MAPPING POCKET GOPHER BURROW SYSTEMS WITH EXPANDING POLYURETHANE FOAM

MARK FELTHAUSER and DAVID McINROY, Group LS-6, MS-K495, Los Alamos National Laboratory, Los Alamos, NM 87545.

Previous studies of small-mammal burrow system configurations have been based primarily on measurements of ground-surface soil casts (Reid et al. 1966, Richens 1966, Hansen and Morris 1968, Gunderson 1976, Vleck 1981). However, surface indications of burrow system dimensions are not adequate when precise data are needed on burrow physiognomy.

The impetus for this study arose from the need to isolate buried chemical and radioactive waste from burrowing animals. In a study of barrier materials that inhibit burrowing by pocket gophers (*Thomomys* spp.) into waste material, it was necessary to map tunnel systems as a function of depth and soil type. We wanted a method of mapping burrow systems that would be economical, portable, useful in a variety of soil types, and give accurate, permanent records of burrow configurations. This paper describes a method for injecting an expanding polyurethane foam to map burrow systems in situ.

INJECTION APPARATUS

The device used to map burrow systems was developed for injecting insulating foam into closed building spaces (Fig. 1). The foam is initially in 2 components: an isocyanate and a resin. Freon added to these components causes the foam to expand when mixed and exposed to air. Pressurized nitrogen is used to force the 2 components into a gun assembly where mixing takes place. The resulting foam is expelled in a stream that, depending upon the nitrogen pressure, can travel several meters in air. Nitrogen pressure of about 60 p.s.i. produced good results when mapping extensive burrow systems. The residue remaining in the gun after an injection is flushed from the nozzle with a methylene chloride solvent. Each component tank holds 67.5 kg of chemical. A

Fig. 1. Apparatus used to inject foam into pocket gopher burrow systems. The unit was placed in a truck for transport to field sites.

yield of 9–18 m^3 of foam results from 135 kg of the 2 chemicals. Yield varies with temperature, atmospheric pressure, and restrictions placed on the expanding foam (e.g., size and shape of the burrow). When we used the foaming apparatus, the ambient air temperature was between 10 and 32 C. Good results were obtained within this temperature range. Because soil temperatures vary less than air temperatures, quality foam casts could probably be made in considerably colder and warmer aboveground conditions than we tested.

The entire apparatus was mounted on a metal cart and weighed about 450 kg. A forklift was required to lift the assembly into a truck. To maximize accessibility to field sites, a 4-wheel-drive vehicle was used to transport the apparatus.

The foam components and cleaning solvent are potentially hazardous if contacted by skin or eyes. Therefore, safety goggles, gloves, and protective clothing must be worn during the injection process.

FIELD TESTING

The foam injection apparatus was tested under a variety of natural and experimental conditions involving several soil types. Fifteen pocket gopher tunnel systems occurring under natural conditions were injected with foam to determine applicability of the technique to different soil types. Tunnel systems were examined in a sandy alluvium, a sandy-loam disturbed by heavy equipment, an undisturbed sandy-loam, and a gravel.

The apparatus also was tested in 4 different soil profiles (60 cm of top soil over bentonite clay, crushed tuff [a sandy-loam], gravel, or cobble-gravel) in 4 metal culverts (1.8 m diam, 2.1 m ht). One pocket gopher was placed in each culvert; the gophers were maintained for 4 months and then removed. The burrow system that had been constructed by each gopher was then injected with foam. Under natural conditions no gophers were trapped in the foam cast. We assumed that our disturbance on the surface caused them to leave their burrows or to retreat to a tunnel end and plug the passage with soil.

The injection procedure that provided the best results consisted of attaching a 2.5-cm-diameter tygon hose, about 45 cm long, to the gun nozzle. Tunnel systems that were observed to branch near the entrance point were injected separately to facilitate filling of all burrows. After inserting the hose into an entrance, soil was tamped around the hose and entrance to prevent back-flow of the foam. Foaming of the tunnel system was continued until back-flow or foam eruptions at remote tunnel entrances prevented further flow.

After the foam was injected, it expanded into an exact cast of the tunnel system

Therefore, safety gog
otective clothing must
injection process.

n apparatus was tested
atural and experimen-
ing several soil types.
ner tunnel systems oc-
al conditions were in-
determine applicabil-
to different soil types.
e examined in a sandy
-loam disturbed by
in undisturbed sandy-

so was tested in 4 dif-
60 cm of top soil over
ed tuff [a sandy-loam],
ravel) in 4 metal cul-
2.1 m ht). One pocket
n each culvert; the go-
ned for 4 months and
e burrow system that
ed ach gopher was
foam. Under natural
ers were trapped in the
umed that our distur-
e caused them to leave
retreat to a tunnel end
ge with soil.
ocedure that provided
nsisted of attaching a
gon hose, about 45 cm
nozzle. Tunnel systems
to branch near the en-
injected separately to
all burrows. After in-
o an entrance, soil was
e hose and entrance to
of the foam. Foaming
m was continued until
n eruptions at remote
revented further flow
was injected, it expands
st of the tunnel system

and hardened in about 15 minutes. The foam was then excavated manually with a shovel and trowel. Four to 8 man-hours were required to inject, excavate, and reassemble each tunnel system. Occasionally, a tunnel cast could be removed intact, although breakage of a cast occurred frequently. Broken casts were easily reassembled on the ground surface (using wire rods for support) to provide a 3-dimensional model of the tunnel system.

The maximum length of a single branch of a burrow mapped by the foaming technique was 15 m. The maximum volume of an injected burrow system was 0.15 m^3 (10 cm diam × 19.1 m total length); the maximum depth of a burrow, as measured by the foam cast, was 1.5 m.

Factors that limited the amount of tunnel system that was mapped by a single injection included (1) a plugged tunnel resulting from a cave-in or from the digging by a gopher, and (2) increased viscosity of the foam as the expanding and hardening process began. Excavation of the cast started at the tunnel entrance and proceeded along the path of the foam. When an end of a tunnel cast was encountered, the surrounding soil was excavated to determine if the foam had reached a short soil plug or a tunnel end. Continuations of tunnel systems beyond the cast were mapped by re-injecting the remaining tunnel with foam. Operating experience suggested that a continuing tunnel system should be re-injected as soon as possible to reduce tunnel cave-ins that would prevent further mapping.

The performance of the foaming apparatus in creating tunnel casts in all soil types except those containing rocks was excellent as judged by the ease of tunnel-cast excavation and reassembly. The technique did not perform well in gravel or [illegible] gravel soil types because the rel- [illegible] large pore spaces between the rocks

Fig. 2. Foam cast from a pocket gopher burrow in a natural, sandy alluvial soil. The bubble in the upper right is from backflow at the injection point. Storage chambers can be seen at the bend in the longest branch. The longest branch is about 8 m long.

filled with foam (regardless of nitrogen pressure). Thus, the exact dimensions of the pocket gopher burrows were obscured.

Burrow systems in surface soil, sandy soil, and sandy-loam were completely mapped in 3 dimensions by the foam. All features of the burrows were apparent from the cast, including food-storage and nest chambers (Fig. 2).

DISCUSSION

The polyurethane foam injection technique provided a relatively easy, accurate method of mapping pocket gopher burrow systems. Features of the burrows that were readily identified or measured included the length, depth, and volume of the tunnel system as well as food-storage and nest chambers.

May 1982 prices for a gun, hoses, solvent tank, and pressure valves totaled about $2,000.00 (available from Olin Chemicals, 120 Long Ridge Road, Stamford, CT 06904). Two full 67.5-kg tanks cost an additional $525.00 (also from Olin). About 6 m^3 of nitrogen is ample for 135 kg of foam and can be obtained locally for less than $20.00. A full set of tanks could map 60–120 burrow systems.

The unit we used was the smallest of its kind available from the commercial foam industry. Smaller units are manufactured that are self-pressurized, solvent-less, and disposable (available from Foam Craft Inc., P.O. Box 15246, Sarasota, FL 33579). Three sizes are available weighing 1, 17, and 30 kg each. Foam yields (under ideal conditions, according to Foam Craft) are 0.024, 0.45, and 1.5 m^3, with May 1982 prices of $22.25, $283.00, and $583.00, respectively.

These small, disposable units are considerably more portable than the reusable system used in this study; however, their cost is much higher (11–35 times more when considering only the cost of the foam and 2.3–7 times more when the initial cost of the system we used is included). The ratio approaches the higher figure as more foam is used.

We did not use any light, disposable foam units but believe the larger sizes would be adequate for mapping burrows. However, the relatively high cost of the foam must be considered when deciding whether portability is a higher priority than cost. Although this technique was tested only on pocket gopher burrow systems, we believe that it could be adapted to map tunnel systems of other burrowing animals.

Acknowledgments.—We thank T. E. Hakonson for suggesting this project and for manuscript review. We also thank group H-1 (Health Physics) of Los Alamos National Laboratory for loaning the foaming equipment to us.

LITERATURE CITED

GUNDERSON, H. L. 1976. Mammalogy. McGraw-Hill Book Co., New York, N.Y. 483pp.

HANSEN, R. M., AND M. J. MORRIS. 1968. Movement of rocks by northern pocket gophers. J. Mammal. 49:391–399.

REID, V. H., R. M. HANSEN, AND A. L. WARD. 1966. Counting mounds and earth plugs to census mountain pocket gophers. J. Wildl. Manage. 30: 327–334.

RICHENS, V. B. 1966. Notes on the digging activity of a northern pocket gopher. J. Mammal. 47: 531–533.

VLECK, D. 1981. Burrow structure and foraging costs in the fossorial rodent, *Thomomys bottae*. Oecologia 49:391–396.

Received 27 October 1981.
Accepted 26 July 1982.

LANL/ER Records Processing Facility

02-Jun-99

Locate | Add Record | User Query | Print Record Listing User Query | Print Report by ER ID Number | Print Index Report | Print This Record | Exit

Apply | Reload All Data | Related Documents

ER ID Number 50280

Record Category R

Date Received 12/1/95

Record Package # N/A

Privilege N

Processor DIC

Correction N

Corrected # N/A

Admin. Record Y

Records Retention INDEFINIT

Corrected By # N/A

AR Type N/A

File Folder N/A

Page Count 2

Miscellaneous Comments N/A

Date Entered 3/4/96

Documents

StartPg	Type	DocDate	Doc To	Org To	Originator
1	REPORT	7/26/82	N/A	N/A	MARK FELTHAUSER/DAVID

Orig Org	Symbol	Subject	Box #	Roll #
LS-6	N/A	MAPPING POCKET GOPHER BURROW SYSTEMS WITH EXPANDING POLYURETHANE FOAM	138	145

This reference set is provided to facilitate review of Laboratory Environmental Restoration (ER) Project documents and is organized by ER identification (ER ID) number.

ER Project documents use ER ID numbers to track reference items through its Records-Processing Facility. Because ER ID numbers are issued on an ongoing basis throughout the entire ER Project, gaps may be present in the numbers included in this table of contents.

REFERENCE SET 1082

VOLUME 5

ER ID	REFERENCE
52027	Keller, D. and D. Dunham, 1995. "Biological Assessment for the Norton Powerline Pole Replacement: Fiscal Year 1996 Replacements," Los Alamos National Laboratory Report LA-UR-95-850, Los Alamos, New Mexico. **(Keller et al. 1996, 52027)**
52032	Dunham, D., January 1996. "Biological and Floodplain/Wetland Assessment for the Stream Plant Replacement Project (TA-16 and TA-9)," Los Alamos National Laboratory Report LA-UR-96-108, Los Alamos, New Mexico. **(Dunham 1996, 52032)**
52951	Environmental Protection Group, July 1994. "Environmental Surveillance at Los Alamos during 1992," Los Alamos National Laboratory Report LA-12764-ENV, Los Alamos, New Mexico. **(Environmental Protections Group 1994, 52951)**
52964	Barr, M.J., June 25, 1992. "Rest House Evaluation and Operations at TA-16 and TA-11," Los Alamos National Laboratory Memorandum WX-3-92-538 to W.B. Martin from M.J. Barr, Los Alamos, New Mexico. **(Barr 1992, 52964)**
54399	Newman, B. D. 1996. Geochemical Investigations of Calcite Fracture Fills and Mesa-Top Water Dynamics on the Pajarito Plateau, New Mexico," Ph.D. Dissertation, New Mexico Tech. pp. 61-109. Los Alamos National Laboratory Report LA-UR-96-1441, Los Alamos, New Mexico. **(Newman 1996, 54399)**
54404	Wohletz K.H., 1995. "Measurement and Analysis of Rock Fractures in the Tshirege Member of the Bandelier Tuff along Los Alamos Canyon adjacent to TA-21," excerpt from Los Alamos National Laboratory Report LA-12934-MS in *Earth Science Investigations for Environmental Restoration—Los Alamos National Laboratory Technical Area 21*, Los Alamos, New Mexico. **(Woheltz 1995, 54404)**
54555	Parkhurst, D.L., 1995. "User's Guide to PHREEQC – A Computer Program for Speciation, Reaction-Path Advective-Transport, and Inverse Geochemical Calculations," US Geological Survey Water-Resources Investigations Report 95-4227, Lakewood, Colorado. **(Parkhurst, 1995, 54555)**
54609	LANL (Los Alamos National Laboratory), 1996. "Quality Assurance Project Plan Requirements for Sampling and Analysis," Los Alamos National Laboratory Document LA-UR-96-441, Los Alamos, New Mexico. **(LANL 1996, 54609)**

54827	McDonald, E. V., R. D. Ryti, P. A. Longmire, and S. L. Reneau, March 1996. "Background Geochemistry of Soils and Colluvium at MDA-P, Los Alamos National Laboratory," Los Alamos National Laboratory Report LA-UR-96-1092, Los Alamos, New Mexico. **(McDonald et al. 1996, 54827)**
54948	Broxton, D. E., Ryti, R. T., Carlson, D., Warren, R. G., Kluk, E., and Chipera, S., 1996. "Natural Background Geochemistry of the Bandelier Tuff at MDA-P," Los Alamos National Laboratory unpublished report, LA-UR-96-1151, 42 p., Los Alamos, New Mexico. **(Broxton et al. 1996, 54948)**
54952	Gilbert, R. O., and J. C. Simpson 1992. "Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3: Reference-Based Standards for Soils and Solid Media," Pacific Northwest Laboratory, Richland, Washington 99352. **(Gilbert and Simpson 1992, 54952)**

replaced 2-11-04 evm

This reference set is provided to facilitate review of Laboratory Environmental Restoration (ER) Project documents and is organized by ER identification (ER ID) number.

ER Project documents use ER ID numbers to track reference items through its Records-Processing Facility. Because ER ID numbers are issued on an ongoing basis throughout the entire ER Project, gaps may be present in the numbers included in this table of contents.

OU 1082 REFERENCE SET
VOLUME 5

ER ID	REFERENCE
52027	Keller, D. and D. Dunham, 1995. "Biological Assessment for the Norton Powerline Pole Replacement: Fiscal Year 1996 Replacements," Los Alamos National Laboratory Report LA-UR-95-850, Los Alamos, New Mexico. **(Keller et al. 1996, 52027)**
52032	Dunham, D., January 1996. "Biological and Floodplain/Wetland Assessment for the Stream Plant Replacement Project (TA-16 and TA-9)," Los Alamos National Laboratory Report LA-UR-96-108, Los Alamos, New Mexico. **(Dunham 1996, 52032)**
52964	Barr, M.J., June 25, 1992. "Rest House Evaluation and Operations at TA-16 and TA-11," Los Alamos National Laboratory Memorandum WX-3-92-538 to W.B. Martin from M.J. Barr, Los Alamos, New Mexico. **(Barr 1992, 52964)**
54399	Newman, B. D. 1996. Geochemical Investigations of Calcite Fracture Fills and Mesa-Top Water Dynamics on the Pajarito Plateau, New Mexico," Ph.D. Dissertation, New Mexico Tech. pp. 61-109. Los Alamos National Laboratory Report LA-UR-96-1441, Los Alamos, New Mexico. **(Newman 1996, 54399)**
54404	Wohletz K.H., 1995. "Measurement and Analysis of Rock Fractures in the Tshirege Member of the Bandelier Tuff along Los Alamos Canyon adjacent to TA-21," excerpt from Los Alamos National Laboratory Report LA-12934-MS in *Earth Science Investigations for Environmental Restoration—Los Alamos National Laboratory Technical Area 21*, Los Alamos, New Mexico. **(Woheltz 1995, 54404)**
54555	Parkhurst, D.L., 1995. "User's Guide to PHREEQC – A Computer Program for Speciation, Reaction-Path Advective-Transport, and Inverse Geochemical Calculations," US Geological Survey Water-Resources Investigations Report 95-4227, Lakewood, Colorado. **(Parkhurst, 1995, 54555)**
54827	McDonald, E. V., R. D. Ryti, P. A. Longmire, and S. L. Reneau, March 1996. "Background Geochemistry of Soils and Colluvium at MDA-P, Los Alamos National Laboratory," Los Alamos National Laboratory Report LA-UR-96-1092, Los Alamos, New Mexico. **(McDonald et al. 1996, 54827)**

ER ID	REFERENCE
54948	Broxton, D. E., Ryti, R. T., Carlson, D., Warren, R. G., Kluk, E., and Chipera, S., 1996. "Natural Background Geochemistry of the Bandelier Tuff at MDA-P," Los Alamos National Laboratory unpublished report, LA-UR-96-1151, 42 p., Los Alamos, New Mexico. **(Broxton et al. 1996, 54948)**
54952	Gilbert, R. O., and J. C. Simpson 1992. "Statistical Methods for Evaluating the Attainment of Cleanup Standards, Volume 3: Reference-Based Standards for Soils and Solid Media," Pacific Northwest Laboratory, Richland, Washington 99352. **(Gilbert and Simpson 1992, 54952)**