What does research tell us about the practice of pruning in arboriculture?

By James R. Clark and Nelda Matheny

Top quality arborists rely on scientific research to provide the basis for tree care. Tree care practices should be founded in good science. At the same time, the practice of arboriculture offers many questions that researchers can answer with experiments.

How is the practice of tree pruning reflected in these two ideas? How has research supported practice? Does practice guide research? With these questions in mind, ISA's Science and Research Committee contracted with HortScience, Inc. to assemble a bibliography of research on the topic of pruning. The complete literature review will be published in *Arboriculture & Urban Forestry* in the 2010-year. This article is a brief summary of that review.

We assembled 201 research citations from peer-reviewed journals, books, book chapters, and conference proceedings. We identified articles dealing with pruning in 44 journals from 12 countries. Our primary focus was on articles published in English. We were, however, able to draw from a number of other languages.

The scientists most frequently cited should be familiar to English-speaking arborists: Alex Shigo, Ed Gilman, Jason Grabosky, Brian Kane, Dan Neely, and Tom Smiley. Yet scientists from other countries were also cited: Karen Barry and Elizabeth Pinkard of Australia; Dirk Dujesiefsken, Walter Liese, D. Eckstein, Francis Schwarze, and Horst Stobbe, of Germany; and Francesco Ferrini of Italy. Dujesiefsken and Stobbe's (2002) review of the Hamburg Tree Pruning System is an excellent summary of current pruning practice, applicable to arborists around the world.

The Power of Research to Influence Tree Care Practice

Prior to the 1980s, it was common practice to remove branches by cutting directly against the trunk (Figure 1). This practice may have arisen with the introduction of chain saws. Whatever the origin, cutting "flush" to the trunk became accepted practice. Once the branch was removed, the resulting wound was covered with sealant. Every climber was admonished not to leave any "shiners", or unpainted wounds. Asphalt-based materials were common although a wide range of "wound dressings" were employed.

In current practice, however, arborists avoid flush cuts and leave wounds untreated. Research provided the basis for changing these two long-standing techniques. It was no surprise that the topics of wounding, wound response, and wound treatment were the most frequently noted in the bibliography. Research spans Shigo and Larson's (1969) photographic summary of the patterns of discoloration and decay in U.S. hardwoods to Schubert et al.'s (2008a, 2008b) experiments on biological control of decay fungi. O'Hara (2007) provided an excellent overview of the topic of wounding by pruning.

Figure 1. Research catalyzed the change in arboricultural practice from flush cuts (pictured here), to natural target pruning, particularly when the development of decay in the parent stem as a function of pruning style was evaluated.

Research on the method of pruning and the value of wound dressings focused on two ideas: 1) enhancing closure rates, and 2) reducing internal decay and discoloration. Across a wide range of tree species in a number of countries, wound dressings neither enhanced closure nor reduced discoloration and decay.

In the United States, Alex Shigo was the main critic of flush cuts and the primary advocate for "natural target pruning" where a branch is severed at the edge of the branch collar. The basis for Shigo's argument was his realization that trees had evolved a mechanism to respond to branch loss. When tree branches are naturally shed, the branch collar remains intact and becomes the point from which new wound wood arises. He performed a series of experiments to demonstrate that flush cuts resulted in greater discoloration and decay than cuts made just outside the branch collar. In addition, Shigo observed that trees respond to branch loss with a series of chemical and physical changes that increased resistance to decay. These observations led to the development of the CODIT (compartmentalization of decay in trees) model of tree response to wounding, including those produced by pruning. This work was summarized in Shigo and Marx (1977) and Shigo (1984).

In a similar manner, arboricultural research catalyzed the transformation from round-over trimming to directional pruning as the primary approach to managing trees in close proximity to the energized conductors (Figure 2). For many years, trees below or adjacent to energized conductors had simply been headed back, cut to create a shaved, smooth, crown with adequate clearance. The problem with this technique is the rapid regrowth that results. The goal of directional pruning is to remove branches in conflict with the utility lines (either now or in the future) and retain branches oriented away from the lines. This approach employs both removal and reduction cuts. Instead of a generalized growth response, directional pruning focuses new growth on branches oriented away from the conductors. Shigo's (1990) *Pruning Trees Near Electrical Utility Lines* defined the state of knowledge and practice in the field for many years but has been replaced by Kempter's (2004) summary of best management practices.

Outside North America, there has been little or no research in the utility arboriculture area. One exception was Millet and Bouchard's (2003) application of the French architectural analysis methods to the utility setting. Architectural analysis is based on the concept that the species-specific patterns of shoot and root development are repeated throughout the life of a tree. Even the large, complex nature of a crown is based on relatively simple patterns of development. The process of development is described in 10 stages, from youth to death. In applying this approach to utility systems, Millet and Bouchard suggested that species architectural patterns should be considered in making pruning decisions.

Figure 2. Research has had a profound impact on the manner in which trees located under utility lines are managed. As a result, roundover trimming (a), has been replaced with directional pruning (b), as the method of choice.

The theme of Millet and Bouchard is that a species architectural pattern informs us how to prune and develop an appropriate crown structure. This concept could have broader application to tree management as providing a basis for pruning programs for a young, mature, and overmature tree.

Research has established that the seasonal timing of pruning determines whether it has positive or negative consequences. For example, a plant health care program for problems such as bronze birch borer, oak wilt, and bark beetles includes pruning during the dormant season, when insect activity is low. (These insects are attracted to the chemical produced by fresh wounds.)

Pruning Practices Where Research is Limited or Lacking

Not every aspect of pruning has a strong research foundation. The practice of crown cleaning removes dead, diseased, detached, and broken branches. One result is a reduction in the potential for branch failure. The logic of this type of pruning is clear. Taking these limbs out of the crown prevents them from failing, thereby improving safety around the tree. Removing stubs located outside the branch collar may improve wound wood development, but no documentation for this was identified in our search. Alternatively, retaining these branches in the crown may increase opportunities for wildlife habitat.

A larger question is whether tree health is improved by pruning. There is only a tenuous scientific link. Miller and Sylvester (1981) examined the frequency of pruning for some 40,000 street and boulevard trees in Milwaukee, WI. What constituted pruning was not defined but we assume that it included crown cleaning and other pruning practices. Miller and Sylvester documented a decline in tree health as the length of the pruning cycle increased, estimating that almost 90 percent of the variation in tree condition was due to the amount of time since pruning (from two to fourteen years). Tree condition was assessed on a percentage scale. The range in average tree condition was 64.3 percent (fourteen years since the last pruning) to 77.6 percent (four years since the previous pruning).

This observation suggests that pruning either improved or maintained tree condition. When pruning was absent for more than 10 years, average tree condition was 10 percent lower than when trees had been pruned in the last several years. Yet, we do not have additional research to demonstrate that cleaning improves either tree life span or vigor.

There is a similar lack of experimental work with the practices of thinning and reduction. Arborists think of the former as a tool to increase light penetration to the interior of the canopy, increase air movement, reduce wind sail, and even out the distribution of foliage.

Arborists often reduce long, heavy branches as a way of reducing failure potential. We know that shortening limbs reduces the overall mass of the branch as well as its lever arm. We assume that failure potential is also reduced. But we do not have any evidence on how much weight or length to remove in order to achieve a specific improvement in stability. Research has shown us how to make a reduction cut but not how application over the entire tree is a benefit.

There has been a great deal of activity investigating the response of young trees to wind as a function of pruning type and intensity. As yet, it is unclear that tests on small trees would also apply to large trees.

In short, there is no sound scientific basis to crown cleaning, thinning, and branch reduction as they relate to an effect on tree health or stability (Figure 3).

Research Opportunities and Constraints

The scientific basis for pruning practices is well-defined in some areas but lacking in others. Such a situation does not mean that arborists should abandon current pruning methods and approaches. We should, however, be careful about the manner in which we describe the benefits of pruning.

The limits of pruning research result in part from the inherent problem of designing experiments with large trees. The results may not be apparent for many years. This has, and always will be, a significant constraint on pruning research. Arborists in Europe can visit the Urban Tree Arboretum in Horsholm, Denmark, where 120 taxa of trees were established in 2001 (Buhler and Kristofferen 2009). Trees have been given different pruning treatments so the differences in growth and development may be observed.

To overcome the limitations of research within arboriculture, arborists must look to scientific research in forestry and, to a lesser extent, tree fruit production. Forest scientists have provided vital information about the response of trees to wounding and crown raising. Tree fruit scientists provide good information on branch attachment, size, and the effect of fruit loading. Arborists should look to colleagues in these fields for information applicable to good pruning practice.

Access to research published in non-English language journals is also a significant limitation to the dissemination of scientific information. English-speaking arborists look to scientists like Ed Gilman, Tom Smiley, Jason Grabosky, and Brian Kane to provide a scientific basis for practical application. What is clear from our literature review is that we should also look to our counterparts in Germany, France, and Italy for good science. Although we face a barrier of language, it is not an insurmountable one, for several reasons.

First, there are increasing levels of interaction among English-speaking and non-English-speaking scientists. ISA and its Chapters have actively sought to include scientists from other countries on educational programs. Second, some scientific journals provide abstracts and summaries in more than one language. *Arboriculture & Urban Forestry* is printed in English but includes abstracts in Spanish, French, and German. The *Canadian Journal of Forest Research* publishes in both English and French with abstracts in both languages. Third, online searching for scientific information provides wider access to journals than would be found outside of an academic library. Abstracts are normally available at no cost, even if there is a cost to obtain the entire article.

In conclusion, scientific research has greatly impacted the way arborists prune trees. However, we still need much more research to fully understand the effect of pruning on tree health and longevity. The International Society of Arboriculture is working hard to guide this research, provide a network of international connections, and

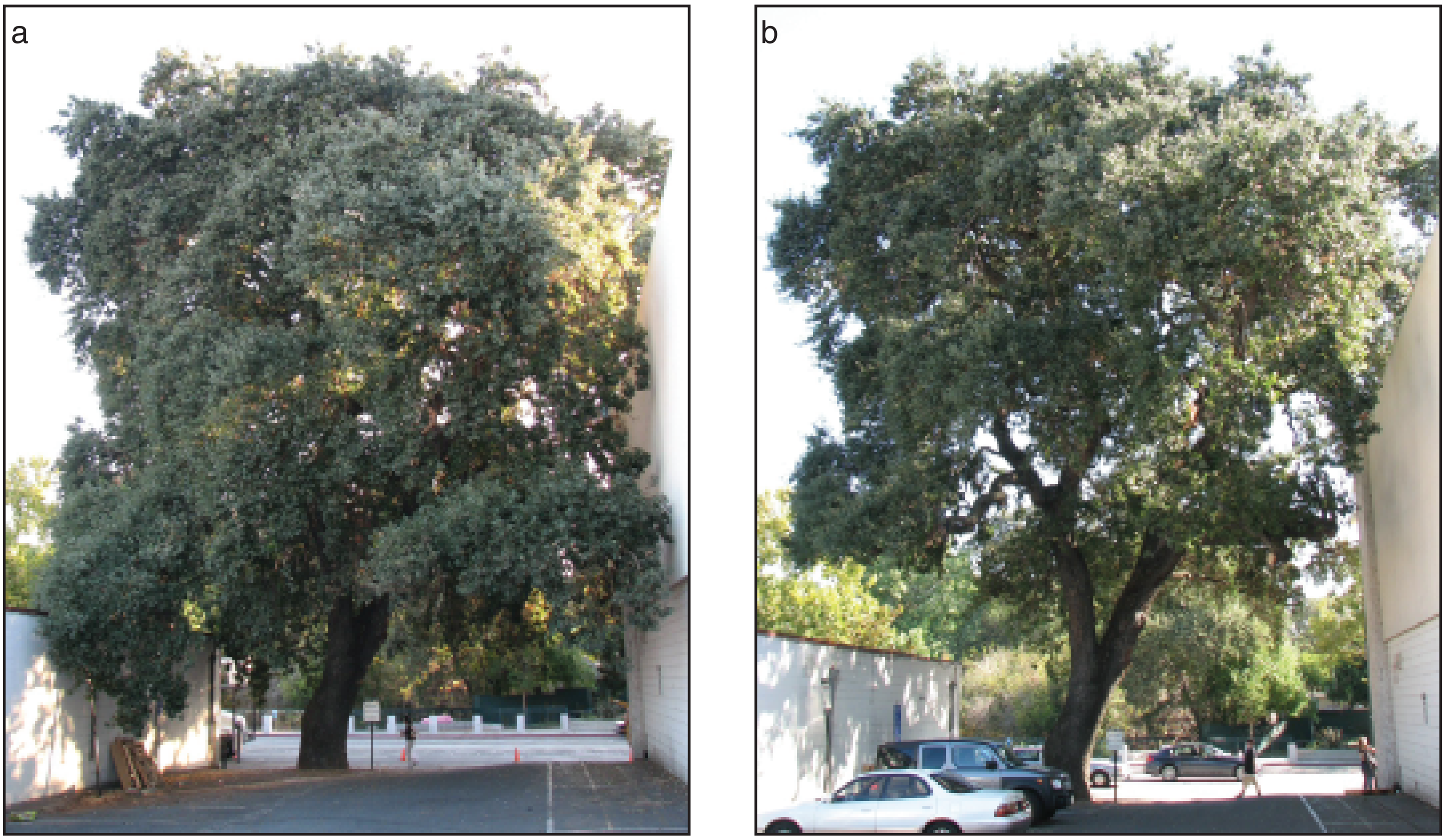

Figure 3. The crown of this mature oak was raised to provide clearance over parking, street, sidewalk, and roof areas. One long limb was reduced in length. Some cleaning and thinning was also undertaken. We do not know however, if tree health and/or longevity were improved by this treatment. Photos represent the tree prior to pruning (a), and after pruning (b).

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provide money through the TREE Fund and other sources, to pay for and support this important information.

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