once connected northern America with western Europe. Later, others came from Asia. At that time the physical geography of the northern hemisphere was widely different from the present.

These various data have as yet been but imperfectly studied: when they shall have received the attention they merit, we may confidently calculate on a large increase in our knowledge of the course of events in ancient America.

ECONOMY IN MANAGEMENT OF SOIL.[1]

IN this great metropolis, or wherever our association meets, we are shown with pride the abounding evidences of the progress of a great nation, and the material prosperity of its people.

Tracing this visible wealth to its source, we find that it has all, with insignificant exceptions, been produced from the soil. The American inheritance was a fertile soil. A policy perhaps warranted by the circumstances, but none the less improvident, has marked the growth of the nation. Generation after generation has recklessly drawn upon the stored fertility of the land, with no systematic effort at restitution, not only to supply the current support of people, but the surplus which has provided all our apparent wealth and private improvements.

The rapidly increasing demands of our own country are met, and more than met, so far as mere quantity is concerned, for a great surplus is annually sent abroad. For twenty years agricultural products have constituted three-fourths of the total exports from the United States, while in single recent years this proportion has reached eighty-three per cent, and amounted in value to nearly nine hundred million dollars. And it is manifest that this superabundance of soil-products will continue, despite any possible increase in population, at least well into the next century. We boast of our great exportation of soil-products, forgetting that this really means the sending to foreign lands great blocks of our store of natural fertility, thus disposing of the main source of our material wealth by the ton and by the million. The steady reduction in the fertility of the soil, which results from the annual draught by cropping and the absolute loss incident to ordinary disposition of the crops, is much greater than commonly understood, and a matter so important as to demand serious consideration.

For present purposes it is sufficient to refer to only three elements of plant-food, which are of vital importance, and in which the soil is most likely to be, or to become, deficient. A computation based upon the mean annual agricultural products of the United States at the present time, the average composition of these products as far as known to chemistry, and the cash value of the chief fertilizing-materials in domestic markets, gives the following stated quantities and values of the three elements named, which are taken from the land by the farming operations of every year: —

4,000,000	tons of	nitrogen,	worth $360	per ton.....	$1,440,000,000
3,000,000	,,	potash,	100	,, ...	300,000,000
2,000,000	,,	phosphoric acid,	120	,, ...	240,000,000
		Total value.....			$1,980,000,000

The effect upon the soil depends, of course, upon the disposition of the products embodying these enormous quantities and values. Fortunately, a very large part remain upon or are returned to the land, in the process of harvesting and preparing for market, and more in the form of water and residues incident to consumption.

On the other hand, there are vast absolute losses resulting from the well-known wastes of towns and cities, besides the portions actually sent to foreign countries. To exactly apportion the disposition made of these products, and hence of the fertilizing elements represented thereby, is impossible; but as to the latter, a rough approximation divides the total into three parts, respectively remaining on the land, returned to the soil, and wholly removed from it.

This country imports the agricultural products of other countries in considerable quantity, but in kind far less important to the question in hand than our exports.

The articles exported are largely of a character especially rich in plant-food. Making due allowances, therefore, I estimate the average exportations as representing thirteen per cent of the fertility value of our total products, and our absolute wastes at home at more than twenty per cent additional. Together these constitute a full third of the figures above given, or an annual removal from American soil, of nitrogen, potash, and phosphoric acid, worth, in the markets of this city to-day, more than six hundred million dollars. By our present system, or rather continued improvidence in the production of the necessaries of life, we are thus diminishing, at this alarming rate, the original capital of our foundation industry.

When products are exported, mainly food, which are worth seven hundred million dollars on our shores, there is included plant-food, all needed at home, which we cannot replace for one-third of that sum.

This fertility never comes back. It goes to enrich other lands, or is washed into seas from which we do not ever get the fish and the carp. Those of us who are contending with impoverished soils are well placed to appreciate the sober subject of agricultural exhaustion, and are in duty bound to send an earnest word of warning to those who labor on newer lands. The researches of modern times have done much in establishing truths of practical value regarding the effect upon the fertility of the land, of the removal of different crops and products, and hence teaching us what should be consumed at home, and what may be profitably sold.

Thus, if ton after ton of farm-produce be removed from a Western farm to an Eastern market, or from any American farm to a European market, it makes a great difference eventually, to the land where produced, and to its owner or user, whether these tons be cotton or corn, beef or butter.

The following table illustrates this point: —

Articles of Export.	Mean Annual Exports in Tons.	Approximate Value of 1 Ton at Place of Export.	Value of the Plant-Food in 1 Ton.	Percentage of Plant-Food Value on the Market-Value 1 Ton.
Cottonseed-meal...	250,000	$ 26.00	$28.04	108.00%
All 'oil-cake' and 'oil-meals'.....		24.00	23.80	100.00
Tobacco.....	150,000	200.00	15.92	8.00
Beeves alive.....	100,000	100.00	13.98	14.00
Dressed beef.....	50,000	160.00	13.99	8.75
Pork products.....	500,000	200.00	13.43	6.25
Wheat.....	3,000,000	(34 bus.) 34.00	8.80	26.00
Wheat-flour.....	750,000	(10 bbls.) 50.00	7.08	14.00
Corn (maize).....	14,000,000	(36 bus.) 23.00	6.94	30.00
Cotton.....	1,000,000	(4 bales) 200.00	.60	–
Butter.....	15,000	(40 tubs) 400.00	.52	0.13

It merely mitigates the evil presented, to note that the soil holds large quantities of plant-food still in store; that nature has provided supplies of mineral manures in concentrated form, deposited in various places; and that some investigators yet believe they will prove conclusively the assimilation by plants of the free nitrogen of the atmosphere.

Should this much-disputed question of nitrogen-supply be so settled, it would certainly remove a vast deal of anxiety, trouble, and expense; for, as we have seen, nitrogen constitutes three-fourths in value of the plant-food annually used by crops. But the prevalence of the belief that the growing plant depends almost exclusively upon the nitrates of the soil, and has no power to assimilate the free nitrogen of the air, is amply shown by the market-prices of ammoniated manures and the extent of their sale and use.

The trade in commercial fertilizers has reached wonderful proportions, and agriculturists hail with joy the discovery of every new deposit like the potash-salts of Germany and the mineral phosphates of Canada and the Carolinas. But the expense incident to mining, manipulation, and transportation, greatly impedes the use of these natural stores, and makes the more important every means of husbanding the home resources of every acre of valuable land. If the

[1] Abstract of an address before the Section of Economic Science and Statistics of the American Association for the Advancement of Science, at New York, Aug. 10–17, 1887, by Henry E. Alvord, C.E., of Amherst, Mass., vice-president of the section.

statement could be accepted without much qualification, we might derive great comfort from the assurance that chemical examination of soils shows the presence, within reach of the plough, of nine thousand pounds of potash, and half as much phosphoric acid, on every acre, or enough to furnish the average crop for from two hundred and twenty-five to two hundred and fifty years.

Now, in the first place, the average land in tillage at the present time by no means reaches such a standard; and, in the second place, it is well known that but a very small fraction of the plant-food actually present in soil is in an available form. Ordinarily more than ninety-nine per cent of the plant-food found in soil by the chemist the plant itself finds dormant or unavailable. Time and natural agencies gradually convert their inert elements; but, to keep pace with agricultural demands, the physical properties of soils must be closely studied, and knowledge obtained and applied regarding the proper mechanical treatment of land. Figures already sufficiently demonstrate the recognized condition and needs of the soil. So difficult is it to make the once fertile land take back into use the natural resources, and so active the demand for plant-food in every available form to return to the soil, that, incredible as it appears, commercial fertilizers are maintained at such selling rates as to make the entire annual farm-products of this country worth half as much for manure as they are in market.

With our rapidly increasing population, and a constantly lessening fertility of soil, we have presented to us questions of the gravest import. By the wasteful processes prevailing, we are expending our very substance, and daily adding to a burden under which generations to come will stagger.

The true economy of soil management, involving the production for our people of food and clothing, fuel and shelter, and the wise management and disposition of our surplus, are problems great enough to satisfy the ambition of both scientists and statesmen.

In all expositions of the condition and prospects of the agriculture of this country, Gen. Francis A. Walker claims that the American people have been fully justified, upon sound economical principles, in the past system of cultivation of the soil at the expense of future generations.

"Thirty-eight noble States, in an indissoluble union, are the justification of this policy. Their school-houses and factories, their roads and bridges, their railways and warehouses, are the fruits of the characteristic agriculture of the past."

But the reason for wasteful systems no longer exists. "The country in the arable parts is settled, and the line of population now rests near the base of the great sterile mountains which occupy so large a portion of the continent. . . . A continuance of this policy will be, not the improvement of our patrimony, but the impoverishment of our posterity. . . . Economical and political considerations alike demand that the soil bequeathed to this generation, or opened up by its own exertions, shall hereafter be deemed and held as a sacred trust for the American people through all time to come, not to be diminished or impaired for the selfish enjoyment of its immediate possessors."

These considerations should increase our regard for and interest in the business of farming. We should all rejoice at the revival of agricultural studies, and the increasing number of able men who are making them their life's work.

Let me cordially invite continued contributions to the proceedings of this section, upon foods, fabrics, forestry, industrial education, and other topics closely related to our material welfare. And I appeal for more encouragement and aid for the earnest workers in other sections,— in biology and chemistry, physics and mechanics,— who are laboring in the various branches of science, that its practical results may be applied to economizing the fertility of the soil, which is the basis of our material prosperity.

MENTAL SCIENCE.

The Sense of Smell in Dogs.

DR. G. J. ROMANES, by his careful observations and happy generalizations, has made himself the representative of the growing science of comparative psychology. His two books on animal intelligence and on mental evolution in animals (to which is to be added a third on the mental evolution of man), written under the inspiration of Darwin, have done more, perhaps, than the works of any other writer, to introduce scientific order into a field formerly given over to poorly described, exaggerated stories, and hasty, unwarranted generalizations. With the downfall of the anthropomorphic theory of the universe, the importance of the mental phenomena observable in animals was more readily recognized and appreciated. Hundreds of observations drawn up with the requisite details and accuracy have been collected, and a number of reliable and suggestive generalizations have been recorded. To these Dr. Romanes has added an important study on the method by which his dog follows the scent of the master.

The observations were made on Dr. Romanes' setter-bitch, an animal very much attached to him. They were made on the grounds adjoining his house, and a number of precautions not easily described were taken. (1) When Dr. Romanes walks over the ground with his hunting-boots on, the dog follows the scent with the greatest readiness. (2) If she is put to the track of a stranger, she pays no attention to it. (3) The dog was led into the room when preparations were going on for an outing, but, instead of Dr. Romanes going out, the gamekeeper (whose scent he follows next after that of Dr. Romanes) went: when set free, the animal at first followed the track, but, finding that her master was not with the gamekeeper, returned. (4) The next experiment was a very ingenious one. Twelve men walked in Indian file, so that they all trod the same footsteps, thus producing a conglomerate of olfactory impressions. Dr. Romanes headed the company, so that the traces of his steps should be most obliterated; and, after walking thus two hundred yards, the first six men walked in one direction, the last six in another. The dog quickly ran along the route followed by the twelve, overshot the point of division, but soon returned and followed the direction taken by the six headed by Dr. Romanes. (5) A number of experiments were made to ascertain what part of Dr. Romanes' person or of his apparel gave the clew to the animal. It was suspected to be the hunting-boots, and this proved correct. A stranger put on these boots, and the dog eagerly followed the scent; and, contrariwise, when (6) Dr. Romanes put on the stranger's boots, the animal was indifferent to his track. (7) Further experiments were made to locate the source of the scent in the boots. The dog did not follow the scent of a stranger walking in bare feet. (8) When Dr. Romanes walked in bare feet, the dog followed the trace, but less eagerly than usual, and with much hesitation. (9) Again, the animal did not follow Dr. Romanes when he put on new shooting-boots. (10) Next a single sheet of brown paper was glued to the soles of his usual hunting-boots. The dog did not catch the trail until he came to a place where, as Dr. Romanes had previously noted, a few square millimetres of the paper had come off. (11) When her master walked in new cotton socks, the trail was lazily followed, and soon given up. With woollen socks worn all day the result was the same. (12) Dr. Romanes next walked fifty yards in shooting-boots; then three hundred yards in his stocking-soles, carrying his boots; then three hundred yards in his bare feet. The animal caught the scent, and followed it unhesitatingly through the whole distance, though the trace left by stockings or bare feet alone was not sufficient to guide the animal. (13) The next test was a modification of the last. Dr. Romanes and a stranger entered a carriage and drove for several hundred yards. The former, in his hunting-boots, then alighted and walked fifty yards, whereupon he re-entered the carriage, and the stranger walked the next two hundred yards: the dog, when shown the track, ran the whole two hundred and fifty yards without pausing. The experiment was repeated with another stranger, with the same result. (14) To test the power which the dog had of selecting the distinctive odor accompanying her master from other odors, Dr. Romanes soaked his hunting-boots in anise-seed-oil. The odor was so strong that a friend could follow the track an hour later by the odor of the oil; yet the dog was not confused except that she hesitated about the first few steps, but then pursued as usual.

The next test was directed towards ascertaining whether the animal could distinguish her master by odors emanating from other portions of his person. (15) Dr. Romanes, after pursuing a zigzag course just trodden over by a number of footsteps, hid behind a wall, with his eyes just visible. The animal went at once to the hiding-place. (16) Again he hid in a ditch, with only the top of