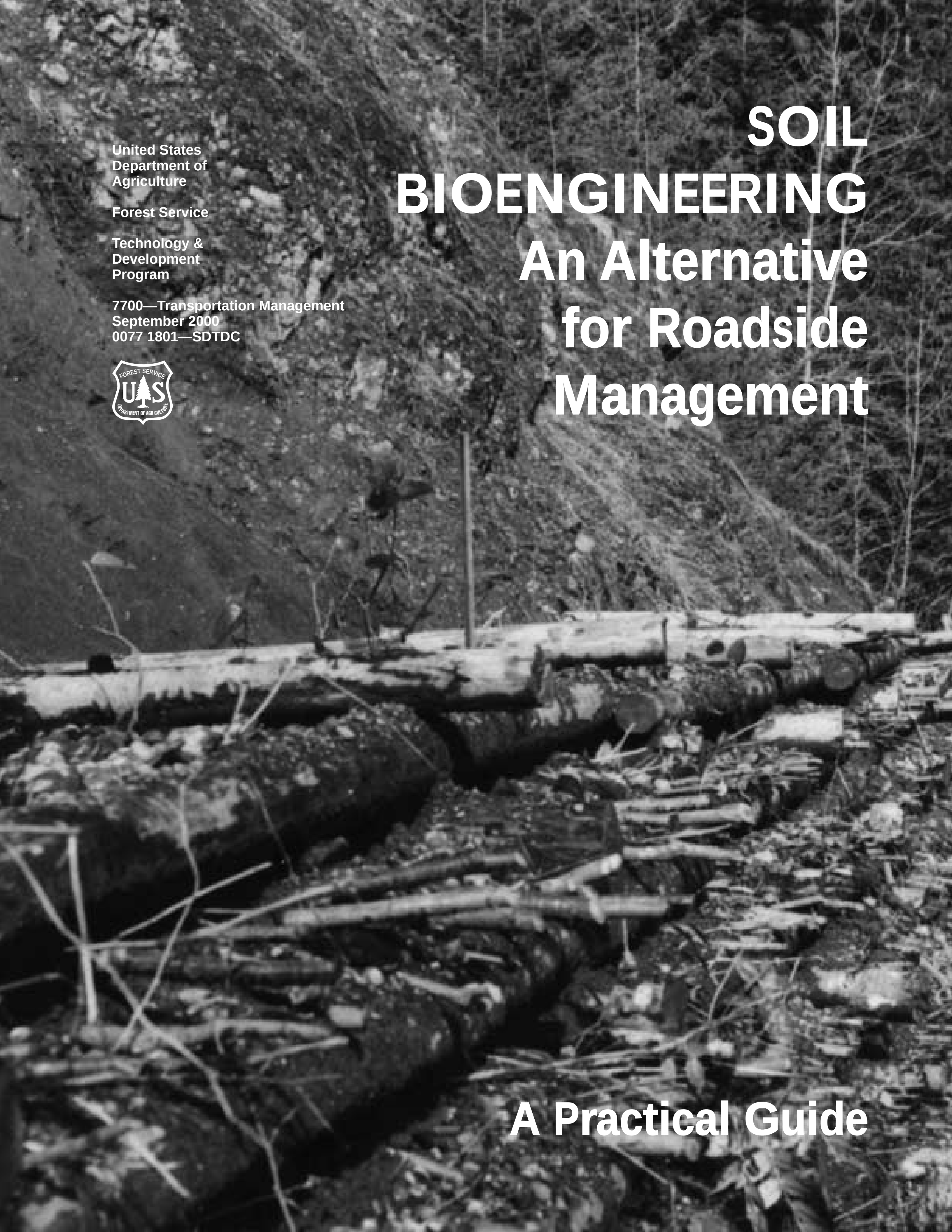

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Technology &
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SOIL BIOENGINEERING
An Alternative for Roadside Management

A Practical Guide

MAP

FIGURES

DEDICATION

To Clifford Gershom Jordan my grandfather, who farmed 150 acres of southwest Georgia's sandy clay loam soils with a team of mules, never once using mechanized equipment. And to his beloved helpmate my grandmother Rachel Culbreth Jordan, also known as Miss Pinky. From this land, they grew and hand-harvested cotton, peanuts, and corn. From their garden, she canned fruits and vegetables, creating the most beautiful art gallery I have ever seen, her pantry. Their spirits circle my every step.

Heartfelt thanks to my parents, Betty Jordan Phillips and Charles Andrew Phillips, whose loving guidance and support made possible my career as a soil scientist.

To Dave Craig, silviculturalist, district ranger, and mentor. His artful management of the land and people will never cease to amaze me.

And to Marsha Stitt, whose support through this arduous task made possible this publication.

ACKNOWLEDGEMENTS

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The author would also like to acknowledge the following contributions. Kevin Finney who provided information on the history of soil bioengineering as well as several photographs for the document. Robbin Sotir provided a technical review, furnished figures and photographs of several of the described techniques. Mark Cullington also provided several of the USDA Forest Service photographs and Susan Clements and George Toyama provided valuable assistance in turning these many pages into a book.

The author extends a thank you to the following individuals for the time they offered in review and comment: Forrest Berg, Dave Craig, Mark Cullington, Wayne Elmore, Ellen Eubanks, Kevin Finney, Shannon Hagen, Chris Hoag, Susan Holtzman, Steve Leonard, Marcus Miller, Tom Moore, Kyle Noble, Larry Ogg, Janice Staats, Ron Wiley and Janie Ybarra.

The content of this publication must be credited to the work of Arthur von Kruedener, Charles Kraebel, Donald Gray, and Robbin Sotir–all pioneering soil bioengineering practioners.

FORWARD

Contents of this document are directed primarily to areas that have 30 inches or more annual precipitation. However, several techniques included in this guide can be used in semi arid and arid environments. Work with vegetation and soil specialists to understand what plants you can use in these environments.

INTRODUCTION

Purpose and Scope

Transportation systems provide tremendous opportunities and, if properly located on the landscape with well-designed drainage features, can remain stable for years with negligible affects to adjoining areas. Roads, however, are often linked to increased rates of erosion and accumulated adverse environmental impacts to both aquatic and terrestrial resources.

Transportation systems provide access and allow utilization of land and resources. Development priorities usually emphasize access, safety, and economics while environmental concerns refer to operational and maintenance problems such as surface condition; plugged drainage structures, including ditchlines; mass failures and surface erosion; or reduced access.

This is not new information to land managers. Road maintenance personnel, for example, face a substantial task in maintaining roads under their jurisdiction. Major storms resulting in significant increases in road related erosion events and impacts to adjoining resources have compounded their challenge.

Objectives

Considerable funds are expended annually in an effort to improve road conditions and adjoining resources. Historically, engineers relied primarily on hard/conventional solutions, or "non-living" approaches, for slope and landslide stabilization. The purpose of this publication is to provide viable alternatives known as soil bioengineering. This is not to argue one solution is better than the other, but to provide additional alternatives, and to encourage an integration of these two practices. Land managers need all available tools to effectively do their jobs. This publication is an effort to meet that need.

Specifically, this publication provides field personnel with the basic merits of soil bioengineering concepts and gives examples of several techniques especially effective in stabilizing and revegetating upland roadside enviroments. The information provided in this document is intended to stimulate additional interest for the reader to seek out and use other bioengineering publications.

Benefits and Limitations

Soil bioengineering is an excellent tool for stabilizing areas of soil instability. These methods should not, however, be viewed as the sole solution to most erosion problems. Soil bioengineering has unique requirements and is not appropriate for all sites and situations. On certain surface erosion areas, for example, distribution of grass and forb seed mixes, hydromulching, or spreading of a protective layer of weed-free straw may be satisfactory and less costly than more extensive bioengineering treatments. On areas of potential or existing mass wasting, it may be best to use a geotechnically-engineered system alone or in combination with soil bioengineering. Project areas require periodic monitoring. On highly erosive sites, maintenance of the combined system will be needed until plants have established. Established vegetation can be vulnerable to drought, soil nutrient and sunlight deficiencies, road maintenance sidecast debris, grazing, or trampling and may require special management measures to ensure longterm project success.

Benefits of soil bioengineering include:

- Projects usually require less heavy equipment excavation. As a result, there is less cost and less impact. In addition, limiting hand crews to one entrance and exit route will cause less soil disturbance to the site and adjoining areas.

- Erosion areas often begin small and eventually expand to a size requiring costly traditional engineering solutions. Installation of soil bioengineered systems while the site problem is small will provide economic savings and minimize potential impacts to the road and adjoining resources.

- Use of native plant materials and seed may provide additional savings. Costs are limited to labor for harvesting, handling and transport to the project site. Indigenous plant species are usually readily available and well adapted to local climate and soil conditions.

- Soil bioengineering projects may be installed during the dormant season of late fall, winter, and early spring. This is the best time to install soil bioengineered work and it often coincides timewise when other construction work is slow.

- Soil bioengineering work is often useful on sensitive or steep sites where heavy machinery is not feasible.

- Years of monitoring has demonstrated that soil bioengineering systems are strong initially and grow stronger with time as vegetation becomes established. Even if plants die, roots and surface organic litter continues playing an important role during reestablishment of other plants.

- Once plants are established, root systems reinforce the soil mantel and remove excess moisture from the soil profile. This often is the key to long-term soil stability.

- Soil bioengineering provides improved landscape and habitat values.

History of Soil Bioengineering

The following text is an excerpt from a paper presented by Kevin Finney, Landscape Architect, at the Eleventh Annual California Salmonid Restoration Federation Conference in Eureka, California, March 20, 1993.

Soil bioengineering is the use of live plant materials and flexible engineering techniques to alleviate environmental problems such as destabilized and eroding slopes, streambanks and trail systems. Unlike other technologies in which plants are chiefly an aesthetic component of the project, in soil bioengineering systems, plants are an important structural component.

The system of technologies, which today we call soil bioengineering, can be traced to ancient peoples of Asia and Europe. Chinese historians, for example, recorded use of bioengineering techniques for dike repair as early as 28 BC. Early western visitors to China told of riverbanks and dikes stabilized with large baskets woven of willow, hemp, or bamboo and filled with rocks. In Europe, Celtic and Illyrian villagers developed techniques of weaving willow branches together to create fences and walls. Later, Romans used fascines, bundles of willow poles, for hydroconstruction.

China 28 B.C. Bundling live stems for use in riverbank and dike repair. Kevin Finney

By the 16th Century, soil bioengineering techniques were being used and codified throughout Europe from the Alps to the Baltic Sea and west to the British Isles. One of the earliest surviving written accounts of the use of soil bioengineering techniques, a publication by Woltmann from 1791, illustrated use of live stakes for vegetating and stabilizing streambanks (Stiles, 1991, p.ii). About the same time, other early soil bioengineers working in Austria were developing live siltation construction techniques, planting rows of brushy cuttings in waterways for trapping sediment and reshaping channels.

Bender Board Fencing

Advantages: These structures reduce slope angle, providing a stable platform for vegetation to establish. Like willow fencing, bender board structures trap rolling rocks and sliding debris and protects vegetation growing lower on the slope. Bender board fences provide support for small translational or rotational failures.

Dry sites where soils receive very little precipitation this type of structure. The bender board shelf is considered a temporary planting platform. It is important, therefore, to establish deeper rooting shrubs and trees within the shelves. When the structures begins to decay, root systems of other plants will serve as the permanent feature.

Disadvantage: Significant quantity of plant material is required.

Redwood or cedar bender board fencing is essentially a fence supported on a short layer of shrub or tree stems. Specifically, it is a short retaining wall built of redwood or cedar bender fencing with a stem layered base.

Tools needed:

Hand pruners and clippers, pulaski or hazel hoe, McLeod rake, deadblow or rubber hammer, wood stakes.

Procedure:

Stem Layered Base

- Begin project at base of treatment area. Excavate a 24-inch deep terrace along slope contour and for full width of treatment area. The back of the terrace should be dug with an approximate 70 degree angle. To allow ample planting platforms, space terraces about 5 feet apart.

- Lay 2 feet 6-inch long stems and 2 feet 6-inch long wood stakes (50/50 mix) 2-inches apart and for full length of terrace. Diameter can range from 1/2 to 2-inches. Approximatly 6-inches will extend beyond slope face.

Bender board Fencing

- Drive supporting 4 foot 6-inch (2 by 2) long stakes 2 to 3 feet into ground, spaced 1 foot apart, and perpendicular to the slope. Rebar may be used instead of wooden stakes.

- Weave 10 foot long bender boards through these stakes until the wall reaches a height of 2 feet. Once complete the bender board fence wall should be at a 15 degree angle to the slope. Note: As shown in photo, some bender board are too brittle to weave.

- Once the wall frame is constructed, carefully rake enough soil into the terrace to cover the stem layered base.

- Stand in terrace and begin excavation of second row. This process will allow soil into the terrace to cover the stem layered base.

- A goal should be to construct a 2:1 slope, or less, between the top of the bender board fence wall and the bottom of the one above.

- Move upslope to next terrace alignment and repeat process.

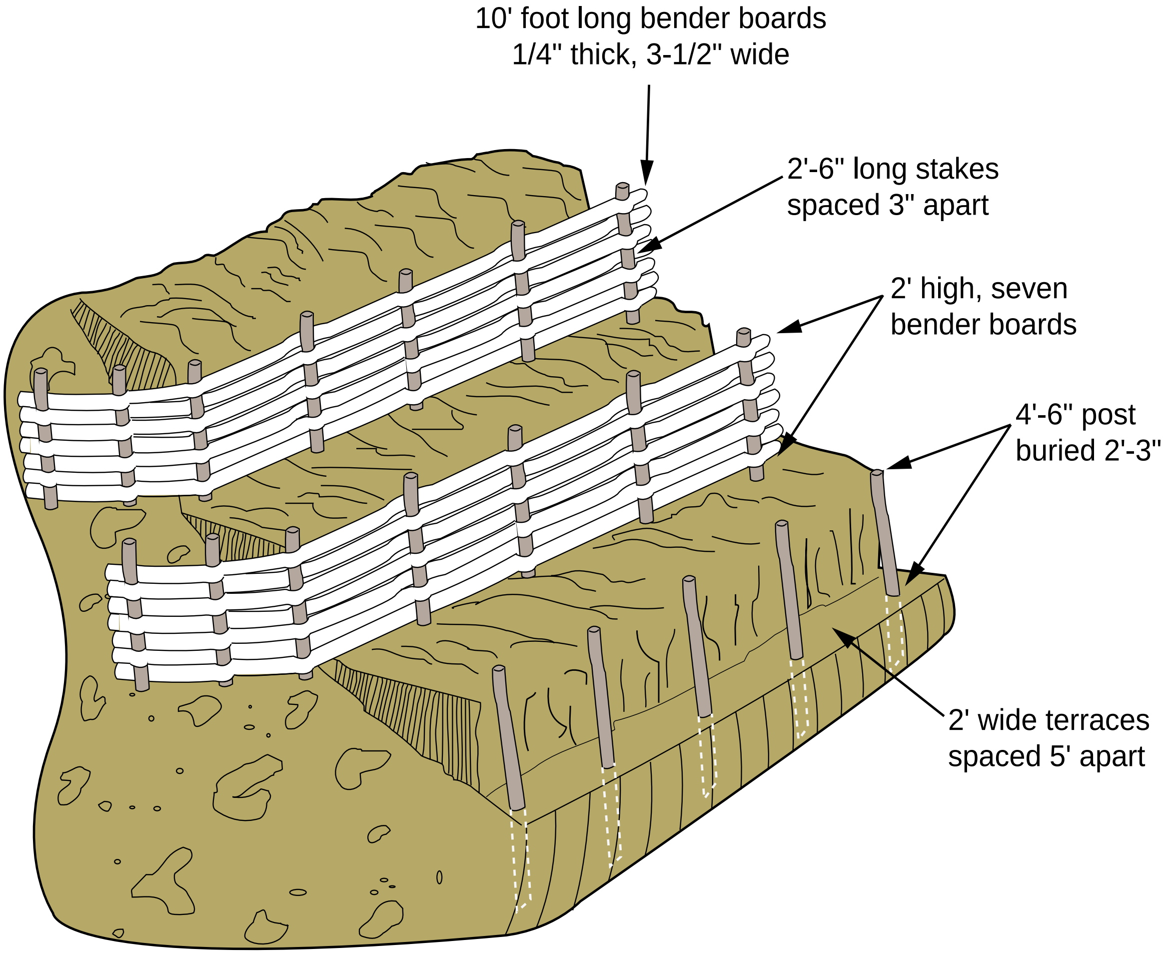

Figure 19–Bender board fencing.

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Lisa Lewis graduated in 1987 from Fort Valley State University, Fort Valley, Georgia with a Bachelor of Science degree in Soil and Plant Sciences. Lisa began her career with the Forest Service in August 1987 on the Hood Canal Ranger District. She continued her career in the Pacific Northwest and since 1998 she has been a soil scientist with the National Riparian Service Team (NRST). As a member of the NRST, Lisa provides training and technology transfer; consulting and advisory services and program review for riparian restoration nationwide. She specializes in road management issues and soil bioengineering techniques.

Library Card

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Keywords: Soil bioengineering, road management, road maintenance, restoration, erosion, native plant materials, revegetation

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