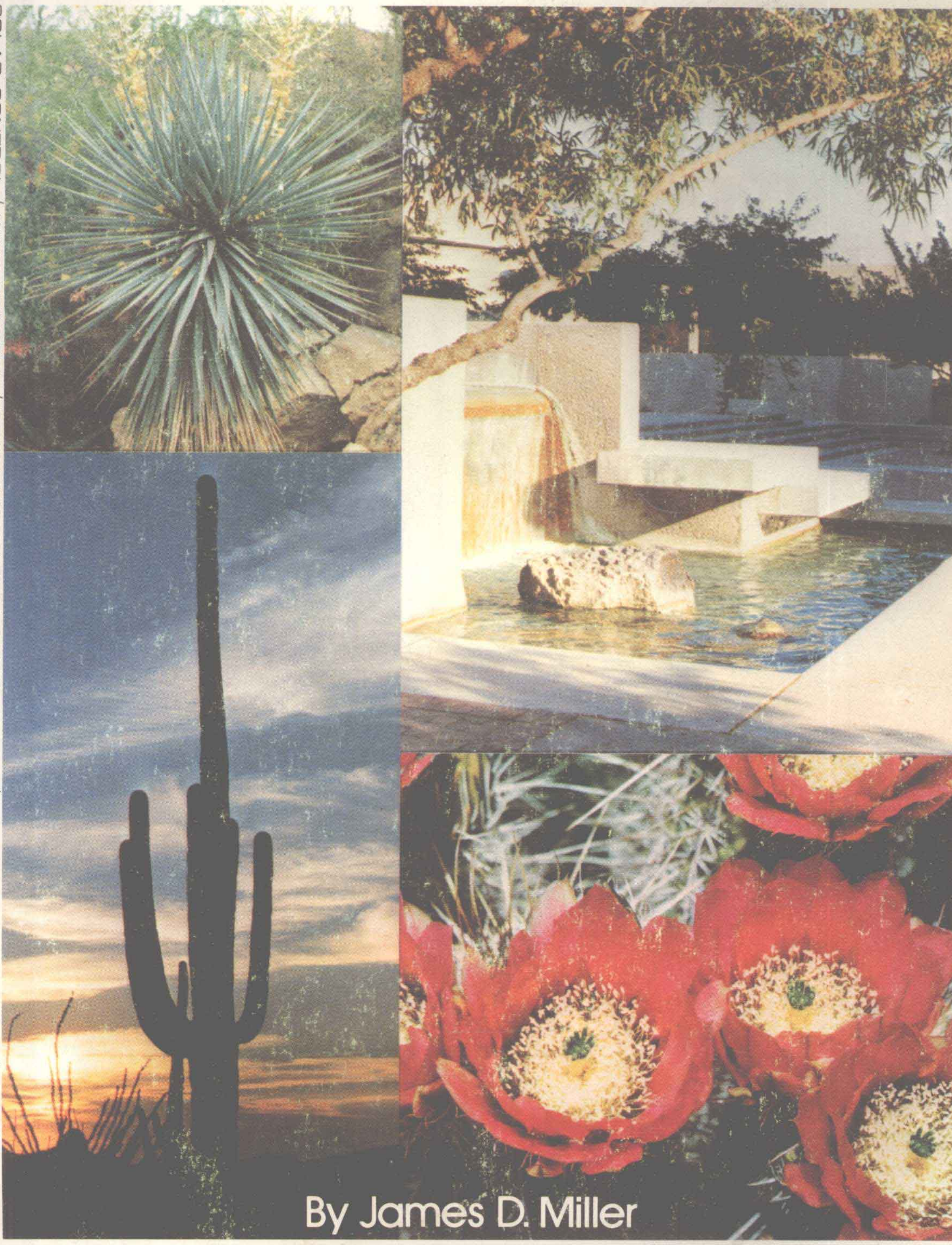
Design and the Desert Environment

Landscape Architecture in the American Southwest

SOLAR CONTROL / WIND CONTROL / DROUGHT-TOLERANT VEGETATION / WATER CONSERVATION / SITE PLANNING



SOLAR CONTROL / WIND CONTROL / DROUGHT-TOLERANT VEGETATION / WATER CONSERVATION / SITE PLANNING

By James D. Miller

Office of Arid Lands Studies • University of Arizona • Tucson, Arizona
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DESIGN AND THE DESERT ENVIRONMENT:
Landscape Architecture and the American Southwest

by

James D. Miller

The University of Arizona
OFFICE OF ARID LANDS STUDIES
Tucson, Arizona 85721

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FOREWORD

The Arid Lands Resource Information Paper presented here, the eleventh prepared for the Water Resources Scientific Information Center (WRSIC), was supported in part by the U. S. Department of the Interior, Office of Water Research and Technology (OWRT) Grant No. 14-34-0001-6254 (W-211), to the University of Arizona, Office of Arid Lands Studies, Patricia Paylore, Principal Investigator.

The National Science Foundation, over a period of several years, supported the early development of the computerized Arid Lands Information System (ALIS), a program that produced the 132-item bibliography accompanying this Paper. The abstracts were prepared by the author except for the few where users are referred to SWRA [Selected Water Resources Abstracts], accessible through any RECON terminal from the U. S. Department of Energy's Oak Ridge data bases.

With an ever-diminishing water supply, plus increasing water costs imposed as a conservation measure, there is growing need for information about drought-tolerant native plants (or suitable introduced species) that can be used in landscaping, both residential and institutional, as well as industrial complexes, and for erosion control. Nurserymen, horticulturists, highway engineers, and soil and water conservationists are seeking a compact source of information on plants, trees, shrubs, and groundcovers that thrive on the natural rainfall only in arid climates, and that are not only aesthetically pleasing but also suitable for introduction and cultivation for a variety of very practical needs and uses.

In this Paper author Miller has addressed the growing awareness on the part of inhabitants of arid climates of both scarcity and cost of water uses for landscaping dominated by water-loving plants, and offers a guide to alternatives.

While the University of Arizona, Office of Arid Lands Studies, is grateful to OWRT/WRSIC for their support in helping maintain the Office as a Center of Competence in water-related problems of arid lands, neither the U. S. Department of the Interior nor the University of Arizona is responsible for the views expressed herein.

Patricia Paylore
Assistant Director
Office of Arid Lands Studies
University of Arizona

Tucson, Arizona
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16. Abstract

Landscape architecture (environmental design) in the hot, arid southwestern U. S. must respond to the extremes of climate, the distinctive landforms, and the vegetative communities that combine to create unique patterns within the desert landscape. Human comfort is defined and serves as a criterion for the manipulation of microclimates to achieve a relative sense of comfort within a hot arid environment. Methods of solar radiation control, wind control, and conservation of water resources are reviewed. The text is supplemented with many illustrations and drawings. Over 200 drought-tolerant plant species are listed for use in the desert landscape. Cultural information for each plant is included in a matrix, and many of the plants so described are represented photographically as well. In addition to the references used for the text, a computerized bibliography, including abstracts, of related topics is added in the appendix. (Miller-Arizona)

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Abstractor James D. Miller

Institution University of Arizona, Tucson

INTRODUCTION

A quick review of the Contents of this Paper shows its division into three sections: the first, "Deserts: Their Natural Context," defines aridity and discusses the climate, the landforms, the vegetative communities, and combined, the natural patterns they create in the warm deserts of the southwestern United States. "Implications for Design," the second section, builds on this background information and describes passive methods for achieving solar radiation control, wind control, and the conservation of water resources within the arid landscape. The final section, "Recommended Plant Material," which can be used independently of the first two sections, lists over 200 plant species (trees, shrubs, groundcovers and vines) that are recommended for use in the desert landscape.

In addition to the three main parts of the Paper, a list of selected references covering a variety of subjects related to the development of arid lands worldwide is included in an appendix.

The text of this paper has been kept relatively direct and to the point. It is not intended to be a survey or collection of past expressions in desert landscape architecture, but rather a sourcebook, or an idea book, on arid environmental design concepts that can be used by professionals and non-professionals alike, who find themselves involved in today's rapidly developing desert regions.

I should like to extend my appreciation to Professor Warren D. Jones, Landscape Architect, a true "desert rat," in every admirable sense of that term, for his contributions in the preparation of the recommended plant material information. And a very special thanks to Patricia Paylore who generously devoted her time, talents, and steadfast patience throughout every phase of this work, who made it possible for me to start, and complete, these pages.

jdm 9/15/78

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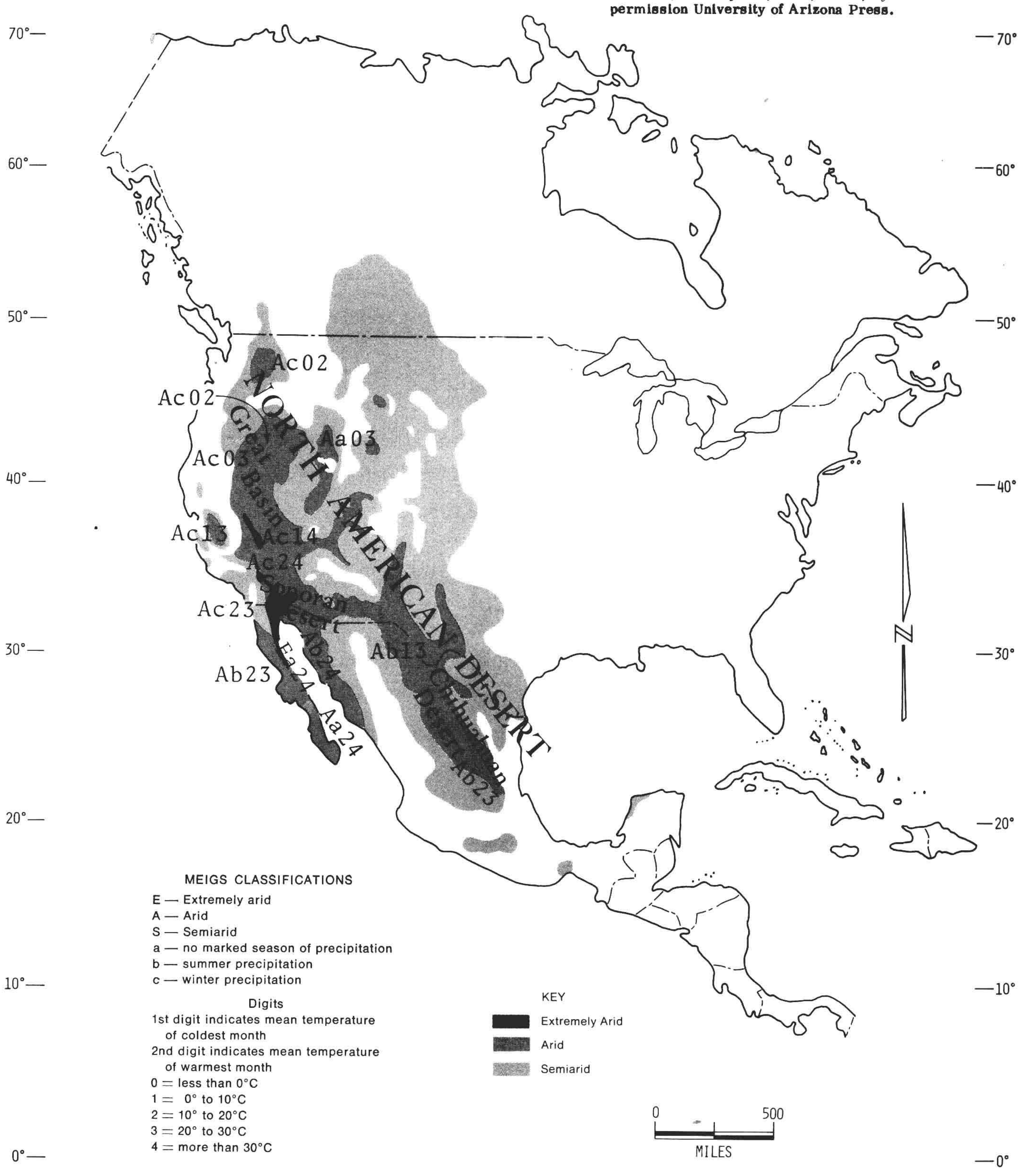

Fig. 1.1. Arid Lands of North America (after Meigs)

CONTENTS

1. DEFINITION AND WORLD DISTRIBUTION

We all know what a desert is ... don't we?

Deserts have been the home and the inspiration for more than one great civilization. And for many, history tells us that those deserts' unrelenting hostility has been the seed of ruin. Deserts may be at once stark and barren, yet simultaneously beautiful, pristine landscapes. Deserts may be charming, pleasant winterlands of abundant sunshine, oases of untapped resources. Overall, the desert environment is a constant challenge to the human condition.

Admittedly, the desert is an elusive phenomenon to tag. Not everyone thinks of the desert similarly, for each of us must concede his own peculiar biases and viewpoint. So exactly how does one define a desert? Even among those accustomed to thinking objectively, it is the scale one chooses and the combination of elements considered that determine the way in which the individual defines the desert environment. The geologist, for example, might choose large-scale geophysical and edaphic characteristics to define a desert, while the climatologist could refer to synoptic weather patterns of wind, precipitation, and temperature. An ecologist might speak in terms of biotic communities and the intricate systems that function to keep the delicate infrastructure of nature in balance.

This difficult task is further complicated by the fact that there are several kinds of deserts. Arid lands exist within a wide range of latitudes, from the Earth's polar regions to the tropics, and include a remarkable variety of landforms, soil types, and plant and animal life. There are arid regions that are predominantly blowing sand, like much of the Sahara of northern Africa, a naked landscape of endlessly shifting dunes. Others are more arborescent, nurturing dense stands of trees and succulents, and supporting a diversified animal population. Deserts may be isolated far within the interior of continental land masses, like the Gobi of Central Asia, or they may be coastal like the Atacama of Chile's western littoral where the Pacific provides sharp contrast to the extremely arid inland areas. Moreover, there is no common climate attributable to desert biomes. They prevail worldwide under nearly every major wind and pressure belt.

What, then, is the common denominator for all these desert regions? Lack of moisture, simply. There may be too little moisture initially, or that which does occur may be evaporated by extremely high temperatures or locked up in ice by extreme cold. With the exception of the polar regions, which will not be discussed here, arid lands are found primarily in the low and middle latitudes of the tropics and subtropics.

Qualitatively these deserts may be defined as hot, dry, and windy. But even within this category of deserts, widespread differences in local climate, geomorphology, vegetation, and the influences of human activities on the desert condition are all inevitably linked to the availability of moisture.

Indices of Aridity

With the intent to delineate and subdivide the arid regions of the world, several indices of aridity have been developed over the years to define empirically relative degrees of moisture deficiency. Opinions have varied considerably over what parameters should be included in these indices, as well as the emphasis to be placed on each.

Perhaps the simplest quantitative definition of a desert is that of early investigators who used isohyets (lines of equal rainfall) at approximately 10 inches per year. But this has proved an over-simplification for a rather dynamic condition. Rainfall alone is an insufficient criterion by which we may measure aridity accurately. Furthermore, the effectiveness of precipitation depends on seasonal occurrence, duration and intensity of rainfall, rate of evaporation, and the nature of the soil, all of which may vary considerably from one arid region to the next.

Temperature is also an important agent of aridity. Areas with higher annual temperatures are known to support more xeric vegetation typical of true deserts, while cooler regions with similar rainfall will generally support a more mesic plant life.

In 1918 Dr. W. Köppen linked temperature to rainfall to define the boundaries of desert and steppe lands. His formula provided different isohyets for areas of different mean annual temperatures. Köppen's maps of aridity were widely accepted and can still be found today in many world atlases. Later, de Martonne and Lang created still another index based on the ratio of precipitation to temperature.

These indices, decidedly more sophisticated than a 10-inch isohyet, were still only approximations. There are many inherent difficulties in using climatic parameters alone to define aridity quantitatively, especially when based on mean annual values of temperature and precipitation. Such values can be dangerously misleading in a land where yearly variations are so extreme. *

Vegetation has been used as an indicator of aridity (Shreve and Wiggins, 1964), but migrating vegetational patterns caused by high variability of annual rainfall typical of many arid regions form zones of transition rather than distinct edges of demarcation, making it difficult to rely on vegetation alone (McGinnies, Goldman, and Paylore, 1968). Nevertheless, there is clearly an important link between climatological processes that result in geomorphological change and vegetational distribution evident as desert landscape.

Evapotranspiration, as one of these processes, was first considered by C. W. Thornthwaite in 1948, when he devised a useful general index of aridity still widely used today. His formula was based on the relationship of rainfall to potential evapotranspiration (Pet): i. e. the amount of water which will return to the atmosphere from the ground completely covered with vegetation where there is sufficient soil moisture for use by vegetation at all times (Walton, 1969). By definition Pet considers several important implications of aridity. Air

* In 1899, Yuma, Arizona, recorded an annual rainfall of one inch. Six years later, 11 inches was recorded (Walton, 1969).

temperature, relative humidity, type of vegetation, soil temperature and texture, all interact to determine the rate of evapotranspiration.

Thornthwaite's basic hypothesis was that aridity existed wherever annual precipitation was insufficient to meet the moisture demands for potential evapotranspiration. Where they were equal, the index assigned a rating of zero. Where precipitation was deficient, Thornthwaite classified regions as subhumid, semiarid, or arid, based on their degree of moisture deficiency. In 1952, Peveril Meigs prepared a series of maps based on Thornthwaite's index, modified so as to subdivide the latter category into arid and extremely arid, extreme aridity being defined as the condition experienced by a region that has recorded at least 12 consecutive months without rainfall, and where no regular seasonal rhythm of precipitation exists. Figures 1.1-7 show approximately 36 percent of the total land area of the world (52 million square miles) as either semiarid, arid, or extremely arid (after Meigs).

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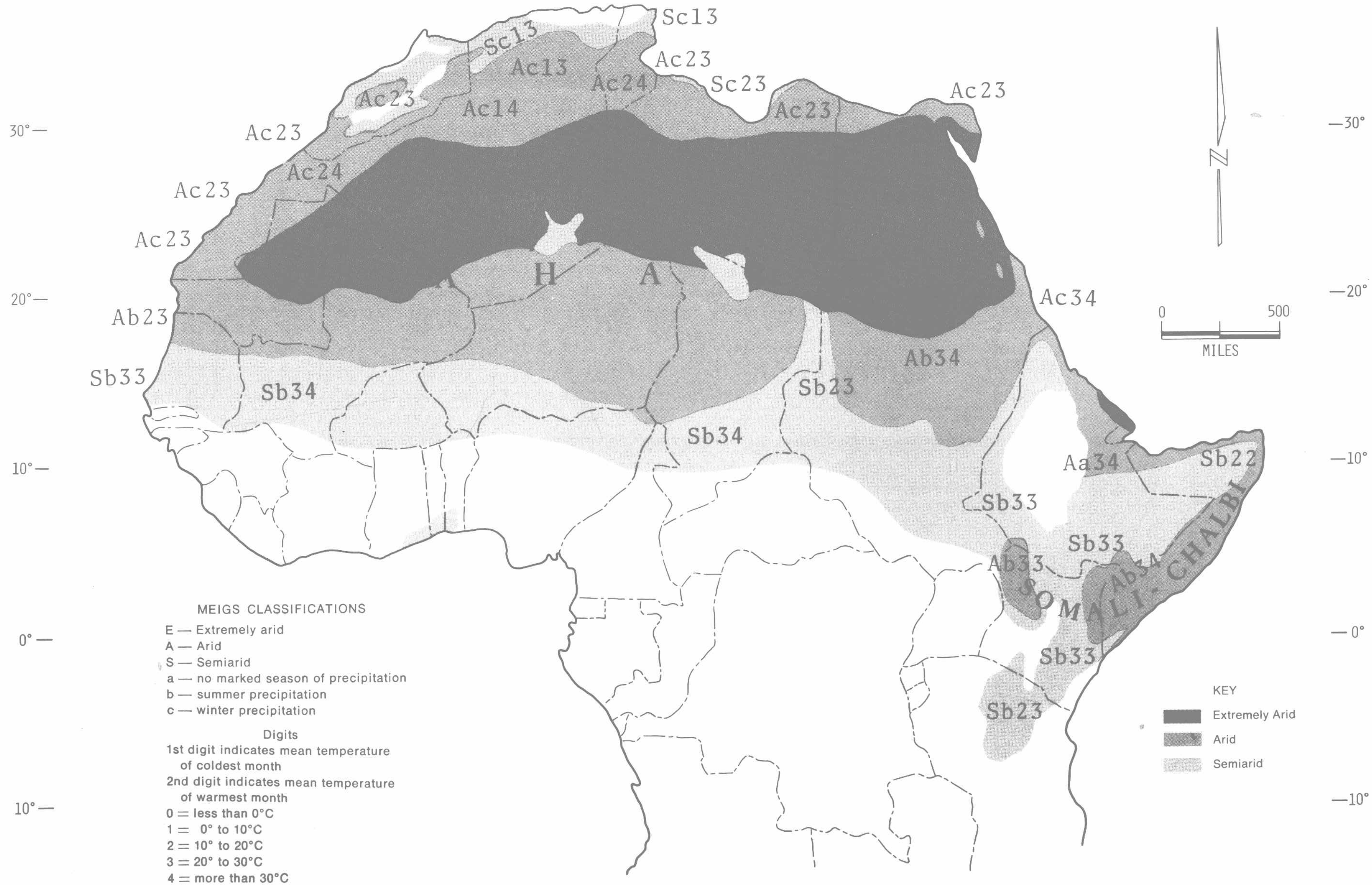

Fig. 1.2. Arid Lands of Northern Africa (after Meigs)

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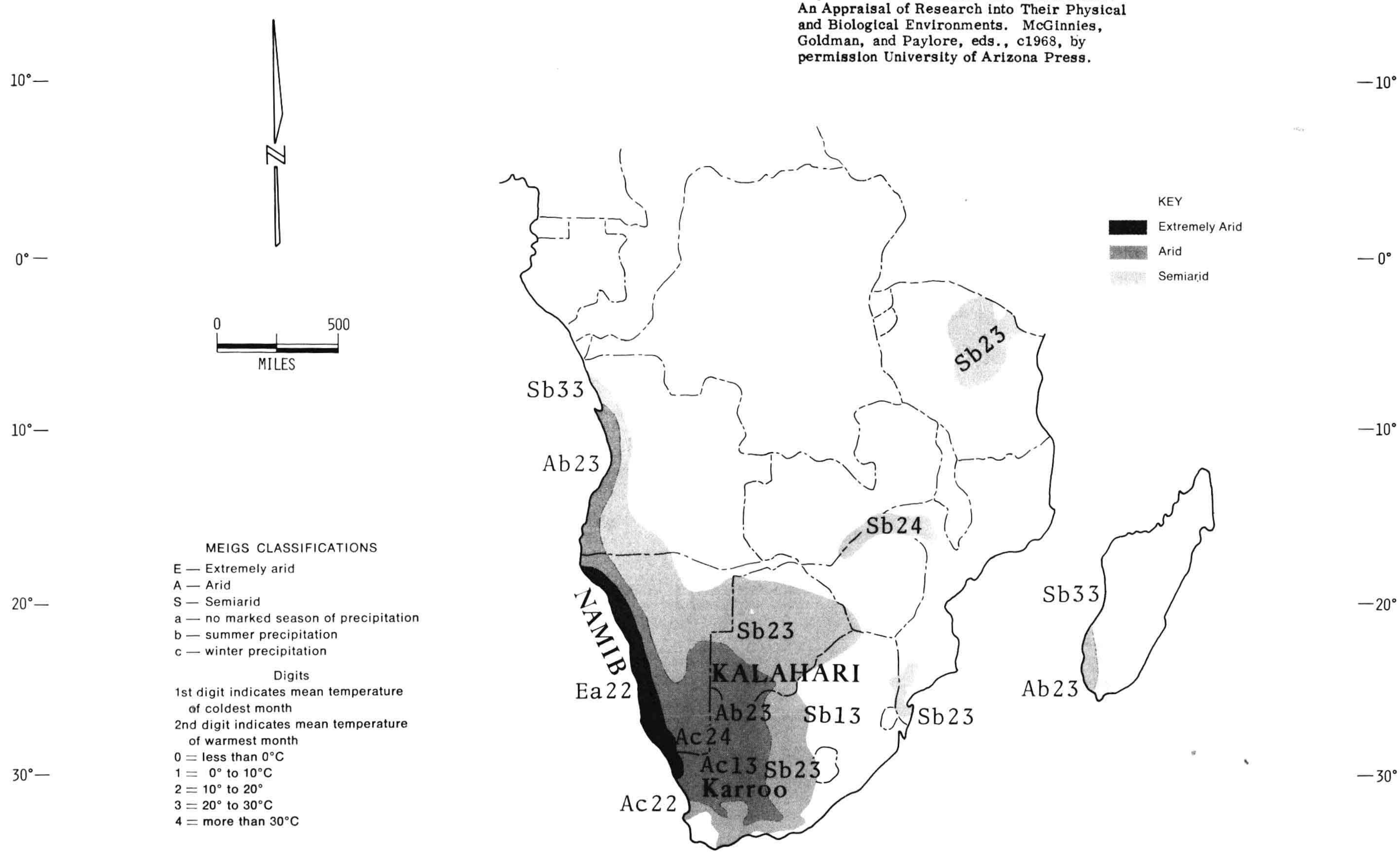

.1.3. Arid Lands of Southern Africa (after Meigs)

Fig. 1.4. Arid Lands of Asia: Western Portion (after Meigs)

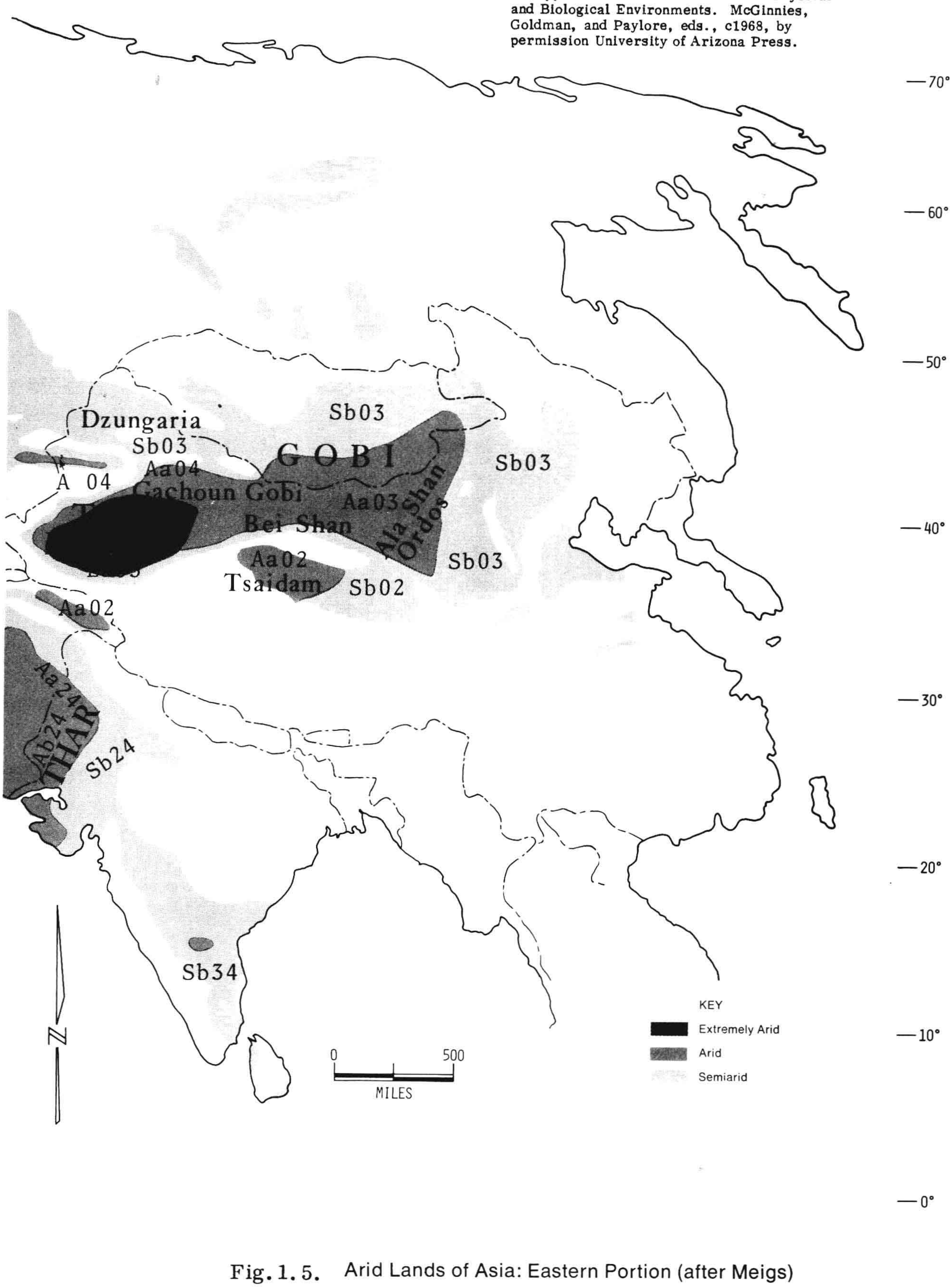

Fig. 1. 5. Arid Lands of Asia: Eastern Portion (after Meigs)

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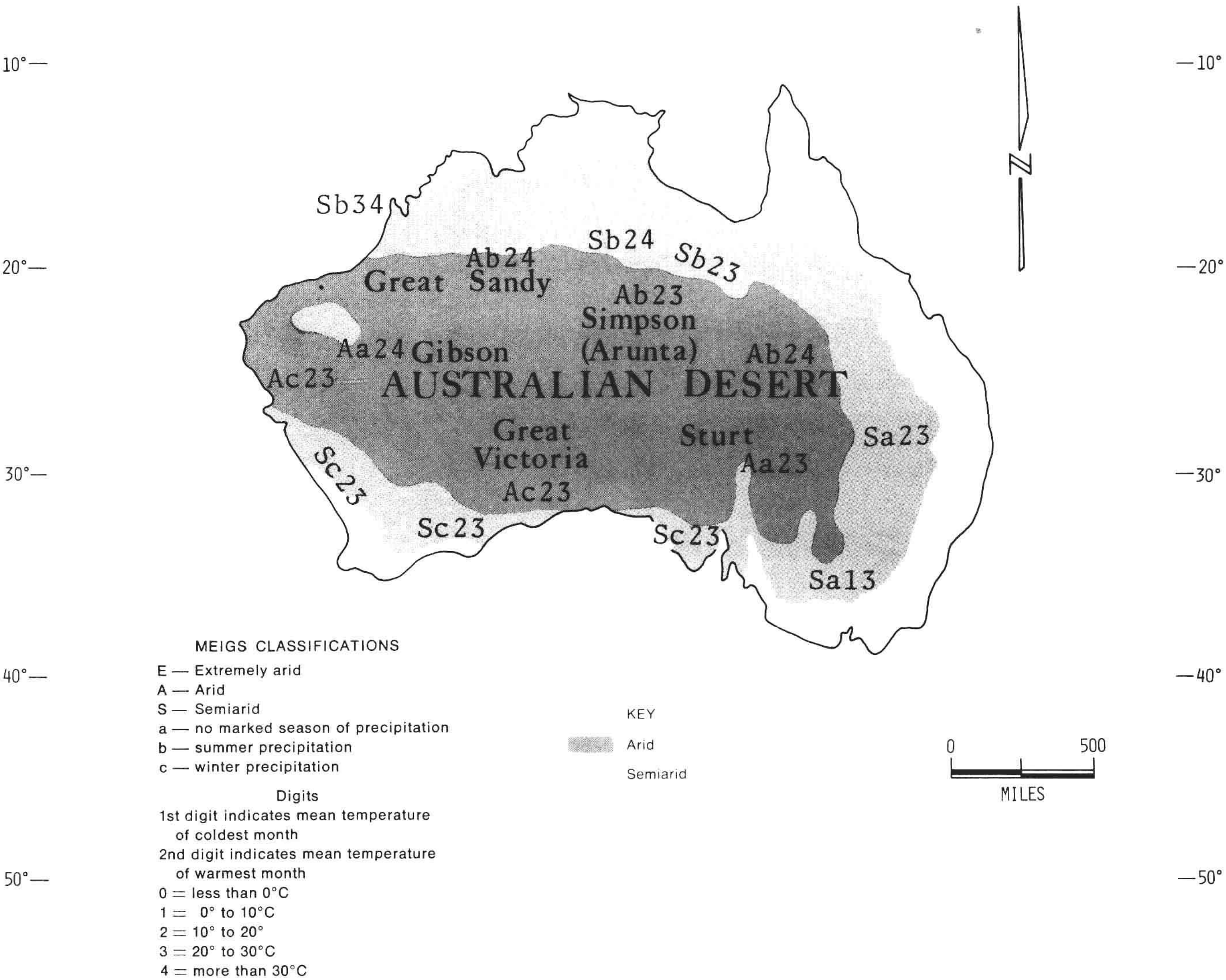

Fig. 1. 6. Arid Lands of Australia (after Meigs)