SURVIVAL OF PLANT LIFE DURING THE FLOOD IN THE TIME OF NOAH

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"In the six hundredth year of Noah's life in the second month, on the seventeenth day of the month, on the same day, all the fountains of the great deep burst open, and the floodgates of the sky were opened. And rain fell upon the earth for forty days and forty nights. And the water prevailed more and more upon the earth, so that all the high mountains everywhere under the heavens were covered. And the water prevailed upon the earth one hundred and fifty days." Genesis 7 v 11, 12, 19, 24 NASB.

Introduction

A single storm lasting a few hours can bring havoc on land and at sea, but what of the cataclysmic event recorded above? Not only did it rain without stopping for the period of forty days and nights, but at the same time water was bursting through to the surface of the earth from below (Genesis 7 v 11). We can only speculate as to the ferocity of the storms and the earth movements occurring at this time. The rainfall would probably be associated with strong winds and storms which are known to be most destructive at the coastline. In recent storms, breaking surf and waves are known to have engulfed lighthouses and shattered buildings. In the nineteenth century, on the coast of Scotland, blocks of concrete forming the end of the break-water at Wick, the first of 1350 tons and a later one of 2600 tons both bound to underlying rocks by iron rods were torn loose and moved bodily towards the shore (Carson, 1968). The destructive power of such waves is greatly enhanced by debris carried along and flung against the shore in the waves. At the same time, the waters bursting up through the earth's crust to the surface from "the fountains of the deep" would be likely to cause earthquakes with associated waves (tsunamis) in the sea, and vulcanic activity with the release of molten lava through fractures in the earth's crust in various places. The picture is one of total destruction when after 40 days the whole of the surface of the earth was lying beneath the water. The historical account in Genesis tells us that all animals that lived on dry land, and all of the human race died in this catastrophe, except those in the ark which God commanded Noah to build and equip in preparation for the flood. The account in Genesis does not specifically refer to the fate of plant life, but it does mention that Noah took into the ark "some of all the food which is edible" (Genesis 6 v 21). This then would include all cultivated plants know to Noah, also

All biblical quotations have been taken from the New American Standard Bible.

plants grazed by domestic and wild animals and a range of weeds and wild plants collected accidentally. The only other mention of plant life in the account is that of the olive brought back to the ark by the dove, (Genesis 8) a clear indication that some plant life survived the flood outside the ark. We face the problem of plant survival in what was a double disaster. Firstly, survival during the storms and flooding, and secondly, survival and propagation in the harsh conditions remaining once the flood waters had evaporated. The original soil on the land surface would have been completely destroyed and deposits ranging from clay and sand to rocky ground and decomposing debris would be in its place.

Plant life before the flood

There has been considerable speculation about what the world was like before the flood. It would certainly be helpful in the understanding of plant survival during the flood to know the types of climate and vegetation which could be found at that time. The Genesis account tells us very little, except that during the period of creation God commanded the earth to "bring forth vegetation", "plants yielding seed after its kind" (Genesis 1 v 11-12). This indicates variety both within and between different plant life forms. However, we can deduce something about the plant life and the conditions in which they grew from fossil remains in sedimentary rocks which were formed as a result of the flood. It is probable that a large proportion of the sedimentary deposits were laid down during, or as a direct consequence of the flood and some contain the remains of plants and animals alive before this worldwide catastrophe. Various different types of vegetation are represented in fossiliferous rocks.

Perhaps the most familiar are those known from coal deposits. These consist mainly of spore-bearing plants, of herbaceous, shrub and tree-types with club-mosses, horsetails, ferns and seedferns being especially prominent. Growth was prolific and the vegetation lush, which is indicative of a warm, humid and equable climate in the areas where these plants had grown. The frequent occurrence of plants with aerial roots suggests that this vegetation type was growing on swampy ground (Banks, 1970).

In other sedimentary deposits (Triassic, Jurassic and Cretaceous) herbaceous forms were found to be more dominant, although trees such as cycads and ginkgos still formed an important part of the flora, and conifers were also present. Many upper Cretaceous rocks contain a rich diversity of flowering plants; some 460 species were reported from the Dakota sandstone in Kansas by Lesquereux (1891) and from the London Clay Flora (Eocene) 314 different types of seeds (Reid, 1933). In the fossiliferous strata found as far apart as Colorado in the USA, Vancouver Island in Canada, Alaska (latitude 62 degrees north), France and

Portugal, palms have been found (Andrews, 1961). In other places, for example in Western Greenland around Disco Island, in Eastern Siberia, and in Spitzbergen, the fossils found are also from plant groups associated with much warmer climates than the species growing there at the present time. In Greenland and Siberia, fossils found included those of breadfruit (*Artocarpus*), oak and sycamore. Whilst it is possible that some plant material was carried from other areas further south before being fossilised, it is thought that much was fossilised in situ. One example are the fossils of leaves, leafy shoots, and cones found in Spitzbergen which are well preserved and therefore unlikely to have been transported any great distance (Nathorst, 1911).

Other fossil floras found at similar latitudes are more typical of a temperate climate, for example the tertiary deposits in Iceland (Heer, 1869), Alaska (Hollick, 1936) and Spitzbergen (Schloemer-Jager, 1958). Succulents, which are adapted for survival in dry climates and also arctic-alpines, which typically indicate the occurrence of long, cold winters are conspicuous by their absence from most sedimentary deposits. They have only been found in very recent strata which extend over relatively limited areas, probably deposited at a later time than Noah's flood. Examples are *Mamillaria tuberculae*, a succulent found in quaternary Pleistocene deposits in New Mexico and *Menyanthes arctica* (arctic bogbean) in Tertiary Paleocene from Greenland (Heer, 1883).

To summarize, on the assumption that much of the sedimentary rock was formed as a direct consequence of the Noachian flood, it can be concluded from the fossil plants found in these deposits, that tropical and subtropical conditions extended over a much wider area than at present. A subtropical climate was probably found in some areas as far north as Spitzbergen. The variety of plant types found indicate a diversity of climates from tropical to temperate, but without the extremes typical of arctic, alpine or desert environments. These conditions were then abruptly interrupted by 40 days and nights of incessant rain falling on the earth which, together with the water released from the earth's crust, were sufficient to flood the world to a depth greater than the highest point on the pre-flood earth. Many plants would be buried in the mass of debris eroded by the water and these would become fossilised as the sediments were compacted. Much of the remainder would float on the surface of the water, some rotting and sinking to the sea floor.

How did plant life survive the flood?

The first point to be made is that many plants did not survive the flood. Numerous species are known to us only from the fossil record. Examples include many of the fossils which make up the coal deposits of the world, the tree-like forms of club mosses and horsetails (*Lepidodendron* and *Calamites*) are now extinct and are represented only by small plants of less than a metre in height (Andrews, 1961). The London Clay Flora, fossils of which can be found on the beaches of the Island of Sheppey near the mouth of the river Thames contains representations of 100 genera of flowering plants, only 28 of which can still be found growing in some part of the world today (Reid, 1933).

Secondly, although the account of the Genesis Flood contains many instances of supernatural intervention, for example the door of the ark being shut (Genesis 7 v 16), there is no mention of such acts to ensure the survival of plant life and it is therefore valid to consider the natural means available to plants to enable them to survive. It is argued by some that plant life was endowed with new characteristics at this time, but it is my contention that since scripture declares the work of creation to have been completed at the end of the sixth day (Genesis 2 v 1-2), all characteristics found in plants today must have been present at the time, within the genetic makeup (genotype), if not actually expressed.

Features contributing to survival of plants during the flood

Many fruits and seed can remain dormant when conditions are unsuitable for growth, for example during low temperature or drought, and they would have had a much greater likelihood of survival during the flood than vegetative parts such as leaves and stems which readily become water soaked and rotten. Seeds can lie dormant, but still retain the capability to germinate for various lengths of time from a few days (willow), a few months (oak, beech and hazel) to over a hundred years (claimed for a species of Leguminosae, the Indian water lily, *Nelubrium*, Ohga, 1926). It is common occurrence on land that has not been ploughed for 20-40 years for weed seeds to germinate from the newly tilled soil even though plants of those species had not been found on the land during the intervening period (Turrill, 1957). Seed dormancy is dependent on a variety of mechanisms within the seed, some of which are controlled by the external environmental conditions. These mechanisms are dealt with comprehensively in many textbooks of botany, for example Kozlowski (1972), Wareing and Phillips (1981) and Salisbury and Ross (1985). It is sufficient here to refer to them briefly.

1. Mechanisms of seed dormancy

HARD SEED COATS. The external covering of many seeds is impermeable to water and oxygen, both of which are necessary for germination. The seed will lie in the ground until the seed coat becomes sufficiently degraded to allow penetration of both water and oxygen.

A PERIOD OF AFTER-RIPENING. Some seeds require a period of after-ripening or further development before germination can occur. In some species this must take place in the dry seed, and in others the seed must first imbibe water. These processes which occur after the seed has ripened are probably independent of external environmental conditions.

SPECIFIC ENVIRONMENTAL REQUIREMENTS. Some seeds will only germinate after they have been exposed to certain environmental conditions. Examples include the requirement for light, low temperature or a certain amount of rainfall to leach substances (inhibitors of germination) from the seed coat. The viability of those seeds floating in the flood waters which possessed this type of dormancy would have been drastically reduced during the flood.

EXAMPLES OF SEED SURVIVAL IN WATER. Survival of seeds in salt or brackish water has been tested on a number of occasions. Darwin and his contemporaries placed seeds of 87 different species in sea water to see if they would survive a sufficient length of time to permit the migration of plants between continents (Darwin, 1859). Whilst we do not know how similar the flood waters would have been to sea water, the work is still instructive. Out of those tested, a few survived immersion of 137 days, but most of the seeds used were small and sank in the water. In later experiments larger fruit were used. Out of 94 species, 14 percent floated for 28 days and retained the ability to germinate. Results for longer periods of exposure to sea water were not reported. In another piece of research, Martens, quoted by Darwin (1859) found an 18 percent germination rate in seeds allowed to float on a raft exposed to sea water. In a more recent publication (Howe, 1968), seeds from five different families of flowering plants were soaked in sea water, fresh water, or a 1:1 mixture of salt and fresh water. Seeds from three out of five species germinated and grew after 140 days exposed to sea water or the 1:1 mixture. In two of the three species, *Medicago sp.* and *Malva sp.*, the seeds were still dormant, as they had to be split open before germination would occur, which suggests that they would probably have survived a longer period of exposure. These examples demonstrate that the tolerance of seeds to water is variable, but some can survive extended periods of soaking in sea water without damage.

2. Other features which increase the possibility of plant survival.

Dormant buds can be found on trees and shrubs at all times of the year and these buds are more resistant to adverse conditions than growing shoots. The most conspicuous buds are those formed at the transition between periods of growth and quiescence, for example the winter bud. In many tropical trees, up to several flushes of growth can occur within a year, and these alternate with periods of quiescence. However, in climates with a marked dry season or cold winter period, a single period of growth during the year alternates with a time of dormancy. In cool temperate areas such as the U.K., for example, growth ceases towards the end of the summer, a resting bud develops around the growing point and the whole becomes dormant until spring. Such dormant plants, and shoots taken from them, can be kept in cold storage for several months, longer than the normal winter period, and still survive. Similarly, branches and logs cut away from the main plant when it is dormant, will sprout in the following growing season if partially embedded in soil or mud which can supply water to the developing shoot.

Dormant buds are also found on the bulbs, corms, tubers, stolons, rhizomes and rootstocks of herbaceous perennials in which form such plants survive inhospitable conditions. They would not be as tolerant of the flooded conditions as woody plants because they would rot more readily than seeds or woody branches bearing buds. However, stolons of lymegrass (*Elymus arenaria*) have been known to survive long enough to be transported to Surtsey from neighbouring islands in the vicinity of Iceland (Fridriksson, 1975).

3. Situations in which plants could survive during the flood.

Apart from floating in the flood waters, seeds, fruits, shoots and underground plant organs such as bulbs would be present in the top layers of the sediment, and would be uncovered when the flood waters receded. Less exposed to decay than plant material floating in the water, and firmly embedded in the ground, they probably contributed substantially to the first post-flood vegetation.

Large masses of debris floating together in rafts would have protected some vegetation from the damaging effects of sea water. Carson (1968) refers to such rafts occurring in present day oceans and being sighted over 1000 miles from the mouths of the great tropical rivers, such as the Congo, Ganges, Amazon and Orinoco from where they are thought to have originated. Seeds, storage organs such as bulbs, and small plants could be embedded between the roots of floating trees, and also amongst the matted and rotting remains of both plants and animals as well as amongst other debris. Darwin (1859), in his travels, found drifting oak logs and he was able to germinate three species of dicotyledenous plants from seeds embedded in soil lodged in amongst the roots. He also found seeds of peas and vetches which were still viable after 30 days in the crop and gizzard of the floating carcasses of birds.

It is also likely that a wide range of plants survived inside the ark, as Noah stored some of all of the types of plants known to be food for either man or animals (Genesis 6 v 21). Presumably seeds, dormant shoots and various plant parts such as tubers, bulbs and rootstocks would have been loaded on board the ark, and those more tolerant to such a long period without growth, a total of 371 days, would have survived to be replanted.

Plant survival - a summary.

Plant survival would be most likely as seeds, dormant shoots with resting buds, dormant bulbs, tubers, corms and stolons. Some would have survived in the flood waters, others on floating masses or debris, partly protected from water, and others would have survived in the ark in dry storage. Other plant material may have been buried in the flood sediments to be partially exposed at a later stage allowing the possibility of regrowth. The remainder of the pre-flood plant life would have been permanently buried or would have rotted in the flooded conditions.

Recolonization

1. Could plants recolonize the surface of the earth after the flood?

Seeds and vegetative material in the flood water would eventually settle on the ground as the flood waters receded, and some plants buried in the sediments would be exposed by erosion as the flood waters drained away. However, the ground would be very different from the original soil cover which would have been completely destroyed in the early stages of the flood. Much of it would now be dry and sandy or muddy, with clumps of rotting debris scattered through it. Plants need a continual supply of water and nutrients to grow and flourish, but they are often found growing in most inhospitable conditions. Recolonization of flooded ground was studied after the Yorkshire flood of 1968 (Radley and Simms, 1971). Partly rotting clumps of annual meadow grass (*Poa annuum*) left on the strandline recolonized areas of sediment. Seeds also germinated from the flood debris and also from soil which had been immersed for various lengths of time. In some cases the seedlings became established in apparently inhospitable sandy sediments containing little water or nutrients. Examples of the first plants to colonize the area were coltsfoot, small stinging nettle, silverweed, chickweed, horsetail, shepherd's purse and tormentil. Although this example from Yorkshire was a flood of short duration, it does demonstrate the ability of some plants to survive and also to recolonize impoverished ground. The initial colonizing species would have enriched the land by the addition of dead plant parts. These would act like a sponge to retain water, and so encourage plants less tolerant of dry conditions to colonize the same ground subsequently.

The colonization of volcanic rocks on Krakatoa after the 1883 eruption also demonstrates how readily plants can grow on ground which is very different from a mature soil (Backer, 1929). After 14 years, 50 species of vascular plants were found; these had presumably been transported from neighbouring islands. After 25 years, the ground was completely covered by plant life. The higher temperatures and greater humidity of this tropical island would have enabled more rapid colonization to occur here than on Surtsey, a volcanic island off the south coast of Iceland which first appeared in 1963 (Fridriksson, 1975). Surtsey is a windswept island with mean annual temperatures of 5-7 degrees centigrade. Rainfall, though abundant, rapidly drains through the volcanic ash leaving the ground surface very dry. The first plants to be found on this newly formed island germinated on the strandline, where rotting plant and animal remains provided a source of mineral nutrients and retained rainwater. By 1971, 83 vascular plants had become established, originating mainly from neighbouring islands through seed dispersal by wind or water. The plant colonies gradually advanced inland and at the same time nitrogen-fixing bacteria and also mosses had begun to colonize the inland lava flows.

The speed of revegetation of the earth's surface after the flood similarly would be dependent largely on the temperature and the abundance of seeds or other plant parts which were still viable. Rotting debris, by providing a source of nutrients and a store of water would increase the rate of establishment of vegetation. We do know that 120 days after the ark was grounded, leafy shoots had already sprouted, as the dove found an olive leaf on the second occasion that it was released from the ark.

It is interesting to note that animals were not released from the ark until 93 days had elapsed after the olive leaf was brought back by the dove. The vegetation which had grown during this period would have become sufficiently established to survive trampling and provide grazing for the animals when they were released from the ark.

2. How did plants adapt to the changed conditions after the flood?

The evaporation of the flood waters by the wind referred to in Genesis 8 v 1 would have caused considerable cooling of the surface of the earth, probably a major contributory factor in the formation of the ice caps at both poles and the ensuing Pleistocene glaciation in the northern hemisphere. The subsequent retreat of the ice caps was coupled with decreased rainfall in some tropical areas and was probably responsible for the formation of the desert regions of the world which are still increasing in area at the present time (Good, 1974). The Sahara is known to have supported grassland vegetation and several species of Mediterranean woodland plants until about 4000 B.C. according to the results of pollen analysis of material from the Tibesti and Haggar massifs (Clark, 1967). However, by about 2000 B.C. archaeological finds indicate that people were moving out of the region (Harlan, 1975). Similar evidence from the Pacific south-western deserts in North America shows that the area once supported mixed arable farming of corn, beans and squash (Lammerts, 1971).

Changes in the world climate after the flood obviously would have had a profound effect on the vegetation types of the world. The plants which initially colonised an area as the flood waters drained away would not necessarily have been suited to the climatic and soil conditions which developed and presumably many became extinct especially in the less hospitable environments. However, the genetic variation between individuals of the same plant species permits a certain amount of elasticity, for example, in the tolerance limits to colder or drier conditions. One present day example is the tolerance of plants to air pollution from industrial societies. Strains of ryegrass tolerant to pollution by acid gases have been found down-wind of the prevailing southwesterly airstream passing over the industrial northwest of England (Horsman, Roberts and Bradshaw, 1979). Similarly, strains of bent grass growing on mine waste at the old Drws-y-coed copper mine in north Wales were found to be tolerant to this heavy metal (Bradshaw and McNeilly, 1981). Selection of individuals for a particular characteristic, for example, early flowering in Kent strains of perennial ryegrass (Cooper, 1961) or cold tolerance in cocksfoot (Cooper, 1963) can occur within relatively few generations; tolerance to air pollution by sulphur dioxide was found in populations of perennial ryegrass and timothy after three or four generations (Wilson and Bell, 1985).

The process by which tolerant strains develop is a relatively simple one, and involves competitive advantage in growth and in reproduction. When exposed to the different environmental conditions, the tolerant individuals are those which grow more vigorously and eventually they will take a greater proportion of the available light, nutrients and water. By such competition, the sensitive individuals which are growing more slowly and producing less seed will contribute less to each succeeding generation, until eventually they are eliminated.

Another process which enhances adaptation to changed environmental conditions is the 'switching on' or 'switching off' of part of the genetic material and this can alter the characteristics of the plant. Studies in which local populations of *Achillea* were transplanted to other environments along an east-west transect across Central California, showed that each population only had a uniform growth habit in it's original environment (Clausen, Keck and Hiesey, 1948). The different plant forms and growth habits at other sites led the authors to suggest that another set of genes was operating. Alternatively, the interaction between the genetic material and the environmental conditions could have affected gene expression. Furthermore, an even greater divergence of plant structure was seen amongst the offspring, notably in the second generation.

In the changing post-flood environment, those plants less able to adapt to the changes in environmental conditions would be gradually eliminated, whereas those species with particular strains capable of tolerating the new conditions would predominate. It can be predicted from the mechanism of selection described above that the greatest abundance of different plants would be found growing in the post-flood climates most nearly approaching those which predominated before the flood. Conversely, where there is only a limited variety of plant life it can be assumed that the climates have diverged the most from the pre-flood environments and the plant life represented is that which possessed the potential to adapt to these new conditions. In general, the greatest variety of plant life is found in subtropical and tropical areas with abundant rainfall, and examples of the harsh environments with few types of plants would be desert, arctic and alpine areas.

Recolonization - a summary.

Recolonization would have occurred in all areas where there was sufficient water and nutrients to sustain plant life. Climatic changes occurring after the flood would have restricted the distribution of many plants, but tolerant strains of some species would colonise the less favourable climatic areas to give distinctive floras, for example desert, arctic and alpine plant associations. The selection of such tolerant strains can occur within a few generations and this would have prevented many species from becoming extinct.

Present plant distribution

1. How did the present distribution of plants occur?

One important factor in the development of post-flood vegetation types in the different continents would be the fairly random distribution of viable plant material left on the surface of the ground as the flood waters receded. As we have already seen, some of this would have been floating on the surface of the flood waters and the rest would have been embedded in the uppermost layers of the sediment left behind. Presuming that there was little opportunity after the flood for plant migration between land masses of the world, then we would expect a fairly random distribution of plant groups between the continents, limited only by the different environmental tolerances of each group. One would predict that some plant groups would be found in a single area, for example, tropical Africa, others in two or more separate areas, for example tropical South America and tropical Africa, but not in other areas with similar environmental conditions, whilst yet other groups would be found in all areas that were climatically suitable.

This pattern of distribution is very different from that which would be predicted from an evolutionary model of the origin of vegetation types. Distribution of plant groups would occur solely by migration from the areas in which the groups evolved. It is therefore necessary, in the evolutionary model to account for all discontinuities in plant distribution by past migrations between land masses at the right period in the evolutionary time scale. Land bridges between continents and the timing of continental separation have been implicated in the pattern of present day plant distributions, but little geological data is available to support these claims.

A comprehensive text on the distribution of flowering plants has provided a detailed analysis of world flora (Good, 1974). One trend in the vegetation distribution which is noted is the increasing paucity of species with increasing distance from the subtropics and towards the poles or towards desert areas. This is compatible with the distribution of plant species predicted from the flood model, with only a proportion of species being able to adapt to the less hospitable regions away from subtropical and tropical climates with abundant rainfall as discussed above.

Some families of flowering plants are cosmopolitan, with representatives on all continents and islands. The most notable example being that of the grasses (Graminae), with the Compositae (this family includes familiar plants such as thistles, dandelions, daisies and sunflowers) a less dominant but almost equally ubiquitous family. Other families are restricted entirely to tropical areas, for example palms, whilst others are only found in temperate regions. A study of the families of these regions reveals a more or less random distribution (Good, 1974).

The random pattern of distribution of plant families is reflected more strongly in the distribution of plant genera and species. One example is the occurrence of arctic-alpine species. The patterns of distribution include every combination of the following:- Arctic, Antarctic, Himalayas, Alps, Rockies and Urals. Examples are as follows:- the least willow *(Salix herbacea)* is found in the Alps, Urals, Rockies and Antarctica, and the pygmy buttercup *(Ranunculus pygmaeus)* in the Alps, Rockies and Arctic. There are many examples of such discontinuous distribution for all climatic zones. Other groups with limited distribution have been trans-planted successfully to new areas with similar climatic conditions. One example is found in the plant tribe Magnoliaceae, found in southeast Asia, southeast U.S.A., Central America and in parts of South America. Many magnolias have been planted successfully in Europe. Other introduced species have become established so successfully that they have become serious weeds in some areas, for example rhododendron and Japanese knotweed *(Reynoutria japonica)*. These examples demonstrate the random nature of plant family, genera and species distribution worldwide. This is more compatible with the random distribution of living plant parts on the post-flood earth as the flood waters receded, rather than the evolutionary model of plant distribution where each plant family evolved in a particular place and then subsequent plant migration across oceans and unsuitable climates must account for the present distribution.

2. How did crop plants survive the flood?

We are not told specifically in the Genesis account which crops were grown before the flood, but we do know that both arable and pastoral agriculture were practised (Genesis 4 v 2). Immediately prior to the flood, a quantity of all types of edible plants known to Noah were stored in the ark as a supply of food for both man and animals. These plants would have formed the basis for post-flood agriculture. Some crop plants may have survived in the flood waters, certainly this was true for the olive tree (Genesis 8 v 11). It was probably not the case for most annual crops such as wheat and barley, as the characteristics of seed dormancy which enable the survival of wild plants in unfavourable environmental conditions are often absent from cultivated species.

We do not know how great a difference there was between the pre-flood climates and early post-flood climate in the area in which man first settled again on the earth, around Mount Ararat in the Middle East. Obviously it was sufficiently similar to enable Noah to harvest crops and plant a vineyard (Genesis 9 v 20). Peoples migrating from this region to all parts of the world would have taken their domesticated animals and plants with them. This means that evidence of cultivated plants and domesticated animals and agriculture should be present at the earliest archaeological sites of man's settlement (Darrall, in press).

However, as people moved further afield they would have encountered climatic zones (once they became established) that were increasingly different from that in the Near East. Examples of this would be the cool temperate climate of north west Europe and the tropical monsoon climate of India and south east Asia. Unconcious selection of tolerant types would have increased the climatic range of the more variable and hence adaptable crops, but harvests would fail in other crops. New crops, which were formerly wild plants or weeds of the original crops which were tolerant of the new climatic conditions, would gradually be introduced. One example is the introduction of oats and rye into cultivation in north west Europe; these were formerly weeds in wheat and barley crops in the Near East. Other examples are the gradual replacement of crops cultivated in the Near East by plants native to tropical areas of the sub-continent of India and by different native plants in the tropical highlands of East Africa in Ethiopia (Harlan, 1975).

The origin of agriculture in the Americas remains an enigma. The earliest records are of crops quite different from those found in the Near East. However, evidence is very limited and comes from a few sites in north east Mexico, the Tehuacan valley to the south east of Mexico City, from Coastal Peru and at Ancash also in Peru (Harlan, 1975). Remains of crops such as maize, squash, pumpkins, gourds, chili peppers and avocados have been found, most of which were clearly cultivated rather than wild plants. This led authorities in the field to conclude that domestication occurred elsewhere in the Americas and that these sites were occupied at a later date (Heiser, 1979). The assumption behind these statements is that the first people to settle in the Americas were too primitive to have in their possession the techniques of cultivation and that the discovery of agricultural methods occurred many times throughout the world.

An alternative interpretation of the scientific data which is compatible with the Genesis account is also possible. Groups of peoples migrating originally from the Middle East and arriving in the Americas had lost their original crops because of the successive different climatic zones through which they had travelled. However, an understanding of agricultural practice remained and new crops were rapidly selected from indigenous wild plants.

Plant distribution - a summary

The greatest variety of plant life is found in subtropical climates with a decreased diversity towards desert areas and colder areas. It is suggested that the pre-flood climate was uniform and similar to a sub-tropical climate and that after the flood a range of climatic conditions came into being. In the harsher climatic zones the only plants to survive and succeed were those species already possessing in their genetic make-up a greater inherent tolerance to climatic variations than those species which became extinct. This tolerance was then expressed in an increasing percentage of populations colonising these harsher environments after the flood.

Plant distribution within climatic zones is of a random nature, not readily explained by the hypothesis of evolution. According to this hypothesis, flowering plants evolved on one, or a few separate occasions and were then distributed through the various continents by migration. An alternative hypothesis based on the Genesis account is that survival of plant types through the flood outside the ark was fairly random in the different continents of the world, and therefore discontinuous distributions of plant groups are likely to occur as well as all the various combinations of presence and absence between the continents.

Some agricultural plants had been domesticated from earliest times and survived through the Genesis flood either in the ark or in the flood waters. These were then distributed with migrating peoples in all directions from the area of Ararat. In regions where the original cultivated plants did not survive because of climatic or other reasons, substitutes were cultivated; either plants which had previously been weeds of agriculture or native wild species.

Summary

The problem of plant survival during the worldwide flood in the time of Noah Genesis (6-8) and the problem of subsequent re-establishment of both natural vegetation and agricultural crops is one that is often overlooked. In this article possible solutions to these problems are suggested.

The devastating nature of this event, which submerged and destroyed all the land surfaces known before the flood, would have decimated all plant communities. Survival would have been possible only for dormant seeds, shoots, and plant storage organs such as corms. Some would have been sufficiently resistant to survive in the flood waters, whereas others would have survived only where protected on floating debris. Some may have been temporarily buried in sediments which were exposed as the flood waters receded, and others, including most of the then cultivated plants would have survived only if stored in the ark. A significant proportion of the plant life did not survive the flood.

The present distribution of natural vegetation is partly due to the relatively random distribution of plant debris by the receding floodwaters and partly as a result of the differences in environmental tolerances of the recolonising species. Adaptation to the different post-flood climates occurred in some groups of plants, whilst others were restricted to environments more nearly approaching pre-flood conditions.

Agriculture was first re-established in the Near East, close to the area of the Ararat Mountain range where the ark was grounded. During subsequent migrations of agricultural peoples, some of these crops became adapted to different climatic conditions, whilst others which did not possess the genetic variability to form

viable populations were replaced either by plants which had been weeds of the original crop, or by domesticated indigenous species which gave better yields. There is little archaeological evidence from which to trace the movement of post-flood agriculture. However, the information that is available does not conflict with the hypothesis based on the Genesis account, that present day agriculture originated from a single source in the Near East.

In conclusion, it is perfectly reasonable to suggest that plant life survived the Noachian flood either in the ark, in the flood waters, or buried in the uppermost sediments deposited at that time. Naturally occurring mechanisms such as seed and bud dormancy can account for the survival of these plants. Recolonisation of the land surface devoid of soil and with less hospitable environmental conditions can also be understood in terms of the process of natural selection. However, not all types of plants would have survived, and the present continents carry only an impoverished range of the original diversity of plant life which flourished before this cataclysmic event.

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