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Low-Cost Diagonal Fence Strainer

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INTRODUCTION

Corner, line, and gate or fence end braces, known as strainers, are an important part of any fence. With the use of high-tensile, smooth wire, these strainers are of even greater importance because of the necessity of maintaining the complete fence at the recommended tension.

In recent years, the horizontal fence strainer (figure 1) and the double-horizontal fence strainer have been accepted as the standard and strongest fence strainer designs. However, another design, known as a diagonal fence strainer (figure 2), is structurally equal to the horizontal fence strainer; it is equal in strength and holding force and has the same lifting force on the corner post as a horizontal strainer of the same size. At the same time, however, the diagonal strainer is much less costly to install. It requires one less post and only about half the labor to install as does the horizontal fence strainer.

On a high-tensile, smooth-wire fence, one diagonal strainer (as shown in figure 3) can be used for a corner in place of the currently used two horizontal braces (as shown in figure 4).

In the design shown in figure 3, the high-tensile, smooth wire must be bent around the corner and must not be tied to the corner post. Also, it should be noted that this single strainer may be undesirable if livestock are present. Cattle could straddle the brace or go on both sides, and calves could go under the brace. If this is a problem, use two diagonal strainers running at the same angle as the fence, as shown in figure 5. A single diagonal strainer is not recommended for corners less than 90 degrees. For corners less than 90 degrees, use two diagonal strainers. A single diagonal strainer works very well for corners greater than 90 degrees.

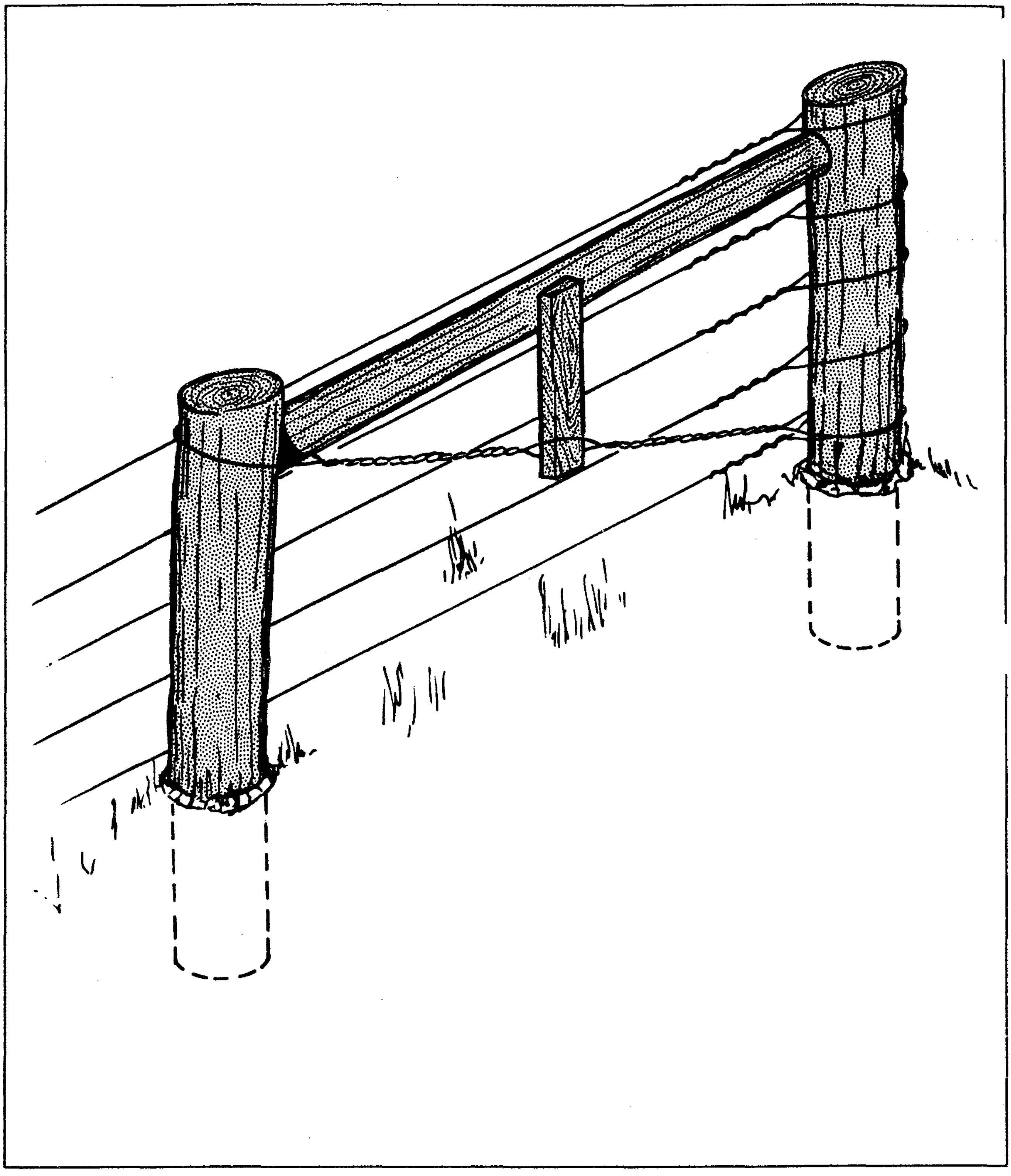

Figure 1.--Horizontal gate or fence end strainer.

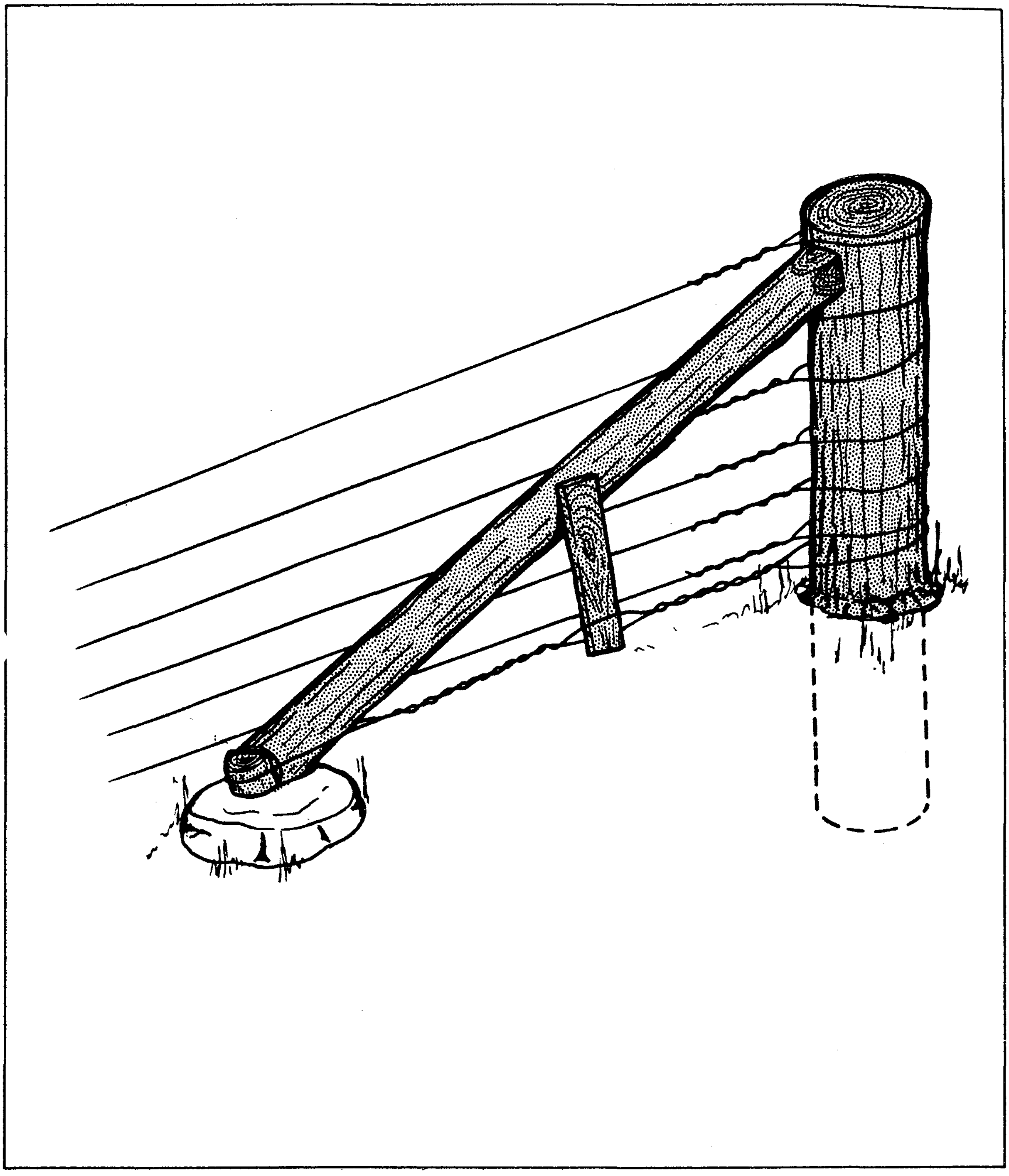

Figure 2.--Diagonal gate or fence end strainer.

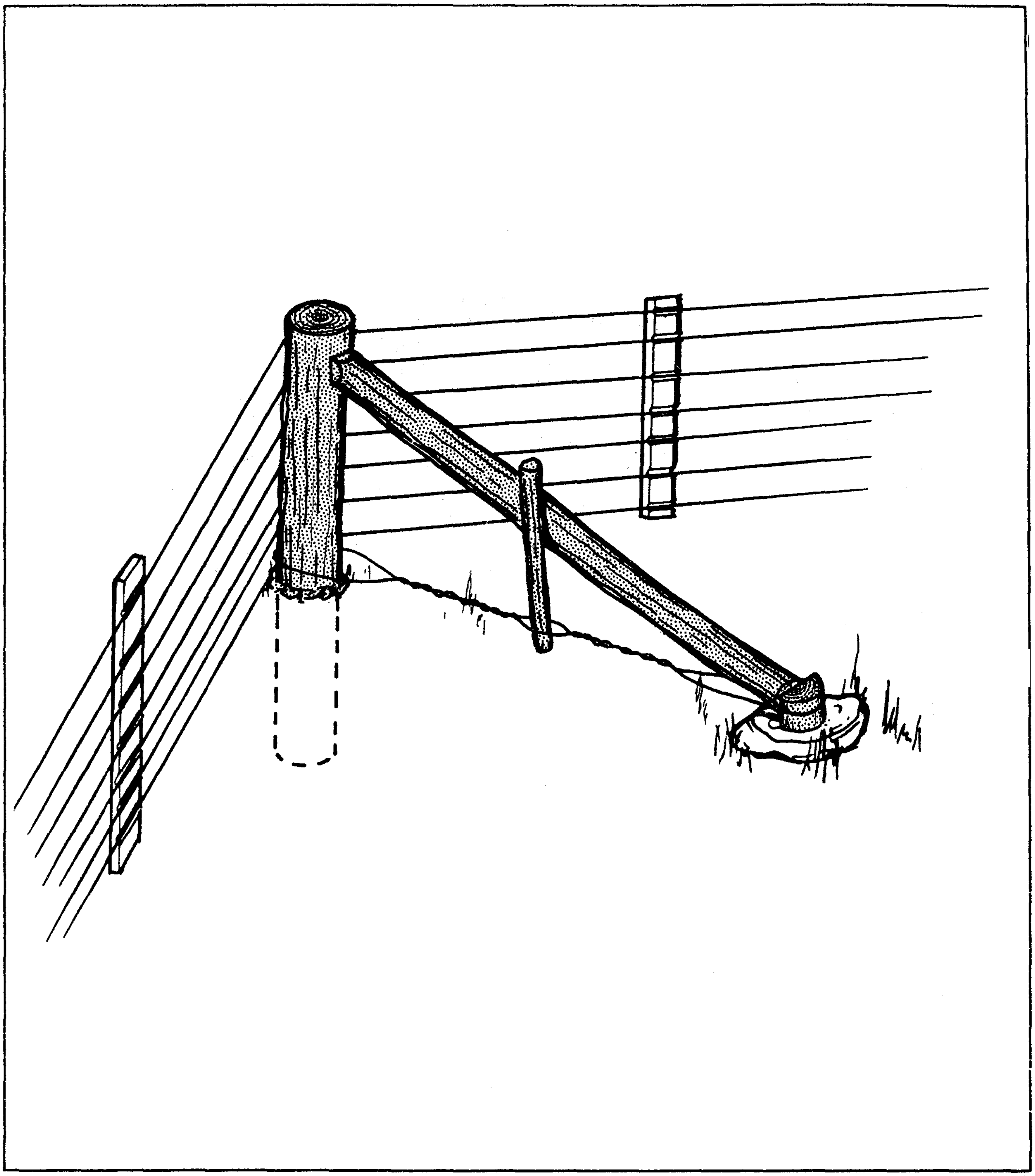

Figure 3.--The use of one diagonal strainer for a corner brace on a high-tensile, smooth-wire fence.

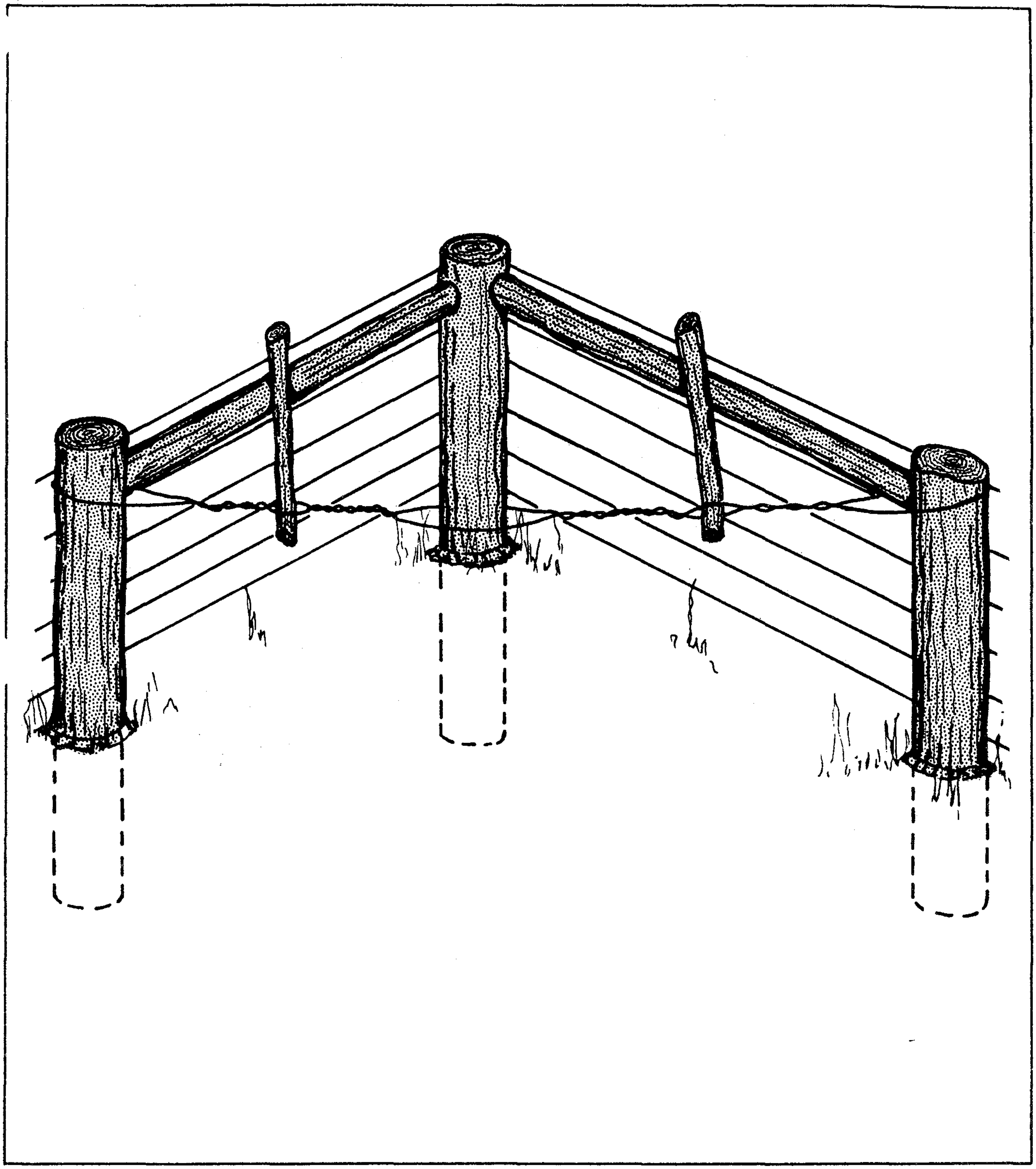

Figure 4.--Currently used two horizontal strainer corner brace, which can be replaced by a single diagonal strainer or by two diagonal strainers.

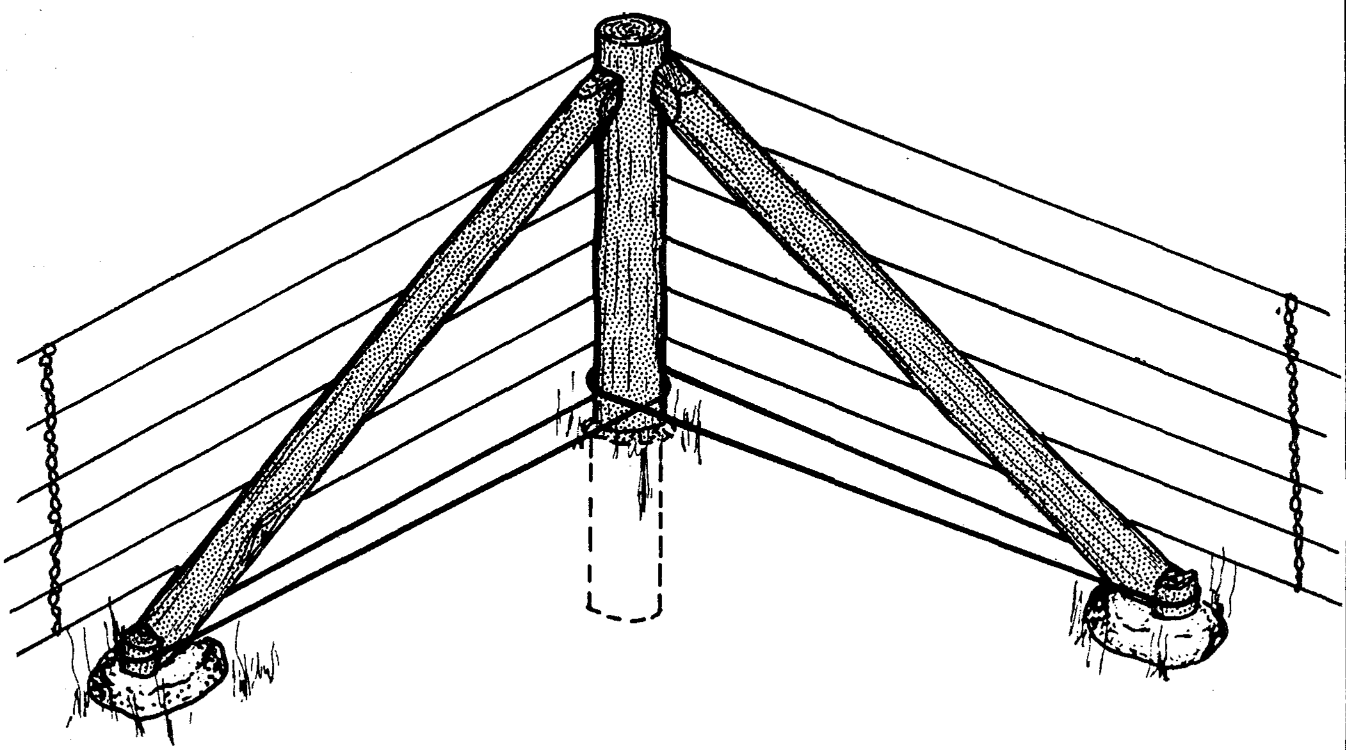

Figure 5.--Two diagonal strainer corner braces.

DESIGNING a DIAGONAL BRACE

In designing and installing a diagonal strainer, several principles should be kept in mind:

(1) Make the diagonal brace as long as possible. This applies to horizontal strainers as well. (See table 1.)

(2) Be sure that the end of the diagonal brace in contact with the ground is free to move forward and is not blocked by a stake or post. When the end of a diagonal brace bears against a stake or post and is not free to move, one-half to two-thirds of the total fence tension can be transmitted to the stake or post. This reduces the ability of the strainer to resist pullout (failure).

(3) The diagonal brace can bear against the corner post in any location from the middle of the post to the top. In general, however, the best place to have the diagonal brace contact the corner post is at the top.

The maximum bending moment of the corner post (located at ground level where the brace wire is attached to the corner post) is the same whether the diagonal brace bears at the top or middle of the corner post. However, the loading in the diagonal brace (compression) and lower

Table 1.--Practical lengths for compression members of diagonal (or horizontal) fence strainers.

Pipe size (in)	Wood diameter[1] (in)	Practical length (ft)	Allowable length (ft)
2		8	10
2.5		9.5	12
3		12	14.5
3.5		13.5	17
4		15	19
	3	7.5	
	4	10	
	5	12.5	
	6	15	
	7	17.5	
	8	20	

[1]Diameter at center and straight length assumed.

brace wire (tension) will be double when the diagonal brace bears against the middle of the corner post as compared to when the diagonal brace bears against the top of the corner post. In the diagonal strainer, when the diagonal brace bears against the top of the post, the tension force in the wire brace is about equal to or a little less than the total tension in the fence; the length of the diagonal has no effect on this tension force. In the horizontal strainer, the tension force in the wire brace is about equal to or a little more than the total tension in the fence. The length of the top brace of the horizontal strainer does affect the tension force in the wire brace, causing it to vary a relatively limited degree (15 percent to 25 percent). The longer the horizontal strainer, the lower the tension force in the wire brace. The tension force of the wire brace of a horizontal strainer is higher (by 5 percent to 15 percent) than the tension force of the wire brace of a diagonal strainer of equal length.

(4) When installing a diagonal strainer, set the corner post first, then install the diagonal brace, put in the bottom holding wire brace, and finally, attach the wires and tighten them to the proper tension. If this procedure is followed, the lower wire brace will not have to be twisted to be tightened.

(5) Use a corner post with as large a diameter as possible.

(6) If one diagonal strainer will not hold the fence tension, install a second diagonal strainer (as shown in figure 6), with each strainer taking half the tension of the fence.

COMPARING DIAGONAL & HORIZONTAL STRAINERS

Upon initial comparison, it may be difficult to realize that the diagonal and horizontal strainers are structurally equal. However, a complete examination of the forces in each of these structures shows that the reaction of the ground on the strainer is the same in both cases (see figure 7). A force (F_1) horizontal to and below the ground pushes on the corner post in reaction to the tension in the fence. A second force (F_2) exerts an upward pressure on the end of the brace resting on the ground, in the case of the diagonal strainer,

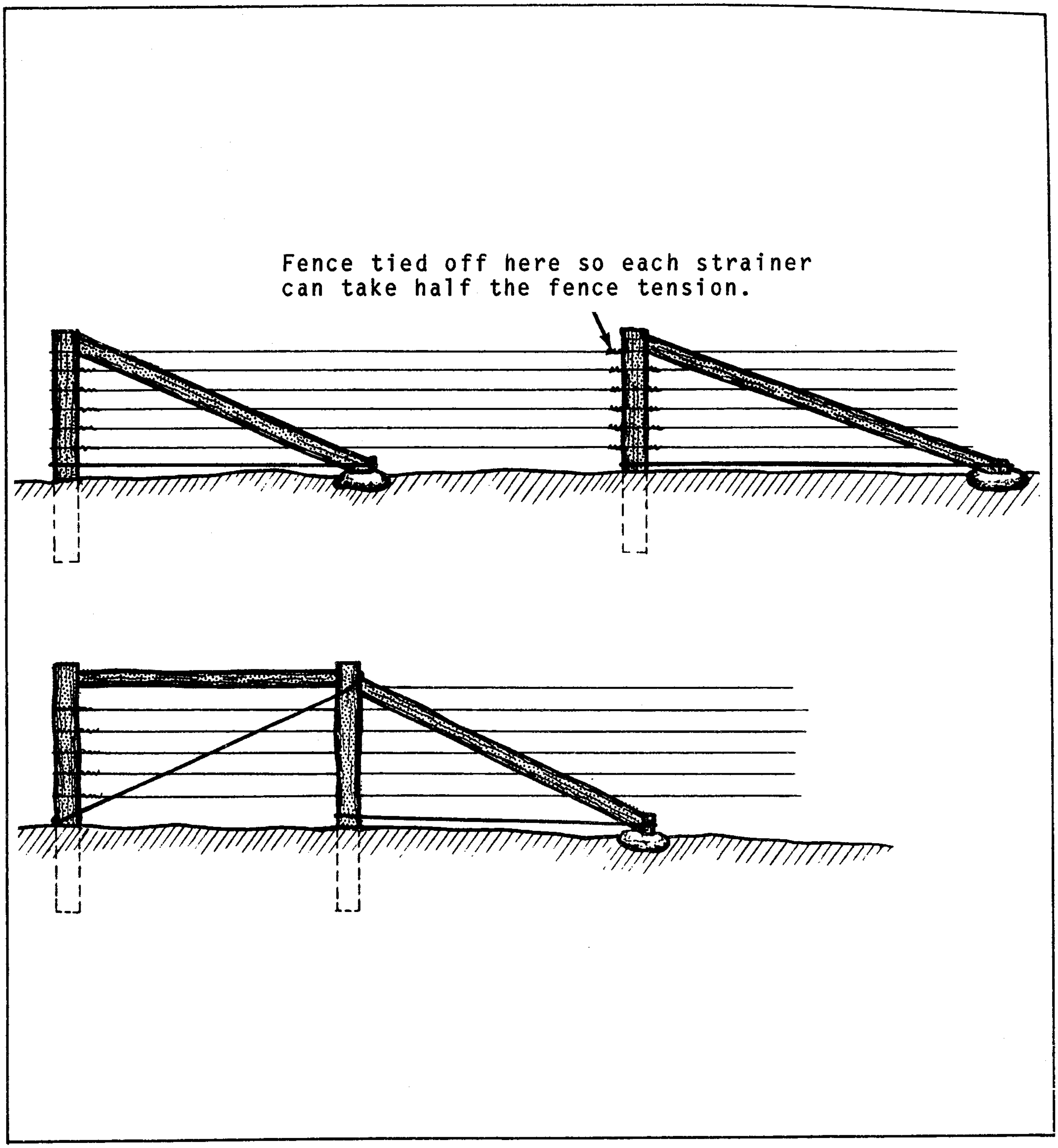

Figure 6.--Use of two diagonal strainers for holding in soft soil. Also shown is the use of a horizontal and a diagonal strainer together. Each of the diagonal strainers takes half of the tension in the fence; therefore, the fence must be tied off at each diagonal strainer.

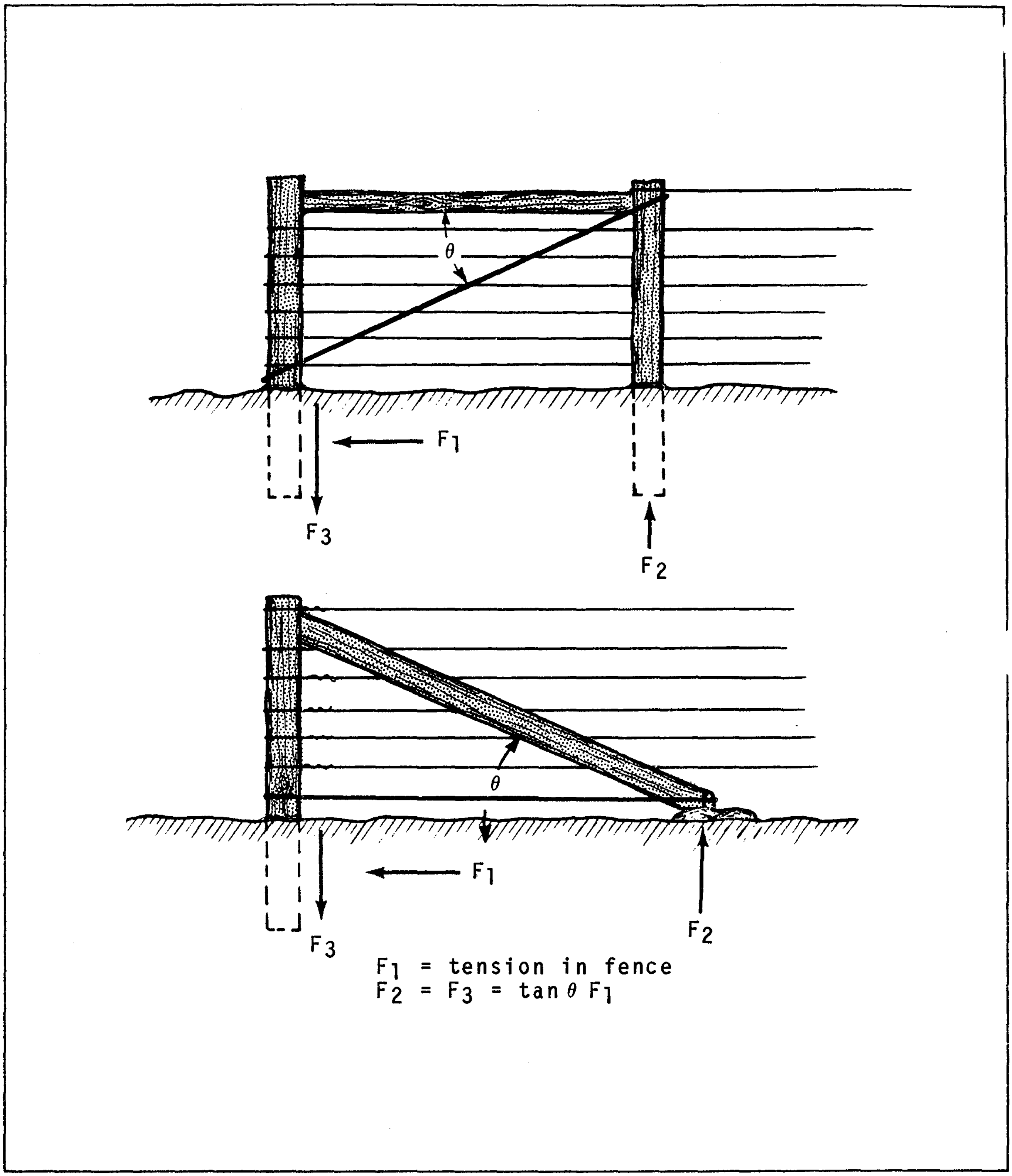

Figure 7.--Reaction of the ground on horizontal and diagonal strainers.

on the second post, in the case of the horizontal strainer. Also, the ground exerts a downward-pulling force (F_3) on the corner post, holding it in place. The greater the fence tension force is in either the horizontal or diagonal strainer, the greater this force (F_3) can be. By making the diagonal as long as possible or, for that matter, the top of the horizontal strainer as long as possible, the force tending to pull the corner post out of the ground will be reduced.

When the diagonal strainer is used as a line brace (see figure 8), the brace wires must not be overtightened. If they are, the vertical post can be jacked out of the ground. For this reason, the diagonal strainer may not be as good a line brace as a horizontal brace with two brace wires. However, using high-tensile, smooth wire reduces or eliminates the need for line braces.

CONCLUSION

There is an old German proverb that says, "Everything that is good is probably not new, and everything that is new is probably not good." This proverb applies to the diagonal strainer. The diagonal strainer design is not exactly new--it was in use 50 years ago in South Dakota. It also has been used in eastern Washington and, to a limited extent, in New Zealand.

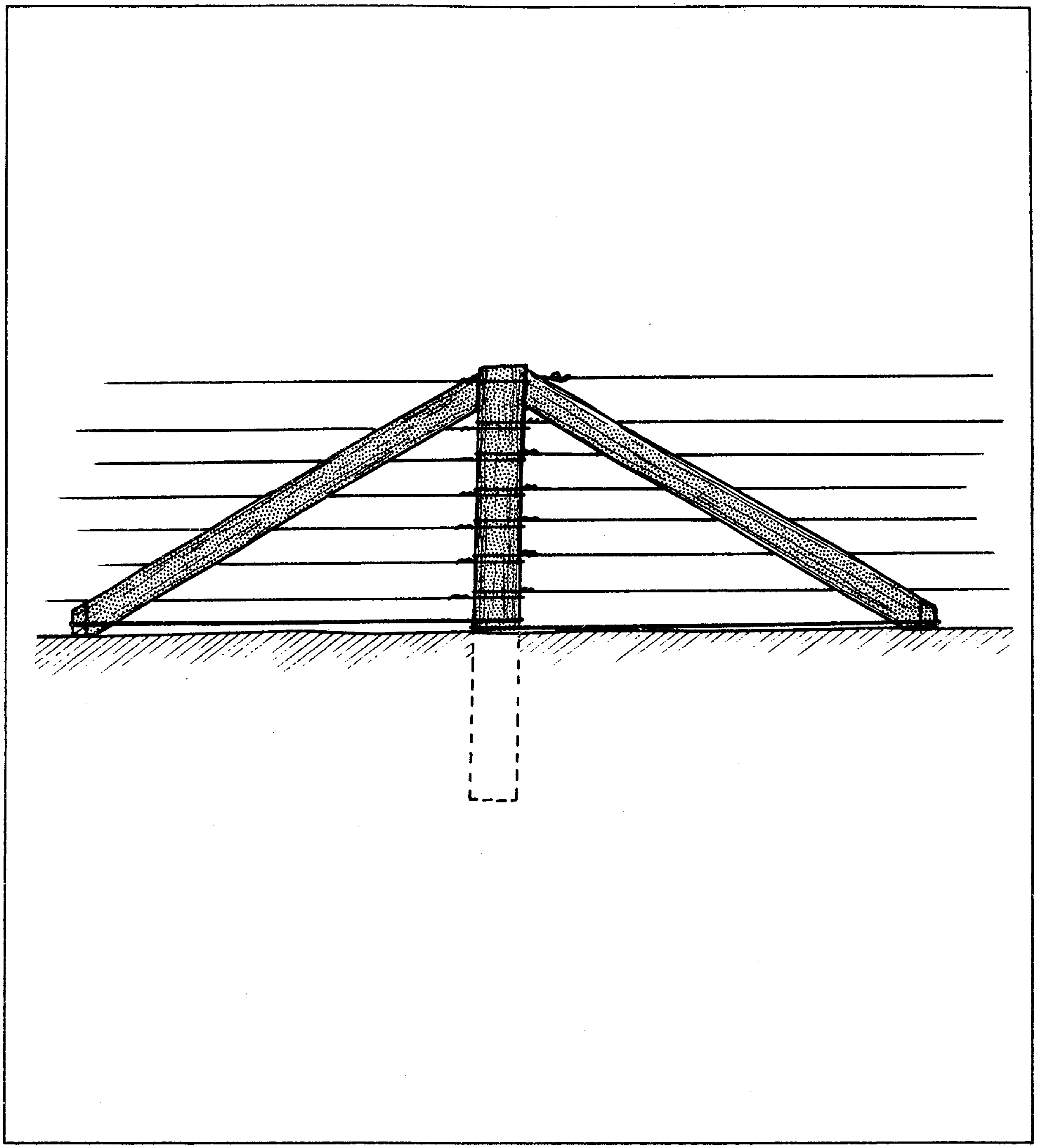

Figure 8.--Design for a line strainer, using the diagonal strainer design. When using the diagonal strainer design for a line strainer, avoid overtightening the brace wire, which would jack the post out of the ground.

Grider Creek Area Planning Contract

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INTRODUCTION

During the fall of 1980, the Klamath National Forest began considering ways to meet the increased harvest (departure) goals set by the Regional Forester. Ceiling limitations and Forest planning efforts made an in-house study nearly impossible. The Forest Engineering and Timber Staffs brainstormed solutions to the dilemma and settled on the development of a planning contract for the Grider Creek drainage. With the help of the Regional Office, a request for proposal was prepared that provided for an investigation and analysis to be completed in four phases. The resulting documents (area development plan, environmental assessment, and sale development plan) were required within a 300-day period that included only one field season. This resulted in the cost ($528,230, or $26 per acre) being somewhat higher than it might otherwise have been. The Klamath National Forest is very pleased with the resulting planning efforts and the documents, which have set a standard for the Forest's own ID teams to meet.

The Grider Creek drainage is a 20,000-acre area located on the Klamath National Forest in northern California, 30 miles west of Eureka. This pear-shaped, RARE II and California State Law Suit[1] Area is bounded by the Marble Mountain Wilderness to the south, the Klamath River to the north, and high ridges on the east and west sides.

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[1]State Law Suit Areas are RARE II Mountain Wilderness areas successfully challenged by the State of California in a law suit filed January 1980, requiring an environmental impact statement prior to Federal actions that may change the wilderness character of the area.

A FOUR-PHASE CONTRACT

The contract for developing the Grider Creek Area drainage development plan and environmental assessment required four phases that allowed Forest interaction with the planning process (see figure 1).

Phase I called for preparing a minimum of three plans for the development of the Grider Creek drainage. Each plan was to address one of three alternatives: no action, maximum production, and an alternative in between the two. In addition, the plans were to include a range of management strategies:

(1) Maximum net return to the Treasury.

(2) Maximum initial development of roading and harvest systems.

(3) Some mixes of these strategies.

The contractor produced four alternatives to meet these requirements.

Phase II consisted of the feasibility analysis of the selected plans. This required field verification and analysis of the plans, including tradeoffs, mitigation measures, issues and concerns, and resource enhancement opportunities. As a part of the documentation required in this phase, the contractor produced written inventories (such as level II soils, complete archaeological, threatened and endangered species) of the data collected during the field verification and analysis. The contractor also presented the options developed as a result of the analysis.

Phase III was the development of the final area drainage development plan, project development plan, and environmental assessment (without decision notice). The area drainage development plan report documented all the plan options considered under Phases I and II, so that any of them could be selected for implementation at a later date. All environmental assessment alternatives were fully developed, so that any could be selected. The project development plan covered the entries proposed for fiscal years 1983, 1985, and 1986.

Phase IV entailed the physical location of the roads and unit boundaries in the project development plan. Roads were flagged with intervisible orange flagging;

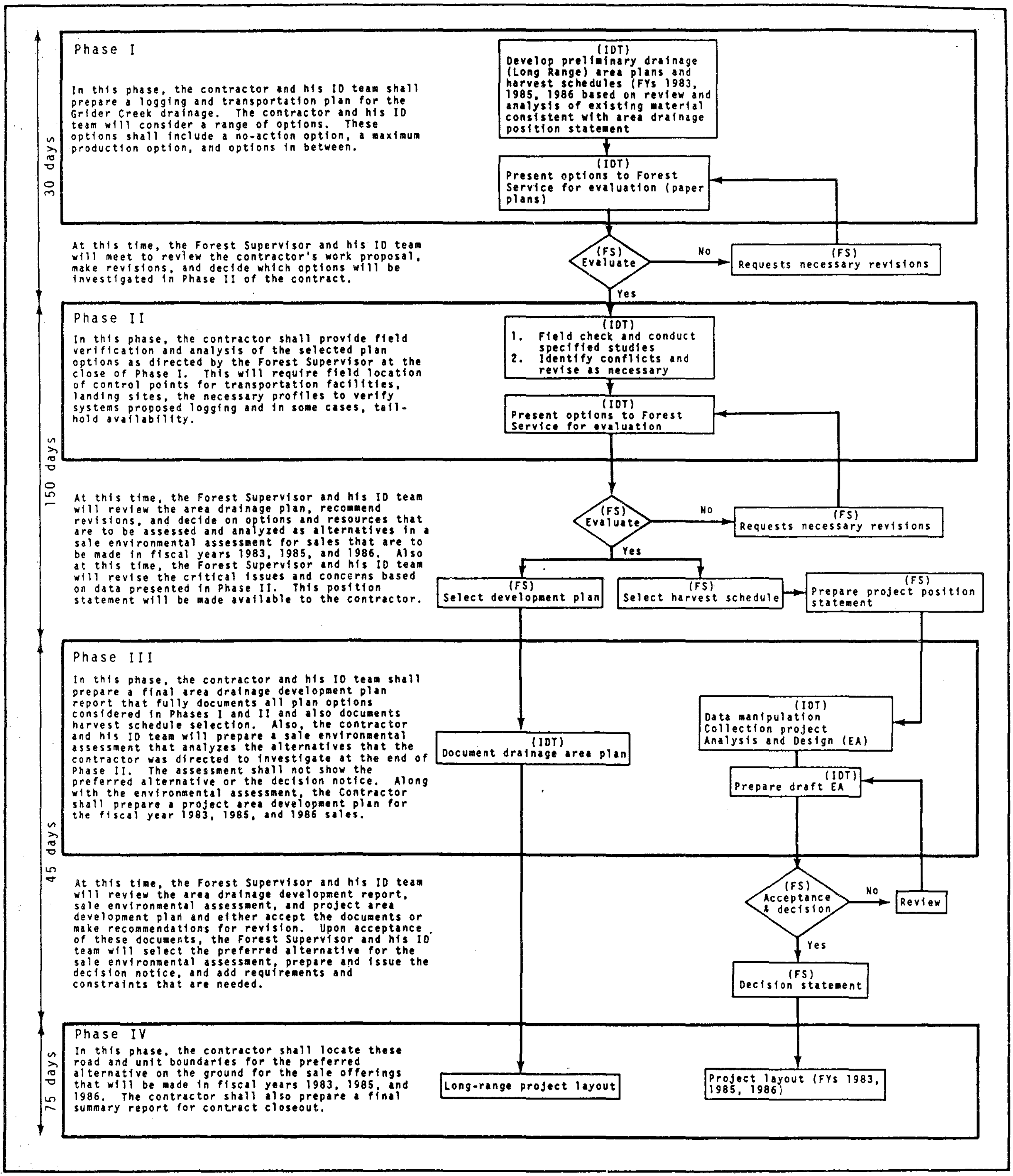

Figure 1.--Four-phase planning effort for the Grider Creek Area drainage.

landing locations and critical control points on the road system were marked with metal tags. The contractor prepared a final summary report to document any field-generated changes or conditions needing further attention.

CONCLUSION

The Grider Creek planning contract (the first of its kind) was developed to meet timber departure goals. It was a four-phase contract that allowed the Forest to monitor the progress and process closely. The final environmental assessment, area development plan, and project development plan were timely and well done; and the inventories were professionally done and the analysis excellent. The Forest reports that the results set a standard for its own ID teams to meet. Several other Regions are involved in similar efforts at this time.

Crime Analysis, Electronic Sensors, & Wilderness Management

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An electromagnetic vehicle-direction sensor was installed on an abandoned roadway within the Sandia Mountain Wilderness Area during spring 1983. The sensor data were used for the immediate apprehension of people who were operating vehicles inside the boundary of a designated wilderness area. The data proved to be even more valuable in crime analysis. A cross-tabulation analysis of the data identified the times when most violations occurred. A patrol schedule based on this analysis permitted an officer to be in the study area when 79 percent of the violations were predicted to occur. This article will discuss the characteristics of the sensor used, the techniques of data collection, and the processing of the data for crime analysis.

INTRODUCTION

Crime analysis is a method of analyzing data to determine the what, where, why, who, and how of crime. While the technique is being used increasingly in urban areas, there is also a need for it in the management of rural and undeveloped wildlands.

Effective crime analysis leads to better enforcement of laws and regulations. Better enforcement results in crime prevention. When crimes such as littering, vandalism, theft, and inappropriate use of resources are prevented, both the resources and the citizens benefit.

Under consideration in this paper is a specific crime problem in wilderness management and the techniques developed to collect data that could be used in both solving the problem and enforcing regulations. Although this specific case concerned only the wilderness resource, the techniques of data collection and data analysis can be used to quantify any law enforcement problem in any resource, activity, or area of concern.

THE PROBLEM & a SOLUTION

Some people violate rules because they are unaware of restrictions. Others are aware of restrictions but violate them in the belief that the risk of apprehension and prosecution is small. The problem is not that people are escaping apprehension after committing crimes but, rather, that the crimes are occurring and the resources are being damaged.

The solution is education. The public needs to be better informed so that willful and inadvertent violations will not occur. The objective of law enforcement is to prevent violations. Apprehension and prosecution are methods of education and therefore contribute to crime prevention. Prevention actions should be based on occurrence patterns, which can be identified by collecting and analyzing data.

THE SANDIA MOUNTAIN WILDERNESS SITUATION

The Sandia Mountain Wilderness Area is administered by the Sandia Ranger District of the Cibola National Forest. Three miles of the western wilderness boundary border the eastern city limits of Albuquerque, New Mexico. Housing developments meet the wilderness boundary in several places, and more developments adjacent to the boundary are planned. Several old roadways extend into the wilderness. They predate the area's 1978 wilderness designation by many years. Embudo Canyon, the study area, is one of several canyons that lead from the heavily developed city area into the wilderness.

Bernalillo County, including the City of Albuquerque, has a population of around 500,000, nearly one-third of the total population of the State of New Mexico. The City of Albuquerque owns and manages many blocks of undeveloped land as open spaces. These open spaces, undeveloped private land, and the Sandia Mountain Wilderness Area (in the vicinity of Embudo Canyon) are used heavily by hikers, joggers, motocross bikers, and people in off-road, four-wheel-drive vehicles. Many drivers carry cutting pliers, and all fences in the area have been cut. Generally, boundary signs are impossible to keep in place and must be replaced monthly.

At Embudo, there are 20 wilderness boundary signs posted on a five-wire fence. There are also two "indestructible" steel wilderness signs. This portion of the boundary, barely a mile long, is considered to be adequately marked. Serious soil erosion and damage to vegetative cover is occurring in all areas affected by extremely heavy off-road vehicle use. Riders and operators cross the wilderness boundary in full view of boundary signs.

SURVEILLANCE

Spartan Technology of Albuquerque manufactures a series of intrusion detection devices, including a sensor and transmitter that were used in the surveillance of activity in the Embudo Canyon area.

The Spartan Magnetic Vehicle Direction Sensor is a passive vehicular intrusion detector that produces alarm signals in response to magnetic stimuli created by the movement of vehicles within its range. The Magnetic Vehicle Direction Sensor does not require a line-of-sight environment for operation and can be concealed underground. The sensor detects movement through the use of magnetometers.

The Spartan Integral Transmitter is specifically designed for use with intrusion detectors in those installations where hard wiring the sensors into a central monitoring facility either is not feasible or is not desirable. The integral VHF transmitter is tone-encoded frequency modulated with 5 watts of output.

On April 20, 1983, a site was selected on the old roadway in Embudo Canyon inside the wilderness boundary. This appeared to be the most heavily traveled route. The two sensor magnetometers were buried about 1 foot on the edge of the road. A scattering of woody debris and a gentle raking left the area looking undisturbed. Hours later, the unit was difficult to locate.

The unit was turned on at the time of installation. The sensitivity was adjusted so that any mass of metal passing within 30 feet of the magnetometers would be detected. Two tests were conducted to ensure the unit was dependably operational. First, a shovel was tossed over the area. The shovel passed over the detectors at a height between 4 and 6 feet. Each passing was detected, and an alarm was transmitted. Second, the technician ran past the detectors as fast as he could. Each time the unit detected him because of his heavy belt buckle and large ring of keys. Walking over the detector carrying the shovel would not activate the unit.

The unit is designed to evaluate the passing of a metal mass and to transmit a tone indicating the direction of travel of the mass. In this installation, any vehicles heading into the wilderness (to the east) were identified by a series of two high tones. Vehicles going west, or out of the wilderness, were identified by a high tone followed by a low tone.

Each alarm signal generated by the sensor was transmitted to the Sandia Ranger Station. Alarm signals were recorded by both the receptionist at the Sandia Ranger Station and by the Forest Dispatcher between the hours of 8:00 a.m. and 5:00 p.m. All evening monitoring was done by an employee at home. Evening monitoring covered the hours between 5:00 p.m. and 11:00 p.m. Some alarms were undoubtely missed, and the data should not be assumed to be 100 percent accurate. The receptionist, being out of the room, on the telephone with callers, or assisting visitors, would miss alarms. The dispatcher could be out of the room or otherwise involved. Higher powered radio transmissions on the Forest net channel 1 would mask any sensor alarm transmission occurring at the same moment. Evening monitoring was very accurate.

Records kept at the three different locations were cross-checked before the final data entry sheets were prepared. Any duplicate entries were dropped at that time. Events on the separate records were considered discrete if their recorded times of occurrence were 3 or more minutes apart. An entry was considered a duplicate if its recorded, observed time was within 3 minutes of another entry and if the indicated direction of motion was the same.

In addition to gathering data about the time distribution of illegal entries of motor vehicles, the first plan called for a Forest Officer to respond to any intrusion signal that indicated that the violator was traveling into the wilderness. It soon became apparent that the volume of traffic was so great that not every alarm could be answered. The accumulating data also showed an apparently signficant imbalance between IN and OUT signals. This indicated that vehicles entering by this route had an alternative way out. An IN alarm did not guarantee that someone was in the area. Subsequent field checks confirmed that traffic was being monitored on one side of a loop travel-way system. Subsequently, alarms only were investigated on an opportunity basis, but data collection continued.

DATA ANALYSIS

The analysis and use of the data were based on three assumptions:

(1) In evaluating total activity, no distinction was made between IN and OUT alarm signals. The difference between IN and OUT was important when an officer responded, but was not meaningful in our evaluation of total activity. (In a more sophisticated statistical analysis, they should probably be evaluated separately.)

(2) The study period extended from April 21, 1983, through May 30, 1983. The distribution of events during this period was assumed to be characteristic of the remainder of the season. Subsequent scheduling of patrol coverage was based on this premise.

(3) A direct relationship between the total number of alarm signals transmitted by the sensor and the level of activity in the area was assumed.

As data were received, they were recoded in a format compatible with the Forest Service Law Enforcement Management and Reporting System (LEMARS). The entry documents were completed at the District and were sent to the Forest Supervisor's office, where the data were keyed into disk files in a true flatfile or SDF format. These files subsequently were fed into the LEMARS system. After all Embudo data had been sent to LEMARS, the raw data were analyzed. The Univac 1100 at the Forest Service Fort Collins Computer Center was used to perform a cross-tab correlation using a statistical analysis from the "Statistical Package for the Social Sciences."[1]

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[1]Norman H. Nie et al., "Statistical Package for the Social Sciences," 2d Edition, (New York: McGraw Hill, 1975).

Contingency table or cross-tabulation analysis is one of the more common analytical techniques used in the social sciences. For crime analysis, it is sufficient to understand that a cross-tabulation is simply a joint frequency distribution of events that are quantifiable by two or more variables. Cross-tabulation, then, is the display on a chart of the distribution of the events by their position on each variable.

The analysis of the Embudo data was simple and straightforward. Only two variables were analyzed--day of week and time of day. Contingency table analysis permits the evaluation of effects of third, fourth, fifth, and more variables if a manager should choose to do so. For example, the changes in the distribution of events by month could be evaluated.

The analysis performed on the Embudo data yields information that management at all levels can use. The result is a bivariant table displaying the occurrence of events by day for each block of time. With this analysis, a manager can quickly recognize when officers should be assigned to problem areas.

The results of the analysis are shown in table 1. The cross-tabulation analysis proved to be of exceptional value in making decisions about scheduling patrols in an area. A Forest Officer was scheduled to patrol Embudo Canyon if the number of events during a time block equaled or exceeded 1.5 percent of the total events occurring during the study. One block of time (9 a.m. to 10 a.m. on Wednesday) met this criterion but was not included because it was not economically feasible to send an officer to the area for that one, relatively isolated block of time.

A sample patrol schedule for Embudo Canyon might look like this:

Sunday	11:00 a.m. to 7:00 p.m.
Monday	1:00 a.m. to 5:00 p.m.
Tuesday	2:00 a.m. to 3:00 p.m. and 4:00 p.m. to 5:00 p.m.
Wednesday	noon to 1:00 p.m. and 3:00 p.m. to 5:00 p.m.
Thursday	1:00 p.m. to 6:00 p.m.
Friday	6:00 p.m. to 7:00 p.m.
Saturday	2:00 p.m. to 5:00 p.m.

Table 1.--Cross-tabulation table, Embudo Canyon Wilderness encroachment data analysis.[1]

TIME OF DAY IN 1-HOUR INCREMENTS / DAY OF THE WEEK

COUNT ROW PCT COL PCT TOT PCT	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	ROW TOTAL
8:00 am	0 .0 .0 .0	0 .0 .0 .0	0 .0 .0 .0	1 100.0 3.6 .4	0 .0 .0 .0	0 .0 .0 .0	0 .0 .0 .0	1 .4
9:00	3 25.0 3.8 1.1	1 8.3 2.4 .4	0 .0 .0 .0	5 41.7 17.9 1.9	1 8.3 2.2 .4	0 .0 .0 .0	2 16.7 5.6 .8	12 4.6
10:00	2 66.7 2.6 .8	0 .0 .0 .0	0 .0 .0 .0	0 .0 .0 .0	0 .0 .0 .0	0 .0 .0 .0	1 33.3 2.8 .4	3 1.1
11:00	11 68.8 14.1 4.2	0 .0 .0 .0	3 18.8 12.5 1.1	0 .0 .0 .0	1 6.3 2.2 .4	0 .0 .0 .0	1 6.3 2.8 .4	16 6.1
12:00	8 38.1 10.3 3.1	1 4.8 2.4 .4	0 .0 .0 .0	6 28.6 21.4 2.3	2 9.5 4.4 .8	0 .0 .0 .0	4 19.0 11.1 1.5	21 8.0
1:00 pm	5 21.7 6.4 1.9	8 34.8 19.0 3.1	0 .0 .0 .0	2 8.7 7.1 .8	5 21.7 11.1 1.9	1 4.3 12.5 .4	2 8.7 5.6 .8	23 8.8
2:00	15 31.3 19.2 5.7	5 10.4 11.9 1.9	9 18.8 37.5 3.4	2 4.2 7.1 .8	11 22.9 24.4 4.2	0 .0 .0 .0	6 12.5 16.7 2.3	48 18.4
3:00	7 20.6 9.0 2.7	5 14.7 11.9 1.9	0 .0 .0 .0	7 20.6 25.0 2.7	4 11.8 8.9 1.5	0 .0 .0 .0	11 32.4 30.6 4.2	34 13.0
4:00	8 13.8 10.3 3.1	16 27.6 38.1 6.1	7 12.1 29.2 2.7	5 8.6 17.9 1.9	14 24.1 31.1 5.4	3 5.2 37.5 1.1	5 8.6 13.9 1.9	58 22.2
5:00	12 50.0 15.4 4.6	3 12.5 7.1 1.1	1 4.2 4.2 .4	0 .0 .0 .0	6 25.0 13.3 2.3	0 .0 .0 .0	2 8.3 5.6 .8	24 9.2
6:00	6 33.3 7.7 2.3	3 16.7 7.1 1.1	3 16.7 12.5 1.1	6 .0 .0 .0	0 .0 .0 .0	4 22.2 50.0 1.5	2 11.1 5.6 .8	18 6.9
7:00	1 33.3 1.3 .4	0 .0 .0 .0	1 33.3 4.2 .4	0 .0 .0 .0	1 33.3 2.2 .4	0 .0 .0 .0	0 .0 .0 .0	3 1.1
COLUMN TOTAL	78 29.9	42 16.1	24 9.2	28 10.7	45 17.2	8 3.1	36 13.8	261 100.00

[1]Explanation of the Analysis Format: All recorded events are arranged by day and by hour within the day. Each "box" contains four numbers. The first number in the box column is the count of events that occurred on that day within that block of time. The second number represents the percentage of total events that occurred during this block of time for all days. The third number is the column percentage and represents the percentage of total events at this hour that occurred on the specified day. The fourth number is a total percentage figure and represents the percentage of all events in the study.

The row totals (on the right side of the table) show the total number of events occurring during a block of time for all days and the percentage of events that occurred during that time.

The column total (across the bottom of the table) shows the total number of events occurring during a day for all blocks of time and the percentage of events that occurred on that day.

In Embudo Canyon, this scheduling permitted having a uniformed officer present when 79 percent (206 of 261 events) of the violations were predicted to occur. This, it was assumed, would be a strong deterrent to potential violators. Deterrence is crime prevention. During time blocks of lower activity, attention could be given to other high-priority needs.

CONCLUSION & OBSERVATIONS

(1) The electromagnetic sensing unit proved to be of significant value in identifying the parameters of a problem in wilderness encroachment by motorized vehicles.

(2) The unit appears to be extremely accurate, and the data transmitted is indicative of real events.

(3) The accuracy of data collection is more than acceptable when recorded by people monitoring the radio. Accuracy could be improved by using an automatic recording system.

(4) The unit is easily camouflaged. The Embudo unit was not discovered by any of the hundreds of passersby in the area. It was difficult to relocate the unit after it had been left in place for 6 weeks.

(5) The data supplied by the unit are extremely valuable in making decisions about the scheduling of personnel to enforce law and regulations. Crime analysis is dependent upon valid and reliable data.

(6) There are significant and major cost advantages to using sensors in the surveillance of problems areas. The costs for the Embudo Canyon project are as follows:

   (a) Cost for the sensor unit (purchase price of $228) amortized over 10 years equals $4.39 per week $21.95

   (b) Cost of recording the data . . . . $ 0.00

   (c) Cost of data entry (at contract cost of 10 cents per line) $26.50

   (d) Installation of unit on site (estimate) $40.00

(d) Cost of Univac time share for SPSS Analysis . . . . $ 0.58

TOTAL COST $89.03

For comparison purposes, collecting the identical data by using employees is outlined as follows. This rough cost is based on a 16-hour monitoring period requiring two GS-3 people onsite 7 days per week with daily travel.

(a) Cost of salary, straight-time for 112 hours per week at a 1983 rate of $5.50 per hour $3080.00

(b) Cost of daily travel . . . . . . $ 420.00

TOTAL COST $3500.00

OTHER USES for SENSORS

By using magnetic sensors, infrared units, seismic units, pressure sensitive units, and visible spectrum light detectors either independently or in combination, many kinds of problems can be analyzed. Table 2 lists 40 possible uses for sensors.

Table 2.--Some possible uses for remote sensors.

Monitoring fuelwood and timber theft
Hunting violations (spotlight)
Detecting Wilderness Area intrusions
Detecting vehicles in areas closed to off-the-road vehicles
Protecting threatened and endangered species
Detecting theft of topsoil, gravel, stone, and other products
Detecting unauthorized activities on unpatented mining claims
Detecting illegal entry in lookouts, buildings, and remote stations
Ensuring security of air tankers and helicopters
Determining trail and road traffic counts and patterns, and so forth
Detecting fires in sites, areas, and structures
Detecting entry by persons into areas closed for public safety
Monitoring use patterns in picnic areas or campgrounds
Detecting vandalism to signs, toilets, bridges, and so forth

Table 2. (cont.)--Some possible uses for remote sensors.

Detecting illegal road construction in sensitive areas
Detecting the cutting of unmarked trees in a timber sale area
Detecting the opening and closing of gates and trespass by livestock
Detecting the occurrence of repeated fence cutting
Detecting the use of firearms in game refuges
Detecting people in an area closed to overnight use
Detecting the disturbance of impounded livestock
Detecting the digging of wildlings
Monitoring activities at archaelogical sites
Monitoring severe wild-dog problems in confined areas
Detecting the presence of horses, cattle, sheep, and goats in areas closed to their presence
Monitoring camping in sensitive areas closed to camping
Monitoring traffic patterns in areas where law violations are occurring
Detecting and monitoring illegal residency in shelters or caves
Detecting excessive noise in picnic areas or campgrounds
Detecting landing of aircraft on closed areas
Detecting use of roads closed to the public
Detecting bicycles on wilderness trails
Detecting motorized watercraft on restricted waters
Detecting use of or swimming in closed bodies of water
Monitoring emergency wildfire conditions (such as potential blowups on "secure" lines)
Monitoring the movement of wildlife species
Monitoring suspected violations of prescribed use patterns in grazing allotments
Monitoring areas where illegal dumping is a constant problem (such as closed dumps)

Prestressed, Treated Timber Bridges

Clyde Weller
Chief Road Structures Engineer
Washington Office

Transverse prestressing of wood was conceived in 1976 as a method for rehabilitating nailed laminated wood decks. Since then, the concept has become the subject of a major development program, aimed at revitalizing wood as a viable design alternative in bridge construction. This paper highlights the development of this type of construction from its original application to existing bridges, to the subsequent research and development leading to its inclusion in the Ontario Highway Bridge Design Code. Various field applications are discussed, including the recent design and construction of the first prototype prestressed wood bridge. Transverse prestressing increases load distribution and results in a very efficient load sharing system. It promotes the use of lower grade materials, utilizes renewable resources, and requires far less energy than other construction materials.[1]

The design and construction process for prestressed, treated timber bridges has been researched and tested in the field. It offers an economical method for building short- and medium-span bridges. It also offers a method for rehabilitating nailed, laminated treated timber decks.

---

[1]The executive summary is from the report "Prestressed Wood Bridges" by R. J. Taylor, B. Dev. Batchelor, and K. Van Dalens. The text was published by the Research and Development Branch of the Ontario Ministry of Transportation and Communications.

Prestressed, treated timber bridges have been built in Canada at costs estimated to be two-thirds the costs of conventional steel and concrete bridges. It is time to implement this relatively new technology in the United States.

We have glued laminates together to avoid delamination found in nailed, laminated decks. Glue-laminating increases strength tremendously because it distributes loads better and the laminates act as a unit rather than separately. The laminates can be either transverse or longitudinal. The main problem with this process is that it is expensive and joints are necessary every 4 feet or so.

Timber laminates are prestressed by predrilling the laminated members, facing the external laminate with a continuous steel channel member (for bearing strength), threading a tension rod through the laminates, and uniformly tensioning all rods (see figure 1).

The prestressing system shown in figure 2 is used to rehabilitate nailed, laminated decks that have become delaminated.

For new construction, the Fox Lake Bridge near Espanola, Ontario, provides an excellent prototype design (see figures 3 and 4). This bridge, which is 42 feet long with 2- by 12-inch deck laminates and 2- by 8-inch leg laminates, withstood a 200-ton load test with a mid-span deflection of only $\frac{3}{8}$ inch. Obviously, this bridge was overdesigned, yet its cost was two-thirds the cost of a conventional concrete bridge.

A prototype of a floor truss that is based on the truss-frame home concept is being designed and built to test further prestressed timber. Chord members of 2 by 6 inches will carry the AASHTO HS 20 loads on up to 50-foot spans. Further information will be forthcoming in early 1986. It appears that a 40-foot span with 6-inch chords and a 24-inch depth, a 50-foot span with 6-inch chords and a 30-inch depth, and a 60-foot span with 8-inch chords and a 32-inch depth will work.

Deflection or longitudinal stiffness is the controlling design criteria. For copies of the Canadian paper write to the Editor, Research and Development Branch, Ministry of Transportation and Communications, 1201 Wilson Avenue, Downsview, Ontario M3M 1J8, Canada.

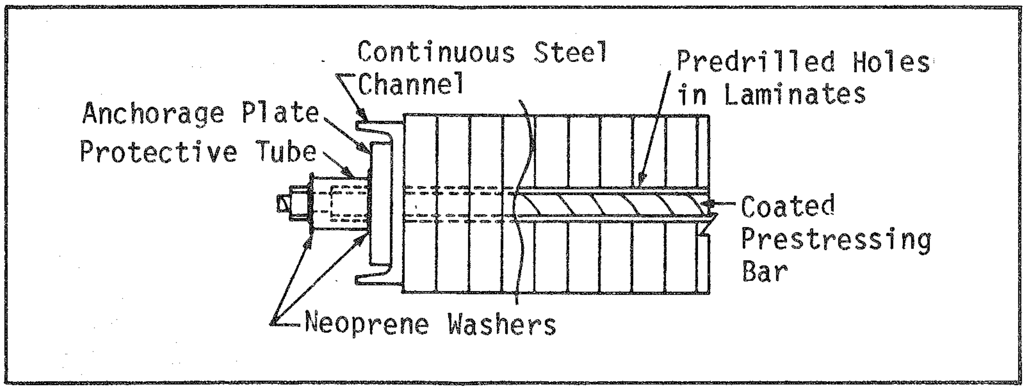

Figure 1.--Prestressing system for new construction.

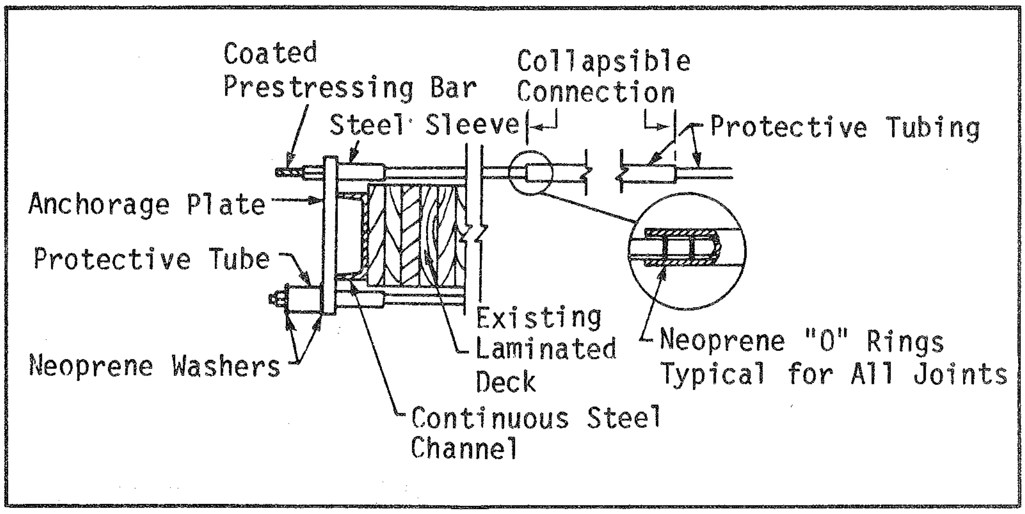

Figure 2.--Prestressing system for rehabilitation.

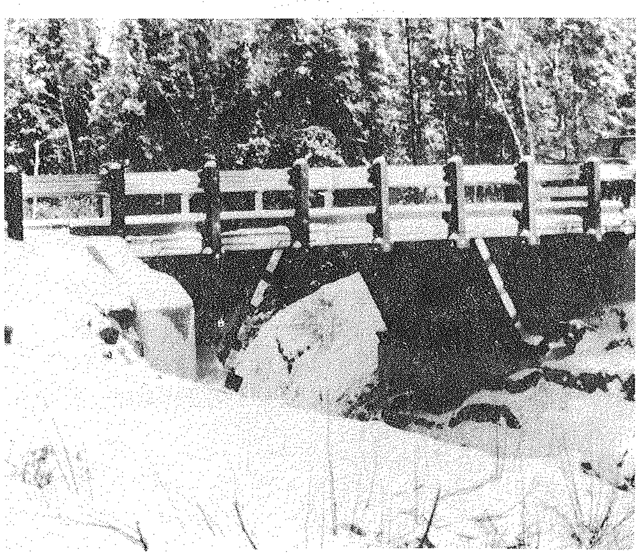

Figure 3.--Fox Lake Bridge, MNR Sudbury.

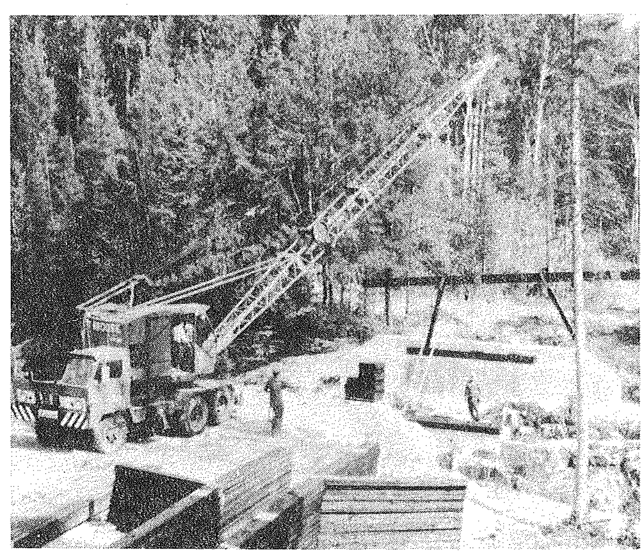

Figure 4.--Fox Lake Bridge assembly.

Potential Use of Regression Analysis in Road Cost Estimation

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This article is presented in Field Notes to increase awareness of the potential use of regression analysis in construction cost estimating. The system concept is adaptable to any construction cost estimate. This article does not intend to suggest weakness or deficiency in current Forest Service policies or practices but rather is intended to illustrate a potential application of regression analysis.

INTRODUCTION

In conventional practice, road costs are estimated by constructed costs, historical bids, or a combination of the two. The constructed cost method uses production rates, labor and equipment costs, profit and risk, taxes, and material costs to estimate the unit price of a particular work item. In contrast, the historical bid approach estimates the unit price using the weighted average of bids submitted by contractors during a specified period of time. These unit prices are adjusted by a cost-trend factor to reflect future costs before they are used to forecast the project cost for the planning years under consideration.

The present study uses regression analysis to develop a unit-price-estimating model based on historical bid data. This study develops its model from a sample of 26 new timber sale construction projects.

DATA SOURCE

A sample of 26 projects was collected from the Pacific Southwest Region (Region 5), which includes the State of California. The sample includes most of the timber sale road projects in the Region where the bids took place during the 1980-82 period. The Region's automated bid-tabulation system provided the information on quantities, bid cost, and engineering cost estimates. A questionnaire was used to collect other road characteristics, such as side slope and clearing.

The construction activities included in this study were chosen according to Forest Service "Standard Specifications for Construction of Roads and Bridges." The six components under consideration are engineering, earthwork, bases, pavement, bridge, and incidentals.

A review of past projects in Region 5 indicated that, although the relative proportion of the total cost attributable to each of the components varies from job to job, earthwork costs generally constitute the largest portion of the total--nearly 50 percent. The breakdown of the construction costs for the 26 timber sale roads in Region 5 is approximately as follows:

Item	Percentage of Total Construction Cost
Engineering	2.7
Earthwork	46.9
Bases	26.4
Pavement	4.1
Bridge	0.7
Incidentals	19.2

While these six components will be used as explanatory variables for estimating total construction cost of a project, 14 major items were chosen for estimating unit prices.

METHODOLOGY

The system assumes that the bid price is a function of project characteristics, including road characteristics and project quantity. Road characteristics reflect the required effort and cost for completing the project, while project quantity indicates the size of project. These factors may affect the bidder's bidding behavior and bid cost. The project characteristics are as follows:

(1) Side slope percent.

(2) Soil condition.

   (a) Common (percent).

   (b) Solid rock (percent).

   (c) Riprap (percent).

(3) Clearing.

   (a) Light (percent).

   (b) Medium (percent).

   (c) Heavy (percent).

(4) Remoteness (travel distance in miles from center of local community to project).

(5) Length of road (miles).

(6) Net gradient of the project (percent).

(7) Complexity of project (in terms of number of items).

(8) Quantity of project (by items or overall).

Notice that, in addition to the aforementioned factors, socioeconomic conditions, including per capita personal income, unemployment rate, the number of construction workers, and the number of bidders, also were used to examine the bidding behavior. However, this study found that these factors have no significant bearing on the bid cost.

Model Structure

Assume unit price (U) as a function of road characteristics (y_r) and quantities (q_k).

That is,

$$U = a + \sum_{k=1}^{d} b_k q_k + \sum_{r=1}^{e} b_r y_r$$

where a and b are constants to be estimated by using empirical data. The variables r and k represent the number of road characteristics and quantity of work items, respectively.

The 14 major items mentioned earlier that were selected for unit price estimate are as follows:

(1) 201 (01) Clearing and grubbing.

(2) 201 (03) Clearing and grubbing.

(3) 203 (01) Excavation Method 1.

(4) 203 (02) Excavation Method 2.

(5) 203 (03) Excavation Method 3.

(6) 304 (01) Crushed aggregate.

(7) 306 (01) Reconditioning of roadbed.

(8) 408 (01) Liquid asphalt.

(9) 601 (01) Mobilization.

(10) 603 (01) Corrugated metal pipe.

(11) 611 (01) Pit development.

(12) 619 (01) Hard-placed riprap.

(13) 621 (01) Spillway inlet assemblies.

(14) 625 (03) Seeding, hydraulic method.

The regression analysis was used for the model development. The computation was made in a stepwise fashion--that is, entering a variable one at a time--using the Statistical Package for the Social Sciences that is available from the Fort Collins Computer Center.

MODEL CALIBRATION

As shown in table 1, unit price equations have been developed for the 14 major cost items. The table indicates that the unit price of clearing and grubbing in terms of dollars per acre is related to the percentage of clearing in the light category, the side slope, the road length, and the time of the year when the bid took place. The first two variables represent the requirement of effort involved, and the third variable serves as a surrogate for project size. The signs for these three variables are as expected. The variable for the time of the year is a dummy variable that equals 1 for the time period of April to September, and 0 otherwise. This means that for bids taking place

Table 1.--Unit price models.

Specifications Number	Description of Items	Unit Price Models	R^2	Mean ($/Unit)	Standard Error of Estimate	Durbin-Watson Test
201 (01)	Clearing and Grubbing ($/AC)	$U=2987.49-14.6864X_1-1.805X_2-213.5127X_3+11.2200X_4$	.2194	2742.45	1359.57	1.7461
201 (03)	Clearing and Grubbing ($/Mi)	$U=1667.82-174.6936X_5+48.0763X_4$	.3538	1196.23	1820.34	1.7184
203 (01)	Excavation, Method 1 ($/CY)	$U=2.63-.0140X_6-.00036X_2$	.7628	1.96	0.38	2.1573
203 (02)	Excavation, Method 2 ($/CY)	$U=2.78+.0715X_7-1.2506X_3-.00053X_2$	.8731	2.09	0.42	1.7052
203 (03)	Excavation, Method 3 ($/CY)	$U=8.02-.7174X_2$	.6964	3.94	1.56	2.1752
304 (10)	Crushed Aggregate ($/CY)	$U=19.54-.00108X_8-.00198X_2$	.9309	1.34	13.66	3.1312
306 (01)	Reconditioning of Roadbed ($/Mi)	$U=286.19+14.3063X_4-68.1271X_3$	.2898	847.67	267.03	1.7702
408 (01)	Liquid Asphalt ($/ton)	$U=266.19-.1568X_{10}-.7525X_6$	.8865	195.00	130.51	1.9974
601 (01)	Mobilization ($/job)	$U=1555.82+125.0380X_9-8.6642X_2+213.4994X_6$	.7539	13324.95	9422.94	2.2350
603 (01)	Corrugated Metal Pipe ($/Foot)	$U=26.61+3.2709X_7-.2364X_4-.0013X_2$	.7955	25.73	10.22	1.1010
611 (10)	Pit Development ($/Pit)	$U=3472.56+65.2432X_{11}-2359.7274X_3-.2272X_{12}$	.9271	1714.29	760.02	1.8307
619 (01)	Hand-placed riprap ($/CY)	$U=70.39-5.5560X_2$	.3549	47.47	22.19	2.3570
621 (01)	Spillway Inlet Assemblies ($/each)	$U=4.64+2.5157X_7+1.4864X_9+.5282X_4+.7984X_{11}$	.7933	88.85	18.08	1.8184
625 (03)	Seeding, Hydraulic Method w/mulch ($/AC)	$U=502.11-74.9600X_{13}+20.7764X_4$	.4320	902.71	501.77	1.1744

Where U = Unit price ($1,000 per unit).
X_1 = Percent of clearing in light category (%).
X_2 = Length of road (mi).
X_3 = Time of year (1 for the months April to September, 0 for the rest of the year).
X_4 = Side slope (%).
X_5 = Clearing and grubbing (AC) - 201 (03).
X_6 = Total excavation (1000 CY).
X_7 = Percent of solid rock (%)
X_8 = Crushed aggregate (CY) - 304 (01).
X_9 = Remoteness (miles from local community to project).
X_{10} = Liquid asphalt (ton).
X_{11} = Percent of rip rock (%).
X_{12} = Pit run aggregate (CY) - 304 (01).
X_{13} = Seeding, hydraulic method with mulch (AC) - 625 (03).

R^2 = Coefficient of determination (ranges from 0 to 1 for the quality of model from poor to perfect).

Note: Standard error of estimate = $\sqrt{(u-\bar{u})^2/(n-2)}$ where $\bar{u}$ is the mean, u is the estimated value, and n is the number of observation.

during the construction season, the unit price of clearing and grubbing is $213 per acre lower than for off-construction season bids. The coefficient of determination R^2 for the equation is 0.2194.

When clearing and grubbing is measured by dollars per mile, the unit price can be explained by quantity and side slope. As expected, the unit price tends to decrease when the size of the project increases. On the other hand, the increase in side slope tends to increase the unit price. The coefficient of determination R^2 of the model is 0.3538.

The size of the project in terms of road length has been found to be a significant variable for explaining the unit price of excavation no matter which of the three methods is used. However, the unit price for excavation method 1 also is related to the total excavation of a project, while the unit price of method 2 is affected by the percent of solid rock and the time of the year when the bid took place. The models for the unit prices for the three methods of excavation are significant, with R^2 ranging from 0.6964 to 0.8731.

Two models have been developed for the component of bases. One is for crushed aggregate, and the other is for reconditioning of roadbed. The unit price of crushed aggregate is related strongly to the quantity of crushed aggregate and the road length. The coefficient of determination R^2 is equal to 0.9309. The unit price for reconditioning the roadbed can be explained by side slope and the time of the year when the bid took place. However, R^2 for the model is only 0.2898. The low value of R^2 is due to the stability of the unit price for this item.

The unit price of liquid asphalt is strongly related to the quantity of liquid asphalt and the total excavation. The model indicates that the liquid asphalt unit price tends to be low when the quantities of asphalt and excavation are large. For paved roads, excavation accounts for more thqn half of new construction costs and may represent the size of the project. Therefore, the tradeoff between the liquid asphalt unit price and excavation quantity is as expected. However, this tradeoff is ignored in the conventional cost estimate approaches. The model has an R^2 as high as 0.8865.

The last six models listed in table 1 were developed for six major items of incidental construction. As expected, the cost of mobilization is related strongly to the remoteness of the site--the distance from the local community to the project site--and the length of the road. Since the remoteness reflects the transportation cost and the road length represents the size of project, the bidder considers distance as the major factor for determining mobilization cost and is willing to trade off this cost with the cost of other items. The model has a significant coefficient of determination, with R^2 equal to 0.7539.

The unit price of corrugated metal pipe can be explained by the percent of solid rock, the side slope, and the road length. Solid rock requires extra effort for excavation and, thus, tends to increase unit price. On the other hand, steep ground requires less effort for pipe installation, tending to reduce unit price. The equation also indicates that the bidder is willing to trade off the unit price of corrugated metal pipe with the size of the project in terms of road length in miles. The unit price of pit development is a function of the percentage of riprap, the quantity of aggregate, and the time of year when the bid took place. As expected, riprap increases difficulty in pit development and raises unit price. However, the cost would be reduced if the quantity of aggregate to be produced is large or the bid takes place during the construction season. These two models are highly significant, with R^2 equal to 0.7955 and 0.9271, respectively.

The unit price of hand-placed riprap is related to road length. In this case, the road length represents the size of the project or the quantity of hand-placed riprap, or both. Therefore, the longer the road segment is, the lower the unit price of hand-placed riprap.

Four important explanatory variables included in the model for the unit price of spillway inlet assemblies are percent of solid rock, remoteness, side slope, and percent of riprap. All four factors tend to increase the unit price of spillway inlet assemblies as a result of the difficulty in installation or high transport cost.

The unit price of seeding, hydraulic method with mulch, can be explained by the quantity of seeding, hydraulic method with mulch, and the side slope. The coefficients of determination of R^2 for these models are 0.3549, 0.7933, and 0.4320, respectively.

The foregoing discussion indicates that the unit price is determined by the level of effort a job requires, as defined by side slope, category of clearing, type of soil, and project size in terms of road length or quantities of specific items. On the one hand, the more the required effort is, the higher the unit price; on the other hand, the larger the project, the lower the unit price.

CONCLUSION

Multiple regression analysis was applied to historical bid data to develop estimating models for determining construction costs of future hypothetical Forest roads. A sample collected from Region 5 located in California was used to develop 14 unit price equations for major items. In the modeling, 13 project characteristics were identified and analyzed as the independent variables of unit price equations.

It was found that the bid price is a function of the effort required to complete a particular job item and the size of the project overall. The effort is defined by the level of clearing and grubbing, the side slope, the soil conditions, and the remoteness of the job site, while the project size is described by the quantity of a particular job item. Less effort and larger projects tend to lower the unit price, and the converse is also true that greater effort and smaller projects have higher unit prices. Equations were developed from a limited sample in Region 5. Transferability to other Regions has not been tested, and experimental use of these equations requires verification of local data samples.

Topographic Mapping Using Airborne Laser & Radar Profile Data: Three Case Studies

Roger Crystal
Region 6
& Ray Jensen
Region 10
& John Peters
Northeastern Station
& Henry Lachowski
Washington Office
& Paul Simmons
Washington Office

INTRODUCTION

National Forests require reliable, current topographic maps of heavily forested mountainous terrain. This information is needed by Timber Management for logging systems planning and by other groups who require good terrain information for field work. Topographic maps of heavily forested areas produced by conventional techniques (photogrammetric compilation) have, in many cases, vertical errors in excess of 100 feet. Since it is very time consuming and expensive to obtain accurate topographic data by field surveys, Forest Service Engineering is investigating new remote-sensing techniques to satisfy this requirement. The techniques described here include the use of airborne laser and radar systems.

The groups listed below conducted three interrelated studies that investigated laser and radar technology:

(1) The Geometronics Development group of Washington Office Engineering and the Renewable Resources Evaluation group of the Northeastern Station, in cooperation with the National Aeronautics and Space Administration (NASA), Wallops Flight Center (Wallops Island, Virginia).

(2) Region 6 Engineering.

(3) Region 10 Engineering.

This report summarizes the Forest Service experience with the laser and radar technology; it does not include technical details or descriptions of hardware.

OBJECTIVES

The objectives of these studies are to

(1) Gain understanding of the state of the art in laser and radar mapping and gain experience with specific techniques.

(2) Determine the quality of contour maps generated from laser and radar data for densely forested terrain.

(3) Determine the feasibility of using laser and radar mapping techniques on a production basis.

(4) Derive parameters that may be helpful in forest inventory (for instance, tree heights, density, and so forth).

In general, the study conducted by the Washington Office and the Northeastern Station addressed the objectives from the point of view of development--where is the technology, and what is necessary to adapt it to Forest Service use? Studies conducted by Regions 6 and 10 involved operational tests of the technology. Both Regions contracted with commercial vendors to perform mapping over specific test areas to Forest Service specifications.

BACKGROUND

Airborne laser and radar mapping is performed in areas where conventional techniques are insufficient or too expensive (for instance, dense tree canopies, inaccessible areas, and so forth). Engineering requirements for mapping usually call for penetrating vegetation cover and maintaining vertical and horizontal control of the aircraft to specified accuracies. The "airborne system" therefore combines a laser or radar transceiver ranging instrument and a 3-axis aircraft positioning system (such as a ground-based microwave system). Electromagnetic wave pulses emitted by the laser or radar reflect from the ground or treetops or other objects on the ground (see figures 1 and 2). Elevation and positional data determined from the energy returning to the transceiver are used in creating a contour map. High pulse density ensures that a sufficient number of wave pulses will penetrate the forest canopy and reflect from the ground surface to define the shape of the terrain along the flight path (the transect). System output is a digital tape providing parameters for x,y,z position computations for both the aircraft and the point of measurement. A framing camera is

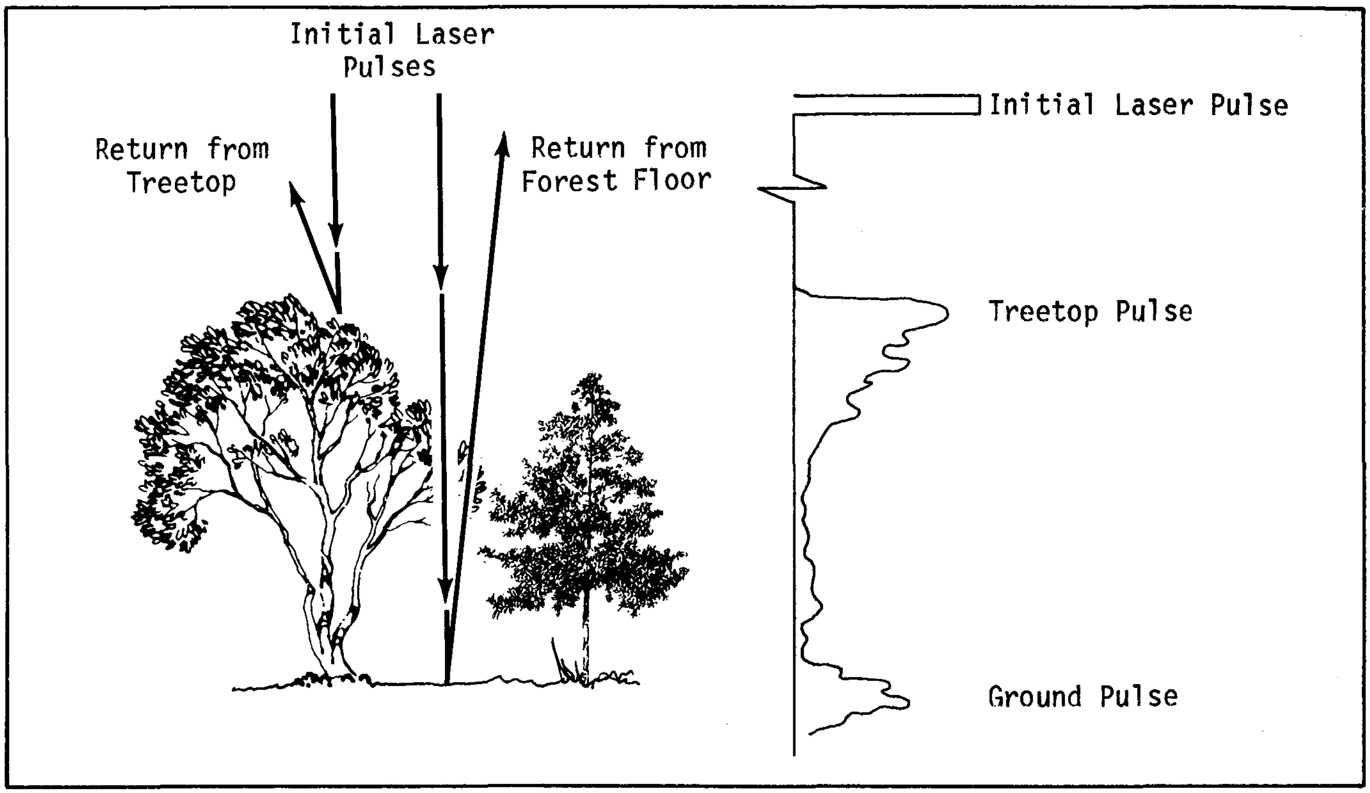

Figure 1.--Return signals from reflection of laser pulses in a forest terrain.

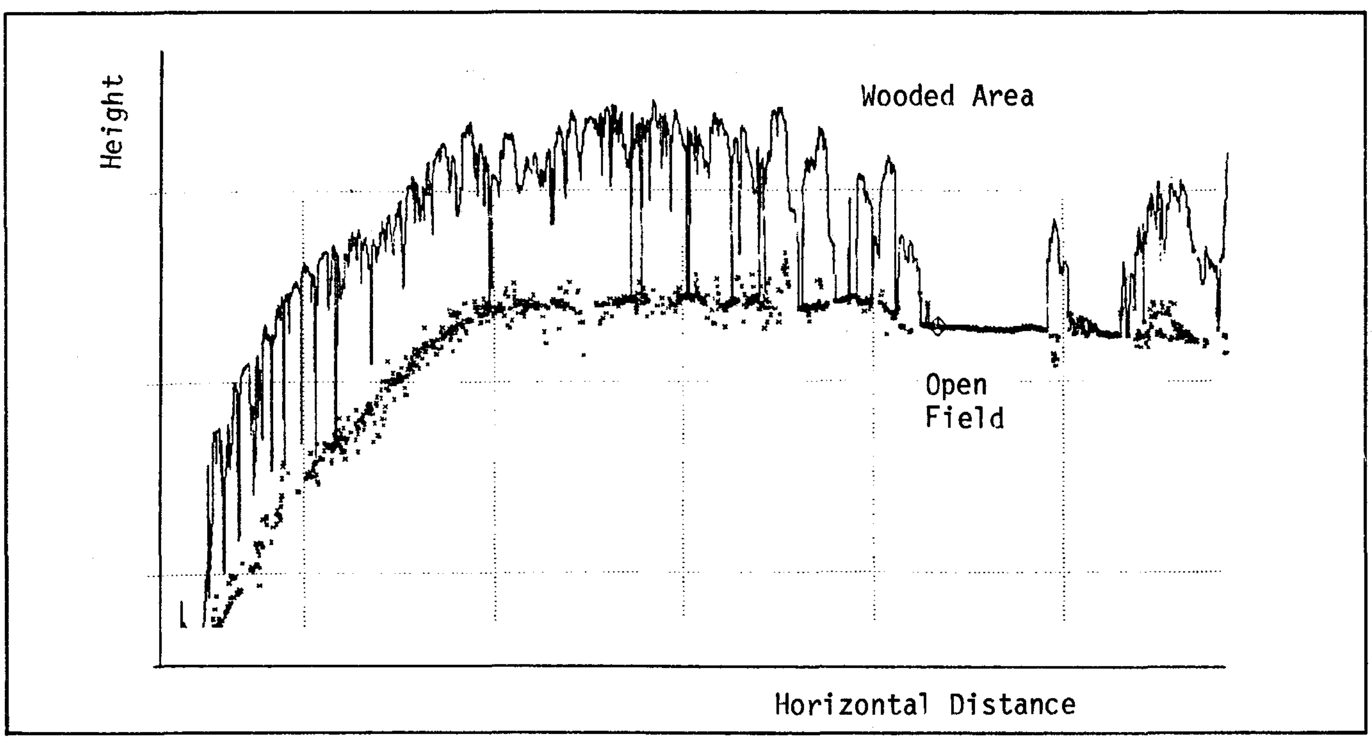

Figure 2.--Example of a terrain profile generated by an airborne laser mapping system.

boresighted to the laser for scene and ground truth correlations. At a rate of 10 pulses per second, and with the aircraft flying at an altitude of 915 meters (3,000 feet) at a speed of 216 kilometers per hour (135 miles per hour), survey measurements are made every 6 meters (20 feet) along the flight path with a laser spot diameter of 3 meters (10 feet). An adjustable laser divergence can vary the spot diameter.

PROCEDURE

East Coast Study--Northeastern Station & Washington Office Engineering

The east coast study was conducted in cooperation with NASA's Wallops Flight Center, over a test site located in the Holyoke Mountain Range of Massachusetts. The site, known as Mt. Tom, has a mixed forest cover (coniferous and deciduous), an elevation relief of approximately 1,000 feet, and a slope of up to 100 percent. The site was within range of NASA aircraft based at the Wallops Flight Center and in proximity to Northeastern Station field crews. NASA collected and reduced the data using an airborne oceanographic lidar.

The procedure after site selection was as follows:

(1) NASA collected laser data using an airborne oceanographic lidar with ground support from the Northeastern Station. Ground positioning for laser data was determined with the use of large-scale aerial photography acquired along with the laser data.

(2) The Northeastern Station collected timber inventory data at several sample points. These data were used to estimate timber volume to be used in verification of parameters computed from the laser data.

(3) A photogrammetric map of the test site was generated by the Geometronics Service Center, Salt Lake City, Utah.

(4) A ground survey of the test site was performed by surveyors from the Green Mountain National Forest.

(5) Elevation data collected by laser were evaluated using the aerial photography and ground survey data.

Region 6 Study

Region 6 awarded a contract to Teledyne Geotronics of Long Beach, California, in May 1983 to map 36 square miles of the Silver Peak Planning Area on the Siskiyou National Forest in southwest Oregon. The required product was a topographic map at a scale of 1 inch equals 400 feet with a 20-foot contour interval. The area to be mapped contained old growth timber with a close crown, heavy understory, and extreme topographic relief, which precluded exclusive use of traditional photogrammetric mapping methods. Teledyne proposed to map the area using a combination of remotely sensed data, conventional photogrammetry mensuration and compilation, airborne profiling with forest-penetrating radar (FPR), digitizing, and automated contouring.

The airborne profiling system proposed by Teledyne contained a Model II FPR, a static pressure-sensing unit, a small tracking camera, and a strip-chart recorder. For this project, the system was guided by a Motorola Mini-Ranger with at least two known ground stations and an airborne transponder. The system was designed so that a pulse of electric current triggers the spotting camera and places a mark on the strip-chart recorder while recording on magnetic tape the x,y position derived from the Mini-Ranger. This action correlates the recordings from the FPR, the tracking camera, and the Mini-Ranger.

Teledyne's work plan included the following procedures:

(1) Obtain existing aerial photography covering the area at scales of 1:24,000 and 1:80,000, and identify all available geodetic control on the photography. Use field surveys in areas where the required control was deficient.

(2) Perform a block adjustment using analytical aerotriangulation to extend horizontal and vertical control, and establish a dense distribution of accurate reference points (spot elevations).

(3) Digitize all spot elevations and create a file for use in the data reproduction process, and for making quality-control evaluations of the final product.

(4) Use the existing photography, control data, and spot elevation data to compile all planimetry and drainage in the project area via conventional photogrammetric methods.

(5) Fly a grid network (north-south and east-west) of FPR profiles spaced 400 feet (ground distance) between profiles. In addition, fly profiles along major terrain features, such as ridges and streams.

(6) Develop a digital terrain data base for the project area by merging the horizontal (x,y) positional data recorded by the Mini-Ranger guidance system, the FPR ground profile (z) digitized from the strip-chart records, and the digital drainage and spot elevation files generated photogrammetrically.

(7) Grid the digital terrain data developed in the previous step and, using the computer and a Versatec plotter, generate contour plots (20 by 30 inches, basic sheet size) on a scale of 1:4,800.

(8) Produce final topographic maps by registering and compositing (a) a clear positive containing neatlines, Oregon State plane coordinate grid, marginal data, and place names; (b) a clear positive containing the planimetry and drainage generated photogrammetrically; and (c) a clear positive containing the automated contours with appropriate tags and labels. Produce a magnetic tape of digital terrain in the format specified in the contract.

Region 10 Study

The purpose of the Region 10 study was to produce digital terrain data and large-scale topographic maps as planning tools for the design of roads and administrative facilities. A contract was awarded to Data Systems International, Inc. (DSI), of Woburn, Massachusetts, in October 1983 to map two project sites on the Tongass National Forest in southeast Alaska. The product required at each site was a topographic map at a scale of 1 inch equals 200 feet with a 10-foot contour interval and 5-foot bathymetric contours. The project site consisted of 495 acres at Port Stewart on the Cleveland Peninsula and 1,005 acres at Whale Pass on Prince of Wales Island. Each site includes dense coniferous forest bordered by tidal waters. The proximity of both sites to Ketchikan, Alaska, combined with their physical characteristics and the availability of accurate ground truth data for each site, made them prime locations for evaluation of laser mapping techniques.

The project work was accomplished as follows:

(1) Using NAVSAT receivers, DSI established horizontal positions and elevations for three microwave beacons at each project site. A horizontal control station was used for a geodetic tie in each project area. An average of 25 satellite passes were recorded for each beacon position.

(2) Airborne laser profile data were acquired over the Port Stewart and Whale Pass sites. All data were collected using the AVCO laser mapping system. Thirty-seven flight lines (transects) were flown at 2,000 feet over the Port Stewart site, and 44 flight lines at 2,500 feet over the Whale Pass site.

(3) Data reduction was accomplished using software programs developed by DSI. Aircraft trajectory was calculated and digital terrain data were developed for each transect with a program named MAPPER. This routine interpolates the aircraft trajectory to the time of each laser pulse and calculates the resulting x,y,z values for each laser spot on the ground.

(4) The data then were used to produce the two products specified in the contract using DSI software. A digital terrain data file was produced to Forest Service format specifications. Topographic maps at a scale of 1 inch equals 200 feet with a 10-foot land contour interval and a 5-foot bathymetric interval were produced for each site. The automated contours produced from the gridded terrain data were combined with the planimetric features derived from the 35 millimeter photography using a combination of conventional and digital methods.

RESULTS

East Coast Study--Northeastern Station & Washington Office Engineering

The Northeastern Station and Washington Office study provided both units with valuable experience and demonstrated capabilities and limitations of the laser mapping system. The data acquisition system and the software used for the data reduction and map generation work well in a research environment.

Proper location and spacing of transects over a small test area are possible, even though they are time consuming. Most elevation data meet the desired accuracy criteria. However, accurate geographic location of the data points was very time consuming and labor intensive. A hardware failure in the equipment affected about 25 percent of all laser pulses. An evaluation of what effect this had on the overall accuracy of the system has not been made. Based upon the results and experience gained from this study, it is impractical to use NASA's current laser mapping techniques on a production basis.

One objective of the study was to derive parameters helpful in forest inventory. Results indicate that this is not practical for the Mt. Tom test site. The site is characterized as being of mixed species (deciduous and evergreen) and mixed age. This procedure should be successful in a heterogeneous, even-age forest. The system's inability to tie ground sample sites to the laser data prohibited accurate analysis of inventory data.

Region 6 Study

The experience gained with radar techniques was limited. Teledyne's proposal for topographic mapping using profile data from an FPR system seemed feasible and well thought out. Considerable effort was put into collection of data, including field data. However, unexplained difficulties were encountered, and the required maps were not produced. Apparently, there were gaps in the data that could not be resolved. Another apparent problem encountered was that radar waves long enough to penetrate the canopy did not give an accurate enough return, while shorter radar waves that could meet the accuracy requirements would not penetrate the vegetation.

In February 1984, Teledyne stopped work and notified Region 6 that they could not deliver the products required by the contract. As a result, it is difficult to make a fair and true assessment of the capability of using an airborne FPR system to produce topographic maps.

Region 10 Study

The experience gained in this study provided a good appreciation of the technical procedures, capabilities, and limitations of laser mapping technology as currently employed by DSI. The project did not meet accuracy requirements; however, the ability of the system to produce topographic maps and digital terrain data files was demonstrated for both test sites. Region 10 Geometronics personnel were able to use the digital terrain data provided by DSI as input to the Forest Service Digital Terrain Information System (DTIS) II program to plot contours and compute root-mean-square (RMS) values for the data. Evaluation and testing of the laser mapping data provided valuable experience and established a base upon which future laser mapping efforts can be built.

Topographic maps at a scale of 1:2,400 were produced for both sites. The map for the Whale Pass site was determined to be unsuitable for Forest Service Engineering applications because of large RMS errors found through computer analysis of the laser terrain data used to produce the map. The RMS errors indicated that a contour interval of 33 feet or greater and planimetric accuracies of plus or minus 27 feet could be achieved from the laser terrain data. Horizontal and vertical accuracies of this magnitude are generally suitable only for planning and reconnaissance type maps. The collection of more digital terrain data would have produced a better quality map. The 1:2,400 topographic map produced by DSI for the Port Stewart site still is being evaluated.

CONCLUSIONS

The three studies lead to the following conclusions:

(1) Contour maps for heavily timbered terrain can be produced. Their accuracy depends on the spacing of the flight lines and the complexity of terrain.

(2) Several data collection systems are available commercially, and some are being developed within the Government for specific tasks.

(3) A highly accurate horizontal and vertical positioning system for the aircraft is of vital importance.

(4) Use of small-format photography for location of the laser "path" on the ground is cumbersome and sometimes not accurate.

(5) The process of generating contour maps from laser data is labor intensive and therefore costly. Many of the functions can be automated.

(6) The cost of generating maps for a small area is high.

(7) Use of laser profile data for estimating forest inventory parameters is not practical in heterogeneous forest cover at this time. Further testing is recommended for homogeneous forest stands.

SUMMARY

Based on the results of these three case studies, Washington Office Engineering does not recommend use of laser and radar profiling for topographic mapping in heavily forested mountainous terrain. This technology, while promising, still needs additional research and development to be able to perform reliably and economically. Several commercial firms and Government agencies are working in this area. The Washington Office Geometronics Staff will continue to monitor this technology and report on progress made. In the meantime, more conventional alternatives should be considered for producing topographic maps.

How Much Is Good Enough?

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This article is a complete change from most found in Field Notes. Instead of covering a technical subject or the people who do technical work, it's about your retirement. What? Yes, your retirement. Some Engineering folks faced with an early retirement option because of position elimination, or those faced with regular retirement, ask "How much is good enough?" This question was posed at a recent Washington Office Engineering retirement seminar. Most of us will take a reduction in income when we retire. So the question is one of how much is needed for the lifestyle desired, be it pleasure or a new career. Hopefully, this article will help those faced with the retirement question. It may cast new light on ways to view retirement economics. The ideas in the article were chosen from those recent discussions that arose in Washington Office Engineering about retirement. One thing learned is that there is no one place to go to get all answers. This article may minimize footsteps of others.

WHY DO WE RETIRE?

We all have different reasons for retiring besides our age or health. For many it boils down to economics, a new career, leisure, freedom, or relocation. This article will concentrate on the economic aspects, generally a potential retiree's first thought, which is complicated enough.

WHAT ARE the BROAD ECONOMIC CONSIDERATIONS?

Consider the following on an annual basis:

(1) How much will your retirement annuity yield?

(2) Will you have Social Security and how much will it yield?

(3) How much will your other income sources (IRAs, annuities, savings, investments, and so forth) yield?

(4) What will be your spouse's income?

(5) Where will you live? How does that affect living costs?

(6) How much will your lump sum leave yield?

(7) Do you foresee major changes of expenditures?

(8) What are life and health insurance considerations?

(9) How long do you and your spouse expect to live? What will inflation be?

(10) What are the tax considerations?

(11) What are likely changes in retirement laws that may affect you?

There may be other considerations. If so, list and consider them. It would not be a good idea to count on possible inheritances unless an estate is in the process of being divided. Otherwise, there are too many uncertainties, such as taxes, remarriages, and surprises in wills. The trick is to estimate accurately each of the above considerations to determine an income level after taxes and living expenses. This then can be compared with the "now" situation. Finally, retirement income should be approached from a budget standpoint to verify that it will adequately cover expected expenses. Now, let's look at each of the above separately and then try to combine all the data into some logical scenarios.

YOUR RETIREMENT ANNUITY

There are several methods of estimating your retirement:

(1) Annuity = (0.02 x (years service including sick leave - 4)) x (salary $1\frac{1}{2}$ years ago) x 0.91.

Another formula you can use if you are eligible for an early out but have not reached 55:

(2) Annuity = (0.02 x (years service including sick leave - 4) x (salary $1\frac{1}{2}$ years ago) x (1 - (0.02 x years to age 55))) x 0.91.

(3) Annuity = Personnel calculated annuity (with survivor benefits).

(4) Annuity = From chart in the back of booklet from Personnel Management, "Your Retirement System."

You can make estimates based on a variety of retirement dates, such as now and every 6 months in the future, considering possible pay increases. Obviously, each future calculation will look better because it will be larger. Be guided by "how much is good enough." All of the above are considered using a 9-percent reduction (0.91 factor) for providing a survivor's annuity. Your annuity is a percent of gross salary, not net income, that is, prior to all deductions. "When do you retire during the year?" may be influenced by income tax considerations.

Your Social Security Annuity

This one is more elusive. First, to be eligible you need 40 quarters or 10 years of work to qualify based on qualifying work before, during, or after your Federal career. The formula is rather complicated. You can get estimates from a Social Security (S.S.) office. A rough formula that will help you estimate your Social Security annuity is as follows:

(5) Annuity = (35-year annual income under S.S. x 1.3) x 0.90 of 1st $2,532 earned + (35-year annual income average under S.S. x 1.3) x 0.32 of next $12,756 earned + (35-year annual income under S.S. x 1.3) x 0.15 of balance of 35-year average.

Be sure not to duplicate military time in calculating the 35-year annual income. Consider maximums per year ranging from $3,600 in 1951 to $37,800 in 1985. You also must estimate future income until eligible for S.S. Full annuity will not be available until 65 or a reduced annuity based upon 6.7 percent per year for years under 65. Remember this is rough and is subject to change and inaccuracies, depending upon your income pattern. The 90 percent (0.90) will drop 10 percent per year to 40 percent beginning in 1986 if you do not receive a Government retirement check by that time.

Other Investment Yields

(6) Yields = (Principal x estimate average return) + principal liquidation per year.

Spouse's Income

(7) Spouse income = Estimated annual amount via income or retirement benefits. (Use similar methods shown elsewhere and add them where applicable.)

Living Costs

(8) Differential living costs = Cost now - cost where you plan to live. (Include housing and other significant differences.)

Major Change of Expenditures

(9) Major changes = Expenditures now - expenditures retired. (Include major expenditure changes that can be identified like entertainment, commuting, medical, and so forth.)

Length of Life & Inflation

(10) Estimate length of lives of you and your spouse. (This can affect projections on some estimates.)

(11) Inflation. (Can affect some projections.)

Tax Considerations

(12) Tax changes = Taxes now - taxes when retired.

Other Considerations

(13) Other changes = Situation now - situation then.

Lump Sum Leave

(14) Lump sum leave = (Hours x gross hourly rate) (Calculate for various likely times of retirement.)

When to receive lump sum leave should be weighed against the maximum allowed under the law and income tax considerations.

How To Get the Bottom Line

Obviously there are so many variables that you could "choke" a computer with all the possibilities. A suggestion is to narrow the choices to a range that seems reasonable. Forget the reduced tax burden for the first couple of years while you are repaid taxable contributions. That will be a bonus and can compensate you for unexpected expenses during the transition. For each scenario desired, including the "now" condition, considering living location, job situation, and inflation, complete a sheet as shown on the following page to get the bottom line for various time periods. The column head "formula" in parentheses in the chart refers to the numbered items of the previous nine sections. It may be clearer to compare scenarios in each time column and have a separate sheet for each time period.

(15) Scenario = ______________________________.

Time Date	Present	+1 Year	+3 Years	+5 Years	+10 Years	+20 Years
(Formula) Income or Expense						
Pay check or Annuity (1, 2, 3, or 4) +						
S.S. (5) +						
Yields (6) +						
Spouse (7) +						
Living cost (8) ±						
Major chgs. (9) ±						
Taxes (12) ± (not considered above)						
Other chgs. (13) ±						
Estimated Annual Net (Sum column)						
Lump Sum (14)						

For starters, complete the table for the "now" working situation. Project ahead, considering likely inflation and job progression. It may be that you will have two job scenarios and two inflation rates or four or more scenarios for the "now" situation. You may think of five retirement "what if" scenarios. With two inflation rates, that's 10 scenarios or 14 in total. Each scenario is an estimate of how things will be as time, location, or inflation changes. If you have access to a microcomputer and an electronic spreadsheet, these calculations are relatively easy. Use shorter or different time periods if you wish. The future gets "fuzzier" further away. Once established, you can do the bottom line calculations anytime to determine "How much is good enough?" These efforts can validate previous estimates, which can then help you improve future estimates.

Budget Review

Now choose the most likely scenario results that look acceptable. With that income, budget for all likely expenses and verify that the chosen income will cover everything with a savings surplus. In other words, this is an adverse consequences review looking at "how much is enough" for each time period. When completed, you may be surprised at how "well off" you are or how "poor" you could be. This information should help you decide economically about retirement.

OTHER FACTORS ABOUT RETIREMENT

Realizing again that there are other reasons to retire than economics, the latter should not be the whole reason for choosing. Besides the personal factors, verify that you are eligible for health and life insurance coverage. If you are not, factor these added costs into your projections. At the recent Washington Office Engineering retirement seminar, the following were given as hangups that beset full-time retirees:

(1) Too much time available. Bored. Restless.

(2) Social life of work associates lost. May miss that. Feel lost.

(3) Not enough money. (Must balance with good life and risk of illness/death).

(4) Looking back. (Don't!) Easy to see what could have been better.

(5) Trap of being conned into doing something for pay or volunteer and into "earning one's worth (in one's own eyes or the eyes of others)."

(6) Not getting full agreement with family before retirement.

With efforts under way to reduce retirement benefits, it is a good idea to keep an eye on legislation that could affect potential benefits. You may want to consider this in an economic scenario.

Once retired you would do well to join one or more of several retiree organizations to learn how to save money and to help protect retiree rights and benefits. One, the National Association of Retired Federal Employees, looks after Federal retirees.

SOME LAST THOUGHTS

Obviously, a book could be written on this subject. Only highlights are provided. Any readers who have new insight or corrections to make, please submit them. If there are enough added ideas, we may run a followup.

None of us should be apologetic for an early out or for full retirement benefits. The system provides for these options, which we have earned. While there are forces at work to reduce our retirement, the system is sound. While it is true that there is a very large unfunded liability, in the past year it was reduced. As long as good money management practices are applied to the Federal Retirement Fund, little adjustments to the system are needed. You can prove this yourself by compounding your and the Government's matching contributions over your years of employment. A past average T-bill interest rate of 7 percent should be used to arrive at this principal amount. You will find a surprisingly close correlation between your annuity and annual payments based on 10 percent interest and the number of years you expect to live beyond retirement. Tables are available in economics books to arrive at annual payment factors needed for this calculation.

It would not be wise to compare present or potential income with others. We each have different spending appetites and lifestyles. The key is "How much is good enough?" for you.

I thank Tom Kerns and Dirck Rotty in Washington Office Engineering and Jerry Baughman in Washington Office Personnel, who contributed to this article.

Clark C. Heritage Memorial Series on Wood

Clyde Weller
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A four-volume set of books, "Clark C. Heritage Memorial Series on Wood," has been produced by the Forest Products Laboratory in cooperation with the University of Wisconsin (Extension) in Madison. These volumes are publications of the Educational Modules for Materials Science and Engineering (EMMSE) Project of the Materials Research Laboratory at The Pennsylvania State University.

The four volumes are summarized below.

VOLUME I. WOOD: ITS STRUCTURE & PROPERTIES

This text discusses in nine modules the basic insights into the structure, treatment, and properties of wood. The modules are as follows:

I. "Overview of Wood as a Material" by G. G. Marra.
II. "Molecular and Cell Wall Structure of Wood" by R. E. Mark.
III. "Wood Anatomy and Ultrastructure" by R. J. Thomas.
IV. "Wood and Moisture" by H. Tarkow.
V. "Physical Properties of Wood" by R. M. Kellogg.
VI. "Mechanical Behavior and Properties of Wood" by A. P. Schniewind.
VII. "Chemical Treatment of Wood for End Use" by C. S. Walters.
VIII. "Paper" by A. H. Nissan.
IX. "Wood-Based Composites" by J. J. Zahn.

VOLUME II. WOOD as a STRUCTURAL MATERIAL

This text describes many old and some new wood materials and their use as structural members. The text was taken from eight modules that have been documented, taught, and peer reviewed. The modules are as follows:

I. "Structural Wood Systems" by D. H. Percival and S. K. Suddarth.
II. "Properties of Wood Building Materials" by John G. Haygreen.
III. "Mechanical Behavior and Properties of Wood" by A. P. Schniewind.
IV. "Laboratory Testing of Wood and Structural Wood Products" by M. E. Criswell and M. D. Vanderbilt.
V. "Lumber: Grades, Sizes, Species" by Robert J. Hoyle, Jr.
VI. "Structural and Round Timbers" by Russel P. Wibbens.
VII. "Panel Products" by H. M. Montrey.
VIII. "Degradation of Wood in Use and Wood Protection" by Duane E. Lyon.

VOLUME III. ADHESIVE BONDING of WOOD & OTHER STRUCTURAL MATERIALS

This text covers the extensive application in recent years of adhesively bonded wood products and structures that was made possible by the chemical industry's development of highly durable synthetic adhesives. The use of these materials is increasing and is expected to continue to expand. The modules in this text are as follows:

I. "Adhesives--An Overview" by Richard F. Blomquist.
II. "Fundamentals of Adhesion" by A. N. Gent and G. R. Hamed.
III. "The Adherends and Their Preparation for Bonding" by J. D. Wellons.
IV. "The Adhesive System" by R. V. Subramanian.
V. "The Bonding Process" by James T. Rice.
VI. "Testing and Evaluation of Adhesives and Bonded Products" by Dick W. Caster.
VII. "Metal, Plastic, and Inorganic Bonding: Practice and Trends" by Gerald L. Schneberger.
VIII. "Design Methodology for Adhesives Based on Safety and Durability" by Gordon P. Krueger.
IX. "Applications of Wood Bonding" by Alan A. Marra.

VOLUME IV. WOOD: ENGINEERING DESIGN CONCEPTS

This text will be published near the end of fiscal year 1985 and will detail the design of wood structures. Eight modules cover the design of the major members of structures. The modules are as follows:

I. "Materials and Their Design Properties" by A. Louis DeBonis.
II. "Design of Beams--Solid and Laminated" by Vijaya K. A. Gopu.

III. "Design of Beams--Composite" by Robert J. Hoyle, Jr.
IV. "Design of Columns" by Marvin E. Criswell.
V. "Design of Connections" by Keith A. Faherty.
VI. "Design of Trusses" by Larry A. Beineke.
VII. "Design of Diaphrams" by E. F. Diekmann.
VIII. "Design of Curved Members" by Robert K. Kaseguma.

For information on obtaining the "Clark C. Heritage Memorial Series on Wood" or any individual volumes in the series, contact the EMMSE project at the following address or telephone number: EMMSE Project, 110 Materials Research Laboratory, The Pennsylvania State University, University Park, Pennsylvania 16802, (814) 865-1643.

TRAFFIC: A Program for Analyzing Traffic Surveillance Data

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TRAFFIC is a program developed for the Hewlett-Packard model HP-41C programmable calculator that aids in statistical analyses of traffic surveillance data. Data, in either of two formats, are analyzed and reported for use in decisionmaking for road standards, maintenance levels, and cost-sharing agreements. This article describes the use of TRAFFIC for Project Planning Engineers and Traffic Surveillance Technicians.

DEFINITIONS

TRAFFIC is based on the formula for calculating confidence interval (CI) for normally distributed data found in Schaum's "Outline Series on Statistics" (pages 157 and 158). The formula is:

$$CI = \overline{X} \pm \frac{Z_c \sigma}{\sqrt{n}} \sqrt{\frac{N - n}{N - 1}}$$

where

$\overline{X}$ = *Mean;*

Z_c = *Confidence Coefficient;*[1]

σ = *Standard Deviation;*

n = *Sample Size (number of reading); and*

N = *Population Size (number of possible readings).*

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[1]Note: When used in a Forest setting, the small highly skewed samples require that the Z_c be defined as:

$$Z_c = \frac{1}{\sqrt{\frac{(100 - \text{Confidence Level})}{100}}}$$

Other definitions needed to understand the process are the following:

Confidence Interval (CI). That interval within which the mean ($\bar{X}$) of the population (N) is expected to fall.

Confidence Level. The degree of confidence that the mean ($\bar{X}$) will fall within CI; that is, if the mean ($\bar{X}$) will fall within the confidence interval 3 times in 4, then the confidence level is 75 percent.

Count Period. The nominal or "standard" period of time for each reading; that is, 1 week, 7 days, 168 hours could equal 1 count period. N and n are always in the same units as the count period.

Count Duration. The actual length of time for each reading; that is, the first week the count duration might be 165 hours, while the next week it might be 172 hours. Count duration equals count period for recording counters.

Normalized Data. Count duration divided by count period and multiplied by the traffic volume reading for the period. For nonrecording counters only, data must be normalized to obtain statistically valid results.

HOW TO USE TRAFFIC

This discussion assumes a basic knowledge of algebra traffic classification techniques, and traffic surveillance equipment operation.

TRAFFIC is entered or loaded into the calculator by card or wand input, the data are entered on the keyboard, the analysis is performed, and the results are interpreted and displayed. This simplified description of data analysis shows the power of using this program in traffic surveillance programs.

Setting Up the Calculator

When setting up the calculator, it is useful to attach all peripherals at once. If cards are used, a card reader must also be used; thus, the card reader or wand, as well as the printer and extra memory modules, should be attached.

Loading the Program

TRAFFIC is loaded into the calculator either with a series of magnetic cards or with a wand.

Initializing the Registers

The calculator registers and flags must be set by pressing the SHIFT and "E" keys. If the count periods are nonuniform, press the SHIFT and "B" keys. (For uniform count periods, see Uniform Periods under Entering the Data).

Entering the Data

Nonuniform Periods. For nonuniform count periods, follow the steps given below:

(1) Enter the first counter reading (n_1), then press the "ENTER" key.

(2) Enter the second counter reading (n_2), then press the "ENTER" key.

(3) Enter the count duration (X_i), then press the "A" key.

(4) If n_2 (above) also equals n_1, for the next set of data, enter the next counter reading (the new n_2); press the "ENTER" key; then enter the count duration as above, and press the "A" key.

(5) If there is a break in the counter readings (the counter was moved or stopped working), enter both the first (n_1) and second (n_2) counter readings as well as the count duration (X_i).

Uniform Periods. When the count duration (uniform periods) equals the count period (as it will with a recording traffic counter), move from initialization to data entry. In this case of uniform count duration, only the count reading (n_1) taken from the tape is entered by pressing the "A" key. All subsequent entries are made the same way.

Series of Zeros

When a series of legitimate zero readings have been recorded (as when a road was closed because of fire), it may be desirable to make one entry rather than many. To enter the string of zeros, enter the number of zeros in the string (i) and press the SHIFT and the "A" keys; then return to the input format you were using before entering the string of zeros.

Analysis

When the last datum has been entered, move on to the analysis. The analysis can take one of two forms, displaying: (1) confidence intervals at the 50-percent, 75-percent, and 90-percent confidence levels; or (2) only one confidence interval at the 50-percent, the 75-percent, or the 90-percent confidence level.

Case 1. First, press the "E" key; the display will ask "N = ?". Then enter the population size (N) and press the "R/S" key; TRAFFIC will print out the mean and range in the correct form (mean ± range) for each confidence level, and TRAFFIC will print out the standard deviation for the data set.

Case 2. The procedure for case 2 is exactly the same as for case 1 with the exception that pressing the "B" key yields output for a 75-percent confidence level, pressing the "C" key yields output for a 90-percent confidence level, and pressing the "D" key yields output for a 50-percent confidence level. To calculate the standard deviation only, press the SHIFT and "C" keys.

Units

The calculator will not indicate units on the printout. Therefore, you must identify what the units are--that is, average daily traffic (ADT) or average weekly traffic (AWT)--and these units must conform to the units of the input data (N, n, and count period).

Confidence Level Guidelines

The guidelines in table 1 for confidence level needs were developed by the 1978 Region Road Managers meeting.

Table 1.--Guidelines for confidence level needs (percent).

	Timber Sale Commensurate Share	Annual Maintenance Plan Commensurate Share
Local Roads	50	60-75
Collector Roads	60-75	75-90
Arterial Roads	75-90	75-90

Display

The analyst must determine which confidence level to use and must display both the confidence level and confidence interval; for example,

CI = 153 ± 25 AWT at the 75-percent confidence level.

Normally, the CI is displayed best both in tabular form in the report and on a map showing the counter location.

SUMMARY

TRAFFIC is a program for the statistical analysis of traffic surveillance data that provides an economical way to load, analyze, and display the results. Input can represent either of two kinds of data: uniform periods and nonuniform periods. Analysis can be either of 1 confidence interval or of 3 confidence intervals representing 1 or 3 confidence levels. Questions about TRAFFIC should be directed to Eugene Smith, Region 5 Engineering, Pleasant Hill Engineering Center, Pleasant Hill, California 94523, (415) 825-9800.

Change to *Engineering Field Notes* (Volume 17, January - February 1985)

Please make the change shown below in your copy of Engineering Field Notes.

In the article "Cross-Country Ski Trail Planning, Development, & Operation Considerations," on page 43, the 10th line from the top should read:

"generally 20 feet to 50 feet."

Engineering Technical Information System

The Series:

THE ENGINEERING FIELD NOTES SERIES is published periodically as a means of exchanging engineering-related ideas and information on activities, problems encountered and solutions developed, or other data that may be of value to Engineers Service-wide. Articles are usually less than six pages, and include material that is not appropriate for an Engineering Technical Report, or suitable for Engineering Management publications (FSM 1630 and 7113).

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Every reader is a potential author of a Field Notes article. If you have a news item or short description about your work that you wish to share with Forest Service Engineers, we invite you to submit the article for publication. Field Personnel should send material to their Regional Information Coordinator for review by the Regional Office to assure inclusion of information that is accurate, timely, and of interest Service-wide; short articles and news items are preferred. Type the manuscript double-spaced; include original drawings and black-and-white photographs (if only color photographs are available, send transparencies or negatives), and two machine copies of the manuscript.

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