Royal Botanic Garden Edinburgh

PHENOLOGY – FUNCTIONAL GROUPS OF FLOWERING PLANTS
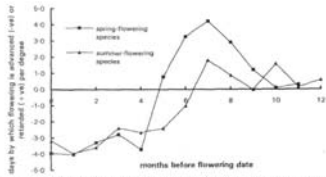
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ROYAL BOTANIC GARDEN EDINBURGH

Fig. 4. The effect of mean monthly temperature at different times before flowering on first flowering date (FFD) of both spring-(January–April) and summer-(May–August) flowering species. Effect of temperature is defined as the value of the regression coefficient from a multiple regression equation and represents the number of days by which flowering is advanced (negative values) or retarded (positive values) by a one degree change in mean monthly temperature.

The diagram above is taken from the pioneering study by Fitter A.H., Fitter R.S.R., Harris I.T.B. & Williamson M.H. (1995) 'Relationships between first flowering date and temperature in the flora of a locality in central England' *Functional Ecology* 9: 55-60.

Both early- and late-flowering groups show flowering advancement associated with higher temperatures in the 4 months preceding flowering.

Remarkably, both groups also show maximum flowering retardation effect 7 months before flowering.

The **table (right)** summarizes significant correlation & regression coefficients between first-flowering/leafing date and monthly mean temperatures from various studies.

Taxa are listed where possible in order of flowering/leafing. Positive correlations (meaning later flowering associated with higher temperatures) are shown in blue.

Data from C.E.Jeffree included analysis of first-flowering date and temperatures of months post-flowering. These taxa show no significant post-anthesis correlations with the exception of hazel *Corylus avellana* and *Convolvulus sepium*.

DEVELOPMENTAL STAGES AFFECTED BY TEMPERATURE

(1) **Negative correlations immediately before flowering** may be due to simple acceleration of development.

(2) **Positive correlations 3-11 months before flowering** were explained by Fitter *et al.* as due to interference with vernalization, but may be due to some other process, such as competition for resources (for growth, storage?).

(3) **Negative correlations 7-15 months before flowering** may be linked with initiation of reproductive development.

(4) **Chilling** is not expected to appear in an analysis of monthly mean temperatures, since it extends over a longer period.
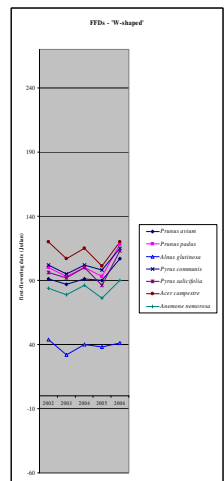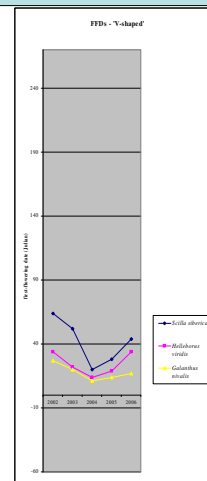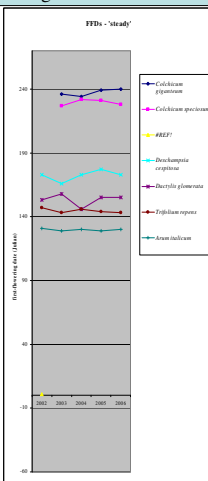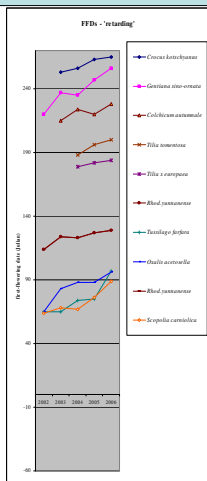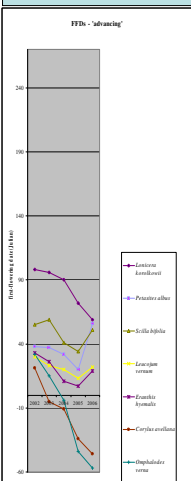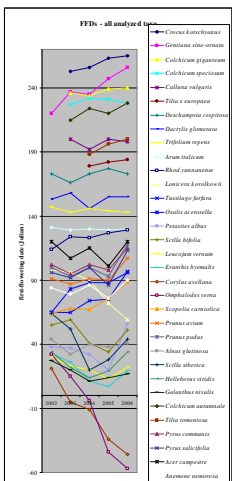
FUNCTIONAL GROUPS OF TAXA

On the basis of this interpretation, it is expected that distinct **functional groups** of taxa can be described, such that each will respond to climate change in a predictable way, depending on how temperature and other factors affect the different developmental stages.

Taxa with **'Mediterranean-type' phenology** form one such group (see diagram below, 2nd from left). These plants can flower at any time of year except summer, and are already showing extreme reactions to climate warming.

FIRST-FLOWERING & LEAFING DATES - STEPWISE REGRESSION & CORRELATION ANALYSES

[analysis/regressionsimplified.xls G.H.Harper 5.x.06]

grey cells - average peak flowering;
blue cells - significant (p=or<0.05) positive correlation or regression flowering date on temperature
neg. - significant (p=or<0.05) negative correlation

regression coefficients (days/degC), or correlation coefficients

Taxon	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
FLOWERING																			
Helleborus niger									-1.9										
Galanthus nivalis		neg																	
Eranthis hiemalis									-1.9	-2.8									
Galanthus nivalis											-3.4								
Leucojum vernum				pos						neg	neg	neg							
Crocus aureus										-2.8	-3.0								
Corylus avellana		neg	neg				1.1		neg	-2.4	-2.8	neg		0.3				0.3	
Ranunculus ficaria										-2.2	-2.1	-2.4							
Tussilago farfara		neg.						1.3		-0.9	-1.7	-2.9							
Rhod. praecox 'Praecox' 164			pos					pos.			neg	neg							
Narcissus pseudonarc.		pos									neg	neg							
Amygdalus communis										-2.0	-1.5	-3.0	-2.4						
Anemone nemorosa											neg	neg							
Pentaglottis sempervirens				pos.							neg								
Anemone nemorosa		neg.						1.4		-0.9	-1.6	-2.5							
Brassica turnip				pos.							neg	neg	neg						
Ribes rubrum										-0.9		-1.4	-2.7	-1.7					
Alliaria petiolata		neg.					1.1	0.6		-0.6	-1.0	-2.5	-1.7						
Cytisus scop. hybrids 028					pos.						neg								
Prunus padus												-3.7	-5.4						
Syringa vulgaris purple												-4.0	-4.8						
Aesculus hippocast.	neg.	neg.		neg.			0.6					-2.8	-4.1	-1.4					
Crataegus sp		neg.																	
Cytisus laburnum												-0.8	-2.9	-4.2					
Crataegus monogyna								0.7			-1.1	-2.8	-3.6	-1.8					
Daboecia cantabrica 061			pos.																
Leucanthemum vulgare							0.6					-0.5	-1.2	-1.8	-2.0				
Sambucus nigra												-2.4	-4.1						
Antirrhinum majus 011							pos.												
Rosa canina		neg.									-0.9	-1.5	-2.1	-3.7					
Photinia davidiana 190							pos.												
Calceolaria sp 031							neg	pos.											
Rubus sp 172							pos.												
Convolvulus sepium	neg.											-1.2	-2.4	-3.3	-3.0		neg.		
Campanula rotundifolia										0.8			-1.5	-1.9					
Lilium candidum									0.7			-1.5	-3.1	-2.5					
Colchicum autumnale						3.5	1.3					-1.0							
Hedera helix												-0.8	-1.3	-2.7	-1.3		-1.2		
LEAFING																			
Crataegus sp				pos	pos					neg	neg	neg							
Acer pseudoplatanus											neg	neg							
Aesculus hippocastanum				pos							neg	neg							
Betula (pendula?)				pos							neg	neg							
Sorbus aucuparia					pos						neg	neg	neg						
Carpinus betulus				pos						neg	neg	neg							
Aesculus hippocastanum												-3.4	-1.5						
Tilia spp											neg	neg							
Castanea sativa			pos								neg	neg	neg						
Acer (campestre?)											neg		neg						
Fagus sylvatica												neg	neg	neg					
Quercus sp					pos						neg	neg							
Fraxinus excelsior											neg	neg	neg						

The diagrams below show a selection of the taxa so far analysed (left) and various subsets that might eventually be recognized as separate functional groups of plants differing by virtue of the mechanisms determining timing of flowering.

FFDs - all analyzed taxa

FFDs - 'advancing'

FFDs - 'retarding'

FFDs - 'steady'

FFDs - 'V-shaped'

FFDs - 'W-shaped'

The general impression is of marked trend to earliness in some early flowering taxa, while later in the year flowering dates are more constant; some appear to be flowering later.

This group shows a trend to earliness. In 2006 *Corylus* and *Omphalodes* flowered before the cold spell began, but later-flowering taxa showed the effects of the cold spell. *Lonicera korolkowii* appeared unaffected by the cold spell.

All these taxa appear to be flowering later, but it is unlikely that all will be statistically significant. Note the overlap in dates between this group and the previous one.

A few taxa show remarkably stable first-flowering dates, particularly *Arum italicum*. It remains to be seen whether this stability is retained in future years.

A small number of taxa show earliest first-flowering dates in 2004. These may be responding to temperatures at different developmental stages than is the case in other groups (the analysis has not yet been attempted).

It is unlikely that the apparent 'W'-shaped graphs are in all cases significant, but most taxa belong to the Rosaceae. The 'W'-shape may reflect a 24-month cycle in various functions, including first-flowering date.