WOOD TRACKING SYSTEM IMPLEMENTATION PROJECT IN GHANA

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1. BACKGROUND

Ghana has signed a Voluntary Partnership Agreement (VPA) with the European Union (UE) which proposes measures to increase the capacity of developing and emerging market countries to control illegal logging, while reducing trade in illegal timber products. The Ghana VPA includes compliance and licensing for all timber and wood product exports through the Forest Law Enforcement, Governance and Trade (FLEGT) Licensing system. The system to be established checks compliance with all aspects of forest-related legislation and monitors legal compliance through the production chain from the forest through the mill and to the port of exportation.

For the issuing of FLEGT licence a wood tracking system is required which will be able to trace the wood from the forest where it is harvested until the point of export.

The "Wood tracking system implementation project in Ghana" sponsored by ITTO , consists of an investigation into the current wood tracking system in Ghana, with the objective of detecting and analyzing possible weaknesses and critical points, with the purpose of developing a new wood tracking system that allows companies to verify the traceability of their material from the forest until sawmill, warehouse and port.

The aim of this project is to increase the capacity of small and medium companies to produce and commercialize wood products from legal sources. It should be recognised that this project is being carried out in parallel to and in concert with the Ghana Forestry Commission's own wood tracking project which is based on the use of a bar coded marking system and hand held GPS referenced computers.

It is necessary to point out that the efficacy of a system for ensuring legal compliance can never be fully assured. In situations where control and supervision of those responsible for management of the system is weak or where the levels of corruption are high then any control system can be overcome. Ghana already has a rather large number of officials involved in legal compliance in comparison with for example the UK, yet is still afflicted with a very high level of illegal activities in the forest sector. It is not the systems designed alone that will provide legal compliance, but more importantly, the level of trust and professionalism practised by those entrusted with responsibility to manage its forests.

2. METHODOLOGY

The project was carried out in three main phases:

1. Preparation phase was carried out prior to the field work in Ghana. The following points were researched and analyzed:

    - Analysis of the Ghana Wood Tracking System.
    - wood tracking systems implemented in small and medium enterprises in other countries.
    - Details of FSC Chain of Custody control systems implemented in small and medium enterprises
    - available wood tracking technologies in use elsewhere or proposed for use.

2. Field Work. This was carried out from August 4th through August 14th in Kumasi (Ghana). The following tasks were done:

    - Investigation of the current WTS in both on and off reserve situations
    - Research about log transport from the forest to the sawmill.
    - Physical tracking of the wood from the forest until it reaches the sawmill. This included checking the activities at all of the different checkpoints along the road, and verifying the information that was recorded and checked at each of these control points.
    - Research about the procedures used in small and medium sawmills. This included an examination of all of the documents required for legal harvesting and transport of timber from the forest to the mill gate.

3. Develop a Wood tracking system

    A new wood tracking system recommended for its simplicity and efficacy has been introduced in this report for the consideration of the FC, with the objective of allowing small and medium enterprises to keep the track of the wood, in order to demonstrate that their products come from a legal source. A complete set of new information recording forms will be designed as generic templates for SMFEs to adapt in full or in part should the new tracking system be consistent with what is being developed by the FC.

3. CURRENT WOOD TRACKING SYSTEM IN GHANA

Below the current wood tracking system in Ghana is described. The research was carried out in on and off reserve situations where active harvesting was taking place. Copies of all documents relating to the harvest were made available to us. The field work was carried out over a period of six days and involved inspections of harvested sites, forwarding operations, log bucking operations, loading and transport to the mill and finally reception procedures at the mill. Log dimensions were physically measured and compared to those stated in the transport documentation. We did not verify the payment of necessary royalties, taxes and other duties with the regulatory authorities.

3.1 Pre-harvest Planning

3.1.1 Reserve situation

The first step to obtain the endorsement of the forest harvest in a reserve situation is the issue of the Timber Utilisation Contract (TUC). The objective of the TUC is to tighten the planning controls on timber utilisation and at the same time to ensure that the interests of the communities and land owners are fully taken into account through the specification of the Social Responsibility Agreements.

The Forest Service Division (FSD) is responsible for the first steps of TUC allocation. Together with the RMSC harvesting areas are identified by carrying out the following activities:

- updating of compartment maps
- initial scheduling of compartments for harvesting
- field checks
- fixing of boundaries where there are protection zones for the purpose of fine and coarse grained environmental conservation.
- Main accesses and road revision

In other words the TUC gives the overview of the contract as a whole.

Different companies give proposals to harvest the forest, which are evaluated and selected by the Timber Rights Evaluation Committee.

In the management of the TUC areas, the first step corresponds to the development of the TUC operation plan by the contractor. This plan provides the major details of the operations are given which will be carried out in the coming years.

Later comes the pre-survey compartment inspection, this is an inspection of each compartment to be harvested by the district level staff of the forestry commission and the contractor before the stock survey. The purpose is to check in detail topography, storage and access characteristics.

The next step is the Stock Survey. The stock survey registers the species, diameter and establishes the location of all trees (over 50 cm diameter) and at the same time the tree is designated with the corresponding stock number. Additionally the protected species, the slopes, forest conditions, hydrological resources and roads are identified and mapped. This work is responsibility of the FSD. In some cases this activity can be performed by the contractor, whenever the FSD has verified that their staff is able to do this task.

With the information obtained in the stock Survey, the stock map is prepared which details the position of the registered trees in the forest, showing their species and diameters. This work maybe performed by an experienced contractor, being checked by district officers for their approval.

In the Yield Estimation the trees for each compartment are selected, these trees are authorized to be harvested by the contractor in a particular period of time.

This selection is based on the following criteria:

- Ensure a good distribution of trees after logging.
- Need to favour removal of damaged, but still utilisable trees.
- No more than 3 trees/ha can be removed
- Trees to be removed must conform to the minimum felling diameter regulations for the species.

Besides, the following rules of forest protection are considered:

- No harvesting within 25 m of small watercourses and 50m of rivers.
- No logging on slopes above 30%
- Open areas in the forest should be prevented..

Yield approval can only be done by a district forest officer. From the above information the Yield List for each compartment is generated, where the stock number, species and diameter of the harvest authorized trees are indicated. In the same time the yield map is produced showing the location in the forest of the trees to be harvested.

The contractor receives copies of the yield list and yield map indicating the stock numbers, species and estimated diameters of the selected trees. With this information the contractor may start the harvest activities in the compartment.

<u>Weaknesses:</u>

In the Pre-harvest planning stage, certain aspects were found that can weaken the subsequent wood tracking system.

One of the main weaknesses is the stock and yield map prepared by the FSD or by the contractor. These maps are not a correct representation of the elements found in the field. During checks made in the forest it was found that many trees have different locations to the ones in the map or the maps are not accurate. In addition to this, it was clear that the company staff that use the map information, for example to identify the tree to be harvested do not have enough knowledge to understand and read the map information.

Another weakness found was that the marks of the stock number scribed by FSD onto the stumps are not sufficiently durable since in some stumps observed, the stock number was almost illegible and in other cases missing completely.

Another important factor to consider is that many stolen trees were detected in the field. These were stolen before the contractor arrived in the compartment. In most cases there was evidence of trees having been stolen and sawn into boards in-situ before being carried out of the forest. In some cases trees were felled but the log never was removed from the forest.

3.1.2 Off-Reserve situation

In the off-reserve situation the identification preparation and management procedure of TUC are performed in a very similar way to the on-reserve situation ones. The difference is that quotas are calculated in the districts for the different off-reserve situations in order to limit the annual quantity of wood extracted in a particular area.

Additionally, in the off-reserve situation the Social Responsibility Agreement has an enormous importance since it is not possible to do the harvest without consulting the corresponding community.

The stock survey consists in that the same contractor selects the trees he/she wishes to fell. Later, the pre-inspection of trees to be harvested come, where the district officer marks with a correlative number the authorized trees to be harvested. In addition, the approval by the land owner and farmers is required; compensation payments are fixed for the possible damage to crops that the forest harvest may cause.

The approval permission for the harvesting of said trees is issued by the district officer and the contractor prepares the annual harvest plan.

<u>Weaknesses:</u>

The weakness found in the off-reserve situation is when the contractor carries out the assessment of compensation due to the farmers for the damages suffered by their crops from the harvesting activities; it does not consider the damage to the soil caused by the machines and the possible erosion in those areas.

3.2 Harvest

3.2.1 Reserve situation

The contractor in the forest identifies the trees indicated in the yield list and proceeds to fell them. Immediately after felling the stump is marked with the following information which is encoded in an abbreviated form:

- Locality mark
- Contractor name
- Stock Survey number
- Species Code
- Compartment number
- Reserve name

Thereupon after harvesting the tree and before removal from the felling site, a Technical Officer of the FSD measures the log diameters and its length. Subsequently, he/she completes the Tree Information Form (TIF). The following information is registered for each tree:

- Stock Survey number
- Tree number
- Species
- Length
- Butt end diameter and the small end diameter
- Volume is estimated

An example of a TIF is provided in Annex 1.

Furthermore in each form the contractor and information about the place where the wood was harvested is detailed. The TIF is signed by the Technical Officer of the FSD and the contractor staff. With the information in the TIF, the FSD calculates the corresponding royalty the contractor must pay.

Where the tree can be forwarded without further crosscutting it is forwarded to the landing for crosscutting. Some larger trees need to be crosscut in the field before forwarding. The tree or log is now forwarded to the log landing where it is crosscut. The logs are recorded and their new dimensions are entered into the Log Information Form

(LIF). This process is carried out by the contractor. In this form the following information is registered.

- Contractor
- Location Compartment
- Stock Survey number
- Tree number
- Species
- Log´s Length
- Log´s Butt end diameter and the small end diameter
- Log´s Volume

Annex 2 provides an example of a LIF

At the log landing each log that will be removed from the forest is marked with the following information:

- Locality mark
- Contractor's Name
- Log Number
- Stock Survey number
- Compartment number
- Species
- Reserve name

Each LIF is delivered to the Forest Services Division (FSD) office and their staff cross-check the LIF registers with the TIF information. They check for the existence of repeated tree numbers and the coherence between the volume of all the logs and the volume of their respective tree of origin.

If there is no problem, the LIF is approved by the Technical Officer of the FSD.

<u>Weaknesses:</u>

A variety of problems were detected in the harvesting process which resulted in an immediate failure of the log tracking system. It can safely be said that already at this stage it is practically impossible to be sure of linking logs exported from the forest to the stumps remaining in the forest. These failures in the system included evidence for the harvesting of trees prior to the opening of the compartment, the harvesting of trees not in the yield and the failure to properly register information about trees legally harvested.

In the first place, it was detected that the log marking process was carried out in the landing and not in the forest after the crosscut as it should be. It means that the logs are

cut and subsequently removed from their origin in the forest to the landing where they are stored unmarked and mixed with other logs from different origins; this is when the logs are marked. With this current situation the frequency of making mistakes increases and the possibility to change or invent new numbers does not assure the wood traceability. The log marking process should take place immediately after the crosscut, in order to identify each log before it is removed to the landing and mixed with other logs from different trees. Only in this way can the loss of traceability be avoided.

Furthermore, some trees which were planned to be harvested in the yield list of the compartment were not present in the forest. The reason is those trees were harvested before time, when adjacent the compartment was harvested. These logs must be considered illegal since the compartment had not been opened for harvest when they were taken.

In the field work, in some cases, the swapping of stock numbers in trees was observed. For example, the contractor felled a tree that is not indicated in the yield list and allocates the number of the other tree registered in the yield list. In other word the company staff records a false stock ID number taken from another tree within the yield allocated by FSD. This situation happens mainly with large diameter trees with easy access which are located close to roads and landings.

Some recently harvested trees were detected that do not have the stock number marked on the stump. Probably they have been stolen by illegal loggers between the stock survey date and compartment opening which can be over a year. In some cases there is clear evidence that these trees were sawn into boards in situ and the boards than removed by hand. In other cases the tree is left in the forest untouched.

Another critical point found is the process of filling in the TIF by the Technical Officer of the FSD, it is not an independent work done by them because they always do this process accompanied by someone from the company. In many cases the FSD officer is not actually present at the time the TIF is filled in since in most cases they visit the harvesting site sporadically and the harvesting team does not wait for their presence before hauling logs to the landing and carrying out the cross-cutting. Besides, the officer measures the dimensions of recently felled trees and does not check if the tree number coincides with the stock number so as to detect and inform possible problems.

The LIF are issued by the contractor and handed in when the truck leaves the forest. In order to demonstrate a reliable process this form should be sent immediately after the crosscut process. This change would reduce the time to issue the LMCC and the transport cost.

The last weakness found was that in case of detecting a problem like the cases above mentioned, the contractor does not inform to the FSD, in order to find a solution and determine responsibility and assign compensation.

In effect the contractors control the entire process and carry out most of the work that should be carried out by the forestry commission. The supervision of this process by the FSD is extremely lax and as a result there is no effective control of the chain of custody. The present system allows illegally harvested timber to enter the supply chain freely.

3.2.2 Off-Reserve situation

This process in an off-reserve situation is very similar to a forest in a reserve. The contractor felled all the authorized trees. The Logs and stump are marked with the following registers:

- Property Mark
- Type of forest
- Region Code
- Species
- Stock number/log number
- Off-reserve

Weaknesses:

Several logs were found stored in a landing without the corresponding stock numbers. In other words these logs were hauled from the forest to the landing without their stock numbers or information written on them making it impossible to trace them to their origin. The stumps of those trees in the forest have not been marked with the corresponding information.

Once again there is an immediate loss of the chain of custody at the point of origin in the forest, it is therefore impossible to verify if the logs to be transported are of legal origin.

3.3 Transport

3.3.1 Reserve situation

a) Transport documentation

The truck is loaded with the logs at the landing. Before the loaded truck leaves the forest the contractor issues the waybill. This is an internal company transport document issued for each truck describing their load.

The waybill contains the following information:

- Contractor name
- Waybill number

- Origin and destination
- Vehicle number and driver´s name
- Species
- Stock Survey Number
- Log Number
- Date

Annex 3 shows an example of a waybill.

With this document the truck leaves the forest and travels to the nearest FSD office. At this point, the FSD officer using the LIF registers completes the Log Measurement and Conveyance Certificate (LMCC) which is handed to the driver and is kept until the sawmill.

The following information is registered in the LMCC:

- Contractor
- Property Mark
- Forest District
- Driver's name
- Vehicle Number
- Destination
- TIF number
- Reserve code
- Compartment
- Stock survey number
- Tree number
- Log number
- Species
- Diameters
- Length
- Volume

Each LMCC have five copies, one is kept in the FSD Office. Two are handed in to the TIDD checkpoint, and two remain in the company. The original copy has the official FSD stamp. (see Annex 4)

b) Checkpoints

Along the path from the forest to the destination (sawmill, plymill, etc), there are different checkpoints where some transport documents are checked.
The checkpoints are the following:

- **Police Checkpoints:** There are several police checkpoints in the roads that connect the forest (On and Off Reserve) to the facilities. The following document is checked:

  - LMCC. The police check the authenticity of this document, to go through the FSD stamp, date, origin. In addition police check the truck information, such as the driver's name and the vehicle number.

- **FSD Checkpoint:** In the road there is a checkpoint belonging to this division, and they check the following document:

  - LMCC. FSD Staff check the authenticity of this document through the FSD stamp, issue date, origin and duplicated copies. In addition the staff check the vehicle number and driver's name.

  The staff carry out a visual inspection of the loaded truck, checking the species and stock numbers.

- **TIDD (Timber Industry Development Division) Checkpoint:** All trucks must be checked in at the TIDD checkpoint. These are located in areas near to the facilities, for example around the cities. The staff check the following documents:

  - LMCC. TIDD staff check the authenticity of this document through the FSD Stamp, and check the logs number and their species loaded on the truck.

  - Way Bill. Check the information of diameters and species registered in the waybill with the registers of the LMCC, in order to confirm the information coherence.

<u>Weaknesses:</u>

The principal weaknesses in the system arise from the fact that it is not applied in the way it was designed. Officially the LMCC forms should be completed by an FSD officer in the forest before the loaded trucks are dispatched. This is not possible because the FSD officer is usually not present in the forest when the trucks leave. As a result the LMCC is issued by an FSD officer with an office at a transport node located some distance from the forest and able to service several TUCs.

In addition there is no point along the transport route where the logs are properly measured by an officer of the FSD. The measurements provided by the company are never checked and as we will see are usually understatements of log volumes.

Finally the FSD officers responsible often do not carry out even the reduced task that they are supposed to and simply sign the relevant documents without even the most cursory inspection of the loads.

Several weaknesses in the transport documents issue were found. The waybills issued by the contractor do not register the logs dimension (diameters and length), and only registered the stock numbers and species.

The LMCC issued by the FSD presents some failures such as:

- The LMCC information is only a repetition of the LIF registers, which is issued by the contractor.
- The official does not carry out any log measurement of the load on the truck.
- Subsequent to the LMCC issue, the official carries out only a visual inspection of the logs in the truck. The official does not always perform this activity.
- The LMCC issue process is extremely slow. In the field work a waiting time of more than 24 hours was observed to issue an LMCC, resulting in a significant increase in transport cost due to capital costs of truck and labour cost of idle drives.

The FSD staff does not store the document in secure conditions and it is not recorded in a proper filing and document control system. This constitutes a significant breach of chain of custody procedures.

Furthermore, a weakness in the checking by the checkpoint staff along the road was observed. All of them mainly check the LMCC authenticity, but they do not measure the logs transported by the truck. In the FSD checkpoint there is only at best a simple visual and inspection of the load, while in the TIDD checkpoint the stock number and species were checked but they do not measure the logs diameter and length to corroborate the LMCC information.

3.3.2 Off-Reserve situation

The wood transported from an off-reserve to the sawmill is carried out in the same way as that from a forest reserve. It therefore presents all of the same weaknesses in the COC system.

3.4 Log Reception at the Sawmill

3.4.1 Reception situation

The truck carrying logs enters the sawmill through the main gate. The first control is the sawmill gate where the input and output truck information is registered.

The documents registered at the security gate are the following:

- ***Gate Pass.*** Contractor's internal document issued when the truck leaves the factory. In this document the destination, date, vehicle number and driver´s name are registered.

- ***Driver´s time book***. Document belonging to the company, that registered the date and hour of the input and output of the truck from the forest and sawmill.

- ***Log Book***. Book is kept in the security gate and details the truck input and output information. The following information is registered in the log book when a truck leaves the sawmill to the forest.

    - Exit date
    - Vehicle Number
    - Driver´s name
    - Time out
    - Gate pass
    - Destination

    When the same truck returns to the sawmill, the following information is added.

    - Log number for each species
    - Entry Date
    - Time in

    Additionally, the reception clerk registers in the book the waybill number and the species name.

With the approval of the security gate staff, the truck is sent to the log yard. The reception clerk carries out a visual inspection of the load and checks the LMCC. Subsequently, the logs are unloaded and the clerk measures the logs.

The re-measurement is as follows:

- Diameters: The clerk carries out two diameter measurements in each side of the log.
- Length: The clerk measures the length of each log.

The new measurements are registered on the back of the waybill and are handed over to the log yard supervisor. This register is used to generate the internal reception information. These are:

- ***Daily Trucking report.*** This gives details of the wood loads received in the factory, showing truck information, species, log numbers and volume, and their respective waybill number.

- ***Daily logs stock chart-sawmill.*** This report indicates the current wood stock by species available to process in the sawmill.

- ***Daily logs stock chart-plymill.*** This report indicates the current wood stock by species available to process in the plymill.

- ***Daily logs stock chart-slicermill.*** This report indicates the current wood stock by species available to process in the slicermill.

In addition to this, the reception staff carries out a check between the waybill and LMCC register, with the purpose of assuring the information coherence of both documents.

Weaknesses:

Principal weaknesses occur in relation to timber that is purchased from third parties in the city or town where a factory is located . These logs since they do not need to pass any control point are transported without an LMCC so there is no properly recorded information about their origins or of their volumes. As long as this situation continues it is impossible to verify that products exported from the mills are of legal origin since there is no proper official record of input volumes. In addition a number of other weaknesses were detected which result in the failure of the paper evidence for integrity of the chain of custody even in situations where the timber is of legal and verified origin.

Some weaknesses were detected in the reception process, as such:

- No check what-so-ever on legal papers of logs purchased from suppliers (LMCC) in the city.
- The corresponding waybill is not always joined to the LMCC.
- Reception checks volumes again based on different criteria. No feedback or measures taken when irregularities are detected.
- There is no check to determine if the logs entering the mill from other sources are legal.

3.4.2 Measure study

During the field work a study was performed with the purpose of detecting possible differences between the log measurements carried out in the forest (registered in the LMCC) and those recorded in the sawmill reception.

The study consisted of the following. Ten logs that came from the Suhuma Reserve were randomly chosen. These were all logs which have been received in the sawmill during August. The consultant made a comparison of the diameter and length between the LMCC registers (which measurements took place in the forest and form the basis of the payment of royalties), and the register of the measures carried out in the log yard of the sawmill. In addition the consultant measured the diameter of each side of the log and the length of 6 of the selected logs.

In the following Table (1) a comparison between the length measure of each log carried out in the forest (LMCC) and the length of the same log measured by reception clerk in the sawmill log yard, are presented.

Table Nº1 "Comparison between the length of logs as measured in the forest and at the sawmill reception"

Log Number	Length (m)		
	LMCC	Reception	difference
25-1	12,0	12,0	0,0
9-2	10,5	11,9	1,4
24-1	12,2	12,1	-0,1
6-1	9,7	13,3	3,6
6-2	10,3	13,0	2,7
23-1	9,8	12,5	2,7
17-1	10,1	13,3	3,2
18-2	10,0	13,4	3,4
21-2	11,0	10,9	-0,1
18-1	10,0	12,2	2,2
Average	**10,6**	**12,5**	**1,9**

As shown in the **Table**, 70% of the selected logs showed significant differences (more than one meter) between the measurements carried out in the forest and registered in the LMCC and the measure taken at reception in the sawmill, presenting an average difference of 1.9 meters. The maximum difference observed was of 3.6 meters, between the length measures for the same log. In other word this study shows that the volume measure in the sawmill were over 15% more than those declared in the LMCC.
In the next Table (2) it is possible to observe the differences between the length measures in the forest (LMCC), in the log yard by company staff and the consultant measure.

Table Nº2 "Comparison between length measures carried out in the forest, log yard, and by the consultant"

Log Number	Length (m)		
	LMCC	Reception	Consultant
25-1	12,0	12,0	12,0
9-2	10,5	11,9	11,9
24-1	12,2	12,1	12,1
18-2	10,0	13,4	13,4
21-2	11,0	10,9	10,9
18-1	10,0	12,2	12,3
Promedio	**11,0**	**12,1**	**12,1**

As shown in the Table, the measurements made by the reception clerk and by the consultant coincide in 100%. There is no difference between these measures. But there are differences between the measures carried out in the forest and the consultant measure. Consequently, the LMCC registers do not represent the real length dimensions.

With respect to the diameters, the study shows that there are not significant differences between the measures registered in the LMCC and those registered by the company staff. The average difference was 0.4 mm, without any tendency to under or over estimate the measurements. In Annex 5 is possible to observe the details of this study.

In the consultant measure, significant differences were not detected with the LMCC and Log yard register. In the case of diameter measures carried out in the forest, an under estimation of 0.3 cm was obtained compared with the measure done by the consultant. In the case of diameter measures carried out in the log yard an under estimation of 0,7 cm was obtained compared with the measure done by the consultant.

In short, the FSD officer failed to check the stated measurements. Lengths showed under measurements which are difficult to be verified while logs are on the truck since this would require a two man team of fit men in order to climb onto the truck and make the measurements.

3.5 Factory

The received wood in the factory is stored in log yards where it is mixed with other logs from different origins remaining available for the production process.

Weaknesses:

We have examined the flows of timber in the mill and the recordkeeping. We found that in the veneer mill examined, it was possible to link the veneer outputs back to the logs in most cases for the peeler veneer, and in all cases for the sliced veneer. In the veneer finishing mill that was examined, it was no longer possible to continue this link although it was possible to determine that in most cases stitched veneer sheets originated from the same original flitch.

In the sawmill it was possible to link volume recovery to individual logs but not necessarily to link material directly to the log. This was due to the rather chaotic storage of sawn timber so that the identity of individual piles was not clearly indicated.

In the sawmill process the following weaknesses were found:

One important anomaly detected is that the wood tracking report on process recovery and yield do not make sense (Input-Output). Because in the yield process they consider the commercially useful volume instead of the total volume produced. This means that the factory considers only the export volume and considers the products commercialized in the local market and sawdust as waste products.

Other weaknesses were found, such as:

- It is not possible to know how much and what products came from a given log.
- Main issue of concern is from tree to process log. Crosscutting at several stages without tracking.
- Chaotic storage of finished products means that it is not possible to link to input trees

Although these weaknesses are significant, to link output products to individual trees need to be assessed; we believe that this is neither necessary nor desirable. The amount of information generated by such a process will become effectively unauditable.

4. REQUIREMENTS FOR AN EFFECTIVE WOOD TRACKING SYSTEM FOR LEGALITY ASSURANCE

4.0.1 Timber Tracking and Tracing

Tracking and Tracing are two related concepts which are both required in order to have a robust system for the establishment of a strong chain of custody such as that required for legality verification. They are often confused or used interchangeably in the literature around chain of custody. Tracking refers to the ability to know about the location and such other parameters as may be required of a particular good at any time during its transit from origin to point of sale (and occasionally beyond). Tracing refers to the ability after the event to reconstruct the history of the good in terms of its location, ownership and any other parameters of interest. Thus tracking on its own does not provide sufficient information to establish a defined Chain of Custody there is also a need to record and retain the information required to trace the goods. For the purpose of this discussion we will use the term Tracking to cover both Tracking and Tracing except where it is clear that the tracing aspect is not included. In addition much of the technology related to tracking is based on the marking of timber in some way. It should be obvious that the simple marking of a good is not an adequate system of tracking since further information is required to achieve tracking and that information needs to be retained in an accessible manner in order to achieve tracing.

4.0.2 Tracking Techniques

A wide range of techniques have been developed for the tracking of timber. Some of these techniques are useful for tracking only, and some for tracking and tracing. Few are applicable throughout the entire production chain.

To be complete a system will require a secure labelling system, information recording systems and information retrieval systems. **An information system incorporates labelling devices, documentation processes, data protocols, communication systems, systems for data storage, retrieval and analysis.** Information systems can be developed for a special part of the chain or management of the entire chain. The latter is often made complicated because of inability to trace material outside the organization's activities.

Information systems require standardized procedures and data. Standards are further required for capture of label data. Field data loggers are commonly used to electronically record data. Common forms of data communication are standard phones, mobile phones, radio and satellite communication.

4.0.3 Current Situation in Ghana

The current wood tracking system in Ghana is too bureaucratic with too many documents and too many people involved, and the main problems detected in the field were:

- The system slows down log movements significantly (delay in issue of documents issued)
- Nobody in the chain from the forest to the mill is fully trustworthy. This does not necessarily mean that everyone is dishonest however it was clear from our experience that several persons between the forest and the point of delivery of logs could not be trusted to carry out their task completely.
- At best, several of the officers of the Forestry Commission involved in the verification of the control system are failing to carry out the tasks assigned to them properly.
- Companies are liable to understate their volumes.
- Regulatory officials are vulnerable to corruption.
- Control systems must overcome the problem of trust.

4.0.4 The New Tracking System

We recommend that the new system for legality assurance is based on a simplified and less bureaucratic system. Two principal control systems will be required. Firstly complete stock surveys will be carried out immediately before that harvest and immediately after the closure of the compartment. The TUC holder will be responsible for payment for all trees removed during this period.

The principal control point for volumes will be situated at the mill gate. A duly authorised person will be located at every mill and will be responsible for measuring all incoming timber volumes of whatever origin. They will also be responsible for verifying the waybills and/or any timber conveyance certificate (vide L.I. 1649, 24.1.2.3) in whatever form approved by the FC, in order to confirm origin etc.

Ideally the authorised persons should be from a third party organisation outside of both FC and the companies. This is the practice in Sweden and it has been found reliable and trustworthy by both mill owners and forest owners for almost 100 years. An important aspect of this organisation is that its controlling board is made up equally of representatives of the buyers and sellers. It has a particularly strong internal control system to ensure that logs are reliably measured and graded. A more detailed description of the current Swedish practice is presented in Annexe 10.

A full description of the new process is given in 4.1, 4.2, 4.3, 4.4 and 5.0.

4.0.4 Brief Description of the Helveta system based on hand held computers and GPS units.

The Forestry Commission has contracted Helveta a UK based company to deliver a timber tracking system which will eventually be capable of tracking timber from the forest to the point of export. The system will also deliver the verification information to assure that the timber is of legal origin within Ghana. The system is based on bar coded tree and log tags which are scanned by hand held computers which contain a GPS locator so that

information is linked to a geographical location with a high level of precision (+/-10m). Tree and log information is recorded and this is automatically uploaded to a central computer database where it can be verified. Log measurements are taken and recorded on the system. When measurements are taken at further in transit control points the measures are correlated with the original measurement in order to detect anomalies.
This system is now undergoing pilot trials in 3 or 4 companies in Ghana. It is the intention that the system will be extended to include the tracking of timber through production processes.

4.0.5 Available Technologies for Timber Marking

A review of different labelling technologies is given in Annexe 11. They range from simple marking using traditional methods such as paint or marking hammers to technically advanced systems like radio transponders.

4.0.6 Suitability of Labelling Technologies

There is no single labelling technology superior to others. Table X has a compilation of what technology is suitable for what. We will recommend the use of a plastic nail based label for both stumps and logs. These labels are constructed in such a way that they cannot be removed without damaging the label. The labels bear a simple number and/or a barcode and can also have a removable tag.

Figure 1 Tag produced by Signumat with removable tag.

It must be recognised that timber tags have significant value since they can be used to launder illegal timber. In some countries timber tags have become an effective currency. It is therefore vital that there is a secure system for storing, issuing and recording tags in order to ensure that they do not fall into the wrong hands. It is recommended that tags are centrally stored and sold to timber buyers by the timber selling organisation, in this case the forestry commission. In order to ensure that timber buyers do not buy unnecessary tags the price of the tags should be set at a level where the value of the tag in the hands of a legal buyer is higher than in the hands of an illegal third party.

Label type	**Tree labels**	**Log labels**	**Processed wood labels**	**Transport documentation**
Paint and chisel	Suitable	Suitable	Not suitable	Not suitable

Branding hammers	Not suitable	Not suitable	Not suitable	Not suitable
Conventional labels	Suitable	Suitable	Suitable	Not suitable
Nail-based labels	Suitable	Suitable	Not suitable	Not suitable
Magnetic stripe cards	Not suitable	Not suitable	Not suitable	Suitable
Smart cards	Not suitable	Not suitable	Not suitable	Suitable
RFID Labels	Suitable	Suitable	Suitable	Suitable
Microtaggant tracers	Suitable	Suitable for adding security to other labels or for tracking batches of logs	Suitable for adding security to other labels or for tracking batches of logs	Not suitable
Chemical tracer paint	Suitable	Suitable for adding security to other labels or for tracking batches of logs	Suitable for adding security to other labels or for tracking batches of logs	Not suitable
Chemical and genetic fingerprinting	Suitable for individual tree fingerprinting	Technology not sufficiently developed	Technology not sufficiently developed	Technology not sufficiently developed

Source: Dykstra *et al*. (2002). Suitable means the technology can be used as a stand alone method. Not suitable means that not enough information can be provided, not cost efficient or not robust enough for what they will be subjected to.

Now the requirements for an effective wood tracking system for legality assurance for small and medium enterprises in Ghana are presented:

4.1 Pre-harvest Planning

In this phase the FSD should make an inspection in each compartment to carry out a marking with correlative numbers to all commercial trees with diameters greater than 50 cm. The marking process is carried out at the bottom of the tree with heat and rain resistant paint or some other permanent marking system which cannot be falsified.

The FSD should prepare a map with the precise (+-3m) geographic location of all marked trees in each compartment and a list indicating their species and diameters. It is important that both FSD staff and company staff are trained and competent in the interpretation of these maps.

4.2 Pre-harvest Inspection

The FSD staff should make a pre-harvest inspection in the forest, which will be done in the following activities:

- Check that all commercial trees have their respective stock numbers.
- Visual inspection with the purpose of detecting stolen trees.

Subsequently, the FSD will determine the trees to be harvested generating the yield list and map. These documents show the trees that the contractor will be authorized by the FSD to fell. The FSD gives the yield list, a download of information of the assigned trees from its database, and the map with the approval for harvest activities to the contractor (TUC holder).

Later the contractor should carry out their own pre-harvest inspection, with the purpose of checking the yield list and map and must communicate to the FSD any anomaly found.

4.3 Harvest

The contractor will carry out the harvest of only the trees indicated in the yield list, identifying and felling the corresponding stock number marked by the FSD. Immediately after felling a tag is attached to stump and another attached to the felled tree.

The tag should fulfil with the following characteristics:

- Heat and rain resistant
- Cannot be removed without destroying them
- Correlative number in each tag
- Tags should carry encrypted information that prevents their duplication or falsification

Each tag will have the following information:

- Reserve Name
- Compartment number
- Stock number
- Tag number
- Felled Date
- Length (m)

- Butt end diameter and the small end diameter (cm)

In Annex Nº6 it is possible to see an example.

Additionally, this information is filled out in the Tree information Form (TIF). This is a document issued in the forest, and is completed with the harvest place (Reserve code, Compartment, etc), and characteristics and dimensions of the tree recently felled. (See Annex Nº7). The tree information form will have a unique serial number.

After the crosscutting process (carried out in the forest or at the landing), a tag is immediately attached to each new log from the tree. The new tag will have the same information that the previous tags, only the log number and their new dimensions will be added (See Annex Nº8). Subsequently, these new elements of each log will be registered in the TIF document.

In each TIF, the following characteristics should be presented:

- Correlative number.
- Issued by the FSD.
- The document presents a duplicate. The original copy is handed in to the FSD, and the duplicate is kept by the contractor.

When the truck is loaded the contractor issues the waybill (can theis serve as conveyance certificate?) the (internal) document that authorizes the logs to be transported from the forest to the sawmill. The waybill contains the following information:

- Company name
- Waybill number
- Origin and destination
- Vehicle number and driver´s name
- Date
- Species code
- TIF number(s)
- Stock Survey number(s)
- Tag number(s)
- Log Number(s)
- Logs dimensions (diameters and length)

An example of a waybill is provided in Annex 9.

The waybill is the only document that is carried to the sawmill on the truck.

4.4 Factory reception

We suggest that factory reception is carried out by staff belonging to a trusted third party organisation. These staff carry out the log reception in order to guarantee the information correctness and the wood traceability. Alternatives to the use of a trusted third party organisation are reliant on a high level of external control since both parties have a potential interest in falsifying the volume and quality data. It is possible that this could be carried out by the independent monitor however the intensity of monitoring required in order to verify compliance on a log for log basis is so high that the monitor would require a staff almost as large as the reception staff and this would make the operation uneconomic. The use of an independent measurement organisation at factory reception would be economically feasible since it would absorb three jobs that are now being done separately once by the FSD for issuing of the LMCC, once by TIDD at the control point and again by the company at the factory gate. Provided the job is done properly at the factory gate the other measuring points will become unnecessary and their costs can be reallocated. It is possible that either a division of the TIDD or TVD could carry out this work but this would require that the organisation be removed from the Forestry Commission in terms of its responsibility and it should instead report directly to parliament through the office of the auditor general (or equivalent).

The staff should be located at the entrance of each sawmill or factory replacing the current measurement clerk employed by them.

The new staff must fulfil the following characteristics:

- A person from an organization independent to the companies and government department.
- Personnel rotation cycle (6 months)
- Knowledge in species and measuring

This independent trusted third party will perform the following activities:

- Logs Reception
- Check the waybill brought on the truck.
- Check the logs against yield map of FSD.
- Carry out a independent measurement of each log (diameters and length)
- Make a comparison between their measure and the records in the waybill.
- The staffs do not accept differences higher than 5 cm in diameters measure, and differences higher than 20 cm in length measure.

- If the measurements carried out by the staff agree with the recording in the documents, the reception is approved and the wood is entered into the sawmill.
- If there are differences, the truck is not authorized to enter to the sawmill and the situation will be informed to the Timber Validation Department (TVD), carrying out an immediate investigation about the log origin.
- The official measures are informed to the FSD and the company, this should preferably be done by immediately entering the information into a computer linked to a central database. If such a central database is properly designed then the information can immediately be made available to the company for internal stock control purposes.
- traceability information of logs bought from suppliers or from other factories must be checked, checking their corresponding waybills to assure the legality of the wood.

4.4.2 Log Dispatch

Significant numbers of logs are traded between companies and do not arrive from the forest. In order to verify legality it is necessary that these are recorded. In the case of logs leaving the sawmill the receptionist must measure the logs and attach a new tag. The old tag should be removed and recorded.

4.5 Post harvest inspection

The independent staff periodically performs checks of traceability information of the logs received in the factories.

The staff should check in the forest that the trees received in the sawmill were indicated in the yield list, in other words, if those trees were authorized to be felled. The staff will carry out the following activities:

- Check the TIF information and if the form was properly filled in.
- Verify stump tag numbers against stock numbers.
- Verify that all felled trees have stock number and stump tag.
- Check that the stock number allocated by the FSD coincides with the tag information

The independent third party will verify the following documents:

- Yield Maps
- Yield List
- TIF
- Waybills

All the documents should be kept tidy and securely stored.

Any anomaly detected will be immediately communicated to TVD. The staff keeps register up to date of any anomalies detected.

It is suggest that the TVD carries out a sample check of efficacy of post harvest stock survey with the purpose of detecting possible anomalies.

5. Timber Tracking in the processing plant.

Although it is possible to track timber through the sawmill it is our view that this is in most cases neither necessary nor desirable. There are significant exceptions where for example the final product is a veneer and it is necessary to be able to identify veneers made from other flitches taken from the same tree in order to achieve colour matching. However in this case the tracking system is instituted for commercial reasons. In other cases where for example articles are made by finger-jointing offcuts and then veneering them it is possible that the timber in a single item derives from many trees and the information becomes virtually impossible to reconcile.

We assume that the timber receiving process is adequate to ensure that all timber inputs are from legal sources and that in the case that any illegal timber is identified in a processing plant that 100% of the products coming from that mill are disqualified from FLEGT licensing.

We recommend that the verification process is based on a reconciliation of volumes by product. Thus it is necessary to record incoming timber volumes by species and it is necessary to record outgoing product volumes also by species. Where products are made up of timber coming from more than one species, for example a Wawa moulding covered in a Khaya veneer it will be necessary to calculate the volumes of each in the product.

Outgoing volumes of all products must be recorded including those for both the internal market and the export market. It is important to note that products in this case will include logs sent to other processors, peeler cores, veneer residues sent for stitching as well as any other timber products including sawdusts and chips.

A full reconciliation of timber volumes should be carried out on a monthly basis and this should be collated on a quarterly and annual basis. Dispatch from the processing plant should take place in sealed containers. If repackaging is to take place at the port facility before export then the port facility should have its own volume control system.

6. CONCLUSION

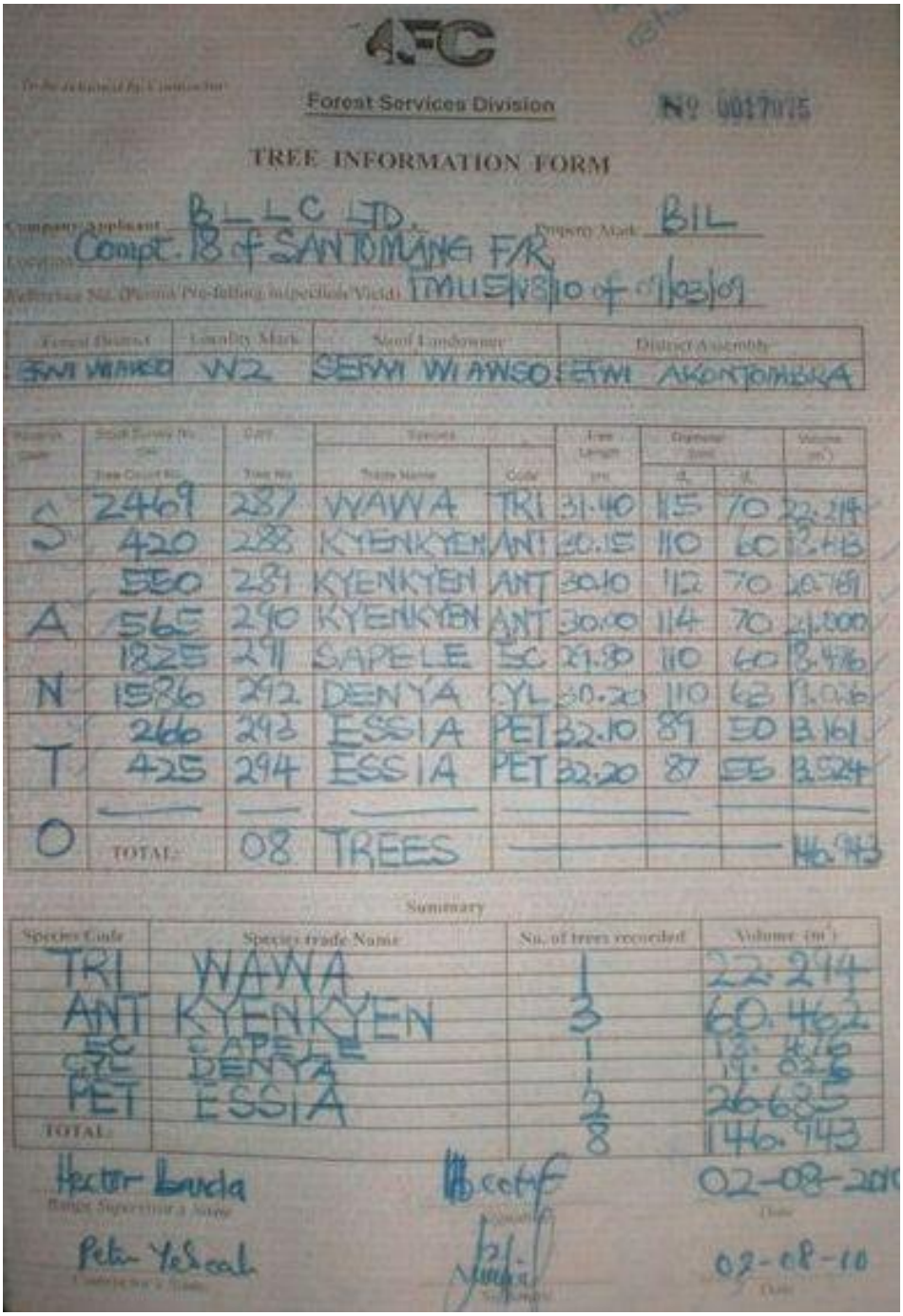
The current wood tracking system used in small and medium enterprises presents several deficiencies along its chain. Most importantly, the FSD staff is not present in the forest and does not check measurements, the checkpoints in transport do not check information properly, paper evidence is lost in many places, the post harvest checks in the forest are not effective and the documents are not stored in secured conditions and recorded in filing systems. On their side the companies fail to act in a legal manner and do not report infringements of their responsibilities when they occur. There is a clear and systematic abuse of the volume control and harvest control systems.

The above mention allows illegally harvested trees to enter the production stream and it does not give COC assurance to legal trees traded between companies in Kumasi, given as a result that the existing system is not working well.

The research done suggests major changes in the implementation of the present system are necessary, such as log tagging, independent measurement of volumes by an independent trusted partner and a post harvest stock survey to achieve an effective wood tracking system for legality assurance.

7. Annexes

Annex 1. Tree Information Form



FC

Forest Services Division

TREE INFORMATION FORM

Company/Applicant: B L C LTD. Property Mark: BIL

Location: Compt. 18 of SANTOMANG F/R

Reference No. (Permit/ Pre-felling inspection Visit): TMU ES/8/10 of 01/03/09

Forest District	Locality Mark	Stool Landowner	District Assembly
SEFWI WIAWSO	W2	SEFWI WIAWSO	SEFWI AKONTOMBRA

Sample Tree No.	Stool Survey No. or Tree Count No.	Cert. Tree No.	Species Name	Species Code	Tree Length (m)	Diameter (cm) B.	Diameter (cm) T.	Volume (m³)
	2469	287	WAWA	TRI	31.40	115	70	22.214
	420	288	KYENKYEN	ANT	20.15	110	60	13.413
	550	289	KYENKYEN	ANT	30.10	112	70	20.769
A	562	290	KYENKYEN	ANT	30.00	114	70	21.280
	1825	291	SAPELE	SC	21.80	110	60	13.476
N	1586	292	DENYA	CYL	30.20	110	62	19.026
	266	293	ESSIA	PET	32.10	89	50	13.161
T	425	294	ESSIA	PET	32.20	87	55	13.524
	—	—	—	—	—	—	—	—
O	TOTAL:	08	TREES	—	—	—	—	146.943

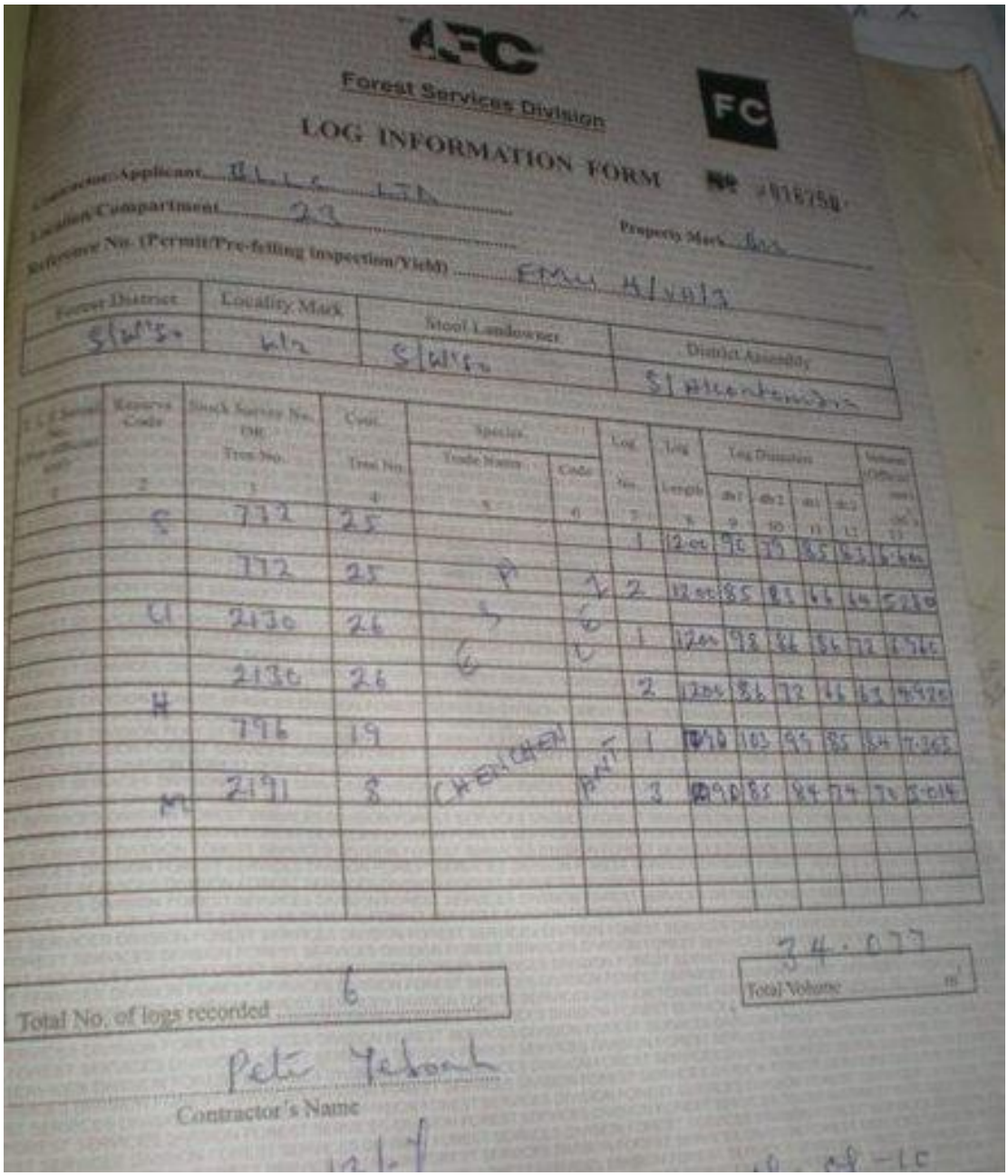
Summary

Species Code	Species trade Name	No. of trees recorded	Volume (m³)
TRI	WAWA	1	22.214
ANT	KYENKYEN	3	60.462
SC	SAPELE	1	13.476
CYL	DENYA	1	19.026
PET	ESSIA	2	26.685
TOTAL		8	146.943

Hector Lucia — 02-08-2010

Peter Yeboah — 02-08-10

Annex 2. Log Information Form



Forest Services Division

LOG INFORMATION FORM

Locality/Compartment 23

Property Mark

Reference No. (Permit/Pre-felling inspection/Yield) FMSU H/VOL

Forest District	Locality Mark	Stool Landowner	District Assembly
S/W'S	412	S/W'S	S/

Reserve Code	Stock Survey No. OR Tree No.	Cost Tree No.	Species Trade Name	Species Code	Log No.	Log Length	Log Diameter				Volume (Official use only)
							dia1	dia2	dia3	dia4	
	772	25			1	12 ft	96	79	85	83	5.660
	772	25			2	12 ft	85	83	66	64	5.230
	2130	26			1	12ft	98	88	86	72	7.360
	2130	26			2	12ft	86	78	66	63	4.970
	796	19			1	12ft	103	95	85	84	7.363
	2191	3			3	12ft	85	84	74	70	5.014

Total No. of logs recorded 6

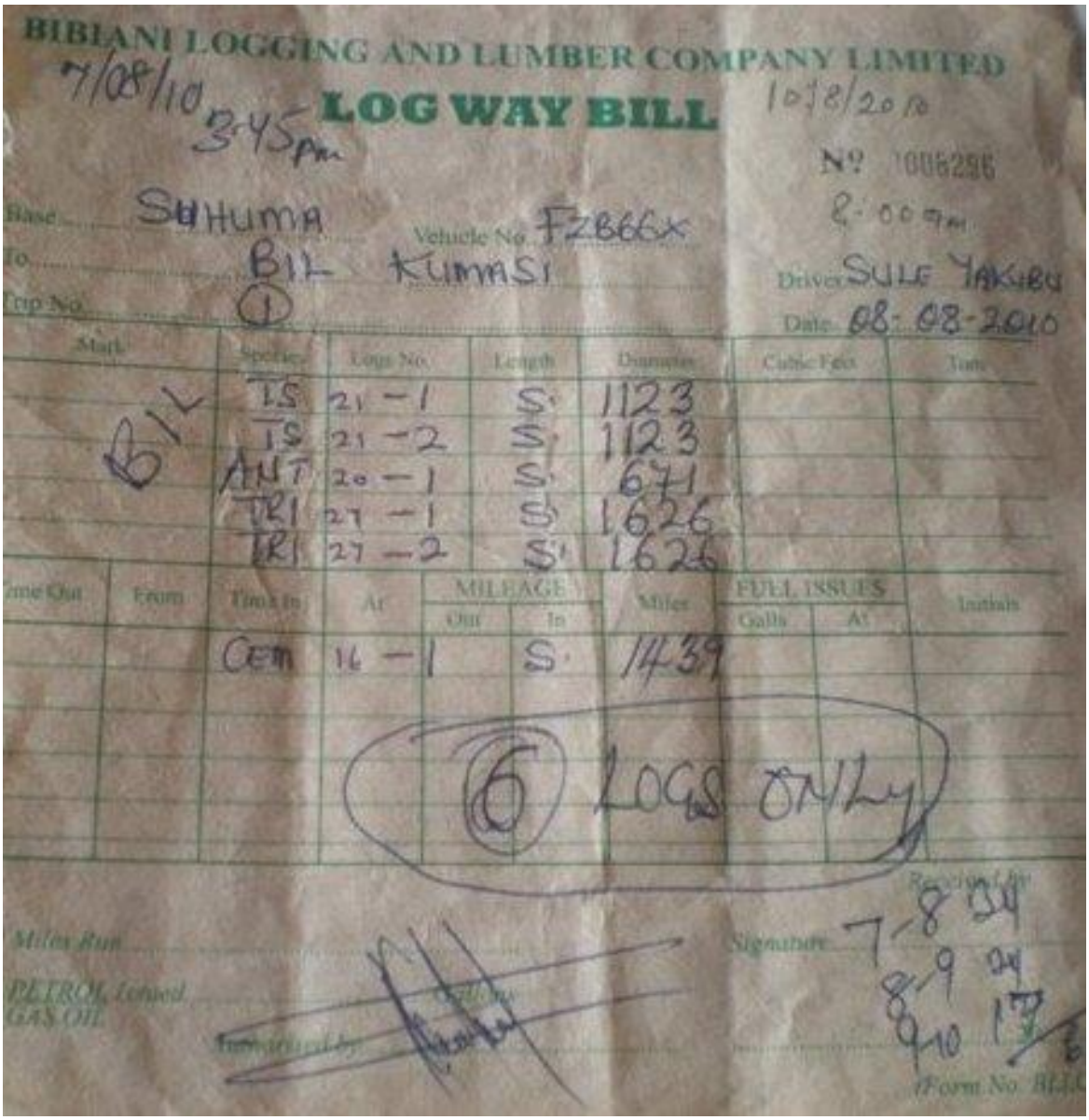
34.077

Total Volume m³

Pete Yeboah

Contractor's Name

Annex 3. Waybill issued in Suhuma Reserve



BIBIANI LOGGING AND LUMBER COMPANY LIMITED

7/08/10 3:45pm

LOG WAY BILL

10/8/2010

No 1005295

8:00pm

Base SUHUMA Vehicle No. FZ866X

To BIL KUMASI Driver SULE YAKUBU

Trip No. 1 Date 08-08-2010

Mark	Species	Logs No.	Length	Diameter	Cubic Feet	Tons
B/L	TS	21 -1	S.	1123		
	TS	21 -2	S.	1123		
	ANT	20 -1	S.	671		
	TRI	27 -1	S.	1626		
	TRI	27 -2	S.	1626		

Time Out	From	Time In	At	MILEAGE Out	MILEAGE In	Miles	FUEL ISSUES Gallons	FUEL ISSUES At	Initials
		CEM	16 -1		S.	1439			

6 LOGS ONLY

Miles Run

PETROL Issued

GAS OIL

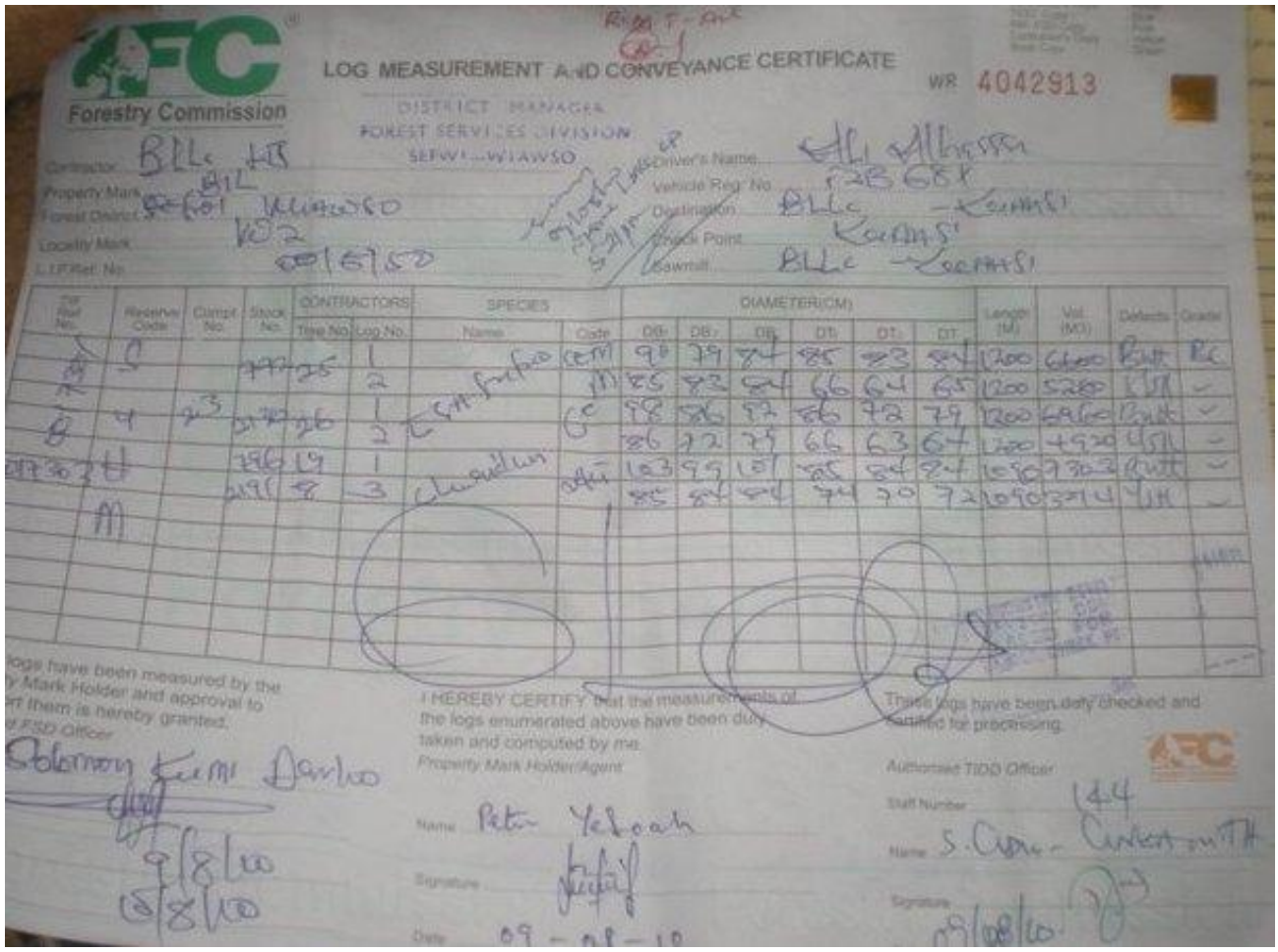
Signature 7-8 24

8-9 24

8-10 17

(Form No. BIL

Annex 4. Log Measurement and Conveyance Certificate



Forestry Commission

LOG MEASUREMENT AND CONVEYANCE CERTIFICATE

WR 4042913

DISTRICT MANAGER
FOREST SERVICES DIVISION
SEFWI - WIAWSO

Contractor: BLLc LTD
Property Mark: BLL
Forest District: WIAWSO
Locality Mark: KD2
LI/FR Ref. No: 016150

Driver's Name: Ali Alhassan
Vehicle Reg. No: GR 2868 X
Destination: BLLc - Kaamasi
Check Point: Kaamasi
Sawmill: BLLc - Kaamasi

LI/FR Ref. No.	Reserve Code	Compt. No.	Stock No.	CONTRACTORS Tree No.	CONTRACTORS Log No.	SPECIES Name	SPECIES Code	DIAMETER(CM) DB1	DB2	DB3	DT1	DT2	DT3	Length (M)	Vol. (M3)	Defects	Grade
A	C			25	1	Emfoa	CEM	90	79	84	85	83	84	1200	6600	Butt	RC
A	C			25	2	Emfoa	CEM	85	83	84	66	64	65	1200	5280	Butt	✓
B	4	23		26	1	Emfoa	CEM	98	86	87	86	78	79	1200	6960	Butt	✓
B	4	23		26	2	Emfoa	CEM	86	72	79	66	63	67	1200	4920	Butt	✓
A	H			19	1	Chrysophyllum	ALB	103	99	101	85	84	87	1200	7302	Butt	✓
A	H			8	3	Chrysophyllum	ALB	85	84	84	74	70	72	1090	3714	Butt	✓
A	M																

logs have been measured by the
y Mark Holder and approval to
rt them is hereby granted.
FSD Officer
Solomon Kumi Darkoo
9/8/10
9/8/10

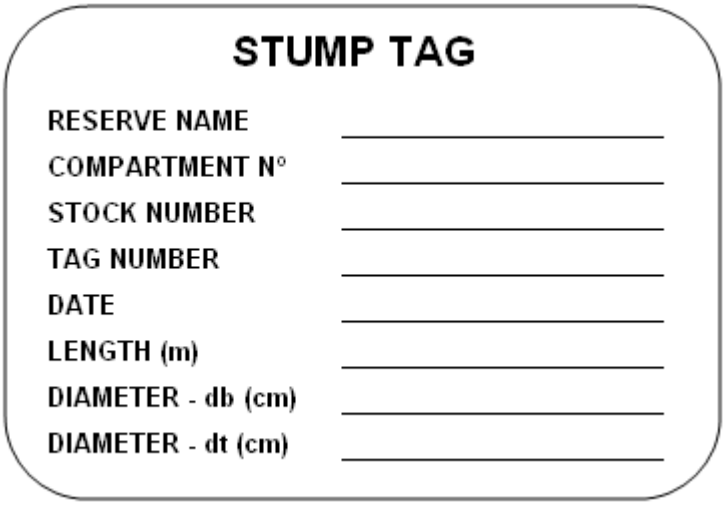
I HEREBY CERTIFY that the measurements of the logs enumerated above have been duly taken and computed by me.
Property Mark Holder/Agent
Name: Peter Yeboah
Signature:
Date: 09-08-10

These logs have been duly checked and cleared for processing.
Authorised TIDD Officer
Staff Number: 144
Name: S. Cudjoe-Cantonment
Signature:
09/08/10

Annex 5. Measure study data

Log N°	LMCC Registers					Log Yard Measuring					Consultant Measuring				
	Diameters				Average	Diameters				Average	Diameters				Average
	dA1	dA2	dB1	dB2		dA1	dA2	dB1	dB2		dA1	dA2	dB1	dB2	
25-1	98	79	85	83	**86,3**	84	82	90	71	**81,8**	95	90	84	82	**87,8**
9-2	77	72	76	64	**72,3**	70	76	73	70	**72,3**	78	69	75	68	**72,5**
24-1	83	78	81	77	**79,8**	86	82	77	81	**81,5**	77	82	80	87	**81,5**
6-1	97	85	100	95	**94,3**	83	96	100	90	**92,3**	96	86	94	97	**93,3**
6-2	100	95	77	74	**86,5**	94	96	75	77	**85,5**	99	96	73	76	**86,0**
23-1	103	85	93	90	**92,8**	88	103	92	90	**93,3**	82	100	91	92	**91,3**
17-1	64	56	64	64	**62,0**	64	56	64	62	**61,5**	65	56	62	64	**61,8**
18-2	72	66	82	74	**73,5**	82	78	72	66	**74,5**	84	80	72	66	**75,5**
21-2	86	86	76	73	**80,3**	77	73	90	82	**80,5**	72	77	82	93	**81,0**
18-1	88	80	79	78	**81,3**	84	87	78	78	**81,8**	78	78	82	87	**81,3**
Average					**80,9**					**80,5**					**81,2**

Annex Nº6. Example of a tag to be attached to the stump and the tree



The tag number must be unique and pre-printed on the tag.

Annex 7. New design of the Tree Information Form. (TIF)

TREE INFORMATION FORM Nº

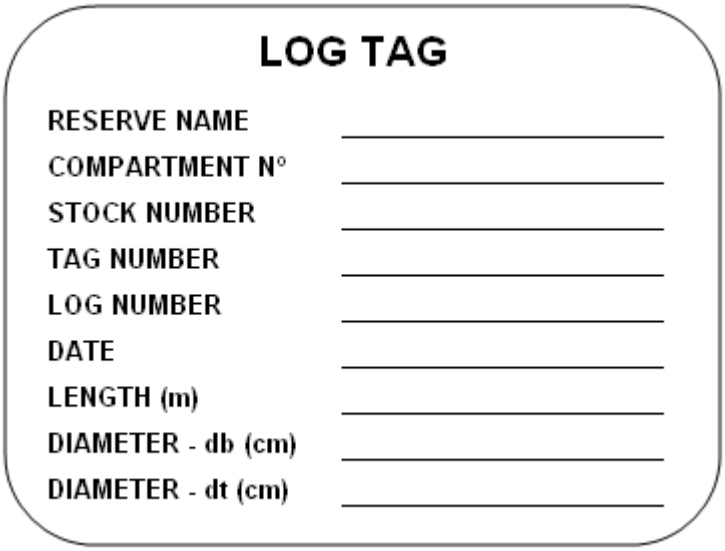
Company: **Property Mark:**

Reserve: **Comparment:**

Forest District __________ Locality Mark ____________ Stool Landowner____________ District Assembly ____________

Reserve Code	Stock Survey Number	Tag Number	Species	Code	Tree			Nº Logs	Log 1			Log 2			Log 3			Log 4		
					Legth (m)	Diameter			Legth (m)	Diameter		Legth (m)	Diameter		Legth (m)	Diameter		Legth (m)	Diameter	
						Db	Dt			Db	Dt		Db	Dt		Db	Dt		Db	Dt

Annex 8. Example of a tag to be attached to the log



The tag number must be pre-printed on the tag and there must be an additional space for entering the TIF number. There must be a space for inserting the stump tag number.

Annex 9. Waybill

WAYBILL N°

Company Name: Vehicle Nº:
Origin: Driver's name:
To: Date:

Property Mark	Species Code	Nº TIF	Stock Survey Number	Tag Number	Log Number	Length (m)	Diameter (cm)	
							db	dt

The column for tag number refers to the stump tag number while log number refers to log tag number.

Annexe 10 Timber tracing in Sweden (Lars Bjorklund 2010) for SSC Forestry

Introduction

This chapter aims at describing ”the case of Sweden” as to the subject of timber tracing. First it must be said that timber tracing is not, and has not been, any hot issue on the domestic Swedish market for roundwood. Neither have there in Sweden been any debates concerning illegally harvested timber. Instead, the debates concerning forestry that have been ongoing for decades have mainly related to environmental issues. How much forest, where and what, should be protected from harvesting? But that debate has not triggered any demand for timber tracing systems. Another reason for tracing systems could be to prevent theft of timber. But this is seen as a marginal problem in Sweden although there are reports on increasing volumes of fuelwood being stolen.

The development of forest certification during the last 15 years has partly changed the view upon timber tracing systems. Export oriented Swedish forest industries are today very interested in systems that would fulfil chain-of-custody requirements for FSC or PEFC certificates for products based on Swedish timber.

Even though timber tracing has not been any key issue itself, the Swedish systems for control of harvesting, independent timber measurement, and a common and centralised data handling, might provide a basis for timber tracing. Maybe even better than in many countries where specific timber tracing systems have been set up?

Organisations with relevance to the trade of forest products

Governmental organisations

The Ministry of Agriculture issues laws regulating forestry activities. Most important is the Forestry Act that reflects the national forest policy. It was last revised in xxxx. It sets a foundation for the balance between production and conservation goals. One important knowledge basis for political decisions concerning the forest sector in Sweden is the National Forest Inventory that has been ongoing since the 1920-ies. It provides reliable figures for annual growth and felling in Sweden and is used to make sure that national harvesting levels are on a sustainable level.

More important for timber tracing is the Timber Measurement Law (1966:209). The Ministry of Agriculture has given the National Board of Forestry (NBF) the duty of issuing regulations with more specific details on how to interpret the law. A revision work concerning the regulations under the Timber Measurement Law was done during 2009-2010.The revised regulations are supposed to be implemented late 2011. When doing this revision NBF established a working group with representatives from the timber market and from the measurement organisation. The work was reported and discussed at hearings where all relevant forestry organisations were invited. The resulting new regulations were then reached in full consensus between NFB and the forestry sector.

As mentioned above the National Board of Forestry (NBF) issues regulations on how to interpret forestry laws. NBF should also make sure that the laws are followed and may send violation cases to court. However, that is extremely seldom needed despite that the forestry law includes many regulations on where and how much it is allowed to harvest. Generally speaking one can say that the forest owners respect and follow the law. Surely this is due to that there is a common understanding between government representatives and forest owners of what constitutes a sustainable forestry.

Other ministries of interest in the context of timber tracing are the Ministry of Environment, the Ministry of Industries and the Ministry of Foreign Affairs. For example these three ministries assign participants to Swedish delegations to international political-driven meetings, like the United Nations Forum on Forests. Thus, they participate in the formation of international policies concerning forestry and the trade of forest products.

Private "sector" organisations

Forests industries

Swedish forest industries are, with some minor exceptions, privately owned. Most of it belongs to Swedish companies. Many sawmills are family based enterprises. They cooperate through the Swedish Forest Industries Federation. This organisation originates from the big private forest companies with both vast forest lands and forest industries. After merging with the Sawmillers Association the organisation represents a large majority of Swedish forest industries. From their web-site we can read:
The Swedish Forest Industries Federation is the trade and employers' organisation for the pulp, paper and wood mechanical industries. Its role is to foster the competitiveness of its members and promote greater use of wood-based products. The Federation is involved, in association with its member companies, in Swedish and European industrial policy, in market issues on wood mechanical products, and in employer issues. The Federation represents around 60 pulp and paper mills owned by 29 groups of companies and almost 150 sawmills owned by approximately 80 companies, as well as a number of companies that have close ties with the production of pulp, paper and sawn timber.

Forest owner organisations

Approximately half of the forest land in Sweden is owned by private forest owners. Half of these are members of forest owners associations. The four regional forest owners associations cooperate through the Federation of Swedish Farmers (LRF). From their web-site we can read:
The Federation of Swedish Farmers – LRF – is an interest and business organisation for the green industry with approximately 170 000 individual members. Together they represent some 90 000 enterprises, which makes LRF the largest organisation for small enterprises in Sweden. Almost all cooperatives within Swedish agriculture and forestry are also members. LRF, and its seven subsidiaries, promote development of the green industry and its farmers of agricultural and forest land, growers and entrepreneurs so that they can fulfil their vision of growth, profitability and power of attraction. LRF seeks to create the appropriate conditions for sustainable and competitive companies and to develop a favourable base for social life and enterprise in rural areas.

The timber measurement organisation

The brief descriptions above of the main private sector organisations are meant to provide a background to a more thorough description of timber measurement in Sweden. The two organisations, the Forest Industries Federation and the Forest Owners Associations, are "statutory bodies" to the timber measurement organisation in Sweden. This organisation consists of independent companies for timber measurement and related IT-services where sellers and buyers have equal share of the power. This way of organising timber

measurement has a long tradition in Sweden with the first timber measurement association founded more than a hundred years ago. Membership in these associations, and the use of its services, is voluntary but it is adopted by almost all actors on the timber market. Today almost 100 % of the main timber assortments, meaning sawlogs and pulpwood, is measured by the three regional timber measurement associations. The measurement data is transferred to, and processed by, SDC - the joint company for IT-services. SDC was founded in 1961, meaning it is celebrating its 50th anniversary in 2011. During this period a tremendous development in IT techniques has taken place. From punch cards sent by mail to on-line access to all measurement stations across the country. Also many harvesters and timber trucks report directly to the SDC systems. All data is stored in SDC´s data bases.

To have independent timber measurement associations, who measure almost all industrial timber, is quite unique to Sweden. However, neighbouring Norway has the same situation and (relatively) independent measurement organisations also exist in for example northeastern USA.

Thus, the organisation of timber measurement in Sweden consists of a governmental level where laws and measurement regulations are issued, and a private level where practical measurement is carried out by independent third-party companies. On a national level the actors on the timber market has given SDC a coordinating role for all issues relating to the practical work of timber measurement. As a support SDC has three advisory groups. These groups, as well as the boards in the different companies, are composed of equal numbers of representatives from sellers and buyers, see figures x-x.

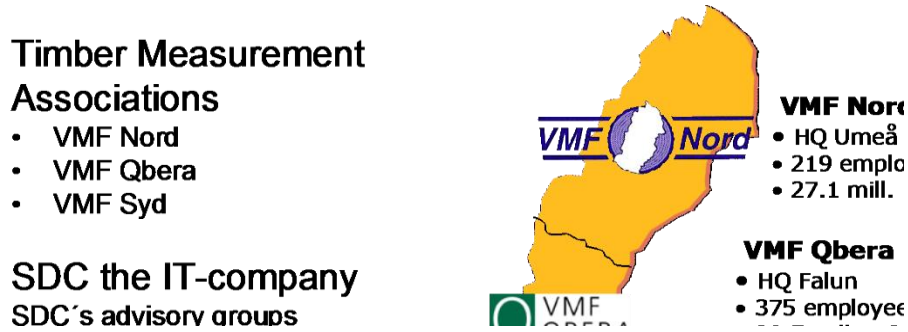


Figure x. Timber measurement is carried out by three regional timber measurement associations. Measurement data is processed and distributed to parties concerned by SDC.

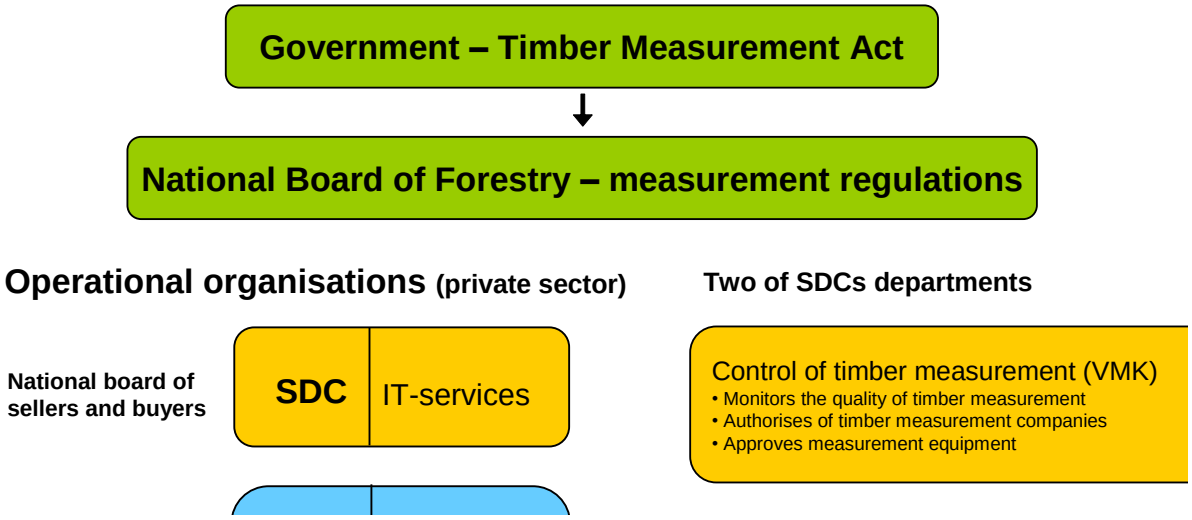


Figure x. Organisation of timber measurement in Sweden has a governmental level where laws and measurement regulations are issued, and a private level where practical measurement is carried out by independent third-party companies

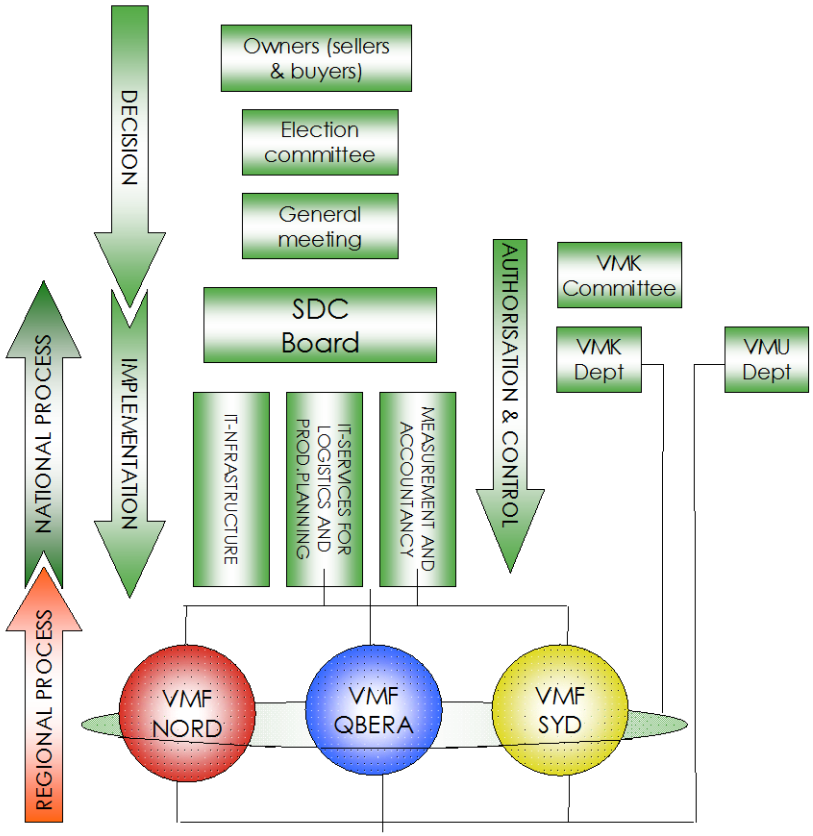


Figure x. The parties on the timber market have, after many years of discussions headed by the Forest Industries Federation and the Forest Owners Associations, in 2009 decided that the board of SDC should have the overall responsibility for timber measurement in Sweden. As a support to that work three advisory groups were established.

NGOs

Non-governmental organisations in Sweden are important stakeholders both concerning high-level forest policy making and practical forest management. Especially the environmental NGOs have for a long time been active in protecting and defending biodiversity values.
NGOs are today actively involved in the development of forest certification standards and they are also invited to comment forestry related suggestions from authorities like the National Board of forestry.

Some activities when timber is harvested and sold

Activity list

Management plans – key biotope inventories
Practically all forest owners have management plans that include suggested future harvesting figures. To have such plans used to be compulsory. (Or is it still to some extent?) Does NBF have access to ÖSI?
Forest management plans include marking of areas with extra high biodiversity value (key biotopes). Key biotope inventories are always part of the inventory for a management plan. Special key biotope inventories have also been done by NBF, often by hiring personnel from NGOs. NBF use these inventories when they check harvesting applications. Thus it can be concluded that there is relatively good knowledge of, and control of, high biodiversity value forests in Sweden.
Agreement between seller and buyer
It is the obligation of the seller to inform the buyer about key biotopes or other circumstances that will influence the planned harvesting. After an agreement is reached the buyer will (normally) register the agreement in the SDC system. He will also initiate the so called Wood Order (see below) in the SDC system that will be the basis for forthcoming data processing.
Announcement to, and checks by, the National Board of Forestry (NBF)
Final fellings (but not thinnings) must be announced six weeks ahead to NBF. NBF can stop the planned felling, for example if the area is designated to become a nature reserve. The felling announcements include a map of the felling area and an estimated Volume to be harvested. NBF conducts at certain intervals sample checks of harvested areas. This is mainly done by using satellite images and comparing areas announced for harvesting with areas actually harvested.
Harvesting and forwarding.
The production of the harvesters and forwarders is often reported daily to SDC. Sometimes different assortments are marked with colour-codes. Some logs are marked for identification of seller and buyer when they are stored at roadside, see further under 3.3.
Transport to industries and measurement

Most timber is transported to industries or terminals by truck. Almost all timber is measured by the measurement associations upon arrival to terminals or industries

The role of the SDC document "Wood Order"

SDC provides a number of IT-services related to selling and buying timber to its clients. The Wood Order (WO, in Swedish VirkesOrder) is an electronic document at SDC that is the "umbrella" for all activities from signing a contract for harvesting to distributing measurement documentation to the parties concerned. When the WO is set up, which is done by the buyer, it includes:

- Information about seller and buyer
- Location of the area to be harvested (map coordinates or name of the municipality)
- Estimated volume to be harvested
- Receiving industries

When the timber arrives at receiving industries it is measured by the timber measurement associations and the volume of each truck load is accounted to the WO. When the harvesting and transport is reported to be finalised the WO will contain detailed information on volumes (specified on assortments and qualities), delivery dates and delivery locations (receiving industries). This can be compared with what was estimated before harvest.

Normally a WO should be registered for each harvesting site. However, this is not always the case and some users of the SDC IT-services use the same WO for several harvesting operations within a region during a certain period of time. In such cases the value of the WO for timber tracing is reduced.

Marking for identification of timber

The National Board of Forestry regulations for timber measurement specifies in § 19 rules concerning marking of timber consignments:

19 § A timber consignment that is measured in the forest or at roadside, must be marked with information containing the date of measurement and the measurement document for the consignment. Other timber consignments are to be marked with details that identify the seller.

This means, since almost all timber is measured at industries or terminals, that the only official rule is that the timber consignment should be marked so that the seller can be identified. The parties on the Swedish timber market have agreed upon two slightly different ways to do this.

In northern Sweden a number of the harvested logs are marked with a 3-5-digit code after they have been transported to roadside. The code provides a reference to the WO. The number of marked logs should make sure that each truck-load will contain at least one marked log. This means that the frequency of marked logs is very low. The low frequency is also motivated by the high cost of manual marking. The marking is done by the machine operators who do the harvesting by stamping, using colour paint, on log end faces. Different seller organisations (companies, forest owners associations etc) use different colours. Thus, the stamp provides a direct identification of the selling organisation and the code gives a reference to the WO where more information about the timber consignment can be found

In south and central Sweden paper tags are used instead of stamping a number. The paper tags are attached to log ends and contain information about seller, buyer and the WO. The number of tags should, like with the stamped marks in northern Sweden, be attached in a sufficient number to make sure that each truck-load will contain at least one marked log.

Figure x. Marked log ends (left) and paper tags (right).

When the timber is loaded on trucks (which is the normal case) at the roadside it is the responsibility of the person loading the truck to check that each load contains marked logs. When the timber arrives at a measurement station only truck loads with a minimum of one marked log will be accepted.

Figure x. At the roadside different assortments are stored in different piles. These are normally transported to different industries.

Ongoing development activities

Marking systems – the research project Indisputable Key

From 2006 to 2010 the Swedish research institute SP-Trätek was coordinating a big European project called "Indisputable Key". The main purpose of this project was to develop marking and tracking systems for forest products that would enable for materials at any point in the value chain to be tracked back to the original source of the raw material. This knowledge should help to improve the use of wood materials and optimise production while minimizing environmental impacts. Among implementation examples was mentioned: Defeating illegal logging by tagging and entering the log codes in a database that authorities can check at a roadside control.

Within the project a search for methods for log marking was done. This resulted in development work on two techniques. One was Radio Frequency Identification Data (RFID) tags. The system consisted of passive ultra high frequency (UHF) transponders

used to mark the logs, a specially designed transponder applicator for automatic and manual marking, readers and control software. Field tests of the automated applicator were done. Overall, the automated RFID insertion system added about five to seven seconds to the log processing time – a significant delay that future research should address. The tags are also still expensive, it was calculated with a price range of 0.1–0.2€ per transponder within the next five years. These two circumstances, too slow insertion system and too high price, made that the development work was stopped.

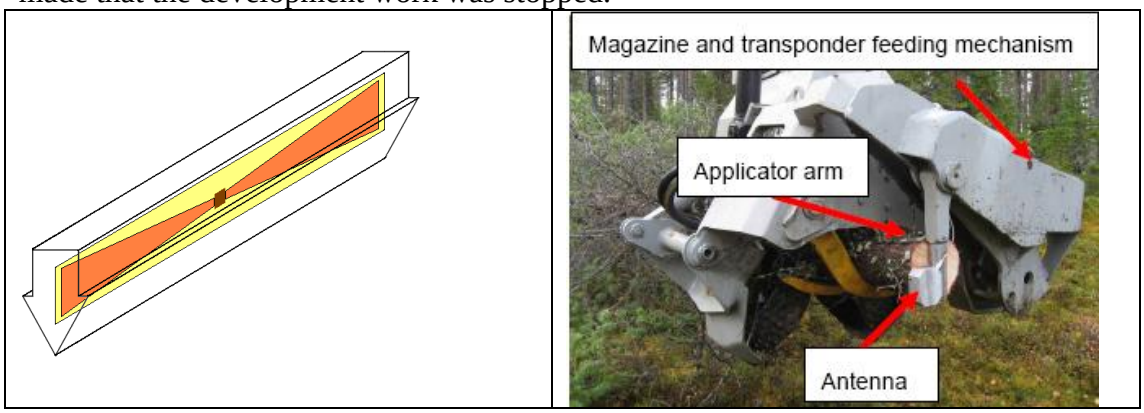


Figure x. The UHF RFID transponder, developed for inserting into the end of a log, was made of artificial wood compatible with pulping processes (left). Prototype transponder applicator in the harvester head (right).

The second technique that was tested to apply a colour ink marking to the top end surface of each harvested log. The ink was channelled through grooves etched into the saw blade and nozzles attached to the blade marked the log as it was being cut. Trials showed that the cost of marking was as low as €0.002 per item. The marking was automated and integrated into the normal processing procedures of the harvester meaning there were no time costs associated with the marking. Still, the system was not considered interesting enough to motivate further development.

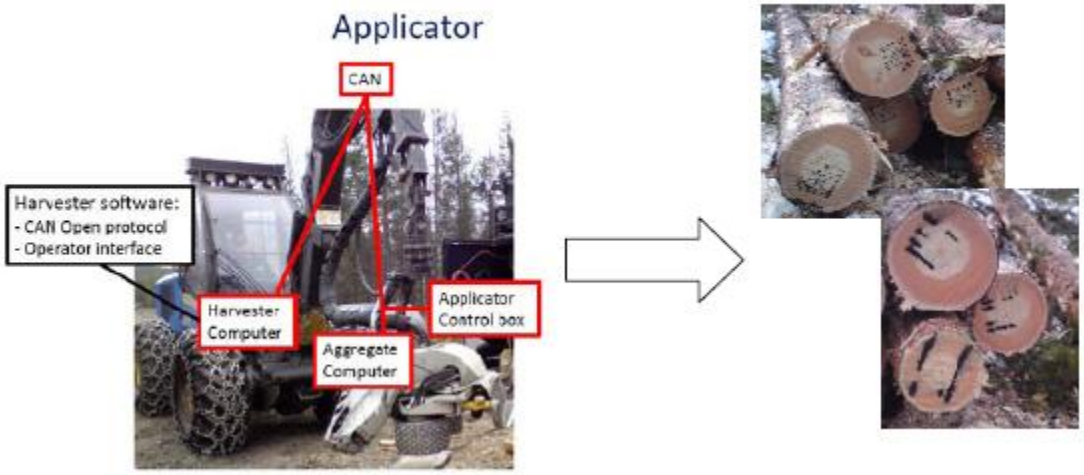


Figure x. The colour ink marking system was based on two dimensional codes of dots or/and lines that were printed on top end of log.

Thus, the project did not result in any break-through concerning log marking systems. But many interesting results, like techniques for transfer of identities from logs to boards were achieved. It was also concluded, by for example Sveaskog, that systems where a low

number of sample logs are marked have a significantly higher chance to become profitable compared to systems where all logs are marked. Through sampling systems, control of for example the measuring devices in a harvester can be done.
This means that it does not seem likely that marking systems that are efficient and cheap enough to be used for all logs will come in a near future. Instead, marking will probably mean that a limited number of logs per "batch" can get an individual marking.

An unbroken information chain from forest to industry

Above it was concluded that systems where all logs get an individual identity are unlikely for the Swedish forestry in the near future. Instead it is more likely that it will be possible to have an unbroken information chain from forest to industry for batches of logs. As discussed above, some sampled logs in these batches could very well be automatically marked by the harvester.
This will be possible since most harvesters have GPS and the coming version of the SDC information system will support GPS-coordinates for each harvested tree. This is being developed in order to further improve the productivity of the harvesting operation, including harvesting of logging residues and stumps, but can of course also be used to trace individual logs back to their original position in the forest. Next step in the information chain is that accountancy system for timber transports are integrated with the IT-systems related to timber measurement. Together these IT-systems will also provide storage information for all storage points from forest to industry. This means that the flow of timber can be fully controlled from the stump in the forest to the receiving industry. If timber should be lost or added it should be seen as deviations between storage points.

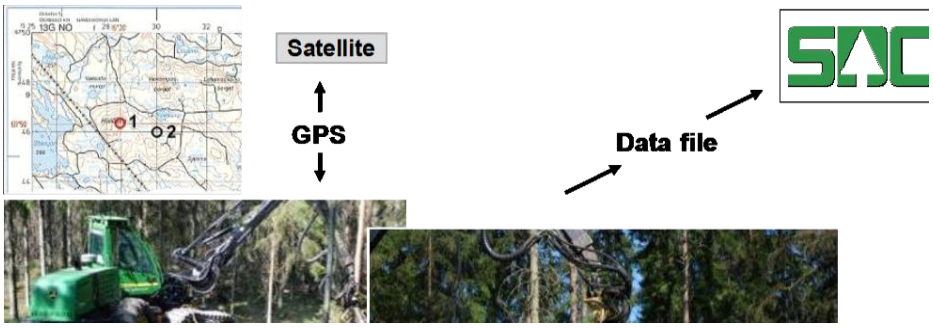


Figure x. Production information from the harvesters will in a near future contain detailed log-by-log information and gps-coordinates for each felled tree. However, the information will probably not be transferred by marking all individual logs. Instead, information on volumes and wood properties will be used for process control on a batch level.

Accountancy system for certified timber (SDC)

Many of the companies using SDC have for a number of years asked for the development of an accountancy system for certified timber. This is meant to function like a bank account where certified volumes can be entered and withdrawn. Pre-feasibility studies have been made but the final development is pending an ongoing discussion within FSC on rules

concerning how volumes of certified timber should be allowed to be transferred between industries and/or regions.
Such a system would not depend on timber marking. The users would enter timber volumes and an auditor would check that batch figures are reliable and that batches can be traced back to the harvesting site.

Discussion

What kind of timber tracing system is relevant for Sweden?

In Sweden there are, as was pointed out in the introduction negligible problems with illegal harvesting. The National Board of Forestry has sufficient means to find illegal harvesting if it reached noticeable volumes.
Concerning theft of timber we concluded in the introduction that it is a marginal problem. Timber is not a first hand choice for thieves. Timber is bulky, heavy and has a low value per ton. For the main assortments, pulpwood and sawlogs, the production and transport can be characterised as "lean production" meaning the time from felling a tree to delivery at an industry is minimised. Almost all timber go to industries where it is measured by the measurement associations. To steal bigger volumes would be very difficult without being spotted somewhere. Thus, there is no need to develop specific systems to prevent thefts of such timber in Sweden. But one can say that the systems that have been designed of other reasons, for example to have independent timber measurement associations, does counteract potential problems like theft.
However, the situation for roundwood that is used as fuelwood is different. Here theft is reported to have become a problem when the market has grown and prices have risen. The handling of fuelwood is in many ways different compared to the traditional assortments. Logs are often left for longer time at roadside, there are many unmanned terminals where it is stored, and the buyers are often small-scale enterprises or private persons who do not use timber measurement associations or SDC services. But the preventive measures discussed by fuelwood traders focus more on camera surveillance, blocking the entries to storage sites etc than on systems for timber tracing.
Instead the main driving forces for timber tracing are linked to environmental considerations and the protection of biodiversity values. In this respect two levels can be distinguished:

- Rules set by the National Board of Forestry concerning protection of areas with high biodiversity value, and maximum harvesting levels.
- Voluntary agreements under the forest certification schemes. In this case it becomes important to prove that the timber comes from certified forest holdings.

At this point we can ask what do we mean with "Timber tracing"? Some alternatives can be:

1) The possibility to trace an individual log back to the harvesting site
   a) By marking all logs with individual codes
   b) By marking a sample of logs with individual codes
2) The possibility to control the flow of timber to make sure that there are no batches of logs from unwanted sources
   a) Control only by comparing volumes

b) Including marking of sampled logs for batch identification

In a system based on control by comparing volumes, alternative 2a above, the control could be conducted by:

- Checking that forest management plans are correct and that they suggest sustainable harvesting levels.
- Checking that harvesting announcements (applications) sent to forestry authorities contain reliable information concerning size and location of the harvest, estimated timber Volumes etc.
- Random post-harvest checks to control that announced areas have been harvested (and nothing more).
- Systematic follow-up by comparing estimated volumes with sold/measured volumes. To do this a data base operated by an independent actor is needed to make sure that pre-harvest estimations are not changed afterwards.
- Aggregation of volumes to facilitate comparisons of regional or national data concerning industrial consumption, export/import etc.

Today´s Swedish timber tracing has many of the components needed for alternative 2b. A sample of logs are marked for batch identification. Comparisons of pre-harvest volume estimations with actually measured and sold Volumes can be done for those who have access to the SDC data base. This is done by auditors of the certification schemes (FSC and PEFC). In the future maybe also forest authorities could be granted access to the SDC data base.

Can timber be traced back to a certain harvesting site? Yes, if the WO contains geographical coordinates. This is compulsory in central Sweden and optional in southern and northern Sweden. The alternative to coordinates is to use municipality codes, which is an older system predating modern geographical information systems.

The marking system used in Sweden, see chapter 3.3, is mainly intended to prevent accidental mix-ups of timber from different sellers. Thus, the marking is important to safe-guard the interest of the seller. But the marking is not developed and designed to be part of a timber tracing system. If it had been intended to be part of such a system then it would have been justified to ask if it could be manipulated? In theory yes, technically it would be easy to change stamps or falsify paper tags. But when doing so it must be done in a way that the timber can be delivered as part of another consignment. And that makes it in practice almost impossible since there need to be several actors involved. How to involve truck drivers, employees from the measurement associations (who often recognise trucks and timber characteristics), a buyer (there must be a WO or the delivery will be refused)? In a Swedish context, this just does not work.

At this point we can ask: - Is timber tracing the best way to prove that Swedish timber complies with for example the “EU-Regulation No 995/2010 - laying down the obligations of operators who place timber and timber products on the market”? Probably not, instead it seems more efficient to talk about control of the flow of timber where timber volumes are entered into central data bases in a way that can be transparently audited. By using coordinates for all felling areas a sample of these can be visited by auditors to verify that environmental caution has been taken.

However, the present Swedish system will probably, of process-linked reasons, develop into a system with better possibilities to trace individual logs back to the exact position it

had in the forest. When this is done, it will be a system that the actors on the timber market needs and wants in order to generate more value from the timber. That means very different pre-requisites compared to when a system is intended to prevent a certain kind of timber from entering the market.

Key components of the Swedish system for controlled wood

A number of circumstances contribute to what we can call "the Swedish model":

- The private ownership of both the forest land and the forest industries, and the very limited involvement of government authorities, provides a situation with no place for corruption.
- The high degree of consensus between government, forest owners and forest industry. This is reflected in the Forest Act, the regulations for timber measurement etc. When all actors find rules and regulations to be relevant there are no reasons for anyone not to follow them.
- The knowledge level concerning timber production, including its distribution on regions, species, age classes etc, is very high. This is much thanks to the National forest inventory that has been ongoing since the 1920-ies. This provides a solid basis for setting sustainable harvesting levels.
- Almost all forest owners have forest management plans. These are normally of good quality and provide reliable basis for future harvesting levels.
- There are very strong private sector organisations for both sellers and buyers of timber. These organisations contribute to a climate of transparent cooperation on questions of common interest, like timber measurement and prevention of unwanted activities like theft of timber.
- There is an independent measurement organisation conducting almost all timber measurement for the main assortments pulpwood and sawlogs.
- All measurement data is sent to one central system for data processing and distribution of results. Results cannot be manipulated or changed by sellers or buyers. Compare this to the situation when every company has its own data system. Or even worse, if data is stored on paper in various remote locations!
- The flow of timber, including quantities and locations, can be followed more or less on-line for those who use the SDC system.
- The "lean production" limits both the time timber is stored at different locations along the production chain, and the volume concerned at a given time. This means less volume to control and reduced possibilities to steal.

There is a saying among actors on the timber market that in Sweden we compete via price lists, not via timber measuring methods. A reason is that everyone understands and agrees that they all will benefit from correct and reliable measurement information. This will in the future most probably also apply for timber tracing information.

Annexe 11 Labelling Technologies for Timber and Timber Products

This is section is restricted to technologies used, or of potential use, for forest products. Labelling means attachment of information to products or materials. Labels should provide products description, unique identification, instructions as needed and security (possibly by covert means). Sources used are Dykstra (2002) and Lounasvuori & Sheikh Ibrahim (2006)

Conventional Paint and Chisel Labels

This is the oldest log labelling technology. Information is painted or chiselled on the log. The method is mainly used in conjunction with log identification.

Chisel marks and paint are easily applied. The method is also quick and cost effective. There is no need of specially trained staff, and material is normally available locally. Labelling can easily be integrated into forest management, e.g. follow up of operational efficiency.

The technique is somewhat time consuming, and could be costly where wages are high. Labels require space, thus rendering it less suitable for smaller logs. Errors are easily made, paint labels can be duplicated without too much trouble.

There are drawbacks from a security standpoint. Auditing and documentation standards determine security.

The technique is well established and used developed as well as developing countries.

Branding Hammers

A traditional and widely used method in the logging industry. Hammer brand usually only indicate custodian of a log, and thus need to be used in conjunction with other documentation to provide more detailed information.

The method is cheap and easily used. Hammer marks do not require large space, and are suitable for smaller logs. Marking tends to be robust. Hammer marks can be difficult to read and easy to duplicate. It is not easy to key them to supporting documentation. Security wise they resemble paint and chisel labels.

It is a suitable method for areas with sound forest governance.

Conventional Labels

Treated paper or plastic tags attached to products by e.g. nails or staples. Often imprinted with barcodes. The technique is fast and relatively inexpensive. Labels are easy to read compared to other technologies. Labels are reliable and can store large amounts of data.

It is fairly easy to duplicate labels. Barcodes can be difficult to read in rough conditions. Labels have to be pre-printed, limiting the amount of data that can be stored. Scanners are expensive.

There are techniques to achieve a high level of security, e.g. water marked paper, destructible labels inclusion of localized data etc. Conventional labels are suitable for trees, logs and forest products.

The technology is proven and used in both developed and developing countries. Only modest training is required for implementation. Users need to take the trouble to ensure that appropriate material and label format are selected.

Nail Based Labels

Nail based labels are hammered onto the end of a log or processed product. Nail based labels are usually made of hardened plastics or metal with barcode information that is readable by scanners.

Application is quick and easy and the labels are robust. Reading labels is not normally a problem. Large amounts of data can be stored. The technique can be integrated into forest management.

A drawback with the method is that nails usually have to be removed before processing. Labels can be difficult to remove. Nail labels are produced by specialised manufacturers, thus not readily available locally. Scanners are expensive and have their limitations in trying circumstances.

Nail based labels can be duplicated, but not as easily as the labels mentioned above. Quality of auditing and documentation determines security using this technique. The technology is proven and used in a wide range of countries.

Magnetic Stripe Cards

Magnetic stripe cards, sometimes referred to as swipe cards, are made of plastics or paper. The card contains a magnetic stripe on which information can be stored. Reading the information requires special readers. Bankcards and air tickets are well known applications. Proprietary encoding is possible and most readers can be programmed to reads custom encoding. An ISO standard exists for encoding magnetic stripes.

Magnetic stripes are more useful for attaching information to documentation than for labelling individual products. They can facilitate data processing and security audits. Paper based cards are not robust. Readers are expensive and not generally mobile. The cards accommodate less information than 2D barcode labels and smart cards.

Magnetic stripe cards offer inherent security in how data is encoded, stored and read. Information on the cards can be used to enhance security. These cards are not generally used in forestry for chain of custody management. The technology requires sophisticated data management, and more sophisticated training than the methods above.

Smart Cards

Smart cards are credit card size plastic cards that can store and process large amounts of data. They are often referred to as smart cards, chip cards and integrated circuit cards. The cards fall into two categories (1) dumb smart cards only capable of storing data and (2) true smart cards capable of processing data independently. The latter type of card offers opportunities to achieve high levels of security.

Historically physical contact between the card and pins in a reader has been required. More and more cards are now “contactless”, some operating through electric inductance or capacitance and longer range cards operating through radio signals.

Advantages of smart cards are the high security levels and the amount of data that can be stored. Duplication and counterfeiting is further difficult. Finally they can enhance logistics and inventory functions. He main disadvantages is that it is costly hi-tech and not terribly mobile. The technology is not suitable for single logs, but has potential for large log lists, thus replacing functions traditionally performed using paper documentation.

The technology is often used in transportation of valuable commodities, often in conjunction with RFID technologies. There is no evidence of technology being used in forestry. That will however surely change.

RFID (Radio Frequency Identification) Labels

The labels contain radio transceivers and can therefore send and transmit data through radio signals. They are normally inserted into nail based labels. The technology permits contact with the product without direct contact with the label. There is great versatility in the technology.

Data will only be transmitted after being prompted by a signal from a reader. The technology offers a high level of security. Signals can also be read under the most adverse conditions. The labels can be encoded at all stages in the chain of custody.

It is however difficult to standardise technologies. Installation and label costs are high. Once put in use there tends to be no manual fallback should technology fail.

The technology is used in a wide array of industries, and is reported to make its mark on the forest industry. It has been suggested that the technology will become feasible for forestry when tag prices have dropped to 0.20 USD per tag. Initial application is thought to be stock control of processed wood products.

A British company, Helveta, has developed tracing method combining RFID and GPS technology. GPS devices ensure that felling is done within the boundaries of permitted areas (Murray 2010). The software has been applied in a number of tropical countries.

Gjerdrum (2008) shows the potential of the technology in assessing performance and enabling tracing. Costs however still hamper wider implementation in Europe.

RFID Chips versus Plastic Tags

Blackett (2008) compares RFID techniques with plastic tags. The comparison is found in Table X.

	Plastic tags	RFID chips
Cost	Low (about 0.1 USD)	High (about 1 USD)
Durability	Moderate to high	High
Readability range	Low (a few cm.)	High (up to 200 m)
Number display	Visible	Invisible

Source: Blackett (2008)

Microtaggant Tracers

The tracers are microscopic particles composed of distinct layers of different coloured plastics. Each taggant is a colour coded chip. Millions of permutations are possible. Reading the codes requires a 100X microscope.

Labels are accurate and close to impossible to counterfeit or tamper with. Taggants are inexpensive, as are the microscopes required to read them. The technology can be used along the entire chain of custody and is compatible with other technologies. Taggants are durable.

Taggants are suitable for batches rather than individual logs. They have to be read manually through a microscope. Initial set up and development costs can be high. Sourcing can be a problem.

The technology has yet to be introduced in forestry, but has proven itself in tracing stolen good in other sectors.

Chemical Tracer Paint

This technology is based on paint with two chemical tracers, one distinguishable in the field and one only with laboratory equipment. The technology is used by the USDA Forest Service. Trees and stumps of trees to be harvested, or to be retained, are painted with paint containing the tracer.

The technology offers a high level of security, is difficult to counterfeit, and serves as a deterrent in ways other technologies do not. The paint is durable and can be used along the entire chain of custody.

The technology is suitable for batches rather than single trees. At present the technology is available only to the US Forest Service. Proper accountability is required, unauthorised use is intolerable. Identification in the lab can be time consuming.

Chemical and Genetic Fingerprinting

Chemical fingerprinting includes:

- Near infrared analysis
- Pyrolysis
- Analysis of trace elements
- Gas chromatography

Genetic fingerprinting methods include:

- Nuclear genome
- Plastid genome
- Mitochondrial genome

Different molecular marker systems exist. Below follows a brief account based on Lyerh (2010) and a comparison also based on Lyerh (2010).

Restricted Fragment Length Polymorphism (RFLP). Markers detected treating DNA with enzymes that cut DNA at specific sequences. RFLPs were the first markers to be widely used. As technology has progressed the use of RFLP has been phased out.

Random Applied Polymorphic DNA (RAPD). Markers fiors described in 1990. Permits production of multiple copies of specific DNA sequences (amplification). Quicker analysis than RFLP, but sensitive to laboratory conditions. They have been deemed inappropriate for timber tracing because of this sensitivity.

Amplified Fragment Length Polymorphism (AFLP). Technology allowing amplification of certain sequences which gives rise to a large number of markers which can be located on the genome relatively quickly and reliably.

Microsatellites. Simple DNA sequences repeated a variable number of times in tandem. A typical marker has more variants than other marker systems, Initial identification however is expensive.

Single Nucleotide Polymorphisms (SNP). The potential number of markers is very high and procedures have been developed to identify SNP loci at a very low cost per sample. Probably unsuitable for timber tracing As they need high quality DNA

Feature	RFLP	RAPD	AFLP	Microsatellite	SNP
Amount of DNA required (microgrammes)	10	0.02	1.0	0.05	0.05

Quality of DNA required	High	High	Moderate	Low/moderate	Moderate/high
PCR based	No	Yes	Yes	Yes	Yes
Size of markers	1.0 – 3.0	1.5 - 50	20 - 100	1.0 – 3.0	1.0
Ease of use	Not easy	Easy	Easy	Easy	Easy
Amenable to automation	Low	Moderate	Moderate	High	High
Reproducibility	High	Unreliable	High	High	High
Development cost	Low	Low	Moderate	High	High
Cost of testing per sample	High	Low	Moderate	Low/moderate	Low/moderate

High quality DNA means that most of the DNA sequence is intact. PCR means Polymerase Chain Reaction – a method to detect markers.

These technologies can be used to track individual trees. They do however at present require comprehensive databases and time consuming laboratory work. The usefulness as a tool to monitor chains of custody is, at the time of writing, questionable, it is rather a tool for verification.

Methods are under development at a number of institutions. Efforts under way are reviewed in Degen (2007) and Nilsen & Kjaer (2008). Discussions and further networking are called for by both. Exclusion scenarios seem to be the most promising method. Standardisation and harmonisation have to be made. Methods should be developed for use in court.

Analyses of inorganic elements is tested and discussed in Durand et al. (1999) and Hoffman et al (1994). It is difficult to see practical applications in the nearest future. The same applies to analyses of isotopes of strontium (English et al. 2001). A test of a combination of stable isotopes and inorganic elements on *Rubroshorea* spp. (Kagawa et al 2007) showed that specimens from the Philippines could be distinguished from specimens from Borneo, but that variation within Borneo was indistinguishable. In plantation forestry it must be made clear whether variation in chemical markers is due to site or seed origin. An approach that deserves to be evaluated is analyses of microbial flora and fauna. A potential problem is contamination of microbes during transport and storing. Tests on fish are in progress (CIRAD 2005).

Although DNA and other chemical markers have yet to make their way into practical timber tracing and verification, there is a number of projects going on. A joint Japanese and Malaysian project (Fuji 2007) is working to identify *Shorea* species and their origin. The objective is to develop tools to monitor trade regulations. A set of different methods are

tested on their own and in combination. Tests have also been carried out with *Neobalanocarpus heimii* (Lee *et al*. 2010).

A Singaporean verification company, Certisource, is said to have developed a method to verify the legality of Merbau (*Intsia palembaica*). The method aims at creating a biogeographical database. The method is under patent¨, and no details are available at the moment. Kew Gardens is involved in a project to detect species under CITES. Another Singaporean company, Double Helix Tracking Technologies, uses tgechniques from forensics and those similar to paternity testing. DNA is taken from trees at the place and time of harvesting, then again further down the chain of custody. Mismatches in DNA will have to be explained.

Stable carbon isotopes of tree rings to determine origin of timber using reference populations, dendroprovenancing, is tested in Kagawa & Leavitt (2009) on *Pinus edulis* and *Pinus monophylla* in southwestern USA. The method showed higher success rate than ring width measurements. Provenancing could be done with a precision of 114-304 km. Provenancing was done in a laboratory.

Anonymous (2008) identifies three key areas for development. They are:

- Species identification
- Country of origin
- Origin on a regional scale within countries

Aroma Tagging

The method involves spraying a particular scent to an object, e.g. a log and tracking it using a scent detection device. A company may create its own "smell" and apply to trees to be harvested.