TWENTY-SECOND ANNUAL REPORT OF THE MICHIGAN ACADEMY OF SCIENCE

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TABLE OF CONTENTS

Letter of Transmittal 1

Officers for 1920-1921. 1

Past Presidents. 1

Symposium on Michigan's Idle Lands. 2

Resolutions 2

The Forest Fire Menace. 2

The Reclamation of Michigan's Non-productive Area. 2

The Need for a Policy for the Cut-Over Lands of Michigan. P. S. Lovejoy 3

The Effect of Forest Fires upon the Soils of the North Lake States. P. S. Lovejoy 5

The Cut-over Lands in Relation to Agricultural Use. J. F. Cox 11

SECTION OF GEOLOGY AND GEOGRAPHY.
G. M. Ehlers, Chairman.

The Pleistocene Locality at Wailes Bluff, Md., and its Molluscan Fauna. E. R. Smith 13

Studies on the Shore Lines of the Saginaw Basin. (**Abstract.**) Frank Leverett 15

Results of Glacial Studies in the Northern Peninsula of Michigan in 1919. (**Abstract.**) Frank Leverett 16

[Letter of Transmittal]

TO HON. ALBERT E. SLEEPER,

Governor of the State of Michigan:

SIR:—I have the honor to submit herewith the XXII Annual Report of the Michigan Academy of Science for publication, in accordance with Section 14 of Act No. 44 of the Public Acts of the Legislature of 1899.

Respectfully,
I. D. SCOTT,
Secretary.

Ann Arbor, Mich., November, 1920.

Published August, 1921.

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TWENTY-FIFTH ANNUAL MEETING OF THE MICHIGAN ACADEMY OF SCIENCE

ANN ARBOR, MICHIGAN, MARCH 31--APRIL 2, 1920.

SYMPOSIUM ON MICHIGAN'S IDLE LANDS.

Within the membership of the Michigan Academy of Science there are scientific experts who are engaged in varied lines of research which has to deal directly with Michigan's forestry and land problems. From their work, their acquaintance with the state, and their broad conception of the pressing problem involved in "Michigan's Idle Lands," these men have the viewpoint and the knowledge to state the basic facts underlying the great reforestation and reclamation problem which confronts us and which yearly becomes more imperative in its demand for adequate and effective solution.

Furthermore, they are singularly fitted to advise the proper course for legislative and public commission action, which shall appropriately meet the situation in which the state now finds itself.

At the 25th Annual Meeting of the Academy, held in Ann Arbor March 31 to April 2, 1920, a symposium having for its subject, "Michigan Idle Lands," was held, which in its bearings and recommendations is of vital significance.

In this symposium such leaders of science as Dr. Filbert Roth, Professor of Forestry at the University of Michigan; Prof. J. F. Cox, Professor of Farm Crops, Michigan Agricultural College; Prof. P. S. Lovejoy of the University of Michigan, Dean R. S. Shaw of the Michigan Agricultural College spoke. In the subsequent deliberations, Prof. C. O. Sauer of the University of Michigan as chairman, Mr. John I. Gibson of the Western Michigan Development Bureau, Hon. George L. Lusk of the Public Domain Commission, Dr. R. A. Smith, State Geologist, Hon. Junius Beal, Regent of the University of Michigan, took active part.

The following resolutions were unanimously adopted:

RESOLUTION ON THE FOREST FIRE MENACE.

1. The prevention and control of wild fire on the cut-over lands of Michigan is the most urgent item in any plan for the development of these lands, and irrespective of whether they are to be utilized for farming, grazing, forests, or recreation.

2. The fires have caused and are causing enormous damage. They take human life. They destroy improvements and manufactured forest products. They destroy forests and prevent the natural reproduction of forest growth. They damage the soil by burning out its organic constituents and by exposing it to the wasting of wind and water action. They destroy game animals and birds and remove the cover which alone can furnish safe and suitable breeding grounds. They destroy the native beauty of the region, leaving only waste and desolation, unattractive for recreation purposes.

3. It is perfectly practicable to prevent and control wild fire to a degree which will make fire losses negligible. The costs of such prevention and control are justified on any one of the items of damage alone.

4. The Public Domain Commission is directly responsible under the statutes for the enforcement of the fire laws. It is the duty of the Public Domain Commission to take such action as lies within its power, looking toward the control of fires upon the lands of the state.

5. The Public Domain Commission is urgently requested to secure a full enforcement of the existing fire laws, to investigate, determine and report, to the people of the state and the legislature, in full and unequivocal manner, as to the damage done by fire, and as to the appropriations, modifications of existing laws, organization or other items required, in order to secure for the lands of the state prompt and adequate fire protection.

RESOLUTION ON THE RECLAMATION OF MICHIGAN'S NON-PRODUCTIVE AREA.

The following procedure is deemed the proper course of action for the reclamation of Michigan's non-productive area:

1. That an inventory be made of the land resources of Michigan by counties. This inventory should constitute a series of county reports, accompanied by maps, along the following lines:

   (*a*) Nature of physical conditions.

   (*b*) Present economic conditions, together with the record of past and present experiences in the use of the area,

   (*c*) A classification of the land according to its highest indicated use.

2. That in the study of physical conditions of the land (*a*) first and chief attention be given to soil conditions, with a classification of soils which will recognize their genesis and which will give maximum emphasis to their distinguishing qualities. (*b*) that climate be adequately considered as a factor in utilization; and (*c*) that topography, drainage, location, and the size of areas of unit characteristics be separately recognized and considered as factors affecting possible use.

3. That an intensive study in land economics be made for each area on the manner of present utilization of the land and the history of its use. In connection with this study there should be determined (*a*) extent of idleness of the land, (*b*) the different types of use to which land is now being put, and (*c*) the returns from the several uses and the place of these uses in an economy of the area.

4. That the land of Michigan shall be classified into a series of classes on the basis of return, or anticipated return, ranging from land suited to highest grade and most permanent agriculture through grazing and forest land to permanent waste land.

5. That the work of this survey be carried out with the fullest utilization of the scientific personnel in the State and in consultation, and if feasible, in cooperation, with the proper federal agencies.

6. That the committee succeeding the present committee of the Michigan Academy of Science be charged in particular with inquiring into the

most desirable soil classification, of analysis of existing land use, and of land classification.

To this end the following action is recommended to the State Legislature:

1. That the law providing for the Soil and Economic Survey be made operative.

2. That the law be amended by providing for a Board of Control, consisting of the Secretary of the Public Domain Commission, a professional expert in agronomy, a professional expert in soils, a professional expert in forestry, a professional expert in land economics, and an additional representative from the northern and one from the southern peninsula.

3. That the initiation of county studies be adequately safeguarded by prior experimental application of the principles on which the survey is to be executed.

THE NEED FOR A POLICY FOR THE CUT-OVER LANDS OF MICHIGAN.

BY P. S. LOVEJOY.

Concerning many public questions Michigan has a well-defined policy. We have a good road policy, a policy as to education, as to the sale of securities, for instance. But we have no policy as respects our idle stump lands—nothing more than fragments and odds and ends of policy and procedure.

Over a third of this state in non-productive, idle land and the gross area of idle land is increasing instead of decreasing. Great areas of the idle lands are depreciating in quality. These great and growing tracts of idle and depreciating lands are a liability instead of an asset to the state, and a liability which constantly becomes greater.

Over a third of Michigan is virtually bankrupt, is paying hardly more in taxes than the cost of collecting the taxes, is unable to provide itself with tolerable roads and schools, is unable even to furnish itself with police protection.

Over a third of Michigan is idle and non-productive not wholly because the soil is poor, for some of the soil is excellent; not wholly because the climate is inhospitable, for over great areas the climate is excellent; not because the lumbermen cut the old virgin forests, for they were ripe for harvest; not for lack of some manner of effort to develop the country, for there has been constant effort. These lands are idle and worse primarily because of fire, fires, repeated burning over. The fires have come year after year; they have burned and reburned over millions and millions of acres; they have killed old timber and young timber and the seed in the ground; they have destroyed the organic materials on and in the soil, the improvements of settlers, villages and towns; they have taken hundreds of lives. These things are matters of public record and general knowledge: so constant in their recurrence that they have become matters of course, like rain or frost or sickness. For generations we have had laws and more laws concerning fires upon the statute books. For decades we have had officer, charged with fire prevention and suppression. But the fires have not been controlled and the state still lacks anything like a clean-cut policy as to the fires of the stump-country.

As to fish and game the state has a policy, of a sort. There is unanimous agreement that the game supply is dependent more upon the cover than upon the enforcement of restrictive legislation. But the presence of cover is determined by fire and, over great areas, the fires have practically exterminated the game birds and animals. Upon our statutes fire control is made subordinate to the game and fish business. If this is a matter of policy it requires radical revision. The game will increase if the fires are stopped—cannot be maintained if the fires continue.

We have a new policy as to State Parks. We desire the development of the north country in connection with tourist traffic. But millions of acres of the state's north country is black and desolate and dreary with the devastation of fires. Summer visitors are apt to prefer a safe and green country. If our summer resort business is to develop the fires must be stopped.

For thirty years the greatest exporter of the best lumber the world ever had, today Michigan imports more timber than it grows, and grows no timber save by accident. In a decade timber consumption will exceed the timber cut by 50%. The annual freight bill on imported forest products totals a sum great enough to plant half a million acres to new forests. Trainloads of timber are coming into Michigan from Arkansas, from Oregon and Idaho. With over ten million acres splendidly suited to the production of pulping species, our publishers are paying five and ten cents a pound for newsprint. The lumber for a ready-cut, one-story, five-room frame house, which was listed at $883 in 1915, is now quoted at $3,272. There is a world-wide shortage in high-grade timber. In the face of all these things Michigan still lacks a policy.

Our statutes require that not less than 600,000 acres of State Forest be maintained. For years the State Forests have received reasonably good fire protection—enough to demonstrate the perfect feasibility of protecting forest lands from fire: but the State Forests are the remnants

of tax-delinquent and bankrupted lands which have finally dribbled into state ownership; they are cut-over, skinned and burned lands, for the most part "forests" by courtesy only. Planting operations have been carried on upon the State Forests with marked success and with a low cost hardly to be duplicated in America, but, at the present rate of planting, some 60 years will be required to put the state's present 600,000 acres to work—and near fifteen million acres are idle and, non-productive. The existing State Forest policy is but a fragment and wholly inadequate to meet the situation. Nobody has ever maintained that it was adequate.

Great aggregates of our idle lands have soil of high agricultural value, but the areas with good soil and location lie mixed and scattered through still greater areas of low-grade sand and swamp and rock areas. Attempts to develop the agricultural possibilities have not been lacking. Too often such attempts have been mere exploitation of hopeless sands and too hopeful settlers, and this situation has so long prevailed that the state has suffered enormously in reputation and in the sale value of its good and improved lands. The scandals of the sand-land exploitations yet continue. Great areas of good land lie idle, often held off the market for speculation.

Nearly a sixth of Michigan is owned by 32 concerns. A single firm owns a million and a half acres of Michigan. This system of ownership has been possible because of our system of taxation. Should the state decide that land monopoly in this degree is not desirable, and should it take steps to terminate such monopoly, that would involve a matter of policy where today there is none.

It is certainly in the interest of the state that the maximum possible acreage become permanently productive and profitably at work. Our fifteen million acres of idle lands can be put to profitable work in but few ways. A portion of them are suitable for agriculture, another portion is suitable for grazing. A still greater portion is suitable for neither farming or grazing in any form. This great fraction, millions upon millions of acres, is suitable for forest production and with it, game and fish and fur production. With the presence of forests and their game and fur and fish, an enormous industry in tourist traffic is assured. The question then is: Do we want these idle lands of Michigan put to permanent and profitable work? If so, how may that be contrived?

Such situations are often met in the business world, as in the case of other forms of bankruptcy. How does the business world proceed in such cases?

The first thing is to take stock of the resources—to make an inventory. Michigan needs an inventory of its idle lands. That will be a soil-survey plus an economic-survey which shall consider and appraise the properties at their true value. A law providing for such work is today upon our books. It is inoperative. To bring that law to life and put it into execution will require a policy.

The items required of an adequate land policy in Michigan are not new or untested. Wisconsin has a soil-survey. California has in operation a modern plan for settling idle lands. The Governor of Kansas has proposed a scheme for the eradication of the land-hog. Nebraska protects her citizens against the land-shark. Pennsylvania has millions of acres in her State Forests. Nothing new or untried in the way of policy or plan is required by Michigan. In practically every item Michigan has already made tentative experiments. But we move too slowly and the situation becomes acute, for we have ten or fifteen million acres of idle lands and the area increases.

To remedy these things nothing can suffice save a real policy soon put into effect. It needs to be a real policy and a workable policy and a policy upon which the state can unite to the end that every acre of the state may he working steadily and profitably all the time.

As to the basic facts no question is raised. As to the ends desired there is agreement. As to the means to those ends there should be discussion, but it should soon terminate in specific and adequate action. The legislature has never tackled these problems as a group and save by handling them as a group they cannot be worked out. In the face of the bankruptcy of over a third of the state the legislature has failed us. With all these things crying for attention the University has remained aloof and superior; the Agricultural College busily content with its own problems; the commercial organizations of the state have not even recognized that the prosperity of the state is in grave jeopardy.

To open this subject and follow it through to solution will require vision and technical skill and patience and work. If those qualities are to be found in the Michigan Academy of Science, it has such an opportunity and such a duty as seldom presents itself to any group of men.

UNIVERSITY OF MICHIGAN.

22d Mich. Acad. Science Report, 1920.

THE EFFECT OF FOREST FIRES UPON THE SOIL OF THE NORTH LAKE STATES.

BY P. S. LOVEJOY.

Question having arisen as to the character and appraisal of the damages done by forest fires, inquiry as to the effect of fires upon the soils burned over was addressed to the U. S. Bureau of Soils, reply (dated Nov. 13, 1919) toeing received from the Chief of the Bureau reading in part as follows:

". . . With the exception of one or two determinations for calcium carbonate and four or five for organic matter, we have made no chemical analyses of soil samples in connection with our soil survey work in Northern Michigan, Wisconsin and Minnesota . . . As to whether or not the Bureau of Soils is able to place any value upon so-called "humus" in soils, I have to say that so far we have not studied this question sufficiently to be able to assign such value to organic matter either in cumulose deposits like muck or peat or to the organic matter present in normal timbered or prairie upland soils. . . ."

Another inquiry of similar character was sent the Bureau of Soils at about the same time by J. A. Doelle, Secretary of the Upper Peninsula Development Bureau, reply (dated Nov. 2, 1919) being received from Dr. C. F. Marbut, in charge of the soil survey work of the Bureau. This reply reads in part:

". . . No reliable information on the subject (injury to soils caused by uncontrolled woods' fires) has ever been obtained . . . It is impossible, therefore, to give an affirmative or negative answer to the question. In a general way the humus that is of value to a soil is in the soil and not on it. The organic matter that is burned by forest fires, or by prairie fires, is on the soil and not in it. For that reason it seems probable that the injury done to the soil by forest fires is not as great as is often supposed . . ."

Dr. Marbut's letter having been referred to me by Mr. Doelle, reply was made to the following effect: Specific data and centuries of careful observation are not wanting and definite answer to this question is available. Professor Snyder (1) records a loss from the soil of 2,500 pounds of nitrogen per acre as a result of the Hinckley, Minnesota, fire, the humus content of the soil being 1.69% before the fire and only 0.41% after the fire.

This analysis is quoted with approval by Mosier and Gustafason (2) who add further evidence as to the soil injuries associated with the depletion, by fire and otherwise, of the organic contents of agricultural soils. There is a mass of similar data and conclusions.

This statement having been forwarded to Dr. Marbut, he replied (Dec. 2, 1919) in part as follows:

"I note the quotations (from Snyder, Mosier and Gustafason) and desire to say that the difference between us lies wholly on the question of humus. The leaves and moss lying on the surface of the ground in forested regions of the northern part of the United States is not humus . . . I think it probable that the (Snyder) analysis showed a content of organic matter on top of the soil of 1.69% before the fire and after the fire it showed a content of 0.41% . . . I think it probable that a further discussion of the matter is not profitable because no exact value has ever been placed on this layer of leaves and moss . . . Until some value is placed on it, it is hardly worth while to discuss the matter . . . The question can only be determined by experiment . . . It is extremely probable that the prairies were burned every year . . . (but) the fires did not preclude the prairies from accumulating humus. Would it be right, then, to conclude that the fires prevent the accumulation of humus in forests? . . . I must again insist upon the statement . . . that 'injury done the soil by forest fires is not as great as is often supposed.'"

The statements of Professors Snyder and Mosier thus being challenged, the matter was referred to them. Professor Snyder replies (Dec. 19, 1919) that the Hinckley analyses were made quite in accord with the technique, of the Association of Official Agricultural Chemists, and that leaves and moss were not included in the samples. He further remarks that: "A fire confined to the surface of the soil, as a mild prairie fire, is entirely different in its action to an intense forest fire where iron rails are warped and twisted, and the combustion is not confined alone to the surface accumulations . . . "And again: "I consider that the permanent crop-producing capacity of many of our burned-over forest soils . . . has been appreciably lowered, because of forest fires which could have been prevented. . . ."

Professor Snyder cites further references to his published work, from one of which I quote: (3) "Soils covered with pine, in which sand largely predominates, frequently lose one-half to three-fourths of their total nitrogen when visited by forest fires. The sand being of open and porous nature aids in the complete combustion of the humus. In the timbered region of the Northwest, the great fires of 1894 resulted in the average destruction of over 1,500 pounds of humus nitrogen per acre, to say nothing of the nitrogen lost in the burning of the timber . . . The prairie fires have not been so destructive upon the humus as the forest fires because the burning has been confined more to the surface. An average prairie fire, however, will remove more nitrogen from the soil than five ordinary crops of wheat."

Professor Mosier writes (Dec. 12, 1919) in part as follows: "There is no question at all in my mind that the burning of a forest will destroy a great deal of very valuable organic matter that lies on the surface and which, upon clearing, could easily be incorporated with the soil when plowing is done . . . The sand dunes in part of Illinois are covered with black-jack oak, and where the fires have taken place the sand to the very surface is yellow with almost no organic matter, while in other parts where no fires have occurred there is not only a surface of leaf mould an inch or two in thickness,

but the surface two inches of sand is quite dark with humus . . .

"It would be my estimate that where fires have not occurred in forests for a great many years (as described for the Lake States) there would be on the surface and in the surface two inches of soil . . . from 100 to 125 tons of organic matter . . . Supposing that we assume that this contains 16 pounds of nitrogen per ton, which is probably too low, then in 100 tons there would be 1,600 pounds of nitrogen, which, at present price, would be worth $480 per acre . . . not to say anything of the value of the organic matter in the physical improvement of the soil. I sometimes estimate . . . (this) as worth about one-fourth that of the nitrogen . . . If we consider the large areas that burn over, the losses would simply be incalculable. . . . There is considerable difficulty in supplying or restoring the organic matter to the soil, especially in northern latitudes. Even if two tons of clover could be grown and all this turned under, it would take six years to restore the nitrogen . . . In general the upland timber soils of the Lake States are in need of organic matter . . . There is no question but that the leaf mould and the organic debris that is accumulated on the surface and in the surface few inches of soil is of immense value to the agriculture that is to be practiced there . . . The minimum value that would be placed upon this material will be much higher than the cost of replacing a sufficient amount to produce good crops."

The comments from Professors Snyder and Mosier having been briefed and forwarded, Dr. Marbut replies (Jan. 17, 1920) at some length. I abstract this reply in part as follows:

"Samples have recently been collected from an area which was severely burned by a forest fire. A sample was also taken from an average spot in an adjacent unburned area. It may not be stated when or where the samples were collected, for the results have not yet been officially published. The results of the analysis of these samples may not settle the matter but are worth as much as any other data of the same kind and quantity. The samples from the burned area show an organic content averaging about 3.5%, while the (one) sample from the unburned area had a little less than 3% of organic matter. Certainly no burning of the organic matter took place in this soil. A large proportion of the burned area, after the fire, still had a covering of unburned organic matter ranging up to nearly an inch in thickness. As to the comparison between prairie and forest fires it is only necessary to refer to the analyses just quoted. The prairie fire could not well be confined more to the surface than this case indicates is true for forest fires. In severe forest fires the leaf mould is not always removed, and, if these results are applicable generally, it is rarely removed. A prairie fire could not well remove more nitrogen from the soil than five ordinary wheat crops, for the humus removed by a prairie fire is not *in* the soil at all.

"The analysis quoted above fully answers Professor Mosier's statement, and his figuring, which seems to be correct, is based upon an assumption which is wrong. The material burned is not part of the soil when, burned."

Dr. Marbut concludes: "On the basis of the *supposed injury*, as stated by Professors Snyder and Mosier, when compared with my own figures showing no loss of soil organic matter at all, I *still* feel justified in repeating . . . that 'it seems probable that the injury done to the soil by forest fires is not as great as is often supposed.'"

There follows a set of quotations and interpolated comment which I reproduce verbatim.

"I desire to quote some opinions myself: 'The quality of the humus present (in forests) is in inverse proportion to its quantity.' (Grebes, Bodenkunde, 3rd Edition, p. 176, quoted by Ramann, Bodenkunde, 3rd Edition p. 170.)

"'In general a high humus content in forest soils is no evidence of any special soil fertility (quality), it is, however (such an evidence), if the humus is uniformly mixed (incorporated) with the soil; one can then, as a rule infer that other things being equal, the soil with the higher humus content is the richer. On the other hand, however, the *presence of a compact layer of humus* (decaying or partially decayed plant debris) overlying the soil is to be considered as an evidence of soil degeneration' (ruckgang). Ramann, Bodenkunde, 3rd Edition, p. 170.

"The layer of humus burned by forest fires in northern forests is in many if not most cases exactly what is described here."

"'The physical changes which take place in a soil when covered with rohhumus (the layer of leaf mould, etc., lying on the surface in northern forests) takes place along with the chemical changes. *Through the removal of the soluble salts one of the most important conditions for the formation of crumb structure is removed*. The crumbs (previously formed) are destroyed and the soil grains become *packed close together*. Comparative investigations show a progressive decrease in volume of (soil) pores and also of the air space in the soil. All heath soils show almost a minimum of aeration. Often the top layer of the mineral soil is so compact that, when made up of sand, it breaks up in flakes.

"'A further unfavorable action lies in the annihilation, or at least a *very important reduction of the animal life. Earthworms disappear rapidly as the soil becomes covered with, a layer of organic matter* (rohhumus). The acid reaction of the soil *decreases the bacterial content of the soil and this decreases the rate of decomposition of the organic matter*. On the basis of these conditions it is evident that once the accumulation of a covering of forest debris has begun it proceeds rapidly, since an important cause of the destruction of the forest debris is decreased.'

"'While the mixing of "sound" humus (with the soil) and the covering of the surface with a layer of *loose and open* forest debris is of great importance for forest soils, the existence of a *thick layer* of forest debris is *unfavorable both to the soil and to the forest*. If such

material accumulates to considerable thickness it assumes the character finally of a typical humus soil which, in many cases, constitutes a starting point for the formation of a "hochmoor" (peat soil).' Ramann, Bodenkunde, 3rd Edition, p. 207.

"Under *changes effected in the soil under* (a layer of) *rohhumus*, Ramann, Bodenkunde, 3rd Edition, p. 199, states:

"'With progressive leaching, the upper horizon of the soil becomes *poor in soluble material*. The leaching is hastened by the compactness of the soil (because of the layer of surface organic matter) and the action of the humus colloids, the latter effecting the removal from the surface of iron and aluminum.

"'If "rohhumus" covers the soil, a humus "sole" is formed which hastens the leaching and in a relatively short time the surface horizon of the soil is *exhausted of its soluble material* and there is thereby developed a gray horizon low in humus' (and mineral matter also)."

"On the succeeding page, at top, he shows how hardpan is formed through the continued action of the same process.

"On page 550 he states that 'for forest trees, or at least for most of the species, the content of the mineral plant food in the soil is less important than a good physical condition.' Anything that acts on physical character unfavorably is an injury therefore. It is stated above in another quotation from Ramann that a *thick cover of organic matter on forest soils acts unfavorably on their physical character*.

"The figures cited in this letter show that Professor Snyder's analyses do not have universal applicability. My observations show the 'humus' layer not to have been completely burned and, therefore, there was no burning of humus out of the soil. I disagree wholly with the statement that a prairie fire removes as much nitrogen *from the soils as* five ordinary wheat crops.

"Professor Mosier's figuring seems to be correct, but the assumption on. which it is based is wrong.

"The position Professor Lovejoy tries to maintain by means of these quotations in not tenable therefore.

"The quotations from Ramann show clearly that according to the studies made by German specialists, *the accumulation of a thick layer of forest debris, such as that which accumulates in the forests of the Lake Region, is injurious not only to the soil, but to the forest.* Anything that can prevent such accumulation, will not only injure the soil, but will benefit it."

Thus Dr. Marbut, in charge of the soil survey work of the U. S. Bureau of Soils, arrives at the conclusion that, so far as the soil is concerned, uncontrolled and miscellaneous forest fire is beneficial.

The question would now seem to be as to the weight to be given the Ramann quotations. For this purpose the correspondence was placed in the hands of Professors Sauer (Geology) and Roth (Forestry) with the request that they pass judgment upon the technical matters involved.

Dr. Sauer's memorandum is as follows:

"A consideration of Ramann's 'Bodenkunde' does not indicate that the author believes humus accumulation in the latitude of the Great Lakes on uplands of loam, silt or clay, to have harmful influence in forest areas. The direct implication of pages 170 ff. (3rd Edition) is quite the contrary. His general attitude is expressed in the statement: 'One can assume as a rule that under the same conditions the soil that is more richly supplied with humus is also more productive. In contrast to this condition is the occurrence of compact layers of humus materials that are superimposed on the mineral soil as a sealed cover. On page 171 he refers to the latter condition as a firm, fibrous, acid layer that may be cut (schneidbar), later elaborated under the terms 'rohhumus' and 'trockentorf' (p. 193 ff.). The causes of such formation are stated as (1) very poor soils by reason of lack of plant food; (2) exclusion of air, especially by submergence; (3) excess of water, commonly combined with low temperatures; (4) low temperatures of very high latitudes; (5) aridity, especially in the warm season. Further statements indicate that these conditions are applicable especially to poor sands with orstein formation; ill-drained surfaces; heaths and highland moors; tundras and regions or aridity. In forests the condition is characterized by compact and excessive accumulations of forest litter (streudecke).

"These conditions are not characteristic of the Great Lakes except for normal bogs and, possibly, exceedingly local upland moors. They are most certainly not the conditions of lands of agricultural possibilities, nor of the bulk of the pineries of the Lake States. Moreover, the forest conditions of the higher European latitudes with which the observations of Ramann are mainly concerned, possessing lower summer temperatures and lower evaporation, cannot be transferred by inference to the Great Lakes region. The type of soil produced by rohhumus accumulation is podsol, or podsol-like (see especially Ramann, 'Bodenbildung und Bodeneinteilung,' 1918) and its American equivalents, if found, will be in higher latitudes than those of the Great Lakes."

Professor Roth's memorandum is as follows:

"Ramann is perfectly correct. He is writing a text on forest soils, and the Marbut quotations refer to a certain well-known forest soil type.

"But there is not one square rod of Michigan hardwood and hemlock where this (soil degeneration as indicated by podsol) applies. There is not a square rod of 'hochmoor' in the state. There is nothing of the sort in our normal pineries.

"'The layer of leaf mould under our Lake State forests is rohhumus!' We have the finest leaf mould in the world under our Michigan timber. This typical north woods mulch has kept our soils in the finest fettle for untold

centuries, fine, friable, continually getting better with the forests they carry—up to the coming of the fires.

"To compare our conditions with those of the Luneberge heath and of Labrador and Archangel is completely unwarranted. To figure it out that fire, by preventing 'such an accumulation' will 'not only not injure the soil, but will benefit it,' is entirely fallacious."

If it may now be conceded that the Ramann references are largely irrelevant, it remains to comment upon the technique of Dr. Marbut's investigations and upon the legitimacy of the conclusions at which he arrives. It will be noted that soil samples (number, location, condition and by whom not specified on account of departmental regulations) from a "severely burned" area are reported to show an average organic content of about 3.5%, and that the single check sample from an adjacent unburned area analyses a little less than 3% in organic matter. From these results it is announced that "certainly no burning of organic matter took place in this soil." But something did burn: what, in what quantity and where, is information also lacking.

According to the record, the soil from the burned area had a higher organic content that that from the unburned area. Aside from the fact that but a single sample was taken from the unburned area, and that there is nothing to demonstrate that this sample represents a true average, and .aside from the fact that the fire left a covering of unburned organic material up to nearly an inch in thickness, thus demonstrating that the fire was not really severe, as such fires go, so far as the reported results indicate, it would be logical to assume that the fire increased the organic content of the soil by about 0.5%. Perhaps another fire, consuming the balance of the organic material left by the first fire, might increase the organic content of the soil to 4 or 5%, and repeated fires might still further add to the combustible ingredients of the soil.

It would be interesting to learn whether the laboratory technique used in these investigations was such as to distinguish between humous materials and charcoal. Much of the dark material in the surface of our Lake States soils may well be charcoal, but the plant food value of charcoal is not apt to be high.

As to the question of the severity of the fire the circumstances related are adequate. Professor Roth mentions heat enough to melt sand. Professor Snyder speaks of heat enough to warp iron rails. I have seen rock slopes where the surface ran into slag, all from forest fires. But fires of such severity are indeed as rare as those which increase the organic constituents of soils by burning them up.

It is true, however, that under average Lake States conditions, the first fire over virgin formation does not, as a rule, consume the entire organic layer of the forest floor. But, under Lake State conditions, the first fire is to succeeding fires as. a comber on a beach is to succeeding combers, and if Dr. Marbut does not know this, or choose to concede it, other and competent observers have made record of the circumstances, as will be shown.

Between the humus of prairie soils and that of forest soils there is no legitimate comparison in this connection. While fires on the prairies were common enough they were not annual affairs and no one who has had experience with both prairie and forest fires would presume to compare their relative severity. Moreover, in the nature of the case, where prairie soils obtained the bulk of their humus from the decomposition of roots, the forests, with their heavy and continuous shade, their higher humidity, their soft and heavy mulch and radically different root system, obtain the bulk of their humus from the decomposition, not of roots but of the layer of fallen leaves, twigs and logs which makes up the forest floor. If very full and competent confirmation of this point is required it is not lacking, as will be shown.

Under Lake States conditions, the fires recur, forest and brush and "plains" fires, year after year, each in turn removing most of the current accumulations of organic material and yet more of the ancient accumulations laid down by the virgin forest. Each fire anew exposes more of the mineral soil with its remaining organic material to the action of direct light, rapid evaporation, frost and wind action, and to slope-wash, these in, turn wasting away whatever the fires may have left of the original organic material and decimating the living things associated with fertile soils.

If the narrow terminology of the soil technologist is to be justified in insistence upon the fact that the bulk of the organic material of the forest floor is *on* the soil and not *in* it, such insistence is, nevertheless, futile. The roof of a house is not *in* the house but may not, therefore, be burned without affecting the value and usefulness of the house. If humus, in the strict sense, is a valuable ingredient of forest soils, and if the humus of forest soils originates in large part from the progressive decomposition of the fallen forest litter which makes the forest floor, then the destruction of the litter *on* the soil must operate to prevent the development of humus in the soil. This is, of course, the case, and, all chemical determinations notwithstanding, it must be insisted that forest litter burned on the soil can never, under any circumstances whatsoever, become humus in the soil, on the soil, or otherwise available to plants, soil or man. It is this consideration and understanding on the part of Professors Snyder and Mosier to which Dr. Marbut objects as being merely an "assumption" and a "supposed injury."

Professor Fernow remarks (4) "that from fire a damage even greater than the loss of the crop is experienced in the loss of the soil cover, the litter and duff, which is the forest's manure. . . . Even the soil itself, often formed only by the mould from the decay of leaves and litter accumulated through centuries, is destroyed, and thus not only the practicability but the possibility of forest restoration is frustrated. . . . The yearly conflagrations destroy . . . standing timber, they kill the young growth

and destroy even the soil, the fertility, an accumulation of centuries of decayed leaf mould."

In his classic text on soils, Dr. Hilgard (5) remarks, in passing and as too obvious to warrant detailed discussion, that: "Forest soils are usually dark tinted for some inches near the surface, owing to the presence of leaf mould," that "in forests of humid climates . . . not only does the autumnal leaf fall, as well as decaying twigs and trunks, become obviously incorporated with the surface soil as decay progresses, but active animal agencies carry the organic remnants bodily down." He remarks upon "the uniformity, lack of structure and loose texture of the surface soil, especially of forests" and that "meadows and woodlands generally show the highest humus content in their surface soils, gradually increasing (the humus) while in that condition."

Van Hise (6), in discussing the effect of forest fires, states that: "Another serious result . . . is in the deterioration of the soil. The fires do not simply confine themselves to the timber, but they burn the humus in the soil itself. Frequently . . . and especially if the fires run over the same area several times, there is left but little or no organic material. In this case must again begin the slow process of accumulating a sufficient amount of organic material in the soil before a good growth . . . can be secured."

If European references of specific applicability are necessary, perhaps Professor Schlich (7) may be a competent witness. "The burning of the dead leaves and litter on the ground prevents the accumulation of humus and the improvement of the soil and renders the soil poor and hard." Further, speaking of the European practice of raking out the forest litter for sale as compost material, he says: "Only places with fertile, deep and fresh soil can bear a limited removal of litter." And, "Among the worst instances of damage to the soil by the removal of litter are the State Forests near Nuremberg, where even Scotch pine . . . can now only grow as a dwarfed scrubby tree almost useless unless for fuel."

"It is the duty of the State to impart public instruction as to the extreme impoverishment of forest soil by the constant removal of litter," says this authority in concluding a chapter on "Forest Protection." In more ways than one it would appear obvious that European conditions may set no precedents for American procedure, for Dr. Marbut of the U. S. Bureau of Soils advocates the use of fire as a measure for soil improvement, and quotes German authority in alleged approval.

Endless references of equal standing and import might be quoted, all, so far as discovered, further substantiating the fact that fire may be expected to damage the soil over which it runs, but the question is not merely as to the effect of fire on soil; it is as to the effect of fire upon Lake State soils. Of the Lake State soils there are three main classes, the clays and loams, the sands, and the mucks and peats, each respectively the typical sites for hardwood-hemlock, pine, and cedar-tamarack forests.

As to the effect of fire upon these soils, Dr. Marbut first states that: "No reliable information has ever been obtained." To this contention the following citations seem opposed, as typical of many more which are available.

Leverett says of Minnesota: (8) "Large areas have been swept by forest fires, and these fires have destroyed much of the accumulated leaf mould. . . . The principal damage by fire in this State, both past and prospective, seems to be the destruction of peat in the bogs. In such cases there is not only the loss of a valuable fuel, but the land is left in rough state, ill-suited to cultivation." This is surely a mild statement as to the effect of wild fire upon cumulose soils which may run 90% organic and combustible in like degree. That controlled fire may be used to advantage in the muck areas, under certain circumstances, is, of course, beside the question. As a matter of fact, great aggregates of peat and muck soils have been utterly devastated in each of the three Lake States and within very recent years. The item would seem to be undebatable.

As to the sandy soils, competent evidence is also ample. The United States Department of Agriculture—if evidence from this source is to be credited under the present circumstances—in discussing the possibilities of farming the lighter Lake States sands, states: (9) "The successful handling of the jack-pine plains begin with the clearing of the land. The logs, stumps and brush must be cleared away, but nothing should be burned off that can be plowed under for humus. The great need of the soil is for humus. Rotted logs should be picked to pieces and scattered thinly over the ground. All sweet ferns, huckleberry bushes, brakes and other small growth should be plowed under and not burned off.

"Burning over the soil not only depletes it of its humus content, but tends to make it sterile and dead. . . . A fierce fire left to run over the land in clearing will destroy most of the beneficial organisms, leaving the soil inert and unresponsive, like freshly turned subsoil. . . .

"The, land has been repeatedly burned over every few years, for nobody knows how many generations; hence, there is little humus or vegetable matter in it. It lacks nitrogen. It is likely to be a little leachy. It is likely to suffer severely in time of drought. It needs protection from the winds."

Says a Wisconsin bulletin: (10) "Originally nature, through a forest . . . covering, protected these loose sands against severe winds. Man removed the forest covering . . . and later . . . the organic matter which bound these soils together . . . until many acres are left to the mercy of the winds. . . . Farmers who live in the sandy soil region agree that each spring's sandstorm is worse than preceding ones."

Referring to Michigan conditions, Leverett says: (11) "The extensive areas of pine plains . . . furnish a

problem as to methods of management . . . and especially since parts of them have been devastated by fires."

"Forest fires have frequently swept the cut-over lands," says a Wisconsin authority (12), "adding to the desolateness of the country. . . . There are areas which have been burnt over repeatedly, leaving little of the rich vegetable matter in the soil. . . . Where forest fires have burnt over the ground so completely, considerable difficulty may be experienced . . . in getting a (new) growth started."

So much for the mucks and the sands. As to the loams and the clays the situation is identical save in that, being originally of higher quality, these soils are not injured by fire in so radical and obvious a way as are the open textured mucks and sands.

Concerning a typical group of silt-loam soils Whitson and Gieb says: (13) "Compared with prairie soils which have shown lasting fertility, these soils are distinctly low in organic matter and nitrogen. In fact, most upland soils of wooded regions are low in organic matter. However, the vegetable matter which they do contain when first cleared and broken is of an active character, but provision must be made for maintaining and increasing this material."

As to sandy loams, which make up the bulk of the Lake State loams, it is reported: (14) "The organic matter of these soils is also low. . . . This organic matter is largely in the form of leaf mould and fine roots, and hence is of an active character . . . furnishing sufficient nitrogen for a few years. It is, however, exhausted with readiness (by farming) and the most important point in the management of such lands . . . is to increase the organic matter."

With the clay soils the situation remains the same with the further consideration that they are more subject to slope-wash and erosion when once stripped of the forest cover and mulch.

In speaking of the heavy soils the Wisconsin authorities say: (15) "On many of the steeper slopes erosion will be a problem requiring attention. . . . Small ravines soon form if the surface of the ground is not covered. . . . These gullies enlarge quite rapidly unless checked."

The relation between forests and erosion has been studied in vast detail, and in many countries the results of such studies being in remarkable accord and especially with respect to the relation between forest fires and the resultant washing and wasting of the soil.

Dana remarks (16) that: "From the standpoint of erosion, every fire on hilly land is a menace—the steeper the slope the greater the menace. Conflagrations which completely destroy the cover are, of course, most dangerous, but even light surface fires are not to be disregarded.

"By destroying the humus . . . these light fires tend to harden the soil and to reduce materially its absorptive capacity. Repeated fires on the same area are particularly dangerous, since they open the stand, remove all trace of vegetable matter, and may cause the soil to harden and pack so as to be almost impervious" (thus increasing the rate of run-off).

No mention has yet been made of the type of country where the surface is rough and the country rock lies close to the surface with the mineral soil thin and patchy, or of the broken boulder fields typical of a considerable area of the north Lake States. In spite of their unfavorable condition these areas orginally supported a very fair hardwood forest. With the advent of fire to such lands, and the rapid destruction of the organic accumulations, wash is often immediate and rapid, and easily results in the total and practically permanent devastation of the area. Leverett remarks upon the situation in Minnesota (17) and the Canadian reports show enormous areas to have suffered terribly from this form of fire and soil damage. (18) But perhaps it will be argued that this is not a soil damage, properly speaking, insomuch as the soil has merely been moved about, thereby suffering no material change in its ability to go through a set of sieves or in its test-tube reactions. Millions of acres of once productive country have, nevertheless, been rendered permanently useless to man on this account.

It is to be presumed that no particular demonstration will be required as to the ubiquity and recurrence of fires throughout the north Lake States, but, if wanted, the State Forester's and Fire Warden's reports are available and the region itself is an open book of fire writings.

Only an insignificant proportion of the whole region has been free from fire during the last fifty years; the bulk of the lands have been fired repeatedly; millions of acres have been burned over time and again during the last decade.

The fires have run and do run and no class of soil or type of country has been free from them. Of the many and tremendous forms of damage done by the fires, damage to the soil is but one, and, perhaps, not the most important. But it is important and vastly more important for the future than it has been in the past. Before long all those thirty of forty million acres of idle land, now lying fire-swept and non-productive in the north Lake States, must be returned to productiveness. Whether these lands can be most profitably devoted to agriculture, grazing, or forest, whatever they may be able to produce will depend primarily upon the quality of their soil. By whatever fractions these soils are reduced in fertility, in their ability to produce useful products, by that much the past depreciates the labors and the investments of the future. The total of the depreciation in soil productivity and availability, caused by fire, will place a heavy burden upon many years.

But we may take heart for perhaps the situation is otherwise. On November 2, 1919, the official in charge of the U. S. Soil Survey certified that "no reliable information has ever been obtained" as to the effect of

fire upon our soils. Subsequently, having found no occasion to give consideration to the work or opinions of Professors Snyder and Mosier, Dr. Marbut has consulted a German text and has conducted certain analyses of soil specimens from a "severely burned" area, these being checked by one sample from an adjacent unburned area. (Location, numbers, condition and so forth being yet unavailable on account of departmental regulations.) These things having been accomplished, Dr. Marbut revises his opinions, and, that reliable information which was lacking now having become available, he enunciated the doctrine that (according to the studies made by German specialists, and provided the results of his experiments are applicable generally): "The accumulation of a thick layer of forest debris, such as that which accumulates in the forests of the Lake Region, is injurious not only to the soil but to the forest. Anything which can prevent such an accumulation will not only not injure the soil but will benefit it"

Were all this merely a matter to be mooted among scientists, pending experimental determinations of greater particularity; were it merely a matter of laboratory technique, or of shades of meaning among translators, no presentation such as this might be justified. But in this situation there is a perversion of science and the promulgation of a doctrine so pernicious as to permit of no half-way measures in its rebuttal. To acquiesce, not to say to advocate, the needless and wanton destruction by fire or any other means, of the age-old, scant and precious organic material of our Lake State forest soils, and this as of being a benefit to the soil, is not only a scientific absurdity, it partakes of the nature of a public outrage.

University of Michigan, March, 1920.

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22d Mich. Acad. Science Report, 1920.

THE CUT-OVER LANDS IN RELATION TO AGRICULTURAL USE.

BY J. F. COX.

Approximately one-third of Michigan's total land area may be classed .as undeveloped land from an agricultural standpoint. This immense tract of millions of acres is, in the main, cut-over land situated in the Upper Peninsula of Michigan and in the northern half of the Lower Peninsula, a comparatively small area of land under standing timber, and extensive areas of poorly drained land, most of which is muck. The cut-over land was cleared for the most part thirty years or more ago. The holding of large tracts by individuals, the presence of stumps in the cut-over, and the poorly drained conditions of other areas have prevented the development of this great tract, during the period that the more easily cleared prairie lands of the West were rapidly taken up in spite of their great distance from eastern markets. Michigan's undeveloped area represents one of the few great reserves of land, suited to agricultural purposes, awaiting development.

AGRICULTURAL VALUE.

The extreme variability of the soils of this area has been another factor which has markedly delayed its development. On the better soils, scattered throughout this northern region, numerous instances of successful and profitable agricultural development may be found, but in these same areas a great number of attempts on the part of pioneer farmers to make a livelihood at farming have failed, due chiefly to the fact that they were unfortunate in their choice of land, either selecting land too poor for profitable agricultural development, too remote from developed markets, or were unskilled in farm practice.

It is a most regrettable circumstance that during past years and at the present time a large proportion of incoming settlers have been encouraged in the purchase

of land unfitted for profitable development by short-sighted speculators with an eye to immediate profits. These "land sharks," as they have been justly called, have frequently used, as examples, successful settlers on better lands in the immediate vicinity to aid in making sales, and have taken advantage of the ignorance of prospective buyers in establishing them on inferior soils from which, under present conditions, it is impossible to wrest a suitable livelihood by farming. This condition has not only greatly retarded the development of the entire region, but has brought great loss to the state, to the individual who attempted settlement, and seriously injured the possible business of reliable land developers who have attempted to encourage the settlement of land of good quality. The maxim "*caveat emptor*" is a poor guide in empire building, and even a few of those engaged in the sale of lands who do business on the "let the buyer beware" basis can greatly retard the legitimate and ethical efforts of a majority of honest land dealers.

GOOD LAND AND POOR.

Close observation of extensive areas of northern Michigan lands and of present farming conditions in these localities has convinced the writer that there are great areas of excellent soil, capable of high-crop development, and of sustaining prosperous farming communities if rightly handled. On the other hand, there are even more extensive areas of frosty light pine plains, of extremely light hardwood soil, of poorly drained lands and of rocky areas which, under present conditions, cannot be utilized for the profitable production of crops. While areas of both types are often found in comparatively large tracts, they are to a great extent intermingled, which makes great care in the selection of land for development highly necessary.

CROPS ADAPTED TO THE NORTHERN CUT-OVER LANDS.

The experience of occasional farmers and experiments at the Upper Peninsula sub-station and throughout the region have demonstrated the fitness a wide range of crops to the climate and better soils of the cut-over region. It is also an apparent fact that through ignorance or design the cropping possibilities of certain sections have been grossly misrepresented to prospective settlers, and through lack of sufficient knowledge many farmers are attempting to produce crops not suited to the climate or the soil.

Generally speaking, the better sandy loams, loams, and clays of the entire cut-over country are well adapted to clover, grasses, and other forage crops which can be depended upon to furnish excellent pastures and meadows. At the present time the grazing of cut-over lands with sheep and cattle is undertaken with more or less success. The better types of soils are naturally seeded to June grass, alsike clover and timothy. The heavier loams, clay loams and clays, where second growth is not too thick, carry good pasture throughout summer seasons. On the lighter loams, the pasture tends to dry up and run short. The light pine and hardwood soils and Jack pine plains are of little value for grazing purposes, except for a very brief period in late spring and early summer, when they offer light grazing.

After clearing, the loams, clay loams and clay can be depended upon to produce excellent crops of rye, barley, oats, spring wheat, root crops, peas and oats and buckwheat. Winter wheat is gaining rapidly in acreage, and bids fair to become a dependable crop on adapted soils.

Corn can be depended upon on the above-named soils for silage purposes in the lower part of Menominee and Delta Counties, throughout the northern part of the Lower Peninsula and along the southern shore on adapted soils of the Upper Peninsula. Early varieties are dependable for grain, but these regions cannot be termed "corn lands" in the sense that corn can compete with barley or oats as a feed grain.

The well-drained loams and sandy loams of northern Michigan, in general, are splendidly adapted to potatoes. It is well within the realm of possibility that northern Michigan will become one of the greatest centers of potato production in the United States.

One of the problems of feeders, who have recently brought stock into upper Michigan, is to provide for winter feed. Summer pasturage is plentiful. The clearing of more land for the production of barley, rye and oats for grain feed, of silage, root crops and clover and timothy hay, and alfalfa to winter over stock, will make this business much more secure.

Certain areas of the Upper Peninsula can produce all crops necessary to sustain a thriving dairy and livestock development. The Ontonagon Valley, for instance, a great range of approximately 250,000 acres of strong clays and clay loams of high fertility, can produce the grass, grains and winter feed such as roots, peas and oats, or possibly sunflowers and early corn varieties for silage to maintain a profitable dairying or beef cattle industry.

At the present time at Ewen a cheese factory and creamery is maintained. The same condition exists in Chippewa County, which has been a profitably farmed timothy and small grain region for a number of years. Great diversity of crops and proper drainage in both these regions is advisable.

In Menominee, Delta, Dickinson and part of Alger Counties are large areas of loams, and less extensive areas of clay loams, well adapted to farming which have been taken up to a comparatively small extent. Loams and better sandy loams of this region offer excellent conditions for potato growing. The rotation of rye or spring seeded small grains with clover is well adapted.

In the northern part of the Lower Peninsula and the Upper Peninsula considerable development has been accomplished on the better lands, but there still remain large areas of excellent land awaiting clearing.

In briefly stating the situation the following facts stand out:

1. Michigan possesses a vast area of undeveloped land.

2. For the most part this land is stump land or poorly drained land, which will require considerable time and expense to prepare for cropping.

3. Long-time loans at a low rate of interest would be. of great help to individual farmers.

4. The soils are extremely variable. A comparatively large acreage is well adapted to farming, and an even larger acreage can be termed unsuited for farming under present conditions.

5. The agricultural possibilities of this area are frequently misrepresented to the detriment of its development.

6. With proper crops, under the right conditions, a great development of successful farm communities can be made, much to the benefit of the state.

7. Forest fires cause great damage to incoming settlers, a great loss to standing timber and the young growth, and injury to soils through burning out of organic matter. More adequate forest-fire regulation to remove this menace is necessary.

8. *A state agricultural and soil survey to properly designate the value of land for farming, grazing and forestry purposes and adequate fire control are necessary for the sound and reasonably rapid development of Michigan idle lands.*

9. Settlers must in all cases be established on the good lands only and prevented by an interested State from dissipating their energies on land which can not be profitably worked. In no case should they be permitted to be persuaded by the occasional ignorant or unscrupulous land dealer to settle on Jack pine and light blueberry plains and other inferior areas. The right type of land dealer should receive all possible encouragement, and, on the other hand, proper laws should be established to deal justly with the speculator who, through ignorance or design, misrepresents the agricultural value of land to the incoming settler.

10. Michigan's northern country has been represented both as a great desert from an agricultural standpoint and as "clover land," a coining Eden Somewhere between the two statments lies the truth. On the whole Michigan has in her undeveloped northern country a region of great agricultural potentiality, which, if properly developed as farming land, grazing land and forestry land, in accordance with its fitness from a soil and climatic standpoint, will add materially to the wealth and prosperity of the State

Michigan Agricultural College.

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THE PLEISTOCENE LOCALITY AT WAILES BLUFF, MD., AND ITS MOLLUSCAN FAUNA.

BY E. R. SMITH.

In the year 1830, Timothy A. Conrad, that father of American Tertiary Invertebrate Paleontology, read a paper before the Philadelphia Academy of Natural Sciences on the Pleistocene locality at Wailes Bluff, just above the mouth of the Potomac river, St. Mary's county, Md. Since that date, many American paleontologists and geologists have visited this easily accessible locality and have published lists of the fossils and discussions of the significance of its fauna. The most important of these was contained in the Monograph on the Pliocene and Pleistocene of Maryland published by the Maryland Geological Survey in 1906. In the summers of 1914 and 1915, parties of students under the leadership of Professor G. D. Harris of Cornell University made two brief stops at Wailes Bluff. They were but incidents in trips of over 2,500 miles each in Professor Harris' cabin-cruiser Ecphora. The material, collected at this time largely in bulk and later carefully washed and sorted, has been made the subject of study for this paper.

To describe the locality, one can hardly improve upon the following original description by Mr. Conrad:

"About three miles north of the low sandy point which forms the southern extremity of the peninsula, the bank of the Potomac rises to an elevation of about fifteen feet at its highest point; the fossils are visible in this bank to the extent of a quarter of a mile. The inferior stratum is a lead-colored clay, containing vast numbers of the (*Mulinia*) *lateralis* of Say; which, in many instances, appear in nearly vertical veins as though they had fallen into fissures. The (*Barnea*) *costata* is also numerous, and each individual remains in the position in which the living shell is usually buried in the sand or mud; that is, vertical, with the posterior or short side pointing downwards; they are so fragile, that they can rarely be taken entire from the matrix. Upon this stratum of clay, in a matrix of sand, lies a bed of the *Ostrea virginiana*, in some places a foot in thickness. It is nearly horizontal; in some places at least eight or ten and in others not more than four feet above high water mark."

In more detail, the section as exposed at present is as follows:

Langley's Bluff, St. Mary's county, exposes a section, in some ways, of greater interest. There the Pleistocene overlies unconformably the fossiliferous St. Mary's Miocene with a zone of mixed Miocene and Pleistocene fossils between the distinct faunal zones. The Wailes Bluff fauna, small as it is, as compared with some others on the Atlantic coastal plain, for example, Simmons Bluff, S, C., is considerably larger than that at Langley's Bluff. For this reason, it is made the subject of this brief report. An effort has been made to include every species ever reported on good authority from Wailes Bluff.

TABLE I.

				Ft.
Talbot substage	Nonfoss. Beds.		Sandy loam	1±
			Gravelly sandy loam	2±
			Cross-bedded sand and gravel	3±
	Foss. Beds.	**Ostrea** Bed.	Sandy clay with great numbers of gigantic **Ostrea virginica** Gmelin, with which are associated **Mytilus hamatus** Say, **Mya arenaria** L. and **Crepidula fornicata** L. The **Mya** becomes much more abundant toward the top	1±
		Venus Bed.	Blue-gray clay with large numbers of **Venus mercenaria** L., accompanied by the fauna of the **Mulinia** bed	0-1
		Rangia Bed.	Blue-gray clay with the fauna of the **Mulinia** bed, but with marked concentration of considerably worn valves of **Rangia cuneata** (Gray), no specimens found showing the two valves together in position as in life	0-1
		Mulinia Bed.	The main fossil-bearing bed, a lead-colored, very sticky clay, carrying the complete fauna. The large numbers of **Mulinia lateralis** (Say) are characteristic. The appearance of fissures filled with shells is due to borings of **Barnea costata** (L.), which in places are completely filled with the smaller species of shells. Well-preserved specimens of **Busycon caricum** (Gmelin) are also prominent features of this bed	0-6

The species of the family Pyramidellidae are being studied by Dr. Paul Bartsch of the U. S. National Museum and will be described in one of the publications of that museum. Combining the specimens sent him by the present writer with those in the National Museum and the museums of Johns Hopkins University, the Maryland Geological Survey, the Philadelphia Academy and various other sources, he has found a wealth of hitherto unknown species in this family of minute Gastropoda. He considers that there are sixty-three species in this one family in the Wailes Bluff fauna, of which sixty-two are new. The one species hitherto described *Odostomia* (*Chrysallida*) *melanoides*, was described by Conrad from this very locality, with a list of St. Mary's Miocene new species. Later writers, even Conrad himself in later works, considered this as a Miocene species. Clark, in the Monograph on the Pliocene and Pleistocene of Maryland, states as follows: "This species [*Odostomia* (*Chrysallida*) *seminuda* (C. B. Adams)] is very closely related to, if not identical with, *O. melanoides* (Conrad), described in 1830 from the Miocene." However, reference to the original article will prove that Wailes Bluff is the type locality for this minute form, assuring its typical Pleistocene form here.

The systematic arrangement follows the American revised translation of Zittel's "Textbook of Paleontology." The source of material aside from the writer's collections are given in a list appended to this article. In the discussion of evidences of climate, depth of water, etc., the Pyramidellidae will, of necessity, be disregarded. In the fauna, there are twenty-eight species of Pelecypoda and twenty-two species of Gastropoda. Of these, twelve species have not been reported before from Wailes Bluff. Fourteen of the species begin in the Miocene; twenty in the Pliocene; and sixteen in the Pleistocene. With but one exception, *Callocardia* (*Agriopoma*) *sayana* (Conrad), referred by Dall to this locality, all species are found living on our eastern coast. This fixes beyond doubt the Pleistocene age of the deposit.

During Pleistocene time, a considerable number of the species had wide distribution along our east coast. Wilson reports eighteen of the same species from Sankaty Head, Mass.; the writer has collected thirty-eight of the same species from the Neuse river, below New Bern, N. C., and thirty-seven from Simmons Bluff, S. C.; Dall reports ten of these species from North Creek, Osprey, Fla. All of these deposits are of undoubted Pleistocene age with the exception of that on the Neuse river. In the opinion of the writer that deposit also is of Pleistocene age. A later study will take up that very interesting locality with certain other notes on the Upper Tertiary and Pleistocene history of the lower Neuse river basin.

In the recent fauna, Henderson and Bartsch report a list of thirty-eight Pelecypoda and forty-five Gastropoda from Chincoteague Island, Va. Of these, thirty-four are found at Wailes Bluff, showing similarity in the faunas. Only five of the Wailes Bluff species do not have a recent distribution farther north than Maryland. Seven go no farther south than Cape Hatteras. This mixture of faunas is not due to distinct beds as at Sankaty Head, Mass., where the lower faunas are of southerly affinities and the upper faunas of northerly affinities. The most remarkable instance of a southern form in the beds is *Rangia cuneata* (Gray). Although we cannot accept as a whole Conrad's conclusions regarding its Pleistocene distribution, his remarks on this subject in the Proceedings of the National Institution are of exceeding interest. He wrote as follows:

"I have before alluded to the peculiar and highly important distribution of the existing (*Rangia*), burrowing in myriads in the mud flats near Mobile, and confined to the estuaries of the Gulf of Mexico. An occasional water-worn valve in the deposit on the Potomac, above described (Wailes Bluff), seemed to indicate that the species lived in that river in the upper Tertiary (Pleistocene) period. This conjecture was converted into certainty by an exploration of the shore farther north, which resulted in discovering a bed composed exclusively of the *Rangia* on the land of Mr. Ebb, above the mouth of St. Mary's river. This bed, except that the shells are smaller, is precisely the same as those which line the bay shore near Mobile. The valves of the shells are frequently connected and there can be no doubt that here was the spot where they lived and were embedded; that this was a region of sand flats bared at low tide, the water brackish, as it is now, and that the deposit near the mouth of the Potomac was of the same period, but more directly connecting with the ocean." His further conclusions that climatic conditions in the Chesapeake Bay of this bit of Pleistocene time was much the same as that of the gulf today are not supported by the other evidence. The very considerable admixture of northern forms forces the conclusion that conditions were not far different from those existing today at that latitude.

The water was certainly almost of the salinity of the present exposed portions of the Chesapeake Bay. It was shallow, as shown by the figures of depth given in

the last column of the chart. It was not a sea exposed to great waves. Such fine, sticky clay could not have been laid down in shallow water agitated by the waves of the open ocean.

In conclusion, I may well quote further from that rare Conrad paper in the Proceedings of the National Institution:

"Deep harbors and bays seem to have been filled up by the very gradual accumulation of fine silt or mud; generations of shells were entombed in frequent succession, until the harbors, bays, or part of the ocean itself shrinking into shallow lagoons, no longer furnished the conditions necessary to their increase, and myriads of oysters took possession of the deserted beds. There is no pause, no interruption to this ceaseless mutability. Our harbors and our bays must, in the lapse of ages, be filled up by the unfailing influx of silt; our present beds of oysters be converted into dry banks of shells. New bays will succeed to those which we now behold; and other lagoons will encroach upon the sea. Whoever attentively examines the locality last described (Wailes Bluff) on the Potomac river, will be forcibly reminded of the mutability of the present features of our earth: he can read distinctly the history of the past, and anticipate, in a measure, the annals of futurity, the new order of things, the relative condition of sea and land yet to be, long after he has passed away, and his name, his influence, his labors having left no more trace of his existence than the baseless fabric of a vision."

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1915—Johnson, C. W.—List of the Mollusca, Fauna of New England, No. 13. Occasional papers of the Bost. Soc. Nat. Hist., vol. VII.

Department of Geology, University of Michigan, Ann Arbor, Mich.

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WAILES BLUFF MOLLUSCA.

GEOLOGICAL AND GEOGRAPHICAL DISTRIBUTION.

PELECYPODA.

Species	Geological range		Wailes Bluff, Maryland.*	Sankaty Head, Massachusetts.	Neuse River, North Carolina.	Simmons Bluff, South Carolina.	North Creek, Florida.	Northern limit.	Chincoteague Island, Virginia.	Southern limit.	Range in depth, fathoms.
Nucula proxima Say truncula Dall	Miocene	Recent	f. c.		x	x		Nova Scotia	x	Florida	2/100
Leda acuta (Conrad)	Miocene	Recent	f. c.		x	x		Rhode Island	x	Mexico	7/225
Yoldia limatula (Say)	Pliocene	Recent	u. c.		x	x		Norway	x	North Carolina	2/56
Arca (Noetia) ponderosa Say	Pleist.	Recent	f. c.	x	x	x		Cape Cod	x	Yucatan	Shallow water
Arca (Scapharca) transversa Say	Pliocene	Recent	c.	x	x	x	x	Cape Cod	x	Mexico	2/10
Ostrea virginica Gmelin	Pliocene	Recent	v. c.	x	x	x	x	New Hampshire	x	Mexico	Shallow water
Unio complanatus (Solander) Dillwyn	Pleist.	Recent	r.					Maine		Mississippi	Fresh water
Mytilus (Hormomya) hamatus Say	Pliocene	Recent	c.		x			Rhode Island		Costa Rica	Shallow water
Pandora (Clidiophora) gouldiana Dall	Pleist.	Recent	r.		x			Nova Scotia		Virginia	0/30
Divaricella quadrisulcata d'Orb.	Mio.	Recent	r.		x	x		Massachusetts		Trinidad	6/50
Aligena elevata (Stimpson)	Pleist.	Recent	r.					Maine		Hatteras	2/43
Rochefortia planulata (Stimpson)	Plio.	Recent	r.		x	x		Maine		Hatteras	1/15
Callocardia (Agriopoma) morrhuana (Linsley)	Mio.	Recent	r.		x			Prince Edward Island	x	Hatteras	2/10
Callocardia (Agriopoma) sayana (Conrad)	Mio.	Pleist.	r.								
Venus mercenaria Linne	Mio.	Recent	c.	x	x	x		Nova Scotia	x	Yucatan	Shallow water
Gemma gemma Totten	Pleist.	Recent	r.	x				Labrador		New York	Shallow water
Petricola pholadiformis Lamarck	Pleist.	Recent	r.	x	x	x		Prince Edward Island	x	Nicaragua	Shallow water
Tellina (Angulus) tenera Say	Pleist.	Recent	u. c.		x	x		Cape Gaspe	x	Barbadoes	0/58
Macoma calcarea Gmelin	Pleist.	Recent	r.					Arctic Seas		Long Island Sound	2/100
Macoma balthica Linne	Pleist.	Recent	r.					Arctic Seas		South Carolina	Shallow water
Cumingia tellinoides (Conrad)	Pleist.	Recent	r.	x	x	x		Prince Edward Island		Florida	0/50
Tagelus gibbus (Spengler)	Mio.	Recent	f. c.		x	x		Cape Cod	x	Brazil	Shallow water
Ensis directus (Conrad)	Mio.	Recent	m. c.	x	x	x		Labrador		Florida	0/25
Mulinia lateralis (Say)	Mio.	Recent	m. c.		x	x	x	New Brunswick	x	Texas	1/15
Rangia cuneata (Gray)	Plio.	Recent	c.		x	x		Alabama Gulf Coast		Vera Cruz	Brackish water
Mya arenaria (Linne)	Mio.	Recent	c.	x	x	x		Arctic Seas	x	South Carolina	0/48
Corbula contracta Say	Plio.	Recent	c.	x	x	x		Cape Cod	x	Jamaica	3/62
Barnea (Scobina) costata (Linne)	Plio.	Recent	c.			x		Cape Cod	x	South America	Shallow water

GASTROPODA.

Species	Geological range		Wailes Bluff, Maryland.*	Sankaty Head, Massachusetts.	Neuse River, North Carolina.	Simmons Bluff, South Carolina.	North Creek, Florida.	Northern limit.	Chincoteague Island, Virginia.	Southern limit.	Range in depth, fathoms.
Teinostoma cryptospira (Verrill)	Pleist.	Recent	r.				x	North Carolina		Florida	28/116
Epitonium lineatum (Say)	Plio.	Recent	r.		x	x		Cape Cod	x	Texas	Shallow water
Epitonium Humphreysii (Kiener)	Plio.	Recent	r.		x	x		Connecticut	x	Texas	Shallow water
Epitonium denticulatum (Sby.)	Pleist.	Recent	r.					Hatteras		Bahamas	Shallow water
Epitonium multistriatum (Say)	Plio.	Recent	m. c.		x	x		Cape Cod	x	South Carolina	Shallow water
Epitonium cf. Samanae (d'Orb.)	Pleist.	Recent	r.							West Indies	
Epitonium sp.	Pleist.		r.								
Pyramidella (Sulcorinella) n. sp.	Pleist.		r.								
Turbonilla (Chemnitzia) n. sp.	Pleist.		r.								
Turbonilla (Strioturbonilla) n. sp.	Pleist.		r.								
Turbonilla (Pyrgiscus) 36 n. sp.	Pleist.		r.								
Turbonilla (Mormula) 12 n. sp.	Pleist.		r.								
Turbonilla (Bartschella) n. sp.	Pleist.		r.								
Odostomia (Chrysallida) melanoides (Con.)	Pleist.		r.								
Odostomia (Chrysallida) n. sp.	Pleist.		r.								
Odostomia (Menestho) n. sp.	Pleist.		r.								
Odostomia (Evalea) 5 n. sp.	Pleist.		r.								
Crepidula fornicata (Linne)	Mio.	Recent	c.	x	x	x		Prince Edward Island		South America	0/15
Crepidula convexa Say	Plio.	Recent	f. c.	x		x	x	Nova Scotia	x	Texas	0/22
Crepidula plana Say	Mio.	Recent	f. c.	x	x	x	x	Prince Edward Island	x	Trinidad	0/437
Polynices (Neverita) duplicatus (Say)	Plio.	Recent	c.	x	x	x	x	Massachusetts	x	Vera Cruz	Shallow water
Triphoris perversa (Linne) nigrocincta (C.B.A.)	Plio.	Recent	r.		x	x		Massachusetts	x	Antilles	0/30
Columbella (Astyris) lunata (Say)	Plio.	Recent	c.	x	x	x	x	Maine	x	Florida	0/12
Alectrion (Tritia) trivittata (Say)	Pleist.	Recent	f. c.		x	x		Nova Scotia	x	Florida	1/40
Alectrion (Ilyanassa) obsoleta (Say)	Pleist.	Recent	f. c.	x	x	x		Nova Scotia	x	Florida	Shallow water
Busycon canaliculatum (Linne)	Plio.	Recent	f. c.		x	x		Cape Cod	x	Gulf of Mexico	Shallow water
Busycon carica (Gmelin)	Plio.	Recent	f. c.		x	x		Cape Cod	x	West Indies	0/20
Eupleura caudata (Say)	Plio.	Recent	f. c.	x	x	x		Cape Cod	x	Florida	1/3
Urosalpinx cinereus (Say)	Plio.	Recent	m. c.	x	x	x		Nova Scotia	x	Florida	0/10
Terebra (Oxymeris) dislocata (Say)	Mio.	Recent	r.		x	x	x	Maryland	x	Venezuela	Shallow water
Mangilia cerina Kurtz & Stimpson	Mio.	Recent	m. c.		x	x		Cape Cod	x	Florida	3/19
Actaeocina canaliculata (Say)	Plio.	Recent	c.		x	x	x	Maine	x	Gulf of Mexico	0/63

*r., u. c., f. c., c., v. c. represent a series of increasing abundance of individuals of a species.

STUDIES ON THE SHORE LINES OF THE SAGINAW BASIN.[1]

(Abstract.)

BY FRANK LEVERETT.

In a paper presented before this academy two years ago, entitled "Drainage Features and Uplift of Shore Lines in the Elsie and Perrinton Quadrangles," the writer gave results of studies bearing on the time of the uplift of the shore lines and evidence as to which of them were affected by the northward differential uplift. It was shown that in these quadrangles the beaches of Lake Saginaw and Lake Arkona were affected by that uplift, but the beach of Lake Warren was not thus uplifted here, though it has suffered uplift in districts farther north. Thus the area affected by uplift had become reduced at the south at the time of the later glacial lake stages. This was a condition that had previously been worked out by F. B. Taylor and the present writer in the part of the shores of the glacial lakes bordering the St. Clair basin and south part of the Huron basin, and brought to notice in Monograph 53, U. S. Geological Survey.

In the field work of 1919 the present writer continued the mapping of the glacial and lake features over several quadrangles in the Saginaw basin which had been covered by glacial lakes, namely, the Chesaning, St. Charles, Saginaw, and Bay City quadrangles, and over the part of the Burt and Flint quadrangles which were covered by glacial lakes. This broader field gave opportunity to determine the direction as well as the time of uplift in the south part of the Saginaw basin. It was

found that on the east side of this basin the Warren shore line has been unaffected by uplift about as far north as the north end of the Flint quadrangle, but that northward from there it is uplifted.

It was found that the direction of the tilt line of the Saginaw and Arkona beaches is more nearly northward in this southern part of the Saginaw basin than in the neighboring southern part of the Huron basin, the direction being not more than 10 degrees east of north in the Saginaw basin, while it is about north-northeast in the Huron basin. The direction of the tilt line in the Michigan basin is about 10 degrees east of north. The Saginaw basin thus shows a closer relation to the Michigan basin than to the Huron basin in the direction of tilting. The cause for this divergence in the tilt lines remains to be determined.

Ann Arbor, Mich.

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RESULTS OF GLACIAL STUDIES IN THE NORTHERN PENINSULA OF MICHIGAN IN 1919.[1] (Abstract.)

BY FRANK LEVERETT.

About a month was spent in field work in 1919 in Menominee and southwestern Delta counties, and a week in the eastern end of the northern peninsula, in all of which the present writer was assisted by Ralph W. Peterson from the Michigan Agricultural College.

The work in Menominee and Delta counties was directed to the determination of the distribution and extent of swamp land as well as classification of the dry or cultivated lands. Much land that had been classed as swamp in the plats of the Linear Land Survey has been rendered tillable by merely removing obstructions such as fallen trees and beaver dams which had prevented the escape of the water. The distribution of the drumlins and eskers was also worked out, especial attention being given to eskers, since they are valuable sources for road material. The drumlin district was found to be more extensive than hitherto represented, its western limits being near the Sturgeon river in eastern Dickinson county, and near Menominee river where that stream forms the border of Menominee county. A few drumlins are present in Marinette county, Wisconsin, west of the river.

Attention was directed to the degree of weathering and alteration and evidence of age in the drift of the drumlins compared with the drift in the moraines, for Russell in his reports published in the Annual Reports for 1904 and 1906 of the Michigan Geological Survey, had referred the drift of the drumlins to an earlier ice movement than that which produced the moraines. He cited the occurrence of copper and iron ores which had been brought in from the northwest as evidence that the drift in the drumlins was deposited by a southeastward ice movement, while the drift in the moraines and the shaping of the drumlins into their peculiar form are evidently due to a southwestward ice movement. The studies in 1919, however, failed to bring out any evidence that the drift of the drumlins is markedly older than that of the moraines, its aspect being fresh in both classes of drift. The presence of drift copper and iron ores is probably due to gathering up from older drift and redeposition in the drift of the last or Wisconsin stage of glaciation.

In Menominee and Delta counties the limits of Lake Algonquin were determined with more accuracy than hitherto, and this is also the case at points farther east in the peninsula.

On Drummond Island a few drumlinoid ridges were found in a low-lying area of poorly drained clayey drift in the northeast part of the island. These drumlins, and also striae on ledges near them, three miles east of Drummond village, have a nearly north to south trend and are directed toward a belt of thick drift which runs from east to west across the middle part of the island. In this there are basins and small lakes and a gently undulating till. These features all favor the view that the strip of relatively thick drift is a morainic belt. The altitude of its highest points is far below the level of Lake Algonquin, so the drift appears to have been laid down in the waters of that lake. It is therefore not surprising that there is not stronger morainic expression, for as a rule the waterlaid moraines are almost featureless smooth ridges.

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