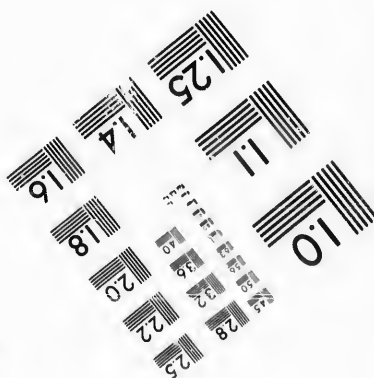
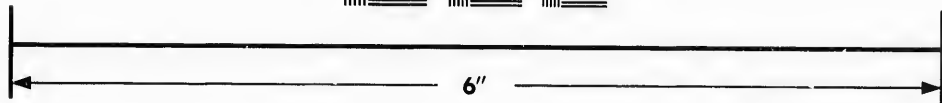
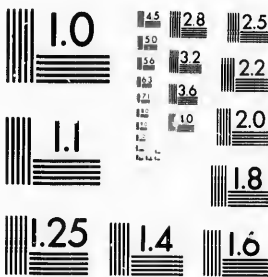


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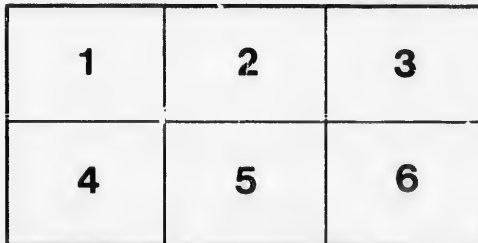
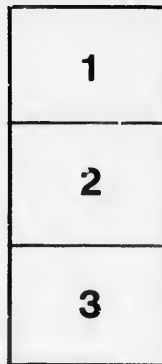
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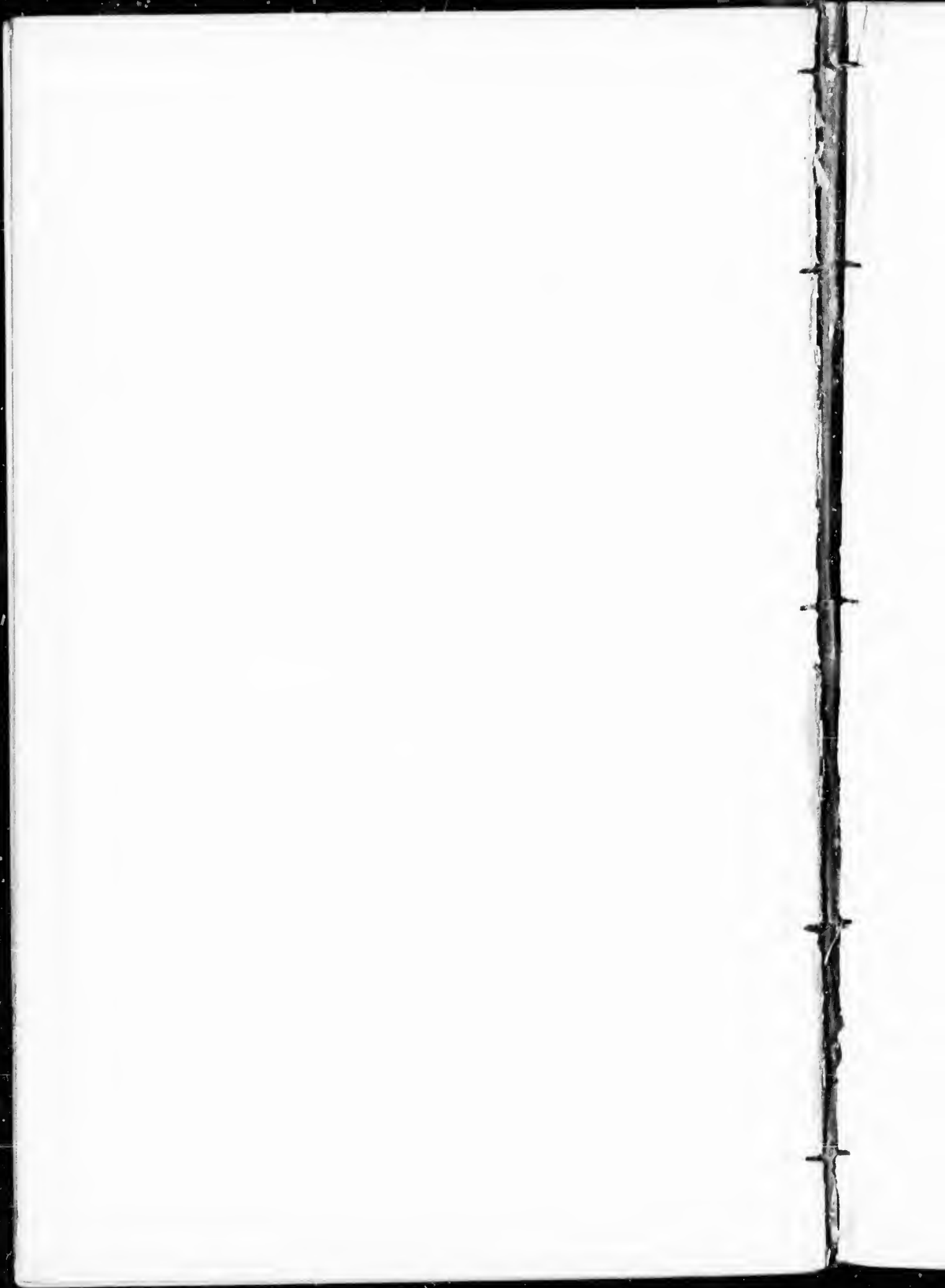
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OF
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IN
NORTH-EASTERN AMERICA.

No. II.

By JAMES F. W. JOHNSTON, F.R.S.L. & E.,
HON. MEMBER OF THE ROYAL AGRICULTURAL SOCIETY.

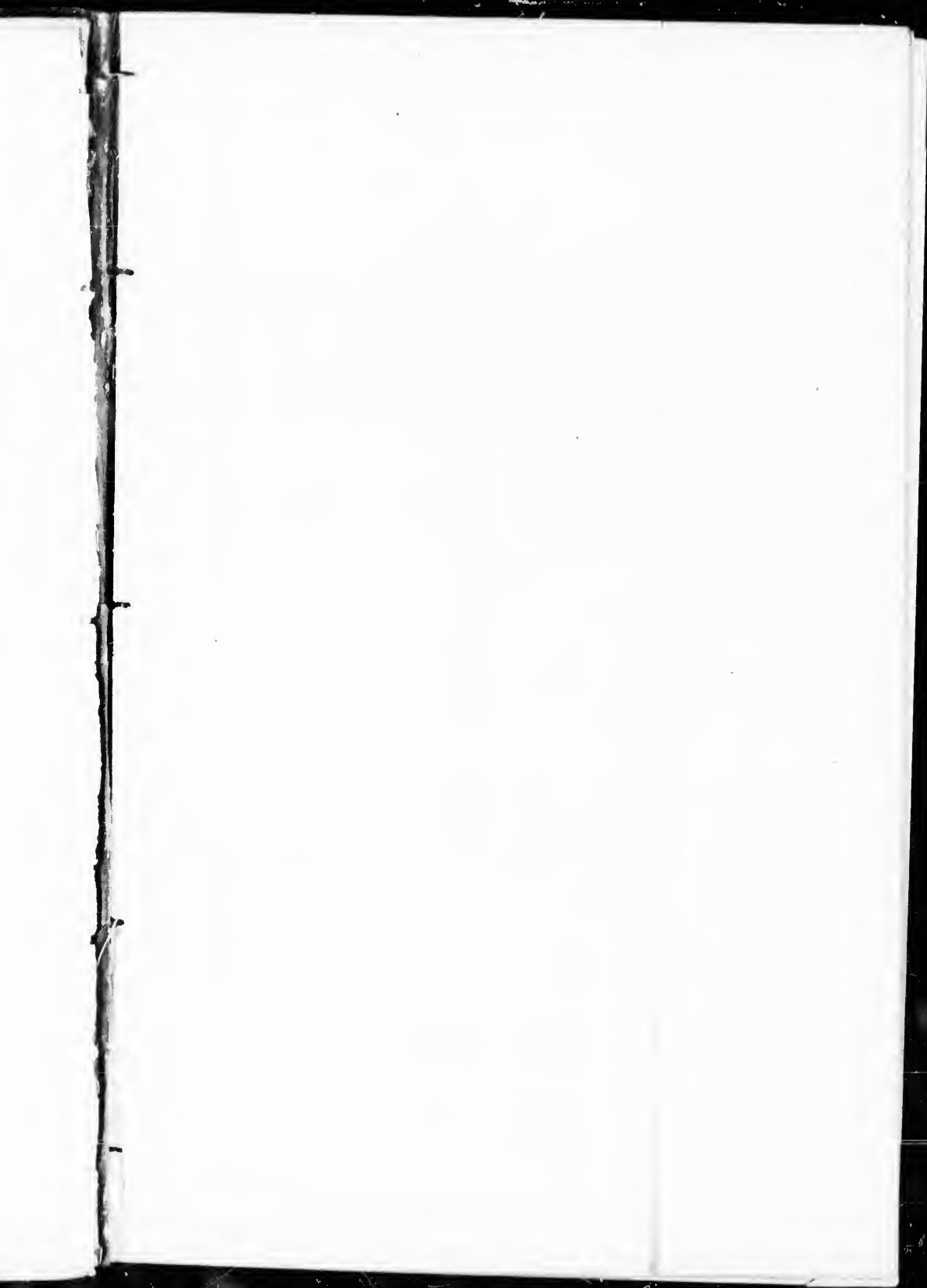
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1881
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M A P
 TO ILLUSTRATE THE
 RELATIONS OF GEOLOGY TO AGRICULTURE
 IN
 NORTH-EASTERN AMERICA.



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| Soils No. I. and II. |  |
| Soil . . . No. III. |  |
| Soil . . . No. IV. |  |
| Soil . . . No. V. |  |
| Bogs and Swamps . |  |

RELATIONS OF GEOLOGY TO AGRICULTURE

IS

NORTH-EASTERN AMERICA.






III. *Relations of Geological Structure to Agricultural Capability in the Province of New Brunswick.*—The examples of a close relation between geological structure and agricultural capability, which I introduced into the preceding part of this paper,* were interesting to the English reader chiefly in their purely scientific and economical bearings. Referring to the Atlantic border of the United States, and to the interior of the State of New York, they would come home, if I may so express myself, to few among ourselves as a matter of directly personal concern. It will be somewhat different as regards the example I am now about to submit. It is drawn from one of our own British provinces, where many of us have friends and relatives, and where wide unoccupied lands exist, to which we may emigrate without either abandoning our loyalty or giving up our connexion with the homes of our fathers.

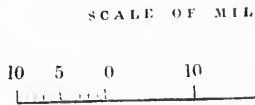
The province of New Brunswick contains an area of 18 millions of acres; much of this is still covered with forests, and many districts still unexplored even by the lumberer. As represented in the geological maps hitherto published, its central part forms an extensive coal-field, bounded on the north by a riband of granitic and of old metamorphic and slate rocks, which runs diagonally—or in a north-east and south-west direction—across the whole province. On the south and south-west it is bounded along the shores of the Bay of Fundy by a belt of slate rocks of uncertain age, altered and hardened by extensive masses of hard, intrusive trap, which give an inhospitable and uninviting character to the region over which they extend. This coal-field occupies about one-half of the whole area of New Brunswick; and, as it is situated in the central part of the province, the rocks

* See this Journal, vol. xiii. Part I.

M A P
 TO ILLUSTRATE THE
 RELATIONS OF GEOLOGY TO AGRICULTURE
 IN
 NORTH-EASTERN AMERICA.



- Soils No. I. and II. 
- Soil . . . No. III. 
- Soil . . . No. IV. 
- Soil . . . No. V. 
- Bogs and Swamps . 





of which it consists impart their prevailing physical characters to the soils of this large portion of the colony.

It may be said with truth that the extensive prevalence of this coal-field in New Brunswick forms alone a striking illustration of the close natural connexion which exists between geological structure and agricultural capability. Of every extensive coal-field this might, to some extent, be said; but there are two circumstances in connexion with the coal measures of New Brunswick, which in an especial manner determine the agricultural relations of the soils which rest upon them.

The *first* is the chemical nature of the numerous beds of rock of which this coal formation consists. These are, for the most part, grey sandstones, sometimes dark and greenish, and sometimes of a pale-yellow colour. The siliceous matter which they contain is cemented together or mixed with only a small proportion of clay (decayed felspar principally), so that when these rocks crumble, which they readily do, they form light soils, pale in colour, easily worked, little retentive of water, admitting therefore of being ploughed early in spring and late in autumn; but hungry, greedy of manure, liable to be burnt up in droughty summers, and less favourable for the production of successive crops of hay.

Of course, among the vast number of beds of varied thickness which come to the surface in different parts of this large area, there are many to which the above general description will not apply—some which contain more clay and form stiffer soils; and some which, though green or gray internally, weather of a red colour, and form reddish soils: but lightness in texture and in colour forms the distinguishing characteristic of the soils of the whole formation. The generalization drawn from this single fact, therefore, gives us already a clear idea of the prevailing physical character of the soils over a large portion of the province, and illustrates the nature of the broad views which make the possession of geological maps so valuable to the student of general agriculture.

In other countries, as in England and Scotland, the coal measures contain a greater variety of rocks than is found over the carboniferous area of New Brunswick. They are distinguished in our island by the frequent recurrence of beds of dark-coloured shale, often of great thickness, which form cold, stiff, dark-coloured, poor clays, hard to work, and, until thoroughly drained, scarcely—except in rare seasons—remunerating the farmer's labour. Numerous sandstones do indeed occur, producing poor, sandy, and rocky soils; but it is the conjoined presence of the cold clays and the poor sands, which, in the midst of their mineral riches, have caused large portions of the counties of Durham and Northumberland to remain among the

least-agriculturally advanced and least-productive parts of the low country of Great Britain.

The *second* circumstance by which the agricultural relations of this portion of New Brunswick are determined, is found in its general physical conformation. It is distinguished by a general flatness of surface: it undulates here and there, indeed, and is intersected by rivers and occasional lakes; but it consists for the most part of table-lands more or less elevated, over which forests, chiefly of pine-timber, extend in every direction. This general flatness is owing to the small inclination of the sandstone strata on which the country rests, and to the small number of striking physical disturbances to which, as a whole, they have been subjected. These level tracts of land are not unfrequently stony, covered with blocks of grey sandstone of various sizes, among which the trees grow luxuriantly, and from among which the settler may reap a first crop of corn, but which almost defy the labour of man to bring the land into a fit condition for the plough. It is chiefly on the borders of the coal-field, however, that these stony tracts occur, as if the disturbances, to which the neighbouring rocks have in many places been subjected, had broken up the edges of the sandstone strata, and scattered their fragments over the adjoining surface.

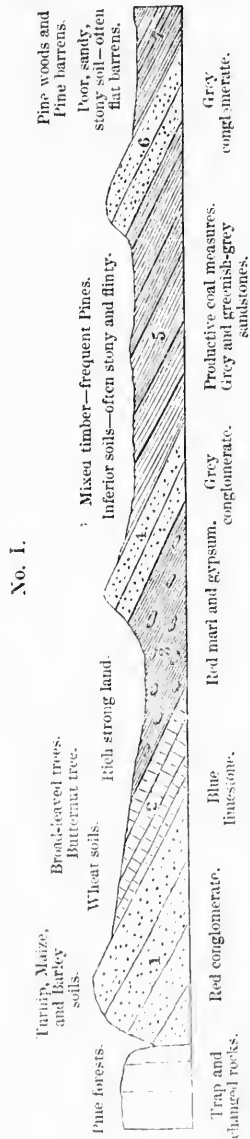
A characteristic feature which results from this physical flatness is the occurrence of frequent bogs, swamps, cariboo plains, and sandy barrens. The waters which fall in rain or accumulate from the melted snow rest on the flat lands, fill the hollows, and, for want of an outlet, stagnate, causing the growth of mosses and of plants of various other kinds, to which such swampy places are propitious. Thus bogs and barrens, more or less extensive, are produced, and these greatly modify the natural agricultural relations of the surface.

Thus the geological age, the chemical composition, and the physical disposition of this coal region, in reality appear almost equally to conspire in producing the peculiar general agricultural character of the central half of the province of New Brunswick. To this conjoined influence of important modifying causes I shall again advert before the close of the present article.

But New Brunswick also presents examples of the most striking and immediate dependence of agricultural value upon geological structure alone. On the outskirts of the coal-field, and rising up from beneath its edges, appear red sandstones and red conglomerates, associated with limestones, red marls, and gypsum. These give rise to soils of a remarkably fertile character, in the midst generally of scenery of a most picturesque description. In such localities rock and soil so closely accompany each other, that the most sceptical is compelled to admit that the

change in forest trees, in character of soil, and in nature of rock, are at once simultaneous and determined by a common cause.

The following section (No. I.) gives an idea of the way in which these rocks occur in connexion with the coal measures, and of the kind of soils which they respectively form:—



The section commences on the left with the trap and altered rocks which bound the coal-field towards the south, as at the head of Belleisle bay, or on the Hammond river, about twenty miles from the town of St. John. On these rocks scanty soils are found, and the gloom of the narrow-leaved forest is rarely broken by the intrusion of the more cheerful beech, the oak, or the maple. But on the rounded hills of the red conglomerate (1),—which in Albert county remind the English traveller of the hills of our own Monmouthshire—broad-leaved forests of various trees cheer the eye, while the free and open soils which rest on them, though sometimes too gravelly, yet admit of being cultivated along steep slopes till the waving corn crowns the very tops of the hills. In the beautiful Sussex vale—justly the boast and pride of the province—and in some of its tributary valleys, the eye recognises with pleasure the features, both physical and agricultural, which are familiar in the red sandstone slopes of Strathmore, in the richly-farmed red sandstone fringe of Sutherland, and where a tillage hardly to be surpassed crowns the hills of Wooler, and accompanies the Northumbrian tourist to the foot of the Cheviot hills.

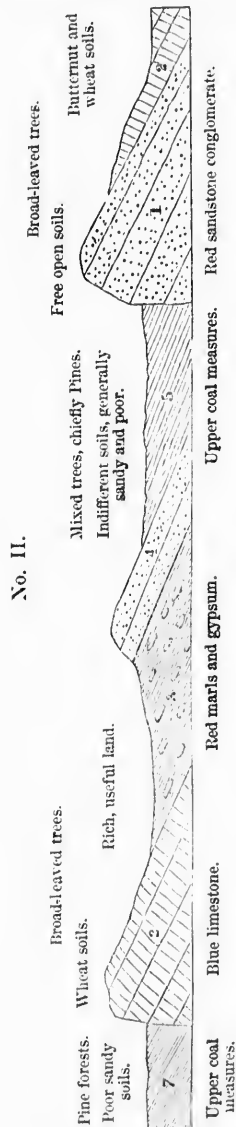
Over the red conglomerate (1) lies the blue limestone (2). On this rock the soil is sometimes thin, and, like our own blue limestones, the rock breaks out in some places into abrupt cliffs and naked slopes. Generally, however, it is covered with soils which are easily brought into culture, and are especially favourable to the growth of wheat. Of the native forest trees of North America, the white

walnut (*Juglans cinerea*)—or Butternut, as it is called from its large oily nut—is one of those which appear to delight in calcareous soils. It is not known in the woods of Nova Scotia, but it occasionally abounds on the blue limestone ridges of New Brunswick. The *Butternut ridge*, the seat of a thriving settlement, about eight miles north of the Sussex vale, derives its name from having been originally covered with these trees. It consists of the blue limestone lying between the red conglomerate (1) on the one hand, and the red marls (3) on the other, and the settlement owes its existence altogether to these happy geological conditions. The explorer of still untrodden regions, from a distance of many miles, sees the setting sun in summer playing among the broad leaves of the butternut, or marks their peculiar autumnal tints when winter approaches, and records at once that good land exists on the spot, and a place desirable for settlement. The geologist may with almost equal certainty pronounce that there also limestone rocks abound, and near them in all probability the red rocks represented in our section.

Above the blue limestone rest thin beds of soft red marl, in which occur deposits of gypsum often of great extent and thickness. The softness of these beds has caused them to crumble readily and to form deep soils, and has also exposed them to be washed away by the rains and by the currents of water which in ancient times flowed over them. Hence the surface, where these rocks prevail, is of an undulating character, or it is scooped out into valleys of greater or less depth and breadth as is represented in the section. The soil is strong and rich, and in its natural state is covered with broad-leaved trees, where it is not oversaturated with water. When cleared, it yields excellent crops of wheat, and when laid sufficiently dry by arterial drainage, or by smaller conduits, it becomes fitted for almost every crop to which the climate is propitious. I mention arterial drainage, because the same soft character of these rocks which has led to the scooping out of valleys, has also caused the production in many places of flat plains possessing little natural inclination or outfall, and on which the waters from springs and rains and melting snows continually rest. Such places are covered by swamps or stunted forests of youthful pines. They can be laid dry and fitted for agricultural labour only by drainage operations, sometimes on a large scale, and such as in the present partial settlement of the colony, and while abundance of dry unoccupied land still remains in the market, are not likely to be undertaken either by individual proprietors, or at the expense of the provincial authorities.

To the red marls with gypsum succeed the grey conglomerates and sandstones of the coal measures (4, 5, 6, 7), of which I have

already spoken, as giving the general character to the agricultural



capabilities of the central part of the province of New Brunswick. And with these rocks, as is shown in the section, the comparatively-poor soils to which they give rise succeed to the rich and productive soils of the red marls which lie below them.

It does not always happen that the whole series of the rocks above described (1, 2, 3) is seen together in the same locality. While passing over the poor soils of the upper coal measures (7), the traveller may all at once be arrested by the blue limestone (2), and beyond it may come upon the beautiful rich soils of the red marls and gypsum, and after crossing these may find himself again among the flats and pine forests of the coal measures (4, 5, &c.). This is shown in the section No. II., in which the several rocks are numbered as before.

This section represents the blue limestone (2) as rising up and abutting against the upper coal measures (7); an effect produced by one of those disturbances from beneath, to which, as I have said, the edges of the coal-field have in many places been subjected. To this limestone succeed, towards the right, as in the previous section, the red marl and gypsum rocks, with the good soils they invariably produce, and beyond these come on again the indifferent soils of the lower coal measures. Further to the right again I have represented the red sandstone conglomerate (1) as reappearing in immediate contact with the lower coal measures (5), and producing consequently another sudden transition from an inferior to a superior quality of soil. Such transitions frequently recur along the southern and eastern skirts of the coal-field, and they are almost invariably to be connected with the direct

and visible presence of these red and limestone rocks. Although, therefore, the presence of each of the red rocks and of the limestone is not always to be inferred from the discovery of any one

of them, yet two things are almost certain in this province—*first*, that wherever one of these three rocky formations comes to day, good land and broad-leaved trees will be met with; and *second*, that the best land in the southern half of the province, and the best-peopled settlements, are almost invariably situated upon these rocks; and at the same time the transitions are so sudden as to leave no doubt, on any observing mind, that upon the change in the geological structure alone are the changes in soil dependent.

The reader who is least familiar with the mode of settling a new country will readily understand that it is usual, in every district, to select, occupy, and cultivate the best and richest land first, provided it be equally accessible. He will understand it, therefore, to be in the natural course of things that many of the oldest and best settled agricultural districts in New Brunswick are situated upon the rocks which I have described.

But in speaking of fertility in a colony which, in the minds of many in this country, is associated with the idea of long winters, deep snows, and cold of intense severity, it may not be out of place to specify, in intelligible terms, the amount of productiveness which this fertility implies. By this means also a practical idea will be conveyed of the value of the province to the farming emigrant. During my stay in New Brunswick I collected a valuable body of special information, in which I was much assisted by the provincial authorities, in reference to the actual produce per acre of the cultivated land throughout the province. The average of the numerous returns obtained from practical men gave the following as the yearly produce of land per imperial acre throughout the whole of New Brunswick:—

Wheat . . .	18 bushels	Buckwheat . . .	28 bushels.
Oats . . .	33 "	Indian corn . . .	36 "
Rye . . .	18 "	Potatoes . . .	6 tons.
Barley . . .	27 "	Turnips . . .	11½ "

We are not to compare these averages with those of our own skilfully cultivated, well-manured, and generally high-farmed country, but with the yield of land in other parts of North America, if we wish to form a fair estimate of the comparative position of New Brunswick as an agricultural country. Now, leaving out New England, in which the soils are generally of a less rich description, we may select New York, Ohio, and Upper Canada, as among the most highly-esteemed regions of North America, in an agricultural sense. The following table exhibits the average produce of land in these several regions compared with that of New Brunswick:—

	New Brunswick.	New York.	Ohio.	Canada West.
	Bush.	Bush.	Bush.	Bush.
Wheat	18	14	15 $\frac{1}{4}$	13
Barley	27	16	24	17 $\frac{1}{2}$
Oats	33	26	34	25
Buckwheat	28	14	20	16
Rye	18	9 $\frac{1}{2}$	16	11 $\frac{1}{2}$
Indian corn	36 $\frac{1}{2}$	25	41	—
Potatoes	204	90	69	84
Turnips	390	88	—	—*

This table places the agricultural capability of New Brunswick in a very favourable light, and shows that, notwithstanding its severe winters, the soil of this province, if properly farmed, may favourably compete with the most productive States and Provinces of North America. And although the actual averages for the whole of the cultivated land in New Brunswick do not directly exhibit the amount of produce yielded by the more favoured portions of the province in which the red sands, marls, and limestones described in this paper exist, yet they do in reality prove these districts to be highly productive, inasmuch as the comparatively high averages for the whole colony arise from the admixture of the higher numbers representing *their* yield, with the lower numbers representing the general yield of the soils of the widely-extended coal measures.

IV. Influence of Circumstances in Modifying the immediate Relations of the Soils to the rocky Formations of a Country.

—The illustrations I have presented in this and a former paper leave no room for doubt that in many cases the agricultural value of the soil over very large areas is directly determined by the nature of the rocks below, and sometimes by the mere geological epoch to which these rocks belong. It is so with the coal measures of New Brunswick, and with the other rocks I have described.

But I have shown also that the physical geography of this coal region—its extreme flatness especially—and the impervious character of its thin-bedded strata, have materially modified, in many places, the natural quality of the surface in respect to agricultural value. Bogs, swamps, and cariboo plains, through these agencies, are made to cover large areas, and thus to give an economical character to the surface, which is altogether independent of the chemical composition which distinguishes the rocks beneath. As the time appears now to have arrived when the influence of circumstances in producing such modifications in the agricultural indications of general geology ought to obtain a more prominent place in our systematic works, I take this opportunity of illustrating the general effect of such influences

* See the author's 'Notes on North America,' ii. p. 193.

upon the agricultural value of the soils which rest upon the coal-field of New Brunswick.

During my stay in that province I was enabled, through the kind co-operation of the Surveyor-general, the Hon. Mr. Brown, and other parties, to publish a map, in which, by different colours, were represented the qualities of the soils over its entire surface. This map included, in addition to the observations made and information collected during my own tour, the greater part of the knowledge which had previously been obtained during the numerous surveys made under the direction of the Surveyor-general and by order of the provincial government. It was, therefore, an exceedingly valuable document, not only in a directly-economical point of view to the practical men of the province—but theoretically also, as affording the means of comparing the actual observed value of the soil in any locality with the indications of its geological structure. From that map I have extracted the accompanying triangular portion, which represents the area of the coal-field, over which, almost everywhere, those grey, generally thin-bedded, sandstones extend, which are exhibited in the geological sections above given (Nos. I. and II.), and which naturally produce the poor soils I have already repeatedly described. On looking at this map, however, it will be seen that various kinds of shading, here substituted for the colours of the original map, are scattered irregularly over its surface. These different shadings indicate to the eye the kinds of soil which are actually found in the several parts of this extensive area. The shading—

- No. I. indicates land of the first class, which in its natural state will produce $2\frac{1}{2}$ tons of hay an acre.
- No. II. is land of the second quality, which produces 2 tons of hay an acre.

These two are represented by the same shading, as the quantity of each in this part of the province is very small.

- No. III. is land which produces $1\frac{1}{2}$ tons of hay.
- No. IV. produces 1 ton of hay per acre.
- No. V., though covered for the most part with narrow-leaved timber, is considered in its present condition to be incapable of profitable cultivation; and the shading
- No. VI. indicates the sites of known bogs, swamps, &c., which in various places rest upon this incapable surface.

Now, at first sight, it might appear as if there were no accordance whatever between the indications of geology taken alone, and the actual observed qualities of the soil, as represented

in this map. A little examination, however, removes this impression, while, at the same time, it shows how other causes operate in modifying purely geological influences, what these causes are, and to what extent they operate. Thus it will be seen—

1st. That only in a few places of limited extent do soils of the first or second quality occur;—therefore it is generally true of the whole area, that the rocks of the coal measures produce or are covered by soils of an inferior quality.

2nd. That the poorest or most worthless portions (Nos. V. and VI.) lie towards the sources of the rivers—form the higher table-lands in other words, which the rains of summer and the snows of winter may wash and impoverish, but which, in a state of nature, receive nothing by which their natural quality can be materially improved. The highest parts of these regions rarely rise more than 200 or 300 feet above the sea-level, they may therefore be regarded as representing in their soils a quality something inferior to what the rocks themselves, by their crumbling, would naturally produce. The rains have yearly washed them for an indefinite period of time, and the rivers have carried off their soluble portions and their finer insoluble particles, reducing them thus gradually to the condition in which they now are.

There is, besides, in this country, another cause of impoverishment to which, in a state of nature, the surface is exposed, which is not undeserving of special notice. Forests prevail everywhere over the unreclaimed territory, and these, in the scorching days of the North American summers, are subject to frequent fires. The ash of the burned forests, when it falls and rests where the trees grew, excites and quickens a new vegetation, and hence the easy and luxuriant crops which the settler obtains when he has strewed upon his young clearing the heaps of ashes which the felled timber has yielded. But, if the fires are succeeded by heavy rains, the ashes are swept off from the sloping grounds, and the blackened naked surface is robbed of its most fertilising constituents. Hence where frequent forest burnings have taken place the land becomes notoriously worthless. The wind besides assists the rains, and, on the whole, is probably a still more rapid and widely-acting exhauster of these forest lands. Whenever great fires have occurred in the woods of New Brunswick, and along the shores of the St. Lawrence, they have almost invariably been accompanied by powerful winds. The great fire which, in 1825, desolated the northern part of New Brunswick, along the course of the Miramichi river, was pushed on by an irresistible gale of wind, before which it galloped across the country with a speed which carried it over a

distance of thirty miles in a single hour. Such hurricanes sweep smoke and ash and light twigs, and even burning brands, over land and sea, to unknown distances, and thus effectually rob the soil of those quickening materials which the living trees had probably, for half a century, been extracting from it by their roots. It is easy to see how, in these various ways, the rains and winds of heaven must have gradually rendered poorer the naturally poor uplands of this coal measure district; so that, as I have said, the quality of the soils represented by No. V. must be considerably below that which the soils on the same spots must have possessed when the rocks, from which they are derived, began first to crumble through the agency of natural causes.

3rd. Passing over the soils No. IV. which, if what is above stated be considered probable, may be looked upon as representing in some degree the natural quality of the soils of this region, we may dwell for a little on those richer soils which are indicated by the shading No. III. In regard to these it will be observed that they lie in general along the lines of drainage of the country, and towards the outfalls of the rivers. On the one hand, we find this quality of soil bordering the course of the Washedamoak river, skirting the Grand Lake and its tributaries, and following the line of the St. John river, as it crosses this region. On the other hand, the Miramichi river and its feeders, for a great part of their descent, flow through soils of this quality; and so also towards the sea (*Northumberland Straits*, which separate New Brunswick from Prince Edward's Island) into which many streams, rising in the flats and swamps of the higher country, empty themselves, the same better quality of soil prevails. So that generally, we may say, that towards the outfalls of the rivers in every direction the better soils are to be found,—a circumstance very generally observed still in most of the long-inhabited and long-cultivated countries of Europe. And the explanation of this circumstance is easy:—the same atmospheric agencies which have robbed the higher land have enriched the lower. The ever-flowing and frequently-flooded rivers have brought down and deposited in the line of their descent, the materials of richer soils, and have thus gradually—upon rocks of the same geological age and of the same chemical composition—established diversities of soil, which a knowledge of the geological structure alone would not lead us to anticipate, and for which, in fact, this knowledge does not enable us to account. That here and there such richer soils occur in places which existing rivers appear unable to reach, only reminds us how imperfect our information still is in regard to the actual condition of this new country, and to the modifying causes now in operation in different localities; and how still more imperfect is our acquaintance with the earlier

history of the surface of New Brunswick, with the changes which the river-courses have undergone, with the cause of the great deepening which their channels have suffered, and with the numerous other physical alterations by which the influence of the streams upon the country through which they pass must have been very much modified.

It is the character of running streams, when they lose themselves in seas or lakes, or other large bodies of comparatively still water, to let go and deposit near their mouths the solid matters they were able, while in motion, to keep in suspension and bear along with them. Now along the shores of Northumberland Strait there are many indications of a later lifting up of the province, by which a fringe in some places of twenty or thirty miles in breadth, previously under water, was laid dry. While under water, the numerous rivers which cross this coast-line would meet the sea at an earlier part of their course, and all the mud they brought down would be distributed along the sea-bottom, and deposited by tides and currents, probably at considerable distances from their actual mouths, so as to form wide patches of more capable soil, as the shading (No. III.) along this coast-line actually represents. The numerous terraces, rising one above another, along the banks of the St. John river, are unmistakable evidence of the anciently higher levels at which its waters ran. When this was the case, the surfaces numbered I, II., and III., may have been subject to overflow, while the waters of the Grand Lake and of the Washedamoak river may, in like manner, have covered a large portion of the better land by which they are now fringed round or accompanied. Thus, by the aid of ancient changes of level, we may be enabled to explain, in other cases as well as in the present, how existing causes may have given rise to anomalous appearances, which the operation of these causes, in present physical conditions, are insufficient thoroughly to explain.

4th. The soils Nos. I. and II., though very limited in extent, point out another agency, in addition to those already noticed, by which the agricultural indications of geological structure may be, and no doubt are, in many cases, materially modified. In the map before us, there are two spots upon which these soils occupy a considerable area. The first is on the river St. John, below Fredericton; the second at the head of Cumberland Basin, one of the upper branches of the Bay of Fundy. The existence of soils so rich in the first of these localities is explained by the circumstance that, before entering the carboniferous region, the river St. John, or its tributaries, had passed through geological formations of red marls, red sandstones, and Silurian slates, which naturally form very fertile soils, and thence had brought

with them materials of productiveness which were foreign to this region. These were naturally deposited where the river first widened into a shallow lake, and gave birth to the fertile alluvium of which the first and second class soils on the St. John river in a great measure consist. In the second locality, on the head waters of the Bay of Fundy, the lofty tides of that Bay, thick with red mud--the spoils of the soft rocks which they wear down in their daily ebb and flow--have, like the waters of the St. John, brought upwards the materials of other formations, and have overlaid with most fertile soil the more barren surface natural to the rocks on which they rest. It is a natural warping with foreign materials--similar to that performed by our own Humber and Trent on the adjoining moor-lands, or by the river Ombrone upon the Tuscan Maremma--that the existence of these first-class soils in this portion of New Brunswick, are for the most part to be ascribed.

It is unnecessary, I think, to follow this subject at present into further detail; I shall therefore briefly sum up the results to which the study of this case has led us in regard to the relations of Geology with Agriculture, and to the causes by which these relations, naturally close, may be materially modified. These results are--

1st. That the actual agricultural value of the soil in a district may differ very much from that which pure geology alone would indicate. This is shown by the map before us, in which, although the soils special to the formation do predominate, yet soils of all qualities are seen extending often over very large areas.

2nd. That the physical structure of a country has much influence in causing the production of such diversities of soil upon, or from, the debris of rocks of the same age and kind.

3rd. That the existence of flat table-lands; for example, or of depressions having no natural outlet, will cover extensive portions of such a surface with swamps and bogs, in climates, which favour the accumulation of vegetable matter. Thus, as in Ireland not less extensively than in New Brunswick, the economic-agricultural influence of geological structure may be disguised or wholly hidden by the purely superficial covering of decaying vegetable matter.

4th. That, generally speaking, the soil of a district of uniform geological character will improve in the direction of the natural drainage and river outfalls. Where rains fall or snows melt, it is the tendency of the flowing water to enrich the lower at the expense of the higher country, and thus to establish differences of soil which did not originally exist. At the same time the final result of such action will depend very much upon the nature

of the rocks themselves. If they consist of limestone, the rains may wash down the finer particles from many places; but wherever soil remains it will still retain nearly the same composition as at first, and will be little impaired in fertility by the action of the rains. Hence the fine sweet herbage which clothes our limestone-hills, and makes them so grateful to the pasturing flocks. Or if hills or table-lands of red marl* form the higher country, portions may be washed down without materially affecting the quality of what remains. Let a fresh portion of the rock crumble, and things are again as they were before. A new soil is produced, equally fertile with that which has been washed away, and thus the fertility natural to the rock will be permanently maintained.

It is different, however, in the case of sandstone rocks, such as those of the coal-fields of New Brunswick. When such rocks crumble they form soils more or less sandy, according to the proportion of fine clay which has been originally contained in the materials from which the rock was formed. Now, the action of heavy rains upon such a soil is not to carry it away bodily, as in the case of the limestone or of the fine red marl, but to wash out the fine clayey particles, and carry them down to lower levels. Thus on the uplands the sandy soils become every day more sandy and of less value, while, in the direction of the drainage, they become, on the other hand, constantly more tenacious and productive.

Thus the amount of influence exercised by physical drainage is itself limited, and determined by the chemical composition of the rocks of which the country consists.

5th. That the passage of rivers or of sea-arms across a poor country, after it has previously traversed a richer geological region, is sure, to a greater or less extent, to modify—to increase, in fact, the value of the surface in the line of its course. This is seen, as I have pointed out, on the St. John river, and at the head of the Bay of Fundy, and is confirmed by observations made by myself and others in nearly all parts of the world.

6th. That partial elevations of the land at successive periods will aid other physical causes in establishing such differences, often, as in New Brunswick, covering with more fertile land the surface which has been most recently raised from beneath the waters of seas or lakes. It is conceivable, however, that in other conditions the very converse may take place.

These practical results are drawn directly from the map before us. Of course they do not indicate or exhaust all the causes by which modifications are introduced into the agricultural indications of

* Such as is represented in our sections by (3).

pure geology. A similar analysis of other examples will indicate other causes of similar change; and I think these causes ought now, in reference to the specialities of each country, to be made the subject of critical study and examination. The problem in each case to be solved is this. Given a certain geological structure, which indicates generally, and generally produces, certain agricultural capabilities; to what extent and in what localities have these indications been interfered with and modified by other agencies? In what way and to what extent have climate, physical structure, recent changes of physical structure, the neighbourhood of unlike geological formations, the action of those influences which produce what geologists call changed or metamorphic rocks, or other natural causes, been instrumental in producing such modifications? This, like all other more advanced inquiries, is more complicated and difficult than the simple problem of the direct relation between the character and age of a rock, and the quality of the soil it produces when broken up. But it will result in furnishing us with special surface maps, which will be of direct and immediate use to the practical agriculture of every country. And, what will be not less interesting, theoretically, it will at once connect these soil-maps with our strictly-geological ones, through the intermediate agency of physical causes, similar to those which have operated in a greater or less degree at all geological epochs.

