WHAT IS THE BEST RIGGING CONFIGURATION TO USE IN NEW ZEALAND CABLE LOGGING OPERATIONS?

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ABSTRACT

There are a number of cable logging documents which describe the various rigging configurations, but very few provide any detailed information as to what system will be more productive, or safer, under what stand and terrain conditions. The purpose of this study was to interview experienced cable loggers in New Zealand to find out what they knew about rigging configurations and their applications. Fifty people across eight different regions participated in the study including company planners, yarder operators, foreman, and crew owners. The majority of participants had a good understanding of four of the most common rigging configurations; North-bend, Running Skyline (Scab), Highlead, and Shotgun. Results show that the North-bend system was the most commonly used rigging configuration with 48% of individuals stating they used it more often than others. Less often used rigging configurations generated lots of interest and discussion, but knowledge and experience with these configurations was highly variable. Motorized carriages for example were recognized as versatile for long haul distances, broken terrain, and for obtaining full suspension over Stream Management Zones (SMZ's). However, only 4% stated they used motorized carriages most often, and only 28% said they had used them in the last five years. There is often a wide overlap in applicability of rigging configurations, but choosing one to match conditions can be difficult. Perceived advantages and disadvantages of each system are presented in the paper. This study aims to make the configuration selection process easier by sharing the knowledge and experience of industry professionals.

INTRODUCTION

Cable logging practices date back centuries in Europe, but modern cable yarding practices were developed in the late 19th century with the advent of steam powered engines like the Dolbeer Steam donkey in 1881 in Eureka, California (www.ci.eureka.ca.gov). Modern cable logging with integrated tower yarders (referred to as haulers in New Zealand) was introduced into plantation forestry in the 1950's, with the development of diesel yarders, and have continued to be the preferred method of extracting timber on slopes limiting conventional ground based equipment around the world (Kirk and Sullman 2001). Cable yarding is also preferred due to its' environmental benefits over ground based yarding, because the partial or full suspension of logs generated results in minimal soil disturbance (McMahon 1995; Visser 1998). Alternatives, such as modified ground-based equipment and helicopters exist for the extraction of timber on steep slopes. Helicopters are not often preferred due to their high rate of fuel consumption and expensive operating costs. Modified ground-based equipment are limited in their application due to their short economic yarding distance and their difficulty in traversing rough terrain.

Despite its wide use and environmental benefits cable logging is expensive, has tended to have high incidence of accidents to workers, and is generally less productive than ground-based methods of harvesting timber (Slappendel et al. 1993). Even those who have had only a brief introduction to cable logging appreciate that it is more complex than either tractor or skidder logging.

Cable yarding practices can vary widely world-wide, with significant differences in types of machines and the selection of rigging and accessories. Two main regions of significant development include the Pacific North West and central Europe. Cable logging as it is practiced in New Zealand differs in several respects from how it is practiced elsewhere, especially in terms of choice of rigging configurations. The reasons are various, but the nature of Pinus *radiata*, the value of the wood recovered, features of New Zealand's terrain and climate, and the reliance on plantation forestry, are all factors (Liley 1983).

Evanson and Amishev (2010) have investigated new equipment development options to push the limits of ground based machinery on steep terrain. However, as ground based machinery become increasingly dangerous and less productive to operate on steep terrain (> 45% slope); cable extraction of stems still remains as one of the only viable options for harvesting.

When using a yarder for cable extraction the main criteria determining the extraction method to be used is the ground slope or profile, of the area to be harvested (Visser 1998). The first decision made is whether the extraction of timber will be uphill or downhill. Then there are a variety of factors including desired lift, tower height of the yarder, number of drums for the yarder, crew size, and availability of carriages and gear, to name a few, which all determine which rigging configurations can be used. There are about ten different basic cable yarder rigging configurations and literately hundreds of variations when including different carriages and attachments. Therefore, a given stand of timber can be typically be harvested with a range of rigging configurations.

One of the most common challenges in cable logging operations is deciding when and where to use which rigging configuration and furthermore, which gear to pair with the chosen configuration. There are a number of cable logging texts describing the various rigging configurations, like the LIRO Cable Logging Handbook (Liley, 1983), Yarding and Loading by Oregon Occupational Safety and Health Division (OSHA, 1993), and Cable Logging Systems (Studier and Binkley, 1974). There are also many documents which provide detailed information about safety for workers in cable logging operations like the Approved Code of Practice for Safety and Health in Forest Operations (Department of Labour, 1999), the FITEC Best Practice Guidelines for Cable Logging (FITEC 2000), the Cable Yarding Systems Handbook (WorkSafeBC 2006) or OSHA's Oregon Bush Code (OR-OSHA 2008). However, very few provide any detailed information as to which system will be more productive, or safer, under given stand and terrain conditions. Before improvements to current practices can be made, one must first gain a better understanding of the abilities and limitations between the various cable logging systems.

The objective of this study was to determine the current use and applications of rigging configurations and equipment in New Zealand cable logging operations. Emphasis was placed on appropriate rigging configuration selection, given their perceived advantages and disadvantages, as well as some operational variables such as yarding distance and deflection.

METHODS

A questionnaire was developed and interviews were conducted in person from a variety of regions in New Zealand. The rigging configurations referred to in this report are as presented in Studier and Binkley (1974). During visits to active logging operations, forest management offices, and equipment manufacturers, interviews were conducted with the most knowledgeable and experienced person with cable yarding on site. Individuals who contributed to the study had the option to remain anonymous. Basic information collected included; job title, the company they worked for, equipment they owned, and which rigging configurations they were most familiar with. Then the advantages and disadvantages of each rigging configuration were noted. Finally some terrain scenarios were discussed in terms of which rigging configuration might be best suited. Each of the interviews asked the same questions in the same order so that the answers could be easily compared from person to person and region to region.

Interview data was then entered into Microsoft Excel 2007 spreadsheet software. Summary statics as well as graphs and tables were then generated for each of the interview questions using functions within excel.

RESULTS AND DISCUSSION

Survey Participation

A total of 50 interviews were conducted, from eight different regions in New Zealand and one region in the United States. Most (52%) were from the North Island, although Otago/Southland on the South Island was equally one of the most heavily sampled regions (20%). The majority of interviews were with crew owners who acted as foreman, followed by company planners, crew foreman, and yarder operators. Interviews were also given to equipment operators and in some cases crew owners not onsite with their logging crews.

Use and Knowledge of Rigging Configurations

When asked which rigging configuration they most often used 48% stated North-bend, while the second most common configuration was Running Skyline followed closely by shotgun carriage (Figure 1). Despite North-bend's popularity most had used various rigging configurations recently.

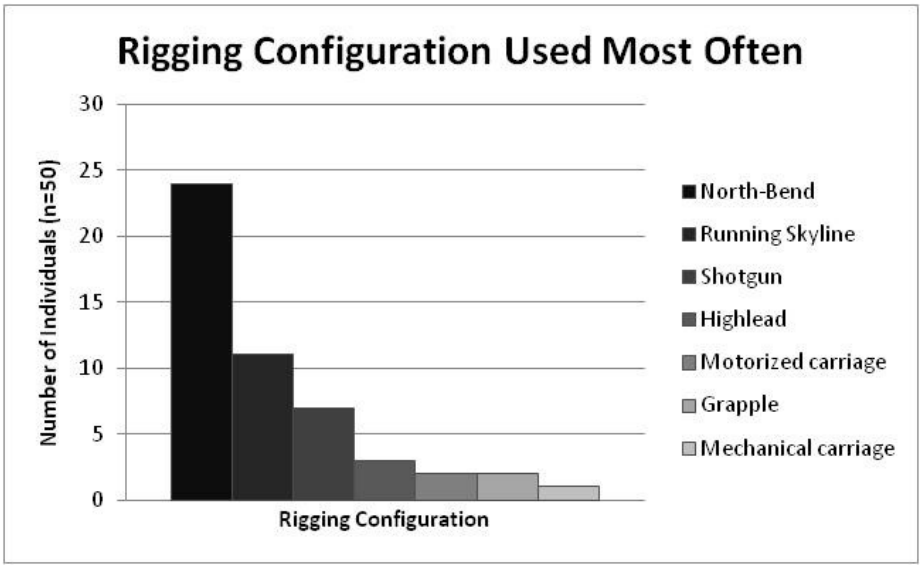

Figure1: Rigging configuration most often used by survey participants.

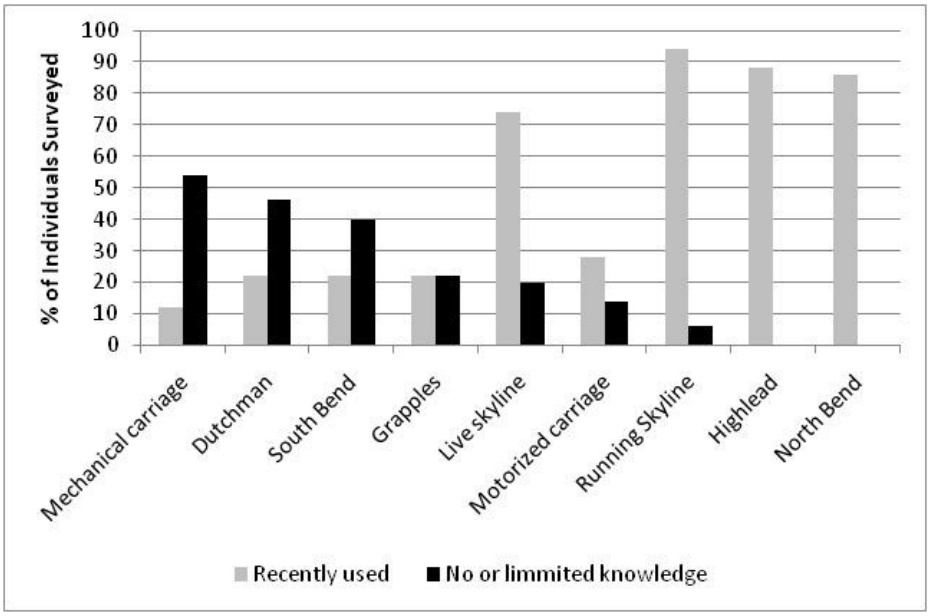

Figure 2: Study participant's recent use of various rigging configurations, as well as configurations and equipment which survey participants stated they had no or limited knowledge of.

More than 70% of survey participants said they had used Highlead, Running Skyline, North-bend, and Shotgun carriages within the last five years. However, it's interesting that 28% or less said they had used any of the other rigging configurations, including either motorized or mechanical carriages, within the last 5 years (Figure 2). Survey participants may be less likely to use alternate rigging configurations depending on terrain suitability or availability of personnel and equipment. However, the results indicate that perhaps they are deterred from using alternative rigging configurations because of their lack of knowledge or experience (Figure 2). The rigging configuration that most study participants (54%) said they had limited knowledge or experience with was mechanical carriages, which corroborates with only 12% saying they have used one in the last 5 years. Other configurations and equipment that

individuals stated they had limited knowledge of were Dutchman, South-bend, and Grapples, all of which had limited use by study participants over the last 5 years.

A separate section of the interview asked participants about their experience and knowledge with swing yarders. The most recent survey indicates that about 25% of all yarders currently operating in New Zealand are swing yarders (Finnegan and Faircloth, 2002). 46% of the participants were familiar enough to discuss them in detail and only some of them owned or used one. While, 16% claimed they didn't know much about them at all or had never seen one working. This may explain why less than 25% of individuals have used a grapple in the last five years (Figure 2). Although many of the rigging configurations previously mentioned can be setup up with an integrated tower yarder or a swing yarder, some configurations like grapples are almost exclusively used in New Zealand on swing yarders. Many indicated that swing yarders were advantageous for short haul distances and their ability to work on small landings rotating and landing wood to the side out of the shoot. Concerns with swing yarders were with their relatively short tower height and complexity, as well as their high cost.

Advantages and Disadvantages of Common Rigging Configurations

Brian Tuor, a consultant and trainer currently lives in Oregon but has worked extensively in New Zealand, concluded his response with the following statement:

"In my experience, systems are often chosen not based on any or all of the criteria but on what the crew knows and are familiar with. This is not always bad, because given the wide overlaps in applicability of the systems, a crew is often more productive and safer using the system they know and are familiar with, rather than trying to learn and adapt to a new system. However this tendency keeps the crews from learning new and often more appropriate systems."

Some of the most informative and interesting results came from the discussions about the advantages and disadvantages associated with different rigging configurations and equipment. The following tables summarize these findings for the four most often used rigging configurations; Highlead, Running Skyline, North-bend, and Shotgun carriage. Responses were grouped during the analyses phase, and only those where three or more of the interviewees noted a similar advantages or disadvantage is presented.

Highlead

The most common advantages of Highleading were the simplicity in operation and setup, as well as its ability to function when there is limited to no deflection which prohibits most other configurations from being used (Table 1). Despite the advantages, Highleading's lack of lift poses a problem for the level of ground disturbance, breaking of gear and stems, and productivity (Table 2).

Table 1: Advantages associated with highleading.

Response	#
Quick to setup/Simple to operate	25
Good when there is limited deflection	19
Easy line shifts/No skyline	11
Good for short hauling distances	9
Ability to pull from blind areas	9
Productive system	8
Good last resort when nothing else works	7
Cheap system to run/Less expensive yarder	4

Table 2: Disadvantages associated with Highleading.

Response	#
No lift/Rigging drags on ground	31
Ground disturbance	17
Little control of drag/Drags get stuck/Breakage	19
Slow pulls = low productivity/Low Payloads	17
Rope wear	9
Chains tangle	7
Hard on breakerouts/Hazardous to workers	4
Fuel use is high	4
Loss of hp power due to breaking tail rope	4
Limited to short distance/terrain conditions	4

Running Skyline (Scab or Grabinski)

The second most commonly used of all configurations was Running Skyline, which many prefer because like Highleading it is simple to setup and run, but it provides more lift (Table 3). The ability to make quick line shifts especially when using a mobile tail hold, and the increased lift is thought to increase overall productivity making Running Skyline one of the popular rigging configurations. Although Running Skyline is relatively quick concerns came with the configuration's payload capacity and yarding distance, as well as functional problems with gear such as line wrapping, rope wear, and brake wear. Its improved lift over Highlead is good but, often isn't enough to minimize soil disturbance or to be suited for all terrain conditions (Table 4).

Table 3: Advantages associated with Running Skyline (Scab or Grabinski).

Response	#
Simple/Quick setup & line shifts	30
Productive/Quick	19
Simple to operate/less skill required	17
Less ground disturbance/More lift than highlead	11
Minimal deflection required/Good for short distances	7
Easy to get slack in rope/Easy to land gear	4
Gear elevated off ground/Less rope wear	3
Can downhill yard	2
Less hp required/More pulling strength	3
More control over drag	3

Table 4: Disadvantages associated with Running Skyline (Scav or Grabinski).

Response	#
Rope wear & tangle/Gear break	17
Brake wear/Pulling against self/Tail pull	10
Short distances/Terrain limited	11
Lack of lift/need good deflection/need tall tower	14
Productivity/Smaller Payloads/More hp required	10
Fuel consumption	6
Soil disturbance	5
Lots of line shifts/Line shift time without mobile tail	3

North-bend

The most commonly used rigging configurations was North-bend, primarily because of its' versatility and ability to lateral yard due to bridling. Other common advantages were its robustness because crews find it hard to break and it's easy on the yarder and ropes, while still having good productivity and payload capability (Table 5). Despite being the most popular rigging configuration there were many disadvantages stated about the configuration. Most of the disadvantages had to do with longer setup time as well as longer and more complicated line shifts. The temptation to bridle to far often resulted in lower production and higher operating costs were of concern (Table 6).

Table 5: Advantages associated with North-bend.

Response	#
Bridling capability/Lateral yarding/Versatility	25
Increased lift/Less soil disturbance	23
Productivity/Good payloads	18
Easy setup and rope shifts/Simple to operate	11
Robust/Hard to break/Easy on machine & ropes	8
Good control over drag/Getting around obstacles	8
Good for long distances	3

Table 6: Disadvantages associated with North-bend.

Response	#
Longer skyline shifts/Tempted to bridle too far	12
Longer setup/Cost of operation	11
Production	8
Hard to drop gear to right location for hook-up	7
Suspension/Less control over drag/Breakage	6
Walk in & out for breaker outs	5
Lack of skill	5
Rope wear	5
Overloading hazard/Pull out stumps	4
Blind leads/Deep gulley's	4
Long distance yarding	3
Landing and unhooking	3
Rider block and fall block hit together	3

Shotgun

Another one of the most commonly used configurations was live skyline with a Shotgun carriage. This configuration is very popular among users because highly regarded as the cheapest configuration to run due to its' limited fuel use. It is also very simple to operate and setup, productive, and tends to maximized deflection and payloads. It has good suspension of logs which often makes it a useful choice to fly logs over creeks or around obstacles (Table 7). Some of the disadvantages with this cheap configuration to operate are the expensive maintenance due to brake, rope, and gear wear. The configuration is also limited to terrain where you have a steep enough cord slope for gravity to outhaul the carriage. Although the concept is simple there is a hazard of overloading the skyline and therefore you need to have good communication and breaker outs need to be well trained (Table 8).

Table 7: Advantages associated with Shotgun.

Response	#
Maximizes deflection & payloads/Full suspension	19
Fuel use/Cheap to run	17
Productivity/Quick	16
Easy setup/Simple to operate	14
Less hp required	3
Easy on breaker outs/Easy to land logs & drop gear	3

Table 8: Disadvantages associated with Shotgun.

Response	#
Limited to terrain/Can't do back face without slack line	13
Brake, rope, & gear wear	7
Complicated/Harder line shifts	6
Overloading hazard/Need good communication	6
Deflection/Soil disturbance	6
Productivity	4
Hard to get caught drags unstuck	4

Variables for selecting the appropriate rigging configuration

Yarding distance

Through the interview process we noticed that one commonly used factor for determining the appropriate rigging configuration is haul distance. Some rigging configurations like highlead are better suited for short distances while others are better suited for long haul distances. However, defining what is a short and what is a long haul distance proved to be a challenge. Most participants in the study would agree that somewhere around 300 meters or less is a short haul distance (Figure 3). When it came to determining what a long haul distance, responses varied even more. Most stated that more than 300 meters was long, but many would state that a long haul distance is greater than 400 meters and some would even say 500 (Figure 3). The results suggest that maybe we don't understand these configurations at the 100 meter level of resolution or maybe there are more factors that come into play.

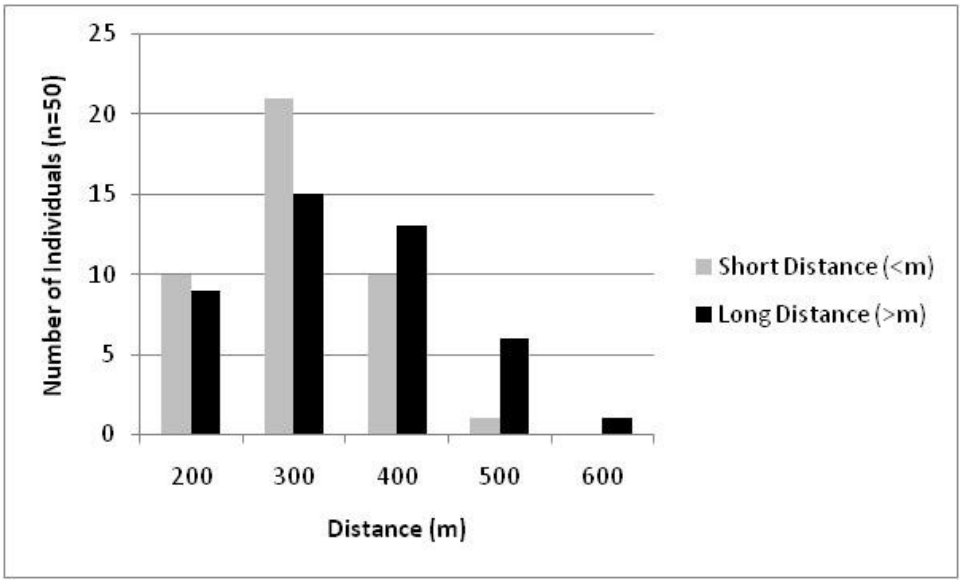

Figure 3: What survey participants perceive as a short and as a long cable logging haul distance in meters.

When asked which rigging configurations were preferred for short and long hauling distances the answers again varied. Most individuals (32) would agree that Running Skyline would be a good option for short distances. Other than Running Skyline there were a variety of configurations that participants stated would work well for short haul distances including,

shotgun, highlead, grappling, and even North-bend (Table 9). Statements on the preferred configuration for long haul distances were heavily concentrated to 3 different configurations. Half or more of individuals interviewed would agree that North-bend or shotgun are probably best suited for long distances followed closely by motorized carriages (Table 9). The choice of motorized carriage is interesting to note since only a few individuals stated they used them most often, and less than 30% say they have used one within the last 5 years.

Table 9: Participants preference in rigging configurations for short and long haul distances.

Rigging System	**Short (#)**	**Long (#)**
Running Skyline	32	9
Shotgun	19	25
Highlead	15	1
Grapple	13	2
North-Bend	12	29
Motorized carriage	7	15
Slackline	2	7
Mechanical carriage	1	2

Yarding direction

Yarding direction is another main criterion for determining which rigging configuration to choose, since some configurations are not mechanically capable or are inherently dangerous to operate when pulling downhill. When participants were asked which configurations they preferred for pulling uphill the results were similar to which systems they use most often (North-bend, Shotgun, Running Skyline) this is most likely because most of the time they are yarding uphill. However, again note the preference to use a motorized carriage which are not commonly used yet 15 individuals said would work well (Table 10). For downhill yarding the preferences were concentrated to mainly two different configurations, Running Skyline and North-bend (Table 10). Most individuals said Running Skyline would work well and was preferred due to its simplicity, but many would also prefer North-bend for a little more control of the drag. Highlead and grappling were also common answers, highleading is not ideal due to associated ground disturbance, and grapples usually require the use of a swing yarder which many individuals do not possess.

Table 10: Participants preference in rigging configurations for uphill and downhill yarding.

Rigging System	**Uphill (#)**	**Downhill (#)**
Shotgun	34	0
North-Bend	19	20
Motorized carriage	15	2
Running skyline	7	32
Grapple	4	9
Highlead	3	10
Mechanical carriage	2	0
South-Bend	2	1
Slackline	2	6

Deflection

Deflection is probably one of the leading criteria for appropriate rigging configuration selection, since it ultimately dictates ground clearance and payload capacity. Often deflection is expressed as a percentage of the span length with low deflection being less than 6%, and high deflection being greater than 15%. When asked which rigging configuration was preferred given deflection alone the top four responses consisted of only six different rigging configurations (Figure 4).

Highleading was most popular for low deflection scenarios since it often works well with little deflection where others do not, and coincidentally it is not even considered when deflection is high or extreme. Running Skyline was the second highest choice for both low and medium deflection scenarios but then becomes less popular as deflection increases. North-bend was a popular choice and results show how versatile the configuration is since it was preferred in almost any deflection scenario. Although north-bend may be difficult to operate in low deflection settings, it is still most preferred configuration in medium, high, and sometimes extreme deflection settings. The shotgun configuration is another that works given most types of deflection. Shotgun never seems to be the first choice but higher consideration is given to the configuration as deflection increases. Grapples are considered to be preferable in any scenarios other than low deflection, but are less popular than other most likely due to other variables, but also because many crews do not own swing yarders which they are commonly used with and the limited experience and knowledge surrounding them. Most interesting to note was the preference for motorized carriages, which were selected for all deflection scenarios except for low, but again are not as widely used as other configurations. Motorized carriages appear to have a growing preference as deflection increases, and are the most preferred in extreme or very high deflection scenarios.

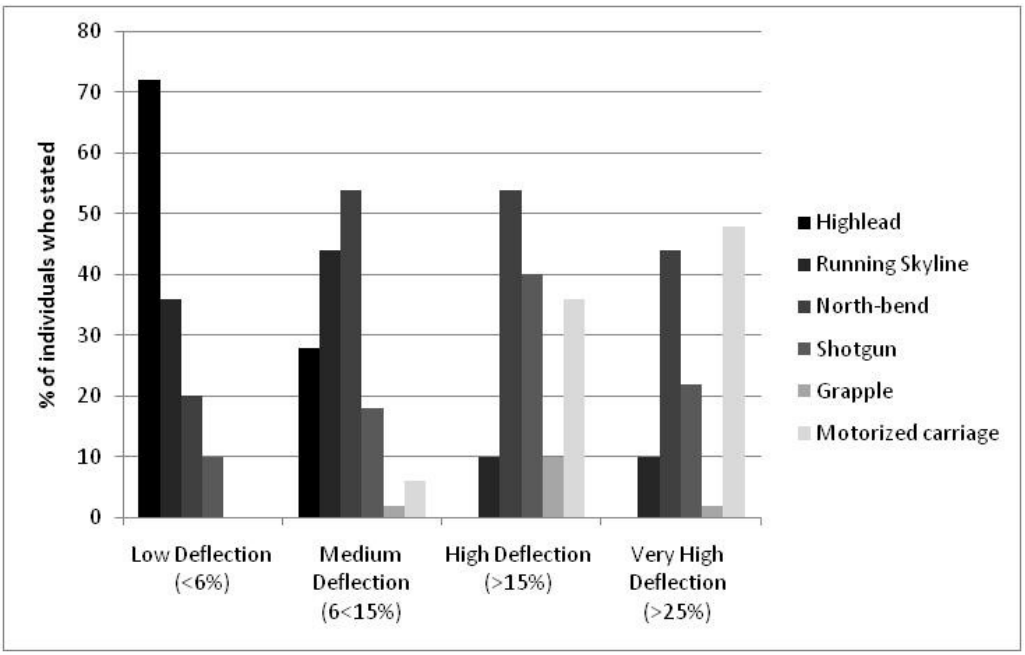

Figure 4: Participants preference in rigging configuration given percent deflection.

Operational constraints scenarios

Part of the interview process asked individuals which rigging configurations had the ability to handle certain operational constraints or challenges. Excluding all other variables participants then stated which configurations they thought would work best given the scenario.

Pulling across broken terrain or incised gulleys

Inconsistent terrain is a common challenge face in New Zealand cable logging operations. Sometimes crews have to pull across several incised gulleys or small ridges. This often times requires the load to be raised and lowered during inhaul to navigate potential obstacles. Most participants stated that North-bend was their preferred rigging configuration for this scenario, but motorized carriages were also given strong consideration (Table 11).

Having to pull away from or around a native bush boundary or other obstacle

Native tree species are not allowed to be harvested in New Zealand so any native patches of trees have to be protected and all operations are required to work around them. Pulling away from or around obstacles like native bush boundaries or rock faces often requires the configuration to have a lateral yarding capability. Again North-bend was the preferred choice for most participants due to its bridling capability. Motorized carriages were also highly regarded due to the slack pulling capabilities which allows them to lateral yard (Table 11).

Ability to fly trees over a watercourse or stream management zone (SMZ)

Best management practice guidelines in New Zealand prohibit trees from being yarded through or drug across any major watercourse. The only acceptable way to yard across a watercourse is obtained through full suspension of the load, so there is no ground disturbance. Success if often determined by the ability to hold the load fully suspended during inhaul. Motorized carriages were the most common choice most likely due to their ability to lock the load in place at a given height while yarding across a watercourse (Table 11). North-bend and South-bend were also popular choices due to their vertical lifting abilities. However, the bend systems pose a slight challenge where the load can be unexpectedly lowered during inhaul if there is insufficient tension in the tail rope (haul back).

Table 11: Participants preferred rigging configuration for yarding across broken terrain.

Rigging Configuration	Across Broken Terrain (#)	Around Native Bush (#)	Over SMZ (#)
North-Bend	27	33	15
Motorized carriage	16	21	33
South-Bend	6	8	14
Slackline	5	3	9
Highlead	4	2	0
Shotgun	3	2	2
Running Skyline	2	1	3
Grapple	1	0	1
Mechanical carriage	1	1	0
Block in the Bight	0	3	0

CONCLUSION

This study discussed the responses and opinions of 50 individuals practicing cable yarding in New Zealand at a professional level. The majority of these individuals were crew owners acting as foreman, followed by company planners and crew forman. The most widely used rigging configuration was North-bend followed by Running Skyline (scab), shotgun, and highlead. Less than 30% of participants use other configurations outside of these four in the last five years. More than half of individuals interviewed stated they had no or limited knowledge with mechanical carriages, and 40% or more said they also had no or limited knowledge with Dutchman and South-bend.

Although there appears to be dependence on a few common configurations, most participants were interested in, or recognized the potentials of, other configurations. In particular, motorized carriages which were not widely used, but recognized as having great versatility with their ability to work in higher deflection settings, pull across broken terrain, around obstacles, and across water courses. Swing yarders were also of great interest, yet only 46% of individuals could discuss them in detail. They are also recognized as being versatile and can work on small landing and are commonly paired with grapples. Coupling a swing yarder with a grapple was also of great interest, but 20% say they have no or limited knowledge with grapples and only 20% say they have used one in the last five years.

It's clear from the results we have collected that some configurations are more often used than others, and that there are certain advantages and disadvantages associated with each. There are also criteria like yarding distance, direction, and percent deflection which help steer ones decision for selecting the appropriate rigging configuration. However, there is no clear indication as to which rigging configuration is best. This is most likely due to the versatility of certain configurations and the wide overlap of application between systems. In order to guide practitioners towards which system is most applicable given their harvest setting, future research will compare and analyze configurations based on a combination of some of the variables and criteria mentioned in this study.

LITERATURE CITED

Department of Labour. 1999. Approved code of practice for safety and health in forest operations. Department of Labour 1999, ISBN 0-477-03622-8. Wellington, New Zealand.

Evanson, A.W., D. Amishev. 2010. A steep terrain excavator feller buncher. Harvesting Technical Note, HTN03-02. Future Forests Research: Rotorua, New Zealand. 8 p.

Finnegan D. and J. Faircloth. 2002. New Zealand Hauler Census. Unpublished report.
FITEC, 2000. Best Practice Guidelines for Cable Logging. Forest Industry Training and Educational Council New Zealand.

Liley, B. 1983. Cable logging handbook. Published by the New Zealand Logging Industry Research Association. 147 p.

McMahon, S. 1995. Cable logging disturbance on an unstable slope: A case study. New Zealand Logging Industry Research Organization Report 20(12): 9 p.

OR-OSHA, 2008. Division 7 Forest Activities code. Oregon Occupational Safety and Health Standards 2008. Oregon OSHA.

OR-OSHA, 1993. Yarding and Loading Handbook. Oregon Occupational Safety and Health Division, Salem, OR 97310, USA. 184p.

Slappendel, C., Laird, I., Kawachi, I., Marshall, S., Cryer, C., 1993. Factors affecting work-related injury among forestry workers: a review. Journal of Safety Research 24(1), 19–32.

Studier, D.D., V.W. Binkley. 1974. Cable logging systems. USDA For. Serv., Div. of Timber Management, Portland, Oregon. 205 p.

Studier, D. D. 1993. Carriages for Skylines. Research Contribution, Forest Research Laboratory. Oregon State University. 13 p.

Visser, R.J.M. 1998. Tensions monitoring of forestry cable systems, PhD Dissertation from the Forest Engineering Department, Bodenkultur University, Vienna, Austria. 183p.

WorkSafeBC 2006. Cable Yarding Systems Handbook. Workers' Compensation Board of British Columbia. 2006 Edition.

City of Eureka, California History, downloaded 20 Dec 2010 from: http://www.ci.eureka.ca.gov/civica/filebank/blobdload.asp?BlobID=4459