

BRUSHING REVIEW

A Review of Manual Brushing Practices in the Bulkley TSA (with emphasis on Girdling)



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Executive Summary:

In the summer and fall of 2001, a review of recent brushing practices in the Bulkley TSA was undertaken. The techniques looked at were Manual Brushing, Bend and Break, and Girdling.

The theory behind each of these techniques is examined and discussed, and examples of them are illustrated.

No one technique was superior as far as target tree mortality was concerned, and all broadleaf species examined showed a degree of re-sprouting following any treatment. Despite this, the brushing treatments as a whole were largely successful in achieving Free Growing status on a whole block basis. There were however, instances of individual tree competition by remaining or re-sprouted broadleaf trees.

Each brushing technique reviewed its own relative advantages and disadvantages depending upon the situation, and these are outlined in the report. Recommendations are provided that should assist in selecting an appropriate brushing technique.

Emphasis was placed on girdling and a review of the tools and techniques used in girdling are outlined in part 2. Girdling of all species studied showed mixed results, and there was no clear trend around method, timing, or species treated.

Aspen tends to re-establish basal or root sprouts to some degree after any brushing treatment including girdling. There was however a difference in the apparent form and vigour of those sprouts between treatment types. This may have an effect on the suitability of aspen sprouts as future crop trees. Recommendations around this observation are presented.

There was concern noted over database reporting of different techniques on the same site at the same time due to limitations of the database. The author endeavours to develop procedures to address this issue in the future.

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Review of Manual Brushing Practices in the Bulkley

Section 1 - Introduction:

In the summer of 2001, a review of recent brushing practices in the Bulkley TSA was undertaken. A total of 20 sites that had been brushed from 1 to 8 years ago were inspected. Some had multiple or combination treatments. The types of brushing methods investigated were manual cutting, bend and break, and girdling. These are defined and outlined in Section 4.

The objective of the study was to examine the efficacy of various manual brushing treatments on the target stem as well as any immediate effects on neighbouring crop trees. The broader results of brushing—subsequent conifer crop tree release and growth on a stand or cut-block level—was not specifically studied unless noted. In fact many of the stands visited were clearly free growing, even though they included some instances of individual tree competition. Other types of competition from herbaceous growth or grasses for example was not specifically studied in this report.

Section 2 - Background:

The young, newly established forests of the Bulkley TSA have been reforested predominantly with conifers (see Figure 1 and Table 1). That was in keeping with the provincial objectives of the day. Broadleaf trees were viewed more or less as competitors to those conifers. When the level of broadleaf competition reached a threshold (either initially set by the Silviculture Prescription document or determined on a site-specific case basis) it was common practice to remove some or all of this competition using a variety of techniques (see Table 2). The purpose of this review was to examine the efficacy of some of these techniques.

While the importance of broadleaf trees—especially Aspen—as potential merchantable crop trees in the future, and their support role for biological and biodiversity reasons is becoming well recognised, provincial standards for their management were not prevalent during the time period under review.

It is not the intent of this report to criticise the custom of targeting broadleaf trees for removal, but rather to recognise that it was the practice of the day, and evaluate its effectiveness. Thus the term “crop tree” in this report generally denotes a conifer, and likewise “target tree” a broadleaf, unless otherwise specified. This does not purport a conifer bias, but merely reflects the practices that were reviewed.

Broadleaf forests in the Bulkley traditionally made up less than 10% of the mature volume. There are at present no local objectives for broadleaf management, although it is recognised that opportunities may exist for co-management with conifers as either mixed crops or double cropping. Objectives on the use of broadleaf trees for use as either merchantable crop trees or for other ameliorating purposes is an ongoing process.

The following table (Table 1) represents an aggregate weighted-average species percentage of 2nd growth stands in the Bulkley TSA. Data was derived from ISIS forest cover data and is current to the spring of 2001.

Table 1 - Aggregate species breakdown of 2nd growth stands in the Bulkley (weighted averages)

Species	%	Total area
Interior Spruce	39.0	39,423
Lodgepole Pine	38.8	39,231
SubAlpine & Amabilis fir	18.8	18,988
Aspen	2.3	2312
Western & Mtn. Hemlock	0.9	869
Cottonwood	0.2	139
Birch	0.1	72
Western Red Cedar	0.1	6
Totals¹	100	101,099

From 1992 till 2001, a total of 7,612 ha were brushed and weeded as outlined in Table 2. Figure 1 illustrates the treatments studied in this report. A complete listing by ISIS codes² (base, technique and method) is included as appendix 1.

It is apparent that manual brushing (as defined in section 1) is by far the most prevalent, making up over 75% of all treatments (see Table 2).

Table 2: - Brushing trends (ha.) by brushing method:

Brushing Method	Year										Total
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	
Manual Cutting	685.8	286.9	788	948.1	721.1	837.7	491.6	257.9	400.9	310.8	5,728.8
Grazing/Grass Seeding	100	0	146.7	247.4	67.6	0	55	0	0	0	616.7
Chemical	152	34.2	0	258.4	0	0	0	0	0	0	444.6
Bend & Break	0	2	13.3	6.7	45.2	123	236	0	0	0	426.2
Girdling	0	128.5	66.6	78.5	22	0	0	48	52	0	395.6
Totals	937.8	451.6	1,015	1,539.1	855.9	960.7	782.6	305.9	452.9	310.8	7,611.9

¹ Totals may not add due to rounding.

² For an explanation of codes used in ISIS—the Ministry silviculture database—see section 5

Illustrations of Brushing practices in the Bulkley TSA are presented below in Figure 1:

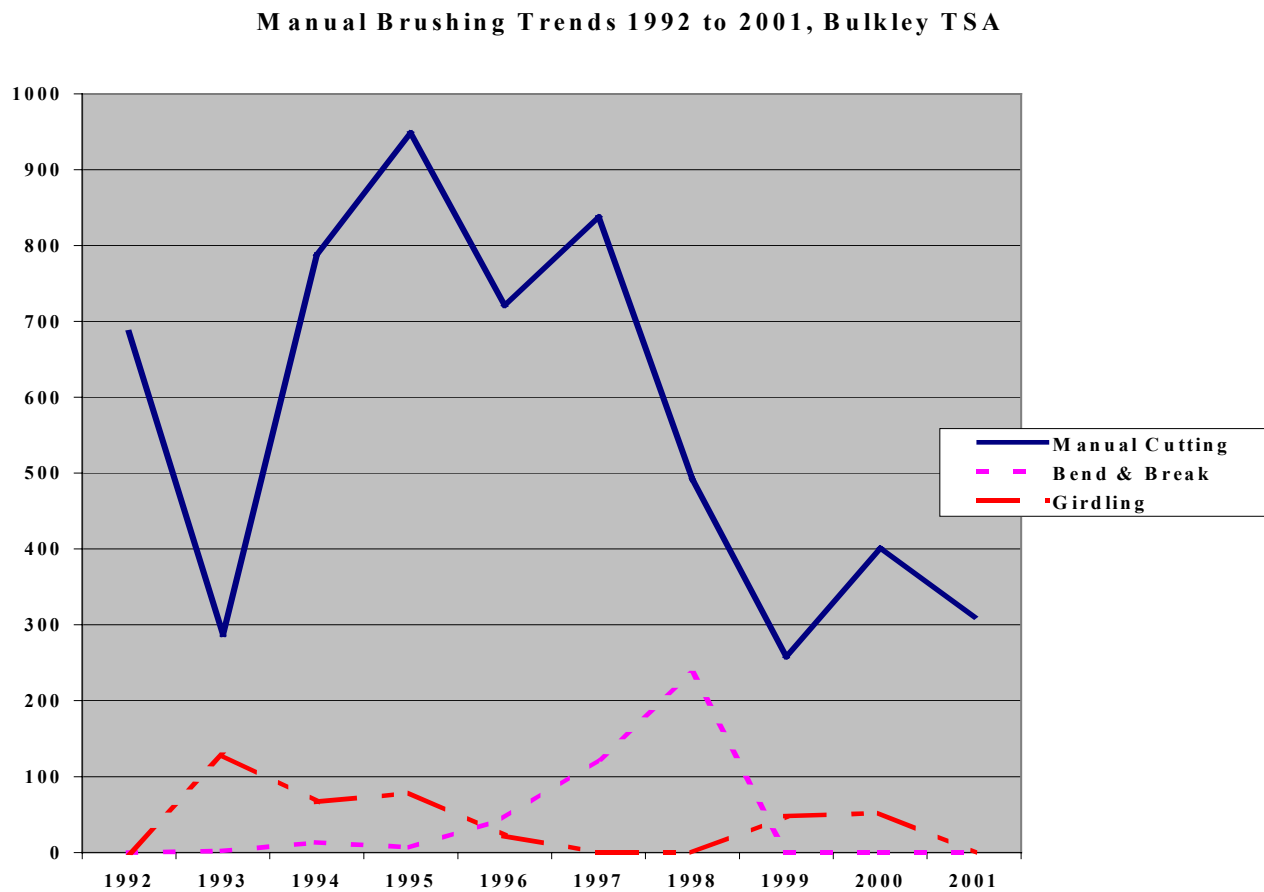


Figure 1 – Manual Brushing trends in Bulkley, 1992 to 2001

Section 3 – Definitions and Terminology:

This report focuses almost exclusively on the action of treating a competing broadleaf stem and thus the following definitions were used within this report with that in mind:

Brushing and Weeding, or simply ***Brushing*** – Defined as the practise of removing competing brush from a young conifer stand. The term “*Conifer Release*” was occasionally used in the past but is no longer recognised as a formal description. Other jurisdictions use terms such as “*crop enhancement*”, “*cleaning*”, or “*liberation cutting*”, but *brushing and weeding* or *brushing* is the recognised term in the Bulkley and thus in this report. The various types of brushing techniques are explained in the subsequent section. Likewise, the term “***Brush***” is colloquially used to describe any kind of competing vegetation, and in this report is generally limited to broadleaf trees or shrubs.

Competition A target stem (broadleaf) is deemed to be competing with an adjacent crop tree (conifer) when the former is as tall as, or taller than, the crop tree.

Complete mortality – In this report, death of entire target stem or upper portion with no significant re-sprouting. (As an example, a live stump with small, withered sprouts would be considered complete mortality within the context of this report—see Figure 2).

Control – The situation after treatment when the target stem is no longer in competition with the adjacent crop tree. Used in this report as a measure of success; i.e. complete control, temporary control, etc.

Control Period – The length of time following treatment that the crop tree is free of competition from the treated target stem(s).

Crop Tree – A tree intended to be retained for a rotation, or at least considered for retention. In this review almost exclusively a conifer unless otherwise mentioned.

Successful treatment – Complete mortality of target tree, or reduced growth of any re-sprouting to an insignificant level (i.e. control as above for foreseeable future—see figure 2)

Target Stem – The stem or tree being treated. In this review, almost exclusively a broadleaf tree unless otherwise mentioned.

Unsuccessful treatment – Little to no mortality and/or re-growth of sprouts same size as crop trees in a short time period.



Figure 2. – An example of a girdling treatment which has killed the original stem, but where subsequent re-sprouting is of relatively little consequence. This would be termed a successful treatment in the context of this report.

Section 4 - Techniques and Methods:

There are various techniques and tools used which are subsets of Brushing, and the most common are listed and explained as follows:

- **Manual Brushing**—completely severing the competing stem(s). Tools used range from manual types like axes, machetes, pruning type shears, or specialised brush cutting tools like the *Sandvik*[®] brush axe or *Fiskars*[®] brush hook; all the way to motorised brush saws or chainsaws. The use of motor driven tools is sometimes called “**Motor-Manual**”³, but is still considered manual brushing as opposed to mechanical brushing as defined below. Manual brushing obviously kills the target stem (but not necessarily the root) that is cut, and removes it (oftentimes only temporarily) from a competing position.
- **Mechanical Brushing**—denotes the use of heavy equipment such as a skidder, or excavator-mounted mowers or choppers. A *Hydro Axe*[®] or boom mounted brush mower are two common examples. Target stems are completely severed, shredded or torn/dug from the ground. This technique is not used in Bulkley for plantation brushing, but is widely used for clearing roadside brush or rights of way vegetation. No mechanical brushing was studied during this review.
- **Girdling**—removal of a continuous band of bark and cambium around the circumference of a tree. Tools used fall into two broad types, ones with blade(s) which are drawn tangentially around the tree’s circumference to remove a uniform width of bark/cambium, or tools scraped up and down the longitudinal axis of the stem to remove the bark/cambium. More discussion on girdling and girdling tools is found in Part Two, Section 1. Girdling is intended to kill or severely impede the target stem above the girdle by interrupting the downward flow of nutrients.
- **Bend and Break**—A technique where competing target stems are manually bent over until they break. Most small broadleaf stems crack or shatter at the point of the bend, but a portion of the bark and cambium on the inside of the bend (usually in the 25 to 50% range) remains more or less intact. In larger stems, a blade cut partway into the stem facilitates bending, but the intent is to leave a section of the cambium intact. This unbroken cambium allows the stem to continue to translocate nutrients into the now horizontal upper portion of the stem. In this horizontal position, the stem offers little competition to adjacent crop trees. Death of the upper part often occurs, but is due more to a combination of stress, competition from adjacent plants, and disease/rot organisms entering the wound; than from the actual treatment itself. The portion of the stem below the bend normally remains alive and usually establishes new sprouts.

³ The Ministry silviculture database (ISIS) uses the method code “MOCUT” to refer to handheld motorised equipment, but this code has historically not been used in the Bulkley.

The following other brushing techniques exist, but were not studied in this report:

- **Biological** – Insects or Microorganisms can be used to target specific plant species. Pitt *et al* (1999) for example discusses the experimental use of a fungus (*Chondrostereum purpurpeum*) applied to freshly cut broadleaf stumps in order to reduce sprouting. Biological techniques have not yet been tried in the Bulkley for operational plantation brushing, but they have been used locally by the Range Management program for noxious weed control⁴.
- **Brush Mats** – Brush mats are plastic or fabric mats anchored to the ground. A planted tree is allowed to protrude through a hole in the centre of the mat, and the mat prevents encroachment of brush (mostly herbaceous species) from competing with that planted tree.
- **Burning** – Burning (either broadcast or spot) can be considered a brush control or brush prevention treatment. It was not specifically studied in this report. Of interest is a reference in Bancroft (1988) who cites Cavanaugh and Weyrick (1978) reporting on stem specific burning for pre-harvest Aspen control. The flame from weed burners (backpack mounted diesel or propane torches) was applied to the target stem for 5 to 10 seconds in order to kill the bark/cambium. This could be considered a type of girdling. Success of this flame girdling was promising, but the authors note the method is not feasible in a fire hazard situation.
- **Chemical** – numerous methods classified according to the application method (Hack & Squirt or stem injection, Aerial spray, Backpack, etc). In addition to herbicides, which are intended to kill the target tree, there is new interest in growth regulators that inhibit re-sprouting⁵.
- **Grass Seeding** – is often done to delay the onset of competing vegetation, and can in theory be called a brushing technique. While it has been practised in the Bulkley, it was not specifically studied in this report.
- **Grazing** – Grazing of competing broadleaf and herbaceous brush has been used in the past in Bulkley (447 ha. were treated from 1992 through 1996), utilising both domestic sheep and cattle.
- **Hand Pulling** – Physically removing competing stems by hand. Rarely done on an operational basis.

⁴ The seed head gall fly *Urophora stylata* has been released on Bull Thistle (*Cirsium vulgare*) in the Bulkley from time to time since 1988. Bob Drinkwater, P.Ag. and Jane Woods, P.Ag. personal communication.

⁵ The growth inhibitor “Sucker Stopper®” by Monterey Chemical (www.montereychemical.com) is one such product.

Section 5 - Database (ISIS) codes used in brushing:

The Ministry's operational database - *Integrated Silviculture Information System* (ISIS) uses a three level hierarchy of identifying and recording treatments. Those three levels—*Base*, *Technique* and *Method*—are used in combination to describe the treatment either at a planning stage or after the treatments are delivered. There are a total of 56 acceptable combinations for brushing (see Appendix 1 for a detailed list). Of these 56, only 7 would have potentially been examined in this report.

Some concerns with reporting have come to light as a result of this review. While there were few obvious examples of unreported or incorrect codes, there were instances of treatments being unidentifiable as a result of compromises in coding. ISIS only allows one combination of Base/Technique/Method to be reported per unit per treatment occurrence. In units where more than one treatment type was carried out at the same time, this resulted in specific treatments not being identified but rather lumped with another treatment label or given the generic code: "Brushing". It is unclear how many areas of a given treatment are not recorded as a result of these compromises.

This proved to be frustrating for the author who could find evidence or maps with reference to various treatments, but no ISIS record. The author will endeavour to develop a procedure so that multiple treatments may be more readily captured within the database in the future.

Section 6 - Discussion on treatment methods:

Section 6-i - Manual Cutting:

Manual cutting of broadleaf stems is the most common type of brush control carried out in the Bulkley, and accounted for 75% of the brushing carried out from 1991 to 2001. All broadleaf species are targeted. Likewise, all broadleaf species potentially exhibit some sort of re-sprouting after treatment, either from the remaining stump or from the roots. See Figure 3 a - d for some examples.

Re-sprouting begins as early as the year following treatment and is often quite vigorous. On very rich sites, vigorous herbaceous growth immediately after treatment may delay or impede the growth of the broadleaf sprouts. These sprouts may even be out-competed by the herbaceous growth. This was evident in a few cases during the Bulkley review.

In most cases however, especially on mesic or drier sites, the re-sprouting stems will continue to grow and may even once again become a competitor to adjacent crop trees. Follow-up brushing may be required to eliminate this next wave of competing stems.

The growth rate of broadleaf sprouts for the first few years is likely the same as or very close to the increment of the parent broadleaf tree. Therefore the time it takes the sprouts to reach the height of the crop trees (the *control period*) can be calculated.

If one makes the assumption that the conifer growth after treatment remains the same as pre-treatment, and is less than the broadleaf increment, then this simple rule of thumb can be applied. Dividing height of crop tree (in cm.) by broadleaf increment less conifer increment (in cm.) will yield the approximate number of years until the broadleaf trees are once again the same height as the crop trees.

While not always exact, this estimate is a good planning tool and can be used to predict when subsequent brushing treatments or at least surveys will be required.

Manual cutting typically emphasised low stumps, to ensure that lower branches were removed. A recent work by Bell *et al* (1999) advocates that higher stumps (in the 50 to 75 cm range) may actually reduce aspen competition by reducing the amount of suckering (although sprouting is increased). More study is warranted in this regard.

Figure 3 – a: Vigorous Birch re-sprouting (felled original stem held upright for scale).



Figure 3 – b: Aspen re-sprouting 1 year after cutting



Figure 3 – c:- Willow re-sprouting



Figure 3 – d:-Vigorous Aspen re-sprouting



Section 6-ii - Bend and Break:

Bend and Break was envisioned as a viable alternative to manual brushing on stems that were too small to girdle. Competing target stems are manually bent over until they break. Most small broadleaf stems crack or shatter at the point of the bend, but a portion of the bark and cambium on the inside of the bend remains more or less intact. In larger stems, a blade cut partway into the stem facilitates bending, but the intent is to leave approximately half of the cambium intact.

This unbroken cambium allows the stem to continue to translocate nutrients into the now horizontal upper portion of the stem. In this horizontal position, the stem offers little competition to adjacent crop trees. Eventual death of the upper part of the stem often occurs, but is due to a combination of stress, competition from adjacent plants, and disease/rot organisms entering the wound; than from the actual treatment itself.

It is also possible to predict the control period associated with Bend and Break treatments using the same technique as with manual cutting, except 1 or possibly 2 years should be added to recognise the delay in sprouting response.

Figure 4a (left) and b: – typical Bend and Break soon after treatment. Bent stem highlighted in picture a. Note abundant low ground cover due to remaining leaves.



Figure 5: Note intact cambium at bottom of break.



The portion of the stem below the bend normally remains alive and typically establishes new sprouts, usually from the stump itself or sometimes from the roots. These sprouts are less likely to occur the year following treatment as is the case with manual cutting.

Death of the bent-over stem is not immediate, nor is it guaranteed. Some stems continue to live for some time. Cottonwood especially seems to re-sprout vigorously after bend and break treatment. Figure 6 shows a particularly resilient cottonwood stem that recovered from a bend and break treatment 4 years previously. This stem rebounded in three separate manners – the horizontal upper stem is attempting to right itself (in fact the “leader” just off the left of the picture had turned fully vertical); branches are now assuming an upright stance; and finally new sprouts have emerged from the rootstock. This particular specimen was located at the edge of a landing on very dry rocky soil, and perhaps the lack of herbaceous competition allowed it to respond so aggressively.



Figure 6: An example of a very aggressive Cottonwood rebounding after a bend and break in three separate manners:

- A – The original leader (off left of photo) has turned itself vertical,
- B— Some side branches have begun to grow upright, and
- C— There is vigorous re-sprouting from the stump.

Section 6-iii - Girdling:

Girdling is defined⁶ as making more or less continuous incisions around a living stem through at least both bark and cambium, generally with the object of killing the tree. Other jurisdictions use the terms: “*ringing*, *ring-girdling*, or *ring-barking*”.

The term girdling is also used to describe natural destruction (usually by insects or rodents) of tissue in a rough ring around a stem, branch or root. (See Figure 7). The term *mechanical girdling* is often used to differentiate manual girdling from that caused by natural agents.



⁶ Definitions synthesised from those found in Ford-Robertson (1983), and Helms (1998).

Figure 7:

Girdling damage to a young tree by a Squirrel.

Figure 8:

Partial girdling on a Peach tree to stimulate fruit production.

Girdling treatments are known to effect trees in two major ways:

- Mortality or reduced growth, and
- Induced stress to stimulate cone, seed or fruit production.

The latter technique is well recognised and used extensively in the viniculture, fruit tree and seed orchard industries to stimulate fruit or flower production. Girdles in this case do not usually completely encircle the tree (see figure 8). Oftentimes only branches are girdled to stimulate fruit production.

Unfortunately for forest managers, this latter affect also often stimulates re-sprouting from the rootstock or the roots themselves, or increased growth from lower branches. Both these conditions may lead to situations where the target stems are once again competing with the crop trees.

This phenomenon was observed during the Bulkley study, and many individual conifer stems were impacted. There were few cases however where the free growing status of the entire stand was in jeopardy. See figure 9 for some examples.

Figure 9:

a - Aspen sprouting

b – Aspen sprouting

c – sample of Aspen



Section 7 - Tree Response to Treatment:

Observations during the Bulkley study illustrated that Aspen, Cottonwood and to some degree Birch (few examples) *all* respond almost every time to all treatments by re-sprouting, either from existing or new branches on the remaining rootstock or the roots themselves.

Aspen is a species that is especially suited to re-establishing sprouts and in fact these sprouts are viewed as Aspen's primary method of reproduction (Perala, 1990). Aspen generally produces much fewer sprouts after girdling as compared to after cutting or fire (Peterson and Peterson, 1995). The reasons for this are outlined in Perala (1990) as follows:

"The development of suckers on aspen roots is suppressed by apical dominance exerted by auxin transported from growing shoots, while cytokinins, hormones synthesised in root tips, apparently initiate adventitious shoot development. When an aspen is cut, cytokinins accumulate in the roots, the supply of inhibitory auxins is eliminated, and suckers are initiated. If aspen is girdled, the downward transport of auxin again is stopped, but upward translocation of cytokinins via the xylem is unimpeded. Cytokinins in this case do not accumulate in the roots, with consequently less sucker production. Thus high cytokinin-to-auxin ratios favour shoot initiation while low ratios inhibit it. A gibberellic-acid-like growth regulator also stimulates shoot elongation after sucker initiation."

However many examples of aspen sprouting after girdling were seen during the Bulkley review. This is no surprise as most references mention the likelihood of some sprouting. It was at first surmised that these sprouts would be of poor vigour and likely not survive much past 2 or 3 years post treatment. While this occasionally occurs, there are many examples observed during this review where the sprouts grew rapidly and remain alive up to 8 years following treatment. Schier and Smith (1979) observed that some surviving aspen sprouts from a girdling treatment were still alive after 12 years. The condition of these sprouts is however a concern as they are not expected to reach maturity, and if they do, they will be of generally poor quality. This phenomenon is discussed in Section 15.

Regardless of how long the sprouts remain alive, it is clear that they are alive during the critical time frame where they may be competing with conifer crop trees for light and nutrients. This is of concern to most Forest practitioners, as they are usually favouring the conifers over the broadleaf trees. It may be necessary to re-treat the areas to remove these lingering sprouts if they are considered competitors.

As with manual cutting and Bend and Break, the time until the sprouts once again reach a competitive size can be calculated, except that 1 or maybe 2 years should be added to recognise the delay in sprouting.

Girdling is essentially a wound and like any wound, the tree attempts to heal itself by growing new tissue over and around the wound. In the case of girdling, this is termed "bridging", and is quite common (See figure 10 and 11). A wide girdle is less apt to bridge than a narrow one. Cutting tools which make a longitudinal cut (see Part 2, Section 1 for a discussion on types of girdling tools) are normally more able to create a wider cut than the tangential type. For this reason, two girdle cuts are often prescribed when tangential cutters are used.

It is common for trees to accumulate tissue above the girdle, since growth producing hormones as well as nutrients are prevented from travelling down past the girdle scar. This phenomenon is evident in figures 10 and 11.

Incomplete girdles (i.e. not the full circumference of the tree) are least likely to cause mortality in the target tree, as are girdles that do not fully penetrate the cambium. Small layers or strips of cambium may be able to sustain enough flow of nutrients to keep the tree alive. These missed layers or strips are likely to occur when dull tools are used or the girdle is not done to standard.

Figure 10: Girdling showing mixed results. Tree on left has survived while the one on the right has been killed.



Figure 11: Note the bridging and swelling of the surviving tree on the left. Tree on the right has been killed.



Intact branches or even buds located below the girdle are known to respond and begin to grow. Removing or treating these branches is important and should always be a contract condition. See Part 2, Section 3). This also applies to bend and break. See figure 12 and 13 for examples of rebounding bend and break and girdled Aspen stem



Figure 12: Rebounding Aspen after bend and break.



Figure 13: Aspen rebounding after girdling

There are reports in the literature (Bancroft, 1988; and Wisconsin, 1999) that girdling which cuts too deep (through the sapwood) may actually promote suckering. It is thought that deep girdles mimic stem severing which triggers the sprouting response. Also, deep girdles on smaller trees may weaken the tree to the point of breakage.

There were a few examples with no attempt by surviving trees to heal the girdling scar, but these almost always had lower branches which had rebounded and were now growing vigorously (see figure 13 as an example). It would appear that the aspen trees in these cases place their resources into the lower branches rather than attempting to bridge the girdling scar.

Mortality of the main stem following girdling when it does occur is not immediate, and some trees are able to heal the wound and survive. See figure 14 for a close-up example of active healing of a girdling scar. Reports of girdling scars more apt to bridge if girdling carried out in growing season (Bob Wilson – Personal Communication).

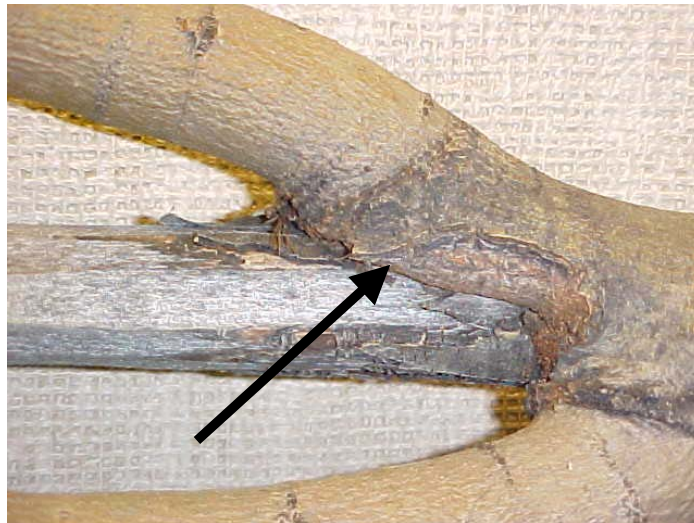


Figure 14:

This example also shows the ongoing healing scar (arrow) that would presumably exist until the dead centre stem was completely engulfed by new tissue. The possibility for disease or rot agents to enter the stem appears high due to this lingering area of active healing. Note also the offset orientation of the sprouts as compared to the original parent stem on the right.

This healing phenomenon is also evident on bend and break, although it is usually new growth accumulating over dead bark rather than bare wood. See figure 15

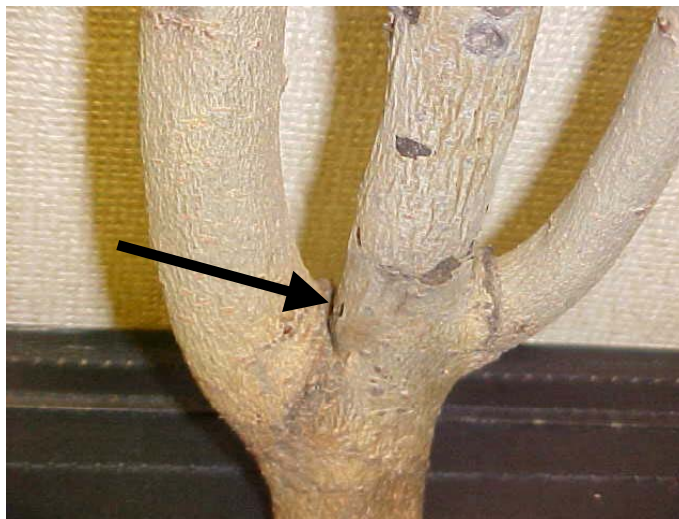


Figure 15: Zone of new growth/healing as new branch engulfs dead bark (arrow).

When mortality of the aspen stem does occur as a result of girdling, time to death varies, but is usually reported to be 1 to 3 years (Schier *et al*, 1985) up to a high of 12 years (Schier and Smith 1979).

One aspen tree observed during the Bulkley study appeared to be recently dead (no living leaves or live twigs) but had both live and dead under the bark above the girdle scar. This particular tree was treated 4 years previously (See figure 16). It is not known if this spotty necrosis is common after girdling.

Figure 16: Spotty necrosis under the bark of an aspen tree girdled 4 years previously. The tree showed outward signs of recent death (markings on measuring pole are 0.5 cm each).



Radius Cutting:

Radius cutting is a term coined by the author to describe a technique employed in brushing where only broadleaf trees within a set radius of a crop tree (usually 1 to 1.5 metres) are cut or otherwise treated. Several examples of this treatment were observed during the Bulkley review. The objectives of this were to reduce costs as well as leave some non-competing broadleaf or other vegetation on site.

There is currently some debate on how well this works when Aspen is the target species, due to its clonal nature and possible interconnected root system (Dave Coates- Personal Communication). There are those who believe treating an Aspen stem which is part of a clone will not be successful since the “parent” clone will continue to support the growth requirements of the cut or treated stem and ensure its re-growth. On the other hand, there are others who argue that the clone will take advantage of the fact that a stem is “wounded” and take nutrients away from it rather than supporting it. More study is warranted in this regard.

It is also reported (Wisconsin Dept. Nat. Resources, 1999) that aspen clones, once sprouting has started are very difficult to control through manual methods due to the hormonal imbalance that triggers the sprouting response. This phenomenon would seem to support the theory that radius cutting is not effective in aspen clones.

Factors associated with Brushing method:

There are a number of factors that either have an effect on the efficacy of various treatment methods, or are in turn affected by the various treatments itself.

Section 8 - Species:

The following Table (Table 3) lists a summary of treatment options and suitability for optimal control by species. Note that these are general trends, not necessarily found on all sites, and are based on the author's observations. Other parameters must be considered.

Table 3 - Summary of Treatment Options by Species:

Species	Girdle	Bend and Break	Cutting
Aspen	Up to 5 years "control". Long term impact is poor quality At stems	3-5 years "control" (Smaller stems). Suspect that long term stem impact similar or worse than Girdle.	2-5 years "control". Results in many small stems. Re-sprouting stems likely to become acceptable tree(s).
Cottonwood	Generally not successful. Vigorous re-growth. (limited examples of larger trees)	Not recommended, vigorous re-growth	Vigorous re-sprouting.
Willow	Usually too small to girdle, not many examples. Probably promotes many small sprouts beneath girdle.	Variable Results Typically many small stems per clump. 2-3 year control. Arduous - (many stems)	Yes, but vigorous resprouting (good moose browse or cover). 2-3 year control
Birch	Not tested locally, but reports of moderate success with larger trees ⁷	Maybe (limited examples)	Stump Sprouts. Note that Mature Birch often occur in clumps.
Red Alder⁸	Yes – Moderate to Good control in larger stems	Unknown- Not studied	No – Re-sprouts readily.

⁷ See Simard *et al* (2001) for discussions on girdling birch. for example.

⁸ Although Red Alder is not present in the Bulkley, Personal Communications with Bob Wilson of the Kalum District and Mike Grainger of the North Coast District supplied these observations for discussion purposes.

Section 9 - Site Quality:

The quality of the site (moisture and nutrient regime) obviously has an effect on the growth of both crop and target trees. Both crop trees and target trees intrinsically have a lower height increment on a poorer site than on a richer one.

Treated target trees seemed slower to re-sprout on poorer sites, but this was of relatively little advantage to the crop trees as they too generally grew more slowly. As each tree species has a different optimum growing condition, one should consider their response on various sites in turn.

On very rich sites, both crop tree and broadleaf trees as a rule showed more height increment than on an average mesic site. However a very interesting interaction became apparent following some treatments. On a number of instances, broadleaf re-sprouting was not as abundant or even virtually non-existent on very rich sites. This is counterintuitive, as the target broadleaf trees were generally very vigorous. It was surmised that the herbaceous vegetation present on the site was hampering the successful re-sprouting of the broadleaf trees. This herbaceous growth was as a rule very lush and even if cut would rebound quickly and probably provide sufficient shade to impede re-sprouting of the broadleaf trees. This situation warrants further study.

This latter situation presents the practitioner with somewhat of a conundrum—the treatment of broadleaf trees is most successful on sites with the most herbaceous competition. If the crop trees are large enough to be above the herbaceous growth, then treating broadleaf competition by any method will probably result in a successful treatment.

Section 10 - Seasonal Effects (Timing):

The literature generally says that treatments at the height of the growing season (late July-Early August) are more effective due to the parent plant's reduced carbohydrate supply in the roots, as opposed to the dormant season where stored reserves are highest. Physically, girdling is easiest in the spring, when the running sap causes the bark/cambium to easily slide off.

There is no mention of girdling in the Interior in the winter, as frozen bark and snow conditions would be problematic. The review did see many examples of areas with both successful and unsuccessful treatments side by side. This fact would seem to diminish the impact of seasonal effects, or at least highlight the importance of other factors such as quality of girdle.

The Bulkley study did not supply enough evidence to set aside the practice of mid season growing season girdling, but it did reinforce the fact that some degree of sprouting is to be expected no matter when the treatment is carried out.

Section 11 - Shade and Visual Impacts:

Shade from overtopping broadleaf competition on crop trees can be detrimental (light competition), or beneficial (cover from elements or possible lessening tree silhouettes which may effect susceptibility to Spruce Leader Weevil {*Pissodes Strobi*} for example). A work by LePage (1992) showed up to 43% reduction in PAR (Photosynthetically Active Radiation – or light useable to the tree) due to large standing Aspen stems even one year after the standing death of those stems. This was evident in a mature canopy with a high component of Aspen stems, and should be considered a worst case scenario, but it does illustrate the effect even dead stems can have in blocking sunlight.

The highest degree of shade is retained after girdling, since the treated stems remain upright, and may retain their fine branches for at least 8 years. Since the target trees are cut down or bent over, as is the case with the other treatments, there is an immediate loss of taller shade.

More and more emphasis is being placed on the visual impact of a particular treatment on close view foreground aesthetics and cover requirements. Different treatment techniques have various effects on the lower or upper canopy. Lower canopy (defined in this review as less than 1 m in height) is important visual cover for small animals and ground birds like grouse whereas the upper canopy (1.5 to ~3 m.) is more applicable to larger animals and general foreground aesthetics.

Girdling has the slowest transition to conifer-only view. This is because treated stems remain upright and stay green in the upper canopy for at least 1 year following treatment. Leaves usually do not fully develop after the second year but may be present in stunted form. Lower branches and sprouts once re-established remain green and follow normal leaf drop. Dead tops of treated Aspen stems retain their fine branches and remain upright for up to 8 years in the upper brush canopy. These dead stems are considered by some to be unsightly or unnatural. The lower brush canopy (sprouts) is the slowest to respond in a girdling treatment but can reach pre-treatment height fairly quickly.

Bend and Break—Upper brush canopy gone immediately at time of treatment, lower rebounds slowly (between manual cutting and girdling).

Manual Cutting—Upper brush canopy gone immediately at time of treatment, lower rebounds the most quickly.

One should consider the effects of both shade and visual consequences when planning a project.

Section 12 - Damage to Crop trees:

Damage to crop trees as a result of brushing the competing broadleaf trees is not uncommon and can take a number of forms. Most obvious is inadvertent physical damage to the crop tree by the operator during treatment. This can range from completely severing branches, the leader or even the main stem; to scratching or nicking the bark with the cutting tool. Physical damage to crop trees is less likely with hand tools due to the operator's gentler approach to selecting the target tree. However a careless operator can still impart damage to crop trees through improper techniques, especially with smaller crop trees. Treatment damage to crop trees is almost non-existent with girdling as the tool is applied to the target stem only.

Felled stems or similar slash created by a brushing treatment can negatively impact crop trees if that slash is allowed to fall onto or accumulate on top of smaller crop trees. This felling/crushing risk is highest when a manual brushing treatment is carried out. There is also a small risk of damage to crop trees in a bend and break treatment when bent over stems land on crop trees. With girdling, there is almost no immediate felling/crushing damage as the treated stems generally remain upright and slowly (if at all) lose their branches.

Crop trees with a high height to diameter ratio are especially susceptible to damage from falling slash as they are prone to tipping over and may have less chance of rebounding. Girdling may be a more appropriate treatment in such cases since there is no falling slash and the treated trees remain upright.

Section 13 - Size of Crop and Target trees:

Notwithstanding moisture or underground root competition for nutrients, it is arguably overhead shade that presents the greatest degree of competition to a crop tree. Therefore, the bigger the crop tree the better, as it presumably can rise above such competition.

As far as treating target trees, any size tree can be cut with a chain saw, although the maximum size for brush saw work is about 10 to 20 cm. at the stump. Likewise girdling can be done on any size tree from about 5 cm. diameter and up. Very large trees can be girdled but it is very strenuous work unless power tools are used. There were few if any examples in the Bulkley of girdling over about 20 cm diameter trees.

There is a maximum size at which trees can be bent/broken, of around 3 cm. It is physically difficult to bend the larger trees. Cut and bend is possible on tree diameters of up to 5 or 6 cm, but that treatment is more likely to sever smaller (< 2 cm.) target trees.

Perhaps more important than the absolute size of either the crop or target tree is the relationship between the two. This relationship effects the degree of potential damage to the crop tree as well as the level of current and future competition. Small crop trees are less likely to be visible, thus more likely to be either cut or buried during a manual cutting or bend and break treatment. Larger crop trees are more able to endure some degree of physical damage, and rebound after slash burial.

Since most broadleaf species re-sprout to some degree, the size of the crop tree will effect how long it takes for those sprouts to once again reach a competitive position. If the crop tree is large enough, then re-sprouting of target trees is less of an issue, as the sprouts may never regain their competitive position.

The choice of treatment method is partly based on the relationship between the size of crop versus target trees is illustrated in Table 4.

Table 4 –Treatment recommendations for eliminating broadleaf trees based on Target versus Crop tree size interactions:

		Target Broadleaf Trees (Diameter)		
		Small (<2cm diameter)	Med. (2-5 cm)	Large (>5 cm)
Crop Tree Height	Small (< 50 cm)	Cutting or Bend/Break. Plan for subsequent cutting(s). Watch for crop tree damage.	Cutting or Bend/Break. Watch for crop tree damage. Plan for subsequent cutting.	Girdle, and subsequent cutting of sprouts. Main issue is crop tree damage from falling stems, which girdling avoids.
	Med. (50 cm. - 2 m)	Cutting/Bending	Bending/Cutting	Girdle, possible follow-up cutting.
	Large (> 2m)	Generally not a situation that requires brushing, but if need be, cutting probably most cost effective, since sprouting generally of little consequence.	Cutting (Subsequent sprouts shouldn't matter).	Girdle if need be, but cutting OK too (Subsequent sprouts shouldn't interfere with crop tree).

Section 14 - Pest Interactions following Treatment:

The relationship between conifers, broadleaf trees and their associated pests is a complex one; thus it is prudent to discuss any pest repercussions that might follow a brushing treatment.

A paper by Simard *et al* (2001) outlines a 5% increase in mortality of Douglas-fir following cutting or girdling of competing broadleaf trees (primarily Birch) in the BC Southern Interior. Mortality was attributed to *Armillaria* root disease. The cause was presumably increased conifer root growth and subsequent contact with *Armillaria* inoculum, as well as increased growth of the inoculum.

There is no *Armillaria* to speak of in the Bulkley TSA, but the local Spruce is highly susceptible to the root disease *Inonotus tomentosus* (Spruce Root rot), which is widespread. The phenomenon of post treatment infection increase in Spruce Root rot was not specifically examined in this report, but there was no obvious evidence of increased spruce mortality following girdling or brushing. The Prince Rupert Regional Pathologist⁹ commented that a similar interaction between Spruce and *Tomentosus* as exists between Douglas-fir and *Armillaria* was unlikely.

There are in addition, no known serious insect pests in the Bulkley whose impact on crop trees might be exacerbated through girdling or other treatment of broadleaf trees. (Ken White, R.P.F.¹⁰ – personal communication).

Small mammals such as squirrels, hares and porcupines are known to occasionally impact conifers through bark feeding (figure 7). However as a rule they do not target larger broadleaf trees. Therefore their impact on conifer crop trees is unlikely to increase in a stand where the broadleaf trees have been killed or wounded by girdling or brushing.

There have been local cases however where small mammal damage to small conifers increased following a manual brushing treatment. This was thought to be as a result of an increase in security cover supplied by a large amount of felled broadleaf stems and slash. Manual cutting and Bend/break treatments obviously produce a large amount of slash and cover. Girdling does not produce such a degree of cover and in fact since there is a reduction in overhead foliage cover for the first few years after treatment, predation of small mammals by raptors or other predators *may* actually increase. No specific studies have been carried out in this regard in the Bulkley.

Large ungulates such as moose and deer have been known to feed on conifer buds as well as conifer bark. The instances in the Bulkley are rarely of a serious concern. Moose generally prefer Red-osier dogwood and willow to conifers. It is thus possible that eliminating these broadleaf species in an area may aggravate moose browse on conifers, but such instances are expected to be of limited scope. Moose browsing on willow and Red-osier dogwood do—on the other hand—tend to keep these species in a short, non-competitive position compared to the conifers. As such these species are often exempted from cutting in a brushing project, unless they are directly interfering with a conifer crop tree. Willow or Red-osier dogwoods that are too

⁹ Alex Woods, R.P.F. – Personal communication.

¹⁰ Prince Rupert Regional Entomologist

large to be reached by moose are often cut down with an aim to increasing the amount of accessible moose browse through re-sprouting.

There has been little recent evidence in the Bulkley of conifer damage by pests dramatically increasing following a brushing treatment. It is thus likely that pest levels associated with the conifers in a stand will not appreciably increase as a result of a brushing treatment. The only possible exception to this is small mammal damage when a large amount of cover is produced through the felling of many broadleaf stems.

Table 5: - Summary of Factors and Treatment Method:

Factor	Girdle	Bend and Break	Cutting
Visual Impact	Slower transition to conifer-only view. Dead target stems complete with fine branches remain upright 5-8 years in upper brush canopy ¹¹ . Lower brush canopy slower to respond.	Upper brush canopy gone immediately at time of treatment, lower rebounds slowly.	Upper brush canopy gone at time of treatment, but lower rebounds the most quickly.
Secondary effects on crop tree	Least impacts (No cutting or crushing damage). Least exposure impact.	Limited cutting damage, possible crushing or obstruction damage. Exposure impact high.	Highest likelihood of cutting damage <u>and</u> crushing/obstruction. Exposure impact high.
Size of Crop trees	Bigger the better Larger trees most likely to stay above re-sprouting brush.	Bigger the better (stay above re-sprouts)	Bigger the better. Small conifers most likely to be damaged by cutting blade or crushed/obstructed by brush.
Size of Target tree	Better control in older/bigger trees.	Physically difficult to bend larger tree. Cut and Bend more likely to inadvertently sever smaller (< 2 cm) target tree.	Any size. Brush saw practically limited to ~15cm. Chain saw possibly more damaging to crop trees because less control over saw tip.
Shade on Crop Trees	Some overtopping shade will remain for long time. Lower shade slow to develop.	Overtopping shade gone, lower remains, and gradually increases.	Overtopping shade gone, Temporary lower shade from felled stems. Most rapid return of first lower, then upper shade.
Cover	Upper cover remains to some degree, lower cover relatively unchanged.	Lower cover temporarily increases with slash. Upper cover gone at time of treatment.	Lower cover temporarily increased due to slash. Upper cover gone at time of treatment.

¹¹ Brush Canopy in this paper refers to the target trees, which are typically 1.5 to 3 m. tall. Lower canopy is thus usually less than 1 meter.

Section 15 - Utilisation of Aspen:

The end use of the Aspen should be taken into account. Since the manual treatments studied seldom resulted in 100% mortality of the target stems, the longevity and condition of the remaining stems or sprouts becomes an issue to be considered. This was particularly important with Aspen as it lives long enough to become a full sized tree, and could have potential uses as a crop tree in the future. The Bulkley study revealed that not only are we failing to completely eliminate Aspen as a competitor, but also in addition we are leaving unsuitable stems behind.

Girdling or bend/break of Aspen often produces sprouts as was confirmed during the Bulkley study. Unlike cutting however, girdling or bend/break produces sprouts from the remaining taller rootstock, usually originating just below the break or girdle scar as opposed to from the roots or root collar as with cutting. Branches left alive below the girdle or bend also usually responded by growing into a dominant position. The number of sprouts per original stem varied, and although not specifically measured, were seldom more than 4 or 5 per tree on girdled stems 2 to 3 years after treatment, which usually self thinned to 1 or 2 sprouts after 8 years.

It was at first thought that the vast majority of these sprouts would eventually die, and this has been cited in previous studies (Schier *et al* 1985) for example noted that time to death varies, but is usually reported to be 1 to 3 years. Schier and Smith (1979) earlier noted that “few suckers were alive 12 years following girdling (of aspen)”. It is not known at this point how much longer the 8 year old sprouts seen during the Bulkley study will survive, but this warrants further study.

The sprouts that did survive (for most references recognised that a few would remain alive) were always presumed to eventually become full sized Aspen trees, since there was vigorous early growth soon after treatment.

However during the Bulkley study the sprouts from girdled or bent and broken Aspen appeared—for the most part—to be in poor condition. This was somewhat surprising, since the sprouts should be able to access the root resources of the parent rootstock. The girdle and/or bend and break origin sprouts appeared relatively healthy with average annual increments, but their form was noticeably different from ground or even root collar sprouts. Since the girdle and bend/break sprouts originated on the side of the bent or girdled stump, the junction grafts were not in line with the vertical axis of the rootstock, and this junction appeared to be physically weak. It is expected that these grafts are likely more prone to stem breakage as the stems get larger, especially during a heavy, wet snowfall. There were little direct signs of this seen during the study however.

Also, the active healing area of the girdle scars (especially large longitudinal scars) tended to contain dead wood. It is possible that this transition area may be more susceptible to disease or damage agents (see figures 14 and 15).

Ground or root sprouts as typically originate from cutting on the other hand tend to be of better physical form and lack the scars that allow entry of disease organisms.

The above conditions (poor form and lingering wounds) put into question the long-term viability of the Aspen sprouts originating from girdled or bend/break treatments. The Aspen may not

become large enough to be a useable saw log because of the stem breakage issue, or it may contain disease, internal decay, or stain. If Aspen is not considered a potential crop tree in the future, then this is of little consequence. However, there some instances where Aspen is retained with an eye to subsequent use, and in such case girdle or bend/break induced sprouts should not be counted on to develop into future crop trees.

This was the most enlightening observation from the entire study. Not only is the control period associated with girdling or bend/break not much different from that of cutting, but that the subsequent Aspen re-growth is likely of poor quality! This phenomenon has a relationship with Land Use zonation, for example in an Enhanced Timber Zone we would probably not be as concerned about the Aspen stems as we would be in an Integrated Resource Management, Wildlife or similar zone.

In those latter zones, it may be desirable to keep some Aspen stems around for a long time, even with an eye to eventually harvesting them. Therefore those sites are best served by cutting (rather than bending or girdling), which stimulates sprouting, since those sprouts are more likely to become higher quality Aspen stems with better form and less chance of decay.

Exact prescription details and appropriate densities of Aspen stems associated with this regard not addressed during this report, but warrant further investigation.

Table 6 – Utilisation of Aspen by Landscape Planning Zone

	Girdling	Bend and Break	Cutting
Zonation			
IRM Zone	No, (Subsequent At of poor quality).	No, (Subsequent At of poor quality).	Yes, (Subsequent At of higher quality)
Enhanced Timber	Yes (subsequent At of poor quality and probably not crop trees).	Yes (subsequent At of poor quality and probably not crop trees).	Yes, but repeated treatments likely required
LC or Core	No, because we in all probability want large, better quality Aspen	No (same reason as Girdle, left).	Yes (If sprouting required for visual)

Section 16 – Treatment Costs:

The accurate depiction of costs in a retrospective study such as this one is always challenging. There were factors however that made it particularly problematical in this case. Firstly, as was mentioned in Section 5, there was a tendency to lump treatments types together to satisfy the reporting requirements of ISIS. Since ISIS records were used to summarise these costs, true costs per individual treatment type may not be accurately reported. Secondly, not all instances of treatment activities in ISIS contained cost information. This was only partly due to incomplete record keeping, as the majority was due to the fact that Licensee funded projects were not obliged to supply costs to the ISIS database. The costs presented below therefore are intended for information only and should not be taken as definitive. Only treatments with both area and costs reported were included in the summary.

Table 7: - Summary of accomplishments and costs by treatment type from 1992 till 2001: All costs are treatment year dollars and have not been adjusted for inflation.

	Manual		Bend/Break		Girdle	
	Ha	Cost	Ha	Cost	Ha	Cost
Totals	4,971.2	\$3,443,876.00	374.4	\$244,619.00	379.9	\$200,143.00
Wt. Avg. \$/Ha	\$692.77		\$653.36		\$526.83	

It is interesting to note nonetheless, when the total areas treated from Table 7 are compared to total areas treated from Table 1, we see that while only 87% of manually treated and 88% of Bend and Break areas are represented in the cost summary, 96% of the girdled areas are. It could be argued therefore that the girdling costs listed in Table 7 are more or less a true representation of actual treatment costs—notwithstanding errors due to lumping of treatments.

Section 17 - Management Implications and Recommendations:

Manual Brushing:

Straightforward and recognised technique, most operators have experience in this method.

Most suited to areas with larger crop trees. No size restrictions on target tree, other than brush saw limitations.

Risk of damaging crop trees is higher than other treatments, both during cutting operation itself and by falling target trees or slash. Smaller target trees least likely to damage crop trees during felling operations.

Sprouting abundant and follow-up treatments likely on all species. Control period before sprouts once again reach height of crop tree can be calculated using crop tree height, and annual height increment of crop tree compared to original competing broadleaf tree.

Build up of slash may increase security cover for small mammals.

High visual impacts as all or most target trees are removed in a short space of time. Therefore most exposure of crop trees to the elements immediately after treatment.

In the case of aspen, should be used where aspen stems may be needed in the future as crop trees, since the spouted aspen stems of better quality than those from a girdled or bend and break stem.

Bend and Break:

Most appropriate when only a few small sized target trees need treatment, and crop trees also small.

Limited to a target tree size range of less than ~5 or 6 cm diameter at break point.

Bent-over stems can damage or impede crop trees, but less of a hazard than manual brushing.

Moderate build-up of slash cover, slightly less than manual cutting.

Re-sprouting from bend and break more or less the same magnitude as with manual cutting, but may be delayed for 1 to 2 years.

Not suited for areas where aspen stems may be needed in the future as crop trees.

Girdling:

Girdling is the most appropriate treatment when target stems are large, and crop trees small (efficacy is highest, and there is no danger of damaging crop trees with saws or falling stems). Therefore in older plantations or Backlog areas where the size of the crop trees is usually much less than the target broadleaf trees, girdling is probably the most suitable treatment. Young plantations which generally have much smaller broadleaf competition present a situation where girdling does not have as much of an advantage over other treatments.

Girdling is more efficient (still not 100%) in larger Aspen stems ($> \sim 10$ cm) and moderately effective with larger Red Alder¹². There were only a few instances of cottonwood girdling, but most were unsuccessful. In Southern BC, girdling is used on Birch, with satisfactory results.

Girdling may be more suitable to areas where the conifer crop trees have a high Height to Diameter ratio. The relatively spindly crop trees are least likely to fall over or be damaged if the surrounding broadleaf stems remain upright, as generally occurs after a girdling treatment.

Girdling, in most cases observed during the Bulkley review, does not completely kill 100% of the target stems treated. On the other hand, neither does bend and break, or manual cutting—if you count ground sprouts as a rebirth of the original stem. Therefore a follow-up treatment to remove re-sprouts may be necessary after girdling, manual, or bend/break treatments. A rough estimate of the time period until re-treatment is needed (the control period) can be calculated using current crop tree height along with crop tree and target tree height increments. One or 2 years should be added to recognise the delay in sprouting from a girdled tree.

With most re-treatments, the crop trees should be large enough to allow the use of manual cutting, as there is less danger of crop tree damage from the smaller sprouts, and any subsequent sprouting will probably not catch up to the height of the crop trees.

Girdling requires the least physical effort in the spring when running sap allows the bark to be readily removed. Girdling in the winter in the Interior is problematic due to frozen bark and snow depth.

Although much of the literature points to mid-growing season as the most efficient in terms of target tree mortality, there were no clear trends in the Bulkley study, and some degree of survival or re-sprouting is certain to occur no matter when the treatment takes place.

A complete girdle will not guarantee success (defined as target tree mortality), but a poorly done or incomplete girdle will almost certainly not be successful.

¹² Mike Grainger, R.P.F. – Personal communication.

Roughly cut girdles, as sometimes happen when a dull tool is used tend to result in frayed bark and cambium edges which can flap back into place and sometimes re-establish the flow of nutrients. Also cracks, seams, flutes and callus growth are difficult to correctly girdle.

Girdling is hard physical work, and there is some level of expertise needed. The training required is relatively straight forward, but the level of quality control must be kept at a high level to maximise success.

The tools used for girdling are simple, inexpensive hand tools for the most part without the maintenance problems and safety issues inherent in power tools. Despite this, ongoing care and sharpening of the tools is necessary to ensure a successful treatment. One powered Girdling tool is currently available and is ideally suited to treating larger trees with thick, furrowed bark.

Girdling's advantage is a relatively slow decline of the treated tree, and the retention of its upper stem, even after it has died. This upper stem provides some shade, and a degree of visual cover. More importantly it does not physically impact any neighbouring crop trees (with the exception of immediately adjacent ones), as might happen if the stem were felled or bent over.

There are reported negative effects on Douglas-fir crop tree survival after girdling (or other brushing) due to an increase in *Armillaria* root disease in the BC Southern Interior. No comparable effects were observed in the Bulkley study with respect to Spruce and *Tomentosus* root disease, and the likelihood of any such risk is low.

There are no known serious pests in the Bulkley whose impact on crop trees might be exacerbated through girdling or other treatment of broadleaf trees, with the possible exception of small mammal damage as a result of an increase in security cover following a manual brushing.

Girdling of Aspen should not be done where there is a need or a potential need to utilise the Aspen sprouts as sawlogs in the future. This is more likely to occur in areas under management zones that emphasise multiple use or integrated resource management more so than in zones that are primarily concerned with exclusively producing conifer trees. Girdling would thus be an appropriate treatment in areas where there was no anticipation of, or insufficient Aspen stems for future utilisation.

Girdling is not the be all and end all brushing treatment that was once thought to be. It does however, remain a suitable broadleaf vegetation control technique under the right circumstances.

Section 18 - Conclusions:

Despite the ongoing trend to recognise broadleaf trees as suitable crop trees or as contributors to biodiversity, there will still be instances where they are considered competitors to the preferred (usually conifer) crop trees. Manual brushing techniques to remove that competition all have their relative advantages and disadvantages, there is no one superior method.

The technique(s) used therefore should be tailored to the situation in hand. Both crop tree and target tree size, current and future conditions must be taken into account.

All of the techniques reviewed (cutting, bend and break, and girdling) result in some degree of re-sprouting from the cut stump or roots. The time period for these sprouts to regain their competitive position can be approximated.

The author is pursuing a procedure that will allow more than one brushing technique to be captured within the ISIS database when carried out at the same time.

Part 2 - Girdling.

Section 1 - Review of girdling tools¹³:

Tools used for girdling fall into two broad types, characterised by their mode of action. There are those with blade(s) which are drawn tangentially around the circumference of the tree to remove a uniform width of bark/cambium; or tools scraped longitudinally up and down the axis of the stem to remove the bark/cambium. See figures 17 to 19 for an illustration of some of the more common types.

Following is a description of the more popular girdling tools.

Tangential Cutters–

- **Girdling knives** – A wide variety of tools exist in this category. Most have a “U” shaped blade, either with a closed or open loop mounted on a handle. They are pulled or pushed around the circumference of the tree, removing bark and cambium. Some types like the JMC “*TreeRinger*®” have adjustable cutting angles or depth, while others have folding blades that can be closed like a pocket-knife. Widely available commercially from Orchard and Forestry equipment suppliers. See figure 17.
- **Saw Chain** – A length of power saw chain held between two handles and sawed back and forth around the tree. Usually two lengths of saw chain are joined side to side, which not only makes a wider cut, but also makes the chain more resistant to flipping on its side. The two saw chains are normally aligned in opposite directions so that cutting will occur both ways. Commercially available from forestry equipment suppliers, or readily fabricated by the end user. See figure 18.
- **Girdling Pliers** – These consist of a large pliers-like implement with cutting teeth set into the jaws. The tool is clamped around the tree, and the handles worked back and forth in a side to side motion. The teeth subsequently cut a groove in the bark/cambium. The pliers type is limited in both minimum and maximum size of target tree.
A commercial version of the tool called the “*Vredenburg North Star*® *Tree Girdler*” was available in the late 1970’s and early 1980’s and was evidently based on a Russian design. See Ministry of Forests (1982) for a review of the tool using various tooth configurations for use in a pre-commercial conifer thinning operation. The *Vredenburg North Star*® *Tree Girdler* is apparently no longer available, but some end users have fabricated their own pliers-type cutters for use in broadleaf girdling. See figure 19.

¹³ The use of Trade or Company names is for information/clarification purposes only, and does not constitute endorsement by the author or the Ministry of Forests.

Figure 17 Tangential Girdling tools.

- A - Two handled ringer
- B - One handled ringers
- C - Simple girdling tool with small hooked blade
- D - Folding girdling knife
- E – JMC “TreeRinger®” Girdling tool.



A



B



C



D



E

Figure 18: Saw Chain Girdler



a – Saw Chain girdler.



b – Note bi-directional orientation of cutting teeth.



Figure 19 – Vrendenberg Girdling Pliers.

Longitudinal Scrapers –

- Carving “*Scorp*” – A round or C-shaped wood carving tool with (usually) a closed loop.
Available from woodworking equipment suppliers. See figure 20
- Girdling knives designed for single-handed use or those of the pocket-knife type as above can be used longitudinally if need be.
- Simple cutting tools like axes; Sandvik® brush axe; knives and machetes, or other bladed tools have been used for girdling, and are most suitable for larger trees or thicker bark. The cutting depth is more difficult to control than with a specialised girdling tool.



Figure 20: (left) Scorp, a wood-carving tool used for girdling.
(right) Close up of blade. Total length of tool is 18 cm.

Power tools –

While regular chainsaws have been used for girdling, the depth of cut is difficult to control and the relatively long saw bar makes their use awkward and potentially hazardous. There are however at least two power tools designed specifically for girdling which are outlined below:

- ***Li'l Beaver®*** is a powered girdling tool designed in British Columbia by *Brinkman and Associates Reforestation*. It consists of a backpack mounted brush saw motor with a flexible drive shaft operating a rotating conical cutting head. Regular replaceable saw chain wrapped around the head does the cutting. The operator holds the spinning head against the trunk and draws it around the trunk's circumference where a 3 to 4 cm wide girdle is produced. The cutting action itself is tangential in nature, while the operator controls the depth of the girdle. The conical head allows small stems to be treated by only using the narrow part of the cone. This tool is proprietary to *Brinkman and Associates Reforestation* and is thus only available for use with that company's crews. (See figure 21 and 22).

Figure 21: - Li'l Beaver® Girdling tool.



Figure 22: Li'l Beaver® in use. Note size of tree and thick furrowed bark



- ***Mechanical Knife for Girdling***, by *AgroTools Ltd.* – A prototype designed and manufactured by the *Agriculture Centre of Israel; Engineering Institute*. This powered girdling tool is intended for the viniculture and orchard industries. The electrically powered tool has a ring-like circular cutting head that is hinged so that it can open to incorporate the trunk. Adjustable cutters inside the curve of the head rotate within the head, carving a strip of bark tangentially from the target trunk. This interesting tool is presented in 2 versions: a cart mounted one for girdling near the root-collar, and a portable version for girdling higher up on the trunk or on branches. This latter version would theoretically be suitable for vegetation control as long as suitable sized target stems were not too close together. This tool is experimental in nature, and not as yet operationally available. (See figure 23 for a picture of the portable version).

Figure 23: - *Mechanical Knife for Girdling*. Note fresh girdle cut at arrow.



Section 2 - Effect of Cutting types on girdle and operator:

Database or file records and stand reports of girdling treatments seldom describe the individual tool(s) used, but some observations on the 2 cutting types (tangential versus longitudinal) were apparent during the study. The two types are usually readily distinguishable even some time after treatment by the shape and size of the bark removed, as well as the cut marks on the wood itself.

While no type was obviously superior as far as control or success, there were certain traits attributable to either type.

Tangential Cutters –

- Tangential cutters normally produce a relatively narrow girdle cut (1 to 4 cm) which is more apt to bridge (grow over the wound), thus it is common practise to make 2 cuts, about 10 cm apart (see cover illustration).
- Tangential marks on the wood are usually concave, due to “U” shaped blades that are common.
- On smaller stems, somewhat more of a chance of cutting too deep, thus triggering sprouting response.
- The girdling operation presumably takes fewer steps, as the operator only has to change tool and/or hand position once or twice.
- Tangential girdlers are arguably the quickest to use, but some like the saw chain types take some care in setting on the tree.
- Some tools allow one-handed use, which leaves the other hand free to pull adjacent stems out of the way for example.
- Smaller target trees more difficult to treat.
- No maximum target tree size restriction (with the exception of girdling pliers and saw chain types), until bark too thick for cutting blade.
- Arduous to use on thick or furrowed bark.
- Difficult to use if target trees close together near point of girdle, although saw chain type is theoretically able to fit between narrow gaps.

Longitudinal Cutters –

- Longitudinal cut marks usually has abrupt edges, especially when a flat cutting blade was used. (See figure 24)
- Width of girdle cut is variable, and usually quite wide (5 to 10+ cm.). Thus less of a chance of the wound bridging closed.
- More chance however of leaving strips of cambium intact, thus creating an incomplete girdle.
- Probably slower per tree than tangential since tool is applied and lifted from tree many times (not specifically studied, but implied). However this is discounted somewhat by the fact that 2 cuts are generally used with a tangential cutter.
- No target tree size restrictions but arduous to use on thick or furrowed bark, even with larger tools like the Sandvik® brush axe.

- Less chance of cutting too deep of a girdle.
- More readily able to treat stems that are close together.
- Easier to make cuts lower down on the tree, instead of at an awkward right angle to the lower part of the stem.
- Most tools allow one-handed use, which leaves the other hand free to pull adjacent stems out of the way for example.

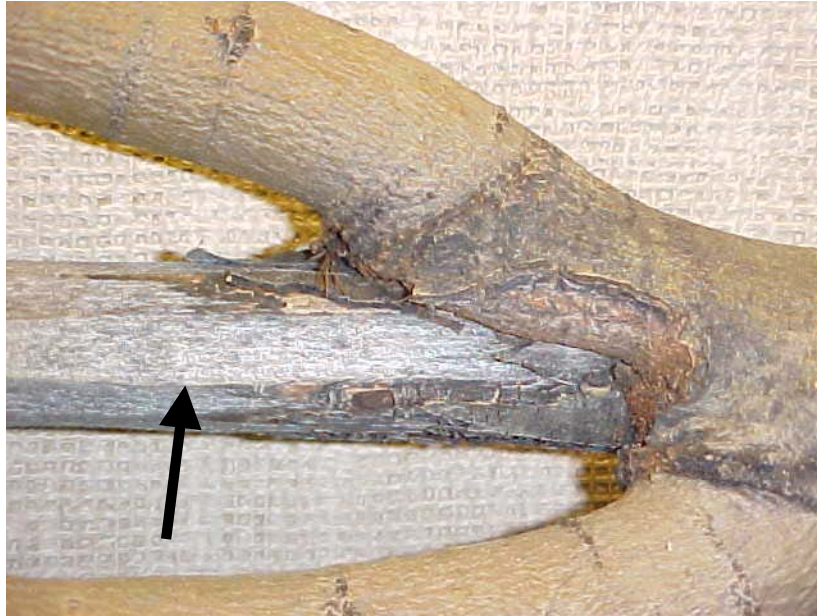


Figure 24: - Note cut marks (arrow) from longitudinal girdling tool.

Girdling with hand girdlers is hard physical work, and can aggravate the operator's wrists, and may produce repetitive strain type injuries. Chain or pliers type tools more apt to be easier on the wrists as arm muscles can be used to a greater degree.

Powered Girdlers –

- No target tree size restrictions, ideal for large mature trees.
- Capable of treating trees very quickly.
- Able to treat trees with thick or furrowed bark.
- Penetration of bark into cambium is assured.
- Operating and maintenance concerns inherent with powered equipment.
- Inexperienced operators may tend to cut too deeply, possibly overly weakening the stem or triggering re-sprouting.

The Li'l Beaver[®] is the only available power girdler as far as is known. At present, Li'l Beaver[®] is only available as a proprietary part of *Brinkman and Associate Reforestation* crews.

The choice of girdling tool is seldom specified in a brushing contract, and is often a question of personal choice. Girdling contracts do list minimum girdle number, width, height above ground, etc. See following section.

Section 3 - Quality Control:

Girdling, since it leaves the treated tree standing and full of leaves, is not as visually obvious as manual cutting. The immediate results after treatment are thus not as dramatic as with a power saw or brush saw and this may give rise to a lack of job satisfaction for the worker(s). It is also more difficult to tell which areas have been treated, unless one can readily see the girdle scar. This may make crew supervision and quality control more problematic. A wider, more obvious girdle may alleviate this visual problem somewhat.

Girdling (hand tool methods) does not need operators skilled in power or brush saw operation with their inherent training requirements, maintenance and safety issues. However girdling is physically demanding and does require some training. There is a misconception that girdling is straightforward and simple. Close supervision and explicit instructions are important for success. Parameters to guide workers that must be incorporated as contract specifications include:

- Species to treat or not treat,
- Height of girdle above ground,
- Number of girdles per tree.
- Treatment of lower branches,
- Size and depth of girdle,
- Whether girdling is necessary for isolated, non-competing trees,
- Radius of treatment around crop trees.

A complete girdle (encircling the complete circumference of the tree) of sufficient depth is paramount to success. A partial or poorly done girdle will most likely not be successful. As mentioned in section 7, many girdled trees survive when the girdle either bridges over or the

cambium re-establishes itself as a result of incomplete cutting. Girdling tools must be kept sharp and in good condition to assure complete girdle cuts with no missed spots or strips (see figure 25).

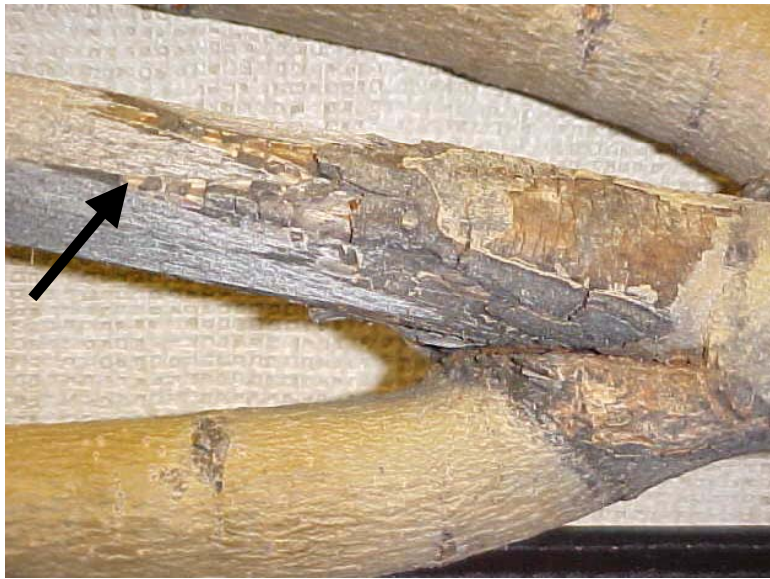


Figure 25: Example of a missed strip of cambium (although in this case it was not continuous and therefore did not support translocation of nutrients).

A lot of girdling was traditionally given to crews under various job creation programs such as EBAP, or FWDP¹⁴, etc. These crews often consisted of unskilled or untrained workers. Many of the quality problems associated with past girdling treatments may be attributable to this lack of training

Contract workers now carry out almost all girdling projects, and payment is more closely tied to production and quality.

¹⁴ Various work programs were:
EBAP – Employment Bridging Assistance Program
FWDP – Forest Worker Development Program.

Selected References:

Bancroft, Bryce, editor “*Can Aspen Regeneration in the Southern Interior be Reduced by PreHarvest Treatments? A literature Review.*” 1988. FRDA Project **3.46** 77 pgs.

Bell, Wayne F., Douglas G. Pitt, Andrée E. Morneau, and Susan M. Pickering. 1999, “*Response of Immature Aspen to Season and Height of Cut*”. Northern Journal of Applied Forestry, Vol **16**, No. 2. Pgs. 108-114.

DeByle, Norbert V., and Robert P. Winokur, editors, 1985 “*Aspen: Ecology and Management in the Western United States*”. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Gen Tech. Rep. **RM-119**.

Ford-Robertson, F.C. (1983), editor “*Terminology of Forest Science Technology Practice and Products*” Society of American Foresters 370 pgs.

LePage, Phil, 1992. “*Evaluation of vegetation competition in hardwood stands in the sub-boreal spruce zone - Project 1.27*”. FRDA Research Memo #**203**. 12 pgs.

Helms, John A. editor, 1998, “*The Dictionary of Forestry.*”, Society of American Foresters, 125 pgs.

Ministry of Forests, 1982. “*SX 7801 Q - Coast and Interior Girdling Trial - Final Report*” Internal Ministry document 10 pgs.

Perala, D.A., “*Quaking Aspen*”, in Burns, Russell M., and Barbara H. Honkala, tech. coords. 1990. “*Silvics of North America: 2. Hardwoods*”. Agriculture Handbook **654**. USDA, Forest Service, Washington, DC. vol.2, 877 p.

Petersen, Everett B., and N. Merle Petersen, 1995 “*Aspen Managers' Handbook for British Columbia*”. FRDA Report No. **230**. 110 pgs.

Pitt, D.G, M.T. Dumas, R.E. Wall, D.G. Thompson, L. Lanteigne, W. Hintz, G. Sampson, and R.G. Wagner. 1999 “*Chondrostereum purpureum as a biological control agent in forest vegetation management. I. Efficacy on speckled alder, red maple, and aspen in eastern Canada*” Can. Jor. For. Res. **29**: 841-851.

Powell, Arlie, David Himmelrick, William Dozier, and David Williams, 1999, “*Fruit Culture in Alabama – Thinning and Girdling*”. Alabama Cooperative Extension Services, Auburn University. Extension Paper **ANR-53-N**, 2 pgs.
URL: (<http://www.aces.edu/dept/extcomm/publications/anr/anr-53/anr-53-n/anr-53-n.html>)

Schier, George A, and Arthur D. Smith 1979 “*Sucker Regeneration in a Utah Aspen Clone after Clearcutting, Scarification, and Girdling*”. USDA Forest Service. Intermountain Forest and Range Experimental Station, Research Note **INT-253** 6 pgs.

Schier, George A. Wayne D, Shepperd, and John R. Jones. 1985 “*Regeneration*” in DeByle, Norbert V., and Robert P. Winokur, editors, 1985 “*Aspen: Ecology and Management in the Western United States*”. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Gen Tech. Rep. **RM-119**.

Simard, Suzanne, W., Jean L Heineman, W. Jean Mather, Donald L. Sachs, and Alan Vyse. (2001), “*Effects of Operational Brushing in Conifers and Plant Communities in the Southern Interior of BC.*” Section 12 in Simard *et al* (2001) “*Results from PROBE 1991-2000 – PROtocol for Operational Brushing Evaluations*”. Res. Br. Min of For. Victoria B.C. Land Manage. Handb. **No. 48** pgs 248-390.
URL: (<http://www.for.gov.bc.ca/hfd/pubs/Docs/Lmh/Lmh48/Lmh48-13.pdf>).

Wisconsin Dept. of Natural Resources.1999. “*Quaking (trembling) Aspen (Populous tremuloides), Big Tooth (Large Tooth) Aspen (Populous grandidentata)*”. Factsheet, 2 pages.
URL: (<http://www.dnr.state.wi.us/org/land/er/invasive/factsheets/aspen.htm>)

Appendix 1 – ISIS codes used in Brushing:

The following illustrates the combination Base/Technique/Method codes that are acceptable within the ISIS database.

Base	Technique	Method	Description
BR			Brushing
BR	BI		Brushing/Biological
BR	BI	COVER	Brushing/Biological/Cover Crop
BR	BI	GRAZE	Brushing/Biological/Grazing
BR	BI	ISECT	Brushing/Biological/Insect
BR	BI	LAYOT	Brushing/Biological/Layout
BR	BI	MICRO	Brushing/Biological/Microorganism
BR	BU		Brushing/Burn
BR	BU	BROAD	Brushing/Burn/Broadcast Burn
BR	BU	LAYOT	Brushing/Burn/Layout
BR	BU	SPOT	Brushing/Burn/Spot Treatment
BR	CA		Brushing/Chemical Air
BR	CA	FIXED	Brushing/Chemical Air/Fixed Wing
BR	CA	HELI	Brushing/Chemical Air/Helicopter
BR	CA	LAYOT	Brushing/Chemical Air/Layout
BR	CG		Brushing/Chemical Ground
BR	CG	BASL	Brushing/Chemical Ground/Basal Spray
BR	CG	BPACK	Brushing/Chemical Ground/Back Pack Applicator
BR	CG	FRILL	Brushing/Chemical Ground/Notch or Frill
BR	CG	GRANU	Brushing/Chemical Ground/Granular Application
BR	CG	LAYOT	Brushing/Chemical Ground/Layout
BR	CG	SBARK	Brushing/Chemical Ground/Stem Bark Spray
BR	CG	SCONE	Brushing/Chemical Ground/Spot Cone
BR	CG	SINJE	Brushing/Chemical Ground/Stem Injection
BR	CG	SPGUN	Brushing/Chemical Ground/Spot Gun Applicator
BR	CG	STUMP	Brushing/Chemical Ground/Stump Treatment
BR	CG	VMSFB	Brushing/Chemical Ground/Vehicle Mount S
BR	CG	VMSGH	Brushing/Chemical Ground/Vehicle Mount S
BR	CG	WIPNG	Brushing/Chemical Ground/Wiping Applicator
BR	GS		Brushing/Grass Seeding
BR	GS	BLOCK	Brushing/Grass Seeding/Clearcut Block
BR	MA		Brushing/Manual

Appendix 1 – ISIS codes used in Brushing (Continued):

BR	MA	BRUSH	Brushing/Manual/Brush Saw
BR	MA	HANDR	Brushing/Manual/Hand Pulling (Removal)
BR	MA	LAYOT	Brushing/Manual/Layout
BR	MA	LCLIP	Brushing/Manual/Leader Clipping
BR	MA	MANCT	Brushing/Manual/Manual Cutting
BR	MA	MANGI	Brushing/Manual/Manual Girdling
BR	MA	MANSB	Brushing/Manual/Manual Stem Bending
BR	MA	MULCH	Brushing/Manual/Mulching
BR	MA	POWER	Brushing/Manual/Power Saw
BR	MA	STAKE	Brushing/Manual/Staking
BR	ME		Brushing/Mechanical
BR	ME	BLADE	Brushing/Mechanical/Blading
BR	ME	CHAIN	Brushing/Mechanical/Chain Drag
BR	ME	CHOP	Brushing/Mechanical/Chopping
BR	ME	EXCAV	Brushing/Mechanical/Excavator
BR	ME	HYDRO	Brushing/Mechanical/Hydro-Axe
BR	ME	LAYOT	Brushing/Mechanical/Layout
BR	ME	MOCUT	Brushing/Mechanical/Motorized Cutting
BR	ME	MOGIR	Brushing/Mechanical/Motorized Girdling
BR	ME	SEPI	Brushing/Mechanical/SEPI
BR	ME	SPYDR	Brushing/Mechanical/Spyder