

Straightening Out the Askenasy Curve

By Andrew Hiron

For twenty years the Askenasy Potential Energy Curve (Shigo 1991) has been used by arborists to inform the optimal timing of tree care operations (e.g., pruning). It has influenced arboricultural best practices, national standards, and arboricultural curricula (e.g., Harris et al. 2004; BSI 2010). The model established by Dr. Alex Shigo in *Modern Arboriculture* describes the modulation of the stored or potential energy within a tree over the course of a year. The model suggests that potential energy rapidly declines during leaf formation and before a period of high photosynthetic activity rapidly restores the potential energy to levels present in dormancy. A much more gradual increase in potential energy continues through summer into autumn, leaving energy levels high at dormancy (Figure 1).

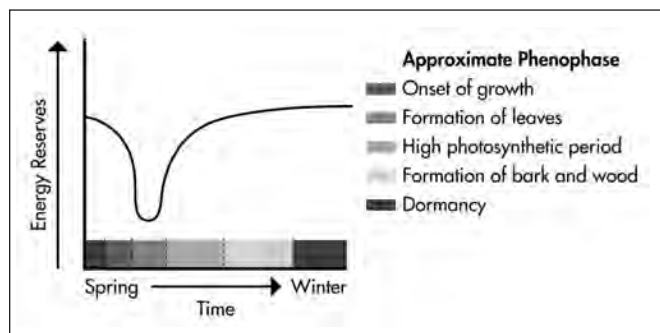


Figure 1. Schematic representing the Askenasy Potential Energy Curve (redrawn from Shigo 1991).

A broadly accepted application of this model is that mechanical wounding caused by pruning should be avoided at times where potential energy is low. If pruning is conducted during phenophases exhibiting high potential energy, then the tree is much better equipped to respond and is more likely to effectively occlude the wound and compartmentalize damage. The logic of the model is difficult to dispute, but can an inquiry into the provenance of the 'Askenasy curve' provide new insight into its significance? Where did the Askenasy Potential Energy Curve come from?

In *Modern Arboriculture*, Shigo graphically represents a written extract of Askenasy's work sourced from a paper by Priestley (1970). However, this publication cites the extract as being recorded in Schimper et al. (1903), an English translation of a classic German text on plant geography. This book makes original reference to Askenasy's 1877 series of papers in the German botanical periodical *Botanische Zeitung* (Askenasy 1877a; Askenasy 1877b; Askenasy 1877c), creating a literature

trail extending more than 130 years. So how can the evaluation of this literature enhance our understanding of Shigo's model?

It is clear that Shigo's model accurately reflects the extract presented in Priestley (1970) and Schimper et al. (1903). However, one of the first things that can be learned from the original text is that Askenasy's commentary relates to seasonal changes in carbohydrates in wood, specifically starch and glucose (which Shigo interpreted as "potential energy"). We also learn that the account is based on a single species, *Prunus avium*. While Shigo would have been clear that this was the case, the omission to note this in his commentary has allowed his readers to make the assumption that all temperate trees display the same trend. This may well have been intentional, as other established texts of the time also advocated similar cycles of annual carbohydrate relations in temperate broadleaved trees (e.g., Kramer and Kozlowski 1979).

More current literature, however, such as Hoch et al. (2003), help provide important resolution on the nature of seasonal carbohydrate relations in temperate trees. Here, the authors analyze the seasonal variation of non-structural carbohydrates (NSC) in temperate trees. NSC are defined as free, low molecular weight sugar (glucose, fructose, and sucrose) and starch concentrations. The study analyzed leaves, branches, and stems of ten temperate tree species; six deciduous broadleaf trees, one deciduous conifer, and three evergreen conifers. When the species data is combined to give a general impression of seasonal variation in NSC (Figure 2), the trend is in contrast to that presented by Shigo [1991 (Figure 1)]. In fact, Hoch et al. (2003) show that the NSC pool of branchwood actually increases during spring and early summer before stabilizing through late summer and into autumn. As a result, the validity of the Askenasy curve may have been brought into question had it not been for the fact that by happy coincidence, *Prunus avium* is one of the species investigated. Hoch et al. (2003) show that at a species level *Prunus avium* clearly exhibits a decrease in NSC (in branch sapwood) prior to budbreak, which the authors attribute to the prolific pre-leaf flowering that occurs in this species (Figure 3). Therefore, it may still be argued that species that exhibit pre-leaf flowering are likely to have a depleted carbohydrate pool at the leaf expansion phenophase. Significantly, this implies that the model presented by Shigo (1991), although accurate for the species Askenasy was describing, should not be applied more widely because *Prunus avium* is an atypical species with regard to its seasonal carbohydrate relations. Incidentally, the other group of trees demonstrated to have a marked reduction (although not necessarily statistically significant) in seasonal fluctuation of NSC are those with a ring-porous xylem structure, such as *Quercus petraea* (Barbaroux et al. 2003; Hoch et al. 2003). This is related to the requirement ring-porous trees have to replace their hydraulic infrastructure (xylem) using reserve carbohydrates prior to leaf initiation and

concomitantly, current season photosynthate (Zimmerman 1974). Perhaps, those species which exhibit a ring porous xylem structure and pre-leaf flowering (such as many *Ulmus* sp.) should be treated with particular caution early in the growth season.

Hoch et al. (2003) also revealed, in the ten temperate forest trees studied, that no particular shortage in non-structural carbohydrates was found during the course of the year despite some fluctuations in levels of NSC. This suggests, at least in healthy trees, that the carbohydrate status of the tree should not be a guiding principle informing the timing of arboricultural operations such as pruning.

Examining the provenance of the Askenasy Potential Energy Curve reminds us that it is crucial to treat generic models on tree performance with caution, and emphasizes the need to understand the diverse characteristics that contrasting species exhibit. The functional diversity of trees is such that no model will apply satisfactorily to a broad range of species in multiple environments. Arboricultural professionals must be aware of this and should be prepared to interrogate models so that they are applied only to those situations in which they have relevance. Careful and ac-

curate citations supporting models are central to enabling this. In addition, those publishing models have the responsibility of alerting the reader to potential limitations. Indeed, it should be noted the Hoch et al. (2003) used mature trees growing on a high quality forest site for their research. The data may, therefore, contrast with trees that are limited by less optimal conditions frequently found in urban environments. Furthermore, although ten species of tree were used in Hoch et al.'s (2003) research, this clearly represents a fraction of the genetic diversity found across temperate trees.

It is hoped that the evidence presented in this short commentary will be useful for informing revisions in arboricultural curricula, act as a reminder that generic models should be evaluated before they are applied, and contribute toward the general discussion on the optimal timing of arboricultural operations.

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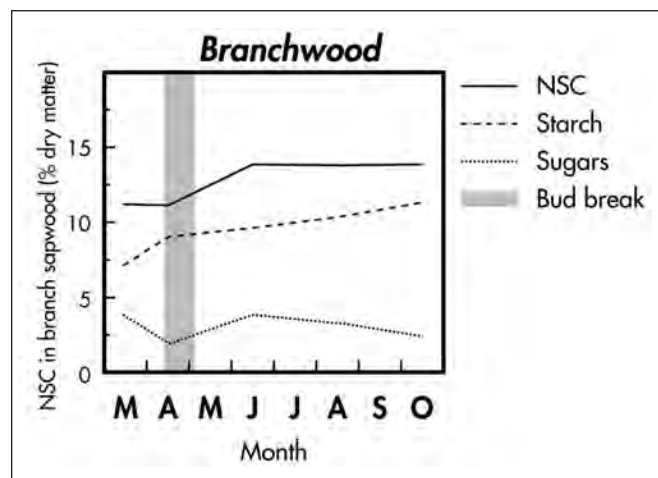


Figure 2. Schematic of mean seasonal change in NSC from the branchwood of six deciduous species (*Acer campestre*, *Carpinus betulus*, *Fagus sylvatica*, *Prunus avium*, *Quercus petraea*, *Tilia platyphyllos*) (redrawn from Hoch et al. 2003).

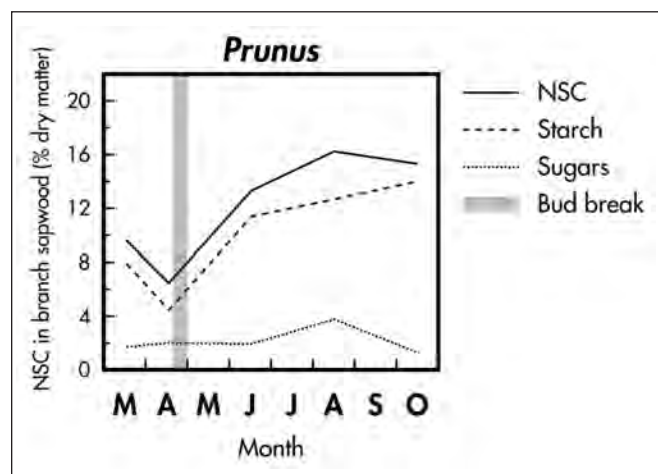


Figure 3. Schematic showing the seasonal change in NSC for *Prunus avium* (redrawn from Hoch et al. 2003).

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