The grass is greener (for longer)

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Most of the rest of the world view the British effort put into lawn cutting with amusement. However, gardening in the UK is economically and socially important with over £3 billion spent annually on gardening, and over 30 million people having access to a garden (www.rhs.org.uk/news/pressreleases/corporatedaihatsu250603.asp).

National lawn cutting results

In 1998 the UK Phenology Network (UKPN) was formed to co-ordinate a large-scale phenological recording scheme (www.phenology.org.uk). One of its aims is to gather past and present phenological data to examine for evidence of climate change impacts. Since autumn 1999, the recording scheme has requested first and last lawn cutting dates. There is a serious motive behind what may seem, at first consideration, to be somewhat frivolous. The dates of first and last lawn cutting represent timings close to the beginning and end of the growing season and there is anecdotal evidence of increased incidence of all-year cutting in some parts of Britain. An examination of data collected so far by the UKPN suggests that grass cutting in the traditional winter months of December to February is currently as high as 31(±1)% of lawn cut records in south-west England, decreasing northwards to 8(±1)% of lawn cut records in Scotland. Anecdotally, winter cutting may now only be restricted by adverse grass and soil wetness. The timing of grass cutting integrates a number of climatic conditions, including soil moisture and temperature with such issues as the behaviour of the gardener him/herself. Figure 1 reveals that the national picture for lawn cutting has reflected seasonal temperatures even considering the small numbers of years of data so far available. For the five years available, the March temperature – first lawn cut date correlation is –0.86, $P = 0.060$ (P represents the probability of the event occurring by chance) and the October temperature – last lawn cut date correlation is 0.95, $P = 0.014$. The latest spring and latest autumn in these graphs both occurred in 2001 when the March Central England Temperature (CET – Parker *et al.* 1992) was cool (equal to the 1961–1990 average, although the January–March period was 1.3 degC below the 1961–1990 average) and the October CET was the highest recorded since 1659 (2.7 degC above the 1961–1990 average). These initial findings suggest that lawn cutting behaviour may be both responsive to temperature and a good candidate to demonstrate climate change impacts if the British climate warms as predicted.

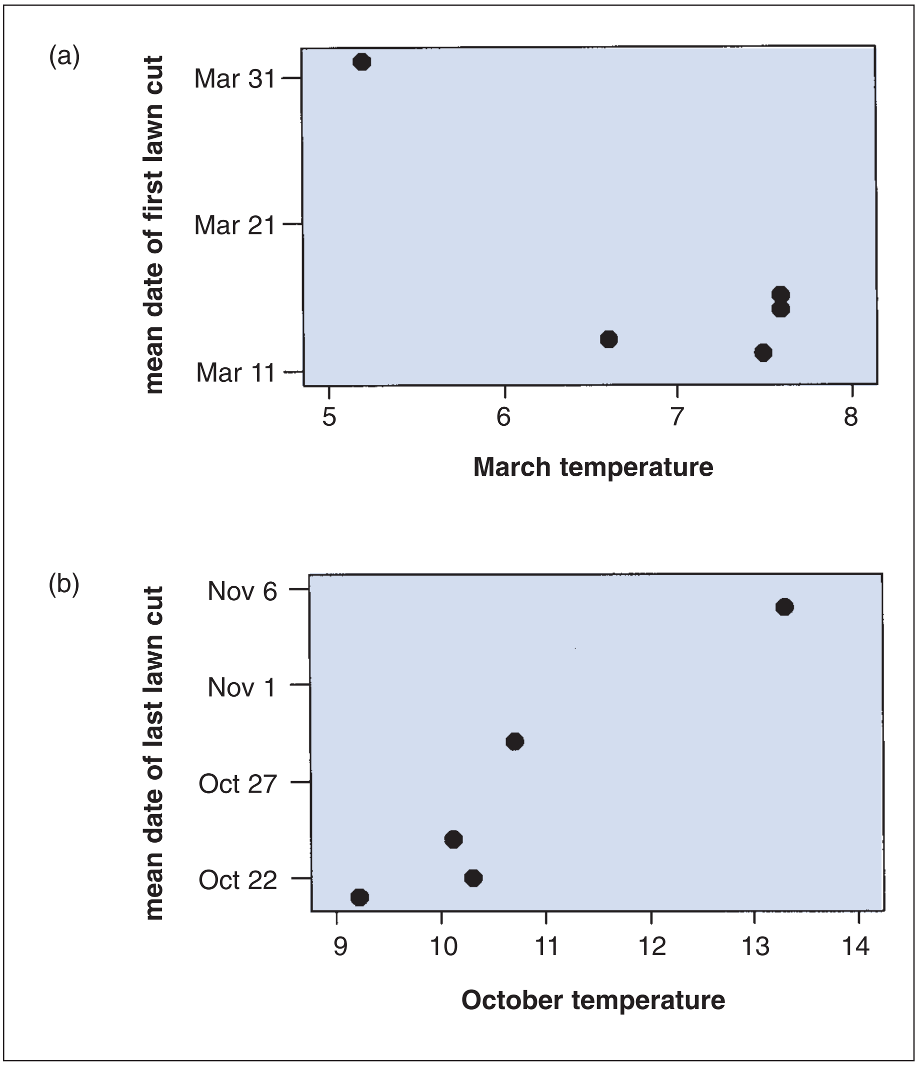

Fig. 1 (a) Mean first lawn cutting date in the UK 2000–2004 in relation to the March mean Central England Temperature (CET) and (b) mean last lawn cutting date in the UK 1999–2003 in relation to the October mean CET. NB These graphs are based on only five years of data.

Despite being based on data from the whole country, the above results only relate to a few years of observations and it is the longer-term trends in lawn cutting that we are interested in. The current paper examines a long-term collection of lawn cutting information (first cut, last cut and number of cuts per annum) over 20 years, that recently came to light as a result of a national appeal for long-term phenological datasets. These data represent the only complete long-term data we are aware of that include both first and last lawn cut dates. The data are examined for evidence of change over time, in relation to climatic data from a nearby meteorological station and in comparison with measures of the start and end of the growing season.

Kirkcaldy lawn cutting information and meteorological data

Dates of first and last cuts and the number of cuts undertaken were collected each year between 1984 and 2003 by D. A. Grisenthwaite in his garden at Kirkcaldy, Fife, Scotland (56°07'N, 03°10'W). Dates were converted to days post-December 31 prior to analysis. The duration of cutting was calculated by subtracting the date of the first cut from the date of the last cut. Over the 20-year period there were no fundamental changes in lawn management.

Daily meteorological data were obtained from the Royal Botanic Garden Edinburgh, approximately 15 km south of Kirkcaldy, and at a similar altitude (20–30 m) and proximity to the sea. These were used to provide monthly summaries of: mean air temperature, 10 cm soil temperature, precipitation and sunshine hours. In addition, Tsum200 (the date on which 200 growing degree days had been accumulated) and total growing degree days for the year were calculated. The former is often used to indicate a suitable date to start nitrogen application to pasture. The daily data were also used to calculate the start, end and duration of the growing season as defined by Mitchell and Hulme (2002). The growing season is defined as the longest period commencing when the daily mean temperature exceeds 5 °C for five consecutive days and finishes when the daily mean temperature drops below 5 °C for five consecutive days (see Mitchell and Hulme (2002) for details). In addition, the number of air frosts per annum, the last air frost of spring, the first air frost of autumn and the difference between the latter two were calculated.

The four lawn cutting measures were examined using regression and correlation techniques. First cut dates were compared to spring summary measures and meteorological variables for January–March. Last cut was compared to autumn summary measures and meteorological variables for August–October. Duration of cutting was compared to summary measures for the year.

First cut

The average first cut date was 21 March and there was a 36-day spread in first cut dates from 25 February to 2 April (Fig. 2). The regression of first cut against year produced a regression estimate of -0.64 (±0.36) days/annum (P = 0.095, R^2 = 14.7%). Whilst this is not significant, it does suggest an advance of first cutting date of 13 days over the 20-year period. Correlation with meteorological variables (Table 1) revealed a lack of significant correlation with Mitchell and Hulme's start season date, last spring frost date or with precipitation or sunshine. However, a significant correlation existed with the date of Tsum200 and temperatures, particularly 10 cm soil temperature (Fig. 2). A stepwise regression model with temperature data did not advance beyond January 10 cm soil temperature and suggested a 1.0 degC rise in temperature was associated with a 5.2 (±1.7) day advance in grass cutting (P = 0.007, R^2 = 34.0%). Not many of the studied variables changed significantly over the study period (Table 1). An increase in February sunshine and a decrease in March precipitation were significant and there was some suggestion of an advance in the growing season start (P = 0.075) and an increase in March temperature (P = 0.079).

Last cut

The average last cut date was 25 October and last dates spread over 41 days from 11 October to 21 November (Fig. 3). The regression of last cut against year produced a regression estimate of 0.86 (±0.40) days/annum (P = 0.043, R^2 = 20.8%); suggesting a delay of 17 days over the 20-year period. Correlations with meteorological variables (Table 2) again suggested stronger correla-

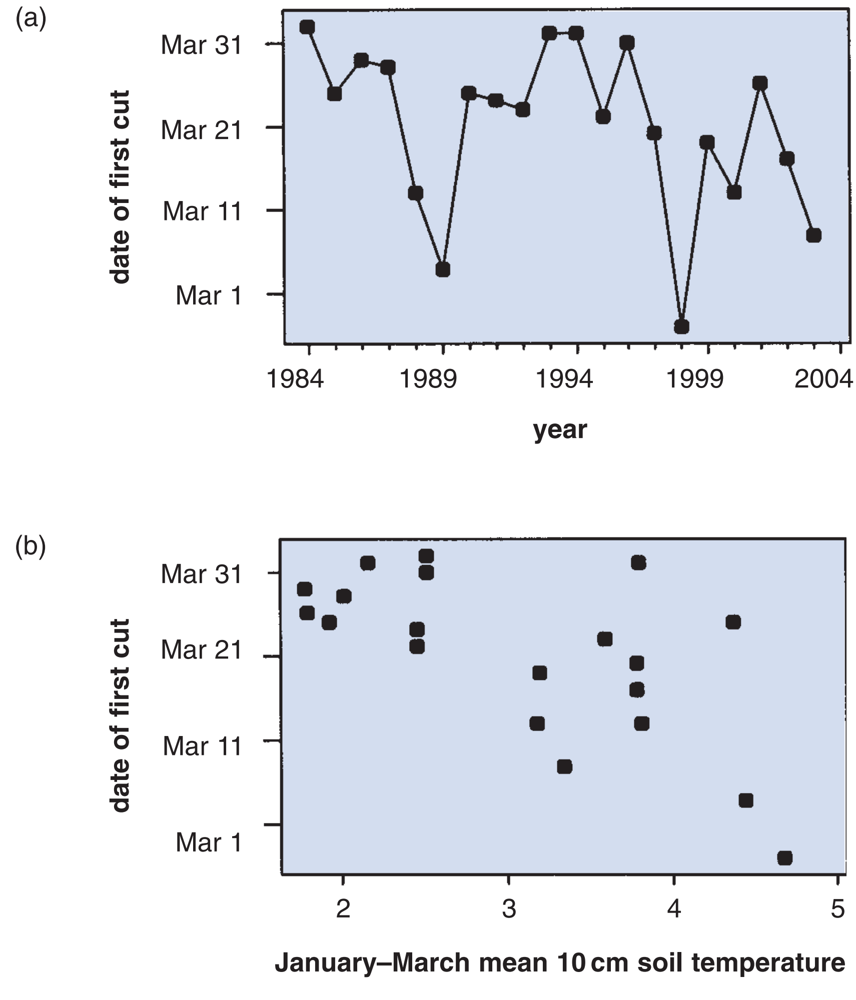

Fig. 2 Changes in date of first lawn cutting in Kirkcaldy (a) between 1984 and 2003 and (b) in relation to January–March mean 10 cm soil temperature (°C)

Table 1

Correlations between last cut date and various meteorological variables (see text for details (left-hand columns)) and between these and "year" (right-hand columns). Significant (P < 0.05) correlations are emboldened.

	Correlation with first cut date		Correlation with year	
	r	*P*	*r*	*P*
Year	–0.383	0.095		
Date of last spring air frost	0.037	0.877	0.106	0.657
Start of growing season	0.181	0.444	–0.407	0.075
Tsum200	**0.483**	**0.031**	–0.365	0.114
Mean air temperature Jan.	**–0.478**	**0.033**	0.339	0.143
Mean air temperature Feb.	**–0.570**	**0.009**	0.309	0.185
Mean air temperature Mar.	**–0.496**	**0.026**	0.402	0.079
10 cm soil temperature Jan.	**–0.583**	**0.007**	0.214	0.364
10 cm soil temperature Feb.	**–0.579**	**0.007**	0.255	0.277
10 cm soil temperature Mar.	**–0.454**	**0.045**	0.290	0.215
Sunshine hours Jan.	–0.079	0.740	0.046	0.847
Sunshine hours Feb.	–0.307	0.188	**0.462**	**0.040**
Sunshine hours Mar.	–0.206	0.383	0.285	0.224
Precipitation Jan.	0.002	0.995	–0.208	0.380
Precipitation Feb.	0.008	0.973	0.155	0.515
Precipitation Mar.	0.171	0.470	**–0.563**	**0.010**

tions with 10 cm soil temperature (Fig. 3), than with air temperature, particularly at the end of the season. Correlations with October air temperature and with Mitchell and Hulme's end season date were close to being statistically significant. A stepwise regression model with temperature data did not advance beyond November 10 cm soil temperature and suggested a 1.0 degC rise in temperature was associated with a 5.7 (±1.8) day delay in final grass cutting ($P = 0.005$, $R^2 = 35.7\%$). Whilst few last cut dates occurred in November, this regression suggests that a cold November would prevent a further cut. The only variables to change significantly over time were September air and soil temperatures (Table 2).

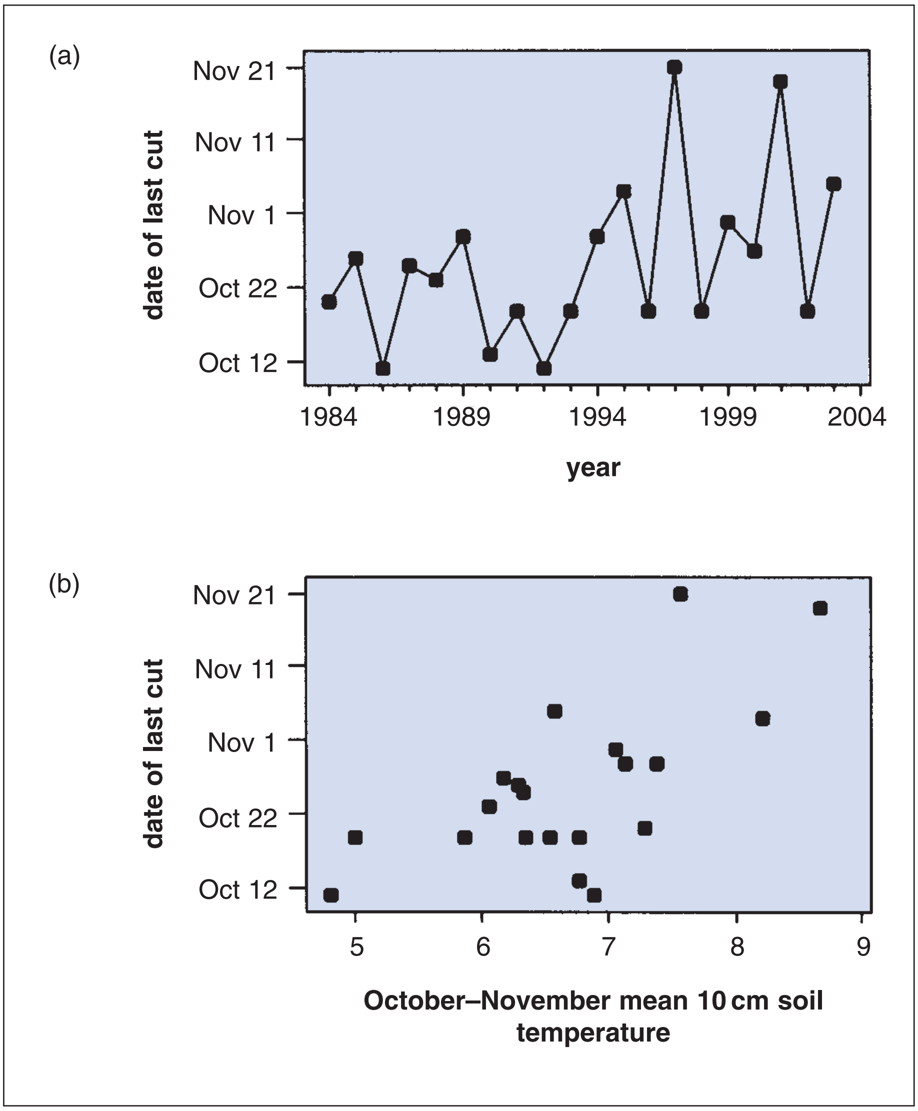

Fig. 3 Changes in date of last lawn cutting in Kirkcaldy (a) between 1984 and 2003 and (b) in relation to October–November mean 10 cm soil temperature (°C)

Duration

The duration of cut varied from 196 to 246 days and increased by 1.50 (±0.53) days per annum ($P = 0.010$, $R^2 = 31.2\%$), suggesting an increase in cutting season of 30 days over the 20 years of study (Fig. 4). The duration of cut was correlated with Mitchell and Hulme's growing season length ($r = 0.486$, $P = 0.030$) and with total annual growing degree days ($r = 0.656$, $P = 0.002$) but not with length of interval between last spring and first autumn air frosts ($r = –0.069$, $P = 0.774$) or with the annual number of air frosts ($r = –0.087$, $P = 0.716$). The former two measures increased significantly over time ($r = 0.532$, $P = 0.016$ and $r = 0.584$, $P = 0.007$ respectively).

Number of cuts

The number of cuts per year ranged from 19 to 42 and averaged 31.8 (Fig. 4). It did not

Table 2

Correlations between last cut date and various meteorological variables (see text for details (left-hand columns)) and between these and "year" (right-hand columns). Significant ($P < 0.05$) correlations are emboldened.

	Correlation with last cut date		Correlation with year	
	r	*P*	*r*	*P*
Year	**0.456**	**0.043**		
Date of first autumn air frost	0.180	0.447	−0.087	0.715
End of growing season	0.414	0.069	0.308	0.187
Mean air temperature Aug.	0.400	0.080	0.340	0.142
Mean air temperature Sep.	0.296	0.206	**0.608**	**0.004**
Mean air temperature Oct.	0.430	0.058	−0.005	0.983
Mean air temperature Nov.	**0.461**	**0.041**	0.318	0.172
10 cm soil temperature Aug.	0.381	0.098	0.301	0.197
10 cm soil temperature Sep.	0.230	0.328	**0.616**	**0.004**
10 cm soil temperature Oct.	**0.445**	**0.049**	−0.016	0.946
10 cm soil temperature Nov.	**0.597**	**0.005**	0.301	0.196
Sunshine hours Aug.	0.242	0.305	0.219	0.353
Sunshine hours Sep.	0.076	0.751	−0.067	0.779
Sunshine hours Oct.	0.339	0.144	0.288	0.219
Sunshine hours Nov.	−0.106	0.656	0.301	0.196
Precipitation Aug.	−0.084	0.723	0.008	0.972
Precipitation Sep.	−0.100	0.675	−0.257	0.274
Precipitation Oct.	−0.306	0.189	0.163	0.492
Precipitation Nov.	0.000	1.000	0.103	0.664

increase over time ($r = -0.025$, $P = 0.918$). There was no significant correlation with any of the measures of season length i.e. duration of cutting, Mitchell and Hulme's season length, total annual growing degree days or frost-free period (all $|r| < 0.23$, $P > 0.33$). The number of cuts might be expected to be related non-linearly to rainfall and temperature i.e. fewer cuts when droughted or waterlogged and when cold or extremely warm but no such pattern was detected with the data examined here.

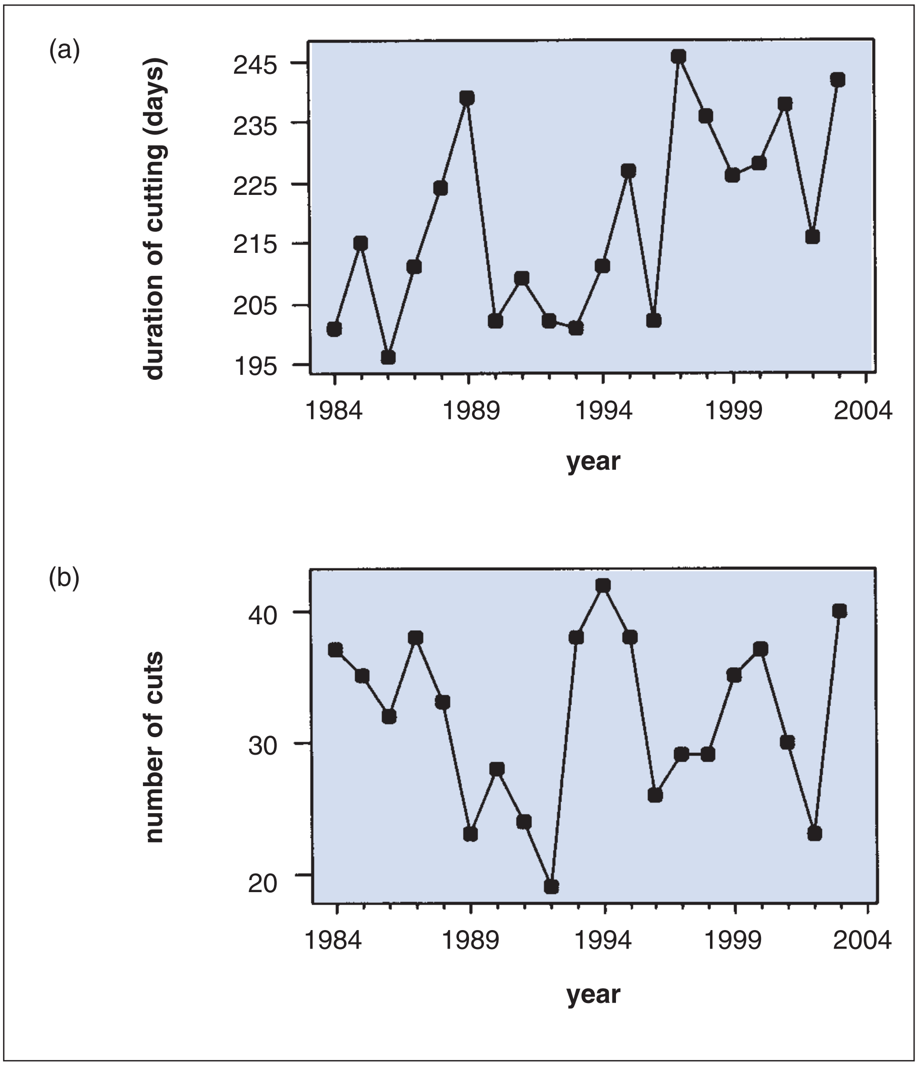

Fig. 4 Duration of lawn cutting in Kirkcaldy between 1984 and 2003, defined as (a) the interval between first and last cuts, and (b) the number of cuts per annum

Lawn cutting in context

Many studies have shown advances in the phenology of trees (e.g. Menzel and Fabian 1999), flowers (e.g. Fitter and Fitter 2002), birds (e.g. Sokolov *et al.* 1998), invertebrates (e.g. Roy and Sparks 2000) and grass pollen (Frei 1998), but few studies have examined changes in the production timing of perennial grasses other than in the short-term or via simulation modelling (e.g. Holden and Brereton 2002). Some changes to other aspects of grassland phenology have been demonstrated. Williams and Abberton (2004) demonstrated change in the flowering phenology of the grass associate White Clover (*Trifolium repens*) which advanced significantly by *c.* 18 days between 1978 and 2002. Within the dataset provided by Abu-Asab *et al.* (2001), Sweet Vernal-grass (*Anthoxanthum odoratum*) advanced flowering phenology by 0.66 (±0.16) days per annum ($P < 0.001$) between 1970 and 1999.

Changes in the length of the growing season based on meteorological definitions (e.g. Mitchell and Hulme 2002; Robeson 2002) have been examined which often, but not always (e.g. Sharratt 1992), suggest an increased growing season. There have been only a few studies looking at the growing season based on long-term biological data (e.g. Menzel and Fabian 1999; Matsumoto *et al.* 2003) and none that we know of based on ground flora.

Despite having a relatively short span of 20 years, the data from Kirkcaldy provide biological evidence of an increase in the length of the growing season and some suggestions of what meteorological factors affect lawn growth. Strictly, we are dealing with the cutting season which is likely to underestimate the growing season. It should be emphasised that the definition of "growing season" depends on the native or cultivated vegetation in question; trees for example tend to have a shorter growing season than ground flora. Our biological estimates provided here do not match strongly the meteorological definitions of growing season, although there is some correlation between Tsum200 and first cut and (almost) between Mitchell and Hulme's end of season and last cut. Of course, our meteorological observations were not made in the immediate vicinity of the study site but the relative good agreement between cutting dates and soil temperatures gives us confidence in their general applicability.

Cannell *et al.* (1999) reported an example from the long-term Park Grass experiment where summer yields were depressed in hot dry conditions and that is likely to be a factor affecting lawns in general. Whilst this was also a conclusion of Holden and Brereton (2002) in their simulation modelling of commercial grass production, we found no evidence of this in the series presented here, nor of autumn cutting being restricted by precipitation. The UKPN data on first lawn cutting (Fig. 1(a)) are positively correlated with UKPN mean first flowering dates of the grasses Meadow Foxtail (*Alopecurus pratensis*) ($r = 0.985$, $P = 0.002$) and Cocksfoot (*Dactylis glomerata*) ($r = 0.959$, $P = 0.010$) and will undoubtedly be correlated with Yorkshire Fog (*Holcus lanatus*) ($r = 0.736$, $P = 0.139$) when more years of data are available. Hence lawn cutting dates may also prove useful in estimating the start of the grass pollen season.

The recording of cutting dates is a simple process, arguably easier that any of the other requested phenological observations in the UKPN, since the definition of the phenophase is unambiguous and requires direct human intervention. It has proved to be amongst the most popular of the UKPN's variables with over 1000 observations recorded each year since 2001. Hence the measurement of lawn cutting presents a unique opportunity to monitor a combination of human behaviour and biological growth. It has been shown to be temperature responsive and can join the growing body of evidence demonstrating climate change impacts (e.g. Parmesan and Yohe 2003; Root *et al.* 2003; Walther *et al.* 2002). As the UKPN accumulates more past and present information, there will be opportunities for more in-depth examination of the influence of climate on lawn cutting.

Acknowledgements

We express our sincere gratitude to Stephan Helfer and the Royal Botanic Garden Edinburgh for providing the meteorological data used here.

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doi: 10.1256/wea.198.04