

the same length as the discal setae, arranged as in apterous viviparous female. Wing membrane hyaline, veins fuscous. Chaetotaxy of legs essentially as in apterous viviparous female. Length of hind tibia 0.1 mm. Length of hind tarsus 0.125 mm. Setae on abdominal terga I-VII blunt, about the same length as discal setae. Setae on abdominal tergum VIII blunt, about as long as the basal diameter of antennal segment III. Abdominal tergum VIII with a small, median, scarcely discernible tubercle. Cornicle smooth, clavate; orifice tends to be on the mesal margin. Cauda triangular, shorter than cornicle, with two pointed setae about the middle and a subapical tuft of 6-8 pointed setae. Integument: Cauda and anal plate with spiculose imbrications; anal plate with spiculose imbrications and with 6-8 pointed or blunt setae situated along lateral margins; venter of abdomen with spiculose imbrications; dorsum of abdomen smooth except for spiculose imbrications on tergum VII and VIII and on pigmented areas; a patch of spiculose imbrications just posterior to each spiracle; antennae and tarsi with smooth imbrications; elsewhere smooth. Length 2 mm. when mounted.

*Holotype*.—Apterous viviparous female, Terrace, B.C., August 27, 1960 (W. R. Richards) on undersurfaces of leaves of *Spiraea* sp. No. 8045 in Canadian National Collection. Paratypes: Two alate viviparous females and 20 apterous viviparous females. Same data as for holotype.

*Comments*.—This species is very similar to *Aspidaphis aquatica* (Gillette and Bragg) and the mounted alatae of *longicauda* can doubtfully be distinguished from the types of this species by the somewhat longer antennal segments. The apterae can be fairly readily distinguished by the absence of antennal pigment in *longicauda* and by the length of the cauda which exceeds the length of the cornicle in *longicauda*. In the types of *aquatica* the cauda is shorter than the cornicle.

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## Perspectives in Biogeography<sup>1</sup>

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### Introduction

I have been assigned a subject that gives considerable latitude for interpretation. I propose to survey the broad outlines of biogeography from several different aspects. First I will discuss the scope of biogeography, in its two dimensions—almost necessarily seen as perspectives—looking outward into the world and looking backward into time. This will lead into a review of some of the principles and processes that underlie biogeographic phenomena. The two dimensions must again be considered, and we will mention both the reasons for present distributions and the not always identical reasons for distributions in the

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past. Then we will broaden the horizon to consider the relationship between biogeography and certain other branches of science. Finally I will try to look a little way forward and to hint at the biogeography of the future and what biogeography may be expected to tell us about the future. This is a large program for a short essay, and the treatment of individual topics must necessarily be brief and simplified.

### Scope of Biogeography

Biogeography can be defined as the study of (a) the distribution of living organisms in space and time, and (b) the principles, processes and parameters influencing this distribution. This means we have to consider not only the geographic distribution and limiting factors of life as we see it today, but also how these have changed in the past, the reasons for the changes, and the prospects for further changes in the future. It will be convenient to consider first the spatial dimension, then the dimension in time.

If we examine the animals and plants around us, we find that there is in any one place a reasonably definite assemblage of species that does not change very much from year to year. True, some species gradually establish themselves or disappear, some are of sporadic occurrence or are so rare they may be considered as accidental visitors rather than as regular members of the biota. Nonetheless, there is enough stability that regional faunistic and floristic handbooks can be written without the need for frequent revision because of changes in the biota.

As we travel outward, the assemblage of organisms changes. This can be looked at from the standpoint of the biota, which varies geographically, or from that of the species, which has a more or less defined geographic range. To some extent ranges tend to have common or closely related limits, and biotas to change more sharply in some geographic zones than in others. It is accordingly possible to define biogeographic regions, provinces and so forth with a considerable degree of success. Such divisions are commonly associated with climatic zones or with prominent topographic boundaries, such as mountain ranges, sea coasts, rivers and the like. Another type of common limit of ranges arises from environmental zonation, according to altitude, rainfall, water table, soil, etc. This determines local assemblages that are based on type of habitat rather than on latitude, longitude or major geographic features.

One of the practical problems of biogeography is how to record and classify data efficiently and usefully. The mechanical difficulties of filing numerous locality records for each species are themselves very large. When locality data are conjoined with information on abundance, habitat, and biological associations, the problems are multiplied. Electronic punch-card systems permit the manipulation of such large bodies of data, and have been applied with success in the Forest Insect Survey of the Department of Forestry of Canada. These systems show promise for the rapid comparison of distributions of different species and for their association with climatic and other geographically correlated information.

Another and more basic practical problem is that of securing on the one hand distributional data that are accurate and representative and on the other hand environmental and biological data suitable for correlation with the distributional information once it has been obtained. Much information exists in the biological literature, but it has obvious defects. It is scattered; the taxonomic identifications are more often than not untrustworthy; the information itself has usually been obtained on a haphazard basis, depending on the interests of different individuals at different times. Organized surveys provide a partial answer, but these are expensive if properly done, and take many years to supply adequate samples and

coverage. Even in the relatively simple environments of the Far North, 15 years and 80-odd parties of the Northern Insect Survey have given us only a partial picture of the ranges of even the major orders of insects. In this simple fauna, and in an organization devoted primarily to insect taxonomy, identifications have caused serious problems and are still far from complete. Sampling and identification problems are multiplied in the complex faunas of more southerly regions.

Yet another set of practical problems concerns what kinds of data shall be sought, and how they shall be correlated and interpreted once they have been obtained. Part of the answer lies in sampling theory and the statistical distribution of abundance. Thanks to the work of Williams, of Preston, and of others, we know a great deal about the patterns of abundance of species. Statistical methods permit us to press our sampling to the desired standard of completion. The deeper questions of interpretation depend on a knowledge of the ecological and evolutionary processes that affect distribution. Their nature and some of the answers will become apparent as we proceed to discuss these processes.

So much for the spatial dimension. Complex as present distribution is, it is only the surface of a pattern that extends with continual and often radical changes millions of years into the past. To peer backward into this vanished world, different methods are needed.

One approach is by way of fossils. These provide the surest evidence for past geographic distribution. Unfortunately, however, the fossil record is both scanty and unevenly distributed. Vast areas of space and time are unrepresented, because of the lack of suitable fossiliferous deposits. Even where fossils exist, they do not provide a fair sample of the biota. Some organisms are preserved more often as fossils than others, either because they have suitable parts, such as hard skeletons, or because they live in habitats, such as swamps or tidal flats, where they are more likely to be buried in sediments. Only a small proportion of the fossils that are formed are ever found, and many of these are fragmentary or damaged.

For all these reasons, fossils are of much greater value as positive than as negative evidence of past distribution. As long as the taxonomic identification and the time correlation are accurate—and the accuracy of neither can safely be taken for granted—presence of a fossil provides definite evidence of occurrence of a species at a particular place and time. With luck it may provide further valuable evidence of climatic association and biotic relationships as well. Absence of a fossil, on the other hand, proves nothing, though systematic absence from some horizons or regions of fossils that occur regularly in a variety of deposits in other horizons or regions may have weight as a statistical argument. Even such arguments are dangerous, however, as is shown by the recent discovery as living organisms of several important groups of animals that are unknown as fossils since the Palaeozoic or Mesozoic.

Indirect methods must therefore be relied on to contribute to our knowledge of past distributions. For organisms such as insects, which are comparatively rarely preserved as fossils, indirect methods may be the only ones that are available.

One set of indirect methods is purely deductive. We know a great deal about the past geography and climates of many regions of the earth. Part of this knowledge comes from stratigraphy—geological study of sedimentary deposits and their succession; part comes, as we have seen, from the study of fossils and from deductions as to their requirements. Extrapolation from these data helps us to guess as to the past distributions of groups for which there is no fossil record:

a group of insects closely tied to coniferous forests is likely to have had a history that can be explained in terms of the known history of those forests; a group restricted to cold habitats is likely to have expanded its range in glacial times and contracted it in warm interglacial intervals.

Deductions of this type are less reliable the farther into the past we extend them, for three reasons. First, the disturbances of succeeding times have obliterated more evidence the older the deposit. Secondly, it becomes less certain that past organisms have had habits similar to those of their present relatives as we go farther back in time. Thirdly, we encounter in older deposits a larger proportion of totally unfamiliar organisms and a smaller proportion of groups that have survived to the present day.

A second set of indirect methods relies on the existing distributions of living organisms, but attempts to find in them features that must be the result of historical events, and that accordingly give some clue as to how past environments or distributions differed from those of the present. For example, the presence of related or identical species in two geographically separated regions means that they must have been in contact in some way in the past. If there are many such correspondences, we may be led to the view that the barriers that now exist were inoperative in the past, e.g., that two islands were united by a "land bridge" or that a stream has changed its connections with other bodies of water.

Considerable progress can be made in this type of analysis by common-sense methods or by inspection and guessing. However, experience shows that guessing can easily get out of hand, leading to ridiculous extremes of "bridge building" or to mutually exclusive hypotheses which cannot easily be resolved by objective means. Such extravagances and dilemmas become tractable only if we understand the underlying processes that govern distribution of organisms, and particularly if we have some idea of the quantities, rates and magnitudes that enter into the biogeographic equation.

### **Principles of Biogeography**

The first principle of biogeography is that we must understand the present to understand the past. Existing distributions are controlled by present environments, and we must eliminate present environmental causes before we seek historical reasons for the distributions we observe. Then, too, the factors influencing distribution in the past were of the same essential kind as those that operate to-day, however much their detailed pattern of action may have differed.

We must begin, then, with an examination of the reasons for present distributions. First we must consider the ability of the species to survive in a given milieu—its reaction to its medium, to the chemical and physical conditions in that medium, and the requisites of food, substratum and a variety of other factors. Most of these factors can be quantified, and in general there is an upper and lower limit of tolerance, with a varying spectrum of success in between. Simple matrices or graphs can be used to diagram these relationships, and these in turn can be plotted against the geographic distribution of values of the appropriate factors in order to determine the possible limits of distribution of the species. Such diagrams are the well-known "climatographs" which were used, for example, to plot the potential range of the pale western cutworm. Two-dimensional temperature-moisture graphs of this kind are of course far too simple to give a complete picture, though where these are the dominant factors the two-dimensional picture may be a useful one.

Multi-dimensional matrices or figures plotting a variety of independent factors give a more adequate representation. We cannot draw these geometrically, but we can deal with them conceptually by mathematical rules, and they are well adapted to electronic computation.

Simple comparison of species characteristics with ordinary weather maps, etc., does not usually give an accurate explanation of distributions. Vagaries of season and of microclimate, and the temporary wanderings of organisms into areas unsuited for permanent colonization necessitate a much more refined approach to the subject of geographic autecology.

Autecology alone does not provide a well rounded answer to the problem of environmental control of distribution. *A priori* we know there is a complicated web of biotic influences that must affect geographic distribution of organisms. *A posteriori*, we know that, for instance, many introduced plants and animals can exist under culture and protection from competition or natural enemies in areas where they would soon die out if left to the mercies of the natural environment. Synecology, then, is important in understanding distributions of organisms. One of its most interesting aspects to the biogeographer is community ecology. The concept of more or less standardized associations, with a typical cycle of development, makes possible considerable simplification in biogeographic concepts. It is true that community theory can readily be pushed farther than the evidence will bear it out, and that an accurate view of communities will probably take the form of extremely complex multiple correlation tables. Nonetheless, used with discretion, or even with the refinement of correlation methods, the community concept permits dealing with major blocks of organisms as units, and often provides interpretations very close to the observed facts.

Synecological data may assume significance in a simple way, as for instance in correspondence of ranges of species with those of favoured hosts, or of others of comparable ranges of tolerance, or, on the other hand, in the mutually exclusive ranges of competing species and of dangerous natural enemies and their prey.

Alternatively, the correspondence may be with whole communities: many species in Canada are for instance restricted to acid bogs, even though their food plants may be of more general occurrence; others are confined to deciduous forest, coniferous forest, grasslands, sand dunes, etc. The determining factors in such associations may be simple ones of the microclimate manufactured by the community—as was shown by Lindroth for certain Scandinavian beetles; or it may depend on food associations, cover or perhaps more complicated or subtle factors still unknown to us. Not only species limits, but also variation within species, may correspond to ecological boundaries. The special colour forms of desert regions are well known, as are those of the Arctic, of humid coastal regions, such as those of both coasts of Canada, and so forth. The particular significance of tree line, whether Arctic or montane, is well known; a large proportion of organisms habituated to the tundra are specifically distinct from their relatives in the adjacent forests.

Over and beyond the details of synecological geographic correlations there is a fundamental pattern of life forms imposed by the interaction of organisms and climate. In wet tropics, for example, we get massive rain forest; at higher altitudes in the tropics moss-forest. Drier conditions lead successively to sclerophyll or deciduous forest, depending on the seasonal regime, to savannah, to grassland, to subdesert and to desert. Cooler conditions lead to coniferous or deciduous forests in areas of sufficient moisture, to steppes and grasslands in drier areas, and ultimately to tundra and rock barrens. Now the interesting point is

that these responses in different continents and hemispheres are very similar as to aggregate form, even though the species that enter into the associations may be almost completely different. Rain forests of New Guinea or the Congo are closely similar in aspect to those of South America. Deserts of South Africa are like those of Mexico. The temperate forests of the northern hemisphere are closely similar to those of New Zealand or Patagonia.

The fact that these similar environments and ecological formations are characterized by different assemblages of species in different parts of the world introduces the idea of barriers and geographic limitation. In one sense all barriers to the spread of species are ecological. However, by their arrangement these barriers may introduce factors into the distributions of organisms that are not primarily ecological.

On investigation we find that not only are the biotas of climatically different regions regularly different, but that those of climatically similar regions are also different if the regions are isolated. The degree of difference increases with the degree of isolation. The types of barriers that can cause isolation are of course very diverse, and different barriers are effective for different species and groups. Land against sea, fresh as against salt water, altitude, moistness or dryness of climate, forest as against open country, deep sea as against continental shelves, are among the types of difference that may constitute barriers.

The limitation of ranges by barriers is in itself an ecological rather than a historical phenomenon, but the differences of biotas or of populations on opposite sides of barriers are very much historical phenomena. They depend on the past changes or wanderings of organisms rather than on their present environmental responses. In general we find that the degree of difference on the two sides of a barrier is related to (i) the degree of ecological difference on the two sides (ii) the effectiveness of the barrier, that is its unit efficiency and its extent, and (iii) the age of the barrier. Old, wide barriers separate profoundly different biotas, for instance those of tropical America and Africa, which, neglecting human introductions, have hardly a species of insect in common.

How do these differences in biotas arise, and what regulates such similarities as persist? They result from a balance of several processes. In the first place, populations evolve. If two populations are separated it is most unlikely that they will evolve along exactly the same course. As in the disturbance of an unstable physical equilibrium, the first small divergences lead to larger ones and eventually to very different courses of events. Species not only change, they evolve into groups of species, which diverge and ramify increasingly. This provides one mechanism for increasing differentiation across barriers.

A second mechanism is provided by the dropping out of species through extinction, either general or local. Differential extinction acting on initially identical biotas can produce totally different though less varied derivative biotas. When this process is coupled with evolution, the possibilities of differentiation are obvious.

A third factor influencing the differentiation of biotas is immigration. This may act as a levelling factor where it represents penetration or circumvention of a barrier. On the other hand differential immigration from different sources may act as an added differentiating factor.

Immigration, like evolution, is a constructive factor, tending to increase the variety of the biota. These two factors are balanced against extinction, which tends to simplify the biota. On the balance that is struck depends not only the nature but also the number of species in the biota. Where evolution or immigra-

tion is favoured, the biota will be rich; where more rigorous conditions give the advantage to extinction, the biota will be poor. On the whole, large, varied and hospitable environments tend to have larger and more progressive biotas than small, uniform or austere ones.

Special types of immigration may lead to special phenomena. It is common for repeated waves of immigration to deposit successive stocks in the same area. In West Indian butterflies, for instance, as many as four species of one stock exist together in a single island, representing successive colonizations of a single mainland stock. Another special type of immigration is the wholesale mixing that follows on the breakdown of a long established barrier. An excellent example is the reunion of North and South America known to have taken place about the end of the Miocene. Such mixing leads to an unstable loading of the environment with an abnormally large number of species, often in direct competition, and consequently to extinction of many of the species or groups of the mixed biota.

The reasons for past distributions were no different in principle from those for present distributions. The influence of ecology and geographic constraints, the processes of evolution, immigration and extinction, interacted then as they do now. However, the continual and sometimes progressive changes in the earth and its biota have determined correspondingly profound changes in the patterns of this interaction.

No longer than 10,000 years ago our own country was to a large extent locked in the grip of the Wisconsin ice sheets, which covered the greater part of it, completely denuding it of life, often even of life-sustaining soil. The Canadian biota was restricted to refugia in the west, in the southeast, and perhaps in the far north, with some doubtful nunataks or minor havens of refuge elsewhere. The effect of the ice ages on the world scene was not quite so dramatic, but there was profound compression of life zones in the North American continent, probably with increased rigour of environment, both factors working in the direction of increased rate of extinction of biota. In fact in those groups that have left a good fossil record, the rate of extinction in Pleistocene times was very high, and was not balanced by the appearance of new and more highly evolved forms as was the case in the earlier and more benign periods of the Cenozoic. Elsewhere in the world, Europe suffered much the same biotic compression as North America; in Asia, with its far less extensive ice sheets, the effects may have been less drastic. It is likely that the effects of the ice ages extended into equatorial zones and the Southern Hemisphere, depressing ocean temperatures by several degrees and lowering the snow line of tropical peaks. The general nature of the effects on tropical biotas is obvious, though the details are still poorly understood.

In the earlier parts of the Cenozoic, conditions were very different. North America was a land of equable, maritime climate, with broad shallow seas extending over much of the present area of plains, with much less mountain relief, and with rich temperate forests of redwood, oak and walnut extending far into the present subarctic or arctic area.

Those familiar with mammalian fossils think of the Cenozoic as a time of dramatic and rapid evolutionary change, following the downfall of the old Mesozoic biota of the age of reptiles. This is probably a one-sided view. Evidence from fossil insects and from better-known groups, such as marine invertebrates, trees and others, indicate that as a general rule there has been rather moderate change in the Cenozoic. Early Cenozoic and even late Cretaceous genera of trees include many of those familiar at the present day, and the rather scanty amber and rock fossils of insects from these times include many familiar types.

The Cenozoic shows not only slow or rapid changes of organisms, but also striking changes of geography. We have mentioned the late-Tertiary union of North and South America. Prior to this these two continents had remained separate since the very earliest Cenozoic. Whole orders of mammals, some now extinct, had developed in the isolation of the southern continent and had proliferated into a variety of forms. The Beringian land bridge between Asia and Alaska was repeatedly formed and broken, with alternating stages of free interchange and isolation of the temperate biotas of the Old and New Worlds. In the Pleistocene a large part of the Indonesian archipelago was connected with the mainland by lowering of the sea level as a result of water becoming frozen in the polar ice caps.

It will be noted that these changes all involve the margins of continents — shallow seas over continental shelves or narrow isthmian links between adjacent continents. There is no good evidence that either dramatic reversals of land and deep ocean, or conspicuous changes in the relative positions of the continents took place in this most recent part of the earth's history. In fact there is considerable biotic evidence to the contrary.

Farther back in time we cannot be so certain. Geological theory seems to preclude the actual raising of oceanic beds or the lowering of major continental areas. However, continental drift remains a live possibility, one that has been reinforced by the study of the orientation of rock deposits to past earth magnetic fields. The disposition of these seems to indicate that the relative orientation of continents to one another and to the magnetic poles must have been very different in the past from what it is now.

Unfortunately our knowledge of the geographic distributions of organisms becomes more sketchy as we go into this remote past. We are lucky if we know what organisms existed, let alone what their ranges were. Nonetheless, certain distribution patterns seem anomalous in the light of present continental arrangements. Particularly the Palaeozoic *Glossopteris* flora, almost universally distributed in the Southern Hemisphere, but absent from the northern continents, has been held to indicate stronger intercontinental links in the Southern Hemisphere than now exist.

Farther back, into the dim ages before there was any terrestrial fauna or flora, we can reach speculatively, but we have little concrete geographic evidence to guide us.

### Biogeography and Other Sciences

What has already been said will make it obvious that biogeography impinges on a number of branches of science. Among the most important of these are geology, evolutionary science, and ecology.

Biogeography is of direct importance in historical geology. Some of the most useful information on past movements of land and sea and changes of climate comes from the fossil record. For example our knowledge of the Cenozoic connections of North and South America comes from the history of increasing dissimilarity followed by sudden mixing of the two land biotas; this is confirmed by a contemporaneous history of similarity followed by separation and divergence of the shallow-water marine biotas of the two sides of the Isthmus of Panama. Often such biological evidence is supported by geological evidence of rising or subsidence of land, of generalized volcanic activity, folding, block faulting, marine transgression, and the like. The positive evidence of subsidence provided by marine deposits is of course more compelling than the usually

indirect evidence of land connections. However, where geological and biological evidence harmonize, a strong case can be made out for a concordant interpretation. Where they conflict, the need for further investigation is indicated.

The importance of biogeography for evolutionary studies was realized by the early evolutionists. Both Darwin and Wallace were led to their discoveries in large part by study of the distributional patterns of related species in groups of islands, in the one case Galapagos, in the other case the Malayan Archipelago. Actual evolutionary histories are often laid out for us diagrammatically along the paths of migration of the organisms concerned, as was shown by Kinsey for gall wasps and by Ross for mountain caddisflies.

Modern evolutionary theory considers that geographic isolation is a primary factor in speciation. On a higher level there is little doubt that geographic isolation and geographic differences in climate have a profound effect on the whole course of evolution in a region. We have only to contrast the poor and marginal Arctic biota with the rich and proliferating biota of the tropics, the progressive biotas of the major continents with the fragmentary, unbalanced and vulnerable biotas of the marginal subcontinents such as Australia and New Zealand or of the oceanic islands such as Hawaii or the Azores.

Such considerations lead us directly to the relationship between biogeography and ecology, already touched on at several points in this paper. In a sense the world can be looked on as a huge ecological laboratory, the only one in which large-scale and long-term processes can be studied. It is true that we sacrifice control in this laboratory, but this loss is compensated for by gain in scope. Any general ecological theory must be consistent with the facts of present and past geographic distribution.

On a more modest scale the geographic element cannot be neglected in ecology. Too often ecological processes are discussed as though they took place at a single point. In fact populations occupy spaces — often large and heterogeneous spaces. Events taking place in one part of the space exert their influence elsewhere only after a time lag. The length and pattern of time-lags may form an integral part of the ecological process, as is seen, for instance, in the study of epidemiology. Spatial constraints, too, may have an important effect on ecological processes, not only by limiting the possibilities for time-lag effects, but in a more general way by limiting the total resources available for partition and consequently determining parameters of both deterministic and stochastic elements of the ecological process.

### **Biogeography and the Future**

What can biogeography tell us of the future? Certainly many things, especially as our detailed knowledge increases. In a general way we can assess some of the special effects of man on geographic distribution. One such effect is pre-emption of space and resources. Man already occupies or modifies a vastly disproportionate amount of these for a single biological species. The effect of this in general is a smaller share for other species, though we benefit some species — either deliberately, by domestication and conservation, or inadvertently, as we do with our parasites and predators, with the pests that thrive on our crops, or on the wasteland and weeds that grow up around the margins of human occupation. Biogeography shows that statistically a smaller share of resources means the more rapid extinction of species and a smaller resultant biota. In some limited areas, as on certain Pacific islands, quite inadvertent human activity has already resulted in wholesale extermination of the native biota

What we may do in the future directly or indirectly, by deliberate activity, with weapons, with pesticides, and even by biotic manipulation, remains to be seen.

Another profound effect of man on biota results from his penchant for travel and transport. This is the mixing of formerly distinct biotas. Part of this is deliberate — the introduction of crops, of ornamental plants, of domestic animals, of game birds and fish, or of organisms as curiosities, or as agents in biological control. The unforeseen results of such introductions as the rabbit and the prickly pear in Australia, the domestic cat in Hawaii, and pigs and goats in many oceanic islands are well known. Another part of man's biotic mixing is accidental. The histories of many of our worst insect pests fall in this category. But aside from the dramatic specific effects of the examples cited, there is a less obvious but more general effect — that of overloading the biota with species. In a sense man is acting as a bridge connecting all continents, and the effects are likely to be similar to the effect of the land-bridge that joined North and South America — that is, wholesale extinction of species and groups, until balance is restored to the biota.

The effects so far produced by man may be small compared to those that may soon be within his power. We have already begun to control weather. No doubt we shall be able to do this on an increasing scale. Will the implications for the wild biota be considered? Past experience would lead one to doubt it. Climatic control may within the reasonable bounds of imagination extend to such projects as creation of a vast epeiric lake in Siberia, with a moderating effect on the extreme continental climate of that area, to building of a sea-dam to divert the Japan Current, perhaps even to melting or fragmentation of the Arctic ice cap. Study of biogeographic precedents might well permit fairly good guesses as to the probable biotic effects of such changes. Possibly with forethought some of the less desirable effects could be avoided.

In this brief survey I hope I have been able to show both some of the avenues along which we can look into the subject of biogeography and some of the lines along which it can exchange influences with other branches of knowledge. If I have been able to afford some glimpse of the interesting vistas that extend in either direction, my time will have been well spent.

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