like Japan. Near the origin of the dislocation the shaking brings down forests from the mountain-sides, and the neighbouring district is devastated. As the waves spread they become less and less violent until, after radiating a few hundred miles, they are no longer appreciable to our senses. But the earthquake has not ended. As long, flat, easy undulations it continues on until it has spread over the whole surface of our globe. The waves passing under Asia and Europe reach England first, while those crossing the meridian of our Antipodes and North America arrive somewhat later. At Potsdam, Wilhelmshaven, and in Japan, waves of this order have often been recorded, but for the rest of the world they are thus far unrecognised. Great cities like London and New York are often rocked gently to and fro; but these world-wide movements, which may be utilised in connection with the determination of physical constants relating to the rigidity of our planet's crust, because they are so gentle, have escaped attention.

That the earth is breathing, that the tall buildings upon its surface are continually being moved to and fro, like the masts of ships upon an ocean, are at present facts which have received but little recognition. Spasmodic movements which ruin cities attract attention for the moment, but when the dead are buried, and the survivors have rebuilt their homes, all is soon forgotten. It seems desirable that more should be done to advance our knowledge of the exact nature of all earth-movements, by establishing seismological observatories, or at least preventing those in existence from sinking to decay.

J. MILNE.

THE CLIMATIC AND NATIONAL-ECONOMIC INFLUENCE OF FORESTS.

IT is to German scientific men that we owe the first steps taken in order to ascertain data concerning the actual climatic effects of forests. Since then, however, most civilised countries, except Britain, have been actively engaged in the collection of accurate data concerning this very important subject. So far as those data have yet been collated and compared they lead to the following results.

It was not until the year 1867 that exact scientific observations were undertaken on an extensive scale to determine the actual influence which forests have in modifying the temperature of the air and of the soil within their own areas and over the surrounding tracts of country, and the first results were published in Ebermayer's celebrated work, *Die physikalischen Einwirkungen des Waldes auf Lufte und Boden*, 1873.

1. *As regards Atmospheric Temperature.*—The average results of observations made during ten years (1876–85) throughout nearly the whole of Germany, and in parts of France and Switzerland, in different kinds of forest, at heights above the sea-level varying from 10 to 3000 feet, and at latitudes varying from 47½° to 55¼°, prove conclusively that in general the annual average temperature within forests growing in closed canopy is lower than in the open, although the crowns of the trees are on the whole a little warmer in winter. The difference is greatest in summer, least in winter, and about midway between these extremes in spring and autumn; the mean annual difference, however, seldom amounts to over 1° Fahr. near the ground, and is scarcely ½° in the crowns. The prevention of insolation of the soil during the long hot days of summer, and the rapid transpiration taking place through the foliage, exert a greater influence on the atmospheric temperature than can be ascribed to shelter from wind and to decrease of nocturnal radiation.

The observations recorded prove (1) that the variations between the temperatures of the trees themselves and the air in the open exceed those between the woodland air and the latter except during winter, (2) that they are largest during the most active period of vegetation in summer, and (3) that they are greater in spring, when the circulation of sap begins, than during the autumn months, when vitality becomes sluggish and dormant.

In the crown of the trees, where insolation by day and radiation by night make their full influence felt, the difference in the daily average over the whole year is less than it is near the ground. In winter it averages little either above or below 0°, and in summer usually about the half of the reading at 5 ft. above the ground.

Observations made in Southern Germany establish the fact that in the forests it is cooler during the day and warmer during the night than in the open.

During the night the trees interfere with the radiation of heat, and in the day-time the shade afforded by the crowns keeps the air from being rapidly warmed by the sun's rays. These influences are naturally strongest during spring, summer, and autumn, when foliage is most abundant, whilst in winter the coniferous forests with evergreen foliage are milder than deciduous forests.

Owing to these differences in temperature, beneficial currents of air are induced between the forests and the open country, which follow the same law as obtains in regard to land and sea breezes. During the day the cooler and moister air of the forest sets outwards to take the place of the heated air ascending in the open; at night the current sets in from the open, cooled by radiation, towards the forest.

The statistics, upon which these deductions are based, prove that the immediate action of forests is to modify the daily maxima and minima of atmospheric temperature, whence it may be deduced that a comparison of the absolute extremes of temperature during the year must exhibit definitely the sum total of the influence exerted by forests on the temperature of the atmosphere. This modification of the extremes of temperature, which are bad alike for man and beast, and also for agricultural operations, is of immense importance from a national-economic point of view, since many places that were once fertile are now little better than barren wastes in consequence of the reckless denudation of forest.

In registering the data, however, it was observed that the geographical position, and the exposure of the forests to winds, exerted a certain amount of modifying influence in lessening the differences, and there are reasons to believe that towards the crown the forest temperature in winter is considerably higher than down nearer the ground. It was found, too, that certain forest trees exerted greater influence than others in consequence of the density of their foliage; for beech forests in summer exert, through their dense foliage and complete canopy, a considerably greater influence in diminishing the extremes of temperature than forests of spruce or Scots pine, although after defoliation their influence is merely similar to that of the pine forest, and only half so great as that of the more densely foliaged spruce.

2. *As regards Soil-Temperature.*—The influence exerted on the soil temperature by forests growing in close canopy is of considerable importance, especially with regard to the soil-moisture. The observations made concerning this point seem to make it clear that the mean annual temperature of the soil in the forest is at all the above depths of observation cooler than in the open, and that the differences are greatest in summer, about the mean in spring and autumn, and very small in winter. In countries with warm summers this reduction of the soil-temperature over large areas by means of forest growth has a decidedly beneficial result. According to observations made in Würtemberg, the difference between the maxima of soil-temperature in forests and in the open can extend so far as up to 14° Fahr.

It was also found that the daily differences in soil-temperature varied according to the season of the year, but that throughout nearly the whole year the upper layers of soil in the open were warmer in the afternoon than in the forenoon, whereas in the forest the variations were inconsiderable.

As with regard to the atmospheric temperature, the influence of the forest trees in equalising the soil-temperature throughout the year is greatest in the case of trees whose foliage is densest, spruce heading the list.

3. *As regards the Degree of Atmospheric Humidity.*—Observations recorded throughout Central Germany show that *as regards the absolute humidity of the air* forests have no appreciable climatic effect, for the annual averages showed merely slight traces of differences at 5 feet above the soil.

The differences between the relative humidity of the air in forests and in the open are, as might be expected, greatest in summer, although very different results as regard variations are obtained with changes of altitude and of other physical conditions.

The results of the various series of observations, corrected so as to eliminate, so far as possible, local differences due to altitude and other physical dissimilarities in the various meteorological stations, show that the mean annual relative humidity of woodland air is from 3½ to 10 per cent. greater than that of air in the open, but that the difference varies greatly according to the season of the year, being greatest in summer and autumn, and least in winter and spring. They show, too, that large

areas covered with spruce will be moister, as well as cooler, than those under woods of less densely foliaged species of trees. In Bavaria it was found that in summer, in consequence of the density of the foliage in beech forests during the most active period of growth, the difference even amounted to 13·6 per cent. of saturation over the relative humidity in the open.

4. *As regards the Precipitation of Aqueous Vapour.*—It has been shown above, not only that the atmosphere within the forest is cooler than in the open, but also that the temperature of the trees themselves is lower, especially in summer, than the air surrounding them; hence, when a current of air is wafted from the open into the forest, and comes in contact with the cooler trees, its temperature is reduced, and it is brought nearer to the point of saturation, *i.e.* its relative humidity increases. But if this air was already in the open at, or near, the point of saturation, then the effect of the cooling process is that a certain amount of surplus moisture beyond the aqueous vapour that can be held by the air up to a point of saturation at its reduced temperature must be released and precipitated in the form of dew. Woodlands, therefore, act as condensers of atmospheric moisture, and decrease the absolute humidity of the air whilst increasing its relative humidity; and in addition to this, they increase the humidity of the air by transpiration from the leaves, whilst the sap is being rendered available for structural purposes, and the work of assimilation is proceeding.

Endeavours have been made to establish, by means of careful observations, the effect of forests in regard to the precipitation of aqueous vapour in the form of dew or rain, but the results are often of so conflicting a nature that, up till the present, safe deductions cannot be drawn. In order to compare observations made in the forests with those made at the usual meteorological stations in the open, a correction would in each case be necessary to reduce the localities to the same sea-level, as air cools in rising and increases in relative humidity, *i.e.* it approaches the point at which it must precipitate some of the aqueous vapour held by it. Hence rainfall generally increases with the height of a locality above the sea-level, although no direct proportional increase can be proved. It fluctuates with the geographical position and the varying physical conditions of each point of observation, whilst variations in the direction of the moist winds of the locality also militate against the collection of reliable data for comparison with readings made in other localities.

The mean of the readings at 192 points of observation in Germany, corrected as carefully as possible with reference to these causes of difference, do not seem capable of giving any more exact inference than the general statement, that at high altitudes large extents of forest may considerably increase the local rainfall. As regards the quantity of rainfall and snowfall which is intercepted in forests by the leaves, branches, and stems of the trees, the observations made in Switzerland, Prussia, and Bavaria show that nearly one-fourth of all the precipitations of aqueous vapour is intercepted by the forest trees, and is given off again by evaporation, or is gradually conducted down the stems to the soil. In lofty forest-clad regions the mechanical action of the rains on the surface-soil is thus very much modified.

By means of their lower temperature, their greater relative humidity, and the mechanical obstruction they offer to the movements of currents of air, extensive forests act decidedly as condensers of the aqueous vapour contained in the atmosphere, and their influence in this respect is more marked at high altitudes and in mountainous districts than on plains or near the sea-coast, where other physical factors come into competition with and modify it. Further data are still requisite to enable us to determine with anything like certainty that forests directly cause increase of precipitations irrespective of such local considerations as the ruling direction of winds and peculiarities of situation; the generally accepted dictum is, however, that in the vicinity of extensive forests the rainfall is greater than at other localities under otherwise similar physical conditions.

In portions of the Russian Steppes, planted up nearly 50 years ago, the inhabitants assert that the summer rainfall has considerably increased, and that the danger to crops from drought is not so great as formerly, whilst the villages are also protected by the forest from the violence of the winter storms.

In summarising and criticising this point Prof. Endres of Karlsruhe remarks as follows[1]:—

[1] Conrad, Elster, Lexis, and Loening's "Handworterbuch der Staatswissenschaften," 1892, vol. iii. page 608.

"The data furnished from tropical countries must be accepted with the greatest caution, and in any case they afford no conclusive deductions for European circumstances. Blandford reports from India (*Meteorological Journal*, 1888) that in an area of 61,000 square miles, which was formerly denuded of woodlands, but has been planted up again from 1875, the rainfall has increased 12 per cent. since then. But H. Gannet (*Weather*, vol. v.) arrives at exactly the opposite conclusions for America, as his observations in the prairie region and in Ohio go to prove that the re-wooding of a tract exerts no perceptible difference on the amount of the aqueous precipitations. Lendenfeld also tries to prove that the clearance of woodlands in Australia has resulted in a better climate and an increase in rainfall, as the soil under eucalyptus remains hard as stone and inabsorptive, whilst it is rendered lighter and more porous by grass. (*Petermann's Geog. Mittheilungen*, vol xxxiv.)."

5. *As regards Evaporation of Soil-Moisture.*—The low temperature and the high relative humidity of the atmosphere in forests are unfavourable to rapid evaporation, which is still further reduced by the protection afforded to the soil against direct insolation and the action of winds. From observations extending over 10 years (1876-85) in various parts of Germany and Austria, the following relation is shown between evaporation in the forests and in the open in the vicinity of the forests: the differences would probably be greater if comparisons had been made with places in the open that were far removed from the modifying influence of the woodlands:—

	Water evaporated.	
In the open . .	20·9 inches	The practical importance of this will be seen, when it is recollected that the mineral food in the soil can be taken up by the rootlets only in the form of *soluble* salts.
In the forest . .	9·5 ,,	
Lower in forest than in open by . .	11·4 inches	
Evaporation in forest expressed in percentage of that in the open .	46 per cent.	

It was also found that the amount of evaporation depended on the class of forest, thus:—

Species of Woodland.	Percentage of Water. Evaporated in the Forest.	Remaining in the Soil.
Beech	40 ...	60
Spruce	45 ...	55
Scots pine	42 ...	58
Clearing for reproduction ...	90 ...	10

In these statistics no account has been taken of the quantity of water given to the air by transpiration through the leaves; but this is not of essential importance, as such supplies of moisture are drawn by trees, except during the earliest stages of growth, from the deeper layers of soil and subsoil not immediately and directly affected by the aqueous precipitations on the surface. This may be less true of spruce than of other trees.

The action of forests, therefore, is to retain in the soil a large proportion of the rainfall or of the moisture arising from the melting of snows, which, by percolation to the lower layers and the subsoil, tends to feed the streams perennially, and to maintain a constant supply of moisture, without which trees could not derive their requisite food-supplies from the soil.

The nature of the soil-covering below the forest trees exerts also considerable influence on the amount of moisture evaporated. From experiments conducted during five years in Bavaria it was found that a good layer of fallen leaves, and of *humus* or vegetable mould formed by their decay, is a powerful factor; it diminishes the evaporation by more than half, or reduces it to less than one quarter of that in the open, and thus adds very considerably to the surplus amount of moisture retained in the soil.

6. *As regards the Feeding of Streams and the Protection of the*

Soil.—From the above data it seems evident that the effect of extensive forests, more especially of those situated at high altitudes, is, by cooling the air and reducing its capacity for retaining aqueous vapour, to increase the precipitations. Whilst these precipitations are taking place the crowns of the trees intercept a large proportion of the total, and by breaking the violence of the rainfall protect the soil from the danger of being washed away during heavy storms. By the decomposition of fallen leaves and twigs a strongly hygroscopic soil-covering is formed, capable of imbibing and retaining moisture with sponge-like capacity. Rapid evaporation of the soil-moisture is counteracted through the protection afforded by the foliage against direct insolation during the day, and by the mechanical hindrance offered to currents of wind. The crown of foliage likewise prevents the soil cooling rapidly at night by radiation. The hotter the summer, the more marked are these beneficial effects of the woodlands.

When, therefore, large tracts of country are denuded of timber, increase of temperature during the days of summer, rapid radiation of soil-warmth by night, diminished precipitations (especially in the spring and summer), and unchecked evaporation of moisture, due to complete insolation of the soil by day and absence of any protection from winds, must be the inevitable consequences. Examples of such actual results can be pointed out in many parts of continental Europe, in Western Asia, and throughout India. In Great Britain and Ireland the effects of the wholesale clearance of woodlands have not been so marked, in consequence of the favourable influences exerted on our climate by the Gulf Stream.

In localities having no protective woodlands heavy rains wash away the surface-soil, torrents and freshets rush down the watercourses with great violence, laden with detritus and discoloured with the soil held in mechanical solution, whilst streams and rivers often overflow their banks in consequence, devastating large areas of low-lying tracts under cultivation. Forests, on the other hand, tend to break the violence of the rainfall, and retain for the time being about one-fourth of the total amount on the foliage and branches; the roots of the trees and of the undergrowth help to bind the soil firmly; the rainfall is retained by the vegetable mould and by the spongy growth usually found on the surface-soil, and thence gradually percolates to the deeper layers, where it is held in reserve, to be finally parted with in being utilised for the feeding of perennial streams having their sources on the wooded slopes.

Thus arose in the Alpine districts of Southern Europe the necessity for maintaining *ban-forests* as a protection against landslips, avalanches, &c., and legal measures were early adopted for safeguarding them in order to protect the lower tracts from erosion of the soil when sodden with rainfall or melted snow.

7. *As regards General Hygienic Effect on the Atmosphere.*—It is well known that on the one hand when large tracts of forest are cleared for cultivation, especially in tropical and subtropical countries, fever and ague are frequently the consequence, and on the other that the planting up of notorious fever districts, such as the Campagna di Roma, the Tuscan marshes, and the Russian Steppes, has decidedly diminished the insalubrity of these localities. But the causes are very probably rather due to the degree of direct insolation of the soil, freely afforded in the one case, and counteracted in the other, than to any hygienic property inherent in tree-growth. In the latter case, too, stagnating surplus of soil-moisture may have been got rid of by transpiration through the foliage, and this would of itself go far towards removing causes of insalubrity, and improving the climate.

It is generally accepted that ozone kills miasma in the air, and purifies it—at any rate impure air contains little or no ozone; the proportion of ozone is therefore usually taken as the measure of atmospheric quality. The belief that the woodland air is, like sea air, very rich in ozone has not yet been satisfactorily proved. Experiments in Bavaria showed that in the forests the percentage of ozone, though greater than that in the vicinity of towns, was slightly less than in the open in the vicinity of forests, and that there was no perceptible difference in this respect between coniferous and deciduous forests.

The woodland air was found to contain most ozone in winter, which shows that its production could not be due to any chemical action of the foliage, for there are no leaves on deciduous trees at that season, whilst conifers transpire merely, and do not assimilate. It also indicates that the excess is probably due to the comparative freedom of air in the forest from the smoke, carbonic acid, and many other impurities with which air in the vicinity of towns is contaminated and defiled, and to the withdrawal of enormous supplies of oxygen from the air which takes place for the support of animal life at all populous centres. Thus whilst in general the quantity of carbonic acid in the atmosphere is somewhat under four volumes in 10,000, that is the normal amount in London air; but in thick fogs this proportion is frequently doubled, and has been known to be more than trebled, or even to exceed 14 volumes in the city.

Sunlight, however, has the power of decomposing carbonic acid in the presence of chlorophyll, the green colouring matter contained in foliage, the carbon being absorbed by the plant for its growth, and the oxygen set free. During darkness a contrary action takes place, oxygen being consumed by the foliage, and carbonic acid given off. As, however, particularly in the case of deciduous trees which are in leaf only from April till October, the hours of light far exceed in number those of darkness, the general hygienic effect of trees in cities and towns—apart from their invaluable æsthetic influence—tends decidedly towards the purification of the atmosphere from excess of carbonic acid.

Ozone again is an allotropic modification of oxygen obtainable by passing a series of electrical discharges through it; hence it is more than probable that in forests in exposed localities, more especially those at high altitudes, where storms and electrical disturbances of the air are most frequent, a greater quantity of ozone must be generated in the atmosphere than in localities less subject to such powerful ozonising influences.

Ebermayer, undoubtedly one of the greatest authorities on this subject, says[1]:—

"In the middle of the great 'ozone-factory,' which we must consider the forest to be, neither more oxygen nor less carbonic acid is offered to mankind for breathing than over large unwooded areas."

At another part of the same article he also adds[2]:—

"From the hygienic standpoint it is worthy of notice that, according to my examinations, the air in and immediately above the crowns, then that in the immediate vicinity of the forests, has more ozone than that in the interior of the forests, where a portion of the ozone is consumed by the decomposing foliage lying on the ground."

It appears, therefore, to be his matured opinion at present that whilst more ozone is found in forests than in the open—which the Austrian students of the subject deny, or at any rate are not yet prepared to admit without further observations and proofs—yet the decomposing matter covering the soil consumes the surplus, and often more than that, so that no difference can be established in favour of the forest air. In this withdrawal of ozone in excessive quantities from the air by decomposing vegetable matter, the unhealthiness of tropical jungles, and the prevalence of malaria at all the lower elevations within the tropics usually covered by woodlands, seem easily explainable.

According to Endres and to Fernow[3] it is claimed that forests tend to resist the spread of epidemics, and to offer a bar to the progress of diseases like cholera and yellow fever.

Regarding the *Sanitary Influence of Forests*, the latter states (*op. cit.* p. 21) as his summary that "(1) the claimed influence of greater purity of the air due to greater oxygen and ozone production does not seem to be significant; (2) the protection against sun and wind, and consequent absence of extreme conditions, may be considered favourable; (3) the soil connections of the forest are unfavourable to the production and existence of pathogenic microbes, especially those of the cholera and yellow fever, and the comparative absence of wind and dust, in which such microbes are carried in the air, may be considered as the principal claim for the hygienic significance of the forest."

Fortunately there are not many infectious diseases the germs of which can be carried by water; as yet only two are known with certainty, cholera and enteric fever. When outbreaks of these diseases occur in tropical countries, the infectious power of the germs is favoured by warmth and moisture; moreover, when epidemic, these diseases usually break out in thickly populated towns and similar localities, where it is impossible to submit

1 "Hygienische Bedeutung der Waldluft und des Waldbodens" in vol. xiii. of "Forschungen auf dem Gebiete der Agricultur-Physik," edited by Prof. Wollny, 1890, p. 429.

2 *Op. cit.*, p. 435.

3 "Forest Influences," p. 172, 1893.

the soil-moisture or the water-supply to the filtrating action of belts of woodland.

8. *As regards the Agricultural Productive Capacity of Neighbouring Tracts, and the National-Economic Effect on the Soil generally.*—From an agricultural standpoint, a dry season is much preferable to a low temperature and excessive rainfall. In the former case the crops, although they may be somewhat scanty, are invariably of superior quality. A wet season may produce abundant crops, but they are generally of low quality.

With regard to the influence of forests on the aqueous precipitations throughout central Europe, Prof. Endres makes the following remarks[1]:—

"The question whether woodlands can influence the rainfall is one of the most important from a national-economic point of view. Even if this could be distinctly affirmed, the beneficial action of forests would only be established in the rarest cases, for throughout central Europe at present the number of too wet years exceeds that of dry years. *In districts where the rainfall is over* 40 *inches, any increase is undesirable.*[2] For agriculture very dry years are on the whole less disastrous than extremely wet years. The precipitations of any district are influenced mainly by the position of the mountain ranges with reference to the cardinal points of the compass, by its elevation above sea-level, and its distance from the sea."

But, as the American investigations prove (*idem.* p. 13), "no influence upon the general climate which depends upon cosmic causes can in reason be expected from a forest cover. Only local modifications of climatic conditions may be anticipated, but these modifications, if they exist, are of great practical value, for upon them rest success or failure in agricultural pursuits, and comfort or discomfort of life, within the given cosmic climate. The same condition must be insisted upon with reference to forest influences upon waterflow, which can exist only as local modifications of water conditions, which are due in the first place to climatic, geologic, and topographic conditions."

Even so early as in Roman times it was recognised that too great a clearance of woodland areas brought undesirable changes in the physical conditions of Italy, and affected the welfare of the inhabitants. That the destruction of the ancient forests throughout Great Britain and Ireland, to such an extent that only 3·8 per cent of the total area can now be classified as woodlands (*vide* Parliamentary Report on "Forestry," dated August 5, 1887), was not followed by such disastrous climatic changes as were occasioned by similar causes throughout the Landes, Syria, Asia Minor, Greece, Russia, and many parts of India, we owe entirely to our insular position with its moist climate, and to the happy effects wrought by that portion of the Gulf Stream which reaches our western and southern shores.

Early in the present century, for example, the Agricultural Society of Marseilles reported that in consequence of the reckless destruction of the forests after the revolution of 1789:—

"The winters are colder, the summers hotter, and the beneficial spring and autumn showers no longer fall; the Uveaune, flowing from east to west, rushes down in flood with the least rain, carrying away its banks and flooding the richest pasturage, while, for nine months of the year, its bed lies dry owing to the drying-up of the streams."

To a similar cause also Prof. Geffcken (in *The Speaker* of January 6, 1893) attributes the Russian famine of 1892 in the following terms:—

"We speak of the deficit (in the Russian Budget) of 1893 as certain, and it is easy to show that it will be so. *The principal cause of the present dearth is the drought during the last spring and early summer, and this absence of rain is greatly due to the devastation of the forests.* The area formerly covered with timber was enormous, the woods belonging to the Crown, to the great landed proprietors, and to the village communities. But the means of transport were then so imperfect and costly that only in the neighbourhood of large rivers did the felling of timber pay. This changed with the construction of railways and the abolition of serfdom; the former gave the possibility of selling with profit, and the peasants abandoned their woods to speculators for what they thought a good price, little thinking of the future; the larger proprietors followed their example; the purchase money was spent in drink and luxurious living, and no one thought of replanting. *Too late has the Government issued a law for the protection of forests. Such a devastation going on for* 20 *years not only exhausts a source of wealth, but has also other bad consequences.* When the country is deprived of its trees, the earth is dried up and crumbles from the hills; the water coming down from heaven cannot be kept back as is the case with the woods, which act as a sponge, but rushes in torrents into the rivers and disappears in the sea, and the consequence is a gradual diminution of the fertility of the soil and the disappearing of numerous brooklets and small rivers, to help the larger ones show a low water-mark, which proves prejudicial to the navigation."

This view is confirmed by the special correspondent of the *Times* (*vide* article "Through Famine-stricken Russia" in issue of April 18, 1892), who writes:—

"I have now travelled over most of the famine-stricken provinces, and I have been struck by the sameness of the picture. Everywhere reckless extravagance meets the eye, the forests have been cut away wantonly, the rivers are neglected, the climate is ruined."

Such also appears to have been the opinion of Major Law, Commercial Attaché to the British Embassy at St. Petersburg, as expressed in his "Report on Agriculture in the South-Eastern Provinces of European Russia," commented on in a leading article of the *Times* of September 17, 1892, in the following words:—

"It is said that this gigantic natural tillage farm (*i.e.* the 'black-soil' region) was formerly hedged in by belts of forest, which served the twofold purpose of sheltering it from the desert winds and of increasing the humidity of the climate. It is certain that these forests do not now exist, and that the black-soil country is often scourged by devastating blasts from the steppe, and not infrequently baked by prolonged droughts. The desert winds pile the snow in drifts into winter, which become the source of destructive torrents in the spring. In summer the same winds are so fierce and arid that in the space of a few hours they wither the corn as it stands, while, when they are laden with sands, they smite the soil itself with perpetual barrenness."

All writers, indeed, who have recently published views on this subject, seem agreed as to the main causes of the recent Russian famine.[1]

In order to obtain the full national-economic benefits that are derivable from woodlands, the areas reserved as forests or planted up should be scattered over the face of the country as equally as possible. In all countries where the population is thin, and primeval forest is still to be found, measures with this end in view can easily be carried out without inflicting any apparent hardship on the existing community. But wherever danger from famine is apt to recur from time to time, it would at the same time seem to be worthy of consideration whether it would not be wise to expropriate tracts of the poorer and higher land here and there, and plant them up on a well-considered scheme for the purpose of ameliorating the climatic conditions for man and beast in the future.

J. NISBET.

1 "Hygienische Bedeutung der Waldluft und des Waldbodens" in vol. xiii. of "Forschungen auf dem Gebiete der Agricultur-Physik," edited by Prof. Wollny, 1890. p. 607.

2 This is a point of very great importance with reference to the proposals of Mr. Munro Ferguson, M.P. (*Contemporary Review* for October 1892, pp. 521, 522), for planting up the Highlands of Scotland, and Dr. Macgregor's three questions in the House on the same subject on November 13, December 12, and December 19, 1893. For if there be already any tendency towards more rainfall during the summer months than is good for agricultural crops, an extensive increase in the acreage of woodlands in such vicinities is not desirable.

SCIENTIFIC SERIALS.

American Journal of Science, January.—Researches in acoustics, No. 9, by Alfred M. Mayer. This paper deals with the law connecting the pitch of a sound with the duration of its residual sensation, and with the smallest consonant intervals among simple tones. The residual sound, *i.e.* the sound perceived by the ear after the actual vibration has ceased, was investigated by means of an apparatus consisting of a tuning-fork vibrating close to the opening of a resonator. The nipple of the resonator was placed opposite a hearing-tube leading to the ear, and the sound was interrupted by a rotating perforated disc interposed between the nipple and the opening of the tube. The discs, which were made of mahogany covered with cardboard, had several circles of holes, and intercepted the sound very

1 See also the article on "The Penury of Russia" in the *Edinburgh Review* for January 1893 (pp. 17-19), which may be said to contain a summary of the best opinions on the matter.