United States
Department of
Agriculture

Forest Service

FOREST PRODUCTS ACCOUNTABILITY IMPROVEMENT

As Recommended By: THE FOREST PRODUCTS IDENTIFICATION AND TRACKING (FPIT) GROUP

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I. EXECUTIVE SUMMARY

What's the situation?

The Forest Service, as a conscientious land steward, desires to assure that appropriate measures are employed for proper accountability of forest products. Products range from intrinsic resources, such as wildlife and superior trees, to commodities sold, such as saw logs. Incidents of incorrect payment for forest products or their unauthorized removal have occurred on a number of forests.

The intention is to also meet responsibilities in monitoring log export and the administration of the small business set-aside program.

What's the direction?

Significant advances in technology and hardware have evolved in recent years that will allow corresponding improvements in forest product accountability.

The Director WO-Timber Management established the Forest Products Identification and Tracking (FPIT) Group to identify those new technologies with potential as management tools in improving accountability and reducing losses.

What were the results?

The FPIT Group studied and analyzed the potential development and application of numerous technologies. Selecting from forty plus concepts, the Group identified a system which it believes will:

- Exhibit field practicality
- Be reliable
- Be cost effective
- Provide the most benefit to the Forest Service in a reasonable time.

What's next?

The FPIT Group recommends a system employing the use of:

TRANSPONDERS (short range)
UNIQUE REFLECTOR IDENTIFIERS
LOG TAGS (with bar codes)

These tools are recommended to be field tested and developed for Forest Service use. The system envisioned consists of transponders and unique reflector identifiers installed in boundaries and selected trees of interest for sale definition. These two tools would be augmented by tags on each log for accountability.

What commitment will be required?

The Group's recommendation is to begin with limited testing to validate the practicality and effectiveness of the system in the field prior to any commitment into full development and tech transfer efforts. The cost for this system effectiveness test is estimated at $220K.

The test would consist of a small number of passive transponders of various configurations installed in a sample of trees and logs. The readability of these devices will be evaluated under field conditions.

The Forest Service would monitor the development of the unique reflector identifiers in other industries and participate in any appropriate cooperative effort. This tool will have its effectiveness measured under field conditions using a modified version of our current laser reader.

The objectives of the log tag field test will include finding durable tag materials and attachment methods with acceptable physical characteristics for forest product processing.

What's the projected timetable?

The FPIT Group believes that these three tools utilized together can provide a system that will improve accountability and help reduce losses of forest products from National Forests. With a combination of existing technologies, modifying existing equipment, and minor development, the recommended validation testing can be accomplished in one to two years. Development of improved tools and broader scale use would be considered for field implementation over the next three to five years.

II. INTRODUCTION AND BACKGROUND

The need to positively identify ownership or the origin of National Forest products has dramatically increased in recent years. Factors including reduced timber supply, increased export demand, greater product values, and increased distances over which logs are transported necessitate accountability improvement. Current methods of identifying specific trees, such as sale boundary, corner, wildlife, and seed trees, and properly accounting for logs from the sale area to the scaling location or port, have remained virtually unchanged for decades. The present system of identification and tracking is primarily based on the use of paint and hammer brands and has been unsatisfactory in many situations. Both paint and hammer brands are difficult to control. These markings can also be illegible when applied to frozen, muddy, or mechanically harvested logs. As the average stem size decreases, the number of logs being harvested mechanically is increasing each year.

Where current methods of identifying forest products are perceived as unreliable, confidence in the accountability system by both the Forest Service and the timber industry has declined. When violations do occur, enforcement and prosecution of violators becomes difficult if there is a lack of positive defensible identification and tracking throughout the process.

The unauthorized cutting of trees and incidents of logs not being properly accounted for has the potential to become a serious problem. The policy of the Forest Service is to take all reasonable precautions and actions to minimize losses of forest products.

This paper is a result of the effort of the Director WO-Timber Management to aggressively develop new methods and technology while improving existing procedures. The goal is to improve the accountability system and thereby minimize the loss of forest products from National Forest lands.

III. ESTABLISHMENT OF INTER-REGIONAL GROUP

On February 8, 1990, the Director WO-Timber Management asked Regional Foresters to recommend an Inter-Regional Group (see Appendix A). The Group's purpose was to investigate potentially useful technologies to help improve log accountability and reduce the potential for theft. Once key technologies were identified, the Forest Service Technology and Development Program (T&D) would carry through with the necessary development and technology transfer.

After receiving Regional Forester input, the FPIT Group was established:

Bob Simonson (Chairperson)	T&D	San Dimas
Dan Castillo	TM	R-1
Ray Walker (also T&D Paint Committee member)	TM	R-2
Monte Dye	TM	R-3
Jimmy Ragland	TM	R-4
Bill Hay	TM	R-5
Jerry Hofer	TM	R-6
Ben Cobb	TM	R-8
Jonathon Marsh	LE	R-9
Larry Knecht	TM	R-10
Ron Briggs	TM	Ft. Collins

IV. SUMMARY OF FPIT GROUP MEETINGS

The FPIT Group conducted three formal meetings. A considerable amount of investigation and staff work by T&D engineers was accomplished in preparation for each of the meetings.

March 1990: At the first meeting a mission statement was developed and problems associated with the current accountability system were identified.

The Mission Statement:

"TO IMPROVE AND DEVELOP TECHNOLOGY FOR FOREST PRODUCT IDENTIFICATION AND TRACKING, TO MAINTAIN INTEGRITY OF RESOURCES, AND RECEIVE PROPER VALUE FOR NATIONAL FOREST PRODUCTS."

During the process of reviewing the present forest product identification and tracking methods, the Group recognized two sides of the problem. The first issue involves employee attitudes and management emphasis. The second is the use of technology that could provide improvements in the designation, measurement, and tracking of forest products. A letter was drafted and sent to the Director WO-Timber Management clarifying the Group's intent to address only technology-related issues (see Appendix B).

Primary problem areas analyzed included: (1) Unit boundaries and designation of timber (2) Log identification, scaling, and cruising (3) Load and bundle identification (4) Sampling and the proper accounting of miscellaneous forest products (Christmas trees, firewood, ferns, mushrooms, etc.).

A thorough discussion of specific problems within each of these areas was held. A brainstorming session of potential solutions followed.

July 1990: For the second meeting T&D had performed preliminary investigations on the improvements proposed at the first meeting as well as a number of other ideas which had surfaced. Results of these investigations were reported. The FPIT Group reviewed the information and decided which of the concepts appeared to have significant merit. It was agreed that more in-depth information would be gathered on the most promising concepts. Those items with less potential to meet the evaluation criteria were eliminated from further appraisal and are described in Appendix D.

August 1991: At the third meeting, studies which had been prepared by professionals in appropriate fields, including T&D, research, universities, and contractors, were presented. T&D recommended against future effort on several concepts, as work to date indicated they were not technically feasible and/or cost effective at this time. A number of ideas for improving forest product accountability remained and were evaluated by the Group using the procedures described in Section V. During this meeting these remaining proposals were seriously reviewed prior to making final selections. Those items eliminated from the Group's final endorsements are described in Appendix C.

V. EVALUATION PROCESS

The Group established selection criteria and a weighting method to allow them to set priorities and focus on those options that would provide the most overall improvement to Forest Service accountability. The Group identified seven criteria against which any new tool or system should be evaluated. Each Group member individually weighed the importance of these criteria to their respective Region. This collective review fixed the order of criteria and their relative weighted factors as follows:

Value protected ----------(32%)
Application costs----------(14%)
Reliable/foolproof----------(14%)
Information provided ----------(13%)
Field practicality ----------(11%)
Scope of the entire range of
FPIT problems addressed ----------(10%)
Regional coverage ----------(6%)

The evaluation criteria and weighting method were then used to guide discussions and evaluations of the merits of the proposals. This resulted in the following ranking:

Ranking	Tools	Ranking Points*
1	Transponders (short range)	79
2	Unique Reflector Identifiers	73
3	Log Tags (bar coded)	72
4	Dye	64
5	Array Tags	61
6	Veneer Tags	55
7	UV Paint	49
8	Mechanized Branding	46
9	Satellite Tracking	43
10	Traffic Monitor	42
11	DNA	40
12	Vapor Element Tracer	30

***Ranking Points are based on a combination of evaluating and weighting the criteria.**

Practicality, cost effectiveness, and other factors were considered to identify the most promising proposals to be implemented. This review led to the recommendation of a system utilizing three tools for further development and testing. The proposals and FPIT Group recommendations follow in section VI.

VI. RECOMMENDED SYSTEM

Transponders (short range)

Description: A transponder is a small electrical device (0.5 by 2.5 inches) which responds to a specific signal when queried. An encoding unit (in conjunction with DG or PC terminal) programs a code into a set of transponders. This code can be unique to each transponder or generic to a group of them used in a sale (i.e., contract #). The transponders could then be inserted into a tree using a battery powered hand held drill with a bit modified specifically for this task. Once in place, the installer may append the data file in the field with additional information. By using a hand held reader, any forest officer could subsequently query the transponder for its identifier and any associated information. Similar efforts are being pursued in industry for telephone pole and railroad tie identification.

The transponder would be used to facilitate location and positive verification of key boundary points, key wildlife and leave trees, plot center, etc. It can also be used by law enforcement personnel for theft detection and positive identification.

Transponder Advantages

- Installed transponders are virtually undetectable
- Ability to selectively query an individual or class of trees
- Life expectancy > 8 years (plus storage)
- Large numbers of transponder codes and query codes
- Transponder codes are reprogrammable
- Effective integration with GPS/tree laser measurement tools
- Based on existing and proven technology
- Application cost can be commensurate with resource value
- Durable construction
- Operationally reliable
- Integrity and security of information
- No adverse effects on cutting or milling of trees
- No negative aesthetic or visual impacts
- Compatible with existing Forest Service hardware and software

Transponder Disadvantages

- Cost discourages mass application
- Limited query distance
- Requires hand held interrogator to locate/read
- Operational training required

Other Potential Applications: Other potential applications could include determination of backcountry recreation use; tracking the movement and location of fire equipment and other vehicles; and to facilitate location and positive verification of mining claims, archaeological sites, land surveys, and engineering projects.

Estimated Costs:

fixed costs - $2000 - $2500 for interrogator, encoding unit, drill/bit, etc.
$800 each additional interrogator

unit costs - $3 - $8 per transponder in 100,000-unit lots (future decrease expected)

Unique Reflector Identifiers

Description: The use of hand held laser devices for taking field measurements is evolving as the state of the art. A prototype model has been developed and a number of units are being used in current field work. Feedback on the prototype units is positive. Measurements are made faster and recorded with more accuracy than with other available tools. The speed and accuracy is increased further with the use of reflectors.

The utilization of laser technology is the future for an increasing amount of field work. The Group recommends that the Forest Service take advantage of technologies which will expand the abilities of these laser devices, so they may provide an efficient and verifiable method of determining unit boundary and leave-tree location. Therefore, this recommendation is to incorporate improvements, such as the use of onboard memory cards into the laser devices, and imbed a unique identifier into the reflectors.

With these two improvements, the devices would register and record not only the measured information but provide a linked identifier as well. Tying accurately measured and recorded information to a specific marker in the field will greatly improve the ease of detecting accountability problems. The development cost of this reflector identifier technology may prohibit the Forest Service from pursuing this identification system on its own. The Group's recommendation is to cooperate in proposed military and/or European transportation industry efforts, where practical, while pursuing appropriate modification to our laser equipment.

Unique Reflector Identifiers Advantages

- Has the ability to tie in a database on wildlife trees, "corner" trees, etc., if desired
- Efficient investigative tool
- Can be used for load identification
- Easier to reconstruct any missing points (minutes vs. hours to retraverse)
- Easier to detect movement of entire boundary
- Provides more conclusive evidence of any movement
- Has onboard memory capability
- Allows individuals unfamiliar with sale to find boundaries
- Easier to locate rafts from the air
- Increases the ability to locate tree or boundary over extended periods of time

Disadvantages

- Development of reflector identifiers dictated by military applications and research

Other Potential Applications: This tool can be used to identify bearing trees, section corners, boundaries and controls of archaeological sites, and even clearing limits on road construction. This technology could also provide quick aerial observation of the location of wells and water sources during fire operations and can help track field personnel and equipment (i.e., smokejumpers, hot shot crews, engines, trail crews or survey crews, etc.).

Estimated Costs:

fixed costs - $500 for laser device modification

unit costs - 75¢ per reflector in 10,000-unit lots

Log Tags (bar coded)

Description: This recommendation is to attach a durable 2- by 3-inch tag to logs. These tags have a minimum five-year life and would identify pertinent information such as the name of the timber sale. The top and bottom of each tag would have a 1/8-inch strip with a color unique to each Region. The top 1 inch will have a numeric code readable with the naked eye from 4 to 5 feet. The bottom 1 inch would have a bar code. Attempts will be made to systematize with bar code identification programs which Weyerhaeuser, Plum Creek, and many end users are instituting. The numerical information, similar to a DG address, would allow a viewer to easily discern the Region, Forest, and District. This would be followed by a numeric combination for sale identification. This regimen could be a potential replacement for log painting and branding applications. Initially, tags available on the market would be combined with the current painting requirements.

Near-future efforts would include developing and field testing appropriate tags, tools, and fasteners. Dependent on cost, a tag could be developed with an integral pouch on the reverse side of the tag that would break upon application impact, releasing yellow paint. This paint would identify the log as a National Forest log even if the tag is lost. In areas where they are cost effective, this would reduce the identification of logs from a two-step operation (paint and brand) to a one-step process, thereby increasing landing safety.

An alternative approach would be to perfect a tag which has a liquid adhesive rather than paint in the back pouch. If a suitable adhesive can be developed, this will increase the difficulty of removing the sale-identifying tag short of cutting off the log end. This would allow the tag to replace branding and, potentially, painting as well.

It is possible to attach the tags with off-the-shelf tools and fasteners that exist today. For safety, development of an application tool which would only require a one-hand operation is recommended. If development of tags incorporating paint or adhesive prove impractical, tools would be developed to apply paint, as well as tags, in one step. Automatic feeding tools would be considered to make tagging more efficient. To resist removal from splintered log ends, especially in areas of mechanical harvesting, fasteners would also be tested.

In those areas where automated information collection is desired, the tags would interface with bar code reading guns already on the market. These guns offer more than adequate data storage including record time and date of readings. Although modification of the software would be required, the Forest Service routinely reads bar-coded information into the DG for other applications.

It is also proposed to implement the use of bar-coded load receipt books. To date, limited field use has demonstrated significantly reduced human error and decreased tampering with truck scale cards. This process automates sample load selection and all trucks are required to go through the scale shack.

Log Tags (bar coded) Advantages

- More consistent readability than with brands
- Can be tied into automatic scaling system
- Tag is at least more visible than paint, especially in low light situations (i.e., dusk)
- Can help automate portions of the accountability system (i.e., road checks)
- Requires little training and average skill levels
- Higher rate of application success to frozen or dirty logs
- More information is attached to log when needed
- Controls manufacture and assignment of brands if desired
- Parallels and/or is compatible with private mill inventory systems
- Could reduce application effort from two "whacks" to one
- Will adhere to sheared, mechanically-cut logs
- Will adhere to southern pine logs, if needed (brands don't work well due to heavy bleeding)

Load Receipts Advantages

- Provides automated printout giving time and date of deliveries
- Eliminates preparing and maintaining the "sample envelope" system (this includes costs of purchasing envelopes and pull tab cards, clerical time preparing envelopes, and administering the sample envelope board and pull-tab cards)

Log Tags (bar coded) Disadvantages

- A bar-code tag is easier to remove than a well-applied brand if an adhesive is not developed. However, retaining the paint requirement still requires sawing off the log end to eliminate identification.

Other Potential Applications: These tags can also be used for marking trees left in the woods. This would allow the tracking of individual trees into inventory. It would also be possible to tie into previously measured tree characteristics and would provide the ability to change the definition of trees (i.e., sale remarking). Other timber uses could include the identification of permanent growth plots, seed orchards, superior trees, etc.

Estimated Costs:

fixed costs - $150 for standard application tool ($300 pneumatic)
$700 - $1000 tool with automatic feed and paint application

unit costs - 5 cents per standard log tag
60 cents per log tag incorporating paint or adhesive

VII. SUMMARY

The FPIT Group believes that these three tools utilized together can provide a system that will improve accountability and help reduce losses of forest products from National Forests. With a combination of existing technologies, modifying existing equipment, and minor development, the recommended validation testing can be accomplished in one to two years. Development of improved tools and broader scale use would be considered for field implementation over the next three to five years.

APPENDIX A

February 8, 1990, Letter Of Direction

United States Department of Agriculture | Forest Service | WO

Reply to: 2430 | Date: February 8, 1990

Subject: Timber Sale Technology, Log Accountability

To: Regional Foresters

REPLY DUE MARCH 1

We would like to set up a small group to investigate potentially useful technology for helping to improve log accountability and reduce the potential for theft. The intention is to help us meet our responsibility for prevention of theft, monitoring of log export, and administration of the small business set-aside program.

The Technology Centers at San Dimas and Missoula will carry through with development of technology identified by the group. Several names have been suggested as potential members of this group and they include the following:

Ray Walker	R-2
Monte Dye	R-3
Bill Hay	R-5
Chuck Graham	R-6
Don Phillips	R-8
Ken Shalda	R-9
John Marsh	R-9
Larry Knecht	R-10
Bob Simonson	San Dimas (Chair) WO7A

We would like your recommendations concerning the participation of these or other potential members. We are interested in having both timber and law enforcement folks represented. The group would probably meet once or twice a year in 1990 and 1991.

An informal response to Doug MacCleery, Bob Simonson, or Milo Larson will be sufficient to get things started.

/s/ Richard O. Fitzgerald (for)
DAVID L. HESSEL
Director of Timber Management

APPENDIX B

May 15, 1990, Letter Of Clarification

United States Department of Agriculture | Forest Service | SDTDC

Reply to: 2430 Date: May 15, 1990

Subject: Timber Sale Technology, Log Accountability

To: David L. Hessel, Director TM - WO

The Forest Products Identification and Tracking Committee (formerly the Log Accountability Committee) which you appointed, developed a mission statement to fulfill its responsibilities:

> To improve and develop technology for forest product identification and tracking, toward maintaining integrity of resources and receiving proper value for National Forest products.

During the process of identifying problems associated with forest product identification and tracking, the committee recognized two general problem areas.

I. The first area consists of problems relating to the designation, measurement, and tracking of forest products. We believe improvement in existing tools and/or development of new technology and the dissemination of information can lead to tools that will assist in improving product accountability. Our focus will be to develop solutions which will reduce the potential for accountability problems occurring, and increase our ability to track or monitor.

   Methods of forest product accountability within the Forest Service have remained fairly constant for many years. Changes in the field such as the move towards tree measurement sales, a reduction in timber sale administrators, an increasing product value on the export market and a reduction of sell levels dictate that an update of our "inventory control" system is needed. Specific problem areas identified by the committee are: designation of trees and unit boundaries, identification of logs and where they originated from, scaling (including sampling) and cruising, and load/bundle identification. Other industries have adopted newer technologies which are already apparent in our daily lives: bar codes, electronic tracers, computerized inventory, satellite transmitters, etc. The committee will look into the feasibility of applying new technology to the area of accountability.

II. The second general area involves problems that cannot be solved through technology development. The committee believes that a large percentage of the problems requiring solutions to improve forest product accountability relate to management emphasis, the attitude of field employees, and appropriate use of the tools already available to carry out existing direction and standards. Several committee members noted cases where they felt field personnel were not being provided sufficient time or training to do a satisfactory job or are just not meeting current National or Regional standards. This was identified for the project planning and implementation phases, as well as the administration and monitoring phases of timber sale activities. The committee was also aware of instances where either actual or potential accountability problems were reported, and it appeared that subsequent corrective action was not undertaken.

To summarize, the committee is not attempting to question the priority decisions of line officers in this letter. We are attempting to outline the general problems associated with improving accountability as we see them, and clarify the committee's responsibilities. Unless directed otherwise our intent is to address only technology related issues.

The committee, however, strongly believes there is also a need to address the problems relating to the proper use of existing tools for work accomplishment to current standards, as well as the need to examine attitudes of field personnel and management priority. To do so may offer another opportunity for significant improvement in forest product accountability. The committee recommends these issues be looked at by a separate group; as attempts toward their solution would require a wider range of disciplines than currently represented in our membership. We would gladly interact with such a group.

/s/ Bob Simonson

BOB SIMONSON
Chairperson, FPIT Committee

APPENDIX C

In-Depth Studies Conducted By Professionals In Appropriate Fields And Included In The Final Evaluation Process

IN-DEPTH STUDIES CONDUCTED

Following are short descriptions of some of the proposals which were seriously considered and included in the final evaluation process, but are not part of the final recommendation.

Array Tags: This is a concept similar to bar coding. However, a unique array pattern is used as the identifier. A video camera at the landing, or along a roadway, can record tags applied to a load of logs. The system can record position and orientation automatically, allowing monitoring of load tampering.

DNA Fingerprinting: This proposal suggested adapting DNA technology, already well proven in the area of human beings, to trees, logs, etc. The system would be a strong deterrent, as it could verify that a log came from a given stand, if development technology proved successful. This method of tracking could not be circumvented by cutting off a brand or imitating paint, etc., since the DNA runs throughout the fiber of the entire tree.

Dye: This proposal would examine the possibility of using a dye as opposed to paint in numerous marking applications. It was felt that if the dye was absorbed into the wood fiber to a sufficient depth, sawing off the log end to remove identification would be uneconomical.

Mechanized Branding: Four areas of development were suggested here: (1) Develop a branding device to be fitted onto mechanized harvesting equipment, (2) Improve on past work performed in the development of a ballistic brander, (3) Develop a pneumatic brander, and (4) Test off-the-shelf products which combine hammer brands with an automatic paint applicator.

Satellite Tracking: This proposal would attach transmitters, such as those used for wildlife tracking, on log rafts, trucks, or logs. The transmitters would be used to track movement via satellite, which could show if rafts arrived at unapproved areas where load changes might occur. This tracking system could also monitor truck-hauling routes divulging if the trucks stopped at locations other than approved sale areas or mills.

Traffic Monitoring: This option would develop a system utilizing short range transmitters installed on log trucks. Any vehicle passing a detector in the roadway would trigger a video camera. Cameras are available with recognition capability so that traffic such as recreational vehicles would not be recorded. Any photograph recognized as a logging vehicle, without a proper transmitter code, would be transmitted to a location such as the district office. Photographs of a legitimate vehicle and its load would be transmitted to the scaling station for video comparison of the load upon arrival.

Ultra Violet Paint: Several UV paints would be tested, with the anticipation of using them to mark wildlife trees, boundary trees, etc. The paint would not be visible to the eye, but if detected on a truck, might be useful in determining log ownership.

Vapor Element Tracer: This alternative uses an application of a fertilizer on an entire sale or drainage. Thousands of combinations of the nitrogen make-up are possible, allowing identification of a specific sale once the material is taken up into the tree. An electronic vapor-detection system, similar to that being developed to detect tree species in mills, would facilitate detection of Forest Service timber.

Veneer Tags: This is a method being used by shippers of veneer to Europe. Using a specialized hammer, 2- by 2-inch plastic/vinyl stamps are hammered into the log end. This would have similar applications as hammer branding.

APPENDIX D

Additional Alternatives Considered

ADDITIONAL ALTERNATIVES CONSIDERED

Acoustic volume measurement: A hand held unit would be developed which uses acoustical waves to determine the volume of a log in the scale yard. An algorithm would be developed to allow the unit to also determine defect.

Auto cruiser: This proposal would develop an automatic laser-based unit which, when placed in the woods on a stake, would scan the forest in a 360-degree rotation. The unit would scan the timber within a defined radius measuring tree diameter, height, and distance.

Bar-coded trucks: Each truck would be required to have a bar code on the door. As the truck is leaving the sale area, the bar code and time would be read. The bar code, time, and weight would be recorded upon arrival at the mill.

Brand recognition: This software would be developed with the logic to design new brands assuring unique visual difference from other existing brands in use in the area. The software would decide if the proposed brand on the sale is different enough from the other brands in potential use in the area to allow easy human recognition.

Brand specification: This proposal would review hammer brands and test them on frozen logs, sheared logs, etc. A specification for hammer brands would be developed which would be required for use on Forest Service sales.

Brand tracking: This concept would develop software which would store, in its memory, all brands registered in a defined zone. When a sale is let and a purchaser submits his brand for approval, the district could use the software to verify the likelihood of visually similar brand patterns being used in the area.

Eagle eye: This proposal would use reflector identifiers, staked on the perimeter of a sale for boundary location with overflights. An overflight before and after the sale might provide a quick indication of boundary movement or trespass.

Economic branding: This proposal would develop software which would be used to determine when log branding and marking is worthwhile based on timber value and other economic factors.

Electric tattoo: A preliminary review was conducted of methodology used in other industries to identify ownership using an electrical array of pins injected into surfaces.

Freeze brands: This proposal would study the possibility of using liquid nitrogen or some other method to brand, using cold instead of heat to avoid fire hazards.

Heat brand: This proposal looked at using heat; electric resistance, gas heated, or laser branding to burn a brand into the log end.

Microtaggants: This proposal would mix microtaggants into paint, instead of or in addition to the current tracers. Microtaggants are extremely small tags which, when viewed under a magnifying glass, could be used as identifiers. The successful use of these would significantly reduce the effort required to account for paint, as they could be added at the district level. Different combinations could be used for any given sale.

Onboard recorder: This proposal would outfit each truck operating on a sale with a data logger tied into the onboard scales. The data logger would continuously monitor the weight of the truck, and could be downloaded anytime by a contract inspector. This would easily show removal of logs en route, which could be cross-checked with required notification.

Phantom scale: This plan would embed a receiver in the road. Each truck operating on a sale would be outfitted with a transmitter connected to the electronic scales onboard the truck. As each truck enters or leaves the sale area, the recorder in the road would register the truck ID number, its weight, and the time. A computer program would then compare this to the weigh scale information at the mill.

Plastic cap: This proposal would develop an identifier which could be "hammered" into the end of a log. The identifier would penetrate approximately six inches, making sawing it off a considerable reduction of product value.

Tracer paint dispenser: This concept would develop a dispensing machine which would require issued cards, similar to an "ATM" card, to check-in and check-out paint. Only one person would be authorized to stock the dispensing machine. The machine would keep track of the user, the number of cans issued, and the time of issue. The machine would also have a return port where the user(s), again with the identifying card, could return paint and/or insert used cans.

Trained dogs: This proposal would utilize dogs to locate logs which had been marked with scent. This application would be primarily used for law enforcement surveillance.

Video scale: Using three video cameras and optical digitizing of patterns, images would be created (i.e., a log or a load of logs). Then using algorithms and optical recognition of defect, a scale would be produced.