Appendices

Appendix 3: Ecological impacts of climate change in The Netherlands

Dr Arnold van Vliet and Prof Rik Leemans

Temperature in The Netherlands has increased substantially. In the last 20 years the annual temperature was 1°C higher than normal while the first months of the years were up to 2°C warmer than before. The increase in temperature has resulted in significant ecological impacts. This is a short summary of phenological changes – changes in the timing of life cycle events and distributional changes in populations of plants and animals – in The Netherlands.

Phenological changes as a response to climate change

The most obvious indicators of ecological impacts of climate change are phenological changes. Phenology deals with the times of annual natural events like flowering, leaf unfolding, ripening of fruits, leaf colouring, leaf fall, bird migration, frog spawning, and bird nesting which can be observed by satellites or in the backyard. The timing of these events is often closely related to temperature and the amount and timing of precipitation. In temperate zones an increase in temperature leads to an earlier start and a later end to the growing season. Plants are flexible in adjusting the timing of their phenological events to changes in climate conditions. In the Netherlands, systematic phenological observations were made from 1869 to 1968 and from 2001 onwards by thousands of observers (www.natuurkalender.nl).

Some examples are presented below.

Plants

A European study on phenological changes in international phenological gardens from 1959 to 1996 showed that spring events such as leaf unfolding had advanced on average by 6.3 days whereas autumn events, such as leaf colouring, had been delayed on average by 4.5 days. The annual growing season thus increased on average by 10.8 days since the early 1960s. An analysis of the satellite data since 1975 showed a clear signal of lengthening growing seasons over large parts of the Northern hemisphere. Also in The Netherlands, large changes have been observed in the start of the growing season. In 2004, for example, the timing of life cycle events in plants was on average 16 days earlier than observations in the past (1868-1968). Not all phases advanced in the same way. Flowering of yellow water-lily was only 4 days earlier, but plants like snowdrop, alder, and cow-parsley flowered, on average, more than three weeks earlier. Furthermore, the start of the pollen season in The Netherlands advanced by up to 22 days between 1969 and 2000.

Insects

The high temperatures have resulted in remarkable changes. Two migratory butterflies, the red admiral (*Vanessa atalanta*) and painted lady (*Vanessa cardui*) normally migrated to arrive in The Netherlands from southern Europe in May. However, the recent warm years have resulted in a large number of first sightings in January. There is evidence that the red admiral now manages to winter in The Netherlands. Most of the butterflies appeared early in the last couple of years. For example, the orange tip (*Anthocharis cardamines*) appeared in early May in the 1940s while nowadays it appears in early April. Because of the earlier start to the flight period, the active season increased substantially, so many butterfly species were able to produce more generations each year.

A recent analysis of dragonfly data revealed that the first appearance advanced in a spectacular way, sometimes by more than a month. Part of the advance is probably caused by observers going into the field earlier in the year. However, the changes in peak flight of 10 common dragonfly species ranged from no advance of the common blue damselfly (*Enallagina cyathigerum*) to an advance of 18.3 days of the large red damselfly (*Pyrrhosoma nymphula*). It is highly likely that many other insect species respond in the same way as the butterflies and dragonflies.

Plants like snowdrop (right) have been recorded as flowering up to three weeks earlier than previously.

Seabury Salmon

Appendix 3: Ecological impacts of climate change in The Netherlands - 2

Birds

Birds are monitored intensively by thousands of people. A lot of birdwatchers record the arrival and to a lesser extent departure of migratory birds. Furthermore, the timing of first singing, egg-laying, egg-hatching and moulting are recorded.

As with plants and insects, the timing of these events is determined by climate variables like temperature and rainfall. Changes in the timing have been observed in the past decades. The recent change in timing of the arrival of many migratory birds, however, has not been as large as the changes recorded for plants and insects.

Aquatic species

Phytoplankton biomass is considered as an indicator for the marine growing season. The biomass has increased considerably over the past few decades in parts of the north-east Atlantic and the North Sea. From the late 1940s to the 1980s, the majority of production was restricted to bloom periods in spring and autumn. However, production has significantly increased since the late 1980s during the winter and especially the summer season. Particularly high increases have been observed since the mid-1980s in the North Sea and west of Ireland between 52°N and 58°N. During the 1990s, phytoplankton biomass increased in winter months by 97% compared to the long-term mean. Change in the seasonal timing of decapod larvae (as an example for zooplankton) over the period 1948–2000 shows a similar behaviour. Although there is considerable inter-annual variability of decapod larvae in the period 1948–2000, since 1988 the seasonal development of the larvae has occurred much earlier than the long-term average. The seasonal cycle was up to 4–5 weeks earlier in the 1990s than the long-term mean.

Changes in distribution

In the last few years, several studies have analysed observed changes in the distribution areas and tried to relate those changes to climate variables. They include increases, changes, and decreases in distribution areas (including expansion into new areas) and the decrease in population numbers. The main conclusion is that the recent changes in climate have had a significant impact on the distribution of plants and animals in both terrestrial and aquatic systems. Some examples are presented below.

Plants

In recent decades, a northward extension of various plant species has been observed in Europe. This is likely to be attributable to increases in temperatures. In Western Europe, thermophilic (warmth demanding) plant species have become more abundant compared with 30 years ago. In the new version of the Dutch flora, 41 new plant species have been added this year. An additional 87 new plants are nominated for the next list as they have been frequently observed.

Lichen and moss flora

Recent changes in the Dutch lichen flora, as well as changes in the moss flora, are very clear examples. Since the end of the 1980s, particularly warm temperate species with a (sub-) Atlantic or Mediterranean distribution pattern have been increasing. Species with a boreo-montane distribution have been decreasing.

Fungi

Just like lichens, fungi can quickly expand their distribution range if conditions are favourable. *Plicaturopsis crispa*, a small fungi that lives on dead branches and trunks of various deciduous trees, had a typical southern distribution in Europe and was until recently completely absent in the lowlands of Western Europe. At the end of the 1980s, the first observations were recorded. Since then, the population expanded strongly and became abundant in many locations far to the north and west of the original range. This dramatic increase can only be explained by a lack of severe winters in recent decades.

Marine species

The distribution of marine species is changing rapidly. The scaldfish (*Arnoglossus laterna*) and the lesser weever fish (*Echiichthys vipera*) could normally be found in the Mediterranean Sea and up to southern Scandinavia. They were rare in the North Sea. However, the population of these fishes increased significantly in the North Sea recently. Trawl data from Scottish research vessels over the last 75 years clearly showed that catches of the warm water pelagic species, anchovy (*Engraulis encrasicholus*) and sardine (*Sardina pilchardus*), increased suddenly after

Appendix 3: Ecological impacts of climate change in The Netherlands - 3

1995. All these increases correlate well with the increase in temperature since the end of the 1980s.

Some remarkable observations of marine coastal organisms including autochthonous crabs and shrimps, molluscs and aliens are observed in Belgium. Populations fluctuated during the last two decades following severe or mild weather conditions. They disappear after harsh winters and come back more rapidly than in the past. Some offshore species are stranded or extirpated more often. Species new to the area turn up and established themselves. These observations are believed to be mainly triggered by changes in oceanographic or climatic conditions, luring or forcing southern species into the North Sea and its coastal waters.

Some zooplankton species have shown a northward shift of up to 1,000 kilometres, in combination with a major reorganisation of marine ecosystems. These shifts have taken place south-west of the British Isles since the early 1980s and from the mid 1980s in the North Sea. In contrast, the diversity of colder temperate, sub-Arctic and Arctic species has decreased. An invasion of warm-water species into the temperate areas of the north-east Atlantic has also been observed. For example, the cold-temperate *Calanus finmarchicus* copepods are now rapidly replaced by the warm-temperate *Calanus helgolandicus*. Most of the warm-temperate and temperate species have migrated northward by about 250 kilometres per decade, which is much faster than the migration rates expected in terrestrial ecosystems.

Calanus finmarchicus is being rapidly replaced by a relative from warmer waters.

Royal Netherlands Institute for Sea Research

Insects

A large study of changes in the distribution area of 35 butterfly species in Europe concluded that 22 of them had shifted their ranges northwards by 35-241 kilometres. This is consistent with a 0.78°C warming over the past century. The comma butterfly (*Polygonia c-album*) has expanded from the southern part of The Netherlands in 1980 to the whole of The Netherlands, including the Wadden Islands in the north, by 2000. Since the very warm summer in 2003 there have also been many reports of the swallowtail (*Papilio machaon*) in the northern provinces of The Netherlands. The northern distribution area of this species was previously limited to the southern part of the country.

In addition, the *Microlepidoptera* species have undergone significant changes in distribution areas that can be attributed to climate change. One range change that is currently becoming a societal problem is the northward expansion of the oak processionary caterpillar (*Thaumetopoea processionea*). After the first observation in 1991 in the southern part of The Netherlands, the species advanced its distribution range to the middle of the country. The species requires warm conditions and originates in southern and central Europe. The caterpillars are a concern to human health because of their stinging hairs that can irritate the skin and bronchial tubes.

The numbers of invertebrate species are very large and are often not included in monitoring programmes. The existing programmes are providing increasingly convincing information. A comprehensive study of a substantial part of the Dutch fauna studied a total of 1331 terrestrial species of *Apidae* (honeybees and stingless bees), *Asilidae* (robber flies), *Carabidae* (ground beetles), *Formicidae* (ants), *Mollusca* (snails and slugs), *Odonata* (dragonflies), *Orthoptera* (grasshoppers) and *Syrphidae* (hoverflies). Of the 339 species that have the northern border of their distribution ranges through The Netherlands, 101 have expanded their range to the north in the 20th century. They were mainly dragonflies and molluscs. In total, 63 species contracted their range and retreated southwards (especially many species of bee). The species which had expanded their ranges were mainly those which need disturbed and cultivated habitats. The declining species are mainly those which require undisturbed conditions.

A useful indicator of climate change-induced distribution shifts is the wasp spider (*Argiope bruennichi*). This species is also moving north in Europe. In 1980 the spider was found in the southern part of The Netherlands and it has now moved up to the central Netherlands. In addition to the higher temperatures, the spider benefits from the increase of grass species in peat and heath vegetation.

Based on Leemans, R. and A. van Vliet, 2004. *Extreme weather: does nature keep up?; observed responses of species and ecosystems to changes in climate and extreme weather events: many more reasons for concern.* WWF & Wageningen University. Pp. 56.

Contact: Arnold.vanvliet@wur.nl, +31 317 485091