Restoring the Forest in a Young Coastal Douglas-fir Plantation

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Abstract

Galiano Island sits in the archipelago of Southern Gulf Islands splitting the waters of the Georgia Strait between Vancouver and Vancouver Island. The Galiano Conservancy Association is a local community-based organization whose goal is to protect, preserve and enhance the quality of the human and natural environment of our area through education and conservation projects. One of our ongoing conservation projects involves the ecological restoration of a 160-acre parcel of forested land owned by the Conservancy. The topic of this paper is the development and application of restoration strategies that will enhance the ecological integrity of the 24-year-old Douglas-fir plantation that occupies most of the protected land. We are developing and applying innovative techniques to foster the diversification of the forest's genetics, composition, and structure with the intention of improving overall forest function and ecological integrity. We are restoring connections at both fine and coarse scales and are stitching ecological anchors together by thinning and by redistributing coarse woody debris from old windrows. Because our approach is intensive yet mandates minimal impact, we are doing the work with a unique small-scale skyline system that can be moved and operated by hand. This paper discusses the project as a case study, including context, history, rationale and application of restoration techniques.

Introduction

After 150 years of logging and settlement, older forest ecosystems occupy only 2.6% (10,605 ha) of Southeast Vancouver Island and the adjacent Gulf Islands (McPhee et al. 2000). Plantations, agricultural lands, roads and urban development have replaced and fragmented old forest, making ecosystems of the Coastal Douglas-fir (CDF) Biogeoclimatic Zone some of the most endangered in British Columbia. In fact, all old-growth forest types that are either dominated or co-dominated by Douglas-fir within the CDF are currently on the province's list of rare and endangered ecosystems (Flynn 1999).

Preservation of the few remaining parcels of land with intact natural ecosystems must be the first conservation priority in this zone. However, because such protection opportunities are limited, ecological restoration of degraded land must be employed to connect and buffer regional intact forest ecosystems.

Local Context

Galiano, the second largest of British Columbia's Southern Gulf Islands, has not been spared the history of timber removal from its own CDF forest. Further, the island's location (Fig. 1) near the urban centres of Vancouver, Seattle, and Victoria means that development pressures from these fast-growing populations play a role in shaping Galiano's future – both ecological and human.

The increasing pressures of development and resource use have led the Galiano community into a heightened ecological awareness, fostering a devoted activism directed at managing the growing demands on the landscape. The Galiano Conservancy Association is one organization that has taken on the resulting challenges.

Figure 1. 2002 Landsat ETM+ Satellite Image *Galiano Conservancy Assoc*.

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The Galiano Conservancy Association is a charitable land trust whose purpose is to preserve and protect the natural and human environment of Galiano Island. The organization pursues its goal through land protection, conservation planning, education and ecological restoration initiatives.

Galiano Island Landscape

Roughly half of Galiano's almost 6000 hectares is recovering from being clearcut within the last fifty years. Old-growth forest patches (older than 250 yrs) larger than a hectare number less than half a dozen. Mature forest ecosystems (between 80 and 250 yrs old), the majority of which were high-graded in the early 20th Century, compose about one-quarter of the landscape (Fig. 2). Impacts from harvesting such a large portion of the island's forests are compounded by extensive fragmentation caused by roads and development. Although conservation efforts on the island have created a network of protected areas that encompass over 14% of the land base, over 85% of all remaining mature forest patches are less than five hectares in size (Emmings & Erickson 2004). The result is a landscape dominated by simplified, young, Douglas-fir plantations encapsulating small islands of mature forest. The direct loss of species and their habitats due to ecosystem conversion is compounded by the lingering effects of fragmentation that may limit:

- the ability of many species to disperse when seeking refuge from disturbance,
- the re-colonizing of areas that have been disturbed,
- the migration between ecosystems in order to meet seasonal and life-stage requirements and/or,
- shifting ecosystem responses influenced by climate change (Noss 1991).

Harrison & Voller (1998) state that harvested areas surrounding islands of older forest must resemble more complex forests rather than structurally simplified plantations if they are to provide source-pools for colonization and connectivity between remnant forest patches.

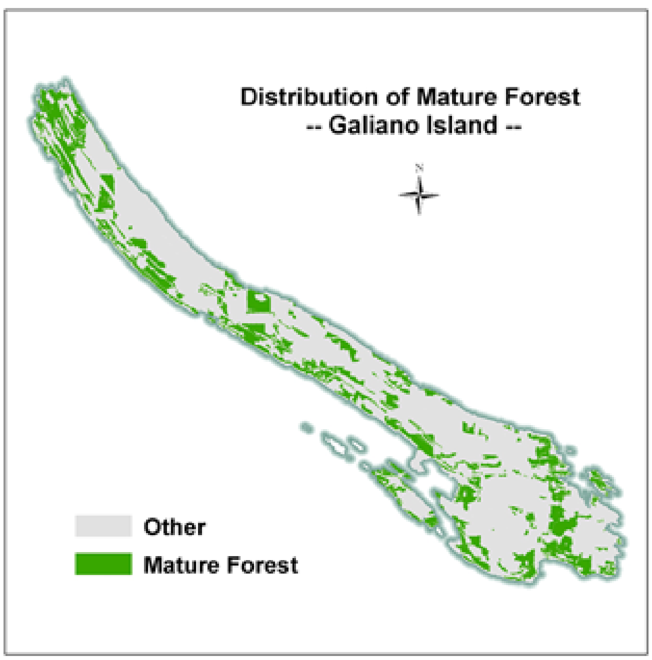

Figure 2. Mature forest includes all forests over 80 years old. 'Other' includes all logged areas under 80 years of age, developed areas, agricultural fields and non-forested natural ecosystems. Non-forested natural ecosystems account for only 6.1% of the landscape.

Restoration Project Area

The Galiano Conservancy has decided to address issues of habitat loss and fragmentation through the "Mid Island Protected Areas Enhancement Project". Located roughly at Galiano's midpoint is a network of protected areas that stretches from the Georgia Strait shoreline across the island's central ridge to the coastal cliffs of the Trincomali Channel (Fig. 3).

Figure 3. Restoration project area in DL 63, adjacent to protected mature forest in the Pebble Beach Reserve and Laughlin Lake protected areas.

Central to this network is District Lot 63 (DL 63), a 62-ha Douglas-fir plantation owned by the Galiano Conservancy. Part of the Pebble Beach Reserve and bordered by large patches of mature forest on three sides, DL 63 was clearcut in two separate entries, one in 1967 that removed 20% of the forested area, and one in 1978 that removed all but 2 ha of the remaining trees (Erickson et al. 2002).

The protected status and central position of DL 63 between three patches of mature forest provide an ideal opportunity for not only increasing diversity within the formerly logged tract but also improving habitat connectivity through a well planned restoration program.

Site Analysis

An initial survey of the DL 63 site (Erickson et al. 2002) used a collection of structural and compositional variables to isolate and describe the site's ecosystems (Table 1). We mapped out polygons based on this list as well as other stand characteristics including geology, topography and site series. We assessed ecosystem health and function based on the criteria of diversity. "Structural complexity or diversity in natural forests is recognizable as the key to much of the richness of organisms, of habitat and of process" (Franklin 1994).

Table 1. Comparison of structure and composition of the restoration site on DL 63 and reference areas.

Variables	*DL 63 Site*			*Mature Forest (DL 60 and DL 66)*	*Old-Growth Forest **
	1980 Plantation	*1967 Plantation*	*Complex Patches*		
Douglas-fir, stems/ha	1008	1275	350	246	153
All tree species, stems/ha	2318	1464	971	1075	409
Trees >.50m dbh, stems/ha	0	0	73.08	200	145
Snags >.50m dbh, stems/ha	0	0	7.69	8.33	11
Average diameter, cm	11.29	17.29	20.96	19.85	40.6
Understory vegetation, % cover	48	20	53.62	106.33	>100
Coarse woody debris, cubic m/ ha	20	107	171	181.33	345

* Old Growth data from Smithsonian Institute Monitoring and Assessment of Biodiversity (SIMAB) protocol one-ha data plots, established at Rocky Point DND lands, Southern Vancouver Island (Chatwin 1997).

The industrial forest treatment of DL 63 was so intensive and thorough that almost all structural complexity from the original stand was either heavily modified or eliminated entirely. The forest floor of the younger, 24-year-old plantation was polarized into vast barren areas interwoven with long snaking piles of saturated windrows. (The use of the windrow treatment was likely part of a 'debris' elimination strategy as the piles showed signs of having been burned.) The trees were a monotonous, homogenous closed canopy of Douglas-firs, uniform in diameter, height, age, and spacing (Fig. 4). Most early successional species were limited to small gaps and windrows, and the fate of those deciduous tree species in the stand was clearly sealed by the height discrepancy with the fast-growing Douglas-fir trees. Barring intervention, within the next 5-10 years Douglas-fir trees would have shut the curtains on much of the other light-dependant indigenous species, simplifying the stand further. We saw evidence of the stem exclusion process by comparing alternate tree species densities in the older, 36-year-old, plantation with those in the younger plantation. We found there where seven times the number of alternate species in the younger plantation and almost the same densities of Douglas-fir trees in both. This was a testament to the persistence and dominance of the well-spaced Douglas-firs.

Our assessment of the two plantations was that the ecological integrity of the site was heavily compromised by the legacy of industrial logging:

- Clearcutting had robbed the site of large live and dead trees, species diversity, spatial heterogeneity and biological community.
- Windrowing and slash burning had robbed the site of its forest floor, coarse woody debris (CWD), and species diversity.
- Planting and brushing had robbed the site of spatial and species diversity.

Figure 4. A Typical scene from within the 1980 plantation before any restoration treatment.

Although most of the forested lands of DL 63 were radically simplified, patches did remain that escaped complete conversion due to site conditions, species composition and/or oversight or plain luck. These patches are recognized by a lingering presence of higher structural and compositional diversity relative to the rest of the stand (Table 1, "Complex Patches"). Some large trees, well distributed CWD, diverse tree species and shrub-dominated gaps all function together to create a diverse patch. The spatial distribution of these complex patches or polygons formed a near connection across the site, bridging two separate watersheds as well as adjacent stands of mature forest. This tantalizing possibility of connectivity pointed to a restoration strategy.

Strategies

Accepting an inherent value in connectivity and using the complex patches as key ecological anchors[1], we set as our key goal the suturing together of fragmented remnant patches to produce a tangible corridor linking the neighbouring mature forest stands. Whether this corridor would provide movement for any specific species is debatable; it may be that the real value is the movement of diversity through this portion of the stand.

With an eye on that guiding goal, we outlined specific restoration strategies for the near term. First, we considered a well planned, ecologically driven thinning treatment as a possible technique for diversifying stand structure and composition. With the right tools, stand structure could be manipulated towards diversity, providing more structural values now and promoting recruitment of further structural variation in the future. At the same time stand composition could be altered to encourage species diversification within the stand.

In addition to the use of thinning as a restoration tool, the windrows presented a unique restoration opportunity for stand diversification, including:

- The windrows, having not been planted to Douglas-fir and having not yet undergone canopy exclusion, were often dominated by early successional species that flourished under limited competition. These sinks would be valuable sources for re-dispersal of native species into the thinned plantation.
- The wood in the windrows could be redistributed around the forest floor to quickly restore structural complexity and function. The CWD would contribute to the soil rebuilding processes and build connectivity through the plantation to isolated complex patches.
- Some of the pieces of wood in the windrows were large enough and solid enough to be erected as snags, enabling some three-dimensional structure to be restored to the stand.

With these general strategies in mind, we needed to develop specific prescriptive plans for thinning and for distribution of CWD, and for this we looked to reference ecosystems to gain perspective into the ecological integrity, past stand structure, and expected successional trajectories of the stands of DL 63. As very little unaltered old-growth forest remains on Galiano Island and in the Coastal Douglas-fir Biogeoclimatic Zone at large, our references included local mature forest stands with high-grade logging histories and other mature and old-growth stands found on Vancouver Island. We also referred to a site on Galiano where a large patch was regenerating naturally after being clearcut, but not treated in any other way. Since the mature forest stands on Galiano were heavily high-graded in the early 20th Century and little true old-growth remains at all, we used stump mapping and stand reconstruction plots to derive targets based on past stand densities and species distributions. Our observations revealed a picture of a target ecosystem characterized by canopy gaps, different size trees, different tree species (although Douglas-fir and cedar were the dominant stumps, partially due their resistance to rot), large snags, lots of woody debris, dense shrub layers, epiphytic vegetation, and horizontal and vertical compositional and structural diversity (Table 1, "Old Growth Forest").

Rebuilding a forest of snags, large trees and well-distributed CWD in the plantation became our more specific restoration objective. We considered the tree density and structural frequency data for large trees, snags and CWD volume from our reference ecosystems as long-term targets for our restoration treatments and short-term guidance. Our immediate restoration objectives were highly tempered by the availability of materials in the stand and the current level of production in the site. We needed to improve the component of CWD, snags and large trees in the stand over the short and long terms. We could do this in two ways, by manipulating the existing materials in the stand and by manipulating the stand with the objective of recruiting desirable structural features over the next 10-20 years. Because of the inherent variation in nature we did not seek dogmatic targets but rather used the numbers from the target ecosystems as guidelines while diversifying the stands current form to nurture successional trajectory options. By remaining flexible with our treatments, by spreading them out over time and by incorporating a strategy of monitoring and response or adaptive management, we would shift natural succession in the DL 63 plantations from their present course towards diversification and ecosystem health as represented in the reference systems.

Treatments

The restoration treatments applied to diversify the stand structure included the redistribution of CWD on the forest

[1] **Anchors** are defined as individual species, micro-sites, patches, stands and watersheds attributed with greater ecological integrity (structure and composition) and lesser restoration needs relative to the dominant matrix (in this case Douglas-fir plantation trees).

floor, the erection of snags, and thinning the plantation stock. Based on our targets and after consultation with Herb Hammond (RPF, Forest Ecologist), project abettor, we determined that two or three thinning entries would be required over the next 10-20 years, and we should be striving for densities of a third to a half of the current figures. Initially we determined we could safely remove 25-30% of the plantation trees in the stand on an initial entry.

Our approach to layout for thinning did not follow commercial thinning practices but rather was guided by the need to develop ecological anchors aimed at maintaining and fostering diversity throughout the stand. Recognizing that we would be inflicting a well-planned restorative disturbance event into the stand, we used these guidelines to guide our work:

- Choose manageable patches of 1000-5000 square meters with obvious natural borders/barriers (i.e., gaps, windrows).
- Flag working downhill, back and forth across slope.
- Move around for greater perspective; consider canopy- and ground-level anchors.
- Consider multiple-scale anchors (individual trees, clusters and large patches).
- Keep aspect in mind; think about canopy and light penetration.
- Thin to release native broad-leaf and conifer tree species.
- Create random patterns using small and large gaps (50-100 square meters) and leave some dense clusters.
- Thin around patches of native vegetation.
- Create small gaps that extend in from windrows and other patches where diversity exists, promoting the dispersal of vegetation.
- Save trees planted close to old stumps to take advantage of nutrient sources (Chen et al. 2001) and potential mychorrizal associations.
- Look at tree form, and select for, on the one hand, strong phenotypes and, conversely, for gnarly funk, large limbs, broken tops (good nest/habitat sites, diversity).
- Preserve tree-borne vegetation (i.e., trumpeter honeysuckle, *Lonicera ciliosa*).
- Look for nests in trees and mark for protection.
- Thin to promote growth in trees providing future large snags upon successive entries.
- Resist culling native tree species to promote plantation stock.
- In dense native tree patches (i.e., red alder, *Alnus rubra*) consider thinning to promote the larger alders and understory successional climax species such as western red cedar (*Thuja plicata*), western hemlock (*Tsuga heterophylla*), and grand fir (*Abies grandis*).
- When in doubt, mark trees for saving; you can always cut later.

The overall intention was not to rid the stand of the plantation trees but to promote species diversity. By favouring native shrubs and deciduous trees in the stand, we are attempting to prolong the beneficial influences these early seral species have on soil building and habitat diversification (cf. Hammond 1991).

Thinning to promote diversity in monoculture stands is not new (Miller & Emmingham 2001). Our approach, however, is unique in several ways. First, we are not removing any timber from the stand. By leaving the trees we cull, we are offering this resource back to the heavily disturbed soil ecosystems and deprived structural systems of the site. In addition we have chosen to thin the plantation by creating snags and by pulling trees over. Trees are culled by pruning and topping to create instant standing pole snags and by girdling at the base to generate slowly dying trees. We also pull down selected trees to provide canopy gaps and additional CWD on the forest floor and to diversify the micro-topography on the forest floor by creating microsites in the form of root wad pits and mounds. By pulling trees instead of cutting them we maintain a more natural aesthetic by simulating a natural windthrow disturbance. For the details of our technique for pulling down trees without heavy machines, see the Appendix.

We are also adding snags for wildlife habitat. The plantation trees are too small to provide desirable cavity nesting sites and besides are of a single decay class and species, so we are raising large intact logs found in the windrows to produce artificial snags (see Appendix for details). We have been able to raise pieces of wood 1m in diameter, allowing us to restore a structural anchor and cornerstone habitat feature that would take the forest centuries to produce naturally.

Our other objective in restoring structural diversity to the stand rests in dismantling windrows and distributing the CWD to add complexity to the forest floor. The idea was to make the windrows disappear, blending them with the rest of the forest floor. We established from the beginning that since this was ecological restoration, our approach and techniques should be designed to minimize any further disturbance to the recovering forest floor and associated vegetation. We therefore ruled out using heavy machinery in the stand. Ken Millard, a director of the Conservancy who voluntarily works with us on this project and is much experienced with mechanics and physics, designed a small-scale hand-operated skyline system based on the Workers' Compensation Board of BC cable yarding handbook (WCB of BC 1993). We have employed this system to lift 2-ton pieces of wood from the windrows and move them to the forest floor (Fig. 5 and 6). The techniques are described in detail in the Appendix. The tools for this system can be transported by hand, eliminating the need for roads and trails and dramatically limiting disturbance.

When moving CWD we use these guidelines:

Figures 5 (left) and 6 (right) show the before and after CWD placement within the restoration treatment area in DL 63. Note the stand was pruned before the photos were taken. In the 'after' shot, the stand has been marked for thinning treatment.

- Prune judiciously around the work site to create safer work conditions while leaving some branches for diversity.
- Connect CWD pieces (think like a vulnerable salamander, frog, mouse or snake)
- Place pieces next to old stumps, where residual mychorriza might reside.
- Keep pieces as intact as possible. Much of the function is in the structure (Hammond, personal communication).
- Move all decay classes (even mushy 4's and 5's).
- Try to maintain the same orientation of the piece with respect to moss, fungi and vegetative growth.
- Avoid placing wood on top of existing vegetation or otherwise disturbing it as these microsites already have a developing ecological structure and function.
- Place a piece to take advantage of micro topography to maximize surface contact, thus promoting decay.
- Place some pieces on top of others (variety, insectivore foraging sites).
- Be artfully chaotic with piece placement.
- After dismantling the windrow, plant appropriate native species in disturbed windrow sites.

The application of our restorative treatments including thinning, creating snags, and distributing CWD has already produced dramatic beneficial effects on this former plantation site.

Monitoring

As we strive to diversify the plantation stand so too have we tried to be creative with the development of our monitoring protocols for DL 63. Monitoring this project serves a dual purpose: to determine whether our work has been successful and to indicate or trigger subsequent restoration treatments that may be required to ensure restoration success. Quite simply, reference ecosystems, restorative treatment, monitoring and adaptive management are all part of the integrated cycle of ecological restoration. Our monitoring techniques range from highly intensive and specific to general anecdotal observations.

Figures 7, 8 and 9 show where our initial restoration efforts have been focused and also highlight the intensive baseline mapping we have produced. By laying out a grid in this area and mapping each 20x20-m quadrate, we have been able to produce a detailed "before" picture of over 4 hectares of the forest, stump by stump, tree by tree. With this degree of detail we will be able to overlay a map of our treatments, and at any time in the future the grid could be reestablished and remapped, allowing the production of map overlays to show transformations that have taken place. We will reproduce this type of mapping within a 7-ha control site for future comparative analysis.

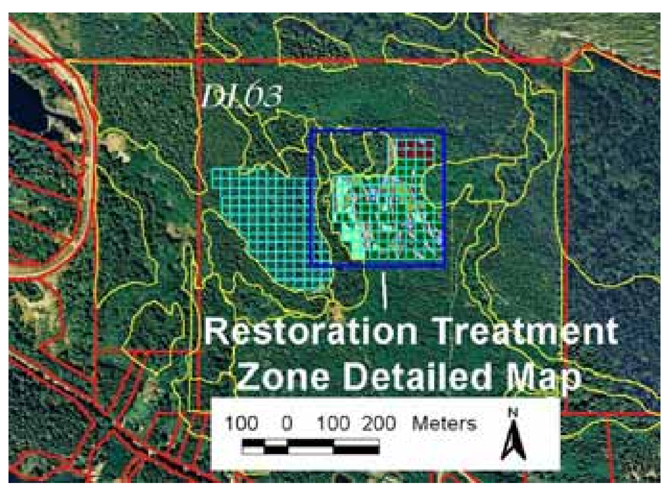

Figure 7. Treatment map for DL 63.

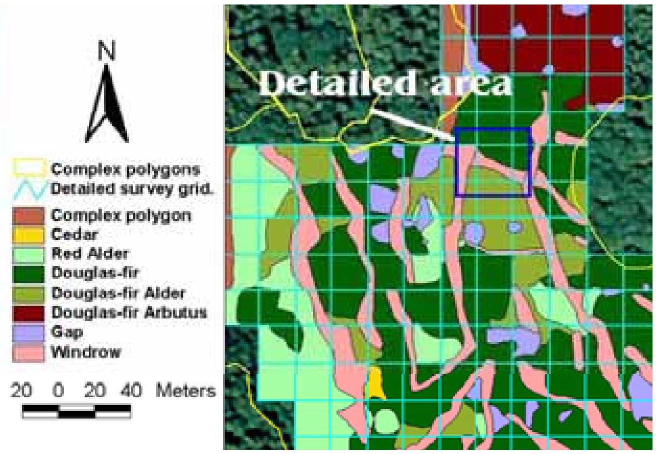

Figure 8. Grid map of DL 63.

In addition to the initial baseline map, our monitoring includes permanent photo monitoring points, which allow us to visually monitor change at a dozen locations throughout the stand. Photo points include shots taken in the four cardinal directions as well as of the canopy. Five permanent plots established within the 4-ha treatment site will monitor vegetation, tree mensuration and canopy data as well as forest floor development and coverage. We are also observing wildlife sign and decay rates in snags, and we have already been rewarded by observation of pileated woodpecker (*Dryocopus pileatus*) foraging on our erected snags. Within the permanent plots all placed CWD has been measured and tagged, and notes on decay class and percent coverage of vegetation have been recorded.

We will be establishing a monitoring trail through the treatment area where a person could record anecdotal data from within the stand and take photos at key monitoring points along the way. In this way a less intensive more frequent monitoring regime could watch for wildlife sign, tree decay, natural regeneration, exotic species and other possible responses to our restoration treatments.

The range in degree of intensity in our monitoring design gives the project the flexibility to evolve in accordance with the responses observed and the reality of available energy and resources into the future. Ideally an appropriate monitoring regime timeline might look as follows:

- Anecdotal monitoring annually for first 25 years, then biennially, depending on restoration treatment and results of observations.
- Complete photo monitoring biennially until otherwise decided.
- Permanent plots repeated every five years for first 25 years and then every 10 years.
- Re-establish the 4-ha grid and re-map stand structure and vegetation every 25-50 years.

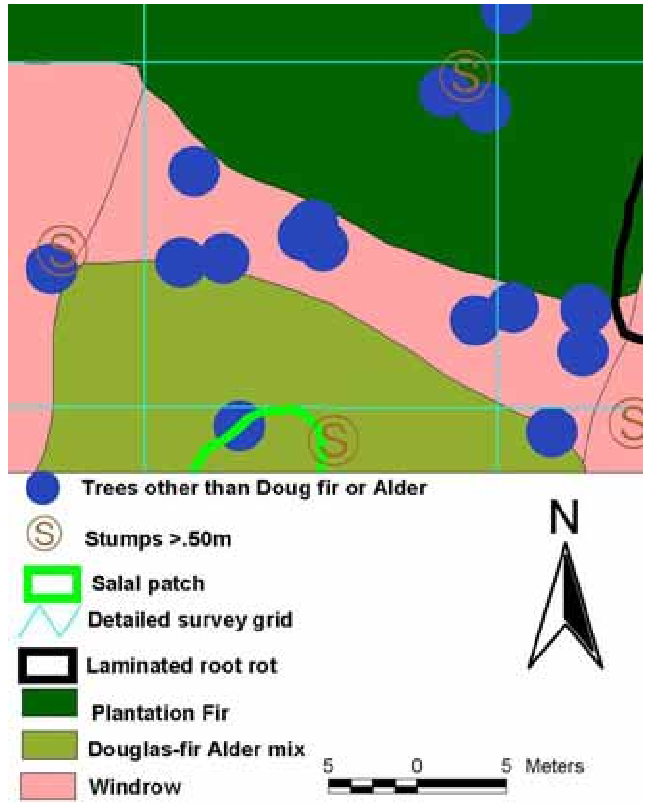

Figure 9. Fine-scale mapping of treatment area. Detailed information about each mapped stump and tree is maintained in a computer database.

The first 10-20 years of monitoring the project will be more intensive as this is the key period when adjustments and repeat, or response, treatments may be required. Exotic species such as Himalayan blackberry (*Rubus discolor*) and Scotch broom (*Cytisus scoparius*) are common on disturbed sites on Galiano Island, and we must be vigilant that they do not become established in the gaps we create. More troublesome, shade-tolerant exotics, including English holly (*Ilex aquifolium*), English ivy (*Hedera helix*) and spurgelaurel (*Daphne laureola*), must command an immediate control response to make sure they do not get established in the stand. Observing recruitment of native trees and shrubs will be an important aspect of monitoring. Gaps created by thinning treatments will close up, and likely this will be an indicator of the need for future thinning treatments. As the culled trees decay and fall we need to respond with future culls as larger diameter trees become available. Since diversification is the general rule, future treatments need not be planned as a one-time all-inclusive event but may require spot treatments annually depending on site-by-site responses and subject to future observations.

Conclusion

The industrially logged and commercially planted DL 63 site presented the Galiano Conservancy Association with an opportunity for initiating a long-term ecological restoration plan for the forest that would consider the local landscape, reference ecosystems, stand trajectories, ecological anchors and connectivity as its central themes. Our primary restoration strategy involved the rearrangement of existing structural resources within the stand to mimic natural diversity. We further manipulated the planted Douglas-fir stand densities to promote spatial and species heterogeneity while providing for future recruitment of structural features. Guided by the concept of ecological anchors and the integrity of reference ecosystems, we have begun to apply creative and innovative restoration techniques to gently assist these humbled sites to express more diverse structure and composition. Nature's response to clearcutting is diversification, not homogenization, but this response has been impeded through windrowing and silvicultural planting and brushing treatments. We developed manual restoration treatments to mitigate these disturbances without compounding the original damage. Our monitoring program will guide further restoration efforts, entrenching adaptability into restoration and allowing for the projects detailed assessment in the long term. It is hoped that this project will serve as a model for other sites with similar histories of which there is no shortage on Galiano and other regions in the Coastal Douglas-fir Biogeoclimatic Zone and beyond.

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Appendix. Manual Tools and Techniques for Forest Restoration

The process of restoring a plantation forest to a more natural state involves three principal tasks:

- Opening up the canopy for more light
- Distributing coarse woody debris that had been piled or windrowed
- Creating snags for wildlife habitat

In their restoration project on Galiano Island, the Galiano Conservancy Association judged that entering the forest with heavy equipment would only compound the damage already done to the soil system, so they developed alternative manual techniques. This appendix describes techniques and equipment for restoring a plantation forest by hand.

Pulling Down Trees

To open up a dense second-growth forest, you can fell trees with a saw, but toppling trees with the root-wad intact better mimics natural processes, such as wind throw. You can pull down trees up to about 30 cm (12 in) DBH safely by hand with a simple system of cables, snatch blocks, and a chain hoist for leverage.

Setting up the layout

After marking the trees in the block you wish to save, choose a large pivot tree from which to run out a cable (Fig. 10). The idea is to pick a tree that will give a good angle to several trees you intend to pull down. Angled off to one side of the pivot tree, choose a spar tree from which to hang a chain hoist. (For a list of all the equipment you'll need, see the sidebar at the end of this article.) You will run a cable from this tree, through a snatch block on the pivot tree, and then out to the tree to be pulled. With planning you can use one spar tree for several pivots and one pivot for several pulls. The time you spend planning this layout will pay off in minimizing setup changes and damage to remaining trees and in keeping the operator safely away from the falling trees.

Setting up the pivot

The pivot tree can be one that you intend to save or one that you'll cull later. If you will pull it or girdle it for a snag, you can anchor the snatch block with a chain, but if you'll be saving the tree, take a loop around the base with the strapping, and shackle your snatch block to that. Keep the block as near the base as possible to give the best angle for pulling.

Setting up the spar

For a spar tree, pick one that you'll eventually be culling so you don't have to worry about scarring it with the rigging. Choose a tree at least 20 cm (8") in diameter and preferably more like 25-30 cm (10-12"). Douglas-fir trees of that size should be able to handle the load safely. Limb the tree to a height of about 4 m (12') and spike one of the angle brackets there, and with the short loop of 5/8" cable, hang the 5-ton chain hoist. At the base of the tree, spike another angle bracket and with a loop of chain shackle a snatch block. A piece of carpet under the chain hoist protects the soil and keeps some of the debris out of the workings of the hoist, reducing maintenance.

You can also rig the chain hoist to pull horizontally. The horizontal rig is simpler, since you don't need to go up into the tree or set a snatch block, but pulling the chain from this position is brutal on the back.

Rigging to the cull tree

Run the long ¾" cable from the lowered chain hoist at the base of the spar tree through the snatch block there, out around the corner block at the pivot tree, and to within a few

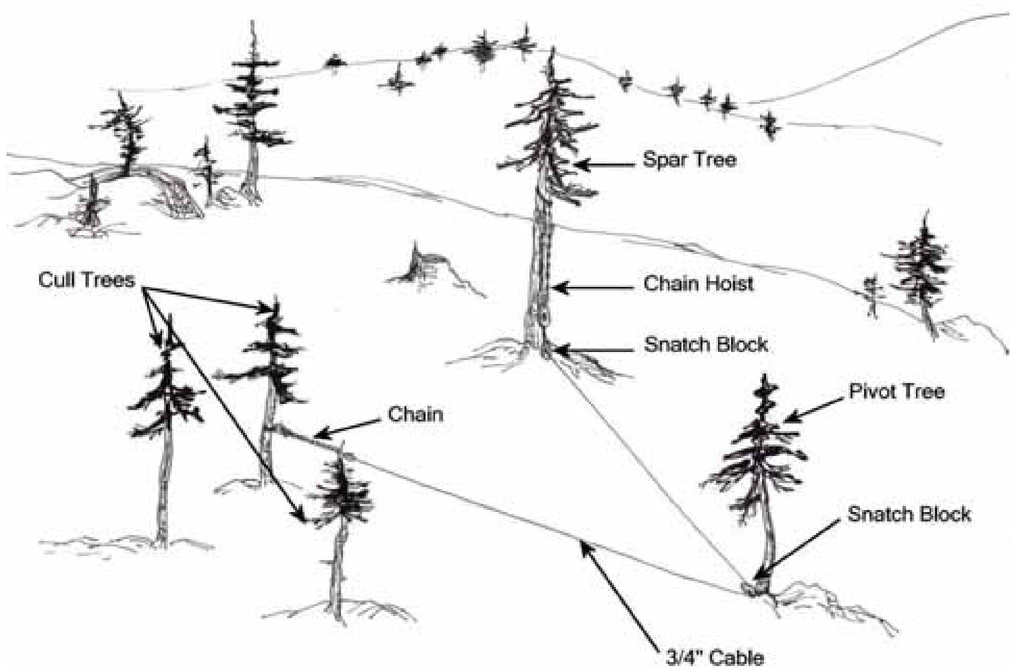

Figure 10. Setup for pulling down trees. *(Illustration by Janice Prevedoros)*

meters of the tree you intend to pull. At that tree, go up about 3 m (9') and take a loop of chain around the stem as a choker. You can vary the height of the pull point to fit the circumstances. A higher pull point gives greater leverage for toppling larger trees but increases the total distance the cable has to travel to bring the tree down and thus creates more work at the chain hoist. Connect the choker chain to the cable (use another length of chain if necessary), cinching the line as tight as possible to reduce the amount of subsequent work at the chain hoist.

Pulling the tree down

Back at the spar tree, start raising the chain hoist. The hoist will put tension on the cable and slowly start to bring the tree down. Roots snap, and the root wad starts to pull up on the tension side. As one person continues to raise the hoist, another should stand behind the pull tree and gauge how it's falling. To guide the tree, the second person can rig a simple side strap with light chains and the 1-ton chain hoist or cable puller to deflect the tree as it slowly comes down (Fig. 11). If there are small trees you want to save in the path of the fall, you can throw a strap on them and pull them to the side enough that their crowns don't get damaged.

Sometimes the tree you're pulling will topple before the hoist gets to the top of its throw, but usually the tree remains standing, at a heart-breaking angle, even after the chain hoist comes to the stop. So run the hoist all the way back down, pull the cable out again, cinch up at the pull point (be careful working around the leaning tree), and start rattling the chain hoist again. Eventually the tree will give up its grasp on the earth and settle into its new role as "coarse woody debris". You can unhook and move onto the next setting.

Figure 11. Kate Emmings uses the small chain hoist to ease the toppling cull tree towards a better fall line. (Photo by Brian Mitchell)

Distributing Large Woody Debris

One of the now-discredited techniques in plantation forestry was to bulldoze into windrows or piles all organic material remaining after logging. Windrows were burned or left to rot, and trees were planted in the scarified soil beside the piles. In plantation restoration one goal is to move the large woody material – logs and stumps – from the windrows and distribute it back over the forest floor.

Setting up the layout

You will be rigging a small skyline, and the log or stump will travel along this line (Fig. 12). Plan a clear path for the skyline, one that will not damage trees you wish to save. Locate a solid spar tree at one end and a tailspar at the other, using your length of ¾" cable to gauge the distance between the two spars. Consider where you'll set your guys. You might take advantage of a gentle slope to let gravity help move the debris, but avoid steep slopes that would make it difficult to control the descent of the debris.

Setting up the spar tree

For a spar tree, choose a cull tree that can handle the load safely. If you must use a tree you want to save, have on hand some steel straps you can nail to the trunk to protect the bark from the rigging. A guyed Douglas-fir tree of at least 20 cm (8") in diameter and preferably more like 25-30 cm (10-12") should be safe for the maximum anticipated working load of five tons. Limb the tree to a height of about 4 m (12') and spike two angle brackets there, and with the short loop of 5/8" cable, hang a snatch block. Above the bracket, take a wrap around the tree with a 24' strap and run each end obliquely back towards two guy trees. Wrap a short strap around the base of each guy tree, and run a chain between that strap and one of the strap ends hanging from the spar tree. For each guy line, use the cable puller to put some tension on the chain, and then cinch it down with a load binder (Fig. 13). The idea is to pre-tension the spar tree so that it remains vertical when you load the skyline. Both ends of the guy strap from the spar should be loaded equally.

Setting up the tailspar tree

Guy a tailspar the same way you rigged the spar tree, except add a third guy directly back from the direction of the spar tree to oppose the force of the skyline. This back guy will shoulder most of the load at the tailspar, so use your heaviest equipment and pay particular attention to the anchor.

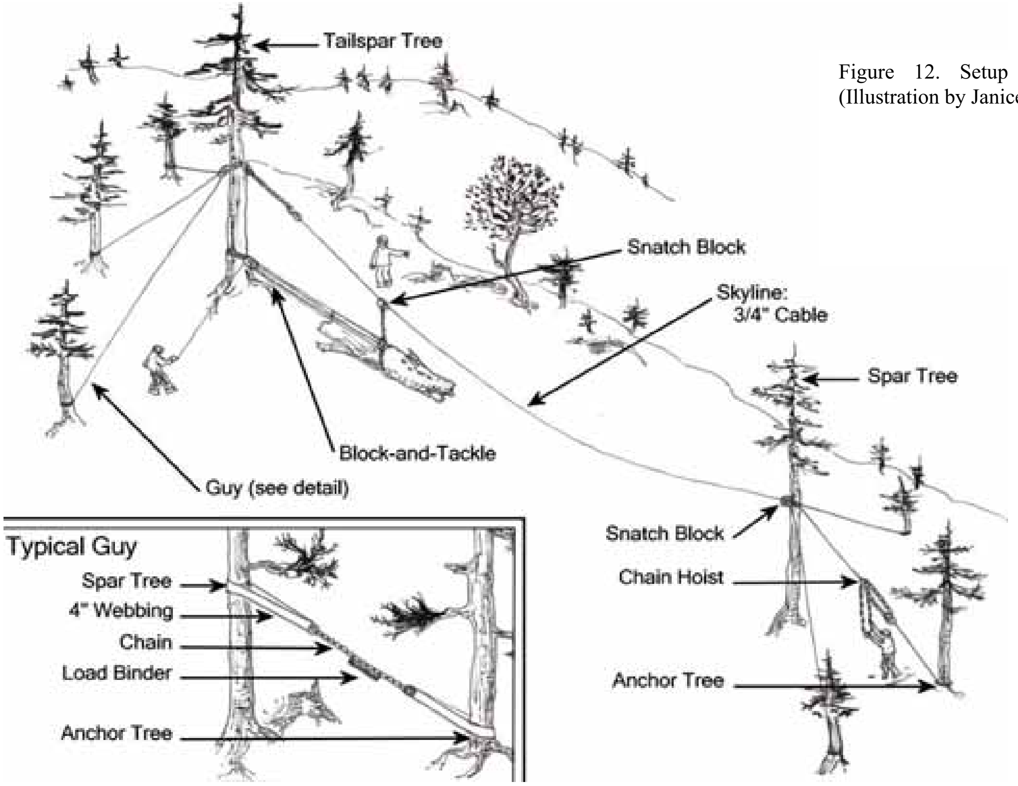

Figure 12. Setup for moving large woody debris. (Illustration by Janice Prevedoros)

Rigging the skyline

From the tailspar, hang a short strap and attach a length of chain and then one end of the long ¾" cable. Run this cable out to the spar tree and up through the snatch block there. From that end of the cable, hang the chain hoist, and take the other end of the extended hoist back to a strap at an anchor tree. Take the slack out of the cable by adjusting the chain near the tailspar.

Now take a turn of heavy chain as a choker at the balance point of the log or stump to be moved and shackle the choker to a snatch block. Clip a snatch block to the skyline. Finally, shackle one end of a block-and-tackle to the choker and the other to an anchor tree. When the skyline raises the piece of wood off the ground, it will slide along the skyline on the snatch block, and you will control it with the block-and-tackle.

Moving the debris

With the block-and-tackle snubbed, start pulling on the chain hoist to tension the skyline and lift the log or stump just clear of the ground. To move the wood, one person carefully slacks the block-and-tackle while another guides the log or stump along the skyline (Fig. 14). If the wood hangs on the ground when it settles into the catenary of the skyline, take some more tension on the cable. If the wood hangs on a standing tree, you can rig a Dutchman on the skyline to pull the cable off to one side enough to clear the obstacle. When the wood gets to its new place out of the windrow, snub the block-and-tackle and run out the chain hoist to lower the cable. You can unhook and move onto the next setting.

Figure 13. Odin Scholz tightens the load binder on a side guy. The 4" webbing wrapped around an anchor tree runs up to a length of chain, which is connected to another wrap of webbing at the spar tree. (Photo by Brian Mitchell)

Figure 14. With the skyline raised, Ken Millard guides a stump out of the windrow while Odin Scholz lets out line on the block-and-tackle. *(Photo by Brian Mitchell)*

Raising Snags

In plantation restoration you can create snags by girdling or topping live trees, but often such snags are too small to be of use for some wildlife and decay patterns in girdled trees don't produce as good a habitat as natural snags. For the Galiano restoration project, the Conservancy not only girdled and topped some live plantation trees but also raised to vertical some large old logs, left in windrows from previous logging, to form artificial snags, totems to wildlife (Fig. 15).

Preparing the log and hole

When moving debris from a windrow, choose a fine old log roughly 10 m long to raise as a snag. The log should be solid enough to tolerate the manhandling of pulling it upright without snapping or crumbling and to remain standing for a good many years. If the butt is especially rotten or hollow, trim up from the bottom a few feet to reach solid wood. Winch the log around to bring the butt near where you want to raise it. Maneuver the log to point directly away from the tree you've chosen as a spar, and plan for a clear line for the snag to come up through the surrounding trees. Then dig a hole about a meter and a half deep near the butt. Save the soil layers on a tarp for back-filling in their original strata.

Setting up the spar tree

For a spar tree, choose one that can handle the load safely, as outlined in the section on moving woody debris. Limb the tree to a height of about 4 m (12') and spike one of the angle brackets there. Above the bracket, take a wrap around the tree with a strap, take both ends evenly out towards the snag, and snap on the chain hoist. With a 24' strap take a wrap on the tree just above the other, and set up two side guys, as outlined in the section on moving woody debris. Add a back guy to counter the force of raising the snag.

Rigging to the log

About 3-4 m (9-12') up from the butt, take a turn of heavy chain around the log as a choker and hook this chain to the extended chain hoist. Before you put tension on the chain,

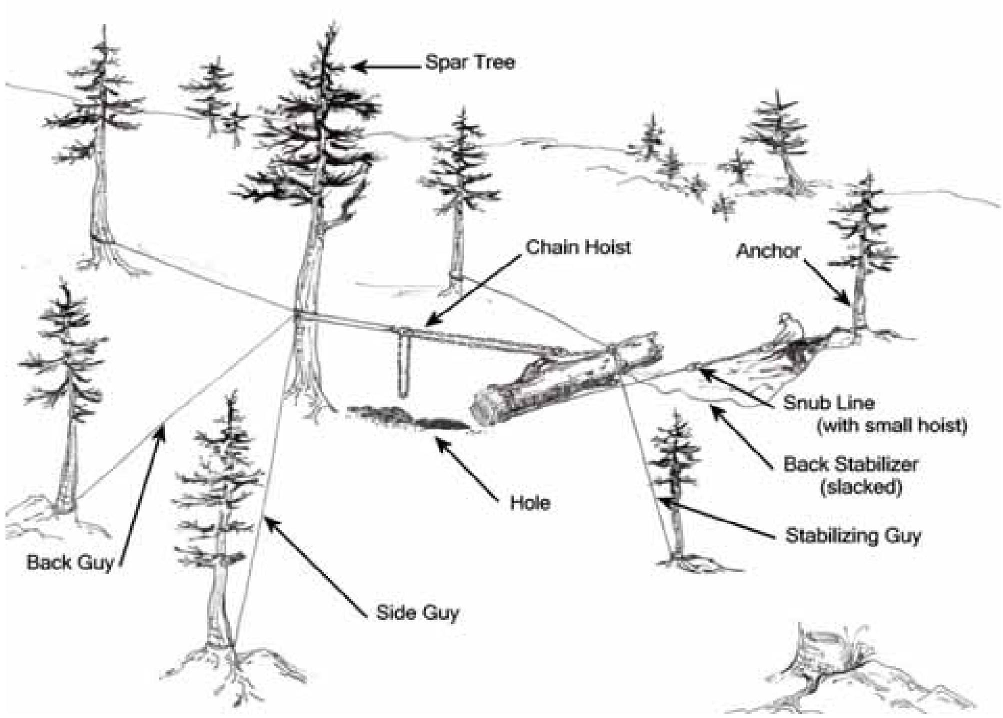

Figure 15. Setup for raising a snag. *(Illustration by Janice Prevedoros)*

though, clip two shackles to it, one on either side of the log. From these, rig side stabilizer guys by running chains to straps around anchor trees. These guys will keep the log from slipping off to one side as it comes up. When choosing anchors for these guys, pick trees that are 90 degrees to the side or a bit back towards the butt. If the guys are too far forward, you will need to loosen them more frequently as the log is raised.

Now throw another loop of chain around the log just a bit more than a meter from the butt, and run a snub line from this choker to an anchor off the end of the log, away from the chain hoist. You will be letting out this snub often, so rig it with the small chain hoist or a block-and-tackle to make the work easier.

Raising the snag

Start hauling on the chain hoist. The chain will drag the butt of the log towards the hole. When the butt passes the edge of the hole, tighten up the snub line. As you continue to haul on the chain hoist, the snag will start to lift (Fig. 16). Monitor the tension on the stabilizer guylines, and loosen them as necessary. They need to be tight enough to keep the snag from wandering but not so tight that they work against the main force of the chain hoist. You might also need to adjust one stabilizer or the other to swing the tree back to center as it comes up. To loosen a stabilizer, first use the cable puller to take the tension off the chain, and then let the chain out a bit and release the cable puller.

When the snag comes off the ground a bit, wrap a single strap around the log near where the chain hoist is attached and run out a back stabilizer. Leave this line slack for now, but as the log comes up, you will use this back stabilizer to keep the log from tipping past vertical.

When the snag comes up to about 30 degrees, start releasing the snub slowly to let the butt settle into the hole. As one person continues to hoist the snag, the other can be releasing the snub until the butt settles into the hole. When you need to adjust the stabilizer guys, though, take a break on the chain hoist. For safety sake, you don't want the snag moving when you're resetting the chains.

When the snag is nearly upright, make small adjustments to the three stabilizers as you pull slowly with the chain hoist to bring the snag to your best approximation of vertical. Then backfill the hole. And if your experience is like the Conservancy's, you'll hear a woodpecker working the snag as you tamp the last shovelful of dirt around the base.

Figure 16. Nathan Gaylor pulls briskly on the chain hoist to raise the snag. *(Photo by J. Azevedo)*

Equipment

For a project such as described here, you will need this equipment:

- Chain hoist with a working load limit (WLL) of 5 ton
- One or more chain hoists with a WLL of at least 1 ton
- Three 6" (15-cm) snatch blocks (WLL 6 ton)
- One 60-foot (20-m) length of 3/4" (2-cm) cable with swaged eyes
- One 4-foot (1.3-m) length of 5/8" (1.6-cm) cable with swaged eyes
- One 20-foot (6.5-m) length of 1/2" (1.25-cm) chain with hooks on each end (Tip: Paint the hooks red to make them easier to find when you drop them in the forest.)
- Five 10-foot (3.25-m) lengths of 3/8" (1-cm) chain with hooks on each end
- Four-inch (10-cm) nylon slings (WLL 3 ton): three 6-foot (2-m), two 12-foot (4-m), and eight 24-foot (8-m) lengths (Tip: Mark the midpoint of each strap with a felt-tip pen to make it easier to even up the strap when taking a wrap around a tree.)
- Various shackles
- Four iron L brackets and short spikes to keep chains from sliding up or down the spar tree (Fig. 17). The Conservancy had theirs cut from angle-iron, but they recommend a sturdier T bracket with a welded brace to keep the tab from bending.
- Five load binders
- Cable puller ("come-along")
- Block-and-tackle
- Wheel barrow
- Loppers or bow saw for pruning
- Extension ladder

Figure 17. A piece of angle-iron keeps chain from slipping up an anchor tree when cable is tightened through the snatch block with a chain hoist. *(Photo by Brian Mitchell)*

Safety Considerations

As with any work in the forest, the job of forest restoration involves certain inherent dangers that require planning, care, and vigilance. Here are a few tips from the Galiano restoration project.

- Keep a first-aid kit nearby on the work site and plan a response in case of an emergency.
- Personal safety equipment: Besides the standard hardhat, leather gloves, and sturdy boots, consider hearing protection when working close to chain hoists. Use eye protection when pruning.
- Match the working load limit (WLL) of all pieces of equipment to be used together. In that way, no one piece of equipment is a weak link. For the Galiano project, the chain hoist was rated at 5 ton, so this was matched with ¾" cable and ½" chain. Smaller chain was used on guys and other less demanding loads.
- Web straps taken around a tree in a simple U have double the rated WLL. If you take a second wrap to keep the strap from slipping, the load must bear evenly on both ends; otherwise you must use the WLL rating of the single strap. Twisting reduces the WLL. As straps age and fray, they lose strength. Moisture and mold speed up the aging, so hang wet straps loosely under cover to dry. Replace old or worn straps.
- Using the chain hoist involves vigorous repetitive motion. To prevent chronic injury, several operators should switch off doing this task, and each one should stretch before taking their turn at the hoist.
- When pulling trees, remember that though the tree is coming down very slowly, it's still coming down. Give it the same berth you would if felling with a saw.
- When moving large pieces of wood, working from upslope to down makes the job easier, but keep a snub on the block-and-tackle to prevent the heavy debris from getting away.
- When raising snags, be especially aware that the deteriorated wood has an unknown strength. Walk around the log rather than underneath to reset guys.