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EARLY AMERICAN
SOIL CONSERVATIONISTS

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INTRODUCTION

The felling of the first tree by colonists in the New World, though never mentioned by historians, was an act of great significance. It marked the beginning of the era of the most rapid rate of wasteful land use in the history of the world. Nature had labored slowly to raise mountains, carve out valleys, build flood plains, and to cover them with soil and vegetation. The first English colonists settled in the Chesapeake country in 1607. They began hacking down the forest with rude tools. They had no knowledge of how to live in the wilderness, nor did they anticipate that the number of people would increase until every acre in the country had to be counted.

The settlers chopped a little way into the wilderness. They built rude shelters of logs. The Indians taught them how to grow corn; they planted it in hills cultivated the crop with hoes because they had no plows. Now and then a hardy settler pushed farther into the wilderness. With his gun nearby he chopped down a few trees, cleared away the brush, and planted his crop and cultivated it. At first the tenderfoot colonists almost starved, but battles with the Indians and the contest with Nature hardened them. They attacked the forest with greater efficiency.

The acreage under cultivation near the coast increased, and farms grew larger. More and more ground was plowed up. More forest was devastated. More grass was eaten by the growing herds of cattle, hogs, and horses. Soon farmers lived all along the coast. They came in larger and larger numbers. Many fell by the wayside, victims of hardship, disease, or Indians. But still they came. The towns grew larger, became crowded. The more adventurous explored the backwoods and carved out farms there.

They banded together and formed inland towns. They advanced farther and farther into the wilderness. They pushed up the river valleys, sought out the richest land and farmed it.

Then a few of the farmers in the older sections noticed a change in the soil. At first it had been dark, in some places almost black. but now it was lighter in color. This change, imperceptible at first, meant that deterioration of the soil had set in. It was a symptom of the slow sickness that would for a long time afflict our land. It meant that much of the organic matter, attacked first by fire and then by the plow, was gone.

When a great rain came the loose soil mixed with the water, and the muddy water flowed down the hills carrying with it the richest portion of the soil--topsoil. Most of the organic matter was concentrated near the surface and, as the plowing was shallow, the richest part was washed away and the less productive subsoil remained.

Year after year, settlers grew the same kind of crops on the same fields. So it is not surprising to find reference to worn-out land in the eighteenth century. In the sections heavily populated before the Revolution, crops became poorer until, finally, the farmers abandoned much of the land. For early Massachusetts, records indicate that most of the land near the coast was abandoned at least once before 1800.

The settlers always had their eyes to the west, for by going west they were able to satisfy their land hunger. So vast was the western country, it did not seem possible that there could ever be a shortage of land. They acted almost as if vegetation was an enemy of man, and removed it ruthlessly with fire and ax. They pushed farther and farther west, burning and chopping as they went. What does it matter, they thought, if we wear out a field in a few years? No matter how much land we spoil, there will always be plenty more.

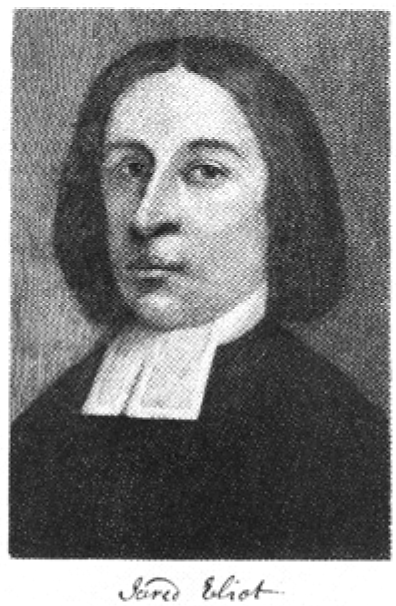
But there were a few who believed differently. They were farsighted men who could imagine the time when the good land would all be used up. They had farmed and had observed others farm and they watched the land grow poor and were worried about it.

By constantly talking and writing about the importance of soil conservation, they began a movement which has grown until now everyone knows that the soil must be conserved. The efforts of these men to prevent soil depletion on their own farms were successful. Although their neighbors often did not profit by their advice and experience, each effort added a little to the knowledge already gained, and in many cases the conservationists developed ways of saving the soil that are still being used, at least in principle. These efforts should be an inspiration to us, today, to carry on our work. The early conservationist had few books to guide him, no engineers or soil scientists, no program of research, no help from the Government. Generally, his plea for the preservation of his country's most precious natural resource, the soil, was a voice crying in the wilderness. The early conservationists were too few in number for a coordinated attack that would preserve the land as a whole. It remained for following generations to carry on from the beginning they made--to coordinate the methods of soil conservation and the initiative of the farmers into a national program for preserving farm lands.

JARED ELIOT

1685-1763

THE BEGINNING OF AMERICAN AGRICULTURAL LITERATURE



In colonial times almost every man was a farmer. Even the preachers and doctors were part-time farmers.

Jared Eliot, a minister and doctor of Killingsworth, Conn., was no exception. In his spare time he practiced farming and when he rode horseback calling upon his parishioners and the sick in his community, he noticed the way other farmers farmed.

He noticed that water running from a vegetated hillside was clear, but that water running from a bare hillside was muddy. He believed that the mud in the water was fertile soil from above. Most of New England was hilly, and every time muddy water ran off one of the fields the field got poorer. Eliot became so much interested in farming that he carried on many experiments, and studied the farming methods advocated by English authors.

At that time there were few books on agriculture and none that was suited to American agriculture. Practically nobody was interested in conserving the soil or in raising better crops or cultivating the land in such a way that it would not wash away.

Because land was so plentiful and capital was so scarce colonial agriculture was wasteful and inefficient. Eliot resolved to do what he could to improve the crops and to conserve the soil. After many years of experimentation and observation he incorporated his ideas into the first American book on agriculture, a series of essays, the first of which was published in 1748.

A large part of the book was devoted to a discussion of English practices. Between the time of the first English settlement in the New World and 1750 English agriculture made rapid strides, but in the colonies there was little improvement.

In England, "Turnip" Townsend was the outstanding advocate of root crops during the late eighteenth century and helped pave the way for scientific rotations. Eliot was familiar with Townsend's work as well as with the writings of another Englishman, Jethro Tull, who believed that the cultivation of soil was the secret of fertility.

EROSION AND ITS RECOGNITION

Eliot's ideas on agriculture were influenced greatly by the work of Tull and Townsend, but perhaps even more by John Bartram, the first native American naturalist (1699-1777). For many years Eliot and Bartram corresponded and their letters show a recognition of the erosion problem which was unusual for the period. In an undated letter to Eliot, John Bartram *(3, pp. 203-204)*[1] wrote:

> *One cause is very obvious in rich low lands. by ye banks of rivers that are fresh. which are Anualy enriched by ye floods that brings down mud & trash deposited there where ye stream doth not run very strong or in eddy or back water or where there grows bushes weed or brambles to retain ye leaves or trash that is brought down: I have observed that in Pensilvania East Jersey & York government thair rich low lands before they was cleared: produced abundance of hasels. weeds & vines. which entangled ye trash which ye floods brought there: & in time rotting kept it very rich. but when cleared & plowed they had A contrary effect upon it & instead of bringing a rich supply & leaving it they often bore away some of ye best of ye soil which was a fine black sandy Loam: & if ye stream hath a fall & Consequently runs swift, it often leaves A coars sand which impoverisheth it: & moreover as ye higher ground & hills is trod & pastured. ye water in great rains washeth ye earth much more in gullies, bringing down more course sand or clay than formerly. as I have observed when I was in ye back parts of ye Country above 20 years past when ye woods was not pastured & full of high weeds & ye ground light then ye rain sunk much more into ye earth and did not wash & tear up Ye surface (as now). ye rivers & brooks in floods would be black with mud but now ye rain runs most of it off on ye surface is colected into ye hollows which it wears to ye sand & clay which it bears away with ye swift current down to brooks & rivers whose banks it overflows & where ye current runs swift it leaves ye sand behind but where ye stream is checked some of ye rich sedimen remains & enricheth it greatly.*

Eliot's ideas regarding sedimentation were substantially the same. He believed that the richness of the valleys was caused by deposition of fine material washed from the hills, and that most water contained fine particles of soil. Turner, who helped edit his essays, observed that a foot or two of sediment might be accumulated in a short time. To determine the amount of matter in suspension, Eliot performed several experiments in which he evaporated various types of

[1] Numbers in parentheses refer to Literature Cited at end of book.

water. Rain water, he found, contained but little foreign material.

Although sedimentation might enrich a valley, the removal of the soil from hills left them sterile. As Eliot *(8, p. 29)* said:

> *When our fore-Fathers settled here, they entered a Land which probably never had been Ploughed since the Creation, the Land being new they depended upon the natural Fertility of the Ground, which served their purpose very well, and when they had worn out one piece they cleared another, without any concern to amend their Land, except a little helped by the Fold and Cart-dung, whereas in England they would think a Man a bad Husband, if he should pretend to sow Wheat on Land without any Dressing.*

At this time few farmers made any effort to save manure from the farmyards, and land had become so poor that "it would raise turnips no larger than buttons." Such land needed dung. This, however, could not be purchased for "love or money." Eliot, while recommending manuring, warned against the use of manure on sloping lands, where it would be washed away by the rain.

EROSION AND DRAINAGE

In some places soil washed from the hills had blocked the watercourses and caused valleys to become wet and swampy. Drainage of such land occupied an important place in Eliot's soil-building program. To accomplish this, he recommended that a hole be dug on the lower side of the land to be drained and connected with the natural drainage system by means of a ditch. The greatest obstacle was the clogging of the drainage hole by sand and sediment. Eliot *(8, p. 67)* found that--

> *in a few Days there will be a fine Sed.iment, thin like a Cob-web in the bottom of the Hole, which will intirely stop the Passage*

of the Water, but this Film is easily broken by stirring up the Bottom with an Hoe.

It was also necessary that the ditches have sufficient fall to maintain a steady flow of water. To keep the ditches free from sediment, Eliot *(8, p. 14)* recommended:

If the Ditches drain well there is another Advantage; in the Spring when there is much Water, by stopping one Ditch you may shift the Water into another to cleanse it, and so to a third: Hereby you will save the charge of the Yearly Scouring of them with the Shovel, which is a good saving: I find by Experience I have that Advantage.

SOILS AND FERTILIZERS

Eliot was firm in the belief that everything in the world was good in its proper place. He was aware of the fact that, as a result of erosion, heavy soils were concentrated in some places and sandy soils in others. It was the duty of man to balance such inequalities. Eliot considered the problem of restoring the original texture of the soil so that eroded lands would again become productive. He believed that swamp mud should be deposited on the worn hillsides and that sand would often convert a wet piece of land into a fertile meadow. He agreed with Turner *(8, p. 156),* his editor, who commented:

when we see the Sand and gravelly Hills we seem to be at a Loss what they were designed for; but as Nature hath not made any Thing in vain, we should turn our Thoughts to the Melloration or mixing of Soils, and we shall then find that every Thing is good for some Thing. When I have travelled the Road, I have seen on one Hand large Sand Hills, where the small Spires of Grass struggled to rise an Inch in Height, and on the other Side a gloomy Bog, that produced only Frogs and Reptiles, and have been at a Loss to know what Use they could be put to; till a few Rods further hath convinced me, that the Rains which have washed the Sand of the Hill on the Cole heavy Soil of the Bog bhath begun a filne Piece of English Meadow; This

Hint which Nature hath kindly given, must be a full Proof that Sand is a proper Dressing for low wet Ground.

Many of Eliot's experiments concerned different types of soil amendments. In addition to mixing soils of different textures, he' also favored burning clay and peat together and using the ashes to enrich the soil. He recognized the value of limestone and shell sand and also subscribed to the principle of enriching lapnd by means of green manure. Although he recommended turning under oats, rye, and millet, he felt that buckwheat was better than any of them.

None of these amendments, Eliot realized, surpassed manure in value. A farmer who did not use the animal manure and wastes of his farm was likened to a man who drew money out of the bank and put none back. Manuring, however, was difficult as long as land remained unenclosed. A few such fields were left at the time when Eliot was writing. Even a provident farmer, using an unenclosed farm, could not conserve the manure of his stock for the benefit of either his tilled fields or pastures. Equally bad from the standpoint of soil wastage, according to Eliot, were large farms that, of necessity, suffered from neglect. He introduced evidence to prove this contention and urged that farmers should concentrate their efforts on a few acres.

PLOWING

One of Eliot's most important contributions was the exposing of the most harmful of Tull's fallacies. From his experiments he found that cultivation increased crop yields, but he also discovered that, without the application of manure, Tull's system of intensive plowing was useless on many soils. He agreed, however, that dry soil could be kept more moist by occasional stirring, that plowing helped to dry out wet land, and that, unless soil was kept loose and mellow, it could not utilize the rainfall effectively.

The farmers of Eliot's generation were prejudiced against deep plowing. When he plowed deep, the old farmers in the neighborhood warned him against spoiling the soil. Like others of his and of later times, Eliot felt that the dew contained enriching, nutritious salts that would fertilize the soil if turned under. This he regarded as an additional reason for deep plowing, preferably at dusk when the dew was on the ground

Tull's horse hoe, Eliot found both inefficient and clumsy. As an improvement, he invented a drill which would open a furrow, plant seed, and drop manure in a single operation. He secured the aid of President Clap of Harvard and Benonai Hylliard, a village blacksmith, in designing the tool. For testing, the drill was sent to William Logan of Philadelphia, who was another outstanding agricultural leader of the period.

SOIL-BUILDING CROPS

At the time Eliot was writing, much of the grazing land of Connecticut was already depleted or exhausted. He felt that prosperous agriculture was dependent upon good pastures. Consequently, many of the soil conservation measures he advocated were designed for pasture improvement. Besides animal and calcareous manures he employed red clover, timothy or herd's-grass (as it was called in New England), and various wild grasses.

Red clover was considered the most valuable crop for building up poor land. He recommended that every farmer should have a bushel or two of clover seed on hand. His advocacy of a clover or grass crop during the fallow years was a very important change in New World agriculture. Eliot attributed the revival of agriculture in England to the use of clover and grasses. As a general rule, however, he did not recommend blind acceptance of English practices and crops for New England.

Because the climate and soil differed from those of England, he favored the introduction of no new methods until they had been thoroughly tested. This conclusion was based on a thorough study of English agriculture. Throughout his book many ideas are borrowed from English writers, but they are usually qualified with accounts of experiments that he or other Connecticut farmers had conducted. Besides clover and grass, which were integral parts of the diversification system, root crops such as turnips and carrots were highly recommended. He observed that many were using turnips as feed for livestock but that few knew of clover.

Jared Eliot, the first of the pioneers, made his contribution by calling attention to soil washing and its dangers while they were still undreamed of by most American farmers. Although when his work was completed, erosion control was still in a most elementary stage, his book was much used by his successors. His works represented a distinct departure. They constituted the beginning of a literature on agriculture in general and on erosion control in particular

SAMUEL DEANE

1733-1814

AN ADVOCATE OF EXPERIMENTAL AGRICULTURE

After the time of Eliot, more farmers became interested in measures for protecting and enriching the soil. Occasionally someone would write a book or a pamphlet on agriculture, and by 1800 about 20 of these had been published. But agriculture as a whole had been going downhill. As the slopes became poorer, the rich valley land suffered, too, because sand, gravel, and poor subsoil were washed down from the hills. In many places the rich soil had long since been washed off.

While the water was at work carrying away the soil, the wind was at work also. Wind erosion in our country has never attracted so much attention as erosion by water until a few years ago when the fertile soil of the Dust Bowl was carried high into the air and carried across half a continent to be deposited in the Atlantic Ocean. A few of our forefathers, however, were bothered by wind erosion.

Samuel Deane, who lived a generation later than Eliot, was the first to attempt to control wind erosion. The lives of the two men were somewhat similar. Both were ministers, both were farmers, and both accepted little on faith alone. Both were familiar with, but questioned, the ideas of English agriculturists.

Deane relied on experiment even more than Eliot did. He became so much interested in his agricultural experiments that when the Revolution broke out, he retired to his farm at Gorham near Portland, Maine,[2] and devoted all of his time to agriculture. About 1787, he began writing his book which he hoped would improve American agriculture. The New England Farmer or Georgical Dictionary was published in 1790 and for a generation became the standard text on American agriculture.

Like Eliot, Deane recognized the ill effects of erosion by water in New England and developed ways to overcome it. He observed in his book that with heavier rainfall in the hills "more of the fine mould would have been washed down into the hollows; and deeper channels would have been made in the soil by the running of water which are considerable inconveniences" *(6, p. 232).*

PLOWING TO PREVENT EROSION

The principles of plowing to prevent erosion, developed by Eliot, were carried forward by Deane. Both recommended deep plowing and Deane suggested that farmers should plow their furrows a little deeper each year.

In addition Deane recommended contour plowing to prevent gullying and sheet washing. In this respect his work paralleled that of Thomas Jefferson (For discussion of Randolph's and Jefferson's contributions to erosion control, see Hall [9].) and Thomas Mann Randolph of Virginia. All agreed that wherever sloping lands were cultivated, contour plowing should be adopted. Randolph directed his efforts toward the development of a hillside plow that would eliminate dead furrows and permit all of the soil to be turned in one direction. Deane, however, suggested that a less cum-

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[2] Until 1820, Maine was a part of Massachusetts. To avoid confusion, "Maine" is used in this paper to identify all places included in the present state of Maine.

bersome plow was needed in order to reduce friction. To some extent this could be accomplished by plating the wooden moldboard with iron.

Where an entire hill lay within one field, Deane recommended that it should be plowed all the way around the hill on the contour. The hentings, or parting furrows, furnished drains in which the water moved so slowly that none of the soil was washed away. If only one side of a hill were to be plowed, the team should return light each time so that the furrows would all be turned in one direction.

At first Deane suggested throwing up banks of earth on the contour but dismissed the idea in favor of ribbing, which was merely running parallel contour furrows at intervals on sloping lands to prevent washing. On cultivated land, the furrows were to be made in the fall and spaced 3 or more feet apart, depending on the steepness of the hill. For pastures that showed a tendency to wash, he recommended furrows 8 or 10 feet apart. In this way, Deane extended the principles of contour plowing to pasture management. (From this time on, some conservationists occasionally suggested a crude form of terrace. Terracing did not become popular until the Civil War, however, and few of the earlier farmers actually carried out the idea.)

The principles of terracing and strip cropping, widely used today, were also advocated, in a combined form, by Deane. His "alternate husbandry" consisted of plowing the land in flat ridges about 9 feet wide. The ridges were alternately planted in grain and allowed to lie fallow.

In addition to general farm improvement as a method of preventing soil wastage, Deane recommended several specific techniques. To prevent erosion on ditch banks, Deane recommended that strong-rooted grasses be planted on their margins. To prevent gullying along roads and paths about the farm, he suggested the use of carts with wide wooden wheels. Some of these in use, he said, had wheels a foot wide.

CROP ROTATIONS

Deane was particularly interested in experimenting with various types of crop rotations. He clung, in part, to the old, bare-fallow system, believing that it was wise in some cases to renovate the land in this way. He did favor, however, planting rows of potatoes or carrots at intervals on the fallow land. Although he had read many English treatises, giving various sequences of root, grain, and brass crops, he was not disposed to accept them until he had tried them in New England. Long experience was necessary to determine the best rotation, but little experimentation had been done along this line.

On the basis of experience and observation, Deane made a few tentative suggestions. For light, warm soils, he recommended corn, peas, or potatoes for the first year; for the second year, rye or barley; the third and fourth years, clover; the fifth, wheat; and the sixth and seventh, clover. For cold stiff soils, he recommended oats or potatoes for the first year; second year, potatoes well dunged; third year, flax or wheat; and for several years thereafter, grass. One of Deane's principles was that the so-called "white" crops should never be grown for more than 2 years in succession. A "green" or soil-building crop should be alternated with "white" crops. (White or exhausting crops included oats, corn, flax, rye, and barley: green or soil-building crops included legumes, root crops, and grasses.)

Observations led him to suggest different rotations for different areas. For Bristol County, Maine, he suggested: The first year, Indian corn; the second year, rye, wheat, oats, or barley; and for the third and fourth years, clover. In Cumberland and Lincoln Counties of Maine, it seemed desirable to raise field peas, oats, or potatoes during the first year; Indian corn with much dung, the second year; barley or rye, the third year; and herd's-grass and clover up to the tenth year.

Deane was one of the few farmers of the colonial period who relied chiefly on potatoes. He was considered the best farmer in the community, but even his total production was low, an indication of the small scale of production of the subsistence farmers of New England. In one year, his total crop yields were as follows: 70 bushels of potatoes, 50 of French turnips, 40 of English turnips, 5 of peas, 2 of buckwheat, 70 of carrots, 3 of parsnips, 4 bushels of beets, and 500 cabbages *(35, p. 366).*

It is significant that Deane, on his own farm, had more or less abandoned grain crops because they depleted the soil. Although clover was inserted in most of his rotations, he still remained critical of it, not conceding that it was better than any other "grass." He admitted that it improved the soil near the surface but doubted if it made the soil as a whole any better, though agricultural authorities of his time agreed that a clover "lay" was a good preparation for wheat.

METHODS OF ENRICHING THE SOIL

In regard to green manures, Deane favored Eliot's suggestion that millet would make poor land rich *(6, p. 116).* He also recommended peas and oats, and said that some farmers had used clover and ryegrass with success.

All of Deane's methods of soil renovation were subsidiary to his main idea that there could be no real improvement without dung. Quoting Dryden, he said that farmers should not be ashamed of their occupations, as many of them were, but "should toss about their dung with an air of majesty" *(6, p. 2).* The practice of saving all manures, in conjunction with a reduction In the size of farms would, he felt, make farming successful in New England.

Deane suggested a number of methods by which the farm manures might be best utilized. He endorsed Eliot's idea of mixing soil and manures, but carried this idea still further by suggesting that the soil and manure be mixed in a declivity so that the wash from the surrounding area might be utilized. In this compost heap, he put all the usual farm wastes including leaves, ashes, and trash of various kinds. In addition, he believed that the practice of folding, whereby cattle were penned nightly for the purpose of preserving their dung to enrich the soil, was a good one although seldom practiced.

Deane's ideas on soil texture were similar to those of other writers of the late eighteenth century, since he thought soil fertility was largely dependent on this characteristic. Like Eliot, he suggested adding sand to clayey soils and clay to sandy soils. In particular, he recommended that marsh mud or any kind of rich intervale soil be transferred to the worn hillsides.

WIND-EROSION CONTROL

Aside from the Cape Cod and Wallingford settlers, Samuel Deane was the only colonial writer who considered wind erosion an important problem for New England farmers. Even then there were numerous, small wind-eroded areas that had to be abandoned and that occasioned the settlers discomfort in times of high wind (fig. 1). "Some barren sands consist of very fine particles, and have no sward over them. The wind drives them before it, and makes what are called *sand-floods,* which bury the neighbouring lands and fences"

FIGURE 1.–Blow sand on the margin of a wooded area in Connecticut.

To prevent the blowing and drifting of sand, Deane *(6, p. 161)* recommended hedge fences as well as plantations of locust trees.

> *This tree grows best in a sandy soil, and will propagate itself in the most barren places, where the soil is so light as to be blown away by winds. By sheltering such places, and dropping its leaves on them, it causes a sword to grow over them, and grass to grow upon them. * * * those who possess hills of barren sand * * * should not delay to make forests of these trees on such spots.*

Like soil conservationists of today he realized that black locust trees not only reduced erosion but also provided valuable weather-resistant material for fence posts.

CONCLUSION

Not all of Deane's ideas regarding the prevention of erosion were original. He acknowledged that many of them had been practiced by other farmers before he tried them. He was the first, however, with the exception of the Cape Cod settlers, to suggest measures for wind-erosion control. His methods of plowing were the forerunners of the hillside ditch. He seems to have put into practice more erosion-control measures than any other American farmer prior to 1790. His book on agriculture, the New England Farmer, probably exerted more influence on New England farming than any other book published in the United States before the Civil War. It ran through a number of editions, and was revised and "brought up-to-date" by later agricultural leaders. It was the only comprehensive treatise on agriculture published in New England before 1800.

SOLOMON DROWN

1753-1834

A FARMER AND SCIENTIST

Solomon and William Drown, of Providence, R. I., father and son, were joint authors of The Compendium of Agriculture, or the Farmer's Guide. Solomon, the father, seems to have been chiefly responsible for the book, which was published in 1824, toward the end of his long and distinguished career. During the Revolution he served as a surgeon in the colonial army. Later, he was prominent as a public official, a scientist, and an author. In recognition of his outstanding scientific contributions, he was appointed professor of botany and *materia medica* by Brown University in 1811. Among his friends were Benjamin Franklin, Thomas Jefferson, and other prominent men.[3]

EROSION AND ITS CAUSES

Throughout his life Solomon Drown retained an active interest in agriculture but noted the progressive deterioration of the land, to which he attributed increasing poverty among the New England farmers. He regarded the current system of tillage as the principal cause of erosion and commented:

> *Whatever may be said to the contrary, all soils certainly suffer some degree of deterioration by long, unremitted tillage. When divested of that clothing with which nature always defends it, if undisturbed, and when turned up naked to abide the force of*

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[3] The information on Solomon and William Drown was selected from the files of the Work Projects Administration Erosion History Research Project, 101-2-26-186, Washington, D. C.

the blast, the happy medium of consistence is deranged, its best particles carried away in torrents, and it is left a feeble skeleton, possessing only the faint semblance of departed fertility. [See Drown (7, p. 82).]

Shallow ploughing, and ploughing up and down hilly land, have, by exposing the loosened soil to be carried off by rains, hastened more than any thing else, the waste of its fertility. When the mere surface is pulverized, moderate rains on land but little uneven, if ploughed up and down, gradually wear it away. And heavy rains on hilly lands, ploughed in that manner soon produce a like effect, notwithstanding the improved practice of deeper ploughing. [See Drown (7, p. 49)]

Not only was the soil washed away when sloping land was plowed up and down hill, but applications of manure often suffered the same fate. The liquid parts of the manure were particularly susceptible to washing by rains and melting snows. Cow dung was probably most erodible, but all animal manure was likely to be washed or blown away if methods of prevention were not employed. Barnyard manure was frequently left in exposed positions on the hillside where every rain carried some of it away. To prevent this evil, Drown advised placing the barnyard in a low place or declivity and the placing of gutters around the edge of the barn roof to drain the water away so that it would not drip on to the manure.

Methods of tillage which caused water erosion left the land in such a depleted condition that it also was subject to wind erosion. The finest particles of soil and the humus were the first to be washed or blown away as the soil was loosened by plowing.

Drown felt that the New England farmer's distaste for so-called book farming was based on the fear that new methods of soil renovation or erosion control might not be practical. Most farmers fancied that those who wrote knew nothing about the practical side of agriculture. When some new method was suggested to them, they contended that it was impractical, or an insult to their ancestors, or that it was not suited to the area. What was good enough for their fathers was good enough for them. Drown believed that the most desirable course to be followed was one to be based on a union of theory and practice.

Farmers of Drown's day seemed to be consumed by land hunger. They enclosed large tracts of land when they could have made just as good or an even better living on small farms by taking proper care of the soil. The American farmer, having had access to large areas of land, refused to believe that a time would come when fertile land would be scarce. Nevertheless, this time had then come in New England. To secure profit from the land, farmers had to concentrate on a few acres and adopt methods for safeguarding the soil against soil erosion.

ALTERNATE HUSTANDRY AS A METHOD OF EROSION CONTROL

Constant cropping combined with bad plowing was the chief cause of soil erosion. Consequently, any system which would prevent erosion and restore the soil to its former fertility must include a proper rotation of crops. Rotation of crops, which Drown called alternate husbandry, was the only way in which fertility could be restored. He contended *(7, p. 83):*

> *Convertible husbandry, or regular alternation's of tillage crops and pastures and meadows, seem therefore, to be the only system by which the fertility of the country can be preserved and improved. Whatever pains we take, whatever expenses we incur, in collecting instruments of husbandry, in accumulating and applying manures, and in tilling the earth; all is to little purpose, unless to these we superadd a succession of crops, adapted to the nature of the soil * * *.*

All crops were divided into two classes, the "culmiferous" or robbing crops--sometimes called white crops--which included corn, wheat, barley, oats, rye, and millet; and the so-called "leguminous" or green crops, which included beans, peas, turnips, cabbages, carrots, parsnips, and buckwheat. Land of average fertility might be kept constantly in crops without fallowing by a proper interchange of white and green crops.

Drown favored a large proportion of root crops on the theory that a rich agricultural country must be a cattle-raising country and that root crops must be raised to furnish cattle with food during the long, cold New England winters.

Rotations were evidently devised in relation to the amount of soil that had been washed away. A gravelly soil was planted first to rye and then to clover, alternately. The soil was plowed deeply and gypsum applied. For a light, reddish, sandy soil Drown employed a rotation consisting of: First year, turnips well-manured with compost; second year, peas with gypsum; third year, rye with red clover seed; fourth and fifth years, clover with the application of gypsum after each mowing. For a dark, sandy loam, which showed no signs of erosion the following rotation was recommended: First year, Indian corn and potatoes, interplanted; second year, turnips, wheat or rye; third year, clover; fourth year, wheat or rye; fifth year, corn; and sixth year, potatoes.

If land was nearing exhaustion, Drown cautioned that two white crops should never be raised successively. Grass should be grown for 2 or 3 years and be followed by green crops. Thereafter alternate husbandry could be practiced with profit.

PLOWING TO PREVENT EROSION

Deep plowing, though helpful in preventing erosion, was not in itself enough. The destructive practice of plowing up and down the slopes must also be stopped. In its place Drown recommended the use of plows adapted to hillside cultivation or else the Butler method, whereby a hillside plow was not necessary. This method was followed "by carrying a furrow down the hill only, and by inclining this furrow to the left hand * * * in proportion to the descent of the declivity--and suffering the team to re-ascend the hill without a furrow" *(7, p. 49).*

Drown estimated that this method would lessen the day's work by one-third instead of one-half, as the team would travel faster on the way back. To this he added:

> *In this way, the steepest hill may be ploughed, a single furrow left open to the wash, except the last one, and the saving in the strength of the team, and in the value of the crop, which will arise from the extra goodness of the ploughing, will doubly compensate for the loss of time.*

THE RELATION OF EROSION TO DRAINAGE AND IRRIGATION

Like some of the southern agricultural leaders, Drown believed that the evil effects of soil erosion might be partially mitigated by a system of irrigation, whereby muddy water or water full of sediment was turned on to eroded land. Muddy water was recognized as the most favorable to vegetation because "besides giving the necessary moisture, it furnishes a considerable portion of alluvial matter" *(7, p. 56).* Water charged with sand and gravel, however, was injurious. Before flushing a gravelly spot with muddy water, Drown recommended that the heavier particles should be allowed to settle in a reservoir.

The easiest way to accomplish such soil renovation was to divert a brook or a part of a river so that it spread its waters over grasslands. Drown determined the quantity of water to be diverted in relation to the needs of the soil. Sandy soils required more sediment than those of finer texture. In all cases the fall of the conveying ditch was very slight so that the ditch banks would not be lavished and the heavy particles of sand would be dropped before the water was turned on the spot to be treated. Drown found this method to be the easiest and cheapest mode of fertilizing poor land because it promoted fertility without the expense of manure.

In draining land or in constructing ditches designed to irrigate land, care was taken to prevent sediment from clogging the ditches. The ditches were wide and deep enough to carry the water even in times of flood. The sides sloped so that the cattle could not trample them down and so that the water would not wash them. Generally the ditches were approximately three times as wide at the top as at the bottom and strong-rooted grass was planted on the banks to prevent erosion and caving.

WIND-EROSION CONTROL

The methods for controlling wind erosion recommended by Drown were similar to those for controlling water erosion except that green manures received more emphasis. The plowing under of green crops was considered beneficial on all light soils. On land particularly susceptible to blowing, at least two crops, plowed under, were necessary before the land was planted to grain. Buckwheat, millet, peas, oats, or turnips were useful for this purpose but rye with an application of gypsum or marl ranked first.

Cover crops were necessary in many cases where the land was subject to severe wind erosion. According to Drown *7, p. 36):*

> *Even a blowing sand may be reduced to a loam by sowing plaister with red top or other fibrous rooted grasses unto a sward call be obtained then dress with plaister * * * and mix them well with the sandy turf by harrowing.*

Blowy soils were also treated with clay, peat, vegetable mold, animal manure, or mud of swamps and ponds. Drown said that a dressing, of clay 2 or 3 inches thick would usually make such a soil productive but in extreme cases, no amount of soil amendments would make it amenable to row crops.

On newly cleared land some trouble was experienced because of wind erosion if the trees and other vegetation had been removed by burning. The wind carried away the ashes and the soil which had been dried out by the intense heat. To prevent this, Drown ran a heavy harrow over the land several times to raise the mold and mix the soil underneath with the fine materials at the surface.

The ideas of Solomon Drown were similar to many others held by contemporary New England agricultural leaders. He, like Deane and Eliot, had considerable influence not only because of his wide acquaintance but also because he wrote voluminously and was at the same time a practical farmer. His work was continued into the next generation by his son, William, whose agricultural career was nearly as distinguished as that of his father.

JOHN TAYLOR

1753-1824

THE UTOPIAN STATE

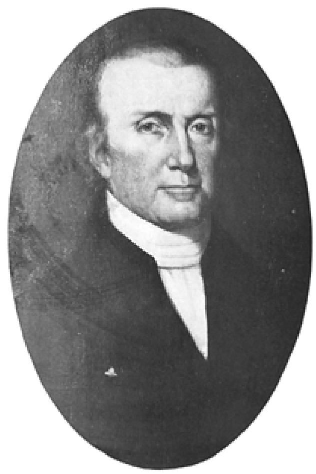

Figure 2.–John Taylor of Caroline County, Va. From Simms (30) *by permission of The William Byrd Press.*

During the years following the Revolution, a large group of southern farmers recognized the dangers of soil erosion and directed their efforts toward its control. Outstanding among these was John Taylor (fig. 2). Like Jefferson and Randolph, Taylor was a Virginian. He was born in Caroline County in 1753, was educated at William and Mary College, and in 1787 became a member of the Philadelphia Society for Promoting Agriculture. He was active in later agricultural organizations and in 1818 was President of the Virginia Society for Promoting Agriculture. Taylor lived on the Rappahannock River near Port Royal, Va., and in the 1780's purchased two large farms in that vicinity.

John Taylor was of the school of wealthy gentlemen farmers who, like Jefferson, wanted to preserve the old order of agriculture. He believed that the well-being of the Nation was to be identified with the well-being of the farmers. What was good for the farmers was good for the country at large.

The Utopia of Taylor's dreams was a country where the soil was well cared for and where the farmers controlled the Government *(33, pp. 278-279):*

> *At the awful day of judgment, the discrimination of the good from the wicked is not made by the criterion of sects or of dogmas, but by one which constitutes the daily employment and the greatest end of Agriculture. The judge upon this occasion has by anticipation pronounced, that to feed the hungry, clothe the naked, and give drink to the thirsty, are the passports to future happiness and the divine intelligence which selected an Agricultural state as a paradise for its first favourites, has here again prescribed the Agricultural virtues as the means for the admission of their posterity into heaven.*

This statement appeared first in a Georgetown, D. C., newspaper in one of a series of agricultural essays. These essays were published as a book, Arator, which appeared first in 1813, and ran through eight editions. It was read more and had more influence on southern farming than any other book on agriculture published before the Civil War, with the possible exception of Edmund Ruffin's Calcareous Manures.

EROSION AND ITS CAUSES

None of the southern agricultural leaders recognized more clearly than did Taylor the havoc that resulted from uncontrolled erosion *(33, pp; 172-173):*

> *If inclosing, manuring, deep and horizontal ploughing, were unattended by any other advantages, that of preventing the land from washing away would in many views be a sufficient recommendation of such a system.--The disaster is not terminated by the destruction of the soil, the impoverishment of individuals, and transmission of a curse to futurity.-- Navigation itself is becoming its victim, and in many parts of the United States, our*

Agriculture has arrived to the insurpassable state of imperfection, of applying its best soil to the removal of the worst farther from market.

To Taylor, it seemed that much agricultural labor was directed toward destroying land rather than building it up; that farmers had applied their energy to "draining the hills of their barren sands, for the purpose of pouring them upon these rich vallies" *(33, p. 245).* Furthermore this "ruinous evil" had so clogged the channels of the streams that they were obstructed by debris that caused flooding in wet periods.

Figure 3.–Erosion and sedimentation on a Virginia cornfield.

This deplorable condition had been in part caused by the three-shift system of corn, wheat, and pasture, in which the soil received neither rest nor fertilizer, and was trampled by the stock. Taylor had little confidence in rotations devised to mitigate the evils of this system (fig. 3). "Trust not," he advised, "to the delusive promises of a rotation of crops for restoring our soil. It will aggravate the evil it pretends to remove" *(33 p. 222).* Still worse was reliance on rotations on farms entrusted to overseers *(33, p. 76):*

This necessary class of men are bribed by Agriculturists, not to improve, but to impoverish their land, by a share of the crop *for one year; an ingenious contrivance for placing the lands in these states under an annual rack rent and removing a tenant. The farm, from several gradations to an unlimited extent, is surrendered to the transient overseer whose salary is increased in proportion as he can impoverish the land. * * * the fees of these land doctors are much higher for killing than for curing.*

The root of the trouble, according to Taylor, lay in the burdens which had been placed upon agriculture by the manufacturing and commercial class. The bankers and traders, who produced nothing and who constituted only one-eighth of the population, had caused agricultural poverty by taxation, currency manipulation, and protective duties. In many cases the higher lands were taxed, the poorer they became.

Taylor opposed tariffs because the best markets for agricultural goods were abroad and the best markets for manufactured products were at home. Transportation charges on foreign manufactured goods gave home manufacturers enough of an advantage on the home market. Since the farmer who sold his products abroad had to pay freight charges and compete with foreign producers, agriculture rather than industry should receive Government protection. But, the Government, he said, was controlled by the commercial and manufacturing classes and, as a result, the farmer was penalized. As a partial remedy Taylor advocated that the United States should create an agricultural board, similar to the English, and that marketing agreements should be made whereby agricultural products could be sold abroad more profitably.

Taylor believed that soil erosion was caused principally by unjust laws and that, unless it received attention from the Government, the country faced ruin. He maintained *(34, p. vii):*

Legislatures must begin to notice and discuss the state of agriculture, before they can discover or remove the causes of the *cadaverous countenance exhibited by the soil. These causes lie concealed in the laws.*

The population, furthermore, was rapidly declining because of soil exhaustion. Whole counties had become sterile, and the people had come to view the country "with horror" and to "flee from it to new climes with joy" *(33, p. 11).*

Other causes of soil waste in the South were the refusal of the planter to look honestly at the situation and the tendency to place the blame for the decline of agriculture on the system of slavery. The slaveholding planters were kept from making improvements "by the lazy and hopeless conclusion, that the destruction of their lands, and the irregularities of their negroes, were incurable consequences of slavery" *(34 p. 218).*

THE TAYLOR SYSTEM AS A METHOD OF EROSION CONTROL

Recognizing that political and economic conditions were not the only causes of agricultural decline, Taylor developed his so-called system of soil renovation, whereby the planters themselves could effectively reduce erosion. This was based on two principal theories; that soil fertility was derived from the air and that this fertility could be restored principally by means of vegetable matter. The best method to restore vegetable matter to the soil was through enclosure, whereby the largest amount of vegetation possible was raised by penning the stock, restricting them from the arable land, and by utilizing fodder crops in place of pasture. This system was similar to John Lorain's system of "soiling" described later [on page 25].

Vegetable matter could also be restored by means of animal manure. If the animals of the farm were kept in small pens and fed on the grass, corn, and other forage crops, manure could be produced in large quantities especially if all the litter, stalks, cobs, leaves, and stems were mixed with it. These methods of soil improving Taylor *(33, pp. 224-225)* found particularly desirable for erosion control.

> *The effect of manuring and enclosing united in stopping gullies and curing galls, is an hundred fold greater, than the most ingenious mechanical contrivance. Land filled with roots, covered with litter, aided by buried bushes forming covered drains, protected against the wounds of swine and hoofs, and replenished sex-ennially with the coarse manure of the farm and stable yards will not wash. Under such management, the bottoms of the gullies will throw up a growth capable of arresting whatever matters the waters shall convey from the higher lands, soon become the richest parts of the field, and thenceforth gradually fill up. I have long cultivated considerable gullies created by the three shift, grazing and unmanuring system, and cured in this mode, which produce the best crops, are secured against washing by their great fertility, and are gradually disappearing by deepening their soil.*

Corn had long been condemned as a soil exhausted, but Taylor believed that by means of this crop larger amounts of manure could be procured. Because it produced more food for cattle and vegetable waste to be used in making compost, he preferred it to any other crop. He warned that rotations might maintain fertility but that they would never restore it.

Taylor's system did not exclude stock from all lands, but only from those intended for crops. In permanent meadows, tooth and hoof would not injure the tougher sod, but fields that had been laid down to grass for the purpose of resting or soil building should never be pastured.

Next to corn, the great soil builder was cowpeas, which Taylor regarded as superior to clover. According to one of his followers *(1, p.101)*--

every prudent landholder will provide a sufficiency of the stock or cowpea, to be sown down broadcast preceding the ploughs, say from 3 to 5 pecks per acre. These protect the lands from the intense rays of a summer's sun, prevent it from washing, leave a rich deposit of vine and leaf.

Taylor's system of enclosing was tried out successfully by other farmers. He reported that in 1817, one of his sons had doubled the value of a hilly plantation in 7 years by means of horizontal plowing, manuring, and enclosing.

PLOWING TO CONTROL EROSION

As a method of turning under a large supply of vegetable matter to enrich and rebuild the soil, Taylor favored deep plowing. This also rendered the soil porous, facilitated subsurface drainage, and thereby helped to prevent soil washing and gully formation. Many of Taylor's ideas on plowing were colored by his belief that as much soil as possible should be exposed to the fertilizing effects of the atmosphere. For this reason he objected to a flat surface. He also stated that ridges left in the field would serve as barriers to the water that would otherwise flow off and cause erosion. To reduce erosion further he recommended that sloping fields be plowed on the contour. He particularly commended Randolph, the son-in-law of Thomas Jefferson, because he had invented a hillside plow and developed a system of contour plowing that had proved highly successful in Albemarle County, Va. For the origin of contour plowing, Taylor credited the highland farmers of Scotland, who had plowed in this way for over a hundred years.

According to Taylor, all slopes should be plowed horizontally whether ridged or flat broken. In case the land was thrown up in ridges for planting, the level and sloping parts could be reversed in alternate years.

GULLY CONTROL

One of the foremost problems of southern agriculture was the reclamation of gullied land. Taylor ordinarily preferred dry vegetable matter to prevent soil washing, but in the case of gullies and on hillsides where all the topsoil had been removed, he found that the application of green bushes was the best method. On the basis of experience he wrote *(33, pp. 223-224):*

> *I have tried this vegetable manure by strewing the whole surface by packing it green in large furrows and covering it with the plough by packing it in such furrows in the same state and leaving it to be covered with the plough three years afterwards and by covering it as soon as the leaves were perfectly dry, sowing it previously with plaster. Each experiment of which the result is determined, is highly gratifying. The last on nearly a caput mortuum of a galled and gravelly hill side exhibits good corn planted over the bushes as soon as they were covered. It is in vain to begin at the wrong end to improve our system of Agriculture. Fertility of soil alone can give success to ingenious theories. These applied to barrenness at best resemble only the beautiful calculations of a speculator, who demonstrates a mode of making fifty thousand dollars from a capital of an hundred thousand to a man worth only an hundred cents. The capital must precede the profit.*

Fortunately the soil, though thin or badly eroded, had the capacity to produce bushes so that there were plenty available for manuring and curing galls and gullies. Pine and cedar bushes not over 2 inches thick were preferred.

THE PREVENTION OF EROSION IN DITCHES AND ON STREAM BANKS

Among the forms of erosion noted by Taylor was the tendency of streams to cut their banks, particularly if they turned at acute angles. This he prevented by planting shrubbery or green cedar trees at strategic points. In places the banks were reinforced by using stones or gravel to withstand the force of the water.

The same principles were followed in the construction of drainage and hillside ditches. Side ditches on lowlands where water concentrated were abandoned as well as ditches with acute angles. Taylor advocated winding ditches that merely slowed the course of the water. As he said *(33, p. 247):*

> *side ditches are speedily filled up. Straight ditches give an impetus to the current exposing a crumbling soil to a constant abrasion and devoting the point upon which it expends its greatest fury to great injury. Acute angles create strong currents and are unable to withstand weak ones.*

Obstructions too heavy to be washed away by the stream were removed. Taylor, however, suggested that streams or ditches might be turned into low places or hollows so that the sediment would lodge there and thus level the field. Recognizing the carrying power of running water, Taylor built a canal to convey sand to a valley bottom and thus caused the creek to retire gradually into a narrower channel.

In time of flood there was a tendency for the ditches to become filled with sediment. To remedy this situation Taylor constructed covered drains by first digging trenches and placing heavy poles in them. These were covered with brush. He inclined the brush upstream at a 45° angle and packed it in to 10 inches from the level of the surrounding ground. The brush was then covered with leaves, followed by dirt. Taylor claimed that a drain of this type would last a hundred years.

TAYLOR'S INFLUENCE ON AGRICULTURE

John Taylor was the most influential southern agricultural reformer of this time. Edmund Ruffin, writing a few years after his death, said that almost every intelligent landholder became a reader of Arator. John Adams believed that no agricultural writer had equaled Taylor, and Madison and Jefferson highly praised him and accepted his word as final on any agricultural subject. Taylor's influence, however, was on the wane before his death in 1824.

Taylor more than any other of the southern planters expressed the feeling of men like Thomas Jefferson--that the city was bad, the country good. He believed patriots might be found on the farm rather than in the city or in the legislatures *(31, p. 291):*

> *When the future historian of our republic, shall search for arts of patriotism and matter for biography, the contrast between the heroes who hate created and the politicians who have ruined a nation, will afford him ample room for exhausting the strongest phrases of eulogy and censure.*

JOHN LORAIN

ABOUT 1764-1819

EROSION UNDER NATURAL CONDITIONS

John Lorain was an active member of the Philadelphia Agricultural Society during the years when Taylor was writing Arator. Although he has received little recognition for his work, he was one of the few men of the Middle Atlantic States who actively tried to solve the erosion problem. Few facts are known about his life. He was born about 1764, spent the first 42 years of his life in Maryland, purchased land in Pennsylvania in 1806, and probably began farming near Philipsburg in 1812. He wrote 13 essays on various agricultural subjects for the Philadelphia Society for Promoting Agriculture, between May 1810 and January 1814. His book Nature and Reason Harmonized in the Practice of Agriculture was published in 1825, after his death.

The ideas of Lorain regarding erosion are strikingly similar to those of today. He believed that under natural conditions the soil gained as much as it lost. This he called the balance of nature. But civilized man had upset this balance and had destroyed in many areas not only the living but also the dead vegetation on which soil fertility was dependent. According to Lorain *(23, p. 518):*

> *Before this inconsiderate being [man] enters the forest glade or prairy, nature had been for ages enriching the soil for his use * * *. The fertility of it might be preserved and increased * * * if a system of agriculture calculated to keep the ground fully replenished with decaying animal and vegetable matter was practiced and due attention were paid to the augmentation of live stock in proportion to an increase of ability, instead of the ruinous practice of perpetual ploughing and cropping.*

Under natural conditions erosion was for the most part beneficial. All alluvial land came into being as a result of erosion processes. Animal and vegetable matter was washed into the low places, and the deep and rich bottoms were formed by the depositions of the ages. Since the banks of creeks and rivers have a tendency to be higher than any other part of the flood plain, excess water collected in low places behind the river banks during floods. In all low areas and declivities "the winds, together with washing rains and melting snows, lodge much animal and vegetable matter" *(23, p. 338).*

The soil which was washed into the valleys, Lorain realized, came from the mountains and hills *(23, p. 347):*

> *Now nothing can be more obvious than that valleys bounded by high hills or mountains are principally indebted to the annual depositions made by ages from those hills or mountains for the very deep covering of vegetable and animal matters * * *.*

Consequently the valleys became richer at the expense of more elevated areas. However, nature was careful to gather and apply animal and vegetable matter to replace that taken away so that weathering and erosion did not as a rule cause a net loss of soil. This process was described by Lorain *(23, p. 339)* in the following manner:

> *The animal and vegetable substances are swept away by torrents of water and high winds, in large quantities from hill sides; more particularly in northerly exposures. We also see even in the lower grounds that torrents of water or some other cause have formed wide and deep hollows. That notwithstanding, time has covered the sides and bottoms of them with soil and timber, the soil on the sides of the declivities, is often much poorer than that on the adjoining grounds above them, as animal and vegetable matter gathers on places from which much of it is washed or blown off.*

Sedimentation in valley bottoms, however, might prove disastrous if the texture of the deposits were coarse. Many

Pennsylvania farmers, Lorain reported, did not want bottom lands because they were inundated by floods, which mixed considerable quantities of sand among the grass.

THE CAUSES OF ACCELERATED EROSION

Destruction of soil before man appeared on the scene was negligible. The activities of man were, Lorain believed, the cause of accelerated erosion. He condemned heartily the ruinous system of agriculture which exposed the soil to washing rains, causing poverty of soil and thereby general poverty of the region. To him soil wastage was an "insatiable monster, [who] like Arron's serpent, swallows all the rest" *(23, p. 518).* To him, man seemed inexcusable and deserved to be punished for his sins against common sense, himself, his posterity, and his community.

Particularly blameworthy was unwise use of the plow *(23, p. 200)* because--

> *this is the principal reason why the sides of hills and declivities are so soon impoverished; the furrows are too generally formed up and down them, and although some form them along the sides of the hill it too often happens that this is done wrong. If the furrows have too much fall, gullies will be formed in them, and if the fall be too little or none at all as sometimes happens in part of them while in other parts the fall is quite too great, the water will find its way over the field and form gullies in it. The farmer too often in forming his furrows along the side of a hill pursues a straight course without duly considering that the inequalities in the surface require that his course should be governed by them or the fall in the furrow will be far from being regular.*

To this Lorain added that the ruin of many fields could be attributed solely to careless furrowing and plowing. Among his acquaintances there were but two farmers who plowed in the proper manner.

Although a sufficient fall was required for furrows, too much was a direct cause of gullying and soil washing. Steep furrows, according to Lorain, caused the sides of hills and declivities to be impoverished quickly. The furrows were too generally plowed straight up and down the slopes. If the fall of the furrows was insufficient however, the water found its way over the fields and formed gullies there.

The whole cropping system increased the evil edects of bad plowing. Lorain *(23, p. 281)* observed that--

> *the injury is much the greatest where long continued and severe cropping without attention to grass or manure has not only reduced the large body of partly dreaded vegetable substances * * * but also reduced the animal and vegetable matter so much that the ground soon after it was ploughed, became a compact mass unless a very considerable proportion of it was sand.*

But sandy land was equally to be feared because it became an easy prey to the wind, and unless the season was very wet the earth was blown from the roots of the plants.

Even in the back country of Pennsylvania the soil was being ruined. Although this was caused in part by cutting of timber, Lorain particularly deprecated the savage practice of burning off the land. He felt that the regular continuation of burning would sooner and more effectively ruin the richest and best of soils than any other mode of management yet proposed.

Other less direct causes of erosion were the tenant system, the application of impractical and expensive methods of soil improvements by the gentlemen farmers, the cheapness of land, the scarcity of labor, the lack of capital, the transient nature of agriculture, and the pursuit of high profits.

While normal profits were consistent with a sound farming system, the desire for quick profits was the principal cause of the poverty of the soil. The mistaken idea that the profits from rearing livestock accumulated too slowly to be financially practical induced the farmers to crop the soil yearly, with but little attention to grass or to increase in the number of cattle. This continued until the land became so exhausted that rest was absolutely essential for subsequent crop production. By this time the soil was greatly impoverished, the seeds of the grasses were destroyed, and the ground cover consisted of a scattering of grass and weeds. Lorain realized that this condition exposed the soil to the injurious action of the wind, washing rains, and melting snows.

Equally to be condemned were the operations of some of the gentlemen farmers who paid no attention to gain but squandered large in order to promote some soil conservation measure. They leveled their fields at great expense, carried mold and mud from woods and creeks to eroded hillsides, and employed other expensive measures. The common farmers were too discouraged by the total expense of erosion control to realize that some of the measures advocated were economically feasible. Consequently all were ignored.

Lorain felt that men like Arthur Young and Sir Humphrey Davy were often unfamiliar with the problems of common farmers and that Young, in particular, was unjust when he characterized the peasants as the most ignorant men in the world *(23, p. 547).* Young should have realized that nature was not partial in her distribution of talents, and that those best qualified to make improvements were often those who were most familiar with farming in practice, although they might be ignorant of the rules of grammar and rhetoric. Economically sound improvements made by poor farmers received little publicity, *(23, p. 547)* but--

if a gentleman has reclaimed a small portion of waste land, even if it has been at an expense which has exceeded the value of the grounds after the improvement has been made, we seldom fail to hear much of it.

The tenant system, as well as slave labor, was condemned by Lorain as bad for the soil. The tenant, since he had no interest in the land, was apt to waste it, and the slave, being forced to labor and made to suffer degradation, could not be expected to employ conservation measures. The remedy was to free the slaves (Lorain freed his slaves very early in his farming career), and make soil improvement a condition of all leases.

Large farms and cheap land also encouraged soil waste. Too much land was cleared in proportion to the capital available for improvement. Consequently, no care was taken of the land, and labor was scattered over such a wide area that the farmer had little time to conserve his soil. Many farmers also had an idea that somewhere they would find a soil which was inexhaustible. Consequently, they were constantly seeking new areas. As Lorain said: "When the Pacific Ocean puts a stop to their progress, it is possible they will be convinced, that no such soil exists" *(23, p. 240).*

While condemning some farmers for ignorance of good agricultural practices, Lorain also criticized those who relied on erroneous and ill-founded theories developed by book farmers. He believed that many of the current theories were fallacious and was very critical of such men as Taylor, Peters, Davy, Arthur Young, and others. He even admitted that some of his own earlier practices were based on ill-founded theories.

GRASS AS AN EROSION-CONTROL CROP

Lorain was firm in the belief that grass was the best crop to ward off the depredations of wind and water. In addition it introduced new vegetable matter into the soil and so helped to maintain or restore its fertility *(22, pp. 326-327):*

> *The grasses are nature's pabulum of cultivated plants, and if properly applied, will create good soil where it never existed before; and will communicate sufficient adhesion to light blowing sands, for growing luxuriant grain crops; and red clover, with the aid of gypsum, will in this highly favoured country, enrich a thin soil to an almost incredible extent, in a very few years: and will plentifully replenish the farmer's mows with excellent hay, if a proper system of management is pursued.*

He incorporated grass into his system of rotations and for steeply sloping land suggested it as a permanent crop. In this way land useless for cultivation could be made more or less profitable. Similarly if fields were laid down to grass before they became exhausted, their fertility could be continually preserved by letting a full crop of grass decay on them as often as seemed necessary. This method of restoring soil fertility Lorain considered as effective as manuring.

Grass served to prevent erosion in several ways. It retarded run-off during heavy storms because instead of falling on the soil with much force, the water trickled down gently and soaked into the earth. Under grass the soil also became more absorbent partly because of the presence of vegetable matter and partly because the roots broke up the soil and kept it loose and porous.

A more luxuriant growth of grass could be secured by spreading a small amount of gypsum over the land. Lorain reported that the use of gypsum or some other form of lime to produce an erosion-resisting vegetation cover was common in Pennsylvania. Seldom had he seen a soil so exhausted that it would not respond to the magic of gypsum. Where farmers spread it in strips across their barren fields, the portion of the field which had been treated could always be recognized by its more luxuriant, dark-green grass. In the other parts the grass was thin, sparse, sickly, and light green in color. Nevertheless, gypsum, alone, was insufficient. Supplementary animal and vegetable manures were frequently necessary, and if the grass crop was removed year after year, the effect of gypsum was soon lost.

Lorain was an ardent believer in pasture restriction, not only because the grass should be left on to protect and enrich the soil, but also because overpasturing was inevitably accompanied by trampling of the ground. This produced a hard, non-absorbent surface from which the manure might be washed away by the first hard rain. But to Loran, grass itself was the chief goal because only grass could prevent "the ultimate ruin of the soil."

CROP SYSTEM TO PREVENT SOIL WASHING

Lorain's whole system of crops and rotations was designed so that a maximum amount of vegetable and animal matter would be introduced into the soil in order to safeguard it from the ravages of water. He believed with John Taylor in the advisability of penning stock and providing them green forage rather than pasture. This method of feeding, which he called "soiling," was devised to provide an adequate supply of manure. By this system, Lorain could regulate the use of manure and apply it to the land which had deteriorated most. Furthermore he believed that more stock, and consequently more manure, could be produced by soiling than by pasturing.

For a plot of 20 acres Lorain's crop system was as follows: 4 acres of manured fallow crops, 4 of wheat and other small grain, and 12 of grass. To him the introduction of fallow crops in place of bare fallow seemed a most important advance. In general, he favored keeping a cover on the land at all times except when it was necessary to plow it.

At least 2 years of grass ordinarily preceded corn, and on especially thin land, from 3 to 9 years of grass or clover was necessary. In Maryland, an old friend of Loran had reclaimed land (which was so high that it got little benefit from washings) by laying it down in timothy for 9 years.

Lorain apparently introduced many variations into his crop system. Although he said that grass and timothy together with soiling formed the backbone of his soil-renovation program, he used a rotation which included cowpeas as a preparation for corn, and beans to prepare the land for wheat or other small grain. Various kinds of clover were also used, as well as the interplanting of rows of potatoes, heavily manured, between rows of corn set 8 feet apart. This latter idea came from George Washington who had reported it to be highly successful.

Lorain, unlike some of his contemporaries, would not agree that any one crop would ruin the soil. He believed that any crop could be introduced into the rotation provided it was preceded by a crop of grass or clover, which would supply the necessary vegetable matter. Corn, he maintained, could be grown in any soil, not excepting blowing sands, if the ground were adequately manured.

PLOWING

A considerable part of Lorain's attention was devoted to methods of plowing. Next to the introduction of vegetable matter into the soil, Lorain considered water-furrowing as the best defense against soil washing. Before the water furrows were run, the ground was to be surveyed and the furrows opened according to the natural lay of the land, even though it were necessary to run them in serpentine courses. Like Taylor, he realized that too steep an incline would create gullies and induce soil washing. The furrows were to be spaced from 11 to 16-1/2 feet apart. For spring grain the interval could be somewhat wider, but not wide enough to permit soil washing between furrows. The crop was sown in rows paralleling the water furrows.

In the system devised by Lorain, furrows here laid out in such a way as to make the water flow through as many furrows as possible, care being taken that they should be deep enough to carry the water. In many cases the plow alone was insufficient and the furrows had to be deepened with shovels and hoes. Care was taken to prevent the water from concentrating at one point and breaking through the furrows in times of excessive precipitation. To preclude such breaks, cuts were made to release impounded water at the proper points thus eliminating the danger of accelerated soil washing.

If possible the water furrows were run before the seed was planted, otherwise the heavy rains and melting snows tended to wash away both the seed and the soil. When cross furrows were necessary, due to the hollows and hills, these were opened after planting and at every cultivation.

Plowing followed the contour also, and the furrowslice was always turned toward the lower side to prevent the water from breaking through. Obstructions were removed, heights leveled, and plowing done as evenly as possible. The land was plowed 7 inches deep in the fall when vegetable matter was thickest on the surface. The system of open furrows was supplemented by the turning of the furrow slice in such a way that it would form an underground drain. As much vegetable matter as possible was turned under in order to make the soil porous, thus increasing underground drainage. In this way, each furrow slice formed an effectual underdrain, more especially if the field had not been pastured and the furrow slice only moderately compressed with the roller. Sometimes drainage of this type made the use of water furrows unnecessary. Lorain, however, was opposed to underdrainage, whereby the water was drained off in covered ditches, considering this method of erosion control too expensive and too difficult to maintain.

CRITICISM OF TAYLOR'S METHODS OF EROSION CONTROL

While Lorain accepted some of Taylor's theories and practically all of his recommended practices, he condemned the ideas that the atmosphere constituted the reservoir from which soil fertility was drawn and that dry vegetable matter constituted better manure than green stuff or animal manure. No vegetable fertilizer, said Lorain, was equal to animal manure. Taylor should have noticed the difference between corn grown on land after clover had been turned under and on land that had been fertilized by animal manure. Even Taylor ignored his own theories when he found that animal manure was necessary in growing tobacco.

Taylor's recommendations concerning the treatment of gullies were accepted by Lorain, who considered them superior to any other method yet discovered. In defense of this idea Lorain *(23, p. 536)* said:

> *Animal manure would soon be washed out from galled declivities or gullies as this gentleman [Taylor] elsewhere calls them; therefore in such places green bushes may be much more profitably employed. They naturally arrest at least a part of the soil washed into them, and with it, the enriching matter s contained in the part arrested. By this means the gullies are eventually filled and commonly with a deep soil well stored with nutriment. Colonel Taylor is certainly justly entitled to great praise for his prompt attention to gullies which are but too generally neglected and much land ruined by them and also for the economical practice he has adopted of making the gullies productive, while time aided by his very ingenious contrivances, is filling them up: likewise for doing this by employing nothing but green bushes and small brushwood * * *.*

Lorain believed that gullies could also be e hacked lay filling them with stones removed from meadow lands.

Although Lorain *(23, p. 550)* contended that some of Taylor's theories were fallacious, he considered them, as a whole, sound, stating:

> *Nothing that is capable of being used as manure seems to escape the notice of this great economist, and almost every thing done by him seems to be accomplished with the least possible labour and expense.*

John Lorain's work in Pennsylvania paralleled that of Taylor in Virginia. Lorain, however, realized that the average farmer of the Middle Atlantic States was financially unable to adopt many of the erosion-control practices recommended for wealthy landowners of the South. He was the first American agricultural leader to emphasize inexpensive control measures by which the poor farmer, as well as the wealthy, could conserve his soil.

ISAAC HILL

1789-1851

THE MAN AND HIS TIMES

Isaac Hill lived when New Hampshire was going through its period of greatest land exploitation (fig. 4).[4] (During the period when Hill was editor of the Farmer's Monthly Visitor, he seems to have been the author of practically all of the anonymous editorials and articles.) From an economic standpoint he considered it inevitable that *(13, p. 34)*--

Figure 4.–Isaac Hill, pioneer soil conservationist of New Hampshire. From Stackpole (32) by permission of the American Historical Society.

> *the virgin soil of every new country must be cultivated in a manner that necessarily leads to its exhaustion, and the more fertile the soil the greater danger that deterioration will not stop until necessity shall either force its abandonment or a change of cultivation from actual suffering.*

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[4] Most of the information on Isaac Hill was selected from the files of the Work Projects Administration Erosion History Research Project, 701 - 2-233, Boston, Mass.

New England had gone through this stage of development, and agricultural improvement was vital to its economic security.

In spite of the handicaps of lameness and of a frail physique, Isaac Hill became the most important agricultural reformer in New Hampshire and the champion of erosion control. He was accused by his political opponents of being insane. At an early age, he embarked on a newspaper career and assumed the editorship of the New Hampshire Patriot in 1809.

Hill was one of the few political leaders of New Hampshire who became an ardent advocate of the principles of Thomas Jefferson. Like Jefferson, he believed that the most ideal country was one composed of free landholders. Later he became a follower of Andrew Jackson. In 1829, when Jackson appointed him to the office of Comptroller of the Treasury Department, the Senate refused to confirm him. The next year, however, he was elected to the United States Senate and in 1836 was elected Governor of New Hampshire. In 1839 he became editor of the Farmer's Monthly Visitor, and it is in the files of this farm journal that he wrote so much about the dangers of soil erosion.

ECONOMIC ASPECTS OF EROSION

Although Hill realized that the washing of soil from the hills into the valley was responsible for the formation of alluvial land, he recognized its disastrous effects upon the uplands. He quoted with approval a comment by a farmer named Nesmith *(17, p. 161)* before the Merrimack County Agricultural Society at Franklin in 1842.

> *We have here in New Hampshire many extensive farms once fertile, that scarcely now by their products pay for the labor employed upon them. Look at many of our hill-tops, rendered*

> *entirely barren by a long course of wasteful cultivation, united with the ordinary action of winds and rain. Do we not hear the voice of help crying to us from such grounds?*

At the time Hill was writing, many New Hampshire farmers were emigrating to the more fertile and virgin West. Although Cheshire and other New Hampshire counties had suffered a decline in farm population from 1830 to 1840, he believed that with proper farming methods and soil-building crops, New Hampshire farmers could make a good living on the land of their forefathers.

Hill feared that New England might suffer the same fate as Virginia and Maryland. New England soil was less subject to erosion, but nevertheless over a long period of exploitation, it also would become depleted. He agreed with John Taylor that the problem of decreasing fertility was a national and not a local problem. In his travels he observed soil erosion wherever he went. When traveling through Virginia to Delaware, he commented on the general land abandonment *(18, p. 153)*--

> *whole districts of country have been abandoned as sterile; and he who travels through this country in many directions would suppose the greater part of the country had never been capable of producing ordinary crops.*

Every new country, Hill believed, passed through a cycle of soil exploitation. All areas of the United States either had gone through this period or would shortly after being put into cultivation. Richness of soil was no barrier against soil erosion. The lands of Virginia and Maryland and other Southern States proved this. New England soils, though not so rich as Virginia land in its virgin state, were now much more fertile. But this was no protection against the future.

The main cause of soil erosion on cultivated land was continued cropping without the return of any plant food to the soil. If man took out of the soil more than he put into it, poverty was inevitable. A point would soon be reached when the exploiting farmer must change his methods of cultivation and his crops or abandon his calling.

EROSION IN NEW ENGLAND

There were several types of soil erosion which Hill considered: Flood erosion, in which large quantities of soil were carried along by the streams; the slower process of sheet erosion; slides and slumps, whereby the soil was moved without the particles becoming disintegrated; and wind erosion, which developed chiefly when the humus content of the soil had become exhausted.

Flood erosion and bank cutting were of great importance to the New Hampshire farmer because the consequent sediment sometimes enriched the land but sometimes destroyed its productivity. The backing waters of a single freshet on the Merrimack, Hill observed, had covered some of the land with black sediment to a depth of 3 or 4 inches. Where the same freshet flowed directly over the land, sand was deposited in beds ranging from 6 inches to 3 feet deep.

Every flood, however, had good effects because some of the deposits were "the wash of fertile particles from lands above." Land was naturally renewed in this manner and consequently did not need fertilizing.

Sedimentation in rivers was responsible indirectly for floods, because the channels became choked and caused the river to overflow. The channels of many rivers were constantly changing. An example cited by Hill *(19, p. 23)* was the Potomac near Washington where a bridge had--

> *arrested many million cords of alluvion coming down from above, partially choking up the whole channel of the river between that and Georgetown. At the time of Braddocks expedi-*

> *tion previous to the war of the American revolution, a British fleet of heavy ships moored in the river above Georgetown--now it is with great difficulty a ship of considerable size can coat in the waters above the Washington navy yard.*

Hill was interested especially in the shifting of river channels and its effects on the farming land. He discussed this subject from time to time in the pages of the Farmer's Monthly Visitor, saying *(14, p. 76):*

> *These phenomena occur frequently on the Merrimack where we reside and in sight of which we are now visiting. The high water freshets of the present spring have made sad inroads upon our own fine alluvion situated on both sides of the river the present spring. It pains us to see several feet of beautiful grass ground caving off every season, although our neighbor on the other side is a gainer of an equal amount of land to that of our own loss.*

Sometimes the river cutting was gradual, but in time of flood it was greatly accelerated. In one case a "river has dashed in and torn down several rods during the past winter, carrying thousands and thousands of cart- loads of sand" *(20, p. 74).* A dam had to be built on one side to prevent the road from being washed away. Later the river was straightened and the water was made to do the work of removing a "tongue of some hundred acres to the west side."

Bank cutting was a characteristic of many New England rivers including the Connecticut and Merrimack. At one point on the Merrimack, the river would float a 74- gun ship. Thirty-five years later he cut good grass at that same point, and where he once raised corn the "center of the river now is." He believed that no human power could completely prevent these changes.

The Merrimack had changed its bed completely in 37 years of its history. Although much land was destroyed, relatively large areas were fertilized in the process of soil removal and deposition. As Hill *(20, pp. 73-74)* said:

> *Much of this falling strata possesses fertilizing qualities hardly less than the best of manures. Laid upon the intervales in rich sediment it makes the place of its deposite a perpetually rich bearing field. In some banks the greatest portion of sand washed down before it reached the river, where there was a chance for it to spring up, we have measured the timothy and red-top standing five and six feet high.*

Hill lived in an area where mass movement of soils was a fairly common phenomenon. He believed that landslides were caused by removal of the vegetative cover on steep slopes, observing that slides commonly occurred after fires and after prolonged periods of excessive precipitation. He agreed with an elderly gentleman of his acquaintance who explained the causes of a landslide on Mt. Monroe as follows *(12, p. 119):*

> ** * * the surface including the body and roots of trees having been burnt off, a long drought converting what remained of the soil to extreme dryness, and this becoming afterwards heady from a superabundance of rain, was precipitated down by its increased weight.*

In 1839, in an article in the Farmer's Monthly Visitor, Hill discussed the landslides of Kearsarge Mountain (near Conway, N. H.) which was once covered with soil and timber. Some 25 to 30 years previously a fire had burned over the top of the mountain, increasing in intensity for several days, and "consuming not only the dead and living trees, but burning up the greater portion of the soil itself" *(10, p. 66).* Hill believed that this caused a slide a few years later in the spring of 1819, when "a large mass of rocks and earth of many thousand tons was precipitated from the top of Bald Hill, carrying trees, rocks, and soil before it for the space of more than 40 rods."

The slide which drew most attention was that of 1826 in the White Mountains. Hill described how the Saco River tore a new channel through a farm because a great mass of earth and rocks filled its old channel *(11, p. 118).*

Slides came down the mountain on the side opposite his [Crawford s] house which choked the river turned its course and covered up much valuable tillage and grass ground. Rocks of great weight overwhelmed him from above and gravel usurped in extended space the region of vegetation. Mr. Crawford supposes that at least one half of his intervale ground in the simple process of one night was covered up or destroyed.

THE FORMATION OF SOIL

The role of water in the formation of soil, under natural conditions, as seen by Hill, was a process whereby land was temporarily deteriorated at the point where the water picked up particles of soil and enriched where they were deposited. The formation of fertile valleys was brought about by this process. Many valleys were once lakes which had been filled with sediment so that the water was drained off to lower ground.

The character of the alluvial material deposited, however, varied under natural conditions. In places where rivers cut new channels, Hill observed that a rich black mold was sometimes underlain by layers of sand and gravel; below this there might be a layer of quicksand, that could easily be undermined by the water.

The richness of the valleys was attributed to the vegetable matter which had been washed down from the hills. As an example, Hill cited a brook flowing from Kearsarge Mountain which frequently overflowed an adjacent meadow. The meadow, he said, "probably owes its fertility to the sediment from the disintegration of rocks and the soil continually flowing down from the mountain" *(10, p. 66).* He also believed that the mountain slopes were originally as rich as the level areas, and that if erosion were prevented on the slopes, nature would heal the wounds caused by fires, by devastation of the vegetation, and by continued cropping.

EROSION CONTROL

Hill's ideas regarding the formation of soil led him to believe that subsoil plowing not only prevented erosion but also helped to remedy any damage that had been done. On one of his excursions, his attention was called to gully control by means of subsoil plowing by a farmer who lived in Fairfax County, Va. The land to begin with was deeply gullied, but after several deep and subsoil plowings the gullies began to fill up.

Subsoil plowing was accomplished by means of a plow invented by Gideon Davis of Georgetown. D. C. One experiment with this plow was described as follows *(21, p. 9):*

> *Friend Gideon Davis, an ingenious plough maker of Georgetown in the District, visited him [Com. Jones] and witnessing his deep ploughing in the hard clay of ten and twelve inches with the necessity of a heavy team, suggested as an improvement the use of his own invented subsoil plough with a lighter team preceding it turning over the more mellow surface. Since that time Com. J. has practised the method of a light common plough with one horse or mule followed with the subsoil plough and two horses or mules. He has continued this at intervals upon the same ground until he has deepened the vegetable mould of his fields from twelve to fifteen and twenty inches. * * * Reflecting on his experience from our own knowledge we are able to say that the deep stirring of the soil is of great use upon every kind of ground.*

Hill also favored other methods of erosion control which almost every progressive agriculturist of his time advocated, including crop rotations, the protection of manure from the rain, and the planting of steep slopes in grass or trees. He also believed in the use of muddy water to enrich land that needed fertilization. In Massachusetts he noted a gravelly hayfield that had been enriched in this manner. The water was led across the field by a series of winding ditches and deposited fine sediment in its progress. As a result the hay crop on this field was doubled *(16, pp. 110-111).*


Figure 5.–an area of wind erosion in New Hampshire.

WIND-EROSION CONTROL

There were many small areas in New Hampshire which were subject to wind erosion and were bare of vegetation (fig. 5). Hill contended that although the badly denuded areas were small, they were increasing in size and would eventually become a serious menace. His first concern was for those spots that were most severely eroded. They were described as *(15, p. 7)*--

> *vacant naked spots of sand where no vegetation springs because the wind is continually moving the surface. * * * Could the surface remain still, there probably would be sufficient strength in much of this ground for vegetation. * * * It is proved that wherever a location can be made so as to arrest and fix in any one point the moving sand, the ground can be made productive.*

This could be accomplished in a number of ways, depending on the location and facilities of the farmer. If he were located near marl deposits, an application of marl and manure would so change the composition of the soil that grass and even row crops could eventually be grown. When Hill traveled through New Jersey and Delaware, he noted that farmers were using this method to prevent the land from blowing.

In New Hampshire other methods were usually preferred. Isaac Hale, a farmer of Franklin, had controlled wind erosion on 2 acres of light, sandy land by plowing in 150 cartloads of clay, followed by a crop of oats plowed under. Compost, lime, animal and vegetable manures, and even sediment were also used on the sandy, "blowy" soil near the Merrimack River *(15, p. 7).*

> *The sand-banks of the higher intervales on the Merrimack nearest the river are often treated as too sterile for cultivation. With the application of no very great quantity of compost, in a part of which slaked lime was mixed, the editor of the Visitor has succeeded in changing entirely the complexion and texture of a portion of blowing sand. Some of this ground, partaking slightly of the sediment which sometimes accompanies sand brought on in a freshet, sprung up spontaneously in white clover and redtop. Water willows, standing where the sand washed, have not prevented rank grass growing almost in the shade.*

Hill preferred light, sandy land for crops because it was easy to cultivate. He was convinced that much of the "pine plain" land, particularly that near Amherst, N. H., could be renovated. No one method was recommended as superior to all others. The main thing was to change the texture of the soil so that it would become stable. One farmer hauled mud from a swamp to prevent wind erosion; another improved "pine plain" land with mud, lime, swine manure, and compost; a third carried manure from town stables, plowed it under and raised root crops. All of these methods and many more Hill observed and tested and recommended in the pages of the Farmer's Monthly Visitor.

To prevent wind erosion, Hill also tried various rotations. The crop sequence to be used depended somewhat on the degree of deterioration of the land. For "light" land Hill found the following rotation to be the best: First year, turnips (winter) followed by spring wheat or barley; third year, clover; fourth year, pasture; and the fifth year, a crop of oats. For "pine plains," not more than 75 percent sand, the following was recommended: In September, rye and clover sowed together and turned under along with manure in the following spring; second year, corn fertilized with plaster; third year, wheat and clover well limed; fourth year, the clover which was allowed to remain on the land; and the following year, a crop of oats or rutabaga.

Farm owners were urged to cooperate by refusing to rent their land to tenants who would not agree to alternate "white" or exhausting crops with "green" or soil-conserving crops.

Isaac Hill was the first American farmer to become interested in mass movement as a form of erosion and to suggest that its cause was the destruction of the natural vegetation. He also consolidated bits of extant information regarding floods, stream flow, and river-bank erosion. Although he claimed no credit for originating many of the erosion-control measures that he advocated, his approval did much to popularize them. He was the leader in an agricultural movement that "proved that the most barren pine plains can be made to yield a profitable crop, and a fair per cent upon capital invested in such lands, by their skillful cultivation" *(24, p. 12).*

NICHOLAS SORSBY

MIDDLE NINETEENTH CENTURY

THE SCIENCE OF HILLSIDE PLOWING

Nicholas T. Sorsby was a physician by training but a farmer by choice. (The dates of Sorsby's birth and death are unknown. Most of his work on erosion control was performed between 1844 and 1857.) He was a native of North Carolina but farmed in Alabama and Mississippi. His book entitled Horizontal Plowing and Hillside Ditching was the only one devoted to erosion control exclusively that was published before the Civil War. For three-quarters of a century it remained the outstanding exposition on this subject. It was published in numerous forms--by the North Carolina State Agricultural Society, for which it was first written; in the North Carolina Planter in 1858; in the Southern Planter of Virginia; in the American Cotton Planter and Soil of the South in 1859; and as a separate pamphlet in Mobile, Ala., in 1860. The editor of the Southern Cultivator recommended Dr. Sorsby to his readers as one of his most valuable contributors--as one who could discuss agriculture from experience as well as from scientific research.

Sorsby first became interested in horizontal plowing on the farm of his stepfather near Jackson, Hinds County, Miss. It was there that, in 1834, his stepfather introduced horizontal cultivation with furrows run exactly on the level. Later Sorsby induced him to use guard drains and hillside ditches in conjunction with horizontal plowing. This system was adopted throughout the entire 1,000-acre estate.

After observing the operation of his stepfather's contour plowing, Sorsby read everything available on the subject. On the basis of ideas derived from Jefferson, Randolph, and others, he developed his elaborate system of hillside ditching and contour plowing. This he called the most important discovery of the modern agricultural era, but claimed no credit for originating it. The discoverer deserved, he said, "a place upon the tablet of memory next to that of the father of our country" *(31, p. 11).*

Sorsby's system, which differed somewhat from that of Randolph, was probably not practiced either in Europe or in the United States until the nineteenth century. Although he spent a number of years in Europe, Sorsby neither saw it practiced there nor saw any mention of it in English agricultural writings. By 1850, however; it was widely practiced in the South, from North Carolina to Mississippi.

To Sorsby, horizontaling was "a beautiful branch of the science of agriculture," which had as its objects irrigation, drainage and manuring in order that the soil and plant food might be stored and preserved. He believed that *(31, p. vii)*--

> *whilst the horizontal culture and the ridge and furrow system are attracting the attention and being adopted by intelligent planters and farmers, its principles must be studied scientifically and practically, and new discoveries in the art applied, tested, and settled in the minds of men, or else there will be no end to the diversity of opinions that may arise and lead to discussions that may retard the advancement of the new science.*

This new science, Sorsby divided into two main classifications, leveling and grading. Each of these classifications was further subdivided on the basis of local variations in crop, slope, and soil type. All had as their goal the effective control of soil erosion and the preservation of agriculture in the South.

THE CAUSES AND RESULTS OF EROSION

Water was regarded by Sorsby as the most destructive agent in the agricultural system (fig. 6). It was very difficult to control because it was movable, always seeking its own level. When in motion, an increase in the volume of the water rapidly increased its power of destruction. Its power to erode the land was dependent on the length of the slope, the depth of plowing, the character of the soil, and the quantity of water in motion.

Figure 6.–Eroded farm lands of Mississippi

Bad cropping systems, careless plowing, and poor supervision of labor, all contributed to increase erosion on farm lands. Sorsby *(31, p. 18)* contended that planters--

> *trust much to overseers, and negroes and kind Providence for gentle showers to make them crops. But overseers make mistakes, plowmen do bad work, and the clouds pour down heavy rains and the soil as it were, melts and runs rapidly away.*

The most widespread and direct cause of erosion, according to Sorsby, was shallow plowing in straight furrows running up and down hill. For generations, southern farmers and planters had plowed in this manner, until the land in many areas was eroded to such an extent that it was no longer fit for cultivation. In condemnation of such conditions he said *(31, p. vii):*

> *The very sight of decay all around excites in the mind of the young man, disgust, despair, a disposition to abandon the old place once so dear to him and the family, now so much abused, and seek a newer and better place, richer land, among strangers. He has no desire to cultivate the worn-out old fields and perhaps there is no new land to clear. The old method of plowing up and down hill has much to answer for; it has driven many a young man to the South-west and perhaps eventually to prison or the gallows who might have been a useful citizen could he have remained at home and made a living.*

To remedy this state of affairs, Sorsby recommended his "system." If the farmers would only try it they would come to wonder at their past folly. Many farmers had attempted to mend their ways but, unfortunately, they did not always apply the principles of the level and grading culture scientifically, and the result was more erosion. An attempt to run the rows or ditches around the hill without a level was the chief cause of failure. If the fall was too great, the rows became gullies, and soil along the sides of the ditches washed badly. The remedy might be worse than the disease.

So erodible was much of the land in the South that small obstructions or depressions in a field were sometimes sufficient to start gullies, which grew rapidly and soon upset whole drainage systems. As Sorsby *(31, p. 17)* said, "A mole, a stump, bad plowing, the wheels of a cart or wagon, and other causes may break the ridges, and cause the land to wash." Far more destructive were the farmers in the South who "checked" their corn and cotton so as to be able to plow it both ways. Sorsby naturally opposed this system, since it was incompatible with horizontal culture. He contended that it was one of the chief reasons that the farmers were loath to give up their old methods.

LEVEL CULTURE

Level culture, as the name indicates, required that rows be run exactly on the contour. Sorsby described in great detail how this could be done scientifically by means of a "level." His level was similar to that used by Randolph and Jefferson and consisted of a triangular frame with a line and plumb suspended from the apex. When the legs were set at exactly the same elevation. the line fell exactly on the middle point on the crosspiece that held the legs of the frame together. The level was calibrated so that the plumb would fall opposite the 1-inch mark on the crosspiece if one leg were placed an inch lower than the other. If the leg were placed 2 inches downhill the string fell opposite the 2-inch mark on the crosspiece. By means of this instrument a row or a ditch could be run on the level or could be given any desired gradient.

To run a row on the contour, the level was placed on the side of the hill so that the string fell on the zero mark. A stake was driven at this point and then the level was stepped across the hill by placing one toe of the frame where the other one had been. Stakes were driven at each point to mark the line of the furrow. Several guide rows were run at intervals across the hill and the other rows were run between. It was not, of course, necessary to use the leveler for every intermediate row.

This system of running rows exactly on the contour Sorsby believed to be the best and only system of preventing gently rolling lands from washing. It worked best on porous, sandy soils and was least satisfactory on wet soils. It was not advisable to use it on fine, close, tenacious, marly, clay soil resting on a retentive yellow clay subsoil. Such conditions prevailed in the blackjack, post oak, and hickory ridges of Hinds, Madison, Yazoo, Carrol, Holmes, Warren, and other counties of Mississippi. Level culture, also, was not adaptable to the compact red and yellow clay soils of some hilly lands or to the blue and white clays of the lowlands.

By use of the level method of plowing, Sorsby maintained that soil washing was stopped and droughts were prevented because all the rain water was absorbed and held in storage, causing equal crop production all over the field. In many fields, however, level cultivation required a multitude of short rows which necessitated many turns of team and plow, and caused a great waste of cropland and time. It also took constant watchfulness and labor to maintain the system.

There were several variations of the level method of cultivation. It might be necessary, in certain cases, to protect the rows with a guard drain, particularly if much water was concentrated at any one point in times of excessive precipitation.

Guard drains, Sorsby defined as shallow open water channels made with a plow or hoe, accurately laid off and directed across slopes to carry off excess water. Hillside ditches were similar but deeper and closer together. They were laid off on a steeper grade and were intended to remove a greater amount of water. Both were constructed with the aid of a level so that they could be given a definite and uniform slope.

Where it was found necessary to install a system of ditches in conjunction with the horizontal rows, Sorsby employed a second type of level culture, calling it "level culture with guard-drains and hillside ditches." The hillside ditches were given a slight grade but the rows were kept exactly on the contour. This resulted in many short and curved rows because the rows were not run parallel to the hillside ditches. Rows run on the contour, supplemented by hillside ditches, were considered best for close tenacious clay soils, because with the hillside ditches the water did not break over the ridges and flow downhill carrying soil with it. Sometimes it was necessary to curve the rows up or down the hill or throw up embankments at certain points to prevent impounded water from breaking over and starting gullies.

Although the level method, with variations, reduced soil erosion it was not always conducive to the best crops. This is one point that Sorsby mentioned repeatedly. It was particularly true of cotton because too much water was held in storage. Sorsby believed, however, that the preservation of the soil was more important than maximum crop production. Also, if much soil was eroded, crop production would inevitably decline to still lower levels.

To Sorsby, level culture seemed the best method not only of holding the soil but also of restoring exhausted lands. If manure was applied to a leveled field, he felt that there was little chance of its being washed away.

THE GRADING METHODS

On some types of soil and on many fields where the slope was steep, level cultivation caused too great concentration of water. In such areas it was necessary to install rows with a fall sufficient to drain off the excess water without causing the soil to be removed also. Although the grading method introduced new erosion hazards; Sorsby practiced it on his brother's farm in Mississippi and found that it worked efficiently if adequate care were given to the requirements of slope, drainage system, and type of soil. He gave his rows 1 to 3 inches fall in each step of the level and also ran short intervening rows which were plowed on a level. In commenting upon this system he said *(31, pp. 12-13):*

> *The grading method is the safest as a general rule for the culture of cotton, and can be pursued to great advantage on many soils that could be cultivated well on the level method, when*

one is willing to lose a little soil to make a better crop, by draining the land.

There were four variations of the grading method. In the first, a slight grade was given to the rows, but no supplementary ditches were required. In general, this method was best suited to close, clay soils. According to Sorsby, the method was beautiful in theory but difficult in practice, because on some fields no grade was necessary; on others, several different grades were required; and on still others, the type of soil varied so greatly within a field that it was difficult to determine what slope was needed (fig. 7). The rows were necessarily irregular in length and the turning of water from short rows into long ones was a source of danger because it might convert them into gullies. Since it was impossible to prevent soil from washing completely by this method, Sorsby considered it advisable to combine it with level culture.

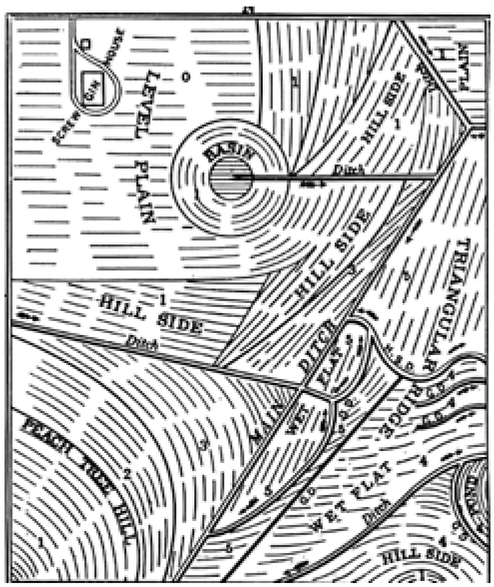

Figure 7.–Sorsby's plan for diversified erosion control on a 45 acre plot: 0, Straight rows run by the eye; 1, level culture; 2, level culture with guard drains; 3, grading method No. 1; 4, grading method No. 2; 5, grading method No. 3.

Above a gully head sufficient slope was provided if the level were set so that the plumb fell opposite the 1-inch mark of the graduated crosspiece. The span of the level was about 15-1/2 feet. If a main ditch was necessary, the rows were not emptied directly into the ditch. Either a drain or two parallel rows were run parallel to the ditch so that the water would drain off gradually. Sorsby seemed unaware that this practice also might cause gullying.

Sorsby's second method of grading required that ditches and rows should have the same fall. Usually a drop of from 1 to 2 inches was given for each step of the level. The main rows were run approximately 5 feet from the drains and the intervening rows were run on the contour to reduce soil washing. The ditches were approximately 12 inches deep and 15 inches wide.

In the third method of grading, a slope was given to the rows so that the water would empty directly into the hillside ditches. The drains and ditches required considerable fall to work efficiently and had to be constructed with great care. In laying off the rows, the level was set at the 1-1/2 inch mark. There was great danger of washing with this system, but it worked well on clay uplands and lowlands.

Sorsby's fourth grading method employed the old system of plowing rows up and down hill, but these rows drained into a series of hillside ditches with a fairly steep gradient. When applying this method the plow had to be raised, during cultivation, whenever it crossed a ditch. It required deep broad ditches with a fall of from 3 to 5 inches in each step of the level. On many types of soil, washing was inevitable when this system was employed and consequently its utility was limited. Plowing and ditching of this type were never to be employed if the slope were steep, but proved generally satisfactory for rich lowlands, slightly rolling uplands, and the prairie or lime lands of Alabama and Mississippi. In all cases, it was better than the old method of plowing up and down hill without any regard for slope.

There were several disadvantages to all the grading methods. If the ditches or the rows were badly constructed, they would choke up and the water would cut the land below them into gullies. If there were too much fall, each row or drain might be converted into a gully and the land below covered with sand and washed from above.

GALLS AND GULLIES

Reclamation of gullied or galled land required the absolute abandonment of plowing in straight rows running up and down hill. Sorsby defined gullies as "open water-channels, caused by rain water and careless up and down hill plowing." To this he added, "They are hideous objects to the eye of a scientific and practical farmer, and should receive the condemnation of all good husbandmen." Galls were defined as "abrasions of the soil, by rain water removing the soil of clay lands long cultivated by the old wash-away method, and leaving the clay exposed" *(31, p. 24).* These he described as land sores, of so virulent a character that they were hard to heal.

A contributory cause of gullies and galls was careless horizontal plowing, in which the planter merely guessed at the contour line and trusted to his eye rather than to a level. Sorsby described the work of one horizontaler on a basin-shaped field. This planter rode a horse around the curve of the hill, with a plowman following his course. Only a guard drain located above the field saved it from being completely ruined by gullies and galls. This example Sorsby called a "horizontal farce." But even horizontal cultivation with the aid of an instrument caused erosion if the fall were too steep. With a proper fall, however, ditches might be used to convey sand for gully filling or to spread sediment over galled spots.

Although the grading system, when properly applied, was an effective method of stopping gullies and galls, variations in grade were necessary because of local topographic differences. In laying off rows and constructing guard drains and hillside ditches, Sorsby considered their relation to existing gullies. Guard drains were always constructed above the heads of gullies. Their construction was described as follows *(31, p. 37):*

> *To lay off the second drain, we commence at the head of the gullies, because if we commence at the fence, the drain might not pass them at that point, and to stop all breaks, gullies and washes, we must remove the cause first, and the cause is usually above the commencement, and sometimes some distance to one side of the break. It requires a skillful eye to detect it sometimes. We commence at the gullies and give two inches fall, and proceed to the south fence, and at the fence we give three inches the last span, to prevent the mouth of the drain from choking with trash and sand.*

To cure galls, Sorsby plowed deeply in the spring and sowed cowpeas, which were plowed under in the fall. This was followed by rye sown in the fall and plowed under the following spring. If stalks, leaves, and other vegetable matter were also turned under, Sorsby predicted that a “tolerable” crop of corn or cotton could be raised from such land by the end of the third year. Such land should always be cut off from the rest of the field by hillside ditches.

Subsoil or trench plowing was another aid in bringing galled land back to life. Because the soil was loosened, less water ran off the field and the subsoil was enriched by the addition of vegetable matter. If the subsoil was sterile, it was not considered advisable to trench plow. Instead a subsoil plow was run in the furrow made by a turning plow, so that only a little of the subsoil would be brought to the surface.

Gullies received special treatment from Sorsby. A few days before the work of horizontaling was started, gully reclamation began. The channels of small or moderately sized gullies were filled by hand with shrubs, pieces of rails, turfs, or other waste matter. Earth was packed in on top and the surface leveled. No gully was to be tolerated either along fence lines or old plantation roads.

For larger gullies more work was necessary. Every 20 paces stakes were driven down and oak boards placed against them to hold back soil and water. The trash packed behind this dam included corn and cotton stalks and pine tops with the branches directed uphill. Each side of the gully was then plowed and the earth thrown into it. Thereafter, the rows were curved in such a way that as little water as possible was concentrated in the old gully.

Gullies that had grown to enormous proportions presented the greatest difficulty. Heavy logs were piled into a ditch dug across the gullies until the top log reached the top of the bank; then heavy material was packed in, and back of it trash and dirt. Hillside ditches were then constructed in such a manner that dirt and sand would be deposited in the old gully. A crop of peas, rye, or grass sown broadcast could be relied upon to hasten the work of reclamation. In 1851, Sorsby told of stopping an enormous gully in 2 years by applying this treatment.

EROSION CONTROL AND DRAINAGE

The drainage of relatively level land was, in Sorsby's opinion, an integral part of the problem of soil conservation. Principles similar to those used in erosion control were employed in draining Care was taken in determining the fall of the ditch, its capacity, and the measures to be adopted to prevent erosion along ditch banks, especially at turns. Since

Sorsby recognized the variations in the carrying capacity of running water, the fall of the land was ascertained before other operations were started. He estimated that a fall of 1 foot in 70 would move pebbles; 1 foot in 400, coarse sand; and 1 foot in 1,000, fine sand. Therefore, he recommended a relatively slight fall of 8 feet per mile, provided the channel could be kept open.

The ditches were kept nearly straight and the fall as slight as possible because crooked channels and steeper gradients increased the erosion hazard. Land subject to inundations in the spring or fall, however, required deep and broad ditches with the fall as great as could be maintained without causing accelerated erosion.

The texture of the soil was also considered in the prevention of erosion when draining land. Some soils, because of mechanical texture, were closer and more disposed to retain water than others. Water flowed more freely through gravel than sand, and through sand than clay.

PLOWING

Deep plowing, trench plowing, subsoil plowing, and the ridge-and-furrow system were used by Sorsby in conjunction with his system of contour plowing and hillside ditching. The ridge-and-furrow system had the advantages of breaking up the soil crust and permitting water to enter the subsoil, of exposing a greater surface of the soil to the sun, of making the land easier to work, and of preventing the soil from washing. Consequently, the ridge-and-furrow system became an important part of Sorsby's farming program of horizontal culture. This practice was, and is, still common throughout the South. Sorsby, however, preferred shallow plowing and flat beds on loose sandy ground or when breaking new land.

Deep plowing was recommended especially for hard upland clay soils, "bald" prairie lands, and for wet bottom lands. The height of the ridges, of course, depended on the crop, the type of soil, and the method of cultivation. For corn, flat ridges were best on dry lands, and high ridges on lowlands. Moderately flat beds were preferred for cotton grown on newly broken ground, porous alluvium, and light sandy soil. On clay lands, high ridges and narrow, deep water furrows were necessary to prevent erosion. The beds varied from 6 to 14 inches in width and from 3 to 4 feet from crown to crown.

In sowing small grain after a tilled crop, Sorsby retained the water-furrow system by sowing on the stubble and then throwing four or five furrows into a land. The stalks were plowed out with a shovel plow and removed from the field.

Subsoil plowing, also, was an important part of Sorsby's system. He believed that it was difficult to horizontalize successfully without subsoiling because of the hard layer of soil which frequently lay beneath the surface. Ditches could not be deepened sufficiently unless this layer of soil was broken *(31, p. 23).*

> *The subsoil plow aids very much the horizontal culture by breaking up the hard pan, the gutters or underground water furrows, galls and gullies, on clay lands; it opens, deepens, pulverizes the subsoil, drains the surface soil by sinking the water, and extending the area of air, manures, and the roots of plants, and thus producing a decided amelioration of the soil and subsoil.*

Subsoiling was performed on all land in the spring or fall, usually with a 2-horse subsoil plow, followed by a turning plow. In cornfields, the land might be subsoiled by running an open furrow with a scooter plow and following it with a subsoil plow. On grain land, the subsoil plow was run in the old and new water furrows. Sorsby believed that subsoiling was necessary on all galled, gullied, packed, or worn land.

Sorsby's system of horizontal plowing and hillside ditching was widely practiced throughout the South after the Civil War. Although his book had great influence, his exhortations did not prevent careless hillside cultivation that caused rather than prevented erosion. The system was in many cases too complicated for the practical farmer to apply properly. In addition, no one man in a single lifetime could develop methods of cultivation adapted to all the variations in soil climate, and topography that occurred in the South. This task Sorsby left to his successors.

EDMUND RUFFIN

1794--1865

GENERAL CONDITIONS OF SOUTHERN AGRICULTURE

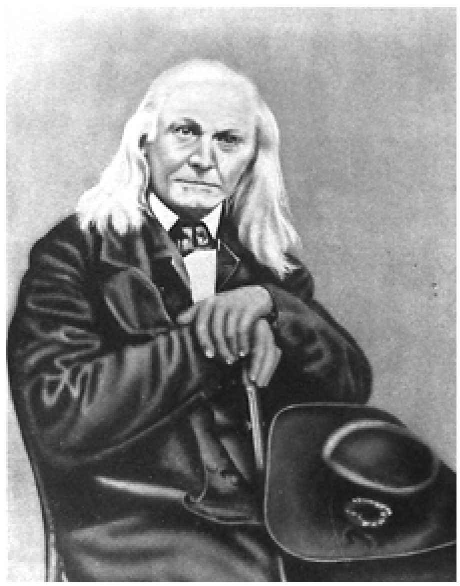

Figure 8.–Edmund Ruffin of Virginia. From Craven (4) by permission of the D. Appleton-Century Co.

Southern agriculture reached a very low point at the close of the Napoleonic wars. The Peace of Ghent, which terminated the wars, ruined the foreign market for grain. Farm after farm in the South had become worn out and gullied. The ruined condition of the Washington and Jefferson estates was typical of many plantations in Virginia. The early efforts of reform had failed, the agricultural societies were dying out. Slaves multiplied in number and became a burden, land was abandoned, and there was general poverty and demoralization.

Although there had been some improvements in agricultural equipment, such as the iron moldboard, most farmers continued to use the old wooden plow, running shallow furrows up and down hill. There was little rotation of crops, and clover and other legumes failed on the eroded and acid lands. Consequently, the supply of manure was cut and fertilization in any large measure was impossible.

The planters were being forced to pay for the ruinous tobacco economy, the whole object of which was immediate great yields regardless of consequence. The scarcity of capital on the one hand and the cheapness of land on the other were substantial causes of the long-continued exploitation of the soil.

It was under such conditions that Edmund Ruffin started farming in 1813 (fig. 8). Although he was destined to play a large part in the agriculture of his country, he was at that time unfamiliar with both the theory and practice of farming. Born in 1794, of wealthy parents, he had received the customary gentleman's education, having been sent to William and Mary College at the age of 16. His record in college was not noteworthy, except that he was suspended because of inattention to his studies. Nevertheless, it seems that he had become a voluminous if undisciplined reader. He stated that he had read a bulky four-volume English work on husbandry and other agricultural books before his affairs required his removal to his father's farm at Coggin's Point on the James River in Prince George County, Va. He remained there for some years, experimenting principally with mineral fertilizers.

Before Ruffin had farmed many years, he became convinced that the poverty of Virginia was caused in large part by man-made soil erosion. He believed that under natural conditions the soil tended to grow better all the time and that under the current exhausting system of agriculture, it tended to grow poorer *(28, pp. 331--332).*

When our ancestors first reached this shore, nearly the whole country was in a state of nature. The savages had cleared for cultivation but a few fertile spots on the banks of the rivers, all the remainder of the land was under one great forest. The streams had not been obstructed by the cutting down of trees across their beds, (by which in many cases streams have since been choked, and swamps thereby formed, or greatly extended.) No dams had obstructed the free and regular course of the streams, and therefore no great artificial floods were formed. The soil not having been cultivated, was not exposed to be washed away by the rains into the rivers. The waters therefore were generally clear, instead of being generally muddy, as since all these circumstances have been changed.

AGRICULTUREAL AND ECONOMIC CAUSES OF EROSION

The river valleys were first cleared by the Europeans who settled Virginia in the seventeenth century. They were tilled without cessation for many years, and, when the population increased to such a point that rich bottom land became scarce, the clearing of the slopes began. Tobacco was first planted on the hill land, then corn for 2 or 3 years in succession, and afterwards corn and wheat were alternated. Between harvesting and planting times the fields were exposed to close grazing. This system, according to Ruffin, was pursued as long as the land would produce 5 or more bushels of corn to the acre. When the land became exhausted or badly eroded, it was abandoned and soon became covered with trees. After 20 or 30 years, the land was again cleared of pines, and the same round of exhausting land use was begun all over again *(26, pp. 36-37).*

This system of farming was dominated by clean-cultivated row crops, which were the greatest direct cause of erosion. As Ruffin *(25, pp. 97-98)* said:

But still there remains in operation one of the surest causes of washing in the almost perpetual recurrence of ploughed crops

> *either corn or cotton by the clean tillage of which the land is kept always in the condition the best adapted to its being washed off by rains.*

The principal natural causes of erosion were slope, heavy precipitation, and the nature of the soil. Ruffin claimed that the farther south one went the more concentrated and intense the rainstorms became. In South Carolina, he said, the lack of adhesion between particles of soil rendered the lands exceptionally susceptible to gullying and washing by heavy rains. This, combined with the hilly surface of the Piedmont, injudicious plowing, and neglect of grain crops sown broadcast, caused an enormous waste of soil by water.

No less important as a cause of erosion was bad farm management. The large landowners of Virginia had from the beginning delegated the direction of their plantations to overseers, frequently ignorant men who neither knew nor cared about soil waste. The South, Ruffin felt, suffered more from soil waste than the North because of the plentiful labor supply. Where labor was plentiful, crops that required a large amount of labor would be grown. Therefore, the South produced tobacco, corn, and cotton; whereas in the North, where labor was scarce, more grass and hay crops were raised. These crops helped to preserve the soil from destructive washing by rains.

In any new country one of the chief causes of erosion is the plenitude of land. This condition, which has existed in practically all parts of the United States at one time or another, encouraged land exploitation. Ruffin attempted to disprove the fallacy that it was profitable to waste land. He contended that a man might reduce the productiveness of his land by half in a single lifetime. He emphasized that destruction of soil had results that went beyond personal interests. It reduced moral, intellectual, and social advantages.

An individual, however, might increase his private fortune by raising successive and profitable crops of tobacco or cotton until his profits exceeded the initial cost of the land. Ruffin was quick to point out the danger of such a ruinous system by comparing an association of farmers to a joint stock company. A company that paid dividends from its reserved capital fund would eventually become bankrupt. This would, of course, be considered the "most marvellous folly." Such, nevertheless, was the system generally pursued by the cultivators of the soil in all the cotton-producing States. Ruffin *(27, p. 6)* also noted:

> *The recuperative powers of nature are indeed continually operating and to great effect to repair the waste of fertility caused by the destructive industry of man, and but for this natural and imperfect remedy, all these Southern states, and most of the Northern likewise would be already barren deserts in which agricultural labours would be hopeless of reward, and civilized men could not exist.*

The Federal Government, controlled by bankers and speculators, indirectly discouraged all efforts at soil conservation. It had penalized agriculture by tariffs, by inflated currency, and by encouraging speculation. According to Ruffin *(26, p. x):*

> *whenever the fraudulent paper system shall be completely exposed and entirely exploded, then both lands and the paper-money system will be estimated at their true value. May the consummation be speedy, complete, and final!*

The impoverishment of lands caused southern farmers, in ever increasing numbers, to go west in search of virgin lands. It was reported that there was scarcely a farm in eastern Virginia that was not for sale, and Ruffin himself, after trying John Taylor's system of soil building for 6 years, observed that he had better give up and join the host that was pushing west.

While the population in large areas of the South declined, Ruffin noted that the population in the North was increasing. Northern politicians, in his opinion, were gaining a controlling influence in the Federal Government which aided the North in exploiting the South. Ruffin's great dream was to make it possible to reclaim the sterile and eroded lands and thus save the South from economic, as well as political, disaster. He attacked the problem of soil rejuvenation, soil building, and erosion control not only as a scientific farmer but as an ardent Southerner.

SEDIMENTATION

Sedimentation was one of the most serious results of erosion. It blocked the stream channels, increased the danger of flooding, and often ruined fertile lowlands. Ruffin *(28, pp. 19-20)* maintained:

> *Bottom lands * * * in their natural state, must have presented scenes of remarkable beauty. The clear stream, not as yet choked by the earth washed from cultivated high land, and rarely obstructed, flowed in a deep and meandering channel * * **
>
> *When the neighboring higher lands, and especially the bordering hill-sides, were cleared and cultivated, and their soil and even the sub-soil in many cases were washing down with every heavy rain, then commenced the ruin of both the natural beauty of the bottoms, and much of their available value for cultivation.*

The formation of swamps as a result of accelerated erosion and the consequent clogging of river beds claimed much of Ruffin's attention. He believed that sedimentation was disastrous in South Carolina not only to agriculture but also to health by causing malaria and other diseases. These evils Ruffin attributed to the incessant and injudicious use of the plow, which had caused soil to clog the small streams and upset the drainage of many of the larger ones. Sediment had been deposited on the vegetation, and in some cases even trees had been killed. This was particularly true in the middle and upper districts of South Carolina. The situation was augmented by injudicious land clearing. Trees and other vegetation were thrown into the streams, often causing them to overflow.

The effects of sedimentation were not necessarily adverse. The Roanoke Valley was an example cited by Ruffin of the enriching effects of overflows. By contrast, Marlbourne, the farm in Albermarle County, on which he settled in 1844, had been badly damaged by sediment washed in by floods. In other cases he noted that "lands have lost much soil, and even sub-soil, by the recent washing and denuding action of the strong currents of the high freshes" *(29, p. 3).*

STREAM FLOW AND EROSION

Ruffin's concern with floods and sedimentation led him to make a study of stream flow. He worked out principles of stream flow and erosion which he felt would apply to streams in mountainous areas. A stream in a hilly region rolled sand along in its channel at all times. During floods, the available supply of earth and sand increased. When the stream overflowed, its speed was retarded. The heaviest particles were deposited in the stream bed and along its banks, the finer material being transported farther inland. Thus, the beds and banks of streams had a tendency to become higher than the adjacent flood plain. Then the water sought a new channel.

Alluvial lands tended to become level because the deposits and sediments sought out the low places. The same principle operated in the stream beds. The rapidly flowing water washed away earth and carried it to a lower level, where the stream flowed more slowly. Similarly, if any part of the channel was blocked, the velocity of the water was decreased and the area behind the obstruction accumulated sediment. The flowing water tended to cut the channel deeper, but in cutting it accumulated material that was later dropped. Then both the gradient and the carrying power of the stream were reduced.

In draining swampy land Ruffin applied these laws of stream behavior. The failure of many drainage programs he attributed to a neglect of the laws of nature. Differences in soil texture were also explained on the basis of the segregating action of running water, due to differences in the rate of flow.

OTHER TYPES OF EROSION

On lands not subject to flooding, Ruffin recognized the danger of sheet wash, commenting on the fact that in many Virginia fields the entire topsoil had been removed. Sheet erosion was especially pernicious in its effects, because the fertility of the soil in most areas in the Tidewater section was confined to the top 3 or 4 inches. He noted that "the washing away of three or four inches in depth exposes a sterile subsoil (or forms a 'gall'), which continues thenceforth bare of all vegetation" *(26, p. 86).*

There were many of these spots in the South where sloping land had been cultivated for a long time. Some types of soil, Ruffin recognized, were more susceptible to erosion than others, but on any one type the rapidity of soil removal by water was proportional to the steepness of the slope

Ruffin's interest in soil erosion was stimulated by experience on his farm in Albemarle County, Va. Much of it was hilly and, having been row-cropped for many years, was badly eroded. It was here that he began to make his soil tests. Early in his investigations he found that the subsoil was usually worthless, and that soil washed from gullies tended, in consequence, to ruin fertile land on which it was deposited. A few subsoils would produce crops, but this was exceptional.

APPLICATION OF JOHN TAYLOR'S SYSTEM

Ruffin was among those who tried Taylor's methods of cultivation but found they were not adapted to conditions on his plantation. Some of Taylor's ideas, however, he accepted and others he modified. He believed in green manure both as a fertilizer and as an erosion preventive, but estimated erroneously that three-fourths of the fertility of green plants turned under came from the air and one-fourth from the soil. Thus, if no other destruction were in progress, a green-manuring crop would have given back to the soil three times as much fertility as it had taken out. Ruffin questioned Taylor's idea that manure should always be turned under. Taylor maintained that the fertility would evaporate if the manure were left exposed but Ruffin suggested that warm spring rains would carry the fertility down into the ground. For some soils, such as Taylor's fertile acres on the Rappahannock, he recommended the system in its totality and for all soils, the application of some features of Taylor's system.

LEGUMINOUS COVER CROPS

When Ruffin began farming, clover was considered to be the most enriching of the leguminous plants. He tried it repeatedly on his sterile and eroded acres at Coggin's Point and after many failures "abandoned as hopeless all attempts for an extended clover culture" *(28, p. 126).* He was successful, however, after he began applying marl. In some cases it grew so rank that machines could not cut it.

For soils that were not acid Ruffin later found that cowpeas were as good or better than clover for erosion control *(28, p. 407):*

> *There is also greatly wanted in the cotton region (though unfortunately few planters recognize the existence of that want,) some broad-cast crop that will suitably precede or alternate with cotton, and which will act well for all the benefits of rotation, including the defending the land from exhaustion, and the washing away of the soil, (on hilly surfaces,) by heavy rains. Broad-cast peas seem to offer all the conditions required.*

Ruffin was certainly not the first to raise peas, but he seems to have been among the first to claim that this crop would control erosion. While visiting in South Carolina, he first encountered peas growing on the farm of John C. Calhoun, and when he moved to Marlbourne he began experimenting with them on a small scale. Becoming more interested, he tried all types of peas reporting: "I am now riding a pea hobby."

His pea experiments caused him to alter his earlier rotation, consisting of corn, wheat, clover, wheat, and pasture. In its place he practiced a six-field system: First year, corn with peas broadcast and plowed under; second, wheat; third, clover for hay; fourth, clover grazed and plowed under; fifth, wheat; and the last year, pasture. His main idea in this rotation was that each crop should prepare the land for the one which followed. He also aimed at a maximum production of wheat as a cash crop. Using this system, he found negro slave labor as profitable in preserving the soil as it had formerly been unprofitable.

Ruffin's efforts were influential in causing an increase in pea growing throughout the South. In 1848, he was gratified to learn that the pea fallow before wheat or corn was an established practice on the lower Roanoke and on Albemarle Sound.

THE THEORY OF SOIL FERTILITY

Ruffin's experiments on his farm at Coggin's Point led him to believe that on sloping, cultivated land only a calcareous soil could effectively resist erosion. Where soils were made calcareous by the application of lime, he said *(36, p. 164)*-

> *a chemical combination and bond of union and coherence is formed between the lime and the putrescent or organic matter, and of both with the silicious and argillaceous parts of the soil; which combination is able to resist any but an unusual force of the washing action of rains.*

Furthermore, as a result of liming "grass grows more kindly and rapidly, and by its decay the vegetable mould is continually augmented, and thereby the power of resisting washing is still more increased." Ruffin noted that in a few years after marling and manuring an eroded hilly field, many of the old gullies began to produce vegetation and that new soil was formed from the dead vegetation which he had placed there.

The power of calcareous soil to resist erosion was a part of Ruffin's theory of soil fertility. On naked subsoils, there was nothing to combine the vegetable matter with the soil and, consequently, there was little cohesion between the particles. Soils tended to become semifluid and were washed away even by gentle rains. A hard rain was much more damaging.

Ruffin did not subscribe to the prevalent theory regarding soil fertility, which held that there was a fixed amount of fertility in the soil and that each crop would reduce it somewhat until eventually the soil would produce nothing. He believed that naturally poor soils differed from naturally rich soils which had been made poor by cultivation and that the capacity for improvement was directly proportional to the degree of natural fertility. This fertility was, he believed, primarily dependent upon the presence of a proper proportion of calcareous earth.

He believed that carbonate of lime acted somewhat as a catalytic agent in bringing about certain chemical combinations which unlocked the fertility of the soil. The use of marl also corrected soil acidity and, while hastening decomposition, assisted in the preservation of organic manures from loss of the gaseous products of decomposition.

Ruffin was the first American to reject publicly the idea that soils were composed of various elements mechanically thrown together and capable of being extracted separately by plants. His ideas of the chemical combination of elements within the soil foreshadowed later discoveries pertaining to the nature of soil fertility.

THE ROLE OF LIME IN SOIL CONSERVATION

Ruffin did not believe that vegetable matter necessarily made a soil rich. He felt that soil sterility was brought about more from lack of lime than from lack of vegetable matter. For example, those soils which were so eroded that only the subsoil remained were often bare of vegetation, because the lime which had been concentrated at the surface had been removed.

Reclamation of galled spots, however, could not be accomplished by the use of marl alone. The power of marl to reclaim soil was proportional to the amount of soil which remained. If the soil had been removed, it was absolutely necessary that vegetable matter and putrescent manures also be applied so that a new soil might be formed. On formerly galled land, even rich and durable soil could be formed by repeated and heavy applications of manure and marl. The cost of such soil building, however, usually exceeded the value of the land.

These ideas of soil fertility did not spring full-grown from the mind of Edmund Ruffin but were painfully acquired from many long years of inquiry and experiment. Ruffin suffered in the beginning the usual penalty of pioneer scientists. The more "practical" farmers jeered at him because of his theories and his inexperience.

Ruffin was puzzled because much of the soil on his farm at Coggin's Point did not respond to manures. He noticed, however, that soil which contained fossil shells or marl produced good crops whereas soil which was rich in vegetable matter failed to produce well. He attempted to find out what the deficiency was by reading works on agriculture. He was attracted by Sir Humphrey Davy's contention that lime would make sterile soils temporarily fertile if they contained "salts of iron or any acid matter." Although Ruffin could not find salts of iron in his soil, he was led to believe that there must be some vegetable acid as yet undiscovered.

He set out then to find the key that would unlock the fertility of the soil. A scientist writing more than half a century later stated *(5, p. 502):*

> *Edmund Ruffin conducted his experiments with such attention to details and with such a truly scientific method of preparation and planning that we may look on his work as some of the best done in the country.*

As a young and inexperienced farmer, he was the object of much ridicule, however. Amid the jeers of his neighbors who called his marling "Ruffin's folly," he patiently acquired scientific books from abroad, conducted soil tests, ran his tests over and over again, built his apparatus as carefully as possible, and gathered soil samples not only from his own and his neighbors' farms, but even from places as far removed as Huntsville, Ala. According to one writer, "each new move was whispered from farmer to farmer, to be laughed over wherever two or three were gathered together" *(4, p. 59).*

Ruffin found early in his experiments that the marl which he applied to his eroded acres restored the fertility when accompanied by manures. But he was anxious to find in what proportions these applications were necessary. In conducting his experiments, two sources of errors seemed to be possible. The reactions of lime and magnesium to acids were similar, and some confusion resulted. Also a small amount of carbonate of lime was lost before penetrating the soil. To offset these errors, large quantities of soil were taken as units for testing. To each a small quantity of chalk was added which was deducted from the total of carbonate of lime found in the soil after the experiment was made.

Ruffin laid off his land in relatively small fields after testing each soil, as well as the percent of carbonate of lime in calcareous earth which he applied. His experiments, which continued for 26 years on this farm, were begun in February 1818, by the application of 160 to 200 bushels of fossil shells to the acre. Experiments on one of these plots, which he denotes as "Experiment 17" in his book on calcareous manures *(26, p. 142)* were conducted in the following manner: The area was an old eroded field full of gullies, abandoned 39 years earlier, and at the time covered by pines. After the pines were removed, the field was heavily marled and was coultered twice, in July and in August. Following a crop of wheat the soil was given a 2-year rest, then corn and wheat were raised consecutively after which clover for hay was raised for a year. These crops were described as being good; and at the end of the period clover was growing well in the bottoms of the old gullies.

In another experiment 100 to 200 bushels of marl containing 33 percent of calcareous earth was applied. The result was a 4-percent increase in the corn crop. A number of tests, however, showed a 100-percent increase in corn after marl was applied. Wheat, clover, and other crops increased in about the same proportion.

Too heavy applications of marl, however, caused crop failures. Wheat was found to suffer less than other crops from too heavy an application of marl, and on poor spots from which all the soil had been washed the wheat suffered most *(26, p. 156).* Land highly calcareous by nature did not show bad effects, even when much of the rich mold was washed away.

The cause, Ruffin figured, was some new combination of lime found only in acid soils. Fields where vegetable matter but no marl was applied showed a diminishing production each successive year. After land was once heavily marled, it seemed to require no additional lime for some years. In one case its effects lasted for 31 years. The improvement on the Coggin's Point farm, however, was relatively slow, because it had been seriously eroded as a result of years of bad tillage.

John Taylor, the most outstanding agricultural leader of the South, referred to marl in a contemptuous manner, which proved, according to Ruffin, that little was known about it. To refute this criticism, he explained that lime had probably been applied improperly, in too large or too small quantities, and that it had not been accompanied by the proper manures.

EROSION AND DRAINAGE

In 1844, Ruffin moved to a new farm which he called Marlbourne. In contrast to the sloping, hilly land of Coggin's Point, this farm was for the most part low, marshy, and wet. A system of drainage had been installed there, but Ruffin considered it no better than a complete lack of drainage, because it was not designed to follow natural conditions of stream flow and so safeguard the land against erosion. The underground drains had been extended into the lowlands. When a heavy rain came the largest conduit overflowed, and the underground stream burst forth at various places. The ditches were obstructed by sand or mud washed down by the stream. The sides of the ditches had caved in along cattle paths and where hogs had rooted. In such places gullies cut through the banks.

For the next few years Ruffin spent a large part of his time in perfecting a system of drainage at Marlbourne farm. His chief concern was to drain the land effectively and at the same time prevent erosion. He found that as a rule a good drainage system and erosion were incompatible. Ruffin's knowledge on drainage like that on marling was gained only after many years of experimentation.

Ruffin recognized that there were several principles of stream flow which must be followed in any successful drainage system. The rate of fall of a ditch or underground drain must be sufficient to carry the moving sand. If the ditch was not properly constructed, the water might fill it with sediment or the water might cut the bottom and sides of the channel. The ditches should not discharge either more or less sand than they receive. Just as the bottom of any stream tends to become stabilized under natural conditions, so does the bottom of a ditch.

The following principles were carefully observed by Ruffin in drainage: (1) Sand in the water will be moved along by the force and pull of the current regardless of the distance, whether it is 1 mile or 20, if the passage is unobstructed, the velocity unchecked, and the fall sufficient; (2) fine particles of clay and soil will pass more rapidly to greater distances than the sand; and (3) when the water slows down, the particles in suspension are dropped in order of their size, the larger ones first. If a depression needs to be filled, the stream may be turned so that the water will pour into it. When its velocity is decreased, the water will drop its load, and the depression will gradually be filled. In this way Ruffin utilized natural laws of water transport to overcome the effects of erosion.

In constructing a drainage ditch, Ruffin applied practically the same principles that had been expounded by Taylor. Open ditches were always constructed with sloping banks because steep banks encouraged erosion and caving walls resulted in choked ditches. Ruffin also noted that freezing and thawing loosened the soil and increased the tendency of steep banks to wash. On the other hand, if the banks of drainage ditches were sloped more gently, an equilibrium was established and little soil was washed into the ditches.

Although the principles of drainage applying to open ditches also extended to covered drains, the method of application, for obvious reasons, was different. In constructing underground drains Ruffin used fence rails laid 2 or 3 inches apart and at least 3-1/2 feet deep. These were covered with boards. Above them he spread straw, pine leaves, shavings, broomsedge, or other coarse grass or roots to a depth of about an inch to keep the soil from washing in. Although he considered the pipes the only sure method of preventing erosion in an underground drainage system, the cost was prohibitive.

In any system there was danger that, in times of flood, soil might clog drains. Since Ruffin's system, however, was based on natural laws of hydraulics, the ditches often lasted many years without needing repair. In his diary for July 1857, Ruffin recorded that "not a drain has been made, or improved for these places since my last operations three years ago," but he added that after the last rain "the open ditches are much filled by sand and mud washed in * * * . *(Diary of Edmund Ruffin, July 4, 1867. Ruffin mss., Library of Con-*

gress.) He considered closed drains indispensable on "oozy hillsides." If open ditches were constructed they would soon filled by soil.

A proper drainage system not only safeguarded the land against erosion but made it possible to utilize areas which hitherto had been low in production or out of production altogether. Ruffin's production of wheat at Marlbourne, increased from 627 bushels to 6,000 bushels. His production per acre increased from 14.75 bushels to the acre in 1845 to 20.02 bushels to the acre in 1 848. Corn production increased from 14.28 bushels to 28.12 bushels during the same period, and the profits from the farm increased from $2,200 to $6,300 *(29, p. 10; 3, p. 142)*

The principles enunciated by Ruffin in his writings on drainage were also applied to hillside ditching. Although he was not so much concerned with hillside ditches as were many others of the period, he recommended them highly for controlling erosion. In traveling from Augusta to Atlanta, Ga., he noted the extensive system of hillside ditches. Some years before this, he had traveled over the same road and observed the gullied fields; now they showed distinct improvement. The hillside ditches, however, were often too small or inaccurately run. This fault lay not in the system but in its application.

FLOOD CONTROL

The clearing of lands in the upper parts of the drainage systems of Virginia and South Carolina had increased the alluvial deposits in the lower parts. More mills were built; more obstructions such as dams, trees, and rotting vegetation were placed in the streams; and more soil was washed into the streams, with the result that the millponds and many of the streams had become shallower. Drainage systems broke down, and sedimentation and floods increased. Like many of his contemporaries Ruffin thought that the impounding of water behind dams increased evaporation and altered the rainfall regime, which in turn, caused floods.

At the time Ruffin was in North Carolina, a few planters had restrained floods by means of levees. A planter in Halifax County, N. C., built his levees 26 feet high. He found the levees could withstand floods if the width of the base was five times their height. On the Palenta River, another planter built a levee that was 100 feet wide at the base and 17 feet high. These required valves and culverts to let out the water that had seeped in.

Ruffin favored the building of additional levees for purposes of flood control even on the Peedee, Santee, and Savannah Rivers but thought that the impounding of the water was a far more difficult undertaking than opening the lesser streams and draining the swamps along their borders.

The dangers of such a system of embankments were pointed out by Ruffin. Every embankment which restrained the water tended to raise the river at some other point. Thus, if all proprietors made embankments, the floods would very likely become uncontrollable. If the river were kept within its banks in time of flood "that confinement would cause much increased velocity and power of abrasion" *(29, p. 31).* The bottom and sides would be washed and the levees would have to be raised higher and higher until finally the levees would be undermined and destroyed

Floods, Ruffin felt, could not be controlled by individuals. Only the State had the authority to devise and carry out a proper plan. A flood-control law was needed, whereby the Government would have power to work out uniform plans in which whole river systems should be included. The banks of the streams should be protected by hard ledges but no protection was needed for the bottoms of the streams. In fact, if they were deepened by the increased velocity of the river, it would be an aid to navigation, without endangering the flood-control system.

WIND-EROSION CONTROL

Some small areas in the South suffered from wind erosion. Ruffin believed that lime in some form was effective in preventing such loss of soil. It caused the soil particles to adhere and made the surface damp by its absorptive power. On fields from which clouds of dust arose, the effect of a coat of marl was often striking. Ruffin (26, p. 165) described the way in which marl controlled erosion as follows:

> *On March 1st, 1850, a few days before the writing of these lines, I saw from the eminence on which my present dwelling stands, a very remarkable exhibition of this conservative power of marl. The night before, there had fallen a heavy shower; and also some drizzle after day-break, succeeded by bright sunshine and a furious wind. Though the rain-water had stood in puddles in the ruts and low spots of hard roads in the morning, by 11 o'clock, A. M., dense clouds of dust, rising as high as the tops of the forest trees on the higher lands, were seen driven off from the light fields of three different and detached neighbouring farms, and which had not been marled. A much broader space of surface intermediate or adjoining, was also in view, much of which was equally sandy and fully as much exposed to the wind. All this land (except one small field which was both stiff, and low-lying, and of course not then dry) had been well marled; and from none of it was any dust seen to rise. Of the several thousand acres of arable land in sight, and mostly of sandy soil, all the farms and fields not marled (and not of clay or wet soil) might have been designated by the clouds of dust then rising and passing off from them.*

THE END OF AN AGRICULTURAL ERA

Edmund Ruffin was the most outstanding agricultural reformer of the pre-Civil War period. Although his theories and his farm practices were at first derided by his neighbors, within a few years after the publication of the first edition of his Essay on Calcareous Manures, many used marl to enrich their lands. His essay, which was later expanded to a volume of 560 pages, probably was read by more farmers and owners of large estates than any other agricultural book of the nineteenth century. In 1830, Ruffin, having by that time worked out his principles of marling, felt that some vehicle of expression was needed to spread his ideas. With a small amount of capital and only a few subscribers, he assumed the editorship of the Farmers' Register and remained in that position for 10 years.

The new periodical was the most successful as well as the most authoritative of the contemporary farm journals. Although Ruffin gave up its publication in 1842 and went into temporary retirement, he continued to enjoy great prestige among agriculturists. The neighbors in Prince George County gave a dinner in his honor and presented him with a piece of slate on which his name was inscribed. They publicly expressed their gratitude to him for devoting his time, talents, money, and industry in an endeavor to convince farmers that the use of marl would help reclaim the barren fields of the county. They agreed that "single and alone, he had buffeted popular prejudices" and that "by his untiring industry * * * enabled * * * [them] to make two ears of corn or two blades of grass to grow upon a spot of earth where only one grew * * * before" *(4, p. 65).*

The increase in the wealth of the Southern States was attributed to the adoption of Ruffin's ideas. From 1838 to 1850, land values of the Tidewater section increased by over

17 million dollars. One estimate placed the increase in value because of marling at 30 million dollars.

Southerners boasted that Mother Earth had altered her face and her constitution under the healing action of lime; that her present appearance and her past differed from each other as greatly as did a healthy man from a lingering and hectic victim of consumption. According to Craven *(3, p. 143):*

> *The stories of changes in Prince George County (Va.) and other eastern counties * * * read like fairy stories. Fields once galled and gullied were now growing rank with clover, lands once abandoned, now brought forth abundant yields of wheat and corn.*

Many honors followed, although Ruffin often protested that he was not appreciated. Ex-President John Tyler placed the picture of Edmund Ruffin over his fireplace as a companion piece to that of Daniel Webster and proclaimed them the greatest American agriculturist and the greatest American statesman *(3, p. 137).* A committee of the Virginia Agricultural Society in 1851 proclaimed him "not Edmund Ruffin of Prince George * * * but Edmund Ruffin of Virginia." He was given extravagant praise in a biography published in DeBow's Review and the United States Agricultural Society made him an honorary member "because he had ended the age of agricultural barbarism" *(4, pp. 88-90).*

In spite of general recognition of his work by agricultural and political leaders, Ruffin felt that his work was not a success. As a young man he had been humiliated by the jibes of his fellow farmers. He reports that Thomas Cocke *(26, p. 422),* one of his neighbors, said in 1822: "In future time, if marling shall then have been abandoned as unprofitable, this place will probably be known by the name of 'Ruffin's Folly.'"

Ruffin commented again and again on the ridicule he suffered, and the tendency of farmers to reject new ideas: "For some years, my marling was a subject for ridicule with some of my neighbours; and this was renewed, when in after-time the great damage caused by improper applications began to be seen" *(26, pp. 422-423).* He was doubtful always of the acceptance of his ideas *(26, p. 189):*

> *The opinions of many farmers have been so long fixed, and their habits are so uniform and unvarying, that it is difficult to excite them to adopt any new plan of improvement, except by promises of profits so great that an uncommon share of credulity would be necessary to expect their fulfilment.*

For this reason, every-improvement in agriculture had to work its way slowly and against every discouragement and obstacle. The agricultural classes were distrustful. They were the least ready either to receive benefit or to be thankful for services, even after the practices had been completely proved and established.

Marling proved no exception to this rule. Ruffin's teachings were generally ignored by farmers although acclaimed by leaders. Although he believed that from 1833 to 1835 the knowledge of marl among farmers doubled and its application was multiplied tenfold, the masses of farmers had not read his book.

Marl at that time (1835) had not been tried much in Virginia and Maryland, only recently in North Carolina, and not at all in South Carolina, Georgia, Florida, and Alabama. Later, marling was widely used, but Ruffin still found that the average farmer had never heard of him. After a trip in southern Virginia during which he had talked to many farmers, he recorded on April 16, 1857, in his diary *(Diary of Edmund Ruffin, April 16, 1857. Ruffin mss., Library of Congress.):*

I did not see a man who appeared even to have heard of me before, or who cared whether he ever heard of me again. Of course, I did not obtrude my opinions or advice on farmers who seemed to desire to have neither."

Because of his bitter disappointments, he retired from public life. He attempted to become a recluse, refusing curtly the Presidency of the Virginia Agricultural Society in February 1845.

The failure of the Farmers' Register was followed by another disappointment. Ruffin had planned a comprehensive program for the State Board of Agriculture, which he had initiated. He was elected corresponding secretary and planned to make this agency a great center of agricultural research and dissemination of information for the farmers. As part of his reforms he divided the State into eight districts, each under the supervision of a member of the board. But the board was violently attacked, its funds were cut off, and Ruffin resigned.

In spite of bitterness at the ingratitude of his countrymen, Ruffin never completely gave up his dream of rebuilding a South impoverished by soil exploitation--at least not until the last. He believed so fervently that the South could regain its place in politics, and in the social and economic life of the nation that he found it impossible to follow his resolves to give up the preaching of soil conservation. His dreams received partial fulfillment in Virginia and he planned the same for the other Southern States.

Again and again he warned his countrymen of the ruin that awaited them if they did not mend their ways *(27, p. 26):*

I can only offer my earnest verbal assurances of your available gain, as great and as sure to be obtained by your pursuing a proper course of improvement, as will be the growing loss and eventual ruin of your country, and humiliation of its people, if the long existing system of exhausting culture is not abandoned.

** * * Choose, and choose quickly! And remember, as my last warning, that your decision will be between your purchasing, at equal rates of price, either wealth and general prosperity, of value exceeding all present power of computation, or ruin, destitution, and the lowest degradation to which the country of a free and noble minded people can possibly be subjected.*

But the people would not heed his voice and the South declined in prosperity and political power. The old Virginian went up and down the country, writing, talking, and making speeches. If the farmers could or would not defend their soil, they would have to defend their country with their lives. He had attempted to save the South through agricultural reform; but now it seemed that the North would gain the upper hand.

His efforts to build an agrarian Utopia were thwarted. He would not accept the inevitable decline of the South. He felt that northern exploitation was the cause of soil erosion in the South. Thus, when war came in 1861, Edmund Ruffin, in spite of his advanced years, served the cause of the Confederacy with a zeal no less than that with which he had struggled to save the soil of the South. He was pursuing the same end as when he was farming at Coggin's Point, making soil tests and draining land at Marlbourne, writing voluminously in the Farmers' Register, or making speeches and pamphleteering. It was his hand that fired the first shot at Fort Sumter.

Edmund Ruffin's efforts ended the pioneer stage of the erosion-control movement in America. His work was equal to that of all his predecessors combined. The knowledge of the soil which he gained from his experiments, his theories and speculations regarding the action of water on soil, and his erosion-control practices provided a foundation for later developments.

CONCLUSION

During the period from 1620 to 1860, erosion became a major problem on many American farms. The New World settlers found that after a few years of farming, the sandy hillsides of New England and the erodible soils of the Southern and Middle Atlantic States were injured by wind and by water. At first, erosion escaped notice by the majority of farmers, but by 1750, many fields were becoming barren, farms had already been abandoned, and in the older, settled regions, erosion was more generally noticed. The destruction of soil by gullies and floods had been noted by writers even before the Revolutionary War. By 1775, rivers that once ran clear were described as being black with mud. Many references to worn-out land provide evidence that sheet erosion also was taking its toll.

A few of the more intelligent and better educated Americans began to realize the folly of exploiting the land. Outstanding among these were Jared Eliot, Samuel Deane, Solomon and William Drown, and Isaac Hill of New England; John Lorain from Maryland and Pennsylvania; and John Taylor, Nicholas Sorsby, and Edmund Ruffin in the South.

These pioneers of erosion control contended that ignorance was one of the causes of soil erosion. In general, the farmers of America were badly informed, many were superstitious, and most of them were not aware that erosion was a danger. Land had always been plentiful and they believed that it always would be.

In order to awaken interest in farm improvement, the early conservationists recommended agricultural societies and organizations, and a wider dissemination of books, pamphlets, and farm journals. The agricultural journals and societies organized by these leaders played a large part in agricultural reform. The smart, influential farm journals were Isaac Hill's Farmer's Monthly Visitor and Edmund Ruffin's Farmers' Register.

John Lorain and John Taylor, in particular, felt that the crop system, more than ignorance, was the chief cause of erosion. Both lived in the South where diversified farming was little practiced. Corn, tobacco, and other row crops were planted repeatedly on the same land until the farmer was faced with declining yields. Eventually much land deteriorated to such an extent that some crops could not be raised profitably. The final result was ruined farms and abandoned fields. Edmund Ruffin correctly analyzed the disastrous effects of such a system of exploitation. He foresaw that land exploitation might be profitable temporarily for the individual, but for the community or the Nation as a whole, would eventually spell ruin.

The early southern conservationists in consequence urged that the Government do something to enable the farmer to grow soil-conserving rather than soil-depleting crops. Prosperous agriculture required a reduction of interest rates, elimination of oppressive tariffs, and agricultural boards to consider the economic aspects of farming. Such an agricultural board could, for example, work out reciprocal trade agreements whereby the farmer could command better prices for his products.

Large landholders were also encouraged by the early conservationists to do their part. They should first of all develop, give publicity to, and encourage the use of erosion-control techniques that were economically feasible for the small farmer. Expensive erosion-control measures were of little avail to the average farmer. In addition, landowners should encourage soil conservation by requiring soil conservation clauses to be written into farm leases instead of requiring tenants to raise those crops which would give the greatest possible gain in a short time.

These general economic and social reforms that had as their goal the maintenance and increase in the fertility of the soil were supplementary to mechanical and agronomic erosion-control measures. Probably the most important recommendations, many of which were applied to some extent, related to farm management. Each farm should be divided in such a way that soil-impoverishing crops would not occupy too large a part of the land. American farms were often too large; they should be small enough so that all the land could be properly cultivated. This was one of the chief contentions, particularly of the agricultural leaders in New England. Land classification was needed on every farm; the steepest and most erodible parts should be retired from cultivation and other areas treated according to their fertility and erosion hazard. Pastures, like cultivated fields, required restrictions; the areas in row crops should be limited; and fences should be built to help carry out the program.

Soil maintenance also required the use of mechanical techniques. Plowing, furrowing, ridging, ditching, draining, and irrigating were not considered the basic remedies for erosion, but they did play a large part in the early American erosion-control movement. There were many variations of plowing designed to prevent soil washing. Some advised using hillside plows. Although these plows attained considerable popularity in the Northern States, they were more generally employed in the South. If a hillside plow was not available, the farmer frequently plowed across the field in one direction, letting the team drag the plow back to its starting point. Or if an entire hill lay in one field, the farmer merely followed the contour all the way around the hill and back to the starting point. Furrowing or ribbing, also a common practice, resembles modern techniques for erosion control. To prevent gully formation and to deter the water from rushing down the hillside, furrows were run at intervals on the contour. In pastures they were farther apart than on tilled fields.

Ridging was another variation of plowing commonly employed. John Lorain's ridges were somewhat similar to the terraces of today. In some cases these ridges had a slight incline so that the impounded water that had collected during a heavy rainstorm would drain off gradually.

The hillside ditch developed from the ridge system and was the forerunner of the modern terrace. Although the hillside ditch has been superseded by more efficient methods of mechanical control, it helped prevent soil washing by diverting the water from points where a gully might have started. The outlets designed by Nicholas Sorsby and his whole system of water control rested on the same principles as modern terrace systems.

In draining the land, care was taken to construct ditches so that they would neither clog nor gully. On the banks of drainage ditches tough-rooted grasses, shrubbery, and cedar trees were planted. In some cases stones, gravel, and stakes were used to prevent the streams from cutting their banks. Ruffin constructed his open drainage ditches with wide sloping banks that were not easily undermined. Taylor and Ruffin also used underground drainage systems constructed of poles, boards, and dead vegetation. Although not as efficient as tiled systems, such drains were economically possible for the poor farmer, provided a wood supply was available. Taylor claimed that his underground drains would last for 100 years

In the early national period, no phase of soil conservation received more attention than did gully control. The pioneers were more concerned with prevention than cures. They pointed out that wagon roads, trails, and drainage ditches were points where gullying might start and should be watched carefully. Contour plowing, hillside ditching, and draining, all contributed to gully prevention. After gullies had once started, Taylor filled them with green bushes and plowed over them. For larger gullies stakes were driven down and trash packed back of them. Sorsby followed this procedure, but also sowed rye and peas in the gully channel, and in addition curved his rows in such a manner that water was diverted from the gully.

Most of the cover crops recommended by the early conservationists are widely advocated and used today. They realized, however, that on extremely sandy land no amount of soil amendment would prevent erosion if row crops were planted. The sowing of cowpeas between rows of corn, a practice emphasized most by these pioneers remains perhaps the most popular method of soil building in the South. Edmund Ruffin ranked them ahead of any other cover crop. All of the conservationists urged farmers to plant grasses, pointing out that not only would a covering of grass reduce run-off, but that a grass crop would change the structure of the soil so that the particles would adhere and not blow or wash away readily. Grass also improved the soil so that it would produce greater crops thereafter.

Many of the rotations developed by the conservationists are in use today. They anticipated the principle of the modern basic rotation consisting of a cultivated crop, a small grain, and a legume or grass. They maintained that organic matter could be conserved only by means of rotation. Rotations, however, were varied in relation to the soil, slope, and climate of different sections of the country. For light easily erodible soils, 3 years of grass or clover in succession were necessary. Clover was more consistently used than any other soil builder. It was a part of almost every rotation listed and was considered more important than grass by most of the pioneers. Eliot lists red clover as the most important crop for building up poor land and Lorain said that timothy, other grasses, and soiling were the backbone of his system to prevent erosion.

Before the Civil War, the turning under of green crops, and the introduction of animal and mineral fertilizers—standard conservation practices today—were both employed and recommended by soil conservationists. These practices formed an essential part of their conservation systems. Fertilizers of all kinds, mineral, animal, and vegetable, were turned under to prevent both wind and water erosion. Among the green manures most strongly advocated were oats, rye, millet, buckwheat, and cowpeas. On wind-eroded soils, two crops in succession were plowed under, together with an application of gypsum or marl. Sorsby restored galled land by plowing deeply and turning under cowpeas. This was followed by rye, which was also turned under. Although Edmund Ruffin believed that the introduction of calcareous manures was the most important method of soil improvement on the acid lands of Virginia, he also recommended the introduction of all kinds of manures.

Conservationists over a century ago called the attention of farmers to the dangers of erosion in this country and correctly analyzed its social, economic, and physical causes. They devised control measures in relation to slope, soil type, and the climatic differences in various parts of the country. They also pointed out the danger of exploiting the land by cash crops, and the necessity for Government cooperation in soil conservation. When John Taylor remarked that the well-being of the farmers and the preservation of the soil were necessary to the well-being of the Nation, he was stating a fact that has become one of the basic principles of soil conservation in the United States.

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