Factsheet

Rubber-tracked mini-skidders

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RECOFTC
THE CENTER FOR PEOPLE AND FORESTS

Rubber-tracked mini-skidders

RECOFTC - The Center for People and Forests

Bangkok, Thailand

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1. Introduction

The Jonsereds **Iron Horse** (Swedish Järn Hästen) was the first commercially available rubber-tracked mini-skidder (crawler) to appear in Scandinavian forest operations in the early 1980s. It was developed from smaller all-terrain crawlers, originally designed for use in hunting to transport moose and other large game over long distances. The first model was equipped with a 3.7 kw Honda engine. Current models manufactured by Lennartsfors are equipped with 4.0 kW, 6.6 kW and 10 kW engines. Also available are a wide range of accessories, including **manual or hydraulic winches** with 1 000 kilogram (kg) pulling capacities and even a **telescopic loading crane** with a 200 centimeter (cm) reach for the nine and 13 hp models. Depending on their accessories, the cost of the iron horse ranges from US$ 14 000 (9 hp) to US$ 20 000 (13 hp). Smaller models are not recommended for forestry operations due to their limited winching and pulling power.

Load capacity of the iron horse reaches at least 1-1.2 meters (m)2 or about 1 000 kilogram (kg) for downhill and flat terrain extraction. Maximum speed of the Iron Horse is 4 to 6 kilometer (km)/hour (hr). Its track system is designed with different size drive and support wheels and specially manufactured rubber tracks.

Figure 1. A 9 hp Iron Horse with hydraulic winch, sidewise loading boom and log trailer.

To operate the Iron Horse, one person walks in front of the machine and controls its speed and direction with the steering handle. Moving the steering handle sideways changes the direction of the Iron Horse. A brake and an emergency-stopping tool are also located on the handle.

Figure 2. 9 hp Iron Horse with telescopic crane (2-m reach)

2. Variants of rubber-tracked crawlers

In addition to the Iron Horse, the last two decades have brought the development of comparable models such as:

2.1 Myrebak oxen

The Myrebak Oxen is equipped with 11 hp (8.1kW), 13 hp (9.6 kW) or 16 hp (11.8 kW) engines with a winch and loading arm. The Myreback Oxen's track system uses two pairs of three standard, equal-sized rubber tire wheels that are covered with double rubber belts and connected using U-profile steel bars. Load capacity is 1 000 kg, machine width is 1 115 millimeters (mm) and driving speed, which corresponds to walking speed, is 4-5 km/hr. The ex works price of the machine is around US$ 12 000 not including the accessories.

Figure 3. The Myreback Gustafsson-Oxen mini skidder with loading boom and log trailer www.myreback.com

2.2 Kapsen iron horse

The Kapsen Iron Horse is a 13 hp (10kW) powered rubber-tracked machine developed for the Czech market. Its hydraulic power system allows the gradual control of travelling speed, which reaches up to 6 km/hr. The Kapsen Iron Horse also has a hydraulic winch and a log-loading boom and can be equipped with a hydraulic clamp bank for smaller-sized materials (e.g. bamboo) and a log trailer. The machine's loading capacity is 1.5 m^3 and its pulling capacity is about 1 000 kg. The width of the machine is 120 cm and the width of its rubber tracks is 40 cm. Its ex works price is around US$ 15 000.

Figure 4. The Kapsen Iron Horse (www.lesni-technika.cz / reparo.servis@lesni-technika.cz)

2.3 Blatna forest horse mk 18

The Blatna Forest Horse was, like the Kapsen Iron Horse, developed for the Czech market. It is equipped with a Kohler Command 18 hp petrol engine. Its loading capacity is 1-1.2 m^3 or 800-1 000 kg. Its winch pulling capacity is 1 500 kg, the highest capacity of all the models discussed thus far. The Forest Horse has a winch with a cable capacity of 45 m if using a 6.3 mm diameter steel cable; the cable volume capacity can be reduced to 35 m if an 8 mm steel cable is used. The winch can be controlled remotely, which is an important safety consideration for log extraction to the point of loading on the mini crawler. The machine's traveling speed is 4-6 km/hr and its width is 120 cm with 40 cm wide rubber tracks. The *ex works* price of the machine is US$ 22 000.

Figure 5. Blatna Forest Horse MK 18 (from www.engineeringblatna).

Figure 6. Hitachi CG 8 7hp 800 kg load capacity Irish R pound 9500

Nonriding Utility Vehicle

Wood Dog (Radio Controlled)

Manufacturer:
Isothermal Systems Research (ISR)
511 3rd Street
Clarkston WA 99403
Phone: (509) 758-2613
Fax: (509) 758-1280
E-mail: wbeasley@spraycool.com

Purchase Price: $25,000

Wood Dog.

Status: Ready for production
Prime mover: Wood Dog is a prime mover.
Engine power: 23 hp
Gas or diesel: Gas, 2-cycle
Transmission: Hydrostatic
Width: 46 inches
Length: 6 ft
Height: 4 ft
Ground clearance: 9 inches
Weight: 1200 lb

Ground pressure: ½ psi empty; 3 psi with 4,000-lb load
Turning Radius: Zero
Slope limitations: Empty: sidehill 45°, forward uphill 60°, forward downhill 50°, traction dependent. Loaded: load dependent.
Track width: 15 inches
Track options: Bolt-on rock or ice cleats
Hydraulic pressure: (minimum) 1,500 psi, auxiliary circuit
Flow: 4 gpm, auxiliary circuit
Radio control distance: 300 ft
Drawbar pull: 4,000 lb
Dedicated attachments: Three designs of fireline trenchers are under development: Chain flail trencher, rotary disk plow trencher, combination chain flail/rotary disk trencher. Contact manufacturer for information on other attachments.

3. Related machinery

It is worth mentioning that there are currently three related Swiss models of self-propelled winches on the market: 1) Alther Raup trac with a 48-hp Kubota engine and a 4-ton winch (www.martin-alther.ch); 2) Wicki Forst Raupe with a 55-hp Lombardini diesel engine, an Adler 4-ton winch and a rope capacity of 150 m (www.wickiforst.ch); and 3) Aggeler Forstraupe with a 33-hp engine, a 4-ton winch and a rope capacity of 100 m (www. Aggeler.ch). All three machines cost over US$ 30 000.

Figure 7. Alther Raup track rubber tracked forwarding winch (www.martin-alther.ch).

3.1 Rubber-tracked mini-crawlers manufactured locally from rice-harvesting machines

There is a wide range of rubber-tracked rice harvesting machines available in Southeast Asia, some of which can be converted into small forestry forwarding machines. In 2011, under RECOFTC – The Center for People and Forest's Enhancing Livelihoods and Markets thematic program, a Yanmar 9-hp rice thresher (see Figure 8) was converted into a mini-crawler/skidder by turning the engine on the chassis, moving the break controls forward onto a 1-m steering arm and arranging the gear system in a reverse position. The mini rubber tracked –crawler/skidder has a maximum groundspeed ranging from 3-4 km/hr and its loading capacity, without any log trailer support, is 600 kg on flat terrain. The machine has a special loading device with spiked vertical claws that prevent smooth bamboo from sliding off the clamp bank and has a drive shaft allowing the attachment of a spill winch and the possibility to increase speed through changes in gear ratio in the transmission belts. Similar machinery can be built for around

US$ 3 000, where about US$ 1 200-1 500 is spent on purchasing used rice thresher machines, while US$ 600 to US$ 800 is spent on mechanical conversion work.

Figure 8. The Yanmar 9HP rice thresher before conversion, note the white handle for forward movement of the machine

Figure 9. Kubota Rice harvester (3 cylinder diesel 18 hp) rubber-tracked base (www.plunkettorchards.com.au).

Figure 10. Hitachi CG 8 mini-dumper

Figure 11. Honda TD 500 (650) mini-dumper

Figure 12. Yanmar bamboo crawler with engine in reverse position and clamping device for bamboo poles

4. Productivity and efficiency in timber extraction

4.1 Nordfjell (1994)

Nordfjell (1994) carried out a thinning study on flat terrain in Sweden with the Jonsereds Iron Horse in a 26-year-old spruce forest. Extraction distance to strip roads was 80 m for loading onto grapple-loading forwarders. Mean volume for thinned trees was 0.06 m3 with an average load size of 0.68 m^3. Harvesting efficiency was 0.71 /m^3/person/hr or 5.7 m^3/person/day, based on an eight-hour shift. The use of the Iron Horse indicated advantages, particularly in pulling down trees that were entangled in neighboring crowns during felling. The performance was similar to motor manual thinning with the manual dragging of logs to strip roads over an average distance of 41 m. The study makes clear that the advantage of the system begins in situations involving large extraction distances where more than 100 m have to be covered.

4.2 UK Forestry commission (2001)

In a study by the UK Forestry Commission (2001), extraction with the Iron Horse was conducted in broadleaf forests (oak/ash/birch) on terrain with a 30 percent slope over extraction distances of about 100 m. Work time included 17 percent for rest and 16 percent for other work. Felling and delimbing was not included in the time study.

Table 1. Output of skidding (winching to machine) and forwarding to roadside

Load size (m^3)	0.20	0.30	0.40	0.50	0.60	0.70	0.80
Skidding output (m^3/person/hr)	1.00	1.21	1.35	1.39	1.47		
Forwarding (good access) (m^3/person/hr over 100 m)				1.75	1.86	2.03	2.30
Forwarding (poor access) (m^3/person/hr over 100 m)				1.49	1.58	1.68	1.90

4.3 UK Forestry commission (1996)

In another study by the UK Forestry Commission (1996), the Myre-back ***Oxen*** mini-skidder was tested in young, mixed broadleaved forests. Work time included 25 percent for rest and 20 percent for other work. Felling and delimbing was not included in the time study.

Table 2. Productivity data for Myre-back Oxen in one-man forwarding operations

Site	I	II
Slope	Moderately steep	Steep
Mean extracted load (m^3)	1.43	1.06
Average piece size (m^3)	0.027	0.028
Extraction distance (m)	168	55
Output (m^3/hr)	1.7	1.35 (manual) - 1.5 (wire loading)
Daily output (m^3/day/person)	13.5	11 - 12

4.4 Gallis (2004)

Gallis (2004) carried out a comparative study between the Jonsereds Iron Horse with a two-man team and another team of two men and a six-pack of horses/mules in the extraction of small timber (fuel wood size 0.01-0.02 m^3) on mountainous terrain in Greece. The 20 extraction cycles for the iron horse resulted in an average distance of 320 m (270-360 m) on sloping terrain (15 percent to 20 percent). The average performance of the team was 29 minutes corresponding to 3.0 m^3/hr covering the average distance. The average output was 1.5 m^3/person/hr. The figures presented here are conversions of the stacked cord cubic meter (1.2 x 1.0 x 1.0 m) used in the study with a factor of 0.6 to arrive at a solid cubic meter. Felling and delimbing were not included in the time study and the study also did not include rest or other time categories. On a daily basis (eight-hr shift), this may correspond to approximately 7 m^3/person/day, assuming that at least 30 percent of the time was allocated to rest and other time categories. Due to the low costs for horse and manual labor, mini-skidder extraction resulted in a cost that was 26 percent higher.

4.5 Halbrook (2005)

In Idaho, United States, Halbrook (2005) studied fuel load reduction using an Iron Horse with a two-man team and compared it with tractor and all-terain vehicle (ATV) extractions. The analysis was divided into felling/delimbing/bucking (Phase 1) and skidding (Phase 2). 45 skidding turns were recorded during this study totaling 130 logs with a total volume of 27 m^3. During Phase 1, the mean total cycle time (including delays) was 8.99 minutes. On average, 3.31 logs were produced ranging 3-8 m in length with an average length of 5.1 m. The average log contained 0.21 m^3 with a butt end diameter of 25 cm. During this study, Phase 1 productivity averaged 15.4 logs (+/- 2 logs) per hour with a total volume of 3.2m^3 per hr (+/- 0.42m^3). Delays accounted for 43 percent of the total cycle time, of which nine percent were mechanical, 38 percent operational and 53 percent personal. Clearing trails, slashing brush and cutting small trees (less than 5 cm DBH) accounted for 92 percent of all operational delays. Analysis of the results suggests that piece-volume ratio was the only statistically significant predictive variable for Phase 1.

Phase 2 involved forwarding logs to a landing. During this phase, the mean total cycle time (including delays) was 13.68 minutes. On average, 2.89 logs (4.7 m in length) were skidded per cycle. The average load volume was 0.6 m^3. Delays made up 28 percent of the total cycle time, which included mechanical (0.1 percent), operational (28.8 percent) and personal (71.1 percent). Personal delays were operator rest periods, which reflect the intensive manual labor component of the Iron Horse system. The predictive model for the Iron Horse skidding phase suggests that the number of logs and overall load volume have a significant influence on a delay-free cycle time. Forwarding productivity averaged 12.7 logs/hr (+/- 0.7 logs/hr) with a total volume of 2.54 m^3 (+/- 0.14 m3/per hour or about 10 m3/person/day).

Fixed, operating and labor costs were calculated for the Iron Horse system on a per scheduled machine hour (SMH) basis. The hourly operating cost for the Iron Horse mini-skidder was computed at US$ 26/hr. Included in the operating cost was a labor component of US$ 21/hr (consisting of US$ 15/hr + 40 percent value of benefits). Labor comprised 81 percent of the overall operating cost. Utilizing the average total cycle times (including delays) for Phase 1, the cost per cubic meter ranged from US$ 16 to 19 with an average of US$ 17.5. The production rates obtained during this study suggest that a single Phase 1 worker could fell, limb, winch and buck enough material to keep one Iron Horse operator busy skidding.

5. Case study: productivity and efficiency in mini-skidder extraction of bamboo

RECOFTC carried out intensive harvesting trials on bamboo (Dendrocalamus membranaceus, local name Mai Sang) during the dry season of 2013-2014 in Bokeo province, northern Lao PDR (Salakka, 2014). These trials studied extraction costs for bamboo poles – with and without branches – that were transported to roadsides where mobile chipping into biomass chips followed to determine the feasibility of using biomass fuel chips for power generation. In addition to the Jonsereds Iron Horse and the local hand sulky crawler converted from a Yanmar rice harvester, motor winches and tractors were also included in the comparative trials, the first study of its kind on record.

5.1 Felling and skidding with iron horse winch

During the harvesting trials in Bokeo province, Lao PDR, the Iron Horse was also used for skidding (winching) trials in combination with chainsaw felling in both thinning culms, leaving U-shaped remnant culms, and clear felling of clumps. The Iron Horse winch proved far more powerful in comparison to the hand and portable winches that it was tested against. Moreover, the force required for entangling bamboo clumps was so strong that, despite the heavy weight of the machine, an additional anchoring point was needed to keep the Iron Horse in place. Skidding distances were 15-25 m, depending on winch placement.

Figure 13. Iron Horse power winch used to extract bundles of entangled bamboo.

The work team consisted of one chainsaw operator for felling and one operator for the mini-crawler. The average cycle time was 37.5 minutes and the average extraction volume was 159 kg (5-10 culms per bundle). Overall productivity reached as high as 0.128 tons/person/hr. Chainsaw productivity increased from 0.665 tons/hr to 1.021 tons/hr when delimbing was omitted. Preparatory work consumed 21.46 percent of the winch operator's total time. These numbers illuminate how time-consuming this process is and shows that this approach is too inefficient and should not be performed.

Noticeable stacking productivity decreased dramatically when delimbing was not performed, due to heavy entangling within the extracted bundle. Stacking required 33.73 percent of the winch operator's total time and 9.38 percent of the chainsaw operator's.

Table 3. Productivity during the iron horse bamboo skidding trial

Productivities	U-shape	Clear cutting	
Chainsaw	0.665	1.021	t/h
Winch	1.428	1.526	t/h
Delimbing, chainsaw	0.306	Omitted	t/h
Stacking	1.099	0.592	t/h

Table 4. Breakdown of time components in the iron horse bamboo skidding cycle

	U-shape	Clear cutting	
Time components		Chainsaw	Winch
Preparatory work	6.6	3.4	8.0
Clearing area around the clump	0.3	2.1	0.0
Removing undesired material	8.2	5.6	0.0
Chainsaw cutting	5.0	3.8	0.0
Bundling the culms	2.9	2.1	3.0
Extraction with winch	3.3	2.5	10.6
Delimbing	28.9	0.0	0.0
Stacking	8.1	3.5	12.6
Delays	2.8	2.3	0.8
Waiting	-	12.3	2.4
Overall time (minutes)	66.1	37.5	37.5

5.2 Forwarding with iron horse mini-skidder

Iron Horse forwarding productivity was measured over an extraction distance of 350 m. Results with different raw material categories are presented in Table 5.

Figure 14. Forwarding bamboo culms with branches using an Iron Horse

Table 5: Iron horse productivity and average load and cycle times with different culm categories

	Productivity, t/h	Average load, kg	Average cycle time, min
Dead culms	0.472	366	46.6
Below 5 cm delimbed	0.731	556	45.6
Over 5 cm delimbed	0.783	710	54.5
Below 5 cm whole culm	0.463	343	44.5
Over 5 cm whole culm	0.532	549	61.9

Table 6: Breakdown of time components in forwarding of bamboo using an Iron Horse at distances over 350 m

Element	Dead	< 5 cm delimbed	> 5 cm delimbed	< 5 cm whole tree	> 5 cm whole tree
Trip without the load	7.2	7.7	6.5	6.2	5.9
Loading	14.7	13.0	13.9	15.0	21.6
Tie-up the belts	5.7	6.7	6.9	3.9	4.5
Trip with the load	9.0	8.3	10.3	5.7	9.4
Opening the belts	2.4	2.1	3.7	0.9	1.5
Unloading	7.7	7.8	10.7	8.9	19.1
Delays	0.0	0.0	2.5	3.9	0.0
Overall time, min	46.6	45.6	54.5	44.5	61.9

Table 6 shows that loading and unloading consumed 40 minutes of total cycle time (65 percent of total cycle time) due to the heavy weight of culms and the large quantity of entangled branches.

5.3 Forwarding with locally manufactured mini-skidder

The locally manufactured mini-skidder was used in the same way as the Iron Horse. Its forwarding productivity varied from 0.241 tons/hr (dead) to 0.401 tons/hr (whole culm size over 5 cm) while covering an extraction distance of over 100 m. The average cycle time of all categories was 63.9 minutes, longer compared to the Iron Horse average cycle time of 45 minutes, mainly due to the mini-skidder's traveling speed, which is 50 percent slower than the Iron Horse. This issue can be addressed by changing the mini-skidder's gear ratio.

Figure 16. Forwarding delimbed bamboo culms by local mini-skidder

Table 7. Productivity of local mini-skidder, average load and cycle times with varying culm categories

	Productivity, t/h	Average load, kg	Average cycle time, min
Dead	0.241	226	56.4
Below 5 cm delimbed	0.362	340	56.4
Over 5 cm delimbed	0.348	437	75.3
Below 5 cm whole culm	0.356	385	65.0
Over 5 cm whole culm	0.401	443	66.3

Table 8. Time elements between different elements of forwarding with local mini-skidder

Element	Dead	< 5 cm delimbed	> 5 cm delimbed	< 5 cm whole tree	> 5 cm whole tree
Trip without the load	12.5	12.5	12.5	12.6	12.6
Loading	4.9	7.8	8.2	16.8	11.0
Tie-up the load with belts	4.9	6.7	7.4	12.4	8.5
Trip with the load	15.2	12.4	13.8	10.7	13.6
Opening the belts	1.1	1.9	2.4	5.9	2.8
Unloading	2.9	6.0	8.2	6.6	11.6
Re-loading during the trip	14.9	9.2	22.9	0.0	6.0
Delays	0.0	0.0	0.0	0.0	0.0
Overall time, min	**56.4**	**56.5**	**75.4**	**65.0**	**66.1**

Both mini-skidder results were better than purely manual operations through which the daily extraction rate only reaches about 300 kg/person over distances ranging from 100 to 150 m. The Iron Horse winch proved to be extremely efficient during felling operations, making the disentangling of individual culms unnecessary and allowing the extraction of partly cut clumps in bundles consisting of five to 10 culms. Further improvements on the local mini-skidder in terms of gear ratio/travel speed and its clamping device will improve its performance by at least 30 percent.

6. Conclusions

Rubber-tracked mini-crawlers offer interesting technical alternatives when extracting medium sized timber, fuel or pulpwood and bamboo, especially if extraction distances are over 200 m or operations are being conducted. For shorter distances, manual extraction or the use of sulkies and animals, in most cases, will be more economically viable. The main disadvantage of rubber-tracked mini-crawlers is their relatively high machine costs. Converting rice-harvesting machinery into crawlers may offer opportunities for improving their economical viability.

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Annex

1: Machine cost calculation template

Manufacturer: _____ Model: _____ HP: _____ Purchase price: $ _____ Total price of transportation to site: $ _____ Total: $ _____		
(P)	INITIAL INVESTMENT	$_____
(S)	Salvage Value (____% of P)	$_____
(N)	Estimated Life: ____ years	
(SH)	Scheduled operating time: ___ hrs/yr	
(U)	Utilization: ___ %	
(H)	Productive time ____ hrs/yr	
(AVI)	Average value of yearly investment **AVI = [((P-S)(N+1))/2N]+S**	$_____/yr

I. Fixed cost:	
Depreciation= (P-S)/N	$_____/yr
Interest (____ %), Insurance (____ %), Taxes (____ %) Total ____ % x ($____/yr)	$_____/yr
(1) Fixed cost per year	$_____
(2) Fixed cost per H (1÷H)	$_____
II. Operating cost: (based on productive time)	
Maintenance and repair (_____% x ((P-S)/(N x H))	$_____
Fuel (____ L x $____/L)	$_____
Oil & lubricants	$_____
Tires (1.15 x (tire cost)/tire life in hrs.)	$_____
(3) Operating cost per H	$_____
III. Machine cost per H (without labor) (2+3)	$_____
IV. Labor cost ($_____/hr ÷U)	$_____
V. Machine cost per productive hr. with labor (III + IV)	$_____

2: Suppliers

1. **Jonsered power products**
   S- 433 81 Jonsered
   Tel: 031-94 90 00, Fax: 031-94 91 10
   www.jonsered.se

2. **Myreback maskin**
   Box 12 S- 667 21 Forshaga
   Tel: 054-87 23 10 Fax: 054-87 42 82
   myreback@telia.com www.myreback.com

3. **Reparoservis (kapsen)**
   Jakobiho 328
   10900 Praha 10-petrovice
   Reparo.servis@lesni-technika.cz, www. lesni-technika.cz

4. **Blatna engineering**
   Vrbenská 25, CZ 300 01 Blatná
   Tel: 383 420 450
   engineeringblatna@seznam.cz

RECOFTC

THE CENTER FOR PEOPLE AND FORESTS

RECOFTC's mission is to enhance capacities for stronger rights, improved governance and fairer benefits for local people in sustainable forested landscapes in the Asia and the Pacific region.

RECOFTC holds a unique and important place in the world of forestry. It is the only international not-for-profit organization that specializes in capacity development for community forestry. RECOFTC engages in strategic networks and effective partnerships with governments, nongovernmental organizations, civil society, the private sector, local people and research and educational institutes throughout the Asia-Pacific region and beyond. With over 25 years of international experience and a dynamic approach to capacity development – involving research and analysis, demonstration sites and training products – RECOFTC delivers innovative solutions for people and forests.

RECOFTC – The Center for People and Forests
P.O. Box 1111
Kasetsart Post Office
Bangkok 10903, Thailand
Tel (66-2) 940-5700
Fax (66-2) 561-4880
info@recoftc.org
www.recoftc.org

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