**Supplemental Material**

**Table S1** Regression analysis of trends (1968-2016) in the timing of leaf colouration (LC), leaf fall (LF) and the duration (LF-LC) of the autumn phenology season for a range of deciduous tree species at four locations in Ireland. Community 1: average of all species 1968-2016; Community 2: average of all species 1982-2016; EVI2 satellite derived Enhanced Vegetation Index (1982-2016). EVI2 data represent mid-senescence (MS), end-senescence (ES) and duration of senescence (ES-MS). Note the satellite data span 1982 to 2016 for mid-senescence (MS), end-senescence (ES) and duration of senescence (ES-MS) and does not correspond exactly to the direct observations (see Methods) but are used for comparative purposes. *R*2 is the coefficient of determination.

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Site** | **Species** | **Leaf colouration**  **(Day of Year)** | | | **Leaf fall**  **(Day of Year)** | | | **Duration**  **(Number of days)** | | | |
| ***p*** | **Slope** | ***R*2** | ***p*** | **Slope** | ***R*2** | ***p*** | **Slope** | ***R*2** |
| **Valentia Observatory** | *Betula pubescens* | 0.579 | 0.075 | 0.008 | 0.210 | 0.191 | 0.035 | 0.980 | 0.003 | 0.000 |
| *Fagus sylvatica* H | 0.275 | 0.321 | 0.049 | **0.002** | **0.752** | **0.267** | 0.859 | 0.015 | 0.001 |
| *Fagus sylvatica* T | **0.029** | **0.842** | **0.191** | **0.006** | **0.860** | **0.237** | **0.000** | **0.561** | **0.420** |
| *Populus canescens* | **0.002** | **-0.633** | **0.447** | 0.398 | -0.149 | 0.027 | 0.713 | 0.049 | 0.008 |
| *Populus tremula* | 0.253 | -0.229 | 0.081 | 0.801 | -0.047 | 0.003 | 0.903 | 0.019 | 0.001 |
| *Prunus avium* Bov | **0.020** | **0.792** | **0.223** | **0.000** | **0.923** | **0.392** | 0.870 | 0.027 | 0.001 |
| *Prunus avium* Lut | **0.064** | **0.734** | **0.154** | **0.000** | **0.992** | **0.410** | 0.695 | 0.057 | 0.008 |
| *Sorbus aucuparia* | **0.012** | **-0.987** | **0.334** | 0.661 | 0.141 | 0.008 | **0.051** | **0.348** | **0.217** |
| *Tilia cordata* | **0.051** | **0.741** | **0.169** | **0.000** | **1.010** | **0.538** | **0.003** | **0.345** | **0.347** |
| *Salix aurita* | **0.056** | **-0.758** | **0.210** | **0.067** | **0.427** | **0.128** | 0.450 | 0.180 | 0.041 |
| *Salix acutifolia* | 0.846 | 0.723 | 0.597 | **0.000** | **0.724** | **0.360** | **0.011** | **0.538** | **0.312** |
| *Salix smithiana* X | 0.088 | -0.455 | 0.171 | **0.002** | **0.630** | **0.314** | 0.334 | 0.157 | 0.060 |
| *Salix viminalis* | 0.821 | 0.594 | 0.150 | **0.075** | **0.594** | **0.150** | 0.234 | 0.273 | 0.087 |
| Community 1 | 0.190 | 0.187 | 0.044 | 0.286 | 0.160 | 0.025 | 0.115 | -0.133 | 0.063 |
| 1982-2016 | | | | | | | | | |
| Community2 | **0.056** | **0.501** | **0.138** | **0.015** | **0.537** | **0.175** | **0.019** | **0.201** | **0.202** |
| Satellite EVI2 | **0.010** | **0.776** | **0.186** | **0.010** | **0.797** | **0.186** | 0.874 | 0.022 | 0.001 |
| **JF Kennedy Arboretum** | *Betula pubescens* | **0.003** | **-0.907** | **0.387** | **0.000** | **-0.591** | **0.387** | 0.445 | -0.081 | 0.021 |
| *Populus canescens* |  |  |  | 0.250 | -0.349 | 0.100 |  |  |  |
| *Fagus sylvatica* H | 0.319 | -0.207 | 0.041 | 0.647 | -0.067 | 0.007 | 0.406 | 0.132 | 0.035 |
| *Fagus sylvatica* Dud |  |  |  | 0.860 | 0.075 | 0.002 |  |  |  |
| *Fagus sylvatica* T | **0.054** | **-0.355** | **0.165** | 0.342 | -0.125 | 0.029 | 0.982 | 0.002 | 0.000 |
| *Tilia cordata* | 0.219 | 0.308 | 0.106 | 0.557 | 0.150 | 0.024 |  |  |  |
| Community 1 | **0.005** | **-0.314** | **0.220** | 0.143 | -0.163 | 0.059 | 0.936 | -0.007 | 0.000 |
| Community 2 | 0.721 | 0.058 | 0.006 | 0.603 | -0.085 | 0.011 | 0.847 | 0.027 | 0.002 |
| Satellite EVI2 | 0.969 | -0.010 | 0.000 | 0.235 | 0.270 | 0.043 | 0.191 | 0.280 | 0.051 |
| **Johnstown Castle** | *Betula pubescens* | 0.268 | -0.175 | 0.047 | 0.657 | -0.064 | 0.008 | 0.976 | 0.004 | 0.000 |
| *Fagus sylvatica* H | **0.001** | **-1.236** | **0.399** | 0.222 | 0.277 | 0.064 | **0.000** | **1.465** | **0.765** |
| *Fagus sylvatica* Dud | 0.277 | -0.242 | 0.044 | 0.861 | -0.026 | 0.001 | 0.274 | 0.198 | 0.048 |
| *Populus canescens* | **0.015** | **-0.631** | **0.300** | 0.451 | -0.163 | 0.020 | 0.112 | 0.345 | 0.160 |
| *Populus tremula* |  |  |  | 0.875 | -0.048 | 0.002 |  |  |  |
| *Prunus avium* Bov | **0.023** | **-0.992** | **0.232** | 0.995 | 0.002 | 0.000 | **0.006** | **0.832** | **0.337** |
| *Prunus avium* Lut | **0.004** | **-1.126** | **0.348** | 0.487 | 0.231 | 0.021 | **0.000** | **1.095** | **0.583** |
| *Tilia cordata* | **0.068** | **-0.468** | **0.118** | 0.542 | -0.130 | 0.015 | 0.313 | 0.156 | 0.041 |
| *Ribes alpinum* |  |  |  | 0.316 | 0.254 | 0.046 |  |  |  |
| *Salix acutifolia* |  |  |  | **0.061** | **0.561** | **0.237** |  |  |  |
| *Salix smithiana* X | **0.031** | **-0.477** | **0.246** | 0.754 | -0.051 | 0.004 | **0.025** | **0.482** | **0.277** |
| *Salix viminalis* | 0.270 | -0.234 | 0.080 | 0.827 | -0.036 | 0.002 | 0.482 | 0.146 | 0.036 |
| Community 1 | 0.254 | -0.174 | 0.040 | 0.608 | 0.059 | 0.008 | 0.071 | 0.180 | 0.098 |
| 1982-2016 | | | | | | | | | |
| Community 2 | **0.003** | **-0.516** | **0.331** | **0.045** | **-0.275** | **0.163** | 0.127 | 0.209 | 0.098 |
| Satellite EVI2 | 0.319 | 0.168 | 0.030 | 0.091 | 0.379 | 0.084 | 0.301 | 0.211 | 0.032 |
| **National Botanic Gardens** | *Betula pubescens* | 0.856 | -0.059 | 0.010 | 0.605 | -0.060 | 0.010 | 0.694 | -0.331 | 0.006 |
| *Populus canescens* | 0.931 | 0.032 | 0.001 | **0.000** | **-0.670** | **0.412** | **0.065** | **-0.356** | **0.198** |
| *Populus tremula* | 0.335 | 0.410 | 0.072 | 0.570 | 0.205 | 0.020 | 0.670 | 0.158 | 0.014 |
| *Prunus avium* Bov | **0.000** | **1.002** | **0.879** | **0.000** | **0.456** | **0.508** | **0.000** | **-0.550** | **0.671** |
| *Prunus avium* Lut | **0.000** | **0.897** | **0.838** | **0.000** | **0.316** | **0.424** | **0.000** | **-0.580** | **0.718** |
| *Robinia pseudoacacia* | 0.237 | -0.274 | 0.081 | **0.000** | **-0.435** | **0.353** | 0.886 | -0.041 | 0.001 |
| *Tilia cordata* | **0.000** | **1.588** | **0.600** | 0.397 | 0.119 | 0.045 | 0.173 | -0.275 | 0.095 |
| *Ribes alpinum* | **0.000** | **0.973** | **0.670** | **0.000** | **0.651** | **0.613** | **0.002** | **-0.713** | **0.377** |
| *Salix aurita* | **0.030** | **0.814** | **0.359** | **0.000** | **0.456** | **0.374** | 0.694 | -0.331 | 0.006 |
| *Salix smithiana* X |  |  |  | **0.000** | **0.833** | **0.536** |  |  |  |
| *Salix viminalis* |  |  |  | **0.000** | **0.989** | **0.783** |  |  |  |
| Community 1 | **0.001** | **0.368** | **0.269** | **0.000** | **0.214** | **0.345** | **0.006** | **-0.205** | **0.178** |
| 1982-2016 | | | | | | | | | |
| Community2 | **0.000** | **0.813** | **0.740** | **0.001** | **0.296** | **0.345** | **0.000** | **-0.542** | **0.631** |
| Satellite EVI2 | 0.206 | 0.297 | 0.048 | **0.000** | **0.711** | **0.338** | 0.067 | 0.413 | 0.098 |

**Table S2** Regression analysis of temperatures in autumn (August to October) and the timing of leaf colour (LC), leaf fall (LF) and the duration (LF-LC) of the autumn phenology for a range of deciduous tree species at four locations in Ireland. Community 1: average of all species 1968-2016; Community 2: average of all species 1982-2016; EVI2 satellite derived Enhanced Vegetation Index (1982-2016). EVI2 data represent mid-senescence (MS), end-senescence (ES) and duration of senescence (ES-MS). Note the satellite data span 1982 to 2016 for mid-senescence (MS), end-senescence (ES) and duration of senescence (ES-MS) and does not correspond exactly to the direct observations (see Methods) but are used for comparative purposes. *N* is the number of years in the time series for which both temperature and phenological data were available. *R*2 is the coefficient of determination.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Site** | **Species** | **Leaf colouration (Day of Year)** | | | | **Leaf fall (Day of Year)** | | | | **Duration (Number of Days)** | | | |
| ***N*** | ***p*** | **Slope** | ***R*2** | ***N*** | ***p*** | **Slope** | ***R*2** | ***N*** | ***p*** | **Slope** | ***R*2** |
| **Valentia Observatory** | *Betula pubescens* | 41 | 0.837 | -0.481 | 0.001 | 47 | 0.162 | 4.118 | 0.043 | 42 | 0.148 | 2.607 | 0.052 |
| *Fagus sylvatica* H | 26 | 0.778 | -0.927 | 0.003 | 34 | 0.660 | 1.661 | 0.006 | 26 | 0.586 | 0.488 | 0.013 |
| *Fagus sylvatica* T | 25 | 0.380 | 3.734 | 0.034 | 30 | 0.061 | 7.415 | 0.120 | 25 | 0.057 | 3.517 | 0.148 |
| *Populus canescens* | 19 | 0.538 | -1.285 | 0.023 | 29 | 0.804 | -0.514 | 0.002 | 19 | 0.223 | -1.436 | 0.086 |
| *Populus tremula* | 18 | 0.707 | -0.699 | 0.009 | 28 | 0.872 | -0.354 | 0.001 | 18 | 0.224 | -1.687 | 0.091 |
| *Prunus avium* Bov | 24 | 0.508 | 2.432 | 0.020 | 32 | 0.149 | 5.050 | 0.068 | 24 | 0.523 | -1.057 | 0.019 |
| *Prunus avium* Lut | 23 | 0.966 | -0.166 | 0.000 | 31 | 0.118 | 5.596 | 0.082 | 23 | 0.063 | 2.486 | 0.155 |
| *Sorbus aucuparia* | 18 | 0.159 | -4.419 | 0.120 | 27 | 0.678 | -1.464 | 0.007 | 18 | 0.695 | 0.552 | 0.010 |
| *Tilia cordata* | 23 | 0.833 | 0.941 | 0.002 | 31 | 0.064 | 6.509 | 0.114 | 23 | 0.454 | 1.083 | 0.027 |
| *Salix aurita* | 18 | 0.167 | -4.196 | 0.116 | 27 | 0.365 | 2.383 | 0.033 | 18 | 0.383 | 1.511 | 0.048 |
| *Salix acutifolia* | 21 | 0.443 | -2.298 | 0.031 | 30 | 0.070 | 4.960 | 0.113 | 20 | 0.069 | 3.351 | 0.172 |
| *Salix smithiana* X | 18 | 0.156 | -2.862 | 0.122 | 29 | 0.200 | 3.260 | 0.060 | 18 | 0.484 | 0.955 | 0.031 |
| *Salix viminalis* | 16 | 0.925 | -0.279 | 0.001 | 22 | 0.342 | 2.854 | 0.045 | 16 | 0.555 | 0.891 | 0.025 |
| Community 1 | 41 | 0.474 | 1.789 | 0.013 | 47 | 0.225 | 3.505 | 0.032 | 41 | 0.467 | 1.072 | 0.014 |
| 1982-2016 | | | | | | | | | | | | |
| Community2 | 27 | 0.940 | -0.231 | 0.000 | 33 | 0.676 | 1.300 | 0.006 | 27 | 0.185 | 1.287 | 0.069 |
| Satellite EVI2 | 34 | 0.325 | 4.299 | 0.030 | 34 | 0.093 | 7.407 | 0.086 | 34 | 0.098 | 3.108 | 0.083 |
| **JF Kennedy Arboretum** | *Betula pubescens* | 29 | 0.618 | 1.249 | 0.009 | 29 | 0.526 | -1.526 | 0.015 | 27 | 0.088 | -2.408 | 0.112 |
| *Populus canescens* |  |  |  |  | 12 | 0.810 | -0.885 | 0.006 |  |  |  |  |
| *Fagus sylvatica* H | 22 | 0.947 | -0.162 | 0.000 | 28 | 0.501 | 2.026 | 0.018 | 18 | 0.436 | 1.598 | 0.038 |
| *Fagus sylvatica* Dud |  |  |  |  | 20 | 0.637 | 4.492 | 0.013 |  |  |  |  |
| *Fagus sylvatica* T | 20 | 0.403 | -1.942 | 0.039 | 30 | 0.536 | -1.305 | 0.014 | 18 | 0.155 | -1.415 | 0.122 |
| *Tilia cordata* | 14 | **0.009** | **6.433** | **0.444** | 15 | **0.005** | **6.171** | **0.467** |  |  |  |  |
| Community 1 | 31 | 0.775 | 0.457 | 0.003 | 34 | 0.544 | 0.989 | 0.012 | 29 | 0.345 | -1.183 | 0.033 |
| 1982-2016 | | | | | | | | | | | | |
| Community 2 | 22 | 0.162 | 1.982 | 0.095 | 24 | 0.319 | 1.604 | 0.045 | 24 | 0.458 | -1.143 | 0.029 |
| Satellite EVI2 | 31 | 0.950 | -0.223 | 0.000 | 31 | 0.551 | 1.721 | 0.012 | 31 | 0.525 | 1.944 | 0.014 |
| **Johnstown Castle** | *Betula pubescens* | 25 | 0.788 | -0.845 | 0.003 | 23 | 0.534 | 1.688 | 0.019 | 23 | 0.327 | 2.269 | 0.046 |
| *Fagus sylvatica* H | 21 | 0.181 | -5.006 | 0.092 | 23 | 0.654 | 0.982 | 0.010 | 20 | 0.227 | 3.789 | 0.080 |
| *Fagus sylvatica* Dud | 26 | 0.097 | -5.760 | 0.110 | 26 | 0.188 | -2.929 | 0.071 | 24 | 0.298 | 2.909 | 0.049 |
| *Populus canescens* | 16 | 0.518 | 2.139 | 0.031 | 28 | 0.382 | 3.058 | 0.030 | 16 | 0.326 | 3.734 | 0.069 |
| *Populus tremula* |  |  |  |  | 14 | 0.890 | -0.199 | 0.002 |  |  |  |  |
| *Prunus avium* Bov | 20 | **0.025** | **-8.351** | **0.250** | 23 | 0.608 | -1.576 | 0.013 | 20 | 0.126 | 4.413 | 0.125 |
| *Prunus avium* Lut | 20 | 0.219 | -4.786 | 0.083 | 23 | 0.998 | 0.009 | 0.000 | 20 | 0.233 | 3.577 | 0.078 |
| *Tilia cordata* | 26 | 0.626 | -2.001 | 0.010 | 25 | 0.464 | -2.463 | 0.024 | 24 | 0.919 | -0.242 | 0.000 |
| *Ribes alpinum* |  |  |  |  | 22 | 0.550 | 1.475 | 0.018 |  |  |  |  |
| *Salix acutifolia* |  |  |  |  | 21 | 0.175 | 2.922 | 0.095 |  |  |  |  |
| *Salix smithiana* X | 16 | 0.131 | -4.162 | 0.156 | 27 | 0.244 | 2.970 | 0.054 | 16 | **0.013** | **6.819** | **0.364** |
| *Salix viminalis* | 15 | 0.085 | -4.699 | 0.211 | 24 | 0.460 | 1.972 | 0.025 | 14 | **0.032** | **5.629** | **0.330** |
| Community 1 | 32 | 0.525 | -1.740 | 0.014 | 32 | 0.719 | 0.740 | 0.004 | 31 | 0.118 | 2.732 | 0.082 |
| 1982-2016 | | | | | | | | | | | | |
| Community 2 | 22 | 0.052 | -4.938 | 0.176 | 22 | 0.460 | -1.471 | 0.028 | 22 | **0.046** | **3.773** | **0.184** |
| Satellite EVI2 | 28 | 0.176 | -3.178 | 0.069 | 28 | 0.981 | 0.083 | 0.000 | 28 | 0.288 | 3.261 | 0.043 |
| **National Botanic Gardens** | *Betula pubescens* | 26 | 0.484 | 0.866 | 0.021 | 27 | 0.985 | -0.025 | 0.000 | 26 | 0.326 | -0.964 | 0.040 |
| *Populus canescens* | 18 | 0.284 | -3.571 | 0.071 | 34 | **0.018** | **-5.891** | **0.162** | 18 | 0.636 | -0.882 | 0.014 |
| *Populus tremula* | 15 | **0.038** | **6.121** | **0.291** | 19 | **0.035** | **7.784** | **0.235** | 15 | 0.547 | 1.655 | 0.029 |
| *Prunus avium* Bov | 33 | **0.004** | **7.499** | **0.242** | 35 | **0.001** | **4.721** | **0.271** | 33 | 0.098 | -2.802 | 0.086 |
| *Prunus avium* Lut | 34 | **0.000** | **8.607** | **0.378** | 35 | **0.000** | **4.398** | **0.408** | 34 | **0.012** | **-4.160** | **0.181** |
| *Robinia pseudoacacia* | 19 | 0.490 | 1.840 | 0.029 | 31 | 0.345 | -2.092 | 0.031 | 18 | 0.662 | 1.783 | 0.012 |
| *Tilia cordata* | 17 | 0.482 | 3.030 | 0.034 | 18 | **0.042** | **2.1965** | **0.233** | 17 | 0.843 | -0.835 | 0.003 |
| *Ribes alpinum* | 21 | **0.048** | **5.513** | **0.190** | 34 | **0.000** | **7.152** | **0.348** | 21 | 0.823 | 0.491 | 0.003 |
| *Salix aurita* | 22 | 0.373 | 2.798 | 0.040 | 30 | **0.006** | **5.807** | **0.239** | 22 | 0.893 | -0.365 | 0.001 |
| *Salix smithiana* X |  |  |  |  | 22 | **0.014** | **10.195** | **0.268** |  |  |  |  |
| *Salix viminalis* |  |  |  |  | 17 | 0.102 | 8.058 | 0.168 |  |  |  |  |
| Community 1 | 40 | **0.007** | **4.893** | **0.178** | 41 | **0.008** | **2.378** | **16.8** | 40 | 0.066 | -2.327 | 0.086 |
| 1982-2016 | | | | | | | | | | | | |
| Community 2 | 28 | **0.001** | **6.472** | **0.333** | 29 | **0.002** | **3.245** | **0.293** | 28 | 0.113 | -2.467 | 0.094 |
| Satellite EVI2 | 34 | 0.987 | 0.045 | 0.000 | 34 | 0.094 | 4.109 | 0.085 | 34 | 0.130 | 4.064 | 0.070 |