Results

Variation in First Flowering Day (FFD)

1. We identified 24 flowering plant species in the Stevens Data set that met the criteria for analysis described in the methods. The first flowering day (FFD) varies extensively both among years within a species and among species. Median FFD varied across the species from a low of X to a high of Y and included early, mid and late spring flowering species (Fig. X) .

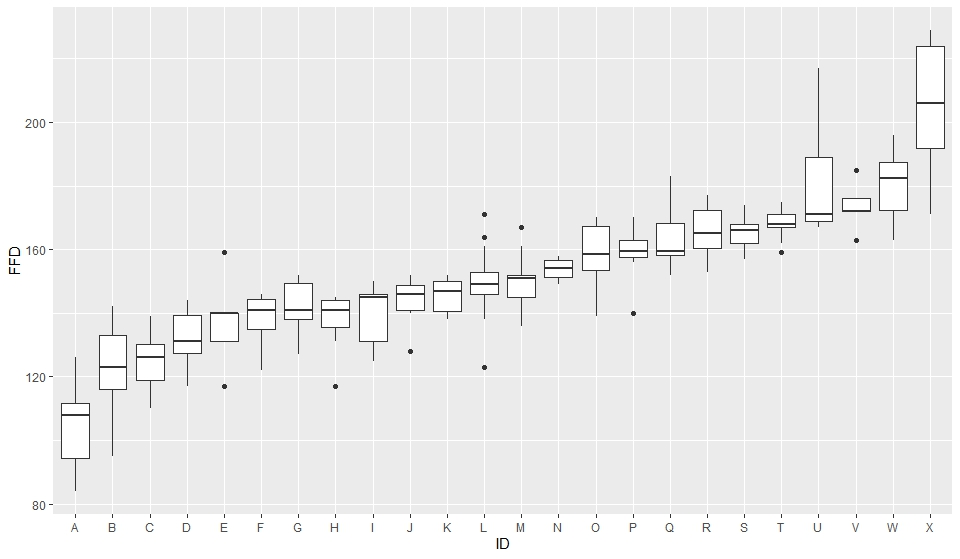


Figure X. Box plots of the first flowering day of 24 plant species from the Bluestem Prairie reserve in Clay county, MN. Observations were made between 1942-1961 and 2012-2020. Box plots indicate distribution quartiles and standard error bars. The species codes are as follows:A=Anemo paten;B=Ranun rhomb;C=Calth palus;D=Ceras arven;E=Ranun abort;F=Oxali viola;G=Sisyr angus;H=Litho canes;I=Trill cernu;J=Litho incis;K=Pedic canad;L=Zizia aurea;M=Vicia ameri;N=Cypri candi;O=Achil mille;P=Anemo canad;Q=Oxytr lambe;R=Rosa arkan;S=Penst grand;T=Penst graci;U=Campa rotun;V=Zigad elega;W=Amorp canes;X=Oenot nutta.

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Figure 2. Correlations of FFD and SPDX for each species in order of early flowering species to later flowering species. R2 and p-values reported.

1. Snow pack correlation – There were variable relationships between FFD and SPDX among species. R2 values ranged from 0.033 to 0.86 indicating a lot of variation in the explanatory power of SPDX on FFD. Three of 21 species were statistically significant (*Cerastium arvense*, *Amorpha canescens*, and *Zigandenus elegans*).

Table 1. Statistical summary of indirect effects for TSNOW and AGDU on FFD. Estimates of indirect relationships and p-values reported from model output.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Species | TSNOW | p-value | AGDU | p-value |
| *Anemone patens* | 0.626 | 0.147 | 0.921 | <0.01 |
| *Ranunculus rhomboides* | 1.139 | <0.01 | 1.053 | <0.01 |
| *Caltha palustris* | 1.221 | <0.01 | 1.049 | <0.01 |
| *Cerastium arvense* | 1.098 | <0.01 | 1.023 | <0.01 |
| *Ranunculus abortivus* |  |  |  |  |
| *Oxalis violacea* | 1.059 | <0.01 | 1.020 | <0.01 |
| *Sisyrinchium angustifolium* | 1.114 | <0.01 | 1.027 | <0.01 |
| *Lithospermum canescens* | 1.013 | <0.01 | 1.003 | <0.01 |
| *Trillium cernuum* | 1.712 | 0.143 | 1.861 | <0.01 |
| *Lithospermum incisum* | 0.967 | <0.01 | 0.997 | <0.01 |
| *Pedicularis canadensis* | 1.205 | <0.01 | 1.113 | <0.01 |
| *Zizia aurea* | 1.131 | <0.01 | 1.031 | <0.01 |
| *Vicia americana* | 0.940 | <0.01 | 0.963 | <0.01 |
| *Cypripedium candidum* | 0.826 | <0.01 | 0.968 | <0.01 |
| *Achillea millefolium* | 1.011 | <0.01 | 1.002 | <0.01 |
| *Anemone canadensis* | 0.963 | <0.01 | 0.993 | <0.01 |
| *Oxytre lambe* | 1.059 | <0.01 | 1.020 | <0.01 |
| *Rosa arkansana* | 1.279 | <0.01 | 1.052 | <0.01 |
| *Penstemon grandifloras* | 1.167 | <0.01 | 1.037 | <0.01 |
| *Penstemon gracilis* | 1.031 | <0.01 | 1.007 | <0.01 |
| *Campanula rotundifolia* | 0.695 | <0.01 | 0.939 | <0.01 |
| *Zigadenus elegans* | 1.067 | <0.01 | 1.043 | <0.01 |
| *Amorpha canescens* | 0.430 | 0.096 | 0.897 | <0.01 |
| *Oenothera nuttallii* | 1.421 | 0.024 | 1.220 | <0.01 |

Table

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Figure 3. Path diagrams with indirect effect estimates labeled. Number of asterisks indicate level of significance for p-value: \*p ≤ 0.05, \*\*p ≤ 0.01, \*\*\*p ≤ 0.001.

1. Model selection –
   1. The model excluding DOBG was selected based on the AIC. This model had the lowest AIC in all species.
2. Path analysis – Goodness of fit parameters indicated that all models had statistical credibility.
   1. Temperature- Many species had a significant regression coefficient for the relationship between AGDU and FFD. Nineteen species had positive regression coefficients, indicating that warmer temperatures earlier in the year led to earlier flowering. Sixteen of these species were significant. Five species had negative regression coefficients, of which only one was significant. The first four flowering species had strong and significant relationships between AGDU and FFD. Later flowering species typically had weaker, inconclusive relationships and few were significant.
   2. Temperature and SPDX- The relationships between AGDU and SPDX were positive in all species and the coefficients ranged from 0.01 to 0.18. Only four species had a statistically significant relationship between these variables.
   3. Snow – The relationship between TSNOW and SPDX had a positive and significant regression coefficient in all species. TSNOW was expected to be related to SPDX because both describe winter snowfall.
   4. SPDX and FFD – Four out of the 21 species had a significant relationship between SPDX and FFD, two were negative and two were positive.