Phenology Studies

Getting to know tree species and

optimizing seed-collection times

Phenology is the study of the responses of living organisms to seasonal cycles in environmental conditions. In forestry, phenological studies are used to determine when to collect seeds and learn how forests function (particularly tree reproduction and forest dynamics), so that the same functionality can be replicated in restored forest.

The flowering and fruiting of many tropical trees are usually related to seasonal variations in moisture and insolation. Cycles in reproductive events are most marked in the seasonal tropics. Not all tropical trees reproduce seasonally. Some flower or fruit twice or several times per year, whilst others exhibit “masting” i.e. mass fruiting at intervals of several years.

Obtaining viable seeds is the first step for tree-planting projects, so it is worth the effort of carrying out phenology studies to determine optimal seed collection schedules. Phenological studies can also enable the identification of “keystone” tree species; those which flower or fruit at times when other food resources for animals are in short supply. Keystone tree species, such as fig trees (*Ficus* spp), support whole communities of animal pollinators and seed dispersers; animals upon which other tree species rely for their reproduction. So they are obvious candidates for testing as framework tree species. During phenological studies, observations of pollination and seed dispersal mechanisms can also be made. Additional data on the leafing phenology of the trees is usually collected at the same time. This can help to predict optimal planting sites for individual tree species.

**How should phenological studies be established?**

Phenology trails are set up as part of the reference forest survey. Label at least five individuals of each tree species that characterize the reference forest type. Collect voucher specimens, from each labeled tree and get a botanist to identify them. Write a brief note, describing where each tree is located in relation to the trail (e.g. “10 m to the left”; “right 20 m by rocky overhang” etc.). As you repeat the observations month by month, you will soon be able to remember where each individual tree is located.

**How often should data be collected?**

At least once per month. Even with monthly observations, some tree flowering events may be missed, since some trees produce and drop their flowers within a month. Usually, such rapid turnover flowering events can be inferred, when trees are subsequently observed in fruit. In such cases, the data set can be adjusted during processing to add the ‘estimated’ time of a flowering event. If many flowering events are being missed, increase the frequency of data collection to twice per month.

**A semi-quantitative scoring system for monitoring tree phenology**

For recording tree phenology we recommend the “crown density” method, originally devised by Koelmeyer (1959). This semi-quantitative method uses a linear scale of 0-4 with 4 representing the maximum intensity of reproductive structures (flower buds (FB), open flowers (FL) and fruits (FR)) in the crown of a single tree. Values of 3, 2 and 1 represent approximately three quarters, half and one quarter of the maximum intensity respectively. The “maximum intensity” of flowering/ fruiting events varies among species and judgments of it are bound to be subjective at first, but they improve with experience.

The same approach can be used to score leafing. For individual tree crowns, estimate scores between 0 to 4 for i) bare branches, ii) young leaves, iii) mature leaves and iv) senescent leaves. The sum of these four scores should always equal 4 (which represents the entire tree crown). Scores for flowers + fruits are always less than 4, except when flowering/fruiting is occurring at the maximum intensity, typical of that species.

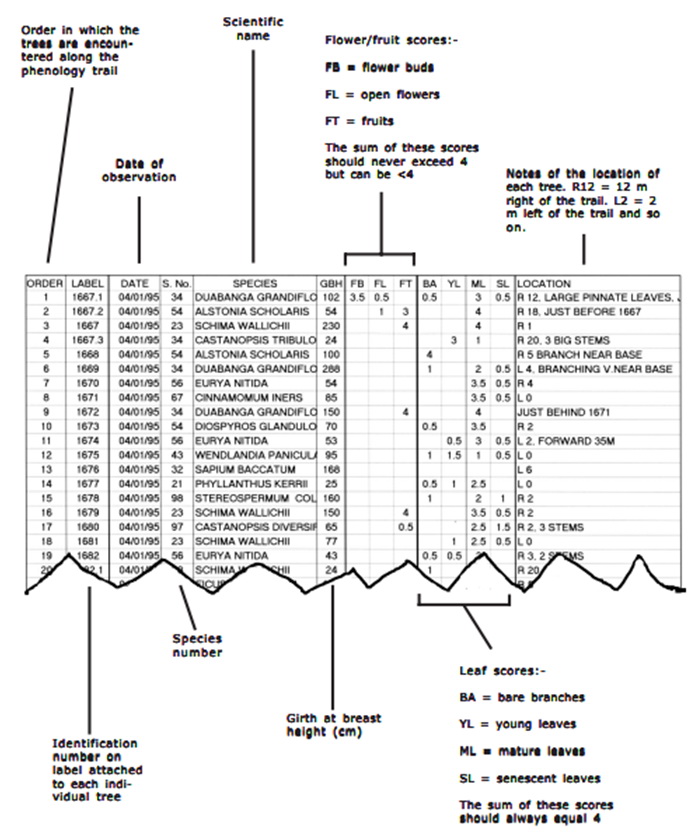
The crown density method is rapid and it allows quantitative analytical techniques to be applied to the data. However, at the beginning of a study, it is important, to train all data collectors to be consistent in their scoring, to minimize the subjectivity of the technique.

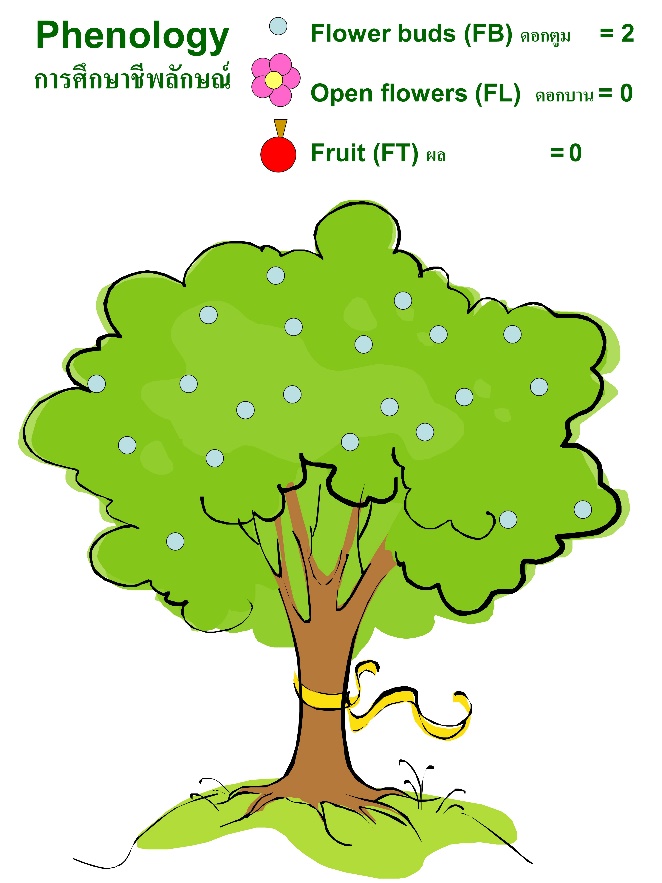
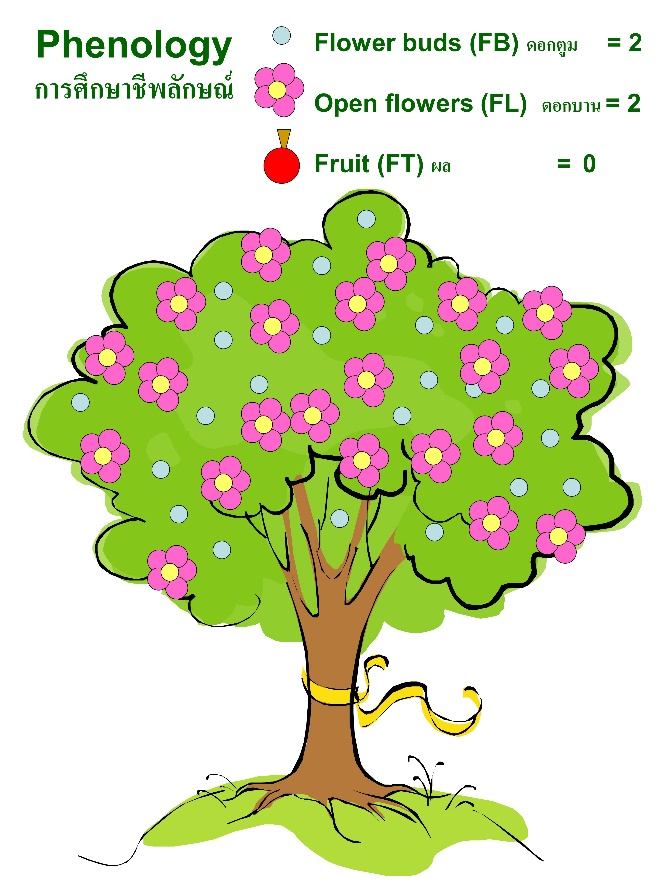
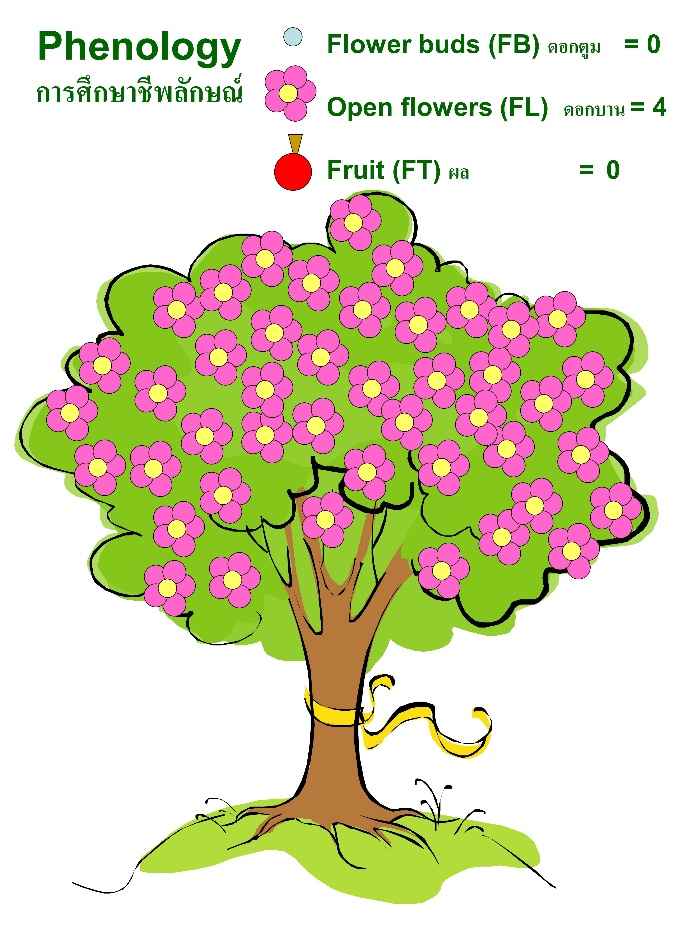
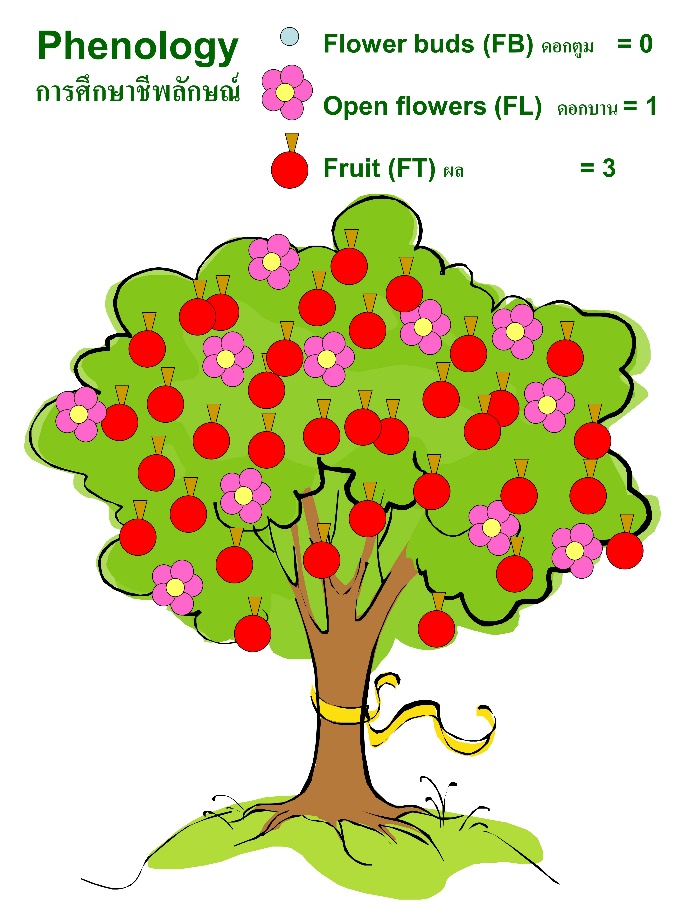
**How should phenology data be presented and analyzed?**

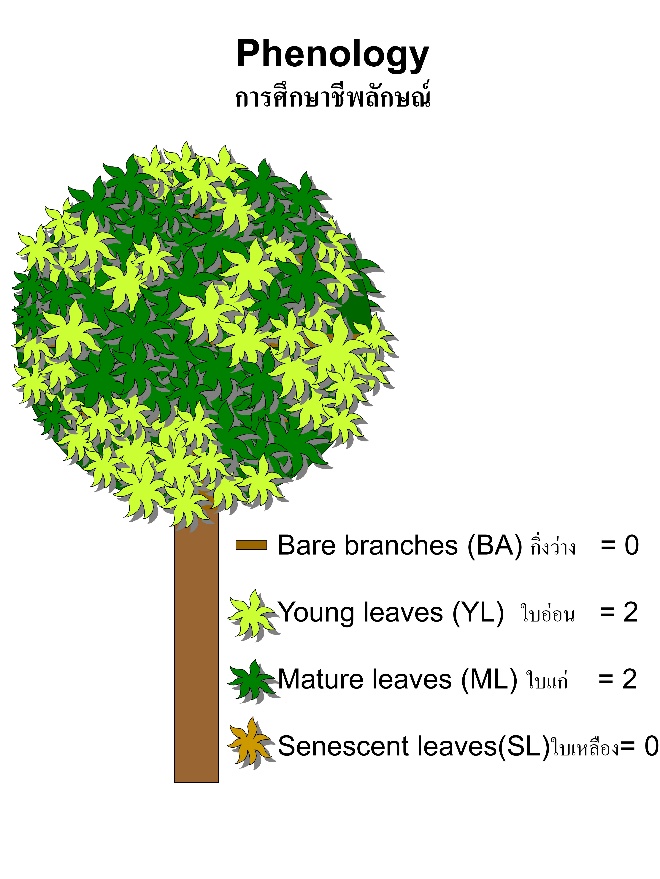
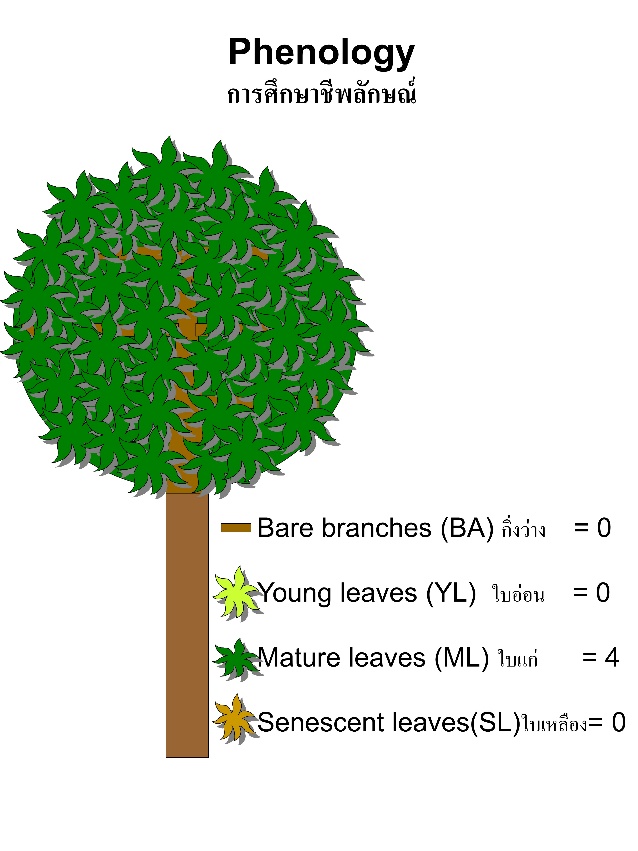
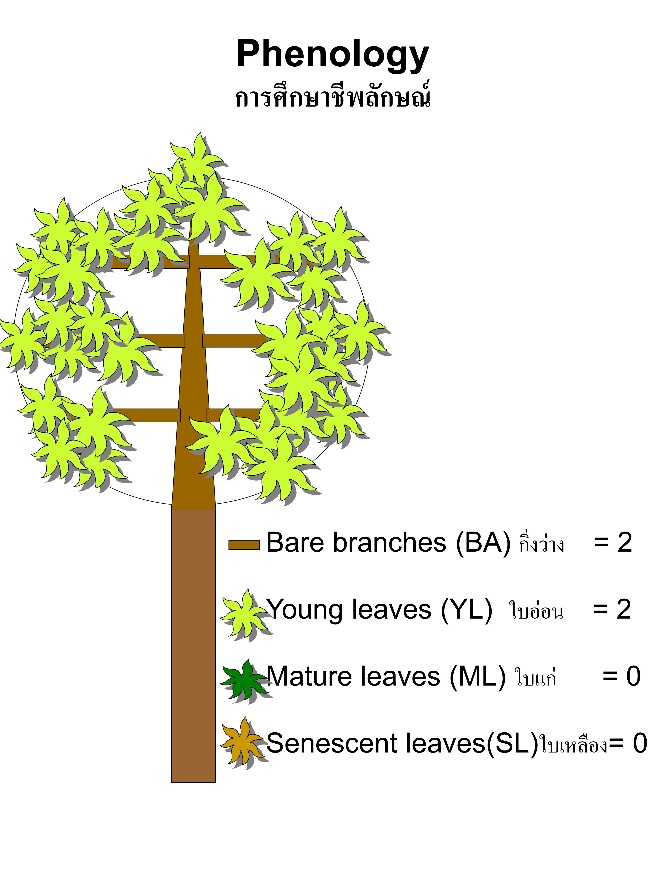
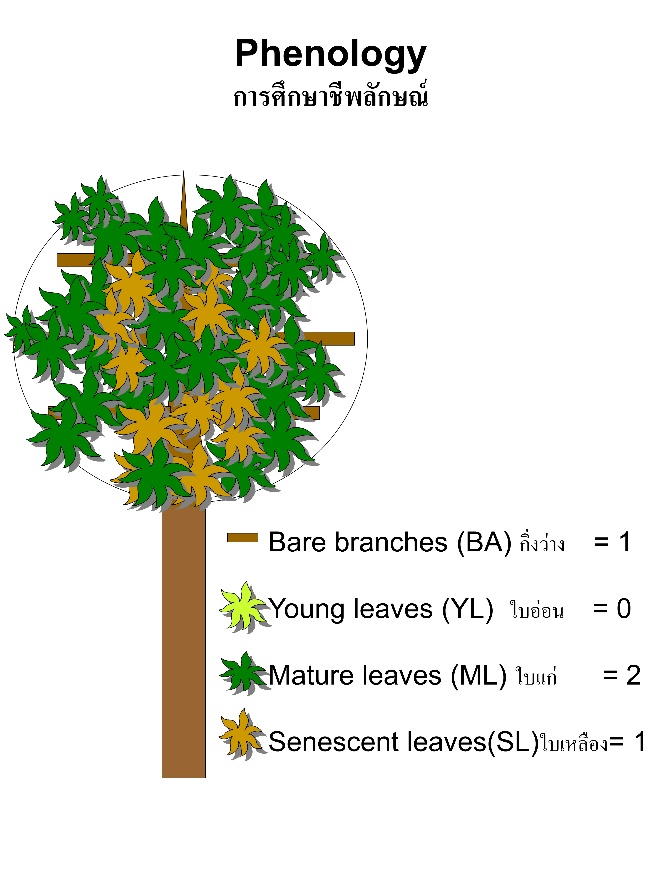
Once the study trees have been selected and labeled, prepare a data sheet, as shown below. List the trees in the order in which they are encountered along the phenology trail. In the field, carry the previous month’s data sheets with you, as well as blank sheets for recording the current month’s data. Month by month, accumulate all data into a single Excel spreadsheet. **Do not** store each month’s data on separate spreadsheets. Always enter new data at the bottom of the spreadsheet (rather than to the right). After each data-collection session, paste a copy of the blank data record sheet at the bottom of the spreadsheet and then add the newly collected data.

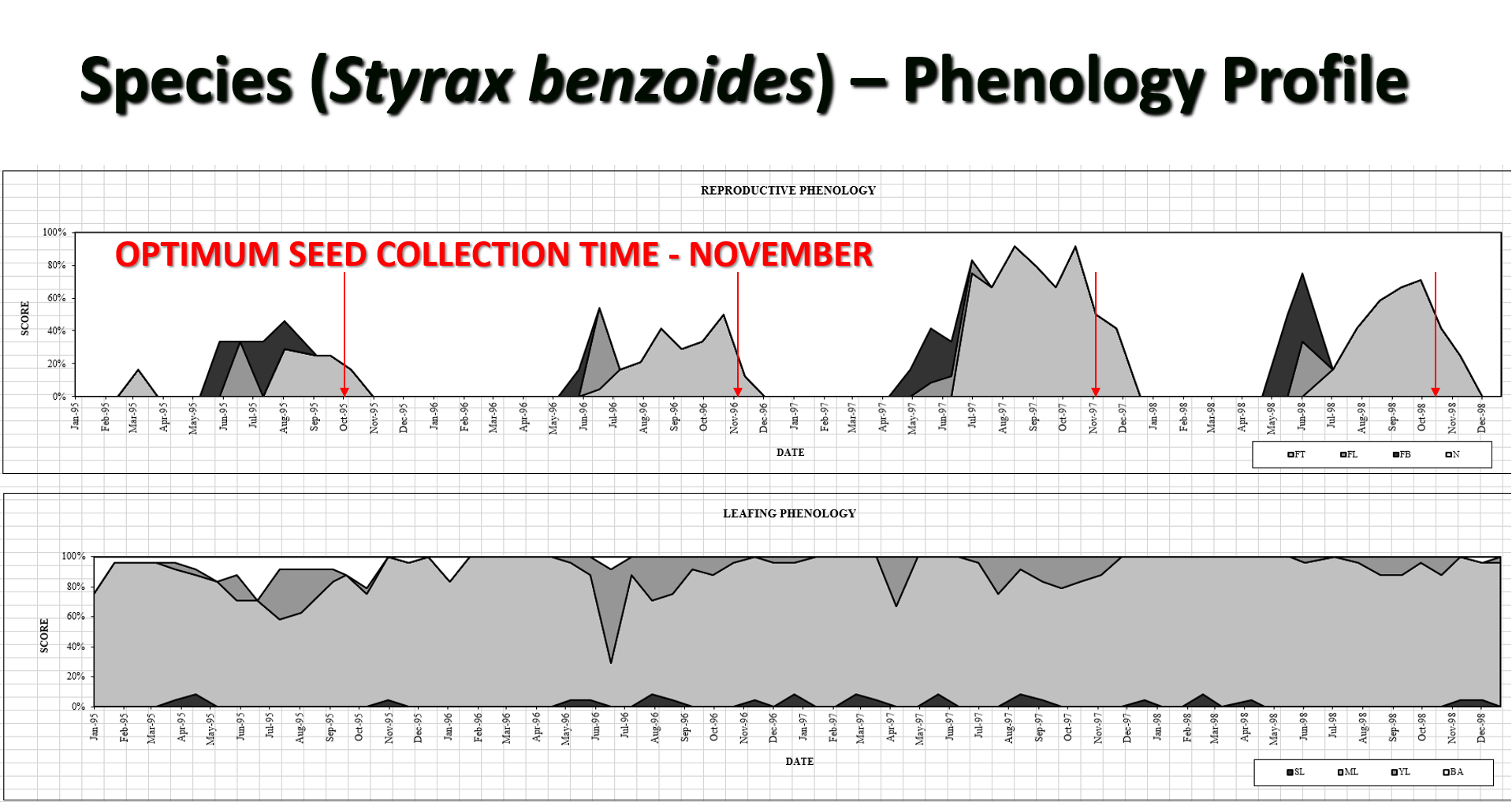
To analyze the data, first select the entire spreadsheet (by clicking on the grey, blank rectangle between the column headings and row numbers in the top left hand corner of the spreadsheet). Next click on “Data” in the top menu bar and select “Sort”. In the dialogue box, sort first by “SPECIES”, then by “LABEL” and finally by “DATE”. This arranges the data in chronological order, for each individual tree of each species

Then use the MS Excel graph wizard to construct a visual phenological profile as shown below. Start by making a profile for each individual tree of each species. This will give you some idea of the variability of phenological behaviour within each species population and will enable you to assess the synchrony of phenological events and calculate several of the indices defined below. The graph wizard can then be used easily to create a graphical phenological profile of each tree. Only after that should you calculate mean score values across all individuals for each species population and construct an “average” profile for each species.









When analyzing flower/fruit data, the most important point to look for is the period during which fruit scores decline for each species. This indicates the optimal seed collection month for that year, when natural seed dispersal is occurring. The example here shows that the optimum seed collection time for *Acrocarpus fraxinifolius* is from late June to early July, when maximum seed dispersal occurs. The fruit/seed maturation period is from February to June.

After the study has continued for several years, various useful indices of seed production may be calculated by extracting data from the spreadsheets:

* **Duration** – the mean length of flowering/fruiting episodes (in weeks or months) for each individual tree and averaged across all trees in a species sample.
* **Frequency** – the total number of flowering/fruiting episodes recorded for each individual divided by the number of years the study has run: then averaged across all individuals of the same species.
* **Intensity** – mean of the maximum flower/fruit scores (for each flowering/fruiting episode) recorded for each individual tree: then averaged for all flowering/fruiting individuals in the species sample.
* **Prevalence** – number of individual trees that flowered/fruited in each year, expressed as a percentage of the total number of individual trees in each species sample, averaged across the total duration of the study (in years).
* **Fruit set index** – for each flowering/fruiting episode, the maximum fruit score observed expressed as a percentage of the maximum flower score: averaged for all flowering/fruiting episodes for all individuals in the species sample.

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13/9/22