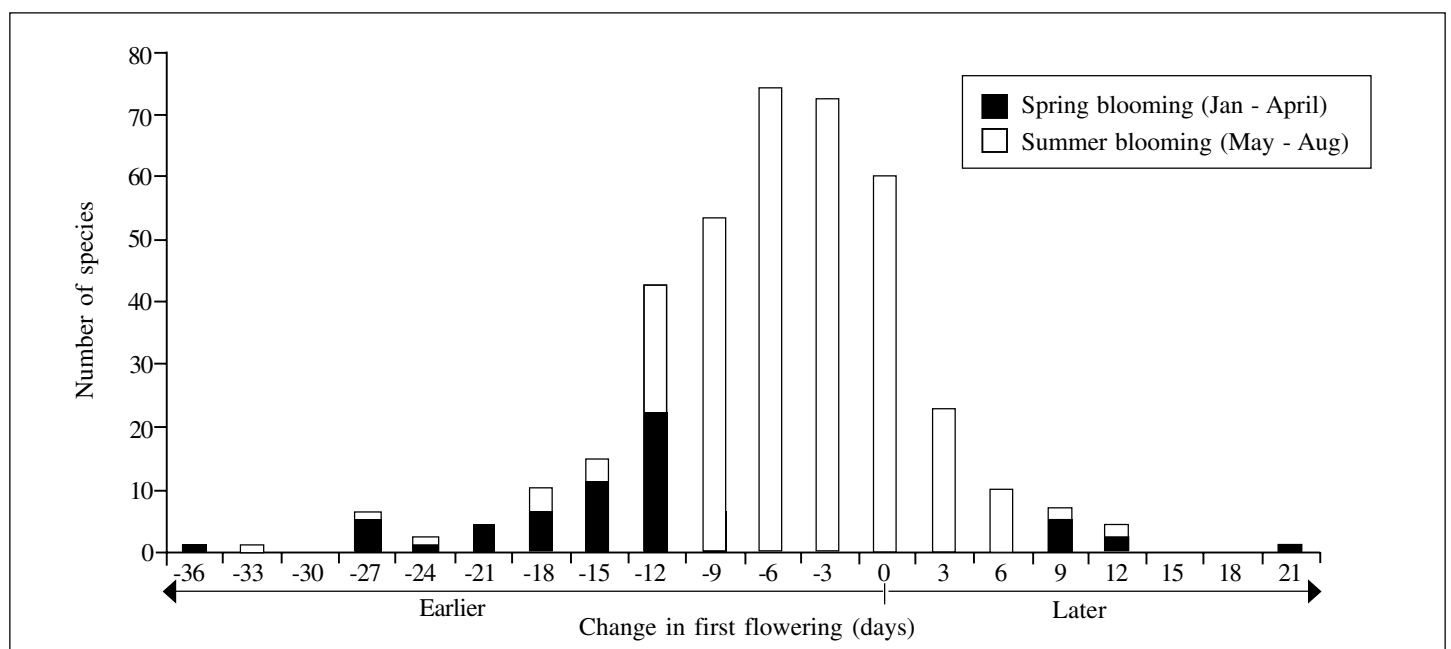
The study found that 385 plants were flowering an average of 4.5 days earlier but that some species were flowering later. Fig 2 summarises first flowering time for each decade compared to the long-term mean (1954 – 2000).

**Fig 2. first flowering time for each decade compared to the long-term mean (1954 – 2000).**



Such changes may have significant effects in the species composition of habitats. For example, species that are more likely to flower synchronously as a result of warming may produce more hybrids – changing the species make-up as they do so. This will have knock-on effects for herbivores and pollinators.

**Fig 1. Flowering dates of plants in the 1990s compared with those of 1940 –1990**



**Length of growing season**

Many studies indicate that the length of the growing season for many species will increase. For example, in Mediterranean ecosystems, the leaves of most deciduous plant species now unfold on average 16 days earlier and fall on average 13 days later than they did 50 years ago.

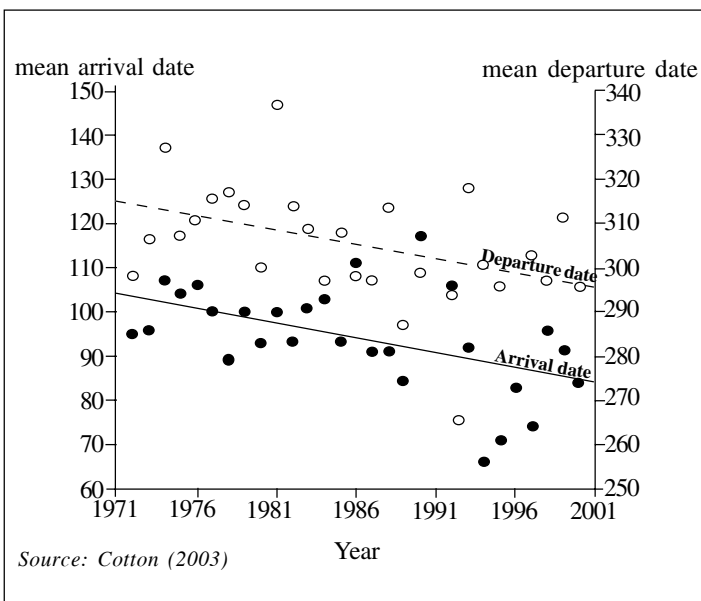
A longer growing season means greater CO<sub>2</sub> fixation. This may be reflected in the increasing amplitude of annual oscillations in atmospheric CO<sub>2</sub> levels between 1960 and 1994.

**Bird migration**

Many birds spend Winter in tropical areas and then migrate to and breed in Europe in Summer. Some studies have shown that species are beginning to arrive late. They are staying longer than normal in the tropics and are arriving in Europe at a less appropriate time. For example, they may face much greater competition with larger numbers of individuals of resident species as more of them survive the winter.

But other studies show just the opposite. Cotton (2003) showed that 17 common migratory species such as Common Cuckoo, Common Swift and Common Redstart, were arriving 8 days earlier in Oxfordshire than they were 30 years ago. Perhaps surprisingly, given the longer growing season, 15 of these early-arrivals were also leaving earlier, so their overall period of stay was unchanged (Fig 3). Three species were arriving later.

**Fig 3. Regression lines of arrival date and departure date of migrant birds in Oxfordshire**



These changes in the timing of plant development (**plant phenology**) and bird migration show that climate warming may lead to a decoupling of species interactions. This could be between plants and their pollinators or between birds and their plant or insect food supplies.

**Case Study: Great tits and caterpillars**

Since 1985 the numbers, health and nesting behaviour of Great tits in 400 bird boxes in woodland at De Hoge Veluwe National Park has been recorded

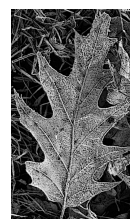
The tits have laid their eggs at almost the same time every year. However, over this same period, spring temperatures have increased by 2°C.

The tits mainly feed their chicks on winter moth caterpillars along with other less abundant species.

Unfortunately for the tits, the increased temperatures have led the caterpillars to emerge, on average, 15 days earlier than they did in 1985.

The chicks are now hatching after caterpillar biomass has peaked and only the earliest chicks get the worms.

The Great tit and its main food source have become **decoupled**. But so too, it seems has the caterpillar with its main food source – oak leaves.

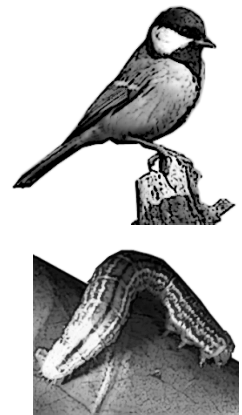
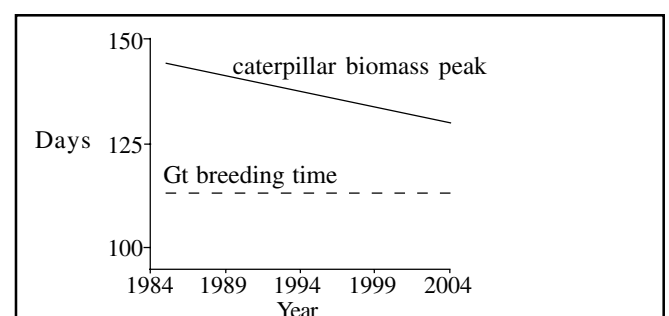


To have the greatest chance of survival, the caterpillar must hatch almost precisely at bud burst, when the oaks' leaves open. If the insect hatches more than about five days before bud burst, it will starve to death before the leaves appear. The caterpillars also starve if they hatch more than two weeks after bud burst. This is because the leaves become impregnated with tannin, a substance that is indigestible to the caterpillars, which leads to smaller females with a reduced egg load.

The warming of the climate has resulted in bud burst occurring about 10 days earlier than it did in 1985. With the caterpillars hatching 15 days earlier, they are out of synch with their food source by about 5 days. The caterpillars were already hatching several days before bud burst in 1985, so now they must wait on average about eight days for food. The evidence suggests that the moth population may also be in decline but the scientists need more years of data to be sure of this conclusion.

In Wytham Wood near Oxford the oak trees now come into leaf 3 weeks earlier than they did 50 years ago. The caterpillars that eat the young leaves are also emerging earlier but almost all studies have suggested that the Great Tits have not yet adapted to the earlier spring by breeding earlier in the year (Fig 4).

**Fig 4. Caterpillar emergence and Gt breeding times, Wytham Wood Oxford**



**Typical Exam Questions**

(a) The following passage about adaptation contains gaps. Complete the passage using the words that follow. Use each word only once or not at all.

**cumulative   genes   generations   grow individuals   mutate   offspring**  
**population   random   reproduce   selection   survival**

Adaptation can take place when ..... are present with a characteristic that gives them an increased chance of .....

When they ....., the characteristic can be passed on to their..... The process can go on through successive..... Gradually, an increasing proportion of the ..... will possess this advantageous characteristic. This process is called ..... natural ..... (7)

(b) Great Tits in Wytham Wood need to adapt to the earlier arrival of spring by breeding earlier. Suggest how this may occur (4)

(c) Northern Canada has long and cold winters and the short summers usually end in early August. Scientists have discovered that populations of the pitcher plant mosquito (*Wyeomyia smithii*) on Northern Canada are becoming dormant (hibernate) in late July, an average of 9 days later than they used to 30 years ago.



Pitcher plant

The mosquitoes hibernate as larvae in the fluid-filled leaves of the pitcher plant which is carnivorous.

- (i) Suggest a possible explanation for the change in hibernation date. (1)
- (ii) Outline the possible consequences of this change in hibernation date in the food web (3)
- (iii) Some scientists have suggested that the trigger for hibernation is shortening day length rather than falling temperature. Why might it help the survival of the mosquitoes to respond to shortening day length rather than to falling temperature? (1)

(a) individuals survival reproduce offspring population cumulative selection  
 (b) pairs breed early; chicks have more food than those that arrived later; ref to selection pressure; greater survival of early chicks; ref to genes/mutation; has to be genetic to be passed on etc; (c) (i) global warming / climate change / natural selection; (ii) food supply lasts longer for predators of mosquito; pitcher plant food source extended; later emergence of adult mosquitoes; effect on predators; (iii) hibernate before it gets cold / might be too late to hibernate once it gets cold / day length better indicator of season than temperature;

**References**

Cotton P.A. (2003) **Avian migration phenology and global climate change** PNAS, October 14, 2003; 100(21): 12219 - 12222.

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