theory of functions of a complex variable are adequately treated. The style in which the book is written is simple, direct and not lacking in a wit entirely appropriate to a disciple of his master, though free from the bitterness and even malice that so often characterizes the latter's amusing outbursts.

A considerable number of interesting and suggestive problems conclude each chapter, and a valuable table of operational formulas is given as an appendix. Professor Bush's colleague, Professor Wiener, has contributed a brief but valuable appendix on Fourier analysis and asymptotic series. The bibliographical references are ample, and the text seems to be reasonably free from typographical errors.

It is to be hoped that in future editions the important subject-matter of Chapter XV, "Networks with Variable Parameters," may be treated at greater length. The problems arising under this heading are at the same time of the greatest importance and offer the most formidable difficulties. In particular, it would seem desirable to add some account of the "perturbation" methods of approximate solution, which Van der Pol has shown how to adapt from astronomical to vacuum tube circuit problems.

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The Economics of Forestry. By W. E. HILEY, M.A., Oxford. Clarendon Press, 1930. Price 21/–.

NEW ground has been broken by the publication on March 20 of a book on "The Economics of Forestry," by Mr. W. E. Hiley, M.A., of the School of Forestry, Oxford. Mr. Hiley is well known in forestry circles not only in Great Britain but also in America and throughout the British Empire by reason of his publications on forestry subjects, one of the most important of which is his book on "The Fungal Diseases of the Common Larch." After the publication of this work he decided to give up the mycological side of forestry, being attracted by the possibilities of the practically unknown field of forest economics, and he started a course of lectures on this subject in the Oxford Forestry School. From this has developed the matter which has been so carefully and lucidly elaborated in the pages of this book, in which the theory of forest economics is applied to the practice of forestry in a more definite manner than has hitherto been done.

Whether the object of forestry should be to obtain the best financial returns has often been questioned; other objects, such as the fixation of mountain slopes and sand dunes, the regularization of the water flow and protection from wind, must always be kept in mind by the forest officer. But apart from these aspects of the subject, the prospect of obtaining satisfactory profits is a very important incentive to private afforestation; in state forestry, also, it is desirable that for every dollar spent the greatest possible value of timber should be produced in the shortest possible time. Thus, in fact, forest economics must be the determining factor in state, as well as private, forestry.

Owing to the long period of production in forestry, calculations have to be made with compound interest, and various methods have been used for estimating profitableness. Mr. Hiley particularly favors two methods: that of determining the "financial yield," which is the rate of compound interest earned on a plantation or forest on the money invested in it; and the method of "cost of production per cubic foot" calculated by allowing some fixed rate of interest on capital. With either method the costs of all operations and the value of intermediate returns are taken into account.

He has applied these methods to all British-grown species for which data are available, and has shown that, whereas Scots pine (*Pinus sylvestris*), for instance, is very expensive to grow and can yield only a low rate of interest on capital, Douglas fir (*Pseudotsuga taxifolia*) and Sitka spruce (*Picea sitchensis*) are very cheap to grow and may yield a comparatively high rate of interest. Since Scots pine is a very easy tree to cultivate and grows on cheap land, such a result is not at first obvious; the high cost of production is due to the slow rate of growth and the long rotation.

It is also shown that timber can be grown much more cheaply on good land than bad even when high prices have to be paid for good land. Heavy thinning is generally more profitable than light thinning, and wide planting than close planting. Also small sizes of timber are so much cheaper to grow than large sizes that, as virgin timber becomes scarcer, there will be very strong inducements towards the use of laminated wood and other artificial forms of large timber.

Thus far the book follows the course which we should expect the study of forest economics to follow in Britain, where reafforestation is the order of the day and a large amount of capital is being invested in making future forests. But in America, too, now that more and more attention is being paid to the reafforestation of denuded lands, it is becoming imperative that the relative economic attractiveness of various tree species and methods of management should be studied in detail. For the particular conditions covered by Hanzlik's data the author has calculated the most favorable rotation for growing Oregon pine ("Douglas fir") in the western states.

Where forests have not yet been destroyed the author shows it is possible to put them under a form of management by which they will yield a continuous supply of timber. Where the existing stand is sufficiently valuable this form of development may be secured without investing fresh capital. It does, however, require restraint in the exploitation of the existing forests, and the economics of this type of development is rather different from that of afforestation. In the last chapter, which is entitled "The Economics of Sustained Yield," the comparative economics of devastation and conservative forest management is discussed, with special reference to America, and tendencies are traced towards a more constructive view of company management being adopted.

The profitableness of forestry will be greatly affected by any change in prices. Questions of timber resources and consumption are dealt with, both as regards Europe and America, and price movements are traced for nearly ninety years. These prices have been corrected for changes in the purchasing power of money, so that movements in real prices may be observed. It is interesting to note that, although the real price of sawn softwoods imported in Britain rose rapidly from 1871 to 1900, there was a subsequent fall lasting till the great war and present real prices are little, if any, higher than in 1900.

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SCIENTIFIC APPARATUS AND LABORATORY METHODS

FRUIT AND VEGETABLE PIGMENTS AS INDICATORS

A FEW years ago a study was made of the coloring matter of certain European grapes by Willstätter and Zollinger,[1] and of several American varieties by Anderson and Nabenhauer.[2, 3] All the pigments were found to be chemically similar, being composed of the monoglucoside oenin in the case of the European grapes, and in the case of the American of anthocyanin, which is similar to oenin but with a smaller percentage of methoxyl. It was noted that solutions of some derivatives of anthocyanin turned bright red when acidified and blue or bluish-green when made alkaline, the pigment decomposing in a short time if left in alkaline solution. It does not appear that these workers investigated the indicator values of grape pigments, and Clark does not list any of the products of grapes or of grape skins among the indicators he describes in his book on hydrogen ions.[4] Industrially, however, advantage is taken of the color changes of grape pigments by wine manufacturers, "since red wine is very commonly titrated for total acidity, using the color change from red to green as an endpoint."[5]

After noting the color change in grape-juice while working on a problem in dietetics and recalling that Clark's list of indicators includes the extract of red cabbage,[4] it occurred to us that the pigments of other fruits and vegetables might exhibit similar characteristics. We accordingly began to study such varieties as were readily obtainable, testing for the presence of pigments showing a color change, for the pH range of such color changes as were observed and for the practical value of the pigments for use where liquid indicators or test papers might be needed.

Apricots, carrots, peaches, pears, persimmons and tomatoes failed to yield pigments with indicator characteristics. The pigment of red beets remained red throughout the acid range and into the alkaline range at least as far as pH 13.0. On the other hand, red apples, blackberries, blueberries, prickly pear cactus fruit, black cherries, cranberries, dewberries, grapes of all colors from red to black, loganberries, Satsuma plums, pomegranates, black and red raspberries and strawberries proved to contain pigments of more or less indicator value.

In all cases we at first made decoctions of the fruits or vegetables. Of grapes and apples we used only the skins. The test material was simmered for about fifteen minutes in as little water as practicable, then the colored solution was separated from the pulp by straining through several layers of cheesecloth. We found later that with blackberries, cactus fruit, black cherries, dewberries, pomegranates, raspberries and strawberries a better solution could be obtained by crushing the raw fruit and pressing out the juice. To clear and preserve the solutions we added half their volume of 95 per cent. alcohol, let them stand for several hours and then filtered them.

A series of standard buffers was used in testing the pH range covered by the color changes. The following table shows what we found in the case of ten pigments.

The pigments from all colors of grapes were found to be similar as to indicator characteristics, the only

[1] R. Willstätter and E. H. Zollinger, *Ann. Chem.*, 408: 83, 1915; 412: 195, 1916.
[2] R. J. Anderson, *J. Biol. Chem.*, 57: 795, 1923; 61: 685, 1924.
[3] R. J. Anderson and F. P. Nabenhauer, *J. Biol. Chem.*, 61: 97, 1924.
[4] W. M. Clark, "Determination of Hydrogen Ions," pp. 84–98, 1923.
[5] S. R. Benedict, personal communication.