Reprinted from SOIL SCIENCE
Vol. 85, No. 6, June, 1958
Printed in U.S.A.

THE SAN DIMAS SOIL CORE SAMPLER

L. A. ANDREWS AND W. M. BROADFOOT
Forest Service, U. S. Department of Agriculture[1]

Received for publication August 5, 1957

The search for satisfactory methods of sampling soils for various purposes under a wide variety of conditions has led to the development of the equally wide variety of soil samplers described by Hoover, Olson, and Metz (5), Lull and Reinhart (8), and the U. S. Dept. Agr. Soil Survey staff (11). Although many of these samplers proved successful for the particular sampling jobs for which they were designed, none, unfortunately, were satisfactory for all sampling jobs.

In 1951, the need for a new type of sampler was recognized at the San Dimas research center where a study of soil-moisture changes in soils to a depth of 17 feet was planned. Several groups of fiberglas soil-moisture units were to be installed. To study the response of undisturbed soil cores, at least 2.5 inches in diameter, to soil-moisture changes through several drying cycles (4), the units were to be inserted in the cores. Thus a satisfactory sampler was needed to obtain the cores.

Soils to be sampled were residual and weathered from deeply fractured diorite. The soil mantle is classified texturally as a sandy clay loam, and is probably closely related to the Vista soil series. Fragments of parent rock large enough to hinder soil sampling are found throughout the profile. Roots of native shrubs are concentrated in the upper 4 feet of soil, but have been observed throughout the soil mantle and occasionally penetrate cracks in the bedrock.

Soil sampling with any sampler which required trenching was precluded from consideration because of the resulting disturbance to the research installation. The King tube, or its modification by Veihmeyer (13), provides a core which is too small in diameter for the calibration of fiberglas soil-moisture units. The samplers designed by Coile (2), Lutz (9), modifications of the latter by Hoover *et al.* (5), and Swanson (12) could not be used because of the necessity of digging pits to sample deep soils. Further, any machine-mounted sampler such as the Utah Soil Sampling machine could not be used because of the disturbance to the installation and inaccessibility of some sites to a wheeled vehicle; the limitation in depth to which the machine is able to sample and its high cost of several thousand dollars also precluded its use in this study.

THE SAN DIMAS SAMPLER

Individual parts of the sampler, identified by numbers 1 to 8 in the lower part of figure 1, and their functions are:

1. Rotating cutter of seamless steel tubing. The cutter has two helical flanges of 45 degrees terminating in cutting bits which have a bevel of 60 degrees. These bits extend beyond the forward edge of the tubing about one-tenth inch. The forward end of the tube was beveled, and four 1-inch notches equally spaced were cut into the edge. In operation these notches release soil displaced by the cutting head. The flanges convey the cut soil upward and away from the sampling tube. The bevel of the cutting bits controls the amount of downward pull for the sampler. This design is favorable for sampling dry compacted soils, but a somewhat lessened bevel is preferable for moist or friable soils. Too rapid cutting in any case will disturb the soil core.

2. Pipe reducer for attaching the rotating cutter to its shaft and handle.

3. Sample collector made of seamless steel tubing. This collector is designed to contain the soil core retainer ring *6* and the spacer ring *7*. Its cutting head is a sleeve 0.87-inch long, inserted 0.75-inch into the forward end of the sample collector tube and riveted into place. Thus, if the cutting edge is damaged, the cutting head is easily replaced. An outside bevel of 0.50-inch was machined to a cutting edge on the com-

[1] Senior author: San Dimas Experimental Forest, maintained by the California Forest and Range Experiment Station, in cooperation with the California Division of Forestry. Junior author: Vicksburg Infiltration Project, maintained by the Southern Forest Experiment Station, in cooperation with the Waterways Experiment Station, Corps of Engineers, U. S. Army.

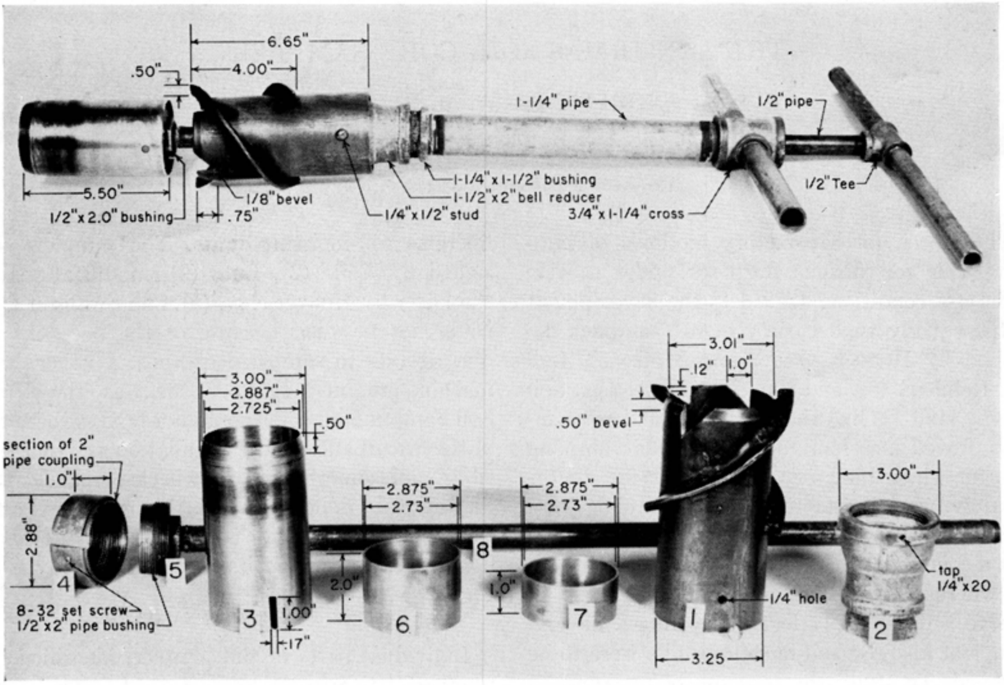

Fig. 1. San Dimas soil-core sampler

bined parts. The inside diameter of the cutting head was machined to 0.005 inch less than the inside diameters (2.730 inches) of the retainer ring *6* and the spacer ring *7*. This permits the soil core to move more freely through retainer and spacer rings. The space above and below the collector ring allows slicing a smooth surface on the ends of the collected core. The beveled edge of the cutting head should be even with the beveled edge of the rotating cutter when the sampler is assembled (shown on left in figure 2).

4. Expansion ring for attaching the sample collector *3* to the stationary shaft *8* through the expander *5*.

5. Tapered pipe bushing for expanding the expansion ring *4* against the inside of the sample collector *3*.

6. Soil core retainer ring made of seamless brass. This ring remains around the sample during moisture unit calibration and provides the constant volume for bulk density determinations.

7. Spacer ring of seamless brass to fit above the retainer ring *6*. Removal of this spacer ring permits the sample to be cut off flush with the upper end of the retainer ring, providing a smooth surface.

8. Operating shaft which holds the sample collector *3* stationary during the sampling operation.

The assembled sampler shown in the upper part of figure 1 includes the operating shaft for the rotating cutter *1*. This shaft, made of 1¼-inch pipe equipped with a handle, was attached to the cutter by means of the pipe reducer *2*. The cutter and its shaft were graduated to indicate the depth of sampling. The assembled sampler also includes the handle attached to the sample collector operating shaft *8*.

Pipe fittings were used for certain parts because they were readily available. The sampler could be made lighter and easier to handle through the use of alloy steels.

On the San Dimas Experimental Forest it was found that the sampler can be operated efficiently by two persons. One holds the sample collector handle stationary while the other turns the rotating cutter handle clockwise. A slight pressure on the handle of the collector causes it to follow the rotating cutter downward, thus allowing the core retainer ring to be eased around the desired core. When the desired depth is reached, the sample collector handle is turned to break off the core before removing the sampler.

To remove the core, first place the sampler in a horizontal position. Expose the sample collector tube by sliding back the rotating cutter. While holding the collector handle stationary, turn the soil sample collector counterclockwise, thus releasing the grip of the expansion ring and permitting removal of the handle. Loosen the soil about ½ inch around the inside of the cutting head with a knife blade; the soil core contained in the retainer and spacer rings can then be easily pushed out of the sample collector.

The section of the soil core which is contained in the cutting head and that contained in the spacer ring will each be exposed. The ends of the core in the retainer ring can then be sliced off smoothly and the core is ready for processing.

To permit smoothing of the ends it is necessary to obtain a longer core than that actually used. The minimum soil layer necessary for a retained sample 2 inches long is about 3.25 inches. Where consecutive samples less than 3.25 inches thick are desired, they must be taken alternately from more than one hole.

The San Dimas soil-core sampler as designed has proved satisfactory when used to sample moist or damp soils of the San Dimas Experimental Forest research installations. To extend the sampler's efficiency in dry hard soils, the sampler was modified recently as follows:

(*a*) A new cutting head 2.730 inches, inside diameter, was made 0.010 inch smaller than the retainer and spacer rings by crimping the cutting edge. Thus, the soil core could slide through the head and into the brass rings more easily and with less danger of compaction.

(*b*) The rotating cutter was redesigned (as shown on right in figure 2) by eliminating the four 1-inch notches in the beveled edge. The forward edge of the tube was removed to a depth of 0.50-inch. A small wedge-shaped segment of tubing attached to and immediately ahead of each augering flange was left for support and beveling purposes. The cut edge of the tube was also beveled.

In operating position, the beveled edge of the rotating cutter is immediately above and conforms to the beveled edge of the cutting head. Thus, the possibility of soil compaction between the two cutting edges was eliminated.

These modifications permitted collection of samples suitable in every respect from sandy clay loam soil having only 6 per cent moisture content.

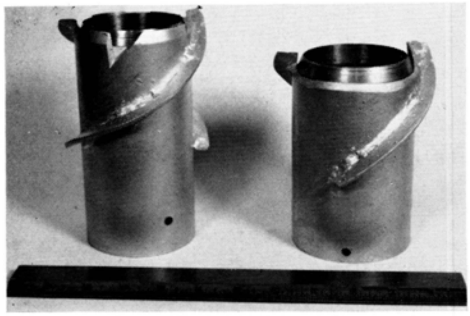

FIG. 2. San Dimas sampler rotating cutter with collector tube in operating position: original type (*left*) and modified type (*right*).

THE VICKSBURG MODIFICATION

In 1951 the Vicksburg Infiltration Project of the Southern Forest Experiment Station, having need for a sampler to aid in determinations of bulk density and soil moisture tension, built a sampler to the San Dimas specifications, but project technicians found it difficult to use in certain soils of the southern region, especially if the soils were dry. To make the sampler more usable in the Project's soil sampling program, certain parts of the San Dimas model were modified as follows:

(*a*) The sampler was designed to utilize the same inner cylinder as Russell's (10) air-picnometer for the determination of soil pore space. This required reduction of the inside diameter of the retainer and spacer rings from 2.730 inches to 2 inches.

(*b*) The pitch of the augering flanges was lessened.

(*c*) Components made of pipe fittings in the San Dimas model were made of commercial steel tubing joined by welding.

(*d*) The sample collector tube and cutting head were machined as one unit rather than constructed separately. Three seamless brass rings were provided instead of two. The cutting head was 5/16-inches long, followed by a ½-inch spacer ring, the 1⅜-inch soil core retainer ring, and then a 1-inch spacer ring. The inside diameter was exactly 2 inches for both the cutting head and the rings.

(*e*) A double bayonet lock was used to fasten the sample collector to the stationary shaft (fig. 3).

(*f*) The retainer ring depth was shortened 0.625 inch whereby a shorter layer of soil can be cut in obtaining a soil core. When the sampler is

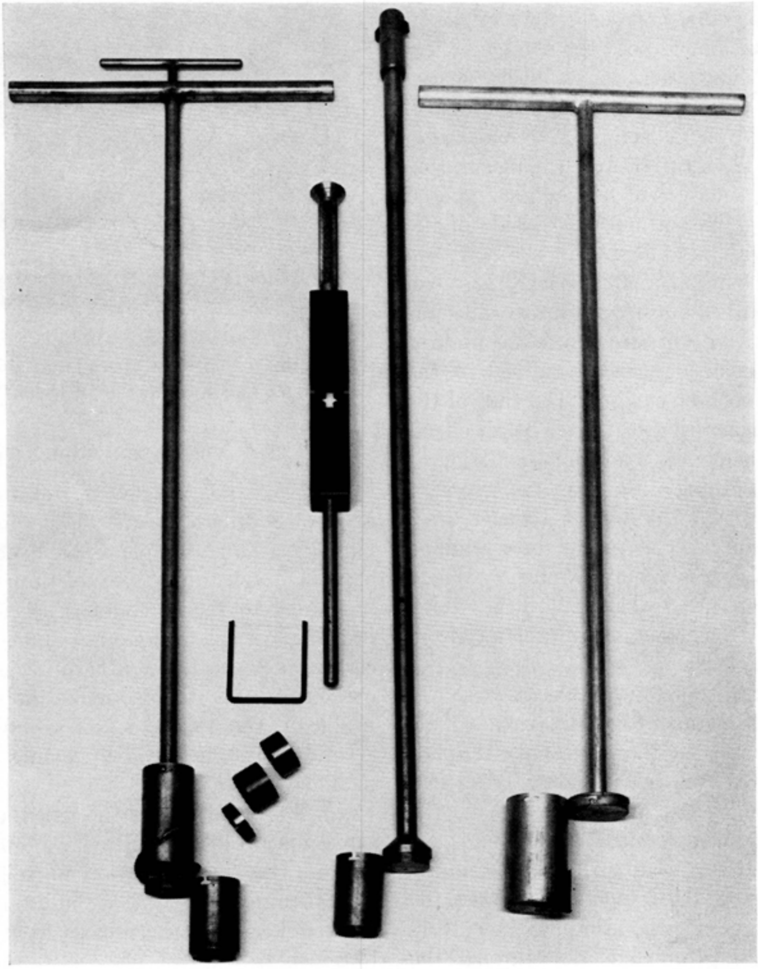

FIG. 3. Samplers built at Vicksburg

augered 3 inches into the soil the core retainer ring is positioned at approximately the center of the 3-inch layer of soil. The outer cylinder and handle were marked for 3-inch increments, so that successive 3-inch soil layers can be sampled from a single sampling hole.

The components of the modified sampler are shown (fig. 3) with a drive-type sampler and its hammer, a core cutter, and a hole cleaner. These latter items were designed on the Infiltration Project for use in its soil sampling program (1).

The drive-type sampler uses the same sample collector tube as the auger-type. The hammer is similar to the one designed for use with the King tube.

A core cutter which slips between the retainer ring and the spacer rings to make a smooth surface on both ends of the soil core is shown between the two samplers in figure 3. It is made of $\frac{1}{32}$-inch piano wire stretched across the open part of a U-shaped piece of $\frac{5}{16}$ inch metal.

The hole cleaner shown on the right can be used to even the soil and adjust the depth for the next core.

The modified San Dimas sampler and the drive-type sampler have been used for collection of undisturbed soil cores for bulk density measurement and tension analysis by the Vicksburg Infiltration Project in a wide variety of soils over 25 states, Alaska and Puerto Rico.

SUMMARY

The San Dimas soil core sampler was developed to take cores in deep soils with a minimum of disturbance to either the core or the area being

sampled. This is the only hand-operated sampler which has a cutter rotating around a stationary inner collector tube. The cutter removes the soil around the cutting head, carrying it upward and away from the tube and thus avoiding compaction of the sample.

The sampler was specifically designed to take undisturbed soil cores for the calibration of fiberglas soil-moisture units. Its cores are also suitable for the determination of bulk density and soil-moisture tension values by use of the Leaner-Shaw tension table (7). The sampler and its modifications have proved satisfactory for obtaining the cores for bulk density measurements and tension analysis in a variety of soils over the United States, Alaska, and Puerto Rico.

REFERENCES

(1) Broadfoot, W. M. 1954 Procedures and equipment for determining soil bulk density. *Southern Forest Expt. Sta. Occas. Paper 135.*

(2) Coile, T. S. 1936 Soil samplers. *Soil Sci.* 42: 139–142.

(3) Colman, E. A. 1947-Rev. 1952 Manual of instructions for use of the fiberglas soil-moisture instrument. California Forest and Range Expt. Sta.

(4) Hendrix, T. M., and E. A. Colman 1951 Calibration of fiberglas soil-moisture units. *Soil Sci.* 71: 419–427.

(5) Hoover, M. D. Olson, D. F., Jr., and Metz, L. J. 1954 Soil sampling for pore space and percolation. *Southeastern Forest Expt. Sta. Paper 42.*

(6) Kelly, O. J., Hardman, J. A., and Jennings, D. S. 1947 A soil sampling machine for obtaining two-, three-, and four-inch cores of undisturbed soil to a depth of six feet. *Soil Sci. Soc. Amer. Proc.* 12: 85–87.

(7) Leamer, R. W., and Shaw, B. 1941 A simple apparatus for measuring non-capillary porosity on an extensive scale. *J. Am. Soc. Agron.* 33: 1003.

(8) Lull, H. W., and Reinhart, K. G. 1955 Soil moisture measurement. *Southern Forest Expt. Sta. Occas. Paper 140.*

(9) Lutz, J. F. 1947 Apparatus for collecting undisturbed soil samples. *Soil Sci.* 64: 399–401.

(10) Russell, M. B. 1949 A simplified air-picnometer for field use. *Soil Sci. Soc. Amer. Proc.* 14: 73–76.

(11) Soil Survey Staff. 1951 *Soil Survey Manual.* U. S. Dep. Agr. Handbook 18.

(12) Swanson, C. L. W. 1950 A portable soil-core sampler and penetrometer. Agron. J. 42: 447–451.

(13) Veihmeyer, F. J. 1929 An improved soil-sampling tube. *Soil Sci.* 27: 147–152.