TREE LOAD

Basic Field Analysis

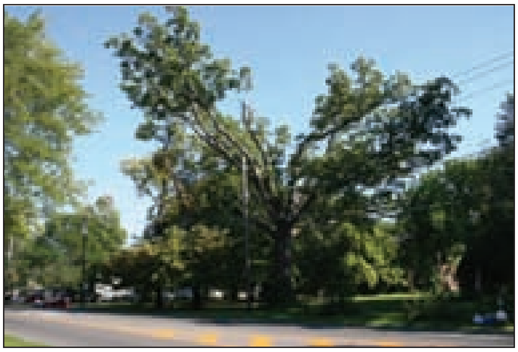
By Jerry Bond

In the first part of this article (Bond 2011), I examined the concept of load in some detail, arguing that an understanding of it should be an important component of risk analysis. In this second part, I propose a simple field method that permits the qualitative estimation of potential load magnitude and distribution.

There is no field protocol for simple tree load analysis that I know of. Yet the basic principles of load analysis should be made available to arborists and tree managers everywhere as a standard tool for everyday work. Clear and quick field protocol, good documentation, and ideally, industry adoption would be required for this to happen. In this article, I address the first step only, hoping to attract serious attention to the topic from tree professionals who, like me, may have hesitated to look at this for lack of an engineering background.

Such a basic field protocol would not be a substitute for a detailed scientific analysis, and it could never be relied on for high-risk situations, for which a trained professional is required. The objective of creating a field protocol would be to make simple load analysis a standard field tool for gaining a "first approximation" of load potential. Employing it would be analogous to the use of a sounding hammer. The hammer is a simple tool often able to detect the

Appreciating the destabilizing effect of saving this hackberry by raising the crown requires a clear understanding of exposure, surface area, and leverage.



The large limb of a 64 in (163 cm) DBH white oak (*Quercus alba*) extended over three-phase wires and completely exposed to the prevailing winds from the west.

presence of significant decay, and a positive result points to the need for advanced techniques to measure the decay's extent and the consequent failure potential. Ultimately, I would like to see basic load analysis be incorporated into standard visual assessment techniques.

In my previous article, I concluded that simple field load analysis needs two critical elements:

- visualize and assess load flow
- search for stress raisers

The first requires that we consider the magnitude of the forces that can typically be expected on the whole tree or one of its parts, while for the second we want to identify locations that will be subjected to high stress levels as the load moves through the tree. We can make this process easier by breaking down the analysis into discrete steps.

Six Questions Toward a Protocol

I will now argue that six questions can lead the field arborist to a functional appreciation of potential load magnitude and distribution. The questions aid the arborist in following load from its origin in the application of a force to its ultimate dispersion.

For ease of application, only categorical responses are required: high, medium, and low. Such responses are not measurements, and they are barely even estimates. Yet the set of answers are sufficient to provide a "fuzzy" portrait of potential load that will help identify and prioritize instability. Also, given the large number of uncertainties in both measurement and interpretation during tree risk assessment, that fuzziness can find a ready defense.

Q1: What is actual exposure potential to high levels of wind, ice, etc.?

Factors:

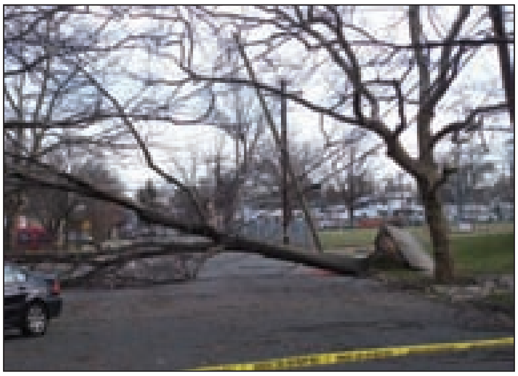
- Weather exposure
    - Frequency, type and severity of extreme events (e.g., a "Pineapple Express," hurricane, or ice storm)

- Site exposure
  - Neighboring vegetation or structures
  - Aspect, if on a slope (i.e., what compass direction does it face?)
- Individual exposure
  - Leaning edge tree, overextended limb, etc.
  - Recent loss of protection through removal of trees, limbs, structures, etc.

Q2: How much surface area is available to capture the force?

Factors:

- Foliage surface area—size and density of foliage on the tree or branch
- Wood surface area—generally only a significant factor in leaf-off periods or during extreme events that escape prediction
- Lopsided foliage distribution increases torsion



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Photograph of the failure of a red oak (*Quercus rubra*) during an early spring storm with large amounts of rain and wind. Despite the absence of leaves, the load resulting from the wind on the crown was enough to exceed the strength of the small root mass in a saturated soil. The failure mode suggests possible root/butt decay on the curb side of the tree as well.

Q3: What stress raisers are present?

Factors:

- Stress raisers concentrate load moving through the tree
- Types
  - Sharp bends, such as doglegs
  - Cankers, cracks, and other material defects
  - Rapid and severe reduction in load-bearing surface area
- Severity level judged with standard visual techniques

Q4: How long is the lever arm to magnify the force?

Factors:

- Lever = distance from center of load to nearest susceptible stress raiser or base of a branch or tree
  - Center of load—here, use the approximate center of the foliage or branch mass
  - Most susceptible stress raiser—select from responses to **Q3** or use termination point
- If the lever is ignored, load and safety cannot be estimated

Q5: What is the degree of excurrent architecture?

Factors:

- Excurrent limbs and trees have a single dominant central axis
- They tend to maximize load transference, and are more likely to resonate to dynamic loading
- A more decurrent architecture has multiple large branches that absorb force (damping)

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Photo of a 70 ft (21 m) tall black cherry (*Prunus serotina*) with a DBH of 17 in (43 cm), newly exposed on the edge of recent construction. The load descending from the small crown is magnified by a very long lever, and the result applied to a restricted surface area at the base with the potential for very high stress.

Picture of a honeylocust (*Gelditsia triacanthos* var. inermis) with limbs repeatedly pruned up to clear utility wires. This common procedure actually increases the stress felt at the limb's base by constantly lengthening the lever arm as the foliage rises into faster winds (here partially blocked by other vegetation).

Q6: How weak is the material along the critical axis?

Factors:

- Species differ in green wood strength by a factor of about four (compression) to six or more (torsion) in standard tests
- Actual individual limbs and trees deviate from laboratory values due to genetics and environment
- Species anatomy is also important to consider—elms (*Ulmus*), for instance, rarely display codominant stem failure

►

Photo of a bur oak (*Quercus macrocarpa*) with 75 ft (23 m) height and 43 in (114 cm) DBH. The many large limbs radiating from the top of the main stem are capable of absorbing a great deal of energy, relieving the stress on the lower stem and roots.

Picture of an old pruning wound on a cottonwood (*Populus deltoides*) over three-phase wires.

The combination of a weak-wooded species with a large decayed wound on the upper load-bearing surface would be a serious threat if the limb were exposed. This particular limb is on the lee side of the crown and surrounded by other limbs, so subject to low external loading.

Conclusions

My persuasion is that this basic field method provides a legitimate contribution to judgments about likelihood of failure that we make every day about individual trees as well as populations. But that persuasion needs to be tested by arborists, and their feedback used to modify and improve the method. This question set needs to be applied to many different situations, and both process and product evaluated carefully. A simple data form can be created for data collection (Bond 2010), which adapts easily to electronic format.

Finally, we need to ask: what would be an actual outcome of such a basic analysis? In the hypothetical tree represented in the illustrated data form, for instance, the observer has estimated that both the second question (How much surface area?) and the sixth (How weak is the material?) should be answered as being high in their capacity to increase risk of failure. But few stress raisers are visible (answer to third question), and any leverage factor is at a minimum (answer to fourth question). Such a profile would probably lead an arborist to check one final time but not move to a higher level of investigation unless there was some other cause. In general, the more questions that are answered with "high," the more an arborist would be inclined to conduct some form of advanced investigation.

ID		Exp	Sur	Str	Lvr	Exc	Mat
	High		x				x
	Medium	x				x	
	Low			x	x		

Example of a possible data form, illustrating the useful output of this basic method of basic load analysis.

It is important to repeat what this proposal does not claim to be. It does not offer a magic bullet for risk assessment, it is not a substitute for formal scientific analysis, it does not provide easy answers, and it does not eliminate the need for experienced and knowledgeable interpretation of its data. But these six questions are one effective means of estimating load analysis in the field that can be put to use without special training and mathematical ability. They also constitute a useful pedagogical tool for workshops, crew training, and other settings for professional learning. With luck, such an approach may bring load analysis into everyday work situations for us non-engineers doing risk analysis with limited time and resources.

Additional Reading

Bond, Jerry. 2010. Data form for basic load analysis. <http://bit.ly/BasicLoadForm> (.pdf)

Bond, Jerry. 2011. Tree Load: Concept. *Arborist News* 20(1):12-16.

Kolarik, J. 2003. The application of the static integrated approach for arboricultural practice. Proceedings of the Fourth Treeworks Environmental Practice/AA Seminar, "Wind Load Simulation in Trees." Westonbirt, UK:2003. pp. 1-5. <http://bit.ly/fnI1LD>

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Photos courtesy of the author except where noted.