Compliance with reduced-impact harvesting guidelines by timber enterprises in *terra firme* forests of the Brazilian Amazon

B. POKORNY, C. SABOGAL, J.N.M. SILVA, P. BERNARDO, J. SOUZA and J. ZWEEDE

University of Freiburg, Institute for Silviculture, Tennenbacher Strasse 4, 79106 Freiburg, Germany

Email: benno.pokorny@waldbau.uni-freiburg.de or bpokorny@cgiar.org

SUMMARY

The paper presents the results and main conclusions of an assessment of compliance with technical guidelines for Reduced Impact Harvesting (RIH) in *terra firme* forests of the Brazilian Amazon. The assessment was carried out in two certified timber enterprises in the State of Para, Brazil applying the RIH-guidelines for a period of over three years. From a tool developed for Amazonian forest enterprises to monitor the sustainability of their harvesting operations, which uses a set of criteria and indicators (C&I), a total of 190 verifiers were selected for assessing the 61 RIH-guidelines. The assessment revealed valuable information with regard to the state of implementation and quality of the forest operations in the two enterprises and important insights for improvement of the RIH-guidelines. Two thirds of the RIH-guidelines were fully implemented. Their acceptance, however, differed according to the situation and interest of the enterprises. Among the reasons for incomplete implementation of the RIH-guidelines, the lack of systematic monitoring, insufficient training and qualification, and inadequate equipment appeared to be most important. The study also showed the need for the continuous assessment of the quality and relevance of RIH-guidelines.

Keywords: Reduced Impact Harvesting (RIH); Brazilian Amazon; Criteria and Indicators (C&I).

INTRODUCTION

Reduced Impact Harvesting (RIH) practices play a key role in achieving sustainable management of tropical forests (e.g. Hendrison 1990, Dykstra and Heinrich 1996, Pearce *et al*. 1999, Hammond *et al*. 2002). RIH practices comprise harvest planning, infrastructure development, and operational techniques, which aim to reduce the damaging impacts of timber harvesting while improving the production efficiency of harvesting operations (Boltz *et al*. 2003). To promote the use of RIH practices, various organizations have been developing codes of practice and technical guidelines suited to specific regions, countries or major forest types (e.g. Dykstra and Heinrich 1996, Australian Department of Natural Resources and Environment 1996, Applegate and Andrewartha 1997, Sist *et al*. 1998, FORTECH 1998, FAO 1999, Asia-Pacific Forestry Commission 1999).

In 1999 the Brazilian Corporation for Agricultural Research (EMBRAPA), together with the Center for International Forestry Research (CIFOR), the Brazilian subsidiary of the Tropical Forestry Foundation (FFT) and the Amazon Institute for People and Environment (IMAZON) developed a set of technical guidelines for RIH in *terra firme* forests of the Brazilian Amazon (Sabogal *et al*. 2000, see Table 1).

These RIH-guidelines were based on past experiences with timber harvesting in the Brazilian Amazon, consultations with practitioners, researchers and governmental officials, and the FAO Model Code of Forest Harvesting Practices (Dykstra and Heinrich 1996). The guidelines consider the minimum set of practices to be applied in timber harvesting operations, and may be adapted by a timber enterprise at the level of individual operations in the pre-harvesting, harvesting and post-harvesting phases.

Since 1999 these RIH-guidelines have been tested by two timber enterprises partnering in the EMBRAPA / CIFOR project 'Sustainable Management of Production Forests at the Commercial Scale in the Brazilian Amazon' funded by the International Tropical Timber Organization (ITTO). JURUÁ Florestal Ltda. first applied RIH techniques on 400 ha of its 2000 ha annual coupe, increasing it to 2000 ha in year 2001. The other enterprise, CIKEL Brasil Verde S.A., applied the RIH-guidelines on 5 000 ha of its approximately 8000 ha annual coupe in the years 2000 and 2001. After two years of increased efforts to improve their forest operations both enterprises were certified by the Forest Stewardship Council (FSC) in 2001.

To take advantage of the practical experience gained over three years, we assessed the degree to which the two

TABLE 1 *Technical Guidelines for Reduced Impact Harvesting in Terra Firme Forests of the Brazilian Amazon (as defined by Sabogal et al. 2000), number of verifiers used for the compliance assessment as well as the level of compliance and main reasons for rejection of two certified timber enterprises in the Eastern Amazon*

Guideline	Number of verifiers	Compliance (✓ = fully, ± = partly, 0 = not, n/a = not assessed) Entpr. 1	Entpr. 2	Reason for rejection: Lack of control	Lack of training	Lack of equipment	Innovations	Lack of acceptance
GENERAL								
1) The enterprise utilizes trained personnel to carry out the harvesting operations	1	±	±	✓	✓			
2) The harvesting crews should be trained and be able to carry out the activities for which they have been trained	10	±	±	✓	✓			
3) All personnel involved in harvesting operations should use individual safety equipment in accordance with their activity	14	±	±	✓	✓	✓		✓
PRE-HARVESTING ACTIVITIES								
Demarcation of annual coupes (AC) and working units								
4) AC may be demarcated by terrain characteristics, by strips or by the combination of both	2	✓	±				✓	
5) AC should be mapped at a scale of up to 1:100.000 to 1:50.000, depending on the forest management unit (FMU) area	3	✓	0				✓	
6) AC do not require to be of a size equivalent to the division of the total area of the FMU divided by the number of years of the planned cutting cycle, but should yield the required volume to supply the industry for one year	1	✓	✓					
7) A reentry to a harvested AC may be possible up to two years after the first cut, provided the same skid trails, roads and log landings are used, and that the maximum volume of the annual allowable cut is respected. No additional reentry is allowed until the end of the planned cutting cycle	2	✓	✓					
8) In well justified cases more than one AC may be harvested in one year; however, forest productivity (in terms of annual growth in volume) and the total area under management have to be considered	1	✓	✓					
Demarcation of working units								
9) A working unit should not have an area below 10 ha and above 100 ha, depending on the size of the enterprise	1	✓	✓					
10) A working unit is demarcated by the terrain characteristics, by strips or by the combination of both	1	✓	✓					
11) A working unit should be located on maps at a scale of between 1:5.000 to 1:1.000, depending on the FMU area	8	✓	✓					
100% timber inventory								
Specification of species and minimum cutting diameter - MCD								
12) In function of the market, the industry should define the list of species and the MCD	1	✓	✓					
13) In addition to the species to be harvested, those species to be protected, rare species, species protected by law and trees with a locally important ecological function (e.g. nest-trees) should be specified	1	±	0					✓
Location, identification and measurement of trees								
14) The cutting units should be previously prepared for carrying out the activity	3	✓	✓					

TABLE 1 *cont.*

Guideline	Number of verifiers	Compliance (✓ = fully, ± = partly, 0 = not, n/a = not assessed)		Reason for rejection				
		Entpr. 1	Entpr. 2	Lack of control	Lack of training	Lack of equipment	Innovations	Lack of acceptance
15) The following minimum information should be collected during timber inventory: tree number, location (coordinates x and y), local name, dbh and bole quality. Biophysical data such as hydrograph, topography, soil and changes in vegetation type (e.g. areas infested by vines) should also be collected	8	✓	±	✓	✓			
16) Prepare maps at a scale of up to 1:2000 showing tree distribution and terrain characteristics of the working units	2	±	±				✓	
Identification and respect of protected areas								
17) Protected areas should be indicated on the maps (AC and working units)	3	✓	±	✓				✓
18) Protected areas should be indicated on the felling and skidding maps	1	✓	✓					
Vine cutting								
19) Vine cutting should be carried out at least six months before harvesting begins, and preferably during 100% inventory	2	✓	✓					
20) Vines should be cut on trees with potential to be harvested, observed during the 100% inventory	5	±	±	✓	✓	✓		
Planning of harvesting activities								
Selection and marking of trees to be harvested								
21) Indicate on the map the trees to be harvested and protected	2	✓	✓					
22) Select the trees according to the MCD of the species	3	✓	✓					
23) Define a limit of total volume/ha to be harvested, based on the annual allowable cut	1	✓	✓					
24) Use the distribution of the number of trees by diameter class to define the limit of volume by species to be harvested	1	±	n/a				✓	
Definition and planning of the harvesting system								
25) Choosing of the harvesting equipment should be scaled in accordance with the physical characteristics of the area and the volume to be harvested	1	±	✓			✓		
Planning of skid trail layout								
26) Planning of skid trail layout is defined according to terrain characteristics, the volume to be harvested and the distribution of harvestable trees	12	✓	✓					
27) The maximum number of trips by the skidders along the same skid trail should be established as a function of tree size, soil and drainage conditions and the characteristics of the skidding machinery to be used	1	✓	✓					
28) Skid trails should not be established on areas with a gradient above 45%	1	✓	✓					
Harvesting planning and estimation of annual volume								
29) Elaborate the felling and skidding maps of the working units at a scale of up to 1:2.000 containing the following information: location and numbering of trees selected for felling; planned skid trails and log landings; terrain characteristics (hydrograph and topography), and a list of trees selected for harvesting (number, local name, dbh and volume)	2	✓	✓					

TABLE 1 *cont.*

Guideline	Number of verifiers	Compliance ✓ = fully ± = partly 0 = not n/a = not assessed		Reason for rejection				
		Entpr. 1	Entpr. 2	Lack of control	Lack of training	Lack of equipment	Innovations	Lack of acceptance
30) Elaborate the annual and monthly harvesting plans for the working units	3	0	0				✓	✓
Construction of main and secondary roads								
31) Main roads should be constructed in a way that they are located higher than the lateral terrain. They should have a road bed width between 8 to 10 m wide	3	✓	✓					
32) Secondary roads should be constructed in a way that they are located at the same level as the lateral terrain. They should have a road bed width between 5 to 7 m wide	2	±	±	✓			✓	
33) The roads to be used during the rainy season have to be surfaced; for instance, with gravel or laterit	2	0	0	✓			✓	✓
Monitoring system								
Elaboration of a system to control production and costs								
34) Control monthly production based on registers of daily production plan	8	±	±					✓
35) Control the quality of execution of field activities	1	±	n/a	✓				
36) Establish an internal auditing system to verify and improve the execution of the control system for production and costs	1	±	±					✓
Permanent sample plots								
37) Permanent sample plots should be planned according to current legislation	8	✓	✓					
HARVESTING ACTIVITIES								
Directional felling								
38) Cutting of selected trees should be oriented to reduce damage to remaining trees (seed trees, future harvest trees and/ or protected trees), facilitate skidding and reduce the size of canopy gaps	1	±	✓	✓	✓			
39) Identify and/or mark selected trees for harvesting, seed trees and future harvest trees	1	✓	±					✓
40) Cutting should be directed so as to avoid multiple connecting crown gaps	1	±	✓	✓	✓			
41) Cutting techniques and bucking should avoid waste	8	✓	✓					
42) Use a numbering system for each felled tree and a sequential code or letters relating each log in a given tree	2	✓	✓					
Skidding								
43) Skid trails should be planned	1	✓	✓					
44) The planning of skid trails should be first done in the office on the harvesting map (tree location map) and then in the field to orient the skidder operator	1	±	±				✓	✓
45) The skidder should utilize the winch to pull in the log when possible	1	±	0	✓	✓	✓		✓
46) Logs are skidded with the leading end above the ground	1	✓	±	✓				
47) The width of skid trails should be minimized	2	✓	✓					
48) Main skid trails should be established as straight as possible in order to improve productivity and reduce damage to trees located on skid trail borders	1	✓	✓					
49) In case it is necessary to make curves, skidder operator uses non-commercial trees as pivots	1	✓	✓					

TABLE 1 *cont.*

Guideline	Number of verifiers	Compliance ✓ = fully ± = partly 0 = not n/a = not assessed		Reason for rejection				
		Entpr. 1	Entpr. 2	Lack of control	Lack of training	Lack of equipment	Innovations	Lack of acceptance
Construction of log landings								
50) Consider ramp and slope limits for adequate operation of skidding equipment	1	✓	✓					
51) Location of log landings should follow planning in the office and in the field, based on volume to be harvested	4	✓	✓					
52) The size and number of log landings should be compatible with the volume to be harvested, aiming to be the minimum possible	2	✓	✓					
53) Numbering of measured logs on landings and log decks should correspond to the number given in the forest	3	✓	✓					
54) Bucking waste on log landings should be avoided	1	✓	✓					
Log transport								
55) Road quality should be compatible with climatic conditions. In the rainy season the transport should no cause damage to road infrastructure	1	n/a	n/a					
Road maintenance								
56) After log transport operations are finished, maintenance of secondary roads should take place (especially with regards to normal flow of watercourses and ruts)	1	n/a	n/a					
57) Main roads should be periodically maintained according to transport intensity, including road surface, drainage structures, and right of way	4	✓	✓					
POST-HARVESTING ACTIVITIES								
Maintenance of skidding trails and landing sites								
58) After the harvesting operations are finished, maintenance should occur in log landings to leave them clean and without ruts. Maintenance should also take place in case skid trails are rutted	2	0	0					✓
59) Harvesting waste should be adequately disposed and reduced	20	✓	✓					
Evaluation of harvesting activities								
60) After harvesting operations are finished, as part of the internal operational auditing, carry out an assessment of the quality of harvesting operations, mainly with regards to damage and waste in felling, skidding and landings, and of the volume harvested	1	±	±					✓
Measures to protect the forest								
61) Maintain a surveillance system in logged over areas to avoid illegal entry, fire and illegal hunting	1	0	✓					✓
62) Carry out educational campaigns with neighbors to create awareness and organize preventive measures against fires	6	✓	✓					
63) Prepare a plan for prevention and fight of forest fires	3	✓	✓					

enterprises were able to comply with the RIH-guidelines, once to learn from enterprise staff the reasons contributing to or constraining the adoption of the RIH-guidelines, and also to identify specific aspects in the RIH-guidelines that need improvement. This paper describes the assessment methodology and presents the results and main conclusions of the assessment carried out during the harvesting period in year 2001.

THE ASSESSMENT METHODOLOGY

Although most of the existing codes of practices consider the importance for regularly evaluating technical guidelines to ensure their validity and practical relevance, only few studies take note of how to do this (*e.g.* Appanah and Kleine 2001, Jonathan *et al.* 2000, Donovan and Putz 1998, Sist *et al.* 1998). Given the lack of adequate methodological guidance, we adapted a tool developed for Amazonian forest enterprises to monitor the sustainability of their harvesting operations (Pokorny *et al.* 2004[a]) to carry out the study. The monitoring tool uses a set of criteria and indicators for assessing sustainability (C&I) at Forest Management Unit level as a basis for planning, assessment and analysis. C&I denote a hierarchy of linked items (principles, criteria, indicators and verifiers), where the information accumulated at the hierarchically lower, more concrete verifier level is used to assess the related items of the upper, more abstract levels (CIFOR 1999). The C&I set in question departed from CIFOR´s C&I generic template (CIFOR 1999) and was defined in various working steps, including national and international workshops, field tests and expert consultations (Pokorny and Bauch 2000, Souza 2002, Pokorny *et al.* 2004[ab]).

As RIH is an essential part of the operational component of sustainable forest management, each of the 63 RIH-guidelines were directly linked to one of the 21 criteria and/or 71 indicators of the C&I set defined for the monitoring tool. Due to this fact it was possible to identify a total of 191 verifiers as relevant for the assessment of 61 out of the 63 RIH guidelines (Table 1). Two guidelines were not assessed because they were related to post-harvesting activities not covered by the fieldwork. For many guidelines, because being very specific, only a small number of verifiers were available for assessment (29 guidelines with only 1 verifier each and 14 guidelines with 2 verifiers each). As guidelines should leave with the enterprises the responsibility for their concrete technical implementation into practice, the high level of specificity of some guidelines indicates a difficulty and may present a burden for their acceptance. On the other hand, some guidelines were related to a high number of verifiers, the extreme being the guideline on garbage management with 20 verifiers. In these cases, there is a need to check for possibilities to be more specific in the definition of the guideline, in order to homogenize the operational level of the RIH-guideline set.

For each selected verifier we defined in detail how and where they should be assessed in the field. In addition, for each verifier quantitative thresholds were defined to facilitate the interpretation of the collected information regarding the level of compliance (Table 2). Verifiers with measured values below the defined thresholds were considered as not fulfilled. Considering that nearly half of the resources for the assessment of forest operations is spent on transport (Souza 2002, Pokorny *et al.* 2004[a]), we tried to increase the efficiency of the assessment by concentrating the assessment of the verifiers into a restricted number of operational units, the 'assessment plots', describing a methodological design to assess a maximum number of verifiers in a specific place. In particular, the following assessment plots were defined: 'timber inventory', 'inventoried forest', 'felling operations', 'forest after felling', 'skid trail planning', 'skidding' and 'forest camp'. For many verifiers information for their assessment were gathered in more than one assessment plot.

To facilitate the fieldwork, we defined four operational elements for each assessment plot:

(1) General description of the assessment plot (see example in Table 3): As a basis for field work planning, this element specifies the equipment and material needed for the assessment and provides an overview about the activities to be carried out as well as a rough estimation of the duration. This information was derived from the field experiences with the development of the C&I-based monitoring tool mentioned above

(2) Spatial visualization of the assessment process. Illustrations of the assessment plots (see example in Figure 1) were designed to visualize where to carry out the collection of the information for the assessment of the verifiers. This provided an understanding of what verifiers should be observed at a certain time and place and thus facilitated the sketching of a work plan for each assessment plot.

(3) List of verifiers grouped according to assessment methodology. The third element listed all verifiers to be assessed in the assessment plot regarding methodological aspects, thus providing an overview about the aspects to be observed during a certain activity (see example in Table 2). The list also showed for each verifier the defined threshold, which enabled the evaluators to better understand the meaning of the field information regarding the final result.

(4) Data forms. As final element, data forms were designed to effectively document the gathered information in the field for further processing (see example in Table 4).

The field team spent between three to four weeks in each enterprise. To receive a complete overview about the quality of the forest operations, we tried to assess a maximum number of plots assuming all working teams were involved in the complete sequence of harvesting activities. For most assessment plots it was possible to consider at least two different working teams in each enterprise. In each assessment plot, the gathered information was directly discussed with the forest workers, in order to get their opinions about the RIH-guidelines, which are relevant to them and also to figure out possible reasons for an eventual lack of implementation. This helped us to have an overview about the advantages and disadvantages of the RIH-guidelines from the practical point of view.

TABLE 2 *List of verifiers structured by methodological groups for the assessment plot 'Skidding operations'.*

	VERIFIER	THRESHOLD
1	**Accompany the skidding team**	**% of observation**
1.1	Skidding operations start after finishing the construction of main and secondary roads and landings	100%
1.2	Skid trails are marked in the field using stakes and colored plastic flagging is fixed to a height that enables the view by the machine operator	90%
1.3	A special marking indicates where the machine has to stop in order to skid a log	90%
1.4	The machine operator follows the marking of the skid trails	95%
1.5	If possible, the operator starts skidding at the end of each main skidding trail	100%
1.6	The machine operator uses the felling map to locate the logs in the forest	80%
1.7	The machine operator uses the winch for skidding in the following cases: on very humid soil, steep slopes, fixed log not falling down, and if it is not possible to reach the log without causing damages to the remaining trees, the location of which is previously marked by the planning crew	95%
1.8	When possible, the machine operator uses the grapple to skid the log	95%
1.9	The skidder blade should be raised when moving along the skid trails	95%
1.10	Logs are skidded with the leading end lifted above the ground level	100%
1.11	In case it is necessary to make curves, the operator uses non-commercial trees as pivots	90%
1.12	Very long logs (above 15 m length) are bucked in shorter lengths before skidding	90%
1.13	Skidding stops during heavy rain fall until such time when no additional ground impact is caused	100%
1.14	The machine operator does not swamp around the tree/log to be removed, in order to provide access to the log	90%
1.15	The chainsaw operator never works without a helper	100%
2	**Check skid trails**	
2.1	No primary or secondary skid trails are not interconnected	85%
2.2	Trees fallen or felled on skid trails are cut to facilitate the movement of the skidder	95%
2.3	The width of the skid trails corresponds to the width of the skidder	95%< 3m
2.4	No more than 15 logs are skidded on a single main skid trail. This number may be reduced depending on size of logs, topography, and soil conditions	95%<15logs
2.5	No skid trail is located within protected areas	95%
2.6	Skid trails never cross water courses	100%
3	**Check log landings and landing activities**	
3.1	Logs at landing sites are adequately separated, e.g. according to transportation requirements	80%
3.2	No useable logs are left behind on landings or log decks	<1 logs/landing
3.3	Logs of the same tree are marked in sequence to ensure the chain of custody	95%
3.4	Only species prescribed in the harvest plan are found on log landings	<1 logs/landing
3.5	There are no ground logs below the minimum harvesting diameter left at landing sites	<1 logs/landing
3.6	Logs are stacked as high as possible in order to reduce the size of the landing or log deck	80% > 2 m
3.7	All logs are numbered correctly	95%
3.8	The standard size of log landings does not exceed 25 x 20 m, with exceptions for special situations, log length requirements, and transportation systems	95% < 500 m^2
4	**Check main roads at 10 points**	
4.1	Main roads are located higher than the surrounding ground. They are crowned for water run off, and build with drainage requirements	95%
4.2	The width of the road bed on main roads is between 8 to 10 m	95%< 6m
5	**Check secondary roads at 10 points**	
5.1	Secondary roads should be built at the same level as the surrounding ground	95%
5.2	The width of the road bed of secondary roads is between 4 to 5 m	95% < 4m
6	**Check river crossings**	
6.1	No harvesting road will impede the normal flow of water and or drainage	
7	**Observe the utilization of individual safety equipment**	
7.1	All forest workers use hard hats	100%
7.2	All forest workers use special footwear to protect them against injuries, depending on their activity	100%
7.3	All forest workers use clothing with bright warning colors	100%
7.4	Chainsaw operators use sound protection	100%

The information collected in the field was stored in a database designed in MS-Access to facilitate the analysis. After experts from CIFOR, EMBRAPA and FFT interpreted the data analysis, the results were presented separately to the managerial and technical personnel of each enterprise. These presentations offered an excellent opportunity to discuss the practical implications of RIH and possibilities for improvement.

forest management. In conventional harvesting enterprises, the teams in the forest work quite independently within a framework of clearly defined simple tasks such as 'cut trees', 'prepare infrastructure' and 'skid logs'. The way of how to fulfill these tasks is under the control of the team leaders. The person responsible for the coordination of the harvesting operations concentrates on logistical issues without interfering into the day-to-day-work of the different teams. If a team manages to achieve the expected production goal, everybody is satisfied. Quality control in general does not exist. Enterprises in transition from conventional timber harvesting to RIH often retain this approach. In the studied enterprises, efforts to qualify and train personnel in the new RIH-techniques were restricted to the initial phase of implementation. Once the teams were trained, the responsibility for the performance and quality of their work was transferred again to the team leaders. Supervision became sporadic, so that the teams very soon felt abandoned. As a result, the initial interest and motivation of the teams diminished, and with it the quality of their work.

TABLE 3 *General information about the assessment plot 'Skidding operations'.*

Location	Forest during skidding operations
Recommended sampling	All skidding teams during work four times a year
Number of verifiers	39
Duration	1,5 hours
Resources needed	- Metric tape (preferably 50 m) - Felling map
Methodologies applied	- Accompany the skidding team (and carried out interviews) - Check the skidding trails - Check log landings and landing activities - Observe the utilization of individual safety equipment - Check main road in 10 points - Check secondary road in 10 points - Look at 10 points of river crossings
Activities to check	- Skid trail planning - Skidding - Landing - Utilization of individual safety equipment - Road construction

RESULTS

The assessment revealed valuable information with regards to the state of implementation and quality of the forest operations in two Amazonian enterprises, as well as important insights for improvement of the RIH-guidelines. The two enterprises showed similar overall results, with two thirds of the guidelines fully implemented (Table 5). However, the enterprises differed in which guidelines were being implemented. Enterprise 1 fulfilled mainly the RIH-guidelines related to pre-harvesting operations (such as timber inventory, tree selection and preparation of maps), whereas Enterprise 2 applied the guidelines related to harvesting, work safety and respect of protected areas. Around a quarter of the RIH-guidelines were only partially implemented and 8% (4 to 6) of the RIH-guidelines were not accepted at all by the enterprises. The discussions with the enterprises' managers and technicians revealed that the reasons for rejecting the RIH-guidelines varied in dependence from the specific situation and interest of each enterprise (Table 1). Each of these is referred to below.

Lack of monitoring. In both enterprises the most important reason for incomplete achievement of the guidelines was the lack of monitoring. This fact reveals one of the biggest difficulties of Amazonian timber enterprises in making the transition from conventional timber harvesting to RIH and

Lack of training and qualification. In many cases, especially for guidelines related to complex technical approaches such as 'forest inventory', 'directional felling', 'planning of skid trails' and 'skidding', both enterprises suffered from a lack of trained and qualified personnel. This is a common situation in the Brazilian Amazon, where there is no institutionalized possibility for obtaining adequate qualifications. Until very recently, the only organization dedicated to training on forest management techniques in the Brazilian Amazon was FFT, with its training center in Cauaxi, Pará. Universities and technical

TABLE 4 *Items of the field report for the assessment plot 'Skidding operations'.*

Harvesting Unit:	Working Unit:	Log landing:	Date:
Teams observed:			
General			
Skidding operations started after finishing the construction of harvesting infrastructure:			
Work stops during heavy rain until such time when no additional ground impact is caused:			
Skidding should start with the last log on the main skid trail:			

Skidding	Landing
N° of observed skidding cycles:	*N° of observed logs:*
Without following the marking of the trail:	N° of not useable logs:
Swamping round the tree/log to be removed to provide access:	N° of logs without numeration:
Log skidded without the leading end lifted above the ground:	N° of logs from the same tree not identified in sequence:
Without using the grapple when it was planned	N° of logs of species not foreseen for harvesting:
Without using the winch when it was planned:	N° of ground logs below the minimum harvesting diameter:
Without using maps:	*Separation of logs in timber groups:*
Logs above 15 m not bucked in shorter lengths:	*Dimension of log landing:*
Using the shield outside the skid trail:	*Height of the stored logs (if finished):*
N° of curves observed where damage was caused:	**Utilization of individual safety equipment**
Without using non-commercial pivot trees:	*N^0 of observed workers:*
Skid trails	Without hard hat:
N° of main skid trails observed:	Without safety shoes:
Without adequate marking:	Without clothes with warning colors:
Without special marking at the point where the skidder either grapples or winches the log:	*N^0 of observed machine operators:*
Maximum number of logs skidded along the main skid trail, considering size of log, soil condition, and topography:	Without ear protection (for sawyers):
Skid trail located within a protected area:	Without eye protection (for sawyers):
Skid trail crossing a water course:	*N° observed activities by chainsaw operator:*
Width measurement:	Working without a helper:
N° of secondary skid trails observed:	**Harvesting infrastructure**
Without adequate marking:	N° of measured points at main roads:
Without special marking at the point where the skidder either grapples or winches the log at the end of the secondary skid trail:	Width measurements:
Interconnected skid trails:	N° below the ground level:
Skid trail located within a protected area:	*N° of measured points at secondary roads:*
Skid trail crossing a water course:	Width measurements:
Width measurements:	N° below the ground (when built):
N° of observed obstacles along the skid trails:	N° of observed water crossings:
Fallen or felled logs crossing skid trails no bucked:	N° of blocked drainage and water courses:

schools do not have the human and financial resources to meet the growing demand for qualified personnel. In view of this, timber enterprises interested in RIH are often forced to train their staff themselves. They ask more experienced, but often not trained workers, to transfer their knowledge to others. The study showed that this practice is not always successful, as this kind of training suffers from a lack of didactic skills of the trainers, and missing qualified supervision. The chronic lack of adequately skilled personnel gets even worse by the fact that enterprises hesitate to adequately increase the salaries of the workers, once qualified. They tend to be strongly concerned with the training costs, and don't want to 'additionally' increase the salary of 'expensive' trained workers. This leads to the paradoxical situation that many trained staff emigrate to enterprises which have not made

TABLE 5 *Compliance assessment of the Brazilian RIH-Guidelines by the two partner timber enterprises.*

Guideline	**Enterprise 1**	**Enterprise 2**	**Overall proportion**
	(N)	*(N)*	*(%)*
Fully implemented	39	41	66
Partly implemented	16	16	26
Not implemented	6	4	8
Total	**61**	**61**	**100**

the investments in training and are thus willing to compensate the increased value of trained workers by higher salaries.

Lack of adequate equipment. Another feature, which seriously affected the implementation of the RIH-guidelines in the two timber enterprises, resulted from the need for significant investments in machines and equipment associated with such a process. Due to extremely high interest rates for credit (up to 30% per year), enterprises try to finance their investments mainly by using own resources. The financial encumbrance resulting from this situation - in the context of a general lack of financial data and limited economic knowledge by the enterprise manager - leads to a generic reluctance against investments independent from their value and profitability. Consequently, the machines and their quality are often not suitable for the work, and existing capacities do not correspond to the demands related to the implementation of new technologies. The forest enterprises avoid even smaller investments for field equipment and material, such as tools important for cutting trees and lianas, unless their utility is proofed by a clear quantitative benefit. In the studied enterprises the unwillingness to make 'unproductive' investments was particularly obvious in relation to the individual safety equipment (not all workers were equipped with a sufficient number of shirts, helmets and shoes) and transport facilities for the workers (no vehicles were available to exclusively transport personnel, so trucks transporting equipment and materials were often used instead).

Own innovations and adaptations. In some cases the enterprises did not accept the RIH-guidelines in full, but adapted them by using their own experience and knowledge, as for instance regarding the scale of the harvesting maps, the marking of Forest Management Unit boundaries, the size of log landings, the definition of endangered species, and the timing for road construction. In these cases the enterprises accepted the content of the corresponding RIH-guidelines, but disagreed with the recommended technical details. This confirmed the observation that some of the guidelines were too specific. Thus, for example, it was not useful that the RIH-guideline requiring harvesting maps to facilitate the work of the felling teams, also determined the scale of these maps. RIH-Guidelines and technical recommendations have to be strictly separated.

Not accepted. Some RIH-guidelines were not accepted at all by the enterprises. In two cases, 'need for leveling secondary roads to the level of log landings' and 'maintenance of skid trails and log landings after harvesting', it was because they were only relevant to a specific type of skidding characterized by permanent skid trails and pre-skidding operations rarely found in the Amazon. Also the RIH-Guidelines, which defined the need for pre-planning of skid trails in the office, was more relevant for harvesting in mountainous regions but not for the Amazon, where skid trails planning is carried out in the field. In the Amazon, the information required on the terrain and the forest condition is simply not available in the office.

With regards to the other RIH-guidelines not accepted by the enterprises, the reasons for rejection were not shared by the experts, in particular: 'Marking of seed trees', 'Prepare a monthly harvesting plan', 'Road maintenance during the rainy season', 'Establish and maintain a surveillance system on logged-over areas', and 'Establish a control system for production and costing'. The discussions between the experts and enterprise managers, however, served to clarify the reasons for existing discrepancies and offered an excellent basis for re-evaluating the RIH-guidelines. Although consensus was not always achieved, it was possible to enhance the acceptance of the RIH-guidelines by making adjustments in light of the practical experience. It became obvious that for some RIH-guidelines the available information was simply not sufficient to argue.

CONCLUSIONS

Technical guidelines for RIH are important tools for the implementation of good forest management. They provide guidance to interested timber enterprises and facilitate an objective assessment of the quality of forest operations. The assessment of harvesting operations of two certified timber enterprises in the Eastern Amazon region showed that most of the RIH-guidelines proposed by Sabogal et al. (2000) have been accepted and successfully implemented into practice. However, the study also detected significant deficiencies in the quality of harvesting operations, mainly resulting from insufficient monitoring efforts. The study revealed the fundamental importance of systematic, objective and continuous monitoring to guarantee the quality of forest operations.

The study identified a variety of deficiencies and inconsistencies of the RIH-guidelines that generated confusion and misunderstandings, not only from the enterprises' staff, but also among researchers. These deficiencies confirmed the need for regular adjustment based on the lessons learnt from the experiences generated during their implementation at the operational scale. Only the systematic use of the practical experience available in the timber enterprises guarantees the viability and practical relevance of the RIH-guidelines, which itself is a central precondition for acceptance and further dissemination.

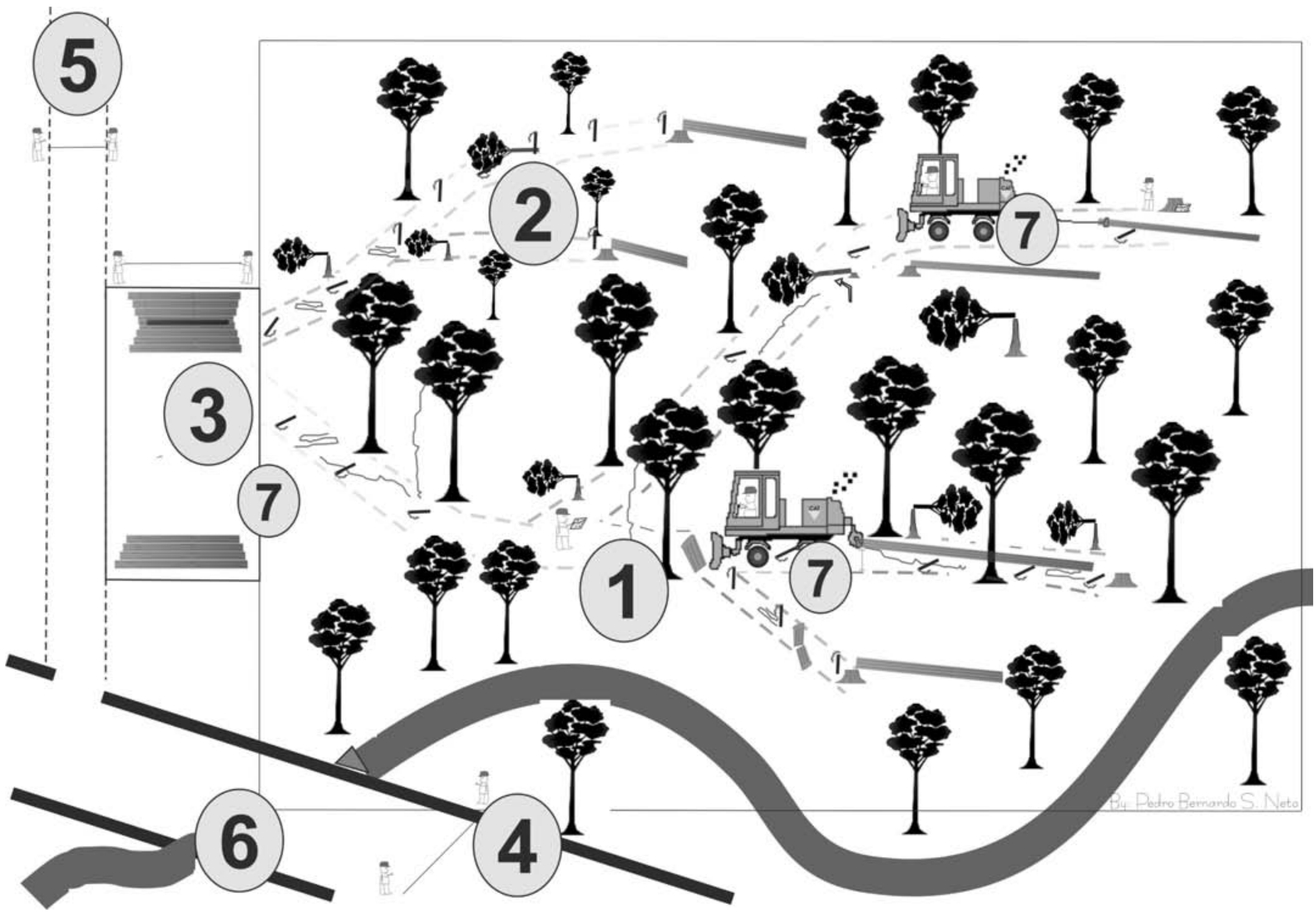
The study also revealed the importance of a well-organized conceptual framework for the understanding and acceptance of RIH-guidelines by timber enterprises. Differing concepts like 'guidelines', recommendations', 'technical norms' and 'methods' are related to a different degree of commitment, and thus should be clearly defined. People use approaches such as 'RIH', 'forest management', 'good forest management' and 'sustainable forest management' differently. While RIH-guidelines concentrate on technical aspects of forest operations, good forest management may also include planning and monitoring activities, whereas guidelines for sustainable forest management must even be much more integrative.

The methodology used for the compliance assessment can be recommended for similar studies. The gained experiences showed the importance of: (1) defining verifiers and methods suitable for assessment, (2) considering all working teams to capture heterogeneity, (3) repeating the assessment along the harvesting period to consider seasonal differences, and (4) working with assessment plots to effectively use the resources for transport.

ACKNOWLEDGEMENTS

This study is part of the scientific cooperation between EMBRAPA and CIFOR and was carried out thanks to a financial contribution from USAID-Global Bureau. The authors thank the enterprises JURUÁ Florestal Ltd. and CIKEL Brasil Verde S.A. and in particular the forest workers for their collaboration. Special thanks to Dr. Laura Snook from CIFOR for her valuable comments on the manuscript.

FIGURE 1 *Spatial visualization of the assessment plot 'Skidding operations'**.



* The numbers correspond to the methodological groups shown on Table 2.

REFERENCES

APPANAH, S. and KLEINE, M. 2001. Auditing of sustainable forest management. A practical guide for developing local auditing systems based on ITTO's Criteria and Indicators. *Forestry Research Support Programme for Asia and the Pacific (FORSPA)* **26**. FAO: Bangkok. 131p.

APPLEGATE, G. and ANDREWARTHA, R. 1997. *Vanuatu Reduced Impact Logging Guidelines*. The Vanuatu Sustainable Forest Utilisation Project, Australian Agency for International Development. Department of Forests: Canberra.

ARMSTRONG, S. and INGLIS, C. 2001. Assessing the Gap Between the Theory and Practice of Reduced Impact Logging. *In:* International Conference on Application of Reduced impact Logging to Advance Sustainable Forest Management Constraints, Challenges and Opportunities. 26 February – 1 March 2001, Kuching, Sarawak, Malaysia.

ASIA-PACIFIC FORESTRY COMMISSION. 1999. *Code of Practice for Forest Harvesting in Asia-Pacific*. Food and Agriculture Organization of the United Nations, Regional Office for Asia and the Pacific. Bangkok, Thailand. RAP Publication: 1999/12. 133p.

AUSTRALIAN DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENT. 1996. *Code of Practice. Code of Forest Practices for Timber Production.* Revision No.2. Department of Natural Resources and Environment: Canberra. 36p.

BOLTZ, F., COLMES, P.T. and CARTER, D.R. 2003. Economic and environmental impacts of conventional and reduced-impact logging in Tropical South America: a comparative review. *Forest Policy and Economics* **5**: 69-81.

CIFOR (Center for International Forestry Research). 1999. The CIFOR Criteria and Indicators Generic Template. *The Criteria and Indicators Toolbox Series* **2**. CIFOR: Bogor.

DONOVAN, R. and PUTZ, F.E.P. 1998. *The protocol for independent verification of natural forest management carbon offsets through Reduced Impact Logging (RIH).* New England Energy Services, Inc. (NEES) and Innoprise, Sbn. RIH Project: Sabah. 10p.

DYKSTRA, P.D. and HEINRICH, R. 1996. *FAO model code of forest harvesting practice*. FAO. Rome. 85p.

FAO, 1999. *Code for Practice for Forest Harvesting in Asia-Pacific*. FAO, Regional Office for Asia and the Pacific: Bangkok. 133p.

FOREST PRACTICES BOARD. 2000. *Forest Practices Code for Tasmania, Australia*. Forest Practices Board: Canberra. 118p.

FORTECH. 1998. *The Cambodian Forest Harvest Code of Practice*. FORTECH, Dames & Moore Enterprise: Turner. 74p.

HAMMOND, D.S., V.D. HOUT, P., ZAGT, R.J., MARSHALL, G., EVANS, J. and CASSELLS, D.S. 2000. Benefits, bottlenecks and uncertainties in the pantropical implementation of reduced impact logging techniques. *International Forestry Review* **2(1)**: 45-53.

HENDRISON, J. 1990. *Damage-controlled logging in managed tropical rain forest in Suriname*. Dissertation Wageningen Agricultural University, The Netherlands.

JONATHAN, R., DAGANG, A.A. and HAHN - SCHILLING, B. 2000. *Compliance Assessment of Reduced-Impact Logging Areas in the FOMISS-Samling Pilot Area (FSPA).* Forest Department of Sarawak - Malaysian-German Technical Cooperation Project, Forest Management Information System Sarawak (FOMISS). MISC Report No. 31. Kuching - Sarawak, Malaysia. December 2000.

NOLAN, T.M. 2000. Good forest management practices: Are we getting real with RIH? *The Land* **4(3)**: 181-186.

PEARCE, D., PUTZ, F.E.P. and VANCLAY, J.K. 1999. *A sustainable forest future?* CSERGE Working Paper GEC 99-15. London, U.K.

POKORNY, B. and BAUCH, R. 2000. Estudo aplicativo de critérios e indicadores para avaliar sustentabilidade em uma empresa florestal em Tailândia, Pará, na Amazônia brasileira. *Documentos* **34**. Embrapa Amazônia Oriental: Belém. 117p.

POKORNY, B., SABOGAL, C., PRABHU, R. and SILVA, J.N.M. 2002. *Introducing criteria and indicators for monitoring and auditing forest management in the Brazilian Amazon. In:* Sabogal C., J.N.M. Silva. 2002. (technical editors). Manejo integrado de florestas úmidas neotropicais por indústrias e comunidades: aplicando resultados de pesquisa, envolvendo atores e definindo políticas públicas. Atas do Simpósio Internacional da IUFRO, Belém – Pará, Brazil, 4th – 7th of September 2000. pp. 390-409.

POKORNY, B., SABOGAL, C., SILVA, J.N.M., LIMA, J and BERNARDO, P. 2004 a. C&I para el monitoreo de operaciones forestales. Un caso en Brasil. *Revista Forestal Centroamericana*.

POKORNY B., PRABHU, R., MCDOUGALL, C. and BAUCH, R. 2004B: Local Stakeholders' Participation in Developing Criteria and Indicators for Sustainable Forest Management. *Journal of Forestry* **102 (1)**, 35-40.

PRABHU, R., COLFER, C.J.P. and SHEPHERD, G. 1998. *Criteria and Indicators for Sustainable Forest Management: New Findings from CIFOR's Forest Management Unit Level Research. In:* Rural Development Forestry Network 23a. Overseas Development Institute: London.

SABOGAL, C., SILVA, J.N.M., ZWEEDE, J., JÚNIOR, R.P., BARRETO, P. and GUERREIRO, C.A. 2000. Diretrizes técnicas para a exploração de impacto reduzido em operações florestais de terra firme na Amazônia Brasileira. *Documentos* **64**. Embrapa: Belém. 57p.

SIST, P., DYKSTRA, D. and FIMBEL, R. 1998. *Reduced-Impact Logging Guidelines for Lowlands and Hill Dipterocarp Forests in Indonesia*. Bulungan Research Report Series **1**. Occasional Paper **15**. CIFOR: Bogor. 19p.

SOUZA, J. 2002. *Os recursos necessários para aplicar um sistema de monitoramento empresarial baseado em critérios e indicadores para avaliar a sustentabilidade do manejo florestal*. FCAP. MSc Thesis. FCAP: Belém.