CLIMBERS' CORNER

Safer Ascent into Trees

By Mark Bridge and Chris Cowell

Ascent – into the unknown! Discussions with colleagues from a number of countries about ascent incidents suggest that the ascent phase of tree climbing is not without its risks. The risk arises from a number of parameters, for example height, the proximity of obstacles, and the structure of the tree.

The aim of this article is to invite discussion about this 'take-off' phase of tree climbing, and move forward together by coming to grips with some of the potential problems and conflict situations during the process of managing risk.

A number of ascent techniques are available to the tree climber — for example, ladder, platform (bucket truck), or climbing (Figure 1). Further differentiation is possible under the heading of climbing:

- an ascent line can be installed with the aid of a thrown pilot line, facilitating the installation of a free hanging rope, which is climbed using dedicated ascent techniques (single, doubled or two rope systems), and
- line advance techniques may be used to climb directly on more complex structures, perhaps where branching starts closer to the ground, by alternately connecting between two or more work positioning systems.

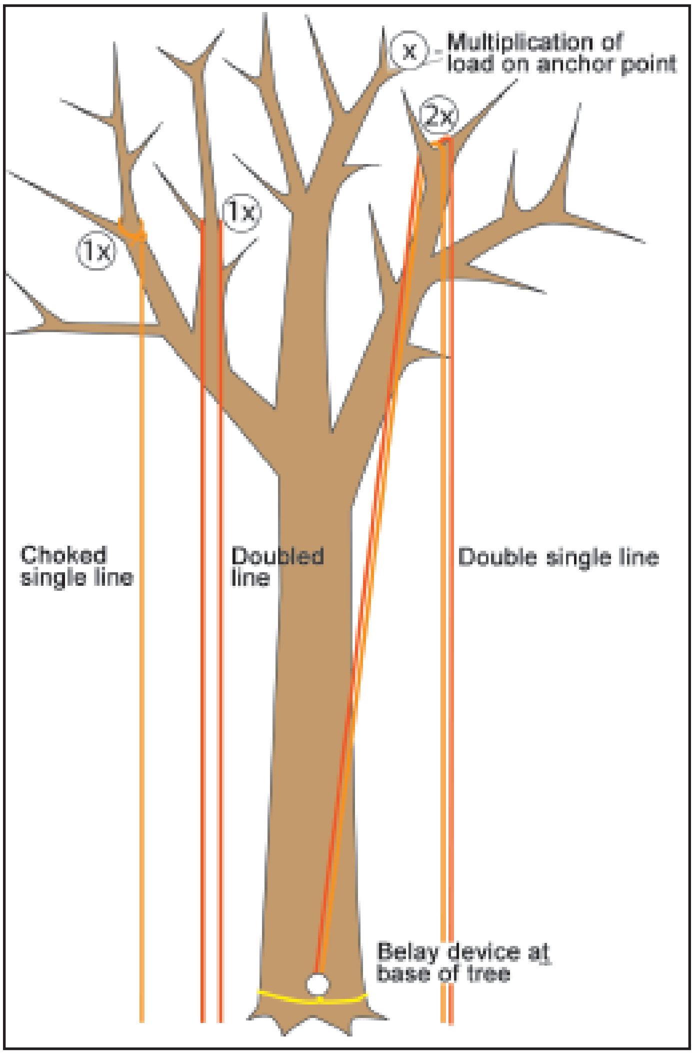

Figure 1. Example of three ways of installing dedicated access lines: single choked, doubled, or doubled single lines. Depending on the configuration, the load on the anchor point will vary.

Each category can be subdivided again, perhaps many times. In this way, it is clear that many tree ascent techniques exist. Only a few of these techniques will be discussed in this article. For all techniques, however, it is perhaps helpful to present a model which discusses the various zones of an ascent into a tree. Each zone has different characteristics and can be described, for example, in terms of:

- the length of rope in the system;
- the proximity of obstacles;
- the potential peak forces generated when arresting a fall; and
- the potential to appropriately integrate shock absorbing components.

Shock Absorption and Ascent Zoning

The concept behind shock absorbing components is to limit potentially harmful forces reaching the climber when a fall is arrested. The thrust of European work at height standards seek to keep peak forces below 6kN (6G deceleration experience by a 100 kg mass). Forces are moderated by using appropriate materials and the ripping of fibers (e.g., stitching or co-braided textiles) at prescribed activation loads.

The length of rope in a system can be a significant element when considering shock absorption. All ropes extend when loaded. This extension takes in energy and helps to mitigate the forces reaching a climber when a fall is arrested. Polyamide (Nylon) extends more than Polyester. Dyneema exhibits such minimal extension that it can be considered to be static. Polyamide is universally adopted in dynamic rock climbing ropes because of the potential for long fall distances and the desire to protect potentially marginal anchors. The greater the length of rope, the higher potential shock absorption. The extension of a Single rope will be approximately twice that of a Doubled rope, because the two legs of the Doubled rope share the force and therefore the extension.

By definition, the Work Positioning techniques used by tree climbers to maneuver through the canopy must minimize slack to within prescribed levels. The amount of slack is related to potential fall distance. During ascent, the potential for a fall can be introduced to the system in a number of ways. Depending on the ascent zone (Figure 2), the presence of branches may significantly reduce or eliminate the 'Clear Area' into which a fall could be safely accommodated. The degree of shock absorption offered by the rope is also a topic for discussion. Is rope extension always good?

Ascent zoning can be generalized thus:

Zone 1 [from the ground up to approximately 3 m (9.8 ft)]: There is much rope in the system and therefore the greatest potential rope extension, which would reduce peak forces when arresting a fall. Where a shock absorber is incorporated into the system,

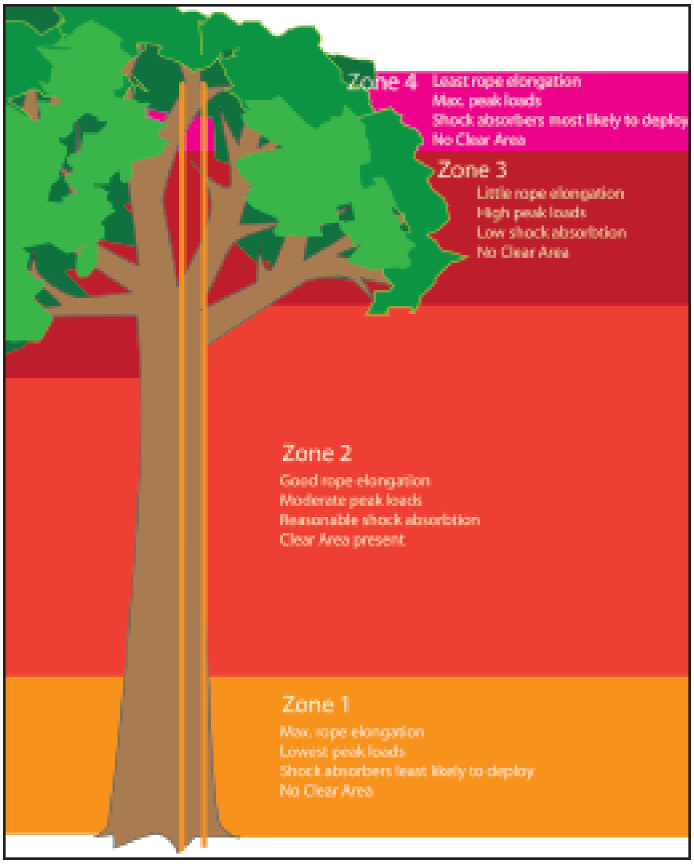

Figure 2. Zoning of an access into a tree. Depending on the structure of the tree and the height of the tree where the climber is at, the risks involved with an ascent will differ.

it is least likely to activate in this zone. There are no branches in this zone, but a fall is likely to result in contact with the ground (i.e., there is no Clear Area).

Zone 2 (from approximately 3 m high, to the lowest branches): Much rope remains in the system and hence shock absorption. There are no branches in this zone and the ground is distant, therefore, a Clear Area exists. A shock absorber could be used to further dissipate energy.

Zone 3 (within the tree canopy): There is little rope in the system and therefore reduced shock absorption from the rope. In the event of a fall, the probability of a shock absorber activating is increased. There are many branches within this zone (i.e., no Clear Area).

Zone 4 (at the anchor point): The least rope in the system, therefore negligible shock absorption and highest resultant forces when arresting a fall. A shock absorber is most likely to activate when arresting a fall in this zone. The many branches again mean there is no Clear Area.

Of the four zones, a Clear Area is only available in Zone 2. The incorporation of shock absorbing components, which greatly increases the arrest distance, is therefore limited to this zone. Naturally, this depends on many variables, notably the branching pattern of the tree.

Footlock

The Footlock technique was brought from the U.S. to Europe in the early 1990s. It enabled fast and efficient ascent into the canopy on a doubled rope with a long Prusik loop acting as fall protection. One of the advantages of this technique is the comparatively minimal equipment required and the ease with which multipurpose equipment can be stored on the harness once the ascent is complete. ►

Disadvantages include the requirement for refining the technique over time and the high physical demands placed on the climber (although these are perhaps generic comments that could be made about any ascent technique!). Another disadvantage is that with every advance up the rope, up to 600 mm (23.6 in) of slack is generated in the Footlock sling. This is potentially a problem, in particular in combination with the trend in recent years towards the adoption of smaller and more static ropes for ascent. In the event of a 600 mm fall onto such a rope, a worryingly high arrest force can be generated.

When two single ropes are installed through an anchor point, secured to the base of a tree, and the climber has an independent fall protection (e.g., Prusik) on each rope, the climber is considered to be 'double secured' (Figure 3). This requires more equipment, but affords a higher level of safety. If the rope(s) are secured at the base of the tree with a lowering device (e.g., Petzl I'd), the system is lowerable by trained personnel in the event of an incident during ascent. When planning for emergency contingencies, a lowerable ascent system is a rational choice. A rescue from an access line is not easy, partly because the casualty is hanging in their system which of course means that the ascent rope above the casualty is under tension. At some point during the rescue, the casualty's system must be completely unloaded before the rescuer and casualty can descend, either on a common system or two systems. Lowering the casualty from the ground is somewhat simpler. A disadvantage of this system configuration is that the loading of the anchor point is relatively high. It remains vital to choose an appropriate anchor point.

Climbers generate large amounts of slack with each lock, increasing explosure to a potential fall. The symbols indicate key locations of independant knots and karabiner that protect against falls.

Footlock with Parallel Ascenders

In a footlock ascent, parallel handled ascenders can replace the Prusik sling as a method of fall protection. In recent years, there have been numerous incidents involving parallel ascenders during footlock ascent. Several factors may come into play here, for example:

- in tree care, debris (e.g., twigs, leaves) may become lodged in the cam area and negatively affect the cams' grab function;
- when the grab function of one cam fails in the doubled rope configuration, no backup is present to prevent a fall; and
- especially when the climber is tired (e.g., during upper ascent) his posture and range of movement changes. This may indicate that it is becoming more difficult to ensure the rope directly approaches the rope channel when the ascender is advanced. Rather than pushing the ascender cleanly up the rope, it may be pushed at an angle toward the rope. A karabiner is often installed through holes at the top of the rope channel on single ascenders to maintain correct alignment, but due to the width of parallel ascenders, this has not been possible. Occasionally, the rope is forced between the top of the rope channel and the cam, releasing the rope from the ascenders and resulting in a fall.

There are solutions available, notably the evolution of products containing additional or better safety features. Take care to observe manufacturers' instructions when configuring components into systems.

Some advantages of parallel ascenders include the comfortable hand position, ease of advancing, and the reliable grab function on rope. It is important to encourage adopting additional measures when using this group of products (i.e., the use of two independent ropes). In the event of the cam grab function failing on one cam/rope combination, fall protection is maintained by the second cam/rope combination.

In addition, an energy saving variant of footlock exists when the connection from harness to the ascenders is shortened. Such a system is not uncommon in France. The climber never hangs on his/her arms, but has the opportunity to rest between advances while the parallel ascenders take the load when the legs are lifted in preparation for the next advance. In this way, almost no slack is generated during the ascent, which must be seen as a positive in the search for minimizing exposure to falls. Foot ascenders may be used in place of taking locks on the rope.

Single Rope Ascents with Mechanical Devices

Single Rope Technique (SRT) is a term often used to describe the increasingly adopted 'Rope Walker' system. Typically, a single rope is passed through a fork and anchored at the base of the tree. By incorporating the appropriate lowering device at the base of the tree, the system can be lowered from the ground. The most common configuration of components is for the climber to be secured to a handled ascender, installed on the rope above a chest ascender, to which the climber is also secured. With the addition of climbing aids (e.g., chest harness, foot loop, foot ascender), an efficient and energy saving ascent technique can be developed. At the anchor point, disconnection and storage of the components is more complex than with the footlock technique. Rope Walker requires a greater level of user focus to ensure correct component function because of the increased complexity of equipment and the subsequent issues of component compatibility and configuration.

Little slack is generated during a Rope Walker ascent, and two connections to the same rope (via the handled and chest ascenders) provide a series security. Should one cam become dysfunctional, the second connection to the same line would prevent a fall to the ground. However, in contrast to the redundancy offered by parallel systems, a line failure on SRT would not prevent a fall to the ground.

Rope Access

The standard technique in industrial Rope Access utilizes two single lines. One rope is constantly loaded (during ascent or work positioning), while a guided fall arrester follows the climber on the second rope offering redundancy in the event of main line failure. Prerequisites for this format are a Clear Area below the operators work site, and the adoption of a harness with sternal and/or dorsal attachment point(s), such as a full body harness for the fall arrest system (depending on national requirements). Ventral attachment is necessary for precise work positioning. The Clear Area must be sufficiently dimensioned to allow not only for the fall of the climber, but for the extension of the fall protection system including the possible activation of a shock absorber. The potential for contact with the ground must be given serious consideration particularly when working on long ropes.

In direct contrast, the failure of one side of a parallel system where both ropes are constantly loaded (e.g., via parallel ascenders), would result in either a minimal fall or no fall at all.

At work, it is also important to consider and minimize the peak forces experienced by mechanical devices such as toothed cam ascenders (body loaded rope clamps). The extent of damage caused to rope by toothed cams depends on many factors; for example, the age and condition of the rope, the ambient temperature and humidity, the size of the falling mass and the height it falls from, the compatibility between the cam and the rope, and so on.

Safe Ascent/Falling Tests

A series of more than 120 tests were carried out by Treemagineers (www.Treemagineers.com) on a range of low stretch rope and toothed ascenders revealed that the mantle of a kernmantle rope could be severed by a toothed ascender with a force between 4.05 and 7.64 kN. For reference, a fall of approximately 500 mm (19.7 in) in the test format adopted would be sufficient to generate 4 kN (see EN12841 for details of the dynamic test setup).

A further 25 dynamic tests looked at the forces generated when a falling mass was arrested by a range of cordage configured as footlock slings [six coil Prusik on Doubled 11 mm (0.43 in) rope]. Here, simply by adopting different cordage, the peak force generated when arresting a 100 kg (220.5 lbs) mass falling one meter, ranged from 4.892 to 12.552 kN. In all cases, the lowest peak forces were recorded when the footlock slings were constructed from 8 mm (0.3 in) dynamic half ropes made entirely of Polyamide. In none of the tests on footlock slings was the rope mantle severed or severely damaged (i.e., subsequent thorough inspection and destructive testing indicate that the rope would have been safe to descend on).

It is important to note that Treemagineers tests do not carry the same credibility as designed research completed with academic rigor. At this stage, there is no statistical base to Treemagineers test results. The range of outcomes presented here can only be seen as indicative.

System Design

The brief outline of test results described earlier is sufficient to highlight the need for the informed design of fall protection systems. The importance of 'Neighbor Component Compatibility' and 'Correct Component Configuration' should not be underestimated. Small changes can dramatically alter safety factors in systems. Many times, sufficient information will accompany a product to allow for more informed decisions. On other occasions, it may be necessary to request further data from a manufacturer.

Anchor Point Adjustment

So why are we discussing dynamic drops on ascenders when slack can be almost eliminated with some ascent techniques? In tree work, an ascent line may be installed around an anchor point more than 25 m (82 ft) aboveground with the aid of a thrown pilot line. Remote installation of such a key link in a fall protection system is highly unusual in industrial work at height. A number of factors, such as the pressure to be productive, can lead to the anchor point inspection being rushed or insufficient. Equally, it is possible that despite considerable checking, an inappropriate anchor is accepted by mistake. Distance, light and weather conditions, and a 'busy' (cluttered) canopy may be factors here. It is important to acknowledge that a climber is totally committed to an anchor point once the ascent has commenced.

Here are two scenarios where a climber may experience considerable falls following an anchor point adjustment:

Scenario 1—A climber is very confident the ascent line has been installed around an anchor point of suitable strength. In fact, the line is routed over a small side branch roughly one meter above the intended anchor.

Scenario 2—The ascent line is installed through the canopy of a large spreading tree. The rope makes contact four times with the tree. Three points are 'bomb proof' forks, the fourth contact is with a small branch a short distance out from a large structural limb. The route of the line is accepted because the three main points act as a 'back up' to the more marginal small branch.

In both scenarios, two people load test the rope prior to the first ascent, confirming the points are 'good'. During the ascent, the small branch fails, the rope relocates and the climber falls 2 m (6.6 ft). The fall is arrested by the ascent system or by contact with the ground or part of the tree.

Let's assume the climber was ascending using the Rope Walker technique and that the climber falls into a Clear Area 10 m (32.8 ft) above the ground. The chest ascender in the Rope Walker technique is designed to capture progress along the rope as quickly as possible, because almost no slack is generated as the climber progresses up the rope (the chest ascenders and the rope they are attached to are not designed to cope with such impact loading). When an anchor point adjusts as described above, the arresting force is first applied to the chest ascender. Given the fall distance, the mantle is likely to be severed and the chest ascender will slide down the core of the rope riding a sleeve of mantle that increasingly bunches as the fall continues. Some core strands may be cut. At some point, the connection between the handled ascender and harness will become loaded. Depending on the energy remaining in the falling mass, the mantle under the handled ascender may or may not be severed. Either way, the climber is likely to remain attached to the core fibers of the rope. This is clearly not ideal.

Where correct compatibility between ascender and rope has not been verified, Treemagineers' test results suggest the rope may be completely severed, or that the ascender may release the falling climber. Connection to a back up line will make the situation safer and easier to deal with. The key objective must however be accident avoidance.

Summary

In the case of ascent systems and ascent anchor points, the following are suggested:

- understand the potential forces placed on ascent anchor points;
- meticulously inspect anchor points before they are approved;
- ensure good binoculars are easily accessible;
- seek a second opinion, especially when in doubt;
- pull out the line and start again if you are still not sure;
- use a lower/stronger anchor point when uncertain about anchor strength;
- select an ascent system that suits the structure you are climbing;
- carefully consider 'Neighbor Component Compatibility' and 'Correct Component Configuration' when designing ascent systems;
- use ascent systems that can be lowered, to facilitate rescues; and
- whenever practicable, use ascent systems with a parallel back up.

The objective of this article is to promote a better understanding of the tools of our trade. This will help ensure their correct configuration and use where they are compatible with neighboring components. Consideration should be given to the exposure to slack, potential fall distance, and resultant high peak forces. When desirable and practicable, install a second line of fall protection during ascent.

Climb Safe!

Mark Bridge and Chris Cowell are ISA Certified Arborists. They represent two-thirds of Treemagineers, a collective of practicing arborists focused on improving safety and efficiency among current tree care practices.

Figures/photos courtesy of the authors.