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Technologies for Wood Tracking

Verifying and Monitoring the Chain of Custody and Legal Compliance in the Timber Industry

Dennis P. Dykstra
George Kuru
Rodney Taylor
Ruth Nussbaum
William B. Magrath
Jane Story

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Foreword

With only 10 percent of the world's forests in protected areas, the World Wide Fund for Nature (WWF) promotes high standards of production forestry as a key strand of forest conservation work. However, a major barrier to improved performance in the forest industry is the lack of differentiation in the marketplace between wood produced from sound forest stewardship and wood supplied from reckless logging. Progressive companies that would like to apply best practices are forced to compete with "hit-and-run" loggers who avoid royalties, taxes, and pre- and post-harvest management expenses. Future wood supplies are threatened by unsustainable harvesting. Furthermore, public perception of widespread destructive or illegal logging indiscriminately taints the whole wood products industry.

However, these circumstances could change if a critical mass of companies begin to apply good forest management practices. Among the important places to begin is to trace wood from its source to its final use. The systems and technologies described in this report provide the means by which responsible elements of the industry can isolate wood from illegal or poorly managed sources. These systems and technologies provide a mechanism by which the marketplace can reject products made from wood with dubious origins. These systems can help assure consumers that they are not buying stolen wood. When combined with forest management certification, these technologies can verify that the wood in a product comes from a well-managed forest.

Wood tracking is not necessarily a hard pill for the industry to swallow. Tracking has enormous potential to improve efficiencies. It can enhance quality control, safety and financial discipline all along the supply chain. Governments can help promote the application of good chain of custody (CoC) practice by integrating requirements for adequate wood flow controls in forest management regulations and compliance monitoring. As this report shows, the costs of sound tracking systems are modest and pay for themselves directly and indirectly. However, in collaboration with governments and the private sector, investors and development assistance agencies may have a role in assisting pilot activities and systems testing. These opportunities put improved CoC work at the center of the agenda for partnership and collaboration among governments, industry, environmental interests and sensitive consumers.

This report surveys the vast array of systems and technologies that can support wood tracking. To the non-expert, it is not always obvious how they fit together, what they can and cannot do, or which options work best in which circumstances. The authors have done an excellent job of mapping this out. They explain the basics of chain of custody systems, explore the pros and cons of different technologies and direct the reader to sources of more detailed information.

This publication provides a solid overview of the "state-of-the-art" in wood tracking for practitioners whether they seek to assure customers of the origins of wood in their products, tighten the management of their supply chain, collect government revenues or enforce forest regulations; or have a broad interest in developing practical tools to curb substandard forestry and related trade.

This report represents one output of the efforts of WWF and the World Bank to follow up on the political commitments of East Asian leaders at the September 2001 Bali Meeting on Strengthening Forest Law Enforcement and Governance. The authors sincerely hope that it also will serve as a model for further analytical and consultative efforts by the regional task force that was discussed at the March 2002 Phnom Penh meeting that led to this report.

Chris Elliott	David Cassells
Director	Co-Chair
Forests for Life	World Bank/WWF Alliance,
WWF International	Senior Environmental Specialist
	World Bank

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This report draws on the information gained at the technical workshop on Log Tracking and Chain of Custody Systems, which was organized by the World Bank/WWF Alliance for Forest Conservation and Sustainable Use and held in Phnom Penh, Cambodia from March 19–21, 2002.

The workshop was kindly hosted by the Department of Forestry and Wildlife of the Royal Government of Cambodia. The workshop was cosponsored by the United Kingdom Department for International Development (DFID), the World Bank/WWF Forest Alliance, and the World Bank Forest Governance Program.

The participants and presenters contributed greatly to the workshop's success with their technical knowledge and experiences. Without them, this report would not have been possible.

Acronyms

AI	Amnesty International
CCD	Charge-coupled device
CIFOR	Center for International Forestry Research (Indonesia)
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CoC	chain of custody
DFID	Department for International Development (UK)
EIA	environmental impact assessment, Environmental Investigation Agency
FAO	Food and Agriculture Organization of the United Nations
FIN	Forest Integrity Network
FSC	Forest Stewardship Council
GPS	global positioning systems
ISO	International Organization for Standardization
ITTO	International Tropical Timber Organization
NGO	nongovernmental organization
OECD	Organisation for Economic Co-operation and Development
RFID	Radio-frequency identification
TI	Transparency International
UPC	universal product code

Executive Summary

This report examines a range of technologies that are potentially useful for managing the wood supply chain, with particular emphasis on tracking logs from their points of origin in the forest to the facilities in which they are processed into primary wood products.* The aim of the report is to provide information useful to individuals and organizations responsible for developing, implementing, and maintaining CoC systems for wood products.

Wood supply and the chain of custody

In a forestry context, the "wood supply chain" may be regarded as a series of handling and processing stages that begin with standing trees in the forest and end with final wood products. The ownership and control aspect of the wood supply chain is referred to as the "chain of custody"—the custodial sequence that occurs as ownership or control of the wood supply is transferred from one custodian to another along the supply chain. A "chain of custody *system*" comprises a set of technologies, procedures, and documents that are used to provide information useful for managing the wood supply chain.

Using a well-designed chain of custody system, the manager of a wood supply chain (or of any link in that chain) should be able to determine where the wood supply is coming from, where it is at any point in time, where it is intended to go, and when it is scheduled to arrive there. Also available should be information on species, volumes, and quality grades, and the system should be able to trace the wood back to its origin so that this information can be tied directly to forest management.

Properly applied, CoC systems can be used to expose log theft and to prevent unscrupulous operators from commingling illegally sourced logs with others of legal origin, a practice known as "log laundering." Chain of custody systems are thus essential components of any effort to reduce illegal logging. But they also are of direct financial benefit to the forest industry because of the information they provide to managers, both in the forest and in manufacturing facilities. Such systems are widely used in many other industries for purposes such as quality management, safety, and financial control, and they can provide the same benefits to the forest industry.

To be effective, chain of custody systems for logs and processed wood products must be based on the principles of *identification, segregation,* and *documentation:*

- Logs or other products must be *identified* using some type of labeling technology.
- At each point along the supply chain at which material from a known source potentially could become mixed with material from unknown sources, it should be *segregated* and handled or processed separately.
- Finally, the labels affixed to the logs or other products must be keyed to *documentation* so

that information on wood volume, species, quality, and other attributes is available to managers of the supply chain.

Users and beneficiaries of chain of custody information

Potential users and beneficiaries of information generated by chain of custody systems for logs and other products include:

- Forest managers, who can use information on the species, volumes, and grades of timber removed from each forest management unit to plan silvicultural activities and to adjust harvesting plans for nearby areas.
- Government agencies charged with oversight of forestry activities can use the information to control illegal logging and to ensure that royalties or other revenues associated with forestry activities are collected.
- Timber companies, which can improve efficiency through improved management of the wood supply chain and at the same time can prevent or expose theft and fraud.
- Timber importers, who are under increasing pressure to ensure that their timber supplies are derived from legal sources.
- Certifiers, inspection companies, and other organizations with an audit or inspection function related to forest products.
- Consumers of retail forest products, who want to be assured that the products they buy have been sourced legally and from well-managed forests.

Labeling technologies

A wide variety of labeling options is available for wood chain of custody systems. No labeling technology is perfect, but some type of label is essential if the chain of custody system is to be effective. Options considered in this report include:

- *Conventional paint and chisel labels.* These can be used effectively if they provide comprehensive information keyed to associated documentation. The chief disadvantages of such labels are that they are time-consuming to prepare and they can be easily counterfeited.
- *Hammer branding,* although perhaps the most widespread technology used for marking logs, is not generally suitable for comprehensive chain of custody systems. Branding hammers are easily counterfeited and the brands provide little information and cannot easily be keyed to associated documentation for individual logs.
- *Conventional labels made of paper or plastic on which barcode information has been imprinted* probably are the best all-around choice for chain of custody systems in the forest sector. Such labels are more difficult to counterfeit than lower-technology labels. They can be scanned electronically or read manually if necessary. They are typically affixed to logs or other products with staples, and experience suggests that 1–5 percent of the labels will become detached during transport or handling. Procedures must therefore accommodate the fact that some logs will arrive at the destination without labels.
- *Nail-based labels* offer similar advantages as conventional labels, provided that they are imprinted with machine-readable (“barcode”) information. They have the additional advantage of being more robust and thus able to withstand transport and handling better. However, they can be more difficult to remove than conventional labels and are more expensive. In addition they cannot usually be printed on-site and thus cannot be customized as easily for an individual location.
- *Magnetic stripe cards and “smart” cards* offer some promise as technologies that might become suitable for wood chain of custody systems in the future but are not generally applicable at present because of high cost and lack of robustness under harsh environmental conditions.
- *Radio-frequency identification (RFID) labels* represent a more advanced technology that holds considerable promise for use in wood chain of custody systems. Currently, they are too expensive to use for labeling individual products, but the price is expected to decline over the next few years.
- *Microtaggant tracers* can be used together with other labels to provide additional security and to aid investigations of log theft or log laundering. They do not represent a stand-alone labeling technology.

- *Tracer paints* can be used to mark trees, logs, and other products to detect or track theft. They are not generally useful as stand-alone labeling technologies.
- *Chemical and genetic fingerprinting* offer some promise for the future but are currently too expensive and have not been sufficiently developed for routine use in wood chain of custody systems. They are likely to prove most useful for proving the origin of wood in investigations of log theft or log laundering.
- Several *mechanized coding systems* are currently under development that will imprint codes in the ends of logs. These codes can then be read with special imaging equipment or even interpreted manually. The systems are not likely to be widely available for several years, and even then may be tied initially to mechanized harvesting systems.

To be most effective, labeling technologies selected for use in a chain of custody system should facilitate rapid collection of large amounts of data that can be electronically time-stamped and cross-checked against records made at other checkpoints to detect (and deter) tampering. In particular, *labels that can be scanned electronically* (such as those that have been imprinted with bar codes) *or that can be accessed using radio signals* (such as RFID labels) offer significant advantages over other types of labels. As with all technological systems, however, it is essential to have a manual backup for times when the technology fails. The manual backup must be designed so that data captured manually can be entered into the electronic system as soon as the capability has been restored.

Regulatory environment

Even a well-designed chain of custody system can be defeated if unscrupulous operators have the will and the technical means to do so. This is of course easier if the system is inherently insecure or if forest governance is poor. When a secure chain of custody system has been put in place and followed rigorously, forest governance becomes the primary issue of concern. Efforts to ensure that loggers and other entities in the forest industry comply with laws and forestry regulations must go well beyond the chain of custody system to examine the general legal environment itself.

As identified in recent high-level discussions around the world, issues of key importance related to forest governance include:

- Concerns over the social and environmental impacts of illegal logging
- Inability of responsible forest-industry operators to compete with low-cost “cut-and-run” operators and corrupt concession-allocation procedures
- Loss of revenues by governments and forest owners from wood theft and smuggling, and due to non-payment or underpayment of royalties, taxes, and export duties.

Tools that can be used to verify or enforce legal compliance in forest operations and related international trade in forest products, or to expose illegal activities, include:

- Forest certification, especially where the certification process requires the existence of a competent chain of custody system
- Inspection by independent auditors to establish legal compliance and/or legal origin of wood products
- Development and implementation of ethical procurement policies and codes of conduct, either by individual companies involved in the timber trade or by trade or industry associations
- Issuance of supplier warranties, which may be independently verified
- Actions by watchdog groups to expose bad actors and also to highlight positive activities by responsible operators.

Finally, it is important to remember that forest industry does not exist in a vacuum but is part of the social and political fabric of the jurisdiction in which it resides. If the underlying system is corrupt, it is likely that forest governance will be corrupt as well. In such situations, changing forestry laws and regulations alone will solve few problems. Because of systemic inertia, significant change cannot be accomplished easily or overnight even with the best political will. Both the private sector and the public sector have important roles to play. The private sector can contribute by awarding contracts only to legitimate enterprises that are attempting to do a good job and by insisting that these enterprises continue to demonstrate gradual improvement over time. The public sector can work through donor agencies and multilateral agencies to improve not only forestry but the general sociopolitical environment in which it exists.

1
Introduction

The purpose of this report is to provide an overview of issues related to chain of custody systems for managing wood supply, with particular emphasis on the chain of custody for logs. The primary focus of the report is on technologies that are potentially useful for tracking logs from the place in the forest in which they originate to the processing facility in which they are converted into primary products such as sawn wood, although many of these technologies also can be used for tracking processed wood products. Because the place of log conversion (such as a plywood mill, sawmill, or similar facility) may or may not be located in the country in which the original tree was harvested, tracking technologies and systems must be sufficiently robust that they can be applied across international borders.

Like other manufacturing processes, wood processing involves a series of stages starting with the initial raw materials and ending with a final product. This is often referred to as the "product supply chain." A related term, "chain of custody," refers to the custodial sequence that occurs as ownership or control of a material such as wood is transferred from one custodian to another along the supply chain. The chain of custody thus represents the ownership and control aspect of the product supply chain.

Because of the complexity of the chain of custody for wood products, various procedures and technologies have been developed to keep track of wood materials at each point along the chain. A particular implementation of tracking technology, together with specified documentation and procedures, is referred to as a "chain of custody system." A more complete introduction to such systems is provided in chapter 2, and a detailed examination of the technologies available for wood chain of custody systems is presented in chapter 4.

Illegal logging

Prevention of log theft and control of illegal logging often are cited as important motivations for the adoption of log chain of custody systems. Over the course of the past few years it has become increasingly evident that illegal logging in particular represents a major threat to the environment, the economy, and even social and political stability in many parts of the world. The problem appears to be especially pervasive in developing countries and in countries in transition to market economies in Asia, Eastern Europe, Africa, and Latin America. It has many causes, but several important conditions are common to nearly all areas in which illegal logging represents a significant problem[1]:

- Processing capacity within the country itself or its neighbors exceeds the capability of the country's forests to sustainably produce timber products. In some cases, processing capacity is several times greater than the sustainable harvest level.

[1] See the Ministerial Declaration from the East Asian Conference on Forest Law Enforcement and Governance, held September 2001 in Bali, Indonesia, <http://www.iisd.ca/linkages/sd/sdfle/>.

- There is little transparency in the way timber contracts are awarded, providing an opportunity for timber concessions to be used as political rewards.
- Governance of forest areas is poor, often because of remote locations, lack of infrastructure, and relatively low population density in the forest zones.
- Compensation for government workers charged with oversight of forest areas is inadequate to permit them to maintain a reasonable standard of living.
- Chain of custody systems for tracking logs are inadequate or are inconsistently applied. This makes it possible for illegal logs to be mixed with legally harvested logs, a practice referred to as “log laundering.”

This report focuses only on the final bullet point above. While recognizing that log tracking is only one aspect of a complex problem, the World Bank and the Worldwide Fund for Nature, through their Alliance for Forest Conservation and Sustainable Use, have determined that an assessment of technologies for chain of custody systems could be helpful to governments struggling to implement practices that will ensure the sustainable use of their forest resources.[2]

Improved management of supply chain

Control of illegal logging is not the only purpose for chain of custody systems; indeed, it is not even the most common purpose for implementing such systems. They are widely used by the forest industry in industrialized countries and by some enterprises in developing countries as well. One purpose of these systems is to prevent log theft but also, and perhaps more importantly, they provide information that is considered essential for proper management of the wood supply chain. In modern forest products manufacturing, managers need to know where their wood comes from, where it is at any point in time, where it is intended to go, and when it is scheduled to arrive there. To close the loop they also require information on whether the wood arrived at its intended destination, when it arrived, and its condition at the time of arrival. Although such information can prevent or expose log theft and can thwart efforts to add illegal logs to the wood mix, its primary use is to enable cost-effective management of the supply chain itself. Forest managers require similar information to meet contractual obligations for wood supply and also to sustainably manage the forest itself.

Target audience

Potential users of the information provided in this report include:

- Forest product suppliers (forest managers, loggers, processors, manufacturers, wholesalers, and retailers) and traders (exporters, importers, agents) who want to better manage their supply chains and provide credible assurance to customers as to the source and legality of their wood raw materials
- Companies and public-sector agencies that want to develop robust procurement policies and practices to screen out illegally sourced timber
- Forestry regulators, tax collectors, customs authorities, and forest law enforcement agencies
- Investors, including banks, pension funds, and export credit agencies, wishing to develop screening mechanisms to ensure that they do not finance illegal logging and smuggling
- Donors, nongovernmental organizations, researchers, and others concerned with developing practical tools for curbing illegal wood harvesting and related trade
- Certifiers, inspection companies, and other organizations with an audit or inspection function related to forest products.

Workshop on log tracking and chain of custody systems

As a means of obtaining information for the preparation of this report, the World Bank/WWF Alliance organized a technical workshop in Phnom Penh, Cambodia, March 19–21, 2002. The workshop, hosted by the Department of Forestry and Wildlife of the Royal Government of Cambodia, was

[2] Known commonly as the World Bank/WWF Alliance, or simply “the Alliance.” For information about the Alliance, see <http://www.worldwildlife.org/forests/forest.cfm?sectionid=181&newspaperid=17>. The Alliance website is <http://www-esd.worldbank.org/wwf/>.

attended by 88 persons from 25 countries, predominantly from Asia but also including participants from Europe and North America. The workshop agenda appears in appendix A. Contact details for presenters, workshop organizers, and authors are listed in appendix B.

Organization of the report

To lay the foundation for a comprehensive discussion of chain of custody technologies, chapter 2 examines in detail the closely related concepts of the wood supply chain and the chain of custody, and discusses the essential ingredients in chain of custody information systems. Chapter 3 builds on this foundation by identifying potential users of chain of custody information and the benefits from such information that can potentially accrue to each type of user. Chapter 4 then describes both the available technology and also several potential future technologies that may become useful in chain of custody information systems. The focus here is on labeling technologies that are suitable for tracking logs and processed wood, as well as the associated recording, printing, and reading devices appropriate for each type of labeling technology. The chapter includes a comprehensive comparison of the advantages and disadvantages of the various technologies. Additional details on the technologies are provided in appendix C. Following the examination of chain of custody technologies, chapter 5 gives an overview of the legal issues associated with efforts to verify the legal origin of wood. Its purpose is to place the discussion of chain of custody technologies in a broader legal context. Finally, chapter 6 offers a set of conclusions, a guide to the application of chain of custody technologies, and recommendations on actions that might be taken immediately by various actors.

2
Chain of Custody: Principles and Practice

Most manufacturing processes are complex and go through a series of stages starting with the initial raw materials and ending with the final product. This is often referred to as the product supply chain. "Chain of custody" (CoC) is the process of tracing material through this supply chain to know from where the material in a particular product came. CoC is widely used in a large number of industries throughout the world for purposes such as quality control, safety, and financial management.

In the timber industry the most common recent use of chain of custody has been in conjunction with forest certification, providing a link between certified forests and the products derived from them. However, chain of custody can be used for a range of purposes including:

- Confirming that timber has been obtained from legal sources
- Improving management of the supply chain itself to minimize disruptions, reduce costs, and ensure that "fresh" wood is delivered to processing facilities
- Linking the quality of a product (for example, pulp quality) back to the part of the forest from which the logs originated.

In this chapter, we discuss the principles and practice of chain of custody and then examine in detail some of the methodologies available to achieve chain of custody in practice.

What is chain of custody?

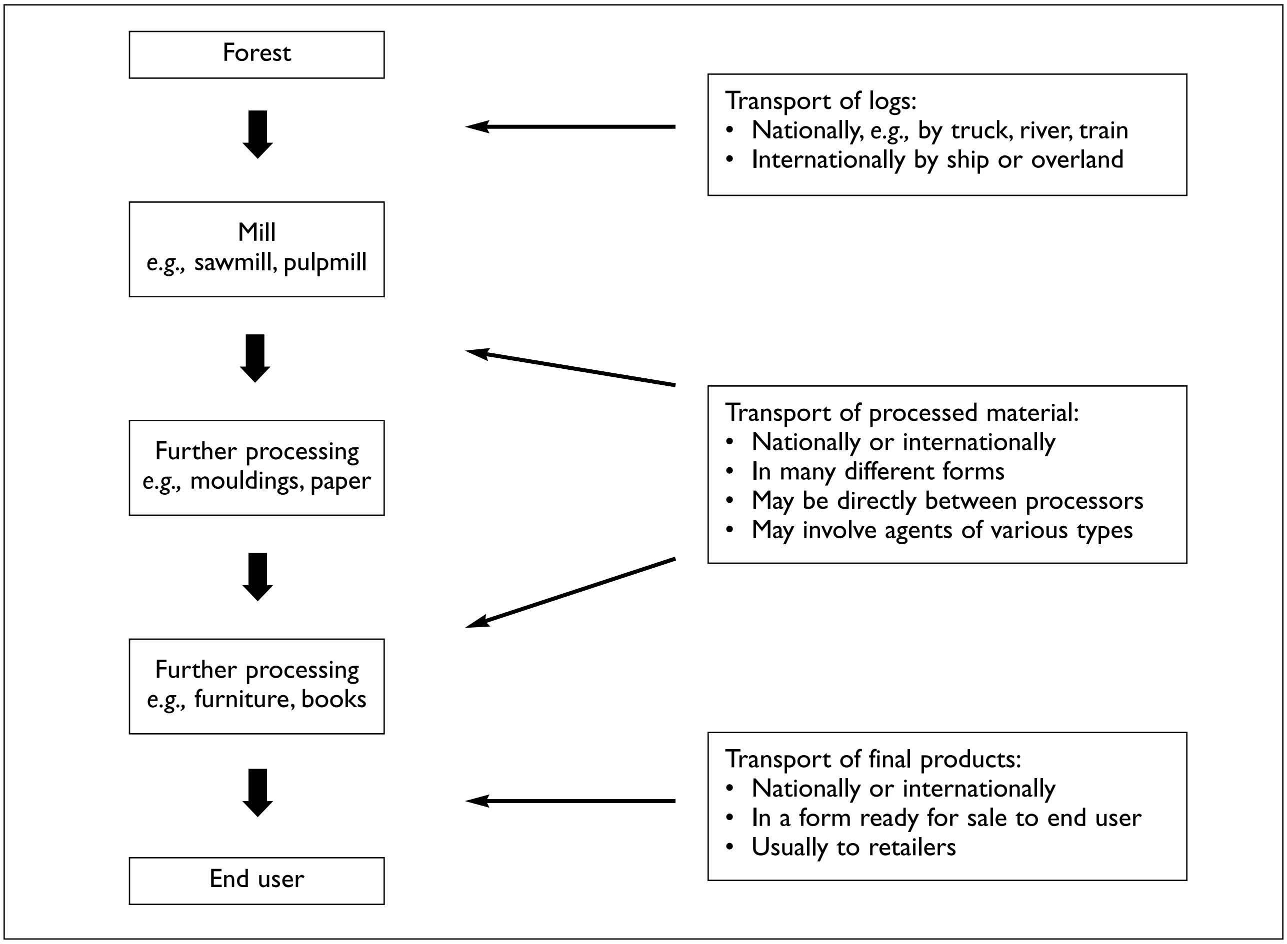
A simple version of a wood supply chain begins with the felling of trees in a forest, the logs then going to a primary processing facility such as a saw mill or pulp mill, and the products from this mill going through additional processing stages before emerging as final products (figure 2.1).

It is immediately clear that the chain of custody for this (or any other) production has two aspects:

1. Chain of custody *within* each processing stage (that is, the forest, the mill, and each subsequent processing stage such as a furniture factory or paper plant). These processing stages are represented in figure 2.1 by the boxes on the left.
2. Chain of custody *between* processing stages as products are moved from one stage to the next. Here, "products" may include logs from the forest, sawn timber, pulp, board products from the mill, or manufactured products from further processing. Movement of such materials between processing stages is described in figure 2.1 by the boxes on the right.

Chain of custody (just like the supply chain itself) can be broken down into a series of stages, and each of these can be addressed more or less separately. This approach is very important for a number of reasons:

Figure 2.1



Schematic representation of a wood supply chain showing the various stages in a typical process. *Left,* boxes represent processing operations; *right,* boxes describe movement of material between processing stages.

- There is no need for all the different players involved in the supply chain (which can often be long and complex) to work together to develop a comprehensive chain of custody information system. Each stage can be addressed separately. The only interaction will be with the immediately preceding and subsequent stages.
- The approach taken at each stage can be quite different. This means that the most appropriate approach at each stage can be used rather than having to come up with a unified approach which is inappropriate to some stages.
- Some parts of the chain may be much more challenging to address than others, but delays in finding solutions for the difficult stages do not prevent work being done on other stages.

In the forest products industry, the chain of custody begins in the forest. These teak logs in Indonesia have been assembled at a landing from which they will be loaded onto trucks for transport to processing facilities. (Courtesy of Center for International Forestry Research, Bogor, Indonesia; photo by Francis Ng.)

Box 2.1
FSC chain of custody standard

As an international accreditation body for certification of sustainably managed forests, the Forest Stewardship Council has developed a chain of custody (CoC) standard, which provides internationally applicable specifications for CoC systems.* However, responsibility lies with the certificate holder to design and implement the actual chain of custody system so that it is appropriate to the certificate holder's local circumstances.

The certificate holder's CoC system is verified against the written standard by an FSC-accredited certifier to ensure full compliance with FSC requirements.

An internationally recognized CoC registration code printed on invoices and attached to products enables buyers worldwide to check the validity of the CoC guarantee.

Important characteristics of the FSC CoC standard include:

- The standard has been designed to help suppliers verify the origins of their raw materials, if necessary, back to the forest.
- FSC provides a global network of certified suppliers (approximately 2000) operating according to the same global standard but with locally adapted systems and technologies.
- Adherence to the standard is independently verified on an annual basis.
- Trade is encouraged by facilitating exchange among suppliers in the network.
- The standard has been adapted to cater to the needs of small and community enterprises as well as those of large suppliers with multiple operations.

**Note:* Part 3.4, Forest Stewardship Council Accreditation Manual.

Source: Sofia V. Ryder, Sofia V. "FSC's Experience in Verification of Legal Compliance." Presentation given at the workshop on Log Tracking and Chain of Custody Systems held March 19-21, 2002 in Phnom Penh, Cambodia.

All chains of custody are built from the same basic elements:

- Information on quantities
- Management of critical control points
- Control and management of people.

Each of these is described below. However, the way in which the elements are implemented in practice varies enormously depending on the local circumstances and the position in the chain (box 2.1). This report aims to provide some guidance on both the basic elements that must be in place and on the options available for implementing them.

Quantities

An essential part of any chain of custody is to collect and maintain information on the amounts of material involved. This may be in the form of volumes, weights, pieces, or even value. Linking and comparing the quantities at different stages provides a first check on whether there is any obvious cheating in the system.

This information is not sufficient on its own to control chain of custody since it does not identify situations where substitution is taking place. In addition, data on quantities can sometimes be forged. Nevertheless, it is an essential element of any chain of custody system.

The two most important types of quantity information are:

1. *Within* one processing stage, information on the quantity of raw material purchased versus the quantity of product sold. For example:

   - *In a forest operation:* inventory data for standing volumes of merchantable timber versus transport data for the volume of logs removed from the site
   - *In a sawmill:* the volume of logs recorded arriving in the log yard versus the volume of sawn timber produced and knowledge of typical conversion rates
   - *In a furniture factory:* the volume of wood supplies entering the factory versus the total volume of wood in furniture items produced.

   In all three cases, information on conversion factors between inputs and outputs also is essential.

2. *Between* two different stages, the information required is the quantity which was sold by one processor versus the quantity purchased by the next processor in the chain. For example:

   - *Between the forest and the mill:* the volume of logs leaving a harvesting site versus the volume recorded arriving at the customer
   - *Between two processors:* the amount of product recorded by processor A as sold to processor B versus the amount of product recorded as purchased by processor B from processor A (that is, compare A's sales records with B's purchase records).

Identifying and managing critical control points

While data on quantities is very important, it is not sufficient on its own to secure the wood supply chain. The second part of a reliable chain of custody is the management of critical control points. Critical control points are all the points in the supply chain where unauthorized material could enter or leave the system (for example, where illegal timber could be introduced or where mixing of two or more types of material, such as logs from certified and uncertified forests, might occur).

Examples of some common critical control points are:

- Forest storage areas in which illegally harvested logs may be added to those harvested legally
- Logs arriving in a log yard in which illegal logs might be mixed with legal logs
- Sawn timber being stacked on pallets where timber from legally sourced logs may be mixed with those from illegal sources.

For each of these critical control points it is necessary to develop systems to minimize the risk of either accidental or intentional mixing of authorized and unauthorized material. This is usually done through an appropriate combination of *product identification, segregation,* and *documentation.* Some of the main ways of achieving each of these are summarized below, and are then discussed in more detail in the following chapters.

Identification

Product identification is one of the simplest ways of tracing a product. By using a mark or label of some kind the product is clearly identified as being from a particular source. However, there are two problems that need to be considered when using identification for chain of custody in the wood supply chain.

First, the material will undergo many changes as it progresses through the supply chain (for example, from log to sawn timber to furniture) and the identification marks may be lost. Therefore, identification is often effective for only one stage in the process.

Second, identifying marks and labels can be forged. Therefore, either identification must be combined with segregation and documentation as discussed below, or a more sophisticated labeling approach that is difficult to forge is required. Some of these approaches are summarized below and are discussed in more detail in chapter 4, with a detailed summary in appendix C.

- *Hammer or scribe marks:* Commonly used to mark individual logs, mainly for large sawmill or plywood logs.
- *Paint:* Ranges from a simple color painted on the end of a log or piece of sawn timber to allow easy identification, to high-technology chemical tracer paints used to mark and track logs and wood products.
- *Labels:* Most simple are painted words or letters or written labels attached to a log or a pallet load of sawn wood. More sophisticated labels include barcodes that can be linked electronically to documentation.
- *Tracing material:* Radio transmitters, microtags, chemical paints, isotope marking.

Segregation

Segregation works by physically separating the material of interest from any other similar material with which it might become mixed. It is a very effective method for preventing accidental mixing, but is rarely sufficient on its own to prevent fraud. There are many ways in which segregation is used. Examples include:

Between processing stages:

- A particular truck carries logs only from a single harvesting site, preventing accidental mixing with logs from an unknown source.
- Trucks carrying logs from a harvesting site or concession are allowed to use only predefined routes, ensuring that they are not accidentally confused with trucks carrying logs from unknown sources.
- A ship loads logs only from legal sources, ensuring that no mixing of legal and illegal logs can occur during loading or unloading.

Within processing stages:

- Separate storage areas in a log yard: It is already common practice to segregate logs by species, size, and quality in log yards. This can be extended to segregate, for example, logs from a known legal source from those obtained through third parties.
- *Separate production lines within a mill:* Where a processing facility has more than one production line doing the same thing,

specific lines can be dedicated to processing only a certain type of product (for example, wood from known legal sources) to reduce the potential for accidental mixing.

- *Separate processing facilities:* By deciding that a particular processing facility such as a mill or a factory will use only one type of raw material (for example, only timber from legal sources) the chain of custody is greatly simplified since it only needs to be in place up to the point of entry of the raw material to the facility and then again from the point where the product leaves the facility. There is no need for any tracing within the processing facility.
- *Separation in time* also can be used, for example, by using a batch system so that where only one production line is available it is used first to process timber from a known source, and then the next batch is timber from an unknown source.

Documentation and records

Documentation and record keeping are essential to all chains of custody. Often "documents" are now computerized and "records" are contained in electronic databases but the principle remains the same. In fact, the increased use of computerized data and records can contribute to a more effective and secure chain of custody in many situations.

For the purposes of this report, a document is anything that is written. This may include a bill of lading or a procedure for performing an activity. A record is an instance of a document that describes an activity or measurement at a particular point in time.

Recordkeeping is an essential part of maintaining the chain of custody for forest products. Here labels painted on log ends are being recorded during the preparation of a local manifest before the log truck departs en route to a sawmill. (Courtesy of the image library of the Food and Agriculture Organization of the United Nations, Rome, Italy.)

A huge range of documents and records can be used as part of a chain of custody system. The types of documents that can be useful include:

- Documents related to harvesting such as inventory, cutting block records, cutting permits, sales documents, inspection records
- Transport documentation such as permits, loading records, transport dockets, weighbridge information, and customs documents
- Process records such as goods-in records, stock control, job cards, batch records.

Most organizations already have many types of documents and, wherever possible existing documents and record-keeping systems should be used in developing the chain of custody system. However, when the required documents are not available it may be necessary to adapt or even develop the required documents.

Personnel

An extremely important component of an effective chain of custody system is the people who run it. People implement the system, and, ultimately, it is people who will determine whether or not it works. Problems related to people can arise for two reasons:

1. Personnel may accidentally break the chain of custody by carrying out their jobs incorrectly.
2. Personnel may purposely break the chain of custody, usually for the benefit of themselves or someone else.

The chain of custody system has to be designed and implemented in a way that minimizes the risk of either of these happening. The system also should include procedures for detecting noncompliance and implementing corrective actions as required (box 2.2).

Preventing accidental mistakes

The main ways to ensure that personnel do not accidentally break the chain of custody is to:

- Design the system to be as practical and simple to use as possible since it is then much more likely to be properly implemented.

Box 2.2
Log tracking by the U.S. Forest Service

The Forest Service, a land management agency within the United States Department of Agriculture, is responsible for managing 78 million hectares of national forests and rangelands from which it sells approximately 12 million m^3 of timber annually. The agency uses a low-technology log tracking system that places considerable reliance on well-trained personnel who are assigned to administer timber sales, coupled with both informal and formal monitoring of those persons' actions. *Informal monitoring* involves periodic visits to timber sale areas by supervisors and law-enforcement personnel. *Formal monitoring* involves unannounced, in-depth reviews of all timber and log accountability activities undertaken by each administrative unit (such as a national forest district office). These reviews are conducted at least once every two years. Past reviews have uncovered timber theft and dishonest or negligent sale administration as well as inadequate policies and practices that made the organization vulnerable to timber theft.

The principal purpose of the log-tracking system used by the Forest Service is to ensure that the government receives full payment for all timber removed from timber sales. In addition, because it is illegal to export unprocessed logs that have been harvested from national forests in the western United States, the system facilitates inspection of logs in export yards. The tracking system includes:

Hauling route. Purchasers are required to identify the specific hauling route to be used between the sale area and the point of delivery. This must be approved by the Forest Service. Trucks are required to stay on the route and this is verified by frequent checks.

Log identification. Although the methodology varies somewhat among different regions of the country, in general the ends of logs are painted with yellow paint and branded with a hammer mark that is unique to each timber sale. This can be keyed to load manifests (below).

Load identification. A load removal receipt is prepared for each truckload. Receipt forms are provided by the Forest Service and are consecutively numbered for accountability. They identify the timber sale, purchaser, date, and time of loading. When ownership of the logs transfers from the Forest Service to the purchaser, the load receipt is signed over to a Forest Service official so that it cannot be reused.

Truck inspections. Timber sale administrators are required to perform and document inspections of trucks on about 2% of all loads hauled. Discrepancies between an inspection and the actual logs on the truck when it reaches the destination are subject to penalties and possibly even criminal action.

Random inspections. In cooperation with law enforcement agencies, the Forest Service conducts random checks of logging trucks to inspect loads for compliance with branding and painting requirements and for conformity between the load receipts and the logs on the truck.

Source: Rex Baumback. "Timber Theft Prevention and Log Tracking by the United States Forest Service." Presentation given at the workshop on Log Tracking and Chain of Custody Systems held March 19-21, 2002 in Phnom Penh, Cambodia.

Using existing documents and asking personnel for their input in designing the system are both good ways of making it effective.

- Provide adequate training, capacity building, and support for the personnel who must implement the system also is essential to ensure that everyone knows exactly what they should be doing and is able to do it consistently.

Preventing fraud

There are a number of ways to prevent intentional subversion of the chain of custody. It is important to:

- Develop a system that makes cheating difficult, particularly in situations where governance is poor or cheating is otherwise likely to be a problem. This is usually done through a combination of system design and technology and is discussed further in the next section.
- Provide adequate monitoring within the system to ensure that any cheating is quickly discovered and stopped.
- Provide incentives for honest behavior so that it is more worthwhile to be honest than to be dishonest.
- Institute penalties for dishonest behavior, thus increasing the perceived risk associated with such actions.
- Periodically use external monitors to pick up systematic or widespread cheating within the system.

Designing an appropriate chain of custody

As discussed above, an effective chain of custody should include:

- Adequate information on quantities
- Control of critical control points through an appropriate combination of identification, segregation, and documentation and records
- Adequate training and control of personnel.

It is very important that the system is properly thought through and designed. While the most appropriate approach to designing a system will depend on both the position in the wood supply chain and the precise local circumstances, some useful guidance is summarized below:

- It is usually worth spending some time analyzing the process and carefully identifying all the critical control points. This is usually more efficient than trying to set up the system ad hoc.
- It is always essential to document the system, even in situations in which many of those involved in implementing it cannot read. The documentation provides a basis for training staff, serves as a reference for checking when anyone is unsure of what to do, and acts as an arbiter when there is disagreement. Documentation should be comprehensive and accurate with clear responsibilities for all tasks. It should include procedures for monitoring and auditing processes and describe how noncompliance is to be addressed.
- Always use the simplest and most reliable method that will meet the requirements of the task. More complex and technological approaches are not necessarily better. However, where simple approaches are unreliable, more complex solutions may prove more satisfactory.
- Wherever possible, build the chain of custody system around existing procedures and documents. There are two reasons for this. First, it minimizes the cost and difficulty of developing the system. Second, personnel are less likely to make mistakes with things they are used to doing than they are with new things. However, if existing procedures and documents are not appropriate or are insufficient then new procedures and documents must be developed and used. This is particularly true in situations where fraud or corruption is perceived to be a problem. In such cases, existing procedures and documents may have been developed to enhance these possibilities. Radical redesign of procedures and documents will therefore be necessary to prevent a continuation of the problems.

Implementing a chain of custody in practice

We noted earlier that chain of custody can be broken down into a series of stages and each of these can be addressed more or less separately. The main stages that need to be considered are:

- Within the forest
- From forest to mill or ship
- Shipping between countries
- Shipping between processors
- Inside a processing facility.

Each stage has its own set of characteristics, and different approaches may be required to implement chain of custody for multiple stages.

Within the forest

Although most people think about chain of custody at the point logs leave a forest, it also is important to control chain of custody within the forest up to the point of departure. Within-forest chain of custody can include:

Information on quantities. Information on the amount of product in the forest is provided by good forest inventory data including standing volumes

This ship being loaded with eucalyptus logs in the port at Pointe-Noir, Republic of Congo, suggests the scale of effort that must be undertaken to maintain an accurate and complete chain of custody for logs. (Courtesy of the Center for International Forestry Research, Bogor, Indonesia; photo by Christian Cossalter.)

by species, size, or diameter distributions. Corresponding information on what has been harvested is provided by records such as log grades, species, and dimensions. This information needs to be systematically collected and compared.

Managing critical control points. The forest is a relatively easy place to mix illegal and legal logs, so the whole process of felling and storing logs needs to be treated as a critical control point. Some of the ways of doing this, which are discussed in detail in chapter 4, include:

- Inscribing, marking, painting, or otherwise labeling trees before they are felled. Optimally this should be done in a way that will permit labels on logs to be matched with marks on the tree stumps.
- Inscribing, marking, painting, or otherwise labeling the logs as they are produced.
- Managing log stocks in the forest for inventory and for distribution.
- Keeping records of truck dispatch and log delivery.

From forest to mill or ship

Securing the chain of custody of logs being transported to the mill or being sent for export is one of the most difficult challenges facing the wood products industry. One reason for this is that unlike later stages, this stage is usually remote, spread over large distances, and poorly monitored. Therefore, it is the stage where both the system and the technology may need to be relatively complex to ensure reliability. Forest to mill or ship chain of custody can include:

Information on quantities. Information on the types and amounts of logs should be recorded in the forest as discussed above, and again at the point of reception (for example, the mill log yard or the port). These numbers should then be compared. In addition, information on quantities, particularly volumes or weights, is often required for transporting by truck and this information also should be used wherever possible.

Managing critical control points. The whole journey from the forest to the mill or ship includes the potential for mixing and should be treated as a critical control point. There are many different ways of controlling this, ranging from sophisticated marking of individual logs using high-tech labels or markers to simple, document-based systems for low-value pulp wood based on control of transport.

Shipping between countries

One of the major problems facing companies and governments wishing to stop purchasing illegal timber is the management of the transport of logs from the country of origin to other countries. If this is not controlled, it is very easy for illegal logs to be "laundered"and reappear as "legal" in a second country prior to further processing. Therefore, this is another critical point in many chains of custody. Doing this properly requires:

- Clear labeling of products being shipped
- Integration of shipping documentation into chain of custody procedures
- Independent inspection or auditing of products at the point of export and again at the point of import.

Inside the processing facility

There are two ways of addressing chain of custody within a processing facility:

1. Purchase 100 percent of the incoming raw material (for example, logs, sawn timber, moldings, pulp, or chips) from an acceptable source. In this case, the only critical control point is the arrival of raw materials.
2. Purchase a mixture of raw materials and develop a system to ensure that they are not mixed during the manufacturing process.

Where the latter approach is adopted, each critical control point throughout the manufacturing process will need to be identified and managed.

Moving material between processors

Chain of custody between processors tends to be controlled by comparing information on what the supplier sells with information on what the customer purchases. This is usually done from order forms, sales documents, invoices, and transport documents, including customs declarations where available. However, it also is possible to use segregation, such as packing product on pallets, in containers, or in boxes, simultaneously with identification through labeling products.

3
Users: Purposes and Requirements

Methods for tracking logs and processed wood products through the chain of custody from the stump to the retail outlet have been used for decades by the forest industry and by government agencies charged with managing public forests. This chapter identifies various parties interested in accurate tracking of wood products and summarizes the purposes for which information on the chain of custody is needed by each of these interested parties. This in turn suggests the type of information and degree of detail needed in the tracking system.

Forest managers

In a background report prepared for the workshop on Log Tracking and Chain of Custody Systems (box 3.1), Moosvi emphasized that one of the fundamental purposes of information on log tracking should be to provide timely feedback to forest managers.[3] Properly implemented, a tracking system can provide details on the species, volumes, and grades of timber removed from each forest management unit. This is valuable information that can be used to update forest plans and related records, and to make comparisons between the production that was anticipated prior to harvest and the actual results. Coupled with a post-harvest assessment showing the condition of the residual stand after harvesting, this information could be used to plan silvicultural activities and to adjust the harvesting plans of nearby areas to make more accurate projections. The data also could be used in conjunction with results for other management units to draw inferences about quality and volume recovery rates in relation to topography, forest density, site quality, and other factors.

Government agencies

A significant fraction of forest land allocated for timber production in many countries is under public ownership. But even on private forest estates, society has an interest in forest operations because of the many offsite effects and the numerous social values associated with such an extensive land use. In either case, governments have an obligation to ensure that the rule of law is observed and that logs and other products illegally removed from forests do not enter the marketplace. At the same time, governance may be less effective in forest areas than in urban areas due to remoteness, lack of infrastructure, and relatively low population density. Tracking systems must therefore be designed to operate reliably under the political and social situations relevant to the locations where forest harvesting and processing will be done.

In addition to the obligation to ensure that the rule of law is observed, governments often have a direct interest in deriving income from the utilization of timber resources. This is true on forest lands under public ownership that have been allocated for timber production, and in some countries it also is true on private lands. In the Unites States, for

[3] A. H. Moosvi, "Log tracking and chain of custody practices in India" (Consultancy report and presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

Box 3.1
Chain of custody tracking in India

In India, tracking of log and processed wood products is regulated under the Forest Produce Transit Rules, which were developed to support the 1927 Forest Act. The Transit Rules deal with the storage, movement and import or export of a broad range of materials defined in the Act as "forest produce", which incidentally include wildflowers and fruits. An elaborate system of passes, licenses, hammer marks and permits is laid down requiring multiple inspections and the decisions of higher officers before a pass can be issued. The procedures are essentially the same for privately owned timber as for government timber. Passes authorizing the transport of the material are required at each stage of transaction.

The log-tracking system starts with the forester who marks trees for felling. Each marked tree is assigned an inventory number which is painted on the tree itself. After felling the same number is chiseled on the logs cut from the tree and a sub-number is added for each individual log. The logs are also branded with hammer marks to identify the location from which they were harvested. When the logs are loaded onto a transport vehicle (whether a lorry, tractor, bullock cart or any other vehicle), a transit pass is issued to the operator for the specific load of logs and for a specified period of time. The pass is issued by a Forest Ranger for government-owned timber and by a District Forest Officer for privately owned timber. Every forest and police officer, regardless of jurisdiction, has the power to stop a vehicle and check the contents using the transit pass and the accompanying list of logs as a reference. In addition, there is a network of check posts of the forest department as well as other agencies of the government where the vehicle must stop and submit to a check of documents. The whole scheme of such checks is common to both government-produced logs and those from private lands. The burden of proof that the logs are not the property of the government is always that of the person found in possession of the logs, even when a transit pass can be produced. When the log is scaled to determine its volume and quality (whether in the forest, at a log yard, or at a processing facility), the scaling information is added to the record, as this is the basis on which payment is made to the original owner (whether government, tribal group, community, or private party). All of this information is recorded in documents that can be traced back to the individual forest management unit.

The system makes it possible to determine from the marks on any log, anywhere in India, where it originated as a tree, when was it felled, who did the logging, who transported it, and other relevant facts.

India's log-tracking system is not impervious to misuse, of course. Unscrupulous operators can cut off the ends of the logs, chisel new identifying marks, and add their own hammer brands. Because the identifying marks on the logs must be keyed to other documentation, however, the trail of forgeries must be extensive for this to go undetected. Furthermore, the penalties for such illegal activity are severe, including confiscation of the transport vehicles and the illegal logs, and imprisonment of the offenders.

Source: A. H. Moosvi. *Log Tracking and Chain of Custody Practices in Forestry and Forest Products: A Case Study for India.* Consultancy report prepared for the World Bank/WWF Alliance on Forests and presented at the workshop on Log Tracking and Chain of Custody Systems held March 19-21, 2002 in Phnom Penh, Cambodia.

instance, some states collect harvest taxes based on the volume of logs and other products harvested from private forests.

Much has been made in recent years of failures by governments in developing countries to capture the full value of timber removed from publicly owned forest lands. While the causes of this failure are many, a primary deficiency is the lack of comprehensive, trustworthy information on the species, volume, and quality of timber harvested from public lands. Providing such information would be a direct and immediate effect of a reliable chain of custody system.

Some countries also earn substantial revenues through export duties levied on logs or other wood products. As one example, the Government of Papua New Guinea has for several years used a third-party auditor on a full-time basis to verify species, volumes, and qualities of logs being exported.[4] The company to which this function has been outsourced, SGS PNG Limited, is present year-round at all of the country's export docks.[5] The verification system incorporates barcode labels and portable data terminals to facilitate accuracy but also is designed so that operators can shift to a manual backup system when technological failures occur. Reported benefits of this system include:

- A substantial increase in export duties collected by the PNG Government due to more accurate assessment of the volumes actually exported. The increased collections are reported to be many times the cost of the third-party auditor.
- An improved climate of understanding and cooperation between the forest industry and the supervisory government agencies.
- Greatly improved information on the total volume and assortments of timber being harvested for export from the nation's forests.
- Provision of a transparent and verifiable audit trail that is useful to all parties.

[4] Bruce Telfer, "Capturing export revenues in the timber trade." (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002.

[5] SGS PNG Limited is a subsidiary of Société Générale de Surveillance SA, Geneva.

- Training of forestry personnel in Papua New Guinea who have been seconded by the government to work alongside the personnel of SGS PNG Limited.

Timber companies

Virtually all legitimate companies implement some type of tracking system to prevent theft of logs or other wood products, and this was undoubtedly the primary motivation behind the original development of log-tracking systems. More recently, companies have begun to realize that significant benefits can be achieved through careful management of logistical operations such as log transport. Many wood-processing facilities in the Scandinavian countries, for instance, insist on receiving "fresh" logs—those that have been harvested only a day or two before arriving at the mill. Because ownership of forest land in Scandinavia is largely private and is dominated by small parcels, this requirement can only be achieved through comprehensive logistical management systems that incorporate log tracking and related technologies as described more fully in chapter 4.

Aside from preventing theft and gaining efficiency, there are several other reasons that timber companies should be interested in effective tracking of logs and processed wood products. An important and growing reason is that such systems are essential if the company is to achieve chain of custody certification (box 3.2).[6,7] In addition, companies harvesting timber from their own lands or from publicly owned lands on which they hold concession rights will benefit from providing feedback from tracking systems to their forest managers as outlined in section 3.1.†

Timber importers

In all importing countries, timber importers are required (as are all other businesses) to operate within the law. Among other things this means that the wood they import must be sourced from legally obtained materials. Without a comprehensive chain of custody system in place it is currently difficult for timber importers to be certain that the wood they are importing adheres to this requirement. Currently, only three options are available to importers seeking guarantees that imported wood has been sourced legally:

Box 3.2
IKEA's staircase model

IKEA is an international retailer of inexpensive yet well-designed and functional home furnishings. These items are sold through its network of 143 stores in 22 countries, plus 20 franchise outlets in 14 countries. The company buys ready-made furniture on long-term contracts from external suppliers. To coordinate the purchasing activity, IKEA operates 40 trading offices in 34 countries.

IKEA's long-term goal is to source all the wood used in its products from forests that have been certified as sustainably managed. To attain this goal, the company has adopted a "staircase model" with four levels that each of its suppliers must successively achieve. All levels require auditing and verification, done in some instances by IKEA itself and in other cases by independent auditors.

Level 1. For a new supplier to be accepted, its wood raw materials cannot be sourced from intact natural forests or from high conservation value forests, unless the forests have been independently certified as sustainably managed. To remain with IKEA, within 3 months after being accepted in Level 1, all suppliers must qualify for Level 2.

Level 2. All wood used by the supplier must come from known sources that can be verified; wood suppliers must adhere to all forest legislation; wood must not come from protected areas unless the forest has been certified; wood cannot be sourced from forest plantations established by clearing intact natural forest after November 1994; and any wood from specified high-value tropical tree species must originate from forests that have been certified as sustainably managed.

Level 3. Forests that are the sources of wood must be managed in a way that qualifies them as being in transition to full certification. The detailed requirements for this transitional stage have been codified in IKEA's "4wood" standard. Auditing against this standard is carried out by IKEA's team of auditors.

Level 4. All wood is sourced from forests that are certified as being sustainably managed in accordance with a set of standards acceptable to IKEA. Currently, the only standard recognized by IKEA is that of the Forest Stewardship Council.

Source: Ulf Johansson. "IKEA's Staircase Model for Verifying the Origin of its Wood Products." (Presentation given at the workshop on Log Tracking and Chain of Custody Systems held March 19–21, 2002 in Phnom Penh, Cambodia.) See also <http://www.ikea.com>.

† Section numbers referenced in the text can be found in the table of contents.

6 Sofia Ryder, "The Forest Stewardship Council's experience in verification of legal compliance" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

7 Agus, Setyarso, "Developing and implementing chain of custody and log audits" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

1. To conduct their own audit of wood sources
2. To purchase wood that has been certified as coming from sustainably managed forests and for which the chain of custody to the point of importation can be verified
3. To purchase wood whose chain of custody has been certified.

For most importers, the first option is impractical (boxes 3.2 and 3.3. The second option provides a more practical solution except that wood from fully certified forests currently represents only a small fraction of the total volume of timber traded in international markets. The third option involves a type of certification that is in essence a subset of full certification. A growing number of independent auditors now offer certification of the chain of custody. For a timber seller or processor to receive such certification, of course, a comprehensive chain of custody system must be in place.

It is worth noting that timber importers must also abide by the terms of CITES, the Convention on International Trade in Endangered Species of Wild Fauna and Flora.[8] Because CITES is an international treaty enacted in 1976 and signed by 158 nations, it carries the full weight of international law. Most signatory countries also have enacted supplementary legislation requiring their citizens to abide by the provisions of CITES. For species whose trade is controlled under various provisions of CITES, proper documentation must be provided before export or import can be allowed. These requirements are controlled directly by customs agents in each country. Three categories of restriction are defined[9]:

1. *CITES Appendix I listing.* Species that are threatened with biological extinction. No commercial trade in these species is permitted. Trade in artificially propagated specimens is permitted with proper documentation from the country of origin. Currently, seven timber species are included on this list.
2. *CITES Appendix II listing.* Species that would become threatened with extinction if trade were not regulated. Commercial trade in these species is permitted, provided that an export permit is obtained from the country of origin certifying that the trade is not detrimental to the survival of the species. Currently, 12 timber species are included on this list.
3. *CITES Appendix III listing.* Species listed by an individual country to obtain international cooperation to control trade originating from that country. The listing country must issue an export permit to accompany shipments. Other countries that permit the listed species to be exported must issue a CITES certificate of origin as proof that the shipment did not originate in the country that listed the species. Currently, six timber species are included on this list.

Box 3.3
ScanCom's direct-audit system

ScanCom International is a distributor of garden and interior furniture, much of which is manufactured from tropical hardwoods. The products are made to ScanCom's designs, either in several factories owned by the company or in any of 45 contract manufacturing firms located in tropical developing countries. Finished products are then supplied to retail outlets in Europe.

ScanCom's Environmental Policy requires all wood raw materials to be sourced from either forests already certified as sustainably managed under Forest Stewardship Council (FSC) standards; forests that are implementing an action plan to achieve this goal; or forests that, with the company's assistance, can be encouraged to do so.

Because only a small fraction of tropical hardwood forests have already been certified to FSC standards, ScanCom has found it necessary to undertake its own auditing during a transitional period. In addition, the company no longer relies on its contractor manufacturers to purchase logs but instead purchases logs directly and supplies them to the manufacturers. All log sources are carefully audited by ScanCom's own team, by checking documentation and through field checks. In addition, the company undertakes a peer review of each forest management unit from which the purchased logs originate. This peer review includes an audit against FSC standards. The forest management unit must maintain verifiable stump-to-mill chain of custody for all logs that are supplied to ScanCom.

Source: Chad Ove. "ScanCom's System for Verifying the Origins of Logs." (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002. See also <http://www.scancom.net>.

[8] Chen Hin Keong, "CITES System: A viable procedure for tracking of logs and timber products?" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

[9] The full CITES appendix listings may be found at <http://www.cites.org/>. A summary of the listings for timber species is available through the International Wood Products Association at <http://www.iwpawood.org/cites.html>.

Consumers

Consumers of retail forest products are potentially beneficiaries of chain of custody information. Many consumers, particularly in the industrialized countries, consider themselves to be "environmentally conscious"—to the extent a choice is available and there is little or no price differential, they prefer to purchase forest products that have been sourced from well-managed forests. The simplest way for consumers to make this determination is if a certificate is available from a known accreditation agency indicating that the forest from which the wood originated meets the standards of sustainable forest management. Rather than demanding proof that wood products have been certified, however, consumers are more likely to choose a retail outlet that has adopted a policy of purchasing wood products sourced from well-managed forests. For this reason, a number of large retail outlets have become major driving forces behind the trend to require that all forest products originate from certified forests. Most international certification standards require reliable and comprehensive chain of custody systems.

4
Chain of Custody Technologies

Materials management and chain of custody

Concepts of materials management
Chain of custody can be categorized as part of the science of materials management. Materials management includes the coordinating functions responsible for planning and controlling the flow of materials (Arnold 1996). Other names include *distribution planning and control* and *logistics management*. Materials management incorporates:

- Production planning
- Materials requirements planning
- Capacity management
- Production control
- Purchasing or other sourcing of supplies
- Administering orders
- Receiving goods
- Handling and storing goods
- Issuance and distribution of goods to users or customers
- Controlling stock levels.

Chain of custody has an integral or indirect part in all these materials management functions. The successful implementation of chain of custody requires an understanding of the wider requirements for materials management within the affected organizations. For chain of custody to be successful, it must be integrated into the overall materials management activities of an organization. An exhaustive discussion of materials management is beyond the scope of this study; however, it is possible to identify specific materials management functions that directly relate to chain of custody:

Sourcing policies:

- Implementation of policies that allow the sourcing of goods to meet the company's requirements
- Supplier appraisal—the assessment of a supplier's probable capabilities for meeting its full contractual obligations.

Physical storekeeping:

- Maintenance of stock receipts, which usually includes documentation for ordering, receiving or accepting, and transferring materials or products.
- Classification and coding of goods so that they can be identified, quantified, and accounted for.
- Labeling of products or materials to allow them to be tracked in time and space. Product segregation can be viewed as a type of labeling in which the identity of goods is maintained by controlling their physical location relative to other goods.

Inventory management:

- Maintenance of stock records that document acceptance, storage location and movement, processing, and issuance of stock.

- Stocktaking – the checking of stock records against actual stock levels. Stocktaking can be a periodic or continuous activity.

Distribution management:

- Packaging and labeling to allow traceability of products
- Issuing consignment notes or other documentation to form an auditable "paper trail."

Application of materials management techniques in forestry

Forest management and wood processing organizations have the same intrinsic requirements for materials management as any other type of organization. However, the practical application of materials management in the forest sector is quite unique because of the diverse planning horizons, the diverse range of outputs from forests, and the complexities of applying industrial management processes to natural resources. Key materials management functions that are related to forest chain of custody include:

Pre-harvest inventory and production planning. This function is indirectly related to chain of custody in that forest management plans, harvest management and cutting plans provide benchmarks against which operational chain of custody information can be audited.

Post-harvest forest assessment. This also is indirectly related to chain of custody in that actual production levels monitored through chain of custody can be audited against an assessment of the residual forest conditions after the harvest has been completed. Post-harvest assessment activities that may be relevant to chain of custody include:

- Assessing actual harvest boundaries
- Assessing quantity and quality of residual standing timber stock
- Matching inventory of stumps against log inventories and other documentation
- Assessing logging waste
- Comparing actual production records against indirect estimates of volumes derived from pre-harvest and post-harvest assessments
- Preparing environmental impact assessment.

Log production tracking and stock control. This is a direct chain of custody function. It extends from the time the tree is harvested until it is delivered to the mill for processing. It includes log and stump labeling, log measurement and grading, maintenance of stock records from the forest through to the destination, log stocktaking, and control of both the actual distribution and the distribution information. Accurate tracking of logs is probably the single largest problem area in forest chain of custody and is the area most prone to abuse. The largest problem is usually the inability to identify the source of logs because of insufficient or inaccurate log labeling. Log tracking also can be made complicated by difficulties in establishing control over:

- Product measurement
- Species identification
- Stock inventory or product delivery records and stock receipts due to the remote location of forests and complicated delivery processes.

Despite the unique attributes of forestry and log production and distribution, log tracking can be achieved satisfactorily by applying standard materials management techniques.

Processed wood production and inventory control techniques. These techniques are similar to those that might be adopted for any manufacturing operation.

Information systems for chain of custody

Introduction to information systems

Conceptually speaking, chain of custody systems incorporate labeling devices, documentation processes, data protocols, communications systems, and computer software and hardware for data storage, retrieval, and analysis. The information system itself is likely to be built with general business management tools. In most cases, maintaining the chain of custody will be only one of several objectives for an organization's management information system.

Computer-based information systems can be developed for specific components of the supply chain:

- Log transport planning systems
- Truck dispatch management systems
- Stock inventory and warehousing systems
- Retail and distribution information systems.

Alternatively, computer-based systems can be used for total supply-chain management. Often the feasibility of total supply-chain management is restricted because of the inability to track goods outside of the organization's activities—this requires access to information from suppliers that may be difficult or impossible to obtain.

Standards for data and business processes

Information systems require standardization of procedures and data. Noncompliant processes and data have to be handled separately, often negating the benefits of the information systems. Several factors are of key importance in establishing an information system:

Standards for logistics procedures. It is highly desirable to establish standard and compatible procedures for controlling logistics management across the whole chain of custody.

Standards for description of internal information. Information systems require that data be captured in standard formats for use in existing databases. The systemization of data applies to products, services, operations, and other processes.

Standards for exchange of information between organizations. Organizations frequently need to exchange information with external parties and this requires standards for the external exchange of information. Electronic data interchange protocols describe how business documents, such as purchase orders, requests for quotes, invoices, and remittance information, may be exchanged electronically between organizations. Expansions of such protocols include paperless or electronic trading and e-commerce.

Standards for electronic capture of label data

Labels are physical devices for storing information. Several standards and protocols have been defined for storing data in physical format so that the information can be electronically scanned.

Unidimensionnel barcodes. Barcodes are electronically readable labels that are attached to goods and provide information in an electronic format. Barcodes use the thickness of vertically drawn bars and the degree of separation between them to code information. Linear barcodes are used in many applications when the use of a numeric or alphanumeric code can provide the key to a database of products. The main limitation is that only a small amount of data can be stored in the linear barcode itself. If the main database is accessible to personnel using barcode scanners, this is not an issue. When

Figure 4.1
Unidimensional barcodes

A universal product code (UPC) label. Such unidimensional barcode labels are commonly used on retail products worldwide.

Figure 4.2
Two-dimensional barcodes

Two-dimensional barcode labels. The coding on such labels is capable of storing much more information than the more common unidimensional barcodes

labels must be read "off-line" (that is, when the database itself is not accessible, as is often the case in forestry), it is advantageous for the barcode itself to store a significant amount of data.

Over 250 barcode symbologies have been designed over time. The most common symbologies in use today are UPC/EAN, Code 128, Code 39, Code 93, and Interleaved 2 of 5. Typical data content capacity varies from 8 to 30 characters with some barcodes restricted to numerals only and others capable of representing full alpha-numeric information (figure 4.1).

Two-dimensional barcodes. A new growth area in the world of bar-coding is that of two-dimensional barcodes. Several variations of 2D barcodes are available, and as these are not limited to bars and spaces, the more accurate name of 2D symbologies is used. 2D symbologies provide a means of storing large amounts of data in a relatively small space. Individual labels available commercially can store as many as 7000 numeric characters or 4200 alphanumeric characters (figure 4.2).

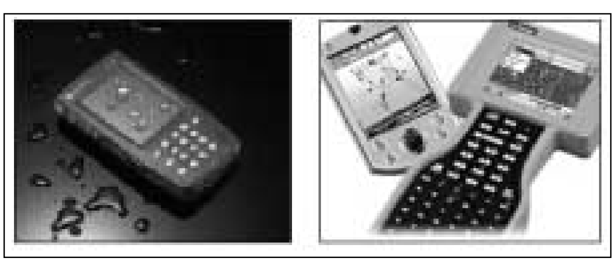
Magnetic stripe cards, smart cards, and RFID labels. Protocols have been developed and standardized for scanning magnetic stripe cards and smart cards (sections 4.3.5 and 4.3.6). Protocols also are emerging for RFID labels (section 4.3.7). One concern with RFID is the lack of international standards for the use of radio frequencies. This absence may inhibit their use for international chain of custody systems until such standards have been developed.

Field data loggers

Field data loggers are used for electronically recording data in the field. Their basic function is data capture and subsequent transfer of captured data to external databases. They can take the form of handheld devices or can be integrated in existing machinery such as trucks and harvesting machines. Data loggers also can act as analysis tools to validate captured data and to verify the data against databases stored internally or accessible to the data loggers through communication systems (figure 4.3).

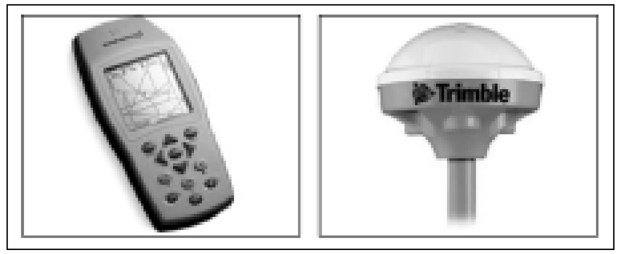
Global Positioning Systems (GPS) are specialized data loggers that enable the location of objects, vehicles, and individuals by using satellites to determine the coordinates of the GPS receiver on the surface of the earth through triangulation. GPS is commonly used in forest inventory to delineate the boundaries of forest areas and to determine field locations. Location information is obtained in real time. When connected to communication systems, GPS can track shipments and provide estimated delivery times (figure 4.4).

Figure 4.3
Field data loggers



Typical field data loggers. *Left,* a relatively simple model that has been sprinkled with water to demonstrate its ruggedness; right, a more elaborate model. The data logger at right is shown with a personal data assistant to which data may be transferred. Like nearly all data loggers, these models also support transfer to data to personal computers

Figure 4.4
Global positioning systems (GPS)



Left, GPS receiver with, *right,* an exterior antenna designed to increase sensitivity, for instance, to enable reception of satellite signals beneath the forest canopy.

Video cameras are data loggers in which information is collected in the form of video images. In practice they are used primarily for surveillance by placing the devices at fixed locations to monitor and record activities. Seismic, infrared, or magnetic sensors can be used to activate the cameras. Images can be either monitored in real time at a remote location or viewed on film at a later date. Video cameras also can be linked to GPS receivers so that geographic coordinates are burned onto the tape as proof of location. This useful feature strengthens the value of video footage as evidence in court and facilitates the integration of video imagery with other spatial data sets in a geographic information system.

Communications systems

Communications technology allows the transmission of electronic data. The common forms of communications are:

- Standard telephone
- Analog mobile telephone
- Digital mobile telephone
- Standard radio
- Satellite.

All wireless communication systems in the list above (except "standard telephone") can communicate and transmit data between the office and field locations. Advances in communications mean that data can be communicated from many locations at a reasonable cost and speed. Wireless communication enables the timely transfer of data and thus facilitates both the aggregation of field data at a central location and the dissemination of data (such as product orders) to the field.

Figure 4.5
Log ends

Logs with individual barcode labels attached. Each label has a unique serial number that can be electronically scanned and tied to documentation about that log.

Management information systems
Management information systems (MIS) provide the comprehensive information that makes it possible to implement chain of custody efficiently. Integration of management-process information into the MIS can significantly improve performance of supply chain management systems in terms of production and delivery times, production costs, and transaction costs. Recent advances in communications technology make it feasible to provide real-time information from centralized databases to almost any location in the world.

Internet and e-commerce
E-commerce, and its underlying technology, the Internet, provide an environment in which stakeholders from all parts of the supply chain can interact. It is now possible to merge traditional supply-chain management functions such as sourcing, production, and distribution with non-traditional processes such as customer and supplier relations.

Labeling technologies

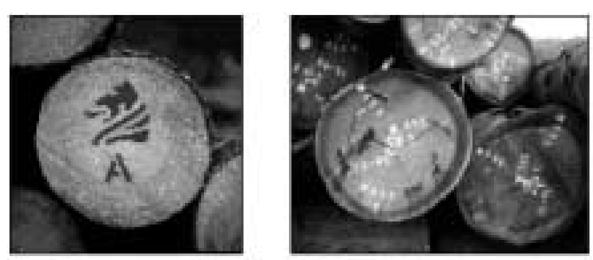
Labeling is defined here as the attachment of information to products or materials. A product label is a device that stores or refers to product information. Labels may provide:

- Descriptions of product classifications such as type, source, and other attributes
- Unique identification of an individual product item or a batch of product items
- Instructions for storage and distribution
- Security through the provision of transparent and overt publication of information and possibly also by covert means.

In this chapter, various labeling technologies that are (or potentially could be) applied in forestry are described and compared. Information systems and the integration of labeling technologies also are described. For detailed summaries of the technologies described in the following sections, refer to the tables in appendix C. A comparison of relative strengths and weaknesses of the various technologies is provided in table 4.1.

Conventional paint and chisel labels
The oldest methods of log labeling involve the painting or chiseling of company information and log identification information, usually on one or both ends of each log. Such labels are commonly used in conjunction with documentation to provide more detailed information about log origin, species, dimensions, and volume. A chisel, also called an inscribing tool or scribe, is a specialized knife used to engrave the information into the end of the log. Although both painting and chiseling require more time than hammer branding (figure 4.6), considerably more information can be included in the labels produced with these methods. The labels produced

Figure 4.6
Conventional paint and chisel labels



Two radically different styles of painted log labels. *Left,* a company logo that can be used to quickly identify ownership of the log. (Photo by George Kuru). *Right,* log labels designed to facilitate tracking so that the logs can be keyed to associated documents. In the center of each log is a company logo. Numbers on the left front log indicate the compartment from which the log was harvested (13/85), the number of the tree (455) felled within that cmpartment, and the number of the individual log (2) cut from the tree. (Photo by Dennis Dykstra.)

Table 4.1 Advantages and disadvantages

Label type	Strengths	Weaknesses
Conventional paint and chisel labels	• Paint and chisel marks are easy to apply. • Application of paint labels using spray paint and stencils is particularly quick. • Painting and chiseling cost very little and require no special training or maintenance programs. • These labels can be very robust and survive road and water transport very well. • Materials are usually readily available locally. • These labels can be integrated with forest management, logistics, and stock inventory functions.	• Painting or chiseling labels is time consuming; this has cost implications in high-labor-cost environments. • Hand-painted labels that use up a lot of space are suitable only for application on large logs. • Painted and chiseled labels are prone to errors during application and when being read. • Unscrupulous persons can easily replicate paint and chisel labels.
Branding hammers	• Hammer branding is quick and easy to apply. • Hammers cost very little, can be fabricated locally, and require no special training or maintenance programs. • Hammer marks do not use up a lot space and are suitable for a range of log sizes and large-dimension sawn timber. • Hammer marks are robust and survive road and water transport well. • Hammer marks can be used in conjunction with coded serial numbers that are not so easy to copy. • These labels can be integrated with forest management, logistics, and stock inventory functions.	• Marks left by hammers often are difficult to read. • Hammers can be easily replicated and widely distributed to unauthorized personnel. • Hammer marks are not easily keyed to associated documentation and thus they cannot easily be used as part of a comprehensive chain of custody system. • Information on the hammer mark cannot be used to identify individual logs.
Conventional labels	• Attaching is usually relatively quick – slower than using hammers but quicker than paint or chisel labeling. • Conventional labels are relatively inexpensive. Most forestry applications use labels in range of US$0.10–US$0.20 each. • Conventional labels are easier to read than other marking technologies. • Well-designed and manufactured labels can be very reliable. The materials can be designed for specific purposes and within the range of operating conditions that occur for wood products. • A large amount of data can be stored and the labels can be coded to include location, ownership, scaling information, and other data to support a wide range of applications. • Barcoded data can be instantly scanned into electronic format and captured in external monitoring and stock inventory systems.	• Conventional labels can be easy to duplicate or counterfeit unless suitable security mechanisms are integrated into the design of the labels. • Barcoded labels can be difficult to read in dusty, dirty, or wet conditions. • They can easily be removed or fall off. Experience shows that 1-5% of labels fall off before the product reaches its destination. • Conventional labels cannot usually be manufactured in the forest and therefore have to be pre-printed for log tracking purposes. This limits the nature of data that can be recorded on the label and imposes constraints on the type of monitoring procedures that can be applied for log tracking. • Barcoded labels require relatively expensive and sensitive electronic scanners, although the cost of these scanners is dropping continuously.

Label type	Strengths	Weaknesses
	• Inexpensive label printers are available, making it possible to produce labels at processing plants and at many storage facilities. This allows specific, locally relevant data to be included in the label. • These labels not only support chain of custody but also can enhance forest management, logistics, and stock inventory functions.	• The amount of data that can be stored in barcode format is limited for unidimensional barcodes.
Nail-based labels	• Nail-based labels are robust compared to paper or plastic labels and withstand movement and transport activities well. • Attaching is usually relatively quick – about the same as using conventional hammers and quicker than applying conventional, paint, or chiseled labels. • Nail-based labels are usually easier to read than other marking technologies. • A large amount of data can be stored and can be coded to include location, ownership, scaling and other data to support a wide range of applications. • Barcoded data can be instantly scanned into electronic format and captured in external monitoring and stock inventory systems. • Nail-based labels are more difficult (but not impossible) to duplicate or counterfeit. This is due to the specialist nature of their design and materials. • These labels can enhance forest management, logistics, and stock inventory functions.	• The base materials often are incompatible with processing, which means the labels must be removed before processing. For example, plastic labels must be removed before chip logs are pulped. • Nail-based labels may be difficult to remove. • They are generally supplied by specialist manufacturers and may not be readily available locally. • Barcoded labels can be difficult to read in dusty, dirty, or wet conditions. • Nail-based labels cannot usually be manufactured *in situ* and therefore have to be pre-printed for tracking purposes. This limits the nature of data that can be recorded on the label and imposes constraints on the type of monitoring procedures that can be used for log tracking. • Barcoded labels require relatively expensive and sensitive electronic scanners to decipher. • The amount of data that can be recorded in barcode format is limited for unidimensional barcodes.
Magnetic stripe cards	• Magnetic stripe cards are useful for attaching information to documentation rather than for labeling individual products. • Magnetic stripe cards are useful for adding security to documentation. • The information stored on these devices is relatively secure and difficult (but not impossible) to alter or counterfeit. • More data can be stored on magnetic stripe cards than conventional barcoded labels, but less than on 2D barcoded labels or smart cards. • These devices can facilitate data processing and security audits of documents. • It is possible to manufacture labels at processing plants and at many storage facilities, allowing more data to be inserted into the documents.	• Stripe card readers are not generally mobile. Therefore the technology is not suitable for general product labeling or stock inventory purposes. • Magnetic stripe cards are not generally suitable for labeling of individual logs or processed wood products. • Paper based stripe cards are not robust. • Stripe card readers and recorders are relatively expensive; significantly more so than barcode scanners. • Only a small amount of data can be stored on them relative to 2D barcodes and smart cards. • Magnetic stripe cards can be difficult to read in dusty, dirty, or wet conditions.

continued

Table 4.1 *(continued)*

Label type	Strengths	Weaknesses
Smart cards	• The biggest advantage of smart cards is the large amount of data that can be stored and the security that can be built into the card. • Smart cards are useful devices for *replacement* of paper documentation. • The information stored on these devices is relatively secure and difficult to interfere with or counterfeit. • Significantly large amount of data can be stored on them relative to other types of labels. • These devices can significantly facilitate data capture, data processing, and security audits. • It is possible to capture data at processing plants and at many storage facilities allowing more data to be inserted into the documents. • These labels can enhance logistics and stock inventory functions.	• The biggest disadvantage today with smart cards is the cost of creating a smart card system; i.e., purchasing the card read/write scanning equipment and the cards themselves. The cards are expensive and therefore not suitable for individual log or wood-product labeling. • The scanners are not generally mobile. Therefore the technology is not suitable for general product labeling and stock inventory purposes.
RFID labels	• An important advantage of RFID systems for log tracking is that signals can be read rapidly, remotely and under difficult conditions, even under water. • RFID labels can potentially store a large amount of data with a high level of security. • The labels can be difficult to counterfeit or tamper with and can provide a high level of covert security. • These devices can significantly facilitate data capture, data processing, and security audits. • It is possible to encode RFID labels at all stages of the wood supply chain from the field to the end-user. • RFID labels can enhance logistics and inventory functions.	• Available frequencies vary from country to country so there are currently no internationally standardized RFID technologies. • The cost of RFID labels is high relative to more conventional labeling methods. • The cost of setting up an RFID system is high. The scanning devices are expensive to purchase and require technical expertise to program them for specific operations. • There is usually no manual fallback when the technology fails.
Microtaggant Tracer	• Microtaggant labels are completely accurate and impart a high level of security to labels and products. • They cannot be counterfeited or tampered with. • The microtaggants themselves are inexpensive and only simple, low-cost magnifiers are required to read them. • They can be applied across the full range of wood chain of custody. • They are compatible with many existing labeling technologies such as paint labels, conventional labels, and nail-based labels. • Microtaggants are long-lasting, non-biodegradable and can survive most wood-processing activities.	• Microtaggants are not a complete chain of custody solution and are only suitable for batch-level labeling. It is not economically feasible to label each individual product with a unique microtracent code. • Microtaggants must be manually read and cannot be electronically scanned. Tests on logs have shown that they are sometimes difficult to read and that the microtaggant chips are not always retained on logs in sufficient quantity to be found easily. • The unit costs are relatively low, but initial setup and development costs may be high. • Currently, the tracers cannot be sourced locally but must be acquired from the producer in the USA.

Label type	Strengths	Weaknesses
Chemical tracer paint	• Tracer paint is accurate and imparts a high level of security to labeled products. • Tracer paint cannot be easily counterfeited. • Tracer paint is a relatively low-cost solution that is simple to apply. • Tracer paints can be applied across the full range of wood chain of custody. • Oil-based tracer paints are long-lasting, non-biodegradable and can survive most wood-processing activities.	• Tracer paint is not a complete chain of custody solution and is only suitable for batch-level labeling. It is not economically feasible to label individual products with a unique type of tracer paint. • The technology is currently only available to the US Forest Service, although similar technology could be developed independently. The cost of independently developing a parallel technology is unknown. • Recent investigations have found water-based tracer paints to be susceptible to degradation from naturally occurring chemicals, reducing their effectiveness as marking and tracking tools. • Solvents used with oil-based tracer paints may induce allergies in some people. • Requires proper accountability and secure storage facilities to prevent theft (and misuse) of the paint. • Laboratory identification of the paint signature is time-consuming and expensive.
Chemical and genetic fingerprinting	• These technologies can provide identification of products at the individual tree level. • These technologies provide additional useful information in relation to wood properties and the effects of local site conditions on wood properties.	• Application of this technology requires a comprehensive database of genetic and chemical characteristics of the target tree population. These databases do not currently exist for most commercial tree species. • Laboratory testing is time-consuming and expensive. • Fingerprinting is not a chain of custody solution but rather a verification solution that might be used to establish the origins of logs suspected of having been illegally harvested.

by painting and chiseling also are generally more legible than hammer brands.

Stamped codes. Recently, coding methods have been developed in which patterns of dots or circles are stamped in the ends of the logs. These stamped codes can be applied automatically by harvesting machines[10] or by using special stamping devices.[11] They can subsequently be interpreted by handheld or machine-mounted readers. The codes can contain a significant amount of information and may also refer to additional documentation.

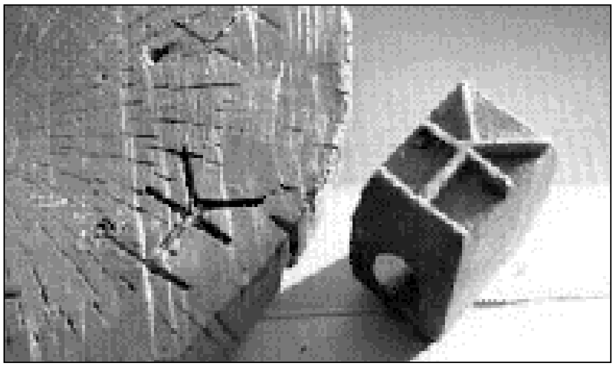
Branding hammers

The branding hammer is a traditional method of log labeling still widely used throughout the logging

[10] Bengt Sörvik, "The Woodpecker system for coded log stamping in mechanized harvesting systems" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

[11] Richard Uusijärvi, "European Lineset Project—combining log stamping with transponders for wood product tracing" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

Figure 4.7
Branding Hammers



The head of a branding hammer with a branded log end. Hammer brands often are more elaborate than the one shown here and may include numeric codes associated with a specific timber sale or forest compartment.

industry. It remains the most widely used system in the United States although many of the larger timber companies are replacing it with the use of barcoded conventional labels. A branding hammer has a raised design on the strike surface that leaves a unique identifying mark on impact. Typically, branding hammers, which usually identify only the custodian of the log, are used in conjunction with other documentation to provide more detailed information about log origin, species, dimensions and volume (figure 4.7).[12]

Conventional labels

Conventional labels use either treated paper or plastic tags and are attached to products with metal or hardened plastic staples, nails, adhesives, or (for pulpwood) with special materials designed to be "digested" during the pulping process. Although conventional labels may include only a company name or log number, the amount of information that can be stored in them can be increased if they are imprinted with barcode information that can be read by barcode scanners (figures 4.5 and 4.8–4.10).[13]

[12] Kimsun Chheng, "Log tracking in Cambodia" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

[13] Antoine de la Rochfordière, "Mechanisms to verify the legality of timber products" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

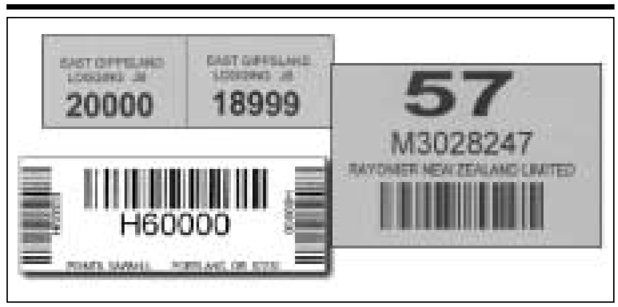
Figure 4.8
Conventional log labels

Log labels can be produced in a wide variety of sizes, colors, and other options. *Top left,* a 1-part label; *top right,* 2-part label; *bottom,* 2 types of 3-part labels. Multipart labels are designed so that segments of the label can easily be separated from the main label and used as data records in situations in which electronic scanning of the barcode is not feasible or has been temporarily suspended due to power outage or other technology failure. (Courtesy of Pointil Systems, Inc., USA, <http://www.pointil.com/>.)

Nail-based labels

Nail-based labels are hammered onto the end of a log or processed wood product. Commonly, nail-based products are made of metal or hardened plastic. Plastic labels often are imprinted with barcode information that can be read by barcode scanners (figure 4.11).

Figure 4.9
Conventional pulpwood labels



Pulpwood labels can be made of materials that will dissolve safely during the pulping process. *Top left,* pulpwood tags with simple serial numbers; *middle right,* a 1-part barcode label; *lower left,* a 3-part barcode label made from "Rite in the Rain" paper. The 3-part barcode label is made so that the side bars can easily be separated from the main label and used as a data record in situations in which electronic scanning of the barcode is not feasible. (Courtesy of Saito Labels Ltd., New Zealand, <http://www.saito.co.nz/forestry/> (colored labels) and Pointil Systems, Inc., USA, <http://www.pointil.com/> ("Rite in the Rain" label).

Figure 4.10
Handheld CCD scanner

A handheld scanner used to read information from barcode labels. The device shown is known as a CCD scanner because it uses a charge-coupled device, a type of integrated circuit that responds to light, to read the data. Other types of barcode scanners include those that use lasers to read the data. Information read by the device is stored electronically and can be transferred to a computer for analysis.

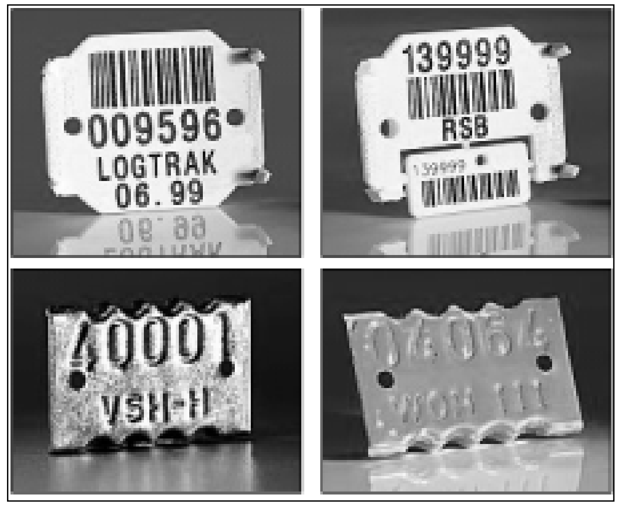
Magnetic stripe cards

Magnetic stripe (swipe) cards are made of either paper or plastic. Each card contains a black magnetic strip. Information can be stored on the magnetic strip and read using specially made readers. The cards require special scanning devices to write to and read the cards. The use of these cards is common in a wide range of applications, such as airport transit tickets and bankcards. It is a ubiquitous technology in the financial and security sectors. However, its dominant market position is being challenged by smart cards and two-dimensional barcodes. There is a specific International Organization for Standardization (ISO) standard for encoding stripe cards.[14] Proprietary encoding is possible, and most readers can be programmed to read custom encoding.

Smart cards

Smart cards are credit-card-sized plastic cards that contain relatively large amounts of information in an imbedded microchip. Several terms are used to identify cards with embedded integrated circuits. "Chip card," "integrated circuit card," and "smart card" all refer to the same thing. There are two types of smart card:

Figure 4.11
Nail-based labels



Top, two plastic labels; *bottom,* two metal labels. Plastic labels offer the option of including printed barcodes but are less rugged than metal labels. Note that the plastic label, *upper right* has a removable code section that can be used as a data record in situations in which electronic scanning of the code is not feasible.

Dumb smart card. A "dumb" smart card is one that only contains memory. These cards are used to store information. An example might be a stored-value card that stores in its memory a shipping manifest.

True smart card. True "smart cards" have an embedded microprocessor as well as memory for storage of information. The microprocessor provides the ability to make decisions about data stored on the card. The card does not depend on an external unit. As there is a microprocessor on the card, various methods can be used to prevent access to the information on the card to provide a secure environment. This security has been touted as the main reason that smart cards will eventually replace other card technologies.

Most smart cards require physical contact between the card and pins in the reader, but a growing set of applications support "contactless" cards. Short-range cards operate by electrical inductive or capacitive coupling when the reader and card are brought within a millimeter or so of each other; longer-range cards communicate by radio signals (figure 4.10).

RFID labels

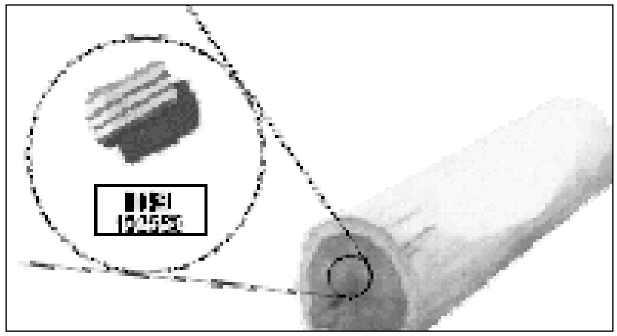
These are labels that contain Radio-Frequency Identification (RFID) transceivers that receive and send data

[14] International Organization for Standardization, Geneva, Switzerland, <http://www.iso.org/>.

Figure 4.12
RFID scanners

A handheld scanner used to read information from RFID labels. The device sends a coded signal instructing the RFID label to transmit its data. The information is then received electronically through the scanner's antenna. Information received by the scanner is stored electronically and can be transferred to a computer for analysis.

Figure 4.13
Microtaggant tracer paint



Inset, a color-coded microtaggant that can be embedded in paint or directly in the end of a log for identification and tracing purposes.

by radio transmission. When used for log-tracking purposes, RFID transceivers are commonly inserted into nail-based labels. RFID provides a means of obtaining information on an item without making direct contact. Reading and writing distances can vary from a few millimeters to several hundred meters depending on the technology used. The tags themselves come in a variety of forms including credit card-sized plastic cards, tiny injectable transponders, and large "bricks" suitable for use on railway freight cars. The technology used to implement RFID varies by manufacturer and application, with frequencies used varying from 37 kHz to 5.8 GHz.

Most RFID labels use transponders, which only transmit data when "excited" by a signal from an appropriate reader. This makes them relatively secure and tamper-proof. They often are used in conjunction with smart card technology to provide "intelligent and remote" capabilities. For example, RFID transponders may be used with contactless smart cards in situations where transactions must be processed quickly, as in mass-transit turnstiles (figure 4.12).

Microtaggant tracer paint

Microtaggants are microscopic particles composed of distinct layers of different colored plastics that can be combined to form a unique code.[15] Each microtaggant is a color-coded, polymer microchip consisting of 10 layers, including a magnetic layer and a fluorescent layer, which is intended to function as an identification device. Millions of permutations are possible by combining several colors in different sequences. Codes can be read in the field with 100-power pocket microscopes (figure 4.13).

Chemical tracer paint

The United States Forest Service has used chemical tracer paint since 1988.[16] Its purpose is to prevent or expose theft of trees from within or near areas designated for harvest. Each paint formulation contains two chemical tracers. One tracer can be detected in the field; the other can be identified only by using laboratory equipment. The field tracer is detected by placing a drop of chemical from a supplied test kit on the suspected paint. The laboratory tracer can be identified only by using sophisticated chemical analysis but provides a high level of identification and increased level of proof.

In practice, the boles and stumps of trees to be harvested (or those to be retained) are marked with paint containing the tracents. Painted trees are easily identified and can be tested at any time using the field test kit. The tracer paint is proprietary to the US Forest Service and can only be used by that agency. The tracer elements have been formulated specifically for the Forest Service, and their chemi-

[15] William Kerns, "Timber tracing and control system" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

[16] Rex Baumback, "Tracer paint for marking trees by the US Forest Service" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

Box 4.1
Greenpeace: Illegal logging in the Amazon

The environmental watchdog organization Greenpeace has played a pivotal role in highlighting the problem of illegal logging in the Brazilian Amazon. In the late 1990s, with the assistance of IBAMA, the Brazilian Government's environmental protection agency, Greenpeace set up an office in the heart of the Amazon to identify and expose illegal logging. The move was prompted by alarming deforestation rates in the region, coupled with a huge increase in logging activity despite increased environmental and zoning regulations on logging. The remoteness and vast size of the Amazon Basin makes active monitoring by the authorities difficult.

The Greenpeace approach includes these activities:

- Aerial surveys with small aircraft, combined with global positioning system data and computer mapping to show the locations of all logging and land-clearing activities. These results are then compared with maps showing where legally licensed operations are underway so that IBAMA can be notified of suspected transgressions.
- Riverboat expeditions along key tributaries of the Amazon to monitor and document log-raft traffic and interview local inhabitants about activities in the area.
- Interviewing officials in logging companies and government agencies.
- Compiling and analyzing data on permits and licenses issued by IBAMA to organize a comprehensive database of legal activities that can be compared against on-the-ground checks.
- Painting logs with ultraviolet paint to track them through the complex chain through which illegal logs move in what is often referred to as "log laundering."

While Greenpeace is known for its aggressive and sometimes belligerent stand on environmental issues, the organization also promotes what it perceives as "good actors," In May 2000, Greenpeace applauded the logging company, Precious Woods Amazon, for its commitment to ecologically responsible logging in tropical rainforest ecosystems. During a meeting onboard a Greenpeace riverboat, Precious Woods presented a new initiative, which was the outcome of negotiations and on-site forest inspections with Greenpeace representatives that lasted more than a year. Precious Woods forest operations were the first in the Brazilian Amazon to be certified under the standards of the Forest Stewardship Council.

Source: Bill Barclay, Greenpeace International, San Francisco, Cal. Detailed reports are available at <http://www.greenpeace.org/amazon/>.

cal compositions are kept secret. However, paint companies could be contracted by other entities to produce tracer paint using different formulations. In addition, other tracer paints are available and have been used in investigations of illegal logging activities. For instance, ultraviolet paint has been used to follow the movements of illegally sourced logs (box 4.1).

Chemical and genetic fingerprinting
These technologies allow the verification of product identity by examining its chemical or genetic composition.[17] Chemical fingerprinting methods include:

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

Genetic fingerprinting methods include the analysis of DNA markers from one or more of the following genomes:

- Nuclear genome
- Plastid genome
- Mitochondrial genome.

Any of these technologies could potentially be useful for tracing the origins of logs as a way of determining whether they have been legally harvested. However, none of them has reached a stage of development that would warrant its general use at present. It is possible that genetic fingerprinting could become a practical tool for selected species in 3 to 10 years.

Comparisons of labeling technologies

Suitability for different tasks
Conventional paint and chisel labels, branding hammers, conventional labels (with or without barcodes), and nail-based labels are all suitable and proven devices for logs and other wood products. Conventional labels (often with barcodes) are the leading method for labeling processed wood products but conventional paint, chisel labels, and hammer brands remain common methods for labeling logs. Barcoded labels are increasingly used as log labels, particularly in situations where high-value logs are being exported and it is important to

[17] Hans-J.Muhs, "New technologies for timber identification" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

capture export revenues.[18] RFID labels represent an emerging technology that will become practical for labeling individual logs and processed wood bundles when the average price falls below about US$0.20 per RFID chip.[19] Current prices for the relatively small quantities that would be used in wood tracking are several times higher than this level.

Magnetic stripe cards and smart cards may eventually replace paper documentation in some instances but are unlikely to be used for labeling individual items such as logs or lumber bundles. Smart cards often are associated with RFID and the merging of these technologies at a reasonable cost has the potential to revolutionize forest products logistics.

Microtaggant tracers,[20] chemical tracer paint,[21] and chemical and genetic fingerprinting,[22] are technologies that can potentially enhance the security provided by labels rather than serving as primary labeling tools in themselves. They could be particularly useful for proving theft of logs or other wood products. Fingerprinting technologies can be used to link specific trees with specific products but have not yet been sufficiently developed to serve any other chain of custody function.

Table 4.2 provides an overall summary of the suitability of the various labeling technologies for log and product tracking.

Security characteristics of labeling technologies

Labeling imparts security to the product being labeled because the product identity and status can be checked against information on the label, which in turn may refer to documents containing more detailed information. Each type of label imparts varying degrees of security. A summary of security characteristics of the types of labels considered in this report is presented in table 4.3. Additional details are provided in appendix C.

Label security can be enhanced by implementing any of several security strategies:

1. *Use the inherent security properties of different labels.* Different types of labels offer varying degrees of security of identification as summarized in table 4.3.

2. *Employ one or more security enhancements:*
   - Labels can be printed in counterfeit-resistant materials such as watermarked paper or hologram-embedded plastics.
   - Labels can be covertly tagged with microtaggants and marker chemicals.
   - Label components such as barcodes can be encrypted to prevent counterfeiting.
   - Labels can be made to disintegrate when an attempt is made to remove them. This provides a mechanism to help identify tampering.

3. *Insert information on labels that uniquely identify the product.* On-site manufacturing of labels allows the insertion of data onto the label that can be used to positively identify the attached goods.

4. *Reference the labels to external documentation and databases.* Products labeled with unique identification numbers can be checked against external documentation and databases. This is the most accurate form of security but requires accurate external documentation and is dependent on the ability of personnel to access data within an acceptable operational timeframe.

Finally, it should be noted that chain of custody is assessed primarily by auditing the organization's chain of custody procedures (as described in chapter 2) and by checking the accuracy of product labels against documented records. Labels by themselves cannot substitute for good management and thorough oversight of activities.

[18] Telfer. See footnote 4.

[19] Sorin Chiorescu, "Traceability issues in the EU and US forestry: What lies ahead?" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

[20] William Kerns, "Timber tracing and control system" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

[21] Rex Baumback, "Tracer paint for marking trees by the U.S. Forest Service" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

[22] Hans-J. Muhs, "New technologies for timber identification" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

Table 4.2 Suitability of labeling technologies for purposes related to log and product tracking

Label type	Tree labels	Log labels	Processed wood labels	Transport documentation
Conventional paint and chisel labels	**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*	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*	Not suitable
Chemical and genetic fingerprinting	Suitable for individual tree fingerprinting	Technology not sufficiently developed	Technology not sufficiently developed	Technology not sufficiently developed

Note: "Suitable" means the technology can be used as a stand-alone method to provide adequate information for tracking individual logs and bundles of processed wood products, or to provide transport documentation. Technologies judged to be "not suitable" either provide insufficient information, are too expensive to be practical for these purposes, or are not sufficiently robust to withstand the difficult conditions inherent in forest operations. For more details, see table 4.1 or to appendix C.

Table 4.3 Security characteristics of alternative labeling technologies

Label type	Security characteristics
Conventional paint and chisel labels; Hammer brands	• These labels have no inherent overt or covert security features other than referencing the label to supporting documentation. • Security is applied by auditing documentation and by field checking of source material. • The level of security is based on the quality of the documentation and audit systems, and the accuracy and comprehensiveness with which they have been implemented. • For paint labels, security can be improved by the addition of microtaggants or chemical markers to paint.
Conventional labels	• These labels are more difficult to counterfeit than paint, chisel, or branding hammers, but counterfeiting them is nevertheless possible. There are several ways to make conventional labels more secure: – Labels can be printed in counterfeit-resistant materials such as watermarked paper or hologram-embedded plastics. – Labels can be covertly tagged with microtaggants and marker chemicals. – Barcodes can be encrypted and can include security information. – Labels can be made destructible so that they disintegrate when an attempt is made to remove them. This is an overt mechanism for identifying tampering. – On-site manufacturing of labels allows the insertion of data onto the labels which can be used to positively identify the attached goods. • In most cases, labels can be referenced to supporting documentation. Security is then applied by auditing documentation and field checking source materials. • The level of security is based on the quality of the documentation and audit systems, and the accuracy and comprehensiveness with which they have been implemented.
Nail-based labels	• Nail-based labels are difficult (but not impossible) to duplicate or counterfeit. There are several ways to make nail-based labels more secure and even tamper-proof: – Labels can be covertly tagged with microtaggants or marker chemicals. – Barcodes can be encrypted and can include security information. • It is difficult (and expensive) to manufacture nail-based labels on-site; therefore it is not usually possible to insert data onto the label that can be used to positively identify the attached goods. • In most cases, labels can be referenced to supporting documentation. Security is then applied by auditing documentation and field checking source materials. • The level of security is based on the quality of the documentation and audit systems, and the accuracy and comprehensiveness with which they have been implemented.
Magnetic stripe cards	• Stripe cards offer inherent security in terms of how information on the magnetic stripe is encoded, stored, and read. Proprietary encoding is possible, offers greater security, and most readers can be programmed to read custom encoding. Like conventional labels, stripe cards can be made more secure and even tamper-proof: – Labels can be printed in counterfeit-resistant materials such as watermarked paper or hologram-embedded plastics. – Labels can be covertly tagged with microtaggants and marker chemicals. – The information stored on the magnetic strip can be encrypted. • On-site recording of stripe cards allows the insertion of data that can be used to positively identify the attached goods. The stripe card can include security information that specifically identifies it with the specific labeled product. The information on the stripe card can be encoded to provide additional security. • Labels also can be referenced to supporting documentation – security is then applied by auditing documentation and field checking source materials.
Smart cards	• Smart cards offer a high level of inherent security in terms of how the information is encoded, stored, and read. Proprietary encoding is possible, offers greater security, and most readers can be programmed to read custom encoding.

<table>
<tr><th>Label type</th><th>Security characteristics</th></tr>
<tr><td></td><td>• The need for security influences the design and handling of the card, its embedded circuitry, and its software. Microprocessors used in smart cards are specifically designed to restrict access to stored information and to prevent the card from use by unauthorized parties. A properly designed device will automatically fail to operate outside certain voltage or clock frequency ranges.
• If desired, circuit links may be designed to become inoperable once a card has been programmed, so that vital data cannot be altered.
• Manufacturers employ special tamper-resistant techniques that prevent access to the microscopic circuitry itself.</td></tr>
<tr><td>RFID labels</td><td>• RFID labels provide the greatest array of security applications of all the labeling products discussed in this report. RFID tags offer similar security characteristics as smart cards (a parallel technology) along with the ability to rapidly and remotely read large volumes of tags in real time.
• RFID labels offer inherent security in terms of how the information stored in them is encoded, stored, and read. Proprietary encoding is possible, offers greater security, and most readers can be programmed to read custom encoding. The need for security influences the design and handling of the card, its embedded circuitry, and its software.
• RFID labels also can be used covertly because they can be hidden within the product (or product bundle) or covertly placed within other labels. The presence or absence of RFID labels can be tested rapidly, at remote distances, and in real time.</td></tr>
<tr><td>Microtaggant tracers</td><td>• Microtaggant labels offer a high level of security. The taggants are basically counterfeit-proof and tamper-proof.
• Microtaggants are suitable for application with other labels, thereby imparting security for those labels.
• They can provide a cost-effective method for detecting counterfeiting and tampering with labels.
• Microtaggants are a deterrent that is only effective when used along with comprehensive surveillance operations. It is not a comprehensive and watertight security solution in itself.</td></tr>
<tr><td>Chemical tracer paint</td><td>• Tracer paint offers a high level of security. Current tracer paint technology is basically counterfeit-proof and tamper-proof.
• Tracer paint is a deterrent that is only effective when used along with surveillance operations. It is not a comprehensive and watertight security solution in itself.</td></tr>
</table>

5
Verifying Legal Compliance

In previous chapters, the focus has been on mechanisms for tracking wood from source to final use. However, on its own, a traceable chain of custody does not guarantee that the wood in a product has been legally harvested. Additional checks are needed to assure buyers that a product's history is free from breaches of the law. This chapter examines tools and approaches available to provide such assurance and the challenges in using them.

Which laws are the focus of concern?

A comprehensive approach to determining legality in forest products could cover:

- Many subjects beyond forestry – laws relating to taxes, labor, health, corporations, transport, customs, pollution, and money laundering
- Many ingredients beyond wood – paints, lacquers, other materials, and packaging
- Many phases of production – harvesting, hauling, milling, shipping, manufacturing, and trading
- The process by which harvesting rights were obtained, including adherence to planning laws, impact assessment requirements, tendering procedures, contractual "fairness" provisions, and absence of any suspicion of corruption or collusion.

The designers of any system to verify legal compliance (or expose illegality) in the forest products industry must therefore identify the scope of concern of likely users and judge which aspects of legality warrant inclusion. A conservation organization, for example, is likely to care more about logging in protected areas than a hauling contractor's failure to correctly record all details of the tracking labels in a load of logs. Systems to monitor or verify legality must therefore balance *scope* in covering the range of issues of concern to different stakeholders, with the practicalities of designing a system that is *affordable* and *workable*.[23]

Approaches to finding this balance include:

- Limiting the scope of inquiry to one or more specific aspects of production, (for example, the circumstances under which the wood is harvested).
- Concentrating routine enquiries on what can be readily verified (for example, existence of a valid permit to harvest in the area where the wood was sourced), while investigating forms of illegality that are harder to pinpoint (for example, fraudulent transfer-pricing schemes) if and when a suspicion is raised.
- Stepwise approaches – starting off with simple checklists and progressively adding complexity as experience and confidence are gained. As an example, the European Commission recently convened a workshop that recommended a phased approach to verifying

[23] Boedijono, "Chain of custody system in Indonesia" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

legality, with an initial focus on whether forest management and processing have been properly licensed and later extending this to include compliance with all national laws (European Commission 2002).

What are the key issues demanding attention from systems that seek to verify or monitor the legality of wood products? The following sampling of recent commitments, reports, and initiatives provides some clues:

- Illegal logging is one of the five focal areas in the G8 Action Program on Forests agreed at the Birmingham Summit in 1998. The justification given is that "illegal logging robs national and subnational governments, forest owners, and local communities of significant revenues and benefits, damages forest ecosystems, distorts timber markets and forest-resource assessments, and acts as a disincentive to sustainable forest management." The Program notes that international trade in illegally harvested timber, including fraudulent transfer pricing, under-invoicing and other illegal practices, exacerbates the problem of illegal logging (G8 1998).
- Ministers participating in the East Asia Forest Law Enforcement and Governance Conference in Bali in September 2001 jointly declared that they would "take immediate action … to address violations of forest law and forest crime, in particular illegal logging, associated illegal trade and corruption, and their negative effects on the rule of law."[24]
- In May 2002, the Brazilian Minister of Environment and Forests, Dr. Jose Carlos Carvalho, called on the International Tropical Timber Organization to do more to combat "illegal logging and illegal trade." He remarked that "honest enterprises should not be penalized by the existence of illegal operations" (ITTO 2002).
- The UK Department for International Development recently commissioned a study on how importing governments might deny market access to timber and wood products "produced and exported illegally." The study provides a list of "illegal activities associated with the timber trade" that includes illegal logging, timber smuggling, misclassification, transfer pricing, illegal processing, and corruption. "Illegal logging" is defined as taking place "when timber is harvested, transported, bought, or sold in violation of national laws." This definition is interpreted as including "corrupt means to gain access to forests." However, the report's precise ambit of concern is unclear. Perhaps due to the problems of defining illegality cited in the report, the relationship between the long list of illegal activities, the narrower definitions of illegal logging and other terms used in the report — such as "illegally sourced products," "illegal timber" and "wood products produced or exported illegally" — are not explained (Brack and others 2002).
- The American Forest and Paper Association recently issued a position statement on illegal logging. It asserts that opposition to illegal logging should be a "basic tenet of any responsible producer." It states that illegal logging "undermines the viability of legally harvested and traded forest products and is a serious detriment to forest sustainability." The statement also notes that "environmental destruction caused by illegal logging creates negative perceptions of the forest products industry in general." It defines illegal logging as "theft of logs, cutting in parks, reserves, or similar areas, and cutting where government approvals are obtained by corrupt practices" (AF&PA 2002).
- IKEA, the world's third-largest retailer by solid-wood volume, uses a "staircase" model to insure that its wood raw materials are legally obtained and that the harvesting and forest management operations meet environmental standards (box 3.2).
- ABN AMRO, one of the world's largest banks, recently announced a policy specific to forestry and tree plantations. The policy includes a prohibition on financing companies or projects "that are involved in, collude with, or purchase timber from illegal logging operations" or "that contravene any relevant binding international environmental

[24] For full text of the Ministerial Declaration from the Bali meeting, see <http://www.iisd.ca/linkages/sd/sdfle/>.

agreement to which the member country concerned is a party or that violates local, state or national environmental or social laws." Illegal logging is defined broadly to include the use of bribes to obtain logging concessions, deceptive transfer pricing, illegal transport, trade, or smuggling of timber, and processing without required licenses or not in compliance with environmental, social, and labor laws (ABN AMRO 2001).
- The recently formed Forest Integrity Network (FIN) seeks to bring together a broad coalition of stakeholders "to fight forest corruption and promote sustainable conservation and management and improved livelihood of forest-dependant populations."[25] Participating organizations include Transparency International, the World Bank, the World Conservation Union, the World Business Council on Sustainable Development, the Food and Agriculture Organization of the United Nations, environmental NGOs, and academic institutions.

Although far from comprehensive, the above sample suggests that key drivers for increased scrutiny of legality with respect to wood products are:

- Concerns over the social and environmental impacts of illegal logging
- Inability of responsible forest managers to compete with low-cost "cut-and-run" illegal logging operators and corrupt concession-allocation procedures
- Loss of revenue by governments and forest owners from wood theft and smuggling due to non-payment or underpayment of royalties, taxes, and export levies.

Core concerns over legality verification and monitoring thus appear to lie at the front end of the value chain — that is, whether the wood was harvested legally, whether harvesting rights were secured without corruption, and whether royalties or taxes related to logging and export were duly paid. At present there is apparently little clamor for increased scrutiny of compliance with laws governing secondary processing, manufacturing, and retailing of wood products.

Emerging systems for verifying or monitoring legal compliance in the forest products industry may well have greater prospects of success if a broad consensus can be achieved around the types of illegal activities that are of concern to the market and other stakeholders. As Brack and others (2002) point out, such a consensus could help avoid inequities in international trade due to more careful scrutiny in one country than another, and would help focus attention on major breaches of law while avoiding stringent and costly efforts to detect relatively minor infringements.

If systems that verify or monitor wood product legality maintain a sharp focus, they can be complemented by other mechanisms, not specific to the forest industry, that identify sound business practices or expose impropriety. Examples of such mechanisms include:

- *OECD Guidelines for Multinational Enterprise.* These contain nonbinding recommendations by governments to multinational enterprises operating in or from the 33 OECD member countries plus Argentina, Brazil, and Chile. Essentially, the guidelines comprise a broad set of principles of corporate responsibility for companies operating in multiple countries (OECD 2001).
- *"Fair Trade" organizations.* In this context, fair trade involves marketing of products in industrialized countries based on equitable partnerships with low-income producers in developing countries. Principles include fair wages, cooperative workplaces, consumer education, environmental sustainability, financial and technical support, respect for cultural identity, and public accountability.[26]
- *Independent monitoring of corporate behavior.* Organizations such as Amnesty International report on human rights abuses by corporations as well as by national governments.

[25] Aarti Gupta, "Building capacity for forest law enforcement and governance: Roles of FAO and FIN" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

[26] See <http://www.fairtradefederation.org> (Fair Trade Federation in USA and Canada) and <http://www.fairtrade.org.uk> (Fair Trade Foundation in UK).

Amnesty International (AI) has produced an "Introductory Checklist" of human rights principles for companies.[27] Transparency International (TI) reports on corruption worldwide and publishes a "Bribe Payers Index" based on surveys of the propensity of companies from different countries and sectors to make corrupt payments to foreign officials.[28]

Challenges in defining illegality

In addition to defining the breadth of concern, a system for verifying or monitoring legal compliance must grapple with another set of definitional issues to determine what constitutes an illegal act. Challenges here include:

- *Drawing the line between a significant offence and a minor transgression.* For example, how many instances of improper road construction are permitted before a concession holder strays beyond poor harvesting practices into the realm of illegal logging?
- *Ambiguous or impractical requirements.* For example, should a forest manager be penalized for adapting practices to fit the local ecosystem of a given forest, while technically breaching a poorly conceived regulation?
- *Conflicts with laws from other sectors and levels of government or at odds with administrative procedures.* For example, should a concession holder be fined by a government agency in charge of overseeing production facilities for failing to meet its annual output targets when the failure is due to increased adherence to environmental regulations on harvesting as promulgated by the forestry department?
- *Conflicts between unwritten customary law and formal laws.* For example, is it illegal for a community with usufruct rights that derive from traditional law to harvest timber in a logging concession that fails to recognize these rights?

In many jurisdictions, rationalization and clarification of such issues is clearly needed to enable effective law enforcement. However, where laws are clouded, verification systems can note the flaws in the relevant laws and clearly state the basis on which verification has been assessed, including where possible the rationale for the interpretation made (box 5.1).

Box 5.1
Forest certification and legal compliance

One example of the relationship between forest certification and legal compliance is the set of regulations defined by the Forest Stewardship Council (FSC) under its forest management certification scheme. The specifications for legal compliance by FSC certificate holders are included under FSC Principle 1, Compliance with Laws and FSC Principles. However, legality is also addressed under Principle 2, Tenure and Use Rights and Responsibilities; Principle 3, Indigenous Peoples' Rights; and Principle 4, Community Relations and Workers' Rights.

Interpreting the standard at national or regional levels. The FSC Principles and Criteria (including those dealing with legality) provide an internationally recognized standard for forest management certification. Interpretation of the international standard to fit local situations takes place through:

- The use of stakeholder processes at national or regional levels to develop specific national or regional standards
- Individual certification bodies, which may modify the generic standards to suit local conditions in situations where national or regional standards do not yet exist.

As of May 2002, FSC Contact Persons in 19 countries and FSC Working Groups in 12 countries were working to define how FSC's Principles and Criteria, including those dealing with legal compliance, should be applied at the national level.

Dealing with contradictions and complications in the law. In some cases, laws can be vague, contradictory, or may even encourage practices that are bad for forests or for local communities. Although experience has shown that such complications are in fact unusual, a credible and widely acceptable system must have mechanisms for dealing with such eventualities. FSC's Criterion 1.4 states that, for the purposes of forest certification, conflicts among laws, regulations, and the FSC Principles and Criteria shall be evaluated case by case by the certifiers and the involved or affected parties.

Failure to comply. In the case of noncompliance, the certificate holder is notified that corrective action is required within a specified period of time. This allows the certificate holder to undertake gradual improvements rather than face immediate failure. Should the parties involved fail to resolve a conflict, or fail to take corrective action within the specified time, the certificate would be suspended or withdrawn.

Source: Sofia V. Ryder. "FSC's Experience in Verification of Legal Compliance." Presentation given at the workshop on Log Tracking and Chain of Custody Systems held March 19-21, 2002 in Phnom Penh, Cambodia.

[27] See <http://www.web.amnesty.org>.

[28] See <http://www.transparency.org>.

Tools for verifying legal compliance within the forest products trade

Forest certification and certificates of legal origin
Forest certification is a process that leads to the issuance of a certificate by an independent auditor, attesting that an area of forest is managed to a defined standard. Certification standards invariably require compliance with national laws related to forest management. Thus, provided that performance against the standard has been properly assessed, forest certification also can serve to verify legal compliance on the part of the company or other entity to which the certificate is issued.

Some certification schemes include chain of custody requirements that oblige certificate holders to track all logs from certified forests and also to track the products made from those logs. In the case of the Forest Stewardship Council (FSC) certification system, a link to the market is created through a product label, which warrants that the timber or wood product originates from well-managed forests. Companies in the supply chain hold chain of custody certificates so that the label can follow the wood from the forest to the retail outlet (box 2.1). The Pan European Forest Certification Scheme requires a segregated chain of custody when the claim, "from sustainably managed forests," is used. This scheme relies on a calculation of the percentage of certified wood entering a production chain, rather than on segregation, in which the less stringent claim, "promoting sustainable forest management," is used. The latter system allows mixing certified and uncertified wood products, and thus, cannot assure the purchaser that the wood pieces in a given consignment come from a certified source. The third international certification scheme in operation, the American Sustainable Forestry Initiative, does not explicitly require chain of custody certification (Ozinger 2001, Brack and others 2002).

Forest management certification with a chain of custody requirement is thus one means of providing verification of legal compliance, but only where the wood is derived from forests that meet *all* criteria required under the certification standard, not just those pertaining to legality.

Full certification of forests to sustainable forest management standards is a slow process and many years will be required before a large fraction of the wood entering international trade bears the stamp of full certification. In the meantime, buyers of wood products need assurance that the wood has been sourced legally. Several auditing firms have responded by offering services that establish legal compliance and/or legal origin of wood products.[29] If a given product shipment meets all audit requirements, the auditing body will provide a certificate of legal origin or a certificate of legal compliance confirming that the relevant requirements have been met. These certificates do not affirm that the forest from which the products originated meets the standards required for certification as a sustainably managed forest, but they do attest to legal conformance up to the point where the certificates are issued. In most cases this requires verification that the chain of custody for the wood has been maintained as described in chapter 2.

Outsourced forest sector monitoring
Various governments have contracted external parties to verify industry compliance with the laws in a particular sector (for example, forestry) or a particular function of government (for example, customs collections). In doing so, these governments have openly acknowledged lack of capacity or conflicts of interest that inhibit their own ability to verify compliance, enforce legislation, and monitor the relevant sector. Motivations for governments to enter into such arrangements include the prospect of additional revenue collection due to stricter enforcement and greater transparency, the provision of on-the-job training to their own staff so that they can eventually take over the outsourced duties, and sometimes even delivery of a "shock treatment" to weed out entrenched corruption. The description in section 3.2 of an outsourced system for monitoring log exports in Papua New Guinea is one example. SGS PNG Limited, the firm contracted to do the monitoring, provided a comprehensive log-tracking information system along with well-trained personnel and competent supervision.[30] These measures significantly increased customs revenues for the government, which also seconded forestry officers to the external monitoring body to develop their skills.

[29] Kevin Grace, "Independent verification of the 'legal origin' of timber" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

[30] SGS PNG Limited is a subsidiary of Société Générale de Surveillance SA, Geneva. The information here and in section 3.2 is based on Bruce Telfer's presentation, note 4.

Ethical procurement policies and codes of conduct
Procurement policies and codes of conduct are "soft tools" through which companies can communicate a commitment to avoid illegally sourced products. These measures can be specific to individual companies or they may serve as a membership requirement for a trade or industry association.

An example of the latter is the Conduct Assurance Scheme of the UK Timber Trade Federation.[31] Members must sign on to an environmental code of practice by which they commit to sourcing their timber and timber products from "legal and well-managed forests." They also pledge to "unreservedly condemn illegal logging practices and commit themselves to working with suppliers and other stakeholders towards their complete elimination." The code recognizes the independent certification of forests and the associated chain of custody process as "the most useful tool in providing assurances that the timber they deal in comes from legal and well-managed forests." Members face fines or expulsion from the Association if they fail to observe the code. The real test of such a scheme is how vigorously it is applied in practice. At the very least, such codes provide a reference point against which other stakeholders can hold companies accountable (section 5.4).

Large companies may invest considerable time and resources in consultation with interest groups to develop procurement policies that are well accepted but agile to their needs. However, smaller organizations can seldom afford to do this and may prefer an "off-the-shelf" policy. For example, the Certified Forest Products Council has produced a model corporate forest resource policy template for companies that trade or use wood products (Certified Forest Products Council 2002). A company adopting the template "will require that all vendors and associated suppliers demonstrate compliance with all legal requirements for forest management, harvesting, and manufacturing." By way of explanation, the template states that it is intended to "ensure that no market advantage is realized by those vendors and associated suppliers that circumvent the law." It also is intended "to support existing forest conservation, protection, and enforcement mechanisms."

Supplier warranties
As retailers, government agencies, architects, building companies, and manufacturers adopt ethical procurement policies, they need to back these with implementation systems. A relatively straightforward step is to integrate the principles within these policies into their supplier contracts. A simple mechanism is to require the supplier to warrant that the wood in the product was sourced in compliance with relevant laws and to state its place of origin. A supplier then must either risk of providing a false warranty or introduce measures that will enable it to make the warranty with confidence. Penalties for false warranties might include payment of damages to the buyer or cancellation of future orders. The prospect of random checks and monitoring by watchdog groups will increase pressure on suppliers to undertake the due diligence needed to provide a valid warranty.

Keeping watch on the forest products trade

"Watchdog" groups clearly have an important role to play in exposing illegality, corruption and other forms of egregious conduct in the forest sector – by private or public sector actors. However, as well as exposing illegal behavior these organizations also can highlight activities by responsible operators (box 4.1). Independent monitoring can strengthen legal-compliance verification systems by highlighting jurisdictions, localities, or actors that should be treated with suspicion. They provide a service to legitimate systems for verifying legal compliance by pinpointing circumstances where a higher level of due diligence is required. They also maintain the credibility of robust systems by exposing bogus or easily manipulated verification systems.

Watchdog groups undertake a wide variety of activities, including:

- Using remote-sensing tools such as satellite imagery to detect changes in forest cover, new access roads, and other indicators that point to either legal or illegal logging activity. Once the locations are known, field checks or analysis of documents such as concession permits

[31] Ita Rugge, "UK imported wood trade practices and initiatives" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

can be used to determine whether the activities are legal.[32]

- Mobilizing local populations, who often suffer environmentally and economically from the depredations of illegal loggers. Examples include the "Cedar Brigades" sponsored by WWF in the Russian Federation.[33]
- Undertaking direct, on-the-ground investigations of illegal logging or smuggling activities. This may be either be done by individuals or groups in local communities or by outside watchdog organizations.[34] As one example, the Environmental Investigation Agency (EIA) recently released a video documenting an investigation of illegal logging and ship-based smuggling of ramin *(Gonystylus spp.),* a group of rare timber species that had been listed in the CITES Appendix III by Indonesia. As a result of the investigation, two shiploads of ramin logs were seized by the Indonesian government, and the perpetrators reportedly were charged with criminal activity.[35]

Perils of enforcing unjust or impractical forest laws

The standard response to illegal logging is to characterize it as a law enforcement issue and propose tighter government policing and enforcement measures. Yet illegality in the wood extraction business is often a symptom of deeper underlying causes. Ill-conceived crackdowns on illegal activities can sometimes do more harm than good.

First, law enforcement efforts that do not address underlying causes are unlikely to prevail over the diverse array of interest groups who either gain from illegal logging or, due to political instability and fragile tenure rights, are motivated to get what they can while they can from the forests. Attempts to enforce central government forestry laws are likely to encounter resistance from district-level politicians and officials, local entrepreneurs and community leaders who receive revenue from the informal logging sector. Actions designed to stamp out illegal logging will need to take these interests into account and provide alternative livelihood strategies.

Second, a narrow focus on illegal activities may perpetuate inequities and corrupt resource allocation processes. Forest laws often reinforce unfair relationships or disregard customary forest rights. Arguably such laws need to be reformed before their enforcement would serve the public interest.

Adapting methods when forest governance is poor

Governance is often less effective in forest areas than in developed areas due to remoteness, lack of infrastructure, and relatively low population densities. Such ineffectiveness sometimes is true even in industrialized countries (box 2.2). However, governance of remote forest districts may be critically deficient in poor countries recently wracked by wars or social unrest. While there are no easy answers, discussions during the workshop suggested that the following guidelines may be helpful.

- Expectations should not be raised that significant change can be accomplished easily or overnight; rather, it will require stepwise transitional approaches with significant support from donor agencies. Indonesia's current move toward decentralization has been accompanied by an apparent increase in illegal logging, rather than the decrease that promoters of decentralization hoped for. Yet many argue that this is a temporary situation, caused largely by poor governance in remote districts that have been neglected by the central government for decades. To overcome the problem, significant capacity building must take place to empower the civilian authorities and local populations in those rural districts.
- Procurement and investment policies by the private sector must recognize that strength-

[32] Togu Manurung, "Monitoring and assessing compliance: Using remote sensing to detect illegal activities" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

[33] Anatoly Kotlobay, "Illegal logging in the southern part of the Russian Far East: Problem analysis and proposed solutions" (Consultancy report prepared for the World Bank / WWF Alliance and presented at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002). <http://www.wwf.ru/publ/log_eng.html>.

[34] Cynthia Josayma and Suchart Thaipetch, "Combating illegal logging in the Pacific Rim countries" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

[35] Sam Lawson, Geetha M. Jayabose, and Hapsoro, "Transparency and civil society involvement to tackle timber smuggling and illegal logging in Indonesia" (Presentation at the workshop on Log Tracking and Chain of Custody Systems, Phnom Penh, Cambodia, Mar. 19–21, 2002).

ening of governance will take time. Often the private sector can significantly contribute to improved governance by awarding contracts to legitimate enterprises that are attempting to do a good job under difficult conditions. This helps keep the good actors engaged and is a more positive way forward than simply boycotting the bad actors. Such contracts, however, must encourage constant improvement, and contracts with firms that fail to take positive steps should not be renewed. IKEA's Staircase Model and "ScanCom's Direct-Audit System are examples of this type of approach by two significant purchasers of tropical wood (boxes 3.2 and 3.3).

- Promotion of independent certification in areas of poor governance, if rewarded by attractive contracts with legitimate purchasers of wood, can serve as a model for other operators and will reinforce the idea that legal operations can provide positive benefits.

6
Conclusions and Recommendations

Conclusions

Several definitive conclusions can be drawn from the information in this report:

1. Worldwide concern about *illegal logging and fraudulent activities* associated with logging operations suggests that chain of custody systems are generally poor in many developing countries and in countries undergoing the transition to market economies. This makes it possible for unscrupulous operators to commingle illegal logs with those from legal sources or to steal logs with relative impunity. As a result the whole forest sector is tainted indiscriminately so that good operators have little incentive to apply best practices.
2. To be effective, *chain of custody systems for wood* must be based on the principles of identification, segregation, and documentation:

   - *Identification.* The logs or other products (or bundles of such products) must be individually identified using some type of labeling technology, and the labels must be keyed to associated documentation.
   - *Segregation.* At each point where logs from a known source could potentially become mixed with logs from other sources, they should be segregated and handled or processed separately. As one example, logs moving from the forest to the next destination should be required to pass through defined checkpoints and adherence to this requirement by log haulers should be verified through frequent, unannounced inspections.
   - *Documentation.* Labeling by itself is insufficient to provide the information needed for a comprehensive chain of custody system. Additional documentation required for log tracking includes such data as the place of origin in the forest (for example, a cutting block, compartment, or timber sale number); reference to cutting permits or sales documents; log species; log measurements; log quality; time and date records along each point in the supply chain (for example, harvesting, departure from the forest, arrival at a transshipment point, arrival at the processing facility); reference to load manifests or other transport documents; and the identity of the custodian at each point along the supply chain.
3. The system must incorporate *regular monitoring* to ensure that the system is being applied according to its design and that employees are adequately trained and are rigorously following the established procedures.
4. When higher technology systems are used, such as labels designed to be read by scanners, *manual backup systems* must be devised so that the chain of custody information can be collected even when the technology fails.
5. Any chain of custody system is subject to *fraud and accidental mistakes* that may compromise its effectiveness. The following criteria may be helpful in judging the likelihood that a chain of custody information system will be effective:

- *Technical conception and design.* Is the system based on identification, segregation, and documentation? Is it well engineered and adapted to the local situation?
- *Governance.* In areas where governance is poor, more robust chain of custody systems are required. This means that the system must be engineered more carefully to prevent fraud, and monitoring must be more vigilant and should involve independent monitors such as third-party auditing firms or law-enforcement agencies.
- *Transparency.* Does the system enhance transparency so that access to information is open and available to interested parties? Have the standards under which the system operates been published? Is oversight by independent monitors or external entities such as law-enforcement agencies an inherent part of the system? Are the political and legal environments under which the system operates generally open and transparent? (This transparency includes information on the methods by which timber concessions are granted and data on concession boundaries.)
- *Capacity.* Training, development of essential technology, and enhancement of facilities are important parts of any successful chain of custody system. Investments made to enhance capacity will pay off through much better management of the supply chain as well as prevention of log theft and fraud.

6. *Consumer assurance.* Where chain of custody systems are in place or in the process of being implemented, information on the standards and procedures used should be openly published. Publication will serve notice to unscrupulous operators that the practices of the past no longer will be tolerated. It also should help to improve the public image of the forest sector among consumers and to motivate good operators.

Guide to application

Any effective wood chain of custody system will involve labeling technology (including methods for recording and reading data from the labels), procedures for segregating logs or products that should not be mixed with products from other sources, and documentation relating to the logs or wood products themselves.

Labeling technology

Much of the attention in chain of custody systems focuses on labeling technology. If labels are not consistently and rigorously applied, effective chain of custody management becomes virtually impossible. All labels are subject to misuse, including errors and intentional fraud, although with higher-technology forms this is much more difficult. Section 4.4 provides a comprehensive comparison of the utility of different labeling technologies for chain of custody systems. General conclusions include:

- One of the most widespread technologies, the use of *branding hammers,* is not generally suitable for comprehensive chain of custody systems. Aside from the ease with which branding hammers can be counterfeited, they provide little information and cannot easily be keyed to associated documentation for individual logs. Hammer branding is probably adequate only in situations in which forest governance is excellent and other components of the chain of custody system are sufficient to compensate for its shortcomings.
- *Conventional paint and chisel labels* can be used effectively if they provide comprehensive information keyed to associated documentation. Their chief disadvantage is the length of time required to paint or chisel the information on log ends, which in turn means that they often are applied ineffectively. Also, they are easier to counterfeit than the higher-technology labels.
- Probably the most widely applicable labeling technology, given the current state of technological development, utilizes *barcode information imprinted on either conventional labels or nail-based labels.* These labels are more difficult to counterfeit than lower-technology solutions. They are quicker to attach than painted or chiseled labels. The labels can be keyed to associated documentation and can be quickly read with scanners. They also can be read manually if necessary. They are less securely affixed than painted or chiseled labels, and experience suggests that 1 percent to 5 percent of such labels will be dislodged during transport. The chain of custody information system therefore must account for the fact that some logs or products will arrive at the destination without labels.

- Other technologies are under development that may become useful in log chain of custody systems at some point in the future as costs decline. The most promising of these are *RFID labels,* which combine radio-frequency transmitters with capabilities for recording and reading significant quantities of data. Their cost is too high at present to warrant widespread use in the forestry sector, although the cost will probably decline significantly over the next few years. RFID labels can be used at present to support investigations of possible theft or fraud and are effective when placed covertly because they can be read at a distance.
- *Microtaggant tracers and chemical tracer paints* are not complete chain of custody solutions but like RFID labels can be useful in investigations of theft or fraud. They are currently less expensive than RFID labels and can be read with simple technology but cannot be scanned remotely. They are particularly effective as systems for marking trees prior to felling to prevent or detect unauthorized harvesting of trees. They also are effective for tracking batches of logs, rather than individual logs.
- Several *mechanized coding systems* that will imprint codes in the ends of logs, either during mechanical harvesting or at a later stage by using special equipment, are under development. These codes are stamped or cut into the log like hammer brands and chisel labels, but can be individualized for each log and can include a significant amount of information. The codes can subsequently be read with special equipment or even interpreted manually. It appears that these technologies will not be widely available for several years and even then they may initially be useful only for mechanically harvested timber.
- *Chemical and genetic fingerprinting techniques* offer some promise for the future but are currently too expensive and have not been sufficiently developed for routine use in chain of custody systems. It is likely that such technologies will prove most useful in helping to establish the origins of logs suspected of having been illegally harvested.

Segregation

In tracking logs from the forest to the initial point of processing, it is important to maintain the integrity of individual loads (truckloads, barge loads, log rafts.) to ensure that the logs contained in each load are either from the same point of origin or are individually marked so that their points of origin can be identified. This is essential to prevent illegally sourced logs from being mixed with those from legal sources, whether this mixing is intentional or accidental. Procedures devised to protect this integrity include:

- For logs originating at a specific point (for example, a timber concession), the transportation route from the point of origin in the forest to the destination should be specified and approved by the authority responsible for the chain of custody system.
- Transportation contractors must be required to use only the approved route. This must be verified by unannounced checks, with violations subject to penalties and further investigation for possible criminal action.
- Where logs do not originate at a single point (for example, in the case of a log buyer picking up a few logs each from several small producers), checkpoints should be set up through which each load must pass. Failure to pass through these checkpoints and secure a clearance for onward passage would be subject to penalties and further investigation for possible criminal action.

Documentation

To the degree possible, the chain of custody system should be built around existing documents. This can include such things as forest inventory records, cutting block or compartment records, cutting permits, sales documents, log books, load manifests, weighbridge records, customs forms, and similar documents.

Load manifests for logs being transported should be verified at the checkpoints described above and at the destination, and such verifications should be audited regularly. Load manifests should identify all of the logs on the load according to their identifying tags or other marks.

Importance of computerization

Manual paper-based systems coupled with paint or chisel identification often have proven adequate when properly implemented. Where they are working satisfactorily, there is no compelling argument for changing them apart from the need to improve efficiency. However, most problems associated with wood tracking occur because the tracking system can too easily be defeated.

A major advantage of electronically based tracking systems is the ease with which cross-checks between records taken at different points can be made so that anomalies, such as counterfeit labels, can be quickly detected. Since data can be electronically time-stamped, altering of records also is easy to detect. These capabilities provide a significant deterrent to individuals who might otherwise try to cheat the system. With manual systems, by contrast, checking of records is a tedious, error-prone task that can only be done on a sampling basis. Where collusion in corruption is widespread, even the most thorough audits are unlikely to reveal anomalies in manual systems.

Apart from improved security against tampering, electronic systems also offer significant advantages for efficiency. A large number of logs moves through the supply chain in a given period of time for a typical processing facility, and electronic scanning of tracking documents significantly reduces the likelihood that errors will be introduced through faulty recording. Electronic storage and transmission of data also facilitate timeliness in reporting. Because of these advantages, log labels that can be electronically scanned, such as those that include bar codes, offer a substantial advantage over other types of labels.

As with all technological systems, it is always important to have a manual backup for times when there are electrical outages or other failures. The manual backup must be designed so that data captured manually can be entered into the electronic system as soon as the capability has been restored.

Auditing

It is worth repeating that *the only effective way of assessing the wood chain of custody is by regularly auditing an organization's chain of custody procedures and by checking the accuracy of product labels against associated documentation.* Labels and documents alone cannot substitute for good management and thorough oversight of activities.

Recommended actions

Perhaps the most important first step that can be taken to improve chain of custody information is for each government agency charged with overseeing the wood chain of custody, at least from the forest to the initial point of processing, to undertake a comprehensive assessment of the current chain of custody systems that are used within its jurisdiction. This would include an analysis of labeling technologies, segregation procedures, and documentation. A set of national standards should then be drawn up through which the chain of custody system will be governed. The standards should specify minimum requirements for labels, procedures, and documents, and should identify authorities responsible for monitoring and validating the system. In countries where illegal logging or log theft is a significant problem, special ways of dealing with the issue should be explored such as the use of high-security systems and monitoring by law-enforcement agencies or independent auditors.

It is important for the chain of custody system to be defined comprehensively at a national level (or for large countries, at the level of a large political subdivision such as a province or state) so that it is universally applied within those boundaries and thus can be monitored more easily. This would also make it easier to develop large-scale training and technology acquisition programs to streamline implementation of the system.

At the international level, a great deal of attention recently has focused on illegal logging. Although implementation of comprehensive chain of custody systems is not a complete solution to this problem, it would have the benefit of making log laundering and log theft more difficult and easier to identify while at the same time providing information useful to everyone involved in managing the wood supply chain. To assist in this effort, regional forestry bodies could use their influence to encourage the widespread adoption of chain of custody systems and to promote standardization of the technologies used in those systems.

Over the past few decades, bilateral and multilateral donor agencies have played a major role in improving forest management practices through programs designed to enhance national capacities and to improve forest governance. Such agencies could be called upon to help finance the implementation of comprehensive chain of custody systems in countries where illegal logging has been identified as a significant problem. By working together, these agencies also could help standardize the technologies, procedures, and documentation requirements of chain of custody systems to facilitate their use in international trade.

7
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Workshop presentations

Following is a listing of presentations, ordered by author, that were given during the workshop on Log Tracking and Chain of Custody Systems organized by the World Bank/WWF Forest Alliance and held in Phnom Penh, Cambodia from March 19–21, 2002. The entire workshop agenda appears in appendix A.

Baumback, Rex. Timber theft prevention and log tracking by the US Forest Service. *Contact* *address* Forest and Rangelands Staff, USDA Forest Service, 201 – 14th Street SW, Washington, D.C. 20024, USA. *Email* <rbaumback@fs.fed.us>. *Website* <www.fs.fed.us>.

Baumback, Rex. Tracer paint for marking trees by the US Forest Service. *Contact:* as above.

Boedijono. Chain of custody system in Indonesia. *Contact address* Natural Production Forest Development, Ministry of Forestry, Manggala Wanabhakti, Blok I, 11th floor, Jalan Gatot Subroto, Jakarta 10270, Indonesia. *Fax* +62 21 573 0381.

Chen Hin Keong. CITES system: A viable procedure for tracking of logs and timber products? *Contact address* TRAFFIC International, Unit 9-3A, 3rd Floor, Jalan SS23/11, Taman SEA, 47400 Petaling Jaya, Selangor, Malaysia. *Email* <hkchen@pc.jaring.my>. *Website* <www.traffic.org>.

Chheng, Kimsun. Log tracking in Cambodia. *Contact address* Forest Managing Office, Department of Forestry and Wildlife, #40 Norodom Blvd., Phnom Penh, Cambodia. *Email* <ckimsun@hotmail.com>.

Chiorescu, Sorin. Traceability issues in the EU and US forestry: What lies ahead? *Contact address* Weyerhaeuser Company, WTC 1K2, P.O. Box 9777, Federal Way, WA 98063-9777 USA. *Email* <sorin.chiorescu@weyerhaeuser.com> or <sorin.chiorescu@tratek.se>.

Grace, Kevin. Independent verification of the 'legal origin' of timber. *Contact address* Manager, Forestry Services Division, SGS (Malaysia) Sdn. Bhd., 3rd Floor, Bangunan John Hancock, Jalan Semantan, Damansara Heights, 50490 Kuala Lumpur, Malaysia. *Email* <kevin.grace@sgsgroup.com>. *Website* <www.sgsgroup.com/my>.

Gupta, Aarti. Building capacity building for forest law enforcement and governance: Roles of FAO and FIN. *Contact address* FAO and Forest Integrity Network (FIN), 1 Thomas Circle NW, Suite 1075, Washington, D.C. 20005, USA. *Email* <Aarti_gupta2000@hotmail.com>.

Johansson, Ulf. IKEA's staircase system for verifying the origin of its wood products. *Contact address* IKEA Asia Sdn. Bhd., #2 Jalan 26/35, Section 26, 40000 Shah Alam, Selangor derul Ehsan, Malaysia. *Email* <ulf.johansson2@memo.ikea.com>. *Website* <www.ikea.com>.

Josayma, Cynthia, and Suchart Thaipetch. Combating illegal logging in the Pacific Rim countries. *Contact address (Josayma):* Pacific Environment USA, 1440 Broadway, Suite 306, Oakland, CA 94612, USA. *Email* <cjosayma@pacificenvironment.org>.

Kerns, William J. Timber tracing and control system. *Contact address* President, Microtrace, Inc., 3100 – 84th Lane N.E., Suite A, Minneapolis, MN 55449-7216, USA. *Email* <microtrace.inc@worldnet.att.net>. *Website* <www.microtaggant.com>.

Kotlobay, Anatoly. Illegal logging in the southern part of the Russian Far East: Problem analysis and proposed solutions. *Contact address* WWF Russia, 19-3 Nikoloyamskaya st., 109240 Moscow, Russia. *Email* <akotlobay@wwf.ru>. *Website* <www.wwf.ru>.

Kuru, George. A draft typology for wood chain of custody methods. *Contact address* Managing Director, ForesTech Research and Development Ltd., 66 Thames Street, Christchurch, New Zealand. *Email* <gkuru@attglobal.net>. *Website* <www.forestechonline.com>.

Lawson, Sam, Geetha M. Jayabose, and Hapsoro. Transparency and civil society involvement to tackle timber smuggling and illegal logging in Indonesia. *Contact address (Lawson):* Environmental Investigation Agency, 62-63 Upper St., Islington, London N1 0NY, UK. *Email* <samlawson@eia-international.org>. *Website* <www.eia-international.org>.

Manurung, Togu. Monitoring and assessing compliance; using remote sensing to detect illegal activities. *Contact address* Forest Watch Indonesia, Jalan Sempur Kaler No. 7, Bogor 16129, Indonesia. *Email* <mtogu@indo.net.id>.

Moosvi, A. H. Log tracking and chain of custody practices in India. *Contact address* Proforest Consulting, 6-3-251/7, Punjagutta, Hyderabad, India 500 082. *Email* <proforest@hotmail.com>.

Muhs, Hans-J. New technologies for timber identification. *Contact address* Forest Genetics and Forest Tree Breeding, Federal Institute for Forest and Wood Science, Sieker Landstrasse 2, D-22927 Grosshansdorf, Germany. *Email* <muhs@holz.uni-hamburg.de>. *Website* <www.bfafh.de>.

Ovel, Chad. ScanCom's system for verifying the origins of logs. *Contact address* ScanCom

International A/S, B16 Nguyen Thai Binh Block, Hoang Van Thu Street, Tan Binh District, Ho Chi Minh City, Vietnam. *Email* <ovel@scancom.net>. *Website* <www.scancom.net>.

de la Rochefordière, Antoine. Mechanisms to verify the legality of timber products. *Contact address* Head Programme Manager, Natural Resource Monitoring Services, SGS Global Trade Solutions, P.O. Box 2152, SH-1211 Geneva 1, Switzerland. *Email* <adelarochefordiere@sgs.com>. *Website* <www.sgs.com>.

Rugge, Ita. UK imported wood trade practices and initiatives. *Contact address* Timber Trade Federation, Claireville House, 26/27 Oxendon St., London SW1Y 4EL, UK. *Email* <irugge@ttf.co.uk>. *Website* <www.ttf.co.uk>.

Ryder, Sofia V. FSC's experience in verification of legal compliance. *Contact address* Forest Stewardship Council, Avenida Hidalgo 502, 68000 Oaxaca, Mexico. *Email* <sryder@fscoax.org>. *Website* <www.fscoax.org>.

Setyarso, Agus. Developing and implementing chain of custody and log audits. *Contact address* Yayasan WWF Indonesia, Kantor Taman A9, Unit A-1, Jalan Mega Kuningan, Lot 8.9/A9, Jakarta 12950, Indonesia. *Email* <asetyarso@wwfnet.org>.

Sörvik, Bengt. The Woodpecker system for coded log stamping in mechanized harvesting systems. *Contact address* NORDPOINTER Information Systems AB, Box 857, SE 801 31 Gävle, Sweden. *Email* <bengt.sorvik@nordpointer.com>. *Website* www.nordpointer.com.

Telfer, Bruce. Capturing export revenues in the timber trade. *Contact address* SGS PNG Limited, P.O. Box 1260, Port Moresby, Papua New Guinea. *Email* <bruce_telfer@sgs.com>.

Ty Sokhun. Welcoming address from the Royal Government of Cambodia. *Contact address* Department of Forestry and Wildlife, Ministry of Agriculture, Forestry and Fisheries, #40 Norodom Blvd., Phnom Penh, Cambodia.

Uusijärvi, Richard. European Lineset Project—combining log stamping with transponders for wood product tracing. *Contact address* Trätek AB–Swedish Institute for Wood Technology Research, P.O. Box 5609, SE-114 86 Stockholm, Sweden. *Email* <richard.uusijarvi@tratek.se>. *Website* <www.tratek.se/eng/index.htm>.

Appendix A
Workshop Agenda

Agenda item	Moderator	Presenters
18 Mar 2002 – Welcoming reception (evening)		
19 Mar 2002		
Welcome and introduction	**William Magrath** (World Bank)	
Welcoming address from the Royal Government of Cambodia		**Ty Sokhun** (Department of Forestry and Wildlife)
Workshop objectives and logistics		**Rod Taylor** (WWF)
Introducing the issues		**Dennis Dykstra** (World Bank/WWF consultant)
A draft typology for wood chain of custody methods		**George Kuru** (World Bank/WWF consultant)
Plenary session: "Learning from experience"	**Dennis Dykstra**	
Log tracking and chain of custody practices in India		**A.H. Moosvi** (World Bank/WWF consultant)
Timber theft prevention and log tracking by the US Forest Service		**Rex Baumback** (US Forest Service)
Illegal logging in the southern part of the Russian Far East: Problem analysis and proposed solutions		**Anatoly Kotlobay** (WWF Russia)
Chain of custody system in Indonesia		**Boedijono** (Ministry of Forestry–Indonesia)
Plenary session: "Tracking systems in the forest"	**George Kuru**	
Timber tracing and control system		**William Kerns** (Microtrace)
The Woodpecker system for coded log stamping in mechanized harvesting systems		**Bengt Sörvik** (NORDPOINTER)
Traceability issues in the EU and US forestry: What lies ahead?		**Sorin Chiorescu** (Weyerhaeuser)
Tracer paint for marking trees by the US Forest Service		**Rex Baumback** (US Forest Service)
European Lineset Project—combining log stamping with transponders for wood product tracing		**Richard Uusijärvi** (Swedish Institute for Wood Technology Research)

Agenda Item	Moderator	Presenters
Plenary session: "Tracking systems after the mill"	**Dennis Dykstra**	
Mechanisms to verify the legality of timber products		**Antoine de la Rochefordière** (SGS)
IKEA's staircase system for verifying the origin of its wood products		**Ulf Johansson** (IKEA Asia)
ScanCom's system for verifying the origins of logs		**Chad Ovel** (ScanCom International)
New technologies for timber identification		**Hans-J. Muhs** (German Federal Institute for Forest and Wood Science)
Evening: Dinner hosted by Royal Government of Cambodia		
20 Mar 2002		
Morning: Field trip to Colexim Enterprise sawmill near Phnom Penh		
Plenary session: "Sustainability and revenue capture"	**Rex Baumback**	
FSC's experience in verification of legal compliance		**Sofia Ryder** (Forest Stewardship Council)
Developing and implementing chain of custody and log audits		**Agus Setyarso** (Lembaba Ekolabel Indonesia and WWF Indonesia)
UK imported wood trade practices and initiatives		**Ita Rugge** (Timber Trade Federation)
Capturing export revenues in the timber trade		**Bruce Telfer** (SGS Papua New Guinea)
Independent verification of the 'legal origin' of timber		**Kevin Grace** (SGS Malaysia)
Plenary session: "Forest law enforcement"	**Dennis Dykstra**	
Monitoring and assessing compliance; using remote sensing to detect illegal activities		**Togu Manurung** (Forest Watch Indonesia)
Transparency and civil society involvement to tackle timber smuggling and illegal logging in Indonesia		**Sam Lawson** and **Geetha M. Jayabose** (Environmental Investigation Agency) and Hapsoro (Telepak Indonesia)
Combating illegal logging in the Pacific Rim countries		**Cynthia Josayma** (Pacific Environment) and Suchart Thaipetch (Thailand Royal Forest Department)
21 Mar 2002		
Plenary session – Discussion of technical options	**Dennis Dykstra**	
Plenary session: "Policy-level considerations"	**Rod Taylor**	
Building capacity building for forest law enforcement and governance: Roles of FAO and FIN		**Aarti Gupta** (Food and Agriculture Organization of the UN; and Forest Integrity Network)
CITES system: A viable procedure for tracking of logs and timber products?		**Chen Hin Keong** (TRAFFIC International Malaysia)
Log tracking in Cambodia		**Chheng Kimsun** (Department of Forestry and Wildlife)
Wrap-up session	**William Magrath**	
Observations by the expert panel, followed by general discussion		**Dennis Dykstra, George Kuru,** and **Rex Baumback**
Plans for completion of the study		**Dennis Dykstra**
Closing and adjournment		**William Magrath, Rod Taylor**

Appendix B
Contact Information for Workshop Organizers and Report Authors

Björkman, Per, World Bank, 1818 H Street NW, Washington, D.C. 20433, USA. *Email* <pbjorkman@worldbank.org>.

Magrath, William B., World Bank, 1818 H Street NW, Washington, D.C. 20433, USA. *Email* <wmagrath@worldbank.org>.

Taylor, Rodney, Asia-Pacific Forest Coordinator, WWF International, Jalan Hayam Wuruk 179, Denpasar 80235, Indonesia. *Email* <rodtaylor@wallacea.wwf.or.id>.

Dykstra, Dennis P., International Forestry Consultant, Blue Ox Forestry, 9770 SW Vista Place, Portland, OR 97225-4251, USA. *Email* <dennisdykstra@blueoxforestry.com>.

Kuru, George, Managing Director, ForesTech Research and Development Ltd., 66 Thames Street, Christchurch, New Zealand. *Email* <gkuru@attglobal.net>.

Nussbaum, Ruth, Director, ProForest, 58 St Aldates, Oxford OX1 1ST, UK. *Email* <Ruth@ProForest.net>.

Story, Jane (workshop rapporteur), WWF Indochina Program, 53 Tran Phu Street, Ba Dinh District, Hanoi, Vietnam. *Email* <jane@wwfvn.org.vn>.

Appendix C
Technical Summary of Labeling Technologies

Conventional paint and chisel labels

Description

The oldest methods of log labeling involve the painting or chiseling of company information and log identification information. Paint labels are commonly used in conjunction with log identification documentation to provide more detailed information about log origin, species, dimensions, and volume.

Oil-based paints have distinct advantages over water-based paints in that they more durable, provide more distinct marking on wood, are easier to apply and less liable to run in wet conditions, and have a lower freezing point. On the other hand, oil-based paints sometimes contain more corrosive and toxic substances than water-based paints.

Strengths

- Paint and chisel marks are easy to apply.
- Application of paint labels using spray paint and stencils is particularly quick.
- Painting and chiseling cost very little and require no special training or maintenance programs.
- These labels can be very robust and survive road and water transport very well.
- Materials are usually readily available locally.
- These labels can be integrated with forest management, logistics, and stock inventory functions.

Weaknesses

- Painting or chiseling labels is time consuming, which has cost implications especially in high labor cost environments.
- Hand-painted labels use up a lot space and are only suitable for application on large logs.
- Painted and chiseled labels are prone to errors during application and when being read.
- Unscrupulous persons can easily duplicate paint labels.

Security

- These labels have no inherent overt or covert security features other than by referencing the label to supporting documentation.
- Security is applied by auditing documentation and field-checking source materials.
- The level of security is based on the quality of the documentation and audit systems and the accuracy of their implementation.
- Security of paint labels can be improved by the addition of microtaggants or chemical markers to the paint.

Practical application	• This is a low-technology solution applicable in low-tech, low-cost environments. • This method is primarily used for labeling larger logs and is not generally used with pulpwood or other small-diameter logs.
Commercial status	This is proven technology. It is applied in both industrialized and developing countries. Its correct use requires careful monitoring and cross-checking with written documentation.
Costs	• Application of labels routinely takes 1-5 minutes per log, and the majority of the cost is in the labeling activity. • Actual materials costs are negligible.
Deployment	• Materials are routinely available on site. • Implementation of this technology requires minimal training.
Suppliers	Local suppliers. Also available through forestry supply catalogs such as Forestry Suppliers <http://www.forestry-suppliers.com> and Bailey's <http://www.baileys-online.com>.

Branding hammers

Description	Branding with hammers is a traditional method of log labeling that is still widely used throughout the logging industry. Branding hammers have a raised design on the strike surface that leaves a unique identifying mark on impact. Typically, hammer brands, which usually only identify the custodian of the log, are used in conjunction with other documentation to provide detailed information about log origin, species, dimensions, and volume.
Strengths	• Marks left by hammers are easy and quick to apply. • Hammers cost very little and require no special training or maintenance programs. • Hammer marks require little space and are suitable for a range of log sizes and large-dimension sawn timber. • Branding hammers can usually be manufactured locally. • Hammer marks are robust and survive road and water transport well. • Hammer marks can be used in conjunction with coded serial numbers that are not so easy to copy. • These labels can be integrated with forest management, logistics, and stock inventory functions.
Weaknesses	• Marks left by hammers often are difficult to read. • Hammers can be easily replicated by unscrupulous persons. • Hammer marks are not easily keyed to supporting documentation. • Information on hammer marks cannot usually be used to identify individual logs.
Security	• Hammer brands have no inherent overt or covert security features other than by referencing the label to supporting documentation. • Security is applied by auditing documentation and field-checking source materials. • The level of security is based on the quality of the documentation and audit systems and the accuracy of their implementation.
Practical application	• This is a low-technology solution applicable in low-tech, low-cost environments. • Branding hammers are primarily suited for labeling logs and large-dimension sawn timber.

Commercial status	This is proven technology that has proven sufficient in areas in which forest governance is sound and the rule of law prevails. It is applied in both industrialized and developing countries.
Costs	Application of hammer marks routinely takes only a few seconds per log, and materials costs are negligible.
Deployment	• Branding hammers can usually be fabricated locally. • Implementation of this technology requires minimal training.
Suppliers	Local suppliers. In some countries, logging contracts specify the brand to be used on all logs harvested from a particular site. In this case, either the branding hammer will be supplied by the timber seller or a specification will be supplied from which the branding hammer can be fabricated.

Conventional labels

Description	Conventional labels use either treated paper or plastic tags and are attached to products with metal or hardened plastic staples, nails, adhesives, or more recently, with special materials designed to be "digested" during the pulping process. Conventional labels often are imprinted with barcode information so that they can be read by barcode scanners.
Strengths	• Attaching is usually relatively quick – slower than using hammers but quicker than paint or chisel labeling. • Conventional labels are relatively inexpensive. Most forestry applications use labels in the US$0.10–0.20 price bracket. • Conventional labels are easier to read than other marking technologies. • Well-designed and manufactured labels can be very reliable. The materials can be designed for specific purposes and within the range of operating conditions that occur for wood products. • A large amount of data can be stored and coded to include location, ownership, scaling, and other data to support a wide range of applications. • Barcode data can be quickly scanned into electronic format and captured in external monitoring and stock inventory systems. • It is possible to manufacture labels at processing plants and at many storage facilities, enabling localized data to be included in the label. • These labels can provide information useful in forest management, logistics, and stock inventory functions.
Weaknesses	• Conventional labels can be easy to duplicate or counterfeit unless suitable security mechanisms are integrated into the design of the labels. • Barcoded labels can be difficult to read in dusty, dirty, or wet conditions. • The labels can easily be removed or may fall off. Routinely 1%–5% of labels fall off. • Conventional labels cannot usually be manufactured in the forest and therefore have to be pre-printed for log tracking purposes. This limits the nature of data that can be recorded on the label and imposes constraints on the type of monitoring procedures that can be applied for log tracking. • Electronic scanners capable of reading barcode data are relatively expensive and may not work well in dusty, dirty, or wet conditions. • The amount of data that can be stored in barcode format is limited for unidimensional barcodes.

Security

Barcode labels are more difficult to counterfeit than paint, chisel, or brand-hammer labels but are not immune to such tampering. There are several ways to make conventional labels more secure:

- Labels can be printed in counterfeit-resistant materials such as watermarked paper or hologram-embedded plastics.
- Labels can be covertly tagged with microtaggants and marker chemicals.
- Barcodes can be encrypted.
- Labels can be made destructible so that they disintegrate when an attempt is made to remove them. This is an overt mechanism for identifying tampering.
- Manufacturing labels on-site allows the insertion of localized data in the label that can be used to positively identify the attached goods.

In most cases, labels can be referenced to supporting documentation. Security is then applied by auditing the documents and field checking. The level of security is based on the quality of the documentation and audit systems and the accuracy of their implementation.

Practical application

Conventional labels are suitable for tree labeling, log labeling, and labeling of processed wood products. Barcoded labeling systems are supported by a wide variety of management information systems.

Commercial status

This is proven technology. It is applied in both industrialized and developing countries.

Costs

US$0.05–1.00 per label; most forestry applications use labels costing between US$0.10–0.20 per label.

Deployment

- Implementation of this technology requires a low-level product development, capital purchase, and training program. The user will need to select the type of label materials and organize number systems, label design, and label production. Conventional labels require a significant design input to ensure that most appropriate materials and label formats are selected.
- Implementation of this technology requires minimal levels of training.

Suppliers

Many local printers are able to supply labels or can arrange for them to be produced in a variety of materials. Technology to print labels on-site also is available (although not typically at the forest worksite). Suppliers of barcode labels widely used in the forest industry include Pointil Systems, Inc. <http://www.pointil.com>, Saito Labels Ltd. <http://www.saito.co.nz>, SignuMat <http://www.latschbacher.com>, Electronic Imaging Materials, Inc. <http://www.eiminc.com/pagelumb.htm>, and Simply Computing <http://www.simplycomputing.com/Bar%20Code%20.html>.

Nail-based labels

Description

Nail-based labels are hammered onto the end of a log or processed wood product. Commonly, nail-based products are made of metal or hardened plastic. These often are imprinted with barcode information and can be read by barcode scanners.

Strengths

- Nail-based labels are robust compared to paper or plastic labels and withstand movement and transport activities well.
- Attachment is usually relatively quick – about the same as using branding hammers and quicker than applying conventional, painted, or chiseled labels.

- Nail-based labels are usually easier to read than other marking technologies.
- A large amount of data can be stored and can be coded to include location, ownership, scaling, and other data to support a wide range of applications.
- Barcoded data can be quickly scanned into electronic format and captured in external monitoring and stock inventory systems.
- Nail-based labels are more difficult (but not impossible) to duplicate or counterfeit. This is due to the specialized nature of their design and materials.
- These labels can provide information to enhance forest management, logistics, and stock inventory functions.

Weaknesses

- The base materials often are incompatible with processing and have to be removed. For example, plastic labels must be removed before pulping.
- They often are difficult to remove.
- They are generally supplied by specialist manufacturers and may not be readily available locally.
- Barcoded labels can be difficult to read in dusty, dirty, or wet conditions.
- Nail-based labels cannot usually be manufactured *in situ* and therefore have to be pre-printed. This limits the nature of data that can be recorded on the label and imposes constraints on the type of monitoring procedures that can be used for log tracking.
- Electronic scanners capable of reading barcode data are relatively expensive and may not work well in dusty, dirty, or wet conditions.
- The amount of data that can be stored in a barcode label is limited for unidimensional barcodes.

Security

Nail-based labels are difficult (but not impossible) to duplicate or counterfeit. There are several ways to make nail-based labels more secure and even tamper proof:

- Labels can be covertly tagged with microtaggants or marker chemicals.
- Barcodes can be encrypted.

It is difficult to manufacture labels on-site. Therefore, it is not usually possible to insert data onto the label that can be used to individually identify the attached product, such as a specific log. In most cases, labels can be referenced to supporting documentation. Security is then applied by auditing documentation and field checking source materials. The level of control over security is based on the quality of the documentation and audit systems and the accuracy of their implementation.

Practical application

Nail-based labels are suited for log labeling and labeling of processed wood products. Barcoded labels are supported by a wide variety of management information systems.

Commercial status

This is proven technology. It is currently applied in both industrialized and developing countries.

Costs

Plastic nail labels US$0.06 –0.12
Barcoded plastic nail labels US$0.07–0.14
Metal nail labels US$0.05–0.08

Deployment

Implementation of this technology requires minimal levels of training.

Suppliers

Major sources include Latschbacher GmbH <http://www.latschbacher.com>; Henvic Inc. (Quebec, Canada; *email* <henvic@videotron.ca>; and Woodtag <http://www.woodtag.net>.

Magnetic stripe cards

Description	Magnetic stripe (swipe) cards are made of either paper or plastic. Each card contains a black magnetic stripe on which information can be stored and read using specially made recorder/readers. Common applications include airport transit tickets and bankcards. Their use is common in a wide range of applications, and it is a ubiquitous technology in the financial and security sectors. Its dominant market position is being challenged by smart cards and 2D barcodes. There is a specific ISO standard for encoding stripe cards. Proprietary encoding is possible and most readers also can be programmed to read custom encoding.
Strengths	• Magnetic stripe cards are useful devices for attaching information to documentation rather than labeling individual products. • Magnetic stripe cards are useful devices for adding security to documentation. • The information stored on these devices is relatively secure and difficult (but not impossible) to interfere with or counterfeit. • More data can be stored on magnetic stripe cards than conventional barcode labels, but less than on 2D barcode labels or smart cards. • These devices can facilitate data processing and security audits of documents. • It is possible to manufacture labels at processing plants and at many storage facilities, allowing localization of data to be inserted onto the magnetic stripe.
Weaknesses	• Stripe card readers are not generally mobile. Therefore the technology is not suitable for general product labeling and stock inventory purposes. • Magnetic stripe cards are not generally suitable for labeling of individual logs or processed wood products. • Paper-based stripe cards are not robust. • Expensive recorder/readers are required to write and read the stripe cards. These devices are significantly more expensive than barcode scanners. • Only a small amount of data can be stored on stripe cards relative to 2D barcodes and smart cards. • Magnetic stripe cards can be unreliable in dusty, dirty, or wet conditions.
Security	Stripe cards offer inherent security in terms of how the data is encoded, stored, and read. Proprietary encoding is possible, offers greater security, and most readers also can be programmed to read custom encoding. Stripe cards can be made more secure by encrypting information on the magnetic strip. On-site manufacturing of stripe cards allow the insertion of data onto the card that can be used to positively identify the attached goods. The stripe card can include security information that specifically identifies it with the labeled product. The information on the stripe card can be encoded to provide additional security. Labels also can be referenced to supporting documentation – security is then applied by auditing documentation and field checking source materials.
Practical application	Stripe cards are useful devices for attaching information to, authorizing, and adding security to documentation. Usually stripe cards are not practical tools for labeling products and are therefore unsuitable for labeling individual logs and processed wood products.

Commercial status

Stripe cards are not widely used in wood chain of custody applications. The technology requires expensive scanning and sophisticated information management systems equipment throughout the supply chain. Smart cards and 2D bar-coding systems are likely to provide more practical solutions for wood chain of custody applications. 2D bar-coding will usually provide similar or more information storage capacity at significantly lower costs while smart cards are able to provide similar functionality but with significantly larger information storage capability.

Costs

Magnetic stripe cards typically cost between US$0.10–0.50 per card.

Deployment

Implementation of this technology requires a coordinated product development, capital purchase, and training program. Software systems must be developed for the card recorder/readers. Card readers need to be acquired in all places where the stripe cards are to be read. Information systems need to be developed to process and manage the information.

Suppliers

A large number of firms supply cards, readers, and printers, many of which are specialized for the banking or hotel industries. Major general suppliers include Eltron <http://www.eltroncards.com>, DataCard Group <http://www.datacard.com>, Fargo Electronics <http://www.fargo.com/products/Magnetic_stripe_cards.asp>, and Persona <http://www.personaprinters.com>. A useful source of information is the Association for Automatic Identification and Data Capture Technologies (http://www.aimglobal.org).

Smart cards

Description

Smart cards are credit card-sized plastic cards that can store (and sometimes process) large amounts of information in an imbedded microchip. There are several terms used to identify cards with integrated circuits embedded in them. The terms “chip card,” “integrated circuit card,” and “smart card” really all refer to the same thing. There are two types of smart cards:

- *Dumb smart card.* “Dumb” cards are those that contain memory but no processing capability. These cards are used to store information for later retrieval. An example of this might include a stored-value card that stores in its memory a shipping manifest.

- *True smart card.* The second type of card is a true “smart” card in which a microprocessor is embedded in the card along with memory. It has the ability to process or make decisions about the data stored on the card. The card is not dependent on an external processor. As there is a microprocessor on the card, various methods can be used to prevent access to the information on the card to provide data security. This has been touted as the main reason that smart cards will replace other card technologies.

Most smart cards require physical contact between the card and pins in the reader, but a growing set of applications rely on so-called “contactless” cards. Short-range cards operate through electrical inductance or capacitance when the reader and card are a millimeter or so apart; longer-range cards communicate through radio signals (see RFID labels below).

Strengths

- The biggest advantage of smart cards is the large amount of data that can be stored and the security that can be built into the card.
- Smart cards are useful for replacing paper documentation.
- The information stored on these devices is relatively secure and difficult to interfere with or counterfeit.

- Significantly large amount of data can be stored on them relative to most other types of labels.
- These devices can significantly facilitate data capture, data processing, and security audits.
- It is possible to capture data at processing plants and storage facilities, allowing data to be inserted into the card's storage registers.
- Smart cards can enhance logistics and stock inventory functions.

Weaknesses

- The biggest disadvantage with smart cards is the cost of creating a smart card system; i.e., purchasing the read/write scanning equipment, software, and cards themselves. The cards are expensive and therefore not suitable for individual log or wood product labeling.
- The scanners are not generally mobile. Therefore the technology is not suitable for general product labeling and stock inventory purposes.

Security

Smart cards provide inherent security in terms of how the data is encoded, stored, and read. Proprietary encoding is possible, offers greater security, and most readers can be programmed to read custom encoding. The need for security influences the design and handling of the card, its embedded circuitry, and its software. Microprocessors used in smart cards are specifically designed to restrict access to stored information and to prevent the card from use by unauthorized parties. A properly designed device will automatically fail to operate outside certain voltage or clock frequency ranges. In some cases, circuit links may be designed to become inoperable once a card has been programmed, so that vital data cannot be altered. Manufacturers also employ special tamper-resistant techniques that would prevent access to the microscopic circuitry.

Practical application

Smart cards are expensive and thus are not suitable for large-scale labeling of individual logs or processed wood products. However, smart cards are capable of storing large amounts of data in a secure environment. They are ideally suited for data recording and reporting functions traditionally performed using paper documentation. For example, a single smart card could store a complete log list for a large shipping manifest. The card can have internal controls that restrict access and read / write activities to authorized personnel.

Commercial status

There is no evidence that smart cards are currently being used for wood chain of custody applications. The technology requires expensive scanning and sophisticated information management equipment throughout the supply chain. Smart cards are widely used in the transportation industry where high-value products are being transported, often in conjunction with RFID technologies. It is only a matter of time before these applications are replicated in the forest industry for logistics management purposes.

Costs

Smart cards range in price from less than US$1.00–20.00. Programmers and readers are purchased separately.

Deployment

Implementation of smart cards requires a coordinated product development, capital purchase, and training program. Software systems must be developed for the card recorders and readers. Card readers need to be acquired and placed at all points where information on the cards is to be accessed. Information systems need to be developed to process and manage the information. Suppliers Major suppliers include Giesecke & Devrient <http://www.gdm.de>, Gemplus <http://www.gemplus.com>, and Schlumberger/Soliac <http://www.slb.com>.

RFID (radio frequency identification) labels

Description	RFID labels contain radio transceivers and can therefore receive and send data by radio transmission. RFID transceivers are commonly inserted into nail-based labels for log tracking purposes. RFID provides a means of obtaining information on an item without making direct contact with the label. Reading and writing distances can vary from a few millimeters to several meters depending on the technology variation used. The tags themselves come in a variety of forms, from credit card-sized plastic cards to tiny injectable transponders, to large "bricks" suitable for use on freight trains. The actual technology used to implement RFID varies depending on the manufacturer and the application, with frequencies used varying from 125 kHz to 5.8 GHz. RFID labels only transmit data when "excited" by a signal from an appropriate reader and this makes them relatively secure and tamper-proof. They often are used in conjunction with smart card technology to provide "intelligent and remote" capabilities, e.g., RFID smart cards often are used in situations where transactions must be processed quickly, as in mass-transit turnstiles.
Strengths	• Advantages of RFID systems for log tracking are that signals can be read rapidly, remotely and under difficult conditions, including under water, and that each tag can contain large amounts of data. • RFID labels can potentially store a large amount of data with a high level of security. • The labels can be difficult to counterfeit or tamper with and can provide a high level of covert security. • These devices can significantly facilitate data capture, data processing, and security audits. • It is possible to encode RFID labels at all stages of the wood supply chain from the field to the end-user. • These labels can enhance logistics and stock inventory functions.
Weaknesses	• Available frequencies vary from country to country and therefore it is difficult to standardize the RFID technologies. • The cost of RFID labels is high relative to most other labeling methods. • The cost of setting up an RFID system is high. The scanning devices are expensive to purchase and need to be programmed for specific operations. • There is usually no manual fallback when the technology is not working.
Security	• RFID labels provide the greatest array of security applications of all the labeling products discussed in this report. RFID tags offer similar security characteristics as smart cards (a parallel technology) along with the ability to read data remotely from the labels. • RFID labels provide inherent security in terms of how the data is encoded, stored, and read. Proprietary encoding is possible, offers greater security, and most readers can be programmed to read custom encoding. The need for security influences the design and handling of the card, its embedded circuitry, and its software. • RFID labels can offer a covert security function because the labels can be hidden within the product itself or covertly placed within other labels. The presence or absence of RFID labels in a shipment can be tested rapidly and in real time.

Practical application	RFID labels can be inserted as nail-based products into logs or processed wood products. They also can be created as flat inlays that can be inserted into conventional labels. The technology can feasibly be applied from the log yard through to the end-user. Experimental research is being conducted that will record the individual tree location at time of harvesting on the RFID label but this is unlikely to be applicable to operations in developing countries within the near future. The initial application of RFID technology in the forest industry is likely to be in stock control of processed wood products.
Commercial status	RFID labels are being used in stock inventory and logistics applications across a wide range of industries. Currently, its use in the forest industry is very small because of the high costs of the technology and because of the fragile nature of the RFID tags. Independent research by Weyerhaeuser suggests that this technology will become feasible in the forest industry when the price per tag drops below US$0.20.
Costs	The cost of individual RFID tags ranges from US$1.00–250.00.
Deployment	As far as is known, RFID labels are not being used in the forest industry except on a trial basis. As prices drop, it is likely that they will become much more widely used for controlling stocks of processed wood products, especially higher-value products.
Suppliers	Major manufacturers include Atmel <http://www.atmel.com/atmel/products/prod26.htm>, Gemplus <http://www.gemplus.com>, Texas Instruments <http://www.ti.com/tiris/docs/products/products.shtml>, and Philips Electronics <http://www.semiconductors.philips.com/markets/identification>. A large list of suppliers is available at <http://rapidttp.com/transponder/supplier.html>.

Microtaggant tracers

Description	Microtaggants are microscopic particles composed of distinct layers of different colored plastics. Each microtaggant is a color-coded, polymer microchip consisting of 10` layers including a magnetic layer and a fluorescent layer. This permits the taggant to function as a coded identifier. Millions of permutations are possible by combining several colors in different sequences. Codes can be read in the field with 100x pocket microscopes.
Strengths	• The microtaggant labels are completely accurate and impart a high level of security to labels and products. • They cannot be counterfeited or tampered with. • Microtaggants are relatively low cost and only simple, low-cost microscopes are required to read them. • They can be applied across the full range of the wood chain of custody. • They are compatible with many of existing labeling technologies such as paint labels, conventional labels, and nail-based labels. • The taggant is long lasting, non-biodegradable and can survive most wood processing activities.
Weaknesses	• Microtaggants are not a complete chain of custody solution and are only suitable for batch-level labeling. It is not economically feasible to label individual products with unique microtaggant codes. • Microtaggants must be manually read and cannot be electronically scanned. Tests on logs have shown that they are sometimes difficult to read and that the microtaggant chips are not always retained on logs in sufficient quantity to be found easily.

	• The unit costs are relatively low, but the initial set-up and development costs may be high. • Currently, the tracers cannot be sourced locally but must be acquired from the producer in the USA.
Security	• Microtaggant labels offer a high level of security. The taggants are basically counterfeit-proof and tamper-proof. • Microtaggants are suitable for application to other labels, thereby imparting security to those labels. • They can provide a cost-effective method for detecting counterfeiting and tampering with labels. • Microtaggants function as a deterrent that is only effective when used along with surveillance operations. It is not a comprehensive and watertight security solution in itself.
Practical application	Unique microtaggants can be developed for specific concessionaires, production periods, or processing plants. The microtaggant is suitable for use in tree marking, log marking, processed wood labeling, and in any application where conventional labels are in use. Microtaggant can be applied in a variety of ways: • Added to paint which is then applied to trees, logs, or processed wood products with either spray or paintball guns. • Directly applied using specially designed marker pens or paintbrushes. • Applied to conventional labels either as a thin overlay film or directly into the printing ink.
Commercial status	Commonly used in industries with high-value products that are otherwise subject to counterfeiting or tampering. Also used by law-enforcement agencies to trace stolen goods.
Costs	Paint price = US$127 per 8-ounce bottle (approximately 225 ml) suitable for application on 2000 items (US$0.065/item) Application of microtaggant film to conventional labels = US$0.09–0.12 per label In practice, the addition of microtaggants to standard paint would result in negligible increases in overall paint price. The addition of microtaggants to conventional labels would increase label costs by approximately 10%–80%.
Deployment	Microtaggants are currently being tested for application in the forest industry but have not yet been deployed operationally. In other industries they have been used effectively to trace stolen goods and to prevent counterfeiting.
Suppliers	The chip was developed by the 3M Company, but is now manufactured by Microtrace, Inc. <http://www.microtaggant.com>, which acquired the production rights in 1984.

Chemical tracer paint

Description	The USDA Forest Service has used chemical tracer paint since 1988. These paints contain two chemical tracers. One can be detected in the field and the other can be identified only with laboratory equipment. The field tracer is detected by placing a drop of chemical from a supplied test kit on the suspected paint. The laboratory tracer can be only identified using sophisticated chemical analysis but provides a high level of identification and increased level of proof.

In practice, the boles and stumps of trees to be harvested (or those to be retained) are painted with brightly colored paint containing the tracer. Painted trees are easily identified and can be tested at any time using the field test kit. The tracer paint is proprietary to the US Forest Service and can only be used by that agency. The tracer elements are unique to the Forest Service and their chemical elements are kept secret.

Strengths

- Tracer paint is accurate and imparts a high level of security to the painted product.
- Tracer paint cannot be easily counterfeited.
- Relatively low cost solution that is simple to apply.
- Can be applied across the full range of the wood chain of custody.
- Oil-based tracer paints are long-lasting, non-biodegradable and can survive most wood-processing activities.

Weaknesses

- Tracer paint is not a complete chain of custody solution and only suitable at a batch level labeling. It is not economically feasible to uniquely label individual products with a unique tracer formula.
- The technology is currently only available to the US Forest Service, although similar technology could be developed independently. The cost effectiveness of independently developing a parallel technology is unknown.
- Recent investigations have found water-based tracer paints to be susceptible to degradation from naturally occurring chemicals, reducing their effectiveness as marking and tracking tools.
- Solvents used with oil-based tracer paints may induce allergies in some people.
- Requires proper accountability and secure storage facilities to prevent theft (and misuse) of the paint.
- Laboratory identification of the tracer is a time-consuming and expensive operation which can usually be justified only when proof is needed that will hold up in a court of law.

Security

- Tracer paint offers a high level of security. Current tracer paint technology is basically counterfeit-proof and tamper-proof.
- Tracer paint is a deterrent that is only effective when used along with surveillance operations. It is not a comprehensive and watertight security solution in itself.

Practical application

The USDA Forest Service has used chemical tracer paint since 1988. Its use reportedly has resulted in a substantial reduction of timber theft. Unfortunately, the technology is available only to the Forest Service.

Commercial status

This technology is proven as a deterrent for timber theft. The deterrent requires adequate policing at harvest sites.

Costs

Approximately US$5.00 per liter of paint. Usage rates vary, but a liter can typically be used to mark several dozen trees.

Deployment

The specially formulated tracer paints used by the USDA Forest Service are not available for use by other agencies or firms. However, paint companies could be contracted by other entities to produce tracer paint using different formulations. General-purpose tracer paints, such as ultraviolet paint, also can be used in a similar way but do not provide the same level of confidence about log identities.

Suppliers

Aervoe-Pacific Company, Inc. <http://www.aervoe.com> provides tracer paint but only to US Government agencies.

Chemical and genetic fingerprinting

Description	This technology allows the verification of product identity by examining its chemical and genetic composition. Chemical fingerprinting methods include: • Near infrared analysis • Pyrolysis • Analysis of trace elements • Gas chromatography. Genetic fingerprinting methods include the analysis of DNA markers from the following genomes of an individual tree: • Nuclear genome • Plastid genome • Mitochondrial genome.
Strengths	• These technologies can provide identification of product source to the individual tree level. • These technologies provide additional useful information in relation to wood properties and the effects of site on wood properties.
Weaknesses	• Application of this technology requires a comprehensive database of the genetic and chemical characteristics of the target tree population. These databases do not exist for most commercial tree species. • Laboratory testing is time-consuming and expensive. • Fingerprinting is not a chain of custody solution but rather a verification solution.
Security	Chemical and genetic fingerprinting are suitable for detailed identification of products. Their use is as a deterrent only. The technology would be seen as a secondary tool for security purposes.
Practical application	At an operational level, the technologies are suitable for matching specific items by comparing their genetic and chemical composition. The tests also could be suitable for determining timber source, but a comprehensive database of population characteristics is required to undertake this type of analysis.
Commercial status	Not used for wood chain of custody applications.
Costs	Not available.
Deployment	Under testing by various universities and research institutes. Genetic fingerprinting may become operationally available for some tree species within 3-10 years. For information on a recent scoping meeting to explore the state of the art in these methods, see <http://www.bfafh.de/aktuell/g8_abstr.htm>.
Suppliers	Not yet applicable for chain of custody purposes.