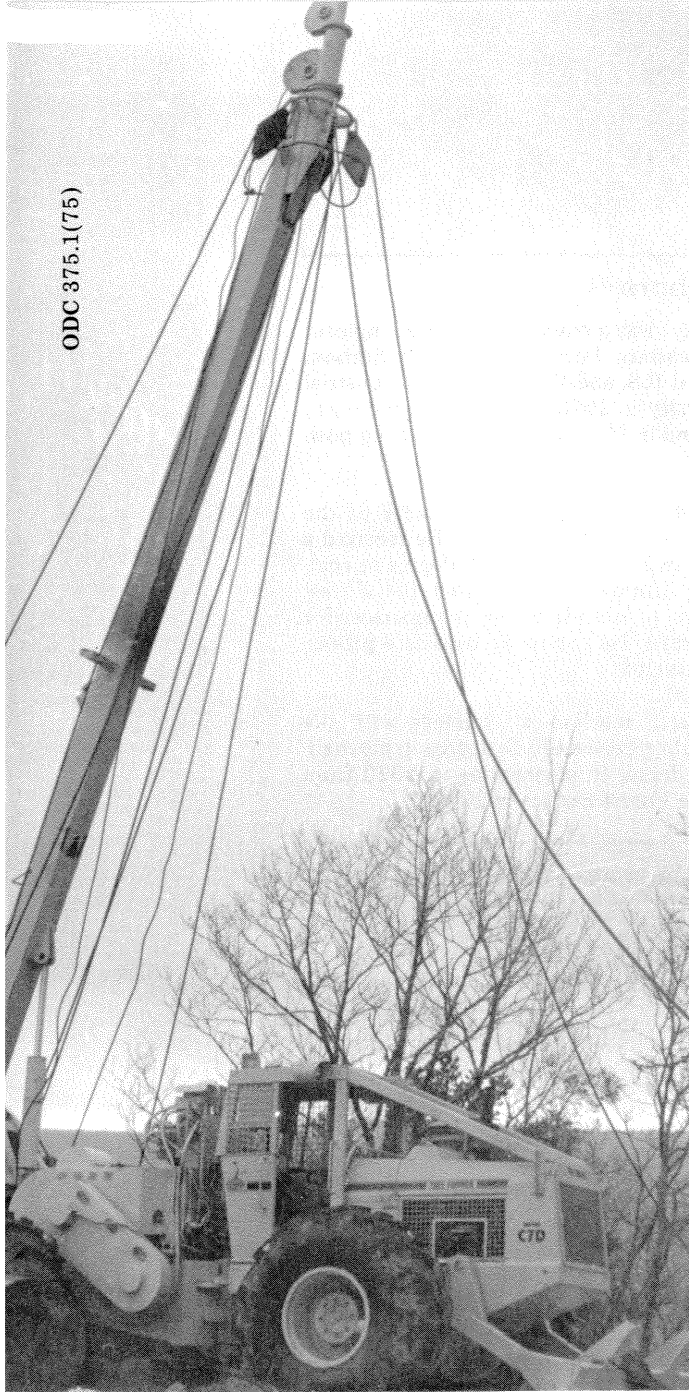


ODC 375.1(75)

by Edward L. Fisher
Harry G. Gibson and
Cleveland J. Biller

Production and Cost of a Live Skyline Cable Yarder Tested in Appalachia



**FOREST SERVICE RESEARCH PAPER NE-465
1980**

FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE
NORTHEASTERN FOREST EXPERIMENT STATION
370 REED ROAD, BROOMALL, PA 19008

The Authors

EDWARD L. FISHER, during this study, was a research industrial engineer in the engineering unit of the Northeastern Forest Experiment Station, Morgantown, West Virginia. He received B.S. and M.S. degrees in industrial engineering from West Virginia University in 1975 and 1978, respectively. He joined the Forest Service in 1975 and in 1980 accepted a teaching position at West Virginia University.

HARRY G. GIBSON, during this study, served as project leader of the engineering unit of the Northeastern Station at Morgantown. He received a B.S. degree in mechanical engineering in 1962 and an M.S. degree in engineering in 1969 from West Virginia University. He joined the Forest Service in 1966 and in 1978 he became plantation harvesting manager for Jari Florestale Agro-Pecuaría Ltda., Brazil. He is now an associate professor of forest engineering at Purdue University.

CLEVELAND J. BILLER is a research mechanical engineer with the Northeastern Station in Morgantown. He received a B.S. degree in mechanical engineering in 1967 and an M.S. degree in engineering in 1970 from West Virginia University. He joined the Forest Service in 1966.

MANUSCRIPT RECEIVED FOR PUBLICATION 3 OCTOBER 1980

Abstract

Logging systems that are profitable and environmentally acceptable are needed in Appalachian hardwood forests. Small, mobile cable yarders show promise in meeting both economic and environmental objectives. One such yarder, the Ecologger, was tested on the Jefferson National Forest near Marion, Virginia. Production rates and costs are presented for the system along with a discussion of the complete operation.

INTRODUCTION

PROFITABLE AND ENVIRONMENTALLY acceptable logging systems are needed in Appalachian forests. These systems should be able to thin even-aged stands, remove individual trees from uneven-aged stands, and harvest mature trees. A critical phase of the logging operation is transporting logs from the stump to the landing. This phase accounts for a large portion of the total harvesting cost—usually at least 30 percent—and can result in serious damage to the environment. The articulated skidders and crawlers currently used in Appalachia often damage residual trees and require a network of logging roads, which are unsightly and a major source of soil disturbance on steep sites.

One objective of forest management is developing a logging system that not only operates economically in Appalachian hardwood stands but also has a less detrimental impact on the environment (primarily by reducing the number of haul and skidroads) than conventional tractor systems. Cable logging shows promise in meeting this objective.

Of the cable systems available, we believe the lighter, less costly systems would be effective in Appalachia (Gibson and Phillips 1973) because:

1. Slopes are predominantly convex in Appalachia. In West Virginia and the steeper areas of Pennsylvania, 95 percent of the slopes fit this category. This is true for much of Appalachia. Smaller cable systems with a reach of 1,000 feet or less would minimize the problems associated with convex slopes.

2. Private individuals own most of the forest land and their tracts are of limited size—80 percent of the growing stock in West Virginia, typical of Appalachia in this regard, is owned

by private individuals. Small cable systems are highly mobile and can easily be moved into small tracts. These machines also can be moved on state highways without violating vehicle standards on height, width, and weight.

3. The small cable systems have a lower initial cost than large cable systems and thus can be better matched to small timber.

4. Small cable systems do not require wide roads; this means more land available for tree production and lower road construction costs in steep areas where these costs are highest. Also, narrow roads are not highly visible and pose a less serious threat of erosion because less soil is disturbed.

In this study we used a small, mobile cable system to harvest timber on steep Appalachian slopes. We then determined production rates, costs, and generally assessed damage to the environment.

TEST AREA

The site chosen for harvest was a 62-acre tract located within the Jefferson National Forest near Marion, Virginia. The sale was planned by the National Forest under the jurisdiction of the Mount Rogers National Recreational Area. A private contractor did the logging; logs were trucked 52 miles to a sawmill in Clinchburg, Virginia. The prescription for all harvesting was clearcutting. Timber harvested was primarily basswood, black and yellow birch, red and white oak, and sugar maple. There were smaller amounts of ash, hard maple, and cherry. The average diameter (average of small and large ends) of the harvested logs was 15 inches with a minimum top diameter of 8 inches. The average slope was 56 percent and the maximum yarding distance was 700 feet.

LOGGING SYSTEM

Equipment and manpower

The equipment used in the operation was an Ecologger¹ live skyline yarder (Figs. 1, 2), mounted on a 130-horsepower Tree Farmer C6D skidder. The system was equipped with a hydraulically operated yarding tower, guy-lines, mainline, and skyline. A Maki carriage was used to bring the logs to the landing. Specifications are given in the Appendix. The cost of the yarder including the skidder was approximately \$130,000 at the time of the operation. This yarder, minus the skidder, can now be purchased for about \$65,000. Other equipment included a small bulldozer, a Prentice 200 loader/mechanical bucker, and two log trucks. The crew consisted of two chokersetters, one operator/chaser, one foreman, two fellers, supervisory personnel (fractional time) and two swing men responsible for bucking at the landing, loading, operating a bulldozer in the construction of additional landings, and hauling logs to the mill. The yarder was equipped with remote electronic controls to enable the operator to unhook logs at the landing. This innovation allowed yarding to be done by a three-man crew.

Description of operation

After felling, the yarder was set up by four men in about 4 hours. This operation included disassembling the set just finished, moving the machine to the next set, leveling it, extending four guy wires and securing them, rigging the skyline to the first tail tree of the set, and setting the carriage stop at the first position.

After the set-up had been completed, the skyline was tensioned and the carriage allowed to travel empty to the line stop. When the carriage hit the stop, the skyline was slackened and the end of the mainline was attached to one or two sawlogs, depending on

Figure 1.—The Ecologger live skyline yarder was mounted on a 130-horsepower Tree Farmer C6D skidder.

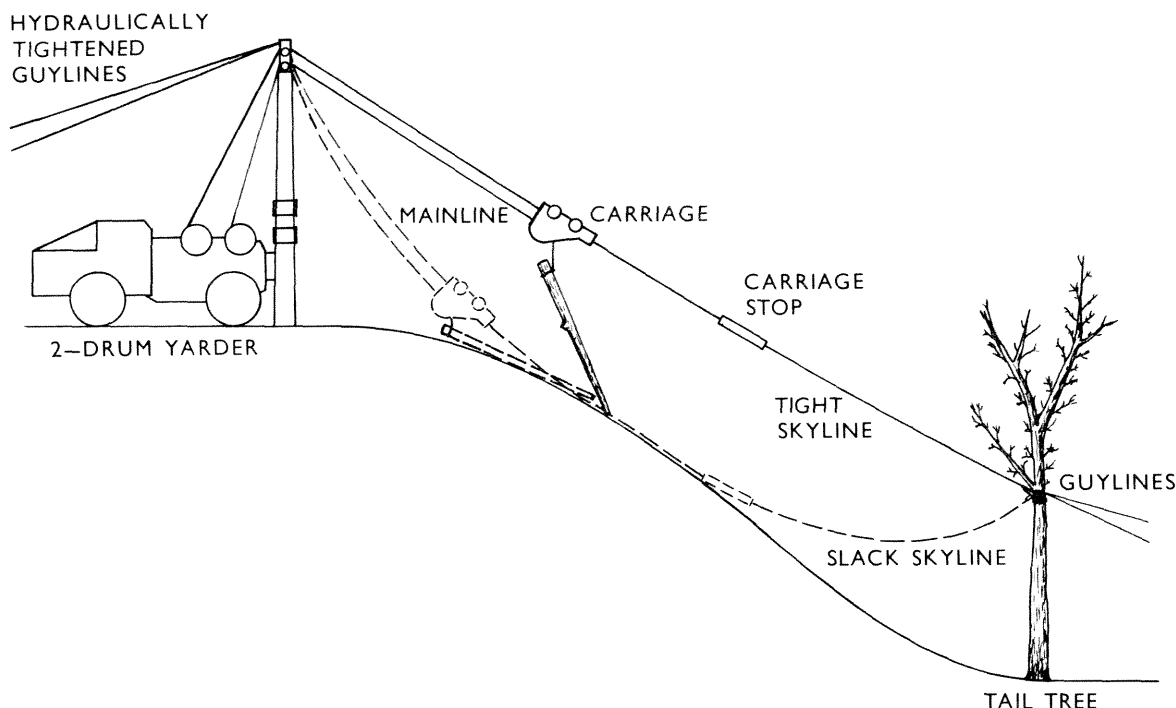


the weight and location of the logs. The skyline is termed “live” because of this ability to be slackened.

Generally, logs were yarded tree length. When a signal was given, the skyline was re-tensioned and the logs were winched laterally to the skyline corridor. When the logs reached the carriage, the carriage was automatically released from the stop, allowing the payload to be pulled uphill to the landing. When the logs reached the landing, the skyline was

¹ The use of trade, firm, or corporation names in this paper is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture or the Forest Service of any product or service to the exclusion of others that may be suitable.

Figure 2.—Schematic of live skyline cable yarding system.



slackened to allow unhooking. Yarding was done in a fan-shaped swath with several paths per set. Usually, each path was yarded top to bottom before the skyline was moved to the next tailhold.

Timing the operation

The snapback timing method of work sampling was used to break down the total productive time into its various components. Most of the sampling was devoted to timing the yarding elements so that regression equations could be developed for each of the five phases of a complete yarding cycle, or turn: (1) travel empty, the time required to move the empty carriage from the landing to the point of loading; (2) hook, the time required to hook a turn of logs to the mainline; (3) winch lateral, the time it takes to winch logs from the hook position into the carriage; (4) travel loaded, the time required to yard the logs to the landing; and (5) unhook, the time required to unhook the logs.

The turns were timed so that no time was

lost as each phase ended and a new one began. The times were recorded in minutes; delays within any phase also were timed and recorded by type.

Delays

In addition to normal delays such as log hangups, there were several major delays. During the test, lightning struck the tower, causing a malfunction of the electronic controls and delaying the operation. Other major delays resulted from a lack of local replacement parts and the absence of a skidder (and frequently a loader) on the landing to remove logs from the deck in front of the yarder. Decking of the logs by the yarder was difficult and slow when the deck became too large. Another factor that slowed the logging operation was the inexperience of the crew. In other cable logging tests, we have found that it can take months of training and experience before workers become proficient in rigging procedures (Gochenour et al. 1979). These problems should be reduced or elimi-

nated before additional field trials are attempted.

RESULTS

Productivity

The men worked four 10-hour days per week. Average production time per cycle was 7.13 minutes. With delays, the average cycle time was 9.20 minutes. The average volume per turn was 52.8 cubic feet with an average log diameter of 15 inches and length of 34 feet. The average number of logs per turn was 1.35, and the average slope yarding distance was 369 feet.

The major delays within a cycle were: 1) moving the carriage stop (8.75 minutes per move) and 2) repairing the cable (21.5 minutes per repair). The time needed to move the stop was longer than expected because large amounts of ground slash made maneuvering difficult. Road changing required an average of 67.2 minutes and ranged from 37 to 97 minutes (Table 1).

Table 1.—Average time and standard deviation of phases and delays in yarding cycle, in minutes^{a/}

Item	Average time	SD
Travel empty	0.55	0.29
Hook	3.11	1.48
Winch laterally	0.56	0.60
Travel loaded	1.02	0.94
Unhook	1.75	0.85
Cycle without delay	7.13	2.28
Cycle with delay	9.20	7.04
Delay per cycle	2.07	7.52
Time per delay	12.38	12.78

^aBased on 95 cycles.

The average time needed to change landings was approximately 4 hours. Results of multiple regression analysis of cycle times are given in Table 2. Variables that were significant at or below the 5-percent level were used in the equations. These included yarding distance (lateral and slope) and the number of stems per turn.

Table 2.—Results of regression analysis of phases of yarding cycle (estimate of time in minutes)^{a/}

Yarding phase	Equation	R ²	SE
Travel empty	$Y = .198 + .00081662(X1)^b$	0.36	.12
Hook	$Y = .776 + .00346128(X1) + .01158483(X2)^c + .32828497(X3)^d$	0.24	.89
Winch Laterally	$Y = .038 + .00105710(X1) + .00250582(X2)$	0.16	.30
Travel loaded	$Y = .111 + .00215421(X1)$	0.44	.28
Unhook	$Y = .552 + .00148312(X1) + .36986199(X3)$	0.22	.57
Total cycle	$Y = 2.374 + .00841141(X1) + .72548570(X3)$	0.40	1.30

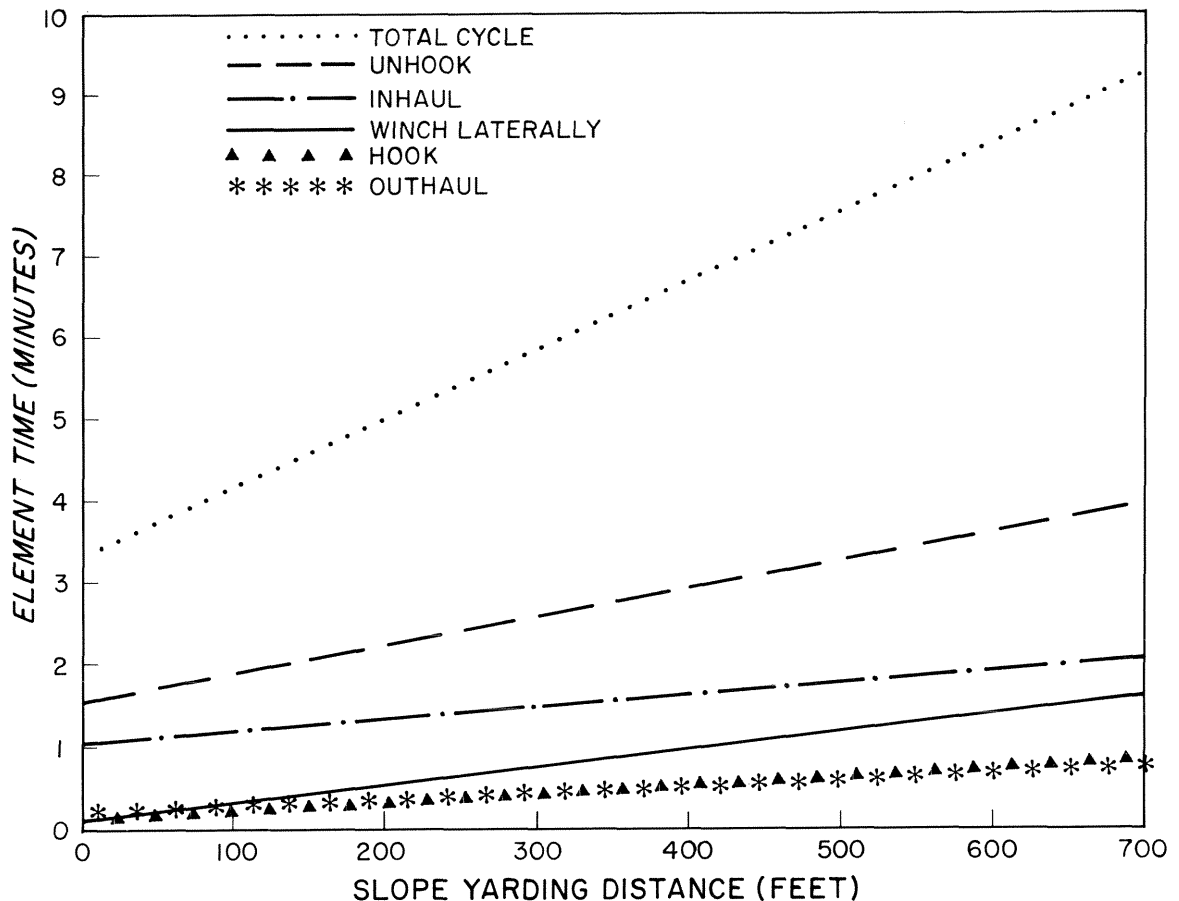
^aAll coefficients significant at 5 percent level.

^bX1 = slope yarding distance (ft).

^cX2 = lateral yarding distance (ft).

^dX3 = number of stems per turn.

Figure 3.—Element time estimates as a function of yarding distance. (Lateral distance held constant at 30 feet and number of stems per turn at 1.35.)



The equations were chosen by comparing R^2 values and the level of significance of the variables. Yarding distance is significant in all phases. This would be expected in travel empty and travel loaded, but not in other elements. One reason for its high influence might be that as yarding distance increases, there is a slowing effect on all elements. That is, since travel empty and travel loaded consume more time, the other elements tend to slow down. Another reason might be an association of worker fatigue with longer yarding distances and increased cable pulling force needed at these distances.

Other significant variables are lateral yarding distance (in the hook and winch lateral equations) and the number of stems per turn

(hook and unhook equations). The correlation coefficients are disappointingly low; however, low correlations are frequently observed in this field (Dykstra 1975). We expected the coefficients to be higher in the travel empty and travel loaded phases but believe the problem may be due in part to the slacking skyline. We found this problem in a similar trial of another slacking skyline machine, especially in the travel empty phase. Figure 3 contains a graph of each time element as a function of slope yarding distance (X1). Where lateral distance (X2) and logs per turn (X3) were also significant, average values of 30 feet and 1.35, respectively, were used for the graphs. Note the apparent effect of yarding distance on hook time.

Figure 4.—Aerial view of harvest area after logging shows only one major road.



Because the R^2 values are very low, the variable means of Table 1 may be the best indicators available, with the possible exception of the travel equations. In the latter, it appears that the time can be predicted to some degree by yarding distance and pieces per turn.

Cost analysis

A cost analysis was conducted using the time-study data and cost information supplied by the Jefferson National Forest and the contractor. These costs² do not reflect the

delays due to control malfunctions and the absence of a skidder in the log decking operation.

<i>Operation</i>	<i>Cost (dollars per M of Doyle)</i>
Road construction	12.34
Yarding (including changing roads)	59.78
Moving yarder	2.39
Loading	16.23
Hauling	25.00
Total	113.74

² 1975 dollars.

CONCLUSION

Cable systems such as the Ecologger warrant further study in Appalachian timber stands. As the timber supply on moderate slopes decreases, cable logging will become more attractive. Although it appears that cable skidding may be more costly than ground skidding, it causes less damage to the environment. An aerial view of the site after logging (Fig. 4) shows only one major road; this is in contrast to the usual network of skidroads on similar slopes for ground skidding.

Environmental costs are difficult to determine, so each logging operation must be assessed individually. If the land manager chooses the more costly cable operation because of its lower environmental impact, one can assume that the environmental costs would equal or exceed the difference in harvesting costs between cable and traditional

systems. The major problems evident during the test were a lack of available replacement parts, the absence of a swing skidder, and the inexperience of the logging crew. By reducing these problems, a logger could significantly improve his operation.

LITERATURE CITED

- Dykstra, D. P.
1975. Production rates and costs for cable, balloon, and helicopter yarding systems in old-growth Douglas-fir. *Oreg. State Univ. Res. Bull.* 18. 57 p.
- Gibson, H. G., and R. A. Phillips.
1973. Cable systems: How do you select one for Appalachian logging? In *Cable logging symposium proceedings*. Va. Polytech. Inst. and State Univ. Div. For. and Wildl. Sci. 27 p.
- Gochenour, Donald L., Jr., Edward L. Fisher, and Cleveland J. Biller.
1978. An analytical appraisal of cable logging technique in Appalachia. *For. Ind.* (105(11): 80-83.
-

APPENDIX

Ecologger Specifications

Basic carrier:

Skidder Tree Farmer C6D
 Engine GM 4:53 N Series,
 130, 2,800 r/min

Hydraulic system:

Pump capacity 25 Imp. gal/min,
 Working pressure 1,750 lb/in²

Tires:

Standard 18.4 x 34 (Can.),
 23.1 x 26 (U.S.)

Spar:

Tower 42-foot hydraulically
 raised 8- by 12-inch
 rectangular tubing
 with base pad

Guylines 4 independent hy-
 draulically driven—
 200 feet of 3/4-inch
 cable on each drum

Controls Digital remote con-
 trol backup umbilical
 cord

Winch system:
 skyline drum

Mainline drum

Strawline drum

Carriage

Weight

Direct coupled—auto-
 matic 2 speed

Line speed: 750 ft/
 min

Maximum line pull:
 23,400 lb

Capacity: 100 feet—
 11/16-inch rope

Maximum line pull:
 8,500 lb—base of
 drum

Line speed: 950 ft/
 min—single speed

Capacity: 1,540 feet
 —9/16-inch rope

Maximum line pull:
 2,500 lb—base of
 drum

Line speed: 2,500
 ft/min—single speed

Capacity: 1,800 feet
 —5/16-inch rope

Maki with stop at
 bottom of skyline

Approximately
 28,000 lb without
 cable

Headquarters of the Northeastern Forest Experiment Station are in Broomall, Pa. Field laboratories and research units are maintained at:

- **Amherst, Massachusetts, in cooperation with the University of Massachusetts.**
 - **Beltsville, Maryland.**
 - **Berea, Kentucky, in cooperation with Berea College.**
 - **Burlington, Vermont, in cooperation with the University of Vermont.**
 - **Delaware, Ohio.**
 - **Durham, New Hampshire, in cooperation with the University of New Hampshire.**
 - **Hamden, Connecticut, in cooperation with Yale University.**
 - **Kingston, Pennsylvania.**
 - **Morgantown, West Virginia, in cooperation with West Virginia University, Morgantown.**
 - **Orono, Maine, in cooperation with the University of Maine, Orono.**
 - **Parsons, West Virginia.**
 - **Princeton, West Virginia.**
 - **Syracuse, New York, in cooperation with the State University of New York College of Environmental Sciences and Forestry at Syracuse University, Syracuse.**
 - **University Park, Pennsylvania, in cooperation with the Pennsylvania State University.**
 - **Warren, Pennsylvania.**
-