

United States
Department of
Agriculture

Forest Service

Technology &
Development
Program

2400—Timber
July 1994
9424 1201—SDTDC



Use of Tags for Identification & Improved Log Accountability

—A Limited Trial



Use of Tags for Identification & Improved Log Accountability

—A Limited Trial



LaMoure Besse, P.E.

**Technology & Development Program
San Dimas, California**

**3E31E79
Log Tags**

July 1994

The Forest Service, U.S. Department of Agriculture has developed this information for the guidance of its employees, its contractors, and its cooperating Federal and State agencies, and is not responsible for the interpretation or use of this information by anyone except its own employees. The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader and does not constitute an endorsement by the U.S. Department of Agriculture of any product or service to the exclusion of others that may be suitable.

The United States Department of Agriculture (USDA) prohibits discrimination in its programs on the basis of race, color, national origin, sex, religion, age, disability, political beliefs and marital or familial status. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (braille, large print, audiotape, etc.) should contact the USDA Office of Communications at (202)720-5881 (voice) or (202)720-7808 (TDD).

To file a complaint, write the Secretary of Agriculture, U.S. Department of Agriculture, Washington, D.C. 20250, or call (202)720-7327 (voice) or (202)720-1127 (TDD). USDA is an equal employment opportunity employer.

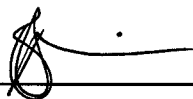
FORWARD

This publication describes one of the field trials conducted within the Log Tag Project. Work continues at the San Dimas Technology and Development Center testing new technologies which can be used in forest product identification and tracking such as log tags, transponders, microtaggants and paint.

Projects are initiated by the Forest Product Sales Technology Committee, a group which meets yearly to discuss field needs ranging from initial sale layout to the transport of products. Work is prioritized and future projects are developed to address needs which appear to be multi-regional in scope.

Field personnel who see a need for information to be distributed, have ideas for new product development, or the application of new technology, are encouraged to contact their regional representative on the committee. The current representatives are:

Don Foth	R01A
Jeff Starnes	R02A
Alan Lucas	R03A
Jim Ragland	R04A
Alan Quan	R05F15A
Don Studier	R06F12A
Jim Sherar	R08F11A
Ken Shalda	R09A
Marvin Rude	R10A
Mike Miller	W01C



Bob Simonson
Program Leader—Timber

TABLE OF CONTENTS

BACKGROUND	1
INTRODUCTION	1
OBJECTIVE AND SCOPE	3
PROCEDURE	
At the Landing	3
At the Sort Yard	4
RESULTS	6
DISCUSSION	8
CONCLUSIONS	11
RECOMMENDATIONS	11

ILLUSTRATIONS

1	A log deck; note tags on log ends	2
2	A tag being installed	2
3	Scaler using data logger to record log data	2
4	Typical log marked for transport from the sale area	3
5	The tagging system	3
6	Closeup of properly installed tag	4
7	Closeup of clips added to staple hammer	4
8	Deck hands at work	4
9	Scanner used in test	5
10	Scaler recording tag numbers with scanner	5
11	Technician removing tags while being timed	5
12	Remainder of tag stapled only twice after transport	9

TABLES

1	Comments about log tagging system	7
2	Comparison of time to tag vs. time to brand and paint logs	8

BACKGROUND

To comply with Federal laws and regulations and to manage the sale of forest products, the USDA Forest Service uses appropriate accountability methods. The need to positively identify ownership and the origin of commodities sold, such as saw logs, has dramatically increased in recent years. Contributing factors include reduced timber supply, increased export demand, greater product values, and increased transport distance. There are also legal requirements for the Forest Service to monitor log export and to participate in the administration of the small business set-aside program.

Methods of identifying and tracking logs from the sale area to the scaling location or port have remained virtually unchanged for decades. The present system is primarily based on the use of paint spots and hammer brands, which have been unsatisfactory in many situations. Both paint and brands are difficult to control and can also become illegible when applied to frozen, muddy, or mechanically harvested logs.

Unauthorized cutting of trees and incidents of logs not being properly accounted for has the potential to become a serious problem. The Forest Service policy is to take all reasonable precautions and actions to minimize loss of forest products. With significant advances in product tracking technologies, which have been widely adopted in other industries, the WO Director-Timber Management established the Forest Product Identification and Tracking (FPIT) Group. This Group was assigned the task of identifying those new technologies with potential to improve log accountability and thereby reduce loss.

One recommendation of the FPIT Group was to evaluate the concept of tagging logs rather than branding them. A project was initiated at the San Dimas Technology and Development Center (SDTDC) to investigate systems, benefits, and restraining forces for implementing log tagging. The benefits envisioned for such a system were that tags would be more consistent, readily traced through coded numbers to the sale origin, easier to apply to frozen or sheared logs, easier to identify from a greater

distance and while in transit, and have the potential to integrate with purchasers inventory systems.

Initial work at SDTDC involved contact with tag manufacturers and other industries implementing tracking systems; becoming familiar with application tools; and visiting with forest products companies that used log tag inventory systems. With this information in hand, a field trial—designed around the most practical approaches—was conducted in the summer of 1993. The trial was conducted on an existing Forest Service timber sale as an initial evaluation of log tags as an alternative identification and tracking method. The trial is the subject of this report.

INTRODUCTION

Early in discussions with label manufacturers, it became apparent that log tags are being used by many major timber corporations. The log tags are commonly sized in the range of 2.5- x 4-in to 3- x 5-in. A large alphanumeric code accompanied by a bar code is almost universal practice. Also very typical are multisection tags, with perforations allowing sections of the tag to be removed at intermediate points for inventory checks and controls. Most log tags are made from Mylar-coated paper. The Mylar coating protects both the paper tag itself and the printed information on the tag from the elements.

Many manufacturers have the luxury of being able to print a bar code or other product identification number directly on a product as it is manufactured. Other industries, including the lumber industry, utilize specially formulated adhesives to apply tags containing such information. To date, adhesive tags have not been accepted in the timber industry due to the difficulty in developing a material which would adhere to such rough surfaces, within such a wide range of environmental conditions.

As part of this project, SDTDC did conduct preliminary testing of some adhesive tags that appeared to perform satisfactorily—if applied to relatively dry log ends that were bucked with a chain saw. Work continues in the area

of adhesives. Without a broad-range adhesive, the common practice is to staple tags onto the log end (fig. 1).

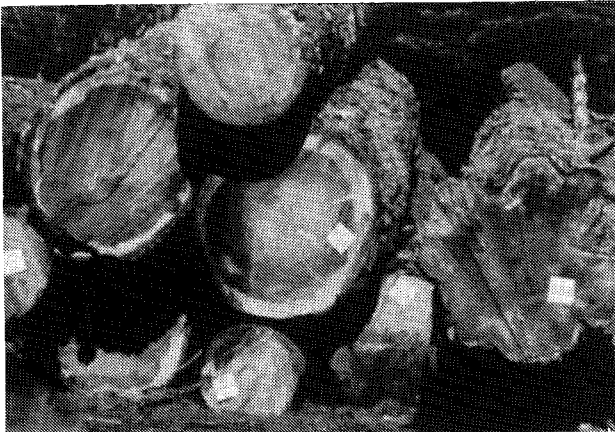


Figure 1. A log deck; note tags on log ends.

Logs are currently tagged during scaling or when they enter the sort yard. Log tags are used extensively in West coast export yards. SDTDC personnel also visited sites where purchasers were tagging Forest Service logs to track them prior to resale or to monitor shipping. In all cases, the owner of the log desired to have an accounting of the inventory site and information about outgoing transfers. The bar coded tag provided an accurate and automated method to accomplish this.

The Forest Service needs to track a log before it leaves the sale area. For this test, we attempted to move the tag application process from the yard to the landing with a minimum amount of change to current practices. Landings are the most common location to hammer brand logs, and appeared to be the logical location for installing tags. It appeared little change or specialized training would be needed. The techniques were quite simple, involving the use of existing industrial staple hammers (fig. 2). The costs were quite low, running less than \$200 for tools.

A test plan was agreed upon with ITT Rayonier Incorporated, Boise Cascade, and Bordges Timber, Inc. Bordges was the logger and purchaser of the Forest Service timber sale on the Forest Hill Ranger District, Tahoe National Forest, Calif. ITT Rayonier operated the scale and sort yard in Sacramento, Calif. Boise Cascade was the final purchaser of the

logs and desired delivery to their mill in Medford, Oreg.

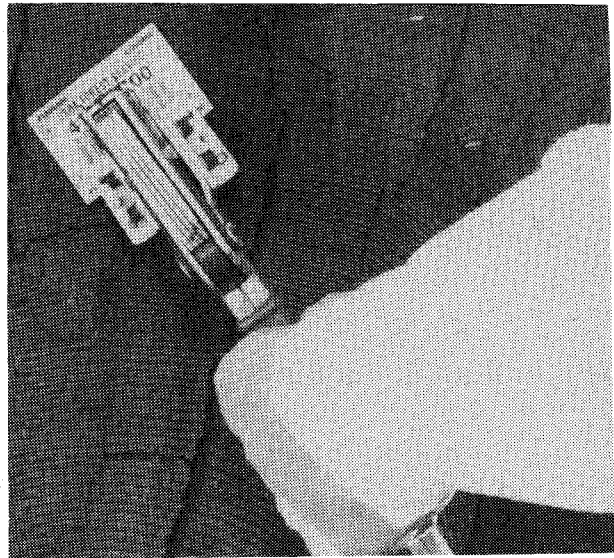


Figure 2. A tag being installed.

Prior to this trial, tags were applied by Northwest Log Scalers Cooperative immediately prior to scaling a log. After a load was rolled out for scaling, the scaler would apply numerically sequenced tags to the load. To initiate input to a portable data logger (a hand-held electronic notebook), the scaler would manually punch in the first tag number, followed by the scale information for that log (fig 3). The data logger's software program was designed so that as the scaler moved to the next log,

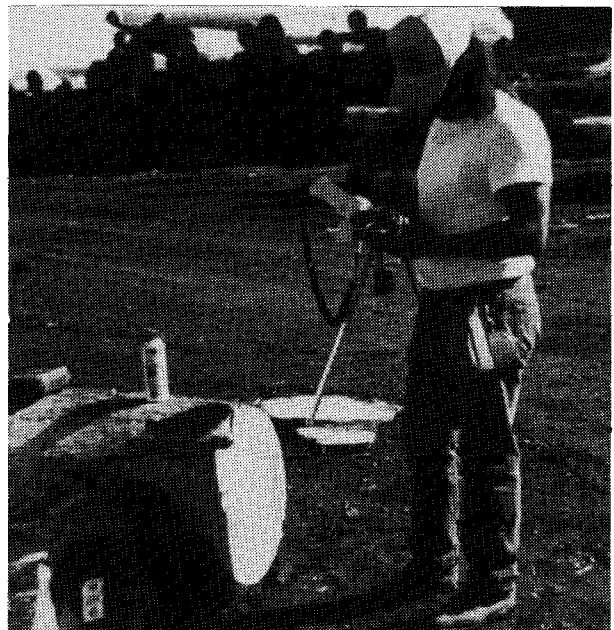


Figure 3. Scaler using data logger to record log data.

the logger would automatically increment the tag number by one, eliminating the need for the scaler to input any tag information for the remaining logs in that load.

For this trial, Bordges Timber agreed to have their deck hands apply the tags at the landing. The only other change to existing procedure was to equip the scaler's data logger with a bar code scanner. During the test, tags were typically applied sequentially in the woods; however, after a woods sort, loading onto the trucks and then rolling out the load at the scale yard, the logs seldom arrived sequentially. To eliminate human error, which would certainly be introduced if the scaler were now required to manually enter every random tag number, the bar code on the tag was scanned (this automatically entered the tag number into the data logger) prior to scaling each log. To avoid adverse reaction from casual observers and to comply with current Federal regulations, logs were also painted and branded on both ends during this test (fig. 4).

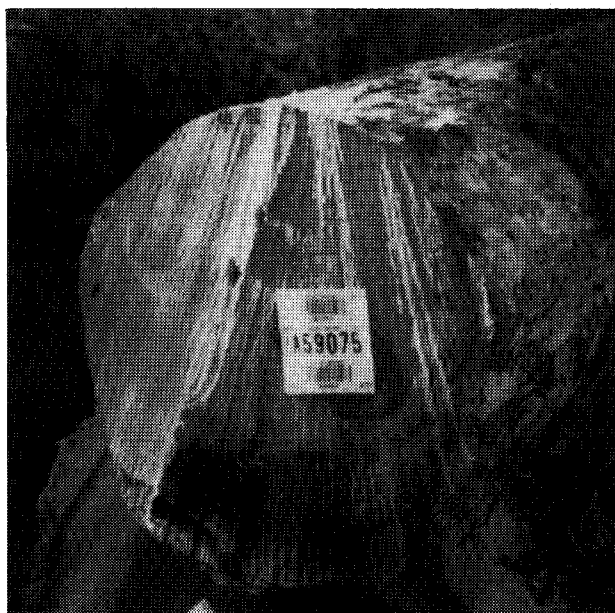


Figure 4. Typical log marked for transport from the sale area.

OBJECTIVE AND SCOPE

The objective of this trial run was to demonstrate the feasibility of tagging logs in the woods and to note the benefits and restraining forces. Boise Cascade provided SDTDC with 500 log tags; these were taken to the

woods for Bordges Timber's crew to staple to logs prior to their leaving the sale boundary. Deck hands tagged logs as they were skidded to the landing over a 3-day period in the summer of 1993.

PROCEDURE At the Landing

A small metal toolbox containing a modified heavy-duty Bostich staple gun (complete with spare parts and repair guidelines), a case of staples, a leather holster to carry the staple gun, and a plastic canister containing the tags were given to the deck hands (fig. 5).

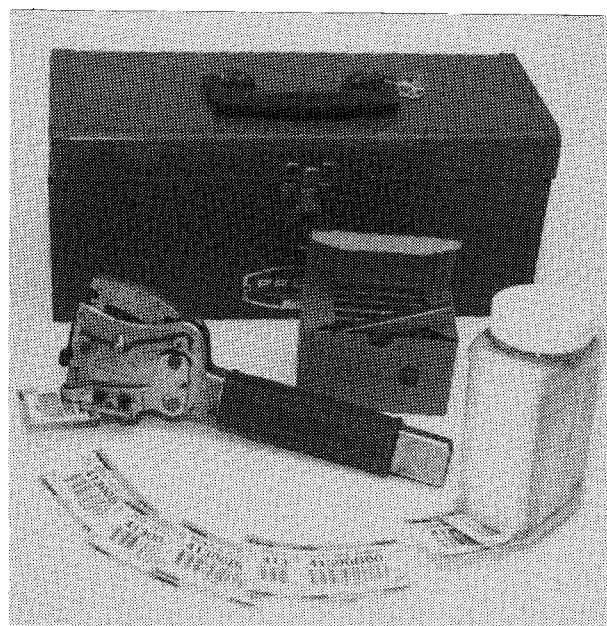


Figure 5. The tagging system.

SDTDC personnel spent a short amount of time training the deck hands on the operation of the tagging system. They were instructed to place one tag with four staples on one end of each log prior to it leaving the sale area (four staples had been routinely used in previous log yard operations). The white plastic tags with black lettering and bar code were 3.75-in square and divided by perforations into three equal segments. Two 3/8- x 1/2-in steel staples were placed in the middle (main) tag segment to ensure attachment to the log and one staple was placed near one end on each of the top and bottom portions (fig. 6).

Prior to this test, SDTDC removed the heat treatment; drilled several holes; and reheat-treated the swinging arm of the heavy-duty



Figure 6. Closeup of properly installed tag.

staple gun for attachment of two small spring steel clips. These clips (fig. 7) were used to hold a tag on the hammer until the first staple was placed, allowing the operator to swing and attach a tag with only one hand.

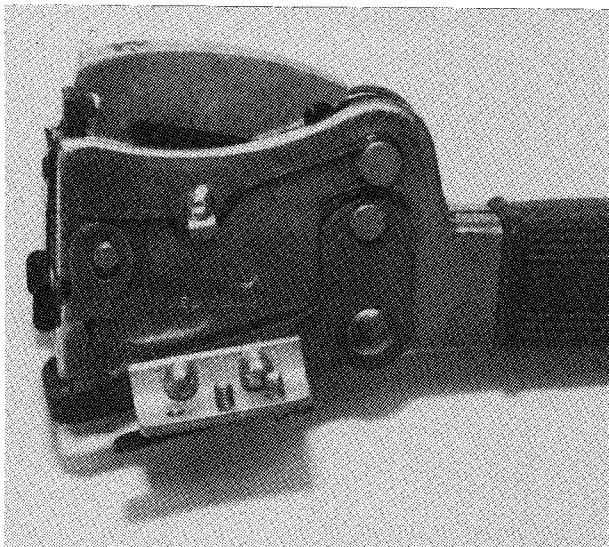


Figure 7. Closeup of clips added to staple hammer.

No changes were required in the size of the woods crew. Before the test period, two deck hands were working the landing. The em-

ployee which had been primarily responsible for painting and branding was now assigned the additional task of tagging the logs.

Delimbing and bucking work slowed or halted during loading operations due to safety considerations and the movement of machinery on the landing. During the loading operation, a deck hand watched for tags as the logs were loaded on the trucks. In the event that a log was not tagged for some reason, the deck hand climbed onto the truck and applied the tag at that point (fig. 8).

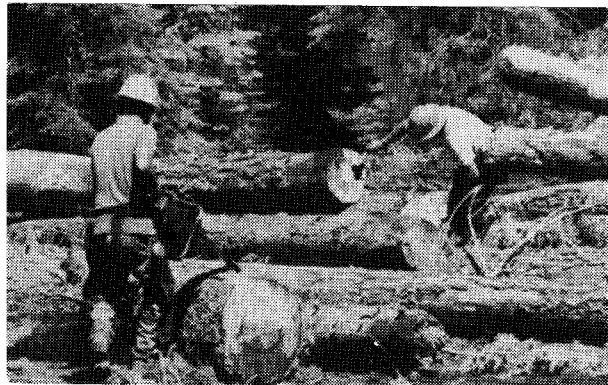


Figure 8. Deck hands at work.

Loaded trucks carried the tagged logs from the landing to the scaling site—a distance of 37 freeway miles, 17 highway miles, and 39 paved but narrow and windy Forest highway miles. This provided a good test for the ability of the staple and tag to withstand wind forces up to 70 mph.

At the Sort Yard

A Photographic Sciences Corp. scanning gun was installed on the Corvallis Microtechnology, Inc., data logger used by the scalers. The data logger's software program was modified to accommodate input from the scanner. A small wire bracket for mounting the scanning gun when not in use was added to the housing of the data logger.

The scaling operation consisted of three test phases. For the first few loads, the scalers verified that the logs arrived with tags in place. These tags were removed by the scaler and replaced with sequentially applied tags, which were then used as before this test. The scaler manually entering the first

tag number and proceeding to scale the logs one-by-one with the data logger automatically advancing the tag number each time.

For the next set of loads, the tags from the woods were left in place. The scaler manually entered each tag number as each log was approached for scaling. For the final phase, and the majority of the test, scalers approached the logs shortly after they were unloaded, scanned the bar coded number into their electronic log scaling notebook (figs. 9 and 10), made the appropriate measurements, and punched in the data.

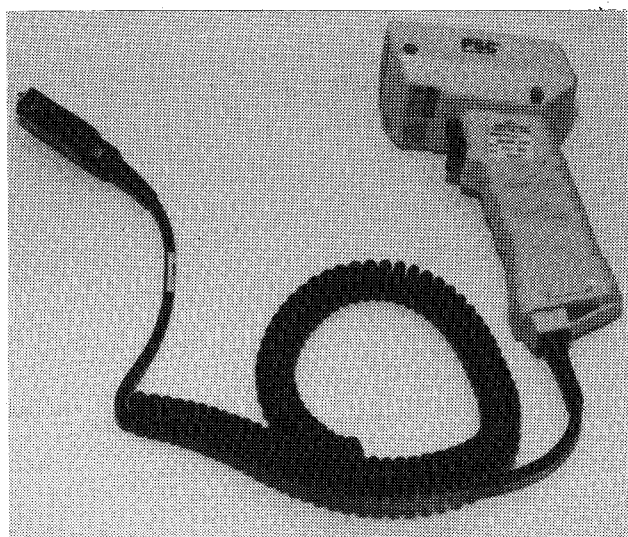


Figure 9. Scanner used in test.



Figure 10. Scaler recording tag numbers with scanner.

The scaling bureau now had information on each individual log, tied to the unique tag

number of each log. For any log which the number was known, the scale information could be retrieved. After scaling, the logs were moved into large sort decks in the ITT Rayonier yard. SDTDC was provided a copy of the scale data sheet. Video and still photos were taken.

When the logs were removed from the decks to be loaded onto rail cars for shipment to the Boise Cascades mill, an ITT Rayonier employee removed one perforated portion of the tag for inventory and record keeping purposes. These tags could be scanned in to verify exact volume of logs shipped out on any given load. When the log arrived at the milling destination, remaining portions of the tag were used to verify arrival and inventory control. This portion of the operation was not monitored directly by SDTDC as a part of this test.

When SDTDC personnel were in the log yard, they inspected tags from this timber sale. Tag numbers were recorded, logs without a tag were inspected for indications that a tag had been lost, and all tags were inspected for wind or other damage such as loose staples, torn tags, etc. Tags applied or removed by scaling personnel were also noted.

In addition to this field test, SDTDC used video tape to analyze the time and motion required to paint and brand, the time required to attach a tag with four staples, and the time required to remove the tags applied with one and four staples (fig. 11).

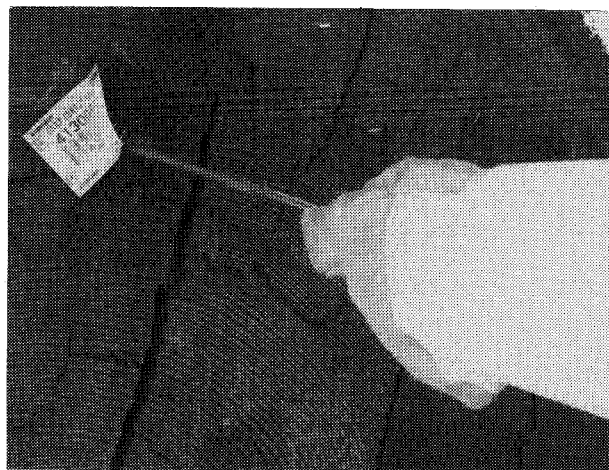


Figure 11. Technician removing tags while being timed.

RESULTS

Table 1 lists the 32 truck loads of tagged logs that were delivered between 4:00 pm June 29, 1993, and 7:00 pm July 1, 1993 (when monitoring ended), by load receipt, the number of logs on each load, and a summary of observations made during the test.

Approximately 2 hours of video were shot to comprehensively document the overall operation. Table 2 summarizes an analysis of this footage for the operations that are critical in this report.

Although stapling a tag with hand tools takes longer than branding and painting, the overall impact was not significant in this test. With the average load of 13 logs, the difference was a little more than 60 sec per load.

Table 1. Comments about log tagging system

Load receipt No.	No. of logs	Comments
—PHASE 1—		
565168	8	2 logs were stapled only twice, allowing the high way wind to tear off perforated sections of the tags.
565169	5	Everything checked out fine.
565170	21	2 logs were double tagged.
—PHASE 2—		
565171	*	Load not inspected by SDTDC.
565172	*	Load not inspected by SDTDC.
565173	*	Load not inspected by SDTDC.
565174	*	Load not inspected by SDTDC.
565175		1 log not tagged; 1 tag punched in as No. 59129—this tag was in load No. 565176.
565176	23	3 logs not tagged; tag No. 59129 was punched in as No. 59128.
565177	11	2 logs not tagged; 1 tag removed from cull log.
565178	15	1 log not tagged, it was short and probably buried in deck; tag No 59206 punched in as No. 59209
* Scale ticket not provided for SDTDC review.		
—PHASE 3—		
565179	5	2 scan errors (No. 159199 scanned as 159179; 159198 scanned as 159180)
565180	29	3 scan failures (probable cause—dirty tags); 2 logs not tagged; 2 scan errors (No. 159295 & 159237 observed by SDTDC are not in scale record; tag 159235 & 159239 in the record were not observed).
565181	11	1 log double tagged.
565182	19	1 scan error (No. 159013 scanned as 159003).
565183	17	1 log double tagged; scale ticket shows 18 logs, including tag No. 159287, which SDTDC did not observe during inspection.
565184	17	This load was not tagged (deck hand was chasing gas and could not tag the logs).
565185	11	1 log not tagged; tag No. 159180 observed in this load, entered into book properly but had shown up in previous data.
565186	27	4 logs not tagged; battery was getting weak on data recorder, mounted additional battery pack on hip.
565187	12	1 log not tagged; 1 tag blew off during haul; 1 tag pulled from cull log.
565188	14	8 logs not tagged.
565189	10	1 log not tagged.
565190	20	This load was not tagged.
565191	4	1 tag pulled from cull log.

Load receipt No.	No. of logs	Comments
565192	6	Everything checked out fine.
565193	7	1 log not tagged.
565194	7	Load not inspectd by SDTDC.
565195	9	Load not inspected by SDTDC.
565196	8	1 tag tore off cull log during haul.
565197	4	1 tag pulled from cull log; 1 scan error (No. 159489 scanned as 159429).
565198	11	Load not inspected by SDTDC, but scan No. 159491 was observed on a tag in a different load; scanner error.
565199	20	1 log not tagged; 1 tag blew off during haul.

(1) In **PHASE 1**, tags which had been applied at the landing on the first three loads (36 tags) were removed and replaced by a sequentially numbered set by the scalers. This was done to avoid hand punching each individual tag number into the data recorders, which were not modified to accept bar code until later in the test. All tags were inspected by SDTDC personnel prior to removal.

(2) In **PHASE 2**, tag numbers for the next eight loads were manually entered into the data recorder. The recorders had still not been modified to accept bar code. It was desired to see what the impacts would be on time and errors if a scanner were not utilized. Three of these loads (49 tags) were inspected by SDTDC personnel.

(3) In **PHASE 3** tags for the remaining 21 loads were electronically scanned into the data recorders using the bar codes. Eighteen of these loads (250 tags) were inspected by SDTDC personnel in the log yard.

Table 2. Comparison of time to tag vs. time to brand and paint logs

<u>Method</u>	<u>Time/log (sec)</u>
Brand and paint	3.5
Install tag with 1 staple	7
Install tag with 4 staples	9
Remove tag and 1 staple	5.8
Remove tag and 4 staples	19.5
Tear off tag only	1.7

DISCUSSION

This trial demonstrated the ease with which a log tagging system can be used by anyone. There is little expense in equipment or training. The comments listed in table 1 demonstrate that there are startup problems as one would expect, but they are easily corrected.

Standard industry practice is to tag only one end of each log. This is because each tag is unique, allowing the owner of the log to track each individual log. In this system, once the log is scaled or otherwise accounted for, it would not be desirable to have more than one tag (i.e., identification number) assigned to any one log. This meant that the deck hand was free to place the tag on the most convenient end.

In this particular test, the deck hand was running back and forth between two skidders and a rubber-tired loader, which concurrently moved logs onto five separate decks and loaded trucks. This often led to confusion. Although most logs on a deck were correctly tagged on one or the other end, a small percentage ended up with tags on both ends, some on neither.

As the logs were loaded onto a truck, the deck hand would check for 100 percent compliance. This became more of a challenge as the number of logs in the load increased, as it became difficult to remember which logs had tags when walking around the truck attempting to locate logs that were not tagged.

If the tags only had to identify ownership (Region, Forest, District) and the timber sale contract number, similar to the information provided with a hammer brand, then tags would be printed with one number for each sale and duplicate tagging would be inconsequential. The percentage of untagged logs would probably also decrease, if the deck hand was not concerned with over tagging.

When the logs were unloaded and rolled out for scaling, the tags were not all on the same end. This was not an impact on the scalers. They were already required to go to both ends of each log to record measurements, and the software program in the data logger allowed the tag number to be entered at any point in the scaling process.

After scaling, the logs were stacked without concern for which side of the stack the tag ended up on. This would make it impractical for an inspector to easily verify that all logs in any large deck were tagged properly on only one end or the other. Forest Service tags could be required on both ends.

Close inspection of the 425 logs revealed that only three tags blew off on the trip to town. It appeared that an additional 17 logs simply were not tagged in the woods. This is a 96 percent compliance rate, which is quite good.

Two tags were only stapled twice in the middle section of the tag and the other sections blew off (fig. 12). This is not considered of importance to Forest Service accountability needs, since the log is still identified correctly.

A few logs were tagged twice. This presented no particular problem, because the scaler simply removed and discarded one tag. Tags attached to cull logs were also removed in this test, as there was no desire by the logger



Figure 12. Remainder of tag stapled only twice after transport.

or purchaser to track these logs. Also, two entire truck loads (37 logs) were not tagged in the woods, due to operational problems beyond the scope of this test.

When the scanner was first used, 10 out of 240 scans resulted in errors. Most errors occurred in the beginning of the test. As familiarity with proper operation increased, and the correct adjustment of scanner sensitivity was found for the conditions of this test, most scanning errors were eliminated.

The use of the scanner appeared to significantly increase the power requirements for recording data. The notebook, with scanner, used over 50 percent of available battery power after scanning and accepting data from 136 logs. A supplemental belt mounted battery pack was attached to the system to alleviate this problem.

Everyone that cooperated in this trial felt that tags could be used to identify logs if their use was mandated by the Forest Service. However, it is reasonable to assume that broad-scale implementation would take an appreciable amount planning and patience before widespread acceptance by industry. Resistance could be anticipated where waivers are granted to eliminate painting and branding; where waivers require only a percentage of the logs to be marked; where log sizes are small, and where pulp mills consider the tag a contaminant that devalues the chips. This is typical of any change introduced to a long-standing system.

Currently, waivers to branding and painting requirements are granted in many areas. Managers in these areas believe adequate ac-

countability is attained by a spot of paint, often simply marking a specified percentage of logs within a load is sufficient. If the same number of logs per load are required to be identified in either a branding and painting or tagging operation, the tagging operation in and of itself should not be an impact.

A decision to require tags on every log in these areas with 30 to 80 logs per load would require investment in an automated tagging tool that was more efficient than a hand-held staple hammer. Since applying a tag with a staple hammer is quite similar to branding a log (from a motion standpoint), there appears to be little (if any) opportunity to improve worker's safety until automated tools are developed.

Tags are visible from a much greater distance than paint spots. In the view of the author, the Forest Service might consider using a trade-marked tag unique to the organization in place of the current requirement for highway yellow paint. Waiving the regulation requiring a yellow paint spot where tags are used could avoid the hazards associated with handling and breathing paint.

Coupling the use of a copyrighted tag with an alphanumeric system similar to the Forest Service's Data General (DG) e-mail address system would also make it easier for an inspector to determine which sale a log originated from. Even logs transported across regional lines would be easily identified. If desired, it is possible to account for every log by extending the numbering system with sufficient digits.

Although these trials did not extend into a variety of seasonal conditions, adverse weather is not envisioned to be a constraint. This compares favorably to branding and painting, which when used on frozen or mechanically fallen trees often become difficult to read.

Where logs are transported by water, trials would need to be made to determine adequate tag durability.

While interacting with industry, several approaches were found which show promise.

Two that SDTDC engineers seriously continue to pursue include:

PAINTBALL SYSTEMS with a sale specific marker to improve efficiency and worker safety.

EUROPEAN TAGGING SYSTEM which was specifically designed for marking logs but may have the problem of chip contamination similar to tag material.

Because current digestible tags are not yet widely accepted, tags used today quite often need to be removed prior to processing the log to avoid potential chip contamination. This additional step makes tagging less attractive, but is an accepted cost of doing business in many major yards where inventory control or some related purpose is a factor. It would be a very significant impact with smaller log size, if 100 percent tagging were required. However, as discussed above, most sales of this type are sold with waivers.

The labeling industry is developing a digestible tag, though information to date is proprietary. A patented log-marking system currently manufactured in Europe also advertises a digestible tag. The chances that this tag is digestible in U.S. kraft and sulfite mills needs to be tested.

Tags do not make theft more difficult. People can get around any marking system if they so desire. A goal of this project was to improve accountability, thereby improving chances of detecting theft. One suggestion to make it more difficult to remove evidence of tags is to require the use of unique staples, similar to requiring use of "highway yellow" paint on Forest Service logs. Staples with information, even a bar code, printed on them are only marginally more expensive than off-the-shelf staples, if purchased in large quantities. Then, even if the tag had been removed, the staple would provide evidence of the log having had a tag. Another alternative is to field test the use of European tags that have barbed edges. These tags are very difficult to remove and would be a deterrent to theft. However, it should be kept in mind that an experienced sawyer can quickly remove "cookies" from the end of either branded or tagged logs.

CONCLUSIONS

1. Attaching tags to logs before they leave the sale boundary is easily done with existing and relatively inexpensive tools and methods.

2. Although attaching tags to logs offers many opportunities, the method used in this study is slower than branding and painting. Having to remove the tag and staples takes additional time; therefore, one can conclude that until better materials and faster tools are available, the techniques used in this study are applicable where large logs are harvested, where only some small logs are marked, and where the tags are used for other purposes, such as inventory control.

3. The FPIT goal of improving log accountability can be attained with the use of tags. Compared to a brand and spot of paint, they are easier to read, contain site specific information, are visible from greater distances, and can be used for other management purposes. These are the benefits. The incompatibility of the tag and staple with the pulping process, the installation time, and (as with branding) the worker's occupational safety are the restraining forces. Therefore, it can be con-

cluded that it is prudent to continue to search for digestible products and more efficient tools with enhanced occupational features; and to evaluate, to the appropriate extent, other ideas that hold as much promise.

RECOMMENDATIONS

1. Continue to evaluate alternatives such as pneumatic staple guns with extendible handles, multiple staple heads, etc., so that design criteria can be available for finding or developing an effective tool. Include other good ideas, such as paintballs in these tests.

2. Research the pulping process to understand the technical problems and learn more about the state of the art in digestible tags. A breakthrough in this technology would greatly improve the acceptance of log tags by purchasers.

3. Search for automated tools to attach tags when it appears that digestible tags will be available.

4. Consider worker safety as a criteria for success.