mine by a study of specimens in captivity whether a lizard is herbivorous or insectivorous, but from such data it is not possible to determine the range of diet, and generally impossible to work out at all satisfactorily the habitat preferences, reproduction, etc. It may readily be seen that this is true by an examination of this book, for it is the food that captive specimens will take that is given in most of the accounts of feeding habits, and habitat preference and reproduction come in for very brief treatment. The author might very profitably have included summaries of the published notes on the habits in nature. On the other hand, it is only just to acknowledge that the observations on the habits of specimens in captivity are of value, not only to those who wish to keep live material but also to scientists, for even general information is desirable in the case of many forms. Thus, on the basis of his observations on captive animals, Ditmars refutes the often repeated statement that the iguanas (subfamily Iguaninæ) and *Basiliscus* are strictly herbivorous (that they are also insectivorous in nature is a fact that may easily be demonstrated by an examination of the stomach contents of wild individuals), and the observations on the breeding habits of *Elaps fulvius* and *Lachesis mutus* are distinct contributions to our knowledge of the habits of these species.

In some respects the book-making is very good. There seem to be very few typographical errors. The upper figure on plate 3 is upside down, and in the table on p. 100 the genus *Coleonyx* is placed under the family Uroplatidæ by a printer's mistake. But these are very unimportant errors. The most unfortunate thing about the book from this standpoint is the absence of appropriate headings. The book is divided into four "parts," dealing with the turtles, crocodiles, lizards and snakes, respectively, but aside from this division there are no subdivisions of the subject matter, if we except the fact that there are center heads to the sections on the structure of lizards, the family Boidæ, and the new world Elapine snakes. The names of the families considered are usually given as side heads and the common names given to families when used as side heads and the common names of the genera and species when beginning a paragraph are placed in small capitals, but this is not sufficient to break up the text conveniently, and it is very difficult to find the descriptions of particular forms. The author states that "the scope of the book prevents it from being, as a previous book ['The Reptile Book'] by the same author was, primarily a volume for identification purposes," and it is probably for this reason that the excellent arrangement of the former work was not followed, but the value of the book could have been greatly increased by the use of at least a general system of headings, such, for example, as the one employed in Knowlton's "Birds of the World." Another fault in the arrangement is that the plates are not referred to in the text, and, as they are often far removed from the descriptions of the species, they can not be conveniently found.

One may, however, easily overlook the defects in the book for it is a valuable contribution to the subject. It is a good popular account, as the author intends it to be, and at the same time it will find its place on the shelves of the general zoologist and herpetologist, both for its very excellent illustrations and for the information on habits that it contains.

ALEXANDER G. RUTHVEN

Natural Vegetation as an Indicator of the Capabilities of Land for Crop Production in the Great Plains Area. By HOMER LEROY SHANTZ, Physiologist, Alkali and Drought Resistant Plant Breeding Investigations. Bulletin 201, Bureau of Plant Industry, U. S. Department of Agriculture. Washington. 1911. Pp. 100; 6 plates and 23 text figures.

This first endeavor to apply the exact methods of quantitative ecology to the problems of agriculture meets with conspicuous and gratifying success. The author is as skillful as thorough in his use of instrumental and

quadrat methods, and he is especially fortunate in his application of the principles of the development and structure of vegetation to a complex vegetational problem. The close and careful analysis of water factors and the intimate correlation of the natural vegetation with them will cause the present study to long remain a model for work in similar fields. The value of the natural crop as an index of agricultural possibilities is so clearly worked out that it must henceforth be taken fully into account in the survey of a new region. The present bulletin merits further praise for the happy way in which the newest ecological facts are combined with a knowledge of crop production in such a fashion as to yield results usable by both the scientists and the layman. It gives further evidence of the fact that the best scientific work is the most practical, and that practise can be permanent or successful only in so far as it is scientific.

In laying down principles for the use of the natural vegetation as an indicator, correlation with the physical or chemical nature of the soil, with rainfall or with temperature is held to be impossible for the region of the great plains. As the ecologist would expect, the water content of the soil furnishes the most reliable correlation, as the most important and controlling of all direct factors in an arid region. The author is probably correct also in insisting that the entire vegetation is a better indicator of conditions than any single species of it. Since the structure of a plant group varies considerably, however, it is not improbable that further study will reveal a few species which are the essence of the group, and hence the clue to it. Indeed, this is not far from the method used, as shown by the terms short-grass land, bunchgrass land, etc. The second step in the problem is to correlate the native vegetation, which should always be regarded as a crop grown by nature, with the culture vegetation, *i. e.*, the crop production. This correlation, of which the ecologist requires no proof, is practically possible only in so far as actual experiments in cropping have been made. In an arid region, all cropping is essentially experimental, and the necessary evidence, quantitative in a large degree, is at hand.

The first essential in correlating vegetation and conditions is a careful analysis of the former into its formations, associations and societies. Over a vast grass-land area, such as the great plains, this is peculiarly difficult, not only because of the disturbing effect of succession, but also on account of the ease of migration in all directions. Two typical grass-land formations are recognized, the prairie grass formation of the prairies proper, which extends westward into the shortgrass formation characteristic of the plains. The prairie grass formation in its plains portion falls into three groups, here called the bunchgrass, sandhills mixed and blowout associations. The shortgrass formation comprises three associations, grama-buffalo grass, wiregrass and *Gutierrezia-Artemisia*. These associations are not all stable groups of the final association, but some, notably the blowout and wiregrass associations, are initial or intermediate stages of a succession. Indeed, it is the skillful working out of the time sequence of the various associations which has made possible the correlations suggested.

The typical short-grass association is made up chiefly of two species, grama grass (*Bouteloua oligostachya*) and buffalo grass (*Buchloe dactyloides*). It is characteristic of loam or clay soils, the so-called "hard lands," upon which the author has worked out in convincing fashion the essential water relations. A thorough study of rainfall, run-off and penetration, rate of water loss, non-available water, and root systems brings out clearly the fact that it is the slight penetration of the rainfall on hard land which controls the root development, and consequently the establishment of the plant. The roots are from 12–18 inches deep, corresponding to a penetration of little more than 20 inches after the heaviest rains, and a consequent water content which repeatedly falls to the non-available during the summer. In accordance with this, the shortgrass association is an indicator of a small amount of available water, of

a short season for growth, and of a relatively high nutrient content. In connection with the heavier rainfall in June and July, the nutrient content of shortgrass land too often produces a deceptively luxuriant growth of crops, which are cut short by dwindling water content in late July and August.

The wiregrass association is dominated by *Aristida longiseta*. It is found chiefly on sandy loam, or at least on soils intermediate between the sandhills and the hard lands. The soil texture in wiregrass land permits greater penetration of rain, available water occurs deeper in the soil, and deep-rooted species become possible. The roots of wire-grass are from 2–3 feet long, while its usual associate, *Psoralea*, reaches a depth of 5 feet. There is nothing, however, to exclude the short-rooted grasses, and two species of grama often occur in this association. The wiregrass association indicates more favorable conditions for crop production than any other group. The soil is sufficiently compact to prevent blowing, and is well-supplied with nutrients. Water penetrates readily to a fair depth, and water loss is lessened by the air content of the sandy surface.

The soil of bunch-grass land is sand, and it allows rain to penetrate to a greater depth than either the hard land or the sandy loam. It contains more available water than these soils, but is relatively poorer in nutrients. Owing to its loose structure, it blows readily, and methods of cultivation must take account of this fact. The runoff from the sandhills is negligible, and the water loss from the soil surface slow, owing to the formation of a mulch of dry sand. The typical species of the association, bunch-grass (*Andropogon scoparius*), develops roots to a depth of 4–6 feet, as is the case also with its most frequent associates. The density of bunch-grass seems to be in direct relation to the water supply, and consequently a fairly close cover indicates a higher water content and better agricultural conditions. When the bunches are scattered, the short-grass finds an opportunity to establish itself in the spaces, utilizing the water content of the first soil foot.

The final vegetation type of the region is the shortgrass association, which may be reached through various successions. Of the two common primary successions, one begins with lichens on disintegrated rocks, passes into the *Gutierrezia-Artemisia* association, and as the soil becomes finer, terminates in the shortgrass association. The pioneers in a blowout initiate a longer succession. As a consequence of rendering the sand more stable, they yield sooner or later to a mixed association of sandhill plants, and finally to the bunchgrass association proper. The effect of fires or grazing is to change the latter to the shortgrass association, often through an intermediate wire-grass stage. When an association is destroyed by breaking the soil, the first vegetation will consist of weeds, but this will soon be replaced by the association which ordinarily precedes the one destroyed. For example, when short-grass is broken, *Gutierrezia-Artemisia* or wire-grass will take possession, to yield again to short-grass in the course of two or three decades, bunch-grass or other sandhill vegetation will temporarily replace wire-grass, etc. The cause of this is readily found in the loosening of the soil, while the reaction which brings back the original stage is seen in the increasing stabilization of the soil.

From the standpoint of crop production, the largest yields are obtained during favorable seasons from the shortgrass land, but failures are also most frequent on it. Bunch-grass land produces the smallest yield in good years, but on the other hand crop failures are rare. Because of its intermediate position, wiregrass land is usually the most valuable of all, since its productivity is not far below that of shortgrass land in good years, and it has much of the advantage of bunchgrass land in dry years.

FREDERIC E. CLEMENTS
THE UNIVERSITY OF MINNESOTA

Blumen und Insekten, ihre Anpassungen aneinander und ihre gegenseitige Abhängigkeit. Von Professor Dr. O. VON KIRCHNER.