# What can we do about toppling? Establishment problems and remedies

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The November 2002 N.Z. Journal of Forestry discussed wood quality issues, and suggested new approaches to plantation silviculture for growing higher quality crops at lower costs. The contributions reflect increasing concerns regarding the wood quality of our radiata pine. The editorial stressed that decisions made at any point of the forestry value chain can have an impact on every other point along the chain. The final article in the journal by Piers Maclaren "No-bull prizes for Forestry" discussed the success of plantation forestry in New Zealand, looked at strengths and weaknesses and identified the high level of toppling on farm sites as a major problem.

This paper addresses the problem of toppling.

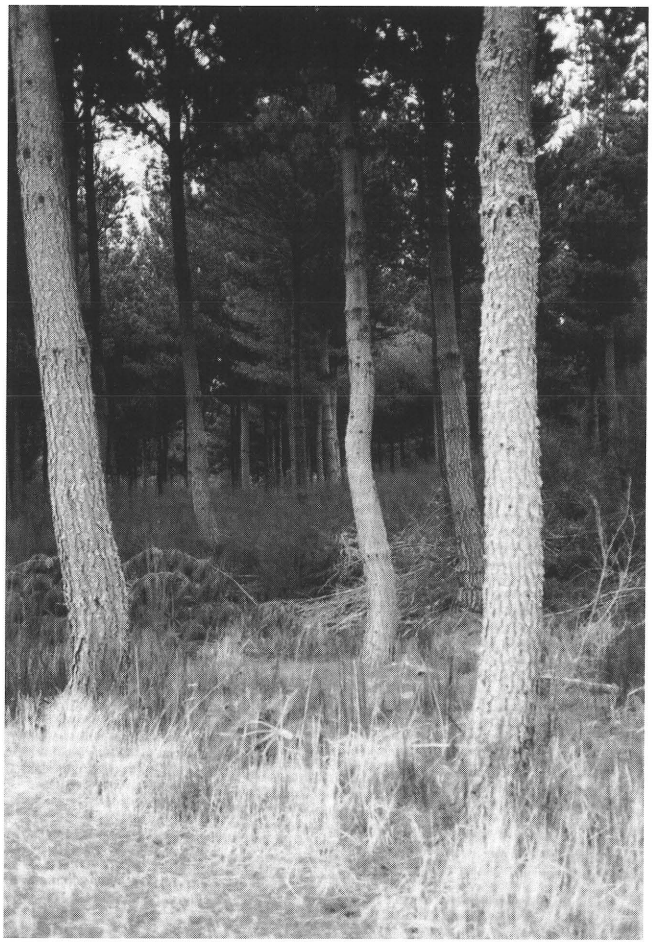
**The value added chain**

A critical point in the value added chain is establishment. Many wood quality problems begin here and an accumulation of bad practice can considerably lower crop returns. Unfortunately, many of our forests are now established with less than optimum tree stocks, which are poorly handled and planted by unskilled, poorly equipped and poorly supervised labour. The result can be variable tree size and poor tree form, which make final crop selection difficult. Toppling is the most obvious problem, especially on fertile farm sites. Some young stands contain so many butt-swept and sinuous stems that there are insufficient straight trees for crop selection (Photo 1). Insufficient straight trees compromise all subsequent silvicultural, harvesting, and manufacturing operations and the final wood quality.

Toppled trees are of little value and money wasted on pruning near worthless bent stems reflects badly on the forest manager. It reduces investor confidence and creates doubt as to the quality of future wood supplies. Part of the problem appears to be the restructuring of the industry. Downsizing of permanent establishment staff over the last decade has resulted in the loss of many experienced establishment managers, supervisors and workers. Too much responsibility is now placed on contractors. They try to do the job but emphasis on cost cutting combined with inadequate training has often led to lower standards.

There are also other weaknesses, which contribute to tree instability; a better understanding of these would lead to improved root development and stem anchorage. Stands would be more uniform and wind-firm resulting in simpler and cheaper selection of crop trees, pruning,

*Photo 1: Toppling may result in insufficient straight trees being available for final crop selection.*



harvesting and log-making. Tree quality improvement will result in higher prices for better quality logs. Reducing toppling would be an efficient way of improving stand profitability.

**Toppling problems**

Some toppling may be unavoidable. In cyclonic winds young trees can develop a lean, especially when accompanied by heavy rain that saturates and loosens soil anchorage. Trees planted in poorly drained or hardpan soils are prone to topple because soil conditions inhibit the development of deep penetrating anchoring roots. Research (Mason 1985) and examination of toppled stands and monitoring or root form in Quality Assurance Indicator plots (Trewin 2000) demonstrate that toppling is rare when trees have straight sinker roots. However, most toppling and subsequent butt-sweep are the result of roots being bent up at planting (Photo 2) or swept sideways into the planting hole. Roots continue to grow in this position providing little anchorage for fast growing trees so that they can fail at any time during the cropping

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*Photo 2: Toppling caused by roots being swept up by "Slit & Stuff" planting.*

*Photo 3: Roots of badly planted trees can fail at any time during the rotation.*

cycle (Photo 3). In extreme cases the pushed up roots grow into and strangle the stem so that it breaks off or fails at the root collar junction.

**Toppling research**

Trials to determine the difference between toppled and stable trees but with similar above ground crowns were reported by Mason (1985). Root systems of 49 pairs of toppled and stable 2 - and 3 - year-old trees were compared. In all comparisons the stable trees had straighter-grained, more vertical tap-roots, and a greater number of sinker roots (roots at an angle of more than 45 degrees down from the horizontal). Trees that had toppled developed butt-sweep and/or sinuous stems and were of lower value as clearwood logs or unpruned logs for sawn timber. A computer simulation showed that when a high percentage of trees develop a lean of greater than 15% from the vertical (topple), a not uncommon problem on some sites, clearwood value could drop by as much as $6,000/ha. This loss could be reduced by improved root placement at planting (Mason & Trewin 1987).

On nutrient rich pasture sites tree growth can be exceptional, up to 3 metres in the first 2 years. This fast growth can outstrip the anchoring capacity of developing roots making trees more prone to toppling in high winds. The use of aged cuttings that have a light branching habit is recommended to reduce sail area and stress on root systems (Menzies & Klomp 1988). The planting of field-collected rooted cuttings, with a physiological age of 3 to 4 years, is recommended for enhancing stability on sites prone to toppling. Cuttings have stiffer, sturdier roots than seedlings, and will develop a more open crown, thereby enhancing stability (Aimers-Halliday *et al* 1999).

Crown lightening, a reduction of a tree's sail area by shortening the lateral branches by pruning, is becoming increasingly common as a means of reducing toppling (Turner & Tombleson 1997). Selection of final-crop trees at pruning, on the basis of sweep, and the accurate prediction of sweep in pruned logs at maturity, are important if the value of a final crop is to be maximized. Sweep models are being developed to assist in the selection of crop trees. Future work needs to involve yearly measurements of actual juvenile sweep and comparisons with final log sweep at varying ages (Turner & Tombleson 1999). However, detecting and measuring juvenile sweep accurately at pruning without first removing tree branches is difficult and costly. Ideally, trees with any perceptible sweep would not need to be selected for pruning as final crop trees.

**Remedial treatments for toppling**

Although radiata pine is most prone to topple in the second and third years after planting, one-year-old trees with confused roots do topple (Photo 4). Remedial treatments include; crown lightening (trimming off branch ends above waist-height), sodding-up (propping the tree up with a stamped-in sod), staking and, in extreme cases, cutting the stem off just above the bottom whorl leaving a vertical branch to form a new stem. The most effective treatment is crown lightening as it also serves as a toppling preventative treatment. Crown lightening is expensive and is not generally considered unless early signs of topple are evident (unstable or leaning trees). Crown lightening of young trees on very exposed sites or in heavy wet soils that inhibit deep rooting is good insurance. Unfortunately, all these treatments have limited value as stems can later topple if their roots were initially bent at planting or confused in containers.

***e.g. A local farmer planted a small stand of radiata pine in 2001 which toppled in the June 2002 gales and was sodded-up. Since then some trees have again toppled and have been staked. Costs of these remedial treatments far exceed the original cost of planting. Examination of a prone tree revealed that all roots were upwards and outwards, i.e. the result of "Slit & Stuff" planting. After toppling the best option would have been to replant (properly). This tree crop is a liability with valuable land tied up for 25 - 30 years.***

*Photo 4: Poorly planted 1-year-old trees can topple.*

**Importance of careful handling**

Trees that regenerate naturally from seed rarely topple as they first develop anchoring tap-roots to hold them firm during periods of high wind. Anchoring roots of nursery propagated bareroot tree stocks are deliberately cut short by undercutting and lateral root-pruning mechanically to condition and harden tree stocks. Such tree stocks can withstand the stress of outplanting (van Dorsser 1981). Conditioning also promotes the development of numerous fibrous roots to ensure adequate uptake of moisture and nutrient for good growth after planting. These fine roots are easily damaged and twisted if carelessly handled during outplanting. This exacerbates stability (toppling) problems.

To reduce root confusion and to facilitate straight root placement at planting, roots are again cut short (trimmed) when lifted from nursery beds for dispatch to the field. Care must be taken not to bruise root-ends with blunt shears as this causes them to rot and inhibits new root initiation. It is important that a light covering of soil is left on roots to provide protection for the fine roots, which take up moisture and nutrients after planting. Careless handling between the nursery bed and the planting hole can damage and inhibit development of anchoring roots essential for wind-firmness.

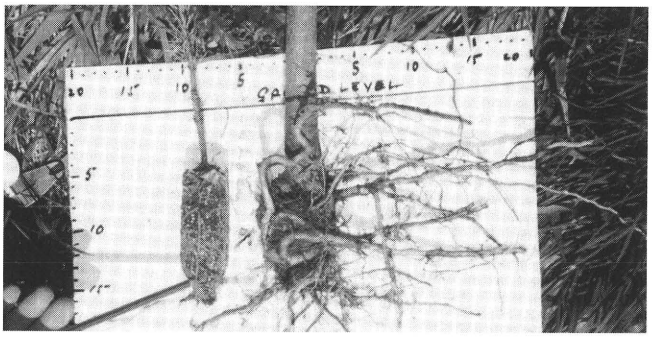
Assuming quality nursery stock, straight anchoring roots are most likely to be the result of careful lifting, handling and planting. Forest managers report that there is less toppling when cuttings instead of seedlings are used, as their sturdier roots are less likely to become damaged or twisted at planting.

**Poor root structure and quality of some container grown tree stocks**

The main advantage of container grown stocks is that they can be planted in the dry summer months immediately after clearfelling, so reducing non-productive growth time and weeding costs. It was thought that the use of container grown tree stocks would overcome many of the stability and survival problems associated with bareroot seedlings and cuttings. However, their smaller and softer stems are more easily damaged by foraging animals or overcome by weeds.

Also, the confinement of roots in small containers can result in serious root distortion. Recent anchorage checks in a two-year old stand grown from container tree stocks revealed that three out of four trees tested could be pulled out with one hand. The original container plug root form had persisted and no sinker roots had developed to anchor the trees. Investigations into toppling of one-year-old container grown trees revealed that they had no anchoring sinkers as plugs had been squashed up and roots deformed at planting. Other toppled trees had been left so long in containers that their roots had became badly deformed (Photo 5).

*Photo 5: Roots can become badly distorted if trees are left too long in containers.*



While researchers and some commercial growers have been successful in producing seedlings in containers there can be serious problems when propagating cuttings in containers. Cuttings have to be set (stuck) deep in the container; this leaves only the bottom half for root development. Roots of some container grown cuttings first grow towards the surface forming a bird's nest configuration that can later strangle the stem. Identification and culling of defective (one-sided) or confused root systems, a major cause of toppling and stem breakage, cannot be detected without pulling the plug apart. Also, poor handling during planting can break the plugs. As roots are then broken and exposed, the benefits of containerisation are lost.

**Planting problems**

Ideally tree stocks would be lifted from nursery beds and planted with as little disturbance as possible. To

keep stock handling and exposure stress to a minimum most forest nurseries now use an easy-to-control on-bed packaging system (Trewin 1978). On planting sites the quality of work is not so easily controlled. Gangs of planters cover large areas so that, unless workers are skilled and supervision efficient, work quality suffers. Unfortunately a high percentage of supervisors and workers are temporarily employed, unskilled and receive little or no tuition in quality planting techniques. Planting spades are often of unsuitable design or badly worn. Few workers are equipped with strong boots for digging and positioning roots straight and deep, essentials for anchoring fast growing trees firmly in strong winds.

Most quality control checks are ineffective as they are not close behind the worker for immediate fault identification and correction by the planter. The punitive nature of most quality control "reworks" with no bonus for good performance provides little incentive for quality planting or for continued employment in this difficult job. Forestry establishment training programmes rarely meet the needs of contractors for field training of planting supervisors and workers in appropriate techniques and quality control measures.

**Assessing planting difficulty and costs**

To ensure that contractors are fully aware of quality requirements they must be invited to visit planting sites to assess the planting difficulty before submitting tenders. Travel distances, access for stock distribution, cell phone communication, first aid, nearest hospital etc. must all be considered. Of specific importance for crop quality are on-site stock quality checks and planting. The specified planting technique relating to site conditions should be discussed, demonstrated and timed for cost tendering. A management representative should demonstrate the planting technique and have the contractor practice and use this to assess difficulty.

Time taken to plant a row of 10 trees on two or three different areas representative of site, soil and terrain should be recorded. By calculating the means of these times a daily planting target can be assessed. (A non-stop period of 6 hours continuous good fast planting is considered a good day's work. The remaining two hours of a normal 8-hour working day should be allowed for collecting tree stocks and meal breaks.) On grassland, the planting of 3 trees per minute or a task of 1080 trees/day is standard. In heavy clays 500 trees may be the maximum that can be planted, while 1500 trees on ripped and bedded loose pumice is possible.

Agreement can then be reached on a fair rate that the workers will be paid per tree to be specified in the tender. As an example, a daily wage of $150.00 (before tax) may be considered for this hard work. For a daily planting of 1000 trees this would equate to 14 cents/tree, plus a management incentive bonus of 1 cent/tree for quality work based on accurate checks on individual planters by management supervisors. Tendering contractors should base their tenders on this price per tree plus overheads.

**Cost-cutting - a need for a change in culture**

The foundation of profitable forestry is a skilled work force. Unfortunately the chronic shortage of experienced and well trained establishment supervisors and workers results in poor quality planting. Retention of labour, skilled or unskilled, is a major problem. A large North Island contractor reports an 80% turnover of planting labour. This indicates that there is something seriously wrong with the current planting labour employment culture. Contractors endeavour to do a good job but the emphasis on cost cutting does not allow time for adequate training or essential close supervision of planting operations. The result is that many planting contractors have to work to minimum standards, which adversely affects quality of root placement and wind-firmness in stands.

The acceptance and inevitability of poor quality planting is witnessed by the fact that one major contractor employs a permanent "rework" gang. Quality planting is such an important link in the wood production chain that forest establishment managers need to spend more time in the field to emphasise the importance of the work by helping train and supervise workers.

**On-site training of planters an essential**

Despite much emphasis by industry on forestry training little flows through to planters. The very few planters with Forest Industry Training (FIT) modules have to work fast to minimum planting standards to earn a reasonable wage, and supposedly efficient and well-regarded contractors complain when they are subjected to strict planting quality checks. Supervisors and planters accustomed to working to minimum standards are difficult to retrain, set bad examples to new labour, and soon revert to "Slit & Stuff" planting unless closely supervised. Also, workers not taught ergonomically sound (energy efficient) planting methods soon tire and planting quality suffers.

Because of the dramatic increase in harvesting and restocking, the serious shortage of skilled planters is likely to continue. On-site training is therefore essential, and a planting contract agreement must allow for one or ideally two days tuition on wages. Planters can then be made aware of the importance of handling tree stocks carefully and developing skills before moving onto fast planting piece rates.

**Training aids for contractors, supervisors and planters**

As a matter of some urgency, training material (video, pamphlets etc.) with a suggested two-day start-of-planting programme for workers and supervisors needs to be provided by industry (FIT). This should be distributed to contractors and through all forest nurseries to clients. The material should include examples of a simple one page contract agreement detailing rates to be paid planters with incentive bonuses for fault-free work. Effective planting QC procedures should also be detailed which allow close supervision and assessment of an individual

planter's work quality for bonus assessments and, if necessary, recall for correction. To avoid any discussion or disputes over planting quality, contracts and training instruction kits must stipulate and illustrate with sketches the exact planting technique to be used and show the position of stem and roots after planting (See Box for example).

For easy identification of an individual's work all planters must be issued with individual number planting tags to be placed at the start and finish of their rows. As it is impossible from above ground appearance to tell whether a tree has been well planted management supervisors must excavate and examine root-positioning close behind individual workers. This is done by using a steel probe to test cultivation depth, checking tree firmness (two finger test), digging roots up in-situ and breaking soil away carefully to reveal the depth of planting and straightness of roots. With random checks on each planter throughout the day workers soon realise that bad work cannot escape detection. A bonus for good planting should be paid, as this will raise morale and the quality of work. Bonus payments must be separate from contract rates and at the sole discretion of management supervisors. To encourage competition and good performance the names of qualifying workers can be announced daily, payment being made weekly.

**Importance of Quality Assurance Indicator Plots**

Weaknesses in radiata pine nursery propagation and outplanting systems are not always recognised. Deficiencies in contract agreements, management supervision, planter training, stock quality, planting and maintenance frequently go undetected and significantly reduce crop value. Toppling is an obvious problem and is evidenced by butt-swept and sinuous stems in many pruned stands. Most growers have no reliable way of detecting problems in establishment procedures and mistakenly blame them on site or climatic conditions. Recent bad toppling of two-year-old trees was attributed to gale force winds. A similar aged but more carefully planted stand on an adjacent properly escaped with only a very few trees toppled. Without the close proximity of these two stands toppling would have been attributed entirely to wind.

A systematic way to monitor establishment procedures and to help identify early growth problems is to establish Quality Assurance Indicator Plots. They are an inexpensive, reliable way of gauging the quality of plantation establishment and management (Trewin 2001).

**Conclusion**

The quality of wood crops depends on the quality of establishment. Best results are obtained when all nursery propagation and field planting operations are carefully integrated and documented, with quality checks at all operational stages. Initial field growth should be monitored in Quality Assurance Indicator Plots to assess the success of establishment procedures and to help identify early growth problems. Every planted tree should be treated as though it were for the final crop. Training materials, video and illustrated pamphlets, need to be supplied, free of charge, to all forest nurserymen for onward distribution to clients to promote appropriate on-site training of managers, supervisors and planters in quality assurance procedures. To emphasise the importance of establishment, forest managers need to spend more time in the field during planting operations to support field staff in the drive for quality plantings.

Following the recommended procedures has reduced toppling on very exposed sites to insignificant levels. It has been found that careful lifting, handling and planting of quality tree stocks results in quick regeneration of straight anchoring roots.

**References**


Aimers-Halliday, J.; Holden,G.; Klomp, B.: Menzies, M. 1999: Soften the blow - plant aged cuttings on topple-prone sites. New Zealand Forest Research Institute, What's New in Forest Research No. 248.

Mason, E.G. 1985: Causes of juvenile instability of *Pinus radiata* in New Zealand. *New Zealand Journal of Forestry Science* 15(3): 263-280.

Mason, E.G.; Trewin, A.R.D. 1987: Toppling of radiata pine. New Zealand Forest Service, What's New in Forest Research No.147.

Menzies, M.I.; Klomp, B.K. 1988: Effects of parent age on growth and form of cuttings and comparisons with seedlings. Pp. 18-40 in: Menzies, M.I.; Aimers, J.P; Whitehouse, L.I. (Ed.) Workshop on growing radiata pine from cuttings, Rotorua, 5-7 May 1986. New Zealand Ministry of Forestry, FRI Bulletin No. 135.

Trewin, A.R.D. 1978: Pine seedlings - handle with care. New Zealand Forest Service, What's New in Forest Research No. 67.

Trewin, A.R.D. 2000: Nursery and Plantation Establishment and Management - Quality Assurance Procedures Pp141-158, In: Proceedings of the International Conference on Timber Plantation Development, November 7, 2000, Manila, Philippines.

Trewin, A.R.D. 2001: Rest assured with quality assurance. *Tropical Forestry Update* Vol. 11 (3):10-11.

Turner, J.A.; Tombleson, J.D. 1997: FRI researches toppling effects. *The New Zealand Farmer* 119(9): 116.

Turner. J.A.; Tombleson, J.D. 1999: Prediction of final stem sweep in pruned logs from sweep measurements. *New Zealand Journal of Forestry Science* 29(1):146-164.

van Dorsser, J.C. 1981: Seedling conditioning. Pp 128-141 in Chavasse, C.G.R. (Ed) Forest Nursery and Establishment practice in New Zealand. Forest Research Symposium No. 22 (Part1).