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ENVIRONMENTALLY SOUND TIMBER EXTRACTING TECHNIQUES FOR SMALL TREE HARVESTING

BY

Lihai Wang
(1) Visiting Scientist
Engineering Research Unit, USDA Forest Service
Auburn, AL 36830, USA
(2) Professor
Northeast Forestry University
Harbin 150040, P. R China

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Summary:

Due to large area disturbed and great deal of energy cost during-its operations, introducing or applying the appropriate timber extracting techniques could significantly reduce the impact of timber extraction operations to forest environment while pursuing the reasonable operation costs. Four environmentally sound timber extraction techniques for small tree harvesting, particularly for thinning operations, were presented and introduced in this paper. These techniques included animal skidding and animal-machine, single circulating cable yarding system, small farming tractor, and mini forwarder. The results of evaluation, test or practices indicated that these timber extracting techniques are feasible, applicable and reasonable in small tree harvesting with a relatively low impact to environment and a moderate operation cost.

Keywords: timber extracting, low environmental impact, small tree harvesting

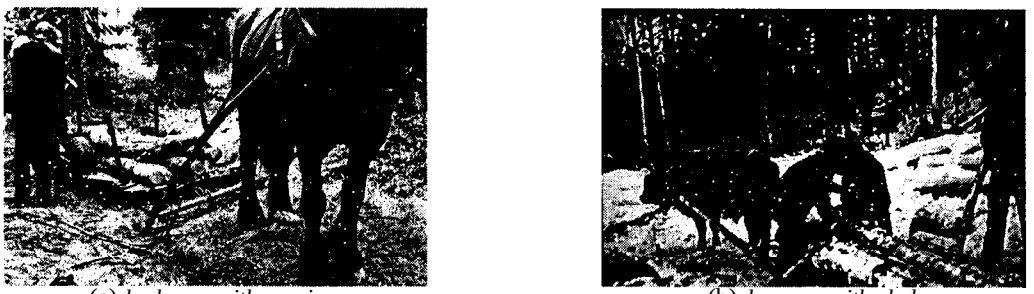
Environmentally Sound Timber Extracting Techniques for Small Tree Harvesting

Lihai Wang

Forest contractors, loggers and engineers have been paying a high attention to timber extraction operations since 1990's. Because timber extracting operation produces the highest proportion of operation costs, largest area disturbed and most residual stands damaged among all operations of small tree harvesting. Therefore, many techniques were developed to meet the requirements of timber extraction in small tree harvesting.

1. Animal Skidding

Animal skidding, one of timber extraction methods, which is powered by animals rather by machines, uses some special devices such as sledges and carriages as shown in Figure 1 to reduce the resistance and touching area between timber and ground.



(a) *by horse with carriage* (b) *by oxen with sledge*

Figure 1 Animal skidding

The proportion of animal skidding is increasing in many developing countries and some developed countries these years[3,5]. One of the main reasons for this is the environmental constraints. Forest contractors and loggers pay more attention than before while they do harvesting.

1.1 Impact to Soil

It is known from the field surveys that animal skidding has a light disturbance on soil surface. If it happens on the frozen soil which has a high bearing capacity, the trials of animal skidding are quite slight (see *Figure* 2). Therefore there is no significant soil disturbance after logging. If it happens on the normal forest soil, animal skidding causes soil bulk density increased by 50% on the main trails and 5% on the operation site, but those caused by machine skidding are significantly higher than animal (see *Table I).*

Table 1 Changes of soil physical properties caused by animal skidding and ground machine skidding [3]

	By Machine			By Animal		
	Trail	Site	Control	Trail	Site	Control
Bulk Density (g/cm^3)	1.01	0.67	0.59	0.85	0.60	0.57
Capillary Porosity (%)	53.7	60.3	61.8	60.4	62.7	63.1

Table 2 Changes of nutrients in soil caused by animal skidding and ground machine skidding[3]

	By Machine			BY Animal		
	Trail	Site	Control	Trail	Site	Control
Organic (%)	5.56	11.68	14.45	13.70	14.99	18.40
Total N (%)	0.292	0.653	0.745	0.476	0.772	0.790
Total P (%)	0.102	0.118	0.124	0.140	0.170	0.178

(a) *animal skidding site*

(b) *machine skidding site*

Figure 2 Skidding sites after operations

Due to the light disturbance to surface soil, animal skidding does not cause more nutrients in the soil lost after skidding. The results of field survey also showed that more nutrients lost at the machine operation site than those at animal logging site (see ***Table*** 2). One of the main reasons for this is that running water took much more soil on the trails and sites away after heavier disturbance by machine than that by animal logging (see ***Figure 3).***

Figure 3 Soil erosion on machine trails

Figure 4 Damage to residual stands

1.2 Damage to residual Stands

Research indicated that the damage ratio of ground skidding operation to residual stands, under a given density of residual stands, has a high correlation with the width and length of equipment, and the length of hauling logs (assumed at least 100 residual stands per hectare) [7]

$$Y = LW\eta\omega$$

$$\omega = \begin{cases} (\alpha X_1 + \beta X_2^{1/3}\ t\ \gamma X_3^{3/2})D \ldots\ldots (in\ the\ woods) \\ C \ldots\ldots (on\ the\ main\ tracks) \end{cases}$$

Where:

Y— ratio of damage residual stands (%);

X_1, X,-width and length of skidding equipment respectively;

X_3 -maximum length of hauling logs;

L -total length of skidding trials;

W-average width of skidding trials;

η — coefficient of skidding trial extending, $\eta > 1$;

ω — coefficient of damage to residual stands at the disturbed site (%),depending on machine dimensions, hauling logs, density and distribution patterns of residual stands;

D-density of residual stands;

C, a, β, y-constants.

The field survey showed that direct damage ratio of machine skidding to residuals is much higher than animal skidding due to big machine dimensions, high power and low flexibility (see *Table* 3). The residuals heavily injured mean that the stands were broken with trunk or branches or at top, which would significantly hinder or even stop the growth of the residuals or young seedlings. The scraped scores on the trunk or branches were categorized into "lightly injured".

Table 3 Ratio of direct damage to residual stands and young seedlings (%) [3]

	Mean	var	Heavily Injured	Lightly Injured
Machine	38	6.7	18	20
Animal	13	4.3	3	10

1.3 Cost and Efficiency

In the labor intensive countries, cost of animal skidding for small tree harvesting, particularly in thinning operations, is lower than that of machine skidding. But it is opposite in some countries with high labor cost due to big part of labor cost. Of course, it also depends on the operation conditions like cutting method, topography, tree distribution and timber volume removed etc.

If calculated in timber volume removed per person per day, operation efficiency of animal skidding is significantly lower than machine skidding. But it would be opposite if calculated in terms of how much energy input into and how much time on the operations, for example, (timber volume removed • hauling distance)/(HP•hour). It is explicit from the surveys that animal logging is more sensitive than machine skidding to the poor weather conditions, such as cold and hot microclimate (see *Figure* 5). Contractors and loggers have to consider this factor while taking the operation alternatives. And even it is different for the individual animal to have different capacity to the poor weather. For example, mules have higher bearing capacity to hot weather than oxen and horses. Animal skidding does not match well to long distance skidding due to lower payload and relatively low travel speed.

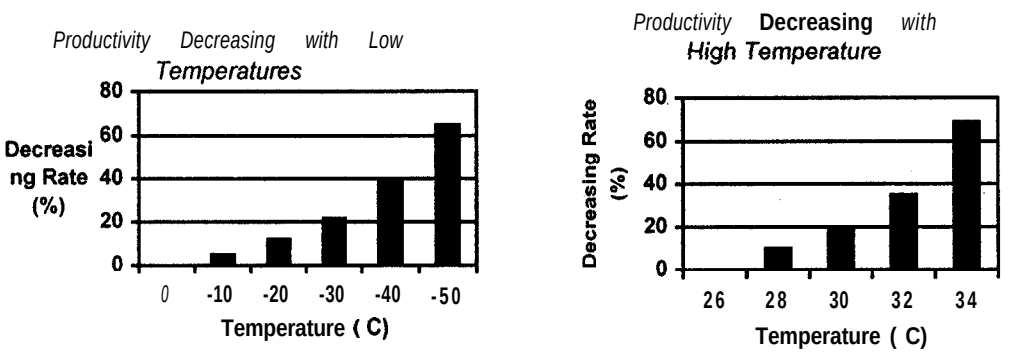


Figure 5 Effects of temperature on operation efficiency of animal skidding

Therefore, the advantages and disadvantages of animal skidding, compared with ground machine skidding, can be derived from analysis above as follows:

Advantages:

- low impact to soil
- low damage to residual stands and young seedlings
- no chemical pollution
- high flexibility

Disadvantages:

- low payload
- low travel speed
- slope limitation (e.g. 28% in China)

- limited accessibility to rocky and swampy woodlots
- more sensitive to poor weather (cold, hot and raining)

1.4 Combination of Animal Skidding and Machine Skidding

The combination of animal skidding and ground machine skidding emerged at the beginning of 1980's in northeast forest region of China due to the poor operation conditions, particularly the long skidding distance and low volume removed per hectare. In the thinning or selective cutting operations, animal skidding was employed for extracting the logs scattered in the woods and rubber tired skidder like CAT528 and J-SO were used for long distance hauling on the main skidding tracks. The log bundles piled by animal skidding, ready for skidder, were along the main tracks, mostly 3-5 kilometers away from landing. This combination worked well in many forestry bureaus because it took the advantages of both animal skidding and machine skidding. But the productivity match must be carefully planned before operations.

2. Single Circulating Cable Yarding System

A new cable yarding technique, single circulating cable yarding system was developed and applied to practices in China and Japan recent years. It is used for extracting the logs at difficult terrain, such as steep terrain, swampy area or rocky belt. The layout of this system is simply shown as Figure 6.

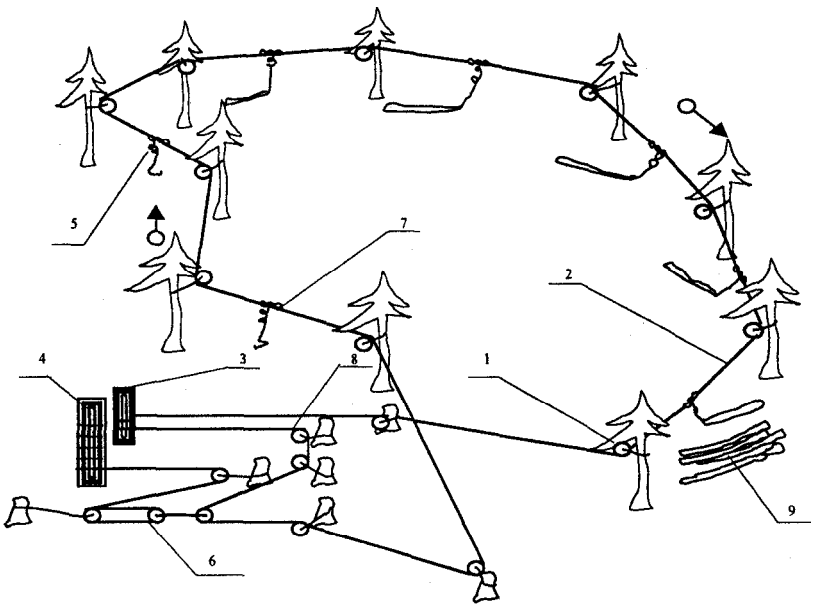


Figure 6 Layout of single circulating cable yarding system
1 — bearing block: 2 — skyline; 3 — driving drum; 4 — adjusting drum; 5 — choker; 6 — adjusting tension system: 7 — connecting chains; 8 -corner block: 9 — logs.

A test for single circulating cable yarding system was carried out in a thinning operation in Xinlin Forestry Bureau, Heilongjiang Province, China. The main parameters of the system are:

- skyline length: 2000 meters
- collecting cable length: 50 meters
- skyline max running velocity: < 0.5 m/s
- max single load: < 1000 kg
- max load on line: < 3000 kg
- numbers of connection of skyline: 40
- number of working crew: 4 people (winch operator 1, unloading operator 1, loading operator 2)

The results of test also showed that (1) this system has a good match to steep slope terrain, slope ranging from 32% to 45%; (2) the bulk density of soil on the main trials of this system is 27% lower than the conventional; (3) ratio of

damage to residual stands was decreased 33% compared with the conventional due to use of special collecting cable set; (4) ratio of natural regeneration per square meter was significantly increased, 25% higher than the conventional on the disturbed area and 50% higher than the crawler tractor skidding site; (5) productivity was 20% lower than the conventional.

The advantages and disadvantages of single circulating cable yarding system were summarized from the test, compared with the conventional cable yarding system:

Advantages:
- ♠ easily install and uninstall as well as move;
- ♠ extending yarding distance;
- ♠ low density of impact to soil;
- ♠ low damage to residual stands;
- ♠ multi-curves for skyline;
- ♠ higher accessibility.

Disadvantages:
- ♣ low payload;
- ♣ low hauling velocity;
- ♣ low productivity.

3. Farming Tractor Equipped with Winch and Simple Tower"'

Forest farmers in Linjiang Forestry Bureau, Jilin Province, China equipped farming tractor with a simple tower and a winch for extracting logs in small tree harvesting. Figure 7 shows the layout of this simple yarding system. The tractor is used both for forest harvesting and agricultural operations. The power of tractor is 55 HP and the maximum payload of yarding system is 300 KG with single load if slope less than 45%. Height of tower is 2.5 meters. The maximum yarding distance is 150 meters. A metal cone cap was used at hauling end of log to reduce the resistance and the damage to both soil and residual stands. About 50% of the operation area was touched by yarding and this also resulted in a quite good natural regeneration after logging. The fresh soil, quite helpful for seeds to land on and grow up, came up after yarding disturbance because the top layer of soil were moved by hauling logs.

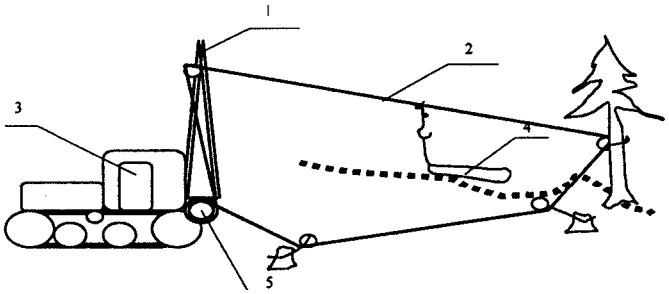


Figure 1 Farming tractor equipped with simple tower and winch
I- simple tower; 2— running cable; 3— farming tractor; 4— log; 5— winch

4. Mini Forwarder

A small forwarder Vimek 606D, equipped with a hydraulic loader, was developed and used in small tree harvesting in Sweden. It was welcome by private woodlot owners since it works well for timber extraction from woods in the thinning and other small tree harvesting.

The data of this mini forwarder as below show that it has a good match to thinning operations[4].

- Engine power: 14.7 Kw (20HP), diesel
- Load capacity: 300 Kg

- Min turning radius: 9.5 meters
- Travel speed: 0 ~ 5.6 m/s
- Width: 1600 mm
- Length: 6000 mm
- Ground clearance: 350 mm
- Total weight: 1960 kg
- Loader length: 3600 mm
- Loading capacity at Max length: 250 kg

It is reported that besides Vimek 606D, there are three other different type of mini forwarders in Swedish market. They are Terri ADT or 2020, Scorpion and Pontus. Vimek 606D, with its simple design, high productivity and low fuel consumption, is a high competitive alternative compared with other mini forwarder [4].

(a) (b)) *Terri 2020*

Figure 8 Mini forwarders[4]

Acknowledgements

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